TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

AGENDA ITEM REQUEST

for Proposed State Implementation Plan Revision

AGENDA REQUESTED: December 13, 2006

DATE OF REQUEST: November 21, 2006

NAME & NUMBER OF PERSON TO CONTACT REGARDING CHANGES TO THIS REQUEST, IF NEEDED: Kerry Howard, 239-0556

CAPTION: Docket No. 2006-1874-SIP. Consideration for publication of, and hearing on, proposed revision to the Houston-Galveston-Brazoria State Implementation Plan.

The proposed SIP revision documents the progress made to attain the one-hour ozone standard, documents steps toward attainment of the eight-hour ozone standard, and estimates 2018 as a reasonable target year for attainment of the eight-hour ozone standard in the Houston-Galveston-Brazoria nonattainment area.

The proposed revision also describes the two concurrently proposed state-level rules in Chapter 114 and Chapter 115. In addition, the Houston-Galveston Area Council has committed to implementing 2.82 tpd of local-level NOx controls by 2009. This revision also includes 2000 base case modeling, 2009 future case modeling, VOC and NOx reasonably available control technology analyses, reasonably available control measures analysis, contingency measures, and the 2002 Houston-Galveston-Brazoria periodic emissions inventory. (Emily Barrett, Janis Hudson) (Rule Project No. 2006-027-SIP-NR)

DC Schaubach

Deputy Director

Richard C Chi for Susana M. Hildebrand

Division Director

Kerry Howard

Agenda Coordinator

Copy to CCC Secretary? NO

Texas Commission on Environmental Quality

INTEROFFICE MEMORANDUM

Commissioners **Date:** November 21, 2006

Thru: LaDonna Castenuela, Chief Clerk
Glenn Shankle, Executive Director

David Schanbacher, P.E., Chief Engineer DCS

Docket No. 2006-1874-SIP

Subject: Commission Approval for Proposal of the Houston-Galveston-Brazoria Eight-Hour Ozone State Implementation Plan (SIP) Revision
Project No. 2006-027-SIP-NR

Reasons for the SIP Revision:
The eight-county Houston-Galveston-Brazoria (HGB) metropolitan area is classified a "moderate" ozone nonattainment area by the U.S. Environmental Protection Agency (EPA) under the eight-hour ozone standard. The Federal Clean Air Act (FCAA), 42 USC, §7410, requires states to submit State Implementation Plan (SIP) revisions for the eight-hour ozone SIP standard by June 15, 2007.

What the SIP Revision will do:
This SIP revision documents the substantial progress made under the one-hour ozone national ambient air quality standard (NAAQS) despite rapid economic and population growth in the area. This SIP also documents steps toward attainment of the eight-hour ozone standard. The challenges to attain the eight-hour ozone standard are great because the area is one of the most comprehensively controlled industrial complexes in the world; the area has unique and complex ozone formation chemistry and meteorology; the magnitude of reductions needed are significant; the TCEQ lacks regulatory authority to set emission standards for on-road and non-road mobile sources, and no additional pollution control technologies are anticipated to be developed before controls would need to be in place (January 1, 2009).

The HGB SIP includes all feasible control measures that can be implemented by 2009. This SIP revision includes two proposed state-level control measures: 1) adds marine diesel fuels to the definition of diesel fuel that is subject to the Texas Low Emission Diesel Rule and 2) addresses under-estimated, unreported, or under-reported volatile organic compounds (VOC) emissions from tank landings, flash emissions, and degassing of storage tanks, transport vessels, and marine vessels with liquid heels. In addition, the Houston-Galveston Area Council has committed to implementing Voluntary Mobile Source Emission Reduction Programs by 2009.

This revision includes the 2000 base case and 2009 future case modeling, which shows that nine monitors will be at or above 85 ppb in 2009 with the current controls in place. Results of modeling sensitivity runs indicate that combined nitrogen oxides (NO_X) and VOC reductions of 53 percent from all sources or NO_X-only reductions of 58 percent from all sources may be needed to achieve the standard. The SIP also includes a preliminary analysis using a limited data set for the year 2018, with all current one-hour ozone controls, the proposed eight-hour controls described in the preceding paragraph, and estimated reductions from federal-level on-road and non-road mobile source strategies that will be phased in between 2009 and 2018. The 2018 analysis predicts four monitors will have ozone concentrations at 85 ppb or greater.

Re: State Implementation Plan draft concept memo
Houston-Galveston-Brazoria Eight-Hour Ozone SIP Revision
2006-027-SIP-NR

Details regarding the next steps, the results of the TexAQS II field study, and the development of a new modeling episode are described in this revision.

The TCEQ believes that, with the ongoing efforts described in Chapter 5, the development of a new modeling episode, the continued implementation of increasingly lower engine emission levels for on-road and non-road mobile sources, and further research and consideration of additional control strategies, 2018 is a reasonable target year for attainment of the eight-hour ozone standard in the HGB area.

This revision also includes the federally required analysis of reasonably available control technology (RACT) and reasonably available control measures (RACM), contingency measures, and the baseline emissions inventory.

Statutory authority:
The authority to propose and adopt this SIP Revision is derived from the Texas Health and Safety Code, Texas Clean Air Act (TCAA), §382.002, which provides that the policy and purpose of the TCAA is to safeguard the state's air resources from pollution; TCAA, §382.011, which authorizes the commission to control the quality of the state's air; and §382.012, which authorizes the commission to prepare and develop a general, comprehensive plan for the control of the state's air, and Texas Water Code §5.102, General Powers, and §5.013, General Jurisdiction of Commission.

The Federal Clean Air Act (FCAA), 42 USC, §7410, *et seq.*, requires states to submit SIP revisions that specify the manner in which the NAAQS will be achieved and maintained within each air quality control region of the state. EPA's Final Rule to Implement the 8-Hour Ozone National Ambient Air Quality Standard (commonly referred to as the Phase II Rule), published on November 29, 2005, outlines the requirements for state plans.

Effect on the:

- Regulated Community:
  Manufacturers and distributors of marine diesel in the HGB nonattainment area must comply with the proposed new TxLED marine diesel rule. The proposed VOC rule will affect owners and operators of storage tanks, transport vessels, and marine vessels located in the HGB nonattainment area. The proposed new storage tank requirements will affect owners or operators storing volatile organic liquids in tanks located at petroleum refineries, chemical plants, gasoline storage terminals, bulk terminals, and oil and natural gas production sites. The limitations on landing floating roofs will have the largest impact on for-hire bulk storage terminals. The proposed changes to the degassing rules will affect owners or operators of storage tanks, transport vessels, and marine vessels and owners or operators of facilities that clean transport and marine vessels. Tanks with capacities between 40,000 and one million gallons will be most affected since these tanks are currently exempt from the degassing control requirements.

- Public:
  The public in the HGB area and surrounding areas will benefit from improved air quality.

- Agency programs:

Re: State Implementation Plan draft concept memo
Houston-Galveston-Brazoria Eight-Hour Ozone SIP Revision
2006-027-SIP-NR

Field Operations Division (FOD) conducts field investigations to verify compliance with rules in SIP revisions. FOD will need to investigate for compliance with the revised requirements when conducting routine site visits. Enforcement of rules in the SIP will not significantly increase the number of facilities investigated by the state and local governments. These rules may increase the Office of Compliance and Enforcement workload when investigating affected facilities.

Controversial Issues:
Stakeholders may comment that the plan is insufficient because it does not demonstrate attainment. Local entities may comment that EPA should not approve the SIP revision, which may result in conformity implications. The preliminary analysis showing that federal-level controls alone may not be enough for the HGB area to attain the eight hour ozone standard by 2018 may be of interest to many stakeholders.

Legislative interest:
Legislative interest will likely be high because this SIP revision will coincide with the 2007 legislative session.

Stakeholder involvement:
Public meetings with interested parties, including local governments, industry, environmental groups, and members of the public were held in Spring 2006. They included three meetings on March 22, 2006, and May 27, 2006, that focused on mobile source (on-road and non-road) control strategy development; March 28, 2006, regarding ports, locomotives, and marine sources; and April 19, 2006, and May 24, 2006, for point and area source control strategy development.

Proposed schedule:
Anticipated proposal date: December 13, 2006
Public hearing dates: In Houston on January 29, 2007; in Austin, February 8, 2007; in Longview, February 6, 2007; in DFW, February 1, 2007
Public comment period: December 29, 2006, to February 12, 2007
Anticipated adoption date: May 2007
SIP Revision due to EPA: June 15, 2007
Controls must be in place: January 1, 2009
Attainment date: End of ozone season 2009

Agency contacts:
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Janis Hudson, Staff Attorney, 239-0466
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Attachments (SIP narrative)

cc: Chief Clerk, 5 copies
Matt Beeter, Office of General Counsel
Sonia Ralls
Kerri Rowland

Re: State Implementation Plan draft concept memo
Houston-Galveston-Brazoria Eight-Hour Ozone SIP Revision
2006-027-SIP-NR

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Revisions to the State Implementation Plan (SIP)
for the Control of Ozone Air Pollution

HOUSTON-GALVESTON-BRAZORIA EIGHT-HOUR OZONE NONATTAINMENT AREA

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
P.O. BOX 13087
AUSTIN, TEXAS 78711-3087

Proposed
December 13, 2006

PROJECT NO. 2006-027-SIP-NR
DOCKET NO. 2006-1874-SIP

EXECUTIVE SUMMARY

The Houston-Galveston-Brazoria (HGB) eight-hour ozone nonattainment area is unique and includes one of the most comprehensively controlled industrial complexes in the world. The Texas Commission on Environmental Quality (TCEQ) has developed extensive regulations that address nitrogen oxides (NO_X), volatile organic compounds (VOC), and the sources of the most reactive ozone precursors in the HGB area, highly-reactive volatile organic compounds (HRVOC).

The substance of the existing plan to control ozone formation in the HGB area centers on the following key measures.

- Control of NO_X to an overall 80 percent level for point sources, and the associated Mass Emission Cap and Trade (MECT) program.
- Control of NO_X from on-road and non-road emissions through the vehicle inspection and maintenance (I/M) program, the Texas Emission Reduction Plan (TERP), and the Texas Low Emission Diesel (TxLED) program.
- Control of HRVOC and the associated HRVOC Emission Cap and Trade (HECT) program.
- Control of VOC.

(See pages 4-1 to 4-3 for a complete list of existing control measures.)

These components were recently approved by the United States Environmental Protection Agency (EPA) in the September 6, 2006, Federal Register notice (71 FR 52656) approving the one-hour ozone attainment demonstration and associated rules.

The one-hour ozone National Ambient Air Quality Standard (NAAQS), which preceded the eight-hour ozone NAAQS, was revoked by the EPA on June 15, 2005 (69 FR 23951). Hence, this SIP revision is the first HGB SIP revision under the eight-hour ozone standard. The eight-hour ozone standard is more stringent than the one-hour ozone standard, as evidenced by a 23 percent reduction in the HGB one-hour ozone design values from 1991 to 2005 versus a 13 percent reduction in the HGB eight-hour ozone design values during the same timeframe.

Rapid economic and population growth continue to create air quality challenges for the HGB area, even as the key ozone-targeting regulatory programs have reduced the number and magnitude of ozone exceedances, the area of exceedance, and the population exposed to exceedances.

The TCEQ continues to evaluate potential options to further reduce precursor pollutant emissions in the HGB area. Few practical options remain because current controls are among the most stringent in existence, TCEQ lacks the regulatory authority to set emission standards for on-road and non-road mobile emissions (which are estimated to account for 44 percent of overall projected NO_X emissions in 2009), and no additional pollution control technologies are anticipated to be developed in time (i.e., January 2009) to make the large and rapid emissions reductions that are needed for the HGB moderate nonattainment area to demonstrate attainment of the eight-hour ozone NAAQS.

This submittal contains three new control measures, summarized below in Table ExSum 1: *New Eight-Hour Ozone Control Strategies for the HGB Ozone Nonattainment Area*. The first control measure brings certain marine fuels under the TxLED rules. The second control measure addresses under-estimated, unreported, or under-reported VOC emissions from storage tank floating roof landings, flash emissions, and from degassing storage tanks, transport vessels, and marine vessels with liquid heels. The Houston-

Galveston Area Council (H-GAC) also committed to 2.82 tons per day (tpd) of NO_X reductions from Voluntary Mobile Source Emission Reduction Programs (VMEP).

The TCEQ continues to use the latest technology and science to direct improvements in air quality in the HGB area but acknowledges that the state regulatory agencies do not have legal authority to set emission standards for on-road and non-road engines. In an effort to provide innovative solutions to these significant sources of emissions, the Texas Legislature has, to date, committed more than $413 million to TERP, of which over $204 million has been awarded to the HGB area, to achieve more than 22 tpd in emissions reductions. Future TERP funds, if appropriated by the legislature, would result in continued reductions in the significant emissions source categories of on-road vehicles and non-road equipment.

Table ExSum1: New Eight-Hour Ozone Control Strategies Proposed for the HGB Ozone Nonattainment Area

Measure	Description	Area(s) Affected	Start Date(s)	NO_X tpd Reduction	VOC tpd Reduction
TxLED Marine	Adds marine distillate fuels commonly known as DMX and DMA, or Marine Gas Oil (MGO), into the definition of diesel fuels, requiring them to be TxLED compliant.	8-county area	June 24, 2007	0.9	0
VOC Rules on Storage and Degassing Operations	Requires controls for slotted guide poles and more stringent controls for other fittings on floating roof tanks, and control requirements or operational limitations on landing floating roof tanks. Eliminates exemption for storage tanks for crude oil or natural gas condensate, and regulates flash emissions from these tanks. Requires vapors from degassing to be vented to a control device for a longer time period, and removes exemption from degassing to control for tanks with capacity 40,000 to 1,000,000 gallons.	8-county area	January 1, 2009	0	Not quantified, but will achieve significant actual reductions.
VMEP	Local programs to reduce on-road emissions. See Appendix A for a full listing.	8-county area	By January 1, 2009	2.82	0

This planned revision includes 2000 base case and 2009 future case modeling. Future case baseline modeling, which does not include the proposed eight-hour ozone controls, predicts ozone concentrations at nine monitors of 85 parts per billion (ppb) or greater in 2009, with Deer Park (at a projected future design value of 97 ppb) as the highest 2009 design value monitor in the HGB area.

A modeling sensitivity run, using the 2009 baseline and various hypothetical NO_X and VOC emission reductions applied to all sources (see Figure 2-38), shows that combined NO_X and VOC reductions of 53 percent and NO_X –only reductions of 58 percent may be needed to achieve attainment in the HGB area.

Another modeling sensitivity run, using the 2009 baseline and various hypothetical NO_X emission reductions applied to ground-level sources (e.g., non-road and on-road and area sources with height or plume rise no higher than 30 meters from the ground), shows that except for the Deer Park monitor, the eight monitors with a DVf of 85 ppb or greater in the 2009 baseline would reach a future design value of less than 85 ppb with a less than a 40 percent reduction from total NO_X sources if all of the NO_X reductions came from ground-level sources. Table ExSum 2: *Summary of Sensitivity Modeling Results of NO_X Reductions from All Sources and Ground-Level Sources*, compares the NO_X reductions needed at each of the nine monitors with a DVf of 85 ppb or greater in the 2009 baseline from all sources of NO_X versus ground-level sources of NO_X. With the exception of the Deer Park monitor, notably less NO_X reductions are needed from ground-level sources compared to all sources. In addition, at each of the monitors, the DVf reduction efficiency, as measured by the amount the 2009 baseline DVf exceeds 85 ppb divided by the NO_X emission reduction, is greater for the ground-level NOx reductions.

Table ExSum2: Summary of Sensitivity Modeling Results of NO_X Reductions from All Sources and Ground-Level Sources

Monitor Code	Attainment Reduction from All NO_X Sources	Attainment Reduction from Ground-Level NO_X Sources	Difference in NO_X Reduction	Reduction Efficiency (ppb/ton)	
				All NO_X	Ground-level NO_X
DRPK	258 tpd (58.1%)	>248 tpd (55.1%)*	<10 tpd	0.048	<0.050
BAYP	237 tpd (53.2%)	177 tpd (39.3%)	60 tpd	0.045	0.060
HOEA	195 tpd (43.2%)	156 tpd (34.5%)	39 tpd	0.029	0.036
HALC	184 tpd (40.9%)	135 tpd (30.6%)	49 tpd	0.045	0.061
HCQA	121 tpd (26.6%)	87 tpd (18.7%)	34 tpd	0.031	0.044
HNWA	56 tpd (11.9%)	37 tpd (7.6%)	19 tpd	0.036	0.054
H08H	56 tpd (11.9%)	45 tpd (10.3%)	11 tpd	0.021	0.027
HROC	35 tpd (7.2%)	24 tpd (4.5%)	11 tpd	0.020	0.029
SHWH	30 tpd (6.0%)	18 tpd (3.3%)	12 tpd	0.023	0.039

* Although tpd values in this column reflect ground-level NO_X emissions reductions, the corresponding percentages are relative to total NO_X emissions (450 tpd). Reducing ground-level NOx emissions alone by 100% (248 tpd) is not predicted to yield a DRPK DVf < 85ppb

A modeling sensitivity run was conducted that included all of the quantifiable reductions that are outlined in Chapter 4. This run includes the cumulative 5.3 tpd of NO_X emissions reductions from the H-GAC's original VMEP estimate (4.4 tpd) plus the TxLED Marine Diesel Rule (0.9 tpd), and demonstrates that these reductions result in a future design value change of less than 1 ppb. Due to the EPA truncating convention, these reductions would result in no net reduction in design value for the Deer Park monitor in 2009. (The VMEP estimated reduction was revised to 2.82 tpd after the sensitivity run was performed.) Additionally, the H-GAC plus TxLED Marine reductions (5.3 tpd) were added to the matrix of ground-level NO_X reductions and even a 75 percent reduction in ground-level sources of NO_X added to the controls in this eight-hour ozone SIP revision, would not bring the HGB area below 85 ppb.

Another modeling sensitivity run removed all point source and shipping activity emissions from the main portion of the Houston Ship Channel (primarily in Harris County) in 2009. At six of the nine monitors where ozone is projected to be 85 ppb or greater in 2009, ozone concentrations would continue to be at or above 85 ppb even if these Houston Ship Channel emissions were eliminated.

Finally, a preliminary technical analysis using a limited data set was performed for the year 2018. This analysis examined all current one-hour ozone controls and the eight-hour ozone controls outlined in Chapter 4, and estimated likely ground-level emission reductions of approximately 98 tpd NO_X resulting from federal-level controls that will be phased in between 2009 and 2018. The analysis predicted that in 2018 four monitors (Deer Park, Bayland Park, Houston East, and Aldine) will monitor 85 ppb or greater. As shown in the first four rows of Table ExSum2: *Summary of Sensitivity Modeling Results of NO_X Reductions from All Sources and Ground-Level Sources*, these monitors require more than the 98 tpd reduction that will be provided by federal-level controls in 2018 to bring their design value below 85 ppb.

Continuing its commitment to invest resources into investigating all facets of ozone formation in Houston, the TCEQ began a second exhaustive field study of ozone formation in the HGB area in June 2005, called the Texas Air Quality Study II (TexAQS II). The field study concluded in September 2006. Examination and evaluation of the data collected will allow the TCEQ to continue to improve the scientific knowledge base for the HGB area. The TCEQ plans to use this information to further the goal of air quality improvement. Additionally, the TCEQ is committed to continue ongoing efforts to identify and control VOC emissions, such as finding unaddressed or under-addressed sources of pollution with new infrared VOC imaging technology. The TCEQ also continues to work to reduce NO_X emissions through efforts that include the routine marine vessel study and to identify new cost effective technologies through the New Technology Research and Development Program. The TCEQ will continue to work with EPA and the local community to explore feasible and practical methods to continue making progress in air quality improvement.

Overall, this plan revision includes the three control strategies in Table ExSum1, details regarding progress that the HGB area has made toward attainment, 2000 base case photochemical modeling, 2009 future case photochemical modeling, modeling sensitivity runs, a reasonably available control measure (RACM) analysis, VOC and NO_X reasonably available control technology (RACT) analyses, contingency measures, the baseline emissions inventory, and projections about the progress expected in future years. The TCEQ believes that, with the ongoing efforts described in Chapter 5, the development of a new modeling episode, the continued implementation of increasingly lower engine emission levels for on-road and non-road mobile sources, and further research and consideration of additional control strategies, 2018 is a reasonable target year for attainment of the eight-hour ozone standard in the HGB area.

SECTION V: LEGAL AUTHORITY

A. General

The TCEQ has the legal authority to implement, maintain and enforce the national ambient air quality standards.

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

Originally, the TCAA stated that the Texas Air Control Board (TACB) is the state air pollution control agency and is principal authority in the state on matters relating to the quality of air resources. In 1991, the Legislature abolished the TACB effective September 1, 1993 and its powers, duties, responsibilities and functions were transferred to the Texas Natural Resource Conservation Commission (TNRCC). With the creation of the TNRCC, the authority over air quality is found in both the Texas Water Code and the TCAA. Specifically, the authority of the TNRCC is found in Chapters 5 and 7. Chapter 5, Subchapters A - F, and H - J and L, include the general provisions, organization and general powers and duties of the TNRCC, and the responsibilities and authority of the Executive Director. This Chapter also authorizes the TNRCC to implement action when emergency conditions arise, and to conduct hearings. Chapter 7 gives the TNRCC enforcement authority. In 2001, the 77th Texas Legislature continued the existence of the TNRCC until September 1, 2013, and changed the name of the TNRCC to the Texas Commission on Environmental Quality (TCEQ).

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

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

Subchapters F, G, and H of the TCAA authorize the TCEQ to establish low emission vehicle requirements for mass transit authorities, local government fleets and private fleets; create a mobile emissions reduction credit program; establish vehicle inspection and maintenance programs in certain

areas of the state, consistent with the requirements of the federal Clean Air Act; establish gasoline volatility and low emission diesel standards; and fund and authorize participating counties to implement low-income vehicle repair assistance, retrofit and accelerated vehicle retirement programs.

B. Applicable Law

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

Statutes

TEXAS HEALTH & SAFETY CODE, Chapter 382	September 1, 2005
TEXAS WATER CODE	September 1, 2005

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

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

Chapter 7: Enforcement
Subchapter A: General Provisions (§§ 7.001, 7.002, 7.0025, 7.004, 7.005 only)
Subchapter B: Corrective Action and Injunctive Relief (§ 7.032 only)
Subchapter C: Administrative Penalties
Subchapter E Criminal Offenses and Penalties: §§ 7.177, 7.179-7.181

Rules

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

Chapter 7, Memoranda of Understanding, §§ 7.110 and 7.119	May 2, 2002
Chapter 35, Subchapters A-C, K: Emergency and Temporary Orders and Permits; Temporary Suspension or Amendment of Permit Conditions	December 10, 1998
Chapter 39, Public Notice, §§ 39.201; 39.401; 39.403(a) and (b)(8)-(10); 39.405(f)(1) and (g);39.409; 39.411 (a), (b)(1)-(6) and (8)-(10) and (c)(1)-(6) and (d); 39.413(9), (11), (12) and (14); 39.418(a) and (b)(3) and (4); 39.419(a), (b),(d) and (e); 39.420(a), (b) and (c)(3) and (4); 39.423 (a) and (b); 39.601; 39.602; 39.603; 39.604; and 39.605	August 15, 2002

Chapter 55, Request for Contested Case Hearings; Public Comment, §§ 55.1; 55.21(a) - (d), (e)(2), (3) and (12), (f) and (g); 55.101(a), (b), (c)(6) - (8); 55.103; 55.150; 55.152(a)(1), (2) and (6) and (b); 55.154; 55.156; 55.200; 55.201(a) - (h); 55.203; 55.205; 55.206; 55.209 and 55.211	August 29, 2002
Chapter 101: General Air Quality Rules	June 23, 2005
Chapter 106: Permits by Rule, Subchapters A	June 30, 2004
Chapter 111: Control of Air Pollution from Visible Emissions and Particulate Matter	November 18, 2004
Chapter 112: Control of Air Pollution from Sulfur Compounds	July 16, 1997
Chapter 113, Standards of Performance for Hazardous Air Pollutants and for Designated Facilities and Pollutants	June 15, 2005
Chapter 114: Control of Air Pollution from Motor Vehicles	May 19, 2005
Chapter 115: Control of Air Pollution from Volatile Organic Compounds	May 5, 2005
Chapter 116: Permits for New Construction or Modification	June 15, 2005
Chapter 117: Control of Air Pollution from Nitrogen Compounds	May 19, 2005
Chapter 118: Control of Air Pollution Episodes	March 5, 2000
Chapter 122, § 122.122: Potential to Emit	December 11, 2002

SECTION VI. CONTROL STRATEGY

A. Introduction (No change)

B. Ozone (Revised)

1. *Dallas-Fort Worth* (No change)
2. *Houston-Galveston-Brazoria* **(Revised)**
   - Chapter 1: Background and Introduction
   - Chapter 2: Photochemical Modeling
   - Chapter 3: Corroborative Analysis
   - Chapter 4: Control Strategies and Required Elements
   - Chapter 5: Ongoing Work and Future Initiatives
3. *Beaumont-Port Arthur* (No change**)**
4. *El Paso* (No change)
5. *Regional Strategies* (No change)
6. *Northeast Texas* (No change)
7. *Austin Area* (No change)
8. *San Antonio Area* (No change)

C. Particulate Matter (No change)

D. Carbon Monoxide (No change)

E. Lead (No change)

F. Oxides of Nitrogen (No change)

G. Sulfur Dioxide (No change)

H. Conformity with the National Ambient Air Quality Standards (No change)

I. Site Specific (No change)

J. Mobile Sources Strategies (No change)

K. Clean Air Interstate Rule (No change)

LIST OF ACRONYMS

ACT -- Alternative Control Techniques
AF -- Air-to-Fuel
APU -- Auxiliary Power Units
ARPDB -- Acid Rain Program Data Base
ATCM – Airborne Toxic Control Measure
auto-GC -- Automated Gas Chromatograph
BACT -- Best Available Control Technology
BCCA-AG -- Business Coalition for Clean Air-Appeal Group
BMP -- Best Management Practices
BPA -- Beaumont-Port Arthur
Btu/hr -- British Thermal Units per Hour
Btu/scf -- British Thermal Units per Square Cubic Feet
CAE -- Cetane Additive Enhanced Diesel Fuel
CAIR -- Clean Air Interstate Rule
CAMx -- Comprehensive Air Model with Extensions
CARB -- California Air Resources Board
CBD -- Houston's Central Business District
CFR -- Code of Federal Regulations
CMAQ -- Congestion Mitigation and Air Quality
CO -- Carbon Monoxide
CTG -- Control Technique Guidelines
DECS -- Diesel Emission Control Strategy
DERC -- Discrete Emission Reduction Credits
DFW -- Dallas-Fort Worth
DPM -- Diesel Particulate Matter
DRRP -- Diesel Risk Reduction Program
DV -- Design Value
DVc -- Current Design Value
DVf -- Future Design Value
EAC -- Early Action Compact
EDMS -- Emissions and Dispersion Modeling System
E-GRID-2007 -- Emissions and Generation Resource Integrated Database
EE/RE -- Energy Efficiency/Renewable Energy
EGAS -- Economic Growth Analysis System
EGF -- Electric Generating Facilities
EGU -- Electric Generating Units
EI -- Emissions Inventory
EPA -- United States Environmental Protection Agency
EPS3 -- Emissions Processing System, version 3
ERC -- Emission Reduction Credits
ERCOT -- Electric Reliability Council of Texas
ESAD -- Emission Specification for Attainment Demonstration
ESL -- Energy Systems Laboratory, the Texas A&M University System
F -- Fahrenheit
FAA -- Federal Aviation Administration
FCAA -- Federal Clean Air Act
FCV -- Fuel Cell Vehicle

FGR -- Flue Gas Recirculation
FHWA -- Federal Highway Administration
FR -- Federal Register
FT -- Fischer-Tropsch Diesel Fuel
GIS -- Geographic Information System
GloBEIS -- Global Biosphere Emissions and Interactions System
gpm -- Gallons per Minute
GTM -- Gross Ton Mile
HAP -- Hazardous Air Pollutant
HARC -- Houston Advanced Research Center
HDT -- Heavy-Duty Truck
HDDV -- Heavy-Duty Diesel Vehicle
HECT -- Highly-Reactive Volatile Organic Compound Emissions Cap and Trade Program
HGB -- Houston-Galveston-Brazoria
H-GAC -- Houston-Galveston Area Council
HOV -- High Occupancy Vehicle
hp -- Horsepower
HPMS -- Highway Performance Monitoring System
HRVOC -- Highly-Reactive Volatile Organic Compound
HSC -- Houston Ship Channel
IC -- Internal Combustion
ICI -- Industrial, Commercial, and Institutional
IECC -- International Energy Conservation Code
I/M -- Inspection and Maintenance
km -- Kilometer
K_Vs -- Vertical Exchange Coefficient
LAER -- Lowest Achievable Emission Rate
lb/MMBtu -- Pound per Million British Thermal Units
LDAR -- Leak Detection and Repair
LDIR -- Light Detection and Ranging
LDEQ -- Louisiana Department of Environmental Quality
LDGV -- Light-Duty Gasoline Vehicle
LDT -- Light-Duty Truck
LDV -- Light-Duty Vehicle
LED -- Low Emission Diesel
LEV -- Low Emission Vehicle
LEV II -- California's Low Emission Vehicle II Program
LIRAP -- Low Income Repair and Assistance Program
LNB -- Low Nitrogen Oxides (NO_X) Burners
LNC -- Low Nitrogen Oxides (NO_X) Combustors
LNG -- Liquefied Natural Gas
LTO -- Landing and Take-Off
MACT -- Maximum Achievable Control Technology
Mcf -- Thousand Cubic Feet
MCR -- Mid-Course Review
MDPV -- Medium-Duty Passenger Vehicle
MECT -- Mass Emissions Cap and Trade Program
MM5 -- Fifth Generation Meteorological Model
MMBtu/hr -- Million British Thermal Units per Hour
MMcf -- Million Cubic Feet

MMS -- Minerals Management Service
MOA -- Memorandum of Agreement
MON -- Miscellaneous Organic National Emission Standards for Hazardous Air Pollutants (NESHAP)
mph -- Miles per Hour
MVEB -- Motor Vehicle Emissions Budget
MW -- Megawatts
MY -- Model Year
NAAQS -- National Ambient Air Quality Standard
NEGU -- Non-Electric Generating Units
NEI -- National Emissions Inventory
NESHAP -- National Emission Standards for Hazardous Air Pollutants
ng/J -- Nanogram per Joule
NMIM -- National Mobile Inventory Model
NOAA -- National Oceanic and Atmospheric Administration
NO_X -- Nitrogen Oxides
NO_y -- Nitrogen Species
NSCR -- Non-Selective Catalytic Reduction
NTRD -- New Technology Research and Development Program
O_3 -- Ozone
OGV -- Ocean-Going Vessel
PAYD -- Pay As You Drive
PBL -- Planetary Boundary Layer
PEI -- Periodic Emissions Inventory
PERP -- Portable Engine Registration Program
PiG -- Plume-in-Grid
PM -- Particulate Matter
$PM_{2.5}$ -- Particulate Matter less than 2.5 microns
ppb -- Parts Per Billion
ppbC -- Parts Per Billion Carbon
ppbv -- Parts Per Billion by Volume
ppm -- Parts Per Million
PSCF -- Potential Source Contribution Factors
PSDB -- Point Source Database
psia -- Pounds per Square Inch Absolute
PUC -- Public Utility Commission
RACT -- Reasonably Available Control Technology
RACM -- Reasonably Available Control Measure
RFP -- Reasonable Further Progress
RMSE -- Root Mean Square Error
ROP -- Rate-of-Progress
RRF -- Relative Reduction Factor
SB -- Senate Bill
SCAQMD -- South Coast Air Quality Management District
scfm -- Square Cubic Feet per Minute
SCR -- Selective Catalytic Reduction
SEP -- Supplemental Environmental Programs
SETPMTC -- Southeast Texas Photochemical Modeling Technical Committee
SIC -- Standard Industrial Classification
SIP -- State Implementation Plan
SNCR -- Selective Non-Catalytic Reduction

SOV -- Single Occupancy Vehicle
STP -- Surface Transportation Program
SWCV -- Solid Waste Collection Vehicle
TAC -- Texas Administrative Code
TACB -- Texas Air Control Board
TCAA -- Texas Clean Air Act
TCEQ -- Texas Commission on Environmental Quality (commission)
TCM -- Transportation Control Measure
TDM -- Travel Demand Model
TERP -- Texas Emission Reduction Plan
TexAQS 2000 -- Texas Air Quality Study 2000
TexAQS II -- Texas Air Quality Study 2006
TKE -- Turbulent Kinetic Energy
TNMHC -- Total Nonmethane Hydrocarbon
TNRCC -- Texas Natural Resource Conservation Commission
tpd -- Tons Per Day
tpy -- Tons Per Year
TSE -- Truck Stop Electrification
TTI -- Texas Transportation Institute
TUC -- Texas Utility Code
TxDOT -- Texas Department of Transportation
TxLED -- Texas Low Emission Diesel
USC -- United States Code
VMEP -- Voluntary Mobile Source Emissions Reduction Program
VMT -- Vehicle Miles Traveled
VOC -- Volatile Organic Compound
VRU -- Vapor Recovery Unit
ZEB -- Zero Emission Bus
ZEV -- Zero Emissions Vehicle

HOUSTON-GALVESTON-BRAZORIA EIGHT-HOUR OZONE SIP REVISION
TABLE OF CONTENTS

Chapter 1: Background and Introduction
1.1 General
1.2 Health Effects
1.3 Public Hearing and Comment Information
1.4 Social and Economic Considerations
1.5 Fiscal and Manpower Resources

Chapter 2: Photochemical Modeling
2.1 Introduction
2.2 Episode Selection
2.3 Model Configuration
2.4 Meteorological Modeling
2.5 Modeling Emissions Development: Base Case, Baseline, and Future Baseline
2.6 Base Case Model Performance Evaluation
2.7 Future Case Modeling Baseline and Modeling Sensitivities
2.8 2018 Analysis
2.9 Future Work
2.10 Accessing Modeling Data
2.11 Bibliography

Chapter 3: Corroborative Analysis
3.1 Introduction
3.2 Ozone Trends
3.3 Population and Geographic Area Analysis
3.4 HRVOC and NO_X Trends
3.5 Bibliography

Chapter 4: Control Strategies and Required Elements
4.1 Overview and Existing Control Strategies
4.2 NO_X and VOC Control Measures
4.3 Additional Measures
4.4 Water Heater Amendment Offsets
4.5 RACT, RACM, Contingency Measures, and Emissions Inventory

Chapter 5: Ongoing Work and Future Initiatives
5.1 Texas Air Quality Study II (TexAQS II)
5.2 Ongoing Efforts to Identify and Control VOC Emissions
5.3 Efforts to Reduce NO_X From Preempted Sources
5.4 Ongoing Efforts to Control NO_X Emissions
5.5 Future Attainment Date

LIST OF APPENDICES

Appendix A	Voluntary Mobile Source Emission Reduction Programs for the Houston-Galveston-Brazoria Eight-Hour State Implementation Plan
Appendix B	Reasonably Available Control Technology Analysis
Appendix C	Reasonably Available Control Measure Analysis
Appendix D	Evaluation of Mobile Source Control Strategies for the Houston-Galveston-Brazoria State Implementation Plan (Drafted by ENVIRON for the Houston-Galveston Area Council)
Appendix E	Final Draft Short List of Potential Mobile Source Control Measures (Drafted by ENVIRON and the Houston-Galveston Area Council)
Appendix F	Suggested Short List and Evaluation of Point and Area Source Emission Control Measures for the Houston-Galveston-Brazoria Eight-Hour Ozone Nonattainment Area (Drafted by ENVIRON for Lamar University)
Appendix G	Texas 2002 Periodic Emissions Inventory for the Houston-Galveston-Brazoria Ozone Nonattainment Area

LIST OF TABLES

Table 2-1 Concentrations (ppb) Used to Define CAMx Initial and Boundary Conditions

Table 2-2 2009 HGB 8-County Area/Non-road Control Measures

Table 2-3 2009 HGB Eight-County On-road Controls

Table 2-4 HGB 2000 Base Case, 2000 Baseline & 2009 Baseline Modeling Emissions by Source

Table 2-5 Eight-Hour Ozone Statistics (Across Monitors) for August 18-September 6, 2000

Table 2-6 Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling Attainment in 2009

Table 2-7 Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling 85 ppb or Greater in 2009

Table 2-8 2009 Baseline Modeling Summary

Table 2-9 2009 H-GAC and TxLED Sensitivity Modeling Summary

Table 2-10 Summary of the Point Source VOC Reduction Matrix Sensitivity Run

Table 2-11 2009 H-GAC and TxLED and Ground-Level NO_X Modeling Matrix Summary

Table 2-12 Houston Ship Channel Zero-Out Test

Table 2-13 NO_X Reduction Estimated from 2009 to 2018

Table 2-14 HGB Eight-County Nonattainment Area Estimated 2018 Mobile Source NO_X Emissions

Table 3-1 Monitor Locations Used in Population and Geographic Area Analysis

Table 3-2 Ambient HRVOC Trends Results

Table 3-3 Ambient NO_X Trends Results Using Log-Transformed Data

Table 4-1 Existing One-hour Ozone Control Strategies

Table 4-2 Existing Voluntary Mobile Emission Reduction Programs (VMEP) Ozone Control Strategies (to achieve a commitment of 7.0 tpd NO_X and 0.8 tpd VOC)

Table 4-3 Voluntary Mobile Source Emission Reduction Programs

LIST OF FIGURES

Figure 1-1 One-Hour and Eight-Hour Ozone Design Value Trends (1991 to 2005) and HGB Area Population.

Figure 2-1 Eight-Hour Peak Ozone Concentrations and Number of Monitors Recording Eight-hour Ozone Concentrations. 85 ppb During TexAQS 2000

Figure 2-2 Eight-Hour Modeling Domain and the Horizontal Grid-Cell Configuration.

Figure 2-3 Vertical Layer Structures

Figure 2-4 MM5 Domain for the HGB Area Eight-Hour Ozone Modeling Analysis

Figure 2-5 MM5 Wind Speed Performance

Figure 2-6 MM5 Wind Direction Performance

Figure 2-7 MM5 Temperature Performance

Figure 2-8 MM5 Humidity Performance

Figure 2-9 Modeled Biogenic VOC Emissions on August 30, a Typical Ozone Season Day

Figure 2-10 Modeled Biogenic NO_X emissions on August 30, a Typical Ozone Season Day

Figure 2-11 2000 Base Case Modeled Point Source VOC Emissions on August 30

Figure 2-12 2000 Base Case Modeled Point Source NO_X Emissions on August 30

Figures 2-13 2009 Baseline Modeled Point Source VOC Emissions for August 30

Figure 2-14 2009 Baseline Modeled Point Source NO_X Emissions for August 30

Figure 2-15 2000 Base Case Modeled Area & Non-Road VOC Emissions for August 30

Figure 2-16 2000 Base Case Modeled Area & Non-Road NO_X Emissions for August 30

Figure 2-17 2000 Base Case Modeled Ship VOC Emissions for August 30

Figure 2-18 2000 Base Case Modeled Ship NO_X Emissions for August 30

Figure 2-19 2000 Base Case Modeled Fire VOC Emissions for August 30

Figure 2-20 2000 Base Case Modeled Fire NO_X Emissions for August 30

Figure 2-21 2009 Baseline Modeled Area & Non-Road VOC Emissions for August 30

Figure 2-22 2009 Baseline Modeled Area & Non-Road Source NO_X Emissions for August 30

Figure 2-23 2009 Baseline Modeled Ship VOC Emissions for August 30

Figure 2-24 2009 Baseline Modeled Ship NO_X Emissions for August 30

Figure 2-25 2000 Base Case Modeling On-Road Mobile Source VOC Emissions for August 30

Figure 2-26 2000 Base Case Modeling On-Road Mobile Source NO_X Emissions for August 30

Figure 2-27 2009 Baseline Modeling On-Road Mobile Source VOC Emissions for August 30

Figure 2-28 2009 Baseline Modeling On-Road Mobile Source NO_X Emissions for August 30

Figure 2-29 Comparison of Monitored Peak Ozone with Eight-Hour (current) and One-Hour Modeling

Figure 2-30 Comparison of Model Bias for Eight-Hour (Current) and One-Hour Modeling

Figure 2-31 Comparison of Model Gross Error for Eight-Hour (Current) and One-Hour Modeling

Figure 2-32 Time Series of Modeled and Measured Ozone Concentrations at Three Monitoring Locations

Figure 2-33 Selected Time Series Plots of Relevant Constituents and Ozone Precursor Concentrations

Figure 2-34 Eight-Hour Ozone Scatterplots by Episode Day, Monitor Location, and All Data Plotted as a Quantile-Quantile Plot

Figure 2-35 2009 to 2000 Baseline Relative Reduction Factors by Monitor

Figure 2-36 Current and 2009 Future Eight-Hour Ozone Design Values by Monitor

Figure 2-37 Modeled Area of Exceedance for the 2000 and 2009 Baselines

Figure 2-38 2009 Ozone DVf Response to NO_X and VOC Emissions Reductions

Figure 2-39 Houston Ship Channel 4-km Mask, Extent of Modeling Run

Figure 2-40 Future Eight-County On-Road Mobile Emissions

Figure 2-41 Future Eight-County Non-Road Emissions Based on NMIM Default Inputs

Figure 3-1 One-Hour and Eight-Hour Ozone Design Values in the HGB Area (1991-2005) and HGB Area Population

Figure 3-2 HGB Ozone Exceedance Days per Monitor, 1990-2005 (monitors with 4 or more years)

Figure 3-3 Map of Ozone Monitors in the HGB Area

Figure 3-4 Baseline Ozone Design Value 2000 Compared with Future Ozone Design Value 2009

Figure 3-5 Area in Exceedance of the Eight-Hour Ozone Standard

Figure 3-6 Population Exposed to Ozone Concentrations of 85 ppb and Greater

Figure 3-7 Concentration-Weighted Area in Exceedance of the Eight-Hour Ozone Standard

Figure 3-8 Concentration-Weighted Population Exposed to Ozone Concentrations of 85 ppb and Greater

Figure 3-9 Geometric Mean Total Nonmethane Hydrocarbon (TNMHC) at Clinton, 1997-2005

Figure 3-10 Geometric Mean TNMHC at Deer Park, 1997-2005

Figure 3-11 Auto-GC Monitors (red icons) and Point Source EI HRVOC Emissions (brown circles) in the Houston Ship Channel Area

Figure 3-12 Geometric Mean Propylene by Wind Direction, Eastern Houston Ship Channel, 2003-2005 (Channelview is 2002-2004)

Figure 3-13 Geometric Mean Ethylene by Wind Direction, Eastern and Western Houston Ship Channel, 2003-2005 (Channelview is 2002-2004)

Figure 3-14 Map of HGB NO_X Monitors Operating Since 1998 or Earlier

Figure 3-15 HGB Peak Average NO_X by Year and Quarter, 1985-2005

Figure 3-16 HGB VOC EI by Inventory Category, 1990-2003

Figure 3-17 HGB NO_X EI by Inventory Category, 1990-2003

Figure 3-18 Reported Emissions from Upset/Maintenance/Startup/Shutdown Events in HGB Area, FY 2003 – 2005

Figure 3-19 HGB Population by County, 1990 – 2005

Figure 4-1 2009 NO_X Source Category Estimates

Figure 4-2 2009 NO_X Emissions Directly Regulated by the TCEQ

Figure 5-1 TexAQS II Study Area

Figure 5-2 The RV Ronald H. Brown and TexAQS II Instrumentation
Figure 5-3 The NOAA WP-3 Orion and TexAQS II Instrumentation

Figure 5-4 2004 Reported VOC Emissions in the Houston Ship Channel and Surrounding Area

CHAPTER 1: BACKGROUND AND INTRODUCTION

1.1 GENERAL

A link to "The History of the Texas State Implementation Plan (SIP)," a comprehensive overview of the SIP revisions submitted to the United States Environmental Protection Agency (EPA) by the State of Texas, is available at the following web site: http://www.tceq.state.tx.us/implementation/air/sip/sipintro.html#History.

On June 15, 2004, the Houston-Galveston-Brazoria (HGB) ozone nonattainment area was classified as a moderate nonattainment area for the eight-hour National Ambient Air Quality Standard (NAAQS) under the Federal Clean Air Act (FCAA) Amendments of 1990 (42 United States Code (USC) §§ 7401 *et seq.*). The HGB area is therefore required to attain the eight-hour ozone NAAQS of 0.08 parts per million (or 85 parts per billion) by the end of ozone season 2009 and to submit a SIP revision by June 15, 2007 (69 Federal Register (FR) 23857). Control strategies for this SIP revision must be in place by January 1, 2009. For the HGB area, comprising Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, the Texas Commission on Environmental Quality (TCEQ) has developed this eight-hour ozone SIP revision in accordance with 42 USC § 7410.

The one-hour ozone NAAQS, which preceded the eight-hour ozone standard, was revoked June 15, 2005 (69 FR 23951). Hence, this SIP revision is the first HGB SIP revision under the eight-hour ozone standard.

The HGB nonattainment area has conditions that are conducive to the formation of ozone. The necessary conditions for ozone formation (sunlight, nitrogen oxides (NO_X), and volatile organic compounds (VOC)) are provided by the HGB area's hot sunny climate, large urban population, and highly concentrated industrial area. The Houston area also has significant biogenic VOC emissions as well as complex meteorology, including land sea breeze air parcel recirculation, both of which complicate air quality modeling.

The HGB SIP development is challenged by the high concentration of industry and motor vehicles in the HGB area and the magnitude of reductions in emissions needed for attainment of the eight-hour ozone standard. Significant NO_X controls are already in place on the industrial sector in the HGB area and further controls on these sources will be difficult. With the complex HGB eight-hour ozone air quality planning situation in mind, the TCEQ contracted with the Houston-Galveston Area Council (H-GAC) to identify possible control strategies for on-road and non-road mobile sources, and with Lamar University to identify possible control strategies for point and area sources. Stakeholders in the HGB area were provided an opportunity to learn about and comment on the possible strategies as they were being analyzed by the contractors. Between March and June 2006, H-GAC, Lamar University, and their subcontractor held six stakeholder meetings to give HGB-area stakeholders the opportunity to hear about the progress of the control strategy development work and provide comment. The subcontractor for H-GAC and Lamar University, ENVIRON International, compiled comprehensive draft control strategy catalogs and evaluated each potential strategy against the EPA's criteria for SIP creditability. The subcontractor then evaluated each strategy meeting the EPA criteria against a second set of criteria, including feasibility, public acceptability, emissions benefit, and cost effectiveness. After presenting the short list of strategies for public comment, ENVIRON quantified the reductions (where possible) associated with the high-ranking strategies and placed them on a finalized list. The TCEQ evaluated the finalized list of strategies for feasibility and chose a subset of the strategies for further analysis and sensitivity modeling purposes. Please see Chapter 4, Control Strategies, for detailed information on the emission reduction measures that were ultimately selected for this SIP revision.

When examining the current revision to the SIP for the HGB area, recent HGB-area SIP revisions should be consulted to provide context and greater understanding of the complex issues involved

in HGB's ozone challenge. The most relevant HGB SIP revisions to date are the December 2000 one-hour ozone standard attainment demonstration, the September 2001 follow-up revision, the December 2002 NO_X/highly-reactive VOC (HRVOC) revision, and the December 2004 mid-course review (MCR).

1.1.1 December 2000

The December 2000 SIP revision contains rules and photochemical modeling analyses in support of the HGB one-hour ozone attainment demonstration. The majority of the emission reductions identified in this revision were from an overall 90 percent reduction in point source NO_X. A modeling analysis, showing a 141 parts per billion peak ozone level, indicated a shortfall of 91 tons per day (tpd) in NO_X emissions reductions that were necessary, but not readily available, for an approvable attainment demonstration. In addition, the revision contained post-1999 rate-of-progress (ROP) plans for the milestone years 2002 and 2005, the attainment year 2007, and transportation conformity motor vehicle emissions budgets (MVEB) for NO_X and VOC. The SIP also contained enforceable commitments to implement further measures (in support of the HGB area's attainment demonstration and to remedy the estimated 91 tpd shortfall), as well as a commitment to perform and submit a MCR to EPA.

1.1.2 September 2001

The September 2001 SIP revision for the HGB one-hour ozone nonattainment area included the following elements: 1) corrections to the ROP table/budget for the years 2002, 2005, and 2007 due to a mathematical error; 2) incorporation of a change to the idling restriction control strategy clarifying that the operator of a rented or leased vehicle is responsible for compliance with the requirements in situations where the operator of a leased or rented vehicle is not employed by the owner of the vehicle; 3) incorporation of revisions to the clean diesel fuel rules to provide greater flexibility in complying with the requirements of the rule while preserving the emission reductions previously represented; 4) incorporation of a stationary diesel engine rule; 5) incorporation of revisions to the point source NO_X rules; 6) incorporation of revisions to the NO_X emissions cap and trade rules; 7) removal of the construction equipment operating restriction and the accelerated purchase requirement for Tier 2/Tier 3 heavy-duty equipment; 8) replacement of the Tier 2/Tier 3 rules with the Texas Emission Reduction Plan; 9) layout of the MCR process which detailed how the state would fulfill the commitment to obtain the additional emission reductions necessary to demonstrate attainment of the one-hour ozone standard in the HGB area; and 10) replacement of 2007 rate-of-progress MVEB to be consistent with the attainment MVEB.

Despite the gap control measures adopted in December 2000 and the stationary diesel engine rules included in the September revision, an estimated 56 tpd NO_x reduction shortfall remained. The state committed to address the remaining shortfall through the MCR process. In the November 14, 2001, issue of the Federal Register, EPA approved the December 2000 and September 2001 submittals.

1.1.3 December 2002

In January 2001, the Business Coalition for Clean Air-Appeal Group (BCCA-AG) and several regulated companies challenged the December 2000 HGB SIP and some of the associated rules. Among other things, BCCA-AG contended that the last 10 percent of the NO_X emissions reductions were not cost effective and that the ozone plan would fail because the TCEQ did not account for VOC emissions associated with upset conditions. In May 2001, the parties agreed to a stay in the case, and Judge Margaret Cooper, Travis County District Court, signed a Consent Order, effective June 8, 2001. The order required the commission to perform an independent and thorough analysis of the causes of rapid ozone formation events and to identify potential mitigating measures not yet identified in the HGB attainment demonstration.

In compliance with the Consent Order, the commission conducted a scientific evaluation based in large part on aircraft data collected by the Texas Air Quality Study 2000 (TexAQS 2000). The TexAQS 2000 was a comprehensive research project, conducted in August and September 2000,

involving more than 40 research organizations and over 200 scientists that studied ground-level ozone air pollution in the HGB and east Texas regions. These and other studies suggested that the HGB area's high ozone events can be attributed to, in part, the presence of significant reactivity in the airshed. An analysis of automated gas chromatograph data (Estes, 2002) revealed that four HRVOC were frequently responsible for high reactivity days: ethylene, propylene, 1,3-butadiene, and butenes. As such, these compounds were selected as the best candidates for HRVOC emission controls. Analysis showed that the ozone control strategy involving limits on emissions of ethylene, propylene, 1,3-butadiene, and butenes from industrial sources, in conjunction with an 80 percent reduction in industrial or point source NO_X, was equivalent or better in terms of air quality benefit than the previous ozone control strategy (a 90 percent point source NO_X emissions reduction requirement alone). Therefore, in December 2002, the TCEQ adopted a SIP revision that replaced the most stringent 10 percent industrial source NO_X emissions reductions with industrial source HRVOC controls. The result was an industrial source ozone control strategy that relies on an 80 percent reduction in NO_X emissions and HRVOC rules that better quantify and reduce emissions of HRVOC from four key industrial sources: fugitives, flares, process vents, and cooling towers. The HRVOC rules are performance-based and emphasize monitoring, recordkeeping, reporting, and enforcement, rather than establishing individual unit emission rates. The 2002 SIP revision exchanging the two strategies for the one strategy met the FCAA Section 110(l) requirement which allow revision of the SIP where that revision would not interfere with reasonable further progress toward attainment of the NAAQS.

1.1.4 December 2004

In December 2000, the TCEQ committed to perform a MCR to ensure attainment of the one-hour ozone standard. The MCR process provides the opportunity to update emissions inventory data, use current modeling tools, and enhance the photochemical grid modeling. The data gathered from the TexAQS 2000 was used to improve the photochemical modeling of the HGB area. These technical improvements provided a more comprehensive understanding of the ozone challenge in Houston that is necessary to develop an attainment plan. In early 2003, as the TCEQ was preparing to move forward with the MCR, EPA announced its plans to begin implementation of the eight-hour ozone standard. On June 2, 2003, the Federal Register published EPA's proposed "Implementation Rule for the Eight-Hour Ozone Standard." In the same timeframe, EPA formalized its intentions to designate areas for the eight-hour ozone standard by April 15, 2004, requiring states to reassess their efforts and control strategies to address this new standard in a revised plan to be submitted to EPA by June 2007. Recognizing that existing one-hour nonattainment areas would soon be subject to the eight-hour ozone standard and in an effort to efficiently manage the state's limited resources, the TCEQ developed an approach that addressed the outstanding obligations under the one-hour ozone standard while beginning to analyze eight-hour ozone issues.

The TCEQ's one-hour ozone SIP commitments that were addressed in the December 2004 revision include:

- completion of a one-hour ozone MCR;
- performance of modeling;
- adoption of measures sufficient to fill the shortfall of NO_X reductions;
- adoption of measures sufficient to demonstrate attainment; and
- revision of the MVEB using the MOBILE6 model.

The December 2004 revision reflects a shift from primarily reducing industrial emissions of NO_X to reducing both industrial emissions of NO_X and point source HRVOC. This revision included measures to ensure compliance with the specific strategies to control HRVOC emissions and created the HRVOC emissions cap-and-trade (HECT) program. The HECT program is an annual cap and trade program to provide compliance flexibility to the Chapter 115 control requirements for flares, process vents, and cooling-tower heat exchangers. Sites subject to the program are

required to possess an HRVOC allowance for each ton of HRVOC emissions. Sites have the option to trade excess HRVOC allowances on the open market. The December 2004 revision also reflected the repeal of the motor vehicle idling rules and modified certain recordkeeping requirements of the general VOC fugitive emission rules to make them apply only to sources of HRVOC fugitive emissions.

1.1.5 EPA Approval of the One-Hour Ozone Attainment Demonstration and Associated Rules

On September 6, 2006, EPA published the approval of the HGB nonattainment area's one-hour ozone attainment demonstration and associated rules (71 FR 52656). The one-hour attainment SIP revision demonstrates that the HGB nonattainment area will comply with the one-hour ozone standard by 2007. The approval was published in six parts, covering the rules for the control of HRVOC, the HECT program, the mass emission cap and trade program for NO_X, the one-hour ozone attainment plan, the emissions credit banking and trading program, and the discrete emission credit banking and trading program.

1.1.6 One-Hour Ozone Control Strategies

Tables 4-1: *Existing One-Hour Ozone Control Strategies*, and 4-2: *Existing Voluntary Mobile Emission Reduction Programs (VMEP) Ozone Control Strategies*, show key control strategies for complying with the one-hour ozone standard in the HGB nonattainment area. Existing control strategies targeted to the one-hour standard, are expected to continue to reduce the emission of precursors to ozone in the HGB area and positively impact progress toward attainment of the eight-hour ozone standard. The one-hour and eight-hour ozone design values for the HGB area from 1991 to 2005 are illustrated in Figure 1-1: *One-Hour and Eight-Hour Ozone Design Value Trends (1991 to 2005) and HGB Area Population.* Both values decrease over the past 15 years. The 2005 one-hour design value was 169 parts per billion (ppb), representing a 23 percent decrease from the value for 1991 (220 ppb). The 2005 eight-hour design value was 103 ppb, a 13 percent decrease from the 1991 value of 119 ppb. These decreases occur in spite of a 36 percent increase in area population, as shown in the figure.

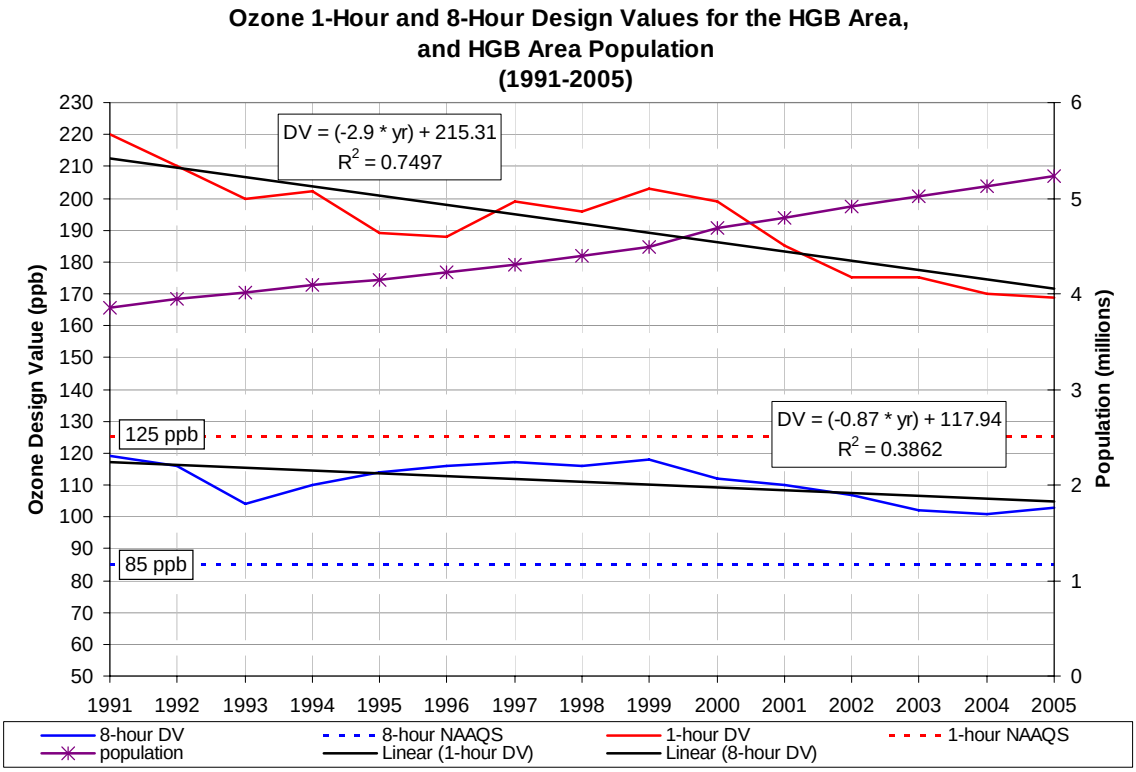


Figure 1-1: One-Hour and Eight-Hour Ozone Design Value Trends (1991 to 2005) and HGB Area Population

1.2 HEALTH EFFECTS

In 1997, EPA revised the NAAQS for ozone from a one-hour to an eight-hour standard based on scientific data that indicated that the eight-hour standard provides better protection of public health from longer-term exposures to moderate levels of ozone. To support the eight-hour ozone standard, EPA provided information that indicated that even low levels of ozone can decrease lung capacity temporarily in some healthy adults and cause inflammation of lung tissue, aggravate asthma, and make people more susceptible to respiratory illnesses such as bronchitis and pneumonia.

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

1.3 PUBLIC HEARING AND COMMENT INFORMATION

The commission will hold public hearings at the following times and locations:

CITY	DATE	TIME	LOCATION
Houston	January 29, 2007	2:00 PM	Houston-Galveston Area Council 3555 Timmons Lane Houston, TX 77027 Conference Room A, on the second floor

Houston	January 29, 2007	6:00 PM	Houston-Galveston Area Council 3555 Timmons Lane Houston, TX 77027 Conference Room A, on the second floor
Dallas	January 31, 2007	7:00 P.M.	Dallas Public Library Auditorium 1515 Young St., Dallas, TX 75201
Arlington	February 1, 2007	2:00 P.M.	Arlington City Hall 101 W. Abram Street Arlington, TX 76010
Midlothian	February 1, 2007	6:00 P.M.	Midlothian Conference Center 1 Community Center Circle Midlothian, TX 76065
Longview	February 6, 2007	2:00 P.M.	Longview Public Library 222 W. Cotton Street Longview, TX 75601
Austin	February 8, 2007	2:00 P.M.	Texas Commission on Environmental Quality 12100 Park 35 Circle, Austin, TX 78753 Building E, Room 201S

The public comment period will open on December 29, 2006, and close on February 12, 2007. Written comments will be accepted via mail, fax, or through the e-comment system. All comments should reference "the HGB SIP revision" and Project Number 2006-027-SIP-NR. Comments may be submitted to Emily Barrett, MC 206, State Implementation Plan Team, Chief Engineer's Office, Texas Commission on Environmental Quality, P.O. Box 13087, Austin, Texas 78711-3087 or faxed to (512) 239-5687. Electronic comments may be submitted at *http://www5.tceq.state.tx.us/rules/ecomments*. Comments must be received by February 12, 2007.

1.4 SOCIAL AND ECONOMIC CONSIDERATIONS

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

1.5 FISCAL AND MANPOWER RESOURCES

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

CHAPTER 2: PHOTOCHEMICAL MODELING

2.1 INTRODUCTION

This chapter describes photochemical grid modeling conducted in support of the eight-hour ozone state implementation plan (SIP) revision for the Houston-Galveston-Brazoria (HGB) area. The modeling for the eight-hour ozone National Ambient Air Quality Standard (NAAQS) is largely an extension of the modeling for the two most recent HGB SIP revisions (Phases 1 and 2 of the Mid-Course Review) for the one-hour ozone NAAQS.

In June 2004, the HGB Consolidated Metropolitan Statistical Area (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties) was classified as a moderate ozone nonattainment area for the eight-hour ozone NAAQS with an attainment date of June 15, 2010, and a SIP submittal date of June 15, 2007. Because the attainment date is early in the 2010 ozone season, the United States Environmental Protection Agency (EPA) has prescribed that the attainment test be applied to the previous ozone season. Thus, 2009 is the future year used in this modeling analysis.

On September 6, 2006, the EPA published the approval of the HGB nonattainment area's one-hour ozone attainment demonstration and associated rules (71 Federal Register 52656). Much of the modeling work is based on the work done for the HGB One-Hour Ozone Attainment Demonstration SIP that was approved by the EPA. See: http://www.tceq.state.tx.us/implementation/air/sip/dec2004hgb_mcr.html.

2.2 EPISODE SELECTION

Texas Commission on Environmental Quality (TCEQ) staff and the Southeast Texas Photochemical Modeling Technical Committee (SETPMTC) meet periodically to discuss air quality technical issues related to the photochemical modeling process, including the development of the conceptual model for ozone and evaluating episode selection criteria. When the current episode was undergoing the selection process, TCEQ staff reviewed ozone episodes between 1998 and 2000 and developed recommendations based on the current conceptual model. In considering episodes to model, the SETPMTC placed special emphasis on using the results of the Texas Air Quality Study 2000 (TexAQS 2000), because it provided extensive data on which to evaluate hypotheses and validate modeling results. This emphasis is also consistent with the EPA's eight-hour modeling guidance (EPA, Nov. 2005) for selecting episodes with extensive aerometric data bases. Although post-2000 episodes were discussed with the SETPMTC, the TCEQ could not reasonably consider post-2000 episodes for the June 15, 2007, submittal due to time and resource constraints. Figure 2-1: *Eight-Hour Peak Ozone Concentrations and Number of Monitors Recording Eight-hour Ozone Concentrations ≥ 85 ppb During TexAQS 2000* shows the maximum eight-hour ozone concentrations measured and the number of continuous monitoring stations at which concentrations reached or exceeded 85 parts per billion (ppb).

2.3 MODEL CONFIGURATION

2.3.1 Selection of Air Quality Model

The air quality model selected must be scientifically appropriate for the intended application and be accessible to all stakeholders. TCEQ and SETPMTC set the following three prerequisites for selecting the photochemical grid model to be used for SIP-related modeling. The model must:

- have a reasonably current, peer-reviewed, scientific formulation;

- be available at low cost to stakeholders; and
- not require the reformatting of available model inputs from earlier rounds of the study.

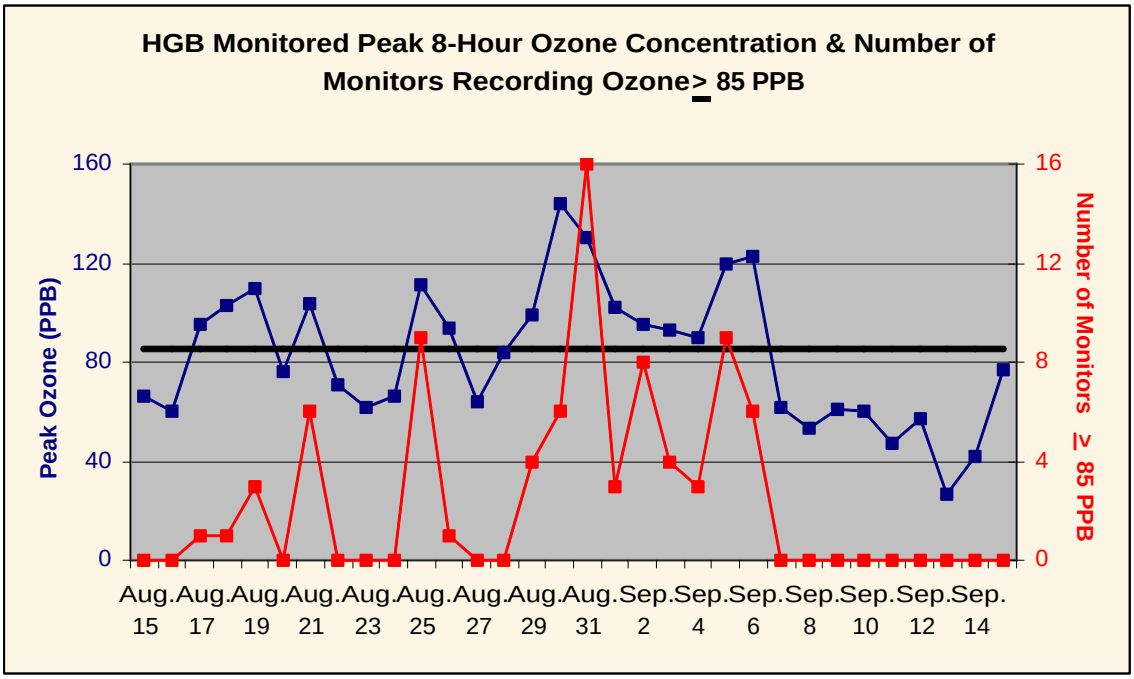


Figure 2-1: Eight-Hour Peak Ozone Concentrations and Number of Monitors Recording Eight-Hour Ozone Concentrations ≥ 85 ppb During TexAQS 2000

The only model to meet all three of these criteria is the Comprehensive Air Model with Extensions (CAMx). The model is based on well-established treatments of advection, diffusion, deposition, and chemistry. Another important feature is that nitrogen oxides (NO_X) emissions from large point sources can be treated with the plume-in-grid sub-model that helps avoid the artificial diffusion that occurs when point source emissions are inserted into a grid volume. The model software and the CAMx user's guide are publicly available at http://www.camx.com.

2.3.2 Modeling Domain, Horizontal, and Vertical Resolution

The modeling domain and the horizontal grid-cell configuration are shown in Figure 2-2: *Eight-Hour Modeling Domain and the Horizontal Grid-Cell Configuration*.

The modeling domain covers the eastern half of the United States with an outer 36 kilometer (km) x 36 km grid. The innermost sub-domain consists of a 4 km x 4 km grid encompassing the HGB and Beaumont-Port Arthur (BPA) ozone nonattainment counties (light blue box), nested within a 12 km x 12 km grid covering the eastern part of Texas (green box), which in turn is nested within the outer 36 km x 36 km grid of the eastern half of the United States (black box).

All grids are projected in a Lambert Conformal Projection with origin at 100° W. and 40° N., and aligned with EPA's National Grid, which was developed for nationwide modeling for haze and particulate matter. Using a grid system compatible with an existing large-scale grid

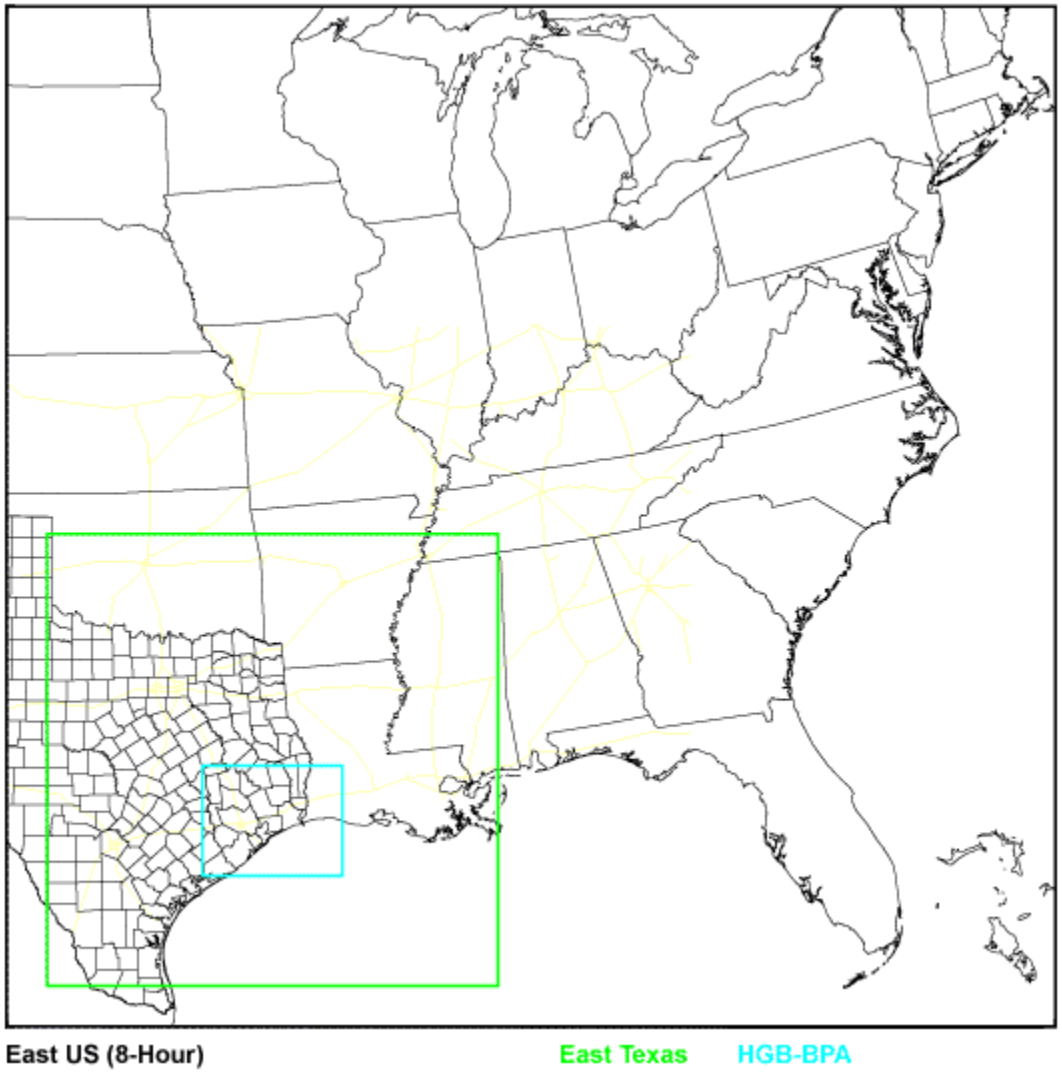


Figure 2-2: Eight-Hour Modeling Domain and the Horizontal Grid-Cell Configuration

system serves several functions, including allowing the TCEQ's modeling to be integrated into regional modeling projects and promoting consistency among various regional and urban modeling applications in the central United States.

Although the number of vertical layers and their respective layer depths vary with the horizontal grid-cell configuration, they all have a top layer that extends to a height of 15,179 meters above ground level. The unique meteorology induced by the land-sea-bay effects and the mixture of industrial sources, which release pollutants across a wide range of elevations, necessitate many vertical layers, particularly near ground level. A 28-layer structure is used within the 4 km x 4 km grid-cell configuration while a 17-layer vertical structure is used in the 12 km x 12 km and 36 km x 36 km grid-cell configurations. Figure 2-3: *Vertical Layer Structures*, presents a tabulation and graphic of the 28-layer and 17-layer vertical structuring.

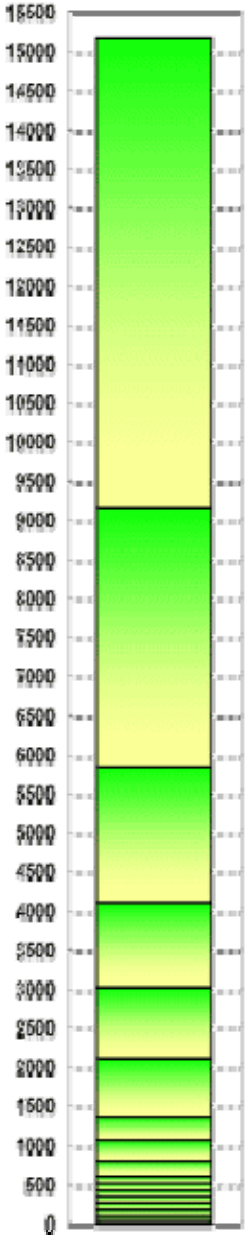
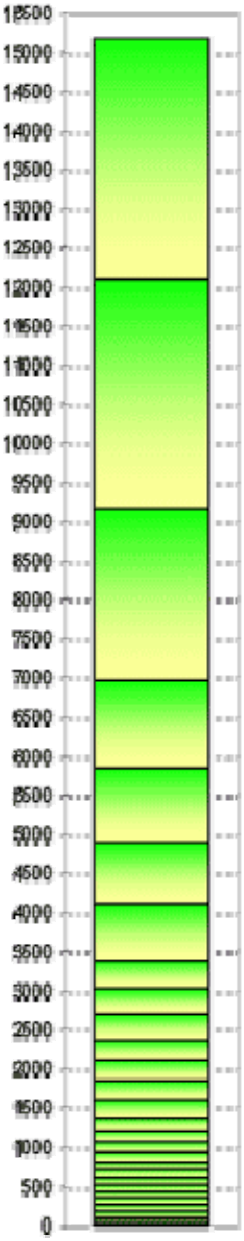
MM5 Layer	Layer Top (m AGL)	East US and East Texas Domains				HGB-BPA, HGB, and BPA Domains			
		CAMx Layer	Center (m AGL)	Thickness (m)		CAMx Layer	Center (m AGL)	Thickness (m)	
38	15179.1	**17**	12172.9	6012.5		**28**	13637.94	3082.5	
36	12096.6					**27**	10631.64	2930.0	
32	9166.6	**16**	7501.3	3330.7		**26**	8063.8	2205.7	
29	6960.9					**25**	6398.4	1125.0	
27	5835.9	**15**	4970.9	1730.0		**24**	5367.0	937.9	
25	4898.0					**23**	4502.2	791.6	
23	4106.4	**14**	3565.9	1080.0		**22**	3739.9	733.0	
21	3373.5					**21**	3199.9	347.2	
20	3026.3	**13**	2564.5	922.9		**20**	2858.3	335.9	
19	2690.4					**19**	2528.3	324.3	
18	2366.1					**18**	2234.7	262.8	
17	2103.3	**12**	1728.1	749.8		**17**	1975.2	256.2	
16	1847.2					**16**	1722.2	249.9	
15	1597.3					**15**	1475.3	243.9	
14	1353.4	**11**	1210.6	285.2		**14**	1281.6	143.6	
13	1209.8					**13**	1139.0	141.6	
12	1068.2	**10**	929.3	277.5		**12**	998.3	139.7	
11	928.5					**11**	859.5	137.8	
10	790.6	**9**	700.0	181.0		**10**	745.2	90.9	
9	699.7					**9**	654.7	90.1	
8	609.7	**8**	564.9	89.3		**8**	565.0	89.3	
7	520.3	**7**	476.0	88.5		**7**	476.1	88.5	
6	431.8	**6**	387.8	87.8		**6**	387.9	87.8	
5	344.0	**5**	300.4	87.0		**5**	300.5	87.1	
4	256.9	**4**	213.7	86.3		**4**	213.8	86.3	
3	170.6	**3**	127.7	85.6		**3**	127.8	85.6	
2	85.0	**2**	59.4	51.0		**2**	59.4	51.0	
1	33.9	**1**	16.9	33.9		**1**	17.0	33.9	

Figure 2-3: Vertical Layer Structures

The 36 km x 36 km horizontal grid-cell configuration extends to the periphery of the modeling domain so that the lateral boundary conditions do not unrealistically influence the modeling results. For the lateral boundary below 1700 meters, moderate concentrations of ozone and its precursors were used. Above 1700 meters, clean concentrations were used, per EPA guidance. The initial conditions are set at the respective lateral boundary concentration, and the top boundary conditions are set at the clean concentration level. Table 2-1: *Concentrations (ppb) Used to Define CAMx Initial and Boundary Conditions* lists the ozone and ozone precursor concentration levels for moderate and clean initial and boundary conditions.

Table 2-1: Concentrations (ppb) Used to Define CAMx Initial and Boundary Conditions

Species or Functional Group		Moderate	Clean
Ozone	O_3	40	40
Carbon Monoxide	CO	200	100
Nitric Oxide	NO	0.1	0.1
Nitrogen Dioxide	NO_2	1	1
Nitric Acid	HNO_3	3	1
Nitrous Acid	HNO_2	0.001	0.001
Other Aldehydes	ALD_2	0.555	0.05
Ethylene	ETH	0.51	0.15
Formaldehyde	HCHO	2.1	0.05
Olefins or Alkenes	OLE	0.3	0.05
Paraffins or Alkanes	PAR	14.9	7.6
Mono-substituted Aromatics	TOL	0.18	0.0786
Di-substituted Aromatics	XYL	0.0975	0.0688
Isoprene	ISOP	0.1	0.001
Peroxyacyl Nitrates	PAN	0.1	0.1
Hydrogen Peroxide	H_2O_2	3	1
Methanol	MEOH	0.001	0.001
Other Alcohols	ETOH	0.001	0.001

2.4 METEOROLOGICAL MODELING

2.4.1 MM5 Modeling Configuration

The TCEQ is using the Fifth Generation Meteorological Model (MM5, version 3.6) developed jointly by the National Center for Atmospheric Research and Pennsylvania State University. This model, supported by a broad user community including the Air Force Weather Agency, national laboratories, and academia, is currently being used extensively for regulatory air quality modeling analyses throughout the United States. For this eight-hour ozone SIP revision, MM5 was applied to the 2000 modeling episode including the dates August 15 to September 6, 2000, primarily because of the wealth of data available from TexAQS 2000 for that time period (note: the first three days of the episode are “spin-up” and are not used in the CAMx modeling).

Figure 2-4: *MM5 Domain for the HGB Area Eight-Hour Ozone Modeling Analysis* shows the MM5 modeling domain, which covers most of the North American continent, with an outer grid of 108 km x 108 km (black box). The innermost sub-domain consists of a 4 km x 4 km grid encompassing the HGB and BPA ozone nonattainment counties (red box), nested within a 12 km x 12 km grid covering the eastern part of Texas (green box), which in turn is nested within a 36 km x 36 km regional grid (blue box) encompassing the eastern part of the United States. Each of the CAMx domains shown in Figure 2-2 was embedded in the respective MM5 domains shown in Figure 2-4.

The vertical layering structure for MM5 consisted of 38-layers (see Figure 2-3), extending to a height of 15,179 meters above ground level, which is the same as the top of the CAMx domains. Unlike CAMx, the same MM5 vertical layering structure is used for all the gridded domains.

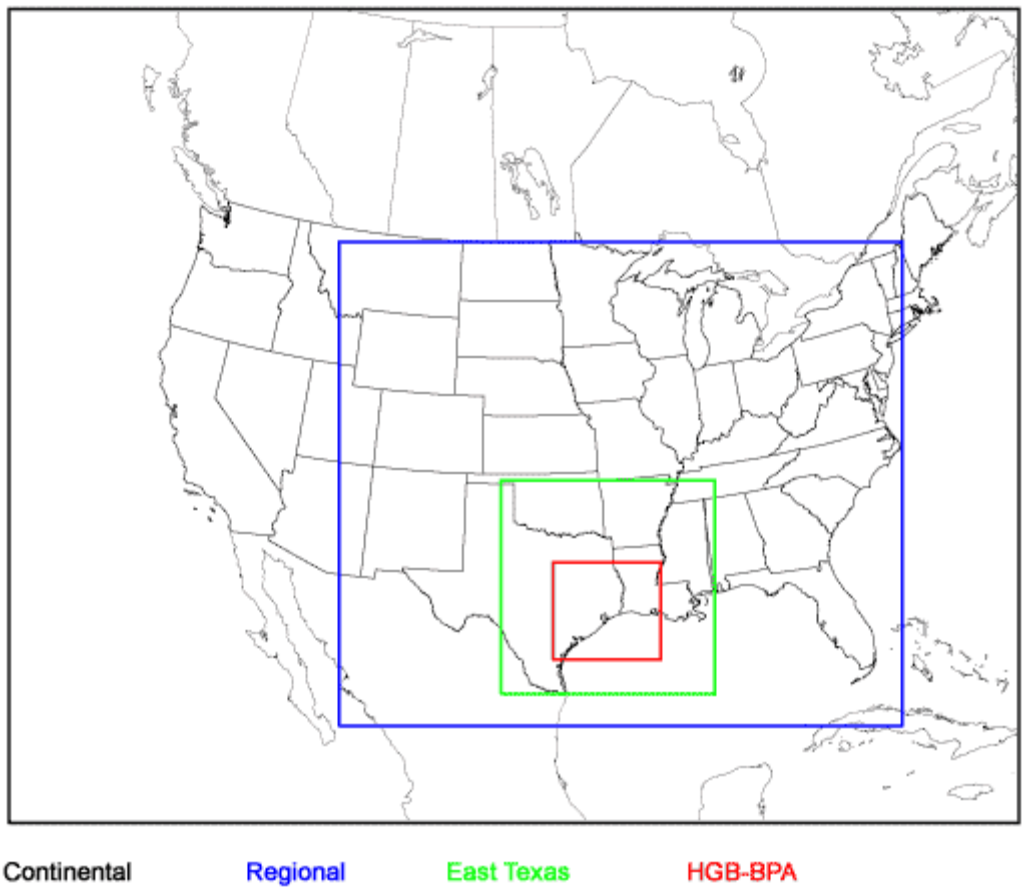


Figure 2-4: MM5 Domain for the HGB Area Eight-Hour Ozone Modeling Analysis

2.4.2 MM5 Configuration

The wind field (i.e., wind speed and direction in each horizontal and vertical grid cell) is the most important parameter predicted by the meteorological model for air quality modeling purposes because the wind field determines the proper transport and dispersion of emitted ozone precursors and their reaction products. The present MM5 modeling incorporates two different types of nudging to improve the predicted wind field. First, MM5-predicted wind fields in the 108 km, 36 km, and 12 km gridded domains are nudged towards the Eta Data Assimilation System reanalysis wind fields, which are based upon a national observational wind monitoring network. (The Eta coordinate system is a pressure-based coordinate system used in the MM5 model that allows for simpler solutions to the equations of motion in areas of widely varying topography.) Second, the MM5-predicted wind field in the 4 km gridded domain is nudged with observational radar profiler wind data, much of which was collected as a part of the TexAQS 2000 study. Each of these techniques enhances the overall predicted MM5 wind field.

The extent of vertical mixing is also an important parameter predicted by the meteorological model for air quality modeling purposes. The extent of vertical mixing establishes the volume of the atmosphere in which emitted ozone precursors and their reaction products can mix and is limited by the height of the planetary boundary layer (PBL). The height of the PBL is influenced by the turbulent kinetic energy (TKE) within the lower atmosphere. In applying MM5, there are several optional algorithms that can be selected for predicting either the PBL or the TKE. When a PBL algorithm is selected, MM5 predicts a two-dimensional meteorological field that specifies, for each horizontal grid cell, the model's vertical layer to which mixing can extend. When a TKE algorithm is selected, MM5 predicts a three-dimensional meteorological field that specifies the strength of mixing between the model's vertical layers at each horizontal grid cell.

For the present eight-hour ozone modeling the Eta-TKE scheme was selected from the optional PBL/TKE algorithms because it most accurately replicated PBL heights. With this choice, a two-dimensional PBL field can also be output for qualitative evaluation and diagnostic purposes. For evaluation purposes, the MM5 predicted PBL field can be compared to PBL estimates made from the radar profiler data. The PBL field also helps in diagnosing the photochemical model output by analyzing the chemical mixing ratios predicted at the vertical layer coincident with the PBL.

Photochemical models, such as CAMx, use vertical diffusivity coefficients (also called vertical exchange coefficients – K_vs) in the calculation of mixing between adjacent vertical CAMx model layers. The MM5CAMx program, which is the program used to convert MM5 output into CAMx input, is used to derive the K_vs input into CAMx, depending on the MM5 algorithm selected (PBL or TKE). The K_vs corresponding to the Eta-TKE scheme were determined using the Mellor-Yamada formulas (Burk & Thompson, 1989).

In addition to the meteorological parameters associated with the winds and the extent of vertical mixing discussed above, the MM5 also predicts three-dimensional fields of temperature, pressure, and water vapor content. Similar to the TKE field, all the MM5 predicted fields are processed through the MM5 CAMx program to generate proper CAMx meteorological inputs.

2.4.3 MM5 Performance

The TCEQ uses a statistical package, developed under contract with ENVIRON, to evaluate the meteorological model performance. The package is designed to interface with the MM5 model and evaluates model performance for four meteorological variables: wind speed, wind direction, temperature, and humidity. The variation between the modeled results and observations are compared to performance benchmarks. The statistical package generates standardized tables and graphs for bias, root mean square error (RMSE), and index of agreement for each meteorological variable. Figures 2-5 to 2-8 show the standardized graphs of these performance metrics for each of the four meteorological variables. The first graph in each of these groupings-of-three show the observed value compared to the modeled value for wind (Figure 2-5), wind direction (Figure 2-6), temperature (Figure 2-7), and humidity (Figure 2-8). This performance metric and the following two charts in each grouping (bias and RMSE) indicate a favorable comparison between the observed and modeled meteorological variables, and therefore these variables are suitable for use in photochemical modeling.

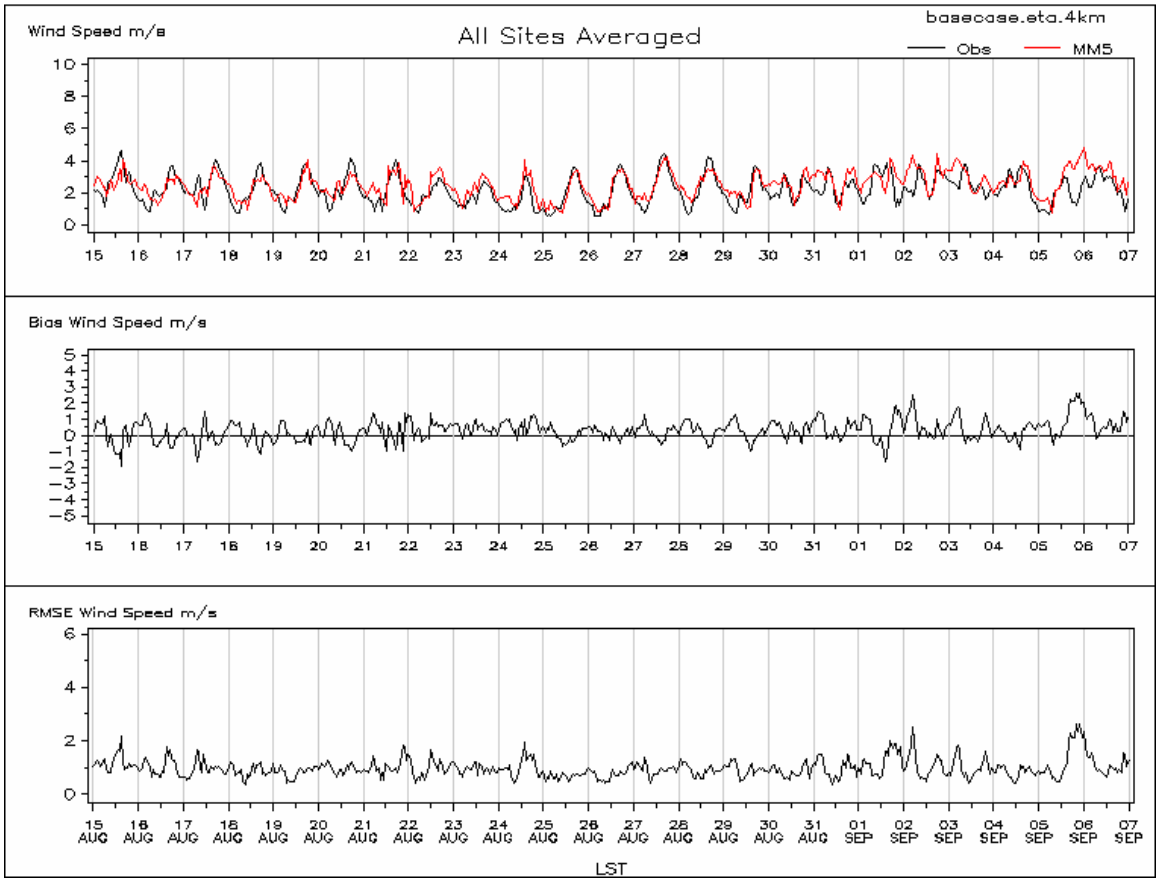


Figure 2-5: MM5 Wind Speed Performance

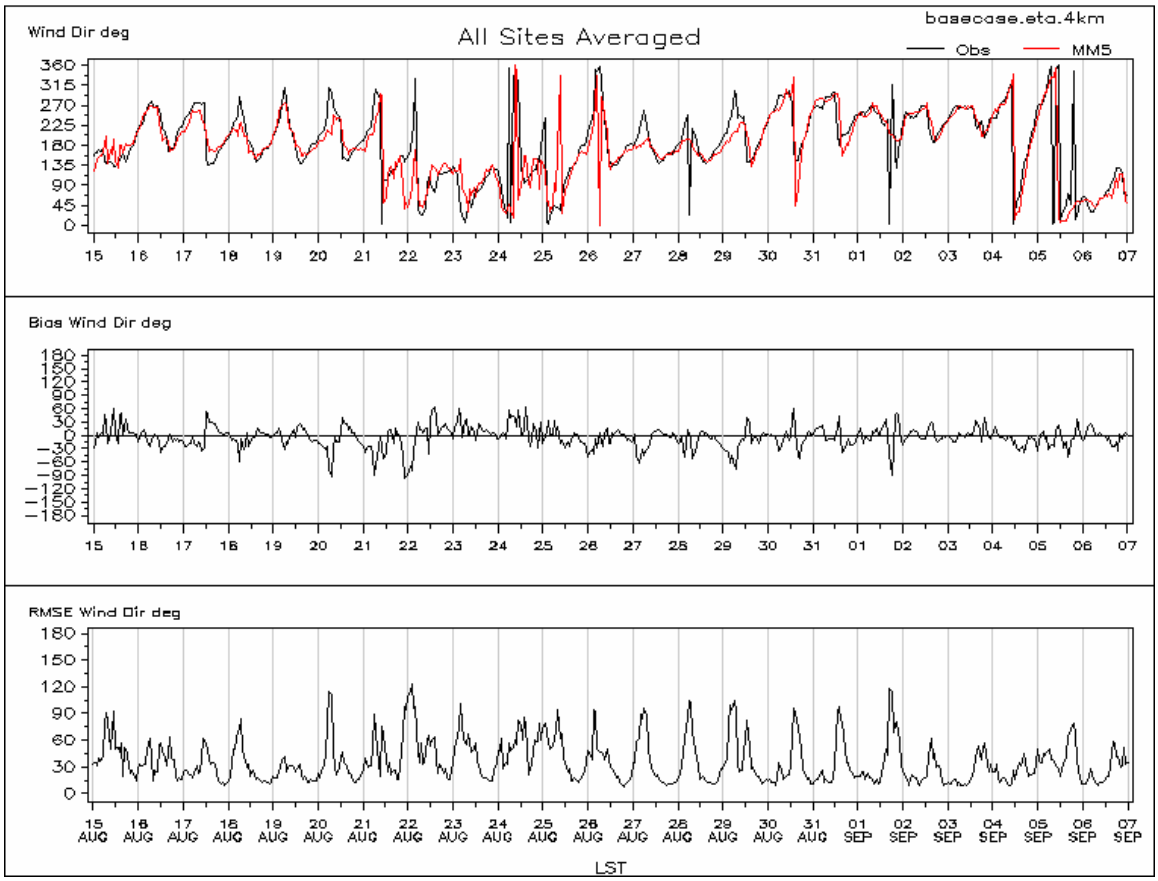


Figure 2-6: MM5 Wind Direction Performance

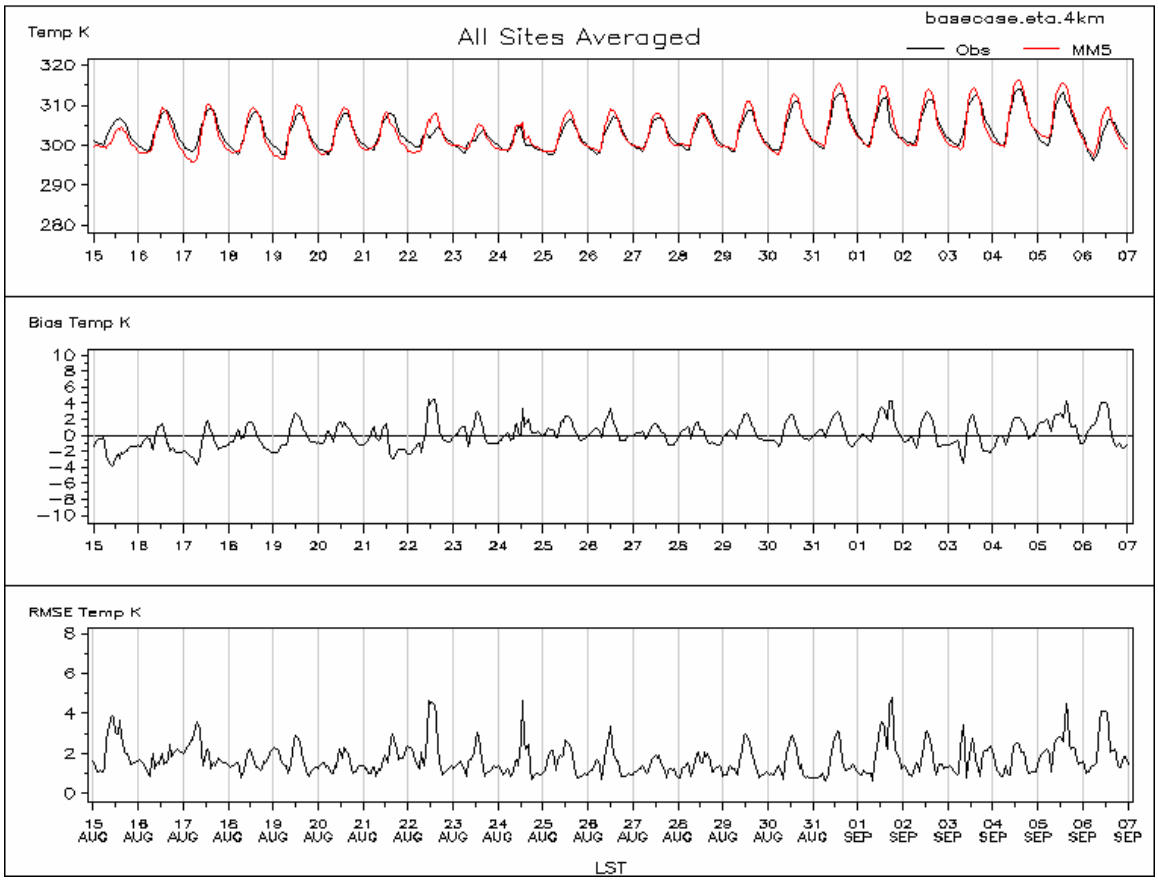


Figure 2-7: MM5 Temperature Performance

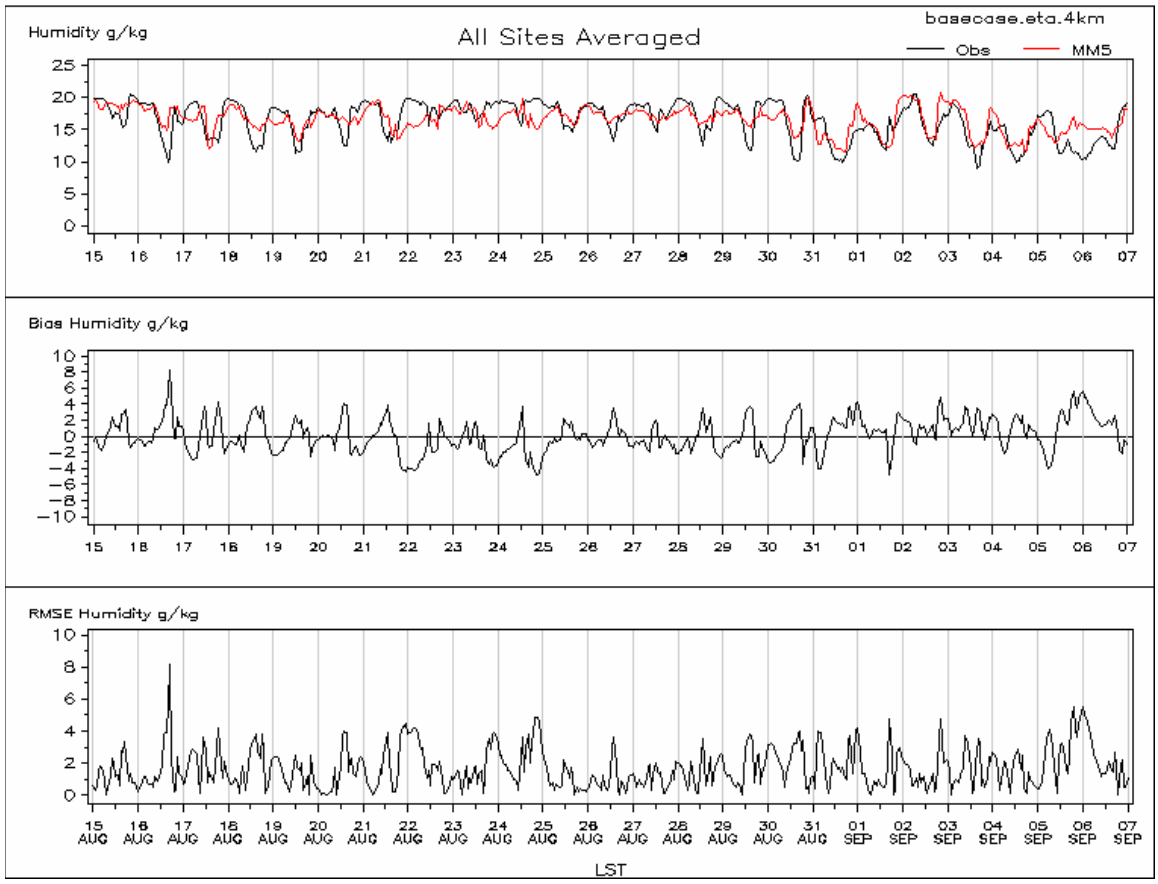


Figure 2-8: MM5 Humidity Performance

2.5 MODELING EMISSIONS DEVELOPMENT: BASE CASE, BASELINE, AND FUTURE BASELINE

2.5.1 Overview

The modeling emissions developed for the HGB eight-hour ozone SIP included three sets: one for the 2000 episode (the 2000 base case), one for a typical ozone season in 2000 (the 2000 baseline) and one for the future year (2009 baseline). The modeling emissions for the 2000 base case were developed to replicate the hourly emissions that occurred during the 2000 episode (i.e., August 18 through September 6). For example, the specific hourly temperature and humidity measurements, which influence the emissions from various sources (e.g., storage tanks, automobiles), were used in the development of the modeling emissions for the 2000 base case. Most of the background information and procedures used to develop the modeling emissions for the 2000 base case are detailed in the documentation for the 2004 HGB SIP revision. The modeling emissions for the 2000 baseline were developed to represent typical emissions that generally occurred during the 2000 ozone season. The modeling emissions for the 2000 baseline differ from the 2000 base case, generally, in that the 2000 baseline emissions are developed from reported ozone season day emissions. The modeling emissions for the 2009 baseline were developed by the application of growth and controls to the 2000 baseline.

The TCEQ uses the Emissions Processing System version 3 (EPS3), acquired from ENVIRON, as its primary emissions processing and modeling tool. A principal feature of EPS tools is that they generate emissions files in CAMx-ready format. EPS3 is faster and has better error reporting and data export capabilities compared to earlier versions of EPS. EPS3 has several advantages over other emissions processing systems including excellent reporting capabilities, stability, and ease-of-use. In addition, TCEQ staff is familiar with the software and have developed numerous scripts and programs to interface with it. The TCEQ has processed all inventory components using EPS3 except for biogenic emissions. Biogenic emissions were modeled using version 3.1 of the Global Biosphere Emissions and Interactions System (GloBEIS) model (Guenther *et al.*, 2002; Yarwood *et al.*, 2001; Yarwood *et al.*, 2000; Guenther *et al.*, 1999).

2.5.2 Biogenic Emissions

The biogenic volatile organic compounds (VOC) and NO_X emissions were developed for the 2000 base case episode using version 3.1 of the GloBEIS model. This version of GloBEIS includes several new features, including modules that vary the biogenic emissions according to changes in leaf area index, antecedent leaf temperatures, and drought, and an improved canopy energy balance model.

Because the 2000 base case episode is representative of the biogenic emissions that occurred during the ozone season, these same emissions were used in the 2000 baseline modeling emissions. Although, urban development does modify the amount, location, and type of vegetation over the years, there are large uncertainties in predicting future land use and cover type. Because there is no reliable method to predict future biogenic emissions, the 2000 base case emissions were held constant and used as the 2009 baseline modeling emissions.

Figure 2-9: *Modeled Biogenic VOC Emissions on August 30, a Typical Ozone Season Day* and Figure 2-10: *Modeled Biogenic NO_X emissions on August 30, a Typical Ozone Season Day* display the graphical distribution of biogenic VOC and NO_X, respectively, for the 4 km x 4 km modeling domain for August 30. August 30 is used to represent a typical ozone season day for 2000. As the tables embedded in the figures indicate, for the HGB eight-county area, the modeled biogenic emissions are 1,675 tons per day (tpd) of VOC and 22 tpd of NO_X.

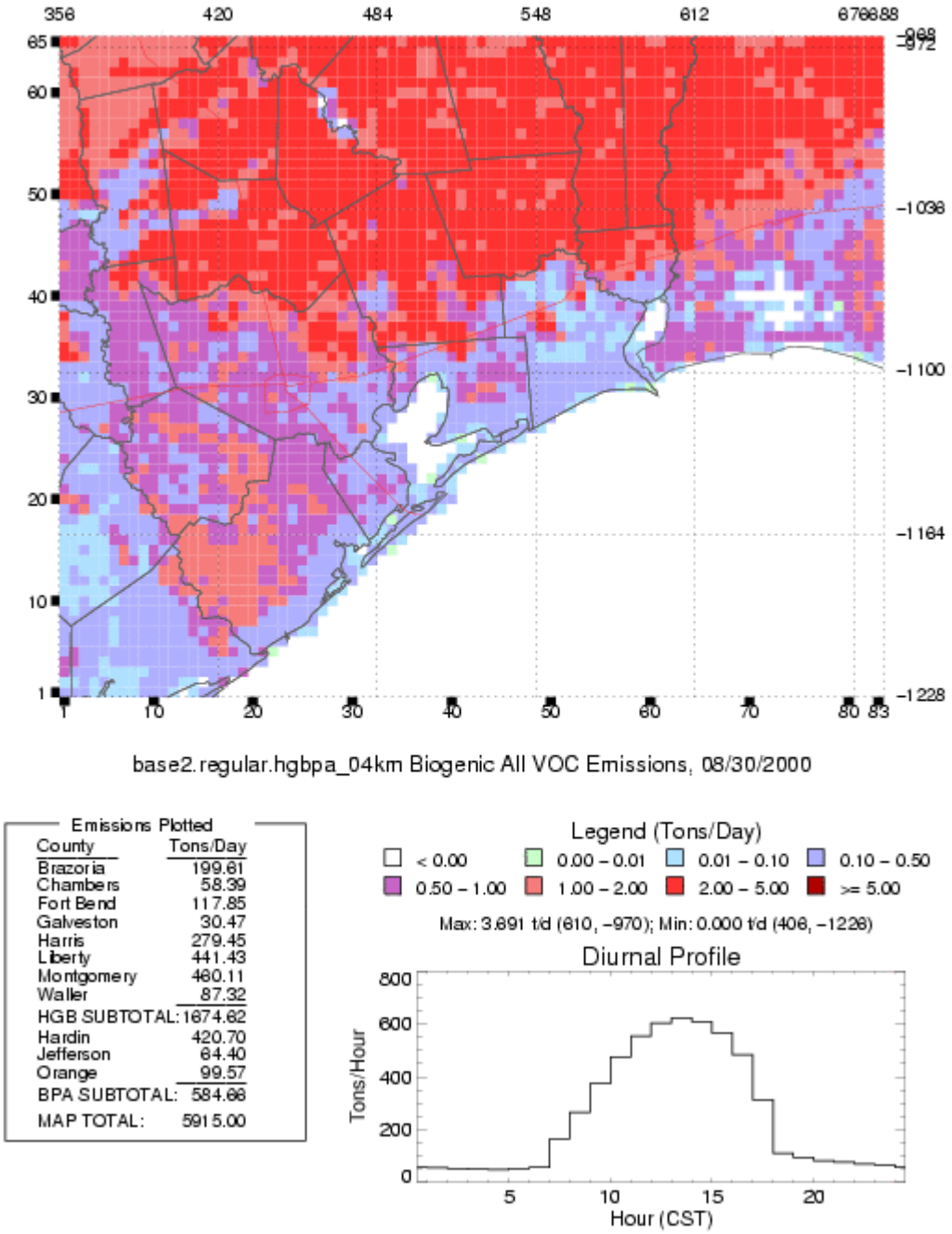


Figure 2-9: Modeled Biogenic VOC Emissions on August 30, a Typical Ozone Season Day

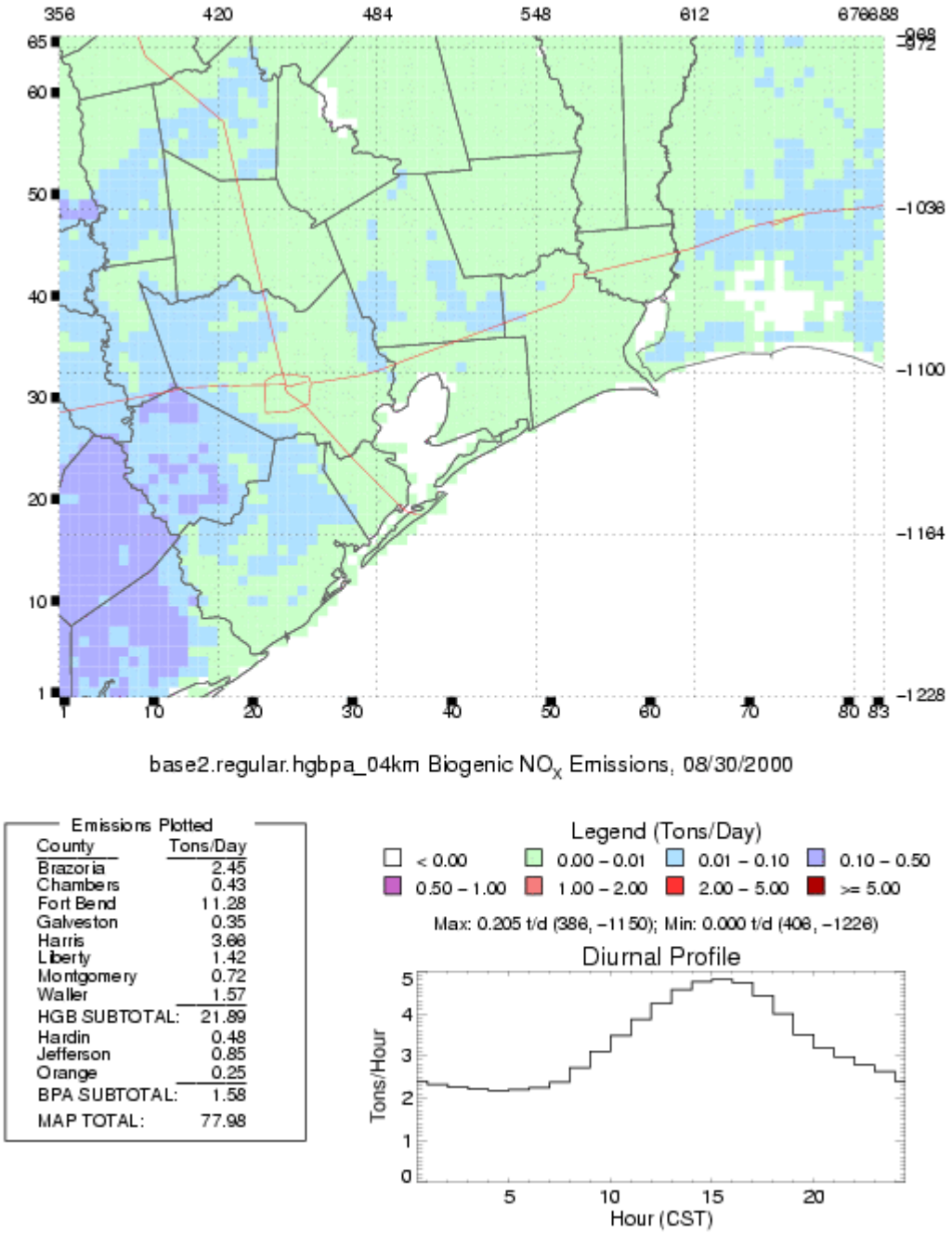


Figure 2-10: Modeled Biogenic NO_X emissions on August 30, a Typical Ozone Season Day

2.5.3 Point Sources

CAMx provides the option to model selected point source emissions with a Plume-in-Grid (PiG) algorithm, which increments the mixing of the plume emissions into the model's grid cells. The PiG sources were selected based on the magnitude of NO_X emissions (i.e., at least 5 tpd with a co-location distance of 1 meter or less). Over 300 sources from across the entire modeling domain were modeled with the PiG algorithm in the 2000 base case, the 2000 baseline, and the 2009 baseline.

2.5.3.1 2000 Base Case

Within Texas

The base case point source emissions within Texas were developed using information compiled from several databases. Emissions data from the TCEQ's Point Source Database (PSDB) reported for the year 2000 were used. The PSDB data are typically annual emissions although some sources report ozone season day emissions as well. Emissions from the PSDB were replaced with hourly emissions from the Acid Rain Program Data Base (ARPDB) where appropriate (e.g., NO_X from electric generating units (EGU)). In addition, the TCEQ's database of reported emission events was reviewed and where appropriate, these emissions were used to replace PSDB emissions. Further, during TexAQS 2000, a special emissions inventory was compiled, primarily for large emitting facilities in the HGB and BPA areas. Where appropriate, these specially compiled emissions were used to replace PSDB emissions.

As described in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP, highly-reactive volatile organic compounds (HRVOC) emissions were increased by 163 to 203 tpd, depending on episode day, in the 2000 base case inventory. This "imputation" is described in detail in the previous SIP revision and was based on observational data indicating that HRVOC emissions were under-reported in the emissions inventory (EI). For the current modeling effort, an alternative distribution was used for the petrochemical point sources within and adjacent to the Houston Ship Channel. These sources received about one-half of the added HRVOC (i.e., approximately 92 tpd). The added HRVOC were redistributed based on a more recent analysis of the hourly ambient HRVOC data collected in 2003 from six automated gas chromatograph (auto-GC) monitoring sites located within and adjacent to the Houston Ship Channel (HSC). This analysis used a triangulation technique to derive potential source contribution factors (PSCF) for the geographical region represented by the auto-GC monitors. The PSCF represent the probabilities that high HRVOC concentrations measured at the auto-GC resulted from emissions within the area.

Outside Texas

The TCEQ acquired a data file from the Louisiana Department of Environmental Quality (LDEQ) of their 2000 point source emissions inventory. As was done for point sources within Texas, hourly ARPDB emissions were substituted for the LDEQ annual emissions.

For the states in the modeling domain beyond Texas and Louisiana, the TCEQ developed regional modeling emissions using the 1999 National Emissions Inventory (NEI), version 3. Again, as was done for point sources within Texas, hourly ARPDB emissions were used. For the small portion of Ontario, Canada within the regional modeling domain, point source emissions were obtained from the EPA Clean Air Interstate Rule (CAIR) modeling website.

The TCEQ acquired 2000 emissions data from the Minerals Management Service (MMS) for platform and non-platform sources in the Gulf of Mexico offshore from Texas and Louisiana. The platform sources were represented as point sources in the model.

The TCEQ generated point source modeling emissions for the portion of Mexico within the regional modeling domain using the 1999 Big Bend Regional Aerosol and Visibility Observational Study emissions inventory.

Figure 2-11: *2000 Base Case Modeled Point Source VOC Emissions on August 30* and Figure 2-12: *2000 Base Case Modeled Point Source NO_X Emissions on August 30* show the graphical distribution of point source VOC and NO_X emissions, respectively, for the 4 km X 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area, the point source emissions are 413.7 tpd VOC and 498.6 tpd NO_X.

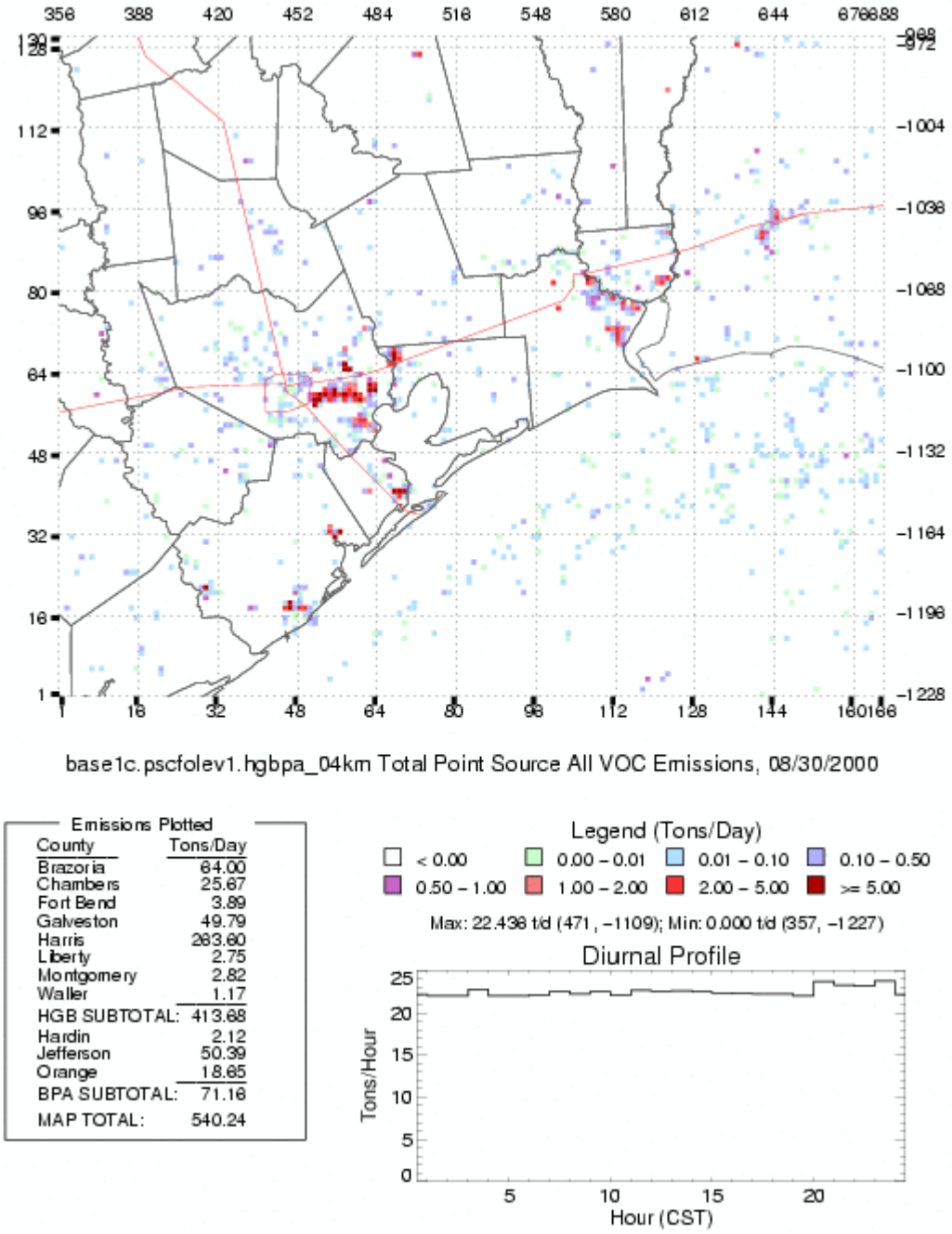


Figure 2-11: 2000 Base Case Modeled Point Source VOC Emissions on August 30

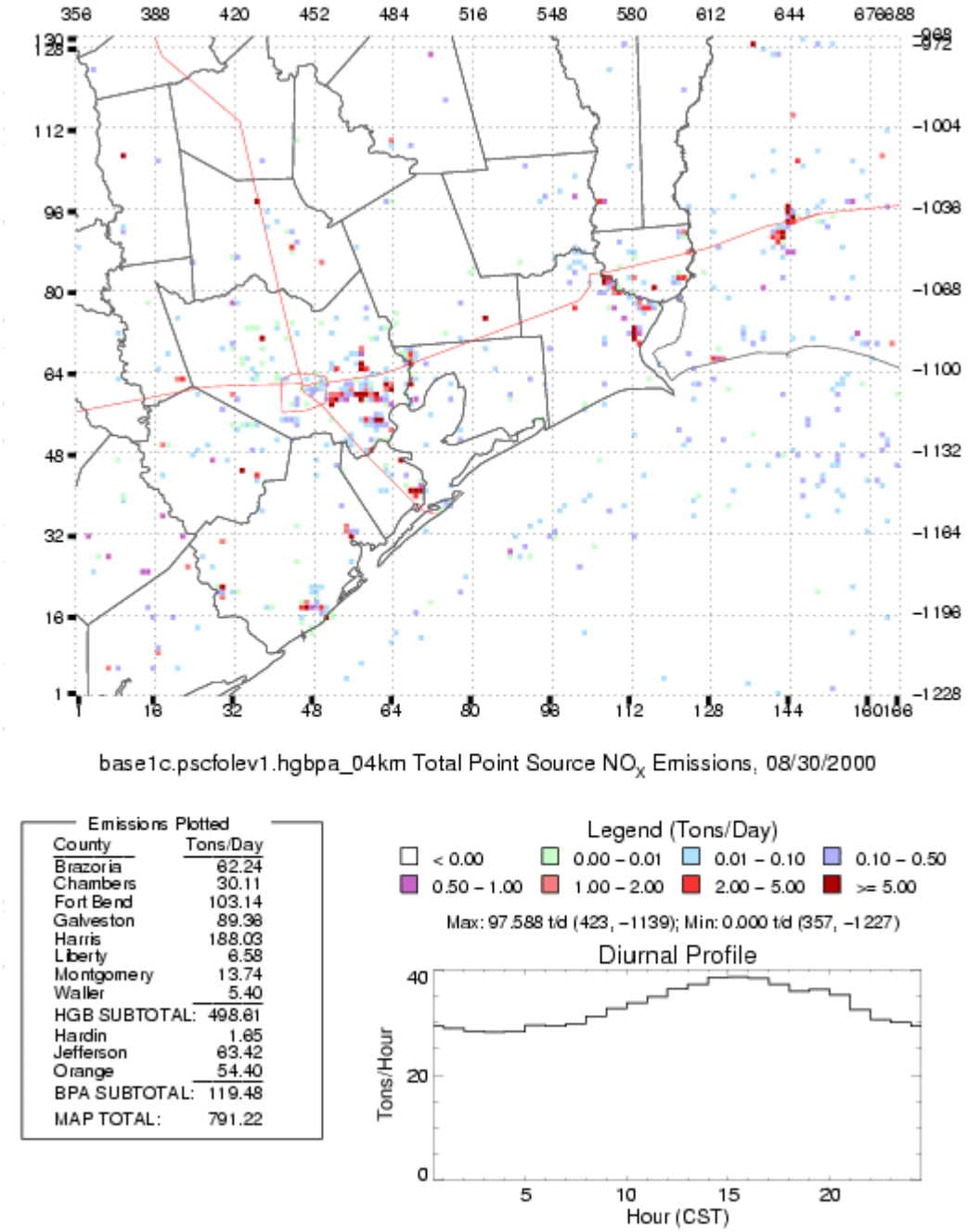


Figure 2-12: 2000 Base Case Modeled Point Source NO_X Emissions on August 30

2.5.3.2 2000 Baseline

Within Texas

The major changes in the point source modeling emissions from the 2000 base case to the 2000 baseline were the episode-specific emissions developed from the ARPDB, the emission events database, and the TexAQS 2000 special inventory. For the 2000 baseline, the episode-specific ARPDB emissions were averaged over the episode period of August 16 through September 6, 2000, for each hour of the day to maintain the temporal profile. The resulting generic day was used for each modeled day in the 2000 baseline. Any base case emissions that had been developed from the emission events database were replaced with the appropriate emissions from the PSDB. Similar to the procedure used for ARPDB emissions, any emissions developed from the TexAQS 2000 special inventory were averaged over the episode period for each hour of the day to maintain the temporal profile. The additional HRVOC added to the 2000 base case were retained in the 2000 baseline.

Outside Texas

For the point source modeling emissions in Louisiana developed from the ARPDB, again a generic episode day was developed by averaging over the episode period for each hour of the day to maintain the temporal profile. For all the other point sources outside Texas, the point source modeling emissions from the 2000 base case were used for the 2000 baseline.

These changes resulted in only minor differences in the point source modeled emissions between the base case and baseline scenarios. For example, within the eight-county HGB area the 2000 baseline point source modeled NO_X emissions are approximately 23 tpd less than the 2000 base case, which is less than a 5 percent difference. The difference in modeled VOC emissions is even smaller at approximately 5 tpd.

2.5.3.3 2009 Baseline

Within Texas

For the 2009 baseline EGU emissions at existing facilities within Texas, data from the ARPDB for the third quarter of 2005 (‘05Q3) were used, unless the facility was retired or shutdown, in which case its emissions were not included in the modeling emissions. The ‘05Q3 data were used, where available, because they include all of the EGU controls required by the TCEQ by 2009. If a non-retired facility had zero emissions for the ‘05Q3 because it was temporarily shut-down (e.g., maintenance) and the third quarter of 2004 (‘04Q3) ARPDB data were available, the ‘04Q3 data were used. However, if the facility had been mothballed, and their ARPDB ‘04Q3 data also had zero emissions, then ozone season daily emissions for 2000 were used with the appropriate reductions reflecting required controls (e.g., Senate Bill (SB) 7, 76th Texas Legislature, 30 Texas Administrative Code Chapter 117, Mass Emissions Cap and Trade (MECT) Program) applied between 2000 and 2009. For the EGU in BPA, Dallas-Fort Worth (DFW) and attainment counties of Texas that did not have ‘05Q3 data, either individual or system-average SB 7 reductions were applied, or emissions limitations in Chapter 117. For EGU within the eight-county HGB nonattainment area, the 2009 baseline modeled NO_X emissions were developed from the MECT program cap level.

The growth in EGU is accounted for via the addition of permitted new EGU that are expected to be operational between 2005 and 2009. All newly-permitted EGU within Texas that are not in the ‘05Q3 ARPDB but are expected to be operational by 2009 were included in the 2009 future baseline modeling emissions at their permitted levels. This growth should not be in excess of the electricity demand that the State requires (plus the Electric Reliability Council of Texas (ERCOT)

reliability margin). ERCOT's megawatts demand projections (as of October 2005) through 2009 were used and it was verified that the megawatt demand between 2005 and 2009 will be met with the megawatt capacity provided by the newly-permitted EGU. These newly-permitted EGU total 29 units/stacks at 10 facilities. All are gas-fired except the Sandow 5 units (lignite-fired, to be operated by TXU) at ALCOA in Milam County. As of June 2006, all 29 of these units have been issued permits and all are scheduled to be operational prior to October 2009. The newly-permitted units add approximately 19 tpd of NO_X to the 2009 inventory, none of which are in the eight-county HGB area.

For non-electric generating units (NEGU) within Texas the 2009 baseline modeling emissions were developed by applying appropriate growth and controls to the 2000 baseline. Growth factors are available from the EPA's Economic Growth Analysis System (EGAS) for various industries within Texas. However, the EPA's EGAS treats all of Texas as one economic zone. Therefore, the TCEQ commissioned the development of a Texas-specific EGAS, which provides growth factors for industries (i.e., NEGU) for each of the 44 economic zones, delineated by Source Category Codes or Standard Industrial Codes. These growth factors were used unless more recent growth factors from the Dallas Federal Reserve Bank's Texas Industrial Production Index were available. Similar to the procedure for EGU, NO_X emission reductions due to controls installed to meet the requirements of Chapter 117 were applied to NEGU in the nonattainment areas (i.e., HGB, DFW, and BPA). In addition, in the eight-county HGB area, the MECT program rule and the HGB HRVOC cap (i.e., the HRVOC Emission Cap and Trade program) were applied to appropriate NEGU.

As in previous SIP revisions, the TCEQ assumes that the only substantial growth that occurs for NEGU in the nonattainment areas occurs when facilities expand by purchasing emissions offsets from the bank during New Source Review of permit applications. It is assumed that all of the emissions in the bank can come back into the airshed, and as the worst case, it is assumed that it can happen all at once during the ozone season of 2009. The procedure for incorporating the banked emissions in the future base is unchanged from that of the previous few SIP revisions.

Outside Texas

In general, the EPA's 2010 CAIR modeling files were used for point source emissions for facilities outside of Texas. For the EGU, in particular, the EPA's October 2005 CAIR modeling files were used. No additional growth or controls were applied to these point sources between 2005 and the 2009. Because growth factors and controls are not readily available for sources in Mexico or the Gulf of Mexico the 2000 baseline emissions were used for the 2009 baseline.

Figures 2-13: *2009 Baseline Modeled Point Source VOC Emissions for August 30* and Figure 2-14: *2009 Baseline Modeled Point Source NO_X Emissions for August 30* show the graphical distribution of the 2009 baseline modeling emissions of point source VOC and NO_X, respectively, for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area the point source emissions are 268.6 tpd of VOC and 157.0 tpd of NO_X for the 2009 baseline.

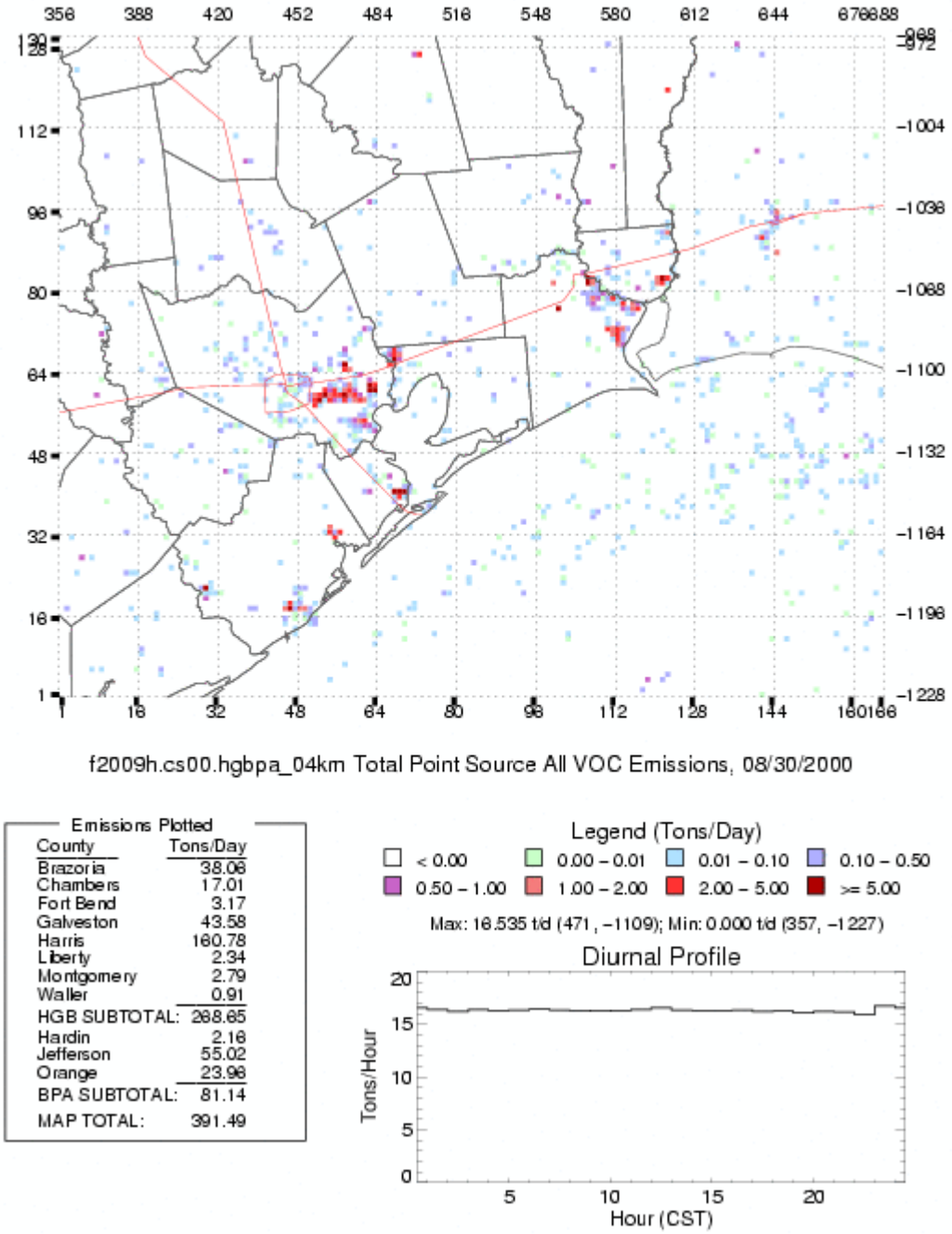


Figure 2-13: 2009 Baseline Modeled Point Source VOC Emissions for August 30

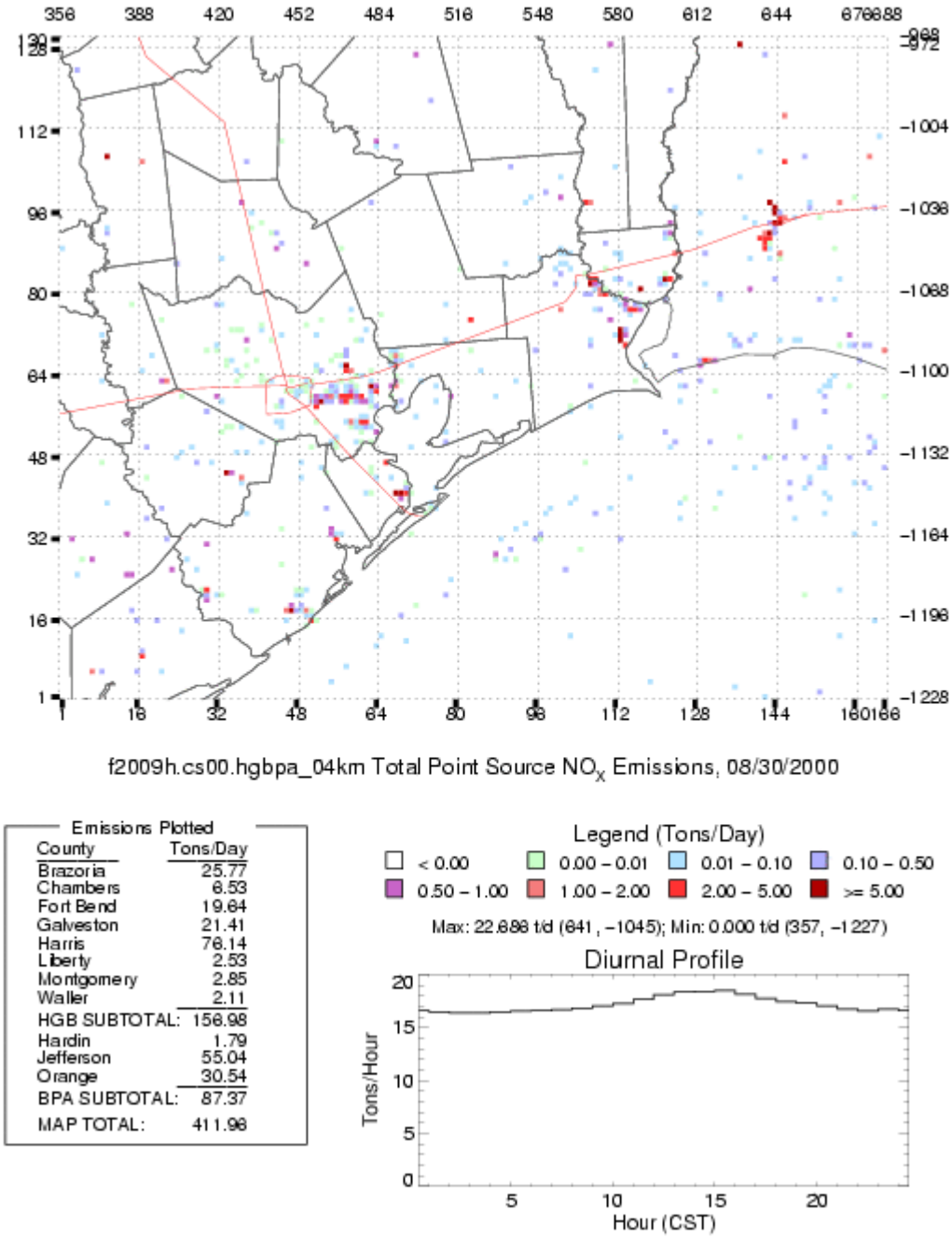


Figure 2-14: 2009 Baseline Modeled Point Source NO_X Emissions for August 30

2.5.4 Area and Non-Road Mobile Sources

2.5.4.1 2000 Base Case

The 2000 base case area and non-road mobile source modeling emissions were primarily developed from the 1999 periodic emissions inventory (PEI; area sources) and the NONROAD2004 model.

Within Texas

2000 base case area source modeling emissions within Texas for the August 18-September 6, 2000, episode were estimated by applying EGAS growth factors to the 1999 PEI emissions. EGAS is available from the EPA and provides growth factors for each area source category. For lawn and garden, recreational marine, and construction activity, more recent source survey data were collected to estimate local equipment populations. These data were used in updating the modeling emissions for area sources.

Three notable categories of non-road mobile sources are not included in the NONROAD2004 model: ships, airplanes, and locomotives. Alternate methods were used to develop the emissions included in the model for these categories. Emissions for ships were developed based on data from a contractor study (December 2000 HGB SIP Revision, Appendix C) conducted in the 1999-2000 time frame and emissions for locomotives and aircraft were developed from studies conducted by the TCEQ. Ship emissions were treated as pseudo-stacks spaced along the major waterways within the Galveston Bay region (e.g., Texas Intracoastal Waterway). Emissions for wildfires developed by the University of Texas (Allen *et al.*, 2002) were also treated as point sources.

Outside Texas

2000 base case area and non-road modeling emissions outside of Texas were obtained from ENVIRON. ENVIRON developed 1999 modeling emissions for a comparable modeling domain to use for their modeling of near-nonattainment areas in Texas. The ENVIRON modeling emissions were based on the 1999 NEI and NONROAD model. Modeling emissions for Ontario, Canada were developed using data obtained from Environment Canada's National Pollutant Release Inventory for the year 2000. Modeling emissions in the western Gulf of Mexico were developed using data obtained from the MMS's year 2000 Gulf-Wide Emissions Inventory. This inventory has emission estimates for area and non-road sources, including spatial allocation.

Details concerning the specific procedures used to develop modeling emissions can be found in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP.

Figures 2-15 through 2-20 show the graphical distribution of modeled emissions of VOC and NO_X, for area and non-road sources combined, ships and fires for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area the combined emissions from these sources are 332.7 tpd of VOC and 202.3 tpd of NO_X.

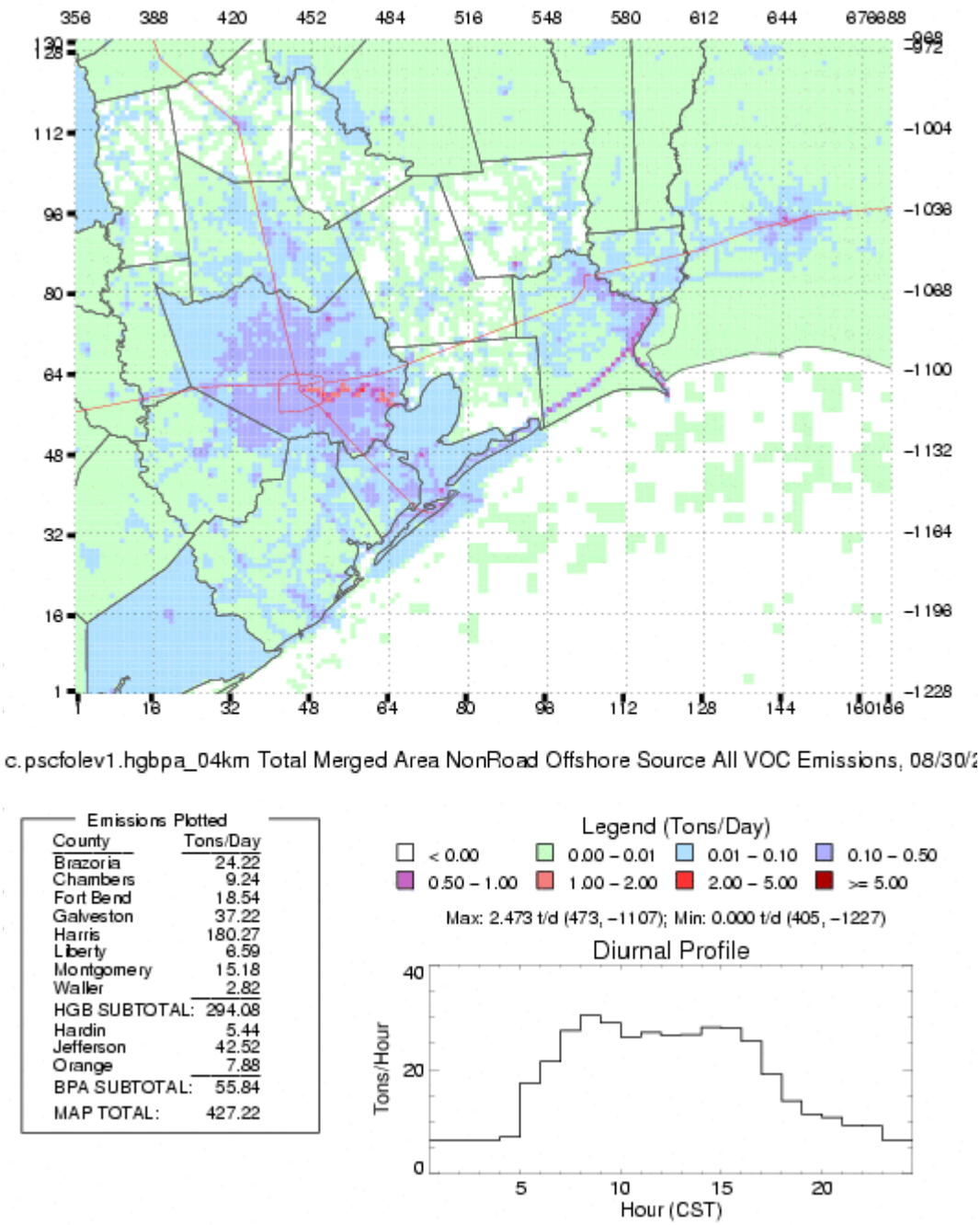


Figure 2-15: 2000 Base Case Modeled Area & Non-Road VOC Emissions for August 30

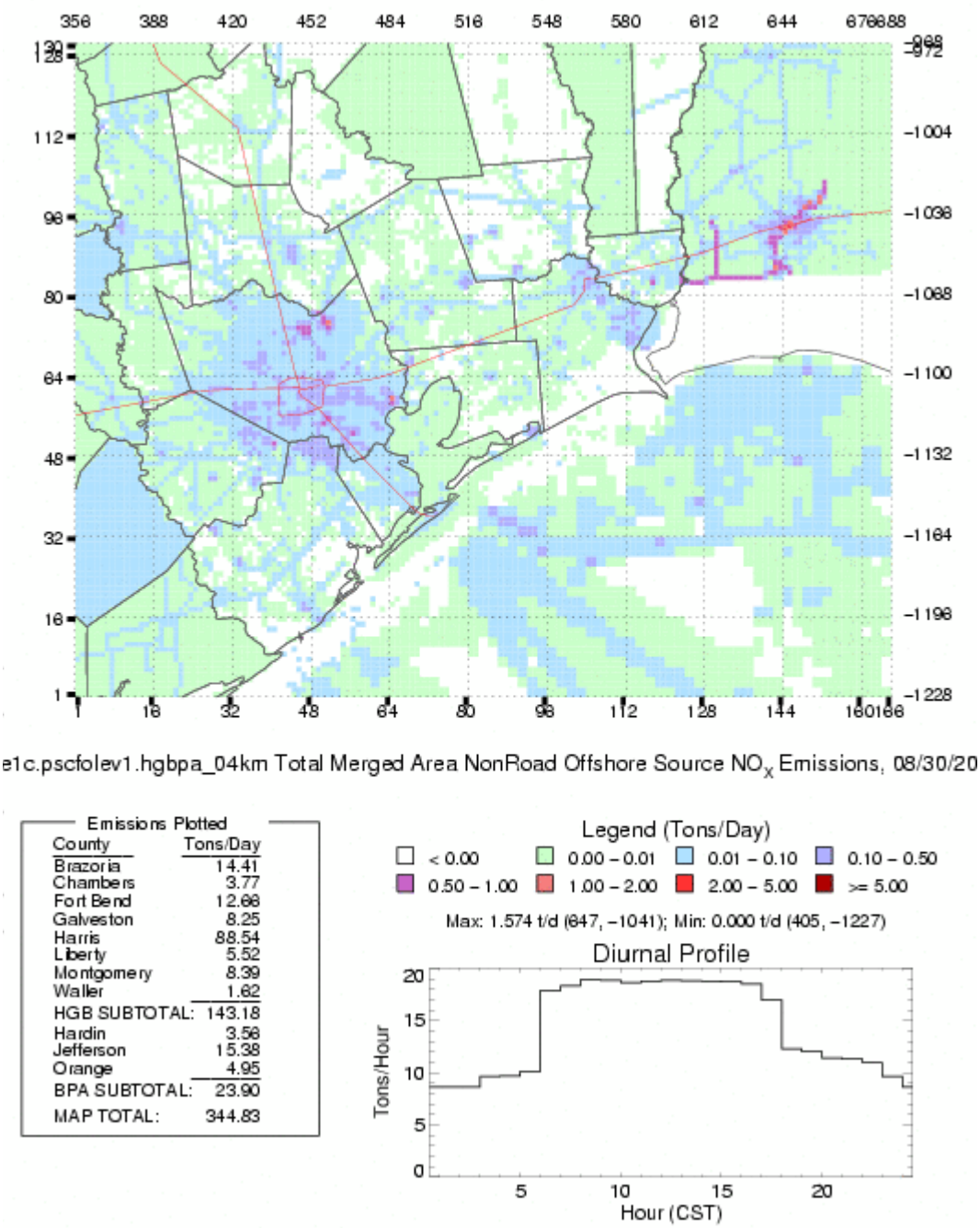


Figure 2-16: 2000 Base Case Modeled Area & Non-Road NO_X Emissions for August 30

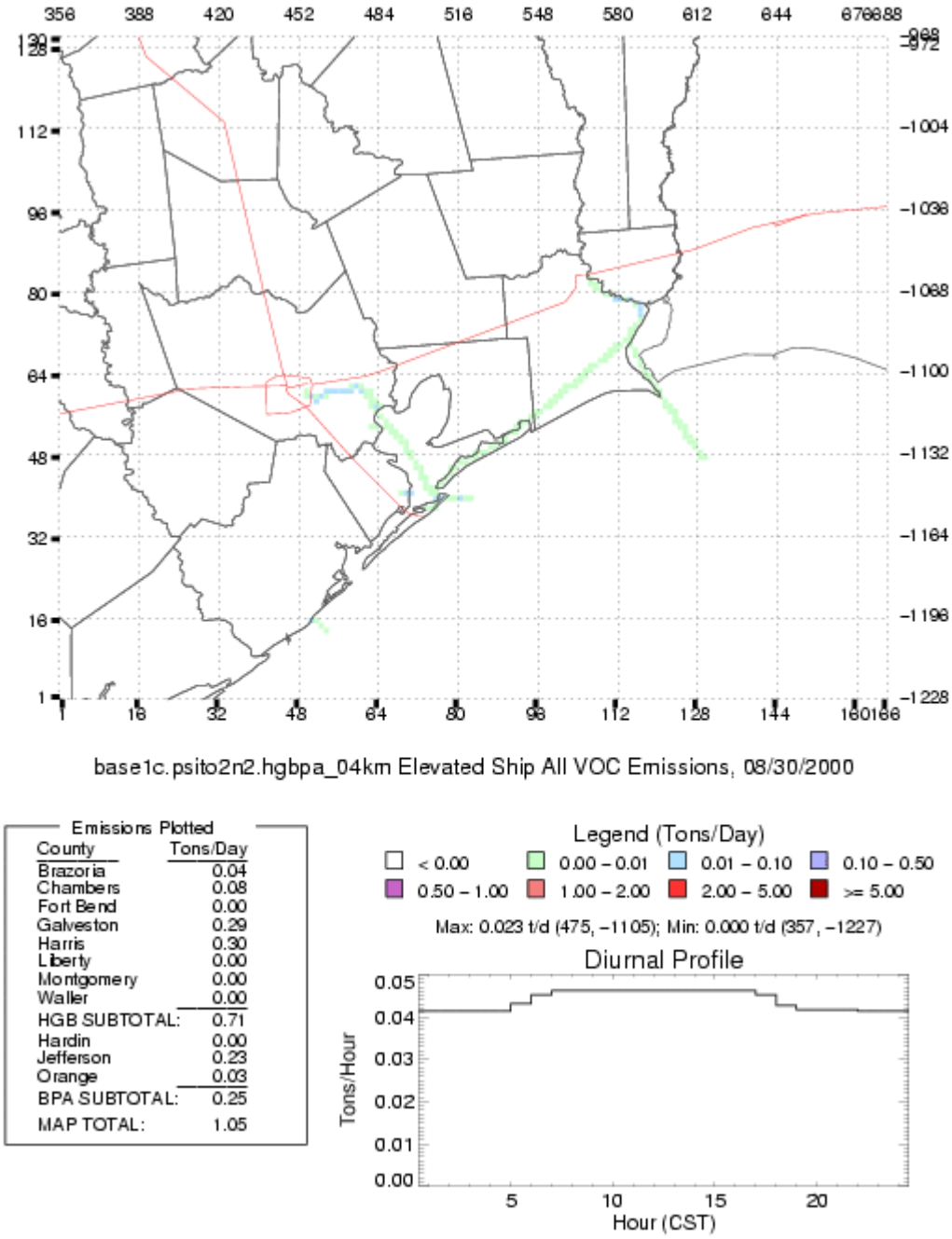


Figure 2-17: 2000 Base Case Modeled Ship VOC Emissions for August 30

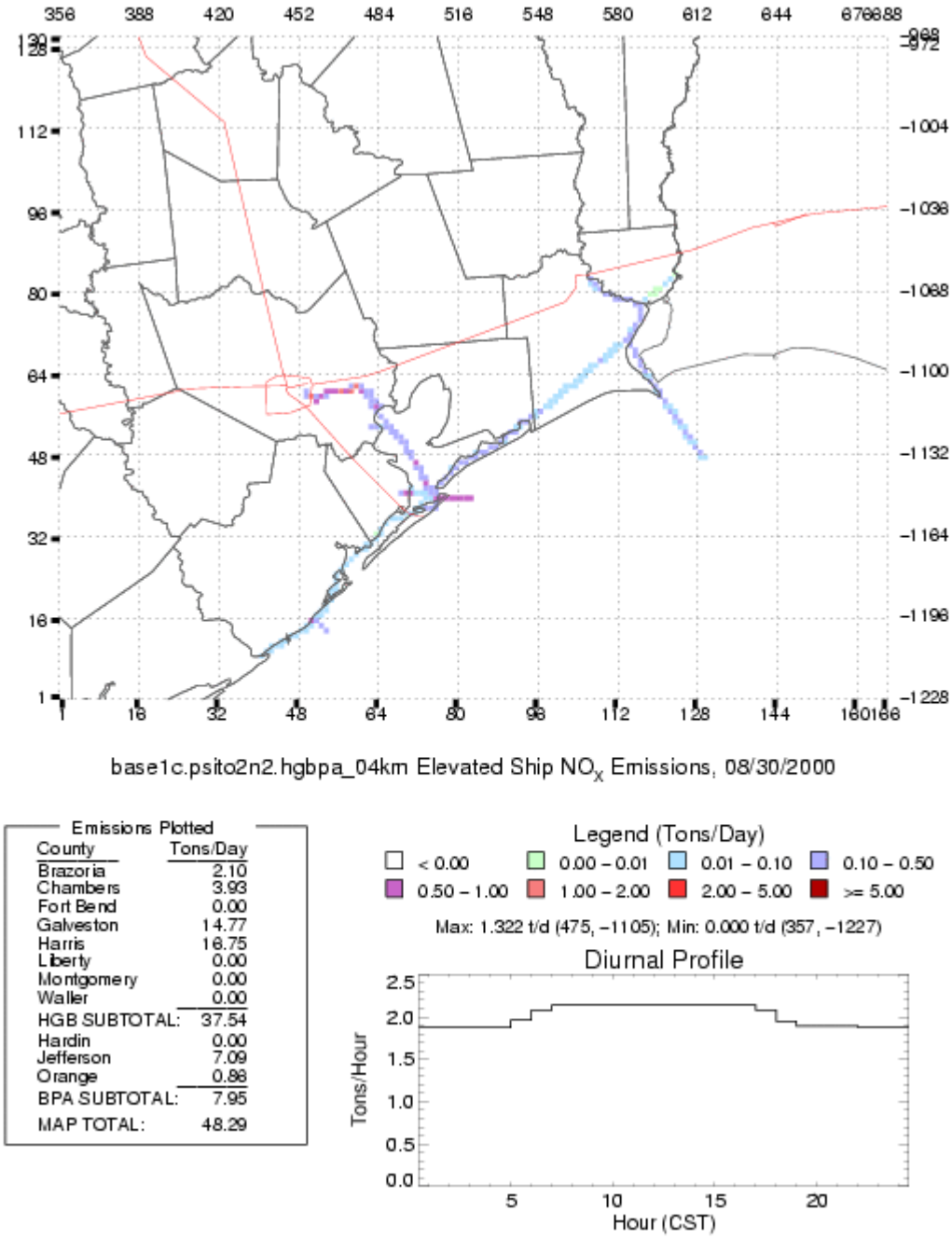


Figure 2-18: 2000 Base Case Modeled Ship NO_X Emissions for August 30

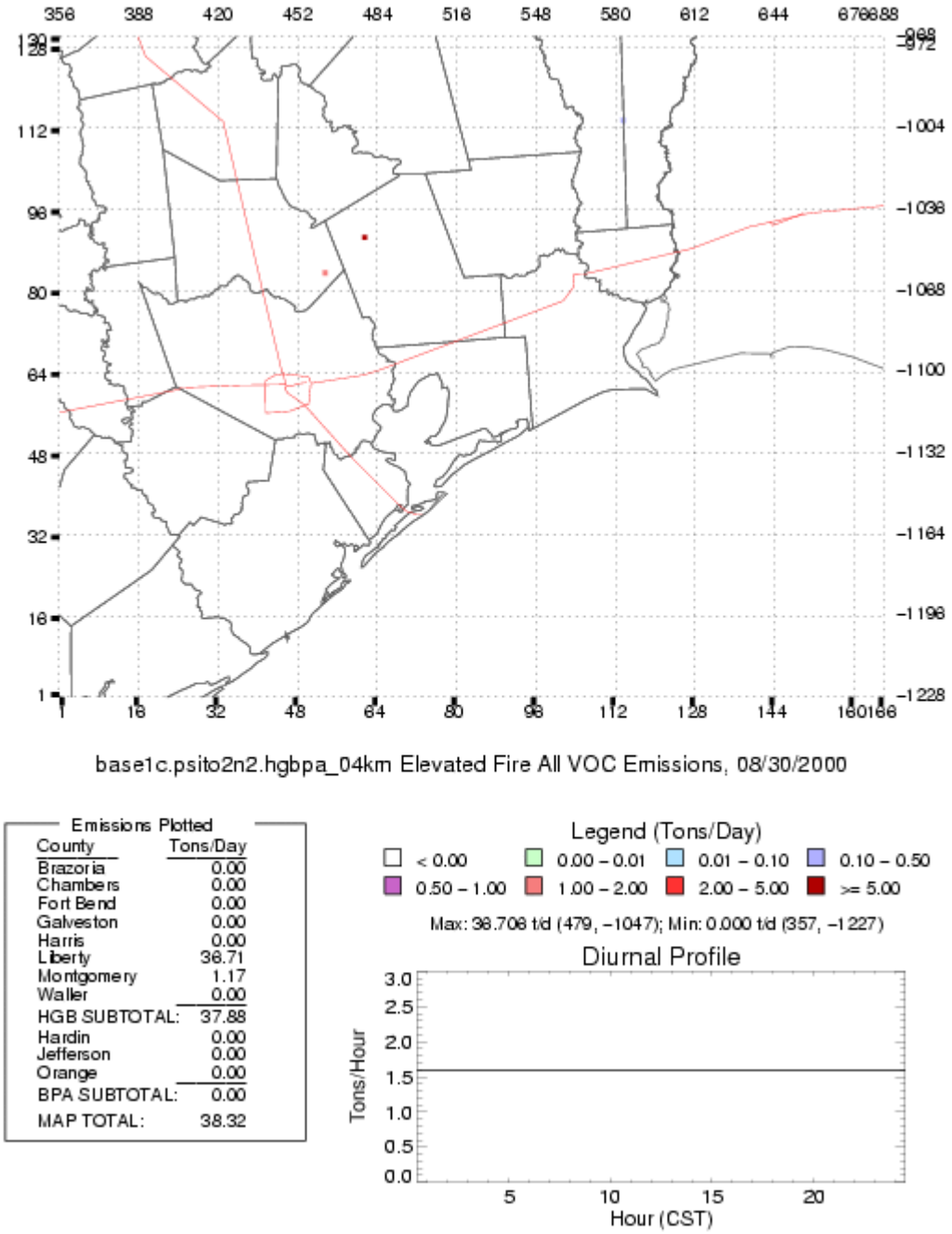


Figure 2-19: 2000 Base Case Modeled Fire VOC Emissions for August 30

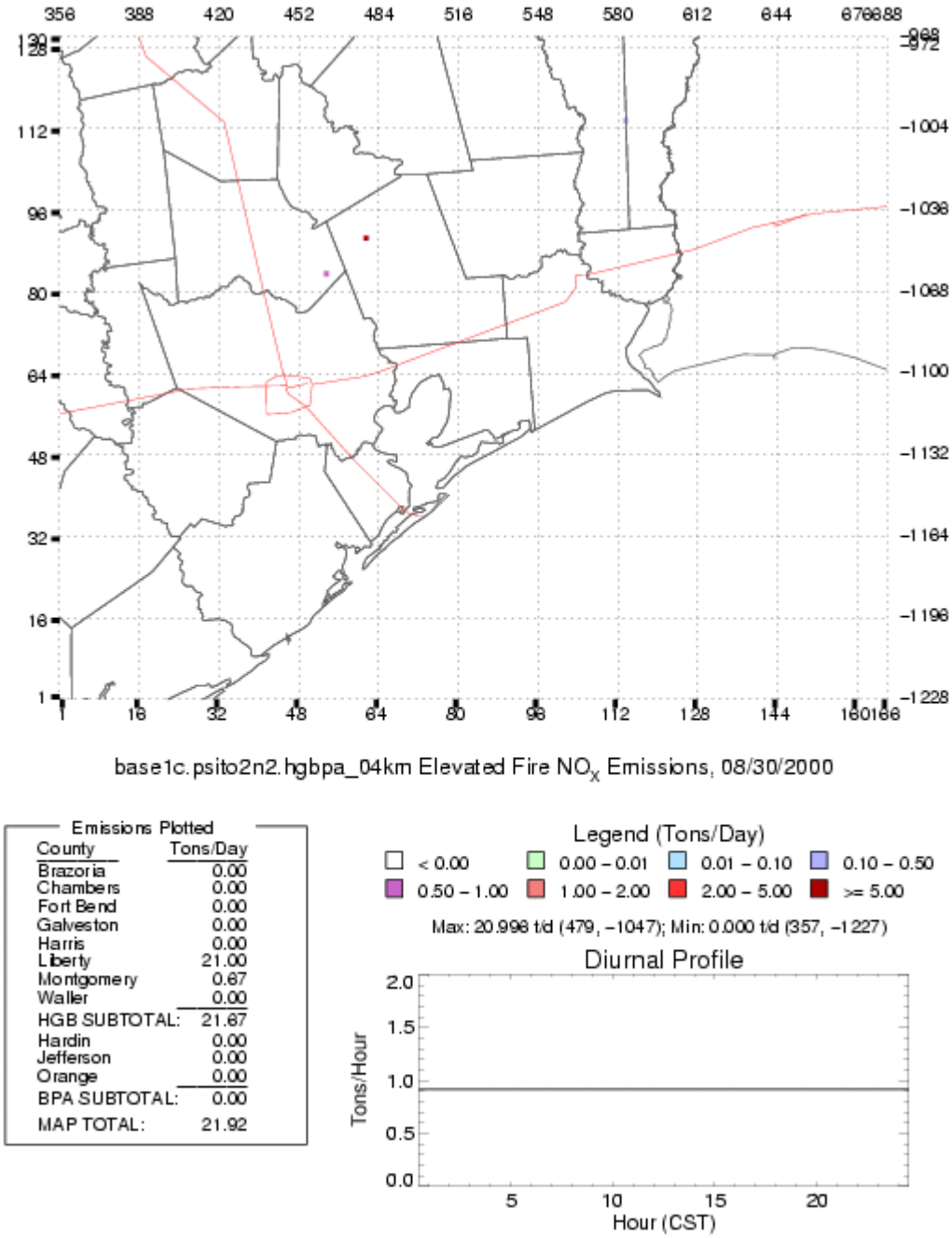


Figure 2-20: 2000 Base Case Modeled Fire NO_X Emissions for August 30

2.5.4.2 2000 Baseline

The 2000 baseline area, non-road, and ship modeling emissions are the same as the 2000 base case. Fires are not included in the 2000 baseline because they are not considered typical emissions.

2.5.4.3 2009 Baseline

Within Texas

Unless more current or locally-generated growth factors were available, area source emissions within Texas, including those from aircraft, ships, and locomotives, were grown to 2009 using the EPA's EGAS growth factors. For example, 2009 emissions for some area source categories were estimated using county-level economic or population growth projections obtained from the Texas Comptroller's Office or for particular emission source categories, using information such as oil and gas production from special studies. Emissions from liquefied natural gas (LNG) facilities (e.g., Freeport, Golden Pass) under construction in 2000 and included in the 2000 base case and 2000 baseline modeling emissions were included in the 2009 baseline at their respective construction emissions level to estimate operational emissions. The decision that LNG construction emissions were a reasonable estimate of operational emissions was based on information available at the time the inventory was developed suggesting that construction and operational emissions were similar. For non-road emissions categories, the NONROAD2004 model was used to project emissions into the future. The model accounts for both growth and federal controls on non-road sources. The control measures listed in Table 2-2: *2009 HGB 8-County Area/Non-Road Control Measures* were applied to reduce NO_X and VOC emissions from the proper area and non-road categories 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 2-2: 2009 HGB 8-County Area/Non-Road Control Measures

Control Measure	NO_X Emissions Reductions (tpd)	VOC Emissions Reductions (tpd)
Texas Emission Reduction Plan (TERP)	35.9	1.86
Texas Low Emission Diesel (TxLED)	3.1	0
Voluntary Mobile Source Emission Reduction Program (VMEP)	3.4	0.2
Minor source rule -- sources exempt from the MECT program	0.5	0
Clean portable fuel containers	0.0	2.9
Diesel engines—MECT program (0.1 tpd) plus all other diesel engine controls (0.9 tpd)	1.0	0
Total	43.9	4.96

Outside Texas

For the 2009 baseline area and non-road modeling emissions outside of Texas, the EPA emissions inventory developed for the CAIR 2010 modeling was used. Similar to the LNG facilities under

construction in Texas, the construction emissions for the LNG facility at Cheniere in Cameron Parish, Louisiana, were used to estimate the operational emissions in the 2009 baseline. Because growth factors and controls are not readily available for sources in Mexico or the Gulf of Mexico, the 2000 baseline emissions were used for the 2009 baseline. Also, similar to the 2000 baseline, fire emissions were not included in the 2009 baseline.

Figures 2-21 through 2-24 show the graphical distribution of the 2009 baseline modeling emissions of VOC and NO_X, for area and non-road sources combined and ships, respectively, for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area the combined emissions are 298.8 tpd of VOC and 135.2 tpd of NO_X.

2.5.5 On-Road Mobile Sources

2.5.5.1 2000 Base Case

Within Texas

For the eight-county HGB and the three-county BPA areas, on-road mobile source modeling emissions were developed from "link-based" emission inventories provided by the Texas Transportation Institute (TTI). To estimate emissions on roadway links for the 2000 episode year, TTI couples the emission factors output from the EPA's MOBILE6.2 model with the travel demand model (TDM) output of vehicle miles traveled (VMT) and speeds, provided by Houston-Galveston Area Council (H-GAC) for HGB and the Texas Department of Transportation (TxDOT) for BPA. However, prior to the coupling of the MOBILE6.2 emission factors, TTI adjusts the TDM output to make it more specific to the August 18 through September 6, 2000, episode using in-use traffic survey data, such as hourly traffic counts and the composition of VMT by vehicle type. In addition, following EPA directive, the TDM-derived VMT is adjusted to account for the difference between the TDM VMT and VMT estimated from the Highway Performance Monitoring System (HPMS) data.

For areas within Texas but outside the HGB and BPA nonattainment areas, TTI coupled the MOBILE6.2 output with county-wide HPMS-based VMT estimates adjusted for the 2000 episode to yield emission inventories by roadway type. In addition, again using traffic survey data, which show that mobile emissions vary by day of the week, hourly emissions for each county were developed for weekday (Monday-Thursday), Friday, Saturday, and Sunday day types for the various vehicle types.

The MOBILE6.2 model accounts for the effects that changes in hourly temperature and humidity have on NO_X emissions, but for only six of the 28 vehicle types. There is no temperature-humidity NO_X correction in MOBILE6.2 for the remaining 22 vehicle types, which include all 13 of the diesel-powered vehicle types and the nine heavy-duty gasoline vehicle types. Because this adjustment to the NO_X emissions can be appreciable during the ozone season in Texas, the Southwest Research Institute was commissioned to develop temperature/humidity NO_X correction equations to apply to these other vehicle types (December 2004 HGB SIP Revision, Appendix F). The temperature-humidity NO_X correction procedure allows not only for improved estimates of the total on-road NO_X emissions, but also for improved spatial and temporal allocation of those emissions.

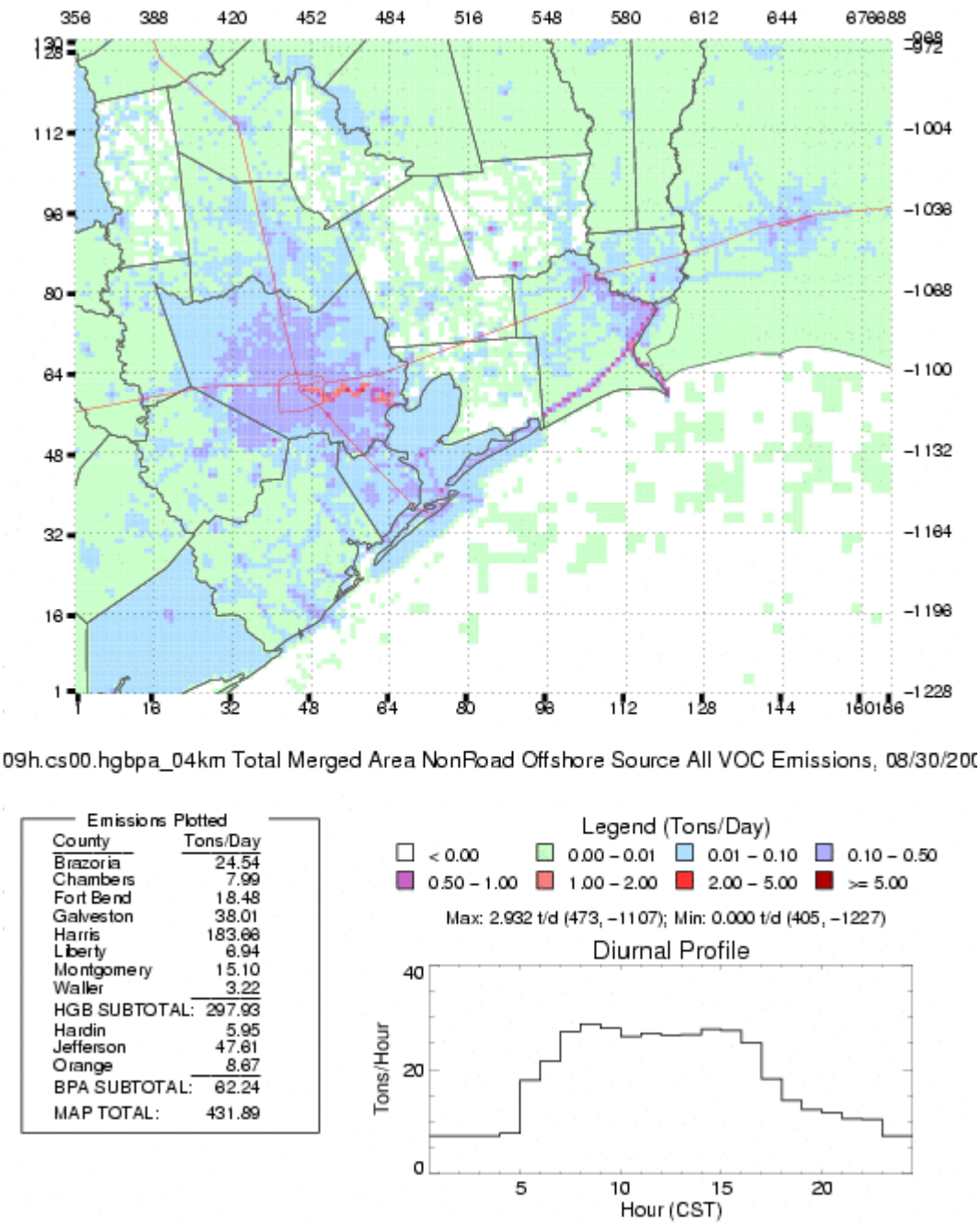


Figure 2-21: 2009 Baseline Modeled Area & Non-Road VOC Emissions for August 30

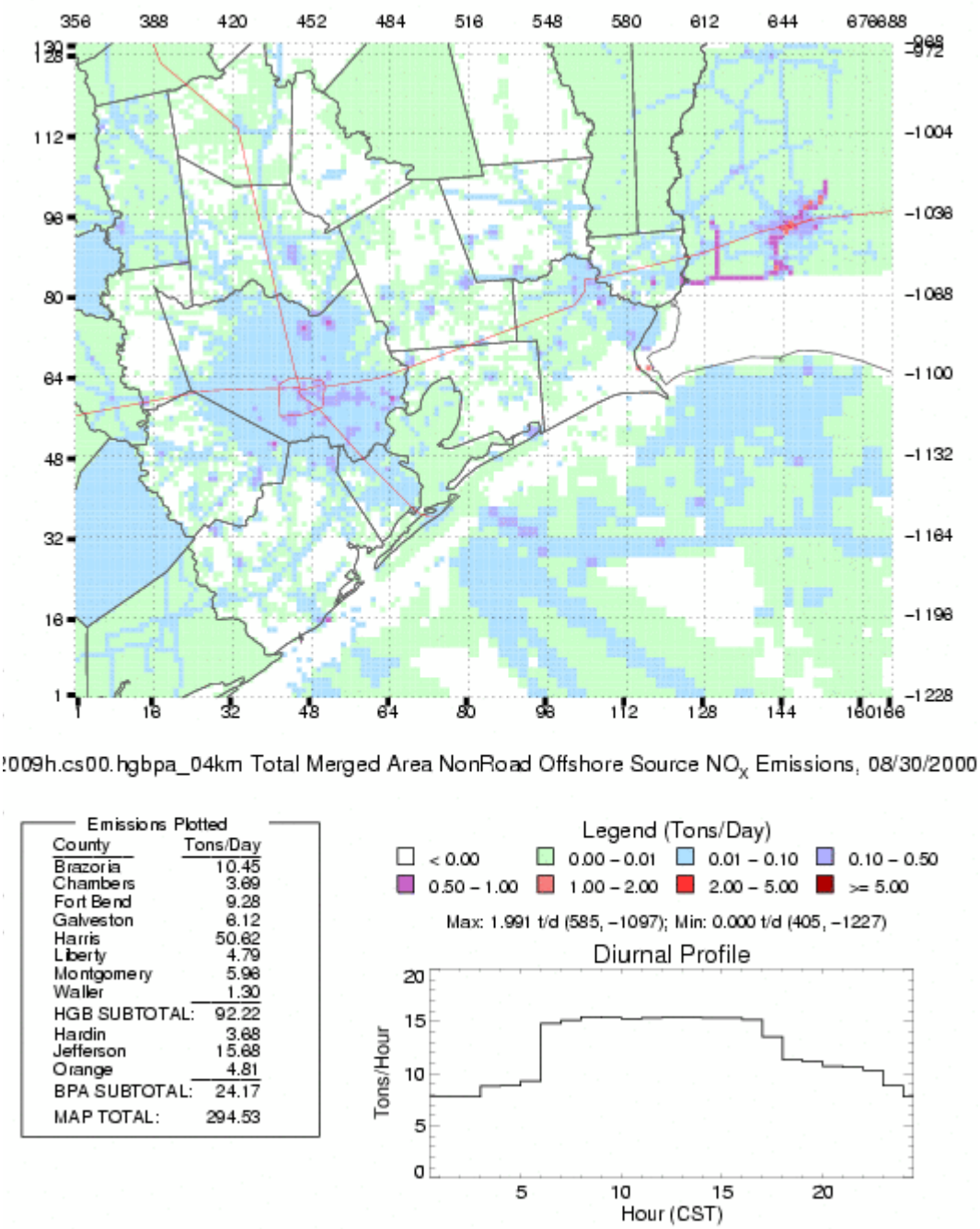


Figure 2-22: 2009 Baseline Modeled Area & Non-Road Source NO_X Emissions for August 30

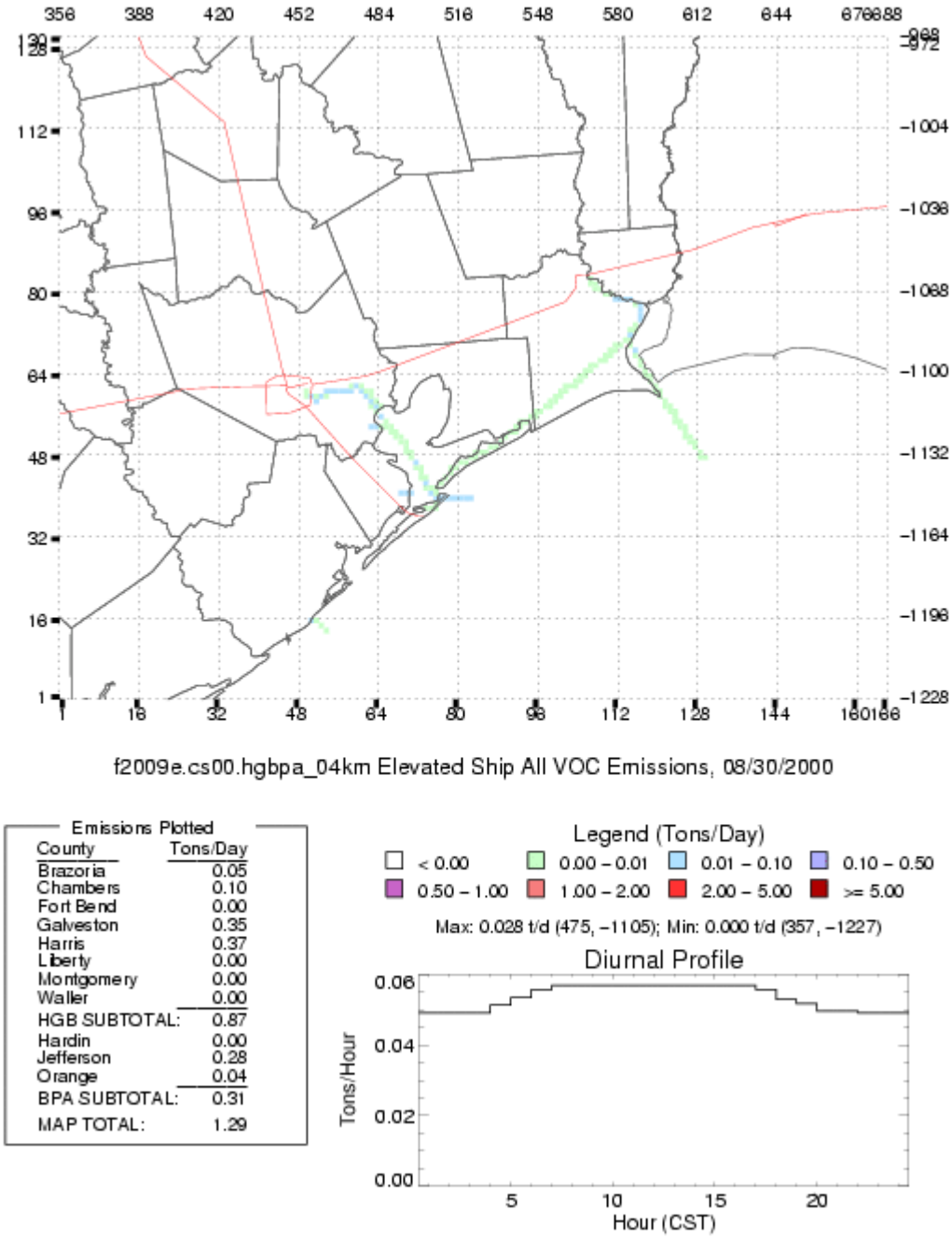


Figure 2-23: 2009 Baseline Modeled Ship VOC Emissions for August 30

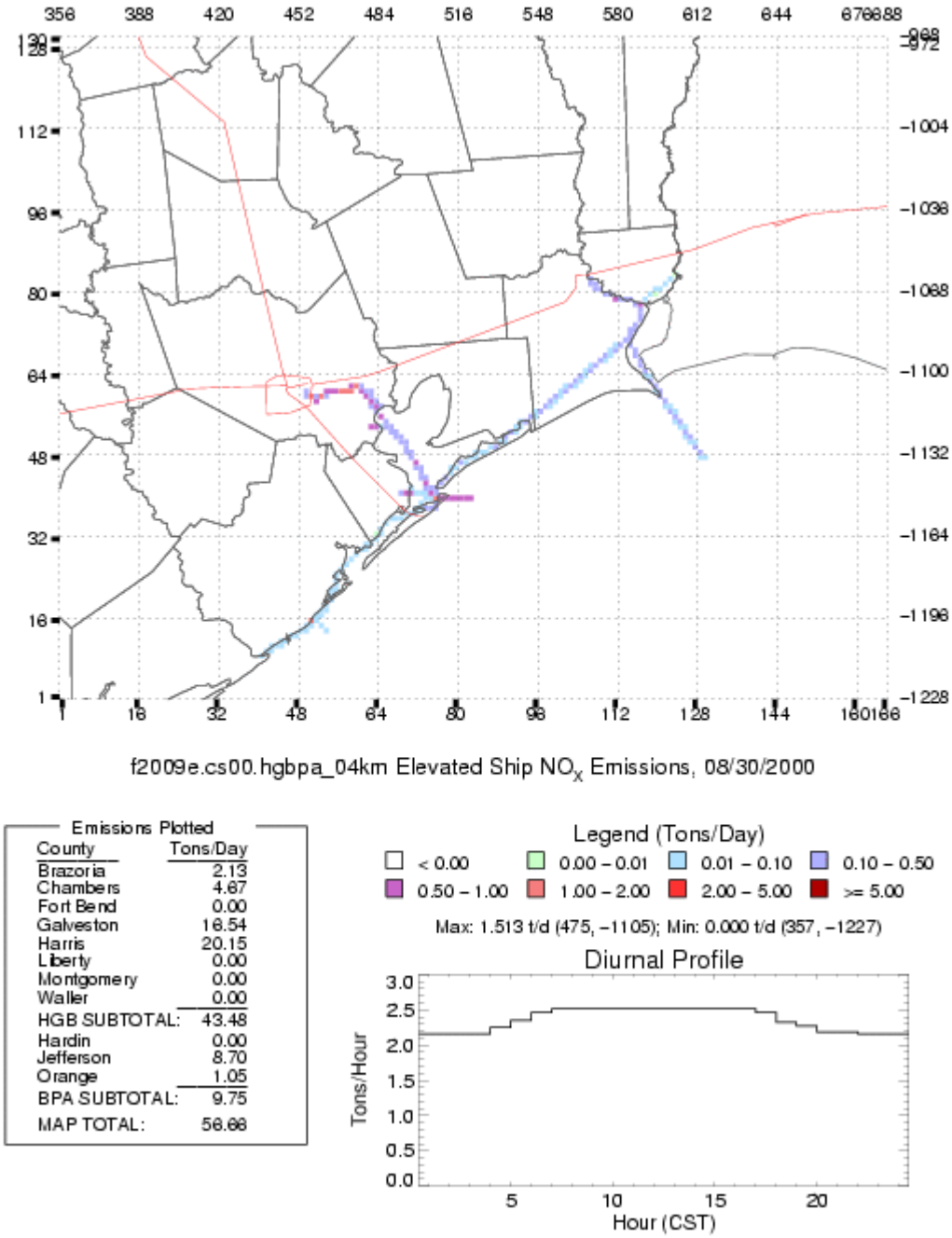


Figure 2-24: 2009 Baseline Modeled Ship NO_X Emissions for August 30

Outside Texas
On-road modeling emissions for areas outside of Texas were developed from the on-road portion of the 1999 NEI. For the 2000 base case, the 1999 on-road NEI emissions were adjusted by the relative fleetwide emission factor differences between MOBILE6.2 model runs for 1999 and 2000 and the relative state-by-state differences in VMT between 1999 and 2000. The VMT adjustment was based on the *Highway Statistics* series published by the Federal Highway Administration (FHWA) of the U.S. Department of Transportation.

Details concerning the development of the on-road modeling emissions can be found in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP.

Figure 2-25: *2000 Base Case Modeling On-Road Mobile Source VOC Emissions for August 30* and Figure 2-26: *2000 Base Case Modeling On-Road Mobile Source NO_X Emissions for August 30* show the graphical distribution of the 2000 base case on-road modeling emissions of VOC and NO_X, respectively, for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, the combined emissions for the HGB eight-county area are 166.2 tpd of VOC and 342.6 tpd of NO_X.

2.5.5.2 2000 Baseline
The 2000 baseline on-road modeling emissions are the same as the 2000 base case.

2.5.5.3 2009 Baseline
Within Texas
Similar to the 2000 base case on-road modeling emissions, TTI in cooperation with H-GAC and TxDOT provided a link-based inventory for the HGB and BPA nonattainment areas, and a county-wide inventory for the remainder of Texas. The main differences from the 2000 base case are that the MOBILE6.2 outputs for 2009 were coupled with 2009 TDM outputs for HGB and BPA, and 2009 estimated county-wide VMT for the remainder of Texas. The 2009 TDM runs for HGB and BPA were based on best available future projections of population growth, demographic patterns, and roadway network changes. 2009 county-wide VMT projections for the areas in Texas outside the HGB and BPA nonattainment areas were made based upon vehicle and population trends.

The MOBILE6.2 runs for 2009 used the same meteorological inputs as the base case (temperatures, humidity, etc.), but other inputs, such as emission standards and the vehicle age distribution, were changed to reflect a 2009 fleet. For example, a 2009 vehicle fleet will be more heavily populated with newer lower-emitting vehicles. To account for existing control strategies in the HGB nonattainment area, the 2009 MOBILE6.2 was run with a maximum speed of 65 mph, rather than 70 mph, and the vehicle inspection and maintenance (I/M) program was expanded to include Brazoria, Fort Bend, Galveston and Montgomery Counties. In addition, the TTI-provided inventory for the HGB on-road emissions was reduced to reflect the benefits from transportation control measures (TCM), the TERP, and the VMEP. Further, as appropriate to many counties in Texas, the 2009 on-road emissions include the benefits of TxLED. The controls listed in Table 2-3: *2009 HGB Eight-County On-Road Controls* were applied to reduce NO_X and VOC emissions from the respective vehicle types.

Outside Texas
The 2009 on-road modeling emissions for areas outside of Texas were developed by applying appropriate growth and controls to the on-road portion of the 2002 NEI. For the 2009 baseline,

the 2002 on-road NEI emissions were adjusted by the relative fleetwide emission factor differences between MOBILE6.2 model runs for 2002 and 2009 and the relative state-by-state differences in VMT between 2002 and 2009. For the emission factor adjustment, MOBILE6.2 was run with the EPA default inputs for 2002 and 2009. The VMT adjustment was based on a growth analysis published by the FHWA in the *Highway Statistics* series.

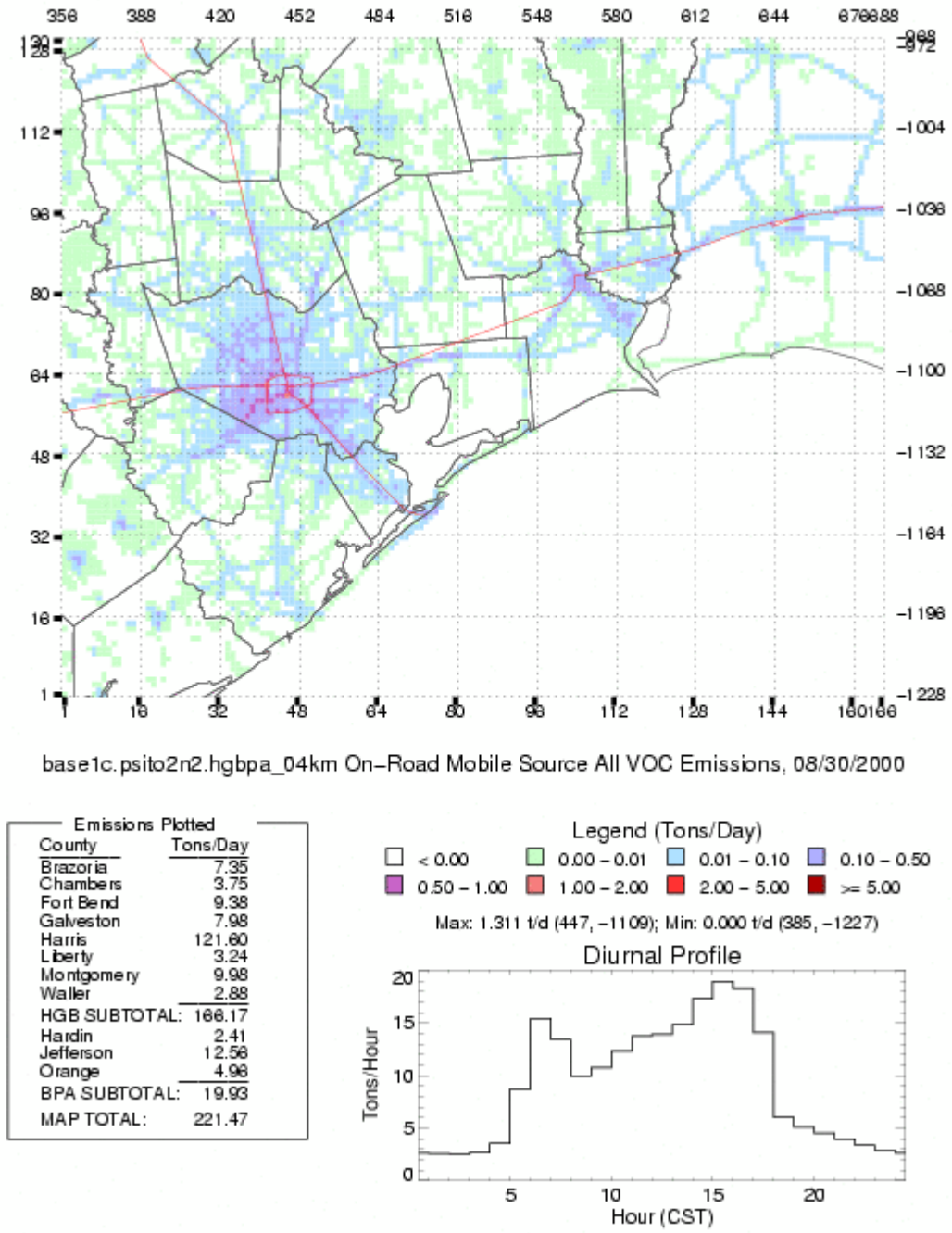


Figure 2-25: 2000 Base Case Modeling On-Road Mobile Source VOC Emissions for August 30

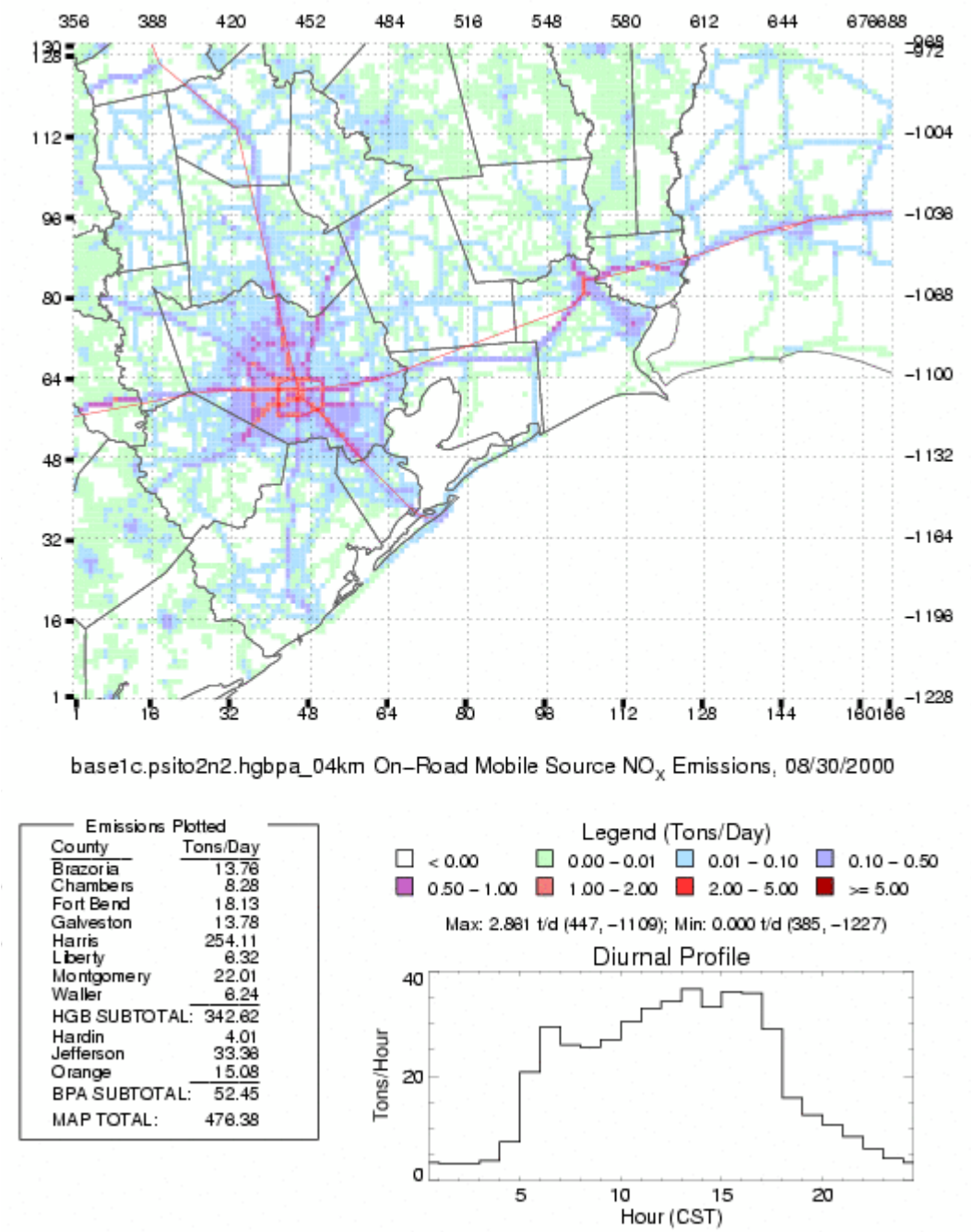


Figure 2-26: 2000 Base Case Modeling On-Road Mobile Source NO_X Emissions for August 30

Table 2-3: 2009 HGB Eight-County On-Road Controls

Control Measure	NO_X Emissions Reductions (tpd)	VOC Emissions Reductions (tpd)
TERP	3.00	0
TCM	0.85	0.52
VMEP	3.60	0.60
TxLED*	5.94	0
Total	13.39	1.12

* a NO_X reduction of 4.8 percent is applied to 2002-and-newer diesel vehicles, while a 6.2 percent NO_X benefit is applied to 2001-and-older diesel vehicles.

Figure 2-27: *2009 Baseline Modeling On-Road Mobile Source VOC Emissions for August 30* and Figure 2-28: *2009 Baseline Modeling On-Road Mobile Source NO_X Emissions for August 30* show the graphical distribution of the 2009 baseline on-road modeling emissions of VOC and NO_X, respectively, for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area the combined emissions are 85.6 tpd of VOC and 152.7 tpd of NO_X.

2.5.6 Modeling Emissions Summary

Table 2-4: *HGB 2000 Base Case, 2000 Baseline & 2009 Baseline Modeling Emissions by Source Category* summarizes the modeling emissions for the eight-county HGB nonattainment area.

Table 2-4: HGB 2000 Base Case, 2000 Baseline & 2009 Baseline Modeling Emissions by Source Category

Source Category	2000 Base Case		2000 Baseline		2009 Baseline	
	NO_X (tpd)	VOC (tpd)	NO_X (tpd)	VOC (tpd)	NO_X (tpd)	VOC (tpd)
Points	498.6	413.7	475.3	409.1	157.0	268.6
Area & Non-Road	143.2	294.1	143.2	294.1	92.2	297.9
Ships	37.5	0.7	37.5	0.7	43.5	0.9
Fires	21.7	37.9	NA	NA	NA	NA
On-Road	342.6	166.2	342.6	166.2	152.7	85.6
Sub-total	1043.6	912.6	998.6	870.1	445.4	653.0
Biogenic	21.9	1674.6	21.9	1674.6	21.9	1674.6
Total	1065.5	2587.2	1020.5	2544.7	467.3	2327.6

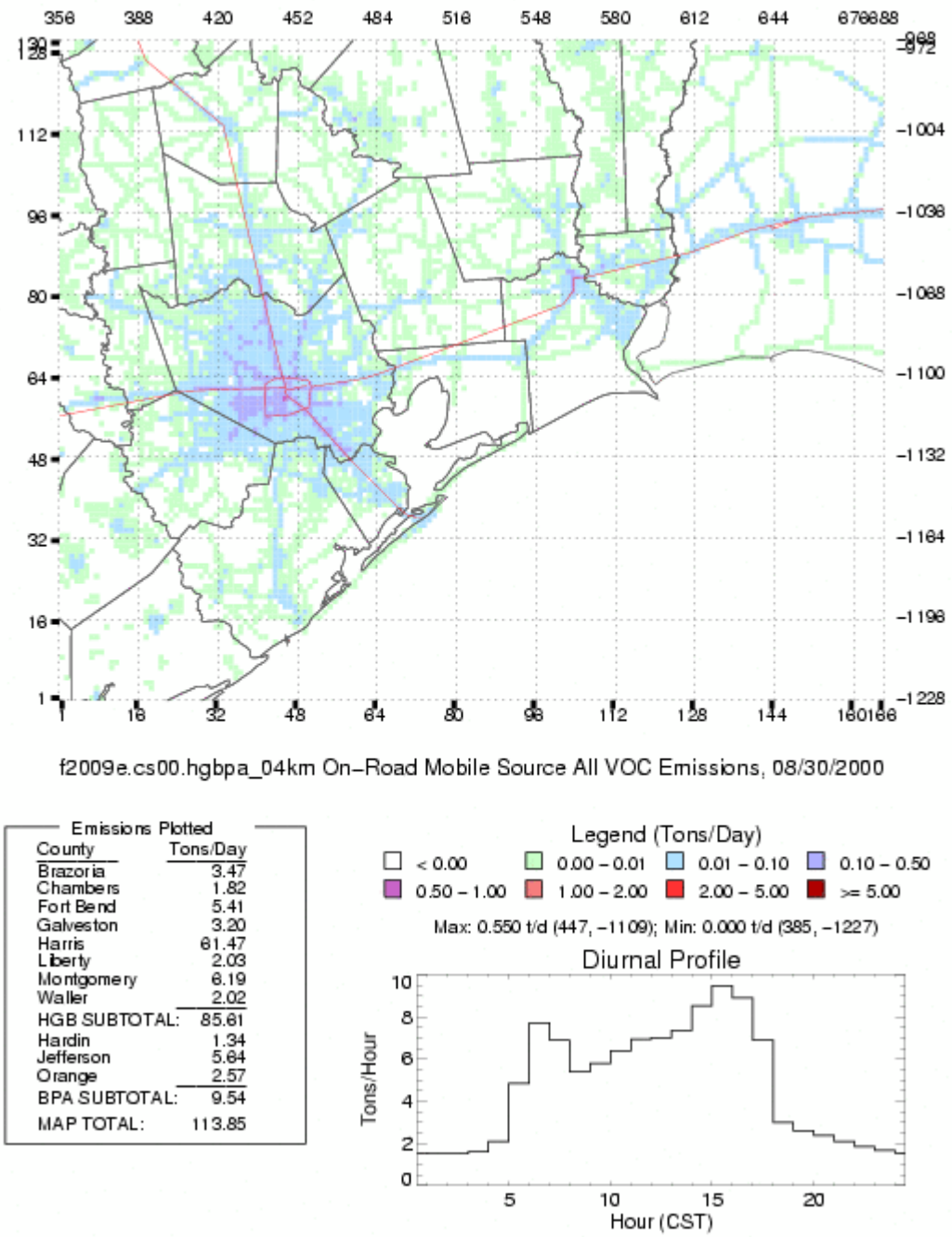


Figure 2-27: 2009 Baseline Modeling On-Road Mobile Source VOC Emissions for August 30

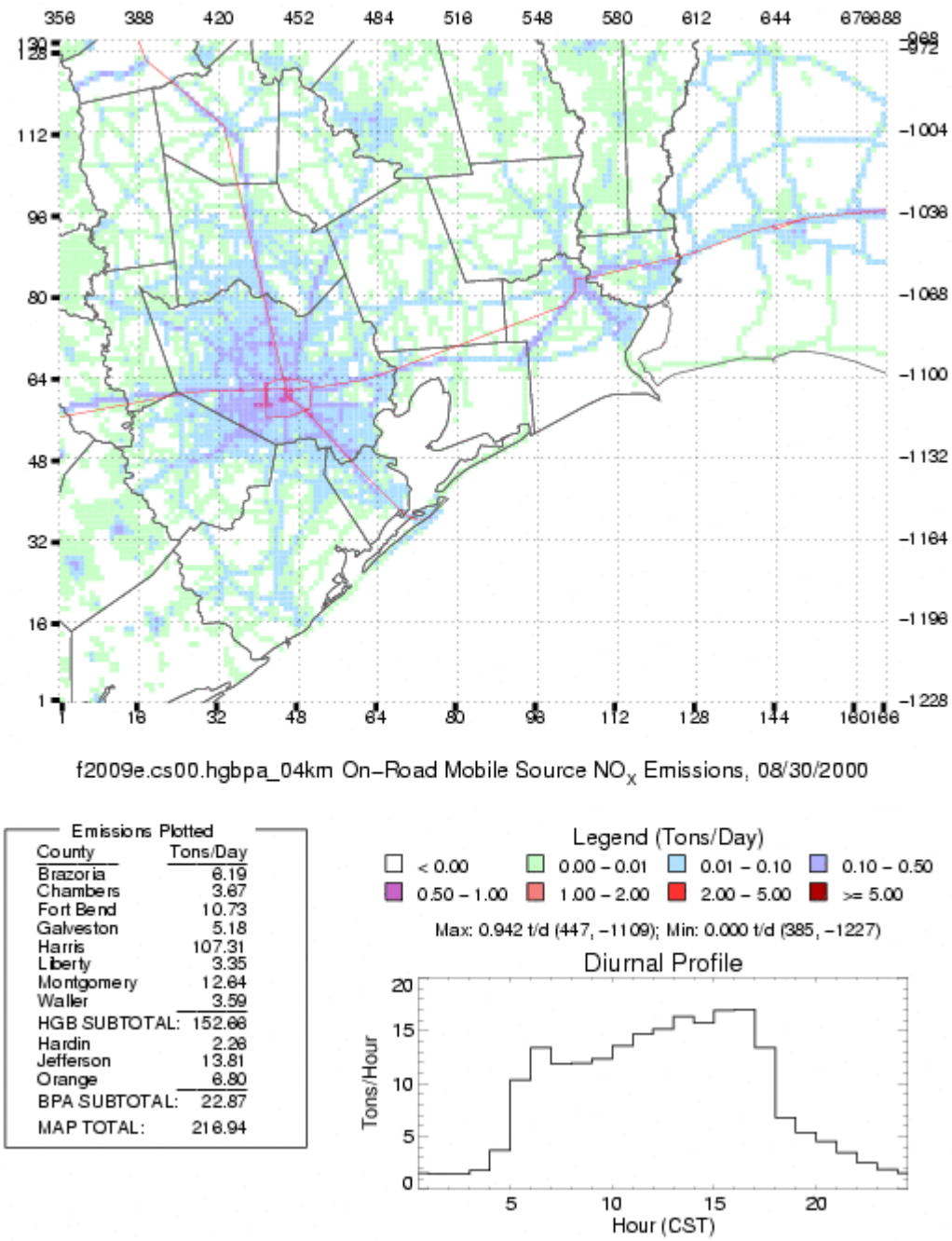


Figure 2-28: 2009 Baseline Modeling On-Road Mobile Source NO_X Emissions for August 30

2.6 BASE CASE MODEL PERFORMANCE EVALUATION

The performance of the base case modeling is evaluated to determine whether the model is adequately simulating the formation of ozone. The model must show reasonable performance for the base case episode before the future case is modeled and control measures are tested. The evaluation of the modeling is primarily conducted by comparing modeled predictions with monitored data. However, the model predicts a volumetric one-hour average throughout an entire grid cell, while hourly monitoring data provide a measure of air quality at a specific point in space. Therefore, modeled and monitored comparisons can only provide insight into model prediction trends but do not provide precise measures of model performance.

Additional information on specific performance evaluation procedures can be found in the *Guideline for Regulatory Application of the Urban Airshed Model* (EPA, 1991) and in the new *Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS* (EPA, 2005). These documents recommend performance evaluation of both quantitative (i.e., statistical) and qualitative (i.e., graphical) measures. The localized small-scale (i.e., high resolution) meteorological and emissions features characteristic of the HGB nonattainment area require model evaluation be performed at the highest resolution possible to evaluate whether or not the model is producing the right answer for the right reasons. Therefore, the performance evaluation focuses on comparisons of hourly modeled and monitored concentrations. This section also indicates how model performance has been improved since the 2004 HGB SIP Revision.

2.6.1 Statistical Performance Evaluations

The most commonly used measures of statistical performance are the three statistics; Unpaired Peak Accuracy, Normalized Bias, and Gross Error, which compare modeled and monitored ozone concentrations. These statistics are calculated separately for each episode day. Figures 2-29 through 2-31 show the classic performance statistics recommended in the EPA's 1992 Guidance for the current modeling. Also shown for comparison are the corresponding statistics from the modeling used in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP. Because August 16 and 17 were modeling initialization days, they should not be considered in the evaluation of performance. Further, the period from August 18 through August 21 was not modeled as part of the previous one-hour ozone SIP revision.

The Unpaired Peak Accuracy measures the model's ability to replicate the highest ozone observed on each day of the episode. A negative value of Unpaired Peak Accuracy is a clear indication that the model is not generating high enough peak ozone, but a positive value does not necessarily signal that the model is generating a peak that is too high, because the actual peak concentration may not occur at a monitoring location. Figure 2-29: *Comparison of Monitored Peak Ozone with Eight-Hour (current) and One-Hour Modeling* compares the modeled and monitored peak ozone concentrations on the various episode days. Although the Unpaired Peak Accuracy target statistic is not shown, the error bars represent the EPA's recommended $\pm$ 20 percent tolerance. Peaks that lie within this tolerance range meet the Unpaired Peak Accuracy performance criterion. For 16 of the 20 episode days, the modeled peak ozone is within this range.

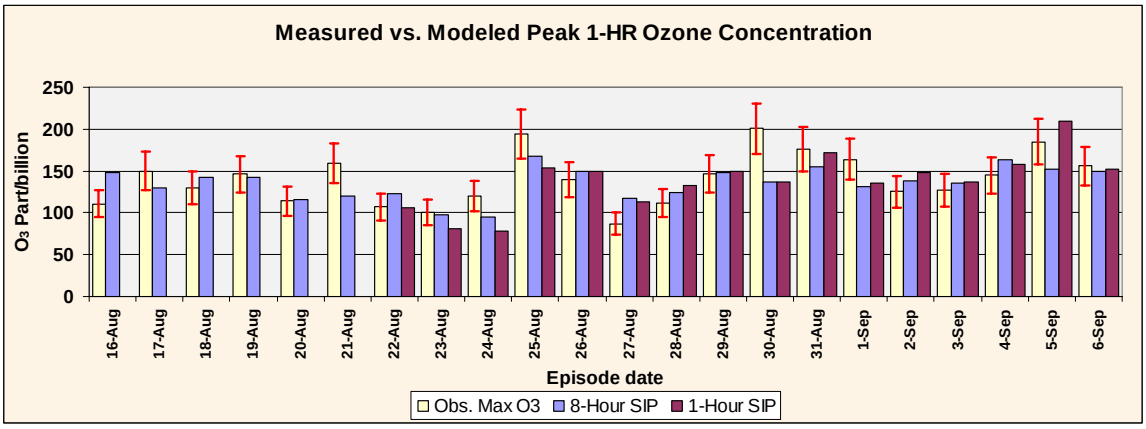


Figure 2-29: Comparison of Monitored Peak Ozone with Eight-Hour (current) and One-Hour Modeling

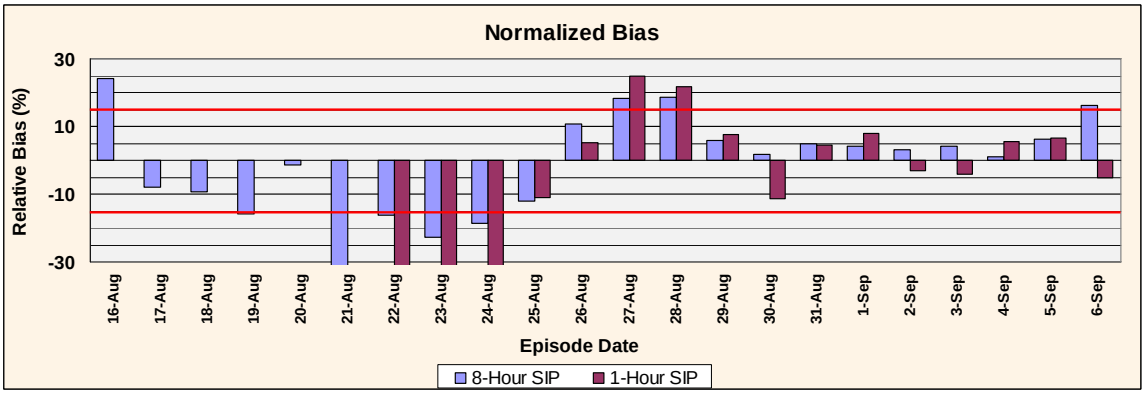


Figure 2-30: Comparison of Model Bias for Eight-Hour (Current) and One-Hour Modeling

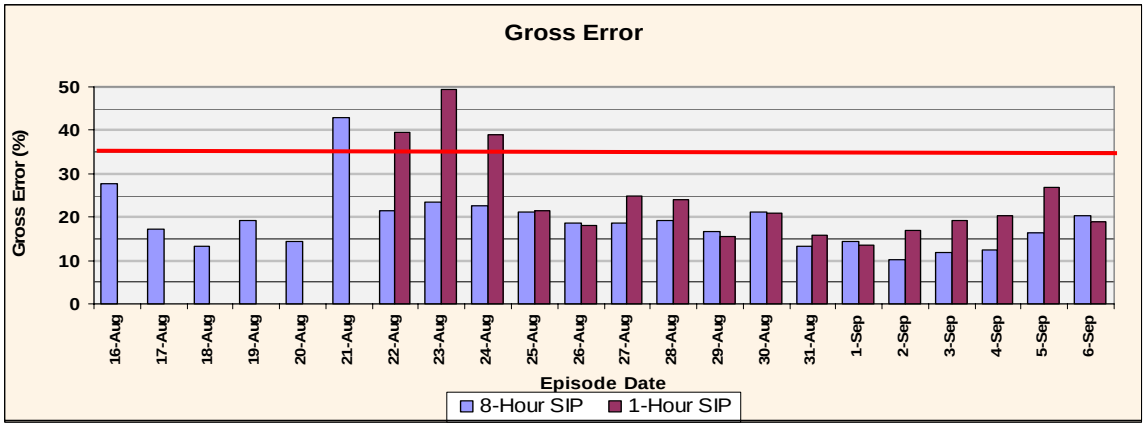


Figure 2-31: Comparison of Model Gross Error for Eight-Hour (Current) and One-Hour Modeling

The Normalized Bias measures the model's overall accuracy. A positive bias indicates the model's tendency to over-predict ozone concentrations and a negative bias indicates the model's tendency to under-predict ozone concentrations. Because this statistic can magnify small differences between monitored and modeled concentrations, it was calculated for monitored and modeled pairs where the monitored ozone was at least 60 ppb. Figure 2-30: *Comparison of Model Bias for Eight-Hour (Current) and One-Hour Modeling,* displays this statistic for the current modeling as well as for the modeling used in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP. The red lines indicate the EPA's recommended tolerance of ±15 percent. The results for the current modeling are somewhat improved over the previous modeling. The model bias is within the EPA-recommended range of ±15 percent on 12 of the 20 episode days.

The Gross Error measures the model's overall precision and represents the absolute deviation of the monitored and modeled pairs. Similar to the Normalized Bias, this statistic was calculated for monitored and modeled pairs where the monitored ozone was at least 60 ppb. Figure 2-31: *Comparison of Model Gross Error for Eight-Hour (Current) and One-Hour Modeling* displays this statistic for the current modeling and the modeling used in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP. The red line indicates the EPA's recommended tolerance of 35 percent. Only one episode day, August 21, has gross error outside the EPA-recommended range of 35 percent.

While one-hour ozone statistics use every hour of the day (subject to measured concentrations being at least 60 ppb), the nature of the eight-hour standard limits most analyses to consider only the daily peak eight-hour concentrations. Table 2-5: *Eight-Hour Ozone Statistics (Across Monitors) for August 18-September 6, 2000*, provides some summary eight-hour statistics, which quantify how well the model replicates daily maximum monitored eight-hour ozone concentrations (averaged across all monitors reporting on each given day). The table shows that for the episode, eight-hour model predictions have a small bias (+2.4 ppb, approximately +8 percent). Mean relative (gross) error (approximately 20 percent) is strongly influenced by the under-prediction on August 21 and by the over-prediction on August 27, but overall is considered acceptably small. Root mean square error is related to mean relative (gross) error, but is expressed in the original units of the data (ppb) instead of as a percentage.

Overall the statistical performance for the current modeling is acceptable and shows notable improvement over that used in the 2004 HGB SIP revision modeling.

2.6.2 Graphical Performance Evaluations

Graphical analysis of the modeling output was used to qualitatively evaluate the model's performance. These graphical analyses include contour plots of simulated ozone concentrations and animations showing the development of ozone throughout the episode. Time series plots were generated for various monitoring sites and for relevant constituents, such as nitrous acid, hydrogen peroxide, nitric acid, and formaldehyde, as well as ozone, all of which were monitored during the TexAQS 2000. In addition, scatter plots for eight-hour ozone concentrations and relevant constituents were developed for each monitoring site and separately for each episode day.

Figure 2-32: *Time Series of Modeled and Measured Ozone Concentrations at Three Monitoring Locations*, shows selected time series plots of ozone at various monitoring locations. The green boxes are the monitored observations, the red trace shows the previous one-hour modeling results, and the blue trace shows the current modeling results.

Table 2-5: Eight-Hour Ozone Statistics (Across Monitors) for August 18-September 6, 2000

Episode Day	Bias (ppb)	Relative Bias (%)	Mean Relative Error (%)	RMS Error (ppb)	Average Modeled Eight-hr. Conc. (ppb)	Average Monitored Eight-hr. Conc. (ppb)
Aug. 18	-3.66	-10.82%	13.70%	10.60	59.68	67.00
Aug. 19	-6.22	-16.10%	18.64%	15.42	62.61	75.04
Aug. 20	4.07	18.52%	18.65%	10.05	59.30	51.17
Aug. 21	-13.67	-33.45%	34.64%	31.94	47.95	75.29
Aug. 22	0.52	3.20%	14.52%	10.94	58.95	57.90
Aug. 23	-0.10	2.24%	19.02%	10.15	47.40	47.60
Aug. 24	0.24	4.89%	18.50%	10.42	49.29	48.81
Aug. 25	-3.15	-3.48%	19.99%	15.59	68.04	74.35
Aug. 26	6.66	27.57%	28.64%	15.40	69.32	56.00
Aug. 27	7.14	35.50%	35.50%	15.42	56.36	42.09
Aug. 28	5.80	29.85%	29.85%	12.84	56.23	44.64
Aug. 29	5.14	24.09%	27.61%	15.47	69.09	58.82
Aug. 30	-0.50	3.48%	17.15%	19.95	79.38	80.38
Aug. 31	1.67	5.02%	9.88%	10.48	95.57	92.22
Sept. 1	2.91	13.28%	18.37%	12.60	77.00	71.17
Sept. 2	1.50	4.65%	8.38%	9.52	79.78	76.78
Sept. 3	3.75	15.17%	16.76%	12.21	77.18	69.68
Sept. 4	0.80	2.83%	8.88%	8.57	77.27	75.68
Sept. 5	3.15	9.21%	13.56%	14.57	90.13	83.83
Sept. 6	7.52	23.68%	24.46%	18.75	91.76	76.71
Episode	**2.40**	**8.02%**	**19.74%**	**14.87**	**68.87**	**66.46**

At Bayland Park on most episode days, the current modeling (blue trace) better replicates observations than does the 2004 HGB SIP revision modeling. At Deer Park, there is no clear preference for either the current or previous modeling. At Aldine the current and previous modeling are comparable on most days, although the current modeling corrects a large over-estimate seen previously on September 5 (red trace).

Figure 2-33: *Six Selected Time Series Plots of Relevant Constituents and Ozone Precursor Concentrations* shows time series plots of some relevant constituents and important ozone precursors at four sites.

The top two panels in Figure 2-33: *Six Selected Time Series Plots of Relevant Constituents and Ozone Precursor Concentrations* show modeled and monitored concentrations of NO and NO_2, respectively, at Bayland Park. At this location, the model appears to reproduce monitored concentrations of NO well; however, the model notably over-estimates NO_2. These patterns are seen for both the current and previous modeling, and are generally true at most monitoring sites

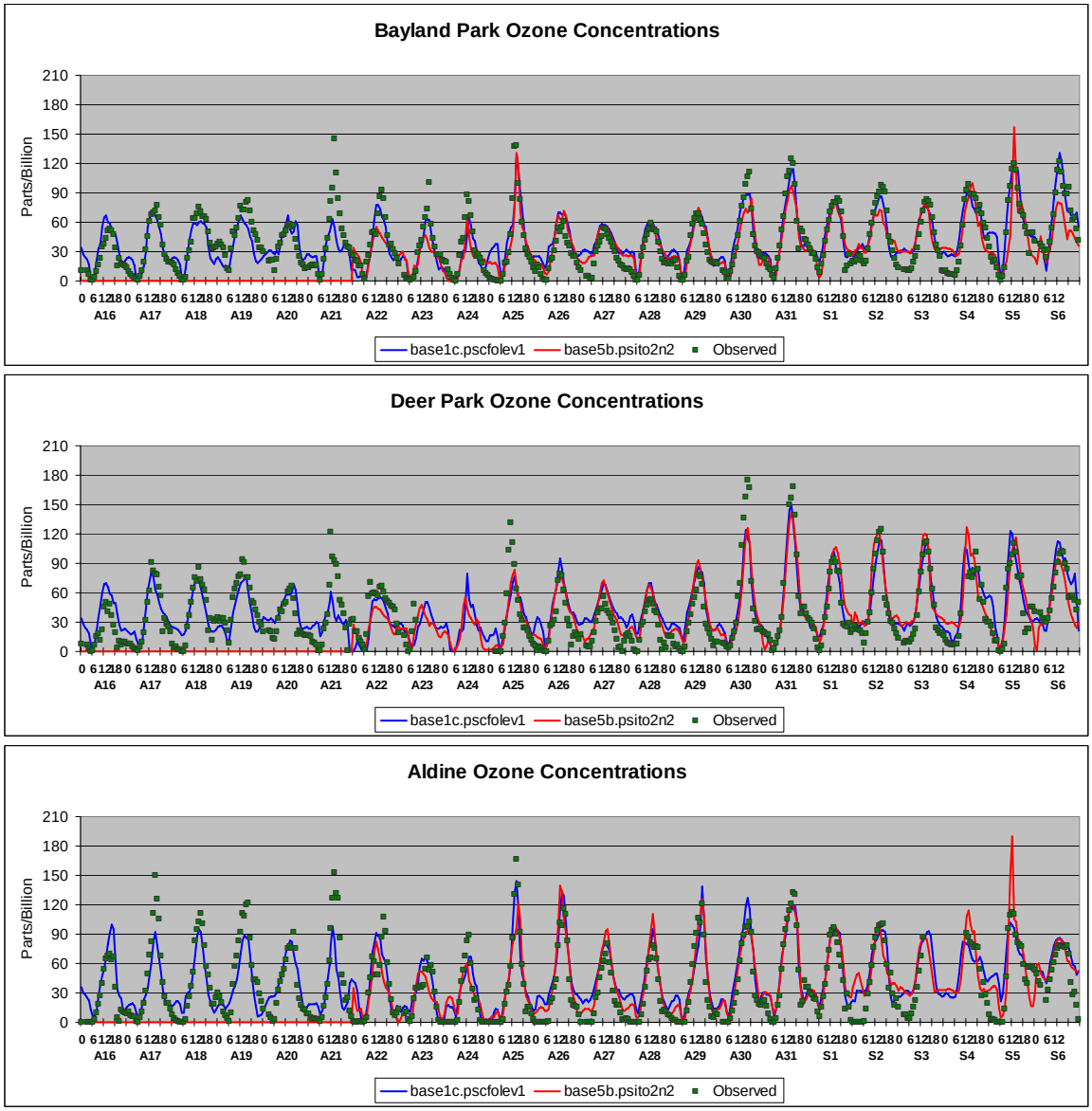
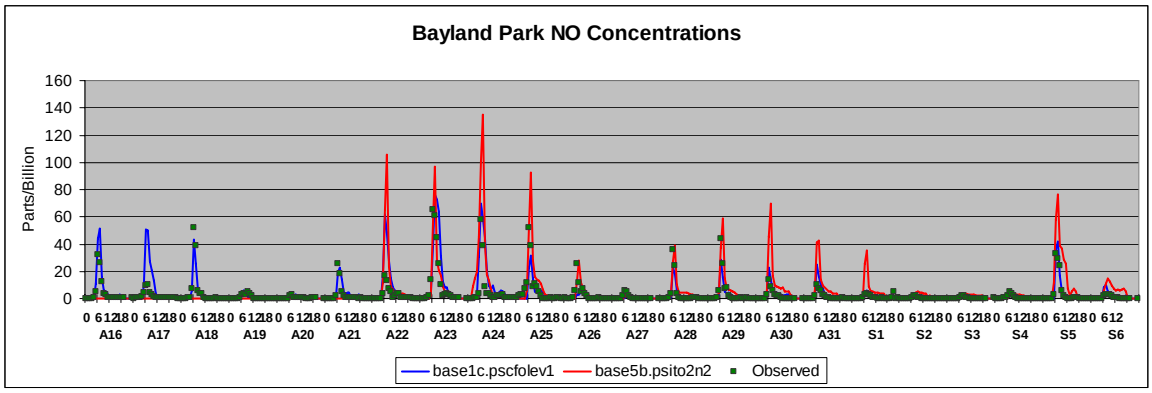


Figure 2-32: Time Series of Modeled and Measured Ozone Concentrations at Three Monitoring Locations


Bayland Park NO Concentrations
Parts/Billion
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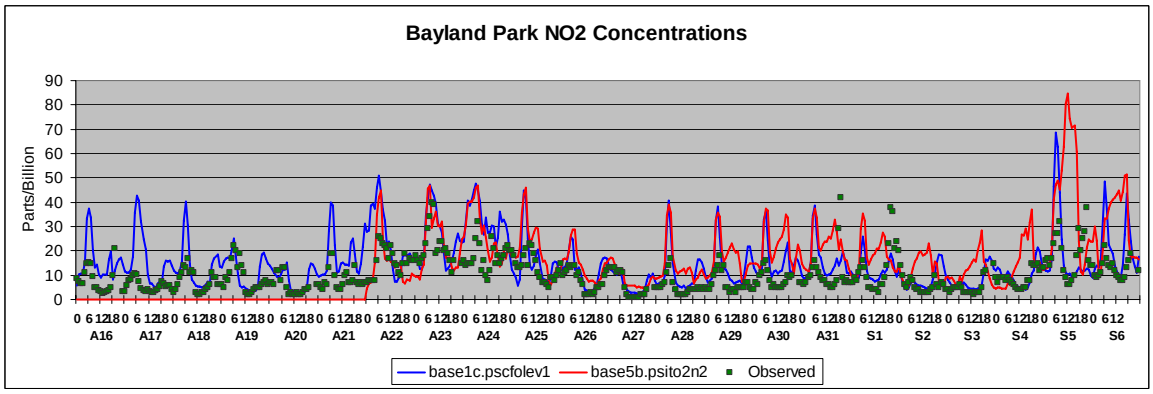
base5b.psito2n2
Observed


Bayland Park NO2 Concentrations
Parts/Billion
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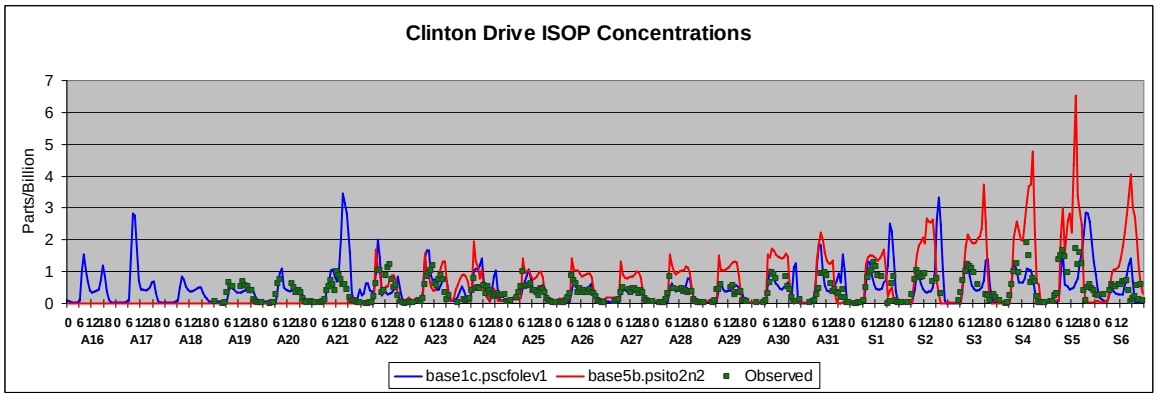
base5b.psito2n2
Observed


Clinton Drive ISOP Concentrations
Parts/Billion
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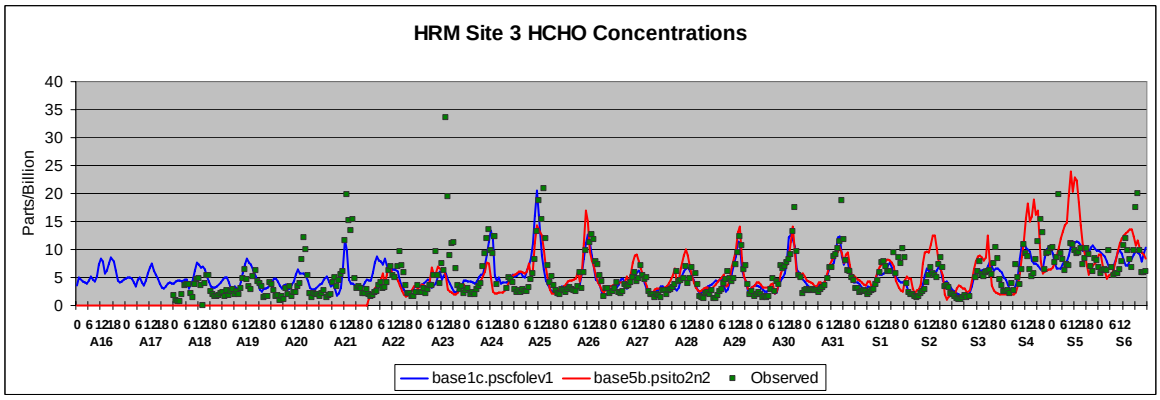
Observed


HRM Site 3 HCHO Concentrations
Parts/Billion
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base5b.psito2n2
Observed

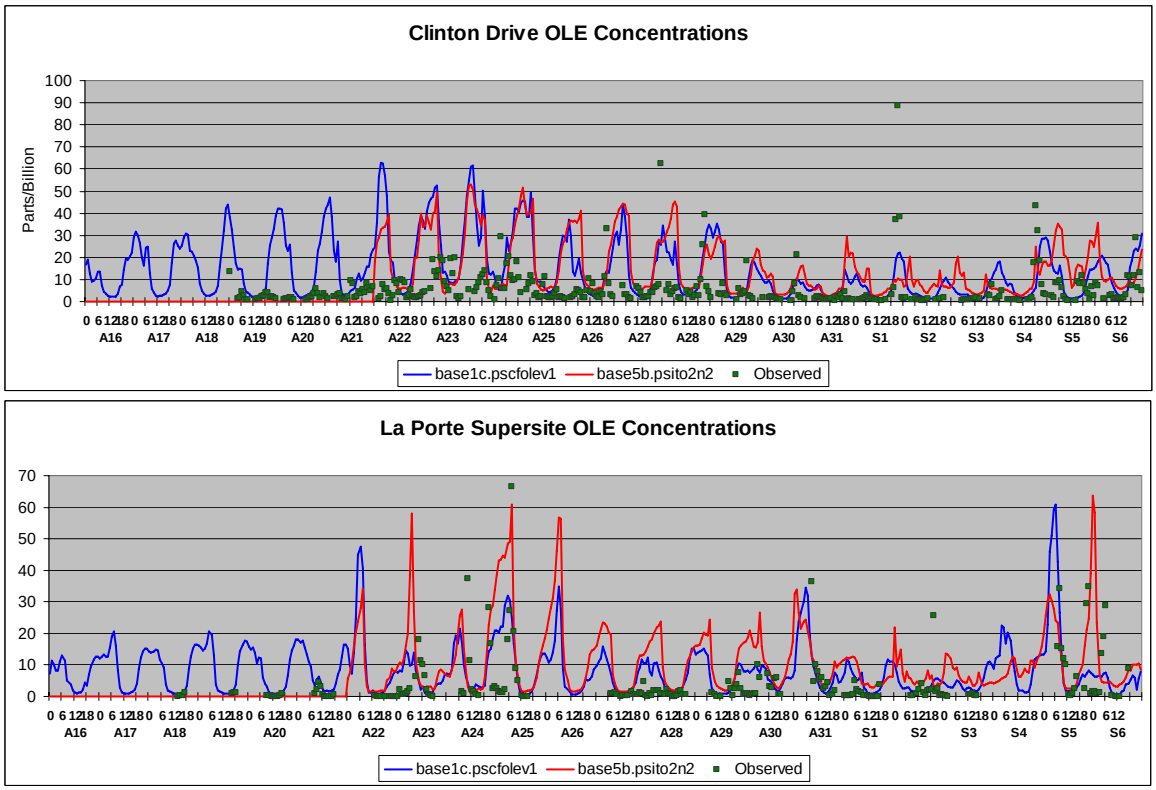

Figure 2-33: Six Selected Time Series Plots of Relevant Constituents and Ozone Precursor Concentrations (Continued From Previous Page)

in the region. This could be an indication that in the model NO is inappropriately titrating ozone and creating NO_2. The cause of this imbalance may be due to vertical mixing complexities, emissions modeled, the model's chemistry, or some combination of these. The analysis of Texas Air Quality Study II (TexAQS II) data should help elucidate the causes of the over-estimation of NO_2.

The third panel shows modeled and monitored concentrations of isoprene at Clinton Drive. The current modeling replicates the isoprene more closely than the previous modeling.

The fourth panel shows modeled and monitored concentrations of formaldehyde, a relevant constituent, at HRM3. The current modeling is somewhat better than the previous modeling, but both reproduce the monitored formaldehyde concentrations quite well. Most atmospheric formaldehyde forms as a product of the oxidation of HRVOC, hence observed concentrations of formaldehyde are related to the emissions of HRVOC. Significantly, if the model is run without imputing additional HRVOC emissions, modeled formaldehyde concentrations are too low on several days of the episode.

The final two panels of Figure 2-33 show modeled and monitored concentrations of the model species OLE at Clinton Drive and the LaPorte airport, respectively. The OLE species represents a variety of olefins excluding ethylene, but is largely composed of propylene, which is one of the HRVOC. At Clinton Drive, the model actually performs reasonably well during daylight hours. Similarly, at the LaPorte airport site, the modeled OLE concentrations are close to the monitored

concentrations except during some overnight periods. The overall agreement at LaPorte appears to be better than that at Clinton Drive, but that may be in part because LaPorte does not have as many nighttime observations as the Clinton Drive Site. The potential causes for the excessive overnight OLE concentrations are similar to those discussed earlier for NO_2, vertical mixing complexities, emissions modeled, the model's chemistry, or some combination. The TexAQS II data will help provide insight into the question of OLE overestimation.

Figure 2-34: *Eight-Hour Ozone Scatterplots by Episode Day, Monitor Location, and All Data Plotted as a Quantile-Quantile Plot*, shows three scatter plots comparing monitored and modeled eight-hour peak ozone concentrations.

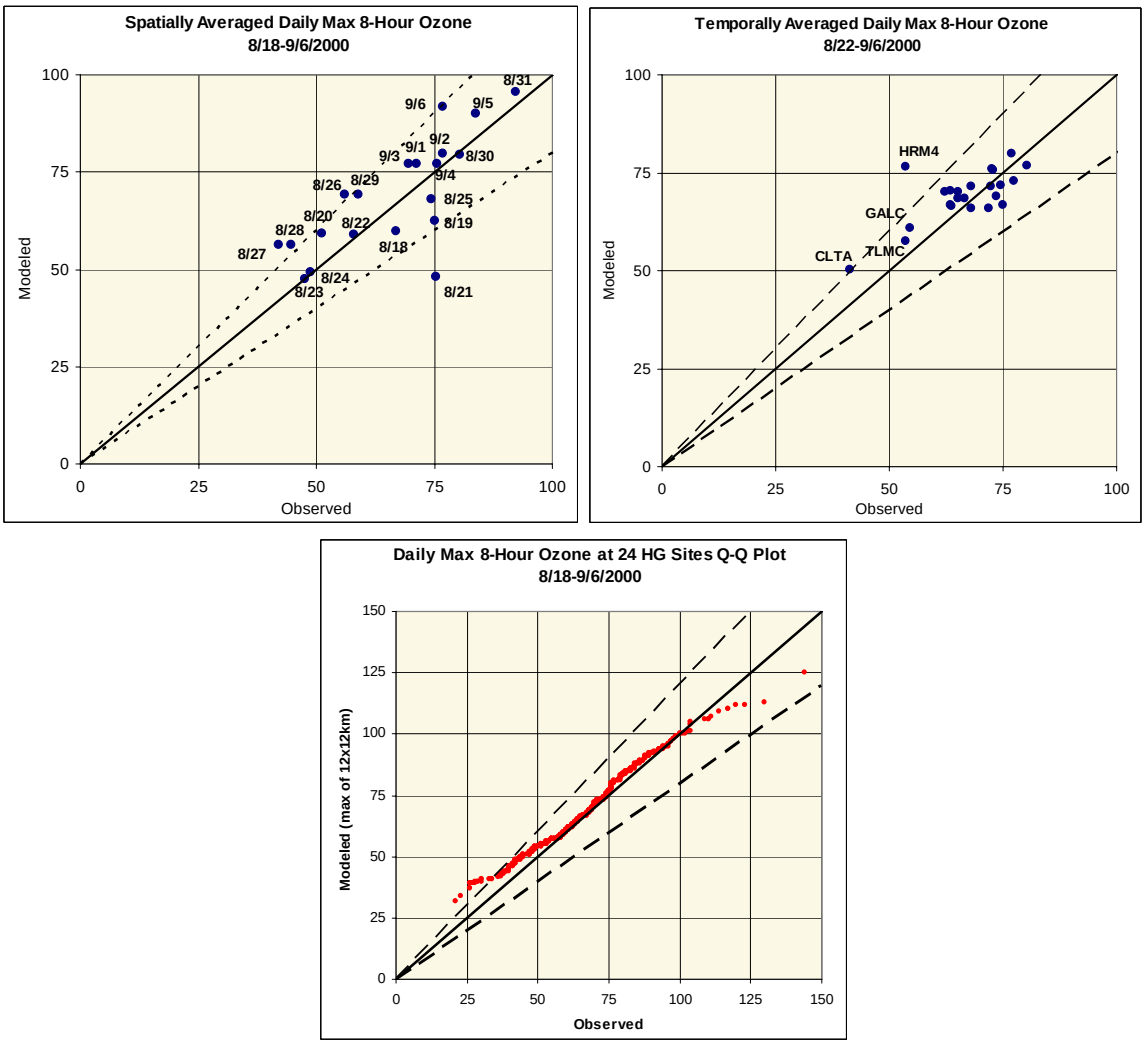

Figure 2-34: Eight-Hour Ozone Scatterplots by Episode Day, Monitor Location, and All Data Plotted as a Quantile-Quantile Plot

The upper left-hand plot shows maximum daily eight-hour ozone concentrations by day, averaged across all monitors in the eight-county HGB nonattainment area. The dashed lines represent ±20 percent deviation from monitored concentrations. On 16 of the 20 episode days the model agrees

well with the monitored maximum daily eight-hour ozone concentrations, but shows a negative bias on August 21 and over-predicts peak ozone by over 20 percent on August 26-28.

The upper right-hand plot shows maximum daily eight-hour ozone concentration by monitor, averaged across days. Most monitors are clustered around a point where both monitored and modeled maximum daily eight-hour ozone concentrations are about 70 ppb. Only monitoring sites outside of this area are individually labeled. HRM4 is notable because of the model's over-prediction of ozone. Since HRM4 is in eastern Harris County not far from other monitors with higher monitored ozone, it is likely that the site experiences NO_X titration from local sources not correctly represented in the model. Clute (labeled CLTA) also shows over-prediction of ozone by a little over 20 percent. The model replicates the average maximum daily eight-hour ozone concentrations reasonably well at the other two sites with lower monitored ozone concentrations, Galveston (GALC) and Texas City/La Marque (TLMC).

The bottom plot is a quantile-quantile plot of monitored vs. modeled maximum daily eight-hour ozone concentrations across all sites and days. Both the monitored and modeled concentrations are sorted from smallest to largest, then the sorted values are plotted against each other (smallest monitored, smallest modeled; 2nd smallest monitored, 2nd smallest modeled, etc). While this technique loses all information about time and space, it provides a comparison of the distribution of modeled versus monitored concentrations. The plot shows that the modeled distribution of maximum daily eight-hour ozone concentrations closely matches the monitored distribution where monitored ozone is between about 60 and 110 ppb.

Overall the graphical performance for the current modeling is acceptable and provides a reasonable representation of not only the observed ozone concentrations but also the fundamental physical and chemical processes which result in the formation of high levels of ozone. Therefore, the TCEQ is confident that the modeling in this proposed SIP revision provides an appropriate platform for predicting future air quality.

2.7 FUTURE CASE MODELING BASELINE AND MODELING SENSITIVITIES

2.7.1 2009 Baseline

The 2009 baseline photochemical CAMx modeling was conducted using the MM5-generated meteorological parameters for the 2000 episode and the 2009 baseline modeling emissions. As per the EPA guidance for estimating future eight-hour ozone design values, relative reduction factors (RRF) were calculated for each of the monitors with a year 2000 current design value (DVc). The RRF are calculated by taking the ratio of the daily average 2009 baseline modeling results to the daily average of the 2000 baseline modeling results. Figure 2-35: *2009 to 2000 Baseline Relative Reduction Factors by Monitor* shows the RRF calculated at each of the 20 monitors with a year 2000 DVc that exceeds the standard.

Multiplying these RRF by the appropriate monitor's DVc yields the estimated future design value (DVf). That is;

$$DVf = RRF * DVc$$

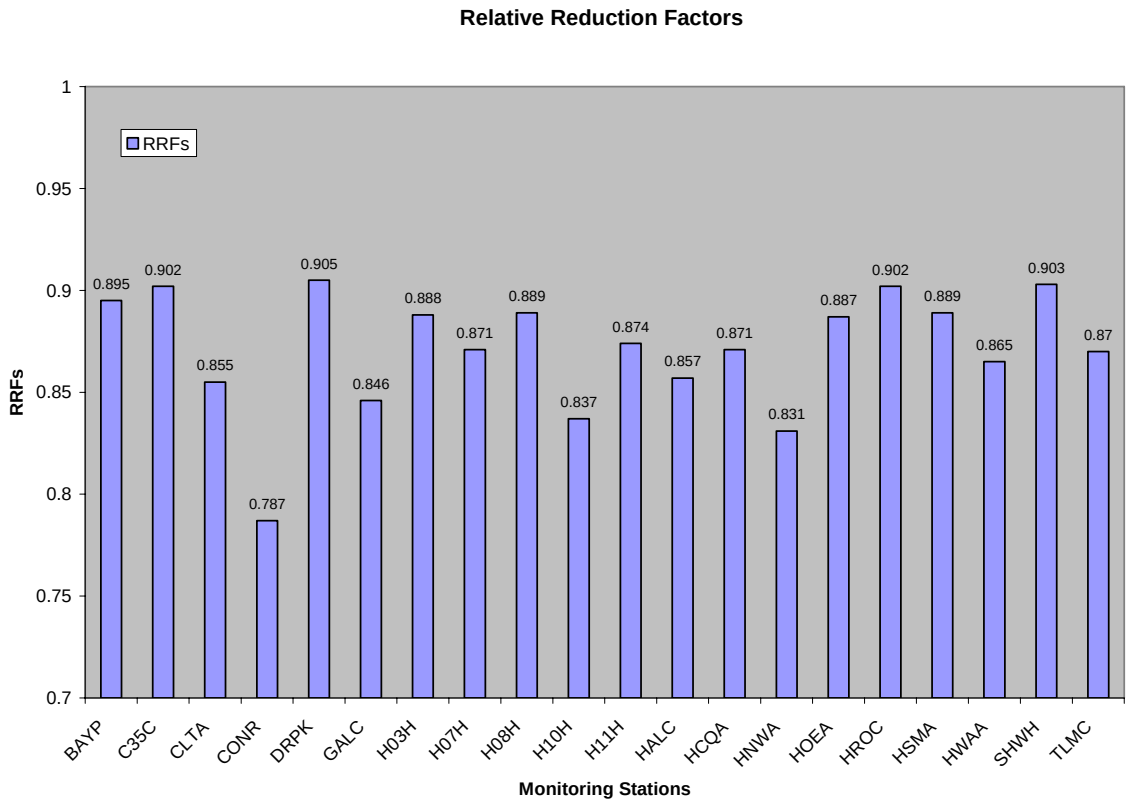

Figure 2-35: 2009 to 2000 Baseline Relative Reduction Factors by Monitor

Figure 2-36: *Current and 2009 Future Eight-Hour Ozone Design Values by Monitor*, shows the year 2000 DVc and estimated 2009 DVf for each of the 20 monitors with a year 2000 DVc of 85 ppb or greater. For the 2009 baseline, 11 of the 20 monitors are projected to move from modeling 85 ppb or greater in 2000 to modeling less than 85 ppb in 2009. Table 2-6: *Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling Attainment in 2009*, summarizes the DVc and DVf values for these 11 monitors. Nine of the 20 monitors are projected to remain at or above 85 ppb. Table 2-7: *Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling 85 ppb or Greater in 2009*, summarizes the DVc and DVf values for these nine monitors. The Deer Park monitor has the highest DVf at 97 ppb.

Additionally, the exceedance area (the area and population with projected eight-hour ozone of 85 ppb or higher) and the number of episode days with projected exceedances, are reduced in the 2009 baseline. For the 18 episode days with modeled exceedances in the 2000 baseline, on average only 20.1 percent of the exceedance area remains in the 2009 baseline. (Note: ozone exceedances were not modeled or monitored for August 23 or 24). Figure 2-37: *Modeled Area of Exceedance for the 2000 and 2009 Baselines* shows the reductions in the exceedance area for each of the exceedance days.

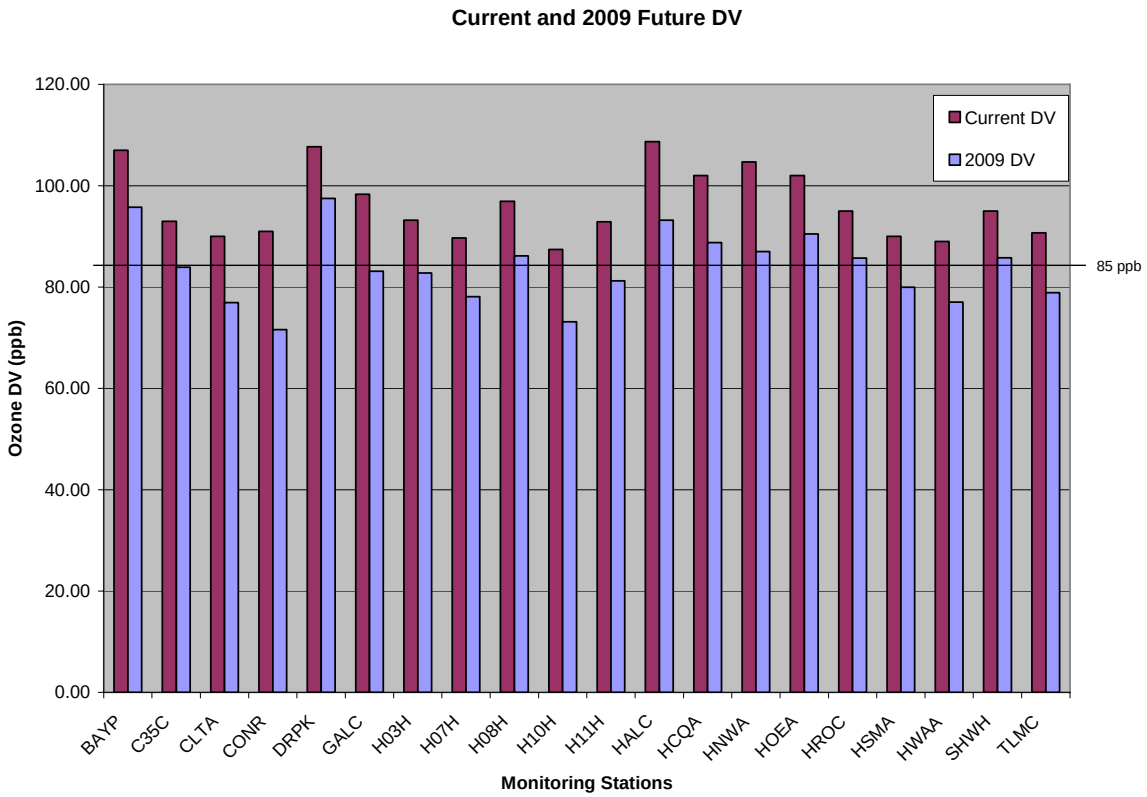

Figure 2-36: Current and 2009 Future Eight-Hour Ozone Design Values by Monitor

Table 2-6: Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling Attainment in 2009

Monitoring Site (Code)	Current 2000 and Future 2009 Design Values		Design Value Change (ppb)
	2000 DVc (ppb)	2009 DVf (ppb)	
Clinton Drive (C35C)	93.0	83.9	9.1
Clute (CLTA)	90.0	76.9	13.1
Conroe (CONR)	91.0	71.6	19.4
Galveston County (GALC)	98.3	83.1	15.2
HRM 3, Haden Road (H03H)	93.2	82.8	10.4
HRM 7, West Baytown (H07H)	89.7	78.1	11.6
HRM 10, Mont Belvieu (H10H)	87.4	73.1	14.3
HRM 11, East Baytown (H11H)	92.9	81.2	11.7
Swiss & Monroe (HSMA)	90.0	80.0	10.0
North Wayside (HWAA)	89.0	77.0	12.0
Texas City (TLMC)	90.7	78.9	11.8

Table 2-7: Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling 85 ppb or Greater in 2009

Monitoring Site (Code)	Current 2000 and Future 2009 Design Values		Design Value Change (ppb)
	2000 DVc (ppb)	2009 DVf (ppb)	
Bayland Park (BAYP)	107.0	95.8	11.2
Deer Park (DRPK)	107.7	97.5	10.2
HRM 8, La Porte (H08H)	96.9	86.1	10.8
Aldine (HALC)	108.7	93.2	15.5
Croquet (HCQA)	102.0	88.8	13.2
Northwest Harris (HNWA)	104.7	87.0	17.7
Houston East (HOEA)	102.0	90.5	11.5
Houston Regional Office (HROC)	95.0	85.7	9.3
Westhollow (SHWH)	95.0	85.7	9.3

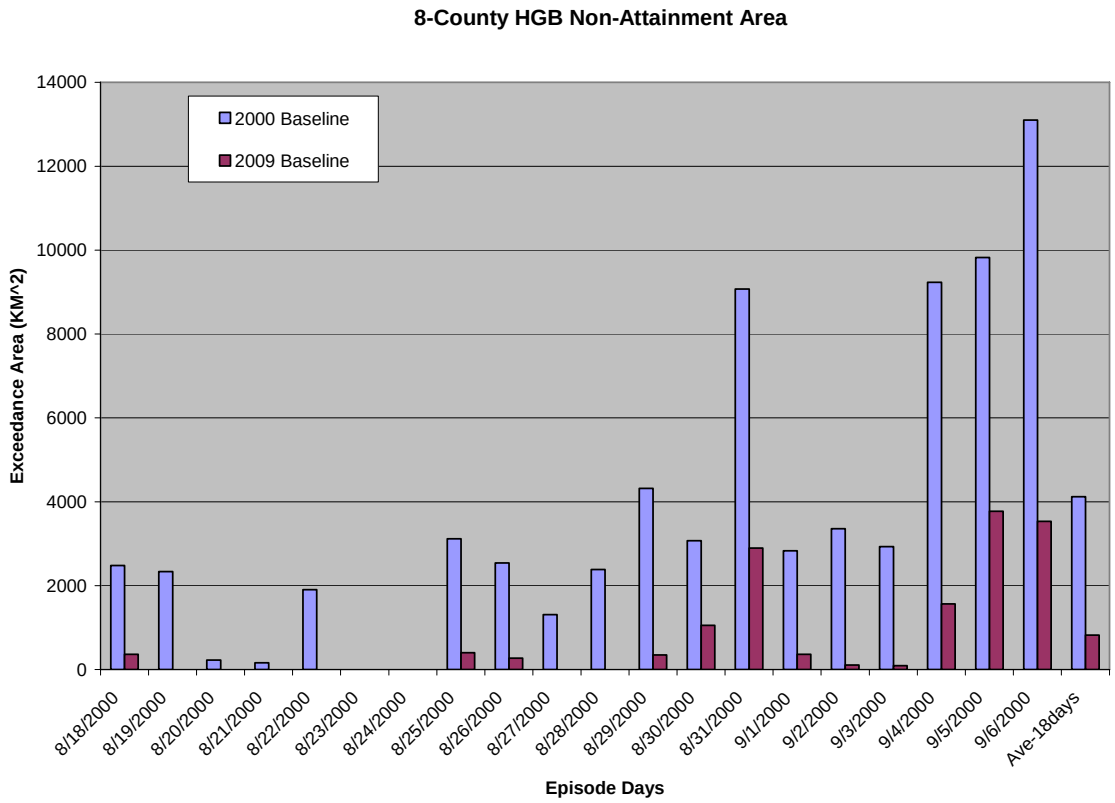

Figure 2-37: Modeled Area of Exceedance for the 2000 and 2009 Baselines

Further, of the 18 episode days with modeled ozone at 85 ppb or greater in the 2000 baseline, six episode days do not model 85 ppb or greater in the 2009 baseline, and 12 episode days continue to model exceedances in the 2009 baseline. Table 2-8: *2009 Baseline Modeling Summary* summarizes the 2009 baseline changes from the 2000 baseline.

Table 2-8: 2009 Baseline Modeling Summary

Emissions Changes			Results in Eight-County HGB Area			
2009 Baseline from:	NO_X (tpd)	VOC (tpd)	DVf Change @ DRPK	Change in Sites at 85 ppb or Greater	Average Change in Area at 85 ppb or Greater	Change in Days at 85 ppb or Greater
2000 Baseline	-563	-221	-10 ppb (107 to 97 ppb)	11 sites (20 to 9 sites)	- 3295 km^2 (-79.9%)	6 days (18 to 12 days)

2.7.2 H-GAC and TxLED Sensitivity Modeling

A modeling sensitivity run was conducted to determine the effect of emissions reductions including the cumulative 5.3 tpd of NO_X reductions from the H-GAC's original VMEP estimate (4.4 tpd) and the TxLED Marine Diesel Rule (0.9 tpd). (The VMEP estimate was revised to 2.82 tpd after this sensitivity run was performed.) These proposed controls (at 5.3 tpd) reduce the 2009 baseline NO_X emissions by approximately 1.2 percent.

Modeling the 5.3 tpd NO_X emissions reduction decreased the projected DVf at all nine monitors projected to be at or above 85 ppb in the 2009 baseline. The average reduction in the projected 2009 DVf for these nine sites is approximately -0.15 ppb, and there is no reduction in the number of monitors at or above 85 ppb, which remains at nine. In the 2009 baseline, the Deer Park (DRPK) monitor's DVf is the highest at 97.5 ppb. With the 5.3 tpd NO_X emissions reduction, the DRPK monitor's DVf remains the highest at 97.4 ppb, which does not decrease the DVf upon applying the EPA truncating convention for the eight-hour ozone NAAQS.

In addition, this NO_X emissions reduction decreased the exceedance area on a number of episode days. In the 2009 baseline, the average exceedance area is 809.8 km^2 and there are 12 days with projected ozone values at or above 85 ppb. With the combined 5.3 tpd NO_X emissions reduction in on- and non-road mobile sources, and ship emissions, the exceedance area is reduced by 2.5 percent and the number of days with projected ozone values at or above 85 ppb remains at 12 days.

Table 2-9: *2009 H-GAC and TxLED Sensitivity Modeling Summary* summarizes the changes from the 2009 baseline of the proposed H-GAC and TxLED controls.

Table 2-9: 2009 H-GAC and TxLED Sensitivity Modeling Summary

Emissions Changes			Results in Eight-County HGB Area			
Change from 2009 Baseline	NO_X (tpd)	VOC (tpd)	DVf Change @ DRPK	Change in Sites at 85 ppb or Greater	Average Change in Area at 85 ppb or Greater	Change in Days at 85 ppb or Greater
H-GAC On- & Non-Road Plus TxLED Marine NO_X Reduction	-5.3	0.0	-0.13 ppb (97.5 to 97.4 ppb)	0 sites (9 to 9 sites)	- 20.5 km^2 (-2.5%)	0 days (12 to 12 days)

2.7.3 Reduction Matrix Sensitivity Run--Across All Source Categories

Starting with the 2009 baseline, a matrix of hypothetical reductions of anthropogenic NO_X, VOC, and combined NO_X and VOC emissions was modeled. Across-the-board emissions reduction levels of 25, 50 and 75 percent were applied uniformly to all source categories. The purpose of this analysis was to test the effect of emissions reductions on the projected eight-hour ozone design values. Figure 2-38: *2009 Ozone DVf Response to NO_X and VOC Emissions Reductions*, shows the results of the matrix modeling, which indicates that combined NO_X and VOC emission reductions are slightly more effective than just NO_X emission reductions in reducing the projected eight-hour ozone design values. The curves indicate that combined NO_X and VOC reductions of 53 percent each or NO_X-only reductions of 58 percent may be needed to reach attainment. However, the needed emission reductions are probably over-estimated, since all source categories were reduced uniformly. Just as predicted eight-hour ozone design values respond differently to reductions of NO_X versus VOC, the DVf will likely respond differently to comparable mass emission reductions from various source categories (e.g., point sources versus on-road mobile).

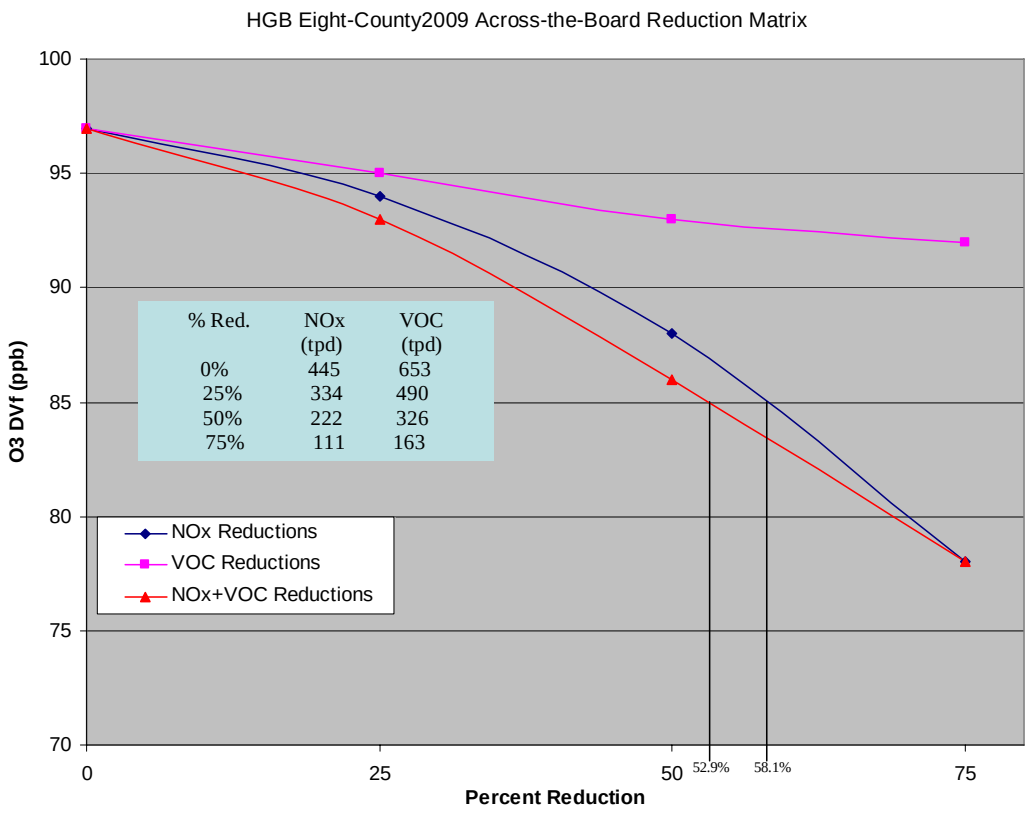

Figure 2-38: 2009 Ozone DVf Response to NO_X and VOC Emissions Reductions

2.7.4 Reduction Matrix Sensitivity Run - Point Source VOC

Starting with the 2009 baseline, a matrix of hypothetical VOC emissions reductions was applied to the point source category within the eight-county HGB area at levels of 25, 50, and 75 percent. These hypothetical VOC emissions reductions amounted to overall reductions of 65 tpd, 130 tpd and 196 tpd, respectively, from the 261 tpd of point source VOC in the 2009 baseline. The purpose of this analysis was to test the effect of emissions reductions on the projected eight-hour ozone design values. Table 2-10: *Summary of the Point Source VOC Reduction Matrix Sensitivity Run*, shows the results of the matrix modeling, indicating that VOC reductions of 25, 50, and 75 percent would reduce the design value at the monitor with the highest projected future design value by 1, 2, and 3.2 ppb, respectively, and would result in reduced exceedance areas across all three reduction values by 65, 128, and 185 km^2, respectively. The 25 percent reduction did not reduce the number of days at or above 85 ppb. However, the 50 and 75 percent reductions projected a reduction of the number of days at or above 85 ppb by 3 and 4 days, respectively.

Table 2-10: Summary of the Point Source VOC Reduction Matrix Sensitivity Run

Emissions Changes			Results In Eight-County HGB Area			
Change from 2009	NO_X (tpd)	VOC (tpd)	Average DVf change	DVf Change Max. Mon	Average Change in Area at 85 ppb or Greater	Change in Days at 85 ppb or Greater
25% Point Source VOC Reduction	0.0	-65	-0.65 ppb	-1.0 ppb (DRPK)	- 65 km^2 (-8.1%)	0 days (12 to 12 days)
50% Point Source VOC Reduction	0.0	-130	-1.35 ppb	-2.0 ppb (DRPK)	- 129 km^2 (-16.3%)	3 days (12 to 9 days)
75% Point Source VOC Reduction	0.0	-196	-2.09 ppb	-3.2 ppb (DRPK)	- 185 km^2 (-23.3%)	4 days (12 to 8 days)

2.7.5 Reduction Sensitivity Matrix Sensitivity Run - H-GAC and TxLED and Ground-Level NO_X Modeling Matrix

A modeling sensitivity was conducted to determine the effect on projected future eight-hour ozone metrics of reducing ground-level sources of NO_X emissions within the eight-county HGB nonattainment area. (Ground-level sources, as used here, includes primarily on-road mobile and non-road mobile sources; it also includes some point and area sources which may have stack height and or plume rise up to 30 meters.) In addition to the 2009 H-GAC plus TxLED marine modeling sensitivity, a matrix of hypothetical NO_X emissions reductions was applied to the ground-level source categories within the eight-county HGB area at levels of 25, 50 and 75 percent. These NO_X emissions reductions amounted to overall reductions of 62 tpd, 124 tpd, and 186 tpd, respectively, from the 248 tpd of ground-level NO_X in the 2009 H-GAC plus TxLED marine scenario.

With a 25 percent reduction in ground-level NO_X (62 tpd), the average reduction in the projected 2009 DVf for the nine sites at or above 85 ppb is approximately -2.4 ppb, and the number of monitors at or above 85 ppb is reduced to five. The DRPK monitor's DVf, which is the highest,

was reduced from 97.4 ppb to 95.8 ppb, which results in a 2 ppb reduction in the DVf after applying the EPA truncating convention for the eight-hour ozone NAAQS. With a 50 percent reduction in ground-level NO_X (124 tpd), the average reduction in the projected 2009 DVf for the nine sites at or above 85 ppb is approximately -5.5 ppb, and the number of monitors at or above 85 ppb is reduced to four. The DRPK monitor's DVf, which is the highest, was reduced from 97.4 ppb to 93.5 ppb, which reduces the DVf by 4 ppb after applying the EPA truncating convention for the eight-hour ozone NAAQS. With a 75 percent reduction in ground-level NO_X (186 tpd), the average reduction in the projected 2009 DVf for the nine sites that are projected to be 85 ppb or higher is approximately -9.8 ppb, and the number of monitors at or above 85 ppb is reduced to one. The DRPK monitor's DVf, which is the highest, was reduced from 97.4 ppb to 90.3 ppb, which reduces the DVf by 7 ppb after applying the EPA truncating convention for the eight-hour ozone NAAQS.

Table 2-11: *2009 H-GAC and TxLED and Ground-Level NO_X Modeling Matrix Summary* summarizes the changes from the 2009 baseline of the proposed H-GAC and TxLED controls.

Table 2-11: 2009 H-GAC and TxLED and Ground-Level NO_X Modeling Matrix Summary

Emissions Changes			Results in Eight-County HGB Area			
Change from 2009 H-GAC & TxLED Marine	NO_X (tpd)	VOC (tpd)	DVf Change @ DRPK	Change in Sites at 85 ppb or Greater	Average Change in Area at 85 ppb or Greater	Change in Days
25% Ground-level NO_X Reduction	-62	0	-1.6 ppb (97.4 to 95.8)	4 sites (9 to 5)	- 242 km^2 (-27.3%)	1 days (12 to 11 days)
50% Ground-level NO_X Reduction	-124	0	-3.9 ppb (97.4 to 93.5)	5 sites (9 to 4)	- 366 km^2 (-46.4%)	7 days (12 to 5 days)
75% Ground-level NO_X Reduction	-186	0	-7.1 ppb (97.4 to 90.3)	8 sites (9 to 1)	- 476 km^2 (-60.4%)	7 days (12 to 5 days)

2.7.6 Ship Channel Zero-Out Test

A modeling test was conducted to estimate the 2009 future design value assuming all of the point source emissions and shipping emissions in the HSC were removed. The HSC, for the purposes of this model run, includes sources along the main channel, primarily in Harris County, but does not include sources in the Bayport, Channelview, or Mont Belvieu areas. Figure 2-39: *Houston Ship Channel 4-km Mask, Extent of Modeling Run*, shows the HSC, as defined for this test.

From the 2009 emissions estimates, 69 tpd of NO_X and 109 tpd of VOC were removed. The subset removed represents approximately 16 percent of the total NO_X and 21 percent of the total VOC in the eight-county HGB area. Table 2-12: *Houston Ship Channel Zero-Out Test*, lists the future design values for the 2009 baseline and this modeling sensitivity.

As the table shows, even if the emissions associated with the HSC are removed, six of the nine monitors would still not model attainment and the area's design value would be 93 ppb at the

Bayland Park (BAYP) monitor. This modeling sensitivity indicates that even with a sizable decrease in emissions associated with the HSC, there are still enough ozone precursors from other sources in the HGB area for ozone levels to exceed the standard.

Figure 2-39: Houston Ship Channel 4-km Mask, Extent of Modeling Run

Table 2-12: Houston Ship Channel Zero-Out Test

Monitoring Site (Code)	Future 2009 Design Values	
	Baseline DVf (ppb)	w/o HSC DVf (ppb)
Bayland Park (BAYP)	95	93
Deer Park (DRPK)	97	91
HRM 8, La Porte (H08H)	86	80*
Aldine (HALC)	93	88
Croquet (HCQA)	88	86
Northwest Harris (HNWA)	87	85
Houston East (HOEA)	90	86
Houston Regional Office (HROC)	85	83*
Westhollow (SHWH)	85	84*

* denotes monitors below 85 ppb

2.8 2018 ANALYSIS

A technical analysis, using a limited data set, was performed for the HGB in 2018. The previously described 2009 H-GAC/TxLED sensitivity run and the Ground-Level NO_X Modeling Matrix results were used to estimate how many tons of ground-level NO_X reduction would be needed to reduce the monitors predicted to be 85 ppb or higher to below 85 ppb by 2018. See Table 2-13: *NO_X Reduction Estimated from 2009 to 2018*. Ground-level NO_X reductions were the focus of this analysis because many of the federal emissions control measures scheduled to come on-line between 2009 and 2018 are applicable to ground-level emissions sources, e.g., on-road and non-road mobile.

Table 2-13: NO_X Reduction Estimated from 2009 to 2018

Monitor Site (Code)	NO_X Reduction needed to get below 85 ppb
Deer Park (DRPK)	256 tpd
Bayland Park (BAYP)	174 tpd
Houston East (HOEA)	152 tpd
Aldine (HALC)	135 tpd
Croquet (HCQA)	82.6 tpd
HRM 8, La Porte (H08H)	45.4 tpd
Northwest Harris (HNWA)	33.5 tpd
Houston Regional Office (HROC)	19.7 tpd
Westhollow (SHWH)	14.5 tpd

In a separate effort, mobile source emissions changes anticipated by 2018 were estimated. To show long-term trends, future on-road mobile emissions were projected to 2015, 2018, 2020, 2025, 2030, and 2035. Emissions were projected by coupling on-road VMT growth (at 2 percent per year) with the reduced emission factors arising from federal vehicle and fuel requirements. The final estimates included the emissions benefit of vehicle I/M, TxLED, and reformulated gasoline, but did not include adjustments for TERP, VMEP, TCM, or the proposed eight-hour ozone control measures detailed in Chapter 4. Figure 2-40: *Future Eight-County On-Road Mobile Emissions* shows the resulting predicted weekday emissions of NO_X and VOC. A NO_X reduction of approximately 110 tpd in on-road mobile source emissions is expected between 2009 and 2018.

The National Mobile Inventory Model (NMIM) was run with default assumptions to estimate future non-road emissions reductions for the same future years. The results of this analysis are shown in Figure 2-41: *Future Eight-County Non-Road Emissions Based on NMIM Default Inputs*. A reduction of approximately 30 tpd in non-road mobile source emissions is expected between 2009 and 2018.

NMIM does not address emissions from ships, aircraft and locomotives, and growth is anticipated in these categories, although it is not explicitly accounted for in this analysis. Area sources were also not specifically accounted for in this analysis and are also anticipated to grow between now and 2018. Further, care must be taken not to double-count emissions reductions already accounted for by TERP.

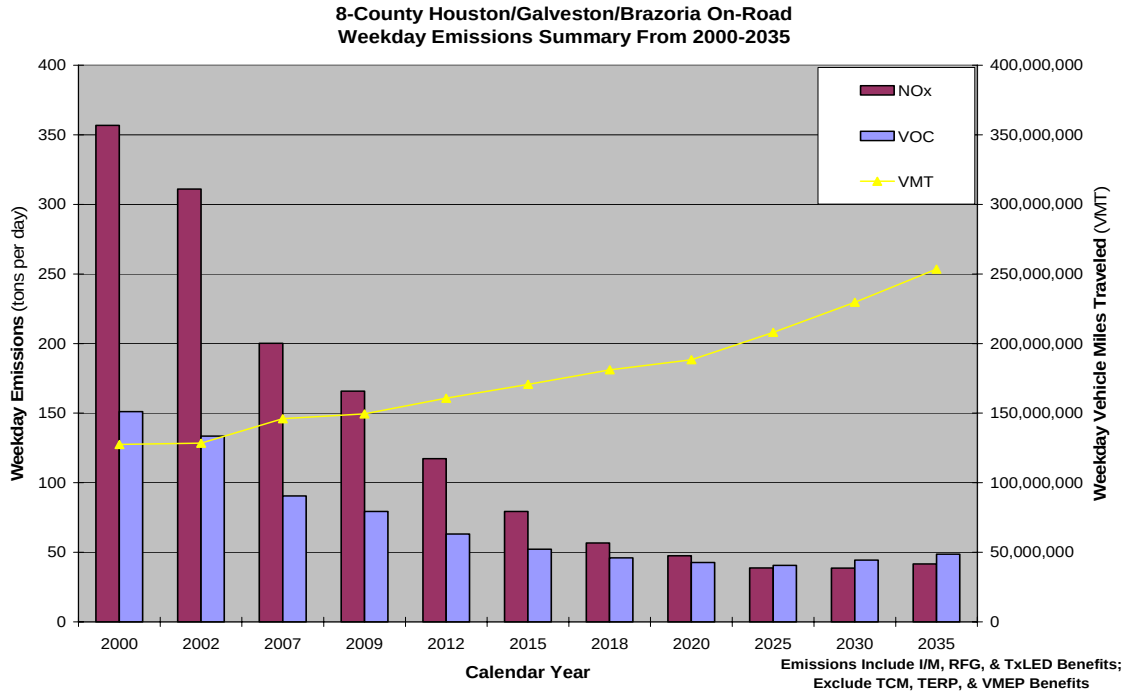

Figure 2-40: Future Eight-County On-Road Mobile Emissions

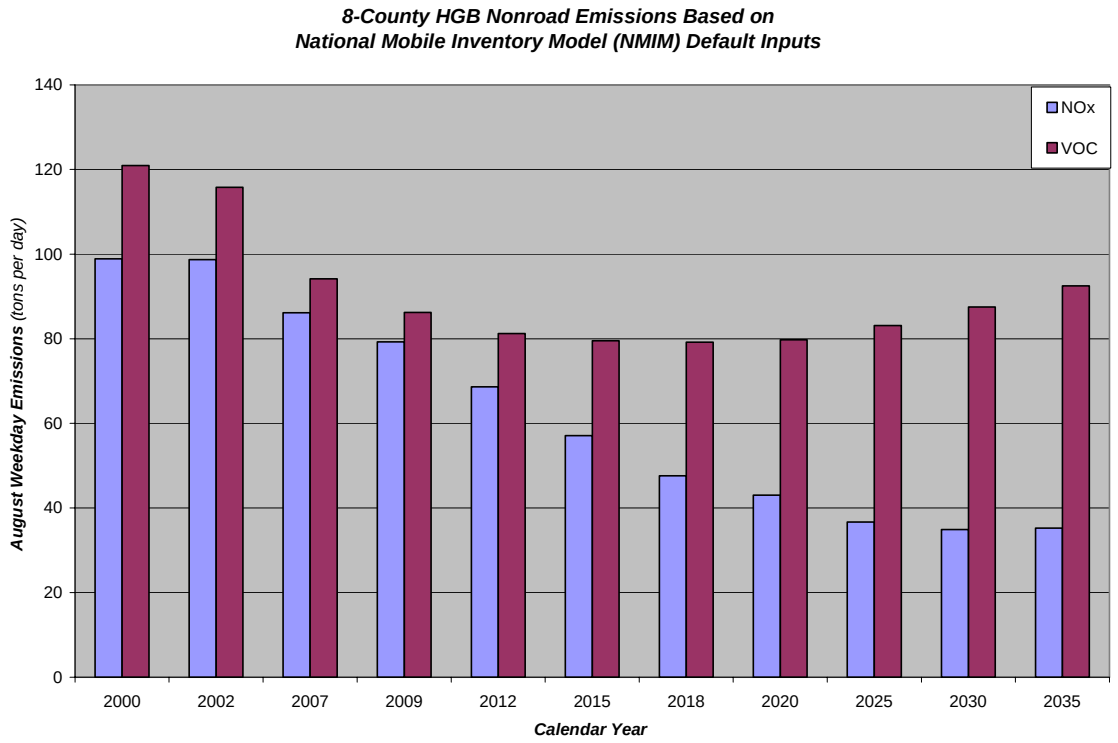

Figure 2-41: Future Eight-County Non-Road Emissions Based on NMIM Default Inputs

Finally, for this analysis, point sources were assumed to remain constant from 2009 to 2018. Although CAIR Phase II will be in place in 2018 and should result in reductions in Texas, the banking and trading component of these regulations makes it difficult to predict actual reductions resulting from the program. Based on federal nonattainment New Source Review requirements, NO_X emissions are not likely to increase in this area.

Table 2-14: *HGB Eight-County Nonattainment Area Estimated 2018 Mobile Source NO_X Emissions* summarizes the mobile source emissions changes between 2009 and 2018 because the available information for these sources is more quantitative than changes described for other emissions categories.

Table 2-14: HGB Eight-County Nonattainment Area Estimated 2018 Mobile Source NO_X Emissions

Source Category	2009	2018
On-Road Mobile	163 tpd	53 tpd
Non-Road Mobile	78 tpd	48 tpd
Total TERP + VMEP (on-road & non-road)	-42 tpd	NA
Subtotal On-Road & Non-Road	199 tpd	101 tpd
2009 to 2018 difference	NA	98 tpd

The 2009 to 2018 anticipated mobile source emissions reductions were compared with the results of the ground-level NO_X reduction matrix modeling (Table 2-13). Five of the monitors, Westhollow, Houston Regional Office, Northwest Harris, HRM8 - La Porte, and Croquet, are expected to be below 85 ppb in 2018, even factoring in the stated uncertainties and assuming net growth of no more than 10 to 20 tpd in emissions from those ground-level sources described previously as expected to grow.

Although this analysis shows that further progress will be made in air quality by 2018, there are four monitors (Deer Park, Bayland Park, Houston East, and Aldine) in the HGB area that are estimated to be 85 ppb or greater in 2018. Data collected during TexAQS II will likely provide further insight into ozone formation in HGB and guidance on potentially effective control strategies that may assist the effort to bring the HGB area into attainment by 2018.

2.9 FUTURE WORK

The next modeling effort for HGB will be to develop a new ozone episode (using days from 2005 and/or 2006) and the corresponding meteorological characterization and EI. In establishing this new base case, emphasis will be placed on replicating measured ozone and precursor concentrations. TexAQS II, as discussed in Chapter 5, will provide a wealth of new data and findings which will support model performance evaluation, and further characterization of ozone formation in the HGB area. Various external organizations have begun modeling exercises using episodic days from 2005 and 2006, and TCEQ will review and consider these other modeling efforts as work progresses.

Once the new base case is established, modeling a new future year will be the focus and the future year inventory will be developed. It will be determined what level of emissions reductions are needed for attainment demonstration. Following this determination, the TCEQ will proceed with a series of modeling runs testing the sensitivity of the future case to reductions in emissions of various source categories and the testing of potential control strategies as needed. This

technical work is expected to take between 18 and 24 months, and the TCEQ will work with stakeholders and interested parties through updates and briefings at the Southeast Texas Photochemical Modeling Committee meetings and other technical workshops as appropriate.

2.10 ACCESSING MODELING DATA

All documentation and modeling input/output files generated as part of the HGB eight-hour ozone SIP modeling have been archived. Dick Karp of the TCEQ is responsible for these products and may be reached by telephone at (512) 239-1462 or via e-mail, dkarp@tceq.state.tx.us for information regarding data access or project documentation.

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CHAPTER 3: CORROBORATIVE ANALYSIS

3.1 INTRODUCTION

This chapter describes data analyses that corroborate the conclusions of Chapter 2 regarding photochemical modeling. These analyses examine patterns and trends in population, ozone, and ozone precursors.

3.2 OZONE TRENDS

The one-hour and eight-hour ozone design values for the Houston-Galveston-Brazoria (HGB) area from 1991 to 2005 are illustrated in Figure 3-1: *One-Hour and Eight-Hour Ozone Design Values in the HGB Area (1991-2005) and HGB Area Population*. Both values decrease over the past 15 years. The 2005 one-hour design value was 169 parts per billion (ppb), representing a 23 percent decrease from the value for 1991 (220 ppb). The 2005 eight-hour design value was 103 ppb, a 13 percent decrease from the 1991 value of 119 ppb. These decreases occur in spite of a 36 percent increase in area population, as shown in the figure.

This figure also shows linear fit (trend) lines for both design values; these appear as black lines through each data series. Each line has an associated linear regression equation displayed. The eight-hour trend line suggests a decrease of about 0.9 ppb of ozone per year across the 15-year period. The one-hour trend line shows a decrease of nearly three ppb per year during the same time. Both decreases are statistically significant at the 95 percent confidence level.

Despite its repeal, the one-hour ozone standard is still an important metric for analysis. The HGB area has historically seen frequent, very high one-hour ozone concentrations. These have been strongly influenced by rapid, sharp ozone increases driven in part by high concentrations of highly-reactive volatile organic compounds (HRVOC) released by the numerous petrochemical plants in the area (Trainer; Ryerson et al). Regarding HGB air quality, the Texas Commission on Environmental Quality's (TCEQ) greatest priority in recent years has been to reduce the magnitude and frequency of these sharp ozone increases by regulating emissions of four species of HRVOC from area industrial facilities in combination with regulations that bring about substantial nitrogen oxides (NO_X) reductions. The decreases in NO_X and ambient HRVOC (see Section 3.4.1 of this document), suggest that the state has accomplished much in its efforts to control this important aspect of HGB ozone formation.

Another measure used to assess ozone trends is the number of exceedance days per ozone season. Figure 3-2: *HGB Ozone Exceedance Days per Monitor, 1990-2005 (monitors with 4 or more years)* shows a downward trend in the number of eight-hour ozone exceedance days per monitor across this fifteen-year period. See Figure 3-3: *Map of Ozone Monitors in the HGB Area* for HGB ozone monitor locations.

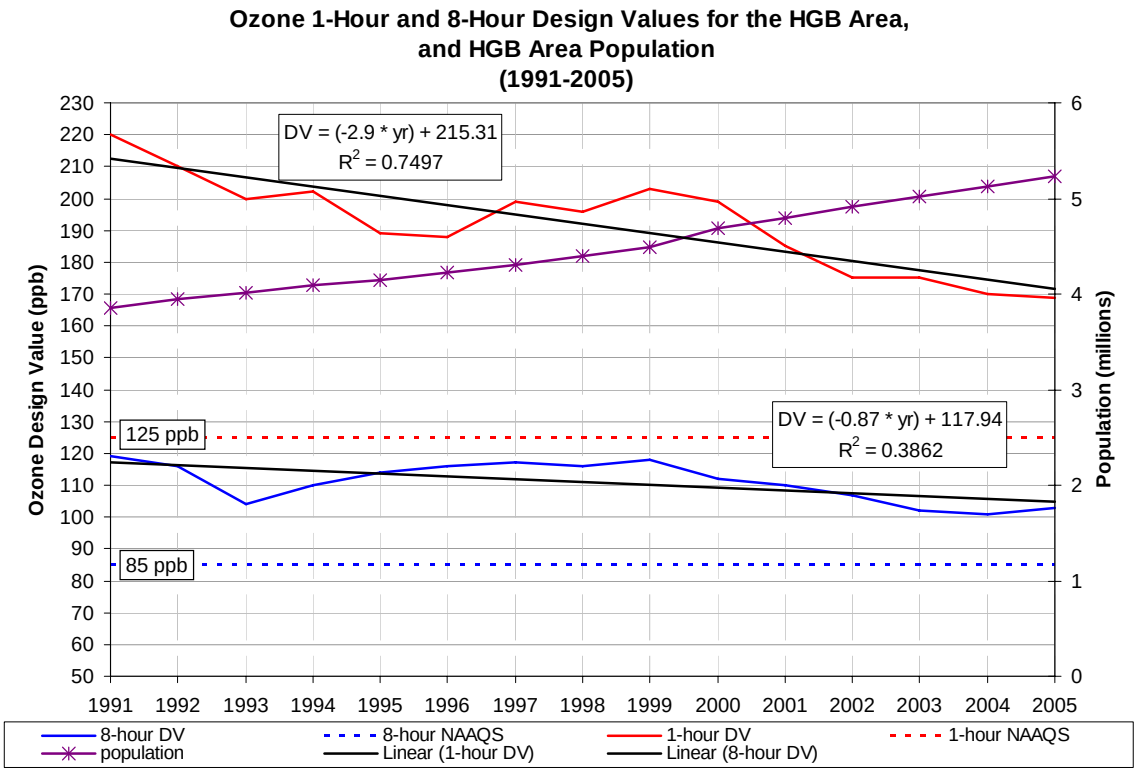

Figure 3-1: One-Hour and Eight-Hour Ozone Design Values in the HGB Area (1991-2005) and HGB Area Population

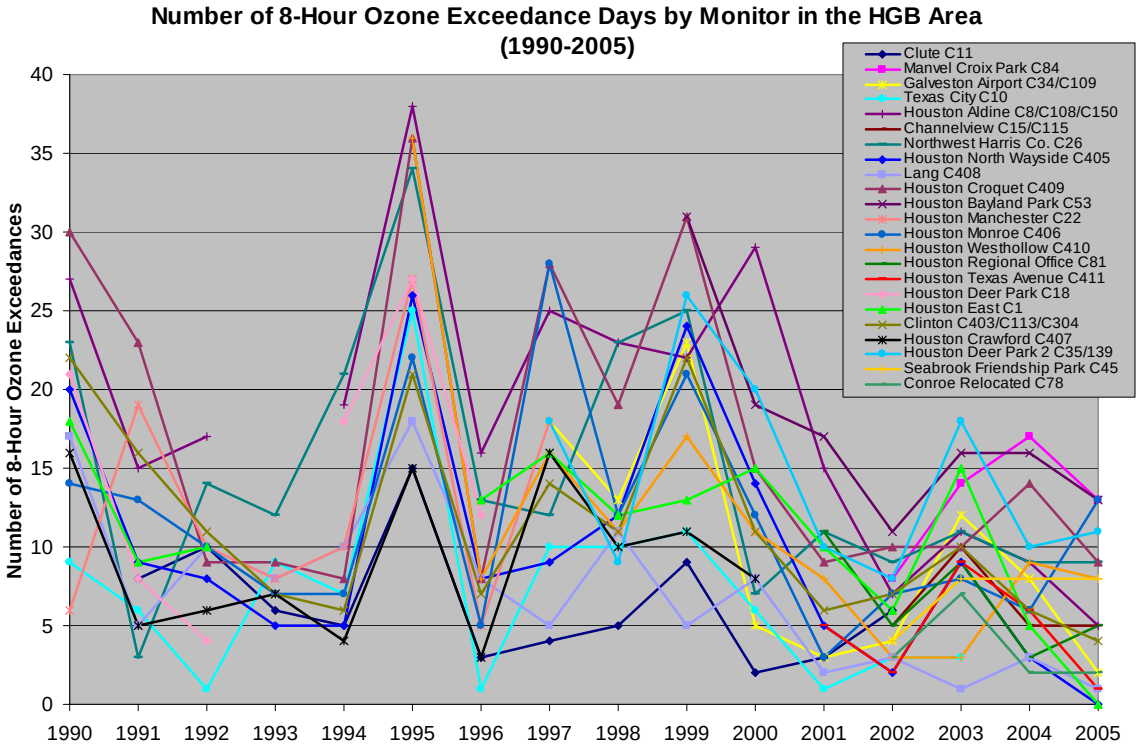

Figure 3-2: HGB Ozone Exceedance Days per Monitor, 1990-2005 (monitors with 4 or more years)

Figure 3-3: Map of Ozone Monitors in the HGB Area

3.3 POPULATION AND GEOGRAPHIC AREA ANALYSIS

Attainment or nonattainment of the eight-hour ozone standard for an area is determined by the eight-hour ozone design value, which is based on ambient measurements at monitor locations. A single monitor whose design value exceeds the National Ambient Air Quality Standard (NAAQS) can cause the entire area to be designated nonattainment. However, within the area designated nonattainment, there may be large areas (and large segments of the population) whose air quality

meets the standard. Put another way, if everyone in the area had an ozone monitor in their backyard, which of these hypothetical monitors would have design values that do not exceed the ozone NAAQS? This section describes the geographical areas in exceedance and the population exposed to concentrations exceeding the NAAQS for 2000 and 2009.

Radius of Representation

In many rural areas, a properly sited monitor should be representative of the air quality for many miles in all directions. However, in an urban area like HGB, with its complex patterns of land use, emission sources, and coastal meteorology, many of the monitors are only representative of the immediate area. In some cases, this immediate area is as small as a few blocks. Despite the very comprehensive monitoring network in the Houston area, many areas (and people) are not directly represented by a monitor. Estimating a design value at each location in the area is possible using spatial interpolation, but such interpolation will not account for the small-scale variations and nonlinear processes that affect ozone formation in an environment as complex as the HGB area.

Modeling vs. Monitoring

Unlike the monitoring network, grid modeling provides air quality information across the entire HGB area. Because the model incorporates emissions, meteorology, atmospheric chemistry, and physics, it can capture much of the smaller-scale variation in the ozone patterns in its predictions. One approach to estimating geographic and population exposed to an exceedance would be to use model output directly, but since the model will not exactly reproduce the design values at the monitors this approach may over- or under-represent the areas and population exposed to exceedances of the standard[1]. The United States Environmental Protection Agency (EPA) has accounted for this expected deviation on page 20 of its guidance document *Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the Eight-Hour Ozone NAAQS*.

A Combined Approach

Limitations of both the modeling and monitoring approaches discussed above make clear that neither approach is entirely adequate to estimate future attainment status in unmonitored areas. There are a number of ways that the two approaches can be combined into a composite approach that avoids the major objections to each. The EPA has proposed use of a modified version of its BenMAP software as part of an "unmonitored area attainment test." BenMAP has the capability of combining modeled and monitored information. Because the EPA's software is not yet available, the TCEQ modeling staff devised an alternate approach that is conceptually similar to BenMAP. The approach was used to develop maps of predicted areas of nonattainment in both the base (2000) and future (2009) years.

Figure 3-4 through Figure 3-9 used a geostatistical interpolation method known as "kriging." Kriging is a commonly-used method that produces a smooth surface across a region containing irregularly-spaced data, such as observations from a monitoring network. Unlike some other interpolation techniques, kriging does not force the resulting surface to pass exactly through the observations. In the current application, this means that the maps produced will show ozone values at the monitor locations slightly different from those used to create the map.

---

[1] Differences between model predictions and monitored design values are not necessarily an indication of any problems with the model. Modeling is conducted over many days, which necessarily exhibit a variety of ozone concentrations, while the design values are based on fourth-highest days at each monitor. Because of the structure of the eight-hour ozone standard, a modeled concentration exceeding 85 parts per billion (ppb) does not indicate that a violation of the standard is expected since it a fourth highest monitored value that is examined for compliance with the standard. So while the model should be representative of elevated ozone levels at the monitor sites, it does not represent the specific days used in the design value calculation.

Directly kriging the design values can produce reasonable-looking surfaces that provide design values across the region of interest. However, as noted earlier, this simplistic method does not account for the complex spatial characteristics of ozone concentrations in the HGB region. Instead, the TCEQ replaced the design values at the monitors with the ratios of the design values to the modeled baseline average concentrations. If the modeled baseline average is close to the design value, the ratio is about 1.0. In the actual HGB modeling, the modeled averages were smaller than the design values at most monitoring locations, and in these cases the ratios were greater than 1.0, but for a couple of monitors the ratios were slightly less than 1.0. Table 3-1: *Monitor Locations Used in Population and Geographic Area Analysis* lists the monitors used in the analysis, along with the baseline design values (DV), modeled baseline average concentrations, and ratios at each.

Table 3-1: Monitor Locations Used in Population and Geographic Area Analysis

Site	Baseline DV (DVc)*	Modeled Average**	Ratio
Bayland Park	107	86.0	1.24
Clinton Drive	93	89.1	1.04
Clute	90	92.3	0.97
Conroe	91	84.4	1.08
Deer Park	107	89.9	1.19
Galveston	98	97.2	1.01
Aldine	108	85.7	1.26
Croquet	102	88.6	1.15
Lang	83	83.3	1.00
NW Harris Co.	104	79.3	1.31
Houston East	102	88.7	1.15
Regional Office	95	88.5	1.07
Monroe	90	88.7	1.02
Wayside	89	85.7	1.04
Shell Westhollow	95	85.7	1.11
La Marque	90	96.2	0.94

*The 2000 Baseline (current) DV, or DVc is actually the average of three years' DV (2000, 2001, & 2002), as per EPA Guidance. This is the value used in calculating future DV for the attainment test.

**The Modeled Average is the average of the highest modeled eight-hour concentrations "near" the monitoring site. It excludes values < 70 ppb, again as per EPA attainment test guidance.

The design value-to-modeled average ratios were then kriged to produce values across the modeling domain. These values represent an adjustment factor by which the modeled averages are multiplied to give model-adjusted design values. At the actual monitor locations, the model-adjusted design values are usually close to the original baseline design values.

For the future case, the kriged adjustment factors are multiplied by the modeled average future-case concentrations to provide future design values across the modeling domain. The future design values at the monitor locations are also usually close to the future design values calculated in the attainment test.

Interpreting the results of analyses using this kriging methodology requires that a few important points be considered. First, spatial interpolation techniques are not reliable outside the geographic range of the observations. Thus, design values estimated in areas beyond the range of the monitoring network (e.g., Waller County) should be viewed with caution. Second, the method's inability to exactly reproduce the original baseline and future-case design values introduces some additional uncertainty in the results. For most monitors, the values derived through the kriging analysis are very close to those calculated using the modeled attainment test, but in a few locations the technique does cause some larger differences; e.g., the kriging-based future design value at Bayland Park is several ppb lower than the modeled attainment test value. Finally, note that the maps shown in Figure 3-4: *Baseline Ozone Design Value 2000 Compared with Future Ozone Design Value 2009* are intended only to provide useful visual representations of design values across the area. Similarly, the summary graphs presented at the end of this section were developed to indicate the relative magnitude of expected improvements in air quality, but are not intended to provide precise estimates of either geographic area or population exposed to ozone concentrations of 85 ppb and greater.

Design Value Maps

Figure 3-4: *Baseline Ozone Design Value 2000 Compared with Future Ozone Design Value 2009* is a map of ozone design values across the HGB area that was produced using the TCEQ approach to combining measured and modeled information. Areas shown in yellow, orange, and red are predicted to be nonattainment (i.e., have design values over the eight-hour NAAQS), while all other areas are predicted to be in attainment[2]. These maps graphically illustrate the expected improvements in air quality in 2009 resulting from existing control strategies.

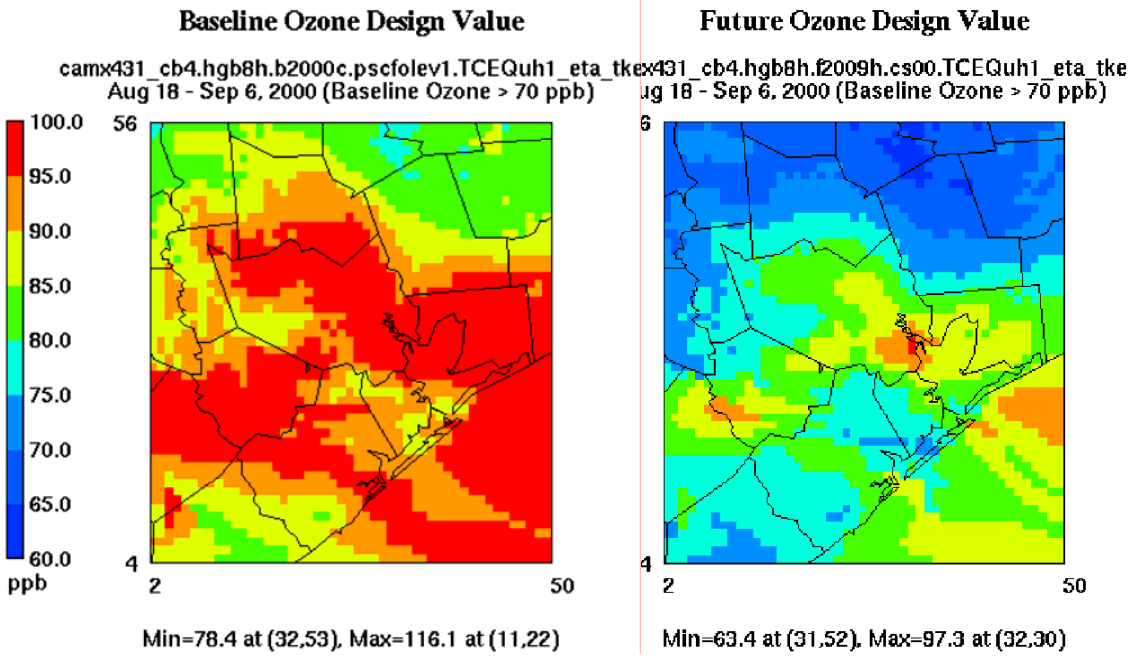

Figure 3-4: Baseline Ozone Design Value 2000 Compared with Future Ozone Design Value 2009

[2] Strictly speaking, an entire group of counties (usually a consolidated metropolitan statistical area) is either attainment or nonattainment under EPA's policy. In this paper, these terms are used also to describe sub-areas within the larger area.

Once the maps for baseline and future years are created, the grid cells where ozone exceeds 85 ppb can be counted and the population within these cells is determined. Population for each cell was calculated from census tracks using GIS software and projected for 2009 using growth projections. The following two graphs provide summary views of the expected improvement in HGB air quality in terms of area and population exposure to ozone nonattainment.

Figure 3-5: *Area in Exceedance of the Eight-Hour Ozone Standard* and Figure 3-6: *Population Exposed to Ozone Concentrations of 85 ppb and Greater* show improvements in area and population in nonattainment, but do not account for how high ozone levels are once the standard is exceeded.

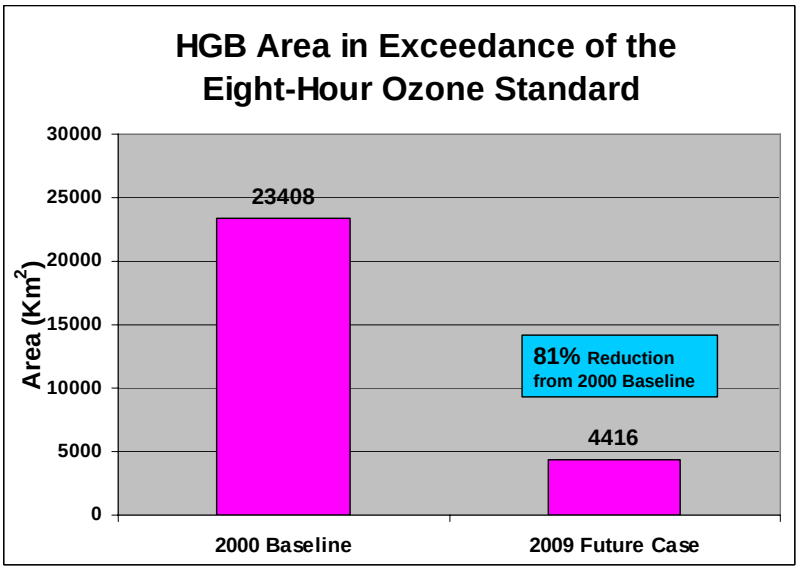

Figure 3-5: Area in Exceedance of the Eight-Hour Ozone Standard

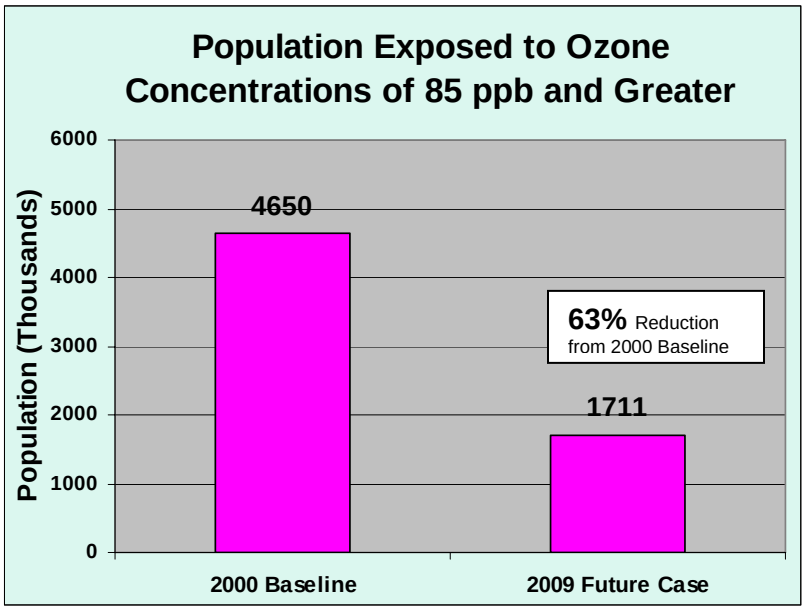

Figure 3-6: Population Exposed to Ozone Concentrations of 85 ppb and Greater

Figure 3-7: *Concentration-Weighted Area in Exceedance of the Eight-Hour Ozone Standard* and Figure 3-8: *Concentration-Weighted Population Exposed to Ozone Concentrations of 85 ppb and Greater* factor in the amount the predicted design value in each grid cell exceeds the standard.

For instance, a value of 89 ppb in a grid cell is weighted twice as heavily as a value of 87 ppb (89-85 = 4; 87-85 = 2). These measures will be referred to as concentration-weighted area in exceedance of the eight-hour ozone standard and concentration-weighted population exposed to ozone concentrations of 85 ppb and greater. Figure 3-7 and Figure 3-8, provide a compact, yet comprehensive, representation of the dramatic improvement expected in HGB air quality from 2000 to 2009.

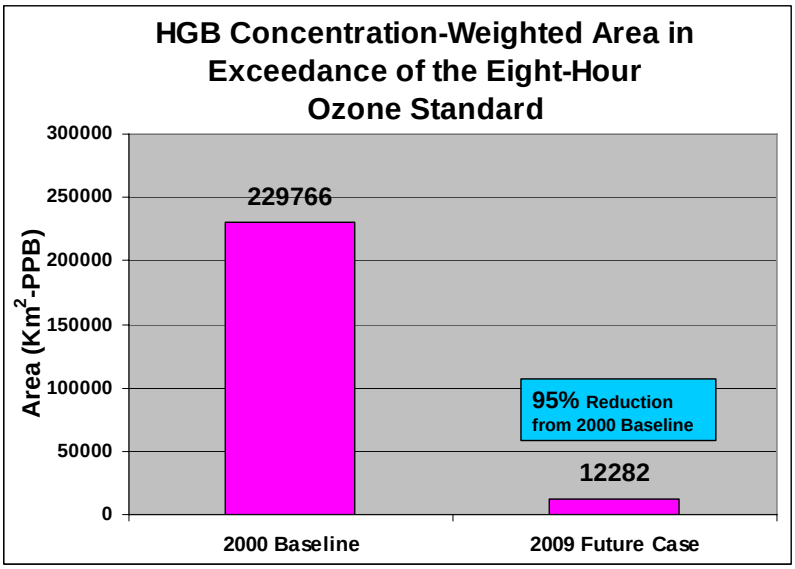

Figure 3-7: Concentration-Weighted Area in Exceedance of the Eight-Hour Ozone Standard

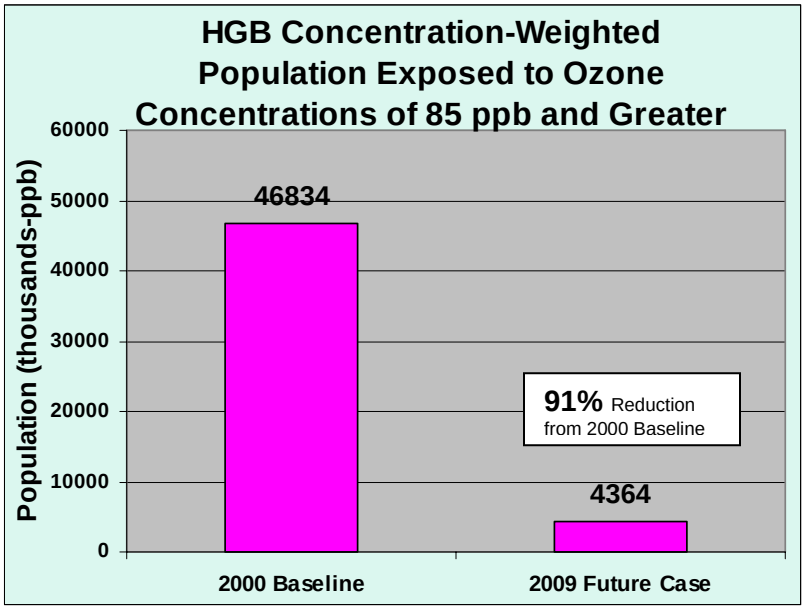

Figure 3-8: Concentration-Weighted Population Exposed to Ozone Concentrations of 85 ppb and Greater

3.4 HRVOC AND NO_X TRENDS

3.4.1 Ambient HRVOC Trends

Starting in the mid-1990s, continuous measurements of ambient volatile organic compounds (VOC) have been taken at two monitors in the HGB area – at Clinton C403, located near the west end of the Houston Ship Channel, and at Deer Park C35, located in the city of Deer Park, a few

miles south of the ship channel. These monitors use automated gas chromatographs (auto-GC) to measure some 55 compounds on an hourly basis. By virtue of this sampling frequency and the range of compounds measured, hundreds of thousands of VOC measurements have been taken in the decade since sampling began. The resulting datasets are valuable for numerous types of analyses, including VOC trends assessment.

In order to assess overall ambient VOC trends in the HGB area, total non-methane hydrocarbon (TNMHC) measurements were used. TNMHC is a commonly used surrogate for total VOC. Figure 3-9: *Geometric Mean Total Nonmethane Hydrocarbon (TNMHC) at Clinton, 1997-2005* and Figure 3-10: *Geometric Mean TNMHC at Deer Park, 1997-2005* show geometric mean values, by year, of TNMHC measurements taken at these two monitors. (Figure 3-11: *Auto-GC Monitors (red icons) and Point Source EI HRVOC Emissions (brown circles) in the Houston Ship Channel Area* shows the locations of these two auto-GCs along with the six others in Harris County.) Both monitors show strong decreases in the study period (1997-2005). At Clinton, mean concentration decreased almost 30 percent in this period, and at Deer Park, the decrease was nearly 35 percent. Both of these decreases are statistically significant at the 95 percent confidence level.

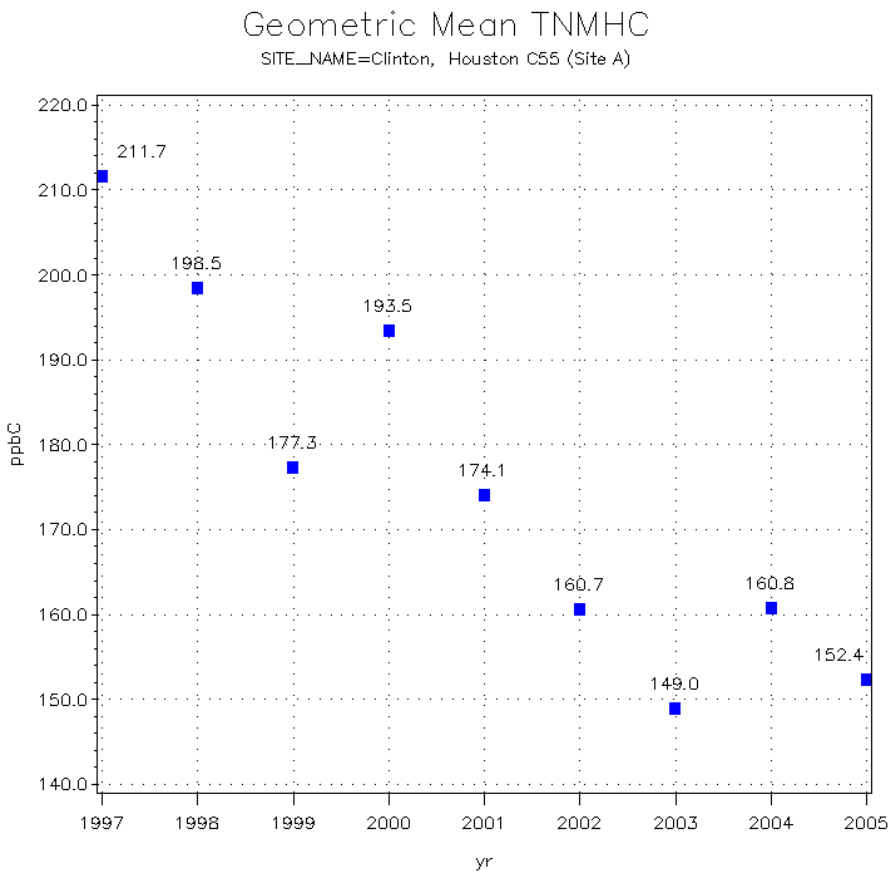

Figure 3-9: Geometric Mean Total Nonmethane Hydrocarbon (TNMHC) at Clinton, 1997-2005

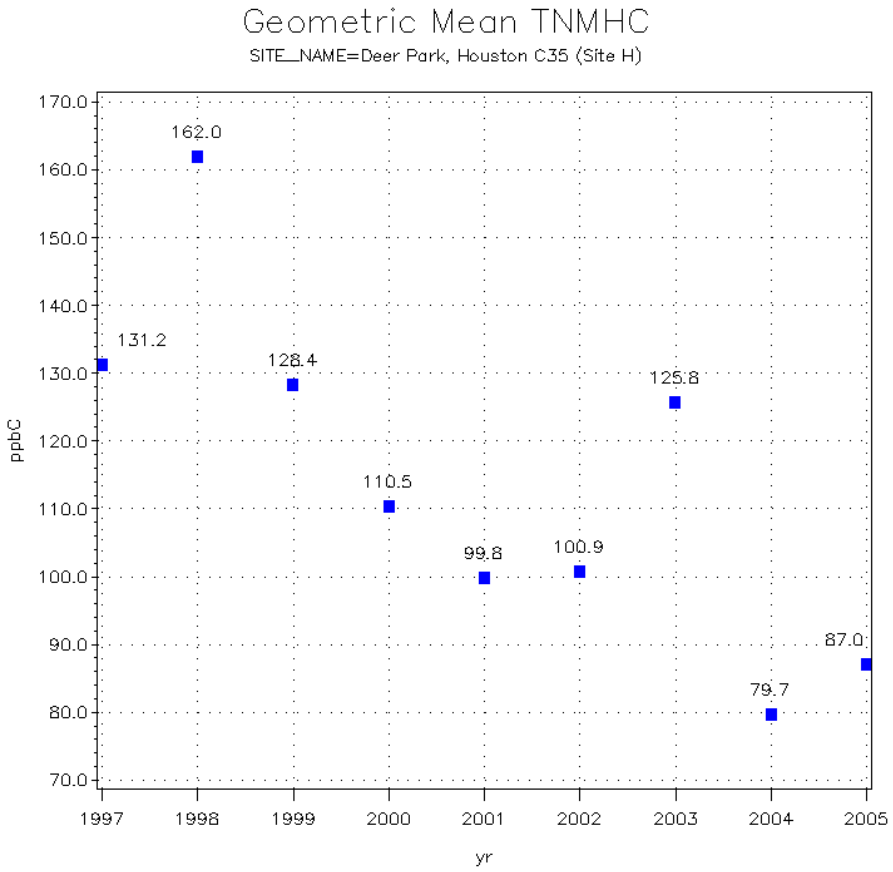

Figure 3-10: Geometric Mean TNMHC at Deer Park, 1997-2005

Houston Ship Channel Auto-GC Monitors and HRVOC Point Source Emission Locations

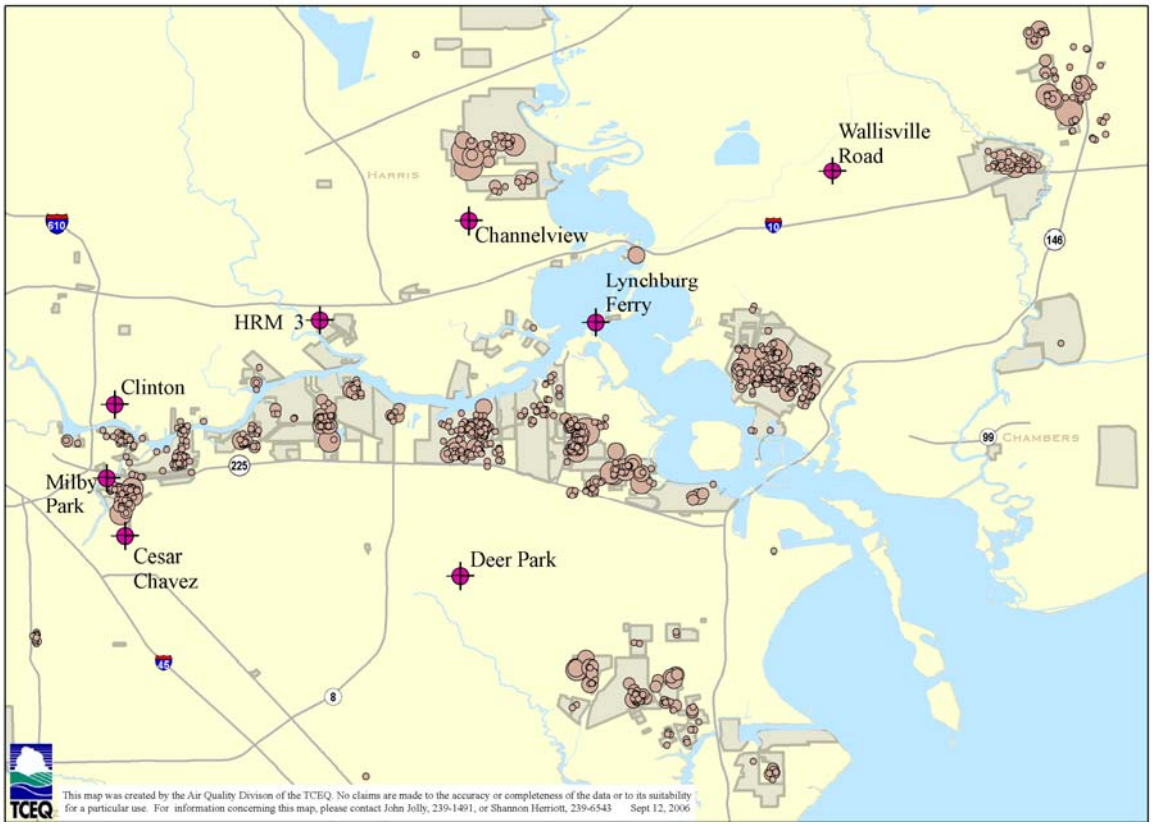

Figure 3-11: Auto-GC Monitors (red icons) and Point Source EI HRVOC Emissions (brown circles) in the Houston Ship Channel Area

Table 3-2: *Ambient HRVOC Trends Results* summarizes results of trends analyses during the same time for the four species of HRVOC: ethylene, propylene, 1,3-butadiene, and butenes (the sum of 1-butene, c-2-butene, and t-2-butene). This table shows that all four species of HRVOC have been decreasing at both monitors, and a majority of these decreases are statistically significant at the 95 percent confidence level. Ethylene and propylene at both monitors showed relatively robust downward trends (R^2 = 0.60-0.71) that were statistically significant at the 95 percent confidence level. This is important because results from the 2000 Texas Air Quality Study showed that these two compounds were the most important VOC in the area, in terms of their contribution to total VOC reactivity.

In addition to looking at overall TNMHC and HRVOC trends, the TCEQ has also looked at trends in certain HRVOC by wind direction. Figure 3-12: *Geometric Mean Propylene by Wind Direction, Eastern Houston Ship Channel, 2003-2005 (Chanelview is 2002-2004)* shows geometric mean propylene concentration for June through August of 2003-2005 at five auto-GCs (2002-2004 at Channelview) in the eastern part of the Houston ship channel, with 2003 propylene point source emissions shown as colored circles. The propylene concentrations are presented as radar plots; the data series for each year and each monitor surrounds the respective monitor. Each series, followed around its full rotation, shows lobes or peaks. These lobes correspond to the wind direction associated with enhanced mean concentration, with the distance from the origin (the monitor) to the tip of the lobe or peak corresponding to the magnitude of concentration at that direction. The largest peak around each monitor has a label showing its mean concentration, enabling one to see the approximate magnitude of some of the other peaks at that monitor. Because the data series surrounding some monitors have been "stretched" so that all monitors' directional and annual trends can be best viewed together, the data series for each monitor are not to scale with those of the other monitors.

Table 3-2: Ambient HRVOC Trends Results

Monitor	HRVOC	Geometric Mean (ppbC)[3]		Linear Trend (ppbC/year)	R^2	Trend Significant? ($\alpha = 0.05$)
		1997	2005			
Clinton	Ethylene	6.96	2.84	-0.43	0.71	Yes
	Propylene	4.07	2.94	-0.13	0.69	Yes
	Butenes	3.34	2.12	-0.21	0.59	Yes
	1,3-Butadiene	1.06	0.53	-0.06	0.65	No
Deer Park	Ethylene	4.29	3.00	-0.18	0.60	Yes
	Propylene	4.28	2.59	-0.20	0.71	Yes
	Butenes	2.19	1.43	-0.07	0.08	No
	1,3-Butadiene	0.57	0.42	-0.02	0.42	No

Figure 3-12 shows at least two notable things. First, the largest peaks for most of the monitors point to a common source region adjacent to Battleground Road, near to and including the large propylene source at the center of the map. While the reported propylene emissions in this area are large, they are similar to those reported in some other areas on this map, such as the sources just north of the Channelview C15 monitor. The fact that the largest peaks for all five monitors point so strongly to Battleground Road indicates that the sources there were emitting disproportionately large amounts of propylene, at least during some of the years presented here. This shows most clearly with the 2003 data series (pink). The other notable finding here is that each monitor shows a sharp decrease in mean concentration from the Battleground Road area in 2005 compared to 2003. The data series around Channelview C15 is 2002 through 2004, and shows this decrease in the last two years. The data from the other four monitors suggests a steep decline in propylene emissions in summer 2005 compared to 2004 and especially 2003. The data from Channelview suggest reductions in both 2003 and 2004, compared to 2002.

Figure 3-13: *Geometric Mean Ethylene by Wind Direction, Eastern and Western Houston Ship Channel, 2003-2005 (Channelview is 2002-2004)* is similar to the previous figure, however ethylene rather than propylene concentrations are plotted, with ethylene point sources displayed as colored circles. Peaks can be seen in several source directions; there is no apparent single source region that has each monitor's strongest peaks pointing at it, unlike with propylene. The plots around Deer Park C35, Wallisville C617, and Lynchburg C1015 suggest that ethylene emissions from the Battleground Road area, or just to the east of it, were lower in 2005 than in the two previous years, but data from Channelview C15 and HRM 3 do not show this pattern.

[3] "ppbC" signifies parts per billion carbon, which is equal to parts per billion by volume (ppbv) times the number of carbon atoms in the molecule. PpbC is a very common unit of measurement for VOC in regards to ozone formation, and is the default unit of measurement for TCEQ's auto-GC data.

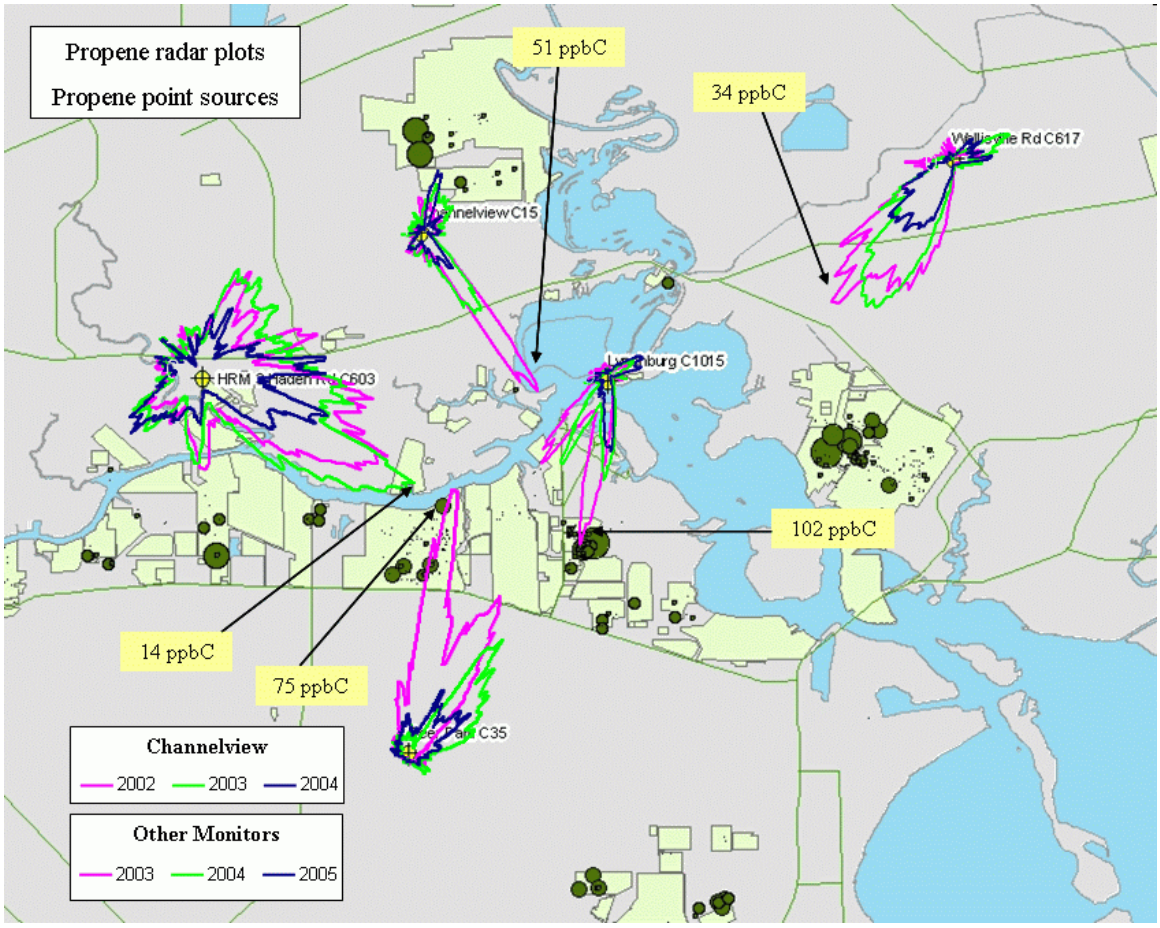

Figure 3-12: Geometric Mean Propylene by Wind Direction, Eastern Houston Ship Channel, 2003-2005 (Chanelview is 2002-2004)

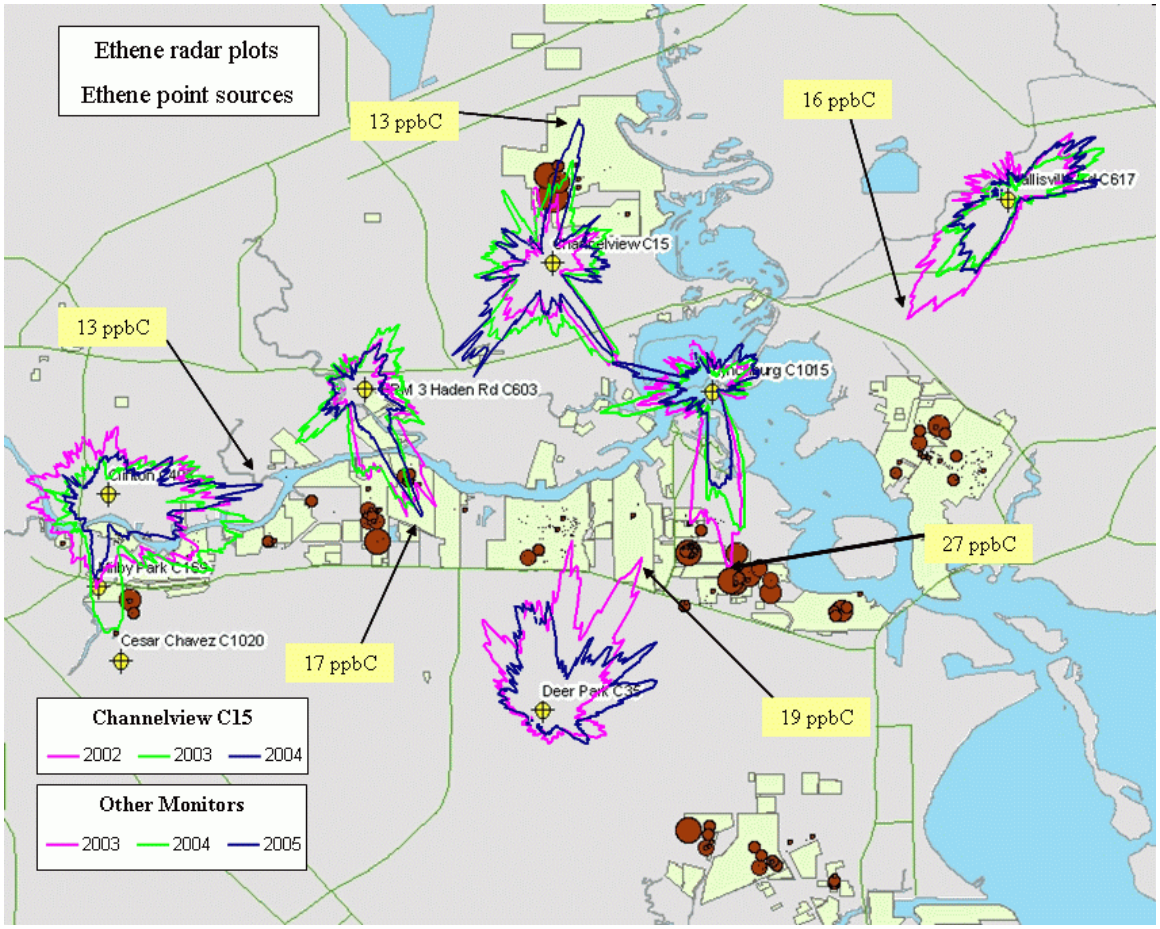

Figure 3-13: Geometric Mean Ethylene by Wind Direction, Eastern and Western Houston Ship Channel, 2003-2005 (Channelview is 2002-2004)

3.4.2 Ambient NO_X Trends

Ambient NO_X trends in HGB were calculated using two methods. In the first method, data were retrieved from nine monitors that started measuring NO_X in 1998 or earlier (see Figure 3-14: *Map of HGB NO_X Monitors Operating Since 1998 or Earlier* for a map showing locations of these monitors). The data are from the months of typical peak ozone, August and September. The distributions of these data are very skewed, therefore statistical trends assessments were performed on the log-transformed measurements. The log-transformed data more closely approximated a normal distribution and was therefore more suitable for standard statistical tests.

Long Term NOx Monitors in the HGB Area

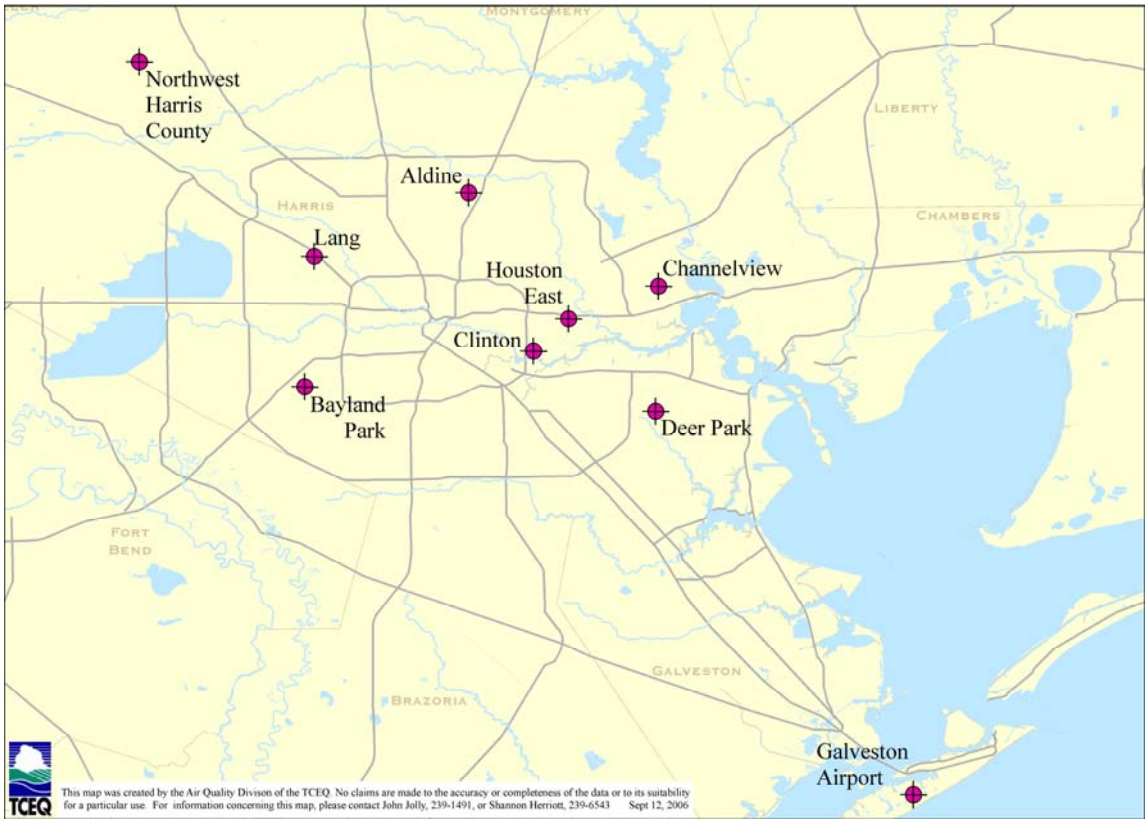

Figure 3-14: Map of HGB NO_X Monitors Operating Since 1998 or Earlier

Table 3-3: *Ambient NO_X Trends Results Using Log-Transformed Data* shows the results of the trends assessment. This table shows that all nine monitors exhibit decreasing trends, with wide-ranging correlations (R^2 = 0.28 to 0.81). At five of the nine monitors, the decreasing trends were statistically significant at the 95 percent confidence level. While not all decreases were statistically significant, the fact that decreases occurred at every monitor, covering a broad geographic area, suggests that ambient NO_X concentrations in the HGB area are decreasing.

Table 3-3: Ambient NO_X Trends Results Using Log-Transformed Data

Results of NO_X Regression Analysis						
Monitor	**Years Analyzed**	**Geometric Mean (ppb)**		**Linear Trend (ppb/year)**	**R^2**	**Trend Significant?** (α = 0.05)
		Start Year	**End Year**			
Aldine	1985-2005	17.8	14.5	-0.45	0.34	No
Bayland Park	1998-2005	13.5	7.32	-0.52	0.41	No
Channelview	1985, 1986, 2001-2005	14.7	11.4	-0.25	0.81	Yes
Clinton	1985-2005	44.2	16.4	-1.0	0.76	Yes
Deer Park	1997-2005	9.87	6.25	-0.22	0.28	No
Galveston Airport	1997-2005	5.67	2.93	-0.30	0.57	Yes

Houston East	1985-2005	22.4	17.8	-0.29	0.32	Yes
Lang	1985-2005	30.3	17.9	-0.64	0.56	Yes
Northwest Harris	1997-2005	7.13	6.53	-0.38	0.35	No

Additionally, ambient NO_X trends were calculated, and statistical assessments performed, using the actual measurements rather than the log-transformed measurements described in the previous paragraph. Using year-round data for the years 1985-2005, quarterly averages were calculated for each monitor, with the highest quarterly average used for trends assessment. Figure 3-15: *HGB Peak Average NO_X by Year and Quarter, 1985-2005* shows these results. One can see both the strong seasonal variation and the steady downward trend across the years. Though the correlation coefficient is rather weak ($R^2 = 0.26$), owing to the seasonal variation, the downward trend – 1.1 ppb per year – is significant at the 95 percent confidence level. The results of the two analyses suggest that NO_X concentrations are decreasing in the HGB area.

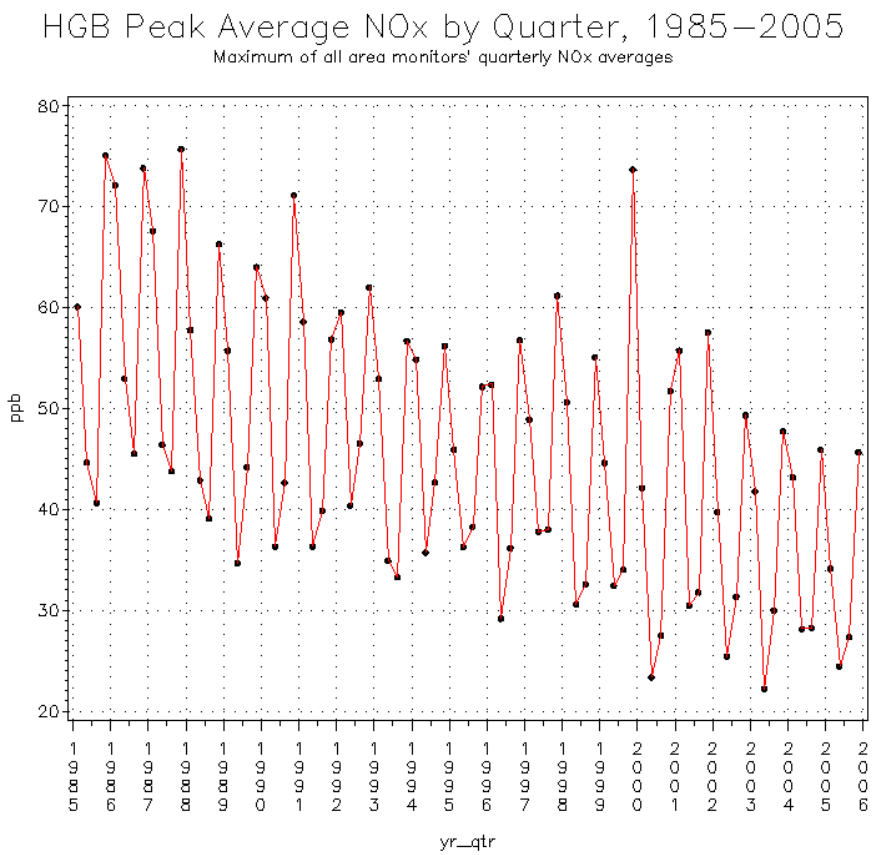

Figure 3-15: HGB Peak Average NO_X by Year and Quarter, 1985-2005

3.4.3 Emissions Inventory NO_X and VOC Trends

Both the NO_X and VOC emission inventories (EI) in the HGB area show trends that agree with the ambient trends described above. Figure 3-16: *HGB VOC EI by Inventory Category, 1990-2003* shows the anthropogenic VOC EI by source category for the area from 1990 to 2003, with an overall emissions decrease of 43 percent from 1990 to 2003. The categories contributing the most to the strong overall decrease are point sources and on-road mobile sources. From 1990 to 2003, point source VOC emissions have decreased about 71,000 tons per year (tpy), or 62

percent, and on-road mobile source VOC Emissions have decreased about 72,000 tpy, or 57 percent. The linear trend line shows that total VOC emissions are decreasing very steadily (R^2 = 0.94), at an estimated rate of nearly 11,000 tpy.

The point source emissions shown in Figure 3-16 are those reported by facilities to the TCEQ for its annual emission inventory and do not reflect the uncertainty found in this category by researchers in recent years (TCEQ).

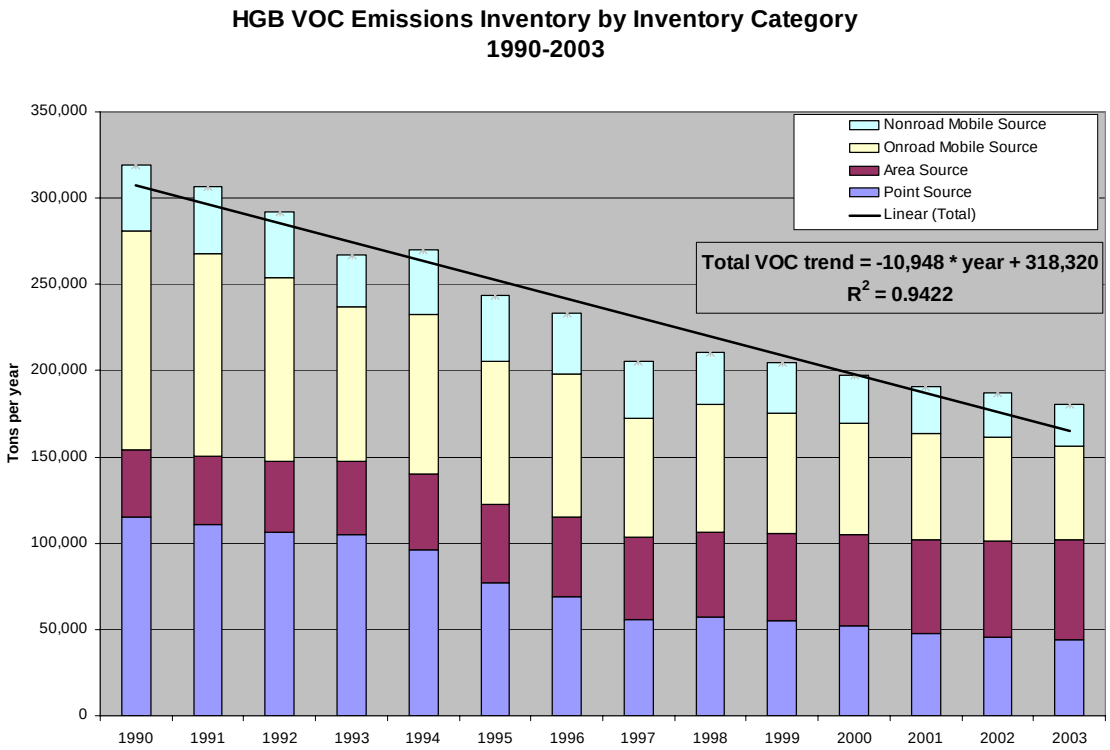

Figure 3-16: HGB VOC EI by Inventory Category, 1990-2003

Similarly, Figure 3-17: *HGB NO_X EI by Inventory Category, 1990-2003* shows the anthropogenic NO_X EI for the area for the same years. While the decrease is not quite as steady as with VOC (R^2 = 0.86), the reductions are nonetheless strong, estimated by the trend line to be about 13,800 tpy. In fact, overall NO_X emissions have decreased even more than VOC – 48 percent from 1990 to 2003. The dominant contributor to this trend is the point source category, which has decreased by 66 percent from 1990 to 2003, from about 277,000 tpy to about 94,000 tpy. This significant trend is expected to continue as the final mass emissions cap and trade program NO_X emission specifications for attainment demonstration become fully effective in April 2007.

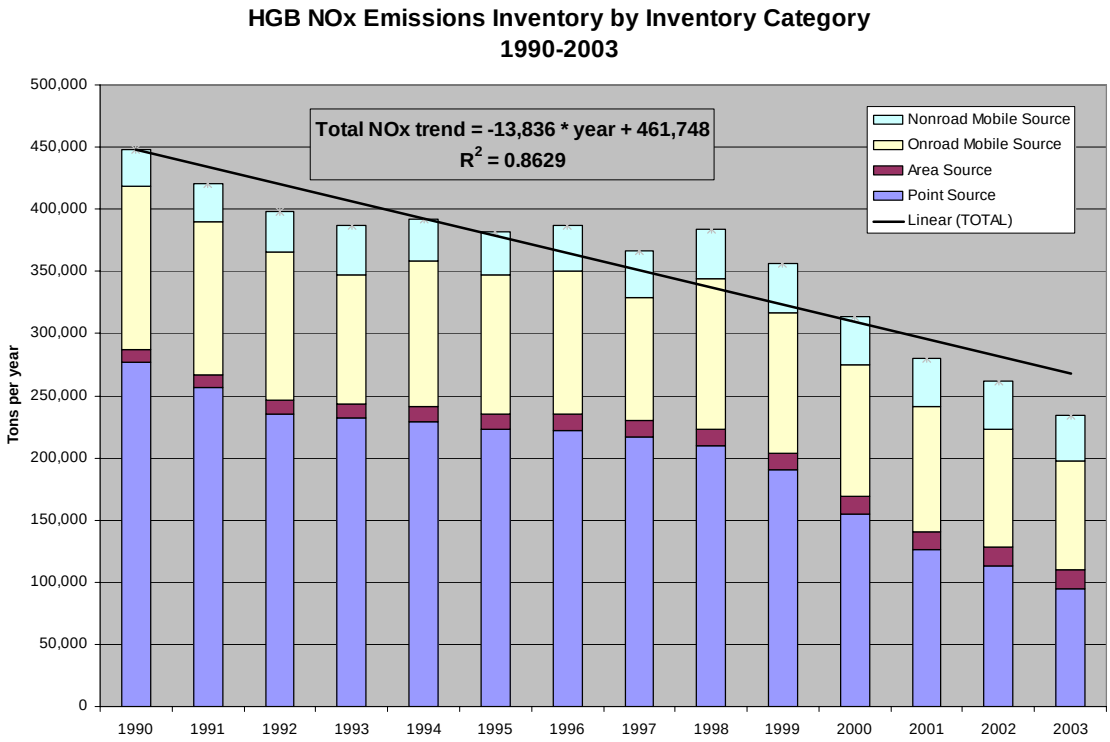

Figure 3-17: HGB NO_X EI by Inventory Category, 1990-2003

In addition to the decreases seen in the VOC and NO_X EI, in recent years the total emissions reported to TCEQ due to "events" – the combination of upset, maintenance, startup, and shutdown emissions – has similarly shown a decrease. Figure 3-18: *Reported Emissions from Upset/Maintenance/Startup/Shutdown Events in HGB Area, FY 2003-2005* shows that from fiscal year 2003 (beginning September 1, 2002) through fiscal year 2005 (ending August 31, 2003) reported event emissions decreased 76 percent, from 18,864 tpy to 4,428 tpy.

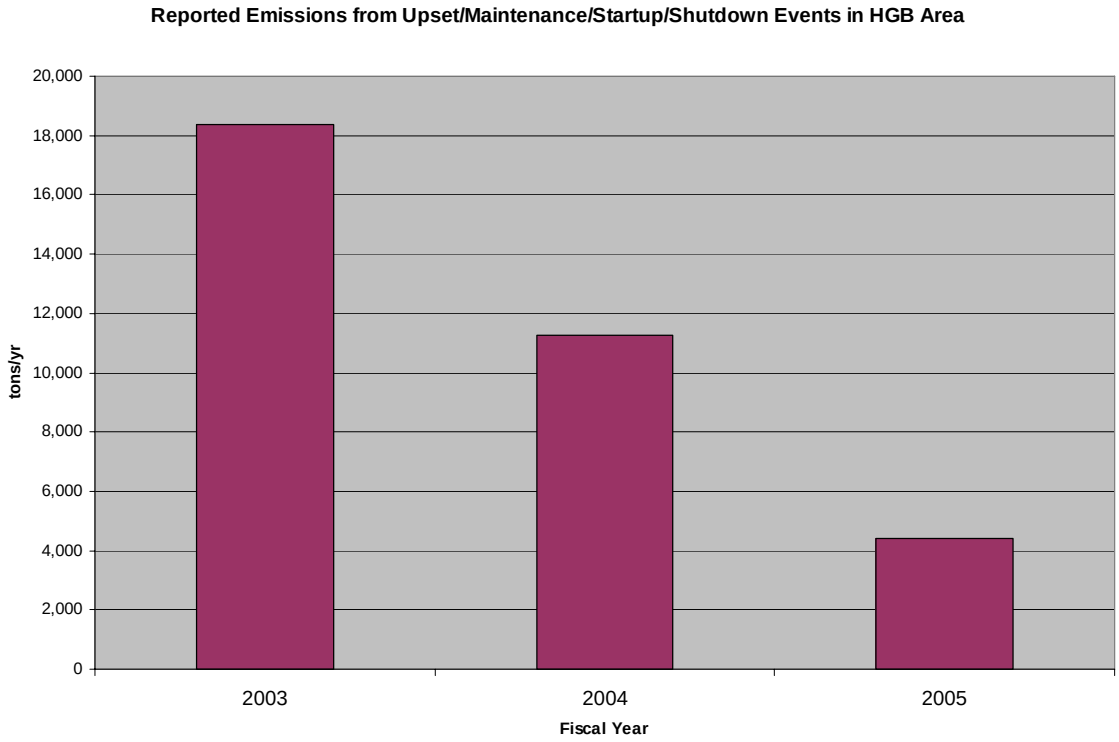

Figure 3-18: Reported Emissions from Upset/Maintenance/Startup/Shutdown Events in HGB Area, FY 2003-2005

The ambient and EI VOC and NO_X trends, and reported event emissions trends, described above are occurring despite a consistent increase in the HGB area population. Figure 3-19: *HGB Population by County, 1990-2005* shows the population by county from 1990 to 2005. As seen in this figure, total area population increased by 39 percent total, or 2.2 percent annually, in the period covered in this chart.

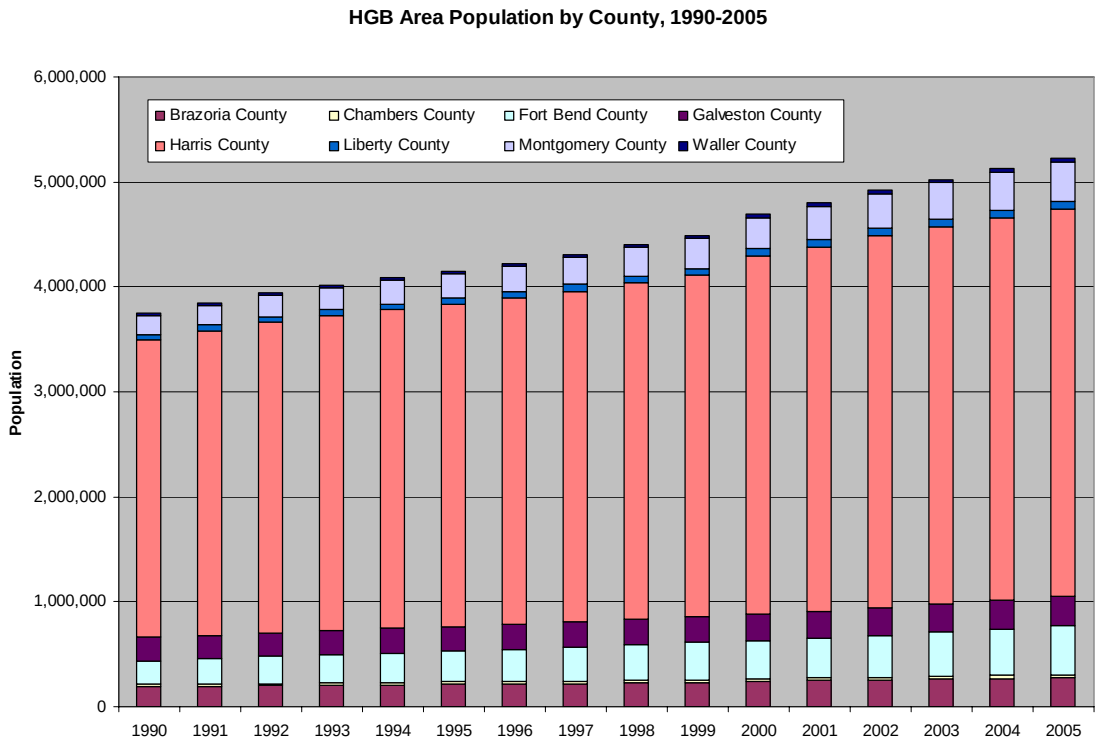

Figure 3-19: HGB Population by County, 1990-2005

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CHAPTER 4: CONTROL STRATEGIES AND REQUIRED ELEMENTS

4.1 OVERVIEW AND EXISTING CONTROL STRATEGIES

The Houston-Galveston-Brazoria (HGB) eight-hour ozone nonattainment area includes one of the most comprehensively controlled industrial complexes in the world. The Texas Commission on Environmental Quality (TCEQ) has developed stringent and innovative regulations that address nitrogen oxides (NO_X), volatile organic compounds (VOC), and the most reactive ozone precursors in the HGB area, highly-reactive volatile organic compounds (HRVOC). Table 4-1: *Existing One-hour Ozone Control Strategies*, and Table 4-2: *Existing Voluntary Mobile Emission Reduction Programs (VMEP) Ozone Control Strategies* list the existing ozone control strategies that were implemented for the one-hour ozone standard in the HGB nonattainment area and give the associated emission reductions quantified in tons per day (tpd). As Chapter 3 demonstrates, significant ozone reductions have resulted from the implementation of one-hour ozone control strategies.

Table 4-1: Existing One-Hour Ozone Control Strategies

Measure	Description	Area(s) Affected	Start Date(s)	NO_X tpd Reduction	VOC tpd Reduction
POINT SOURCE MEASURES					
Point Source NO_X	Overall 80 percent reduction from existing industrial sources and utility power plants, implemented through a cap and trade program. Affects utility boilers, gas turbines, heaters and furnaces, stationary internal combustion engines, and industrial boilers.	8-county area	April 1, 2003, and phased in through April 1, 2007	333.5	0
Emissions Bank and Trade /Mass Emission Cap and Trade (MECT)	NO_X trading program for HGB area.	8-county area	January 2002; First step-down April 1, 2004	See above. The point source NO_X controls and the MECT were credited together.	0
HRVOC Requirements	Affects fugitive, cooling tower, and vent gas control and flares, and establishes an annual emissions cap with a cap and trade program and a short-term, 1200 pounds per hour not-to-exceed limit for each site in Harris County.	8-county area	Monitoring Requirement: Jan. 31, 2006 Cap and Trade Program: Jan. 1, 2007	0	137
AREA/NON-ROAD MEASURES					
Federal Area/Non-Road Measures	The United States Environmental Protection Agncy (EPA) has implemented a series of strategies for area and non-road sources. Some of these include the gas engine rule and marine recreational engine standards.	Nationwide	Through 2007	Non-road model includes changes in federal non-road standards for whatever year the model is run.	
Texas Emission Reduction Plan (TERP) (See also on-road TERP reductions)	Provides grant funds for heavy-duty diesel engine replacement/retrofit. Replaces construction restrictions and Tier 2/3 accelerated purchase.	8-county area	January 2002	35.9	2.1

Measure	Description	Area(s) Affected	Start Date(s)	NO_X tpd Reduction	VOC tpd Reduction
California Gasoline Engines	California standards for non-road gasoline engines 25 horsepower and larger.	Statewide	May 1, 2004	0.4	3.9
Stationary Diesel Engines	Emission standards on stationary diesel engines.	8-county area	April 1, 2002	1.0	0
Gas-Fired Heaters and Small Boilers	Rule limiting NO_x emissions from these small-scale residential and industrial sources.	Statewide	2002	0.5	0
VOC Control Measures	Additional control technology requirements for batch processes, bakeries, and offset lithographic printers.	8-county area		Estimates for these control measures are accounted for in the emissions inventory.	
Texas Low Emission Diesel (TxLED)	Requires all diesel for both on-road and non-road use to have a lower aromatic content and a higher cetane number.	110 East Texas counties	October 31, 2005	2.6	0.5
VMEP	Voluntary measures administered by the Houston-Galveston Area Council (H-GAC). (see separate summary for details)	8-county area	Through 2007	3.4	0.2
ON-ROAD MEASURES					
Federal On-Road Measures	The EPA has implemented a series of strategies for on-road vehicles. Some of these include Tier 1/2 vehicle standards, low sulfur diesel standards, National Low Emission Vehicle standards, and reformulated gasoline.	Nationwide	Through 2007	Mobile model includes changes in federal on-road measures for whatever year the model is run.	
TERP (See also area/non-road TERP reductions)	Provides grant funds for heavy-duty diesel engine replacement/retrofit. Replaces construction restrictions and Tier 2/3 accelerated purchase.	8-county area	January 2002	3	0
Vehicle Inspection/ Maintenance	Yearly treadmill-type testing for pre-1996 vehicles and computer checks for 1996 and newer vehicles. -Begin May 1, 2002, in Harris County. -Begin May 1, 2003, in Brazoria, Fort Bend, Galveston, and Montgomery Counties.	5-county area	May 1, 2002 May 1, 2003	14.43	12.81
Speed Limit Reduction	Speed limits remain at 5 miles per hour (mph) below what was posted before May 1, 2002, where speeds were 65 mph or higher.	8-county area	September 2003	4.16	-0.23

Measure	Description	Area(s) Affected	Start Date(s)	NO_X tpd Reduction	VOC tpd Reduction
TxLED	Requires all diesel for both on-road and non-road use to have a lower aromatic content and a higher cetane number.	110 East Texas counties	Phase in began October 31, 2005	5.94	0
VMEP	Voluntary measures administered by the H-GAC. (see separate summary for details)	8-county area	Through 2007	3.60	0.60
Transportation Control Measures	Various measures in H-GAC's long-range transportation plan.	8-county area	Through 2007	0.47	0.77
OTHER					
Portable Fuel Containers Rule	Establishes new design "no spill" criteria requirements for portable fuel containers sold, offered for sale, manufactured, and/or distributed in Texas.	Statewide	December 31, 2004	0.0	2.9
Voluntary Energy Efficiency/Renewable Energy	Senate Bill (SB) 5 and SB 7 have encouraged energy efficiency and renewable energy projects. Specific credit is difficult to assign in HGB due to the MECT program.	Statewide	December 2000	Took 3.57 tpd in December 2000 State Implementation Plan (SIP). Subsequent SIPs include a qualitative description only.	0

Table 4-2: Existing Voluntary Mobile Emission Reduction Programs (VMEP) Ozone Control Strategies (to achieve a commitment of 7.0 tpd NO_X and 0.8 tpd VOC)

Measure	Description	NO_X tpd Reduction in 2007	VOC tpd Reduction in 2007
Vehicle Scrappage	Emission reductions through H-GAC administered Low Income Repair and Assistance Plan to repair or replace high emitting vehicles.	0.11	0.10
Smoking Vehicle/Clean Air Action	TCEQ program - Marketing and advertising by H-GAC.	0.05	0.04
Clean Cities/Vehicle Program	Public and private heavy-duty engine/vehicle replacement/retrofit.	3.0	0.20
Commute Solutions	Van pools, additional transit, alternative commuting, and other initiatives.	0.30	0.40
Regional Computerized Traffic Signal System	Average speed on local streets increased by 21 percent.	0.03	0.03
Locomotives	Memorandum of Agreement (MOA).	2.0	0.10
Commercial Marine	Tugs/Tows - MOA Ferries – MOA.	1.1 / 0.4	0.0

A control strategy to reduce point source NO_X emissions an overall 80 percent will be fully implemented by 2007, as will HRVOC rules that better quantify and reduce emissions of HRVOC from four key industrial sources: fugitives, flares, process vents, and cooling towers. These two programs represent a regulatory structure for significant reduction in key ozone precursors in the HGB airshed and will reduce ozone beyond what has been seen and documented to date.

A complicating factor in the overall ozone attainment planning picture is that the TCEQ is federally preempted from regulating mobile source engines. Therefore, the TCEQ directly regulates only point and area sources, accounting for approximately 45 percent (~202 tpd) of the NO_X remaining in the 2009 HGB airshed. Even when the innovative TERP for on-road and non-road mobile sources, discussed further in this chapter, is taken into account, mobile sources account for over 50 percent (~242 tpd) of the NO_X emissions in the projected 2009 emission inventory. See Figure 4-1: *2009 NO_X Source Category Estimates* and Figure 4-2: *2009 NO_X Emissions Directly Regulated by the TCEQ*. While the phased implementation of the federal emission standards for on-road and non-road engines will be well underway by 2009, the full emissions benefit for most engine categories will not be realized until a later date. This should reduce the burden of additional emission reductions from other source categories.

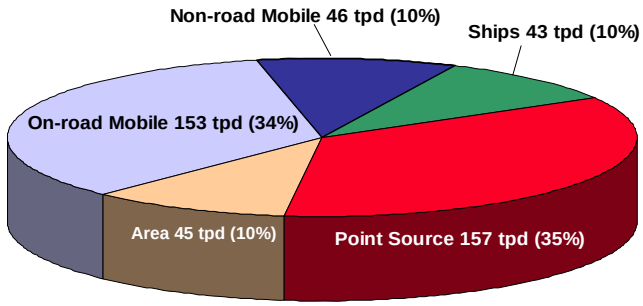

Figure 4-1: 2009 NO_X Source Category Estimates

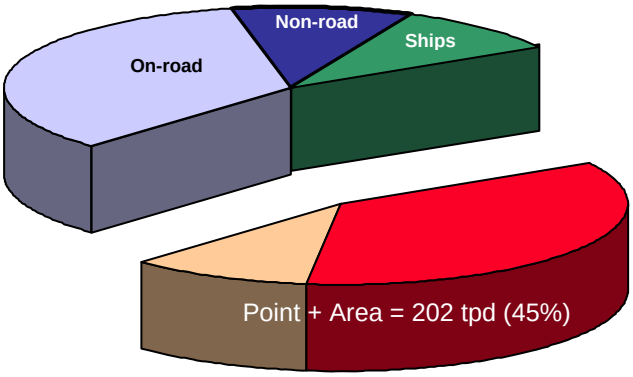

Figure 4-2: 2009 NO_X Emissions Directly Regulated by the TCEQ

The TCEQ and the H-GAC and local leaders have worked to address on-road and non-road sources for which they cannot set emission standards. On-road and non-road measures include TERP, TxLED across East Texas, speed limit reductions, vehicle inspection and maintenance, and the VMEP. Existing controls are listed and enumerated in Tables 4-1 and 4-2. This SIP revision also includes an additional 0.9 tpd of NO_X from the TxLED Marine rule and 2.82 tpd of NO_X from local area on-road VMEP measures.

Modeling projections estimate that in order to attain the eight-hour ozone standard, the HGB area must reduce the overall quantity of NO_X emissions to approximately 186 tpd. This reduction is equivalent to an 82 percent reduction in total NO_X emissions from the 2000 base case. Thus far, the controls put in place for the one-hour ozone SIP are projected to reduce the 2000 NO_X emissions by approximately 57 percent to 445 tpd in 2009. An additional 25 percent reduction of NO_X emissions would be needed to attain the ozone standard.

Currently, NO_X emissions in the HGB area are controlled though a cap and trade program, with the initial allocations established by use of a stringent emission factor and an activity rate. Typically, to accomplish the NO_X reductions required, large NO_X sources have added post-combustion technology, such as selective catalytic reduction, to combustion technology. Additional NO_X reduction requirements require the installation of post-combustion controls on even smaller units, dramatically increasing the cost per ton reduced. Further, due to the timing of this SIP, the installation of additional NO_X reduction technology could not be accomplished by 2009. The TCEQ is planning on adopting rules for inclusion in this SIP revision in May 2007 and control strategies for this SIP revision must be in place by January 1, 2009. This gives the regulated entities just over a year and a half to implement the rules that the TCEQ adopts for the purposes of this SIP revision. In comparison, the regulated community was given more than six years to implement the overall 80 percent point source NO_X controls.

Another complication is that there are potentially significant under-estimated, unreported, and under-reported VOC emissions in the HGB airshed. Some new control strategies may provide real-world reductions in ozone precursor pollutants, but specific quantifiable credit may not be taken in the SIP. For example, the VOC reductions from the rules discussed in Section 4.2.2, Control of VOC Emissions from Storage Vessels and Degassing Operations, cannot be subtracted from the modeling inventory because those VOC emissions are not included since they were likely emissions that were under-estimated, unreported, or under-reported by sources. In short, an emission has to be accounted for in the baseline modeling before it can be removed due to a source-specific rule.

Given these complications, the TCEQ continues to work on control strategy development, emission inventory improvement, and improving the science of ozone formation in the HGB area. This chapter outlines both quantifiable control strategies and control strategies of a more qualitative nature that are part of this SIP revision, as well as covers the reasonably available control technology (RACT) analysis, the reasonably available control measure (RACM) analysis, contingency measures, and emission inventory updates. Chapter 5 discusses ongoing efforts by the TCEQ to improve the substance and the science of the SIP, including an effort to rectify the SIP-creditable versus real-world reductions dichotomy.

4.2 NO_X AND VOC CONTROL MEASURES

4.2.1 Texas Low Emission Diesel for Marine Fuels

Concurrent with this SIP revision, the commission is proposing rule revisions to the low emission fuel definitions of diesel fuel in 30 TAC Chapter 114.6(7) (project number 2006-036-114-EN). This revision requires that any fuel that is commonly or commercially known, sold, or represented as DMA, DMX, or Marine Gas Oil that is sold in the counties listed in §114.319(b)(2), including: Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, meets low emission diesel (LED) requirements. By regulating these marine fuels the commission will be able to reduce NO_X in the HGB nonattainment counties as listed in §114.319(b)(2).

DMX, DMA, 1-D, and 2-D diesel fuels are all light distillates and share many fuel parameters. Therefore, the commission does not anticipate major difficulties in the process of either changing vessels back to 1-D and 2-D or having these marine fuels tested under the LED approved test methods of §114.315.

The grades of marine fuel that are included in this proposal are normally only used by harbor craft vessels (e.g. crew and supply boats, charter fishing vessels, commercial fishing vessels, ferry/excursion vessels, pilot vessels, towboat or push boats, tug boats and work boats). Ocean-going vessels will not be included in these regulations because they typically use heavier marine

residual fuels such as DMB, DMC, or other marine residual fuels that do not share the characteristics of lighter 1-D and 2-D diesel fuels.

The concurrent rulemaking revises the types of fuels for analysis in §114.315(c)(1)(C). DMX and DMA will be added to the fuel types for analysis to require that they meet specifications as set out in the International Organization for Standardization 8217 Specifications of Marine Fuels. This is a quality assurance measure to ensure uniformity between candidate test fuels and fuels used by the end user in marine vessels.

The commission expects this rule to reduce NO_X by 0.9 tpd in 2009. This reduction was included in modeling sensitivity runs described in Chapter 2. VOC reductions from this rule are likely to be negligible because diesel fuel has low levels of VOC.

4.2.2 Control of VOC Emissions from Storage Vessels and Degassing Operations

Concurrent with this SIP revision, the commission is proposing rule revisions to 30 TAC Chapter 115 that would subject owners or operators of VOC storage tanks, transport vessels, and marine vessels located in the HGB eight-hour ozone nonattainment area to revised control, monitoring, testing, recordkeeping, and reporting requirements (project number 2006-038-115-EN). The revised requirements have been developed to reduce VOC emissions that have previously been under-reported in emission inventories.

When the TCEQ and its research partners began the second Texas Air Quality Study (TexAQS II) in May 2005, one of the study's primary goals was to identify VOC emission sources that have been historically under-estimated, unreported, or under-reported in the TCEQ Emissions Inventory (EI) and could potentially be contributing to a discrepancy between measured and reported emissions.

TexAQS II remote sensing VOC project results indicate that certain types of storage tank emissions, including degassing, flash, and landing loss emissions, generally have been under-estimated, unreported, or under-reported in the TCEQ EI. Recent data analysis, a landing loss emissions survey, and other TCEQ studies indicate that these under-estimated, unreported, or under-reported emissions could total several thousand tons per year; under-estimated, unreported, or under-reported landing loss emissions alone in the HGB area totaled approximately 7,250 tons in 2003. The proposed rulemaking would reduce emissions from potentially under-estimated, unreported, or under-reported tank emissions.

The proposed amendments to 30 TAC, Chapter 115 would include more stringent controls for tank fittings on floating roof tanks, such as slotted guidepoles and other openings in internal and external floating roofs. The circumstances under which tank landings are allowed would also be specified in the proposed rule to limit convenience landings unless a control device is used to control the VOC emissions. Crude and condensate storage tanks with uncontrolled flash emissions greater than 25 tons per year would be controlled under the proposed rule. Control of VOC emissions would also be required for storage tanks with a nominal capacity of 40,000 gallons or more. Degassing of vapors from storage vessels, transport vessels, and marine vessels would be required to vent to a control device until the VOC concentration of the vapors is reduced to less than 34,000 parts per million by volume as methane.

Because the emissions from these sources were under-estimated, unreported, or under-reported in the emissions inventory used to develop modeling, emission reductions from this rule proposal are not included in modeling or sensitivity runs. The proposed amendments are described in more detail in the concurrent rule proposal (project number 2006-038-115-EN).

4.2.3 Voluntary Mobile Source Emission Reduction Programs (VMEP)

The Federal Clean Air Act Amendments of 1990 increased the responsibility of states to demonstrate progress toward attainment of the National Ambient Air Quality Standard (NAAQS).

Voluntary mobile source measures have the potential to contribute, in a cost-effective manner, emission reductions needed for progress toward attainment and maintenance of the NAAQS.

Historically, federal mobile source control strategies have focused primarily on reducing emissions per mile through vehicle and fuel technology improvements. Tremendous strides have been made resulting in new light-duty vehicle emission rates that are 70 to 90 percent less than those for the 1970 model year. However, transportation emissions continue to be a significant source of air pollution due to population and employment growth as well as an increase in daily vehicle miles traveled per person. Therefore, mobile source strategies are being explored and developed that attempt to complement existing regulatory programs through voluntary, nonregulatory changes in local transportation sector activity levels or changes in vehicle and engine fleet composition.

Increasing interest by the public and business sectors in creating alternatives to traditional emission reduction strategies have resulted in a number of innovative voluntary mobile source and transportation programs. Some examples include economic and market-based incentive programs, trip reduction programs, growth management strategies, ozone action programs, and targeted public outreach. These programs attempt to gain additional emissions reductions beyond mandatory Clean Air Act programs by engaging the public to make changes in activities that will result in reducing mobile source emissions.

Table 4-3: *Voluntary Mobile Source Emission Reduction Programs* summarizes the new HGB voluntary commitments under this SIP revision. The estimated benefits listed are calculated for the year 2009 only and may not be forecasted to estimate emission reductions for any other year. Appendix A: *Voluntary Mobile Source Emission Reduction Programs for the HGB Eight-Hour SIP* more fully describes these VMEP measures. The VMEP reduction was included in modeling sensitivity runs described in Chapter 2. The 2.82 tpd NO_X reductions are referred to as the H-GAC reductions.

Table 4-3: Voluntary Mobile Source Emission Reduction Programs

Measure	**NO_X Reductions in tons per day (tpd)**
Public and Private Sector Clean Fuel Fleet	2.0
Commute Solutions (5 measures)	0.77
Pooled Ownership of Vehicles	0.05
Total	**2.82**

4.3 ADDITIONAL MEASURES

4.3.1 Energy Efficiency and Renewable Energy

Energy efficiency efforts are typically programs that reduce the amount of electricity and natural gas consumed by residential, commercial, industrial, and municipal energy consumers. Examples include increased insulation in homes, installing compact fluorescent light bulbs and other high efficiency lighting, replacing motors and pumps with high efficiency units, and replacing traffic signal lights with light emitting diode fixtures. Renewable energy efforts include programs that generate energy in a less polluting manner than conventional energy production. Examples include wind energy and solar energy projects.

A variety of energy efficiency and renewable energy (EE/RE) measures reduce demand for traditionally-produced electricity in the HGB area. SB 5 (77th Texas Legislature, 2001), sets goals for political subdivisions in 41 nonattainment and effected counties to implement measures

to reduce energy consumption by existing facilities by 5 percent each year for five years from January 1, 2002. The State Energy Conservation Office is in charge of tracking the implementation of SB 5. SB 7 (76th Texas Legislature) sets goals for each electric utility to reduce projected growth in demand by 10 percent by EE/RE measures each year starting January 1, 2004. The Public Utility Commission of Texas (PUC) is in charge of this program. SB 20 (79th Texas Legislature, First Called Session) requires that the PUC work with electric utilities to assure that the target levels of renewable energy are generated within specified time frames.

The complex nature of the electrical grid makes accurately quantifying emission reductions from energy efficiency and renewable energy projects difficult. At any given time, it is impossible to determine exactly where on the electrical grid electricity comes from for any certain electrical user. The electricity for a user could be from a power plant in west Texas, a nearby attainment county, or from within the nonattainment area. If electrical demand is reduced in the HGB nonattainment area due to these kinds of measures, then emission reductions may occur in any number of locations around the state.

As summarized in the December 2002 HGB SIP revision, staff has developed a methodology designed to estimate NO_X emission reductions resulting from energy efficiency and renewable energy measures. This method has been improved with the support of EPA and the Energy Systems Laboratory (ESL), which is part of Texas Engineering Experiment Station, of the Texas A&M University System. EPA's Emissions and Generation Resource Integrated Database (E-GRID – 2007) was used to spatially allocate the electric energy reductions in each county to electric generating units (EGU) located in the HGB counties and counties outside the HGB area. E-GRID – 2007 then estimated the EGU emissions reductions. For natural gas reductions at project sites, ESL used AP-42 emissions factors to calculate the emissions reductions. The latest projected estimate for NO_X emissions reductions in the 8-county HGB area on an ozone season day in 2009 is 5.07 tpd.

This methodology, though, does not address the complication created from the NO_X cap and trade program in the HGB area. The MECT Program caps the NO_X emissions at point sources, including EGU, in the HGB nonattainment area. If an EGU, like a power plant, is located within the HGB nonattainment area and demand on that EGU is reduced due to effective EE/RE programs, then the EGU may emit less NO_X than its cap allows. The EGU could then have excess NO_X allowances that could be sold or traded in the HGB area, resulting in no net reduction in NO_X emissions. Therefore, in the HGB area, SIP-quality reductions from EE/RE cannot be accounted for and relied upon in the SIP.

While energy efficiency and renewable energy efforts will likely benefit the HGB airshed, the complications associated with the electrical grid and the MECT program make reductions unquantifiable for incorporation into the photochemical model.

4.3.2 Urban Heat Island Measures

The term "urban heat island effect" refers to the observation that urban areas are hotter on average than surrounding rural areas. Urban heat island measures attempt to mitigate the occurrence of this phenomenon by decreasing the amount of heat that is absorbed into surfaces like roads, buildings, and parking lots. Examples include planting trees for shade and paving or painting surfaces with lighter colored materials or paint. In Houston these kinds of measures are being promoted by Cool Houston!, a program at the Houston Advanced Research Center designed to help reduce urban temperatures through use of cool technologies - reflective and green roofing, paving with light colored or porous materials, and a greatly expanded forest canopy.

The overall effect of urban heat island measures must be determined in order to accurately estimate any ozone reductions for use in the SIP. Urban heat island measures may increase energy efficiency because cooler temperatures, even on a house by house scale, can reduce air

conditioner use and result in reduced energy consumption at a micro level. Strategically placed trees can increase shade and provide a secondary energy efficiency benefit by reducing air conditioner use.

The most sophisticated studies on tree planting to date, however, show that ozone will decrease in some areas and increase in other areas if widespread tree planting occurs. With the planting of new vegetation, additional biogenic VOC emissions are created. Studies also show that increasing biogenic VOC emissions in the urban core is likely to increase ozone formation on most days because the ozone chemistry in the urban core is complex and can be VOC-limited. Additionally, if urban temperatures go down, the depth of the mixing layer may decrease, which means that emissions could be trapped in a smaller volume of air, resulting in higher concentrations of emissions and their byproducts. Further, most of the studies that estimate possible ozone reductions from measures like tree planting were done in smaller, arid cities like Sacramento, California. Results in a large, humid city such as Houston will likely differ considerably. Modeling is not capable of determining the effects of urban heat island measures, like tree planting, in the HGB area using the most currently available data.

Since the science and the modeling tools are not adequate for accurately estimating ozone reductions, these measures can only be examined in a qualitative rather than a quantitative way. As the science around the effect of urban heat island measures progresses, the TCEQ will take new information into account as part of the ongoing effort to appropriately account for useful air quality improvement measures in the HGB SIP.

4.3.3 SmartWay Transport Partnership and the Blue Skyways Collaborative

Among its various efforts to improve air quality in Texas, the TCEQ is currently promoting two voluntary programs in cooperation with the EPA: the SmartWay Transport Partnership and the Blue Skyways Collaborative.

The SmartWay Transport Partnership is a collaborative, voluntary program between the EPA and the freight transport industry that promotes strategies and technologies to help improve fleet efficiency while also reducing air emissions. Fleets participating in the SmartWay Transport Partnership commit to implementing these voluntary measures over three years, providing the EPA with annual updates of their progress throughout that period.

SmartWay carriers will typically commit to integrating fuel saving strategies and technologies into their fleet including: improved aerodynamics, single-wide tires, lighter wheels and rims, idle reduction, automatic tire inflation systems, driver training, and advanced powertrain technologies.

Unfortunately, the transient nature of freight transportation makes it difficult to isolate emissions reductions to a certain region, or even a certain state. As a result, any estimates of the impact of these technologies will largely rely on estimates of accumulated reductions based on estimated levels of overall fleet integration. These estimates are possible because through their ongoing research, and in conjunction with the more than 300 companies already committed as SmartWay partners, the EPA has identified a variety of technologies and quantified the potential fuel savings and emissions reductions from those technologies.

Rolling resistance is estimated by the EPA to account for as much as 13 percent of a heavy-duty vehicle's fuel consumption. By reducing rolling resistance, as well as vehicle weight, the EPA believes that single-wide tires will help to improve fuel economy and reduce NO_X emissions by an average of five percent. On the other hand, aerodynamic drag accounts for most of a long-haul truck's energy losses at highway speeds. As a result, the EPA estimates that improving the aerodynamics of both a long-haul truck and its trailer can help to improve fuel economy and reduce NO_X emissions by another five percent.

The extended periods of idling typically associated with long-haul trucks will consume an average of one gallon of fuel per hour, while also generating the associated emissions. New technologies such as auxiliary power units (APU) and truck stop electrification (TSE) reduce vehicle idling by providing power for air conditioning, heating, and onboard electrical accessories, even when the vehicle is not in operation. The EPA estimates that, assuming typical idling levels, idling reduction technologies such as APU and TSE can reduce NO_X emissions by approximately ten percent.

The Blue Skyways Collaborative is a related effort, spearheaded by the EPA Region 6 office in Dallas and the Region 7 office in Kansas City, Missouri.

Partnering with the EPA through this effort are the environmental and energy agencies from the ten states along the I-35 corridor, including Texas, New Mexico, Louisiana, Arkansas, Oklahoma, Kansas, Missouri, Nebraska, Iowa, and Minnesota. In implementing the Blue Skyways Collaborative, the EPA and the participating states recognize that because air quality is often a regional concern, greater reductions are possible through cooperative efforts as opposed to individual efforts initiated independently in each state.

The primary objective of the Blue Skyways Collaborative is to improve air quality in these states by promoting innovative technologies in a variety of sectors. In addition to promoting reduction strategies through the SmartWay Partnership for freight transportation via air, water, and rail, Blue Skyways also focuses on promoting emissions reduction strategies for other on-road sources, non-road sources, and highway fueling and idling reduction infrastructure, while also promoting renewable, efficient, and alternative energy sources.

In order to achieve these objectives, the collaborative will develop partnerships among international, federal, state, and local governments, as well as non-profit organizations, environmental groups and private industries. These partnerships will reduce emissions along the key transportation corridors by sharing technology and leveraging financial resources from a variety of sources.

4.3.4 Clean Air Interstate Rule (CAIR)

The TCEQ analyses indicate that CAIR Phase I will not significantly impact future (2009) ozone attainment in the HGB area, but the EPA projects that CAIR Phase I regional controls will improve air quality in the HGB area. As of May 2005, Texas regulates electric generating units to a higher level of control that is “beyond" the current level of CAIR in East Texas and the HGB area. Additionally, analysis of eight-hour exceedances indicates that on a notable number of days the ozone background transported into the HGB area from states beyond Texas is not appreciable. Therefore CAIR regional controls in states beyond Texas have little or no effect on eight-hour attainment in the HGB area. The TCEQ future case (2009) modeling includes CAIR regional reductions in states beyond Texas, and in East Texas and the HGB area. The TCEQ used EPA’s modeling files that incorporated the latest Integrated Planning Model from October 2005 for all states outside of Texas to accomplish this task, as well as modeling the beyond-CAIR reductions that are in Texas’ rules in order to simulate CAIR Phase I. CAIR Phase II reductions that begin in 2015 will need to be assessed in the future to determine their impact on modeling for 2018.

4.3.5 Texas Emission Reduction Plan (TERP)

The TCEQ does not have the legal authority to set emission standards for on-road and non-road engines. In order to address emissions from these sources the Texas Legislature committed more than $413 million to TERP to provide reductions in these significant emissions source categories that cannot legally be regulated by the TCEQ. Over $204 million of that commitment has been awarded to the HGB area, to achieve more than 22 tpd in emissions reductions. Additional funds will be awarded to the HGB area in subsequent grant application periods to achieve the current commitment of 38 tpd in NO_X reductions. Future TERP funds, if appropriated by the legislature,

will result in continued reductions in the significant emissions source categories of on-road and non-road engines.

4.3.6 Texas Low Emission Diesel for Locally Operated Locomotive Engines

Locomotive switcher engines are almost exclusively operated on a local level, and are typically used to move railcars around a yard. Since these engines are locally operated and use TxLED compliant fuel, there is an associated quantifiable local reduction in NO_X due to TxLED fuel use. This local reduction is estimated to be less than 1 tpd, and reductions of this magnitude do not impact the design value of any of the driving monitors in the HGB area. These NO_X reductions were not included in the 2009 modeling future case inventory due to timing issues but will contribute to progress toward attainment. These reductions will be accounted for in future technical work after the development of the new base case.

4.4 WATER HEATER AMENDMENT OFFSETS

Proposed amendments to 30 TAC Subchapter E: Division 3--Multi-Region Combustion Control, Water Heaters, Small Boilers, and Process Heaters (§§117.3200-3215), would repeal the current statewide emission standard of 10 nanograms NO_X per Joule heat input (ng/J) due to the inability of water heater manufacturers to produce units compliant with the current rule (rule project 2006-034-117-ED). Under the adopted rules, manufacturers, distributors, retailers, and installers of natural gas-fired water heaters with a maximum rated capacity of no more than 75,000 British thermal units per hour, designated as a "Type 0 unit" in the adopted rules, manufactured, distributed, sold, or installed on or after July 1, 2002, but no later than December 31, 2004, are required to meet an emission limit of 40 ng/J. Type 0 units manufactured, distributed, sold, or installed on or after January 1, 2005, were required to meet a 10 ng/J heat input limit. The proposed rules repeal these standards and reinstate the 40 ng/J emission limit in force since July 1, 2002.

HB 965, from the 79th Texas Legislative Session, authorized this amendment and required emission reductions to offset the loss of state implementation plan credits due to the potential repeal of the proposed rule. Reductions from a currently effective rule that were not claimed for the HGB one-hour ozone attainment demonstration will offset the 0.5 tpd of NO_X attributed to the water heater rule in the HGB area. Specifically, 30 TAC Chapter 117, Subchapter D, Division 2, was adopted in April 2000 and applies to minor sources of NO_X in the HGB area. While the rule is mentioned in the HGB SIP, specific reductions associated with the rule from sites that are not subject to the NO_X MECT program were not claimed or modeled for the HGB one-hour ozone attainment demonstration. A minimum of 0.7 tpd NO_X reductions will be achieved from these sources. This estimate is based only on gas-fired boilers subject to 30 TAC Chapter 117, Subchapter D, Division 2 that were not included in the MECT program. Furthermore, the 0.7 tpd estimate is conservative because it does not include reductions from other sources subject to this rule that were also excluded from the MECT program.

4.5 RACT, RACM, CONTINGENCY MEASURES, AND EMISSIONS INVENTORY

4.5.1 Reasonably Available Control Technology (RACT) Demonstration

According to EPA's Final Rule to Implement the Eight-Hour Ozone NAAQS (40 Code of Federal Regulations §51.912, November 29, 2005), areas classified as moderate nonattainment or higher must submit a demonstration that their current rules fulfill eight-hour RACT for all Control Technique Guidelines (CTG) categories and all non-CTG major sources as a revision to their SIP. Such demonstrations can be made with either a new RACT determination or a certification that previously required RACT controls represent RACT for the eight-hour ozone standard. This RACT SIP submittal demonstrates that the RACT requirements for the HGB eight-hour nonattainment area have been fulfilled by identifying all sources within the HGB area requiring RACT, listing the state regulation that implements or exceeds RACT for that category, and submitting negative declarations where there are no major facilities within the HGB area.

Appendix B: *Reasonably Available Control Technology Analysis* provides the full RACT analysis and demonstration.

4.5.2 Reasonably Available Control Measures (RACM) Demonstration

According to EPA guidance, a state's RACM demonstration must show that the state has adopted all reasonable measures to demonstrate attainment as expeditiously as practicable and that no additional measures that are reasonably available will advance the attainment date. Although a state should consider all available measures, it need adopt measures only if the measures are both economically and technologically feasible and will advance the attainment date. Appendix C: *Reasonably Available Control Measure Analysis* provides the full RACM analysis and demonstration.

4.5.3 Contingency Measures

Contingency measures that were put into place for the one-hour ozone standard were never triggered, and as such, they will remain in place for the eight-hour ozone standard. See the TCEQ VOC rules on Municipal Solid Waste Landfills §115.159(c), Offset Lithographic Printing §115.449(e), and Petroleum Dry Cleaning §115.559(c).

4.5.4 Emissions Inventory

As required by 40 CFR 51.915, the HGB 2002 Emissions Inventory was submitted to the EPA as part of the Dallas-Fort Worth (DFW) 5 Percent Increment of Progress SIP Revision in April 2005 (Appendix A of the DFW SIP, and may be viewed at http://www.tceq.state.tx.us/implementation/air/sip/apr2005dal_iop.html.) Tables 1 and 2 of the 2002 Periodic Emissions Inventory are resubmitted as part of this SIP submittal, as Appendix G, to comply with the public comment, public notice, and public hearings requirements.

CHAPTER 5: ONGOING WORK AND FUTURE INITIATIVES

The Texas Commission on Environmental Quality (TCEQ) continues to work towards reducing ozone precursor pollutants. Texas is investing resources into technological research and development for advancing pollution control technology, improving the science for ozone modeling and analysis, and refining quantification of volatile organic compound (VOC) emissions. Additionally, the TCEQ is working with local area leaders to identify new methods for reducing ozone precursor pollutants. This chapter describes ongoing technical and regulatory work that will be beneficial to improving air quality planning, and thus air quality, in Texas.

5.1 TEXAS AIR QUALITY STUDY II (TexAQS II)

The original Texas Air Quality Study (TexAQS 2000) was a comprehensive air quality study that combined the efforts of over 40 research organizations and more than 250 scientists. It provided a large part of the scientific basis for reassessing ozone formation in the Houston-Galveston-Brazoria (HGB) area, and its findings were included in the recently approved HGB one-hour ozone attainment demonstration state implementation plan (SIP) revision. The success of this study, and the outstanding questions that it raised, provided the foundation for planning for the second Texas Air Quality Study (TexAQS II).

TexAQS II was conducted between the spring of 2005 and the fall of 2006, with an intensive study period occurring between August 15 and September 30, 2006. Many unanswered questions remained after TexAQS 2000, and the TexAQS II is designed to help answer questions in several areas, including inventory validation (especially highly-reactive volatile organic compounds (HRVOC)), ozone and particulate matter transport, planetary boundary layer dynamics, nighttime chemistry, and model improvement. While a great deal of interest remains in the HGB area, the TexAQS II broadened the geographic extent of the study area from the upper Texas Coast to now encompass all of eastern and central Texas (see Figure 5-1: *TexAQS II Study Area*).

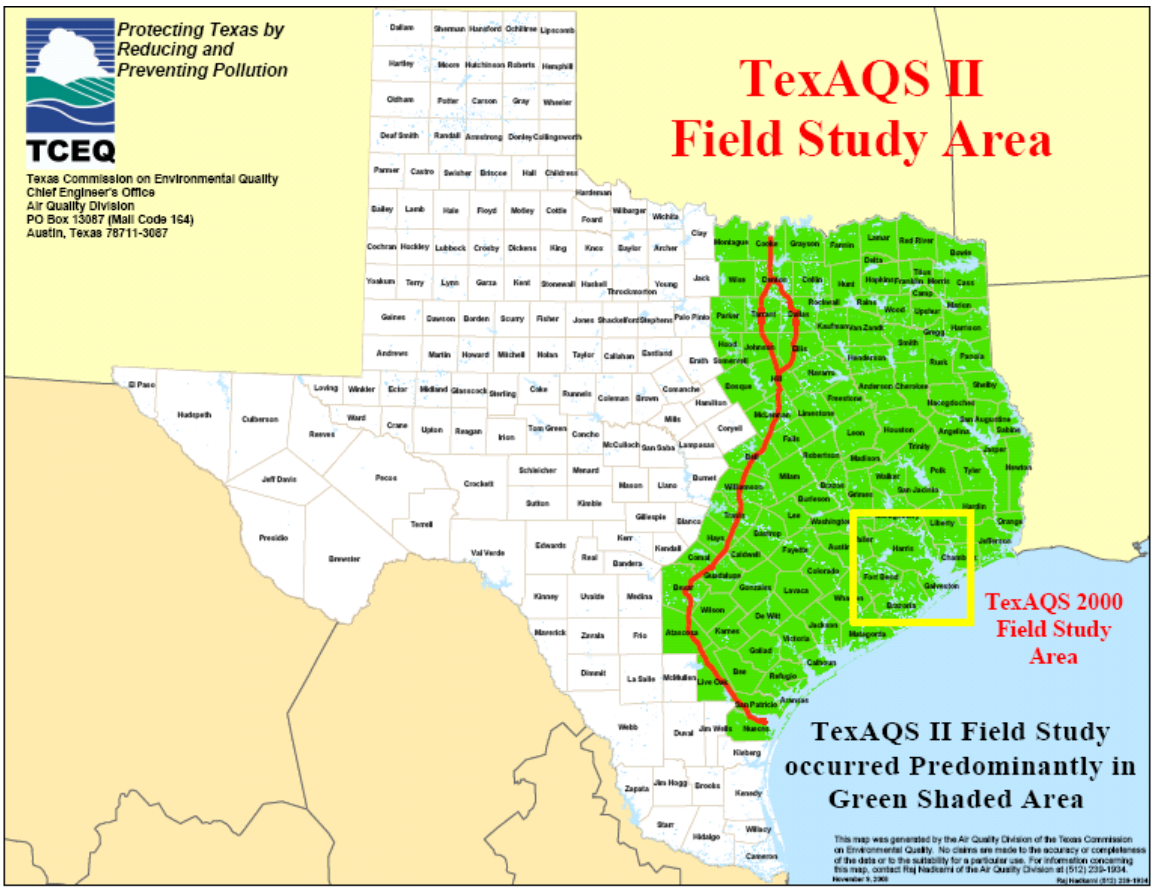

Figure 5-1: TexAQS II Study Area

5.1.1 Description of the TexAQS II

TexAQS II was one of the most extensive air quality studies ever undertaken and included participants from over a dozen federal, state, and local governmental bodies, including the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration, the United States Environmental Protection Agency (EPA), the National Center for Atmospheric Research, the Department of Energy, and the TCEQ. Other participants represented some thirty institutes of higher education, several research organizations, various corporations, and other organizations. In addition to the TCEQ's routine network of meteorological and air quality monitoring equipment, measurement platforms deployed for the study included five research aircraft, NOAA's research vessel Ronald H. Brown, a supersite atop a high-rise dormitory on the University of Houston's campus, a network of rural monitoring stations, a network of meteorological sites including eight radar profilers, ozone sonde and guided balloon launches, tethered balloons, enhanced hydrocarbon measurements at existing monitoring locations, and a mobile instrument to measure hydrocarbon flux. Targeted compounds include ozone, carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), particulates characterized by both size and species composition (nitrates, sulfates, organic and elemental carbon, crustal matter), hydroxyl radicals (OH), nitrous acid (HONO), hydroperoxyl radical (HO_2), hydrogen peroxide (H_2O_2), nitrogen oxides (NO_X), nitrogen species (NO_Y), nitric acid, formaldehyde, acetaldehyde, mercury, hundreds of hydrocarbon species, including HRVOC, various peroxyacyl nitrates (PAN) compounds, and a long list of additional compounds. Figure 5-2: *The RV Ronald H. Brown and TexAQS II Instrumentation* and Figure 5-3: *The NOAA WP-3 Orion and TexAQS II Instrumentation* show, respectively, the Ronald H. Brown with a description of the instruments deployed aboard for TexAQS II, and the NOAA WP-3 Orion aircraft, also with a description of its instrumentation for the study.

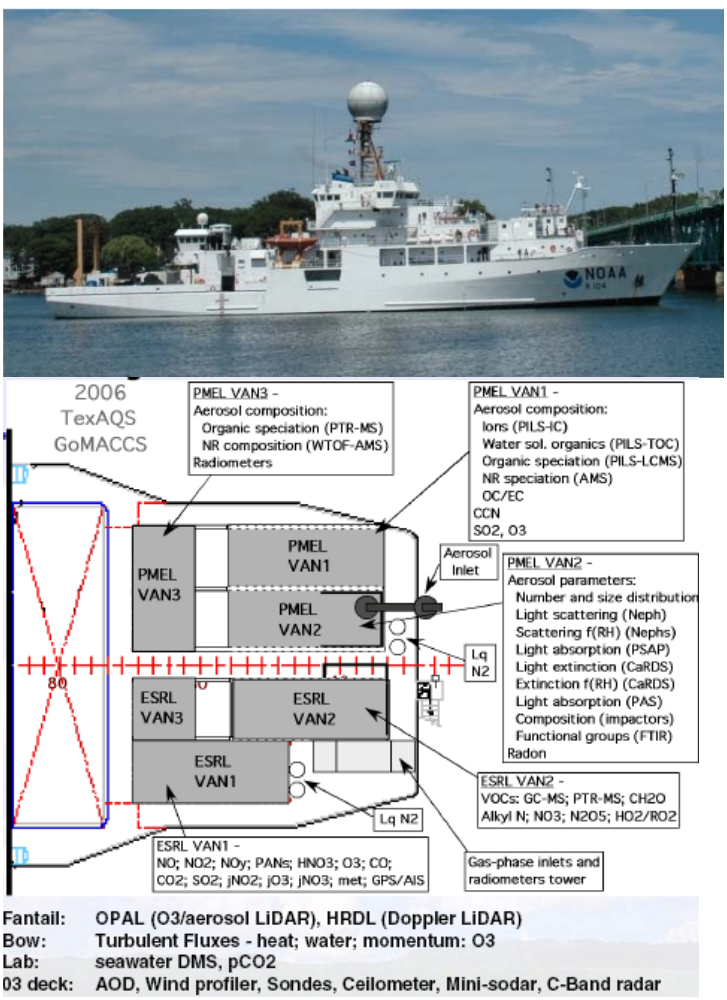

Figure 5-2: The RV Ronald H. Brown and TexAQS II Instrumentation

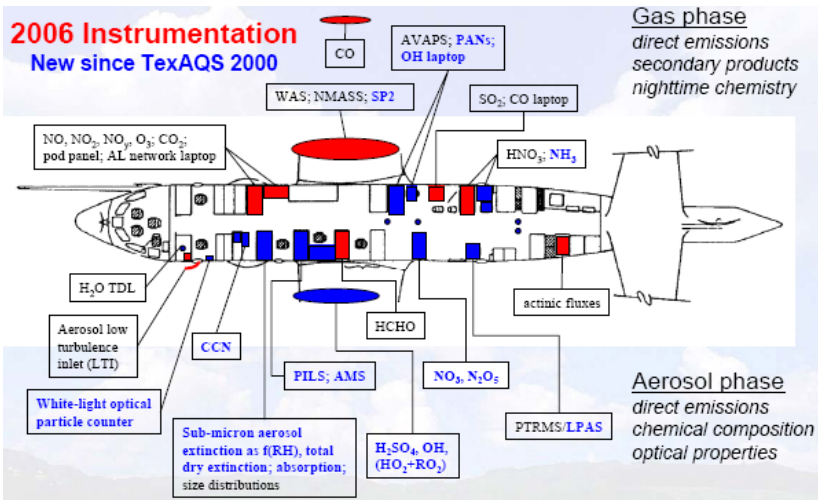

Figure 5-3: The NOAA WP-3 Orion and TexAQS II Instrumentation

5.1.2 Research Questions

The TexAQS 2000 advanced the understanding of the mechanics of ozone formation along the upper Texas coast, yet a number of questions remain unanswered. The TexAQS II was specifically designed to address SIP-related questions, including the following.

- Which local emissions are responsible for the production of high ozone in Houston, Dallas, and eastern and central Texas? Are different kinds of emissions responsible for transient high ozone and eight-hour-average high ozone (i.e., ≥ 84 parts per billion (ppb))?
- How do the structure and dynamics of the planetary boundary layer and lower troposphere affect ozone and aerosol concentrations in Houston, Dallas, and eastern and central Texas?
- Are HRVOC and NO_X emissions and resulting ambient concentrations still at the same levels in Houston as they were in 2000? How have they changed spatially and temporally? Are there specific locations where particularly large quantities of HRVOC are still being emitted? Are those emissions continuous or episodic? How well do the reported emissions inventories explain the observed concentrations of VOC and NO_X?
- What distribution of anthropogenic and biogenic emissions of ozone and aerosol precursors can be inferred from observations?
- Are there sources of ozone and aerosol precursors that are not represented in the reported emissions inventories?
- How do the mesoscale chemical environments (NO_X-sensitive ozone formation vs. radical-sensitive ozone formation) vary spatially and temporally in Houston, Dallas, and

eastern Texas? Which mesoscale chemical environments are most closely associated with high ozone and aerosol?

- How do emissions from local and distant sources interact to determine the air quality in Texas? What meteorological and chemical conditions exist when elevated background ozone and aerosol from distant regions affect Texas? How high are background concentrations of ozone and aerosol, and how do they vary spatially and temporally?
- How do areas within Texas affect the air quality of nonattainment areas within Texas? How do areas outside of Texas affect the air quality of nonattainment areas within Texas?
- Why does the Statewide Air Pollution Research Center chemical mechanism give different results than Carbon Bond-IV? Which replicates the actual chemistry better?
- How well do forecast air quality models predict the observed ozone and aerosol formation? What are the implications for improvement of ozone forecasts?
- How can observation and modeling approaches be used for determining (i) the sensitivities of high ozone in the HGB nonattainment area to the precursor VOC and NO_X emissions, and (ii) the spatial/temporal variation of these sensitivities?
- What existing observational databases are suitable for evaluating and further developing meteorological models for application in the HGB area?

5.1.3 Rapid Science Synthesis

Because of the time requirements imposed by the EPA's eight-hour ozone implementation guidance this proposed SIP revision needed to be finished by late 2006. However, the TexAQS II intensive field study needed to be conducted during August and September when the historically highest and most frequent ozone exceedances occur in the HGB area. Additional scheduling difficulties pushed back the arrival of NOAA's best-equipped airborne platform, the WP-3 Orion, until the end of August, and its mission was not completed until mid-October. Consequently, there was an extremely short period of time to analyze, interpret, and assimilate the TexAQS II data into meaningful, SIP-relevant findings that could be incorporated into the both the DFW and HGB SIP proposals.

To accelerate the synthesis of the field study data, a team of scientists was formed to provide rapid analysis for each of the SIP-relevant questions above. This project, funded by the TCEQ and led by Ellis Cowling of North Carolina State University and David Parrish of NOAA, provided an early analysis of the most important questions on October 31, 2006, and will provide additional information about the research questions through August 31, 2007, with a final report to be issued on that date. The next section summarizes the preliminary results as of October 12, 2006.

Rapid Science Synthesis Findings as of October 12, 2006

Preliminary results of the 2006 TexAQS II intensive field study were presented at the Rapid Science Synthesis Meeting on October 11-12, 2006; some of these results are presented below. The following preliminary results indicate that while the magnitude of the ozone concentrations in the HGB area has been reduced, the principle cause of the highest ozone episodes remains unchanged. Further analyses of the TexAQS II data may produce more detailed conclusions and may indicate appropriate future direction for research, monitoring, and modeling.

- Ozone production efficiency from Houston industrial emissions seems to be at approximately the same level as in 2000. The industrial areas of Houston still generally produce more ozone than the urban areas of Houston.
- Measurements of the ratios of carbon monoxide to NO_X seem to indicate a discrepancy between the MOBILE6 emissions model and the observed ratios.
- Direct emissions of formaldehyde seem to be minor compared to the secondary formation of formaldehyde.
- Concentrations of NO_X in power plant plumes in Houston and eastern Texas seem to be lower than in 2000, in some cases by a factor of 3.

- Concentrations of ethene in the industrial areas of Houston and Brazoria County seem to be substantially lower than in 2000. Propene concentrations downwind of the Houston industrial areas in 2006, however, have not decreased as much as ethene.
- Peak ozone on episode days in 2006 was lower than in 2000.
- Background concentrations of ozone can vary greatly in Houston, depending upon the transport conditions, ranging from 15 ppb to > 80 ppb. Higher background ozone seems to be related to several consecutive days of transport from the east, which occurred only for a few days during the study period.
- Ozone formed in Houston was observed to be transported within Texas to other nonattainment or near-nonattainment areas.
- On a number of days, the peak ozone in the Houston area was found outside the TCEQ Houston monitoring network. This pattern occurred on days with relatively strong winds (greater than 11.2 mph) and no flow reversal.

5.1.4 More Information on TexAQS 2000 and TexAQS II

For more information on the TexAQS 2000 go to http://www.utexas.edu/research/ceer/texaqs/.
For more information on TexAQS II see:
http://www.tceq.state.tx.us/implementation/air/airmod/texaqs-files/TexAQS_II.html,
http://www.utexas.edu/research/ceer/texaqsII/, and
http://esrl.noaa.gov/csd/2006/.

5.2 ONGOING EFFORTS TO IDENTIFY AND CONTROL VOC EMISSIONS

5.2.1 Infrared Gas Imaging Technology

The TCEQ is supportive of using optical gas imaging technology to detect leaks of VOC. Optical gas imaging technology has the potential to advance leak detection and repair (LDAR) work practices and enable monitoring of components that are difficult to monitor with traditional LDAR methods. The technology may also be useful in identifying sources of VOC emissions that are under-reported, unreported, or previously unregulated. However, the commission has technical and enforcement concerns associated with the potential regulatory implementation of this technology. A standardized method or performance specification is necessary to ensure consistent and reliable application of optical gas imaging instrumentation. Methods and specifications are also necessary to set minimum standards of performance to evaluate different potential technologies. The commission does not seek to prescriptively limit optical gas imaging to certain technologies or manufacturers. As with all new and developing measurement technologies, optical gas imaging technology has some limitations that are not completely understood at this time. Application of any optical gas imaging technology across the board to any source of VOC is not appropriate at this time. Based on TCEQ staff experience with gas imaging instruments, the technology can yield highly questionable results when applied to some sources of VOC.

The commission is soliciting comments on ways to advance the use of optical gas imaging technology. Specifically, the commission solicits comments on the appropriate instrument specifications necessary in order to use the technology to detect VOC leaks. The commission is also seeking ideas regarding the development of a method or performance specification to evaluate potential optical gas imaging instruments. In addition, the commission is aware that a number of companies are using optical gas imaging instruments to detect VOC leaks in their facilities. The field experience of these companies with optical gas imaging technology would be valuable in determining initial source categories for applying the technology in any potential regulatory implementation. Therefore, the commission is seeking comment and supporting information on source categories for potential application of optical gas imaging technology, as well as those source categories that the technology should not be applied to.

5.2.2 Remote Sensing VOC Project

When the TCEQ and its research partners began TexAQS II in May 2005, one of the study's primary goals was to identify VOC emission sources that have been historically unreported or under-reported in the EI and could potentially be contributing to the discrepancy between measured and reported emissions.

The Remote Sensing VOC Project, one of the first TexAQS II projects, used an infrared imaging camera to observe VOC plumes from various locations around the HGB area during July 2005. The imaging was conducted from a helicopter, a boat, a passenger vehicle, and the San Jacinto Battleground Monument. The significant findings from this observational project indicate that emissions from landed floating roof storage tanks, barges, and oil field tanks generally have been unreported in the TCEQ EI.

One result of this project was increased agency scrutiny on the landing loss emissions that occur whenever the tank is drained to a level where its roof lands on its legs or other supports. Tank-for-hire bulk terminal facilities (source identification codes 4225, 4226, and 5171) often land floating roof tanks because they empty their tanks relatively frequently. Figure 5-4: *2004 Reported VOC Emissions in the Houston Ship Channel and Surrounding Area* shows the radius around the ship channel in which the average total annual reported VOC emissions from 2002 to 2004 was reported to be approximately 14,000 tpy. TCEQ efforts to improve unreported landing loss emissions increased the reported emissions 6000-7000 tpy in the Houston Ship Channel area alone. Companies that were previously not accounting for tank landing VOC emissions have now submitted plans to decrease landing loss emissions. These companies are in the process of revising permits to reflect both changes in work practices and permitted emissions resulting from tank roof landings.

The TexAQS II also found that barges are emitting VOC when in transit. The commission currently regulates barges while they are at dockside. In addition, Section 4.2.2 describes new rules, to be adopted concurrent with this SIP revision, that more stringently regulate VOC emissions from barges. In addition to dockside regulations, the TCEQ has been working with the Texas Waterway Operators Association's Tug and Tow Division to revise and improve work practices to minimize barge emissions while in transit. The Louisiana Department of Environmental Quality has also identified barges as a previously unidentified source of VOC emissions, and is working to address the problem.

Oil field storage tanks were also found to be a potentially under-reported source of VOC emissions. Plumes were observed coming from 10 percent of the approximately 50 oil field storage tanks observed between Beaumont and Houston. As a result, the Houston Advanced Research Center (HARC) sponsored a project, H-51C, which measured both the flow and concentration of VOC emissions from 33 tank batteries in oil fields located in nonattainment areas around the state. Historically, oil field tank VOC emission factors have been estimated using emission models. Using the measured data, emission factors were derived that represent the losses that occur during production. The factors, in pounds of VOC per barrel produced, account for emissions from flash, working, and breathing/standing losses. The goal is that upstream oil and gas operators may use these emission factors to more accurately estimate VOC emissions. The results of this study are currently being analyzed by staff and additional research in this area is expected.

Another observed source of under-reported VOC emissions was from pressure tank railcars, which are railcars designed to hold gas under pressure. HARC project 51A sampled fittings on these railcars to derive a VOC emissions factor. This new factor will be included in the TCEQ point source guidance for estimating emissions from tank railcars for use in the 2006 emissions inventory. Although these emissions have been historically unreported, they are relatively small compared to emissions from other unreported source categories.

Subsequent agency efforts to identify and control unreported or under-reported industrial VOC sources identified the following potential sources of concern: liquid heel, tank degassing, wastewater, vacuum cleaning, stored liquid temperature, and sumps.

A liquid heel refers to stock liquid remaining in the bottom of a storage tank after it has been emptied. Liquid heels are responsible for numerous cases of under-reported VOC emissions. Degassing a tank with a liquid heel results in unreported VOC emissions because the liquid remaining in bottom of the tank continues to vaporize after the degassing process is completed and those VOC emissions vent to the atmosphere. Cleaning a tank with any liquid heel typically involves rinsing the tank with soap and water. The cleaning process produces wastewater with a significant VOC content and this wastewater typically goes to a wastewater treatment facility where the VOC emissions may evaporate to the atmosphere. Similarly, vacuum cleaning a tank with a liquid heel may result in unreported emissions. These emissions are difficult to quantify.

Typically sites estimate their storage tank emissions using ambient temperature, usually 68 degrees Fahrenheit (F). The temperature of a liquid is the biggest variable affecting the emissions from a storage tank. For example, gasoline at 100 degrees F emits significantly more VOC than gasoline at 68 degrees. Therefore, the TCEQ has revised its emissions inventory guidance to ensure that accurate temperatures are used in emissions calculations.

Sumps at marine loading facilities are a potentially significant source of under-estimated, unreported, or under-reported VOC emissions. Left-over liquid in flexible loading lines is often pumped to a sump that is linked to a slop tank (a VOC storage tank). Usually the sump is equipped with an automatic switch that empties the liquid into the slop tank when a predefined volume is reached. If the automatic switch does not engage, then the liquid evaporates out of the sump. This can be remedied by a change in work practice. The TCEQ is addressing under-estimated, unreported, or under-reported emissions from this source in the 2006 Emissions Inventory Guidelines.

This SIP revision contains a rulemaking that addresses sources of under-estimated, unreported, or under-reported VOC emissions. Section 4.2.2, Control of VOC Emissions from Storage Vessels and Degassing/Cleaning of Vessels, fully describes the rulemaking that will, among other measures, address unreported VOC emissions from tank landings; from flash emissions; and from degassing storage tanks, transport vessels, and marine vessels with liquid heels.

The TCEQ will work to continue to improve the emissions inventory in an effort to improve all aspects of the SIP.

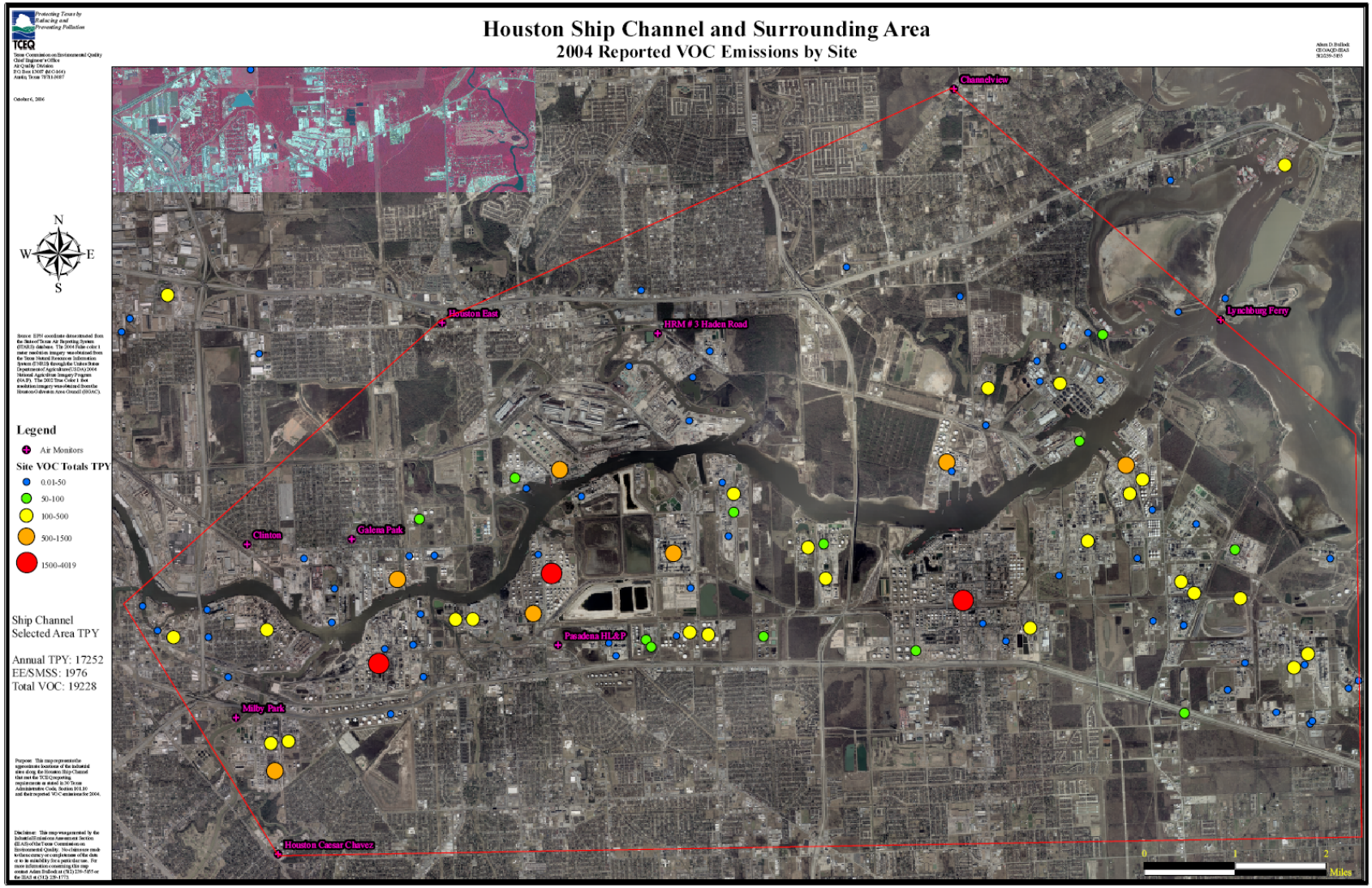

Figure 5-4: 2004 Reported VOC Emissions in the Houston Ship Channel and Surrounding Area

5.3 EFFORTS TO REDUCE NO_X FROM PREEMPTED SOURCES

5.3.1 Routine Vessel Study

The TCEQ, with the assistance of EPA grant funds, initiated a project to identify and count marine vessels that function exclusively in the HGB area or visit the HGB via the Gulf Coast or Intracoastal Waterway at least seven times over an 18-month period. These vessels are collectively referred to as routine vessels. Once the routine vessels are identified, the study will estimate emissions and quantify potential emission reductions from the routine vessel fleet. The study is scheduled to be completed by the end of November 2006. By identifying routine vessels, the EPA, the TCEQ, other states or local stakeholders could pursue actions to reduce NO_X, VOC, and particulate matter pollution. The first such action is to identify a "national routine fleet" to target pollution reduction efforts. This would aid EPA's Blue Skyways program by identifying the national marine fleet that visits the HGB area and other United States ports on a regular basis. The second action is to pursue joint business, interstate, and federal partnerships to reduce pollution from routine vessels.

Draft Study Findings to Date

Preliminary estimates indicate that 46 percent of the routine vessels visiting the HGB area also visited other United States ports. This tells us there may be an opportunity to collaborate with other nonattainment ports to identify the national routine fleet and work with these vessels for emission reductions that benefit several areas. The EPA could play a significant role in these efforts.

A convenient categorization of marine vessels is ocean-going vessels and harbor craft. Ocean-going vessels include tankers, offshore service vehicles, cargo or container ships, and cruise ships. Harbor crafts include tug and tow boats and ferries. Study results may be broken down by these categories and types.

Ocean-Going Vessels (OGV):

- Tankers
  Tankers are, by far, the most frequent OGV routine vessel. 227 tankers visited the Houston Ship Channel 3,045 times in an 18-month period. These vessels primarily visit private petrochemical terminals or "for hire" tank terminals. Preliminary research indicates that many of the routine vessels in this category are oil/product tankers that may visit many HGB terminals on a single trip thus "dwelling" in the ship channel; as dwelling increases, so do emissions. In 2009, oil/product tankers are projected to represent 26 percent of NO_X marine emissions (11.24 tpd).
- Offshore Service Vessels
  The draft report identifies 174 offshore service vessels that visited HGB 7 or more times in the 18-month window.
- Cargo/Container Ships
  The general cargo and container ships category includes approximately 50 routine vessels making a combined total of 1,423 port calls over the same 18-month period.
- Cruise Ships
  Seven cruise ships called on the Galveston Port collectively 245 times. Each ship spent an average of 432 hours in port over the 18-month period.

Harbor Vessels:

Harbor vessels include tugs, tows, and ferries. In 2009, these vessels will account for 29 percent of NO_X marine emissions (12.5 tpd). Harbor vessels may remain in the HGB area 100 percent of the time, or alternatively, they may move throughout the Texas Gulf Coast area or even interstate via the Gulf Coast or the Intracoastal Waterway. The study identified at least 530 tugs and tows that remain in the HGB area most of the time. The TCEQ, together with the Texas Environmental Research Consortium (TERC), is working with the Texas Waterway Operators

Association to identify emission reductions to date, areas, and technologies where we can best reduce NO_X and/or VOC from the routine vessels in this sector.

Harbor vessels also pull product barges in the HGB area. These product barges have been identified by the agency as a potential source of VOC. As mentioned in Section 5.1.2, the American Waterway Operators' Tug and Tow Division implemented a project to encourage industry best management practices (BMP) to reduce VOC emissions from barges. Identification of harbor vessels could also aid in recruiting these vessels to participate in the BMP program.

5.3.2 New Technology Research and Development (NTRD) Program

Texas funds the NTRD Program to fund research and advances in NO_X control technology for on-road and non-road sources. The TCEQ's NTRD Program provides incentives to encourage and support research and to develop and commercialize technologies that reduce pollution in Texas. The primary objective of the NTRD Program is to commercialize technologies that will support projects that are eligible for funding under the TERP Emissions Reduction Incentive Grants Program, which may ultimately provide additional SIP credit for new, innovative, and creative technological advancement.

5.3.3 Anticipated Federal Emission Standards on Marine and Railroad Engines

The EPA is considering locomotive and marine diesel engine emission standards modeled after the 2007/2010 clean highway and non-road diesel engine program, with an emphasis on achieving large reductions in PM emissions as early as possible through the use of advanced emission control technology. These standards, which could apply as early as 2011, would be based on the application of high-efficiency catalytic aftertreatment enabled by the availability of clean diesel fuel with a sulfur content capped at 15 parts per million. The EPA estimated that the 2007/2010 clean highway and non-road diesel engine programs could reduce NO_X and PM by 90 percent. The EPA expects that similar levels of NO_X and PM reductions could be achieved by applying similar technologies to locomotives and marine diesel engines. The EPA is expected to propose the rule by the end of 2006.

5.4 ONGOING EFFORTS TO CONTROL NO_X EMISSIONS

The existing NO_X point source controls are among the most stringent in the country. These controls include the Mass Emission Cap and Trade Program, which has an emissions cap that declines annually until 2008, have resulted in the utilization of highly effective post-combustion controls like selective catalytic reduction. The TCEQ continues to examine possibilities for appropriate additional technically and economically feasible NO_X control measures for point and area sources. In addition, the TCEQ and local governments are interested in potential control measures for on-road and non-road mobile sources that can help reduce NO_X.

5.5 FUTURE ATTAINMENT DATE

This chapter outlines ongoing efforts to improve air quality in the HGB nonattainment area. The beginning of Chapter 4 outlines the challenges to meeting attainment in HGB by 2009. Huge reductions in precursor emissions are needed in a relatively short amount of time, and while the phased implementation of federal on-road and non-road engine and emission standards will advance attainment, these federal-level standards are likely not enough to significantly advance attainment by the end of the ozone season in 2009. Section 2.8 outlines an analysis of 2018 with existing one-hour and proposed eight-hour ozone control measures and federal on-road and non-road standards. Section 2.9 discusses the development of a new modeling base case episode, and work that will follow the completion of the new base case. Chapter 3 demonstrates that, despite a rapidly growing population, great strides have been made in improving the air quality in the HGB nonattainment area. The TCEQ will continue to work with the EPA to explore feasible and practical methods to continue making progress toward attainment of the eight-hour ozone NAAQS. The TCEQ believes that, with the ongoing efforts described in this chapter, the development of a new modeling episode, the continued implementation of increasingly lower engine emission levels for on-road and non-road mobile sources, and further research and

consideration of additional control strategies, 2018 is a reasonable target year for attainment of the eight-hour ozone standard in the HGB area.

Appendices are available upon request.

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