

Appendix I
2007 Future Base Case Modeling and RRF Analysis

**Photochemical Modeling for Austin's Early Action Compact: Development of the
September 13-20, 1999 Photochemical Model with 2007 Projected Emissions and
Analysis of Future 8-Hour Ozone Design Values**

Submitted to

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Executive Summary

Austin is currently preparing an Early Action Compact (EAC) for submission to the Texas Commission on Environmental Quality (TCEQ) and the United States Environmental Protection Agency (U.S. EPA). The purposes of this report are to document the development of the 2007 Future Case for the September 13-20, 1999 CAMx model that will be used to evaluate emission control strategies in the area and to present the calculation of relative reduction factors and future 8-hour ozone design values from the September 13-20, 1999 Base Case and 2007 Future Case.

Comprehensive discussions of the Base Case model development are provided in “Development of the September 13-20, 1999 Base Case Photochemical Model for Austin’s Early Action Compact”, submitted by The Capital Area Planning Council to the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency, March 2004. Model performance has been evaluated using statistical and graphical metrics for both 1-hour and 8-hour averaged ozone concentrations. The September 13-20, 1999 CAMx photochemical model meets or exceeds established U.S. EPA performance criteria for attainment demonstrations.

Projected 2007 emission inventories were developed for the modeling domain and used with the identical meteorological data and CAMx configuration developed for the Base Case to model the Future Case. Relative reduction factors and future 8-hour ozone design values at Austin’s CAMS sites were calculated in accordance with the U.S. EPA’s *Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS* (1999) and the U.S. EPA’s *Protocol for Early Action Compacts* (2003). Modeling based on Austin’s predicted 2007 emission inventory indicates that the area will be on the cusp of attainment or non-attainment with the National Ambient Air Quality Standard for 8-hour averaged ozone concentrations. Emission control strategies have been developed that will provide the area with a margin of safety for attaining the 8-hour NAAQS. These strategies are documented in a separate report, “Photochemical Modeling for Austin’s Early Action Compact: Analysis of Emission Control Strategies for Ozone Precursors”, submitted by The Capital Area Planning Council to the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency, March 2004.

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1. Background

In accordance with the U.S. EPA's *Protocol for Early Action Compacts* (2003), the Capitol Area Planning Council (CAPCO), which coordinates air quality planning activities in the five-county Austin area, submitted documentation of the development of the September 13-20, 1999 Base Case to the TCEQ and the U.S. EPA in November 2003. The area demonstrated that the model achieves performance criteria established by the U.S. EPA. The purposes of this report are to document the development of the 2007 Future Case for the September 13-20, 1999 CAMx model that will be used to evaluate emission control strategies in the area and to present the calculation of relative reduction factors and future 8-hour ozone design values based on the September 13-20, 1999 Base Case and 2007 Future Case.

1.1 Overview of the September 13-20, 1999 Base Case CAMx Model

The area has utilized resources from the State of Texas' Near Non-attainment Areas Program to develop a conceptual model of meteorological conditions during high ozone events in Central Texas. The conceptual model was used to select the September 13-20, 1999 multi-day high ozone episode for development with the Comprehensive Air Quality Model with Extensions (CAMx) photochemical grid model. The September 13-20, 1999 modeling episode fulfills both the requirements of the U.S. EPA's *Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS* (1999) and the U.S. EPA's *Protocol for Early Action Compacts* (2003) that require representation of meteorological regimes typical of ozone exceedances. The episode covers one synoptic cycle for ozone in Austin with two initialization days and six high ozone days. It includes two weekend days (September 18th and 19th), such that control strategies can be evaluated with different emission characteristics.

The model domain is a nested regional/urban scale 36-km/12-km/4-km grid. The area has conducted extensive refinements and analyses of the MM5 version 3.5 meteorological model configuration, emission inventories, boundary and initial conditions, and dry deposition algorithms, since initiating development of the photochemical model in 2001. In accordance with U.S. EPA guidance, a MOBILE6.2-based inventory for on-road mobile source emissions has been developed for the Austin metropolitan area. Emissions for non-road mobile sources were developed using the U.S. EPA's NONROAD2002a model. Emissions from non-road mobile sources, stationary sources, and area sources have been estimated for Austin and other urban areas in the 4-km domain, using local activity data when available. Comprehensive discussions of the model development are provided in "Development of the September 13-20, 1999 Base Case Photochemical Model for Austin's Early Action Compact, submitted by The Capital Area Planning Council to the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency, March 2004".

Model performance has been evaluated using statistical and graphical metrics for both 1-hour and 8-hour averaged ozone concentrations. The September 13-20, 1999 CAMx photochemical model meets or exceeds established U.S. EPA performance criteria for attainment demonstrations.

1.2 Future Case Photochemical Modeling for Austin's Early Action Compact

The following report describes the development of the 2007 Future Case for the September 13-20, 1999 CAMx episode. The remainder of the report is subdivided into the following sections:

Section No.	Description
2.	Model input data and 2007 projected emission inventory development
3.	Future Case Model Predictions
4.	References
Appendix A.	Simple Analysis of Potential 8-Hour Ozone Design Values for 2003 in Austin Based on Historical Monitoring Data

2. Model Input Data and 2007 Projected Emission Inventory Development

The model configuration, meteorological fields, boundary and initial conditions, dry deposition algorithms, and chemical mechanisms remained the same between the September 13-20, 1999 CAMx Base Case and the projected 2007 CAMx Future Case (CAPCO, 2003a). The only differences between the Base Case and the Future Case models are the anthropogenic emission inventory data described below. Although it is recognized that new development density patterns could alter land use/land cover in future years, emissions from biogenic sources were not changed between 1999 and 2007.

Austin's 2007 emission inventory, which is the basis for the emission inputs to the September 13-20, 1999 Future Case CAMx model, is documented in a separate report (CAPCO, 2003b) in accordance with EAC reporting requirements. The purposes of the discussion below are to summarize sources of emission inventory data used in the photochemical model, to note specific emission processing steps, and to compare the magnitude and spatial distribution of 1999 base-year and projected 2007 emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOC) in the five-county Austin area.

Total emissions of ozone precursors are presented for both 1999 and 2007 for comparison purposes. Table 1 presents summaries of daily anthropogenic NO_x emissions for 1999 and 2007 for the five-county Austin Metropolitan Statistical Area. Table 2 presents summaries of daily anthropogenic VOC emissions for 1999 and 2007 for the five-county Austin Metropolitan Statistical Area. The values shown in Tables 1 and 2 represent the emissions that have been chemically speciated for the Carbon Bond IV chemical mechanism (CB-IV) and temporally allocated by processing through the Emission Processor System v.2 (EPS2). It is important to note that these "CAMx-ready" emission totals may vary slightly from totals presented by CAPCO (2003a, 2003b) because of the EPS2 processing steps.

The relative composition of the NO_x and VOC inventories between emission source sectors does not change between 1999 and 2007. Daily anthropogenic NO_x emissions are dominated by emissions from on-road mobile sources followed by emissions from area and non-road mobile sources and elevated point sources, respectively. Daily anthropogenic VOC emissions are dominated by emissions from area and non-road sources followed by emissions from on-road mobile sources in both 1999 and 2007.

Total anthropogenic NO_x emissions are predicted to decrease by approximately 23% between 1999 and 2007 on a typical weekday in the five-county Austin area. Decreases in the total anthropogenic NO_x inventory are primarily due to emissions reductions from on-road mobile sources through fleet turnover and changes in emission control technology. Typical weekday on-road NO_x emissions are predicted to decrease by approximately 36% between 1999 and 2007. Total NO_x emission inventories on weekend days are approximately 15% less in 2007 than in 1999 and are less than differences between 1999 and 2007 on weekdays, which is consistent with lower on-road NO_x emissions on weekend days.

Total anthropogenic VOC emissions are predicted to remain approximately the same between 1999 and 2007 on a typical weekday in the five-county Austin area. On-road mobile source VOC emissions are predicted to decrease by 30% (~16 tpd) across the five-county area on a typical weekday. However, area source VOC emissions are predicted to increase by 11% (12 tpd). These trends result in VOC emission totals for the area that are quite similar between 1999 and 2007.

Spatial distributions of 1999 base-year and projected 2007 NO_x emissions from area and nonroad mobile sources, low-level point sources, elevated point sources, and on-road mobile sources at 0800 on September 17 (weekday) are compared in Figures 1, 2, 3, and 4, respectively. Similar maps for VOC emissions are shown in Figures 5, 6, 7, and 8, respectively. It is important that the reader note variations in scales on maps for different source categories. This was done intentionally because substantial differences in the magnitude of emissions existed between source categories. Map scales were adjusted for each source category in order to show the spatial distributions of emissions.

Spatial distributions of emissions between 1999 and 2007 are very similar. Emissions from area and non-road sources in Central Texas are concentrated within central Travis County, central and eastern Williamson County, and central Bexar County. Isolated point sources are located within the Austin and San Antonio areas, but emissions from stationary source categories are significantly denser in southeastern Texas and along the Gulf Coast. Emissions from on-road mobile sources in Central Texas are concentrated along the I-35 corridor within and between the Austin and San Antonio Metropolitan Statistical Areas.

Data sources and applicable processing notes/assumptions for Central Texas (4-km domain) emission inventories used in the Future Case are summarized in Table 3. Emission inventories for stationary point sources in the 4-km, 12-km, and 36-km domains were generated by the TCEQ in support of the Mid-Course Review of the State Implementation Plan for the Houston/Galveston area (Version 15b Aug. 22 – Sep. 1, 2000 TexAQS EI with applicable controls). The Austin, San Antonio, and Victoria areas updated this inventory with local data as described in Table 3. Chemical speciation and temporal profiles for EPS2 processing of all stationary point source emissions were supplied by the TCEQ. The TCEQ generated and processed emissions for all source categories in states outside of Texas and transferred the CAMx-ready files to UT and CAPCO.

With the exception of local data for Austin, San Antonio, Victoria, and Corpus Christi, emission inventories for area and non-road mobile sources in the 4-km, 12-km, and 36-km domains were also generated by the TCEQ in support of the Mid-Course Review of the State Implementation Plan for the Houston/Galveston area. The TCEQ also supplied temporal and chemical speciation profiles for EPS2 processing for these emissions. Chemical speciation and temporal profiles for EPS2 processing of area and non-road source emissions in Austin, San Antonio, Victoria, and Corpus Christi were supplied by

the Alamo Area Council of Governments and were based on the original ENVIRON data supplemented by local surveys and U.S. EPA defaults.

The TCEQ also provided MOBILE6-based emission files for 2007 for the Houston/Galveston, Austin, San Antonio, and Corpus Christi areas and for Victoria County. Emissions from on-road mobile sources for Texas counties outside of the near non-attainment areas and the Houston/Galveston Area were estimated by applying factors to adjust from 1999 county-wide MOBILE5 totals to 2007 county-wide MOBILE6 totals provided by the Texas Transportation Institute.

Table 1. Daily NO_x emissions in 1999 and 2007 from anthropogenic sources in the five-county Austin Metropolitan Statistical Area. These values represent chemically speciated and temporally allocated emissions that have been processed through EPS2 for use in CAMx.

	Date	1999 NO_x Emissions (tpd)	2007 NO_x Emissions (tpd)
Area and Nonroad Mobile Source Emissions	09/13	37.02	35.08
	09/14	37.02	35.08
	09/15	37.02	35.08
	09/16	37.02	35.08
	09/17	37.02	35.08
	09/18	26.65	24.85
	09/19	25.97	23.96
	09/20	37.02	35.08
On-Road Mobile Source Emissions	09/13	94.50	59.32
	09/14	96.53	60.94
	09/15	98.80	62.70
	09/16	100.04	63.64
	09/17	90.51	59.02
	09/18	60.35	40.72
	09/19	46.22	32.20
	09/20	97.79	62.12
Point Source Emissions	09/13	30.46	31.72
	09/14	29.36	31.72
	09/15	30.04	31.72
	09/16	29.51	31.72
	09/17	28.90	31.72
	09/18	28.47	31.72
	09/19	29.34	31.72
	09/20	33.49	31.72
Total Anthropogenic Emissions	09/13	161.98	126.12
	09/14	162.91	127.74
	09/15	165.86	129.5
	09/16	166.57	130.44
	09/17	156.43	125.82
	09/18	115.47	97.29
	09/19	101.53	87.88
	09/20	168.30	128.92

Table 2. Daily VOC emissions in 1999 and 2007 from anthropogenic sources in the five-county Austin Metropolitan Statistical Area. These values represent chemically speciated and temporally allocated emissions that have been processed through EPS2 for use in CAMx.

	Date	1999 VOC Emissions (tpd)	2007 VOC Emissions (tpd)
Area and Nonroad Mobile Source Emissions	09/13	115.96	128.46
	09/14	115.96	128.46
	09/15	115.96	128.46
	09/16	115.96	128.46
	09/17	115.96	128.46
	09/18	101.92	111.26
	09/19	71.28	80.84
	09/20	115.96	128.46
	On-Road Mobile Source Emissions	09/13	44.34
09/14		45.57	31.27
09/15		46.35	31.70
09/16		46.58	31.87
09/17		53.74	36.56
09/18		39.10	26.27
09/19		34.23	22.82
09/20		50.09	33.71
Point Source Emissions		09/13	3.28
	09/14	3.19	5.66
	09/15	3.17	5.66
	09/16	3.20	5.66
	09/17	3.21	5.66
	09/18	3.21	5.66
	09/19	3.19	5.66
	09/20	3.24	5.66
	Total Anthropogenic Emissions	09/13	163.58
09/14		164.72	165.39
09/15		165.48	165.82
09/16		165.74	165.99
09/17		172.91	170.68
09/18		144.23	143.19
09/19		108.70	109.32
09/20		169.29	167.83

Figure 1a. Area and nonroad mobile source NO_x emissions within the 4-km domain in 1999 at 0800 on September 17.

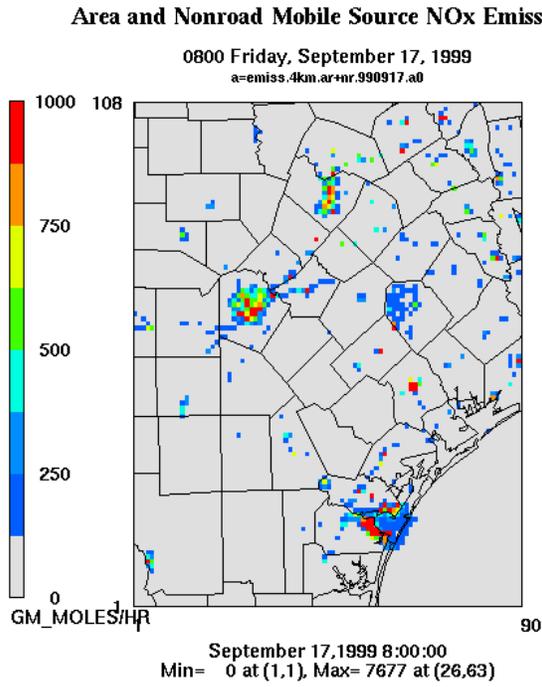


Figure 1b. Area and nonroad mobile source NO_x emissions within the 4-km domain in 2007 at 0800 on September 17.

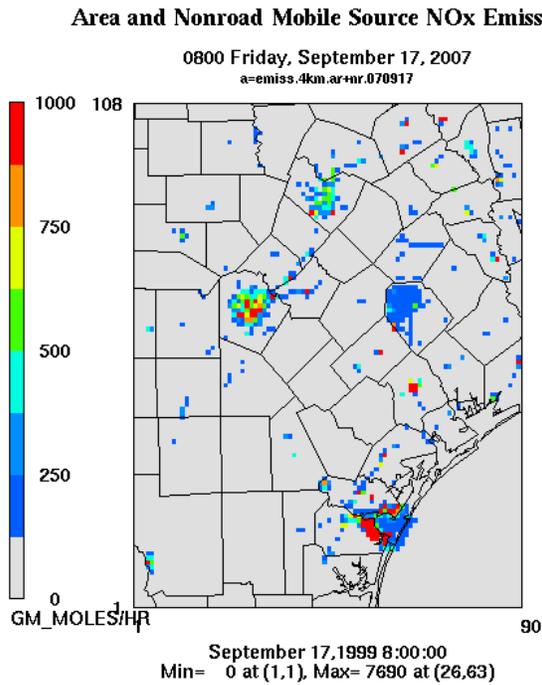


Figure 2a. Low-level point source NOx emissions within the 4-km domain in 1999 at 0800 on September 17.

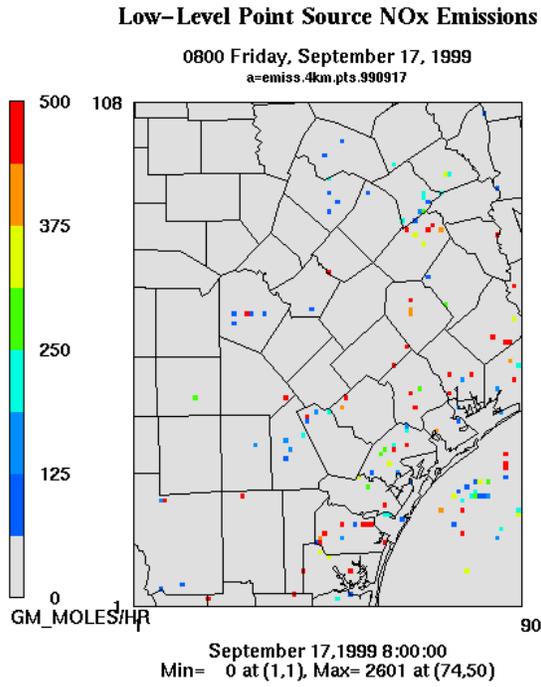


Figure 2b. Low-level point source NOx emissions within the 4-km domain in 2007 at 0800 on September 17.

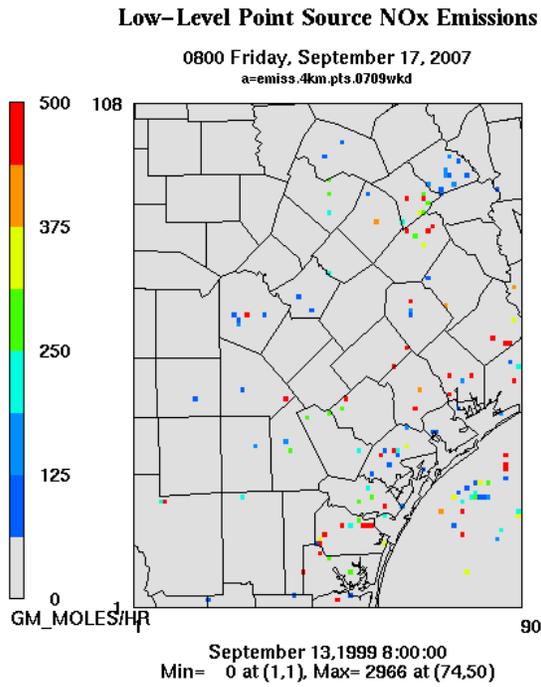


Figure 3a. Elevated point source NOx emissions within the 4km domain at 0800 in 1999 on September 17.

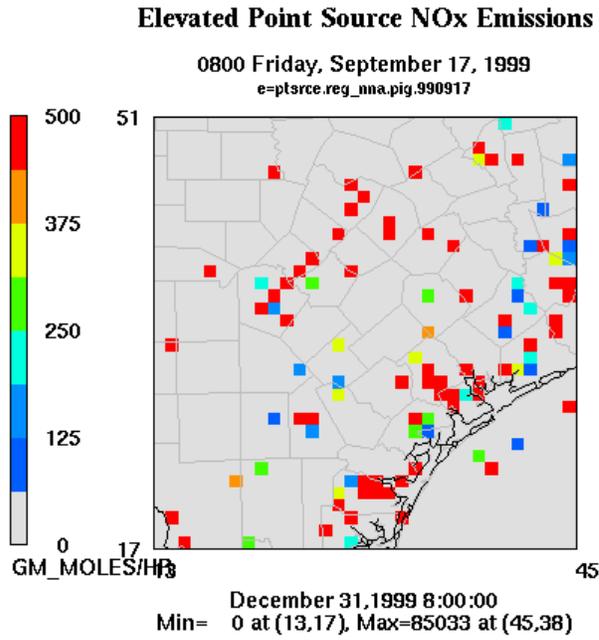


Figure 3b. Elevated point source NOx emissions within the 4km domain at 0800 in 2007 on September 17.

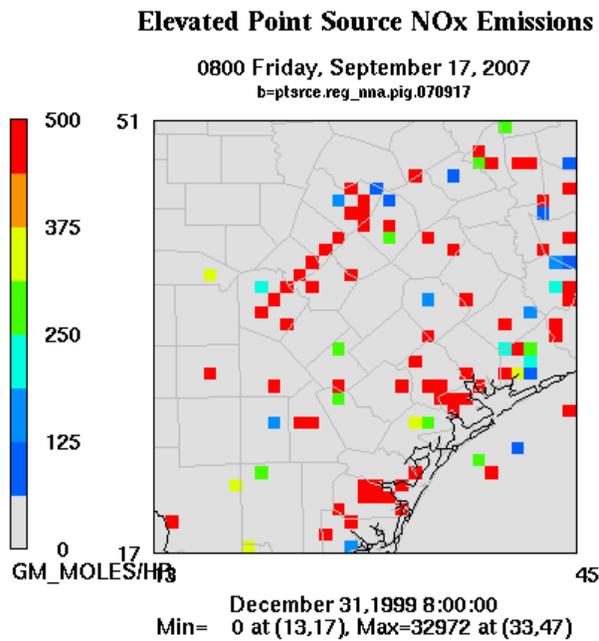


Figure 4a. On-road mobile source NOx emissions within the 4-km domain at 0800 in 1999 on September 17.

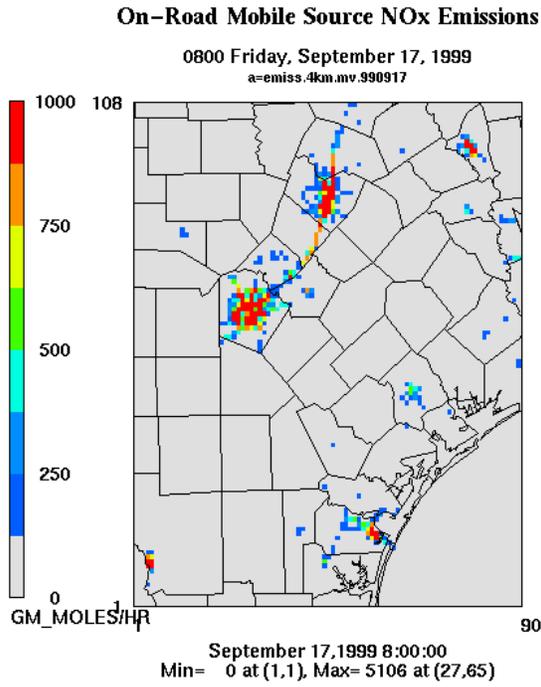


Figure 4b. On-road mobile source NOx emissions within the 4-km domain at 0800 in 2007 on September 17.

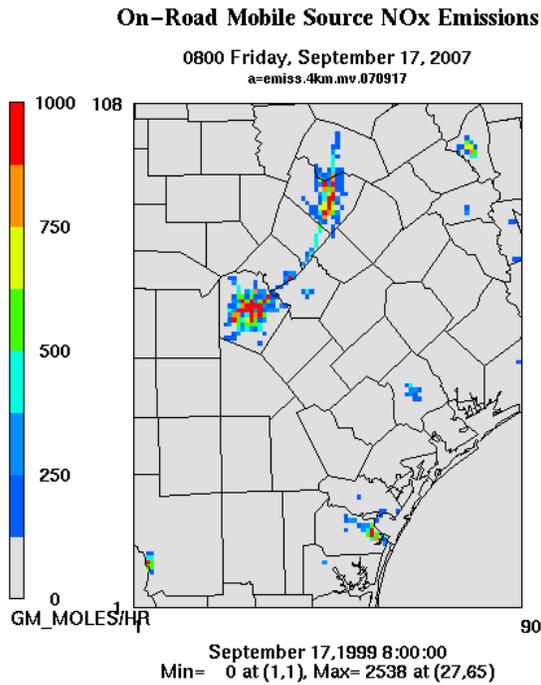


Figure 5a. Area and nonroad mobile source VOC emissions within the 4-km domain in 1999 at 0800 on September 17.

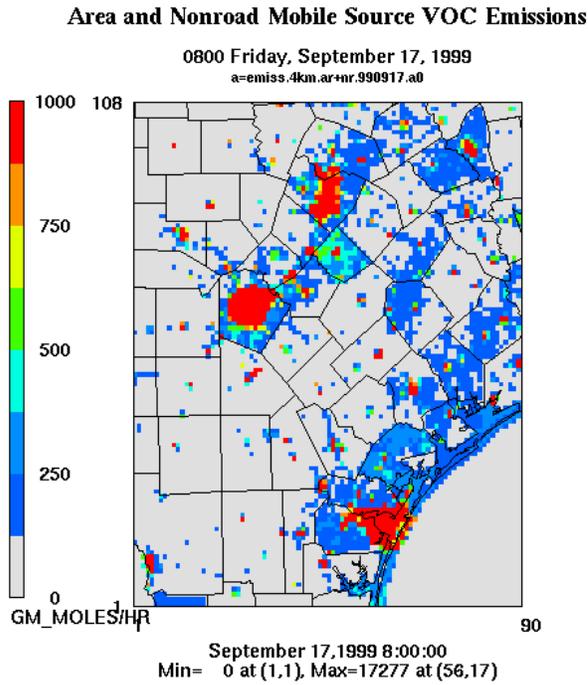


Figure 5b. Area and nonroad mobile source VOC emissions within the 4-km domain in 2007 at 0800 on September 17.

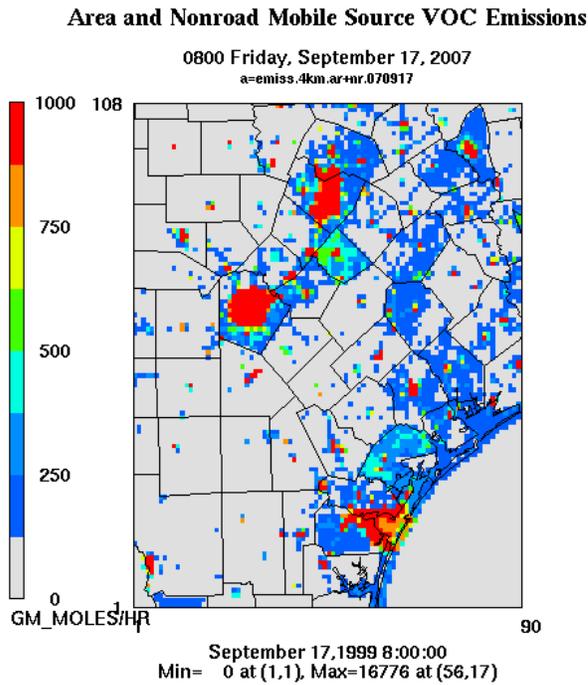


Figure 6a. Low-level point source VOC emissions within the 4-km domain in 1999 at 0800 on September 17.

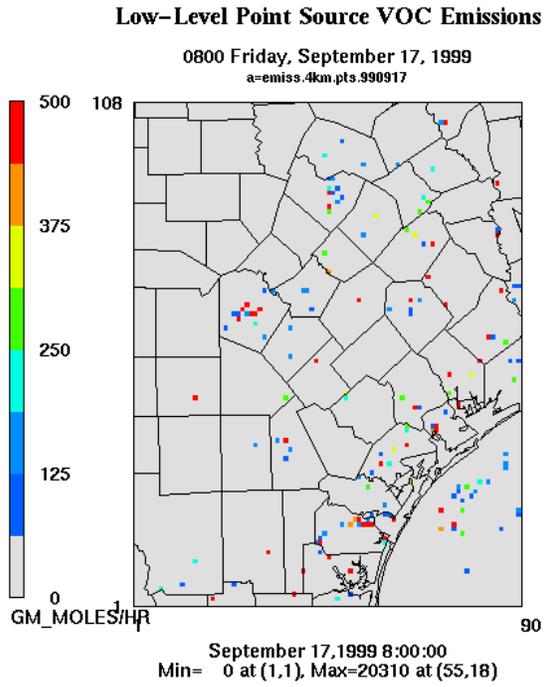


Figure 6b. Low-level point source VOC emissions within the 4-km domain in 2007 at 0800 on September 17.

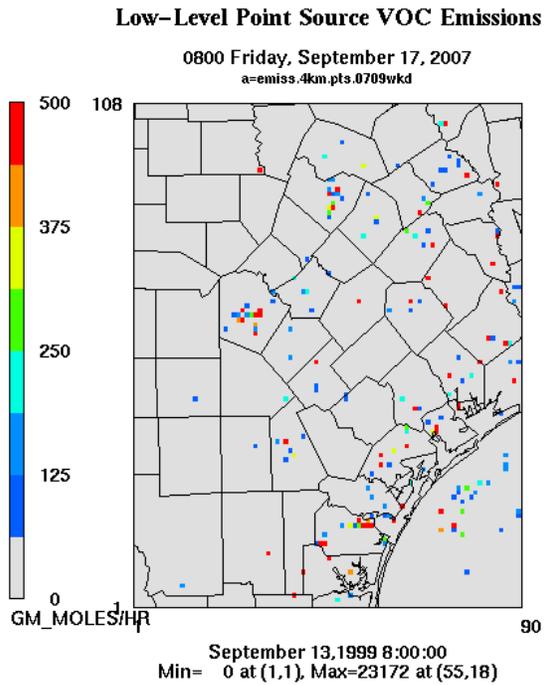


Figure 7a. Elevated point source VOC emissions within the 4km domain in 1999 at 0800 on September 17.

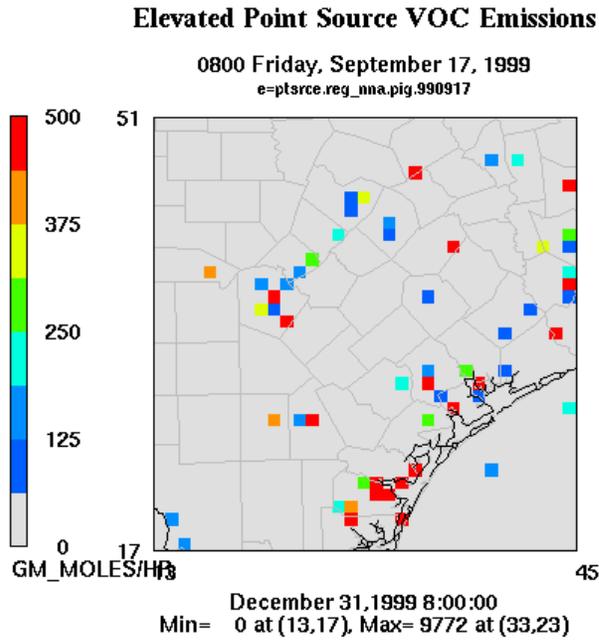


Figure 7b. Elevated point source VOC emissions within the 4km domain in 2007 at 0800 on September 17.

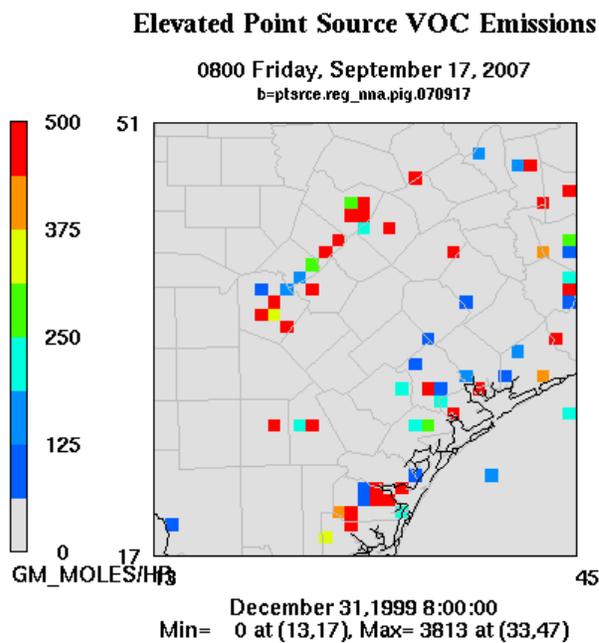


Figure 8a. On-road mobile source VOC emissions within the 4-km domain in 1999 at 0800 on September 17.

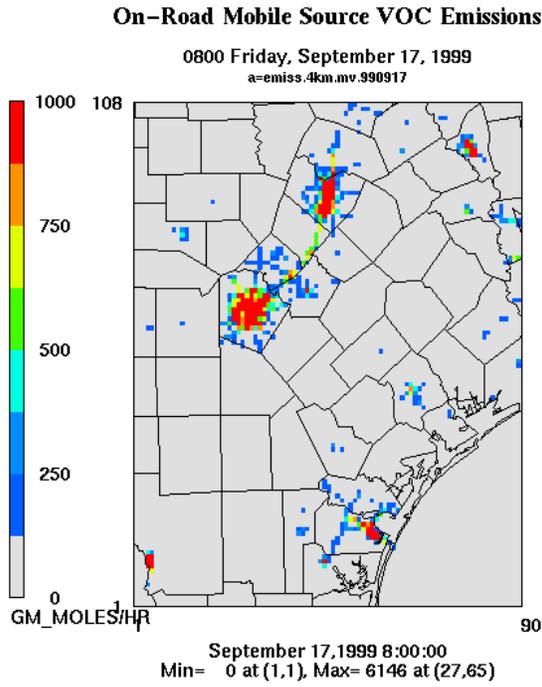


Figure 8b. On-road mobile source VOC emissions within the 4-km domain in 2007 at 0800 on September 17.

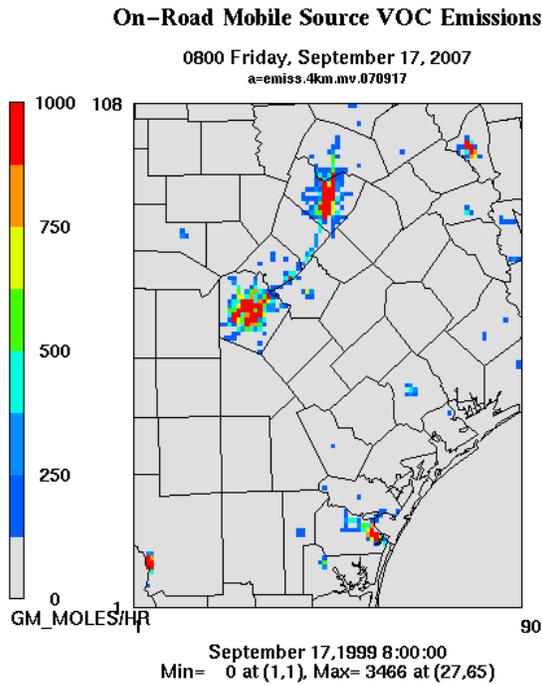


Table 3. Sources of projected 2007 anthropogenic emission data for the 4-km domain.

Region/Source Category	Data Source	Assumptions/Processing Notes (if applicable)
Austin		
On-road Mobile	Emission factors obtained from the U.S. EPA's MOBILE6.2 model in combination with a travel demand model run by the Texas Transportation Institute (TTI). Link-based emissions developed for Hays, Travis, and Williamson Counties. Non-link based emissions developed for Bastrop and Caldwell Counties.	For the link-based counties in the Austin and San Antonio areas, average weekday (Sep. 20 th), Friday (Sep. 17 th), Saturday (Sep. 18 th), and Sunday (Sep. 19 th) data were obtained from the TCEQ. Day-specific temperature and humidity adjustments were made to average weekday emissions (Sep. 20 th) to obtain day-specific emissions for the remaining weekdays in the episode (Sep. 13 th -16 th).
Area	Local data prepared by CAPCO.	Chemical speciation and chemical/temporal cross-references and profiles based on original ENVIRON data supplemented by local surveys or EPA defaults.
Non-road Mobile	NONROAD2002a with local data prepared by CAPCO.	Fuel parameters for NONROAD model based on data collected by the TCEQ (Brown, 2003). Chemical speciation and chemical/temporal cross-references and profiles based on original ENVIRON data supplemented by local surveys or EPA defaults.
Point	Point Source Emissions Data (Version 15b Aug. 22 – Sep. 1, 2000 TexAQS EI with applicable controls) prepared by TCEQ in support of the HGA Mid Course Review provided by Ron Thomas and supplemented with updates prepared by CAPCO.	Emissions from Alcoa Rockdale beginning on Jan 1, 2003 are limited to 9730 tons per year or 26.66 tons per day emissions of NO _x (based on an emission rate of 0.60 lbs/mmBTU NO _x) in accordance with the Consent Decree. Projected 2007 emissions are assumed to be 26.66 tpd. NO _x emissions from Lehigh Cement modeled at 5.24 tpd. EGU emissions updated with local survey data. Chemical speciation and chemical/temporal cross-references and profiles as used for the TexAQS2000 EI and provided

		by Ron Thomas of TCEQ.
San Antonio		
On-road Mobile	Emission factors obtained from the U.S. EPA's MOBILE6.2 model in combination with a travel demand model run by the Texas Transportation Institute (TTI). Link-based emissions developed for Bexar County. Non-link based emissions developed for Comal, Guadalupe, and Wilson Counties.	For the link-based counties in the Austin and San Antonio areas, average weekday (Sep. 20 th), Friday (Sep. 17 th), Saturday (Sep. 18 th), and Sunday (Sep. 19 th) data were obtained from the TCEQ. Day-specific temperature and humidity adjustments were made to average weekday emissions (Sep. 20 th) to obtain day-specific emissions for the remaining weekdays in the episode (Sep. 13 th -16 th).
Area	Local data prepared by AACOG.	Chemical speciation and chemical/temporal cross-references and profiles based on original ENVIRON data supplemented by local surveys or EPA defaults.
Non-road Mobile	NONROAD2002a with local survey data prepared by AACOG.	Chemical speciation and chemical/temporal cross-references and profiles based on original ENVIRON data supplemented by local surveys or EPA defaults.
Point	Point Source Emissions Data (Version 15b Aug. 22 – Sep. 1, 2000 TexAQS EI with applicable controls) prepared by TCEQ in support of the HGA Mid Course Review provided by Ron Thomas and supplemented with local updates prepared by AACOG.	Chemical speciation and chemical/temporal cross-references and profiles as used for the TexAQS2000 EI and provided by Ron Thomas of TCEQ.
Victoria		
On-road Mobile	Link-based MOBILE6 emission files for Victoria County obtained from the TCEQ.	For Victoria County, average weekday (Sep. 13 th), Friday (Sep. 17 th), Saturday (Sep. 18 th), and Sunday (Sep. 19 th) data were obtained from the TCEQ. Day-specific temperature and humidity adjustments were made to average weekday emissions (Sep. 13 th) to obtain day-specific emissions for the remaining weekdays in the episode (Sep. 14 th -16 th , 20 th).
Area	Growth factors based on U.S. Census population data and	Chemical speciation and chemical/temporal cross-references

	EGASv.4.	and profiles based on original ENVIRON data supplemented by local surveys or EPA defaults.
Non-road Mobile	NONROAD2002a. ENVIRON Statewide Trends Inventory used for marine and locomotive emission projections. Local survey data for aircraft and airport ground support equipment.	Fuel parameters for NONROAD model based on data collected by the TCEQ (Brown, 2003). Day-specific meteorological data for NONROAD2002a model from National Weather Service Observations. Chemical speciation and chemical/temporal cross-references and profiles based on original ENVIRON data supplemented by local surveys or EPA defaults.
Point	Point Source Emissions Data (Version 15b Aug. 22 – Sep. 1, 2000 TexAQS EI with applicable controls) prepared by TCEQ in support of the HGA Mid Course Review provided by Ron Thomas and supplemented with local updates prepared by City of Victoria.	Joslin and Victoria facilities removed. Chemical speciation and chemical/temporal cross-references and profiles as used for the TexAQS2000 EI and provided by Ron Thomas of TCEQ.
Corpus Christi		
On-road Mobile	Link-based MOBILE6 emission files for Nueces and San Patricio Counties obtained from the TCEQ.	
Area	Prepared by AACOG	Chemical speciation and chemical/temporal cross-references and profiles based on original ENVIRON data supplemented by local surveys or EPA defaults.
Non-road Mobile	Prepared by AACOG	Chemical speciation and chemical/temporal cross-references and profiles based on original ENVIRON data supplemented by local surveys or EPA defaults.
Point	Point Source Emissions Data (Version 15b Aug. 22 – Sep. 1, 2000 TexAQS EI with applicable controls) prepared by TCEQ in support of the HGA Mid Course Review provided by Ron Thomas.	Chemical speciation and chemical/temporal cross-references and profiles as used for the TexAQS2000 EI and provided by Ron Thomas of TCEQ.
Other Counties Not in Near		

Nonattainment Areas, but within 4-km Domain		
On-road Mobile	Non-link based emission estimates adjusted by applying factors to convert from 1999 county-wide MOBILE5 totals to 2007 county-wide MOBILE6 totals provided by TTI.	
Area	TexAQS2000 EI provided by Jim MacKay of TCEQ (data filename: ams.TX_07.area07_b3).	Chemical speciation and chemical/temporal cross-references and profiles as used for the TexAQS2000 EI and provided by Jim MacKay of TCEQ.
Nonroad Mobile	TexAQS2000 EI provided by Jim MacKay of TCEQ (data filename: ams.TX_07.NR07_b4b).	Chemical speciation and chemical/temporal cross-references and profiles as used for the TexAQS2000 EI and provided by Jim MacKay of TCEQ.
Point	Point Source Emissions Data (Version 15b Aug. 22 – Sep. 1, 2000 TexAQS EI with applicable controls) prepared by TCEQ in support of the HGA Mid Course Review provided by Ron Thomas.	Chemical speciation and chemical/temporal cross-references and profiles as used for the TexAQS2000 EI and provided by Ron Thomas of TCEQ.

3. Future Case Model Predictions

The *Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS*, U.S. EPA Office of Air Quality Planning and Standards, EPA-454/R-99-004, May 1999 describes a methodology for conducting an attainment test under the 8-hour ozone NAAQS. The methodology is dependent upon three critical elements:

1. Current design values (DV)
2. Relative reduction factors (RRFs)
3. Future design values (DV).

The methodology used to calculate relative reduction factors for Austin's 2007 Future Case model is based on a protocol and software developed by ENVIRON. The implementation protocol submitted by ENVIRON has received approval from the U.S. EPA's Office of Air Quality Planning and Standards and is detailed below.

3.1 Determination of Relative Reduction Factors and Future Design Values

Attainment demonstrations under the 8-hour NAAQS are fundamentally different than under the 1-hour NAAQS in that attainment is determined based on the relative response of the photochemical grid model. In accordance with U.S. EPA guidance, future design values for an area are determined by scaling base-year design values by relative reduction factors. The calculation is carried out for each monitor. In addition, a screening calculation is also carried out to identify grid cells with consistently high ozone and estimate scaled DVs for these screening cells. The idea behind the screening cells is to account for any areas with consistently high modeled ozone that are not captured by the monitoring network. The attainment test is passed if all the future year scaled DVs are less than 85 ppb.

Figure 9 shows a schematic outline of the calculations and identifies the following input data required to complete the calculation:

1. A monitor list: the list of monitors and corresponding current year DVs.
2. A screening cell list: the list of cells to be considered in the screening cell calculation along with the monitors that are considered to be associated with that grid cell. This list may be a sub-set of the modeling grid covering just the area for which controls are being developed. The significance of associating monitors with each grid cell is to select an appropriate current year for the grid cell and establish concentration thresholds for including the grid cell in the screening calculation.
3. Gridded 8-hour daily maximum ozone concentrations for the Base Case.
4. Gridded 8-hour daily maximum ozone concentrations for the projected Future Case.

Relative reduction factors and future design values are calculated according to the following methodology for cells associated with monitor sites and screening cells, respectively:

Monitor Design Value Scaling

1. Find the daily maximum 8-hour ozone in an $n \times n$ block of cells ($n = 7$ for a 4-km grid in accordance with U.S. EPA guidance) around each monitor for both the Base Case and Future Case. Repeat for each modeling day.
2. Exclude days when the Base Case daily maximum 8-hour ozone was below 70 ppb.
3. Average the daily maximum 8-hour ozone across days for the Base Case and Future Case, respectively.
4. Calculate the relative reduction factor:
$$\text{RRF} = \frac{\text{average Future Case daily maximum ozone concentration}}{\text{average Base Case daily maximum ozone concentration}}$$
5. Calculate the predicted future design value
Future DV = Current year DV x RRF.
6. Repeat 1-5 for each monitor

Screening Cell Design Value Scaling

7. For each grid cell on the screening cell list, count the number of days where the modeled daily maximum 8-hour ozone is at least 5% greater than the modeled daily maximum 8-hour ozone at any “associated” monitor and at least 70 ppb.
8. If the number of days is 50% or greater of the total days, treat this cell as if it were a monitor (“screened cell”).
9. The current year design value to be used for a screened cell is the maximum of the current year design values for any “associated” monitor.
10. Calculate the scaled design value for each screened cell as if it were a monitor using steps 1-5 above.
11. Repeat steps 7-10 for each grid cell on the screening cell list.

3.2 Current Design Values in the Austin Area

Austin had two CAMS stations in operation during 1999, the CAMS 3 site, located at Murchison Middle School and the CAMS 38 Audubon site, located about 18 miles northwest of downtown Austin. The sites are shown in Figure 10.

U.S. EPA guidance (1999) specifies that the current-year design value for the attainment test is the highest of (1) the design value for the three-years straddling the year of the most current emission inventory for the area or (2) the three-year period used for the non-attainment designation. Austin’s most current emission inventory is for 1999, thus, the current design value would be based on ambient data collected during 1998-2000. The design value for the Murchison monitor based on ambient data for 1998-2000 is 87 ppb. The design value for the Audubon monitor for 1998-2000 is 89 ppb. The approach based on the three years used for the non-attainment designation would require the use of ambient data collected during 2001-2003. The design value for the Murchison monitor based on ambient data for 2001-2003 is 84 ppb. The design value for the Audubon monitor for 2001-2003 is 80 ppb. It is important to note that Austin would be designated as attainment based on data collected during 2001-2003.

Because of the significant differences between design values calculated using the two approaches, Durrenberger and McGaughey (2003) examined historical ozone data collected between 1997 and 2003 to estimate the likelihood of measuring a 8-hour design value of 85 ppb or greater during the 2002-2004 period. Durrenberger and McGaughey used the fourth highest concentration for each year during the 1997 through 2003 period as a surrogate for the fourth highest concentration for 2004. Their analysis found that the 2002-2004 design values at the Audubon monitoring station ranged between 80 ppb and 87 ppb, with only one scenario above the 8-hour design value of 85 ppb. Thus, if 2004 were equally likely to be similar to each year during the 1997 through 2003 period, the 2002-2004 design value at Audubon would likely be below the 8-hour standard of 85 ppb. A similar analysis using historical data collected at the Murchison monitoring station found that the 2002-2004 design values ranged between 84 ppb and 88 ppb. Five of the seven scenarios provided a design value of 85 ppb or higher, suggesting that the design value is likely to exceed 85 ppb at Murchison for the 2002-2004 period. Durrenberger and McGaughey's study is included in Appendix A.

CAPCO, the TCEQ, and the U.S. EPA Region 6 Office continue to engage in analysis and discussion about appropriate design values to use for the area, especially given Austin's current status as attainment under the 8-hour NAAQS. For purposes of this report, current design values are calculated using both the 1998-2000 and 2001-2003 periods, respectively, in accordance with U.S. EPA guidance.

3.3 Relative Reduction Factors and Future Design Values

Daily maximum 8-hour ozone concentrations for the September 15-20, 1999 Base Case and 2007 Future Case, respectively, are compared in Figures 11-16. Daily NO_x and VOC emissions and daily maximum 8-hour ozone concentrations are shown in Table 4 and Table 5 for the Murchison and Audubon monitoring stations, respectively. No screening cells were identified from the analysis. Relative reduction factors and future design values for the Audubon and Murchison monitors for both current-year scenarios are shown in Table 6.

Figures 11-16 and Tables 4-6 indicate several key points. First, the magnitude of predicted ozone concentrations decreases between 1999 and 2007, but the spatial distributions of ozone plumes from the urban areas are quite similar between 1999 and 2007. Second, relative reduction factors show daily variability during the episode, which indicates differences in the relative response of the model even on weekdays that have nearly identical emission inventory trends between 1999 and 2007. Although these modeling results show that the Austin area is predicted to be in attainment in 2007, the area is on the cusp of attainment or non-attainment with the 8-hour NAAQS. In recognition of these results, the Austin area is proceeding with the analysis and implementation of emission control strategies that will provide the area with a margin of safety for attaining the standard.

Figure 9. Overview of the 8-hour ozone attainment test methodology.

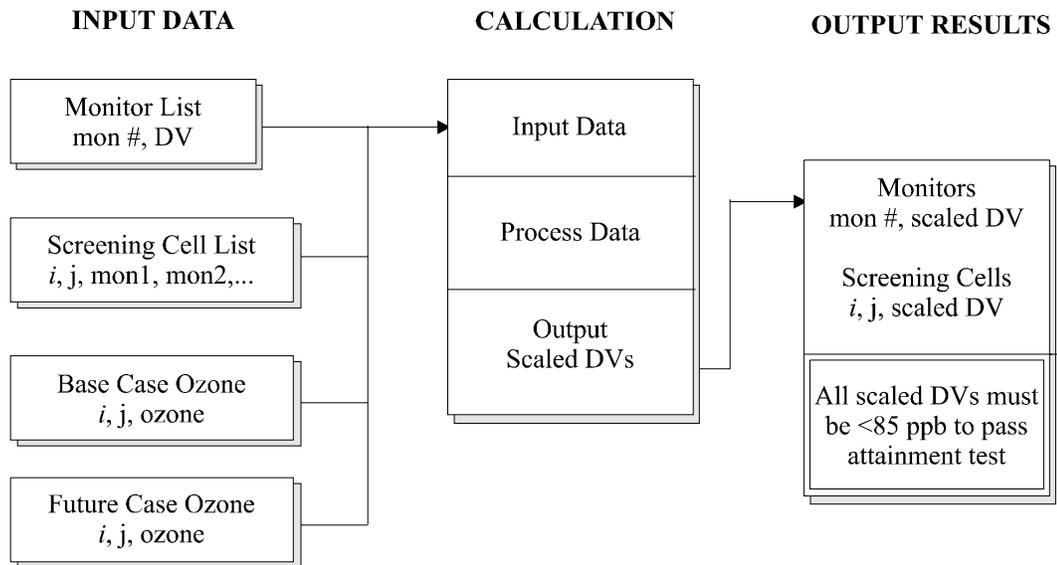


Figure 10. Location of Austin Area Monitors by CAMS # (Active monitors labeled in red. Ozone is not monitored at C171.) Courtesy of TCEQ Website
<http://www.tceq.state.tx.us/updated/air/monops>

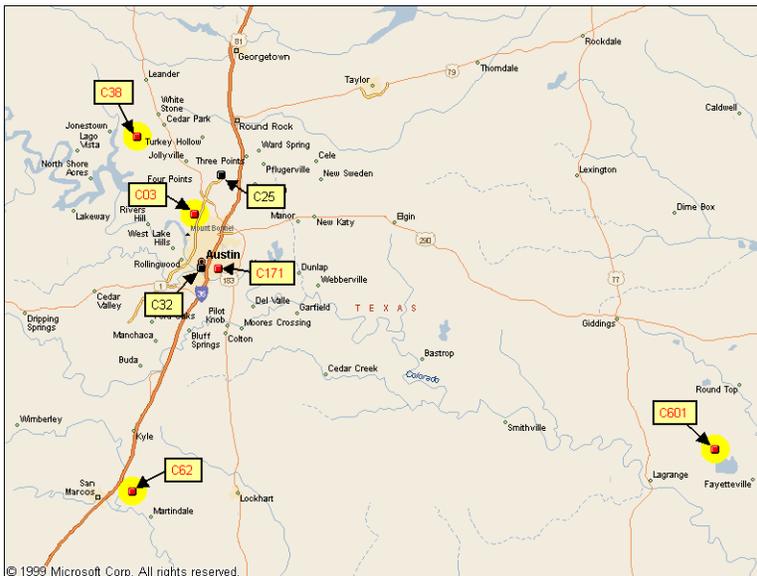


Figure 11a. Daily maximum ozone concentrations in the 4-km domain in 1999 on September 15.

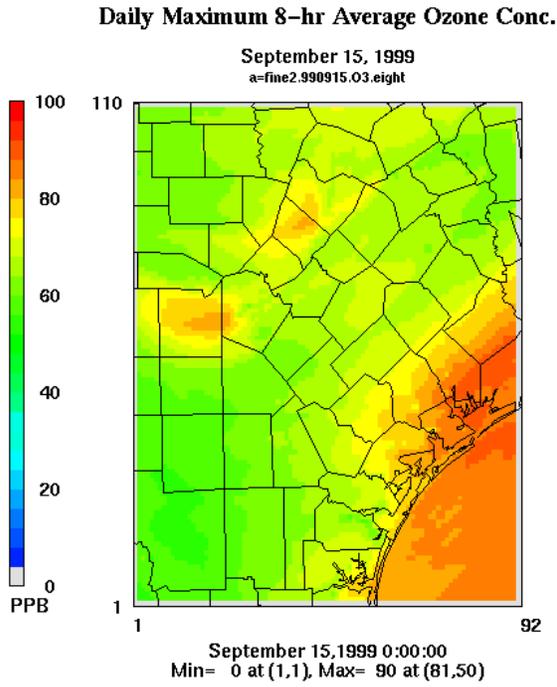


Figure 11b. Daily maximum ozone concentrations in the 4-km domain in 2007 on September 15.

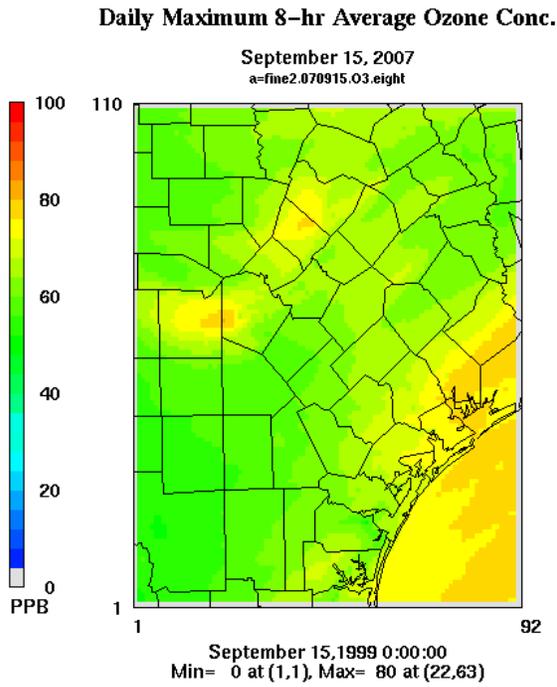


Figure 12a. Daily maximum ozone concentrations in the 4-km domain in 1999 on September 16.

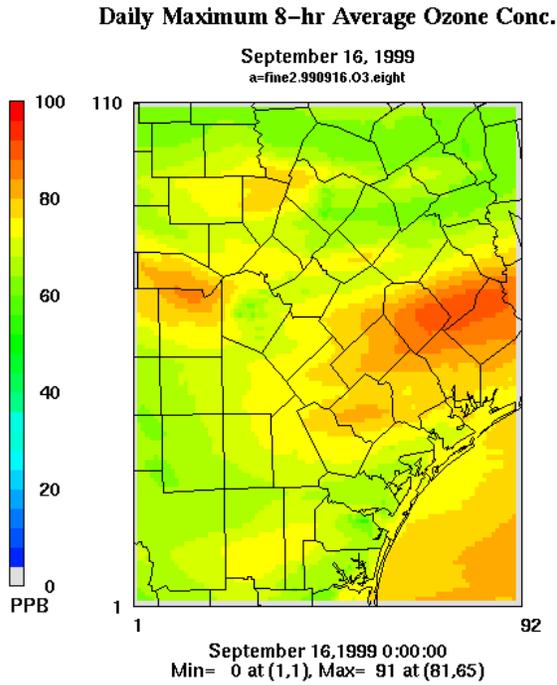


Figure 12b. Daily maximum ozone concentrations in the 4-km domain in 2007 on September 16.

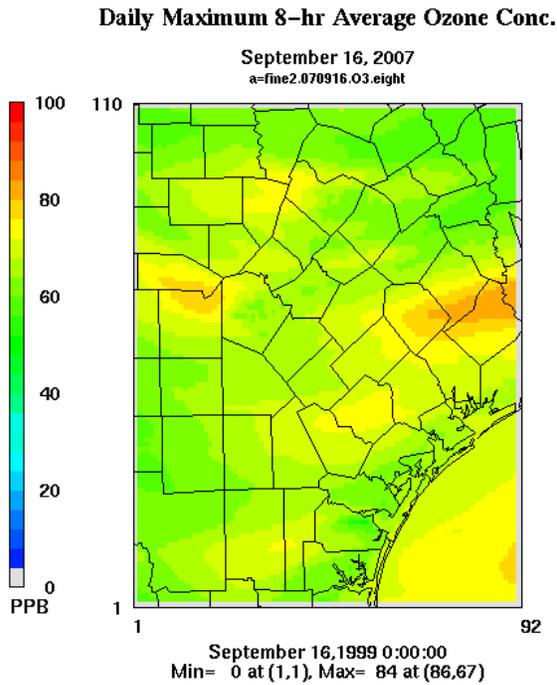


Figure 13a. Daily maximum ozone concentrations in the 4-km domain in 1999 on September 17.

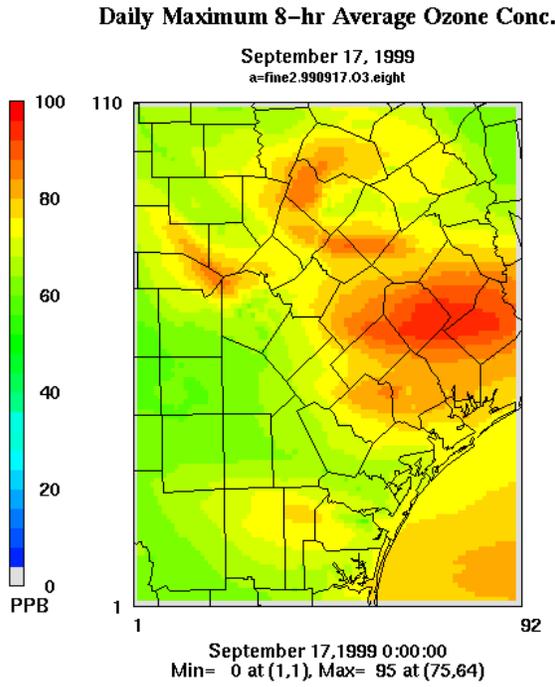


Figure 13b. Daily maximum ozone concentrations in the 4-km domain in 2007 on September 17.

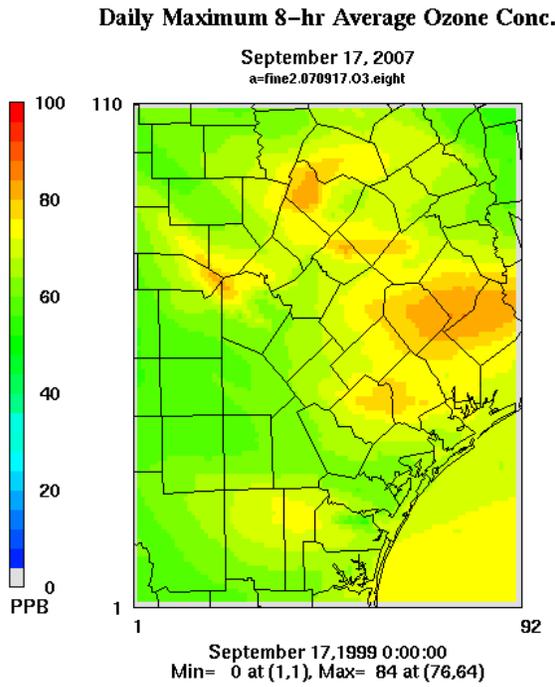


Figure 14a. Daily maximum ozone concentrations in the 4-km domain in 1999 on September 18.

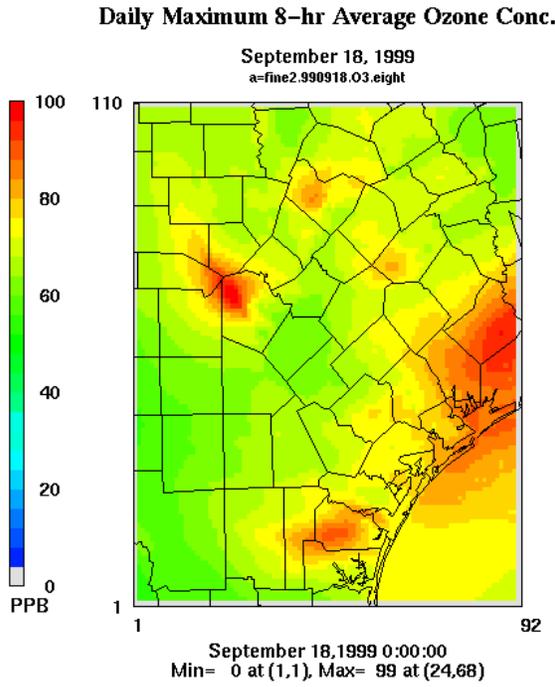


Figure 14b. Daily maximum ozone concentrations in the 4-km domain in 2007 on September 18.

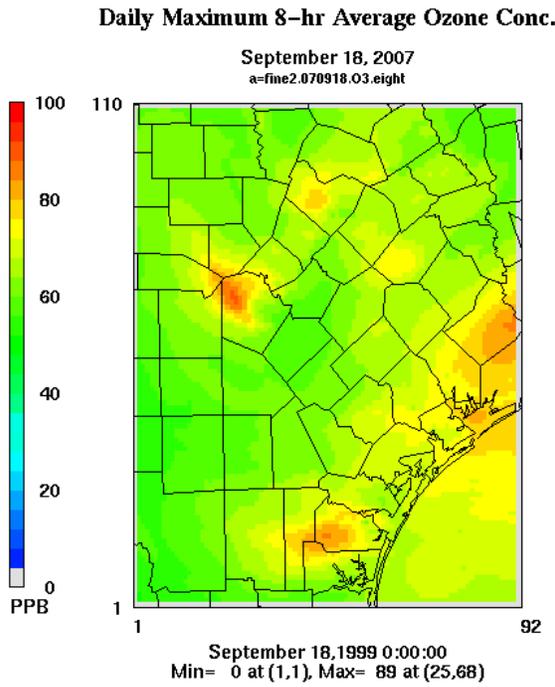


Figure 15a. Daily maximum ozone concentrations in the 4-km domain in 1999 on September 19.

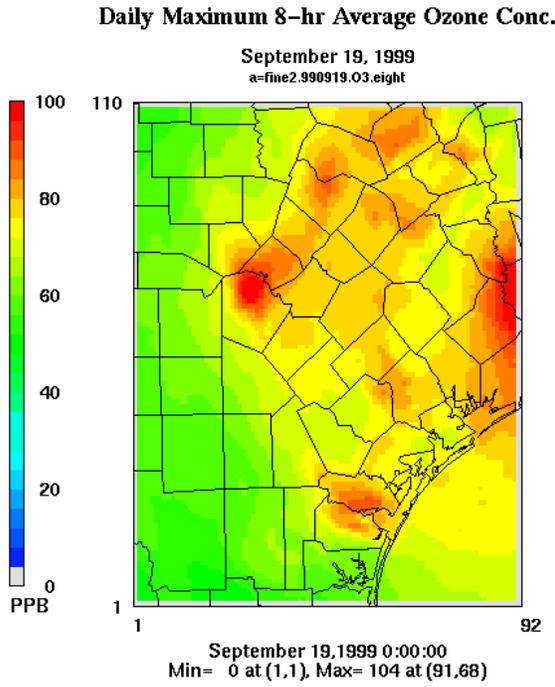


Figure 15b. Daily maximum ozone concentrations in the 4-km domain in 2007 on September 19.

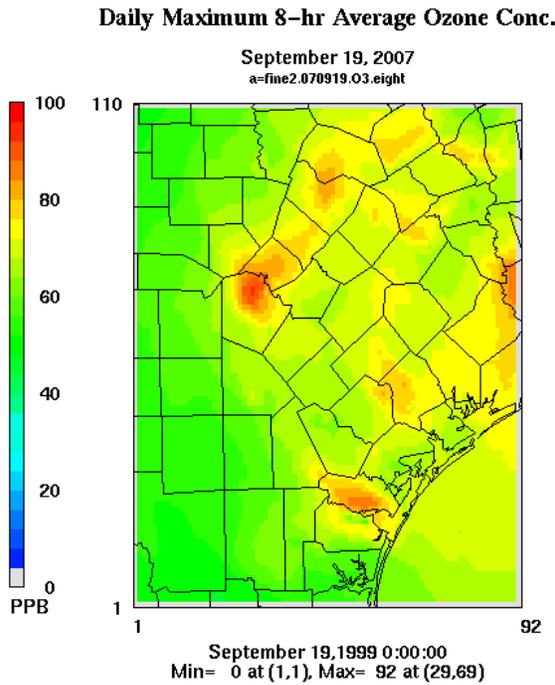


Figure 16a. Daily maximum ozone concentrations in the 4-km domain in 1999 on September 20.

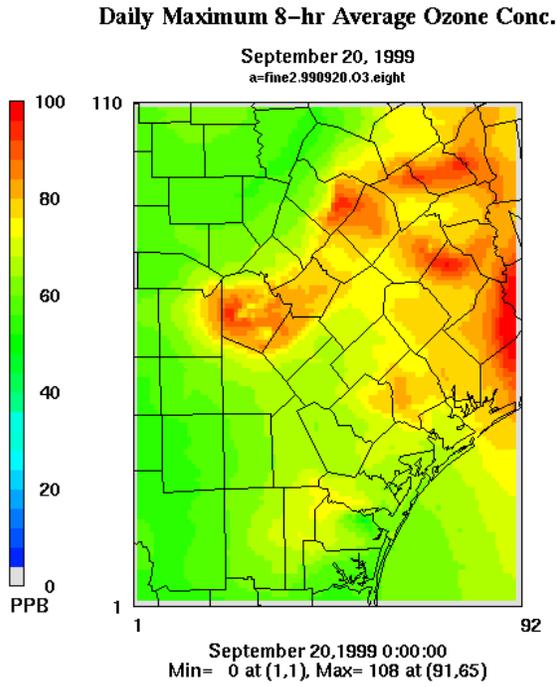


Figure 16b. Daily maximum ozone concentrations in the 4-km domain in 2007 on September 20.

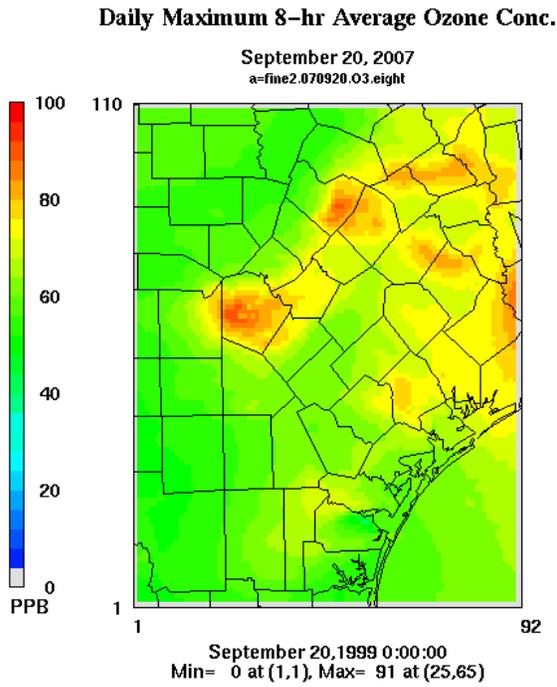


Table 4. Daily total NOx and VOC emissions in 1999 and 2007 from anthropogenic sources in the five-county Austin Metropolitan Statistical Area and daily maximum 8-hour ozone concentrations for the Audubon monitor.

Total Anthropogenic Emission on Date	1999 NOx Emissions (tpd)	2007 NOx Emissions (tpd)	1999 VOC Emissions (tpd)	2007 VOC Emissions (tpd)	Modeled Average Base-Year Daily Maximum Ozone Concentration (ppbv)	Modeled Average Future-Year Daily Maximum Ozone Concentration (ppbv)
09/15	161.98	126.12	163.58	164.68	76.2	73.7
09/16	162.91	127.74	164.72	165.39	78.2	74.6
09/17	165.86	129.5	165.48	165.82	87.4	82.2
09/18	166.57	130.44	165.74	165.99	84.5	78.8
09/19	156.43	125.82	172.91	170.68	89.4	82.9
09/20	115.47	97.29	144.23	143.19	70.1	68.1
Average	--	--	--	--	81.0	76.7

Table 5. Daily total NOx and VOC emissions in 1999 and 2007 from anthropogenic sources in the five-county Austin Metropolitan Statistical Area and daily maximum 8-hour ozone concentrations for the Murchison monitor.

Total Anthropogenic Emission on Date	1999 NOx Emissions (tpd)	2007 NOx Emissions (tpd)	1999 VOC Emissions (tpd)	2007 VOC Emissions (tpd)	Modeled Average Base-Year Daily Maximum Ozone Concentration (ppbv)	Modeled Average Future-Year Daily Maximum Ozone Concentration (ppbv)
09/15	161.98	126.12	163.58	164.68	77.8	75.1
09/16	162.91	127.74	164.72	165.39	75.5	72.8
09/17	165.86	129.5	165.48	165.82	86.8	82.2
09/18	166.57	130.44	165.74	165.99	84.5	79.8
09/19	156.43	125.82	172.91	170.68	89.6	83.4
09/20	115.47	97.29	144.23	143.19	93.6	88.2
Average	--	--	--	--	84.6	80.2

Table 6. Relative reduction factors and future design values at the Audubon and Murchison monitors.

CAMS Station	Modeled Average Base-Year Daily Maximum Ozone Concentration (ppbv)	Modeled Average Future-Year Daily Maximum Ozone Concentration (ppbv)	RRF	Current Design Value (ppbv)	Future Design Value (ppbv)
Murchison	84.6	80.2	0.948	87 (1998-2000) 84 (2000-2003)	82 (1998-2000) 79 (2000-2003)
Audubon	81.0	76.7	0.948	89 (1998-2000) 80 (2000-2003)	84 (1998-2000) 75 (2000-2003)

4. References

Capital Area Planning Council, 2003a. "Development of a 1999 Emission Inventory for the Austin Metropolitan Area." Submitted to the United States Environmental Protection Agency and the Texas Commission on Environmental Quality, November 2003.

Capital Area Planning Council, 2003b. "Development of a 2007 Emission Inventory for the Austin Metropolitan Area." Submitted to the United States Environmental Protection Agency and the Texas Commission on Environmental Quality, December 2003.

Durrenberger, C. and McGaughey, 2003. "Design Values to Use for Early Action Compact Modeling." Prepared for the Capital Area Planning Council and the Texas Natural Resource Conservation Commission (now TCEQ) by The University of Texas at Austin, Center for Energy and Environmental Resources, 10100 Burnet Road, MS R7100, Austin, TX 78758. 22 September 2003.

United States Environmental Protection Agency. 1999. "Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS, EPA 454/R-99-004, U.S. Environmental Protection Agency, Research Triangle Park, NC. May 1999.

**Appendix A: Simple Analysis of Potential 8-Hour Ozone Design Values for 2003 in
Austin Based on Historical Monitoring Data**

Simple Analysis of Potential 8-Hour Ozone Design Values for 2003 in Austin Based on Historical Monitoring Data

October 7, 2003 draft

By Cyril Durrenberger and Gary McGaughey

Introduction

Using data collected at a single monitoring site, the 8-hour ozone design value is the truncated average of the fourth highest daily 8-hour concentrations over three consecutive years. For example, the design value for 2002 is defined as the average of the fourth highest daily 8-hour concentrations measured in 2001, 2002, and 2003. The area-wide design value, which is the maximum across all monitoring stations, is then compared to the 8-hour standard of 85 ppb to determine compliance.

In the Austin area during the 1997 through 2003 period, continuous ozone measurements have been collected at the Audubon and Murchison monitoring stations. Measurements from these stations are used to determine compliance with the 8-hour ozone standard. Although the Austin area-wide maximum 8-hour design value has exceeded the standard of 85 ppb for each year during the 1998 through 2001 period, the 2002 design value of 84 ppb demonstrates attainment for the most recent three-year period. Since the current design value does not exceed the standard, the goal of this report is to use historical data to determine the likelihood of an exceedance of the 2003 8-hour ozone design value.

Ozone Season Data Completeness

Historically (based on all available monitoring data for the 1993 through 2003 period), ozone concentrations of 85 ppb or higher have been measured from late April through early October, however, the overwhelming majority of high ozone concentrations have been observed during the August through early October period. Since ozone concentrations greater than 75 ppb have never been measured during the mid-October through December period, data completeness for determining compliance with the 8-hour ozone standard generally occurs in late October of any given year. Therefore, the design value for 2003 (based on data collected during the 2002 through 2004 period) could potentially be used to determine nonattainment sometime after March 2004, although attainment could not be demonstrated until at least October 2004.

Meteorology and Emissions

The ozone concentration measured at a monitoring site depends on a number of factors, including local emission of ozone precursors, regional transport of ozone, and meteorological conditions. A conceptual model was developed for the Austin area that correlates periods of high ozone with the local meteorological conditions and associated large-scale weather patterns. But this conceptual model can not be used to predict the

meteorology in future years that will be correlated with high ozone, nor does it provide a forecast component to predict the frequency of meteorological conditions associated with high ozone in the past.

Ozone formation is also correlated with emissions of ozone precursors, and it is sensitive to the daily temporal and spatial variation of these emissions. It is not possible to predict the future daily emissions that may cause high ozone. In general, it is appropriate to assume that the average daily emissions for the next year will be similar to those of the previous year, but it is not possible to predict future daily emissions with much precision.

Analysis Procedure

Since there is no skill at predicting ozone concentrations in future years based on monitored concentrations in past years, we can not use trend analysis to predict the fourth highest concentration for 2004. However, we can assume that ozone concentrations for 2004 are likely to be similar to those measured in a previous year. In fact, we can ask the question, if 2004 were similar to each year during the 1997 through 2003 period, what would the 2003 design value be?

The approach used for these analyses is:

1. Assume that ozone concentrations for 2004 are likely to be similar to those measured between 1997 and 2003
2. Use each year during the 1997 through 2003 period as a surrogate for 2004; that is, assume that the fourth highest concentration for 2004 is equally likely to be the fourth highest concentration measured in each year over the 1997 through 2003 period. Then for each case, use this value with the observed concentrations for 2002 and 2003 to calculate the corresponding 2003 design value.
3. This set of calculated design values provides a range of values that is likely for the 2003 design value.

This approach also assumes:

1. That the future year emissions will be similar in magnitude and similar in spatial and temporal distribution as those of the previous years.
2. That the nature and frequency of meteorological events correlated with high ozone will be similar to those of the previous years.
3. That the amount of ozone and ozone precursors transported into the area will be similar to those of previous years.

This approach is based upon historical monitoring, and does not attempt to develop an analysis of trends.

Data Analysis

Table 1 presents the fourth highest 8-hour average ozone concentrations at each monitoring location in the Austin area for each year during the 1997 through 2003 period.

Table 1. Fourth highest 8-hour ozone concentration (ppb).

	1997	1998	1999	2000	2001	2002	2003	Average
Audubon	87	81	99	87	80	81	81 *	85
Murchison	75	88	87	88	78	91	84 *	86

* Based on data until October 5, 2003

Table 2 presents the by-site and area-wide 8-hour design values for the Austin area. The Audubon and Murchison design values and the area-wide design values have been truncated for direct comparison to the 8-hour standard of 85 ppb. A design value of 85 ppb exceeds the standard.

Table 2. Summary of 8-hour design values for the Austin area (ppb).

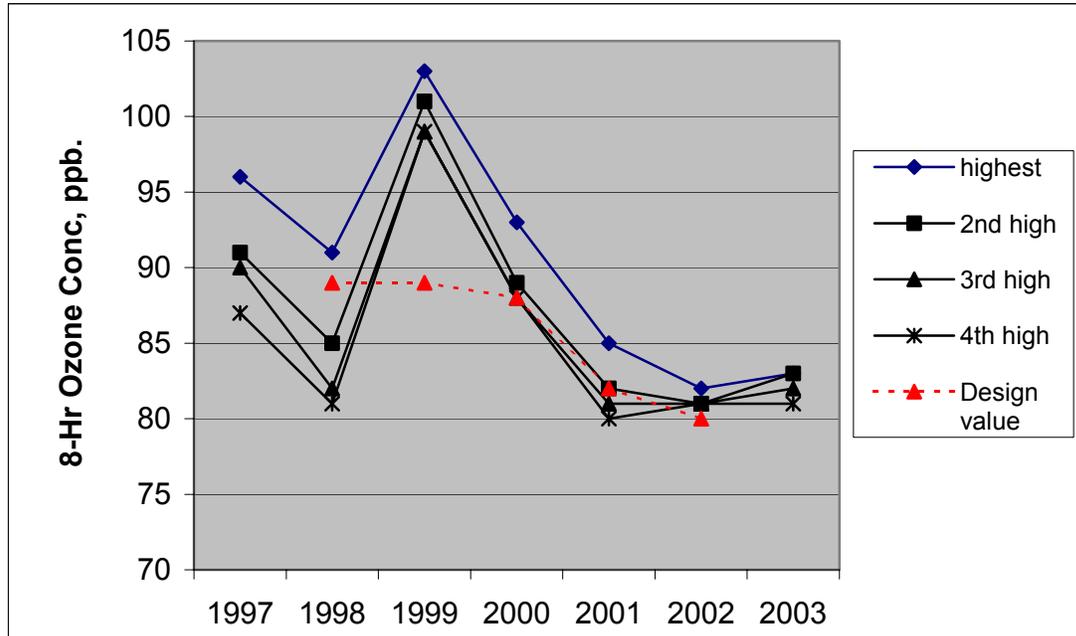
	1998	1999	2000	2001	2002
Audubon	89	89	88	82	80 *
Murchison	83	87	84	85	84 *
Area-wide Maximum	89	89	88	85	84 *

* Based on data until October 5, 2003

Audubon

Figure 1 shows the four highest 8-hour ozone concentrations for the 1997 through 2003 period and the design values for the 1998 through 2002 period.

Figure 1. Four Highest 8-hour Ozone Concentrations and Design Values (ppb) at the Audubon monitoring station for the 1997 through 2003 period.



As indicated above, we can assume that ozone concentrations for 2004 are likely to be similar to those measured in a previous year. Table 3 presents the results of this analysis using each year during the 1997 through 2003 period as a surrogate for 2004.

Table 3. Audubon design values for 2003 using each year during the 1997 through 2003 period as a surrogate for 2004.

Year	4 th highest, ppb	Corresponding design value for 2003, ppb
1997	87	83
1998	81	81
1999	99	87
2000	87	83
2001	80	80
2002	81	81
2003	81	81
average	85	82

As shown in Table 3, the estimated 2003 design values range from 80 ppb to 87 ppb. Only one of the seven scenarios would result in a design value of 85 ppb or higher.

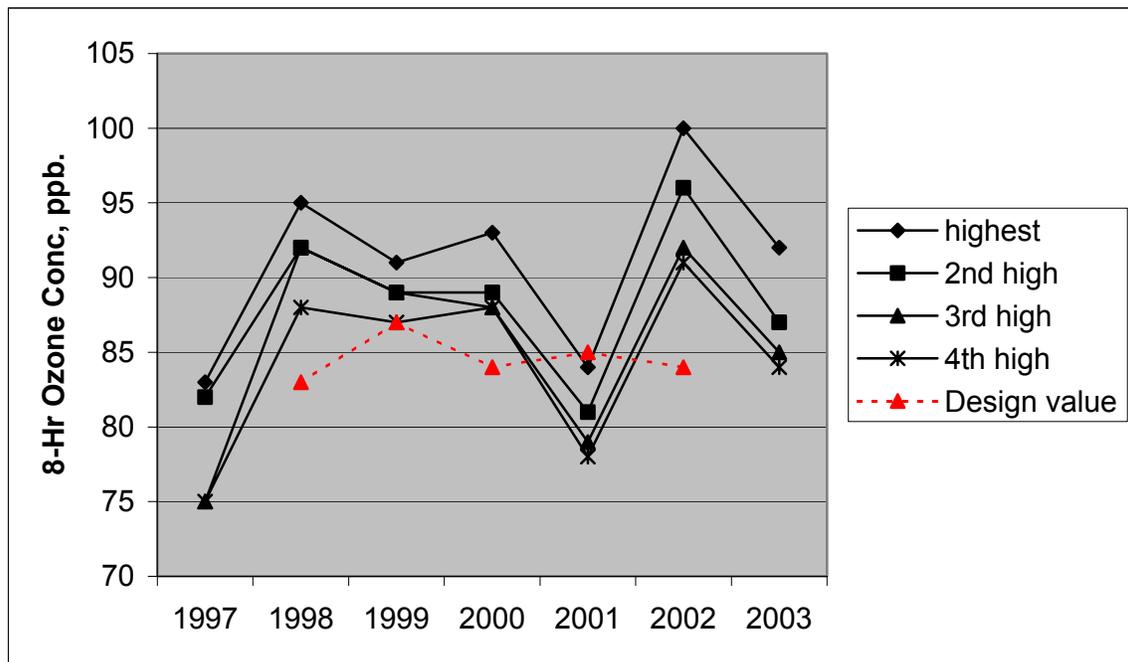
Using the average fourth highest concentration over the 1997 through 2003 period, the design value would be 82 ppb.

Based on historical ozone concentrations from the Audubon monitoring station, the 2003 design value is likely to be between 80 ppb and 87 ppb. Only one year, 1999, provided a fourth highest ozone concentration high enough to exceed the design value. Thus, if 2004 were equally likely to be similar to each year during the 1997 through 2003 period, the 2003 design value will likely be below the 8-hour standard of 85 ppb.

Murchison

Figure 2 shows the four highest 8-hour ozone concentrations for the 1997 through 2003 period and the design values for the 1998 through 2002 period.

Figure 2. Four Highest 8-hour Ozone Concentrations and Design Values (ppb) at the Murchison monitoring station for the 1997 through 2003 period.



As for the Audubon analysis presented in Table 3, we assume that ozone concentrations for 2004 at the Murchison monitoring station are likely to be similar to those measured in a previous year. Table 4 presents the results of this analysis using each year during the 1997 through 2003 period as a surrogate for 2004.

Table 4. Murchison design values for 2003 using each year during the 1997 through 2003 period as a surrogate for 2004.

Year	4 th highest, ppb	Corresponding design value for 2004, ppb
1997	75	83
1998	88	87
1999	87	87
2000	88	87
2001	78	84
2002	91	88
2003	84	86
average	86	87

As shown in Table 4, the estimated 2003 design values range from 84 ppb to 88 ppb. Five of the seven scenarios would result in a design value of 85 ppb or higher. Using the average fourth highest concentration over the 1997 through 2003 period, the design value would be 87 ppb.

Based on historical ozone concentrations from the Murchison monitoring station, the 2003 design value is likely to be between 84 ppb and 88 ppb. Given that five of the seven scenarios provide a design value of 85 ppb or higher, and that using the average fourth highest concentration over the 1997 through 2003 period results in a 2003 design value of 87 ppb, it is likely that the 2003 design value (based on limited historical data and a simplistic analysis) will exceed the 8-hour standard.

Caveat

The goal of this report is to use historical monitoring data to estimate the likelihood of measuring a 2003 8-hour design value of 85 ppb or greater. It is impossible to predict ozone concentrations a year in advance, so we have assumed that there is an equal likelihood that 2004 will produce ozone concentrations similar to a year during the 1997 through 2003 period. We feel this is a useful exercise, and helps to establish a reasonable range for the 2003 design value. However, this analysis is simplistic and does not account for any variability in either precursor ozone emissions or synoptic-scale weather patterns. In particular, the large-scale weather patterns that dominate during the ozone season have a major impact on ozone concentrations by determining the frequency of occurrence of local meteorological conditions that favor high concentrations of ground level pollutants such as ozone. There is no information available at this time to indicate how the large-scale weather patterns or emissions patterns will vary during 2004, and 2004 could be atypical compared to the previous available years.

Summary

Historical data collected at the Audubon and Murchison monitoring stations during the 1997 through 2003 monitoring period have been used to estimate the 2003 8-hour design value for the Austin area. By assuming that 2004 is equally likely to be similar to any year between the 1997 through 2003 period, Audubon is likely to measure a 2003 design value below the 85 ppb standard, while Murchison is likely to measure a 2003 design value above the 85 ppb standard. However, the reader is cautioned that this is a rather simplistic analysis guided by the available historical ozone monitoring data. In 2004, the emissions and/or the large-scale weather patterns that determine the frequency of occurrence of daily local meteorological conditions that favor high ozone concentrations could be quite different from any previous year.