CHAPTER 3: PHOTOCHEMICAL MODELING

3.1 INTRODUCTION

This chapter describes modeling conducted in support of the SIP revision for the HGB area. The Clean Air Act requires that attainment demonstrations be based on photochemical grid modeling or any other analytical methods determined by the EPA to be at least as effective. EPA's "Guidance on the Use of Modeled Results to Demonstrate Attainment of the Ozone NAAQS," (EPA, 1996) provides greater consideration of an area's ozone design value and severity of meteorological conditions in the selection of episodes to model. To reflect the form of the NAAQS, the modeled attainment test allows occasional exceedances at any location. This guidance also acknowledges the uncertainty associated with using models to project ozone concentrations into future years.

This attainment demonstration uses the "Deterministic Approach" described in EPA's guidance consisting of an attainment test and an optional weight of evidence (WoE) determination. If the test is not passed, a WoE determination may be performed. If the additional WoE leads to a compelling conclusion that attainment is likely, attainment is demonstrated. Because of the uncertainty of projecting air quality and emissions many years into the future, the guidance suggests that severe nonattainment areas provide for at least one mid-course review (MCR) of air quality, emissions, and modeled data.

The TCEQ committed in 2000 to perform a MCR to ensure attainment of the 1-hour ozone standard. The MCR process provides the opportunity to update emissions inventory data, use the most current modeling tools, enhance the photochemical grid modeling, and revise control strategies, if necessary. The data gathered from the TexAQS 2000 continues to improve the scientific understanding of ozone formation in the HGB area, which in turn provides a stronger basis for photochemical modeling. The collection of these technical improvements give a more comprehensive understanding of the ozone challenge in Houston, which is necessary for developing a plan to reach attainment. In early 2003, as the TCEQ was preparing to move forward with the MCR, EPA announced its plans to begin implementation of the 8-hour ozone standard. On June 2, 2003, the Federal Register published EPA's proposed Implementation Rule for the 8-Hour Ozone Standard. In the same timeframe, EPA also formalized its intentions to designate areas for the 8-hour ozone standard by April 15, 2004, meaning states would need to reassess their efforts and control strategies to address this new standard by 2007. Recognizing that existing 1-hour ozone nonattainment areas would soon be subject to the 8-hour ozone standard, and in an effort to efficiently manage the state's limited resources, the TCEQ developed an approach that addresses the outstanding obligations under the 1-hour ozone standard while beginning to analyze 8-hour ozone issues.

Results from the TexAQS 2000 and recent photochemical modeling suggest that ozone formation in the HGB area stems from a combination of two different types of emissions. The first is the daily routine emissions of a large industrial base located in an urban core with onroad and nonroad emissions typical of a city of four million people. These emissions can be thought of as the base of emissions that could be expected at any given time in the HGB area.

The second type of emissions can be characterized as the fluctuations that occur daily, even hourly in the HGB area resulting from short-term HRVOC releases. Ozone forms rapidly when these variable emissions occur in the immediate presence of NO_x, under the right atmospheric conditions. While these emission fluctuations can occur in any industrial area, the dense concentration of chemical and refinery sites make this a particular concern in the HGB area.

The design value in the HGB area is driven by a combination of these two types of emissions. To address ozone formation in the HGB area, a dual strategy is needed to reduce the base of emissions occurring continuously in the HGB area, as well as restrictions on a short-term basis to address short-term variations. The "base" emissions are addressed through control strategies that resemble those used by other metropolitan areas with a combination of a large urban population and a significant industrial base are needed. These strategies include vehicle I/M, cleaner fuels, cleaner technology for construction equipment, industrial-based controls for routine emissions of NO_x and VOCs, and a long-term cap on HRVOCs. To address the short-term variable emissions, a restriction of the maximum hourly rate of HRVOC emissions is necessary. This restriction would apply to both unauthorized emissions (emission events) as well as to permitted emissions that may fluctuate on an hourly basis that may combine to cause a sudden sharp increase in emissions.

To achieve the necessary HRVOC reductions, the TCEQ will implement a dual strategy: address variable short-term emissions through a not-to-exceed hourly emission limit and address steady-state and routine emissions through an annual cap. The annual HRVOC cap in Harris County is reduced from the existing HRVOC cap by 20 tpd in order to support the attainment demonstration modeling.

Traditional photochemical modeling is used to replicate the first part of the control strategy since the assumption of a steady-state emission rate is consistent with ozone formation for typical 1-hour ozone nonattainment areas. The TCEQ's primary emphasis has been directed towards understanding and modeling a control strategy that addresses this contributor to ozone formation in the HGB area. The future case control runs demonstrate that an effective strategy has been developed for daily routine emissions.

The second part of the control strategy is represented in modeling provided through a collaborative effort (known as project H-13) of the Houston Advanced Research Center (HARC), the TCEQ, the University of Texas (UT), and the University of North Carolina (UNC). Discrete short-term HRVOC releases like those that occur in the HGB area were added to the TCEQ's future-case photochemical model at sites determined to have the greatest impact on the modeled peak ozone concentrations. The modeling conducted under H-13 can better replicate the effects of transient high ozone events by using very high resolution in a relatively small area near the industrial sources. Project H-13 used computationally-efficient sub-domain modeling as an alternative to full three-dimensional modeling to ease the computational burden by confining the short-term emission releases. Sub-domain modeling provided a screening tool for identifying emission times and locations that would most affect the peak ozone concentrations in a full three-dimensional model.

Multiple 3-D photochemical (CAMx) runs were completed to confirm the conclusions based on the subdomain modeling exercise. These two analytical efforts, availability of additional monitoring data to support the analysis, and the increased understanding of ozone formation in the HGB area, allow the TCEQ to effectively address the 1-hour ozone standard in Houston.

This modeling completes the second phase of the MCR (later referred to as Phase 2 MCR). One-hour ozone attainment demonstration analyses were conducted using a future year of 2007, and these modeling results were also analyzed for the 8-hour ozone standard. The latter analysis is intended to demonstrate that the changes to the SIP will not interfere with attainment of and reasonable further progress towards the 8-hour ozone standard.

The modeling includes the episode modeled in Phase 1 of the MCR, (December 2002 HGB SIP Revision), plus additional episode days from the period of the TexAQS 2000. Using this expanded episode will help ensure selection of control strategies that are effective over a suite of meteorological conditions associated with the formation of unhealthy levels of ozone in the region. As in the Phase 1 MCR modeling, this analysis relies heavily upon data collected during the TexAQS 2000, and incorporates recent scientific advancements as appropriate.

The Phase 1 MCR modeling was not included in the 2002 SIP document itself. Thus, references to the December 2002 HGB SIP Revision throughout this chapter are actually contained in the accompanying Technical Support Document for that SIP revision. The 2002 SIP documents, as well as the Technical Support Document, are available from the web site referenced for TCEQ, 2002 in the bibliography.

Another important goal of modeling is to advance the understanding of the many complex processes and interactions that cause ozone exceedances along the upper Texas coast. The TexAQS 2000 has yielded an immense set of air quality, meteorological, and emissions data that has significantly advanced the science of ozone air pollution in Texas and elsewhere. The modeling provides a means of integrating all the disparate elements of the TexAQS 2000 study into a holistic three-dimensional picture of the HGB airshed necessary to study the interplay of the many factors that drive Houston's ozone problem.

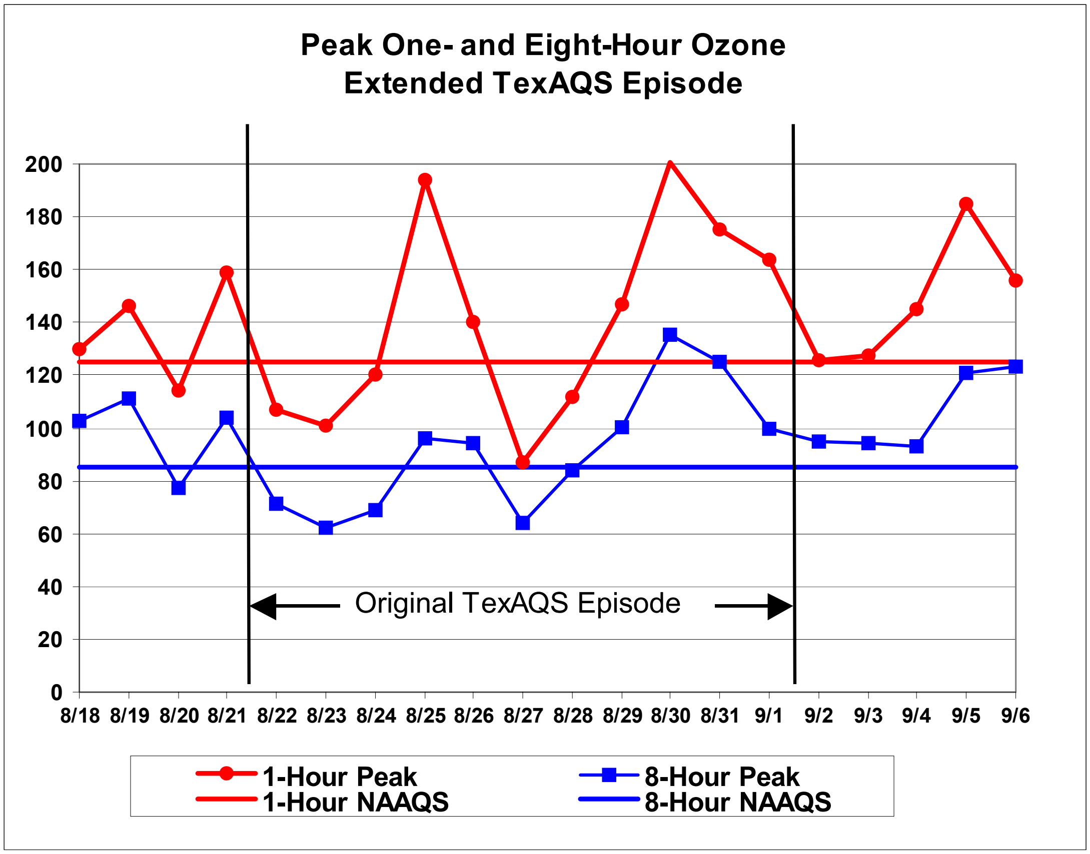
3.2 EPISODE SELECTION

In support of the December 2002 Revision to the SIP, the TCEQ focused on an ozone episode that occurred during the middle of the TexAQS 2000 study period and encompassed ten days (August 23 - September 1, 2000). The rationale for selecting this episode is detailed in the December 2002 SIP Revision and its supporting documentation (TCEQ, 2002). This episode is sometimes referred to as the original or "core" episode.

For Phase 2 MCR modeling, the episode was extended by adding five days at the beginning and five days at the end to produce the "extended episode," running from August 18 through September 6, 2000. This period, like the core episode, is entirely within the TexAQS 2000 study period, providing an extremely rich set of observational data for use in model validation. The extended episode also encompasses a number of meteorological conditions not represented in the original episode. The episode selection process, which included peer review through discussions and presentations with the Houston/Galveston/ Brazoria Photochemical Modeling Technical Committee, is detailed in Appendix A "Protocol for Ozone Modeling of the Houston/Galveston/Brazoria Area." A large excerpt is also included in this section for convenience.

Figure 3.2-1, *Peak 1-Hour and 8-Hour Ozone, Extended TexAQS Episode*, graphically depicts the peak 1-hour and 8-hour ozone concentrations measured during the extended episode. The longer episode contains a number of days that exceed one or both standards, and adds eight exceedance days and a variety of meteorological conditions not present in the core episode.

Figure 3.2-1: Peak 1-Hour and 8-Hour Ozone, Extended TexAQS Episode



3.2.1 EPA Guidance for Episode Selection

EPA guidance for episode selection recommends analyzing the morning wind directions to determine the relative frequency of wind patterns and calms associated with ozone formation. (USEPA, 1991) The Guidance also recommends selecting for modeling one of the top three events from each wind direction associated with high ozone concentrations. During the COAST study, the TCEQ recognized the importance of the morning/afternoon land/sea breeze flow reversal and therefore enhanced the EPA method by including 4 hours of afternoon winds in the analysis. Review of the wind patterns during high ozone events using the improved TCEQ morning/afternoon method indicated that the wind directions change dramatically during the day as a result of the sea breeze flow reversal.

Later analysis suggests a similar but more dynamic picture. Although it is still true that on high ozone days the early morning winds tend to come from the northwest and afternoon winds tend to come from the southeast, the picture is more complex than originally thought. First, high ozone events occur when vertical mixing is limited and the winds are generally light and variable in direction. During ozone episodes, the average wind vectors are light and northwesterly in the early morning hours and shift clockwise through all the compass directions during the 24 hour day. The shifting wind pattern tends to bring local emissions back over the city, resulting in high ozone concentrations.

In contrast, on low ozone days winds are stronger and do not shift throughout the day. The wind direction is relatively persistent, suggesting ventilation and relatively low ozone. Given this clear distinction between high and low ozone events, the ozone episodes selected for modeling must illustrate the typical patterns associated with ozone events.

However, detailed analysis of individual ozone events shows that day-to-day variations in wind direction do not always match the average pattern. The key issue in Houston ozone seems to be that regardless of direction, the winds during episodes are relatively light. Stronger, more persistent winds tend to dilute the ozone and transport it out of the HGB area. As discussed in the conceptual model (Appendix A) the current thinking about the dynamics of ozone formation in the HGB area subsumes the land/sea breeze as part of a wind pattern in which the wind direction shifts clockwise throughout the 24-hour diurnal cycle.

3.2.2 Recommendations for HGB Ozone Episode Selection

Ozone episodes selected for modeling should represent the most frequent, typical, and representative patterns associated with high ozone in the HGB area. The TCEQ considered the following:

- The best time period from which to select additional episodes to model is during the August-September time period when ozone episodes occur most frequently and when the design values at most of the area's monitors are established.
- Recent episodes are preferable to older episodes because recent episodes better represent the current emissions inventory, including mobile and point source configurations.
- Well-monitored episodes (with more meteorology, VOC, and NO_x data) are preferable to data-poor episodes. Additional data allow for more thorough model evaluation and provide information necessary to understand the processes leading to high ozone.
- Episodes should include a variety of wind patterns that lead to high ozone concentrations. For the HGB area the episode should include days exhibiting the land/sea breeze flow reversal and other patterns that shift clockwise throughout the 24-hour day.
- Episodes should include days with monitored ozone concentrations within $\pm$10 ppb of the design value to represent the magnitude of ozone that must be controlled. Episodes should include days that have high ozone concentrations in the geographical areas where high values typically occur. Such selection will allow testing control strategies with representative ozone concentrations in the areas where the strategies must work.
- Multi-day episodes are the most efficient way to model both long range transport of ozone as well as the accumulation of local emissions that are associated with ozone in the HGB area. Multi-day episodes also allow the possibility of testing model responsiveness. If the model can reproduce both the high and low ozone days within a period, the model should be able to replicate ozone events more reliably.
- Episodes should represent the most frequent geographical patterns of exceedances as well as the hot spot areas reflected in the current HGB design value analysis. For the HBG area, high ozone occurs frequently in several different areas, but the highest design values occur in the east near the ship channel.

3.2.3 Selection of Episodes for the Phase 1 MCR

The TCEQ examined potential August-September episodes from the 1998-2000 design value analysis period. Three episodes were initially selected based upon an overall assessment of the selection criteria listed above rather than upon any single criterion. The Photochemical Modeling Technical Committee endorsed the August 25 - September 1, 2000 episode because it was a multi-day episode that occurred during an exceptionally well-monitored period and represented typical ozone conditions. The committee also recommended two additional 1998 episodes to address a broader range of conditions and to include days where additional monitors registered ozone peaks in other areas near their respective design values.

- August 25-September 1, 2000
- August 1-5, 1998
- August 26-30, 1998

The August 25-September 1, 2000 TexAQS 2000 Episode
The August 25-September 1, 2000 episode was selected because it had several exceedances in both Houston and Beaumont, so the episode was useful for both nonattainment areas. Six exceedance days (ozone >124 ppb) occurred in the Houston area during the 8-day period, including two days with multiple-exceedances and a period of apparently low ozone in the middle. The low ozone days were initially selected to test the model's ability to respond to increases and decreases in daily ozone.

The episode includes five days with the shifting winds typically associated with flow reversal and high ozone (see the HGB conceptual model provided as Appendix A). August 25 has light easterly winds resulting in maximum ozone at Crawford in the center of the Houston area. August 26 has southeasterly winds carrying the maximum ozone out of Houston to Conroe. Initially, August 27 and 28 appeared to be two low ozone days, with stronger southeasterly sea breeze winds resulting in substantially lower ozone in the HGB area and transporting the diluted urban plume toward Conroe. August 29, 30, and 31 have westerly morning winds followed by weaker afternoon sea breeze winds which position the ozone pool on the east side of the city at Mt. Belview, La Porte, and Deer Park. September 1 has a relatively persistent westerly land breeze, which carries the maximum ozone to the Baytown monitor and points further east.

The characteristics of this episode are consistent with the recommendations for episode selection.

3.2.4 The TexAQS 2000 Extended Episode
Table 3.2-1, *Summary of the August 19 - September 6, 2000 Extended Episode,* shows some of the statistics for the extended TexAQS 2000 modeling window. Italicized text marks the dates where the aircraft or the Williams Tower measured higher ozone than the surface stations. Underlined text indicates where aircraft measured ozone greater than 125 ppb when the surface monitoring network suggested that no exceedances had occurred on that day.

The extended TexAQS 2000 episode also includes 13 exceedance days measured by the surface monitoring network, 16 days when aircraft measurements were higher than surface measurements, and four additional high ozone days identified by aircraft and the Williams Tower data. The extended episode includes three days with multiple exceedances at 9 to 12 surface monitors, and other periods with ozone occurring at from 1 to 7 surface sites.

The additional days added by the extended episode provide some valuable additional information, while picking up ozone in locations and wind directions not previously represented in the shorter episode used in Phase 1.

- The beginning of the extended episode (Aug 19-22) includes days with surface and aircraft exceedances, and adds another classic flow reversal episode (Aug 21) with numerous exceedances that appear sequentially at different sites.

- The additional days at the end of the period (Sept 2- 6) pick up coastal exceedances driven by the land breeze (Texas City, Galveston, Clute) as well as a transport event with two extended ozone plumes measured by aircraft and supported by a single surface exceedance at Croquet on September 6th.

Finally, and perhaps most important, since the extended TexAQS 2000 episode occurred entirely during the TexAQS 2000 special study period, all the special surface and airborne meteorological and air quality measurements and scientific analysis accomplished during the period are available for use.

The August 16-September 6, 2000 ozone episode occurs during the period most likely to have high ozone and includes a full suite of daily wind directions which is indicative of a full synoptic cycle. This episode also includes days with persistent land breezes and days with stagnation/flow reversal, as well as thirteen 1-hour ozone exceedances and fourteen 8-hour ozone exceedances. Since this episode includes all of the recommendations of the selection process, the episode is fully representative of typical ozone patterns in the HGB area.

Table 3.2-1: Summary of the August 19 - September 6, 2000 Extended Episode

Episode Day	Measured Sfc Max Ozone	Peak Station	# Sfc Stations Exceeding	Aircraft Measured Ozone	Flow Reversal?
August 19	146 ppb	Mt Bellview	1	168 ppb	Yes
August 20	113ppb	Mt Bellview	0	130 ppb	Yes
August 21	159 ppb	Hou Reg Ofc	9	210 ppb	Yes*
August 22	107 ppb	Aldine	0	80 ppb	Yes
August 23	101 ppb	Bayland Park	0	149 ppb**	Yes
August 24	120 ppb	La Porte	0	128 ppb	Yes
August 25	194 ppb	Crawford	12	233 ppb	Yes*
August 26	140 ppb	Conroe	1	152 ppb	Yes
August 27***	87 ppb	Conroe	0	115 ppb	Sea Breeze
August 28***	112 ppb	Conroe	0	140 ppb	Sea Breeze
August 29	146 ppb	Mt Belview	3	211 ppb	Yes
August 30	200 ppb	La Porte	7	220 ppb	Yes
August 31	175 ppb	La Porte	10	194 ppb	Yes
September 1	163 ppb	E Baytown	2	210 ppb	Land Breeze
Sept 2	125 ppb	Deer Park	1	---	Sea Breeze
Sept 3	127 ppb	E Baytown	1	153 ppb	Sea Breeze
Sept 4	164 ppb	Texas City	2	132 ppb	Yes
Sept 5	185 ppb	Galveston	3	239 ppb	Land Breeze
Sept 6	156 ppb	Croquet	1	160 ppb	Land Breeze
Totals	13 Exc Days	---	53 Exc Sites	17 Exc Days	

* Classic Flow Reversal Case with numerous monitors showing sequential exceedances.
** High Ozone measured at Williams Tower.
*** Days previously thought to have low ozone and no exceedances

3.2.5 The August 1-5, and 26-30, 1998 Episodes

Subsequent to selecting the three episodes, extensive study of the TexAQS 2000 data has shown that the wind directions and exceedance areas that led to including the two 1998 episodes had also occurred during the TexAQS 2000 period. However, the aircraft measurements during TexAQS 2000 provided data and insight that was not available during the 1998 episodes. Also, the exceedances that occurred in the 1998 episodes were much higher than the current design value, so those old episodes did not properly represent the current situation.

Analysis of the TexAQS 2000 aircraft data showed ozone plumes and areas of high ozone not reflected in data from the surface monitoring network. Therefore, high ozone was occurring on additional days and in areas that the preliminary analysis had not previously associated with high ozone formation. Since the

TexAQS 2000 study included a larger and substantially improved database (including airborne measurements of NO_x, VOC and other compounds, profiler measurements of mixing height and winds in the boundary layer as well as comprehensive LIDAR and chemistry measurements at the La Porte site and the Williams tower), the TCEQ decided that the dynamics associated with the two 1998 episodes would be better represented by extending the TexAQS 2000 modeling window to include the "missing" sites and wind directions.

3.3 MODEL PARAMETERS

This section discusses the formulation of the model, including selection of the air quality model, modeling domain, and initial and boundary conditions. Much more detailed information is available in Appendix A.

3.3.1 Air Quality Model

In the current modeling application, the Comprehensive Air quality Model with extensions (CAMx) was used, which is available freely from ENVIRON International Corporation (ENVIRON) at the CAMx website http://www.CAMx.com. The latest version, CAMx 4.03, was used in this application, with the Piecewise Parabolic Method (PPM) advection solver option. All modeling reported in this SIP revision was conducted using the Carbon Bond IV (CB-IV) chemical mechanism.

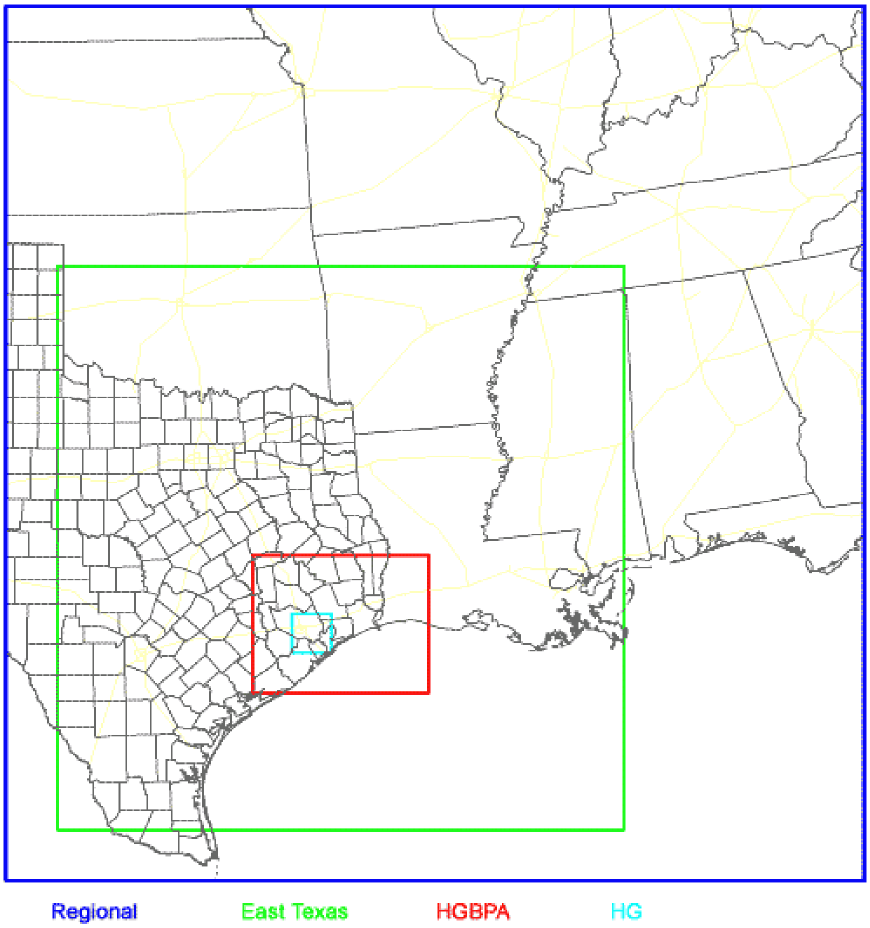
3.3.2 Modeling Domain and Horizontal Grid Cell Size

Figure 3.3-1, *Grids Selected for Use in Phase 2 MCR Modeling Analysis*, shows the grid configuration for the Phase 2 MCR modeling. The CAMx modeling domain consists of a 4 km × 4 km grid encompassing the HGB and BPA ozone nonattainment counties (light blue box), nested within a 12 km × 12 km grid covering the eastern part of Texas (green box). The outer 36 km × 36 km grid (blue box) was selected based on preliminary analyses using back trajectories, indicating that the domain as shown is sufficiently large to minimize the contributions of lateral boundary conditions on the inner grid.

Also shown in Figure 3.3-1 is a superfine 1 km × 1 km grids, centered on the Houston Ship Channel (red box). A more complete description of the modeling domain can be found in Appendix A. The superfine grid was employed specifically to model emission excursions (very high localized emissions) as discussed in Section 3.8. In accordance with EPA Guidance[1], the TCEQ did not use the superfine grid for modeling "routine" ozone formation. However, by their nature, emission excursions can create very high localized concentrations and sharp gradients. The team of researchers, led by Drs. David Allen of UT and Harvey Jeffries of UNC, that studied the impacts of emission excursions believe that superfine resolution is necessary to replicate the associated chemistry.

[1]The 1991 EPA Guidance for Urban Airshed Modeling states that "grid cell sizes smaller than 2 x 2 km are not recommended because of potential model formulation inconsistencies for those grid sizes."

Figure 3.3-1: Grids Selected for Use in Phase 2 MCR Modeling Analysis



The TCEQ has used a 4-km grid cell size modeling to represent the ozone formation for which the model was designed and parameterized. Significant concerns have been raised by the academic community that while the CAMx model will "work" at 1 km, it has never been evaluated for correct performance at this scale and that the uncertainties associated with these concerns may undermine the credibility of the model runs upon which the control strategy was based. One of the suspect parameters within CAMx is horizontal diffusivity, i.e. whether or not the horizontal diffusion of emissions is replicated correctly. Another concern is that the assumptions within CAMx that apply to the hydrostatic equilibrium of horizontal and vertical transport may begin to break down at a finer grid resolution. Similarly, the vertical diffusive treatment of transport (otherwise referred to as the kv's) and vertical layers structure may not be consistent with 1-km horizontal scale.

However, in spite of the issues surrounding modeling at the superfine scale, the researchers believe that the consequence of these inconsistencies are smaller than the effects of large emission events; thus the decision to use the 1 km grid for their work, but not for the "routine" modeling conducted by the TCEQ.

High-resolution modeling is necessary to simulate the transient ozone events associated with highly localized short-term releases, since these phenomena are capable of causing concentration gradients much steeper than would normally occur from routine emissions. Because the photochemistry is driven by precursor concentrations within the individual grid cells, using superfine grids allows the model to more faithfully replicate chemical reactions which occur over small spatial and temporal scales. In these circumstances, the chemistry is believed to dominate the physical components of the Eulerian continuity equation. Therefore, superfine grid modeling is appropriate to evaluate discreet, short-term releases because the photochemistry effects associated with large emission events are so large that the uncertainties introduced through a superfine grid are dwarfed in comparison. As the emission gradients are lessened, i.e. as the magnitude of the emission events is reduced, then the residual uncertainties become relatively much more important. By applying the appropriate tools for interpreting the two aspects of HGB ozone formation, the TCEQ has minimized uncertainty regarding accurate replication of ozone concentrations. Continued evaluation and peer review of these uncertainties is necessary before the model can routinely be applied at a finer resolution to replicate all conditions of ozone formation. The TCEQ will continue to evaluate superfine grids for possible application to the 8-hour ozone attainment demonstrations due in 2007.

The TCEQ plans to assess the suitability of superfine-grid modeling when the 8-hour ozone attainment demonstration is developed. Because the draft guidance for 8-hour ozone attainment demonstrations uses a relative reduction factor approach (ratio of future case to base case modeled concentrations), at least some of the uncertainties introduced through use of the 1 km grid will likely be minimized.

3.3.3 Vertical Layer Structure

The number of vertical layers is a balance between including enough detail to accurately characterize the vertical layering of the atmosphere and managing the amount of time required to run the model. For the Phase 2 MCR modeling analysis, a very detailed vertical layer structure consisting of 24 vertical layers in the fine grids is used, and 15 vertical layers are used elsewhere. This very high level of vertical resolution helps the model characterize concentration gradients of pollutants as the mixing depth changes throughout the day. Details of the vertical layer structure are available in Appendix A.

3.3.4 Initial and Boundary Conditions

The initial and boundary conditions were developed by ENVIRON for modeling conducted in the DFW and Northeast Texas areas. EPA default concentrations were used for most species, but concentrations of some important ozone precursors including isoprene and NO were modified based on monitoring data collected at Kinterbish, Alabama, a rural site near the eastern border of the modeling domain. Additional details may be found starting on page 6-22 of "Final Report - Development of Base Case Photochemical Modeling to Address 1-Hour and 8-Hour Ozone Attainment in the Dallas/Fort Worth Area" at ftp://ftp.tceq.state.tx.us/pub/OEPAA/TAD/Modeling/DFWAQSE/Modeling/Doc/DFW_1999_Basecase_Final_Report_20030831.pdf. Appendix A (Modeling Protocol) describes the boundary conditions used in this attainment demonstration.

3.4 METEOROLOGY

3.4.1 Extended TexAQS 2000 Episode

The original episode selected for this revision occurred from August 25 - September 1, 2000. For this SIP revision, the TCEQ extended the TexAQS modeling episode to include the dates August 18 to September 6, 2000 because of the wealth of data available for that time period. Additional discussion of the rationale for extending this episode has been discussed in Appendix A. In this section, the additional meteorological modeling performed to support the additional air quality model runs for the extended episode is explained.

In the December 2002 SIP revision, numerous enhancements to meteorological and air quality modeling were made. Key among the improvements was the use of the state-of-the-science MM5 meteorological modeling, conducted by the Texas State Climatologist, Dr. John Nielsen-Gammon of Texas A&M University (TAMU). The MM5 modeling, which supports the air quality modeling performed with CAMx, was provided in the Technical Support Documentation for the 2002 SIP Revision.

A summary of work provided by Dr. Nielsen-Gammon during the project period extending from August 31, 2001 through February 28, 2002 resulted in three reports that were attached as appendices to the Technical Support Document that accompanied the December 2002 SIP Revision (TCEQ, 2002). The focus of this preliminary work was the core period of August 23 through September 1, 2000. The first report is titled *Initial Modeling of the August 2000 Houston-Galveston Ozone Episode* (Nielsen-Gammon, 2001). This document introduces the episode and discusses the daily variations that need to be modeled correctly. Also included is the basic MM5 configuration and a preliminary assessment of the dependence of the model results on the model configuration. The second report is the *Evaluation and Comparison of Preliminary Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode* (Nielsen-Gammon, 2002a). This report summarizes the status of special study data that were used in the intermediate series of model runs. Along with this data review, a further discussion of daily weather variations was included so that features that were part of model performance evaluation could be introduced. The last part of this report evaluated the location of precipitation, temperature biases, the development of the planetary boundary layer (PBL), and winds with modeling performed to date. The final report in this series was *Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode: PBL Characteristics, Nudging Procedure, and Performance Evaluation* (Nielsen-Gammon, 2002b). This report described in detail the ability of MM5 to capture those physical features which Dr. Nielsen-Gammon considered most relevant to the core TexAQS 2000 episode.

Subsequent to the 2002 proposed SIP revision, the meteorological modeling proceeded along two parallel paths. The first part used an existing contract with ENVIRON to provide a wide range of services supporting improvements in HGB modeling. ENVIRON's contract with the TCEQ included the subcontracting of meteorological work to Atmospheric, Meteorological, and Environmental Technologies (ATMET). Since ENVIRON was already performing model sensitivity studies on behalf of the Houston Advanced Research Center (HARC), the TCEQ was able to extend the HARC scope of work by entering into an agreement with the Geotechnology Research Institute (GTRI), affiliated with HARC, which identified additional tasks described in a later section. The MM5 modeling conducted by ATMET provided the input meteorology for CAMx modeling between September 2 - September 6, 2000.

Secondly, the TCEQ supported development of an advanced variant of MM5 by scientists at the University of Alabama Huntsville (UAH) and NASA Marshall Space Flight Center (MSFC) to assimilate Geosynchronous Operational Environmental Satellites (GOES) data. This version of MM5 was installed on the TCEQ computers, and the TCEQ and Professor John Nielsen-Gammon of TAMU received training together from UAH. Professor Nielsen-Gammon received support from the TCEQ to evaluate this version of MM5 against his earlier modeling. The GOES-MM5 has certain advantages which are described in the following sections, but the GOES data processed by MSFC for this version of MM5 was only available on the August 23 - September 1 episode days. After extensive model performance evaluation (described later in this chapter and in Appendix B) this version of MM5 was selected in order to provide the input meteorology for the CAMx modeling for August 23 - September 1, 2000.

3.4.2 Description of ATMET MM5 Configuration

The MM5 modeling domain, described in the Modeling Protocol, is identical to what was used for modeling submitted as part of the December 2002 SIP Revision. The extended TexAQS episode is also characterized in the Modeling Protocol. The MM5 configuration developed to support the December 2002 SIP Revisions was used throughout the extended episode to provide consistency between the core period of August 23 - September 1 and the new episode days bracketing this period.

The ATMET modeling effort was led by Dr. Craig Tremback, and it proceeded, by design, with an initial configuration very similar to that of Dr. Nielsen-Gammon. The physics options for the extended period are summarized in Table 3.4-1, *MM5 Physics Options*. Among the options in Table 3.4-1, radiation, cumulus parameterization, and explicit moisture physics are typical choices for a domain at this latitude and for a period without heavy convective activity.

One of the key parameters affecting MM5 performance is the available soil moisture. This parameter can be set to default values dependent upon land use category, adjusted manually when data is available (see Nielsen-Gammon, 2001) or set by a land-surface model (LSM). The primary difference between the initial modeling performed by ATMET and the final configuration arrived at by the TAMU modeling was the choice to use a land-surface model (LSM) to provide surface fluxes. The LSM that became available with MM5 version 3.6 was developed with support of the National Center for Atmospheric Prediction (NCEP), Oregon State University (OSU), Air Force, and the Hydrologic Research Laboratory, and hence is called the NOAH LSM.

Table 3.4-1: MM5 Physics Options

MM5 Parameterization	Physics Option Selected
Radiation	Rapid Radiative Transfer Model (RRTM)
Cumulus Parameterization	Grell (grids 1-3)
Explicit Moisture Physics	Simple ice
Planetary Boundary Layer (PBL)	Medium Range Forecast (MRF)
Nesting	Two-way
Nudging	Analysis nudging above PBL
Soil Model	NOAH LSM

The meteorology for the episode of August 23 through September 6 included very warm ambient temperatures in the latter half of this period. Dr. Nielsen-Gammon accounted for this feature in his work supporting the December 2002 SIP by looking at the afternoon rawinsonde temperature and moisture profiles aloft, assuming a well mixed atmosphere, and inferring that soil was drying out in a manner described in more detail in his 2001 report (Nielsen-Gammon, 2001). The ATMET modeling did not use these *ad hoc* adjustments to available soil moisture because this parameter became a predicted output of the NOAH LSM.

The choice of PBL scheme was discussed at some length in Nielsen-Gammon, 2002a and Nielsen-Gammon, 2002b. The present modeling effort by ATMET is documented in a new series of reports available on the TCEQ website. The first report is titled *Final Report: MM5 Simulations for TexAQS*

2000 Episode, (Tremback, 2003a). As with earlier work, additional attention was paid to model sensitivity to PBL schemes. ATMET, in consultation with the TCEQ, conducted investigations into the performance of PBL choices in this first report. A more detailed discussion followed in *Task 3: Sensitivities to modifications of the MRF PBL scheme* (Tremback, 2003b). This report documents modifications to the MRF code so that sensitivity studies could be explored. MM5 contains alternative PBL algorithms to the MRF which rely upon calculations of Turbulent Kinetic Energy (TKE). Comparisons between MM5 predictions using MRF and one of the alternative TKE PBL choices, called Gayno-Seaman, was a significant part of Nielsen-Gammon, 2002b. Since ATMET has extensive familiarity with TKE-based PBL algorithms using the Regional Atmospheric Modeling System (RAMS), it assessed the possibility of future TKE analyses with MM5. This summary of algorithm differences became *Task 4: Review of the TKE PBL schemes in MM5* (Tremback, 2003c).

A partial summary of observations and conclusions from the present series of ATMET modeling reports referenced above is included here.

- The Meteorological Statistical (METSTAT) package, (Emery, et. al, 2001) statistics for surface temperatures indicate that the NOAH LSM performed favorably when compared to the adjustments made to available soil moisture as described by Dr. Nielsen-Gammon in his reports.
- The initialization of the NOAH LSM by Eta Data Assimilation System (EDAS) contributed to the very low values of available soil moisture that characterized this period. These low values may have contributed to a large sensible heat flux and planetary boundary layer depth that was at least as deep as previously predicted.
- Removal of the convective velocity adjustment in the MRF PBL scheme removed a low daytime wind speed bias that had been observed previously by Dr. Nielsen-Gammon and in the initial ATMET runs. This change was incorporated into the MM5 modeling which comprised the final ATMET MM5 configuration.
- Other MRF PBL sensitivity tests adjusted two parameters that can affect the predicted PBL depth: the first is the value of the critical Richardson number, and the second test removed the virtual temperature excess. These tests support the observations of MRF developers that the algorithm is sensitive to these parameters. However, without criteria for selected alternative values to the default parameters, these tests were not incorporated into the final MM5 runs.

3.4.3 Description of GOES-MM5 Configuration

In addition to supporting the ATMET modeling runs, the TCEQ also supported Dr. Nielsen-Gammon to continue the evaluation of another version of MM5 that uses the data from GOES system. The purpose of this work was to investigate whether MM5, as configured by Nielsen-Gammon, 2002b, could be improved by satellite data and predict the PBL with greater accuracy. This work is also distinguished by its attempts to validate the model output against microwave temperature profiler (MTP) which was deployed on National Oceanic and Atmospheric Administration (NOAA) aircraft during the TexAQS 2000. A preliminary report describing the preparation of MTP data for model validation purposes is described in *Application of Microwave Temperature Profiler (MTP) Data to MM5 Modeling of the August 2000 Houston-Galveston Ozone Episode* (Nielsen-Gammon, 2002c). This GOES-MM5, however, used GOES satellite data to dynamically modify available soil moisture.

The MM5-GOES modeling system was developed by the UAH and the MSFC. Previously published work (Carlson et al., 1981) realized that available soil moisture and thermal inertia were the primary sources of uncertainty in the surface energy budget when radiation could be well characterized. UAH focused on modifying MM5 to use solar insolation (incoming radiation) as provided by GOES data rather than using calculated solar insolation. It is also assumed that during the mid-morning hours the primary difference between the surface energy budget calculated internally by MM5 subroutines and the surface energy budget calculated from GOES data is due to uncertainty of latent heat flux. GOES data provides measured surface temperature, and from these data the change of temperature with time, or tendencies, can be calculated. By taking the difference between temperature tendencies derived from GOES data and from MM5 routines uncertainties, using GOES radiation data, and invoking the above assumptions, a correction for available soil moisture can be calculated. This provides an alternative to the other adjustments of soil moisture described by Nielsen-Gammon, 2001 or by using the NOAH LSM. A more detailed discussion of GOES methodology can be found in McNider, 1994.

The process of validating the MM5-GOES modeling system is still proceeding. A report on the use of evening data to estimate soil heat capacity, and additional performance evaluation work, will be submitted October 31, 2004. A preliminary report of performance is titled *Meteorological Modeling for the August 2000 Houston-Galveston Ozone Episode: Mixing Depths in the GOES Skin Temperature Assimilation* (Nielsen-Gammon, 2003). The conclusions available to date include:

- Comparison of GOES versus non-GOES MM5 runs, when evaluated against surface temperatures and rawinsonde data, indicated that the GOES MM5 performs better during the morning hours, but not as well as the non-GOES performs during the afternoon hours. This finding was expected because the non-GOES MM5 soil moisture was adjusted by afternoon sounding data, and the GOES MM5 was nudged by morning temperature tendencies.
- The GOES-MM5 run continued to have a tendency to over predict PBL heights between August 25 and August 30, but to less of an extent than the non-GOES run. Starting late in the afternoon on August 30, the GOES-MM5 under predicts PBL, and the non-GOES run comes closer to predicting the observed PBL. (See Nielsen-Gammon, 2001 for discussions of the meteorological transition on August 30, 2000.)

By adding the GOES data assimilation into MM5, the wind field features were improved. For example, although the GOES-MM5 predicted PBL was no longer improved over the non-GOES MM5 for August 31 and September 1, overall CAMx model performance was enhanced on these two days compared with either the results of the original Nielsen-Gammon MM5 or the ATMET MM5 analyses.

3.4.4 Influence of Doppler LIDAR data

Dr. Nielsen-Gammon noted an improvement in low level wind on August 25 when Doppler lidar data were included in the observational nudging file. The MM5 responded as expected by nudging to the profiler data which is valid at 200 meters and above. Without data between the surface and 200 meters, MM5 could not capture low level winds recorded by surface stations. Dr. Tremback used the same observational nudging file for the ATMET runs but concluded that the Doppler LIDAR played a smaller role for daily model performance when the NOAH LSM was used. Dr. Nielsen-Gammon judged the MM5-GOES wind field to be acceptable on August 31 in Nielsen-Gammon, 2003. A sensitivity test was conducted by including Doppler LIDAR data on August 31 to see if performance could be improved. The analysis concluded that the Doppler LIDAR data did not change the August 31 model performance.

3.4.5 CAMx Meteorological Input

CAMx meteorological fields are derived from MM5 meteorology using the ENVIRON program MM5CAMX. The only meteorological field modified by post-processing was PBL height. In all cases, the O'Brien option in MM5CAMx was used to calculate the vertical diffusivities (Kv's) which determine vertical mixing in CAMx. An additional program called Kv patch provided corrections to layer one Kv's to reflect weighting of land-use categories in each CAMx grid cell. Unadjusted PBL heights were used whenever possible, and the present meteorology relies on MM5-GOES fields with no PBL adjustments between August 23 and September 1. Dr. Nielsen-Gammon recommended adjustments of PBL height using profiler data for August 31 and September 1, and the CAMx Kv file was re-calculated to include PBL adjustments for sensitivity studies.

ATMET meteorology was used between September 2 and September 6, and on these episode days, MM5-predicted PBL heights were scaled by a ratio of average measured heights derived from radar profiler data to the average calculated PBL height in MM5 grid cells containing profiler locations. This single scaling factor multiplied the MM5 values in all grid cells and adjusted the predicted field between 8:00 a.m. and 3:00 p.m.

3.4.6 Conclusions and Future Directions

The GOES-MM5 work focused on further investigating the impact of GOES data assimilation on MM5 predicted PBL height. As noted above, this version of MM5 generally produced PBL fields that were closer to observations than either the Nielsen-Gammon model runs of 2002 or the ATMET model runs of 2003. In addition to producing PBL fields that did not require adjustments based upon observed data, the characteristics of the wind field were also analyzed . The GOES-MM5 was chosen for the core TexAQS 2000 period of August 23 - September 1 largely because the wind field seems to have been better represented. Figures comparing predicted versus observed winds are available in Appendix C, "Meteorological Model Performance Evaluation." In addition, CAMx model performance was found to be best using the MM5-GOES meteorology with no PBL adjustments on these episode days.

ATMET MM5 output was used between September 2 and September 6. The full set of statistics and other representative figures are provided in Appendix C. With the exception of September 5, statistics and wind field analysis suggest this output is suitable for regulatory modeling. CAMx model performance, described in Section 3.6, is also reasonable on these days.

TexAQS Part II, the next Texas field study scheduled for 2005 and 2006, is expected to provide more detailed meteorological data for the HGB area than is presently available. The future field study is expected to collect micro-meteorological flux measurements and include satellite measurements over a large portion of east Texas. The use of the MM5-GOES modeling system to date has been limited to those periods for which MSFC has processed GOES data into a format suitable for MM5. At the time of the modeling presented in this SIP, only data from August 23 through September 1, 2000 were processed for GOES sensitivity analyses. An attempt to develop GOES-based characterizations for the remaining days of the extended episode partially complete, since additional GOES data was processed in August 2004 and further refinements became available in September 2004. The evaluation of modeling for other episode days will continue although the modeling is not likely to be available for this round of SIP development. Modeling with GOES data is expected to be part of the model analysis during the period of TexAQS II.

3.5 EMISSIONS INVENTORY

The emissions database used for the Phase 2 MCR modeling analysis represents numerous advances over those employed in previous modeling efforts. In addition to modeling emissions over a much longer time frame (August 18 - September 6) vs. (August 23 - September 1), emissions have been updated from nearly every source category. Most significantly, point sources now have a new speciation that is consistent with reported emissions. As in the December 2002 SIP revision, point source emissions of HRVOCs were adjusted in a manner consistent with the conclusions of the TexAQS 2000, but the adjustment is now more broad-based to be consistent with the allocation of emission caps.

Onroad mobile source emissions have been revised to incorporate updated travel-demand modeling, and a humidity-based adjustment has been applied to diesel NO_x emissions based on research conducted by the Southwest Research Institute. Area and nonroad mobile source emissions are also based on newer information, and also now include a humidity correction for diesel nonroad equipment including locomotives and ships. Emissions from specific fires that occurred during the episode are also included from a database developed by UT. Biogenic emissions now use much more representative gridded temperature data and can now be adjusted to account for drought and heat stress (not part of the base case, but investigated as sensitivity analyses).

3.5.1 Point Source Modeling Inventory Development

3.5.1.1 Base Case Point Source Modeling Inventory Development

The point source emissions inventories are composed of information from several databases. The following sections describe the base case point source emission inventory development for the HGB August-September 2000 modeling episode.

Texas Point Sources

For Texas point sources, data from the TCEQ Point Source Data Base (PSDB) provided the basis for modeling the 2000 base case episode. In nonattainment areas, major point sources are defined for inventory reporting purposes as industrial, commercial, or institutional sources which emit actual levels of criteria pollutants at or above the following amounts: 10 tpy of VOC, 25 tpy of NO_x, or 100 tpy of any of the other criteria pollutants including carbon monoxide (CO), sulfur dioxide (SO_2), PM_{10}, or lead. For the attainment areas of the state, any company that emits a minimum of 100 tpy of any criteria pollutant must complete an inventory. Additionally, any source that generates or has the potential to generate at least 10 tpy of any single HAP or 25 tpy of aggregate HAPs is also required to report emissions to the commission.

To collect emissions and industrial process operating data for these plants, the TCEQ sends emissions inventory questionnaires (EIQs) to all sources identified as having triggered the level of emissions stated above. Companies are asked to report not only emissions data for all emissions generating units and emission points, but also the type and, for a representative sample of sources, the amount of materials used in the processes that result in emissions. Information is also requested in the EIQ on process equipment descriptions, operation schedules, emissions control devices currently in use, abatement device control efficiency, and stack parameters such as location, height, and exhaust gas flow rate. All data submitted via the EIQ are then subjected to rigorous quality assurance procedures and entered into the PSDB.

The Texas point source EI was divided into electric generating units (EGUs) and non-EGUs (NEGUs), which were processed as separate files. The EGU portion of the Texas point source EI was supplemented with hourly data from EPA's Acid Rain Program Database (ARPDB). Upon completion of a PSDB-to-ARPDB cross reference, ozone-season daily PSDB emission records were replaced with hourly ARPDB emission rates for each day of the modeled episode. The Texas inventory was also supplemented with hourly data obtained via the TexAQS 2000 Special Inventory and with additional information from the TCEQ Region 12 Upset/Maintenance Database.

Special Inventory

Episode day- and hour-specific point source emissions data were collected by surveying the largest sources of NO_x and VOC emissions in the HGB and BPA areas to account for specific operating conditions, upsets, start-ups, and shut-downs during the TexAQS 2000 study period. Sources emitting at least 250 tpy of non-methane organic compounds (NMOC) or 1000 tpy of NO_x were requested to participate in the survey. A total of 83 TCEQ accounts were queried. Special Inventory data have been incorporated into the base case modeling episode. See Appendix D, "Point Source Modeling Inventory Development."

Region 12 Upset/Maintenance Database

In addition to the TexAQS 2000 Special Inventory data, data submitted to the TCEQ Region 12 Upset/Maintenance Database were reviewed. All emission events reported during the modeling episode time period were examined and cross-referenced with the emission events reported to the Special Inventory. Events not already included in the Special Inventory were extracted from the database and processed as part of the base case modeling inventory. Only events with quantifiable amounts of CO, $NO_{x,}$ or VOC over the episode were considered for inclusion. Some examples of the data included are: a large CO upset of 885 lb/hr, NO_x upsets varying from 4 lb/hr to 295 lb/hr, and VOC upsets varying from 0.07 lb/hr to 295 lb/hr. A summary of these events is also included in Appendix D.

Louisiana Point Sources

The Louisiana Department of Environmental Quality (LDEQ) supplied a copy of its 2000 point source emissions inventory in AIRS Facility Subsystem (AFS) format. The TCEQ and the LDEQ completed an AFS-to-ARPDB cross-reference list, linking Acid Rain Program boilers to their corresponding LDEQ stack identifiers. With this cross reference list completed, the LDEQ annual EGU emission records were replaced with hourly ARPDB emissions for each modeling episode day.

Regional Point Sources

For the states in the remainder of the modeling domain, beyond Texas and Louisiana, point source emission records in AFS format were obtained from ENVIRON. These 1999 National Emissions Inventory (NEI) v1 data were prepared for near-nonattainment modeling performed by ENVIRON for several areas of Texas. The AFS files were reviewed and Texas and Louisiana records were removed from the data to avoid double-counting.

An AFS-to-ARPDB cross-reference list was developed for boilers larger than 750 megawatts capacity that are subject to EPA's Acid Rain Program. This cross-reference list links these boilers to their corresponding NEI/AFS stack identifiers. With this cross-reference, the ozone-season daily emission records were replaced with corresponding hourly ARPDB emissions for each hour of the modeled episode.

Offshore Point Sources

The TCEQ has been in contact with the Minerals Management Service (MMS) over the last several years to monitor the status of the 2000 Gulf-Wide Emission Inventory (GWEI).

In Phase 1 of the MCR, the 2000 offshore EI was generated by growing the 1992 MMS offshore EI, in-place, by a factor to account for the growth in offshore production platforms, based on a previous MMS report. Based on the recommendation of MMS, all point source offshore emissions were grown by 44 percent, assuming that the ancillary stationary point source equipment would grow at the same rate as the number of offshore platforms. An explanation of the 44 percent growth factor follows.

According to MMS's contractor, Eastern Research Group (ERG), 3,154 offshore platforms were counted for 2000. According to the 1995 revised final draft report, Gulf of Mexico Air Quality Study (GMAQS) by MMS's contractor, SAI (Systems Applications International, Inc., 1995), the number of platforms counted for 1992 was 1,857 with an 85 percent response rate. Assuming that 2,185 (1857/0.85) would be the number of platforms in 1992 (and thus providing a more conservative growth estimate), the number of offshore platforms has grown approximately 44 percent (3154/2185) between 1992 and 2000. Although the 2000 offshore inventory has recently been officially released by MMS, the information on the locations of these new platforms was received too late to be included in this SIP revision. As of October 15, 2004, the TCEQ received the new MMS inventory, but did not had time to quality assure it and incorporate it into this SIP modeling. This work will be completed in the near future.

Mexico Point Sources

The Desert Research Institute provided a 1999 Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study Emissions Inventory in Inventory Data Analyzer (IDA) format (Hampden et al., 2001). The inventory was reviewed, the emissions from sources in Mexico were put into a subset, and the data was converted to AFS format for further processing. These emissions were incorporated into current base case modeling.

A preliminary evaluation of the "Mexico National Emissions Inventory, 1999" report (ERG, 2003) has been completed and it has been determined that there were no significant differences in point source emissions between the two inventories. Therefore, the modeling continues to use the 1999 BRAVO inventory.

Plume-in-Grid (PiG) Source Selection

CAMx provides the option to model selected point sources with a PiG algorithm. With today's computer resources, combined with the efficient PiG algorithm built into CAMx, PiG selection does not have to be as carefully limited as it was historically. The PiG sources were selected based on the magnitude of NO_x emissions (5 tpd with a co-location distance of 1 meter). As with Phase 1 of the MCR, over 300 PiG sources across the entire modeling domain, mostly large power plants, were selected.

Point Source VOC Speciation

Emissions from both the PSDB and the Special Inventory contain large amounts of information about specific hydrocarbons emitted by each source; however, some sources report little or no speciation of their hydrocarbon emissions.

In Phase 1 MCR modeling, any source that reported less than 75 percent speciation was assigned either a Texas-specific Source Category Code (SCC)-average or an EPA default speciation profile. For sources reporting 75 percent or more speciation, the unspeciated emissions were assumed to have the same speciation as the reported emissions. This method is a significant improvement over simply assigning default speciation profiles based on SCCs, but it still has some drawbacks. Specifically, for any source whose emissions are less than 75 percent speciated, all reported speciation data would be ignored. See "Development of Source Speciation Profiles from the 2000 TCEQ Point Source Database" (Pacific Environmental Services, Inc., 2002), for more details.

For the Phase 2 MCR modeling analysis, a new process was developed that retains virtually all speciated hydrocarbon data reported to the PSDB, regardless of the completeness of the speciation of each point's emissions. Also new for Phase 2 MCR speciation is the exclusion of non-VOC species, as defined by EPA, from all point-source speciation profiles. These procedures are described in "Speciation of Texas Point Source VOC Emissions for Ambient Air Quality Modeling" (Cantu, 2003).

Companies supplied chemical speciation profiles for their hourly emissions as part of the TexAQS 2000 survey. When available, these data were used to develop the CB-IV speciation profiles used in the EPS2x preprocessor to CAMx. In cases where TexAQS 2000 speciation data were incomplete or not available the procedure described in "Speciation of Texas Point Source VOC Emissions for Ambient Air Quality Modeling" was used.

Houston/Galveston Point Source VOC Emissions Adjustment

One conclusion of the TexAQS 2000 study was that observed concentrations of certain compounds, especially light olefins[2], were much larger than represented in the reported emissions inventories. This conclusion has been reviewed and documented in numerous scientific journals (Berkowitz et al., 2004; Jiang et al., 2004; Lei et al., 2004; Ryerson et al., 2003; Wert et al., 2003). In Phase 1 MCR modeling, the reported emissions resulted in a significant under prediction bias in modeled ozone concentrations. However, when a set of HRVOCs was adjusted and used, the model performance markedly improved.

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[2]Light olefins refers to the class of compounds with at least one double bond with carbon chain lengths of up to four . This class includes ethylene, propylene, butenes and butadiene; the four HRVOCs. Light olefins may or may not also be terminal olefins.

This adjustment served to increase the reactivity of the baseline modeling inventory, i.e., it increased the inventory's ozone yield potential.

The adjustment used in Phase 1 modeling consisted of creating a second point source emissions file containing all emission points for the largest reactive VOC-emitting accounts in the 8-county nonattainment area (NAA). This file was used to provide the extra emissions of 12 VOCs[3] necessary to make the selected facilities' emissions of these specific VOCs equal their individual NO_x emissions. This specific VOC-to-NO_x adjustment was first proposed by Greg Yarwood of Environ, based on data collected by an instrumented aircraft operated by Baylor University. On October 19, 2001 the aircraft monitored a number of industrial plumes where high concentrations of terminal olefins[4] coincided with high NO_y concentrations (NO_y consists of NO_x plus other nitrogen compounds which are typically products of photochemical reactions such as nitric acid). In four of these plumes, the concentration ratio of light olefin to NO_y was observed to be between 0.8 and 1, consistent with the assumption of roughly equal emissions of light olefins and NO_x from the plume sources.

Since the completion of Phase 1 modeling, several additional studies (Berkowitz et al., 2004; Jiang et al., 2004; Lei et al., 2004; Ryerson et al., 2003; Wert et al., 2003) have been conducted comparing reported inventories to ambient measurements, both airborne and at ground level. These studies generally agree that emissions of light olefins are significantly under-reported. The approach used in Phase 1 modeling is supported by an independent study conducted for the Houston Advanced Research Center by ENVIRON, Project No. H6E.2002, "Top-Down Evaluation of the Houston Emission Inventory using Inverse Modeling" (Yarwood et al., 2003). This study used inverse modeling to assess various inventory components, and concluded that further modification of the inventory used in Phase 1 was not warranted under the then-current model formulation.

For the Phase 2 MCR modeling analysis, an adjustment to terminal olefins has been improved significantly over the adjustments made for the 2002 modeling. The extra terminal olefin emissions are now explicitly speciated as individual compounds in this phase of modeling, based on the speciation profiles of individual accounts, whereas in previous modeling, 12 selected VOCs were increased for all accounts using a generic olefin mixture. The specific compounds selected for adjustment are those known as "terminal olefins," which have a specific chemical structure that is easily detectible by an instrument carried aboard the Baylor research aircraft[5]. The list of the olefins for which adjustments were made (all terminal olefins reported in the PSDB) is provided in Table 3.5-1, *Terminal Olefins Selected for Imputation*.

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[3]The 12 VOCs are ethylene, propylene, all butene isomers, all pentene isomers, 1,3-butadiene, isoprene, all trimethylbenzene isomers, all xylene isomers, toluene, all ethyltoluene isomers formaldeyde, acetaldehyde.

[4]A terminal olefin is an olefin with a double bond residing at the end of the carbon chain.

[5]Although the measurement instruments onboard the Baylor aircraft were primarily designed for isoprene detection, they also respond well to other "terminal olefins." A study to determine the instruments' actual response to other olefin species is planned for the near future. Information has been published regarding these instruments' olefin detection limits, and can be found in Guenther and Hills, 1998.

Table 3.5-1: Terminal Olefins Selected for Imputation

Species
Ethylene
Propylene
1-Butene
1,3-Butadiene
1,2-Butadiene
Pentene
2-Methyl-1-Butene
3-Methyl-1-Butene
Hexene
Isoprene
1-Decene
Propadiene
E-1,3-Pentadiene

In the Phase 1 MCR modeling, adjustments to 12 VOCs were applied on a source-by-source basis by setting each selected source's emissions of those specific VOCs equal to that source's reported NO_x emissions. This adjustment method produced good model performance and increased reactivity to levels more commensurate with aircraft observations. However, because the magnitude of adjustment was established on reported NO_x emissions, many large HRVOC sources received little or no adjustment, while some relatively small HRVOC sources (e.g. refineries) received very large increases. In the 2002 SIP revision, this situation was addressed in the allocation of caps by first re-distributing the additional reactivity in proportion to the sources' reported HRVOC emissions, which resulted in a more equitable cap allocation.

Subsequent to the Phase 1 MCR modeling, sensitivity analyses were conducted to determine the impact this re-allocation would have on model performance. The model performance was comparable between the two adjustment methodologies. So for Phase 2, instead of adjusting emissions on a source-by-source basis, the TCEQ first calculated the total NO_x emissions for accounts in the 8-county area whose speciated inventory indicated 10 tpy or more of terminal olefin emissions. Next, the reported emissions of terminal olefins from these sources were totaled and the molar ratio of (total NO_x)/(total terminal olefins) was used to define a scaling factor. This scaling yielded the amount of additional mass included in the non-varying adjustment. This mass was then allocated, via a weighted distribution based on the speciated modeling inventory, to all points whose speciation information included any of the terminal olefins in Table 3.5-1.

Two types of adjustments were developed using this method, a non-varying adjustment similar to that used in previous modeling and an adjustment that incorporates Special Inventory daily and hourly emission fluctuations. Overall, these enhancements change the modeled reactivity only slightly from previous modeling, but provide for much more flexibility in control strategy modeling. The improved non-varying HRVOC adjustment adds 155 tpd of VOC to the HGB 8-county area, as opposed to the 149 tpd added in previous modeling, and the resulting reactivity is approximately 91 percent of the reactivity previously added to the model. The varying adjustment fluctuates from 163 to 203 tpd. The development of this adjustment is documented in Appendix D.

The TCEQ plans to conduct additional studies comparing ambient concentrations of olefins to the inventory, and will work towards developing more targeted adjustments, especially now that several new automatic gas chromatographs (Auto-GCs) have been deployed in the industrial sectors of the HGB area. In addition to in-house analyses, the TCEQ plans to use the results of other pertinent studies of ambient VOC measurements that have been or will be conducted by scientists and consultants using data from the HGB area. Specifically, the TCEQ plans to use the findings of the following studies for guidance, if appropriate:

1. In-house studies of VOC/NO_x ratio measurements from the TCEQ and EISM auto-GC networks;
2. Advanced multivariate receptor modeling using trajectory analyses and matrix separation techniques, to be performed by Pacific Northwest National Lab researchers and their research colleagues;
3. Positive matrix factorization and other ambient/emissions inventory analyses that have recently been performed by consultants for HARC/TERC (Roberts, P., S. Brown, S. Reid, M. Buhr, T. Funk, P.Steifer, P. Hopke, E. Kim (2004). *Emission Inventory Evaluation and Reconciliation in the Houston-Galveston Area: Final Report*. STI-903640-2490-FR, HARC project H6C, prepared for: Houston Advanced Research Center, Texas Environmental Research Consortium, The Woodlands, TX, March 19, 2004);
4. Other studies that may be useful, such as
   (a) Zhao W., P. Hopke, and T. Karl (2004). Source identification of volatile organic compounds in Houston, Texas. *Environ. Sci. Technol*. 38: 1338-1347;
   (b) Karl, T., T. Jobson, W. C. Kuster, E. Williams, J. Stutz, R. Shetter, S. R. Hall, P. Goldan, F. Fehsenfeld, and W. Lindinger, (2003). Use of proton-transfer-reaction mass spectrometry to characterize volatile organic compound sources at the La Porte super site during the Texas Air Quality Study 2000, *J. Geophys. Res*., 108(D16), 4508, doi:10.1029/2002JD003333, 2003.

The TCEQ plans to initiate a stakeholder process that will focus on methods to improve the emissions inventory. The commission will use this stakeholder process, in conjunction with data from other air quality studies and monitoring, to determine future actions regarding other VOCs.

Point Source Base Case Emissions Summary

Tables 3.5-2, *HGB Point Source Emissions (tpd) - August 30, 2000* and 3.5-3, *Domain Wide Point Source Emissions (tpd) - August 30, 2000,* summarize the base case point source emissions for August 30, 2000. The "CB-IV HC" column represents tons of emissions after transformation to the Carbon Bond IV (CB-IV) chemical mechanism, the simplified chemistry used by many photochemical models including CAMx. The CB-IV mechanism converts VOCs into idealized compounds, characterized by the structure of the molecular bonds among carbon atoms, called CB-IV hydrocarbons, or CB-IV HC. As mass of actual VOC is converted to CB-IV HC, some mass is invariably gained or lost. The CB-IV mass typically differs from VOC mass by up to 20 percent. "Region 12 U/M" is the mass added from the TCEQ Region 12 Upset & Maintenance database (this is in addition to the emissions variability reported in the Special Inventory, which is already included in the EGU and NEGU emissions). Finally, "HGB Olefin Adjustment" is the mass added to the model by adjusting emissions of terminal olefins as described above. Details are provided in Appendix D.

Table 3.5-2: HGB Point Source Emissions (tpd) - August 30, 2000

	NO_x	VOC	CB-IV HC
EGU	225.91	3.81	3.44
Non-EGU	265.96	208.86	190.66
Region 12 U/M	0.00	2.93	3.26
Unadjusted Totals	**491.87**	**215.60**	**197.37**
HGB Olefin Adjustment	0.00	168.01	192.20
Adjusted Totals	**491.87**	**383.61**	**389.57**

Table 3.5-3: Domain Wide Point Source Emissions (tpd) - August 30, 2000

	NO_x	VOC	CB-IV HC
Texas EGU	1348.26	19.63	19.24
Texas Non-EGU	856.74	500.67	458.37
Region 12 U/M	0.00	3.01	3.32
HGB Olefin Adjustment	0.00	168.01	192.20
Louisiana EGU	404.04	3.29	3.31
Louisiana Non-EGU	630.90	218.79	197.25
Other EGU	5565.30	39.28	42.10
Other Non-EGU	1862.21	1769.35	1509.63
Offshore Points	546.08	188.85	56.03
Mexico Points	272.34	0.41	0.31
Totals	**11485.88**	**2911.30**	**2481.76**

3.5.1.2 2007 Future Year Point Source Emissions Inventory Development – Growth

This section incorporates all of the changes that were made to the point source future year inventory since the HGB SIP proposal. Appendix D, detailing point source inventory development, includes both the proposal details and these "final" control strategy details.

Table 3.5-4, *2007 Future Base Case Summary of Growth Methods*, summarizes the methods used to grow the point source inventory, the base case inventory upon which the growth was applied, and the computer filename of the modeling "growth packet."

Table 3.5-4: 2007 Future Base Case Summary of Growth Methods

Geographic Area	Inventory Used	Growth Applied	File Name
Regional (Outside of Texas)	EGU (1999 NEI v1 w/ hourly 2000 Acid Rain Data)	EGAS 99-07	*RegionalEGASGrowthFactors99to07*
	NEGU (1999 NEI v1)	EGAS 99-07	*RegionalEGASGrowthFactors99to07*
Louisiana	EGU (LDEQ 2000 AFS EI w/ hourly Acid Rain)	EGAS 00-07	*LouisianaEGASGrowthFactors00to07*
	NEGU (LDEQ 2000 AFS EI)	EGAS 00-07	*LouisianaEGASGrowthFactors00to07*
Offshore	GMAQS points	assumed same as 2000 (grown 44% from 1992 GMAQS)	N/A
Mexico	1999 Mexico "NEI"	none	N/A
HGB	EGU	newly-permitted EGUs (additional AFS file)	N/A (already included in the HGB Cap)
	NEGU	Banked (ERCs/DERCs) for NO_x,VOC	*grow.NAA_Banks_NEGU*
		TIPI-EGAS 00-07 for CO	TIPIEGASGrowthFactors00to07v3
	HRVOC Cap	none	N/A
BPA	EGU	newly-permitted EGUs (additional AFS file)	*afs.hgmcr2004.new_egu_TX-HG.lcp_v3* then apply 75% demand-to-capacity to the new EGUs via *control.075N.new_egu*

Geographic Area	Inventory Used	Growth Applied	File Name
	NEGU	Banked (ERCs/DERCs) for NO_x , VOC	*grow.NAA_Banks_NEGU*
		TIPI-EGAS 00-07 for CO	*TIPIEGASGrowthFactors00to07v3*
DFW	EGU	newly-permitted EGUs (additional AFS file)	*afs.hgmcr2004.new_egu_TX-HG.lcp_v3* then apply 75% demand-to-capacity to the new EGUs via *control.075N.new_egu*
	NEGU	Banked (ERCs/DERCs) for NO_x,VOC	*grow.NAA_Banks_NEGU*
		TIPI-EGAS 00-07 for CO	*TIPIEGASGrowthFactors00to07v3*
East Tx	EGU	newly-permitted EGUs (additional AFS file)	*afs.hgmcr2004.new_egu_TX-HG.lcp_v3* then apply 75% demand-to-capacity to the new EGUs via *control.075N.new_egu*
	Cement Kiln NO_x	newly-permitted units/ modifications and TIPI 00-07 to existing kilns	*afs.MidloKilns._v5* then apply *ellis_kilns.TIPI.00-07*
	Agreed Orders and Consent Decree for East Texas	N/A	N/A (agreed reductions, not growth)
	all others	TIPI-EGAS 00-07	*TIPIEGASGrowthFactors00to07v3*
West Tx	EGU	newly-permitted EGUs (additional AFS file)	*afs.hgmcr2004.new_egu_TX-HG.lcp_v3* then apply 75% demand-to-capacity to the new EGUs via *control.075N.new_egu*
	NEGU	TIPI-EGAS 00-07	*TIPIEGASGrowthFactors00to07v3*

Regional Point Source Growth

The existing 1999 NEI v1 EGU and NEGU files, that had been supplemented with hourly 2000 Acid Rain data, were grown using EGAS 4.0 on a 2-digit SIC basis. The reader is referred to the EGAS 4.0 Reference Manual, which is available on EPA's CHIEF website. Table 3.5-5, *Regional 2007 Modeled Growth for August 30*, is a summary of the "grown" Regional inventory.

Table 3.5-5: Regional 2007 Modeled Growth for August 30

Regional source	1999/2000 NO_x (tpd)	1999/2000 VOC (tpd)	2007 NO_x (tpd)	2007 VOC (tpd)	% NO_x Growth	% VOC Growth
EGU	5565.3	39.3	5710.7	42.3	3%	8%
NEGU	1862.2	1769.3	1945.6	2172.9	4%	23%
Total	7427.5	1808.6	7656.3	2215.2	3%	22%

Louisiana Point Source Growth

The 2000 Louisiana point source inventory was grown to 2007 with EGAS 4.0 projection factors. This NO_x and VOC growth in Louisiana is represented in Table 3.5-6, *Louisiana 2007 Modeled Growth for August 30*.

Table 3.5-6: Louisiana 2007 Modeled Growth for August 30

Louisiana source	2000 NO_x (tpd)	2000 VOC (tpd)	2007 NO_x (tpd)	2007 VOC (tpd)	% NO_x Growth	% VOC Growth
EGU	404.1	3.3	449.6	3.6	11%	9%
NEGU	631.0	218.8	647.4	234.0	3%	7%
Total	1035.1	222.1	1097.0	237.6	6%	7%

Offshore Point Source Growth

As noted in the Base Case Point Source Emissions Inventory Development section, the 2000 GWEI, which may provide guidance for growth of the Offshore points beyond 2000, is unavailable. While it was indicated by MMS that an assumption of 44 percent growth of point source emissions from 2000 to 2007 might be appropriate, it was also indicated that it would not be appropriate to model that growth in-place, since the platforms built after 2000 have typically been erected beyond the 50 to 100 mile point from the coastline. As a result, of these unknowns, offshore emissions from the base case were not grown. Although the GWEI is not available for use in this SIP revision, future modeling will incorporate guidance from GWEI on these sources when available.

Mexico Point Source Growth

Due to a lack of data and the trend toward slowing economic growth in northern Mexico, no growth was applied to point sources in Mexico; hence, the emissions are the same as those used in the base case.

Texas Nonattainment Area Point Source Growth

Growth in NO_x and VOC emissions in the Texas 1-hour ozone nonattainment areas of HGB, BPA, and DFW, was partially accounted for through the emissions banked in the Emissions Banking and Trading (EBT) database. ERC and DERC totals for each of the nonattainment areas (NAA), as of October 9, 2003 were used. These banked emissions could return to the airshed as actual emissions in the future; this growth was applied to the NEGUs, in the respective NAAs. A summary of the emissions is presented here as Table 3.5-7, *Banked Emissions as of October 9, 2003*.

Table 3.5-7: Banked Emissions as of October 9, 2003

NAA	NO_x (tpd)	VOC (tpd)
HGB	1.2*	13.2
BPA	13.9	1.4
DFW	11.4	0.7

* *These emissions could not actually return to the airshed because of the NO_x cap.*

Chapter 101 requires that an ERC must be surplus to any federal, state or local rule. The credits that are in the bank have been devalued to reflect the amount of reduction that is surplus to the Chapter 117 ESADs. Also, the Chapter 101 Mass Emissions Cap and Trade (MECT) program DERC use restrictions were incorporated in the NO_x total in Table 3.7-2. Therefore, the bank in the HGB area has shown a substantial decrease from previous estimates. The totals in Table 3.7-2 for DFW and BPA incorporate offset ratios and a requirement in Chapter 101 to retire an additional 10 percent as an environmental contribution.

In addition, growth in the HGB, BPA, and DFW areas was accounted for by the inclusion of newly-permitted EGUs. Existing EGUs in the state are not expected to grow. Rather, much of the existing EGU capacity in the state is being replaced by new, cleaner, more efficient (typically) combined-cycle EGUs, reflected in Table 3.5-8, *Newly-Permitted EGUs in NAAs as of November 5, 2003*. With a few exceptions, this growth has not been occurring in the nonattainment counties, because of strict nonattainment New Source Review (NSR) requirements. These proposed new EGUs in the NAAs can not obtain a permit without first obtaining offsets, preventing an increase in total nonattainment area emissions. These offsets are may be purchased from the "bank" for the specific NAA. In the HGB area, NO_x growth is further restricted by the requirement that sources must obtain allowances in order to operate. Modeled future actual emissions from these new EGUs used credits that have already been retired from the bank, since they were all permitted prior to the "bank date" of October 2003. Hence, their emissions were not included in the bank values tabulated for October 2003.

Permit applications for new EGUs throughout the state permitted prior to November 5, 2003 were examined. These permits were then cross-referenced against sources in the 2000 base case EI, to ensure no double-counting occurred. These new sources were assembled into a single "new EGU" AFS file of permit allowable emission rates and permitted stack parameters.

Assuming that these newly-permitted EGUs in the state will all operate at their maximum permitted levels likely over-estimates projected demand (and hence, emissions). Given that the allowable emission rate in a permit typically represent full load (capacity) conditions of the equipment, the modeled emissions of new EGU were adjusted downward to more accurately represent future demand on these new EGUs. An analysis of trend data from an October 1, 2003 Electric Reliability Council of Texas (ERCOT) report (ERCOT, The Texas Connection report, "Report on Existing and Potential Electric System Constraints and Needs Within the ERCOT Region"), that included future projections, indicates that demand has typically been, and is expected to be in 2007, 75 percent of capacity. Hence, the new EGUs were ultimately modeled at 75 percent of their permit allowable NO_x emission rates. Table 3.5-8 is a summary of these newly-permitted EGUs in the NAAs.

Table 3.5-8: Newly-Permitted EGUs in NAAs as of November 5, 2003

NAA	NO_x (tpd)	VOC (tpd)	CO (tpd)
HGB	0	0	0
BPA	5.9	1.7	22.2
DFW	0.3	0.1	0.7

Table 3.5-8 reflects no new EGU growth in the HGB NAA. Chapter 101 MECT rules required companies to have an administratively complete permit application prior to January 2, 2001 in order to be granted allowances in the initial allocation. These sites obtained allowances based on permit allowables as a result of the MECT Level of Activity certification. Sites that obtain permit authorization after January 2, 2001, are required to obtain allowances from an account that was initially allocated allowances or from a broker who has obtained surplus allowances from another site. Therefore, any NO_x increases at existing or new sources, that are subject to Chapter 117 ESADs in the HGB area, are already accounted for in the MECT cap; no NO_x growth can occur in the HGB area for those source types (pieces of equipment) for which Chapter 117 ESADs exist.

CO from NEGU combustion sources is also expected to grow as burner modifications are implemented, because of the inherent off-stoichiometric ratio of air-to-fuel required to achieve low-NO_x combustion. Therefore, NEGU CO was grown from 2000 to 2007 via factors derived from the Texas Industrial Production Index (TIPI), discussed below. Where TIPI SIC factors were unavailable, EGAS 4.0. growth factors were used.

East Texas Point Source Growth

As with the NAAs, newly-permitted EGUs in East Texas were added to the inventory as growth at 75 percent of their permitted emissions, due to the demand vs. capacity trend discussed above. A summary of the emissions is provided in Table 3.5-9, *Newly-Permitted EGUs in East Texas as of November 5, 2003.*

Table 3.5-9: Newly-Permitted EGUs in East Texas as of November 5, 2003

Sources	NO_x (tpd)	VOC (tpd)	CO (tpd)
EGU	70.7	13.6	149.8

As in the base case, the future 2007 case Ellis County cement kilns were modeled at their 2000 actual emissions, except that seven years of TIPI growth were applied to all existing 2000 kilns. A separate file of the 2000 emissions for Ellis County cement kilns was created. This file also included one new TXI kiln (EPN E2-22) that became operational since 2000; it was included at its permit allowable emission rates. A permit condition of that permit stated that this new kiln cannot operate simultaneously with two of the older kilns, so a file was created, afs.MidloKilns._v5, that zeros-out two of TXI's kilns and includes the new kiln. TIPI growth for the cement industry was also applied via the file *ellis_kilns.TIPI.00-07*.

All other sources in East Texas were grown using the TIPI-derived factors where available and supplemented with EGAS 4.0 factors where necessary. TIPI was used where possible, because its data are more recent than those in the EGAS 4.0 model. The EGAS model was last updated on January 26, 2001, and uses data and data models which date from the early 1980s to 1999. The REMI model, which is the economic basis of EGAS 4.0 uses economic data which date from 1969 to 1996. Also, EGAS uses historical emissions data from the NEI ranging from 1972 to 1992. (See the EGAS 4.0 Reference Manual, available on EPA's CHIEF website). TIPI uses more recent economic data (November 2003). TIPI-EGAS is the combination of these two databases, as described below.

TIPI data from January 1967 through November 2003 was used in a linear regression analysis to project emissions from 2000 to 2007. A list of the 2-digit SICs for which TIPI data is available is included in Appendix D.

According to the Federal Reserve Bank of Dallas, TIPI is a value-added index (based on a weighted average of employment, man hours, and some production data). The underlying process to derive TIPI data is the same as the Bureau of Economic Analysis gross-state product. A better surrogate would have been local survey data based on production. However, no such data currently exist for the state of Texas, and resources are not available to conduct such a survey. For further information on the TIPI see http://www.dallasfed.org/data/data/mi5000.tab.htm.

For those categories in Texas, not covered by TIPI, EGAS factors were used. The categories for which EGAS was used are listed in Appendix D. Table 3.5-10, *East Texas 2007 TIPI-EGAS Growth for August 30*, presents the growth projections for East Texas based on TIPI-EGAS factors.

Table 3.5-10: East Texas 2007 TIPI-EGAS Growth for August 30

Source	2000 NO_x (tpd)	2000 VOC (tpd)	2007 NO_x (tpd)	2007 VOC (tpd)	% NO_x Growth	% VOC Growth
NEGU	382.6	160.1	408.2	178.5	7%	11%

As stated above, new permits have been used to account for changes in emissions where such data are readily available and where resources were available to extract the data from permits (EGUs and cement kilns).

West Texas Point Source Growth

As with the rest of the Texas inventory, newly-permitted EGUs in West Texas were added to the inventory as growth at 75 percent of their permit allowable emissions. A summary of the emissions from the newly-permitted EGUs is provided in Table 3.5-11, *Newly-Permitted EGUs in West Texas as of November 5, 2003.*

Table 3.5-11: Newly-Permitted EGUs in West Texas as of November 5, 2003

Sources	NO_x (tpd)	VOC (tpd)	CO (tpd)
EGU	6.2	2.5	17.8

Some of these emissions are outside of the modeling domain; therefore, other modeling summaries may show different totals. All other sources in West Texas were grown using the same TIPI-EGAS procedure used for the rest of the state. Table 3.5-12, *West Texas 2007 TIPI-EGAS Growth for August 30,* represents the growth projections for West Texas based on TIPI-EGAS factors.

Table 3.5-12: West Texas 2007 TIPI-EGAS Growth for August 30

Source: NEGU	2000 Emissions (tpd)	2007 Emissions (tpd)	% Growth
NOx	116.6	117.8	1%
VOC	41.1	43.3	5%

3.5.1.3 2007 Future Year Point Source Emissions Inventory Development – Controls

This section incorporates all of the changes that were made to the point source future year inventory since the HGB SIP proposal. Appendix D, detailing point source inventory development, includes both the proposal details and these "final" control strategy details.

In addition to the application of growth projections, as described above, Table 3.5-13, *2007 Future Base Case Summary of Controls Applied,* summarizes the controls applied to arrive at the future base case point source inventory. The future base case includes all of the controls for which rules have already been written, and have ultimate compliance dates prior to the 1-hour ozone attainment date, November 2007. Appendix D contains more details. The subsections that follow describe the controls applied to the various parts of the point source inventory to arrive at the future base case point source emission inventory for the HGB August-September 2000 modeling episode.

The Special Inventory that was modeled in the 2000 base case was considered to be specific to the summer of 2000; hence, it was not carried into the future base cases. The hourly ARPDB-enhanced EGU emissions were projected and controlled in the future, because they represent the typical temporal pattern of baseline, intermediate, or peaking power plants.

Table 3.5-13: 2007 Future Base Case Summary of Controls Applied

Geographic Area	Base Inventory	Controls Applied	File Name
Regional (Outside of Texas)	EGU (1999 NEI v1 w/ hourly 2000 Acid Rain Data)	NO_x SIP Call (Feb. 2002 Federal Register)	*control.NO_xSIPCall_EGU*
	NEGU (1999 NEI v1)	none	none
Louisiana	EGU (LDEQ 2000 AFS EI w/ hourly Acid Rain)	Baton Rouge 9-parish NO_x reductions from LDEQ 12/01 SIP (controlled to tpd level in SIP and then grown)	*control.la.9parish.EGU_NEGU*
	NEGU (LDEQ 2000 AFS EI)	Baton Rouge 9-parish NO_x reductions from LDEQ 12/01 SIP (controlled to tpd level in SIP and then grown)	*control.la.9parish.EGU_NEGU*
Offshore	grown GMAQS	none	none
Mexico	1999 Mexico "NEI"	none	none
HGB	EGU	2007 NO_x Cap	*control.HG_NO_xCap_EGU*
	NEGU	2007 NO_x Cap	*control.HG_07 NO_xCap_NEGU*
	HRVOC Cap	Revised Speciation and Cap Cutoff Levels	*control.new_hga_hrvoc_cap.to2n2_negu* and then apply *control.new_hga_hrvoc_cap.less20inharris*
BPA	EGU	Ch. 117 controls; assuming no VOC controls	*control.07TX-HG_egu* (already applied the 75% demand-to-capacity to the new EGUs)

Geographic Area	Base Inventory	Controls Applied	File Name
	NEGU	Ch. 117 controls via Emission Factor Survey; assuming no VOC controls	*control.2007.BPA.NEGU*
DFW	EGU	Ch. 117 controls; assuming no VOC controls	*control.07TX-HG_egu* (already applied the 75% demand-to-capacity to the new EGUs)
	NEGU	Ch. 117 controls via Emission Factor Survey; assuming no VOC controls	*control.2007.dfw.negu*
East Tx	Existing EGUs	SB7 or Ch. 117 controls; assuming no VOC controls	*control.07TX-HG_egu*
	Newly-Permitted EGUs	none (added as growth)	*control.midlothian.energy* (already applied the new EGU file and the 75% demand-to-capacity of the new EGUs via *control.075N.new_egu*)
	Cement Kiln NO_x	permit modifications	already applied permit modifications to *afs.MidloKilns._v5* via *ellis_kilns.TIPI.00-07*
	Agreed Orders and Consent Decree for East Texas	specific reductions at ALCOA and Eastman	*AgreedOrdersControlFactors00to07*
	all others	none	none
West Tx	Existing EGUs	SB7 controls; assuming no VOC controls	*control.07TX-HG_egu*
	Newly-Permitted EGUs	none	none
	NEGU	none	none

Regional Point Source Controls

The only Regional control strategy modeled was the federal NO_x SIP Call. The latest reductions, as obtained from the Federal Register, dated February 2, 2002, were assumed indicating EGU NO_x reductions of:

- 27% in Illinois
- 32% in Indiana and Kentucky
- 33% in Ohio
- 23% in Tennessee
- 29% in northern counties of Alabama
- 28% in northern counties of Georgia
- 34% in eastern counties of Missouri

These controls were applied to the 1999 NEI v1 EGU file that had been supplemented with hourly 2000 Acid Rain data and grown as described above. No controls were modeled for NEGUs outside of Texas and Louisiana and no VOC reductions were modeled. Table 3.5-14, *Modeled Regional NO_x Emissions Summary for August 30*, represents the 2007 controlled emissions summary for the Regional Point Sources.

Table 3.5-14: Modeled Regional NO_x Emissions Summary for August 30

Source	**1999 NO_x w/2000 Acid Rain (tpd)**	**2007 NO_x w/EGAS Growth (tpd)**	**2007 NO_x w/Growth and NO_x SIP Call Controls (tpd)**
EGU	5565.3	5711.8	4666.8
NEGU	1862.2	1946.0	2074.4
Total	7427.5	7657.8	6741.2

Louisiana Point Source Controls

Based on guidance from the LDEQ, the NO_x SIP control strategy information from the LDEQ's December 2001 Baton Rouge attainment demonstration was applied. Specifically, reductions of 34 percent in EGU and non-EGU NO_x in the Baton Rouge 9-parish area were applied to the LDEQ-supplied 2000 point source inventory. No VOC reductions were modeled. Table 3.5-15, *Louisiana Modeled NO_x Emissions Summary for August 30*, represents the modeled emissions summary for Louisiana Point Sources.

Table 3.5-15: Louisiana Modeled NO_x Emissions Summary for August 30

Source	2000 NO_x w/Acid Rain (tpd)	2007 NO_x w/EGAS Growth (tpd)	2007 NO_x w/Growth and LDEQ SIP Controls (tpd)
EGU	404.0	449.6	403.5
NEGU	630.9	647.4	586.2
Total	1034.9	1097.0	989.7

Offshore Point Source Controls

As discussed in the Offshore Point Source Growth section of this document, the offshore inventory was not grown from the 2000 base case, nor have controls been applied to existing offshore point sources because the information is unavailable.

Mexico Point Source Controls

As with the offshore inventory, it is conservatively being assumed that no controls will be applied to Mexican point sources between 1999 and 2007. Therefore, no controls were applied to Mexican point sources for 2007 modeling.

Texas Nonattainment Area (HGB, BPA, DFW) Point Source Controls

HGB

In the HGB area, reductions attributable to the MECT program were applied. The MECT program incorporates all of the ESADs from Chapter 117 and provides annual NO_x allowances that accounts can emit in each year subsequent to 2002. A summary of the emissions that would be allowed in 2007 was generated and summed:

1. MECT allowances (see Table 3.5-16, *HGB 8-County Ozone Season Daily (OSD) NO_x Cap Summary*),
2. Part of the banked NO_x emissions that can be used in MECT (2.1 tpd EGU and 2.1 tpd NEGU),
3. Estimate of the total tpd from sources that are exempt from ESADs (too small or not a controlled category) (17.1 tpd NEGU), and
4. Estimate of the sources that are subject to ESADs but were not included in MECT (and take 80 percent off of those, since ESADs apply) (4.1 tpd NEGU).

This sum became an estimate of the NO_x emissions in 2007 for the HGB 8-county area. Trading is allowed within the NAA, since this area is under the MECT program. Reductions were spread across the entire area where future emissions could occur or reoccur. Thus, a simple ratio of future allowance to base case emissions was calculated to give the reductions in Table 3.5-16. The numbers in Table 3.5-16 represent the NO_x cap values for a generic ozone day, as opposed to a specific modeled episode day.

Table 3.5-16: HGB 8-County Ozone Season Daily (OSD) NO_x Cap Summary

HGB sources	2000 NO_x OSD (tpd)	2000 NO_x w/Acid Rain (tpd)[1]	2007 MECT NO_x Cap (tpd)	2008 MECT NO_x Cap (tpd)	2007 Modeled NO_x (tpd)[2]
EGU	192	203	23	23	25
NEGU	283	283	113	104	135
Total	475	486	136	127	160

[1] average day of the hourly Acid Rain data over 20-day episode

[2] includes all 4 of the summed estimates above; excludes non-MECT bank and newly-permitted EGUs, and Special Inventory

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

This table shows that the EGUs in the HGB area maintain the same level of NO_x emissions from 2007 to 2008, yet the NEGUs receive another 3 percent reduction from 2007 to 2008. This difference is due to the phased-in approach of the MECT program for the HGB area. The compliance date for the ESADs in Chapter 117 for EGUs is 2005, so all of the reductions for EGUs should be completed by 2005. The last phase of MECT for HGB area NEGUs occurs in April 2008, so the capped NO_x sources will remain unchanged after April 2008.

The NO_x values for the year 2000, in Table 3.5-17, *HGB 8-County Modeled NO_x Emissions Summary for August 30*, represent the emissions modeled for August 30, 2000. These emissions include the Special Inventory and Acid Rain variations. The emissions shown for 2007 do not include the SI emissions, for the reasons discussed above, but do include the growth (non-MECT banked emissions and the newly-permitted EGUs).

Table 3.5-17: HGB 8-County Modeled NO_x Emissions Summary for August 30

HGB sources	2000 NO_x w/SI and Acid Rain (tpd)	2007 Modeled NO_x w/Cap Controls (tpd)	2007 Modeled NO_x w/Cap Controls and Growth (tpd)
EGU	225.9	27.1	27.1
NEGU	266.0	130.4	135.5
Total	491.9	157.5	162.6

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

Modeling the HRVOC Rules in HGB

Table 3.5-18, *HRVOCs Regulated by Chapter 115 Rules by Area,* summarizes the VOC species targeted for regulation in the Chapter 115 rules. These species are a subset of the terminal olefins that were adjusted, as described in the base case modeling inventory section previously presented.

Table 3.5-18: HRVOCs Regulated by Chapter 115 Rules by Area

HGB source	Species
Harris County	Ethylene Propylene 1,3-Butadiene All Butenes
Seven Surrounding Counties	Ethylene Propylene

The HGB HRVOC cap specifically targets flares, cooling towers, and vents, while fugitive emissions are regulated separately. Because there is limited information contained in STARS (and its predecessor database, PSDB) on specific emission point classifications, e.g., flares, fugitives, cooling towers, and vents, it is not possible to explicitly model controls for specific source types. An early attempt at emission point classification, prior to December 2002, suggested a certain percentage of emissions in each portion of the HGB area should be subject to site-wide caps. This classification scheme is reflected in the current HGB HRVOC cap and was the best available at the time. More refined attempts at emission point classification have been made since then, and the commission has expanded the emission point classifications beginning with the 2003 EIQs.

In the interim, the HRVOC totals modeled for each area (Harris County and the seven surrounding counties), as summarized by the cap rules and other fugitive reductions. Due to fundamental changes in modeling inventory speciation and inventory adjustment methodology, both described previously in this document, along with limited information on emission point types, it is not possible to explicitly model the site-specific caps as published in Tables 6-2.1 and 6-2.2 of the *Post-1999 Rate-of-Progress and Attainment Demonstration Follow-up SIP for the Houston/Galveston Ozone Nonattainment Area* adopted on December 13, 2002. Therefore, a method similar to that used in the published December 2002 tables was developed to approximate reductions for the areas using the current modeling inventory and terminal olefin adjustment.

Under this method, the adjusted modeling inventory was screened for account-level HRVOC totals greater than 10 tpy. These totals were then split into what is assumed to be capped sources and non-capped sources (fugitives) according to the percentages published in the aforementioned Tables 6-2.1 and 6-2.2 (80.7 percent for Harris County and 88.7 percent for the seven surrounding counties). "Control Levels" were then assigned to each account's capped source totals according to the method used in Tables 6-2.1 and 6-2.2, i.e. 70 percent control for accounts with totals greater than 500 lb/hr HRVOC, 68 percent control for accounts with totals between 125 and 500 lb/hr HRVOC, 60 percent control for accounts with totals between 10 and 125 lb/hr HRVOC, and 50 percent control for accounts with totals less than 10 lb/hr HRVOC. A 64 percent reduction was applied uniformly to all remaining non-capped sources. Additionally for Control Strategy 08 (CS-08), 20 tpd of HRVOC was removed uniformly from adjusted Harris County totals.

This method of modeling area-wide totals is similar in theory to that used to model the Chapter 101 MECT program, in which, reductions were spread over the entire geographical area since it is unknown where emissions may occur or reoccur under a system in which trading is allowed. Table 3.5-19, *HGB 8-*

County Modeled "Extra" HRVOC Summary, summarizes the total (unadjusted plus extra) ozone season daily HRVOCs for 2000 and 2007.

Table 3.5-19: HGB 8-County Modeled HRVOC Summary

HGB source	2000 Unadjusted Modeling Inventory Ozone Season Daily HRVOC (tpd)[1]	2000 Adjusted Modeling Inventory Ozone Season Daily HRVOC (tpd)[2]	2007 Adjusted Modeling Inventory Ozone Season Daily HRVOC (tpd)
Harris County	20.6	115.0	22.6
Seven Surrounding Counties	10.0	56.3	22.0

[1]Ozone season daily totals do not include Special Inventory or Region 12 Upset/Maintenance data. These totals are adjusted upward slightly due to Commission application of rule effectiveness estimates.

[2]The "Total Adjusted Modeling Inventory Ozone Season Daily HRVOC" is the sum of the unadjusted and extra (imputed) terminal olefins.

BPA

In the BPA 3-county area, Chapter 117 NO_x rules affect EGUs and NEGUs, with separate and distinct control packets applied to simulate these rules. No VOC controls were applied to BPA. The emission factor (EF), e.g., lb/MMBtu, for a piece of equipment is dictated by Chapter 117. In order to determine the reduction to apply to the unit from 2000, EFs from the 2000 point source inventory were needed. This information is not consistently supplied by a company representative when completing their annual EIQ. For EGUs that are Acid Rain units, the EF can be found in the ARPDB. The third quarter 2000 ARPDB was used as the basis for the EGU EFs. The simple formula

$$EF_{2007} / EF_{2000} = CF$$

provides the control factor (CF) that can be found in the control packet that was applied. See Table 3.5-13 for the file name. The 2007 emission rate is calculated by multiplying the 2000 emission rate (or the grown 2000 emissions) by the CF. The reduction factor (RF) from 2000 to 2007 is then

$$1 - (EF_{2007} / EF_{2000}) = RF$$

For BPA NEGUs, a similar process was used, yet there is no ARPDB for NEGUs. Instead a survey was conducted of all of the BPA NEGU units reporting more than 25 tpy of NO_x in their 2000 EIQ. These units represented 92 percent of the total BPA NEGU NO_x. This survey included email requests to company account representatives for EF information for these units. Where no response was provided by a company representative, the hardcopy EIQ was searched for information that may have lead to an inferred EF. See Table 3.5-13 for the file name of the control packet developed as the result of this survey project. Table 3.5-20, *BPA 3-County Modeled NO_x Emissions Reduction Summary for August 30,* is a summary of BPA NO_x reductions to estimate 2007 future year emissions. All existing Chapter 117 rule compliance dates for BPA are prior to 2007, so all 2007 CFs based on those Chapter 117 compliance EFs were modeled. No VOC reductions were modeled.

Table 3.5-20: BPA 3-County Modeled NO_x Emissions Reduction Summary for August 30

BPA sources	2000 NO_x OSD (tpd)[1]	2000 NO_x w/SI and Acid Rain (tpd)[2]	2007 Modeled NO_x w/Growth (tpd)[3]	2007 Modeled NO_x w/ Growth and Controls (tpd)
EGU	26.4	34.9	42.7	25.5
NEGU	96.6	84.3	98.2	81.9
Total	123.0	119.2	140.9	107.4

[1] Typical ozone season day (emissions directly from PSDB/STARS)

[2] This day includes a 12 tpd NO_x NEGU decrease due to Special Inventory reporting.

[3] Includes the banked emissions (put into NEGU) and newly-permitted EGUs, excludes Special Inventory

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

DFW

For the DFW 4-county area, a procedure very similar to the BPA approach was used to arrive at future case point source inventories. As with BPA, an EF survey was performed. Table 3.5-21, *DFW 4-County Modeled NO_x Emissions Reduction Summary for August 30*, summarizes the 2007 DFW NO_x emissions. No VOC reductions were modeled.

Table 3.5-21: DFW 4-County Modeled NO_x Emissions Reduction Summary for August 30

DFW sources	2000 NO_x OSD (tpd)[1]	2000 NO_x w/ Acid Rain (tpd)	2007 Modeled NO_x w/Growth (tpd)[2]	2007 Modeled NO_x w/ Growth and Controls (tpd)
EGU	72.9	107.0	107.4	23.7
NEGU	6.9	6.9	18.3	13.1
Total	79.8	113.9	125.7	36.8

[1] typical ozone season day (emissions directly from PSDB/STARS)

[2] includes the banked emissions (put into NEGU) and the newly-permitted EGUs

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

East Texas Point Source Controls

EGUs were controlled in the 95 attainment counties of East Texas with SB7 reductions if they have SB7 allowances, or if located in one of the 31counties specified within Chapter 117, if they do not have SB7 allowances. The appropriate reduction method was determined for each of the EGU accounts in Texas. The list of EGUs with SB7 allowances can be found in Appendix D and at http://www.tnrcc.state.tx.us/permitting/airperm/banking/allowreg.htm.

For East Texas SB7 accounts, an average reduction necessary to comply with the 2007 EF was calculated and modeled, since SB7 allows trading among all of the East Texas accounts that have SB7 allowances. This East Texas average SB7 reduction from the year 2000, based on third quarter 2000 ARPDB, was calculated and modeled to be 45 percent. The non-SB7 accounts in East Texas required reductions between 31 percent and 60 percent. Overall, the reductions in East Texas EGUs total 373.6 tpd. The reductions are represented in the control packet listed in Table 3.5-13. Table 3.5-22, *East Texas Attainment Counties Modeled NO_x Emissions Reduction Summary for August 30*, represents the overall reductions modeled for East Texas.

Table 3.5-22: East Texas Attainment Counties Modeled NO_x Emissions Reduction Summary for August 30

E Tx sources	2000 NO_x OSD[1] (tpd)	2000 NO_x w/ Acid Rain (tpd)	2007 Modeled NO_x w/Growth[2] (tpd)	2007 Modeled NO_x w/ Growth and Controls[3] (tpd)
EGU	776.1	835.9	930.2	532.9
NEGU	382.5	382.5	408.2	385.3
Total	1158.6	1218.4	1338.4	918.2

[1] typical ozone season day (emissions directly from PSDB/STARS)

[2] includes TIPI-EGAS projections (put into NEGU) and the newly-permitted EGUs

[3] includes the SB7/Ch117 EGU controls, the Midlothian kiln NEGU "controls," and NEGU Agreed Orders

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

As noted in the growth discussion subsection above, the EGUs in East Texas were grown through the addition of newly-permitted EGUs. At least one EGU source reported only partial emissions in its 2000 EIQ, because the source was newly operational in 2000. Since these emissions would not be representative of the emissions a source would be emitting in the future, the 2000 EIQ emissions were zeroed out, via the control packet, "control.midlothian.energy," as represented in Table 3.5-13. Then the permit allowable emissions were modeled via the new EGU AFS file identified in Table 3.5-13.

Recent agreed orders and consent decrees were reviewed and Table 3.5-23, *Sources Affected by Agreed Orders and Consent Decrees*, shows the sources that were affected. Control packets and an AFS file reflecting the changes dictated by these Agreed Orders and the Consent Decree are presented in Appendix D. These reductions totaled 23 tpd in East Texas and are also accounted for in Table 3.5-22.

Table 3.5-23: Sources Affected by Agreed Orders and Consent Decrees

Source	Number	Date	Implementation	Link
Eastman Chemical Co.	2000-0033-SIP	2000	Apr 2000-July 2002	http://www.tnrcc.state.tx.us/oprd/rule_lib/4regapb.pdf
Eastman Chemical Co.	2001-0880-RUL	2001	Apr 2002-May 2003	http://www.tnrcc.state.tx.us/oprd/sips/01026sip-eastman.pdf
Alcoa	Consent Decree fr24ap03-81	2003	2006 - 2007	http://www.epa.gov/compliance/resources/cases/civil/caa/alcoafs.pdf http://www.epa.gov/fedrgstr/EPA-AIR/2003/April/Day-24/a10081.htm http://www.usdoj.gov/opa/pr/2003/April/03_enrd_215.htm

West Texas Point Source Controls

As with East Texas, in the attainment counties of West Texas, EGUs were controlled with SB7 reductions if they have SB7 allowances. Otherwise, no reduction factor was applied. The list of EGUs in West Texas with SB7 allowances can also be found in Appendix D and at http://www.tnrcc.state.tx.us/permitting/airperm/banking/allowreg.htm.

For West Texas SB7 accounts, an average reduction necessary to comply with the 2007 EF was calculated and modeled, since SB7 allows trading among all of the West Texas accounts with SB7 allowances. This West Texas average SB7 reduction from the year 2000, based on third quarter 2000 ARPDB, was calculated and modeled to be 49 percent. The reductions are represented in the control packet listed in Table 3.5-13. No other reductions were modeled for West Texas. Table 3.5-24, *West Texas Attainment Counties (within the Modeling Domain) Modeled NO_x Emissions Reduction Summary for August 30,* represents the overall reductions modeled for West Texas.

Table 3.5-24: West Texas Attainment Counties (within the Modeling Domain) Modeled NO_x Emissions Reduction Summary for August 30

W Tx sources	2000 NO_x w/ Acid Rain (tpd)	2007 Modeled NO_x w/Growth[1] (tpd)	2007 Modeled NO_x w/ Growth and Controls (tpd)
EGU	144.7	149.0	85.0
NEGU	116.6	117.7	117.6
Total	261.3	266.7	202.6

[1] includes TIPI-EGAS projections (put into NEGU) and the newly-permitted EGUs

NOTE: gridded vs. non-gridded emissions summaries may vary slightly

3.5.2 Area/Nonroad Mobile Source Emissions Inventory Development

Area and nonroad mobile source emissions were primarily derived from the 1999 periodic emissions inventory (PEI; area sources) and the 2002a version of the NONROAD model with many Texas specific input files.

3.5.2.1 Periodic Emissions Inventory for Area Sources

To capture information about sources of emissions that fall below the point source reporting levels and are too numerous or too small to identify individually, emissions from these sources are estimated on a source category or group basis. Area sources include commercial, small-scale industrial, and residential categories of sources that use materials or operate processes that can generate emissions.

Area sources can be divided into two groups characterized by the emission mechanism: hydrocarbon evaporative emissions or fuel combustion emissions. Examples of sources of evaporative losses include printing, industrial coatings, degreasing solvents, house paints, leaking underground storage tanks, gasoline service station underground tank filling, and vehicle refueling operations. Fuel combustion sources include stationary source fossil fuel combustion at residences and businesses, as well as outdoor burning, structural fires, and wildfires. These emissions, with some exceptions, may be calculated by multiplication of an established emission factor (emissions per unit of activity) times the appropriate activity or activity surrogate responsible for generating emissions. Population is the most commonly used activity surrogate for many area source categories, while other activity data include amount of gasoline sold in an area, employment by industry type, and acres of cropland.

The forecasting years' emissions inventories were compiled by using the EPA Economic Growth Analysis System (EGAS) growth factors for each area source category, the standard and accepted method for developing future year emissions inventories. The EGAS contains individual growth factors for each category for each forecasting year.

Nonroad mobile sources are a subset of the area source category. This subcategory includes aircraft operations, marine vessels, recreational boats, railroad locomotives, and a very broad category of nonroad equipment that includes everything from 600-horsepower engines mounted on construction equipment to 1-horsepower string trimmers. Calculation methods for emissions from nonroad engine sources are based on information about equipment population, engine horsepower, load factor, emission factor, and annual usage. Emission estimates for all sources in the nonroad category except aircraft, diesel construction equipment, and airport support equipment were originally developed by a contractor to EPA's Office of Transportation Air Quality as a 1990 emissions inventory for all nonattainment areas classified as serious and above. Aircraft emissions were estimated from landings and takeoff data for airports used in conjunction with a suitable aircraft emissions model (FAAED or EDMS).

3.5.2.2 Updates to the PEI

The 1999 Texas PEI has been updated to incorporate many improvements developed in recent years, including use of survey-based emissions for shipping, construction, lawn and garden, locomotive, and recreational boating activities. Spatial allocation for most categories used updated Lambert Conformal Projection (LCP) 2km surrogates.

Special treatment was accorded to ships, by treating them as pseudo-stacks spaced along the major waterways within the Galveston Bay region (as described in the December 6, 2000 SIP revision) and now in the BPA region. New data on wildfires, also treated as point sources, were used for August 18-September 6 modeling. These wildfire data were developed by UT (Allen et al., 2002). Emissions from states outside of Texas were obtained from ENVIRON, who developed 1999 and 2007 inventories for their modeling of near-nonattainment areas in Texas. The ENVIRON data were based on the NEI and NONROAD model.

Through the results of studies which sought to reconcile ambient measurements with the emissions inventory (Appendices B.5 and B.6), it was determined that the toluene levels in the modeling inventory were too high. Using updated speciation profiles from California Air Resources Board for solvents, and updated gasoline profiles from ENVIRON corrected this discrepancy. These new profiles reflect changes in the composition of solvents and gasoline which have occurred over the years since the default profiles were developed.

The emissions developed for the 1992 GMAQS are being used until offshore emissions are obtained from the GWEI. The GMAQS-based emissions were projected to 2000 and 2007 using data obtained from the Minerals Management Service where available. Spatial surrogates were developed for shipping lanes which made it possible for offshore shipping emissions to be spatially allocated more accurately.

The primary quality assurance (QA) method, as outlined in the QA Section of the *Photochemical Modeling QA/QC Plan* (Section 6.1.4 of Appendix A), is to divide the inventory into its separate constituents and separately process each constituent through EPS2x. Table 3.5-25, *2000 HGB 8-County Weekday Nonroad Totals,* and Table 3.5-26, *2000 HGB 8-County Weekday Area Source Totals,* summarize the data for nonroad and area source emissions, respectively, on a typical 2000 ozone season weekday for the HGB area. Although not shown in this summary, emissions from each category were individually plotted to check emissions totals, as well as temporal and spatial distribution for both the 2000 base case and the 2007 future case.

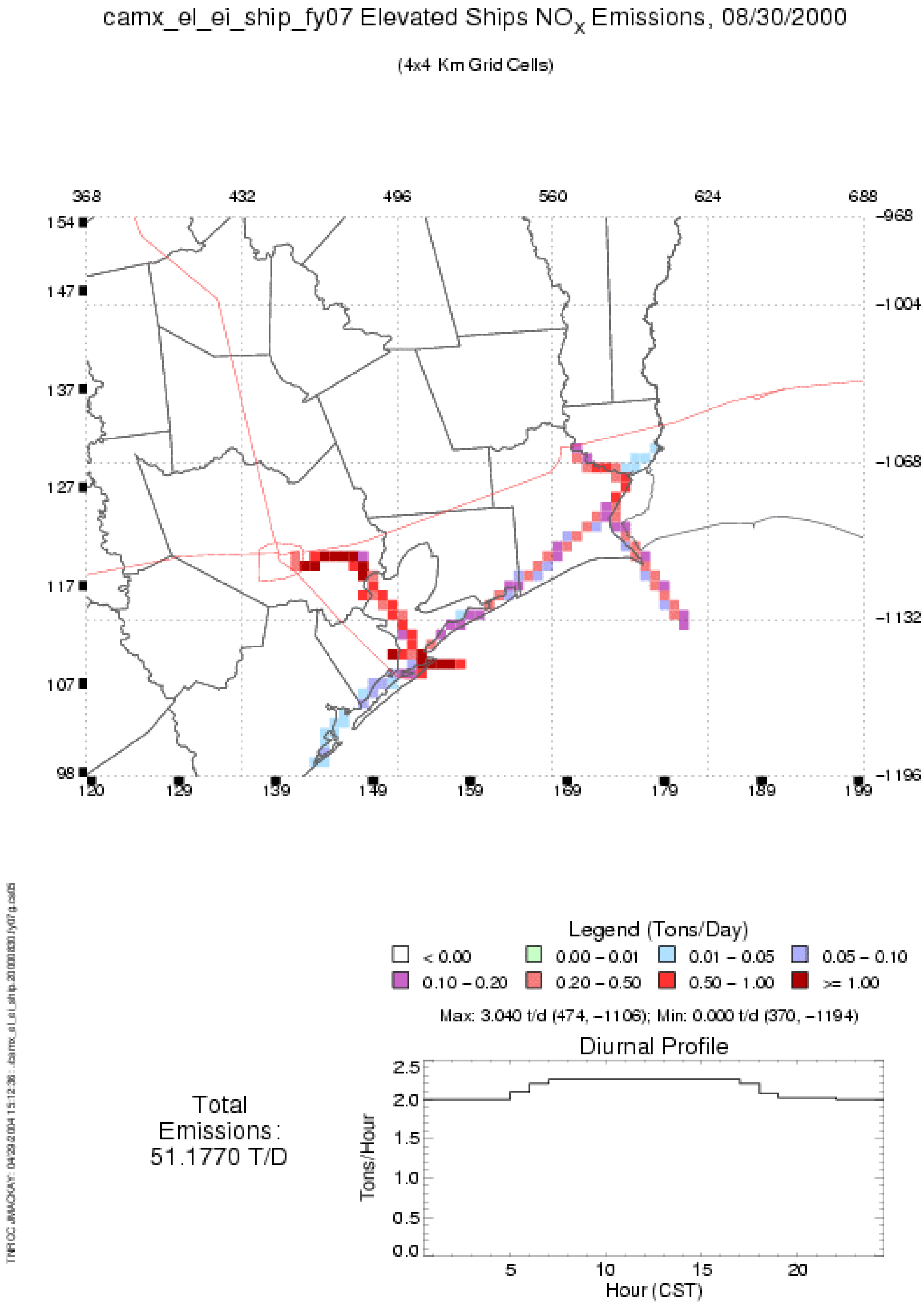
Table 3.5-25: 2000 HGB 8-County Weekday Nonroad Totals		
HG_NR00_b3b (tpd)	**HGB Nonroad Mobile NO_x**	**HGB Nonroad Mobile VOC**
Agriculture	2.93	0.46
Aircraft	5.76	2.31
Commercial	6.23	9.39
Construction	40.02	7.91
GSE	4	3.76
Industrial	17.43	4.62
Commercial Lawn+Garden	3.3	22.76
Residential Lawn+Garden	1.16	12.23
RR Maintenance	0.15	0.04
Logging	0.39	0.24
Locomotives	35.94	1.47
Oil+Gas	1.71	0.16
Recreational Equipment	0.32	7.56
Recreational Boating	0.85	16.68
Ships	34.85	0.79

Table 3.5-26: 2000 HGB 8-County Weekday Area Source Totals		
HGarea00_b2c (tpd)	**HGB Area Source NO_x**	**HGB Area Source VOC**
Architectural Coating	0	18.35
Asphalt Paving	0	6.8
Auto Refinishing	0	2.37
Bakeries+Breweries	0	0.69
Drycleaning	0	4.34
Graphic Arts	0	0.87
Industrial Fuel Use	15.96	0.44
Leaking Underground ST	0	1.9
Oil+Gas Production	19.31	20.31
Open Burning	0.35	7.04
Pesticide Use	0	2.46
Petro Transport+Refueling	0	16.97
Residential Fuel Use	2.44	0.14
Solvent Use	0	53.77
Surface Cleaning	0	12.79
Surface Coating	0	11.63
Traffic Marking	0	0.48
Waste Treatment	0	2.75

The 2007 emissions reflect a future case before SIP controls were applied. The projections of the emissions to 2000 and 2007 for most categories were performed using NONROAD for categories covered by the model, and EGAS for most others. The projected data include both future growth in activity and federal controls in place at this time. The HGB 8-county elevated shipping files use 1997 data for 2000 and are the result of a detailed shipping emissions project described in Appendix C of the December 2000

SIP Revision (TCEQ, 2000). The 2007 HGB shipping emissions result from work performed under the same project. A new, similar set of data for 2000 and 2007 was used for shipping in the three BPA counties (see Figure 3.5-1, *2007 Future Case Elevated Shipping* NO_x *Emissions Tile Plot for HGB and BPA*).

Figure 3.5-1: 2007 Future Case Elevated Shipping NO_x Emissions Tile Plot for HGB and BPA



The use of shipping lanes in the Gulf is evident in these plots.

3.5.2.3 Base Case Area/Nonroad Mobile Emissions Modeling Summary

Tile plots depicting the low-level 2000 base case input modeling files covering the 4 km domain for area and nonroad emissions sources are shown in Figure 3.5-2, *2000 Low-Level Area and Nonroad NO_x Emissions Tile Plot* and Figure 3.5-3, *2000 Low-Level Area and Nonroad VOC Emissions Tile Plot*. The totals in the plots do not exactly match the totals in Table 3.5-27, *2000 HGB 8-County Weekday Area/Nonroad Summary* for several reasons. First, plots show CB-IV Hydrocarbons mass, while data tables show VOC mass. (CB-IV emissions are used internally in CAMx and differ in mass from the originally reported VOC.) While the map total numbers are accurate, the county total numbers are only approximate. Second, tile plot county emission totals are based on a summing of county cell fractions and are subject to some error since the county area plots are generally limited to land area. Although emissions from lake areas are included, some emissions in the bays, which can be significant for sources such as ships, are not yet incorporated into the plotting routine. Further, a concentration of emissions near county borders also leads to some inaccuracy in the county totals on these plots as emissions in a grid cell are allocated to counties based on relative area. For example, a grid cell may be divided evenly across two counties. For the plotting routine, emissions would be allocated as if they were evenly distributed between the two counties when in reality, they might actually all be located in only one of the counties.

Table 3.5-27: 2000 HGB 8-County Weekday Area/Nonroad Summary (base5b Model Run)

	NO_x (tpd)	**VOC (tpd)**
Low-Level Nonroad Mobile (NR00_b3b)	111.5	89.59
2000 HGB Ships	34.85	0.79
Area Sources (area_base2c)	38.06	164.07
HGB 8-County Total	**184.41**	**254.45**

Figure 3.5-2: 2000 Low-Level Area and Nonroad NO_x Emissions Tile Plot

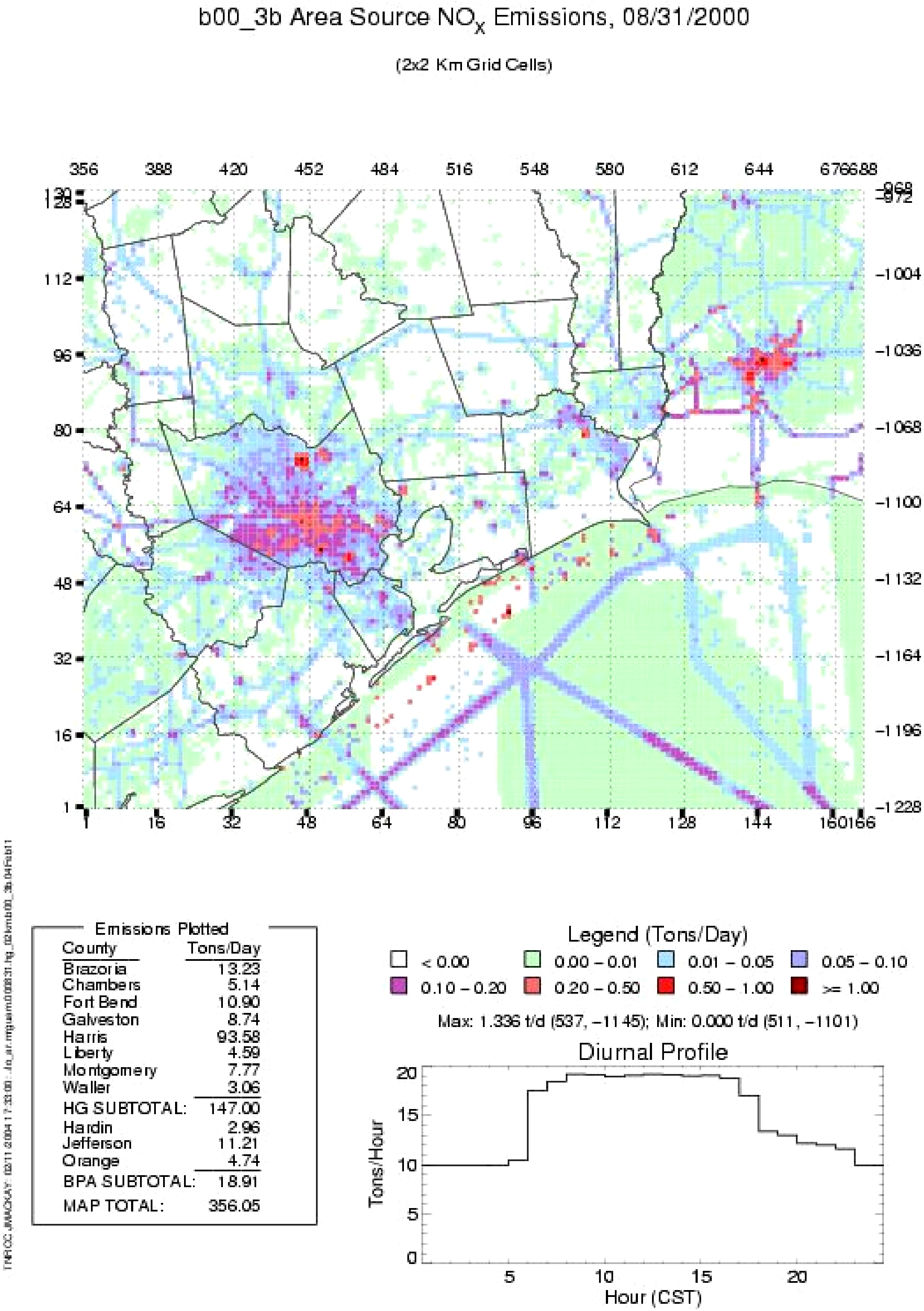
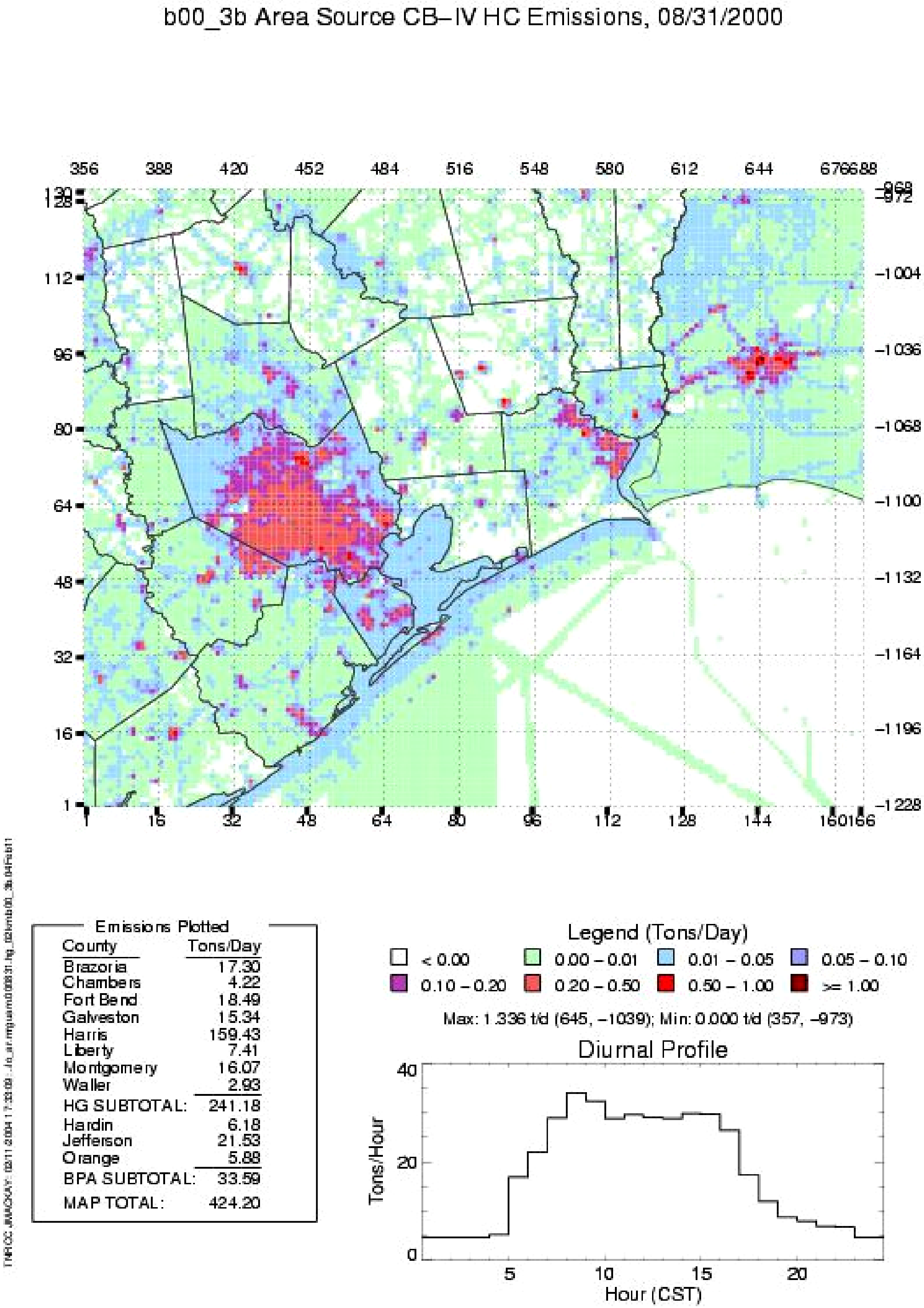


Figure 3.5-3: 2000 Low-Level Area and Nonroad VOC Emissions Tile Plot



3.5.2.4 Future Case Modeling Summary

The future case tile plots in Appendix E, "Area/Nonroad Tile Plots," include the base 2007 emissions summarized in the following tables, plus the additional SIP controls. Low-emission diesel fuel (TxLED), clean gas and California large spark ignition requirements were modeled using conventional control packets that applied to appropriate ASCs (Area Source Categories) and counties. The control measures listed in Table 3.5-28, *2007 HGB 8-County Area/Nonroad Control Measures Applied*, were applied by using HGB 8-county-based factors to remove the proper total NO_x tons across the area/nonroad section of the modeling inventory. The portable fuel container rule was modeled statewide using a factor applied to VOC emissions for gasoline-powered equipment in the Lawn and Garden category. Table 3.5-29, *2007 HGB 8-County Nonroad Weekday Totals before SIP Controls* and Table 3.5-30, *2007 HGB 8-County Area Source Weekday Totals before SIP Controls,* summarize the data for nonroad and area source emissions, respectively, on a typical 2007 ozone season weekday for the HGB area. NO_x emissions of 0.52 tpd and 0.05 tpd of VOC emissions were added to account for construction at the Freeport (Brazoria County) LNG facility. In addition, 1.99 tpd NO_x and 0.26 tpd VOC from construction at the Golden Pass LNG facility and 1.25 tpd of NO_x and 0.15 tpd of VOC emissions from construction at the Cheniere, Louisiana LNG facility were added.

Table 3.5-28: 2007 HGB 8-County Area/Nonroad Control Measures Applied

Control Measure	NO_x Emissions Reductions (tpd)	VOC Emissions Reductions (tpd)
TERP	35.9	1.86
Clean Diesel	2.6	0.5
VMEP	3.4	0.2
Small gas-fired boiler, water heater reductions	0.5	0
California Spark-ignition rules	0.4	3.9
Clean portable fuel containers	0.0	2.9
Airport ground support equipment*	see footnote	see footnote
Stationary engines	1.0	0
Total	43.8	9.36

* Since the 2007 future base case already reflects GSE reductions, no additional reductions are required in the control case.

Table 3.5-29: 2007 HGB 8-County Nonroad Weekday Totals before SIP Controls		
HG07_b4b (tpd)	**HGB Nonroad Mobile NO_x**	**HGB Nonroad Mobile VOC**
Agriculture	2.64	0.33
Aircraft	6.88	2.75
Commercial	6.87	7.43
Construction	34.24	5.21
GSE	1.55	0.67
Industrial	19.03	4.49
Commercial Lawn+Garden	1.81	6.11
Residential Lawn+Garden	1.02	8.12
RR Maintenance	0.15	0.03
Logging	0.25	0.14
Locomotives	39.62	1.62
Oil+Gas	1.71	0.16
Recreational Equipment	0.31	11.36
Recreational Boating	1.08	11.4
Elevated Ships	40.03	0.96

Table 3.5-30: 2007 HGB 8-County Area Source Weekday Totals before SIP Controls		
HG07_b3 (tpd)	**HGB Area Source NO_x**	**HGB Area Source VOC**
Architectural Coating	0	19.15
Asphalt Paving	0	7.83
Auto Refinishing	0	2.76
Bakeries+Breweries	0	0.77
Drycleaning	0	4.94
Graphic Arts	0	1.04
Industrial Fuel Use	18.37	0.54
Leaking Underground ST	0	2.16
Oil+Gas Production	19.12	18.21
Open Burning	0.42	7.37
Pesticide Use	0	2.53
Petro Transport+Refueling	0	15.87
Residential Fuel Use	2.39	0.15
Solvent Use	0	61.97
Surface Cleaning	0	18.13
Surface Coating	0	15.87
Traffic Marking	0	0.44
Waste Treatment	0	3.13

Table 3.5-31, *2007 Weekday HGB 8-County Summary*, provides a summary of the HGB 8-county 2007 weekday area and nonroad emissions.

Table 3.5-31: 2007 Weekday HGB 8-County Summary fy07m Model Run (all SIP controls)		
	NO_x (tpd)	**VOC (tpd)**
Low-Level Nonroad Mobile (NR07_b4f_gc)	64.53	50.62
2007 HGB Ships	40.03	0.96
Area Sources (area07_b3)	40.3	182.86
HGB 8-County Total	**144.86**	**234.49**

3.5.3 2000 & 2007 Onroad Mobile Source Emission Inventories for 8-County HGB Area

The purpose of this section is to provide a brief overview of the 8-county HGB area onroad mobile source emission inventory data which were input into the photochemical model for both the 2000 base case and the 2007 future case. These inventory data were developed under contract by the Texas Transportation Institute (TTI). The TTI couples MOBILE6.2 emission rate output with travel demand model VMT data from the HGAC. The net result is referred to as a "link-based" inventory due to the fact that both hourly VMT and emissions estimates are developed for each roadway segment or "link." Separate inventories were developed for each of the 20 days stretching from August 18 to September 6 based on the 2000 ozone episode. Greater detail covering both the development and processing of these inventory data can be found in the following SIP Appendices:

- F.1 - *Summary of Development and Processing of Onroad Mobile Source Inventories Used for Photochemical Modeling Efforts in Texas*
- F.2 - *2000 Onroad Mobile Source Modeling Emissions Inventories for the Houston/Galveston Ozone Nonattainment Area, TTI Report*
- F.3 - *2007 Onroad Mobile Source Modeling Emissions Inventories for the Houston/Galveston Ozone Nonattainment Area, TTI Report*

Tables 3.5-32, *VMT, NO_x, VOC, & CO Summary for 2000 MOBILE6.2 8-County HGB Inventory* and 3.5-33,*VMT, NO_x, VOC, & CO Summary for 2007 MOBILE6.2 8-County HGB Inventory* provide summaries of the total VMT, NO_x, VOC, and CO MOBILE6.2 emissions for the entire 8-county HGB area for each day of the episode for the 2000 base case and the 2007 future case, respectively. For this modeling episode, the Monday-Thursday periods have the same VMT totals and are considered to be "average weekdays." The two Fridays have the highest total VMT of the week and the Saturdays and Sundays have the least amount of VMT. Because Labor Day occurred on Monday, September 4 in 2000, the VMT for this Monday does not have a typical weekday VMT. Instead, its overall VMT is similar to that of a typical Sunday. Also, even though Fridays have the highest VMT of the week, the estimated NO_x emissions are actually lower on Fridays than on weekdays. This NO_x reduction occurs because the relative contribution of VMT from the "18-wheeler" categories (i.e., HDDV8a and HDDV8b classes from

MOBILE6.2) is lower on Fridays than on weekdays. For onroad mobile source inventories, overall VMT increases with future growth, while total emissions decrease from 2000 to 2007. This reduction is a result of more stringent emissions standards for the onroad fleet and the simultaneous attrition of older, higher-emitting vehicles. Consistent with current federal and state rules, the onroad inventories from TTI for 2007 include the benefits of RFG, the I/M Program in all eight HGB counties, and the use of TxLED. In addition, the 2007 onroad emissions inventory was modeled based on a maximum posted speed limit of 65 mph on appropriate freeway segments.

Table 3.5-32: VMT, NO_x, VOC, & CO Summary for 2000 MOBILE6.2 8-County HGB Inventory

Day of Week	***Episode Day***	***8-County VMT Total***	***Total Emissions** (tpd)*		
			NO_x	*VOC*	*CO*
Friday	*August 18, 2000*	139,452,589	311.32	162.07	2232.50
Saturday	*August 19, 2000*	115,955,895	207.74	118.02	1769.99
Sunday	*August 20, 2000*	96,113,092	149.92	98.34	1521.62
Monday	*August 21, 2000*	127,460,894	351.60	146.08	2053.31
Tuesday	*August 22, 2000*	127,460,894	345.11	139.79	1985.04
Wednesday	*August 23, 2000*	127,460,894	344.20	137.87	1934.85
Thursday	*August 24, 2000*	127,460,894	343.68	137.69	1929.69
Friday	*August 25, 2000*	139,452,589	304.29	158.19	2206.81
Saturday	*August 26, 2000*	115,955,895	204.31	117.08	1774.58
Sunday	*August 27, 2000*	96,113,092	148.18	97.36	1519.97
Monday	*August 28, 2000*	127,460,894	350.58	145.55	2051.96
Tuesday	*August 29, 2000*	127,460,894	350.72	147.17	2072.31
Wednesday	*August 30, 2000*	127,460,894	356.70	151.07	2110.85
Thursday	*August 31, 2000*	127,460,894	362.26	156.29	2160.78
Friday	*September 1, 2000*	139,452,589	311.97	168.62	2340.63
Saturday	*September 2, 2000*	115,955,895	209.42	124.27	1903.65
Sunday	*September 3, 2000*	96,113,092	157.81	104.96	1612.41
Monday	*September 4, 2000*	96,113,092	157.81	104.96	1612.41
Tuesday	*September 5, 2000*	127,460,894	359.24	155.38	2167.14
Wednesday	*September 6, 2000*	127,460,894	355.94	142.28	1945.02

Table 3.5-33: VMT, NO_x, VOC, & CO Summary for 2007 MOBILE6.2 8-County HGB Inventory

Day of Week	*Episode Day*	*8-County VMT Total*	*Total Emissions* (tpd)		
			NO_x	*VOC*	*CO*
Friday	*August 18, 2000*	161,609,890	178.30	98.79	1408.25
Saturday	*August 19, 2000*	135,286,294	149.48	71.56	1101.19
Sunday	*August 20, 2000*	107,474,790	85.99	57.19	911.54
Monday	*August 21, 2000*	146,019,214	196.70	88.03	1268.22
Tuesday	*August 22, 2000*	146,019,214	192.25	85.14	1249.56
Wednesday	*August 23, 2000*	146,019,214	191.52	84.48	1229.89
Thursday	*August 24, 2000*	146,019,214	191.26	84.44	1229.15
Friday	*August 25, 2000*	161,609,890	173.70	96.95	1405.37
Saturday	*August 26, 2000*	135,286,294	147.39	71.05	1105.52
Sunday	*August 27, 2000*	107,474,790	84.82	56.63	910.61
Monday	*August 28, 2000*	146,019,214	196.03	87.76	1269.10
Tuesday	*August 29, 2000*	146,019,214	196.19	88.61	1275.31
Wednesday	*August 30, 2000*	146,019,214	200.09	90.44	1282.97
Thursday	*August 31, 2000*	146,019,214	203.81	92.90	1292.42
Friday	*September 1, 2000*	161,609,890	179.12	101.80	1444.25
Saturday	*September 2, 2000*	135,286,294	151.01	74.34	1152.85
Sunday	*September 3, 2000*	107,474,790	91.35	60.34	941.71
Monday	*September 4, 2000*	107,474,790	92.90	61.55	943.68
Tuesday	*September 5, 2000*	146,019,214	201.95	92.36	1298.51
Wednesday	*September 6, 2000*	146,019,214	199.16	86.52	1226.01

For onroad inventory descriptive purposes, Wednesday, August 30 was selected as the most representative "average weekday." For both the 2000 and 2007 Wednesday, August 30 inventories, Table 3.5-34, *Summary of 2000 HGB Onroad Wednesday, August 30 Inventory by County,* and Table 3.5-35, *Summary of 2007 HGB Onroad Wednesday, August 30 Inventory by County,* present respective summaries of the VMT, NO_x, VOC, and CO MOBILE6 emissions for each of the eight counties in the HGB area. Harris County accounts for roughly 70 to 75 percent of the estimated VMT, NO_x, VOC, and CO from the HGB nonattainment area.

Table 3.5-34: Summary of 2000 HGB Onroad Wednesday, August 30 Inventory by County

County	*8-County VMT*		*Total Emissions* (tpd)		
	Total	*Distribution*	*NO_x*	*VOC*	*CO*
Brazoria	5,591,008	4.39%	14.92	6.79	101.41
Chambers	2,202,239	1.73%	7.76	3.09	50.90
Fort Bend	6,790,771	5.33%	18.91	8.73	124.38
Galveston	6,160,053	4.83%	16.27	7.55	110.07
Harris	95,707,669	75.09%	265.46	110.49	1,503.35
Liberty	2,034,665	1.60%	6.18	2.89	42.36
Montgomery	7,253,818	5.69%	21.34	8.98	137.52
Waller	1,720,671	1.35%	5.85	2.54	40.86
Total	127,460,894	100.00%	356.70	151.07	2,110.85

Table 3.5-35: Summary of 2007 HGB Onroad Wednesday, August 30 Inventory by County

County	VMT		Total Emissions (tpd)		
	Total	Distribution	NO_x	VOC	CO
Brazoria	6,216,326	4.26%	8.86	3.81	58.22
Chambers	2,689,680	1.84%	4.70	1.65	29.90
Fort Bend	10,110,632	6.92%	13.66	5.63	85.65
Galveston	5,839,485	4.00%	7.94	3.68	53.49
Harris	105,704,622	72.39%	141.21	65.62	906.16
Liberty	2,398,364	1.64%	3.86	1.71	24.53
Montgomery	10,742,491	7.36%	15.74	6.52	97.72
Waller	2,317,615	1.59%	4.13	1.80	27.30
Total	146,019,214	100.00%	200.09	90.44	1282.97

The onroad emissions inventory data provided by TTI were prepared for input into the photochemical model using the Emissions Preprocessor System version 2 with extensions (EPS2x). When input into the EPS2x system, the inventory data are in a "readable" text-based format. However, once within the EPS2x system, the emissions data are maintained in a binary format. Table 3.5-36, *EPS2x Modules Used to Process 8-County HGB Onroad Emissions Data*, summarizes the EPS2x modules which were used to process the 8-county HGB link-based inventories.

Table 3.5-36: EPS2x Modules Used to Process 8-County HGB Onroad Emissions Data

EPS2x Module	*Description*
LBASE	"Link-Base" - Spatially allocate link emissions among grid cells
PREPNT	"Pre-Point" - Prepare stationary extended idling emissions for further processing
CHMSPL	"Chemistry Split" - Speciate emissions into NO, NO_2, Parrafins, Olefins, etc.
TMPRL	"Temporal" - Apply temporal profile to extended idling emissions
CNTLEM	"Control Emissions" - Apply controls to model strategies, adjustments, etc.
CNTLHR	"Control Hourly" - Apply adjustments that vary by hour per vehicle type
GRDEM	"Grid Emissions" - Sum emissions by grid cell for photochemical model input
MRGUAM	Merge and adjust multiple gridded emission files for photochemical model input

As described above in Table 3.5-36, adjustments to the inventory are made with either the CNTLEM or CNTLHR modules. The CNTLEM module was used to:

- Remove 3.4 percent of the HDDV8a and HDDV8b ("18-wheeler") emissions for separate processing as "extended idling" emissions in accordance with the January 2004 EPA *Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity*;

- Apply benefits to accrue from January 15, 2004 EPA *Final Rule for Control of Emissions From Highway Motorcycles*; and
- Remove benefits to accrue from I/M Program for Chambers, Liberty, and Waller Counties.

According to the January 15, 2004 motorcycle rule, new NO_x and VOC emission standards for motorcycles are scheduled to take place beginning with the 2006 model year. According to EPA, these benefits have not been included in MOBILE6.2, but are expected to yield a 3.47 percent NO_x reduction and 2.61 percent VOC reduction from the 2007 motorcycle (MC) emission rate output from MOBILE6.2. Because total motorcycle emissions are relatively low, the overall NO_x and VOC benefits for 2007 are both less than 0.01 tpd in the 8-county HGB area as shown in Table 3.5-37, *Eight County HGB NO_x & VOC Benefits from New Motorcycle Rule for August 30*.

Table 3.5-37: Eight County HGB NO_x & VOC Benefits from New Motorcycle Rule for August 30

Calendar Year	*Units Reported*	*NO_x Emissions*	*VOC Emissions*
2007	*tpd*	0.006	0.011
	Pounds Per Day	12.800	21.800

For each of the eight counties within the HGB nonattainment area, the 2007 onroad mobile source inventories received from TTI included the effects of the I/M program which was either already in place or scheduled to be implemented. This revision removes Chambers, Liberty, and Waller Counties from the I/M program which was scheduled to begin in May of 2005. In order to remove the I/M program benefits from the 2007 onroad inventory,"with I/M" and "without I/M" MOBILE6.2 scenarios were performed for each of these three counties. By comparing these two scenarios, the net change in NO_x, VOC, and CO emission rates for each county and affected vehicle type was determined. These differences were used as adjustment factors with the EPS2x CNTLEM module. Table 3.5-38, *2007 Chambers, Liberty, & Waller County I/M Program Benefits Removed for August 30*, contains a summary of the 2007 I/M benefits removed from Chambers, Liberty, and Waller Counties.

Table 3.5-38: 2007 Chambers, Liberty, & Waller County I/M Program Benefits Removed for August 30

I/M Program County	***Emissions Benefits** (tpd)*		
	NO_x	***VOC***	***CO***
Chambers	0.28	0.22	4.79
Liberty	0.30	0.23	4.46
Waller	0.29	0.23	4.47
3-County Total	0.87	0.68	13.72

3.5.3.1 Temperature/Humidity NO_x corrections

The MOBILE6.2 model accounts for the effects that changes in hourly temperature and humidity have on NO_x emissions for only 6 of the 28 total vehicle types. These vehicle types are the MOBILE6.2 LDGV, LDGT1-4, and MC classes. There is no temperature/humidity NO_x correction in MOBILE6.2 for the remaining 22 vehicle classes, which include all 13 of the diesel-powered vehicle classes and the 9 heavy-duty gasoline vehicle classes. Under contract to the Houston Advanced Research Center (HARC), ENVIRON worked with the Southwest Research Institute to develop temperature/humidity NO_x correction equations to apply to both the 13 diesel and 9 heavy-duty gasoline vehicle classes in MOBILE6.2. These equations reflect the fact that as ambient temperature increases, tailpipe NO_x emissions increase. However, as ambient humidity increases, tailpipe NO_x emissions decrease. Greater detail on the development of these correction equations can be found in the following Appendices:

- F.4 - *Humidity and Temperature Correction Factors for NO_x Emissions From Diesel Engines, June 2003, ENVIRON/SwRI Report*
- F.5 - *Humidity and Temperature Correction Factors for NO_x Emissions From Spark Ignited Engines, October 2003, ENVIRON/SwRI Report*

ENVIRON also developed the CNTLHR module referenced above in Table 3.5-36, which allows the user to apply a different NO_x, VOC, and/or CO correction for each hour, episode day, county, and vehicle type combination. SAS code was developed to calculate the appropriate CNTLHR adjustment factors for each vehicle type by obtaining hourly inputs for temperature, relative humidity, and barometric pressure data for each county and episode day combination. The hourly temperature, relative humidity, and barometric pressure inputs used by the SAS software are also used by TTI in its development of the 2000 and 2007 HGB onroad inventories. These meteorological data were obtained from National Weather Service and the TCEQ monitors in the HGB area during the August 18-September 6, 2000 time period.

Table 3.5-39, *Summary of Temperature/Humidity NO_x Correction by County for 2000 Inventory,* and Table 3.5-40, *Summary of Temperature/Humidity NO_x Correction by County for 2007 Inventory,* are 2000 and 2007 summaries, respectively, of this correction procedure by county for the Wednesday, August 30 episode day. In general, the relatively cooler and more humid counties, such as Galveston and Chambers Counties, have a greater reduction of NO_x emissions on a 24-hour basis. Conversely, the relatively hotter and drier counties, such as Liberty and Montgomery Counties, have very slight changes to 24-hour NO_x emission totals. Within each county, there are greater NO_x reductions during the overnight and early morning hours when the temperature is at its minimum and the relatively humidity is at its maximum. However, during the hottest hours of the afternoon when the relative humidity is at its lowest, the temperature/humidity NO_x correction either decreases NO_x very slightly or increases it somewhat, depending upon the specific conditions for that hour. Overall, the temperature/humidity NO_x correction procedure allows not only for improved estimates of the total onroad NO_x emissions, but also for improved spatial and temporal allocation of those emissions. Greater detail on this correction procedure can be found in Appendix F.1.

Table 3.5-39: Summary of Temperature/Humidity NO_x Correction by County for 2000 Inventory

County	*NO_x Emissions (tpd)*			
	Input	***Output***	***Difference***	***Change***
Brazoria	14.72	13.95	-0.77	-5.23%
Chambers	7.96	7.33	-0.63	-7.91%
Fort Bend	19.18	18.61	-0.57	-2.97%
Galveston	16.11	14.33	-1.78	-11.05%
Harris	264.17	253.76	-10.41	-3.94%
Liberty	6.18	6.20	0.02	0.32%
Montgomery	21.75	21.62	-0.13	-0.60%
Waller	6.18	5.98	-0.20	-3.24%
8-County Total	356.25	341.78	-14.47	-4.06%

Table 3.5-40: Summary of Temperature/Humidity NO_x Correction by County for 2007 Inventory

County	*NO_x Emissions (tpd)*			
	Input	***Output***	***Difference***	***Change***
Brazoria	8.75	8.29	-0.46	-5.26%
Chambers	4.79	4.42	-0.37	-7.72%
Fort Bend	13.73	13.34	-0.39	-2.84%
Galveston	7.88	7.01	-0.87	-11.04%
Harris	140.67	135.53	-5.14	-3.65%
Liberty	3.85	3.87	0.02	0.52%
Montgomery	15.88	15.83	-0.05	-0.31%
Waller	4.27	4.16	-0.11	-2.58%
8-County Total	199.82	192.45	-7.37	-3.69%

3.5.3.2 Low Emission Diesel

Based on a September 27, 2001 EPA Memorandum entitled *Texas Low Emission Diesel (LED) Fuel Benefits*, a 4.8 percent NO_x LED benefit should be claimed for 2002-and-newer diesel vehicles and a 6.2 percent NO_x LED benefit should be claimed for 2001-and-older diesel vehicles. In order to determine the specific LED adjustment factors that should apply to each of the 13 diesel vehicle types from MOBILE6.2, MOBILE6.2 runs were performed for the HGB area to determine both VMT and NO_x emission rates by model year. By using these data, the 4.8 percent and 6.2 percent reduction factors were weighted according to NO_x model year contributions for each vehicle type. The resulting LED adjustment factors and benefits for 2007 are summarized in Table 3.5-41, *LED Fuel NO_x Adjustments Applied to 2007 Onroad HGB Inventory*. These LED factors were incorporated by TTI into the onroad inventories by post-processing the MOBILE6.2 diesel NO_x emission rates. Because the LED rule does not go into effect until 2005, the adjustment factors do not apply to the 2000 onroad inventory.

Table 3.5-41: LED Fuel NO_x Adjustments Applied to 2007 Onroad HGB Inventory

Diesel Vehicle Type	*2007 LED Adjustments*		
	NO_x Reduction	*Adjustment Factor*	*Benefit (tpd)*
LDDV	6.09%	0.9391	0.004
LDDT12	6.20%	0.9380	0.001
HDDV2b	5.09%	0.9491	0.204
HDDV3	5.29%	0.9471	0.135
HDDV4	5.37%	0.9463	0.099
HDDV5	5.27%	0.9473	0.069
HDDV6	5.43%	0.9457	0.316
HDDV7	5.53%	0.9447	0.247
HDDV8a	5.84%	0.9416	0.722
HDDV8b	5.61%	0.9439	3.783
HDDBT	5.81%	0.9419	0.157
HDDBS	5.82%	0.9418	0.198
LDDT34	5.40%	0.9460	0.007
Total Diesel	5.60%	0.9440	5.940

3.5.3.3 Idling

EPA issued a document in January 2004 entitled *Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity.* This EPA guidance states that "extended idling" emissions account for 3.4 percent of the total emissions calculated with MOBILE6.2 for the HDDV8a and HDDV8b vehicle classes. As previously stated, the CNTLEM module was used to remove 3.4 percent of the hourly NO_x, VOC, and CO emissions from the link-based "running" emissions prepared for photochemical model input from the HDDV8a and HDDV8b classes. Using a combination of SAS and UNIX code, these extended idling emissions from each hour were grouped into an 8-county 24-hour total and spatially assigned to known truck stop locations. The extended idling emissions were then processed through EPS2x as if they were stationary low-level point sources. The emissions were temporally allocated as the inverse of HDDV8a/HDDV8b VMT. Consequently, more of the extended idling emissions were allocated during overnight hours rather than daytime hours. The extended idling emissions were also run through the CNTLHR module to receive a temperature/humidity NO_x correction. Provided in Table 3.5-42, *2000 HDDV8a & HDDV8b "Extended Idling" Emissions for 8-County HGB Area,* and Table 3.5-43, *2007 HDDV8a & HDDV8b "Extended Idling" Emissions for 8-County HGB Area*, are summaries of the total NO_x, VOC, and CO extended idling emissions for both the 2000 and 2007 Wednesday, August 30 episode days, respectively.

Table 3.5-42: 2000 HDDV8a & HDDV8b "Extended Idling" Emissions for 8-County HGB Area

County	***Total Emissions*** *(tpd)*		
	***NO**$_x$*	***VOC***	***CO***
Brazoria	0.024	0.001	0.004
Chambers	0.292	0.007	0.047
Fort Bend	0.490	0.012	0.075
Galveston	0.076	0.002	0.013
Harris	2.942	0.071	0.461
Liberty	0.080	0.002	0.012
Montgomery	0.666	0.015	0.100
Waller	0.363	0.009	0.058
8-County Total	4.933	0.119	0.770

Table 3.5-43: 2007 HDDV8a & HDDV8b "Extended Idling" Emissions for 8-County HGB Area

County	***Total Emissions*** *(tpd)*		
	***NO**$_x$*	***VOC***	***CO***
Brazoria	0.011	0.001	0.003
Chambers	0.140	0.006	0.034
Fort Bend	0.236	0.010	0.054
Galveston	0.036	0.002	0.009
Harris	1.416	0.061	0.333
Liberty	0.039	0.002	0.009
Montgomery	0.322	0.013	0.072
Waller	0.175	0.008	0.042
8-County Total	2.375	0.103	0.556

3.5.3.4 Summary - Onroad Mobile Source Inventory

Table 3.5-44, *2000 Onroad Mobile Source Inventory for Wednesday, August 30* is a summary of the onroad emissions inventory input into the photochemical model for the 2000 Wednesday, August 30 episode day. This onroad inventory is a combination of both idling emissions (as summarized above in Table 3.5-42) and "running" emissions. The temperature/humidity NO_x correction has been applied as summarized in Table 3.4-39.

Table 3.5-44: 2000 Onroad Mobile Source Inventory for Wednesday, August 30

County	***Total Emissions** (tpd)*		
	NO_x	***VOC***	***CO***
Brazoria	13.95	6.78	101.33
Chambers	7.33	3.09	50.94
Fort Bend	18.61	8.73	124.41
Galveston	14.33	7.54	110.01
Harris	253.76	109.96	1,500.86
Liberty	6.20	2.89	42.34
Montgomery	21.62	8.98	137.53
Waller	5.98	2.55	40.89
8-County Total	341.78	150.52	2,108.31

3.5.4 TCMs, TERP, VMEP

For the 2007 inventory, additional post-processing adjustments were necessary to model the onroad inventory benefits to accrue from TCMs, TERP, and VMEP.

Table 3.5-45, *2007 Onroad TCM, TERP, & VMEP Benefits for 8-County HGB Area,* summarizes the 2007 8-county HGB onroad TCM, TERP, and VMEP benefits. Appendix F.6 is an Excel spreadsheet from HGAC detailing the 2007 onroad TCM benefits for the 8-county HGB area. Appendix F.7 is a report from HGAC detailing the 2007 VMEP benefits for the 8-county HGB area. For additional information on the TERP program benefits, refer to Section 5.3.17 of this SIP revision.

Table 3.5-45: 2007 Onroad TCM, TERP, & VMEP Benefits for 8-County HGB Area

8-County HGB Area	***Total Emissions** (tpd)*		
	NO_x	***VOC***	***CO***
TCM	0.85	0.52	0.00
TERP	3.00	0.00	0.00
VMEP	3.60	0.60	0.00
8-County Total	7.45	1.12	0.00

The TCM, TERP, and VMEP benefits were incorporated into the "running" portion of the onroad inventory with the EPS2x MRGUAM module, which allows for application of adjustment factors by pollutant type. Table 3.5-46, *Development of 2007 Onroad TCM/TERP/VMEP Adjustment Factors*, summarizes development of the TCM/TERP/VMEP onroad adjustment factors for the 2007 Wednesday, August 30 episode day.

Table 3.5-46: Development of 2007 Onroad TCM/TERP/VMEP Adjustment Factors

8-County HGB Area	***"Running" Emissions** (tpd)*		
	NO_x	***VOC***	***CO***
Brazoria	8.28	3.80	58.17
Chambers	4.56	1.87	34.67
Fort Bend	13.11	5.62	85.58
Galveston	6.97	3.67	53.45
Harris	134.11	65.22	904.29
Liberty	4.13	1.94	28.96
Montgomery	15.51	6.51	97.62
Waller	4.27	2.03	31.75
8-County Total	190.95	90.66	1,294.51
TCM, TERP, & VMEP	7.45	1.12	0.00
Revised 8-County Total	183.50	89.54	1,294.51
Adjustment Factor	0.9610	0.9877	1.0000

The NO_x, VOC, and CO adjustment factors shown above were multiplied by the listed running emissions. As a final step, the TCM/TERP/VMEP adjusted running emissions were added to the idling emissions summarized in Table 3.5-43 to obtain the final 2007 Wednesday, August 30 onroad emissions which were input into the photochemical model. The final 2007 onroad inventory for the Wednesday, August 30 episode day is summarized in Table 3.5-47, *Final 2007 Onroad Inventory by County for Wednesday, August 30 Episode Day*. A similar approach was taken to apply the TCM, TERP, and VMEP benefits to all of the episode days. Greater detail is provided in Appendix F.1.

Table 3.5-47: Final 2007 Onroad Inventory by County for Wednesday, August 30 Episode Day

8-County HGB Area	***Total Emissions** (tpd)*		
	NO_x	***VOC***	***CO***
Brazoria	7.97	3.76	58.17
Chambers	4.52	1.85	34.71
Fort Bend	12.83	5.56	85.64
Galveston	6.73	3.63	53.46
Harris	130.30	64.48	904.63
Liberty	4.01	1.92	28.97
Montgomery	15.22	6.44	97.70
Waller	4.28	2.02	31.80
8-County Total	185.86	89.66	1,295.08

3.5.4.1 Development of 2007 Attainment Demonstration Motor Vehicle Emissions Budget for HGB

By definition, the onroad emissions inventory input into the final attainment demonstration photochemical modeling run should establish the MVEB. However, use of the EPS2x processor introduces unique adjustments to the onroad emissions inventory which are necessary for photochemical modeling efforts. One of the primary adjustments relates to the speciation performed by the EPS2x CHMSPL module referred to in Table 3.5-36. CHMSPL categorizes the total VOCs reported into various groupings based on their reactivity with respect to forming ozone. Because each of these reactivity groupings has a different molecular weight, the VOC totals input to CHMSPL differ from those output. In a similar fashion, NO_x emissions are divided by CHMSPL into 90 percent NO and 10 percent NO_2, each with a distinct molecular weight.

Another processing step necessary for photochemical model input involves the use of Central Standard Time (CST) instead of Central Daylight Time (CDT). All photochemical modeling inventory files must be in CST to be consistent with how meteorological data are reported and modeled. However, emission inventory files are typically developed in CDT. As an example, the onroad emissions inventory data for the 2007 Wednesday, August 30 episode day is received from TTI in CDT. However, the onroad inventory data input into EPS2x begins at 1:00 a.m. CDT on August 30 and ends at 1:00 a.m. on August 31, which is 12:00 a.m. CST on August 30 and 12:00 a.m. CST on August 31, respectively.

When governmental organizations need to demonstrate conformity to the MVEB, they will not be developing photochemical modeling inventories and therefore will not apply these necessary speciation and time-shift steps. Consequently, the 2007 MVEB for the 8-county HGB area will start with the Wednesday, August 30 onroad inventory as received from TTI in CDT format. Then, adjustments for the federal motorcycle requirements, I/M program revision, temperature/humidity NO_x correction, and TCM/TERP/VMEP will be applied outside of EPS2x, but in a manner consistent with the descriptions included above. Table 3.5-48, *2007 Attainment Demonstration Motor Vehicle Emissions Budget for HGB,* summarizes this approach. The appropriate reference is noted for each inventory description/adjustment. The slight differences between the 8-county NO_x, VOC, and CO totals in Tables 3.5-47 and 3.5-48 are due solely to the manner in which the EPS2x system converts text-based, non-speciated inventory data in CDT into a binary, gridded, and speciated format in CST appropriate for photochemical model input.

Table 3.5-48: 2007 Attainment Demonstration Motor Vehicle Emissions Budget for HGB

8-County HGB Area	***Total Emissions** (tpd)*		
	NO_x	***VOC***	***CO***
Onroad Inventory From TTI (Table 3.5-33) *Includes RFG, I/M, LED, & 65 mph Speed Limit for 8 Counties*	200.09	90.44	1,282.97
Motorcycle Rule (Table 3.5-37)	-0.01	-0.01	0.00
Removal of Chambers, Liberty, & Waller Counties from the I/M Program (Table 3.5-38)	0.87	0.68	13.72
Temperature/Humidity NO_x Correction (Table 3.5-40)	-7.37	0.00	0.00
TCM (Table 3.5-45 & Appendix F.6)	-0.85	-0.52	0.00
TERP (Table 3.5-45 & Section 5.3.17)	-3.00	0.00	0.00
VMEP (Table 3.5-45 & Appendix F.7)	-3.60	-0.60	0.00
Final 8-County HGB MVEB	186.13	89.99	1,296.69

3.5.5 Biogenic Source Emissions Development

Biogenic emissions for the Phase 2 MCR modeling analysis were developed similarly to those used in modeling for the December 2002 SIP revision. In addition to extending the number of days modeled for the extended episode, the temperature inputs were also significantly improved using advanced geostatistical methods.

3.5.5.1 Input Data for Biogenic Emissions Modeling

Land Cover Data

Land cover and vegetation data for the biogenic emissions modeling was developed by a study described in Wiedinmyer et al., 2001.

Temperature Data

Temperature measurements were obtained from several different monitoring networks. Networks were chosen if they had acceptable QA procedures in place and if data were available for the time period of interest. Differences in sensor height among the temperature networks are usually not an issue during hot summer days, when vigorous mixing leads to small temperature gradients, but they might be an issue during dry, cool, still conditions when larger temperature gradients might occur near the ground.

Figure 3.5-4: Time Series Comparison of Observed and Interpolated Temperatures. The Prairie View site was not included in the data set used to create the interpolated temperature field.

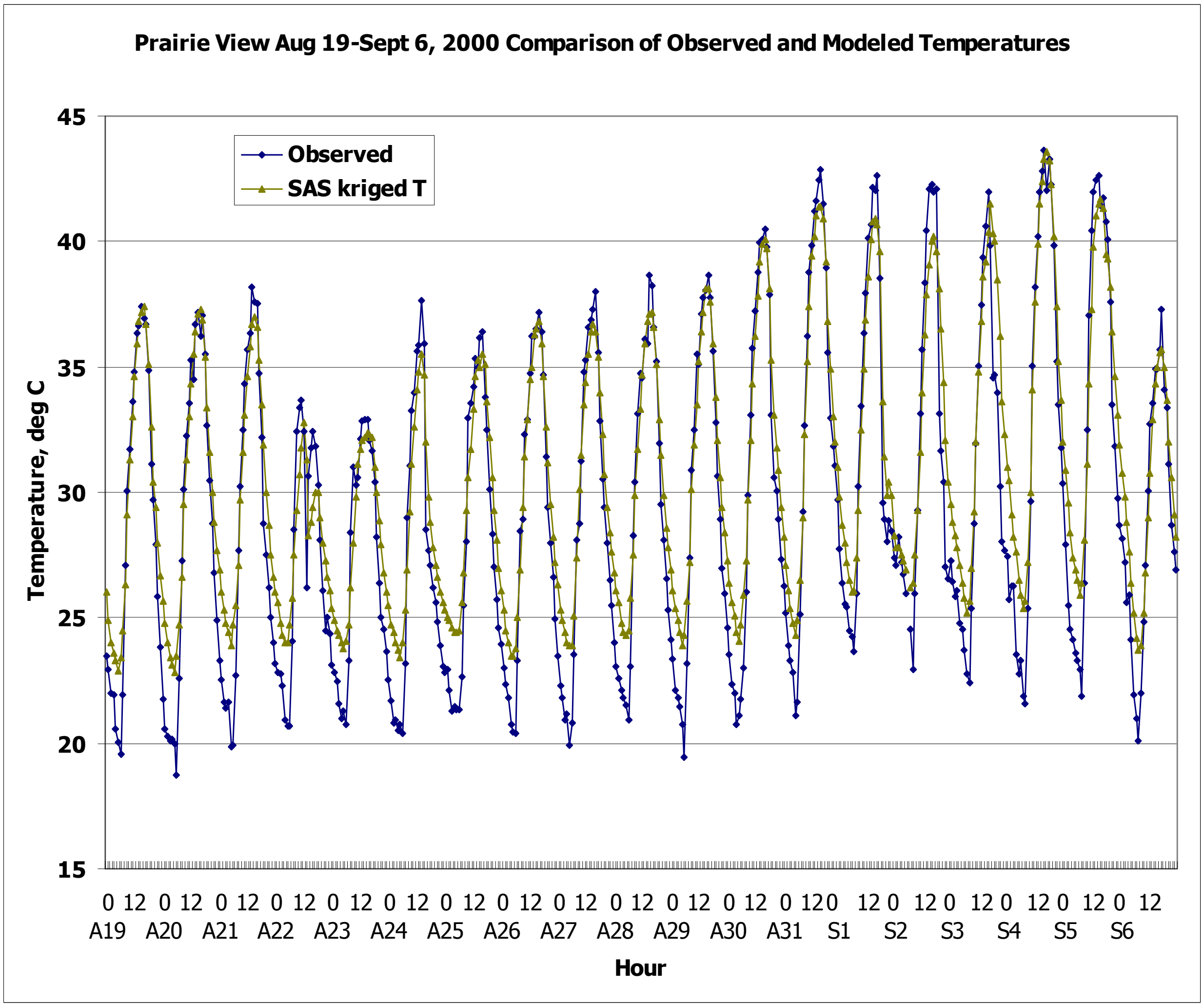
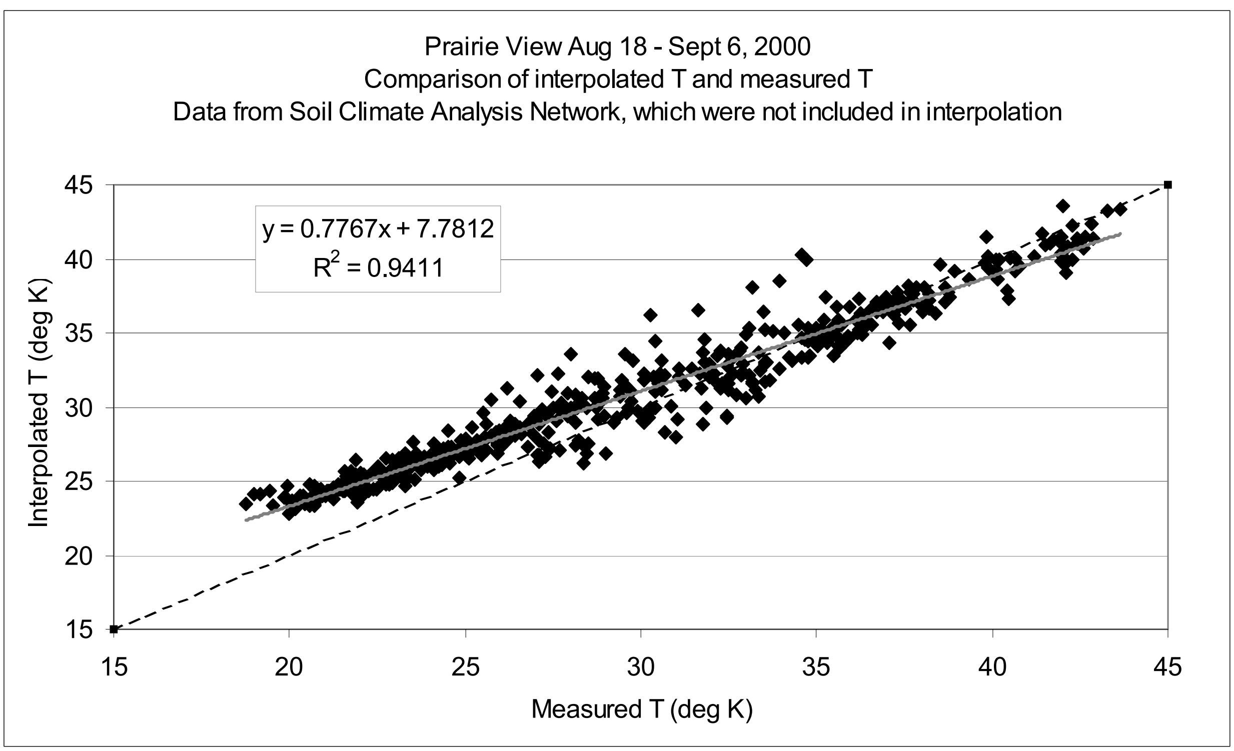


Figure 3.5-5: Scatter Plot of Observed and Interpolated Temperature Data for the Prairie View Site. Dashed line represents the 1:1 line; grey line in the regression line.



Data from the following networks were used: TCEQ, Aerometric Information Retrieval System, National Weather Service, Texas Crop Weather Program, Conrad Blucher Institute Texas Coastal Observation Network, and National Automated Buoy Data. Overall, data from over 100 stations were used.

The statistical technique of kriging was used to interpolate temperature measurements, thus creating a temperature field for each hour of the chosen episode. Vizuete et al. (2002) found that kriging is one of the most effective temperature interpolation methods for the purpose of creating biogenic emission model inputs. Kriging takes into account the tendency of neighboring observations to be more alike than those that are far apart. The function that describes the average similarity of any two observations as a function of distance is called the semivariogram. Because there was considerable variability in the semivariograms calculated for different times of day, unique semivariograms were estimated for each hour. Specifically, a power function was fitted to each hourly semivariogram, and the fitted power function was used in the kriging algorithm. Therefore, each hour had a different semivariogram as the basis of the interpolation. The SAS software kriging algorithm was used in this application. Temperature fields were calculated for each hour at three different spatial resolutions: 4 km x 4 km grid cells, 12 km x 12 km, and 36 km x 36 km. The different grids were nested within each other, and were configured to match the photochemical modeling domains.

Data from a temperature site not used in the interpolations were compared to the temperature field values at that location. The Soil Climate Analysis Network (SCAN) site used in the comparison was located at Prairie View A&M University, in Waller County, Texas (Natural Resource Conservation Service, 2004). The Prairie View site is operated by the Soil Climate Analysis Network, and collects data on behalf of the National Water and Climate Center, an agency within the Natural Resource Conservation Service in the U.S. Department of Agriculture. Figure 3.5-4, *Time Series Comparison of Observed and Interpolated Temperatures,* shows a time series of the interpolated temperatures and the measured temperatures. The time series comparison indicates that the interpolated temperatures generally depict the diurnal variation of temperature at the site reasonably well. The comparison also shows that the overnight temperatures were generally overestimated, and the maximum temperatures, especially on very hot days, were sometimes underestimated. A scatter plot of the same data (Figure 3.5-5, *Scatter Plot of Observed and Interpolated Temperature Data for the Prairie View Site*) shows a high degree of correlation ($r^2 = 0.94$) between the measured and modeled values. The 1:1 line indicates that the interpolation overestimates temperatures on the low end, but generally depicts the higher temperatures (i.e., >30° C) relatively well. Since the higher temperatures are more important in biogenic emissions, the temperature interpolation seems to be a sound method for estimating temperatures for biogenic emissions modeling.

Photosynthetically-Active Solar Radiation Data

Photosynthetically-active solar radiation (PASR) is defined as visible radiation with wavelengths between 400 nm - 700 nm. Biogenic emissions modeling requires input of hourly PASR fields that extend over large domains. Interpolation of surface measurements is unlikely to yield a satisfactory field, given the heterogeneous nature of clouds, and the comparative rarity of PASR measurements.

Meteorological models can generate PASR fields, but sometimes generate spurious clouds, which would greatly affect the PASR field. Therefore, hourly PASR fields were created using algorithms developed by Pinker et al., 2003, and input data from the GOES8 satellite. Cloud cover estimates from satellite imagery were fed into the radiation balance algorithm(s) to create a large-scale field of PASR. High resolution PASR fields were created from 1/16 degree solar field data.

Comparisons between GOES-derived PASR fields and ground-based broadband solar radiation measurements found very high degrees of correlation. Correlations for the TCEQ sites ranged from 0.94 to 0.97, with slopes ranging from 0.47 to 0.53, indicating that PASR comprised approximately 50 percent of broadband solar radiation (i.e., 20 nm - 2000 nm). Figure 3.5-6, *Time Series Comparison of Satellite-derived Photosynthetically-active Solar Radiation and Observed Broadband Solar Data at the TCEQ Bayland Park Monitoring Site* and Figure 3.5-7, *Scatter Plot of Satellite-Derived Photosynthetically-Active Solar Radiation vs. Observed Broadband Solar Radiation,* show an example of the time series and scatter plot comparisons between the GOES-derived PASR values and broadband solar radiation measurements at the TCEQ Bayland Park monitoring site.

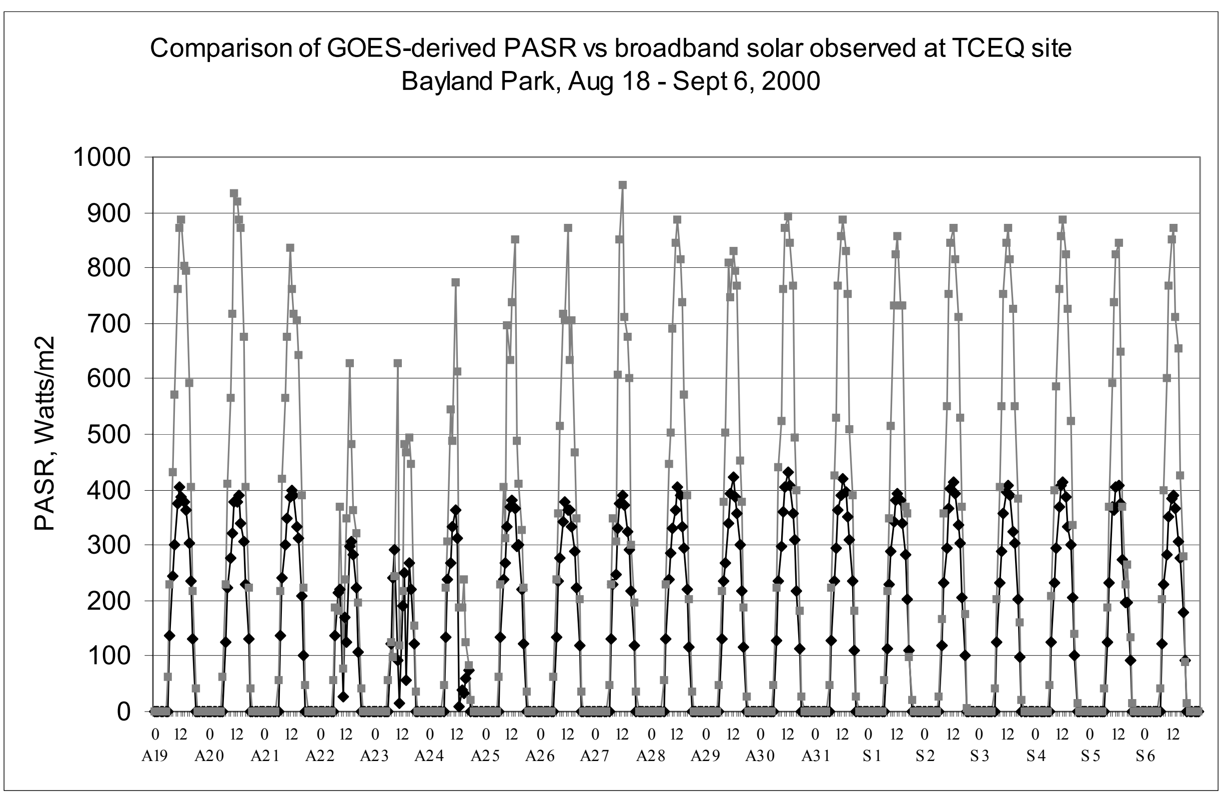
The nearest direct measurements of PASR is at a ground station were at Goodwin Creek, Mississippi, at a NOAA monitoring site. Since that site is located outside the 4-km modeling domain, the comparisons of GOES-derived data and ground observations for that site are not very useful.

3.5.5.2 Biogenic Emissions Model

The model used in the current scenario is version 3.0, released on April 11, 2002. GloBEIS was originally developed by Alex Guenther at the National Center for Atmospheric Research (Guenther et al., 1995; Guenther et al., 1997; Guenther et al., 1999). Guenther et al. developed the original algorithms for the BEIS family of biogenic emissions models (Guenther et al., 1993; Geron et al., 1994), and developed GloBEIS originally as a research-grade model. In 1999 this model was adapted for photochemical grid modeling by Guenther and model developers at ENVIRON, so that the latest developments in the field of biogenic emissions could be incorporated into the TCEQ's ozone modeling. Since then, the model has been revised several times to incorporate new features, and to update the VOC speciation.

For the base case modeling runs, the model was run in default mode, using the GloBEIS3 algorithms. None of the special algorithms (variable leaf area index, variable leaf age, drought index, leaf

Figure 3.5-6: Time Series Comparison of Satellite-Derived Photosynthetically-Active Solar Radiation Data and Observed Broadband Solar Data at the TCEQ Bayland Park Monitoring Site in Houston.



temperature, or antecedent temperature) have been invoked for the standard runs.

Figure 3.5-7: Daily Biogenic VOC emissions, August 22 - September 6, 2000.

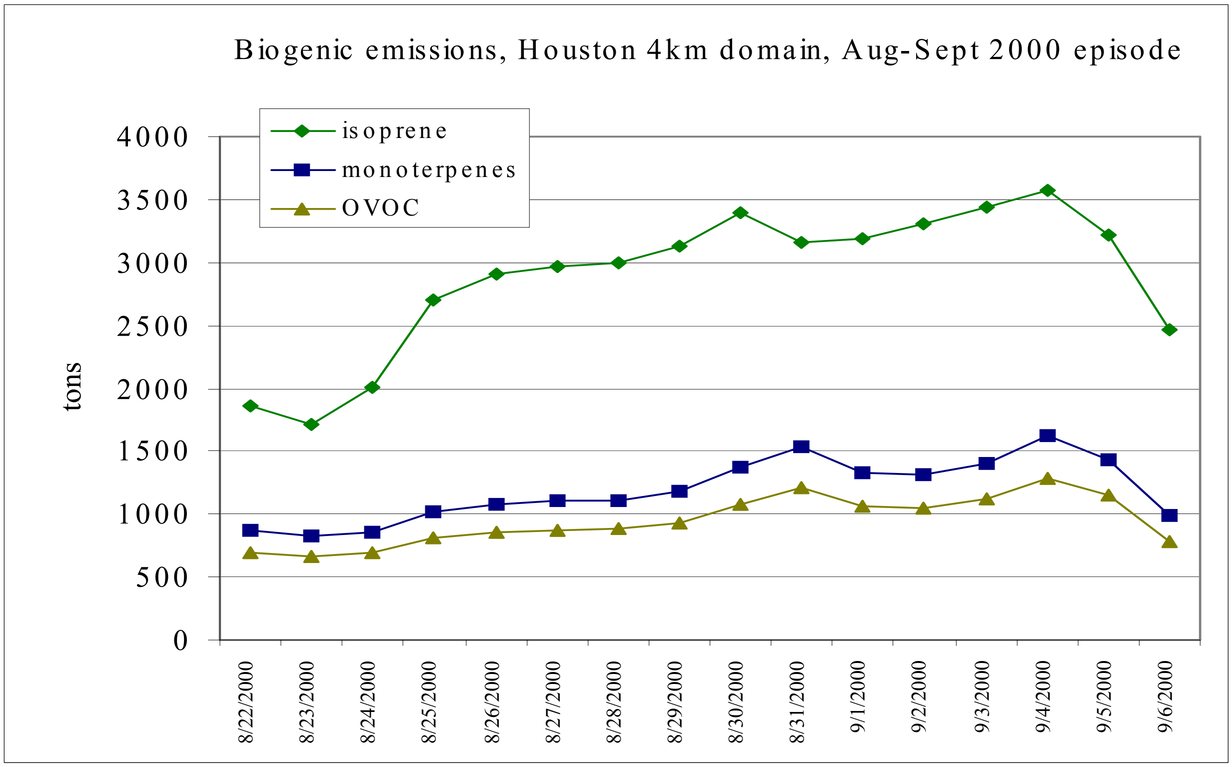


Figure 3.5-7, *Daily Biogenic VOC Emissions, August 22-September 6, 2000,* shows how the biogenic emissions vary among the episode days. Emissions are presented in their form before they have been converted to Carbon Bond 4. The speciation process usually changes the mass, which is why the subsequent tile plot figures show different values. Figure 3.5-8, *Spatial Distribution of Biogenic VOC Emissions, August 25, 2000, 4 km Domain,* shows the spatial distribution of biogenic VOCs emitted during August 25, the temporal variation in emissions, and the daily total for each county in southeast Texas. Figure 3.5-8 shows only the 4km domain. Figure 3.5-9, *Spatial Distribution of Biogenic* NO_x *Emissions, August 25, 2000, 4 km Domain*, shows the same for biogenic NO_x. Figure 3.5-10, *Spatial Distribution of Biogenic VOC Emissions, August 25, 2000, 12 km Domain,* and Figure 3.5-11, *Spatial Distribution of Biogenic* NO_x *Emissions, August 25, 2000, 12 km Domain*, shows the spatial distribution for the 12 km domain for August 25. Additional tile plots can be found in Appendix G.1, "Biogenics Tile Plots."

Figure 3.5-8: Spatial Distribution of Biogenic VOC Emissions, August 25, 2000, 4 km Domain

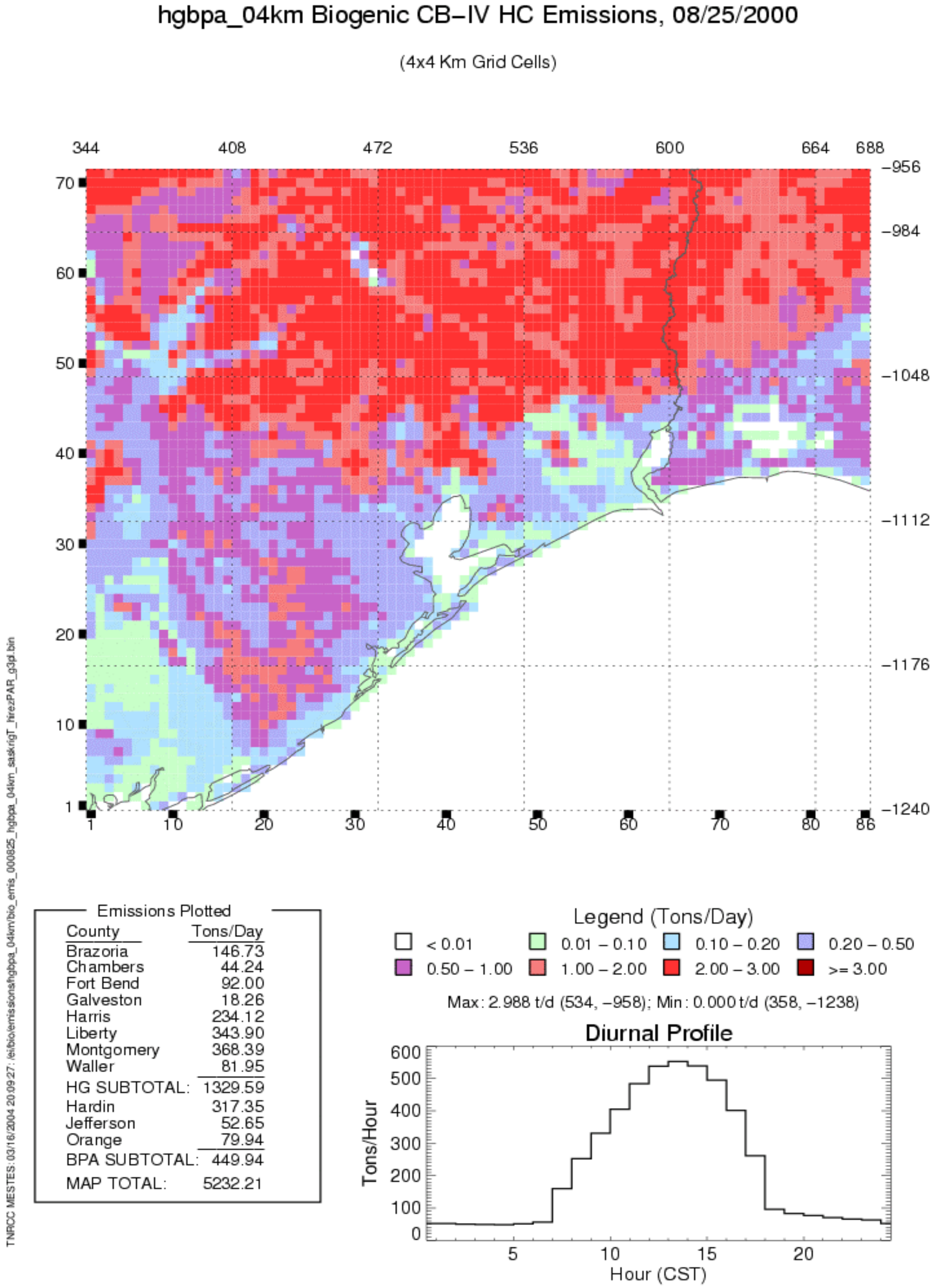


Figure 3.5-9: Spatial Distribution of Biogenic NO_x Emissions, August 25, 2000, 4 km Domain

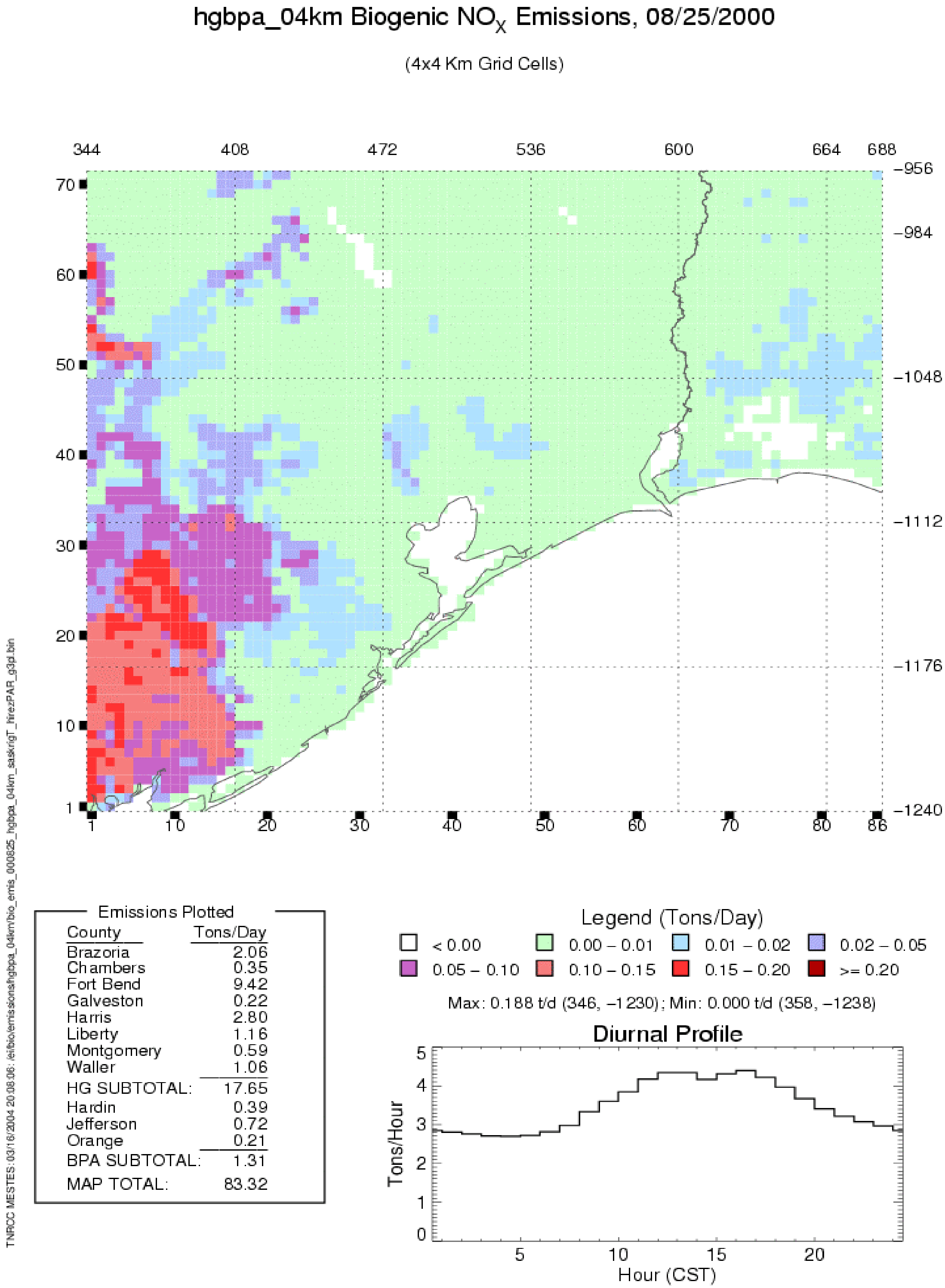


Figure 3.5-10: Spatial Distribution of Biogenic VOC Emissions, August 25, 2000, for 12 km Domain

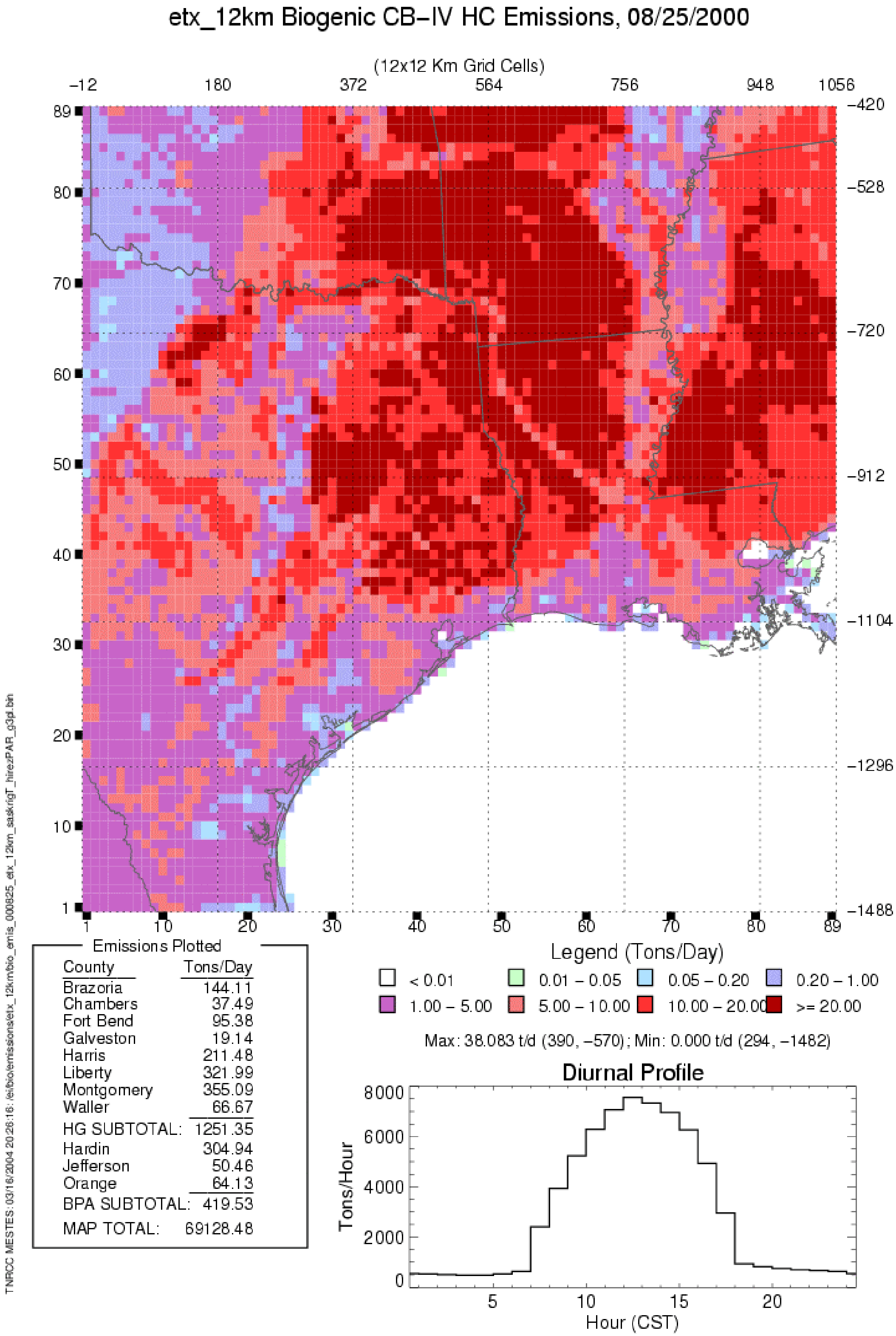
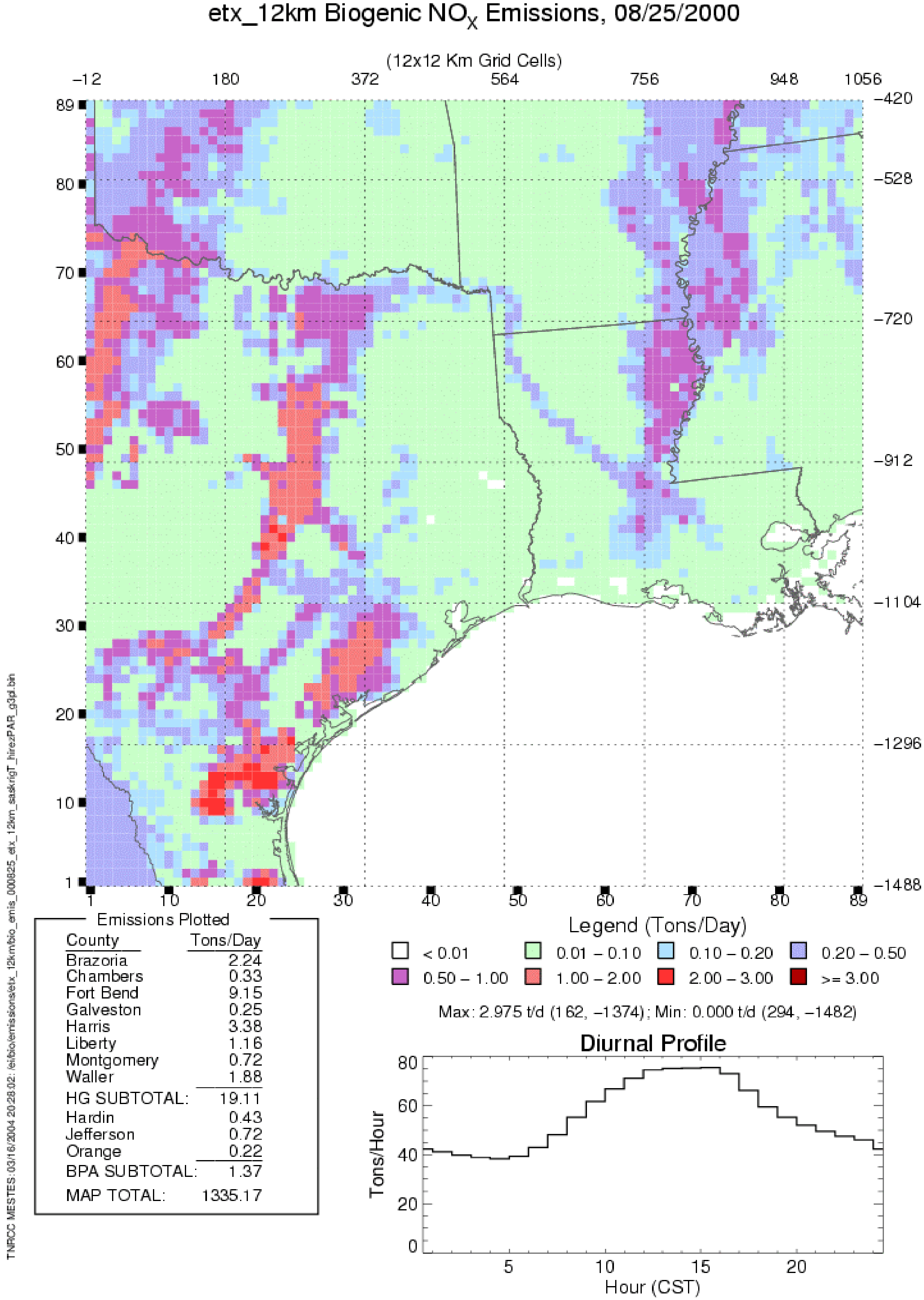


Figure 3.5-11: Spatial Distribution of Biogenic NO_X Emissions, August 25,2000, for 12 km Domain

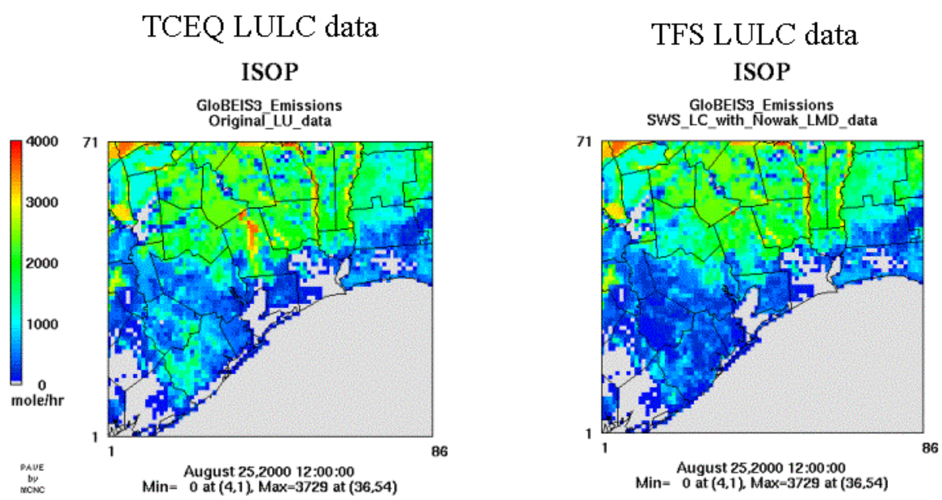


3.5.5.3 Sensitivity analysesResearchers at the Texas Forest Service (TFS), the University of Houston (UH), and UT have been investigating the sensitivity of biogenic emissions to varying methods of estimating temperatures, photosynthetically-active solar radiation, and land cover data. While these studies have not yet been published, and in some aspects have not been completed, the researchers have recently shared their preliminary results with the TCEQ. As a follow-up to the UH and UT investigations, the H-12 project sponsored by TERC/HARC systematically investigated the modeled and measured isoprene and ozone concentrations resulting from varying the input data to the biogenic emissions model GloBEIS. The TCEQ has reviewed all of these studies, and they are included as attachments in Appendix G.1. Although they have not yet been peer-reviewed or published, the TCEQ considers the findings in these documents to be generally credible, and has performed independent analyses that corroborate many of their findings.

Effects of Land Cover Data

The UH study (Appendix G.2) investigated the effect of using different land cover and vegetation data on the modeled biogenic emissions (Byun et al., 2004). Specifically, the data used was obtained by the Texas Forest Service's Houston Green program, a project to survey the urban forest of Houston and vicinity, to identify areas where new trees can be planted, and to quantify the benefits of a tree-planting program. The Texas Forest Service (TFS) project has developed new land cover and vegetation data for the 8-county HGB nonattainment area. Its cooperating partners in this project are the TCEQ, UH, the U.S. Forest Service, HARC, and Global Environmental Management. The new land cover data developed by this multi-partner project became available to the TCEQ recently. The TCEQ did not use these new data in the current SIP revision because they were not available in time to meet deadlines.

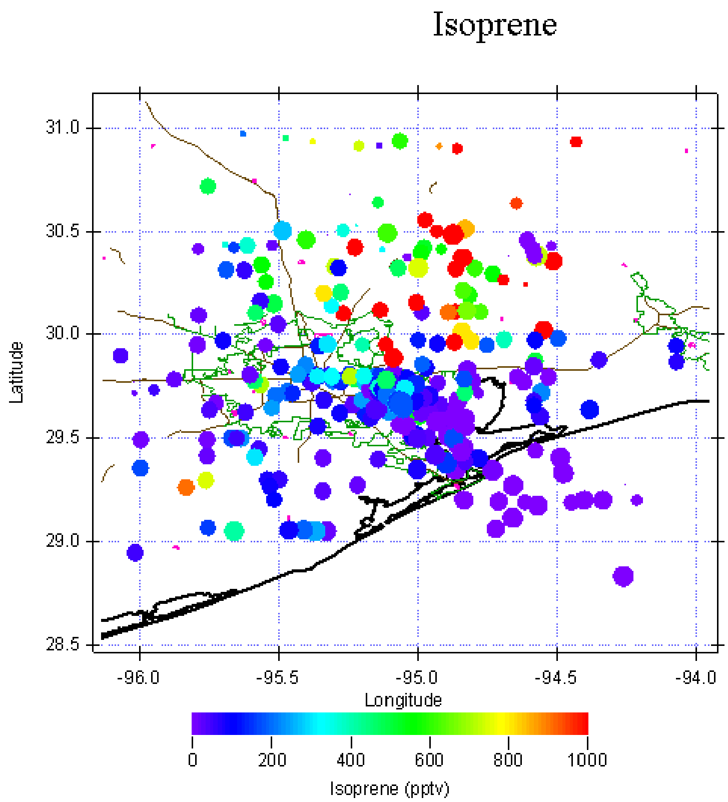
Comparisons of the biogenic emissions generated from the TCEQ and TFS land cover data sets show many areas of strong similarity, but a few areas of marked disagreement (Figure 3.5-12, *Emission Tile Plots for Two Land Cover Data Sets*). In particular, the TFS-derived biogenic emissions differ greatly from the TCEQ data in the river bottomland forests of Liberty, Chambers, Harris, and Fort Bend Counties. These forests have high emissions in the TCEQ-derived biogenic inventory, but usually have much lower emissions in the TFS-derived inventory. In Fort Bend County, the difference appears to be caused by the deforestation due to urban sprawl. In this location, the lower emissions from the TFS data may be more accurate than the TCEQ data.



Tileplots from Byun et al. presentation, Biogenic Emissions: From Meteorology Input to Ambient Ozone Concentrations, Feb. 2004

Figure 3.5-12: Emission tile plots for two land cover data sets.

In Liberty and Northeast Harris counties, however, the TFS data seem to smooth out the biogenic emissions from the river bottomland forests, averaging them with the neighboring forests that have lower emissions. The TCEQ data show these areas as much stronger emitters than the neighboring areas. Figure 3.5-13, *Ambient Isoprene Concentrations Measured by TexAQS Scientists in August - September 2000,* shows that the observational data obtained by aircraft flights during the TexAQS 2000 study is consistent with the TCEQ data; the VOC data from TexAQS 2000 flights indicated hot spots of biogenic isoprene emissions over the river bottomland forests in Liberty and Harris counties. The TFS-derived biogenic isoprene emissions, however, do not reflect these hot spots. Therefore, the TFS land cover and vegetation data represent an improvement in some ways over the TCEQ data, but also have some important flaws that need to be corrected before they can be used without reservation.



From Atlas et al., AMS presentation, "Observations of volatile organic compounds from airborne sample collection during TexAQS 2000, 17 Jan 2002"

Figure 3.5-13: Ambient isoprene concentrations measured by TexAQS scientists in Aug –Sept 2000

The H-12 study(Appendix G.3) has added to the investigations of the effects of land cover on biogenic modeling, and has done a quantitative comparison of the modeled isoprene concentrations and measured isoprene concentration data obtained from TexAQS 2000 aircraft flights (H-12 Project Team, 2004).

Effects of Temperature and Solar Data

The UT study (Appendix G.4) examines the sensitivity of isoprene emissions to different temperature and solar radiation estimation techniques (Song et al., 2004). To create temperature fields, they used a technique of interpolation similar to the technique used by the TCEQ, i.e., kriging. They compared the emissions derived using kriged temperatures to those using MM5 temperature data. For photosynthetically-active solar radiation, they used the satellite-derived solar data that the TCEQ used, and compared it to the solar radiation fields calculated by the GloBEIS model assuming zero cloud cover. The researchers show that biogenic emissions vary by only 10 to 20 percent when different methods of estimating temperatures or solar radiation are used.

In addition, the TCEQ has compared the kriged temperature fields created by the TCEQ to the MM5 temperature fields used in CAMx modeling, and has found that the kriged temperature field seems to be more accurate during the daylight hours than the MM5 data. The TCEQ has compared both the MM5 temperatures and the kriged temperatures to observed temperatures (Figure 3.5-15, *Temperature Comparisons*). In order to do an unbiased comparison, the TCEQ did not include data from one monitoring site in the Houston area in the kriging interpolation. This monitoring site is located at Prairie View A&M University, and is a part of the Soil Climate Analysis Network. Since the bulk of biogenic emissions occur during the day, it is much more important for the temperature fields used in biogenic modeling to be accurate during the day than at night. As the figure shows, the TCEQ kriged temperatures perform better in the daytime, indicating that they will yield more accurate biogenic emissions than MM5 temperatures. Based upon these results, and the findings of the Song et al. study, the TCEQ did not create a biogenic emissions data set using the MM5 temperatures.

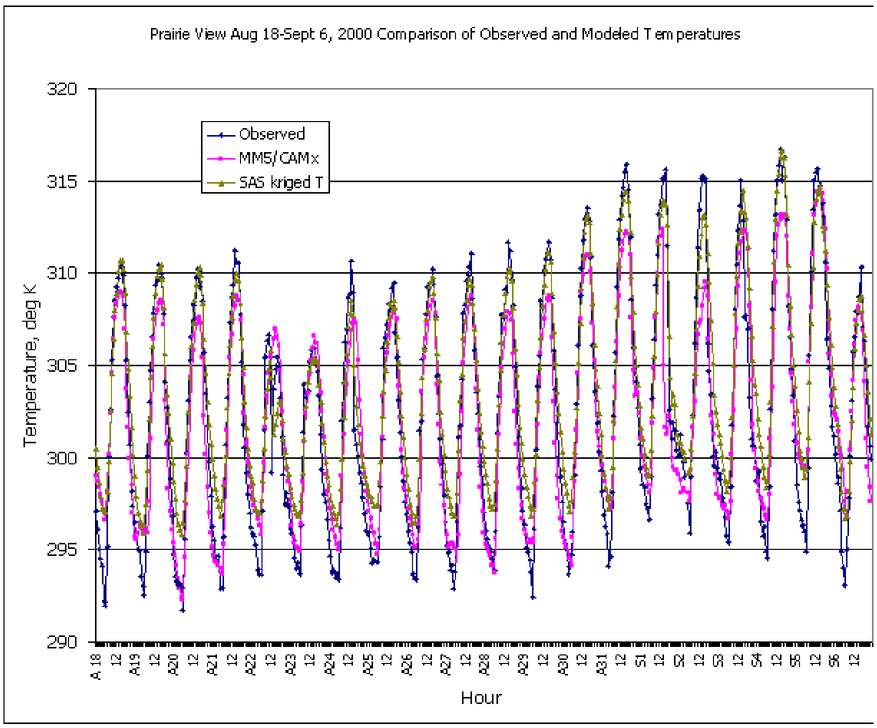


Figure 3.5-14: Temperature Comparisons

Conclusions from Sensitivity Analyses

Primary findings of the biogenic sensitivity analyses include:

- The methods used for estimating surface temperatures and cloud cover account for a minimal amount of uncertainty, on the order of 10 to 20 percent (Song et al., 2004).
- Different land cover data sets can have a significant impact on biogenic emissions, isoprene concentrations in the model, and eventually, ozone concentrations (Byun et al., 2004; H-12 Project Team, 2004).
- The current TCEQ treatment of biogenic emissions in the modeling is the best that can be done with the current scientific understanding, even though uncertainties remain (H-12 Project Team, 2004).

- The current treatment of biogenic emissions likely overstates biogenic emissions in the base case and may overstate biogenic emissions in the attainment demonstration (H-12 Project Team, 2004).
- The discrepancies between the biogenic emissions inventory and isoprene measurements cannot be resolved with existing data (H-12 Project Team, 2004).
- On-going efforts are needed to continue to improve biogenic emission estimates and their ozone impacts, including improvements of land cover and vegetation data, response of biogenic emissions to drought, and the modeled vertical mixing (H-12 Project Team, 2004).