EXHIBIT 4
(CONTINUED)

CHAPTER 5: WEIGHT OF EVIDENCE

5.1 QUANTITATIVE CORROBORATIVE ANALYSIS

5.1.1 Introduction

The corroborative analysis presented in this chapter demonstrates the progress that the Houston-Galveston-Brazoria (HGB) area is making towards attainment of the 1997 eight-hour ozone National Ambient Air Quality Standard (NAAQS) of 0.08 parts per million (ppm). The United States Environmental Protection Agency's (EPA) April 2007 "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze" (EPA, 2007) states that all model attainment demonstrations should include supplemental evidence that the conclusions derived from the basic attainment modeling are supported by other independent sources of information. This document will present the supplemental evidence, i.e., the corroborative analyses, for the current modeling demonstration. The guidance also states that a weight of evidence demonstration is allowed when the future design value is at or below 87.9 parts per billion (ppb).

The first section of the quantitative corroborative analysis will discuss photochemical grid modeling. Modeling is one of the most important tools available for evaluating progress toward meeting air quality standards, but it is not a perfect tool. The first section will also discuss known issues with photochemical grid modeling and how the Texas Commission on Environmental Quality (TCEQ) has dealt with them. It also discusses overall model performance. Finally, it discusses the diagnostic analyses performed by the TCEQ, and the implications of those analyses on the projected attainment status. The second section of the quantitative corroborative analysis will discuss trends in ozone and ozone precursors observed in the HGB area, and examines the possible causes for those trends. The third section describes air quality control measures that cannot yet be adequately quantified but are nonetheless expected to yield tangible air quality benefits.

5.2 Corroborative Analysis: Modeling

Photochemical grid modeling of the HGB area is challenging, due to complex coastal wind circulation, complex petrochemical point sources of emissions in Brazoria, Chambers, Galveston, and Harris Counties, and the challenges associated with modeling a metropolitan area of over five million inhabitants.

One purpose of the Texas Air Quality Study 2000 (TexAQS 2000) and the Texas Air Quality Study 2006 (TexAQS II) field studies was to address the uncertainties that affect photochemical grid modeling and their regulatory applications. Insights gleaned from the TexAQS 2000 and subsequent studies have helped resolve some of these uncertainties.

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

Some of the most important findings of these studies include the following.

- Emissions inventories must be reconciled to some extent with observational data before the model can accurately depict the ozone formation processes in the HGB area, especially for HRVOC.
- Adding HRVOC to modeling emissions inventories generally increases ozone concentrations and alleviates a portion of the ozone and HRVOC under-prediction problems found by every modeling group who has attempted to model the HGB area.
- Reactivities of the TCEQ-defined HRVOC are high regardless of which chemical mechanism is used to evaluate their effects. In addition to the TCEQ list of HRVOC, formaldehyde also displays high reactivity.

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

Some of the most important findings of these meteorological modeling studies include the following.

- Assimilation of radar profiler and other upper air wind data is essential to good meteorological modeling performance in the HGB area.
- Modeling parameterizations need to be chosen carefully to alleviate the common problem of spurious thunderstorms and clouds.
- Accurate simulation of cloud cover is crucial to getting photolysis rates correct in the photochemical grid model, and ozone predictions are very sensitive to photolysis rates.
- An ensemble approach to meteorological and photochemical grid modeling may be warranted, given the sensitivity of ozone modeling to relatively small changes in meteorology. The ensemble approach will allow probabilistic attainment demonstrations to be produced.

In the remainder of this section, modeling issues identified by the studies described above will be discussed, as well as issues raised by TexAQS 2000 research, by TexAQS II research, and by TCEQ-sponsored investigations. Overall performance of the photochemical grid modeling and the implications of the model's ability to accurately simulate ozone episodes will also be discussed. Finally, additional metrics that show the effects of the proposed control strategies on ozone in the HGB area will be presented.

5.2.1 Solving Modeling Problems

For the HGB area, there are several aspects of ozone modeling that require special attention, due to their role in current or historical shortcomings in model performance. This section discusses some of these issues, and how TCEQ has attempted to resolve them in this round of modeling.

5.2.1.1 Industrial Point Source Emission Inventory Issues

High concentrations of light alkenes such as propylene, ethylene, 1,3-butadiene, and butenes have been observed in the HGB metropolitan area, and are closely associated with petrochemical industry facilities in eastern Harris, Galveston, Chambers, and Brazoria Counties (Ryerson et al., 2003; Daum et al., 2003; Daum et al., 2004; Berkowitz et al., 2004; Berkowitz et al., 2005; Kleinman et al., 2002; Kleinman et al., 2005; Jobson et al., 2004; Karl et al., 2003; Buzcu and Fraser, 2006; Xie and Berkowitz, 2006, 2007; Kim et al., 2005). These compounds have been identified as highly reactive, and they play a major role in forming the highest concentrations of ozone observed in the HGB area (Ryerson et al., 2003; Daum et al., 2003, 2004; Kleinman et al., 2002, 2005; Wert et al., 2003; Czader et al., 2008). Historical analyses of routinely collected volatile organic compounds (VOC) data indicate that these compounds are present in high concentrations on a routine basis in the HGB area (Hafner Main et al., 2001; Estes et al., 2002; Brown and Hafner Main, 2002; Brown et al., 2002; Hafner and Brown, 2003; Jolly et al., 2003; Fang and McDowell, 2003; Jolly, 2003; Kim et al., 2005; Buzcu and Fraser, 2006; Xie and Berkowitz, 2006, 2007). Consequently, the high HRVOC concentrations observed during the two field study periods in 2000 and 2006 are not anomalously large, and the conclusions drawn from those data should be generally applicable to the HGB area.

Both field studies sponsored by the TCEQ, TexAQS 2000 and TexAQS II, have indicated that there are substantial discrepancies in the reported emissions of HRVOC, especially ethene and propylene (Ryerson et al., 2003; Daum et al., 2003; Daum et al., 2004; Wert et al., 2003; Gilman et al., 2009; de Gouw et al., 2009). The TCEQ remote sensing studies of flares, storage tanks, cooling towers, and other sources have shown that large quantities of VOC emissions have gone unreported (Robinson et al., 2008; Smylie et al., 2004). In addition, solar occultation flux measurements have shown that 30-minute variations in industrial HRVOC emissions can be an order of magnitude or more (Mellqvist et al., 2007, 2008).

In an attempt to better quantify underreported HRVOC for purposes of photochemical grid modeling, the TCEQ commissioned a study by researchers at the Pacific Northwest National Laboratory (Xie and Berkowitz, 2006, 2007). The researchers used historical HRVOC measurements from the extensive automated gas chromatograph network currently in place in the industrial areas of the HGB area. Most of the sites in this network went into operation during 2003. Using trajectories to link the source areas to the observations, the researchers were able to estimate which areas had the greatest emissions relative to other areas.

For the current round of modeling, TCEQ researchers extended the methods developed by Pacific Northwest National Laboratory to quantitatively estimate underreported HRVOC emissions in the HGB area. The Potential Source Contribution Function method has measurably improved model performance for ozone and its precursors by reconciling the industrial point source emissions inventory with observed HRVOC concentrations during 2005-2006 (Smith and Jarvie, 2008). This method does not attempt to reproduce the temporal variations in emissions, but instead calculates a median rate of emission for each square kilometer of the HGB area. Since two years of data are used to estimate the medians, the metric is statistically robust.

5.2.1.2 Modeling of Emissions Events

Attempts have been made to quantify temporal variations in industrial point source emissions by accessing emission event reports that are delivered by industry to the TCEQ (Murphy and Allen, 2005). Problems with the event report data include the following.

- Emission events were self-reported by industry, and the quantities of emissions reported were not independently observed or verified. Facilities are allowed, by rule, to estimate emissions during emergency releases due to safety concerns.
- Emission events were only reported if estimated emissions were greater than a certain threshold above the permitted emission level. Some facilities have very large permitted emissions levels, and therefore large fluctuations in emissions may occur under an authorized emission rate that are not included in the data set. Consequently, the frequency and magnitude of emission events in this data set does not reflect the actual magnitudes or frequency of emission events.
- Emission event data for the Murphy and Allen study were collected before industry was required to monitor HRVOC. Therefore, most of the emission estimates are not based upon measurements of the events.
- The TCEQ infrared camera studies have found numerous instances where emissions were emanating from locations that were not included in any emissions inventory.
- The TCEQ flare investigations have found that flares are typically managed to reduce noise, smoke, and glare. Optimizing the flare to keep destruction efficiency at a maximum is a secondary consideration. In particular, flares used as both emergency flares and process flares have been observed to operate with poor combustion efficiency when operating in process flare mode (Robinson et al., 2008).

- In addition, flare monitoring records only the chemicals flowing to the flare, not which species are actually being emitted. Combustion efficiencies are estimates of how much of the original material has been destroyed, and no effort is made to estimate the composition or reactivity of the combustion products. Circumstantial evidence from the TexAQS II and from the Study of Houston Atmospheric Radical Precursors (SHARP) suggests that formaldehyde may be produced during flare combustion, though the absolute quantity of emissions may only constitute a small part of the observed ambient formaldehyde (Gilman et al., 2009; De Gouw et al., 2009). The SHARP field campaign in April-May 2009 is investigating this hypothesis in greater depth.
- Field studies (Mellqvist et al., 2007, 2008; de Gouw et al., 2009) and recent infrared camera and differential absorption lidar (DIAL) results (Robinson et al., 2008) show that the techniques used by industry to estimate HRVOC point source emissions are still inadequate to quantify them properly, because these experiments measured much higher emission fluxes than were reported.

A number of recent modeling studies have attempted to investigate the frequency, magnitude, and impact of emission events upon ozone in Houston (Webster et al., 2007; Nam et al., 2006, 2008). Since these studies are based upon the emission event reports, they have not properly quantified the frequency or magnitude of the emission events, due to the problems discussed above. Therefore, the modeled impact of emission events described in the Webster et al. and Nam et al. studies are unlikely to accurately reflect the complete impact of emission events in the HGB area. Since the acquisition of properly quantified emissions for all industrial emission events that occur in the HGB area appears to be far in the future, the TCEQ has not attempted to speculate on the exact frequency or magnitude of sporadic emission events in this modeling exercise.

5.2.1.3 Resolution of Photochemical Modeling Grids

Numerous studies have investigated the effects of grid size on model behavior (Cohan et al., 2006; Esler, 2003; Gego et al., 2005; Valari and Menut, 2008). The main interest in finer grid resolution is that higher resolution can increase concentrations of ozone precursors in narrow plumes, which can affect ozone production rate and sensitivity to VOC or nitrogen oxides (NO_X) within the plumes. In a city such as Houston, using a higher resolution grid is sensible, given the abundance of industrial point sources, which can generate narrow plumes. Researchers during TexAQS 2000 determined that rapid ozone formation occurring within narrow industrial plumes are responsible for the highest observed ozone in the HGB area, and for the strong ozone gradients that can form. Strong ozone gradients can cause large increases in ozone concentration at monitoring sites as the plume is carried across town by winds that have shifted direction and are no longer parallel to the plumes. To resolve these atmospheric features, the TCEQ is using smaller-sized grid cells than previous modeling exercises (2 kilometer (km) × 2 km instead of 4 km × 4 km). In general, the TCEQ has found that smaller grid sizes can yield higher ozone production and can alleviate, in part, the commonly observed low bias for ozone within industrial plumes. There are limits to this solution, however; it is inappropriate to decrease grid size indefinitely. Parameterizations in both the meteorological modeling and the photochemical grid modeling are based upon the assumption that turbulence features within the planetary boundary layer (PBL) are much smaller than the grid size. If the grid size is decreased to 1 km × 1km or lower, the assumption probably no longer holds, and more uncertainty can be added to the modeling as a result of the finer resolution. If smaller grid sizes are desired, large eddy simulation modeling should be considered rather than photochemical grid modeling.

Also, note that if the spatial resolution of the photochemical grid modeling is reduced, then the temporal resolution of the meteorological and chemical processes within the model ought to be reduced, to match the shorter residence time of precursors in each grid cell. In other words, as the size of the box shrinks, the amount of time that a mass of air resides in the box also shrinks, affecting how the ozone chemistry plays out. While the Comprehensive Air Model with Extensions (CAMx) automatically adjusts the time step for chemical processes, the meteorological process time step is fixed, based upon the input data from the Fifth Generation Meteorological Model (MM5). While it is possible to extract meteorological output with higher temporal resolution, reduction of the time steps seems likely to cause unusual model behavior. The reduction of time steps in regulatory photochemical grid modeling has not been well studied. In the future, it may be desirable to use grid sizes smaller than 2 km, and shorter time steps, but for now, TCEQ will refrain from experimenting with finer resolutions. For this round of modeling, the

TCEQ has reduced the size of the CAMx modeling grid cells from 4 km to 2 km through flexi-nesting, but has kept the size of the MM5 modeling grid cells at 4 km.

5.2.1.4 Incommensurability and Model Performance Evaluation

Swall and Foley (2009) discuss the problems inherent in comparing point measurements to grid cell values. In statistical parlance, this problem is known as incommensurability. A portion of the difference between point measurements and grid cell values is due solely to the fact that measurements made at a monitoring station do not generally represent an average of the conditions for the 2 km × 2 km grid cell in which it resides. The ability of a point measurement to represent the average of the entire grid cell area is related to how much sub-grid variation is observed in the area. If sub-grid variation is small, then the point measurement and the grid cell value are commensurate. If the spatial gradients of the variables of interest are large, the point measurements are less able to reflect the average conditions of the entire grid cell, and therefore they are incommensurate with the grid cell value.

HGB area ozone often has strong spatial gradients due to the rapid ozone formation within industrial source plumes. In the HGB area, the worst ozone model performance is sometimes found in areas with the steepest ozone gradients, and the best ozone model performance is often found in areas further downwind, where the ozone gradients have lessened. Swall and Foley demonstrated that incommensurability alone is capable of degrading model performance in areas of steep gradients. They state in their discussion: "This means that, even if the model is performing perfectly and there is no observational error, we cannot expect that in a scatterplot, points representing paired modeled and observed values will lie on a one-to-one line. Our comparison of Gaussian and exponential correlation structures with the same effective range shows that this concern looms larger for correlation structures in which there is a rapid decrease in correlation for small distances relative to grid cell size (like the exponential)." While there are other causes of poor model performance as well, note that incommensurability is likely to be responsible for some of the differences between model output and point measurements.

5.2.1.5 Ensemble Modeling

A number of researchers have discussed the benefits of using ensembles of models to create more accurate forecasts (Pinder et al., 2009; Zhang et al., 2007). Pinder et al. and Zhang et al. have noted that probabilistic attainment demonstrations could be made using ensemble modeling and have argued that this approach can be more scientifically sound than a deterministic attainment demonstration. The TCEQ acknowledges the potential soundness of the ensemble approach but notes that the current regulatory framework does not easily allow for a probabilistic attainment demonstration.

5.2.1.6 Vertical Distribution of Ozone

Ozonesonde measurements have been made each summer in the HGB area since 2003 (Morris et al., 2006). Findings from this study indicate that elevated free tropospheric ozone (i.e., above the PBL) in the HGB area is usually underestimated, and it often does not appear to mix down to the ground. Ozone in the lowest layers of the atmosphere often shows much more structure than the model simulates. The implication is that the model is mixing the lowest layers of the atmosphere more efficiently than they are actually mixing. The TCEQ has attempted to address these two issues. For the free tropospheric ozone, the TCEQ has obtained global model output for the appropriate time periods so that boundary conditions of free tropospheric ozone are more appropriate. Some of the discrepancies still persist; they appear to be related to phenomena that occur between the outermost domain boundaries and the HGB area. . For the PBL mixing issue, the TCEQ has improved the land cover data and sea surface temperature data in its latest round of modeling, in an attempt to improve the simulations of surface energy balance. In addition, the TCEQ has chosen the Eta PBL scheme (i.e., the Mellor-Yamada-Janjic scheme), which appears to be more effective at simulating PBL dynamics in the coastal regions than other available schemes. The TCEQ continues to investigate potential improvements for vertical mixing in the modeling.

5.2.1.7 Photolysis Discrepancies Due to Improper Placement of Clouds

Researchers at the University of Alabama-Huntsville performed a modeling study that examined the effects of modeled cloud cover on ozone performance in the HGB area, and found that some of the shortcomings in model performance could be corrected with better depiction of clouds (Pour-Biazar et al., 2007). University of Houston researchers also found that their forecasts were occasionally biased due to poor depiction of cloud cover (Byun et al., 2007). TCEQ-funded research found that higher-order decoupled direct method analysis of modeling sensitivities indicated substantial sensitivity to photolysis rates (Koo et al., 2008).

The TCEQ has found similar cloud cover effects in the photochemical modeling for this state implementation plan (SIP). The greatest discrepancies tend to involve the model under-predicting cloud cover, and hence, greatly over-predicting ozone on low ozone days. Modeled episode days for which cloud cover problems exist include: May 28, 2005; June 17, 2005; July 31, 2005; Aug 5, 2005; May 31-June 1, 2006; Aug 15, 2006; Aug 19, 2006; Aug 22, 2006; September 12, 2006; October 10, 2006. The average mean normalized bias for these days is +34.6 percent, compared to an average mean normalized bias on exceedance days of +9.7 percent. TCEQ process analysis shows that most of the radical initiation, propagation and termination steps are very sensitive to photolysis rates. Hence, improvements in cloud placement could greatly improve ozone and precursor performance, though the greatest improvements will likely occur on low ozone days.

To improve the cloud distribution, the TCEQ has followed the guidance of Texas A&M University (TAMU) researcher and state climatologist John Nielsen-Gammon and has utilized the Grell cumulus parameterization, which reduces the amount of spurious thunderstorm formation in the HGB area.

5.2.1.8 Radical Shortage

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

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

Model performance evaluation is presented in Chapter 3, *Photochemical Modeling* and in its associated appendices. Appendix I: *Corroborative Analysis for the HGB Attainment Demonstration SIP* includes two discussions of model performance in the Chemical Process Analysis and Intensive Model Performance sections. In addition, Appendix I: *Corroborative Analysis for the HGB Attainment Demonstration SIP* includes a discussion of using 2005 baseline modeling to estimate future 2018 design values. Based upon these evaluations, the following overall conclusions can be reached.

Ozone performance

- The model simulates the location, spatial extent, and relative intensity of ozone relatively well on most of the high-ozone days.
- The model consistently underestimates peak ozone within the highest concentration plumes.
- Simulated ozone depicts rapid morning ozone increases (30-50 ppb) relatively well, but tends to

miss afternoon peak concentrations.

- Radical and ozone precursor budgets were calculated directly from observations by Mao et al. (2009) at the Moody Tower during TexAQS II. They observed that ozone formation in the HGB area is both VOC- and NO_X-sensitive, with VOC-sensitive ozone formation usually occurring in the morning and NO_X-sensitive formation occurring in the afternoon. Based upon the TCEQ's process analysis, the TCEQ modeling appears to be simulating the VOC- and NO_X-sensitivity of ozone formation at Moody Tower relatively well, because the relative radical termination rates generally agree with the Mao et al. data.
- Process analysis and modeling sensitivity analyses show that peak eight-hour ozone is primarily NO_X-sensitive in much of the domain, but can be VOC-sensitive downwind of the urban core and the HGB industrial areas.
- According to TCEQ process analyses, VOC-sensitive conditions occur more often and more strongly in the industrial and urban core plumes. When ozone production is VOC-sensitive, usually more ozone is created than in NO_X-sensitive conditions.
- Chen et al. (2009) used the Moody Tower TexAQS II observations to constrain a steady-state photochemical box model. They used the Carbon Bond 05 chemical mechanism and several other chemical mechanisms to simulate the chemistry with the box model. They found that all of the chemical mechanisms underestimated peak daytime radical concentrations. The Carbon Bond 05 mechanism used by the TCEQ in this modeling exercise is one of the better performing mechanisms, but it still doesn't make enough radicals. The shortfall in radical production may be related to the shortfall in ozone production rates observed in the photochemical grid modeling. Note, however, that the results from Chen et al. are based upon a constrained steady-state box model, which assumes that the chemical system is in a photochemical steady state. It isn't clear whether this assumption is valid all of the time in the HGB area.
- Decreases in ozone production rates and other reaction rates correlate with decreases in NO_2 photolysis, implying that most of the ozone formation chemistry is highly sensitive to photolysis, and hence, highly sensitive to cloud-cover errors.
- Background ozone concentrations are important in accurately simulating the modeling for the HGB area. For most of the modeled days, the background ozone is unlikely to bias the modeling results in the HGB area, but during the July-August 2005 episode, excessively high background concentrations seem to compromise the model performance.
- In rural areas, the model routinely over-predicts nighttime ozone and under-predicts NO_X. The cause of this issue is unknown, but it could involve unreported NO_X sources or problems with vertical mixing in rural areas.
- Above the planetary boundary layer, the model sometimes underestimated ozone concentrations, especially in the springtime. Usually the high ozone above the PBL was not being mixed downward, so that this error usually did not have much effect upon the ozone concentrations in the HGB area.
- Transport and mixing of urban and industrial emissions within the HGB area can apparently affect the ozone chemistry substantially, especially when the urban core plume and the industrial plumes mix together. Ozone behavior, including VOC- and NO_X-sensitivity, appears to change when these plumes mix. The implication is that the VOC- and NO_X-sensitivity of ozone formation in the HGB area depend somewhat on the wind direction.
- Since ozone was sometimes overestimated during the evening hours, the model did not display the amount of dynamic range present in the observations.

<u>Ozone precursor performance</u>

- In general, the modeling simulated ozone precursors relatively well, albeit with a large degree of scatter, and the peak concentrations for some species were underestimated.
- NO_2 was usually simulated in an unbiased manner, but nitric oxide (NO) was often underestimated for the peak concentrations, which were usually observed in the pre-dawn hours, i.e., during morning rush hour.
- The highly reactive Carbon Bond 05 species ETH and OLE, which represent ethylene, propylene, and other alkenes, were well simulated much of the time, but the model tended to underestimate

the peak concentrations. Concentrations of these two species were routinely overestimated at the Wallisville Road (CAMS 617) monitoring site.
- The performance of isoprene, represented by the Carbon Bond 05 species ISOP, was mixed, with some areas showing no bias, others showing high bias, and others showing low bias.
- Formaldehyde data were available during the TexAQS II study at three sites. For the Moody Tower site, the concentrations were usually well simulated, but the peak concentrations were underestimated. For the Lynchburg Ferry (CAMS 1015) and HRM-3 Haden Road (CAMS 603) sites, the performance was mediocre. The HRM-3 Haden Road (CAMS 603) observations were consistent with secondary formaldehyde formation as the main source of formaldehyde, but the diurnal patterns of the modeled concentrations were more consistent with a primary source: concentrations peaked in the pre-dawn hours, like NO. The aircraft data generally show that the model underestimated formaldehyde peaks, though the location, extent, and relative magnitude were well simulated, much like the ozone data.

<u>Meteorological performance evaluation</u>

- The meteorological modeling was able to successfully replicate the major features of ozone episodes in the HGB area much of the time, including the typical veering pattern of local winds, stagnation and flow reversal, and the coastal oscillations associated with the Galveston Bay breeze and Gulf breeze.
- Trajectory analyses and vertical wind profiles in the HGB area show that much of the time on high ozone days, the model transported ozone and precursors to approximately the correct areas at approximately the correct times.
- The model occasionally did not generate enough cloud cover, resulting in high ozone on days when low ozone was observed. While the addition of the Grell cumulus parameterization and improved land surface characteristics data appeared to reduce the common problem of spurious thunderstorms, the problem has not been completely eliminated.
- Episode days with strong stagnation were more difficult to model precisely than days for which the winds did not stagnate. The model sometimes simulated nighttime winds that were too brisk, resulting in more dilution of emissions than was actually observed.
- Ozonesonde and radar profiler data indicate that for most episode days, the PBL over land appeared to be modeled with good accuracy. Over water, however, planetary boundary layer depth was consistently modeled less accurately.

<u>Model response to emission changes</u>

- The base case modeling has been challenged with different emissions inventories in order to evaluate its dynamic response to emission changes (Gilliland et al., 2009).
- Adding more VOC to the flare emissions increases peak ozone concentrations, though the emission changes do not completely correct the ozone underestimations. Addition of formaldehyde emissions to HRVOC flares increases peak ozone concentrations further.
- Substitution of flare emissions for the standard emission reconciliation tends to improve the model performance by increasing ozone production close to the industrial emission sources and by increasing the peak ozone concentrations, without adversely affecting ozone performance at other times and places.
- Modeled ozone appears to decrease slightly in response to NO_X emission decreases typical of the changes that occur on weekends. The observed weekend effect is a slightly stronger response to NO_X emission decreases, implying that the model may be slightly less NO_X-sensitive than it should be.
- Modeled ozone increases substantially in response to VOC and NO_X emission increases commensurate with the difference between 2006 emissions and 2000 emissions in the HGB area. When relative response factors are calculated using 2000 as the baseline year and 2006 as the future year, the modeled response to emission reductions is less vigorous than the observed response. This finding implies that the current modeling appears to underestimate the response to emission controls. If the atmosphere responds to the emission reductions from 2006 to 2018 in a manner similar to its response to the emission reductions between 2000 and 2006, the actual decrease in ozone design value will be greater than the model predicts.

- Some of the strongest model responses to emission changes occur outside the boundaries of the current ozone monitoring network, and sometimes outside the current nonattainment area. This finding suggests that the proposed controls may have a greater impact on ozone than the responses registered at the different monitoring sites would indicate.

5.2.3 Model Response to Proposed Controls: Additional Ways to Measure Progress

Table 5-1: *Changes in the Area and Population Affected by an Eight-Hour Ozone Design Value Greater than or Equal to 85 ppb in Response to Growth and Controls* shows how the area affected by high ozone is expected to shrink dramatically in response to the emission changes projected to occur between 2006 and 2018. Even though peak ozone drops by only 8 percent, the area with an estimated ozone design value greater than the 85 ppb standard shrinks by 96 percent. The population living in those areas and how the changes might reduce the number of people that encounter high ozone were considered. The estimated number of people residing in the high ozone areas decreases by 92 percent. Note that the population data is from the 2000 Census and has not been grown to reflect changes in population in those areas in 2006 or 2018. Also note that the numbers reflect areas where people reside, i.e., their home addresses, not necessarily where they might be during the hours of highest ozone during the ozone season. However, the dramatic decrease in the area with high ozone suggests that ozone decreases arising from the proposed control strategies are likely to benefit many residents of the HGB area.

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

Run name	Peak Ozone, ppb	Area with design value > 85 ppb, km^2	2000 population in area with design value > 85	Area × Concentration (km^2 × ppb)	Population × ppb
Ozone design value > 85 ppb					
baseline 2006.reg2	95	7,236	2,680,249	19,864	11,024,868
future year 2018.cs05	87	296	219,285	291	197,713
Percentage decrease from 2006 to 2018	8%	96%	92%	99%	98%

5.2.4 Conclusion

The photochemical grid model performed by the TCEQ for this SIP revision has been rigorously evaluated against observational data. While there are a number of shortcomings that this modeling has in common with other modeling exercises in the HGB area as discussed in Sections 5.2.1, Solving Modeling Problems, and 5.2.2, , Model Performance Evaluations: Implications of the Model Performance of the Current SIP Modeling, modeling for many of the simulated ozone days appears to behave in a manner consistent with most of the atmospheric phenomena of interest. Evaluation of the modeling response to emission changes appears to show that the modeled ozone is slightly less responsive to emission changes than the observed ozone. Thus, modeling of 2018 emissions with the proposed control package in place may overpredict the future ozone concentrations.

5.3 AIR QUALITY TRENDS IN THE HGB AREA

This section describes analyses of air quality observational data in the HGB area. Trends in ozone and its precursors demonstrate not only the substantial progress the HGB area has made in improving air quality but also the magnitude of the future challenge in attaining the ozone NAAQS. Trends are also useful to show how ozone is related to its precursors. Decreases in NO_X and VOC demonstrate the effectiveness of policies to reduce emissions; however, due to its dependence on meteorological variables, ozone may not always exhibit trends identical to its precursors. Separating variations in meteorological factors from trends in ozone and its precursors can highlight whether ozone reductions are due to decreases in precursor emissions or are due to year-to-year variability in local meteorology (Sullivan, 2009; Camalier, et al., 2007).

5.3.1 Ozone Trends

This section examines the frequency at which the NAAQS for ozone are exceeded, with the understanding that the 1997 eight-hour standard of 0.08 ppm is the subject of interest for this SIP revision and that the one-hour standard is no longer in effect, but still a useful benchmark for understanding ozone behavior in the HGB area. While the NAAQS is expressed in units of ppm, this section will use the familiar convention of expressing concentrations in ppb.

The trend in design values for the HGB area is seen clearly in Figure 5-1: *Ozone Design Values for the HGB Area*. While the HGB area continues to exceed both the one-hour and eight-hour ozone standards, one-hour ozone design values have generally decreased over the past 17 years, and eight-hour ozone design values have decreased over at least the past nine years. The eight-hour ozone design value in 2008 was 91 ppb, a 24 percent decrease from the 1991 design value of 119 ppb. The 2008 value is approaching the 1997 eight-hour ozone NAAQS of 85 ppb. A regression analysis of design value on year estimates that eight-hour ozone design values decreased at the rate of 1.2 ppb per year, which is statistically significant at the 5 percent level ($\alpha = 0.05$). If this trend were to continue at that rate, attainment of the 1997 eight-hour standard could be reached in five years, though if the pace of recent years were maintained, it could occur even sooner.

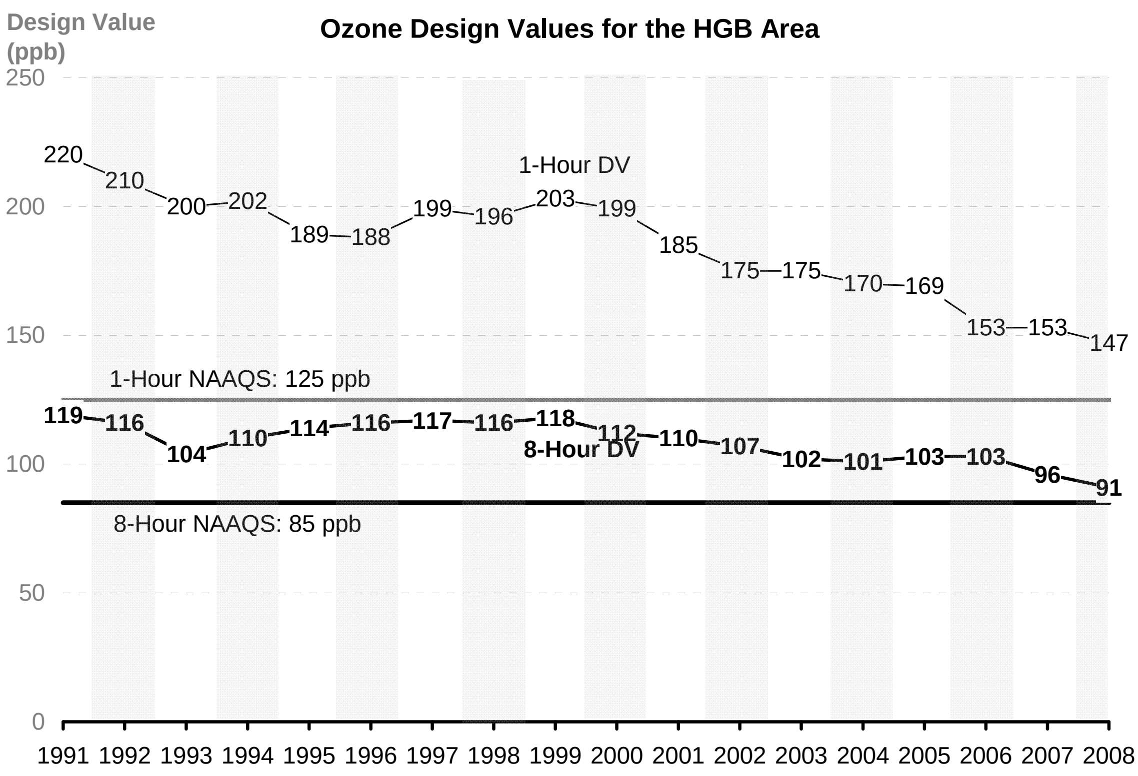


Figure 5-1: Ozone Design Values for the HGB Area

The one-hour ozone design value in 2008 was 147 ppb, a 33 percent decrease from the 1991 design value of 220 ppb. Regression of one-hour design values on year shows they decreased at the rate of 3.6 ppb per year, which is faster than the decrease for eight-hour ozone design values; the slope is also statistically significant at the 5 percent level.

Table 5-2: Eight-Hour Ozone Design Values (in ppb) for Each Regulatory Monitor in the HGB Area

Monitor/CAMS #	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Houston Bayland Park C53										111	110	100	102	101	103	103	96	91
Houston Westhollow C410						95	101	95	102	102	104	95	87	87	89	96	92	89
Park Place C416																		89
Hous.DeerPrk2 C35/235/1001/ AFH139FP239									108	112	108	103	102	101	100	96	93	87
Manvel Croix Park C84													91	97	97	96	91	85
Northwest Harris Co. C26/A110/ X154	98	101	100	110	113	110	106	106	109	108	105	101	100	94	93	91	91	85
Houston Aldine C8/AF108/F150	119	116	104	102	103	114	116	116	108	111	108	107	100	95	92	88	84	83
Houston Monroe C406	105	102	96	93	97	102	109	112	113	106	93	90	90	95	97	99	91	81
Houston Croquet C409	117	112	103	96	104	104	117	115	118	110	104	102	99	99	98	94	87	80
Conroe Relocated C78														85	86	85	84	80
Channelview C15/C115													87	90	89	85	83	80
Houston East C1	104	103	88				86	108	106	102	103	101	100	95	87	83	78	80
Seabrook Friendship Park C45													85	94	92	90	86	79
Houston Texas Avenue C411													88	89	88	84	78	76
Lang C408	105	103	93	95	98	99	100	96	96	96	91	83	78	79	79	80	77	76
Lake Jackson C1016															79	79	76	76
Houston North Wayside C405	114	102	94	91	91	91	96	99	104	105	98	89	86	85	82	78	76	75
Lynchburg Ferry C1015															96	89	82	74
Houston Regional Office C81												95	94	88	88	84	81	74
Clinton C403/C113/C304	115	109	100	100	106	106	107	100	103	101	97	93	96	96	95	85	79	73
Galveston Airport C34/C109/C154								90	112	108	98	89	89	91	87	83	71	
Clute C11		96	93	91	96	92	92	84	95	93	91	86	87					
Texas City C10	93	82	90	89	114	102	105	91	100	98	91	83	80					
Conroe C65											91							
Houston Crawford C407	105	98	89	89	95	91	97	96	100	100								
Houston Manchester C22	103	104	104	103	106	102	103											
Houston Deer Park C18	107	96	85	89	107	116												

Note: Missing values indicate a monitor was not operating during that year or did not produce a valid year of data. Three years of valid data are required to calculate an eight-hour ozone design value.

The design value in a metropolitan area is the highest design value of all of the area's monitors' individual design values. Because ozone varies spatially, it is also prudent to investigate trends at all monitors in an area. Table 5-2: *Eight-Hour Ozone Design Values (in ppb) for Each Regulatory Monitor in the HGB Area* and Table 5-3: *One-Hour Ozone Design Values (in ppb) for Each Regulatory Monitor in the HGB Area* contain the eight-hour and one-hour ozone design values at all regulatory monitors in the HGB area from 1991 to 2008. More monitors than these operate in the HGB area, but because the data at those monitors do not meet the EPA's quality control standards, the design values at those additional monitors are not displayed here. These non-regulatory monitors are discussed in Section 5.2.2: *Model Performance Evaluations: Implications of the Model Performance of the Current SIP Modeling*.

Table 5-3: One-Hour Ozone Design Values (in ppb) for Each Regulatory Monitor in the HGB Area

Monitor/CAMS #	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Houston Bayland Park C53									189	185	173	154	163	148	148	143	142	139
Houston Westhollow C410					164	155	164	155	165	150	150	141	141	128	126	131	127	126
Park Place C416																	136	132
Hous.DeerPrk2 C35/235/1001/ AFH139FP239							147	164	203	185	182	168	161	157	153	150	150	147
Manvel Croix Park C84												143	132	142	134	138	128	128
Northwest Harris Co. C26/A110/ X154	160	160	166	173	172	172	165	164	163	161	157	154	156	148	131	127	127	126
Houston Aldine C8/AF108/X150	220	190	197	197	189	173	189	187	187	180	166	166	143	136	139	125	122	122
Houston Monroe C406	170	170	155	147	154	161	174	196	196	170	143	151	141	141	131	133	131	117
Houston Croquet C409	200	200	178	152	167	167	168	168	167	167	160	157	150	141	136	131	126	117
Conroe Relocated C78												119	137	128	128	128	124	116
Channelview C15/C115												154	141	140	135	134	128	120
Houston East C1	210	200	200	202		177	182	182	198	180	180	171	171	165	154	137	119	119
Seabrook Friendship Park C45												132	135	135	153	153	153	119
Houston Texas Avenue C411												146	172	157	157	127	110	110
Lang C408	200	183	158	159	159	159	158	155	155	175	175	149	128	128	127	126	108	108
Lake Jackson C1016														119	113	105	99	101
Houston North Wayside C405	210	190	173	173	155	143	155	158	189	190	168	153	131	138	138	118	100	102
Lynchburg Ferry C1015														157	157	152	149	117
Houston Regional Office C81											185	178	175	170	169	135	131	119
Clinton C403/C113/C304	210	210	176	158	173	173	173	161	183	199	176	157	175	158	158	124	121	111
Galveston Airport C34/C109/C154							170	170	176	168	164	133	123	129	129	117	103	97
Galveston 99th St. C1034																	115	115
Clute C11	150	150	132	129	144	144	148	134	154	161	154	136	133	136				
Texas City C10	150	150	163	163	184	182	182	146	175	172	139	121	116	116	124			
Conroe C65										145	145	140						
Houston Crawford C407	220	190	165	165	165	166	172	172	164	173	173	194						
Houston Manchester C22	190	190	180	160	172	170	175	173	176									
Houston Deer Park C18	160	160	150	157	188	188	199	163										
San Jacinto Monument C166/C245												143	124	124	94			

Note: Missing values indicate a monitor was not operating during that year or did not produce a valid year of data. Only one year of valid data is required to calculate a one-hour ozone design value; therefore, some monitors that have a one-hour ozone design value may not have an eight-hour ozone design value.

Figure 5-2: *Eight-Hour Ozone Design Value Statistics for All Monitors in the HGB Area* and Figure 5-3: *One-Hour Ozone Design Value Statistics for All Monitors in the HGB Area* display three summary statistics for the eight-hour and one-hour design values, respectively: the maximum, median, and minimum design values computed across all monitors in the HGB area. These figures facilitate assessment of the range of design values observed within a year, as well as how these distributions change over time. From these figures, it appears that neither eight-hour nor one-hour design values exhibited a noticeable trend until about 1999, after which both began falling steadily. Before 2002, no monitors in the HGB area met either standard; since then, the area has seen a steady increase in the number of monitors attaining both standards. By 2008, over half of the monitors in the area had attained both standards, as median ozone design values fell below the NAAQS that year.

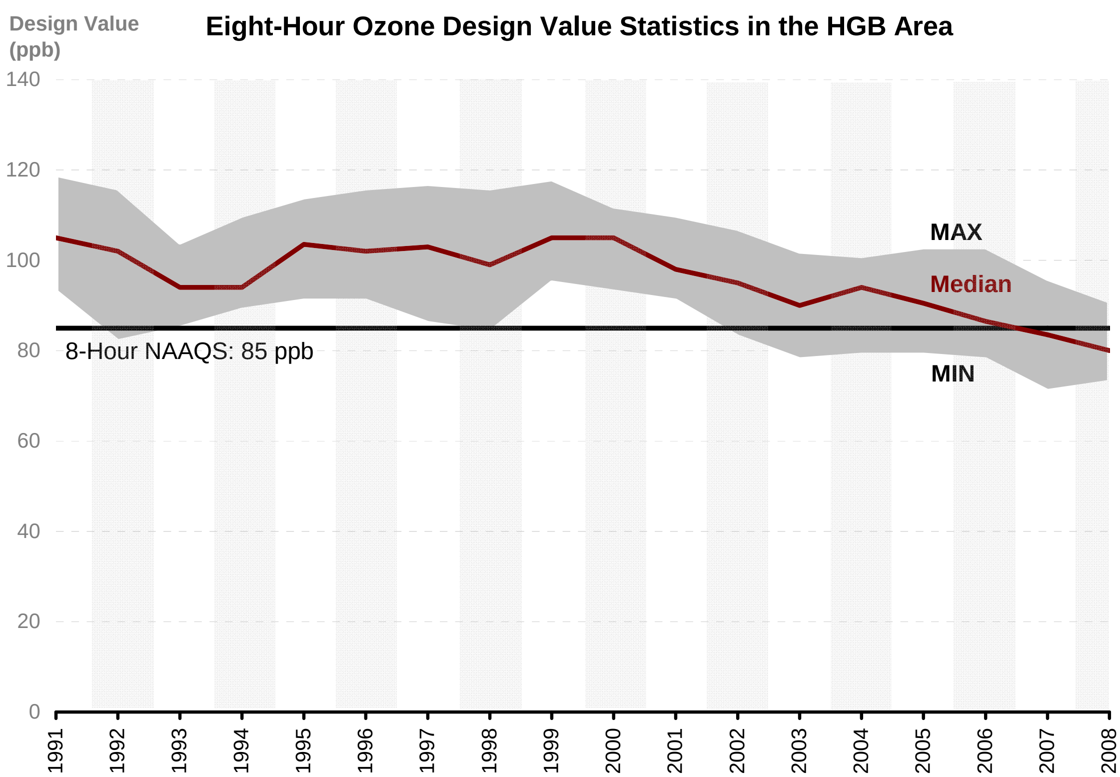


Figure 5-2: Eight-Hour Ozone Design Value Statistics for All Monitors in the HGB Area

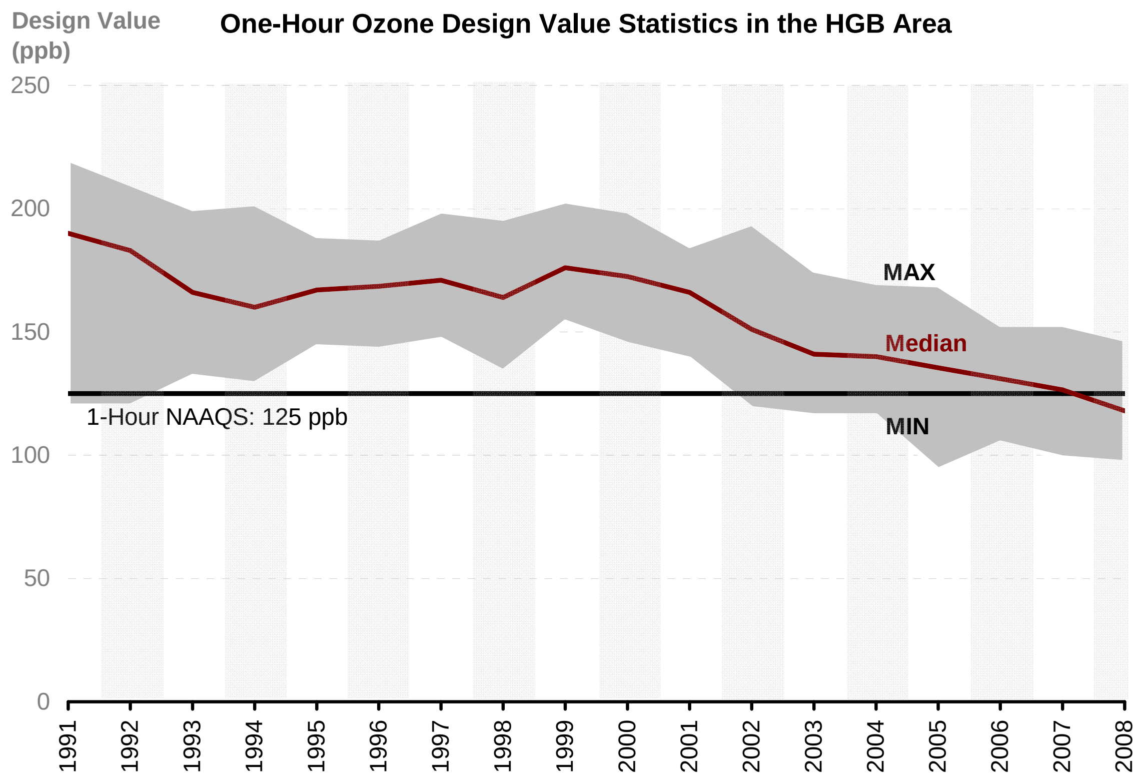


Figure 5-3: One-Hour Ozone Design Value Statistics for All Monitors in the HGB Area

Ozone trends can also be investigated by looking at the number of days an exceedance of the ozone NAAQS was recorded, termed an exceedance day. An exceedance day for the 1997 eight-hour ozone NAAQS is any day that any monitor in the area measures an eight-hour average ozone concentration greater than or equal to 85 ppb over any eight-hour period. An exceedance day for the one-hour ozone NAAQS is any day that any monitor in the area measures a one-hour average ozone concentration greater than or equal to 125 ppb for at least one hour. Previous research (Savanich, unpublished, 2006) by the TCEQ has shown that, until 2006, the number of exceedance days was positively correlated with the number of monitors in a particular area. As the number of monitors increases, so does the number of exceedance days recorded, at least until the area has been saturated with monitors or until ozone concentrations truly decrease. Because of this correlation, when examining exceedance-day trends, the number of monitors must always be considered. Thus, it is especially noteworthy that Figure 5-4: *Number of Monitors and Ozone Exceedance Days in the HGB Area* shows that, despite an increase in the number of monitors, the number of exceedance days for both one-hour and 1997 eight-hour ozone NAAQS has decreased, a decrease that is especially pronounced over the past three years. Since 1999, the number of 1997 eight-hour and one-hour ozone exceedance days occurring in the HGB area has fallen 83 percent and 96 percent, respectively. In just the last three years, the number of 1997 eight-hour and one-hour ozone exceedance days has fallen 76 percent and 92 percent, respectively.

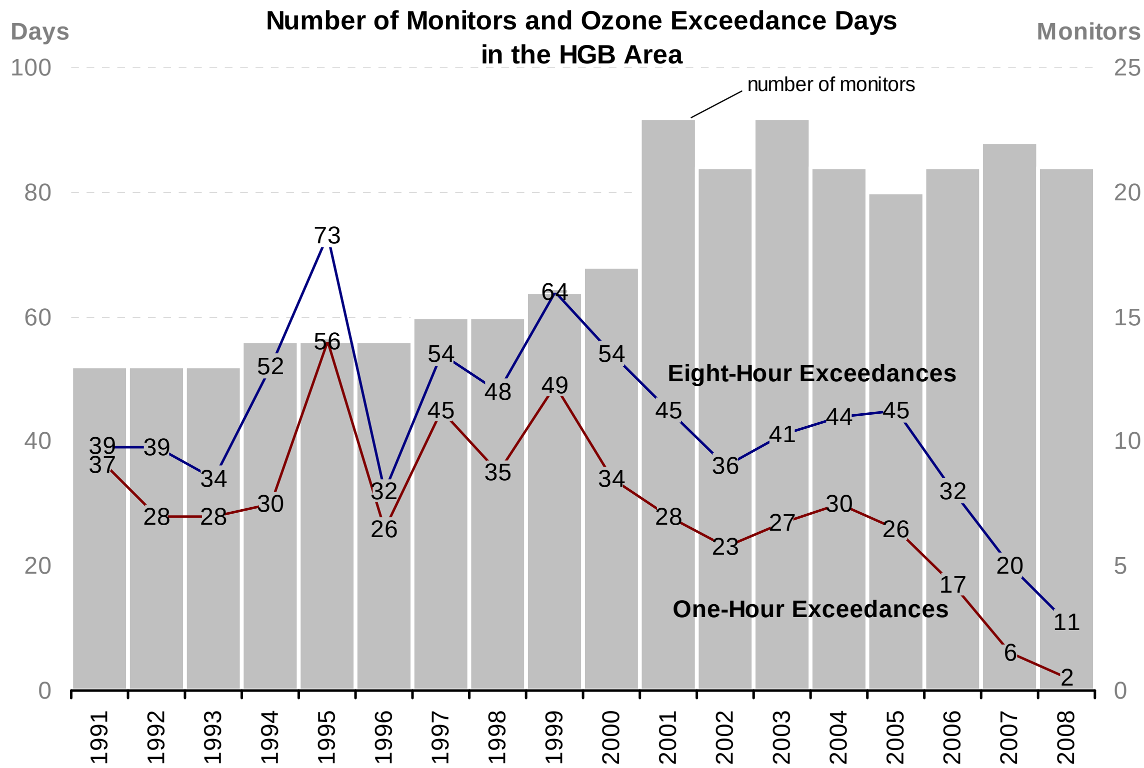


Figure 5-4: Number of Monitors and Ozone Exceedance Days in the HGB Area

Results for individual monitors, displayed in Figure 5-5: *Number of 1997 Eight-Hour Ozone Exceedance Days by Monitor* and Figure 5-6*: Number of One-Hour Ozone Exceedance Days by Monitor* support the conclusion that the number of exceedance days at individual monitors also appears to be decreasing. Figure 5-5: *Number of 1997 Eight-Hour Ozone Exceedance Days by Monitor* highlights two monitors, Houston Aldine (CAMS 8) (red line) and Houston Bayland Park (CAMS 53) (blue line), that recorded the most 1997 eight-hour ozone NAAQS exceedances in the past. Since recent peaks in 1999 (at Houston Bayland Park (CAMS 53)) and in 2000 (Houston Aldine (CAMS 8)), neither monitor, in any year, has come within 60 percent of these peaks; in 2008 both monitors experienced at least an 85 percent reduction from the recent peaks. While results for other monitors are less impressive, overall, the trend in ozone exceedance days at monitors throughout the HGB area is clearly downward. Due to the large number of monitors in the HGB area, data from Figure 5-5: *Number of 1997 Eight-Hour Ozone Exceedance Days by Monitor* and Figure 5-6: *Number of One-Hour Ozone Exceedance Days by Monitor* are presented in Table 5-4: *Number of Days with a 1997 Eight-Hour Ozone Exceedance* and Table 5-5: *Number of Days with a One-Hour Ozone Exceedance* for detailed inspection.

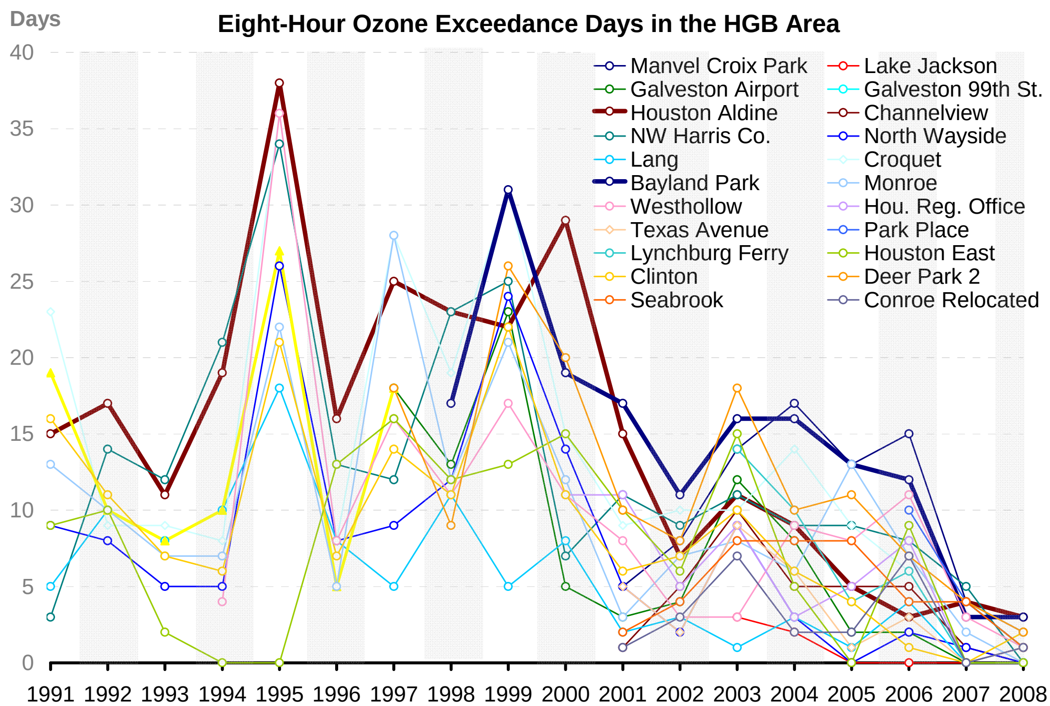


Figure 5-5: Number of 1997 Eight-Hour Ozone Exceedance Days by Monitor

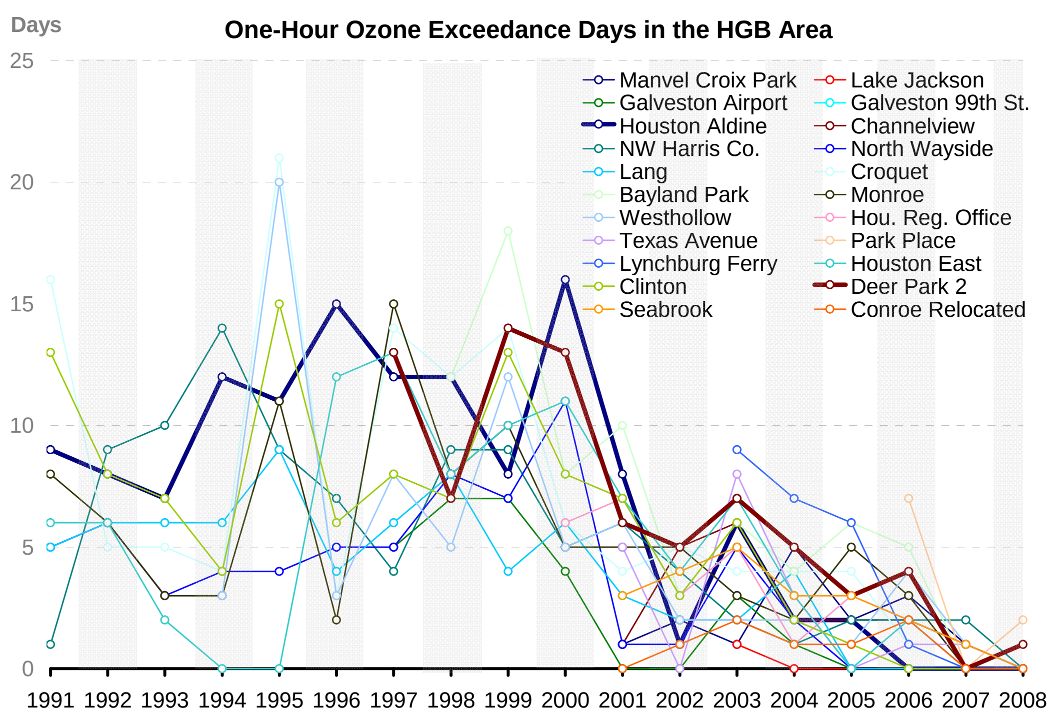


Figure 5-6: Number of One-Hour Ozone Exceedance Days by Monitor

The progress achieved in recent years in reducing eight-hour and one-hour ozone concentrations in the HGB area is evident in Table 5-4: *Number of Days with a 1997 Eight-Hour Ozone Exceedance* and Table 5-5: *Number of Days with a One-Hour Ozone Exceedance*. The number of times the monitors in the HGB area registered daily peak eight-hour ozone ≥ 85 ppb fell from a high of 340 occurrences in 1995, to 39 occurrences in 2007, to 19 occurrences in 2008. Prior to 2007, that number was never below 90. The number of monitors recording at least one exceedance of the 1997 eight-hour ozone standard has fallen by half, from a maximum of 23 monitors in 2003 to only 12 in 2008.

A similar pattern is apparent with the number of exceedances of the one-hour ozone NAAQS presented in Table 5-5: *Number of Days with a One-Hour Ozone Exceedance*. The table shows that the total number of one-hour ozone NAAQS exceedance occurrences fell from a high of 165 in 1995 to just three in 2008. Prior to 2005, the number of one-hour exceedances was never below 50. The three exceedances in 2008 occurred at only two monitors. As recently as 2006, a total of 15 monitors recorded at least one exceedance. This significant progress has occurred in a fairly short amount of time in an area well known for its air quality challenges.

Table 5-4: Number of Days with a 1997 Eight-Hour Ozone Exceedance

Monitor	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Houston Bayland Park C53								17	31	19	17	11	16	16	13	12	3	3
Houston Westhollow C410				4	36	8	16	11	17	11	8	3	3	9	8	11	3	1
Park Place C416																10	4	2
Hou.DeerPrk2 C35/235/1001/AFHP139FP239							18	9	26	20	10	8	18	10	11	7	4	2
Manvel Croix Park C84											5	8	14	17	13	15	4	1
Northwest Harris Co. C26/A110/X154	3	14	12	21	34	13	12	23	25	7	11	9	11	9	9	8	5	0
Houston Aldine C8/AF108/X150	15	17	11	19	38	16	25	23	22	29	15	7	11	9	5	3	4	3
Houston Monroe C406	13	10	7	7	22	5	28	12	21	12	3	7	8	6	13	7	2	0
Houston Croquet C409	23	9	9	8	36	8	28	19	31	15	9	10	10	14	9	6	0	1
Conroe Relocated C78											1	3	7	2	2	7	0	1
Channelview C15/C115											1	5	10	5	5	5	1	0
Houston East C1	9	10	2	0	0	13	16	12	13	15	10	6	15	5	0	9	0	0
Seabrook Friendship Park C45											2	4	8	8	8	4	4	1
Houston Texas Avenue C411											5	2	9	6	1	3	0	0
Lang C408	5	10	8	10	18	8	5	11	5	8	2	3	1	3	1	4	0	0
Lake Jackson C1016													3	2	0	0	0	1
Houston North Wayside C405	9	8	5	5	26	8	9	12	24	14	5	2	9	3	0	2	1	0
Lynchburg Ferry C1015													14	10	4	6	0	0
Houston Regional Office C81										11	11	5	9	3	5	8	0	0
Clinton C403/C113/C304	16	11	7	6	21	7	14	11	22	11	6	7	10	6	4	1	0	2
Galveston Airport C34/C109/C154							18	13	23	5	3	4	12	8	2	2	0	
Clute C11	8	10	6	5	15	3	4	5	9	2	3	6	3					
Conroe C65									4	17	6							
Houston Crawford C407	5	6	7	4	15	3	16	10	11	8	0							
Houston Manchester C22	19	10	8	10	27	5	18											
Houston Deer Park C18	8	4	3	18	27	12												
Texas City C10	6	1	9	7	25	1	10	10	11	6	1	3	3	0				
San Jacinto Monument C166/C245											0	5	1					
Galveston 99th St. C1034																	4	1
Number of Monitors in Operation	13	13	13	14	14	14	15	15	16	17	23	21	23	21	20	21	22	21

Note: Monitors with exceedance days do not necessarily have a complete year of ozone data; therefore, there may be years where a monitor has ozone exceedance days but no ozone design value.

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

Monitor	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Houston Bayland Park C53								12	18	8	10	3	6	4	6	5	0	0
Houston Westhollow C410				3	20	3	8	5	12	5	6	2	2	2	1	4	1	0
Park Place C416																7	0	2
Hou.DeerPrk2 C35/C235/1001/AFH139/FP239							13	7	14	13	6	5	7	5	3	4	0	1
Manvel Croix Park C84											1	2	1	5	2	3	1	0
Northwest Harris Co. C26/A110/C154	1	9	10	14	9	7	4	9	9	5	6	4	2	1	2	2	2	0
Houston Aldine C8/AF108/X150	9	8	7	12	11	15	12	12	8	16	8	1	6	2	2	0	0	0
Houston Monroe C406	8	6	3	3	11	2	15	8	10	5	5	5	3	2	5	3	0	0
Houston Croquet C409	16	5	5	4	21	3	14	12	14	6	4	5	4	4	4	1	0	0
Conroe Relocated C78											0	1	2	1	1	2	0	0
Channelview C15/C115											1	5	6	2	2	2	1	0
Houston East C1	6	6	2	0	0	12	13	8	10	11	7	4	7	3	0	2	0	0
Seabrook Friendship Park C45											3	4	5	3	3	2	1	0
Houston Texas Avenue C411											5	0	8	3	0	1	1	0
Lang C408	5	6	6	6	9	4	6	8	4	6	3	2	2	4	0	0	0	0
Lake Jackson C1016													1	0	0	0	0	0
Houston North Wayside C405	5	6	3	4	4	5	5	8	7	11	1	1	5	2	0	0	0	0
Lynchburg Ferry C1015													9	7	6	1	0	0
Houston Regional Office C81										6	7	3	5	1	3	2	0	0
Clinton C403/C113/C304	13	8	7	4	15	6	8	7	13	8	7	3	6	2	1	0	0	0
Galveston Airport C34/C109/C154							5	7	7	4	0	0	3	1	0	0	0	
Galveston 99th St. C1034																	0	0
Clute C11	3	3	2	0	6	1	3	1	4	2	0	2	1					
Texas City C10	4	1	7	2	14	0	3	3	7	3	0	0	1	0				
Conroe C65									1	5	2							
Houston Crawford C407	5	4	5	3	9	4	11	12	5	8	0							
Houston Manchester C1029	11	7	7	7	18	4	10											
Houston Deer Park C18	6	2	1	6	18	4												
San Jacinto Monument C166/C245											0	2	0					
Number of Monitors in Operation	13	13	13	14	14	14	15	15	16	17	23	21	23	21	20	21	22	21

The ozone season spans the entire year in the HGB area; the period of elevated ozone concentrations, however, varies from year to year. Figure 5-7: *1997 Eight-Hour Ozone Exceedance Days in the HGB Area* shows the frequency of, and variation in, the number of 1997 eight-hour ozone NAAQS exceedance days in the HGB area by month and year. While the duration and intensity of the ozone season does vary from year to year, in the past few years the HGB area has experienced fewer ozone exceedance days over fewer months. The darker areas in the figure show that peak ozone season in the HGB area typically occurs from August to September, with a smaller, secondary peak occurring earlier, roughly in June.

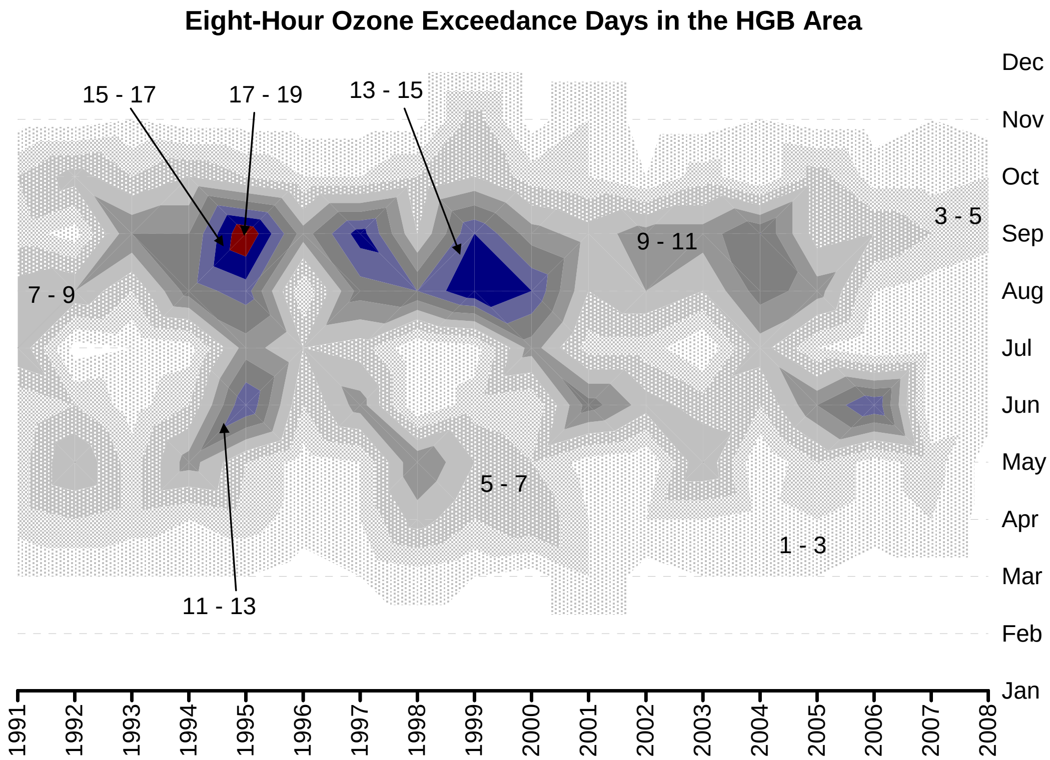


Figure 5-7: 1997 Eight-Hour Ozone Exceedance Days in the HGB Area

In summary, the number and intensity of ozone exceedances in the HGB area has been dropping, especially since 2000, with 2007 and 2008 demonstrating the largest of these decreases.

5.3.2 Ozone Trends at Regulatory and Non-Regulatory Monitors

Twenty-three monitors in the HGB area, listed in Table 5-6: *Eight-Hour Ozone Design Values at Regulatory and Non-Regulatory Monitors* and Table 5-7: *One-Hour Ozone Design Values at Regulatory and Non-Regulatory Monitors* report ozone concentrations following EPA certification protocols and are used for attainment determinations for regulatory purposes. However, since 2003, over 20 additional monitors have become operational in the HGB area that measure ozone concentrations following protocols that have not been certified to EPA standards. Usually, this means fewer calibrations and/or zero and span checks. These non-regulatory monitors are located throughout the HGB area. The locations were chosen with the aim of ensuring that all episodes of elevated ozone and precursors are observed. The additional monitoring sites also help to describe the spatial extent and distribution of high ozone more fully than the regulatory monitors alone. While the non-regulatory monitors are not acceptable for making regulatory determinations, they help describe the spatial patterns of ozone more completely and thus provide a broader perspective on trends in ozone concentrations across the HGB area.

Table 5-6: Eight-Hour Ozone Design Values at Regulatory and Non-Regulatory Monitors

AIRS	Site Name	2003	2004	2005	2006	2007	2008
		ppb	*ppb*	*ppb*	*ppb*	*ppb*	*ppb*
Regulatory Monitors							
482010055	Houston Bayland Park C53	**102**	**101**	**103**	**103**	**96**	**91**
482010066	Houston Westhollow C410	87	87	89	96	92	89
482010416	Park Place C416						89
482011039	Houston Deer Park 2 C35/139	102	101	100	96	93	87
480391004	Manvel Croix Park C84	91	97	97	96	91	85
482010029	Northwest Harris Co. C26/A110/C154	100	94	93	91	91	85
482010024	Houston Aldine C8/AF108/X150	100	95	92	88	84	83
482010062	Houston Monroe C406	90	95	97	99	91	81
482010051	Houston Croquet C409	99	99	98	94	87	80
483390078	Conroe Relocated C78		85	86	85	84	80
482010026	Channelview C15/C115	87	90	89	85	83	80
482011034	Houston East C1	100	95	87	83	78	80
482011050	Seabrook Friendship Park C45	85	94	92	90	86	79
482010075	Houston Texas Avenue C411	88	89	88	84	78	76
482010047	Lang C408	78	79	79	80	77	76
480391016	Lake Jackson C1016			79	79	76	76
482010046	Houston North Wayside C405	86	85	82	78	76	75
482011015	Lynchburg Ferry C1015			96	89	82	74
482010070	Houston Regional Office C81	94	88	88	84	81	74
482011035	Clinton C403/C113/C304	96	96	95	85	79	73
481670014	Galveston Airport C34/C109/C154	89	91	87	83	71	
480391003	Clute C11	87					
481671002	Texas City C10	80					
Non-Regulatory Monitors							
482010554	West Houston C554				102	99	**94**
482010558	Tom Bass C558				**104**	**100**	93
482010559	Katy Park C559				98	96	92
482010562	Bunker Hill Village C652				81	96	91
482010617	Wallisville Road C617			**96**	93	93	90
482010561	Meyer Park C561				90	89	84
482010557	Mercer Arboretum C557				88	88	84
482010560	Atascocita C560				88	86	83
482010556	La Porte Sylvan Beach C556				90	87	82
482010552	Baytown Wetlands Center C552			87	89	86	81
480390619	Mustang Bayou C619			93	89	84	81
482010572	Clear Lake High School C572			83	88	84	81
482010803	HRM-3 Haden Road C603			92	88	84	80
482010553	Crosby Library C553			87	86	84	80
481670056	Texas City 34th St, C620			89	90	84	79
482010570	Clear Brook High School C570			89	92	84	78
480390618	Danciger C618			80	83	80	78
482010555	Kingwood Library C555				82	81	77
482010551	Sheldon C551			92	85	80	76
481670571	Clear Creek High School C571			83	84		

Source: Leading Environmental Analysis and Display System (LEADS).
Monitors are sorted in descending order of 2008 design values, then 2007, 2006, etc. The annual maximum of each series is noted in boldface type. Because of the way design values are computed, some monitors in some years may have one-hour but not eight-hour design values.

Table 5-7: One-Hour Ozone Design Values at Regulatory and Non-Regulatory Monitors

AIRS	Site Name	2003	2004	2005	2006	2007	2008
		ppb	*ppb*	*ppb*	*ppb*	*ppb*	*ppb*
Regulatory Monitors							
482010055	Houston Bayland Park C53	**163**	148	148	143	142	139
482010066	Houston Westhollow C410	141	128	126	131	127	126
482010416	Park Place C416				136	136	136
482011039	Houston Deer Park 2 C35/C139	161	**157**	**153**	**150**	**150**	**147**
480391004	Manvel Croix Park C84	132	142	134	138	128	128
482010029	Northwest Harris Co. C26/A110/C154	156	148	131	127	127	126
482010024	Houston Aldine C8/AF108/X150	143	136	139	125	122	122
482010062	Houston Monroe C406	141	141	131	133	131	117
482010051	Houston Croquet C409	150	141	136	131	126	117
483390078	Conroe Relocated C78	137	128	128	128	124	116
482010026	Channelview C15/C115	141	140	135	134	128	120
482011034	Houston East C1	171	165	154	137	119	119
482011050	Seabrook Friendship Park C45	135	135	153	153	153	119
482010075	Houston Texas Avenue C411	172	157	157	127	110	110
482010047	Lang C408	128	128	127	126	108	108
480391016	Lake Jackson C1016		119	113	105	99	101
482010046	Houston North Wayside C405	131	138	138	118	100	102
482011015	Lynchburg Ferry C1015		157	157	152	149	117
482010070	Houston Regional Office C81	175	170	169	135	131	119
482011035	Clinton C403/C113/C304	175	158	158	124	121	111
481670014	Galveston Airport C34/C109/C154	123	129	129	117	104	97
481671034	Galveston 99th St. C1034					115	115
480391003	Clute C11	133	136				
481671002	Texas City C10	116	116	124			
Non-Regulatory Monitors							
482010554	West Houston C554		141	141	146	145	131
482010558	Tom Bass C558		145	145	146	146	**138**
482010559	Katy Park C559		127	143	143	135	129
482010562	Bunker Hill Village C562			135	137	135	132
482010617	Wallisville Road C617		147	145	138	139	134
482010561	Meyer Park C561			139	133	127	111
482010557	Mercer Arboretum C557		108	118	121	121	121
482010560	Atascosita C560			137	137	125	120
482010556	La Porte Sylvan Beach C556			148	**149**	**149**	133
482010552	Baytown Wetlands Center C552		138	138	133	129	129
480390619	Mustang Bayou C619		134	130	127	112	107
482010572	Clear Lake High School C572		145	141	140	119	114
482010803	HRM-3 Haden Road C603	**161**	**161**	144	135	127	122
482010553	Crosby Library C553		141	147	141	126	123
481670056	Texas City 34th St C620		143	139	136	119	114
482010570	Clear Brook High School C570		140	140	135	117	109
480390618	Danciger C618		121	120	111	108	108
482010555	Kingwood Library C555			130	123	122	108
482010551	Sheldon C551	153	153	**150**	130	125	123
481670571	Clear Creek High School C571		138	138	138	119	99
480710013	Smith Point Hawkins Camp C96				143	143	133
482010808	HRM-8 LaPorte C608	149					
482010804	HRM-4 Sheldon Rd. C604	128					
480710900	HRM-10 Mont Belvieu C610	119					

482010807	HRM-7 W Baytown C607	113

Source: LEADS (Leading Environmental Analysis and Display System).
The annual maximum of each series is noted in boldface type. Because of the way design values are computed, some monitors in some years may have one-hour but not eight-hour design values

Figure 5-8: *Distributions of Eight-Hour Ozone Design Values at Regulatory and Non-Regulatory Monitors in the HGB Area* compares eight-hour ozone design values at regulatory and non-regulatory monitors in the HGB area from 2003 to 2008. This period was chosen because many non-regulatory monitors only became operational, or had complete data, in 2003 and later years. The distributions of eight-hour ozone design values dropped for both types of monitors over the six-year period, though the interquartile range, a measure of spread between high and low values, did not narrow noticeably for either. Annual median fourth high eight-hour ozone design values fell from 90 ppb in 2003 to 80 ppb in 2008 at regulatory monitors, a drop of 11.1 percent. The median at non-regulatory monitors fell from 89 ppb to 81 ppb over the period, a 9.0 percent drop.

While medians and other moments from the distributions all dropped over the period, the annual maximum eight-hour ozone design value is most relevant, as this value is the current standard used for regulatory attainment determinations. The annual maximum eight-hour ozone design value measured at regulatory monitors fell from 102 ppb in 2003 to 91 ppb in 2008, a drop of 10.4 percent. The annual maximum at non-regulatory monitors fell from 96 ppb in 2005, when three-year design values were first computable, to 94 ppb in 2008, a drop of 2.1 percent. Note, however, that maximum eight-hour design values at non-regulatory monitors in 2006 and 2007 were higher than in 2008, 104 ppb and 100 ppb respectively, presumably because those years are strongly influenced by the fourth high value observed at Wallisville Road (CAMS 617) in 2006 (111 ppb). Even though this 2006 fourth high value continued to influence the 2008 design value, when averaged with the 2008 fourth high value of 85 ppb, the three-year average dropped to 94 ppb, a 6 percent decline in a single year.

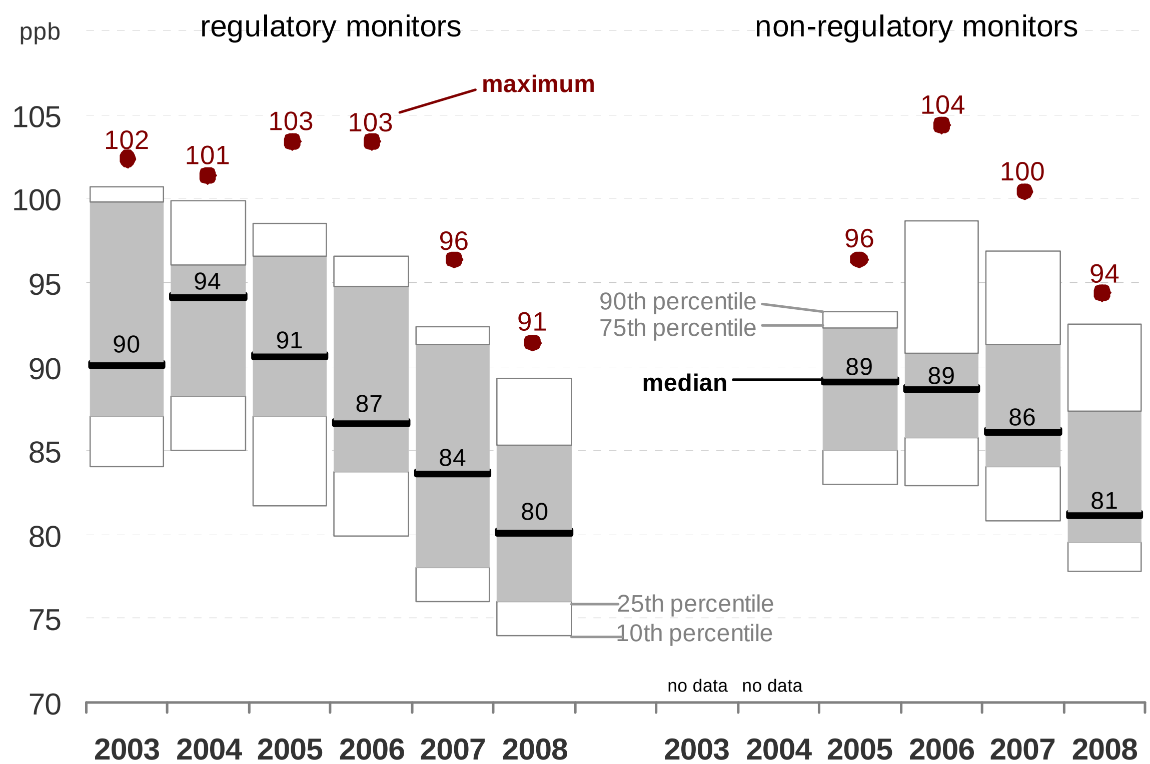
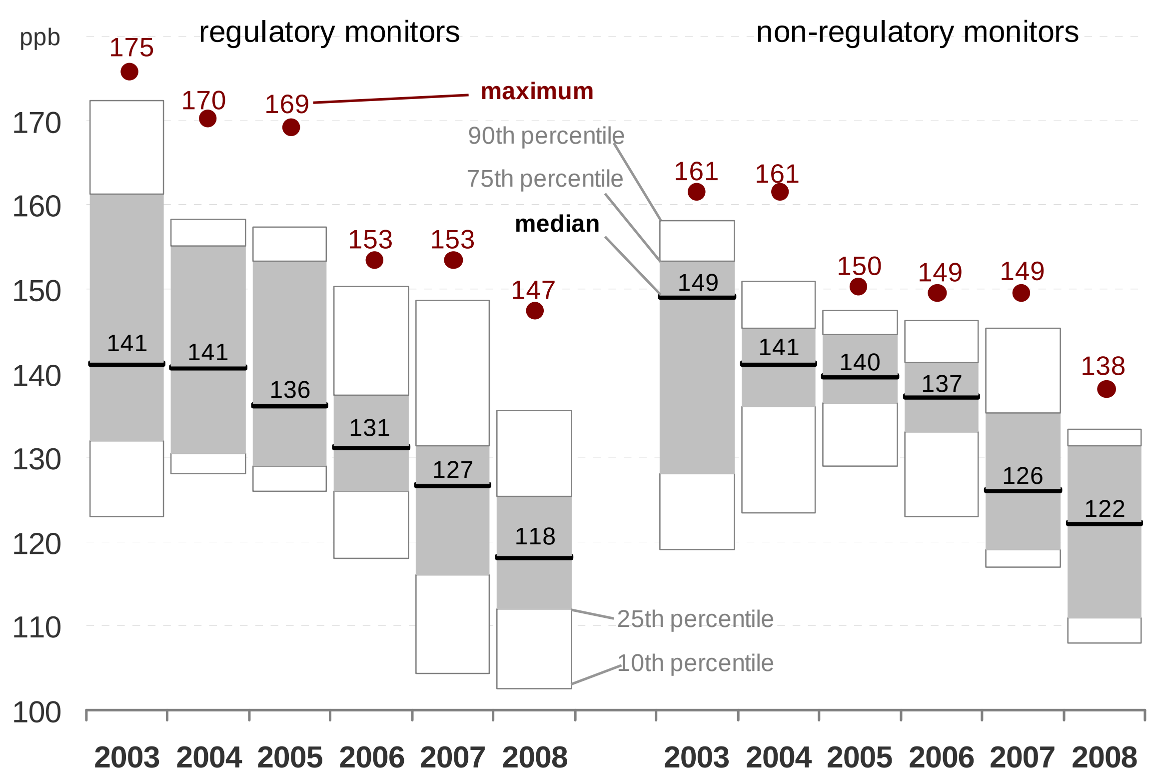


Figure 5-8: Distributions of Eight-Hour Ozone Design Values at Regulatory and Non-Regulatory Monitors in the HGB Area

The ozone design values computed for the non-regulatory monitors are within the range of design values computed for the regulatory monitors. This finding suggests that both sets of monitors observe the same ozone behavior.

Figure 5-9: *Distributions of One-Hour Ozone Design Values at Regulatory and Non-Regulatory Monitors in the HGB Area* compares one-hour ozone design values at regulatory and non-regulatory monitors in the HGB area from 2003 to 2008. This period was chosen because many non-regulatory monitors became operational or had complete data in 2003 and later years. The one-hour design value is computed as the fourth highest one-hour value observed among all values during each rolling three calendar-year period. The distributions of one-hour ozone design values dropped for both types of monitors over the six-year period and the spread between high and low values narrowed for both. Annual median fourth high one-hour ozone design values fell from 141 ppb in 2003 to 118 ppb in 2008 at regulatory monitors, a drop of 16.3 percent. The median at non-regulatory monitors fell from 149 ppb to 122 ppb over the period, an 18.1 percent drop.

While medians and other moments from the distributions all dropped over the period, the annual maximum one-hour ozone design value is most relevant, as this design value would be compared to the one-hour ozone NAAQS to determine attainment, were the one-hour standard still in force. The annual maximum one-hour ozone design value measured at regulatory monitors fell from 175 ppb in 2003 to 147 ppb in 2008, a drop of 16.0 percent. The annual maximum at non-regulatory monitors fell from 161 ppb to 138 ppb over the period, or 14.3 percent. Note that the eight-hour design value does not change when the data from the non-regulatory monitors are added to the calculation.

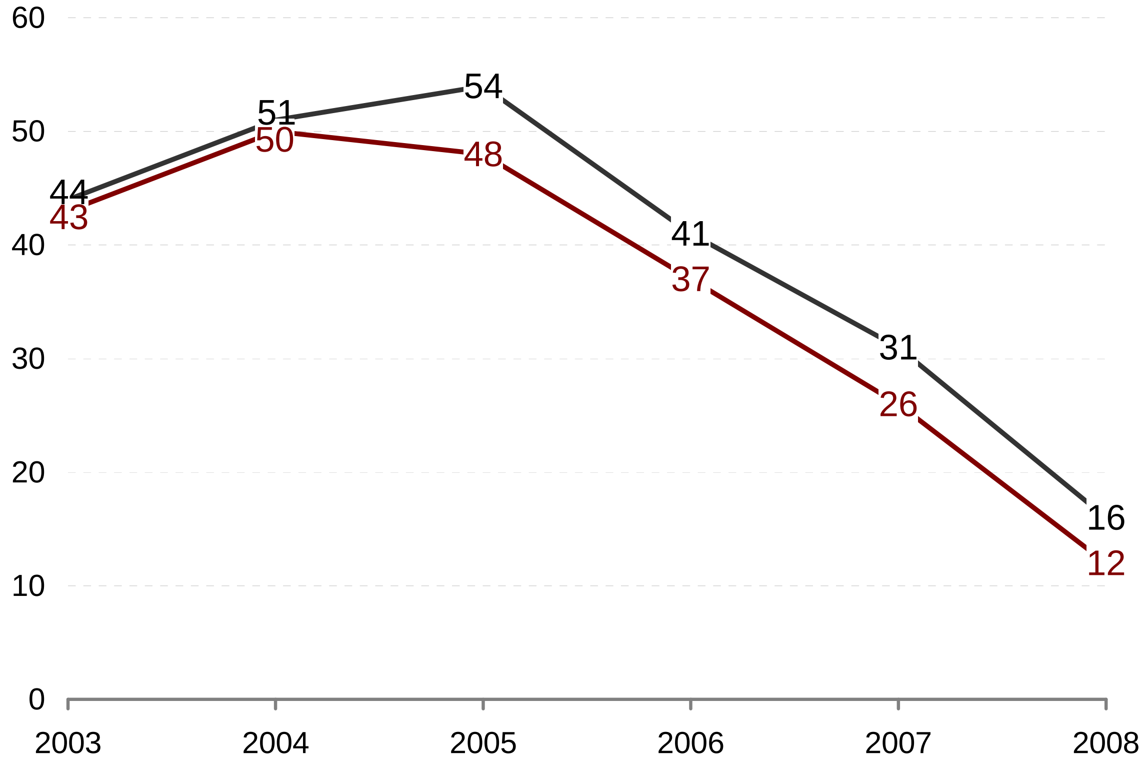


# of monitors:

21 22 21 21 22 22 5 15 20 21 21 21

Figure 5-9: Distributions of One-Hour Ozone Design Values at Regulatory and Non-Regulatory Monitors in the HGB Area

Figure 5-10: *1997 Eight-Hour Ozone Exceedance Days at Regulatory and Non-Regulatory Monitors, 2003 through 2008* presents the number of days per year from 2003 through 2008 that the 1997 eight-hour ozone NAAQS was exceeded in the HGB area at regulatory monitors and at all monitors, both regulatory and non-regulatory. Since 2005, the combined network has recorded a total of 19 additional exceedances of the 1997 eight-hour ozone standard that would not have been captured by the regulatory network, i.e., about four to five per year. This result confirms earlier findings that suggest as the monitoring network has expanded, fewer episodes of elevated ozone concentrations are likely to elude detection.



Number of regulatory monitors operating:

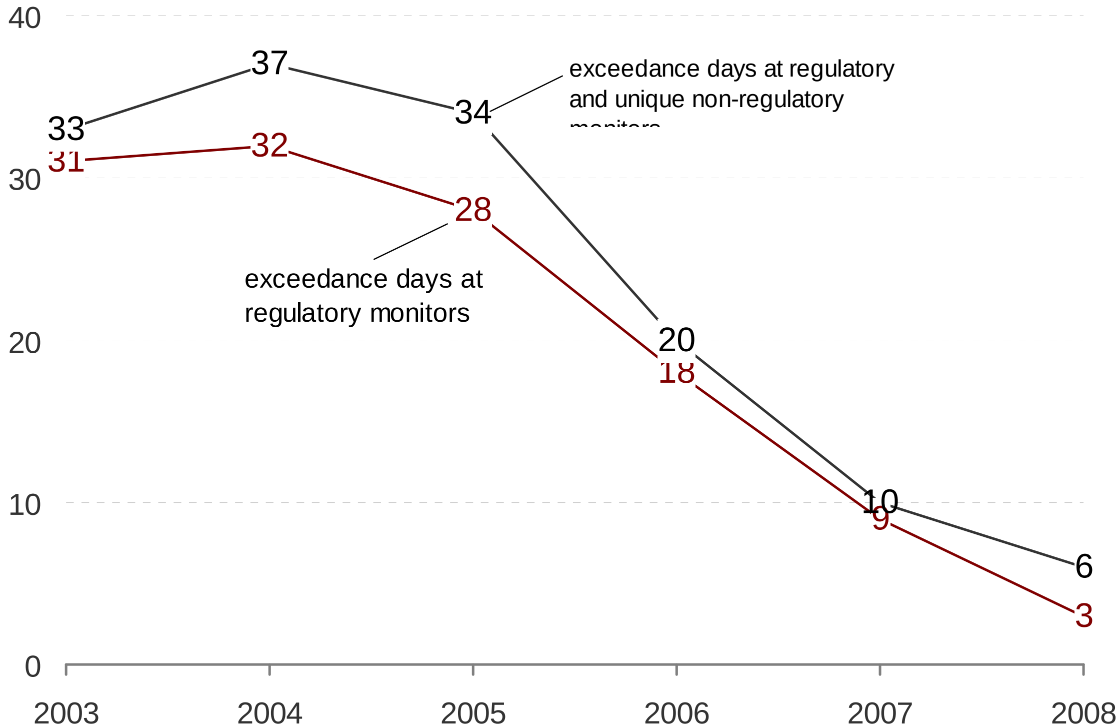
21	22	21	21	22	22

Number of non-regulatory monitors operating:

5	15	20	21	21	21

Figure 5-10: 1997 Eight-Hour Ozone Exceedance Days at Regulatory and Non-Regulatory Monitors, 2003 through 2008

Figure 5-11: *One-Hour Ozone Exceedance Days at Regulatory and Non-Regulatory Monitors, 2003 through 2008* presents the number of days per year from 2003 through 2008 that the one-hour ozone NAAQS was exceeded in the HGB area at regulatory monitors and at all monitors, both regulatory and non-regulatory. Both series initially increased, then fell at similar rates throughout the period, suggesting that the two sets of monitors measure broadly similar phenomena. During the first half of the period, non-regulatory monitors measured from five to nine additional exceedance days that were not detected by regulatory monitors. However, in the second half of the period, that gap dropped to only two to three additional days, indicating that non-regulatory monitors are detecting fewer and fewer events not detected by regulatory monitors. This result confirms earlier findings that suggest that, as the monitoring network has expanded, fewer episodes of elevated ozone concentrations are likely to elude detection.



Number of regulatory monitors operating:

21	22	21	21	22	22

Number of non-regulatory monitors operating:

5	15	20	21	21	21

Figure 5-11: One-Hour Ozone Exceedance Days at Regulatory and Non-Regulatory Monitors, 2003 through 2008

Table 5-8: Exceedance Days at Regulatory and Non-Regulatory Monitors, 2003 through 2008

	One-Hour Ozone Exceedance days			Number of monitors		
Year	regulatory monitors	non-regulatory monitors	total	regulatory monitors	non-regulatory monitors	total
	#	#	#	#	#	#
2003	31	2	33	21	5	35
2004	32	5	37	22	15	37
2005	28	6	34	21	20	41
2006	18	2	20	21	21	42
2007	9	1	10	22	21	43
2008	3	3	6	22	21	43

Source: Leading Environmental Analysis and Display System (LEADS).

Table 5-9: Monitors Recording the Annual Maximum One-Hour Ozone Design Value

	Regulatory monitors		Non-regulatory monitors	
year	site name	value *ppb*	site name	value *ppb*
2003	Houston Bayland Park C53	163	HRM-3 Haden Road C603	161
2004	Houston Deer Park 2 C35/139	157	HRM-3 Haden Road C603	161
2005	Houston Deer Park 2 C35/139	153	Sheldon C551	150
2006	Houston Deer Park 2 C35/139	150	La Porte Sylvan Beach C556	149
2007	Houston Deer Park 2 C35/139	150	La Porte Sylvan Beach C556	149
2008	Houston Deer Park 2 C35/139	147	Tom Bass C558	138

Source: Leading Environmental Analysis and Display System (LEADS).

Another way to see the ozone trend in the HGB area is to examine how the spatial distributions of ozone have changed over the years. Figure 5-12: *Eight-Hour Ozone Design Values for 2000, 2005, and 2008* shows the spatial distribution of eight-hour ozone design values in the HGB area, for regulatory monitors only, and the changes that have occurred from 2000 to 2005 to 2008. In 2000, local peaks in design value were at Houston Aldine (CAMS 8), Houston Bayland Park (CAMS 53), and Deer Park (CAMS 35/139), and all three peaks were 110 ppb or higher.

By 2005, eight-hour ozone design values had dropped across the region. While the highest concentrations still occurred at Houston Bayland Park (CAMS 53) and Deer Park (CAMS 35/139), they were no longer observed in the Houston Aldine (CAMS 8) area. Further, the 2005 peaks are much lower, between 100 and 103 ppb. The lowest eight-hour ozone concentration is still observed at Lang (CAMS 408), but low ozone also occurs to the northeast at Houston North Wayside (CAMS 405), to the north at Conroe (CAMS 65) or Conroe Relocated (CAMS 78), and to the south at Galveston Airport (CAMS 34/CAMS 109/CAMS 154). The minimum eight-hour ozone concentration in 2005 is below the 1997 NAAQS.

In 2008, eight-hour ozone design values dropped even further. Ozone concentrations are substantially lower across a large part of the HGB area, with the kriging model predicting design values below the 1997 eight-hour ozone NAAQS at many locations. Maximum eight-hour ozone concentrations are now considerably lower, between 89 ppb and 91 ppb. The highest measurements occurred at Houston Bayland Park (CAMS 53) and Deer Park (CAMS 35/139), and also at a new monitor, Park Place (CAMS 416), which measured ozone in the same range as Houston Bayland Park (CAMS 53) and Deer Park (CAMS 35/139). The eight-hour ozone concentrations in 2008 are lower throughout the HGB area, with a local ozone minimum located in the urban core area surrounding the Lang (CAMS 408), Houston North Wayside (CAMS 405), Houston Texas Avenue (CAMS 411), Clinton (CAMS 403/CAMS 113/CAMS 304), and the TCEQ Houston Regional Office (CAMS 81) monitors.

Notice that while the overall concentrations of eight-hour ozone are lower, the areas that experience the highest and lowest ozone remain the same. Spatial interpolation shows that high ozone concentrations continue to occur south of downtown Houston, and stretch from the Houston Ship Channel in the east to west Houston, near Houston Bayland Park (CAMS 53). The lowest ozone values are found to the south along the coast, at the northern edge of the nonattainment area towards Conroe (CAMS 65), and to the northwest of downtown Houston, at Lang (CAMS 408).

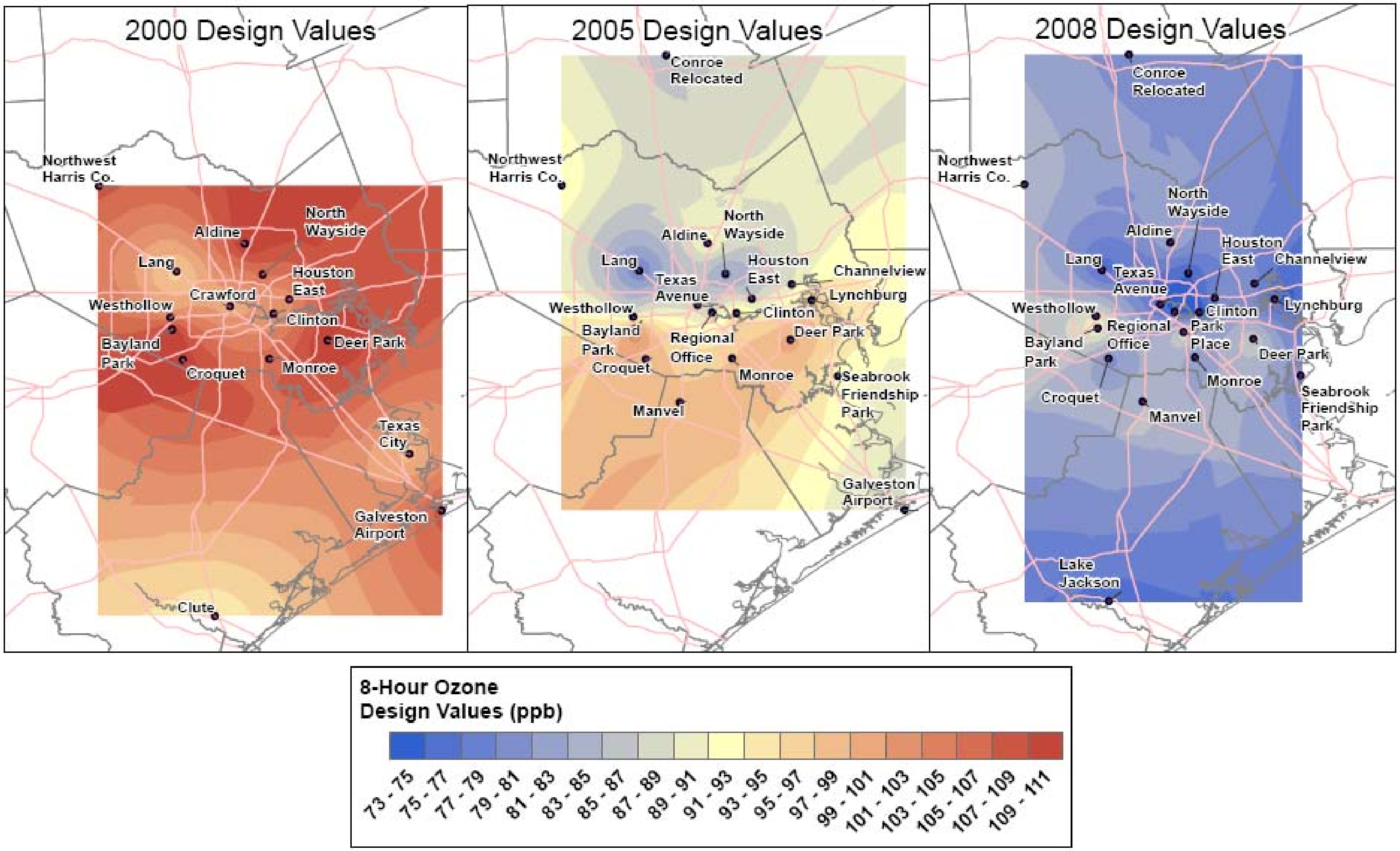


Figure 5-12: Eight-Hour Ozone Design Values for 2000, 2005, and 2008

The kriging method can also be employed to investigate the geographic origins of high ozone concentrations. Studies during the TexAQS 2000 field study reported that the highest ozone in the HGB area occurs in plumes emanating from industrial areas (Daum et al., 2004; Kleinman et al., 2005; Ryerson et al., 2003; Berkowitz et al., 2005; Banta et al., 2005). As these plumes are transported across the region, they can be tracked by the high ozone concentrations recorded at successive downwind monitors as the day progresses. An analysis of the time of day of maximum ozone at each monitoring site can confirm or challenge conclusions of the field study about these origins by revealing spatial patterns of ozone formation and movement.

Yet another way to examine the ozone behavior in the HGB area is to investigate the time of day that ozone peaks, on average, in each part of the monitoring network. Daily maximum ozone concentrations were divided into two groups: days with values exceeding the 1997 eight-hour ozone NAAQS, and days not exceeding the 1997 eight-hour ozone NAAQS. The time of day when peak ozone was recorded at each monitor was determined for each day, then averaged across the two groupings of days. Only monitors that report data to the EPA were included. Days were restricted to March through November to exclude months when few or no exceedance days occur in the HGB area.

Maps of the time of peak ozone in the HGB area, averaged from March through November 1998-2008, are found in Figure 5-13: *Time of Day of Peak Hourly Ozone on Low and High Ozone Days*. The left map shows that on days with low eight-hour ozone values, daily maximum values are recorded in the Galveston area early in the day, between 11:30 a.m. and 11:45 a.m. Inland monitors record their highest daily values at progressively later times of day, as monitors are located farther inland from the Gulf Coast. On low ozone days, the earliest ozone maxima occur near the coast, and the latest occur in the Conroe area between 2:00 p.m. and 2:15 p.m. This pattern of ozone concentrations is consistent with the occurrence of the sea breeze, which often dominates local weather during the summer in the absence of strong synoptic-scale weather influences. After the plume is carried past a monitor, ozone levels often drop, reflecting the cleaner maritime air behind the sea breeze front.

By contrast, the right map of the daily pattern on high eight-hour ozone days looks quite different. Daily maximum ozone concentrations are observed earliest in the industrial areas, and successively later at sites that are progressively farther away from these areas. This pattern indicates that high ozone forms first in the industrial areas, and is transported outward to urban, suburban, and rural sites later in the day. Maximum ozone occurs latest at Lake Jackson (CAMS 1016), Clute (CAMS 11), Northwest Harris Co. (CAMS 26), Conroe (CAMS 65) and Conroe Relocated (CAMS 78), the sites at the greatest distance from the industrial area.

The time of day of maximum ozone on high eight-hour ozone days represents a composite pattern: high ozone formed in industrial areas is carried by winds to Conroe (CAMS 65) and Conroe Relocated (CAMS 78) on some days, to Lake Jackson (CAMS 1016) on other days, and to western Houston on other days. Combined with the earlier spatial design value analysis, the patterns of peak ozone appear to show that the highest ozone concentrations are formed in the vicinity of the heavily industrialized areas of metropolitan Houston and are then transported throughout the area.

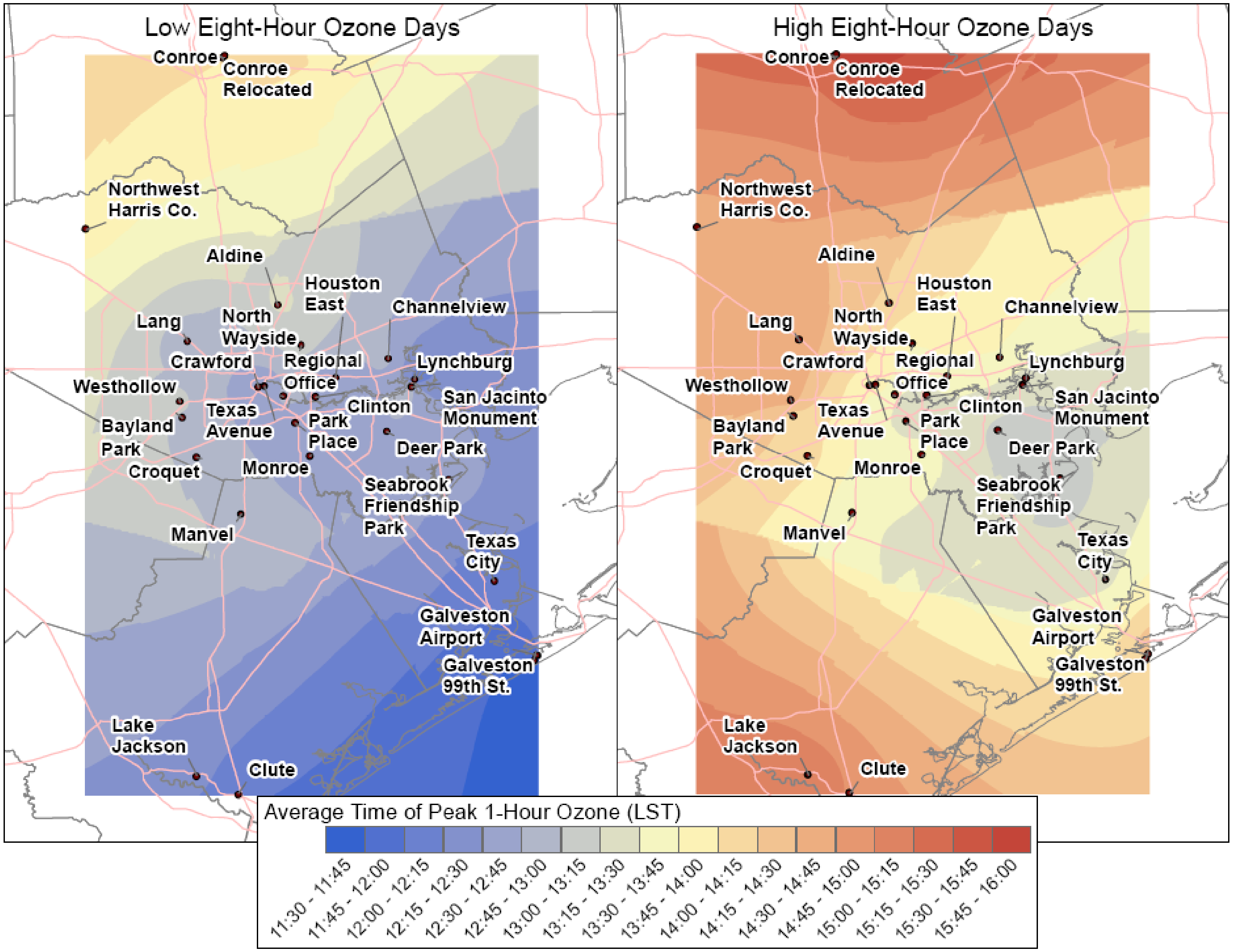


Figure 5-13: Time of Day of Peak Hourly Ozone on Low and High Ozone Days

5.3.3 Trends in the Strength of Observed Ozone Gradients in the HGB Area

Rapid ozone increases have been observed at HGB area monitoring sites for many years, but the phenomenon was not sufficiently explained until the TexAQS 2000 study. Researchers from Brookhaven National Laboratory and National Oceanic and Atmospheric Administration (NOAA) Aeronomy Laboratory were able to establish that the rapid ozone increases were due to strong spatial ozone gradients that arose when ozone formed very rapidly in industrial plumes. The rapid ozone formation observed by Daum et al. (2003, 2004) allowed ozone to build up in the plumes before ozone and its precursors could disperse. Shifting winds due to the coastal oscillation or bay/Gulf breeze phenomena pushed the strong ozone gradients over the monitoring sites, resulting in observations of rapid ozone increases (Banta et al., 2005). The rapid ozone formation occurs when industrial HRVOC reacts with co-emitted NO_X (Ryerson et al., 2003; Wert et al., 2003). The following analysis examines whether the strength of these ozone gradients has lessened, as measured by the magnitude of one-hour changes in ozone observed at monitoring sites.

One-hour changes in ozone concentrations examined for each hour during the ozone season (May through October) at each site for each year. The maximum daily peak change in ozone concentration was chosen for each day, and various statistical measures were calculated from those values. Not all sites were included in this analysis: only those with long operating histories were included.

Figure 5-14: *Trends in the Strength of Ozone Gradients Measured in the HGB Area from 1995 through 2008* shows how the daily maximum one-hour change in ozone has changed since 1995 in the HGB area. While at the mean and median levels the change is slight, the steepest observed ozone gradients have been reduced dramatically since 1995, decreasing by about 40 percent.

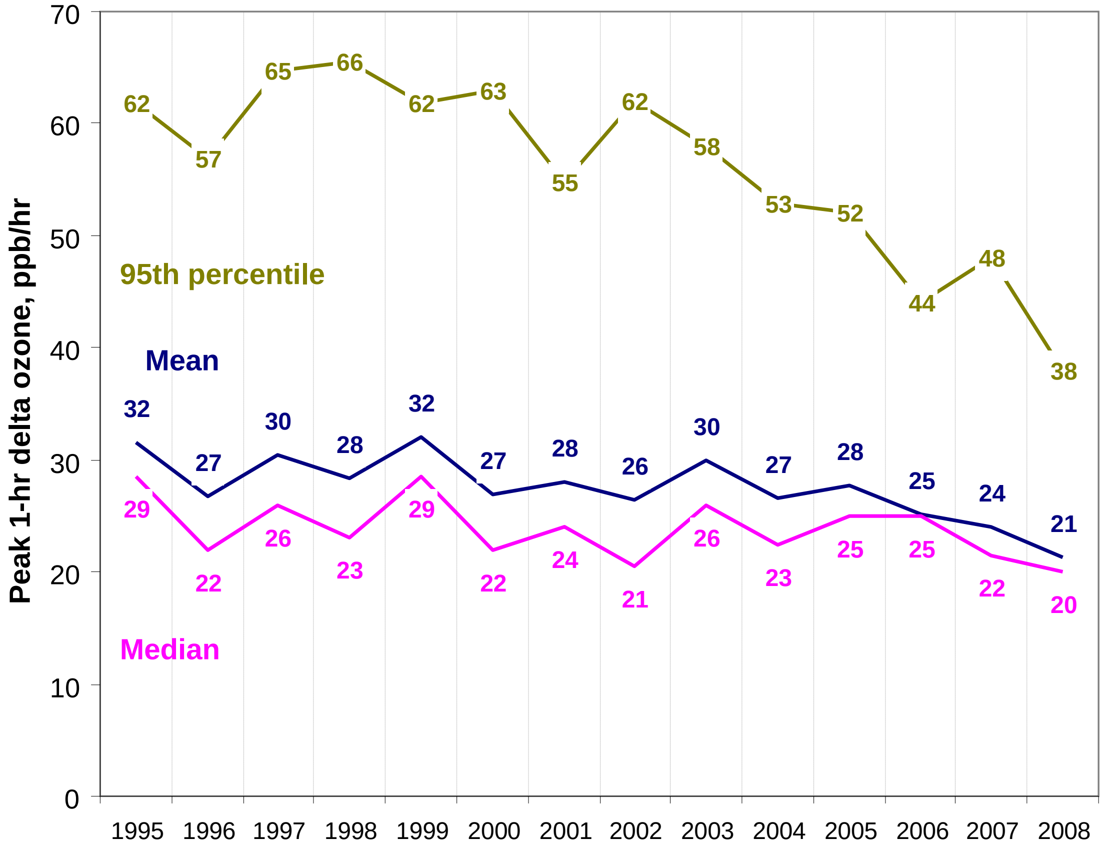


Figure 5-14: Trends in the Strength of Ozone Gradients Measured in the HGB Area from 1995 through 2008

Figure 5-15: *The Number of Occurrences of One-Hour Increases in Ozone Greater Than 40 ppb/hr in the HGB Area for the Subset of Monitors with Long Historical Records* shows that the number of strong ozone gradients observed by monitoring sites in the HGB area has also decreased substantially since the 1990s, matching the general trends in decreasing ozone concentrations. The intensity of ozone gradients has decreased, and the frequency of strong ozone gradient observations has also decreased, which strongly suggests that ozone is forming less rapidly in the HGB area than in previous years. This change in ozone behavior is consistent with decreasing reactivity of VOC emitted in the HGB area. Note that the intensity of ozone gradients can depend upon meteorological factors as well as chemical factors. This analysis has not examined the importance of meteorological factors upon the observed trends. Subsequent sections will discuss trends in HRVOC concentrations.

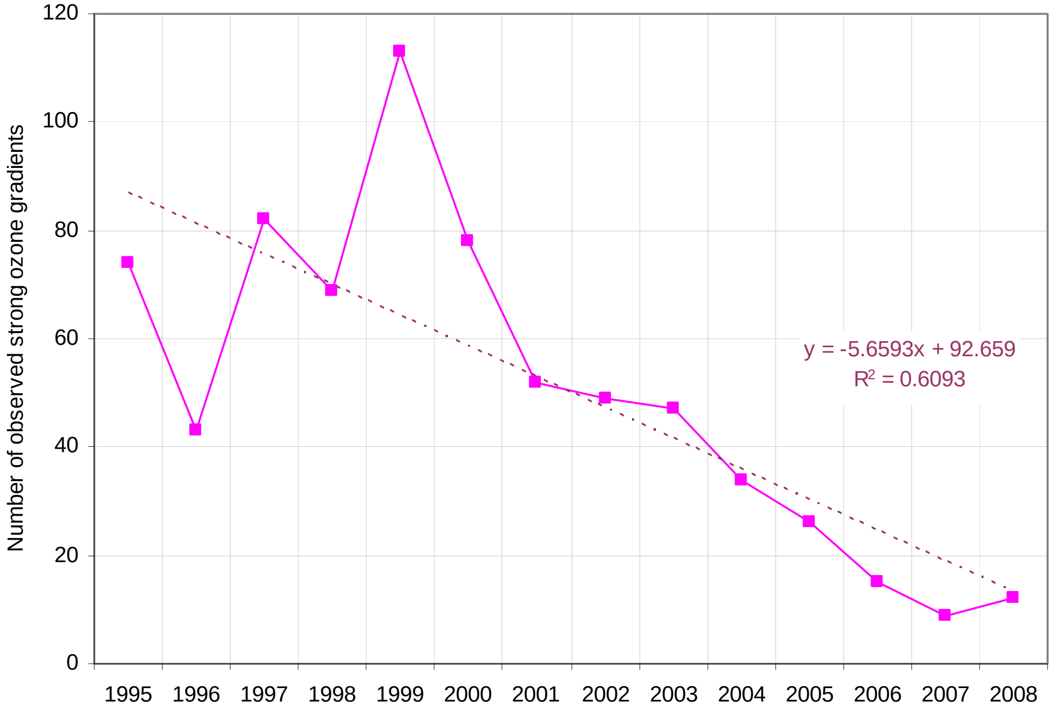


Figure 5-15: The Number of Occurrences of One-Hour Increases in Ozone Greater Than 40 ppb/hr in the HGB Area for the Subset of Monitors with Long Historical Records

5.3.4 The Impact of Hurricane Ike on Ozone Observations in the HGB Area

The HGB area typically records high ozone values each year in September. Sometimes, these values help determine the area-wide design value for that year. The HGB eight-hour ozone design value has been declining recently and was particularly low in 2008 (91 ppb). September 2008 was not typical for the HGB area. Hurricane Ike, a strong Category 2 hurricane, struck the Texas coast near Galveston Bay on September 13, 2008. Most monitors in the area were shut down and emissions patterns were substantially altered.

Hurricane Ike struck the Texas coast near Galveston Bay on September 13, 2008. Before the hurricane struck, the evacuation of Galveston Island and the surrounding areas created enormous traffic jams. After the storm passed, there was far less automobile traffic than normal for several weeks. In preparation for the storm, many of the local petrochemical facilities shut down their operations, generating unknown quantities of emissions in the process, and after the storm, their operations were atypical for an extended period. Rescue operations, tree cutting and burning, lack of electrical power, unusual traffic patterns, and abnormal industrial operations were among the atypical conditions that occurred before, during, and after the hurricane. The exact effect of the emission changes on ozone concentrations is unknown, due to the number of ozone monitoring sites disabled indirectly or directly by Hurricane Ike. Monitors in the HGB area ceased operations for as little as one day, and as long as 69 days at a site that was severely damaged by storm surge. Key monitors that typically record the area design values were down for as much as 16 days, e.g., Houston Bayland Park (CAMS 53) (see Table 5-10: *List of the Number of Days HGB Ozone Regulatory and Non-Regulatory Monitors were Not Operating Before and After the Landfall of Hurricane Ike*).

Table 5-10: List of the Number of Days HGB Ozone Regulatory and Non-Regulatory Monitors were Not Operating Before and After the Landfall of Hurricane Ike

Monitor	First Date Monitor Did Not Report Data	Restart Date	Days Down
Houston Bayland Park C53/A146	9/13/2008	9/29/2008	16
Houston Westhollow C410	9/12/2008	9/30/2008	18
Park Place C416	9/12/2008	9/15/2008	3
Houston Deer Park 2 C35/C139	9/12/2008	9/22/2008	10
Manvel Croix Park C84	9/12/2008	9/21/2008	9
Northwest Harris Co. C26/A110/X150	9/13/2008	9/14/2008	1
Houston Aldine C8/AF108/X150	9/13/2008	9/15/2008	2
Houston Monroe C406	9/12/2008	9/19/2008	7
Houston Croquet C409	9/12/2008	9/26/2008	14
Conroe Relocated C78/A321	9/13/2008	9/17/2008	4
Channelview C15/AH115	9/13/2008	9/16/2008	3
Houston East C1/G316	9/13/2008	9/29/2008	16
Seabrook Friendship Park C45	9/13/2008	9/16/2008	3
Houston Texas Avenue C411	9/12/2008	9/16/2008	4
Lake Jackson C1016	9/12/2008	9/16/2008	4
Lang C408	9/12/2008	9/18/2008	6
Houston North Wayside C405	9/12/2008	9/15/2008	3
Lynchburg Ferry C1015/A165	9/12/2008	10/16/2008	34
Houston Regional Office C81	9/13/2008	9/20/2008	7
Clinton C403/C304/AH113	9/12/2008	9/30/2008	18
West Houston C554	9/13/2008	9/14/2008	1
Tom Bass C558	9/13/2008	9/18/2008	5
Wallisville Road C617	9/12/2008	9/17/2008	5
Meyer Park C561	9/13/2008	9/15/2008	2
Atascocita C560	9/14/2008	9/23/2008	9
La Porte Sylvan Beach C556	9/12/2008	11/6/2008	55
Baytown Wetlands Center C552	9/12/2008	10/31/2008	48
Mustang Bayou C619	9/12/2008	9/26/2008	14
Clear Lake High School C572	9/13/2008	9/14/2008	1
HRM-3 Haden Road C617	9/12/2008	9/22/2008	10
Crosby Library C553	9/13/2008	9/20/2008	7
Texas City 34th St. C620	9/12/2008	9/18/2008	6
Dacinger C618	9/12/2008	9/19/2008	7
Kingwood Library C555	9/13/2008	9/14/2008	1
Mercer Arboretum C557	9/22/2008	10/8/2008	16
Sheldon C551	9/12/2008	9/22/2008	10
Clear Creek High School C571	9/13/2008	9/15/2008	2
Galveston 99th St. C1034/A320/X183	9/12/2008	11/20/2008	69
Pasadena AAMS C672	9/12/2008	9/22/2008	10

Hurricane Ike's greatest impact occurred during the second half of September and the first half of October. August and September are typically the months when the HGB area records the most number of days that exceed the ozone standard. For 2000 through 2008, 21 percent of the 266 observed 85 ppb exceedance days in the HGB area were recorded in September (Figure 5-16: *Number of Days that Exceeded the 1997 Eight-Hour Ozone NAAQS by Month from 2000 through 2008*).

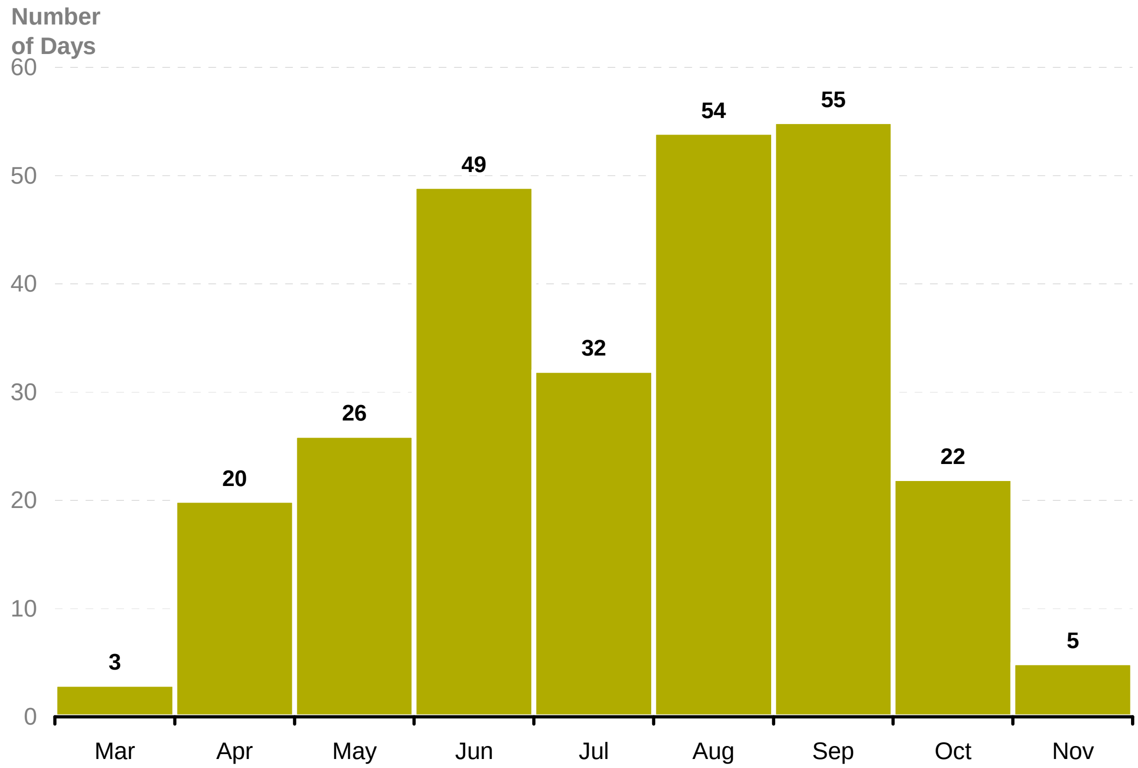


Figure 5-16: Number of Days that Exceeded the 1997 Eight-Hour Ozone NAAQS by Month from 2000 through 2008

Figure 5-17: *Frequency of Daily Peak Eight-Hour Ozone Values for All Ozone Monitoring Sites in Texas, September 2006* and Figure 5-18: *Frequency of Daily Peak Eight-Hour Ozone Values for All Ozone Monitoring Sites in Texas, September 2008* show peak eight-hour ozone at all Texas monitoring sites in September 2006, which was unaffected by tropical systems and in September 2008, the month in which Hurricane Ike struck. In 2008, the number of monitors in operation dropped substantially just before the hurricane made landfall, as they were shut down by the TCEQ. The monitors came back on-line gradually, as electrical power was restored, and storm damage was repaired. Ozone concentrations immediately before and after Ike were fairly low.

The purpose of this analysis is to examine how the ozone behavior in September and October 2008 deviated from the 2000 through 2007 average, and thus to ascertain whether the lower design value observed in 2008 was due primarily to the effects of Hurricane Ike.

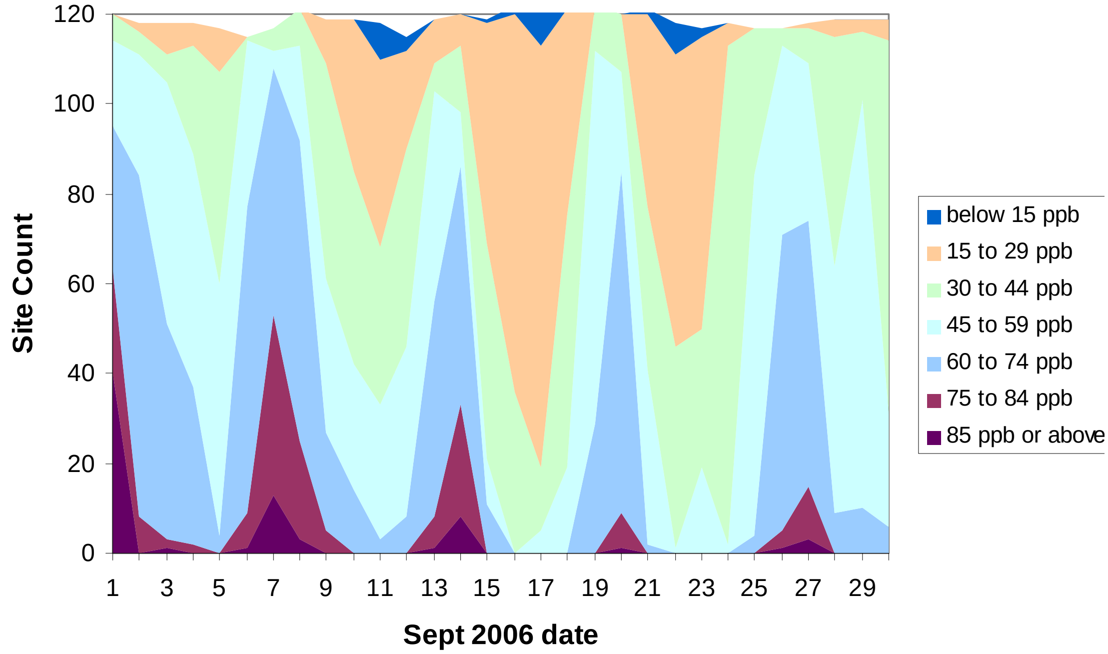


Figure 5-17: Frequency of Daily Peak Eight-Hour Ozone Values for All Ozone Monitoring Sites in Texas, September 2006

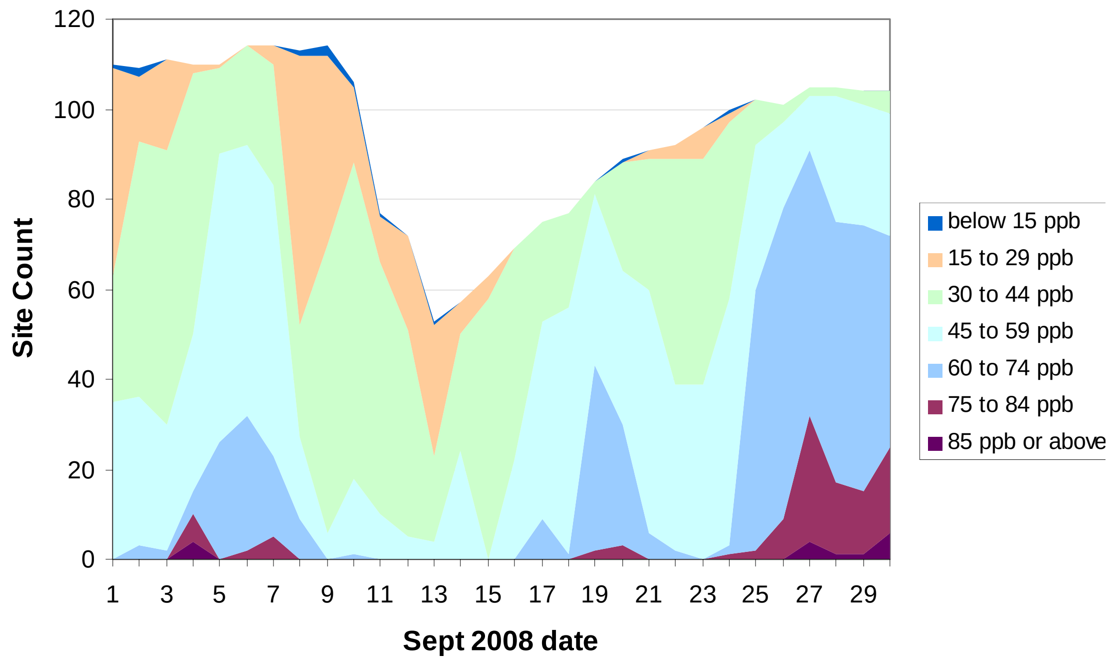


Figure 5-18: Frequency of Daily Peak Eight-Hour Ozone Values for All Ozone Monitoring Sites in Texas, September 2008

5.3.4.1 Approach

One approach to estimate the influence of Hurricane Ike on the HGB area's ozone design value is to estimate what the eight-hour ozone design value might have been in 2008 if Hurricane Ike had not occurred. This estimate is derived from historical data collected during 2000-2007. Removing calendar days affected by Hurricane Ike and replacing them with averages derived from historical data yields a re-calculated fourth-highest eight-hour ozone concentration for each monitor. The actual fourth-high is then divided by the re-calculated fourth-high to obtain an adjustment ratio or an Ike Adjustment Factor (IAF). This ratio is expected to be greater than one, and can be used to adjust 2008 ozone data to non-hurricane conditions. The IAF can be calculated as an area-wide average IAF or as a monitor-specific IAF. An area-wide average IAF is computed as the average of all IAFs from all monitors in the region, applied to all 2008 data. The monitor-specific IAF was applied only to the monitor in question. After the data were adjusted with IAFs, an IAF-corrected design value was calculated and compared to the current unadjusted ozone design value to determine the influence of Hurricane Ike.

The days affected by Hurricane Ike are not easy to identify. As stated before, many unusual activities occurred in the HGB area before the arrival of Hurricane Ike, and many others occurred in the aftermath. For example, many industrial facilities shut down operations before the storm arrived, releasing emissions that they usually would not release. After the hurricane, electrical power was not available in parts of the HGB area for two or more weeks. Given the difficulties in establishing the exact period of Hurricane Ike's influence, alternative IAFs were calculated by removing three different time periods from the historical ozone data. The first period considered for exclusion was a two-week period from September 11 through September 25, 2008, which includes days immediately before and after the hurricane. Two other periods considered for exclusion were a one-month period from September 6 through October 5, 2008, and a one-month period after the storm (September 13 through October 12, 2008). All data used in this analysis were obtained from the TCEQ-LEADS system, and are eight-hour ozone averages. The HGB area eight-hour ozone design value was obtained from the EPA.

5.3.4.2 Results

Table 5-11: *Alternative Fourth-High Daily Peak Eight-Hour Ozone Concentration Calculations Using Different Ike Adjustment Factors (IAFs)* shows results of the six different methods for estimating the fourth-high daily peak eight-hour ozone concentration for each monitoring site. The table shows that the expected fourth high is greater than the observed at most sites, regardless of which method is used to calculate the expected fourth high. This indicates that the atypical conditions experienced during and after Hurricane Ike during September and October in 2008 did have an effect on the monitored values, but the effect was no greater than 4 ppb on the fourth-high daily maximum ozone concentration.

Table 5-11: Alternative Fourth-High Daily Peak Eight-Hour Ozone Concentration Calculations Using Different Ike Adjustment Factors (IAFs)

Monitoring site	2008 observed fourth high	9/11-9/26 average IAF	9/11-9/26 monitor-specific IAF	9/6-10/5 average IAF	9/6-10/5 monitor-specific IAF	9/13-10/12 average IAF	9/13-10/12 monitor-specific IAF
	ppb	*ppb*	*ppb*	*ppb*	*ppb*	*ppb*	*ppb*
Houston Aldine C8 /AF108/X150	83	85	86	87	86	86	86
Houston Bayland Park C53	83	85	84	87	86	86	85
Channelview C15/C115	76	78	77	79	78	79	78
Houston Croquet C409	76	78	78	79	80	79	79
Houston Deer Park C18	76	78	78	79	79	79	78
Lake Jackson C1016	76	78	77	79	80	79	78
Northwest Harris Co. C26/A110/C154	76	78	78	79	81	79	80
Manvel Croix Park C84	75	77	77	78	81	78	78
Conroe C65	73	75	74	76	75	76	75
Houston East C1	73	75	74	76	76	76	76
Houston Monroe C406	71	73	73	74	75	74	74
Seabrook Friendship Park C45	71	73	75	74	75	74	75
Houston North Wayside C405	70	72	70	73	71	73	71
Houston Texas Avenue C411	70	72	71	73	73	73	73
Lang C408	70	72	73	73	75	73	74
Clinton C403/C113/C304	69	71	70	72	72	71	72
Houston Westhollow C410	69	71	70	72	71	71	71
Houston Regional Office C81	68	70	69	71	71	70	70
Lynchburg Ferry C1015	65	66	65	68	66	67	66

This table compares the observed 2008 fourth-high at each monitor to the expected fourth high, as calculated by six different methods.

The attainment status of an area is not based upon fourth-high ozone concentrations, but upon design values. Table 5-12: *Observed and Expected Design Values, Recalculated to Account for Hurricane Ike* shows the observed 2008 design value, and the expected design values, as calculated with the six different methods described above. As Table 5-12: *Observed and Expected Design Values, Recalculated to Account for Hurricane Ike* shows, the effect upon the design value for the HGB area is at most 1 ppb, and for two of the alternatives there is no effect. This analysis is robust, because six different methods of estimating the effect of the hurricane on ozone design value have given substantially the same answer: the 2008 eight-hour ozone design value was not different from the expected design value, based upon comparisons with historical data. Therefore, based upon the historical analysis, the effect of Hurricane Ike upon the eight-hour ozone design value in the HGB area was apparently minimal.

Table 5-12: Observed and Expected Design Values, Recalculated to Account for Hurricane Ike

Observed Design Value: 91 ppb	2-weeks 9/11-9/25	1-month 9/13-10/12	1-month 9/6-10/5
Estimated Design Value after applying area-wide average Ike Adjustment Factor	91 ppb	92 ppb	92 ppb
Estimated Design Value after applying monitor-specific Ike Adjustment Factor	92 ppb	91 ppb	92 ppb

5.3.5 NO_X Trends

Nitrogen oxides, or NO_X, are a variable mixture of NO and NO_2 and are critical precursors to ozone formation. NO_X is primarily created by fossil fuel combustion, lightning, biomass burning, and microbial action in the soil.

Previous analyses performed using aircraft measurements and emission inventories obtained during TexAQS 2000 and TexAQS II indicate that NO_X emissions in the Houston Ship Channel area have decreased between 2000 and 2006 (Cowling et al., 2007). Furthermore, aircraft data obtained during the two field studies were in agreement with data measured by continuous emission monitoring systems (CEMS) located at the facilities. Analyses done by the Rapid Science Synthesis Team of the 2005-2006 Texas Air Quality Study (TexAQS II) indicate that NO_X emissions at several electric generating units (EGUs) have decreased by factors ranging from two to four between 2000 and 2006 (Cowling et al., 2007). These reductions were seen at EGUs that implemented NO_X control features, such as selective catalytic reduction (SCR), between 2000 and 2006, which suggests these control strategies are working. The two field studies effectively describe the emissions during two short time windows, six years apart. To complement these analyses, the TCEQ has performed a more comprehensive investigation of long-term trends in NO_X concentrations.

Daily peak one-hour NO_X from all monitors in the HGB area from 1991 through 2008 is plotted in Figure 5-19: *Daily Peak Hourly NO_X in the HGB Area*. The increasing density of NO_X data points shows that the number of NO_X monitors in the HGB area has greatly increased since 1991. Annual 90th percentile and annual average NO_X values are also plotted in the figure. Both of these measures have decreased markedly over the 1991 to 2008 period, falling 64 percent and 68 percent, respectively. Even more remarkable may be the 53 percent and 48 percent declines since 1999.

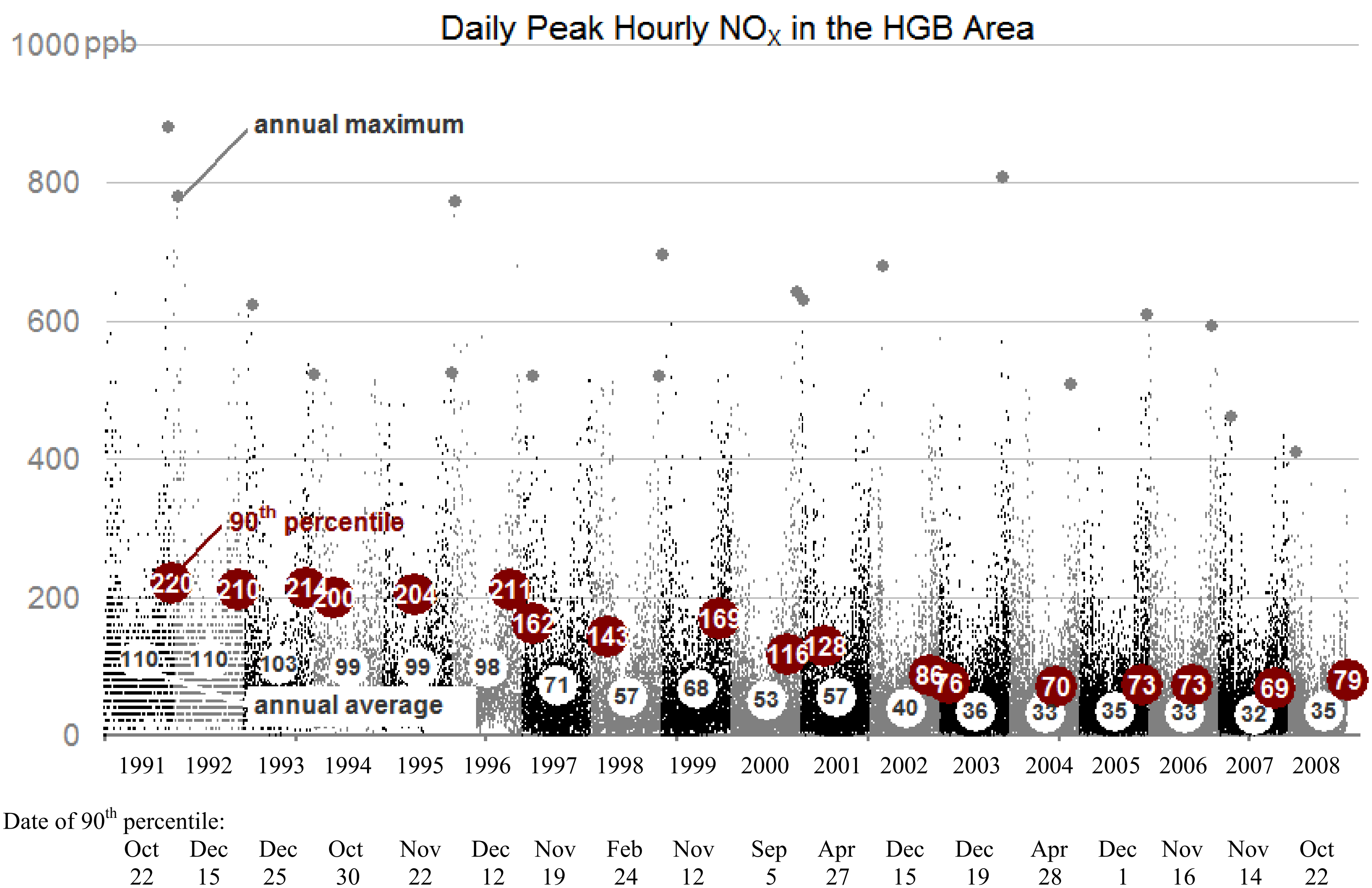


Figure 5-19: Daily Peak Hourly NO_X in the HGB Area

Table 5-13: *NO_X Values in the HGB Area by Year* shows the degree of decrease in *NO_X* concentrations from 1991 through 2008 and 1999 through 2008.

Table 5-13: NO_X Values in the HGB Area by Year

year	annual maximum NO_X *ppb*	annual average NO_X *ppb*
1991	880	110
1992	780	110
1993	622	103
1994	523	99
1995	524	99
1996	773	98
1997	521	75
1998	520	67
1999	696	75
2000	641	57
2001	629	66
2002	678	52
2003	809	53
2004	509	49
2005	609	49
2006	593	49
2007	461	48
2008	409	35
overall decrease through 2008 since:		
1991	-53.5%	-67.7%
1999	-41.2%	-53.0%
annual decrease through 2008 since:		
1991	-4.4%	-6.4%
1999	-5.7%	-8.0%

Annual decreases are computed as compound annual rates.

Though highly variable from season to season, daily peak hourly NO_X also shows a general decreasing trend since 1991. Maximum NO_X concentrations have decreased overall by 41 percent since 1999, an average of roughly 32 ppb per year, or nearly 6 percent per year. The drop since the 1991 high of 880 ppb is 54 percent or greater than 4 percent annually.

Average daily peak hourly NO_X has dropped even more precipitously, falling 53 percent, or 8 percent per year, from 75 ppb to 35 ppb, since 1999. Since 1991, average hourly NO_X has dropped 68 percent, or over 6 percent per year, from the series high of 110 ppb. Notice that in 2008, both the NO_2 design value and maximum daily peak NO_X recorded the lowest values of any previous year back to 1991.

While the highest NO_X values occur in the winter, the NO_X values during the summer months, when ozone production is the highest, are of particular interest. Trends in median hourly NO_X concentrations at individual monitors in the HGB area from May through October, 1998 to 2008, are shown in Figure 5-20: *Median NO_X Concentrations in the HGB Area*. Four monitors of particular interest, Houston Texas Avenue (CAMS 411), Lang (CAMS 408), Clinton (CAMS 403/CAMS 113/CAMS 304), and Houston Bayland Park (CAMS 53), are highlighted. Sites with less than 75 percent complete data for a year were not plotted for that year; for example, Clinton (CAMS 403/CAMS 113/CAMS 304) had less than 75 percent complete data in 2008 and therefore was not plotted.

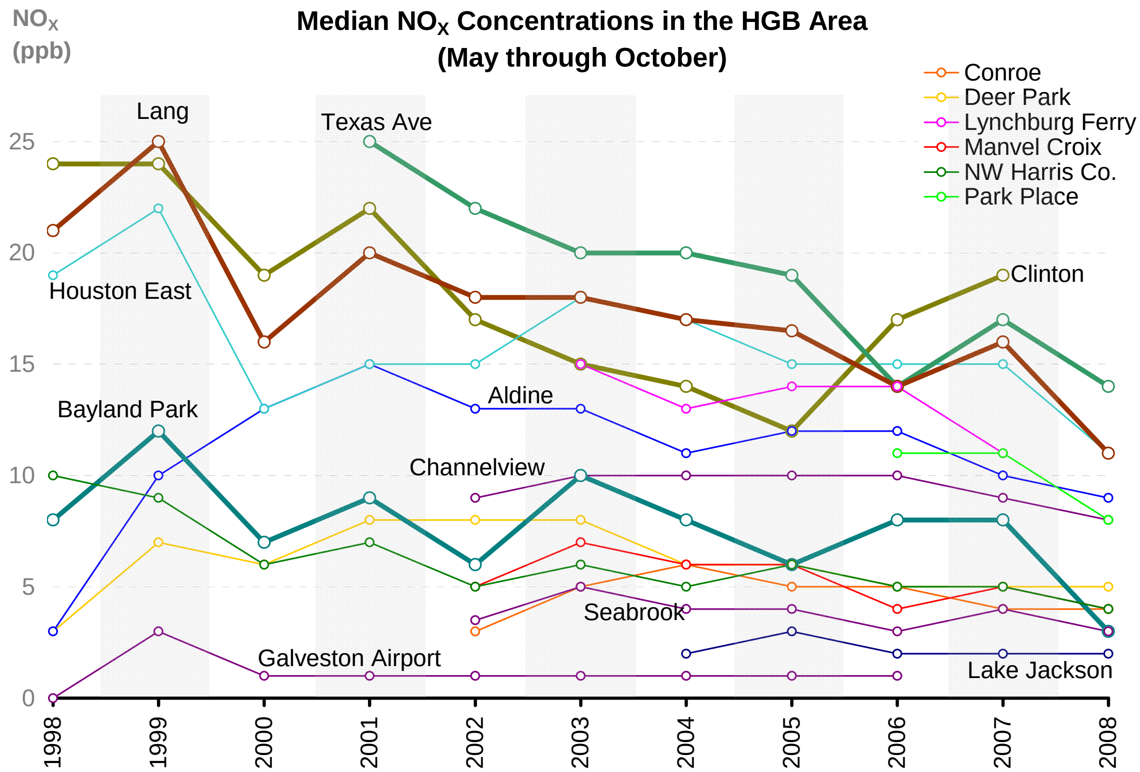


Figure 5-20: Median NO_X Concentrations in the HGB Area

Median NO_X values tend to vary from year to year, but most monitors show overall decreases in median NO_X since 1998. Monitors that show the smallest decreases or show no change are at sites that have traditionally had lower NO_X concentrations. Some of the largest median NO_X concentrations were measured at the Lang (CAMS 408) monitor (in close proximity to Highway 290), and at the Houston Texas Avenue (CAMS 411) monitor (in downtown Houston). These monitors are both near major roadways; their similar trends suggest they may be measuring decreases in NO_X emissions from mobile sources. Monitors at Galveston Airport (CAMS 34/C109/C154), Seabrook Friendship Park (CAMS 45), and Lake Jackson (CAMS 1016) measured the lowest median NO_X concentrations.

Sites recording among the highest ozone design values, for example, Houston Bayland Park (CAMS 53) and Park Place (CAMS 416), are not necessarily the sites with the highest median NO_X concentrations. The previous section showed that Houston Bayland Park (CAMS 53) has the highest eight-hour ozone design value in the HGB area of 91 ppb, yet it has a lower median NO_X concentration than many other sites in the area. This observation is consistent with the behavior expected from ozone chemistry; in addition to being an ozone precursor, NO also reacts directly with ozone and in areas with high NO emissions, can destroy more ozone than it creates.

Downwind from the high emission areas, however, ozone destroyed by reaction with NO can re-form.

The largest decreases since 1998 (Table 5-14: *Median and 90th Percentile Hourly NO_X Values*) were observed at monitors primarily influenced by mobile source emissions, rather than industrial sources. Clinton (CAMS 403/CAMS 113/CAMS 304) and Houston East (CAMS 1), which are located near both industrial sources and highways, have seen larger decreases in median NO_X values than in 90th percentile values since 1998. At Houston East (CAMS 1), the 90th percentile value decreased 34 percent, while the median decreased 42 percent between 1998 and 2008. The Clinton (CAMS 403/CAMS 113/CAMS 304) monitor experienced a drop of 16 percent in the 90th percentile, with a 21 percent decrease in the median between 1998 and 2007 (2008 was not used due to incomplete data), though these measures have increased in recent years.

Table 5-14: Median and 90th Percentile Hourly NO_X Values

	median				90th percentile			
monitor	1998	2007	2008	% change 1998-2008*	1998	2007	2008	% change 1998-2008*
	ppb	*ppb*	*ppb*	*%*	*ppb*	*ppb*	*ppb*	*%*
monitors with decreasing trends								
Houston Bayland Park C53	8	8	3	-63	33	30	19	-42
Northwest Harris Co. C26/ A110/C154	10	5	4	-60	21	12	12	-43
Lang C408	21	16	11	-48	65	48	35	-46
Houston East C1	19	15	11	-42	56	46	37	-34
Clinton C403/C113/C304*	24	19	-	-21	56	47	-	-16
monitors with increasing trends								
Houston Aldine C8/AF108/X150	3	10	9	200	30	32	30	0
Houston Deer Park C18	3	5	5	67	25	21	18	-28
monitors with indeterminate trends								
Channelview C15/C115	-	9	8		-	24	20	
Conroe C65	-	4	4		-	10	10	
Galveston Airport C34/C109/C154	0	-	-		1	-	-	
Houston Texas Avenue C411	-	17	14		-	53	37	
Lake Jackson C1016	-	2	2		-	7	6	
Lynchburg Ferry C1015	-	11	-		-	33	-	
Manvel Croix Park C84	-	5	4		-	17	15	
Park Place C416	-	11	8		-	47	32	
Seabrook Friendship Park C45	-	4	3		-	12	12	

* Percentage changes computed from 1998 to 2007 for years missing 2008 data, due to incomplete data.
Monitors are sorted in increasing order by percentage change in median values. Monitors with indeterminate trends began operating after 1998.

While several monitors recorded large decreases from 2007 to 2008, most others observed only minimal changes over that same period. These large disparities in patterns of ambient NO_X concentrations across the region are appropriate for further investigation, suggesting that larger decreases are not due solely to variations in meteorological conditions, which would be expected to influence all monitors similarly, though not identically. The differences seem to be related to the relative magnitudes of the overall concentrations. Sites with the highest concentrations, which tend to be urban sites, showed the greatest decrease. More rural sites like Lake Jackson (CAMS 1016), Conroe (CAMS 65), and Conroe Relocated (CAMS 78) may reflect slight changes in background values, while more urban sites may reflect actual emission changes.

Similar to ozone, NO_X concentrations in the HGB area appear to be decreasing over time, in large measure the result of the comprehensive suite of NO_X-targeted controls implemented since 2000. Stringent point source NO_X standards have been adopted along with numerous factors affecting mobile source NO_X emissions.

5.3.6 Ambient VOC Concentrations

The other major class of compounds that are ozone precursors are VOC. TexAQS 2000 researchers identified a specific subset of VOC that were closely associated with rapid and efficient ozone formation, i.e., light alkenes (Ryerson et al., 2003; Daum et al., 2003, 2004; Jobson et al., 2004). The TCEQ examined the historical data for these compounds, and decided to regulate several light alkenes emitted by industry that were particularly reactive, and that often had particularly high concentrations: ethylene, propylene, 1,3-butadiene, and butenes.

Since the mid-1990s, the TCEQ has collected 40-minute measurements, on an hourly basis, of 45 VOC compounds using automated gas chromatograph (auto-GC) instruments. Initially, measurements were collected at just one site (Clinton (CAMS 403/CAMS 113/CAMS 304)), but in subsequent years, auto-GC monitors have been added to new sites (see Figure 5-21: *Houston Ship Channel Auto-GC Monitors and 2006 Reported Point Source HRVOC Emissions Points and Plant Boundaries*). Currently, eight sites, listed in Table 5-15: *Auto-GC Monitors in the Houston Ship Channel Area*, along or near the Houston Ship Channel, along with three in Brazoria County and one in Texas City, are collecting VOC measurements with auto-GCs.

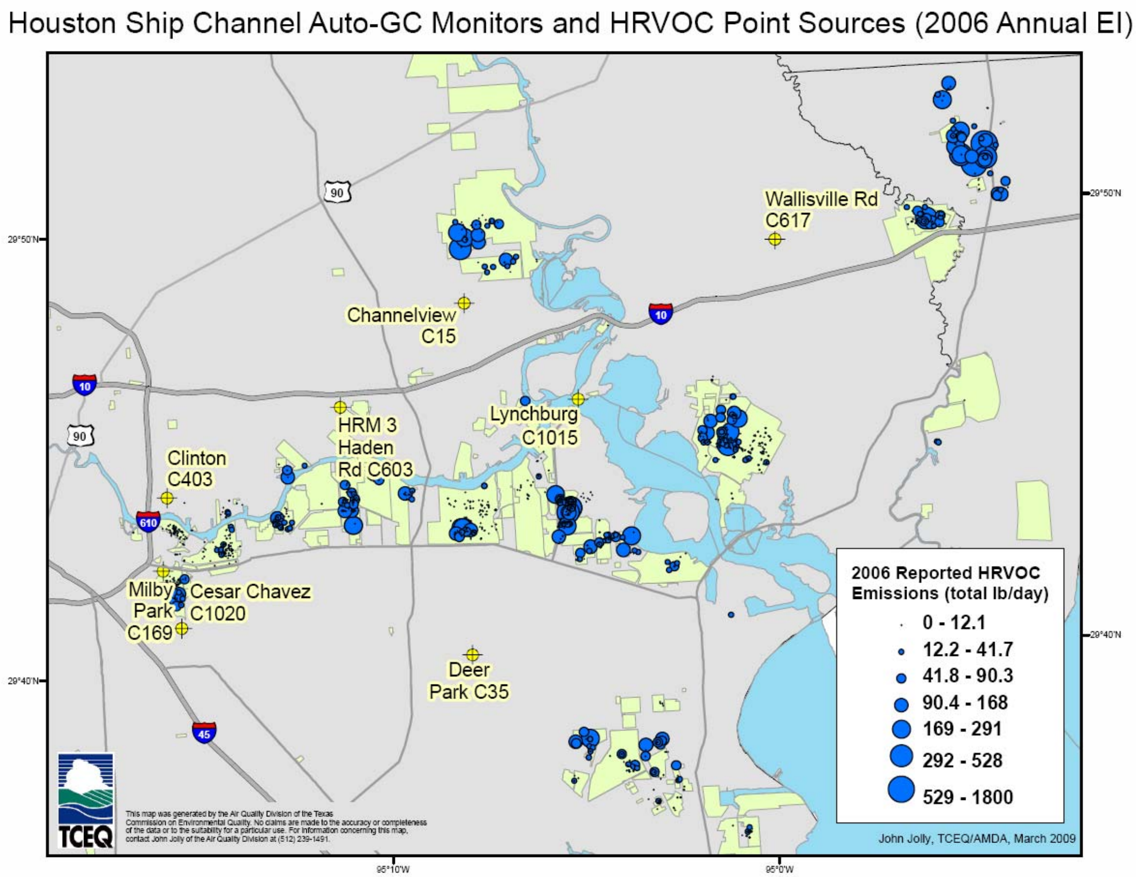


Figure 5-21: Houston Ship Channel Auto-GC Monitors and 2006 Reported Point Source HRVOC Emissions Points and Plant Boundaries

Ambient concentrations of the TCEQ-defined HRVOC (ethylene, propylene, 1,3-butadiene, 1-butene, c-2-butene, and t-2-butene) were analyzed from 1995 to 2008.

Table 5-15: Auto-GC Monitors in the Houston Ship Channel Area

site name	CAMS	AIRS code	latitude	longitude	city	start date
Channelview	C15/C115	482010026	29.8025	-95.1256	Channelview	8/3/2001
Houston Milby Park	A169	482010069	29.7062	-95.2611	Houston	2/19/2005
HRM-3 Haden Road	C603	482010803	29.7483	-95.1811	Houston	8/20/2001
Lynchburg Ferry	C1015	482011015	29.7646	-95.0780	Houston	5/24/2003
Clinton	C403/113/304	482011035	29.7337	-95.2576	Houston	7/1/1995
HousDeerPrk2	C35/139	482011039	29.6700	-95.1285	Deer Park	1/5/1997
Cesar Chavez	C1020/175	482016000	29.6844	-95.2536	Houston	4/13/2004
Wallisville Road	C617	482010617	29.8214	-94.99	Baytown	6/5/2003

Trends at each of the eight Houston Ship Channel monitors were examined. Data from the four other auto-GC monitors were analyzed only for trend slope and possible statistical significance of trends. Daily geometric means were computed from valid ambient hourly measurements for days with at least 18 valid hours of data. A geometric mean was calculated by taking the natural logarithm of each of the measurements, averaging these logs, then calculating the antilog of this mean log value. The geometric mean is a preferable statistic to median or arithmetic (ordinary) mean for evaluating the central tendency of data when the data are skewed, that is, when the data are not symmetrically, or normally, distributed, but clustered around extreme high or low values. It is more robust than an ordinary average, meaning its value is not greatly influenced by one or a few very high or very low values. Many distributions of pollutant measurements in the HGB area are skewed. Monthly geometric means were also computed with a 75 percent data completeness criterion for valid days in a month.

Figure 5-22: *Monthly Geometric Mean Ethylene Concentrations at the Eight Houston Ship Channel Monitors, July 1995 through December 2008* shows monthly geometric mean ethylene concentrations, ordered according to the monitor location from west to east. Grey bars denote the range of values from the 25th through 75th percentile concentrations, for all monitors. Noteworthy in this figure is the frequency of extremely high values recorded during the 1990s at Clinton (CAMS 403/CAMS 113/CAMS 304), at the western end of the Houston Ship Channel, and Deer Park (CAMS 35/139), in south central Houston Ship Channel. These were the only monitors operating during the early years of this period; this pattern suggests that high ethylene concentrations were not restricted to certain areas of the Houston Ship Channel, but were somewhat geographically widespread.

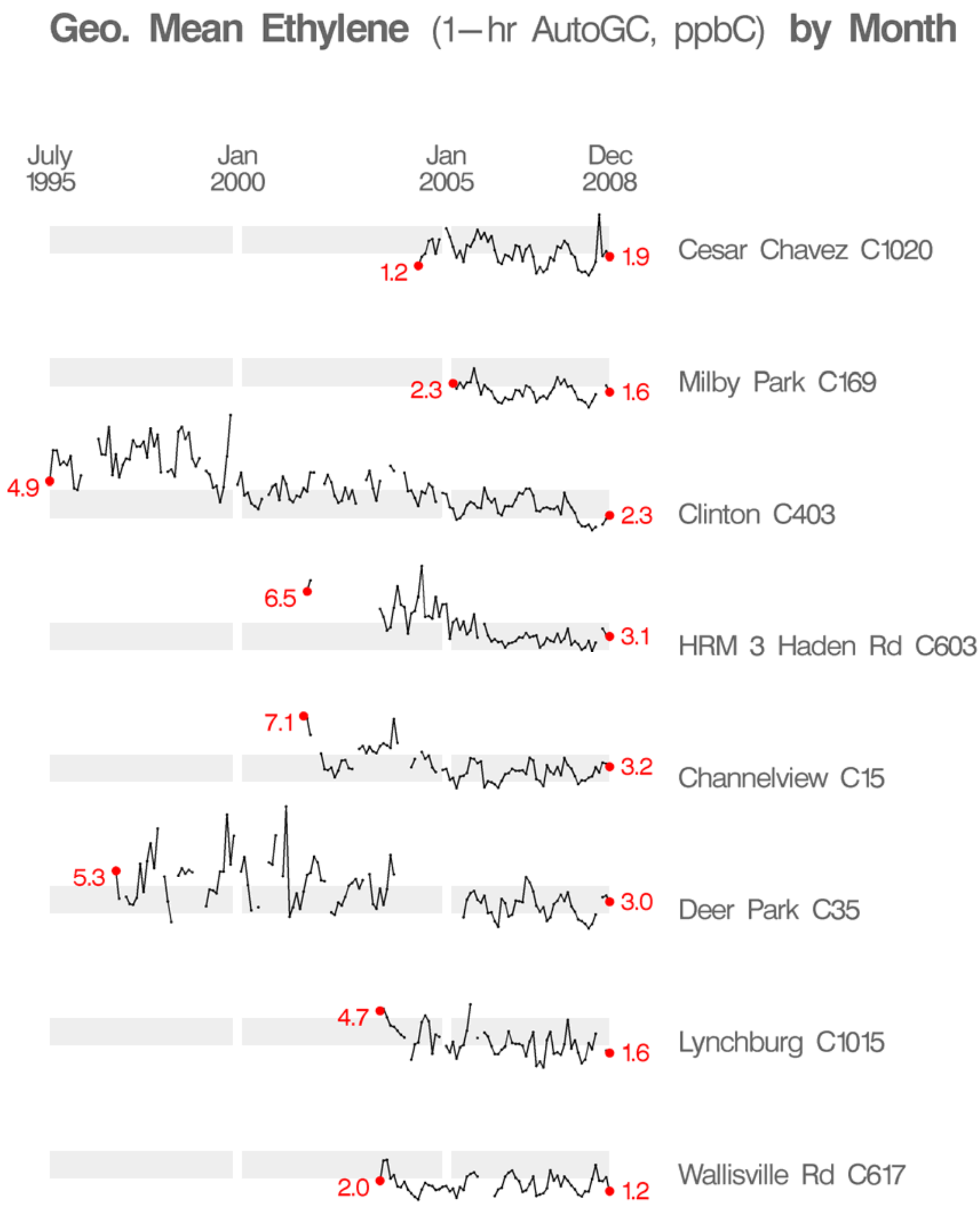


Figure 5-22: Monthly Geometric Mean Ethylene Concentrations at the Eight Houston Ship Channel Monitors, July 1995 through December 2008

For four consecutive years, July 1995 through July 1999, valid monthly geometric mean concentrations at Clinton (CAMS 403/CAMS 113/CAMS 304) exceeded the 75th percentile of the multi-decade series. Deer Park (CAMS 35/139) also exhibited high concentrations in the first several years, including the highest mean value for any complete month, 10.2 parts per billion, carbon (ppbC) in March 2001. By contrast, few monthly mean concentrations exceeded the 75th percentile in the most recent four years, 2005 through 2008.

Though measured ethylene and propylene concentrations show a large degree of variability at all auto-GC monitors, downward trends are apparent at seven of the eight; only Wallisville Road

(CAMS 617) appears to show no decrease. A statistical trend analysis, described below, provides further insight into this.

Peak monthly geometric mean ethylene concentrations at all monitors, 6.9 ppbC and 8.4 ppbC in 2003 and 2004 respectively, decreased to 5.6 ppbC in 2005, 4.9 ppbC in 2006, and 4.5 ppbC in 2007, before climbing to 5.1 ppbC in 2008. This decline in ambient ethylene concentrations suggests that ethylene emissions in the Houston Ship Channel are declining, though meteorology could be responsible for some or all of the decline in geometric mean concentrations.

Similar to Figure 5-22: *Monthly Geometric Mean Ethylene Concentrations at the Eight Houston Ship Channel Monitors, July 1995 through December 2008*, Figure 5-23: *Monthly Geometric Mean Propylene Concentrations at the Eight Houston Ship Channel Monitors, July 1995 through December 2008* displays monthly geometric mean concentrations of propylene for the eight Houston Ship Channel area auto-GC monitors. Again, Clinton (CAMS 403/CAMS 113/CAMS 304) and Deer Park (CAMS 35/139) show higher concentrations in earlier years compared to recent ones; however, the magnitude of concentrations at the two monitors are dissimilar, unlike ethylene, suggesting elevated propylene concentrations are more geographically limited than elevated ethylene concentrations. Two other eastern Houston Ship Channel monitors, Channelview (CAMS 15/CAMS 115) and Lynchburg Ferry (CAMS 1015), report concentrations well above the 75^{th} percentile in 2003, and to a lesser extent in 2004 and subsequent years, suggesting there are greater propylene emissions in the eastern Houston Ship Channel than the western Houston Ship Channel. However, the relatively fast reactivity of propylene, compared to ethylene, may explain part or all of the low concentrations seen in the western Houston Ship Channel.

Similar analyses were performed for 1, 3-butadiene and the isomers of butene; however, trends in these pollutants can be difficult to interpret, as their relatively low concentrations are frequently within accepted measurement uncertainty. Further work is needed before trend estimation for these compounds can be considered accurate.

Though still variable from month to month, pervasive decreases in the ambient concentrations of ethylene and propylene suggest that overall industrial emissions of these compounds have decreased considerably since 1995. This finding agrees with early reports from TexAQS II that ethylene emissions along the Houston Ship Channel have decreased approximately 40 percent from 2000 to 2006.

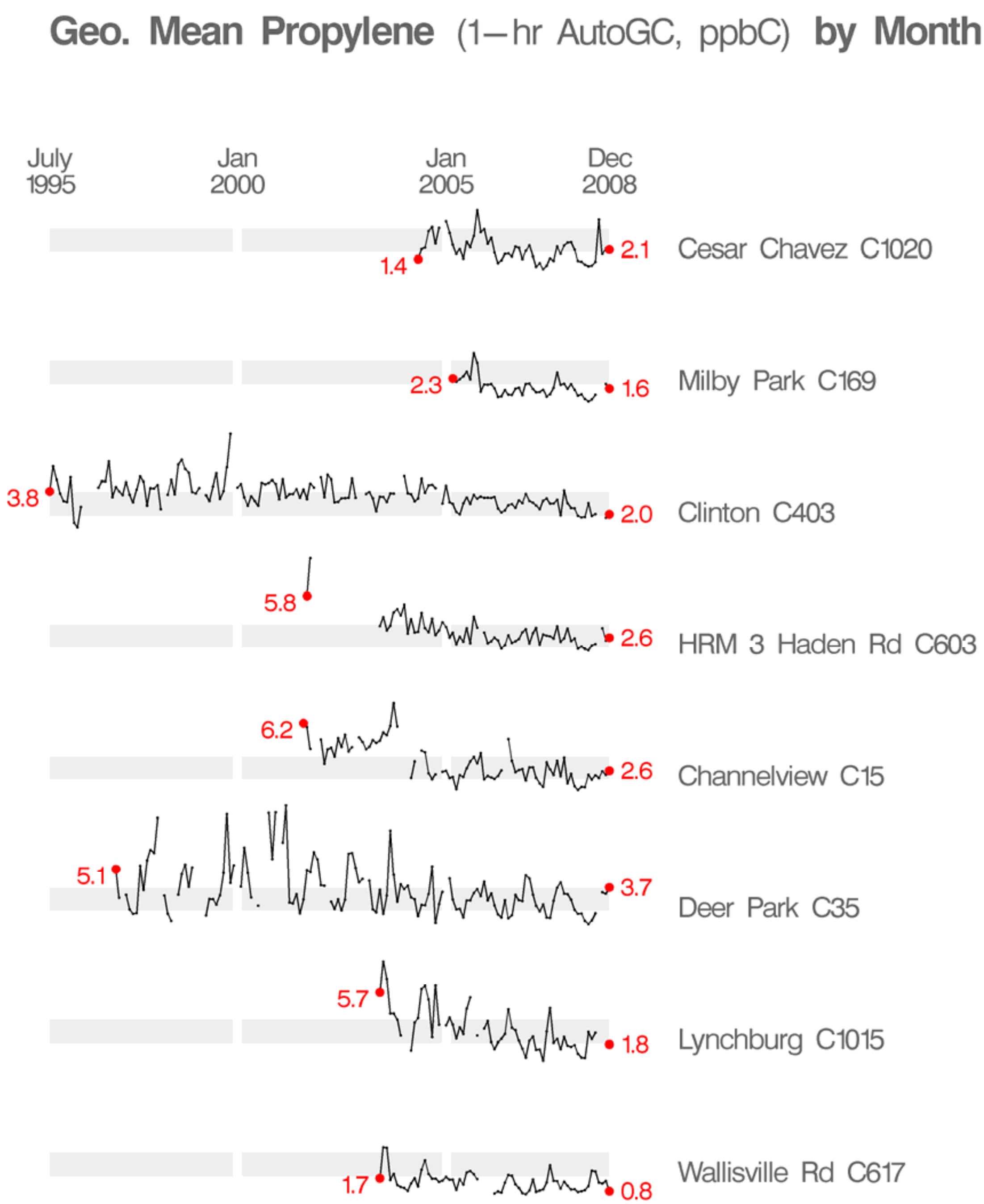


Figure 5-23: Monthly Geometric Mean Propylene Concentrations at the Eight Houston Ship Channel Monitors, July 1995 through December 2008

A preliminary analysis was performed to verify whether decreases observed were statistically significant. Ordinary least squares regression lines were fit to the monthly geometric mean ethylene and propylene concentrations, using an index of month, where the first recorded month was given a value of zero. Results of these fits are reported in Table 5-16: *Parameter Estimates of Monthly Geometric Mean Concentrations Trends*. In 23 of the 24 regressions, concentrations decreased across the respective study periods, with correlation coefficient (R^2) values ranging from 0.045 to 0.549. Eight of 12 monitors recorded statistically significant decreases for ethylene, including six of eight Houston Ship Channel monitors. All 12 monitors recorded statistically significant decreases for propylene. However, caution must be exercised when interpreting these results. First, some of the computed R^2 values are very low, confirming there is a substantial degree of variation in the measured values, with only a portion of it explained by a simple linear model. Further statistical testing and verification, such as testing for and correcting possible autocorrelation, is necessary to fully validate these models.

Table 5-16: Parameter Estimates of Monthly Geometric Mean Concentrations Trends

	ethylene				propylene			
monitoring site	N	slope	intercept	R^2	N	slope	intercept	R^2
Houston Ship Channel-area auto-GC monitors:								
Cesar Chavez C1020/175	52	-0.019*	2.74	0.09	52	-0.025*	2.86	0.16
Channelview C15/C115	62	-0.017*	3.85	0.22	62	-0.039*	4.64	0.49
Clinton C403/C113/C304	60	-0.032*	4.75	0.44	62	-0.018*	3.85	0.36
Deer Park C35/139	54	-0.033*	4.12	0.25	65	-0.026*	4.09	0.22
HRM-3 Haden Road C603	56	-0.051*	5.37	0.55	55	-0.026*	3.82	0.42
Houston Milby Park A169	39	-0.011	1.88	0.06	39	-0.021*	2.05	0.20
Lynchburg Ferry C1015	56	-0.029*	3.41	0.24	56	-0.059*	4.89	0.42
Wallisville Road C617	55	-0.002	1.79	0.00	55	-0.017*	2.08	0.17
Non-Houston Ship Channel-area auto-GC monitors:								
Mustang Bayou C619	53	-0.008*	0.72	0.20	53	-0.006*	0.83	0.13
Danciger C618	56	-0.003	0.57	0.05	56	-0.006*	0.78	0.16
Lake Jackson C1016	50	-0.006	1.00	0.05	50	-0.007*	0.77	0.18
Texas City 34th St. C620	59	-0.027*	2.43	0.50	59	-0.020*	2.19	0.37

*Significant at the 5 percent (0.05) level. Significance levels for intercepts are not reported. Parameter estimates from ordinary least squares fits of monthly geometric mean concentrations of ethylene and propylene on an index of month, by monitoring site and compound.

5.3.7 Geographic Patterns in Ambient HRVOC Concentrations Near the Houston Ship Channel

The next analysis showed that, for some HRVOC, geographic patterns are apparent. Wind speed and wind direction measurements, collected in tandem with HRVOC concentrations at the Houston Ship Channel auto-GC monitors, were used not only to identify these patterns, but to track their changes over time. Radar plots of geometric mean concentrations of ethylene and propylene, by wind direction, were plotted, superimposed on maps of the Houston Ship Channel, and displayed in Figure 5-24: *Geometric Mean Ethylene Concentration at Western Houston Ship Channel Monitors* through Figure 5-27: *Geometric Mean Propylene Concentration at Western Houston Ship Channel Monitors*.

These plots consist of jagged rings encircling a monitor. Each ring around a particular monitor represents the geometric mean concentration of the subject HRVOC at each of the 360 degrees surrounding the monitor, for a particular year. The distance from the origin to any point on the ring is proportional to the concentration of HRVOC arriving at the monitor from that direction. For example, Figure 5-25: *Geometric Mean Ethylene Concentrations at Eastern Houston Ship Channel Monitors* shows that in 2003 at Deer Park (CAMS 35/139), the highest mean ethylene concentration, 16 ppbC, occurred when winds were blowing from the northeast, suggesting there may be large ethylene emissions sources upwind of Deer Park (CAMS 35/139) in that direction.

To help interpret these graphs, it is useful to describe a couple of hypothetical scenarios. In the first one, if HRVOC did not vary when winds arrived from different directions, i.e., the same concentrations were observed regardless of the wind direction, the ring would be a smooth circle.

Conversely, in the second scenario, if HRVOC were detected only when winds arrived from a single direction, the ring would simply be an elongated spike pointing in that direction.

In Figures 5-24: *Geometric Mean Ethylene Concentration at Western Houston Ship Channel Monitors* through 5-27: *Geometric Mean Propylene Concentration at Western Houston Ship Channel Monitors*, for the Houston Ship Channel monitors, a strong directional association with mean concentration is typical. The directional spikes seen in these rings are referred to as "lobes" in this section.

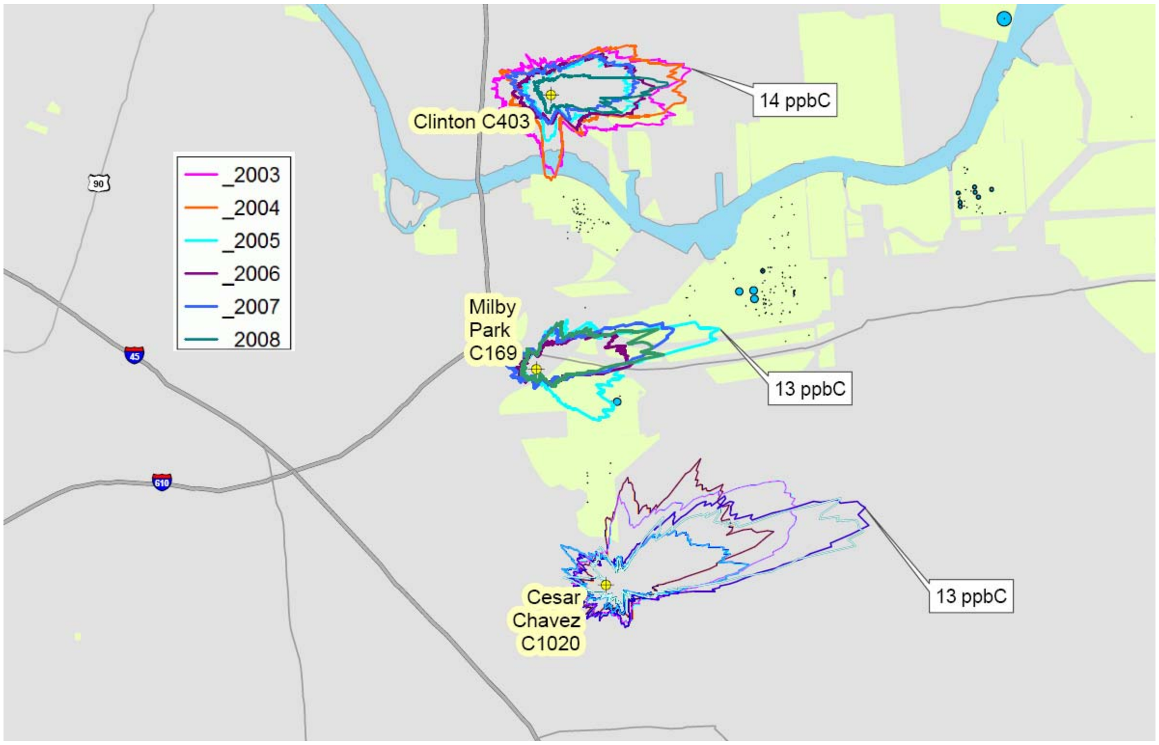


Figure 5-24: Geometric Mean Ethylene Concentration at Western Houston Ship Channel Monitors

Sources of ethylene (blue circles) and propylene (brown circles) are also depicted on the map of the respective compound, with sizes proportional to values reported in the 2006 TCEQ point source emissions inventory. Valid hourly measurements from 2002 through 2008 were used; hours with hourly wind speed measurements less than two miles per hour (mph) were discarded, due to considerable error in wind direction measurements at low wind speeds.

While a compound's concentration for a particular wind direction at a particular monitor is proportional to the distance from the monitor to the ring at that direction, the scale differs across monitors. For example, peak 2003 ethylene concentration (see Figure 5-25: *Geometric Mean Ethylene Concentrations at Eastern Houston Ship Channel Monitors*) at Lynchburg Ferry (CAMS 1015) is 24 ppbC, and 15 ppbC at Wallisville Road (CAMS 617), yet the length from each monitor to its respective peak (tip of sharp "point") is approximately the same. For this reason, peak concentration at each monitor, for each pollutant, is labeled.

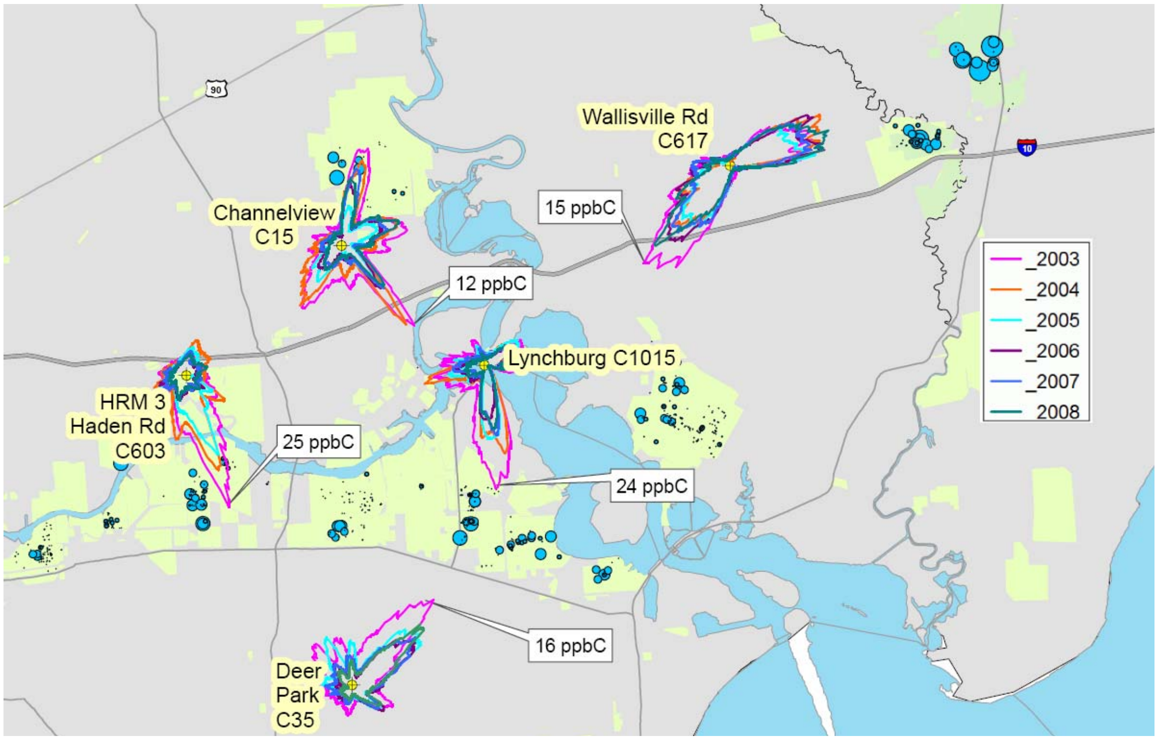


Figure 5-25: Geometric Mean Ethylene Concentrations at Eastern Houston Ship Channel Monitors

Figure 5-24: *Geometric Mean Ethylene Concentration at Western Houston Ship Channel Monitors* shows mean ethylene concentrations at the three western-most Houston Ship Channel auto-GC monitors. Sources of ethylene having the greatest impact on these monitors are all located east of the monitors, because the greatest peaks for each monitor point in this direction for all the years. The plot also shows trends across time at each monitor. At Clinton (CAMS 403/CAMS 113/CAMS 304), peak ethylene occurred in 2003 from almost due east, as seen in the lobe labeled "14 ppbC." Following 2003 and 2004, peak concentrations from that direction have been somewhat lower. Also, the lobes pointing south observed in 2003 and 2004 are markedly smaller in 2005 and subsequent years. An olefins production plant located in the Houston Milby Park (A169) area shut down in 2005; its emissions may have been responsible for those lobes.

The plot shows mean ethylene concentrations for the Cesar Chavez (CAMS 1020/175) and Houston Milby Park (A169) monitors, which started operation in 2004 and 2005, respectively. While these monitors measured peak concentrations in different years, both monitors have peaks pointing in the direction of the Houston Milby Park (A169) olefins plant while it was in operation; Houston Milby Park (A169) observed a large lobe to the southeast in 2005, and Cesar Chavez (CAMS 1020/175) observed a notable lobe to the north in 2004 and 2005. This provides a stronger indication, when combined with the Clinton (CAMS 403/CAMS 113/CAMS 304) peak to the south, of the influence of emissions from that plant on local concentrations.

Figure 5-25: *Geometric Mean Ethylene Concentrations at Eastern Houston Ship Channel Monitors* shows mean ethylene concentrations at the five auto-GC monitors located in the eastern part of the Houston Ship Channel. Variation in mean concentrations by direction is even more pronounced here than in the western portion of the Houston Ship Channel. The pattern in mean concentrations at Lynchburg Ferry (CAMS 1015) suggests there is a large source of ethylene emissions south-southeast of the monitor, near Battleground Road and Highway 225, and that emissions from this area have decreased.

Table 5-17: *Geometric Mean Ethylene for Key Wind Direction Lobes at Eastern Houston Ship Channel Monitors* shows that this lobe's mean 2003 concentration of 24.3 ppbC has halved in recent years.

Table 5-17: Geometric Mean Ethylene for Key Wind Direction Lobes at Eastern Houston Ship Channel Monitors

Monitor	principal direction(s)	2003	2004	2005	2006	2007	2008
		ppbC	*ppbC*	*ppbC*	*ppbC*	*ppbC*	*ppbC*
lobes pointing to the same sources in the central Houston Ship Channel area:							
HRM 3	ESE	**24.8**	**18.0**	**15.6**	5.0	4.7	5.2
Channelview C15/C115	SW	8.9	8.9	5.6	4.3	3.6	4.1
lobes pointing to the same sources in the eastern Houston Ship Channel area:							
Hous.DeerPrk2 C35/139	NE	16.6	missing	12.1	10.7	11.1	**13.0**
Lynchburg Ferry C1015	SSE	24.3	17.7	14.5	10.8	**14.0**	12.6
Channelview C15/C115	SE	12.5	11.9	6.6	6.9	7.1	6.8
Wallisville Road C617	SW	15.0	9.8	8.4	**11.1**	9.9	12.8
lobes pointing in other directions:							
Channelview C15/C115	N	10.5	9.0	3.7	6.3	7.9	6.9
Wallisville Road C617	ENE	9.7	11.5	9.6	10.8	9.2	11.6

Annual maxima are noted in boldface type.

The pattern observed at Deer Park (CAMS 35/139) may provide additional evidence of suspected emission decreases in the same source area. The northeast lobe in Table 5-17: *Geometric Mean Ethylene for Key Wind Direction Lobes at Eastern Houston Ship Channel Monitors* has dropped from a high of 16.6 ppbC in 2003 to a range of about 11 to 13 ppbC in recent years. Similarly, the southeast lobe at Channelview (CAMS 15/CAMS 115), which points yet again to the same source area, peaked at 12.5 ppbC in 2003, dropped to 11.9 ppbC in 2004, and has not exceeded 7.1 ppbC since. While this monitor is farther from this source region than are the other two monitors, and therefore is more likely to be impacted by other emissions sources, consistent decreases observed at these three monitors across the six-year span of available data suggest ethylene emissions have decreased in the subject source region.

HRM-3 Haden Road (CAMS 603) shows a peak of 24.8 ppbC to the southeast in 2003, which fell to 18 ppbC in 2004, then further to 15.6 ppbC in 2005. The mean concentration has dropped since then, not exceeding 5.2 ppbC. The magnitude of the decrease over 2006 to 2008, as compared to 2005 and earlier years, suggests a shut down of one or more major process units, or even entire plants, somewhere southeast of this monitor, or implementation of HRVOC rules.

Peaks at the Wallisville Road (CAMS 617) monitor point southwest, toward the east Houston Ship Channel, and east-northeast, in the direction of the Mont Belvieu industrial area, where there is considerable ethylene and propylene storage in underground salt caverns. Table 5-17: *Geometric Mean Ethylene for Key Wind Direction Lobes at Eastern Houston Ship Channel Monitors* shows that ethylene originating to the southwest decreased from the six-year peak in 2003 (15 ppbC), to a range from 9.9 to 11.1 ppbC, before rising slightly to 12.8 ppbC in 2008. In contrast, the east-northeast lobe at this monitor shows relatively unvarying mean concentrations across the entire six-year period, ranging from 9.2 to 11.6 ppbC, with the six-year peak occurring in 2008.

These conclusions for five monitors and eight directional lobes show a nearly consistent pattern across these monitors. Seven of eight lobes witnessed their highest mean concentration in 2003. Within one or two years of this peak, concentrations at all seven had dropped, from 27 to 65 percent, and have leveled off since; mean concentrations have not varied appreciably from 2006 to 2008. These findings suggest ethylene emissions from source areas close to these monitors, especially Battleground Road, Highway 225 in La Porte, and the petrochemical complex north of the Channelview (CAMS 15/CAMS 115) monitor, have decreased considerably in recent years. These observations suggest that the new TCEQ regulations specifically targeting HRVOC emissions and requiring full compliance by 2006 are proving effective in controlling point source HRVOC emissions. However, the trends shown here have not been corrected for meteorological variations.

Results for the lobe pointing east-northeast from the Wallisville Road (CAMS 617) monitor disagree with some key findings at other lobes. The Wallisville Road (CAMS 617) east-northeast lobe, unique among the eight, experienced an increase in mean concentration from 2003 (9.7 ppbC) to 2004 (11.5 ppbC). While 2006 to 2008 mean concentrations at Wallisville Road (CAMS 617), like those of other monitors and lobes, changed relatively little, mean concentrations of the east-northeast Wallisville Road (CAMS 617) lobe changed relatively little across the entire six-year period. The absence of recent decreases at this lobe compared to earlier years suggests that meteorology may not have caused high concentrations seen at most other lobes in earlier years.

Figure 5-26: *Geometric Mean Propylene Concentration at Eastern Houston Ship Channel Monitors* displays monthly geometric mean concentrations of propylene in the same area of the eastern Houston Ship Channel. Table 5-18: *Geometric Mean Propylene Concentrations for Key Wind Directions at Eastern Houston Ship Channel Monitors* lists mean propylene concentrations across the study period, for each monitor and lobe. Similarities with ethylene are evident. For propylene, all seven lobes measured their highest concentrations in 2003 or 2004; five of the seven had their two lowest annual concentrations in 2007 and 2008. All seven lobes had concentrations in 2007 and 2008 that were 40 percent or more lower than their respective six-year peaks.

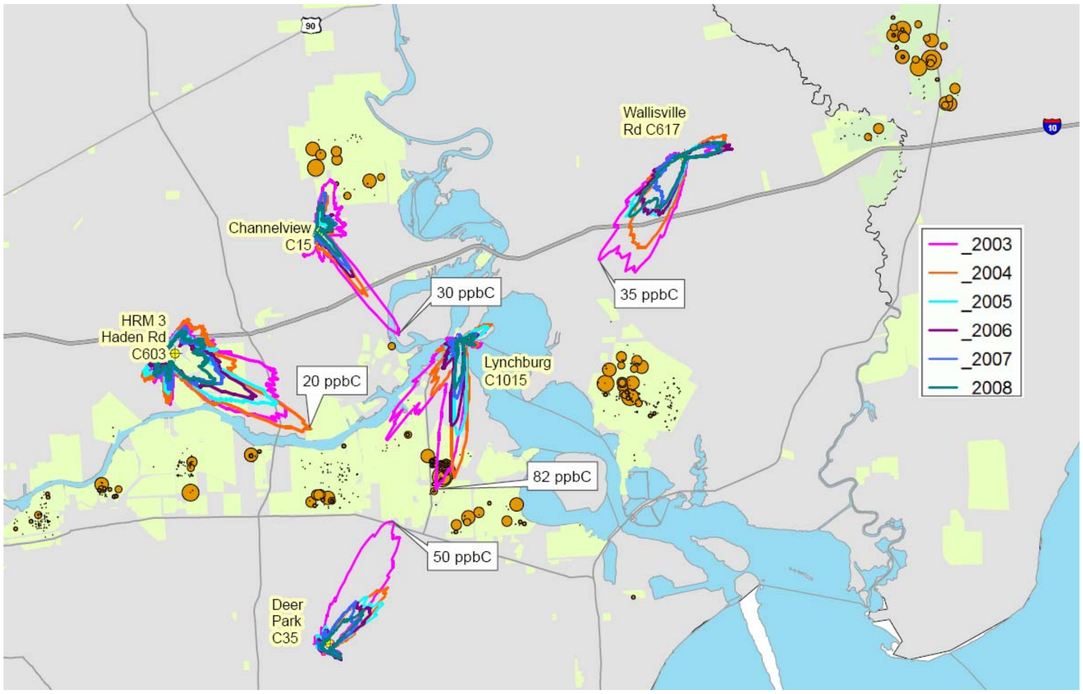


Figure 5-26: Geometric Mean Propylene Concentration at Eastern Houston Ship Channel Monitors

These results suggest that the propylene emissions in the source regions near the monitors have dropped considerably in the six-year study period, and that the HRVOC regulations may be responsible for the decreases. As seen with ethylene, patterns in geometric mean propylene concentrations at the east-northeast Wallisville Road (CAMS 617) lobe differed considerably from the other seven. Propylene concentrations varied relatively little across the six-year period, suggesting that, like ethylene, Mont Belvieu propylene emissions have changed little or not at all, on average, across the study period.

Figure 5-27: *Geometric Mean Propylene Concentration at Western Houston Ship Channel Monitors* shows mean propylene concentrations by wind direction at the three western Houston Ship Channel monitors. Patterns depicted here exhibit strong similarities to those seen with ethylene in this area: the largest propylene source areas are to the east, and judging from the disappearance of strong peaks from 2006 onward, emissions from the now-defunct olefins plant located in the Houston Milby Park (A169) area were probably affecting these monitors.

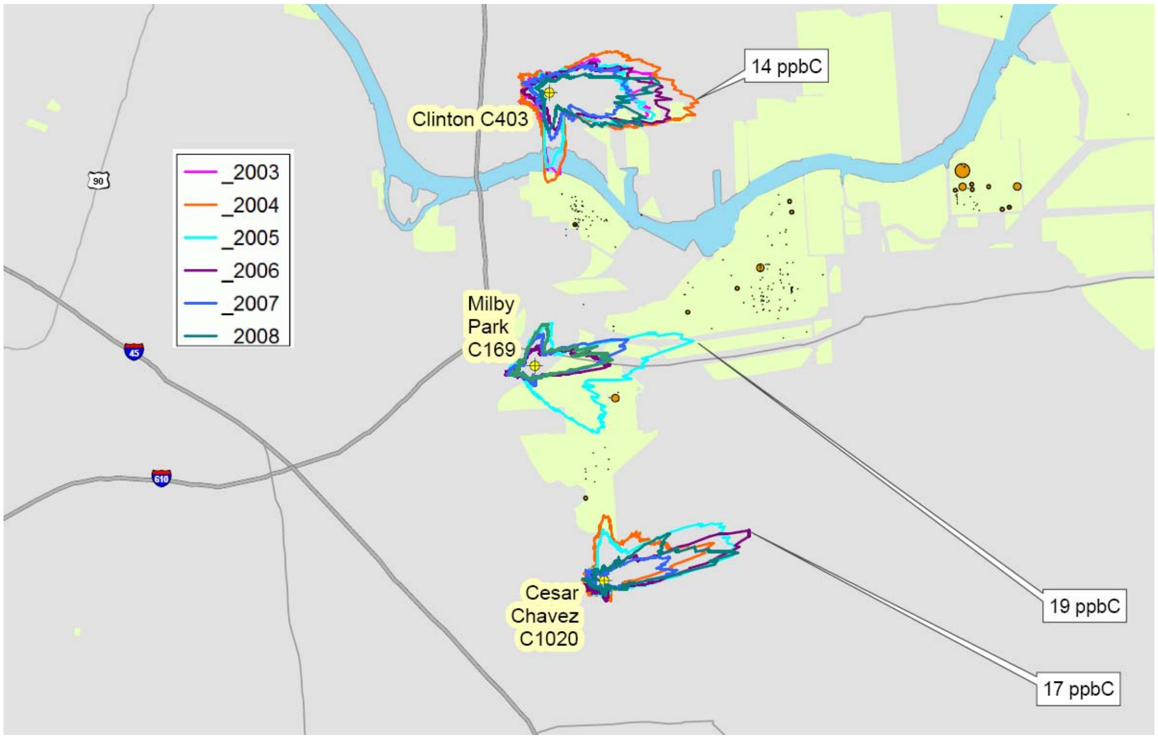


Figure 5-27: Geometric Mean Propylene Concentration at Western Houston Ship Channel Monitors

Table 5-18: *Geometric Mean Propylene Concentrations for Key Wind Directions at Eastern Houston Ship Channel Monitors* lists mean propylene concentrations across the study period, for each monitor and lobe.

Table 5-18: Geometric Mean Propylene Concentrations for Key Wind Directions at Eastern Houston Ship Channel Monitors

Monitor	principal direction(s)	2003	2004	2005	2006	2007	2008
		ppbC	*ppbC*	*ppbC*	*ppbC*	*ppbC*	*ppbC*
lobes pointing to the same source in the eastern Houston Ship Channel area:							
HRM-3 Haden Road C603	SE	17.1	20.5	15.2	12.4	7.8	7.0
Hous.DeerPrk2 C35/139	NE	50.0	30.3	25.4	21.2	19.6	18.6
Lynchburg Ferry C1015	S	**82.8**	**75.4**	**51.5**	**46.2**	**31.5**	**26.3**
Channelview C15/C115	SE	30.1	19.0	11.7	13.8	11.7	8.2
Wallisville Road C617	SW	35.6	27.3	22.3	18.4	14.5	21.3
lobes pointing to other sources:							
Lynchburg Ferry C1015	SW	68.7	33.9	13.7	18.8	9.9	6.8
Channelview C15/C115	N	11.3	7.7	3.0	5.5	8.1	5.2
Wallisville Road C617	ENE	9.0	12.2	9.7	12.3	9.7	11.2

Annual maxima are noted in boldface type.

5.3.8 Ambient Total VOC Concentrations

Considerable research has focused on patterns and trends in HRVOC concentrations in the HGB area (Hafner Main et al. 2001; Brown and Hafner Main, 2002; Jolly et al., 2003; Fang and McDowell, 2003). Less examined are patterns for other, less-reactive VOC. This section presents a detailed examination of patterns in total VOC concentrations in the HGB area, using concentrations of total nonmethane hydrocarbons (TNMHC) as a measure of total VOC. Each TNMHC measurement corresponds to the sum of all chromatogram peaks (identified and unidentified) from the start to the end of sample collection. TNMHC is a useful measure of total VOC because it has been calculated in a consistent manner over the entire study period, unlike other parameters, such as the sum of Photochemical Assessment Monitoring Stations (PAMS) target compounds, whose constituents have changed periodically.

Similar to the first HRVOC analysis presented in this section, geometric mean TNMHC concentrations, by monitor, year, and month, were calculated for valid months for all available data from each of the 12 HGB monitors. Further analysis of the four non-Houston Ship Channel-area monitors has not been completed at this time.

Figure 5-28: *Monthly Geometric Mean TNMHC Concentrations, July 1995 through December 2008* shows, for each of the eight Houston Ship Channel monitors, monthly geometric mean TNMHC concentration for all months with complete data, between the start of monitoring and December 2008. Monitors are sorted according to their location from west (top) to east (bottom); the grey bars denote the 25th through 75th percentile concentrations (85 ppbC and 149 ppbC respectively) of all valid months across all monitors.

As with ethylene and propylene, the two monitors with data before 2001, Clinton (CAMS 403/CAMS 113/CAMS 304) and Deer Park (CAMS 35/139), recorded their highest monthly geometric mean values before 2001. Both monitors exhibited overall decreases across their respective data collection periods. A statistical analysis of possible trends, using ordinary least squares regression, is presented in Table 5-19: *Parameter Estimates of Monthly Geometric Mean TNMHC Concentration Trends Houston Ship Channel Area Auto-GC Monitors*. This statistical model indicates that all 12 monitors had decreasing monthly mean concentrations, from the beginning to the end of each monitor's respective data range. As well, this model indicates that eight of the 12 monitors' decreases were statistically significant at the 95 percent confidence level.

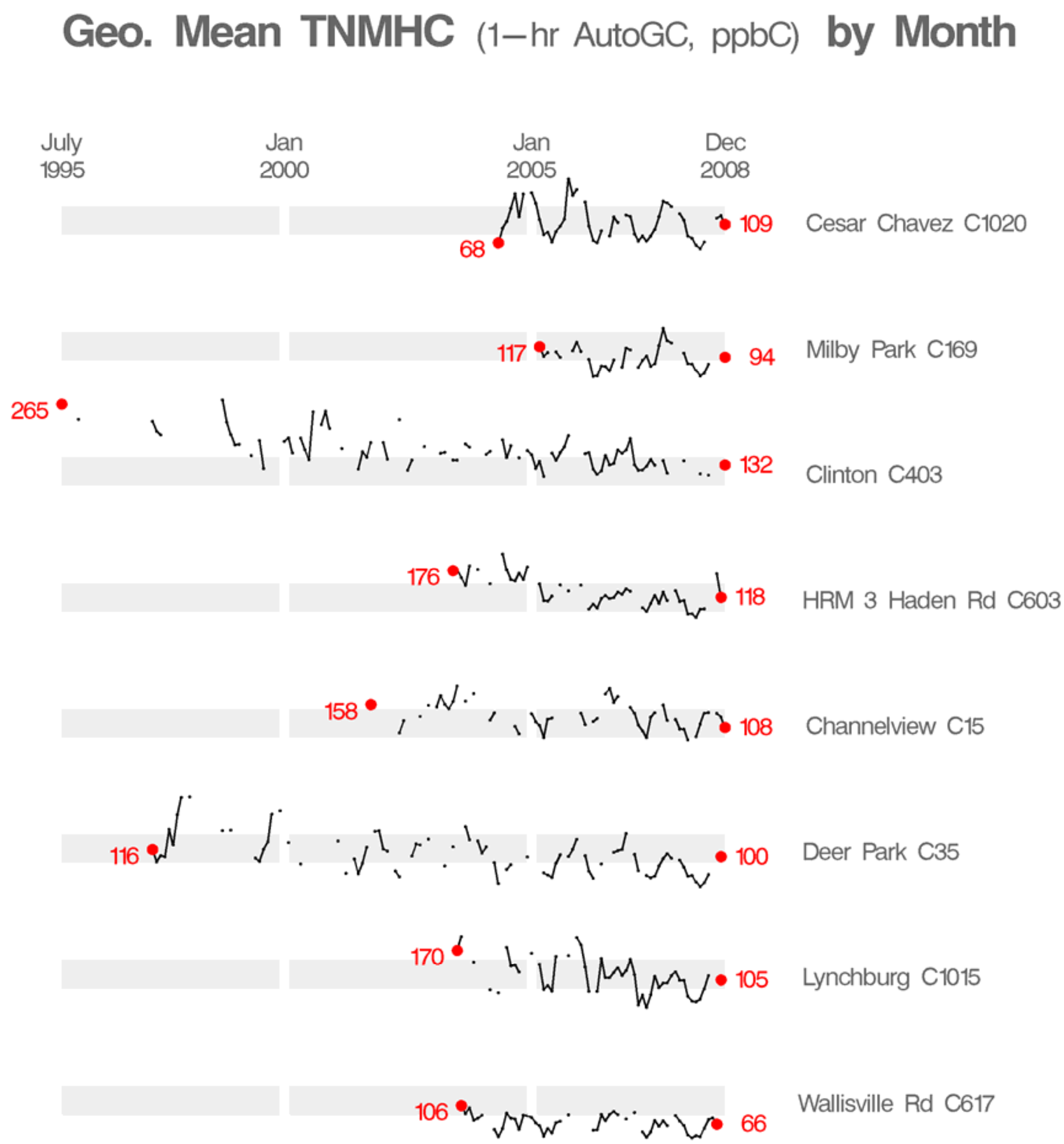


Figure 5-28: Monthly Geometric Mean TNMHC Concentrations, July 1995 through December 2008

Table 5-19: Parameter Estimates of Monthly Geometric Mean TNMHC Concentration Trends Houston Ship Channel Area Auto-GC Monitors

Sitename	Slope of Trend	Intercept	Degrees of Freedom	R squared
Cesar Chavez C1020/175	-0.61	132	47	0.07
Channelview C15/C115	**-0.37***	**153**	**49**	**0.10**
Clinton C403/C113/C304	**-0.63***	**225**	**78**	**0.46**
Hous.DeerPrk2 C35/139	**-0.55***	**148**	**80**	**0.31**
Houston Milby Park A169	-0.33	99	33	0.03
HRM-3 Haden Road C603	**-1.22***	**173**	**47**	**0.52**
Lynchburg Ferry C1015	**-1.14***	**156**	**47**	**0.27**
Wallisville Road C617	**-0.31***	**79**	**49**	**0.11**

Non-Houston Ship Channel-area auto-GC monitors

Sitename	Slope of Trend	Intercept	Degrees of Freedom	R squared
Danciger C618	**-0.22***	**44**	**47**	**0.12**
Lake Jackson C1016	-0.18	34	43	0.04
Mustang Bayou C619	-0.11	61	43	0.01
Texas City 34th St. C620	**-0.95***	**102**	**57**	**0.46**

***Significant at the 5 percent (0.05) level.** Significance levels for intercepts are not reported. Parameter estimates from ordinary least squares fits of monthly geometric mean concentrations of TNMHC on an index of month, by monitoring site.

Figure 5-29: *90th Percentile TNMHC Concentration in the HGB Area* presents 90th percentile TNMHC concentrations at each auto-GC monitor. The area-wide 90th percentile TNMHC concentrations and the 90th percentile TNMHC at most of the individual monitors are decreasing. Smaller decreases are evident at Wallisville Road (CAMS 617), Channelview (CAMS 15/CAMS 115), Lake Jackson (CAMS 1016), Mustang Bayou (CAMS 619), and Danciger (CAMS 618), while larger decreases are observed primarily at monitors closer to the Houston Ship Channel. Monitors in Brazoria County (Danciger (CAMS 618), Lake Jackson (CAMS 1016), and Mustang Bayou (CAMS 619)) and Galveston County (Texas City 34th St. (CAMS 620)) tend to report lower 90th percentile TNMHC than monitors located in Harris County. In the past, Clinton (CAMS 403/CAMS 113/CAMS 304) has recorded the highest TNMHC concentrations, but since 2006 Clinton has decreased at a faster rate and Channelview (CAMS 15/CAMS 115) has recorded the highest concentrations.

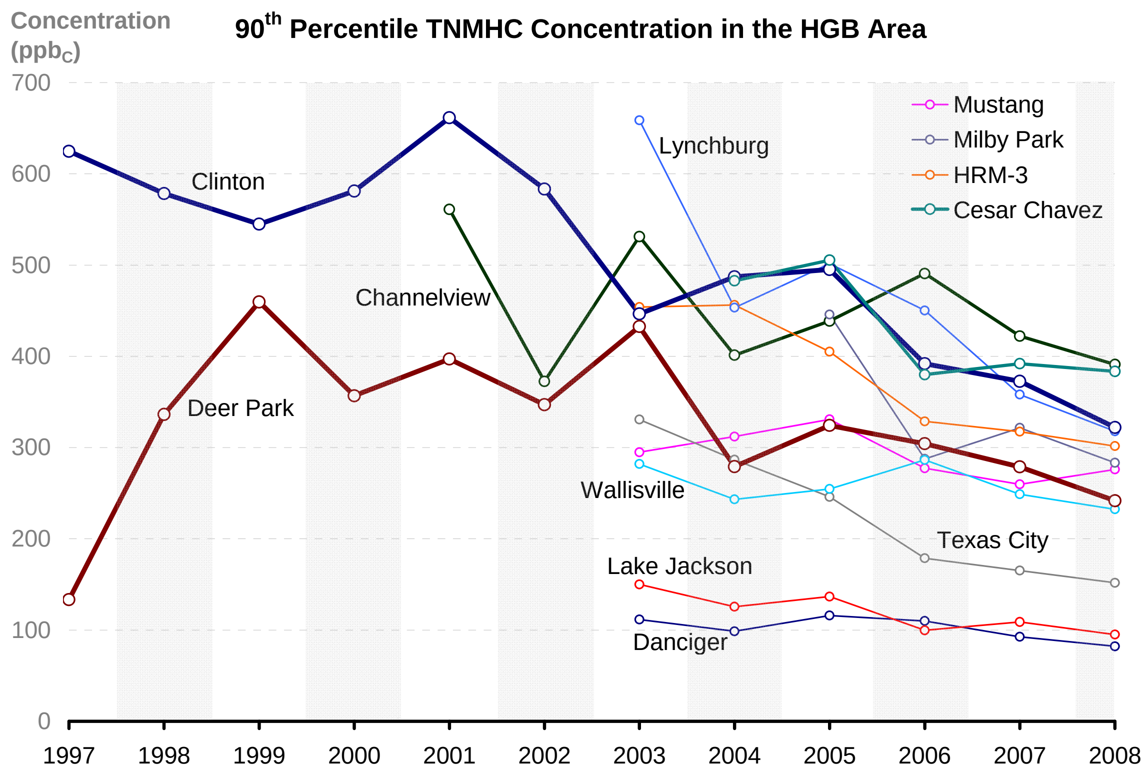


Figure 5-29: 90th Percentile TNMHC Concentration in the HGB Area

5.3.9 Meteorologically Adjusted Ozone Trends

Ozone formation is dependent not only on its precursors (NO_X and VOC), but also on meteorological variables. While trends in ozone design values have been decreasing, design value trends must be examined to determine if the values are decreasing due to emission controls or if they are decreasing simply because of meteorological conditions in the area in the past several years. To determine whether control strategies have been effective, meteorological influences must be removed from ozone trends. Analysis done by Sullivan (2009) used a generalized linear model to account for meteorological influences in ozone trends. The following discussion is based upon Sullivan (2009), who used a modified version of the Camalier et al. (2007) technique for removing the meteorological influences from the ozone trends.

Before meteorological influences can be removed from ozone trends, the meteorological factors that are most important to ozone formation must first be identified. Various correlations and factor analyses were used to identify the most important meteorological variables for ozone formation in the HGB area. Data from the Omnibus Meteorological Database (METDAT) maintained by the EPA was compared to ozone data obtained from surface monitors in the HGB area. Because the set of observed ozone levels can be influenced by the number of monitors in an area, Sullivan (2009) used a consistent set of ozone monitors in the HGB area. These monitors are listed in Table 5-20: *Area Ozone Monitoring Sites with Long-Term Data*. Most contain a consistent set of data from 1990 to 2007. Data from monitors that were moved a short distance during the period from 1990 to 2007 were combined with data from monitors in nearby locations, for example, data at Clute (CAMS 11) were combined with data from Lake Jackson (CAMS 1016).

Table 5-20: Area Ozone Monitoring Sites with Long-Term Data

AQS Number	Site Name
482011039	Hous.DeerPrk2 C35/139
482011035	Clinton C403/C113/C304
482011034	Houston East C1
482010075	Houston Texas Avenue C411
482010062	Houston Monroe C406
482010051	Houston Croquet C409
482010047	Lang C408
482010046	Houston North Wayside C405
482010029	Northwest Harris Co. C26/A110/C154
482010024	Houston Aldine C8/AF108/X150
480391016	Lake Jackson C1016 (and Clute C11)

Source: Sullivan, 2009.

Figure 5-30: *Actual Mean Eight-Hour Ozone Concentrations (Blue Line) and Mean Eight-Hour Predicted Concentrations with the Non-Meteorological Trend Removed (Red Line)*, which was reproduced from Sullivan (2009), displays two time series. The values in blue represent the observed mean daily maximum eight-hour ozone concentrations; values in red represent the daily peak ozone based purely on the meteorological variations, with the non-meteorological factors removed. In other words, the statistical model described above has been used to re-create the ozone time series with only the meteorology taken into account.

For 2006 and 2007, the statistical model predicts that the observed mean daily peak eight-hour ozone should have been higher than observed, based upon the conduciveness of the meteorology toward ozone formation. In other words, based on the weather, ozone concentrations should have been higher in 2006 and 2007. Subtracting the meteorologically-based eight-hour ozone estimates from the actual eight-hour ozone results in a trend with the meteorological effects removed (Figure 5-31: *Residual Meteorologically Adjusted Eight-Hour Ozone Concentrations Trend*). This trend represents how the sum of anthropogenic factors, model error, and undiagnosed meteorological factors have changed from 1996 to 2007. Figure 5-31: *Residual Meteorologically Adjusted Eight-Hour Ozone Concentrations Trend*, which was reproduced from Sullivan et al., 2009, represents the trend in peak daily maximum ozone with the meteorological factors removed. The meteorologically-adjusted ozone trend is clearly downward. Since the meteorological variations have been removed, this downward trend shows the effect of emission reductions in the HGB area. Statistical results of this analysis are listed in Table 5-21: *Summary Statistics for Meteorologically Adjusted Ozone Trends from 1996 to 2007*. The slope of -0.86 shows that eight-hour ozone trends in the HGB area are decreasing and that they are significant (p-value = 0.00).

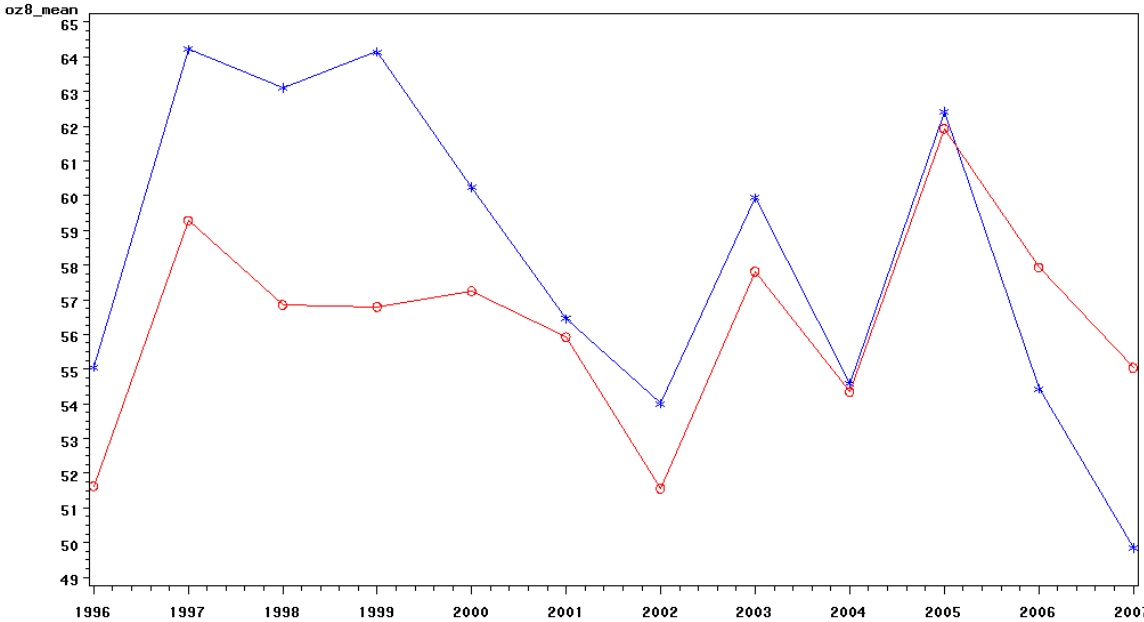


Figure 5-30: Actual Mean Eight-Hour Ozone Concentrations (Blue Line) and Mean Eight-Hour Predicted Concentrations with the Non-Meteorological Trend Removed (Red Line)

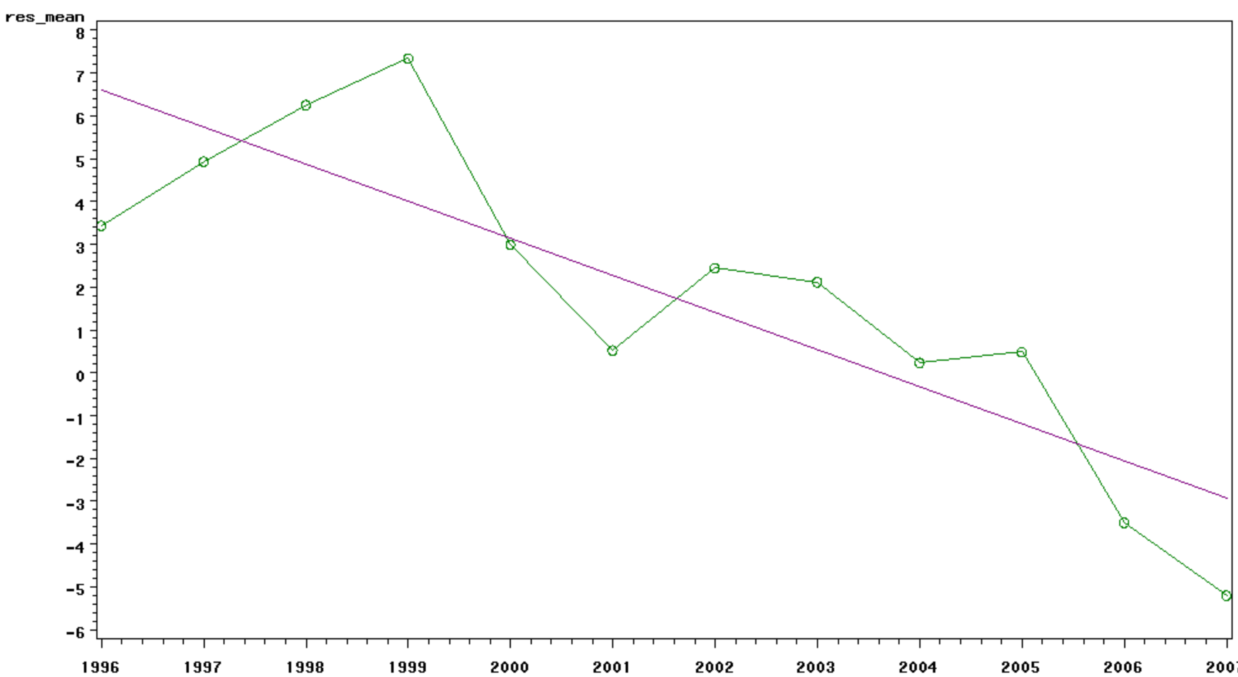


Figure 5-31: Residual Meteorologically Adjusted Eight-Hour Ozone Concentrations Trend

Table 5-21: Summary Statistics for Meteorologically Adjusted Ozone Trends from 1996 to 2007

Parameter	Value
Intercept	6.438
Slope	-0.86*
t-statistic	-4.20
p-value	0.00
Lag 1 Coefficient	-0.20
t-statistic	-0.63

* Value is statistically significant. (Sullivan et al., 2009)

The analysis from Sullivan (2009) shows that, after adjusting for meteorology, concentrations of ozone has declined substantially in the HGB area. All else held equal, daily maximum eight-hour ozone concentrations in the HGB area should be around 9 ppb lower in 2007 compared to 1996.

5.3.10 Background Ozone Concentrations: Transport of Ozone into the HGB Area

Estimating the levels of ozone transported into the HGB area is important in order to identify so that the amount of locally produced ozone. Several researchers have previously investigated the background ozone concentrations in Texas and the transport winds that are associated with them. Nielsen-Gammon et al. (2005) investigated background ozone from 1998-2003 in the HGB area and obtained the following insights (paraphrased from Nielsen-Gammon et al., 2005):

- The seasonal variability in eight-hour maximum ozone in eastern Texas is primarily associated with background ozone. Local contributions tend to be highest during the summer when background ozone reaches a minimum.
- The late spring peak in eight-hour maximum ozone in eastern Texas is primarily associated with "tropospheric background" ozone. This ozone maximum has been observed at rural sites elsewhere and is associated with variations in the lifetime of ozone, the concentrations of NOx, and enhanced transport from the stratosphere.
- The midsummer minimum in background ozone in eastern Texas leads to a minimum in eight-hour peak ozone that is strongest in southeastern Texas and barely noticeable in northeastern Texas. The primary cause of the summertime minimum is a decline in the tropospheric background ozone. Although the relatively clean southerly flow is weakening during this period, most air parcel paths remain maritime in nature.
- When easterly and northeasterly winds become more frequent in late summer, background ozone and total ozone in eastern Texas begin rising. Winds are also less steady than in the middle of summer, so continental transport becomes increasingly frequent.

Langford et al. (2009) showed that the techniques used by Nielsen-Gammon et al. (2005) yielded results consistent with a different technique of estimating background, except on some occasions when the Galveston Airport (CAMS 34/CAMS 109/CAMS 154) site was chosen as the background site. Langford et al. showed that the Galveston site is the site most strongly affected by the Gulf breeze, and that on some days, the maritime air from the Gulf does not affect the Houston area, even though this air affects Galveston. Hardesty et al. (2007) have shown that during the TexAQS II study in August through September 2006, background ozone in southeast Texas averaged about 50 ppb, with background concentrations lower near the coast, and higher in northeast Texas. On one day, September 8, 2006, the background ozone entering Texas from east was 85-90 ppb. The results of these studies have shown that background ozone entering southeast Texas can have a large effect on the total observed eight-hour ozone concentrations. To investigate the role of background ozone for the most recent years, the TCEQ commissioned a study of background ozone and its relationship to larger-scale wind patterns. Below is a description of this work.

Sullivan (2009) used 72-hour back trajectories calculated with the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) algorithm, using data from the Ecosystem Dynamics and the Atmosphere Section (EDAS) meteorological model to estimate the amount of ozone entering into the HGB area. A total of 1,456 backward trajectories were run starting at 12:00 Central Standard Time in central Houston, at 300 meters above ground level, during the peak of ozone season in the HGB area (May 1 through October 31, 2000 to 2007). Analysis of multiple trajectories can distinguish between source areas, or paths, that lead to higher than average, or lower than average ozone concentrations (Sullivan et al., 2009). A clustering algorithm was used to group multiple trajectories based on trajectory size and shape. Six identified clusters appear in Figure 5-32: *Six Clusters Found Using HYSPLIT Backward Trajectory Clustering Algorithm*, which was reproduced from Sullivan, 2009. Forty backward trajectories that did not end up in any of the six clusters, illustrated in Figure 5-33: *Cluster 0 Backward Trajectories*, reproduced from Sullivan (2009), were grouped and assigned a cluster number of zero. All but one of the back trajectories in cluster zero originate from the south and that these trajectories appear to extend beyond the EDAS modeling domain, which is the only difference between cluster zero and cluster two.

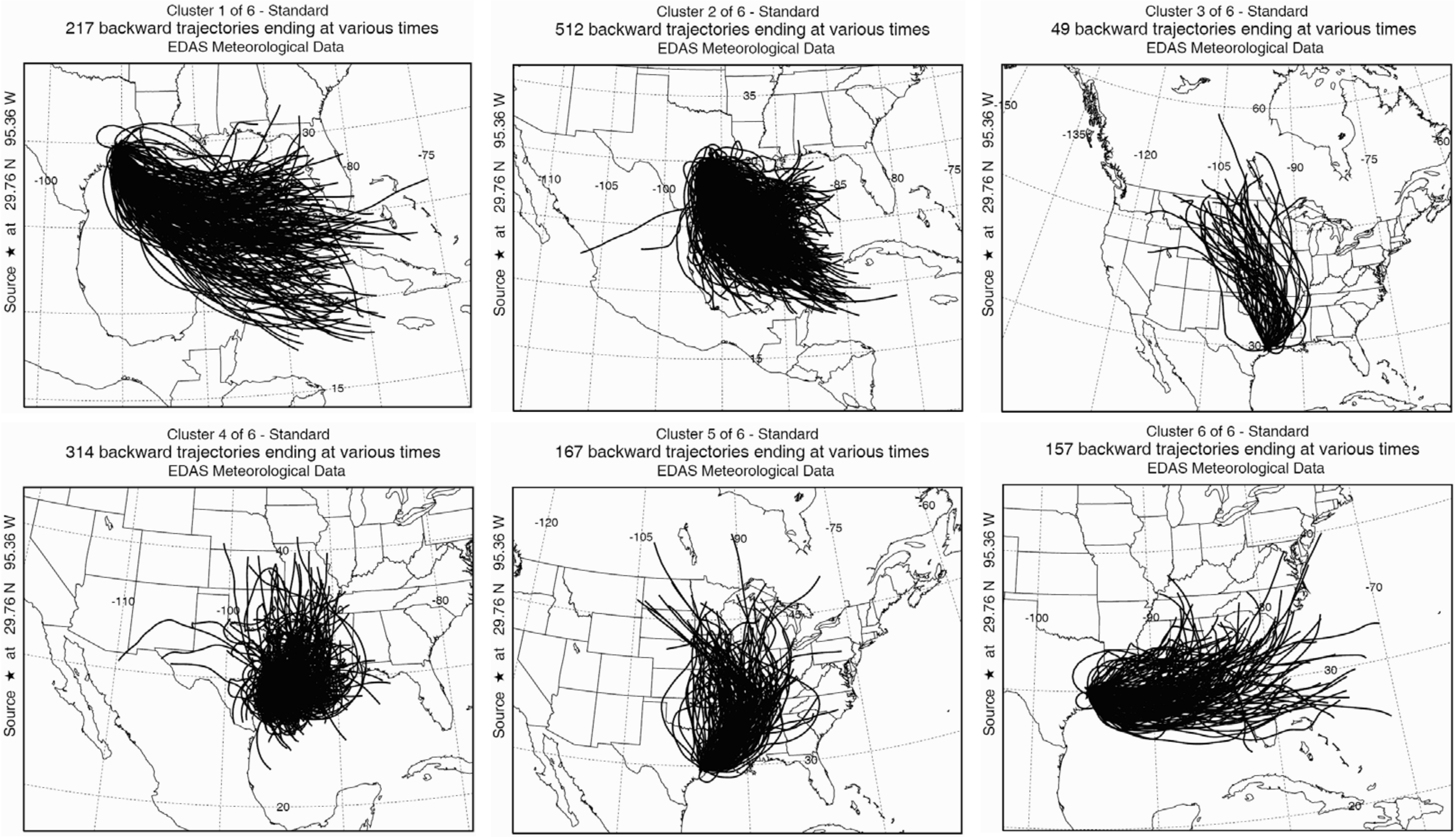


Figure 5-32: Six Clusters Found Using HYSPLIT Backward Trajectory Clustering Algorithm

Figure 5-32*: Six Clusters Found Using HYSPLIT Backward Trajectory Clustering Algorithm* shows that cluster one and cluster two represent days in which winds originated from the Gulf of Mexico; these trajectories typically represent cleaner air coming from the Gulf of Mexico and hence lower observed ozone concentrations in the HGB area. Cluster three represents long trajectories, which come into the HGB area from the north as far away as Canada. This type of trajectory can also bring clean air from northern states and Canada into the HGB area. Cluster four represents stagnant air conditions, a frequent cause of ozone accumulation. Cluster five shows trajectories that originate from the northeast, in the Ohio River Valley, that bring polluted air from more populated areas into the HGB area. Cluster six illustrates trajectories from the east, some of which cross over Louisiana and the Beaumont-Port Arthur (BPA) area and some of which cross over the Gulf of Mexico. The mean centerline from each of the six clusters is shown in Figure 5-34: *Means of Six 60-Hour Backward Trajectory Clusters*. Trajectories were compared to ozone concentrations in the HGB area to quantify how these trajectories are related to ozone in the HGB area.

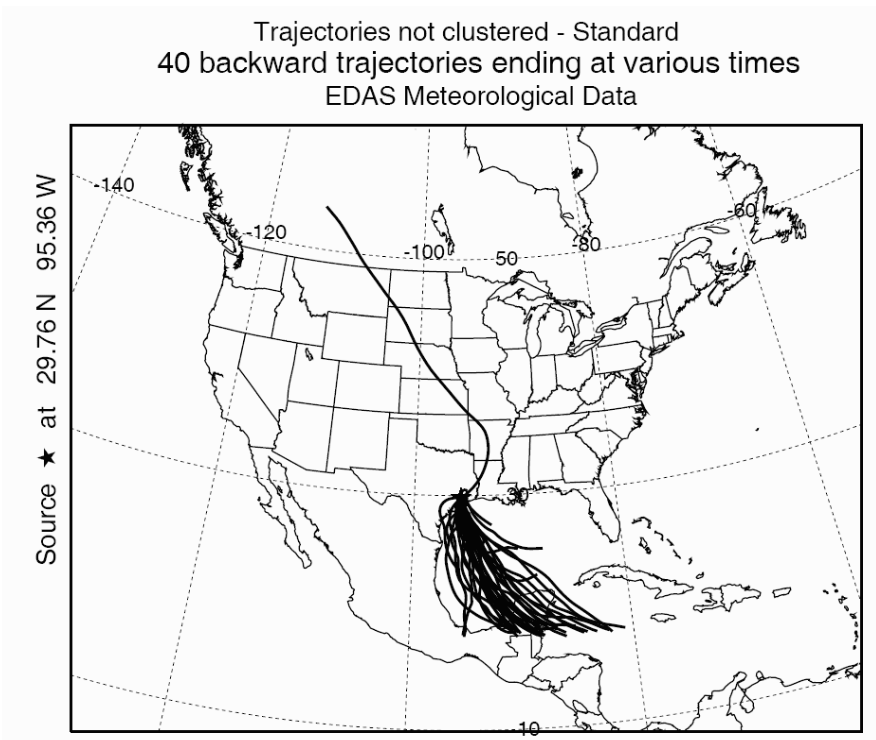


Figure 5-33: Cluster 0 Backward Trajectories

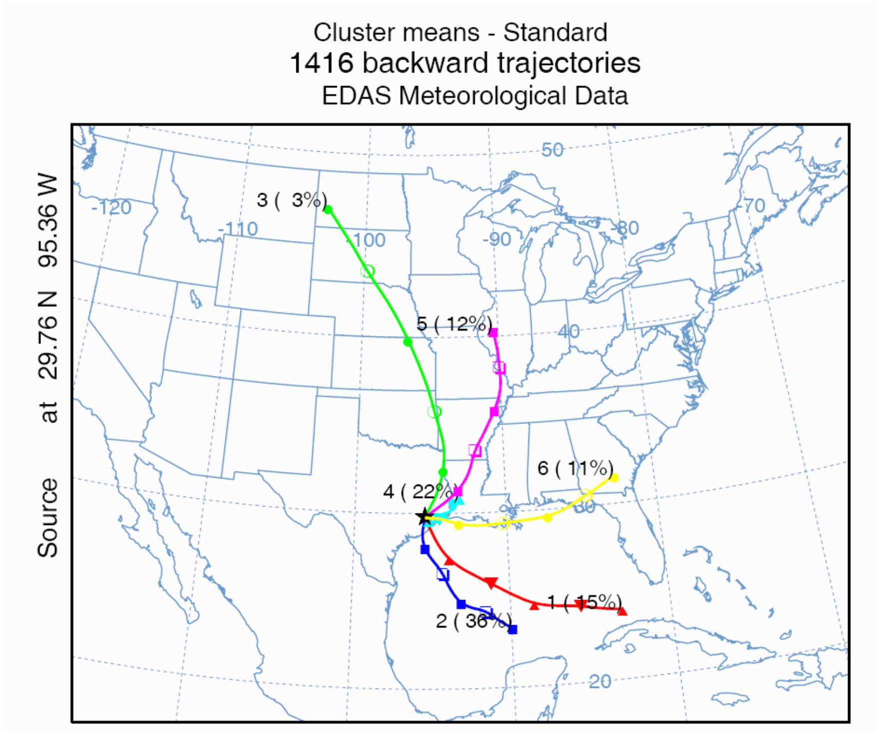


Figure 5-34: Means of Six 60-Hour Backward Trajectory Clusters

Twelve ozone sites, shown in Figure 5-35: *Sites Used in Ozone Area Maximum and Background Determination*, that had near continuous operation from 2000 to 2007 in the HGB area were selected to compare with trajectory clusters. In an effort to use measurements from a consistent, long-term set of monitors, data from sites that were shut down were combined with data from sites that began collecting data near the sites that were taken off-line. Sites where data were combined are Lake Jackson (CAMS 1016) and Clute (CAMS 11), and Galveston Airport (CAMS 34/CAMS 109/CAMS 154) and Galveston Airport 99th St. (CAMS 1034). Sites were selected based on locations as either a site upwind or downwind of the HGB area. Northwest Harris County (CAMS 26), the Lake Jackson (CAMS 1016) / Clute (CAMS 11) combined site pair, and the Galveston Airport (CAMS 34/CAMS 109/CAMS 154)/ Galveston 99th St. (CAMS 1034) combined site pair generally represent sites measuring background ozone concentrations. Sites on the downwind side of downtown Houston and the Houston Ship Channel generally represent sites measuring maximum ozone concentrations in the HGB area. Maximum peak and minimum peak eight-hour ozone concentrations from the twelve monitors were found for each day, then merged with the cluster classification from each day. Following Nielson-Gammon et al. (2005), that minimum peak eight-hour average ozone concentration was used to represent the "background" ozone level in the HGB Area.

Figure 5-35: Sites Used in Ozone Area Maximum and Background Determination

Table 5-22: *Ozone Statistics for HYSPLIT Back Trajectory Clusters* summarizes average maximum and average minimum, or background, ozone concentrations for each cluster. Average maximum peak daily eight-hour ozone among the clusters ranges from 40.6 ppb to 73.3 ppb, while average minimum peak daily eight-hour ozone, considered a proxy for background ozone concentrations, ranges from 21.4 ppb to 45.1 ppb. The difference between these two means can be used as a surrogate for locally produced ozone. Cluster four and cluster five, which represent the short fetch and the northeast fetch, have the highest average maximum ozone concentrations, 71.6 ppb and 73.3 ppb, respectively, and the highest average background, 40.8 ppb and 45.1 ppb. These two clusters also exhibit some of the largest average differences or local contributions. Cluster zero, the far southeast cluster, cluster one, the east southeast cluster, and cluster two, the southeast cluster, exhibited some of the lowest average background and average peak ozone; these clusters are expected to have a lower background ozone due to their origins over the Gulf of Mexico.

Table 5-22: Ozone Statistics for HYSPLIT Back Trajectory Clusters

Cluster	Fetch	Number of back trajec-tories	Average maximum peak daily eight-hour ozone	Average minimum peak daily eight-hour ozone	Average difference, minimum and maximum ozone*
		#	*ppb*	*ppb*	*ppb*
5	NE	166	73.3	45.1	28.1
4	Short	312	71.6	40.8	30.8
6	East	151	61.1	35.6	25.5
3	North	49	59.1	37.2	21.9
2	SE	506	48.5	24.8	23.7
0	far SE	40	45.0	23.8	21.1
1	ESE	217	40.6	21.4	19.1

* May not sum due to rounding. Note: Data is May through October, 2000 to 2007. Fetch represents the main direction of the cluster, count is the number of back trajectories in each cluster, average minimum peak daily eight-hour ozone is taken as the background ozone concentration. Clusters are sorted in descending order by average maximum peak daily eight-hour ozone.

The 95 percent confidence intervals for the mean eight-hour ozone maximum for each cluster are shown in Table 5-23: *Average Maximum Ozone and 95 Percent Confidence Intervals*. Two standard errors were used for the confidence intervals in each row. The confidence intervals in the table show that differences between means are statistically significant for most of the pair-wise comparison. This is shown graphically in Figure 5-36: *Average Maximum Ozone and 95 Percent Confidence Intervals*. Fetches originating from the northeast and east, as well as the "short" fetch, have the highest average peak daily ozone values, and they are tightly clustered. Clusters originating from the north and far southeast have noticeably wider confidence intervals, indicating more variability, but with lower average peak daily ozone concentrations than the northeast and east clusters.

Table 5-23: Average Maximum Ozone and 95 Percent Confidence Intervals

Cluster ranked by maximum average	Fetch	Count	Average maximum peak daily eight-hour ozone	Average maximum + 2 standard errors	Average maximum - 2 standard errors
		#	*ppb*	*ppb*	*ppb*
5	NE	166	73.3	76.7	69.8
4	Short	312	71.6	74.3	68.9
6	East	151	61.1	64.5	57.8
3	North	49	59.1	65.2	53.0
2	SE	506	48.5	50.3	46.6
0	far SE	40	45.0	51.5	38.4
1	ESE	217	40.6	42.7	38.5

Note: Confidence intervals were constructed using two standard errors. Clusters are sorted in descending order by average maximum peak daily eight-hour ozone. Confidence intervals for differences between the area ozone maximums generally do not overlap beyond one or two rows.

Although many of the selected sites were intended to represent background and maximum ozone in the HGB area, note that on many days true background ozone concentrations may be observed farther away, in more rural areas, and the true maximum ozone concentration may also be underestimated. Despite uncertainty in estimates of true background and maximum ozone concentrations, the large number of observations used in this analysis, as well as evidence presented earlier, provide clear evidence that ozone in the HGB area is affected by transport of ozone from external sources.

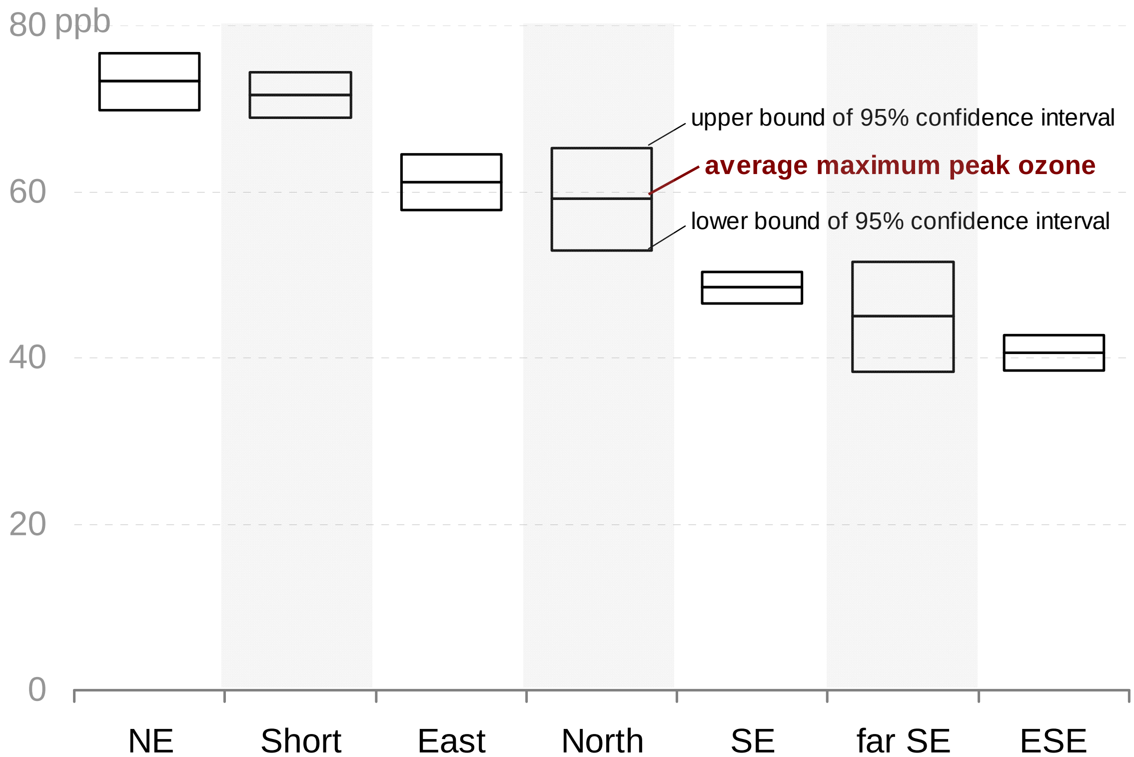


Figure 5-36: Average Maximum Ozone and 95 Percent Confidence Intervals

Figure 5-37*: Relationship Between Minimum and Maximum Ozone Concentrations*, recreated from Sullivan (2009), shows there is a significant linear relationship between mean HGB area minimum and maximum eight-hour average ozone concentrations by trajectory cluster (p-value < 0.01). The dark red points and estimated regression line represent the relationship between mean maximum ozone and mean minimum (background) ozone concentrations by cluster. The olive points and estimated regression line represent the relationship between "local contribution" (difference between maximum and minimum) and mean minimum ozone concentrations by cluster. The relationship between maximum and minimum ozone by cluster suggests that trajectory direction is a factor determining severity of both HGB area maximum and background ozone concentrations (Sullivan, 2009). The estimated slope parameter ($\beta = 1.36$) of the ordinary least squares regression of average minimum ozone concentration against average maximum ozone concentration shows that maximum ozone concentration increases at a greater rate with trajectory direction when compared to minimum ozone.

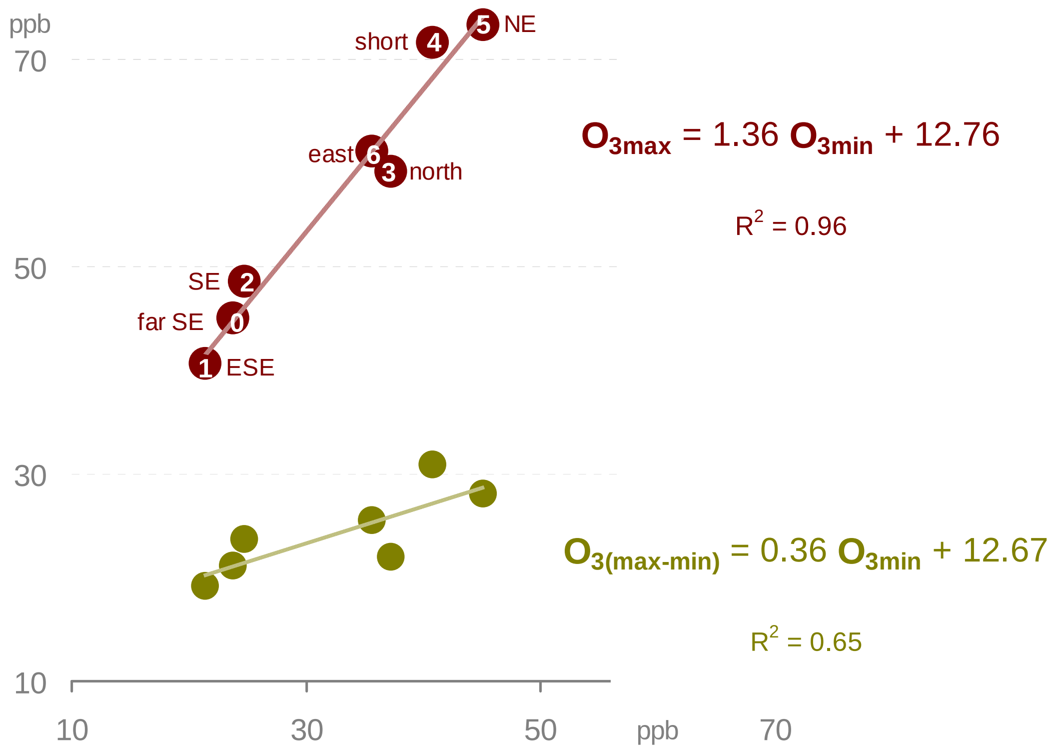


Figure 5-37: Relationship Between Minimum and Maximum Ozone Concentrations

Figure 5-37: *Relationship Between Minimum and Maximum Ozone Concentrations* also shows that the difference between mean HGB area maximum and minimum ozone concentrations is also roughly linear with area minimum, but with a lower slope (β=0.36) and lesser statistical significance (p-value=0.03) (Sullivan, 2009). The linear relationship between the difference and mean HGB area minimum ozone suggests the transport direction also affects local ozone production. The slower air movement of cluster four, which is the "short" cluster, allows greater accumulation in the area under lower local surface wind speeds. Winds originating from the directions of cluster six, the "east" cluster, and cluster five, the "northeast" cluster, help to move surface air along the area around the Houston Ship Channel and across the downtown Houston area, which, as noted, contain large amounts of ozone precursors. Overall, this analysis shows that directions of back trajectories can account for up to 24 ppb of variation in background ozone concentrations, and up to 35 ppb of variation in maximum ozone concentrations.

5.3.11 Transport and Surface Wind Trajectories

While still incomplete, a preliminary analysis of upper level, or transport, wind trajectories was conducted to confirm and extend findings from the previously discussed directional analysis. Additional HYSPLIT modeling of 48-hour back trajectories at 1,500 meters altitude for May through August, 2000 to 2008, was used to detect difference in trajectories across years that may have influenced ozone concentrations in the HGB area.

A simple visual inspection of the densities of distributions of trajectory end points presented in Figure 5-38: *Distributions of End Points from HYSPLIT 48-Hour Back Trajectories* shows that upper level wind patterns for 2008, a year which had relatively low ozone concentrations, do not noticeably differ from patterns in other years. Of the years analyzed, the pattern for 2000, a year with relatively high levels of ozone, is perhaps the most similar to 2008. The spatial distribution is similar among years and wind speeds are also similar. Higher wind speeds are evident in 2004 and 2005, as implied by trajectories with longer fetches. The implication is that the wind patterns observed during 2008 were not responsible for the lower ozone concentrations observed, since high ozone was observed during other years that had wind patterns similar to 2008.

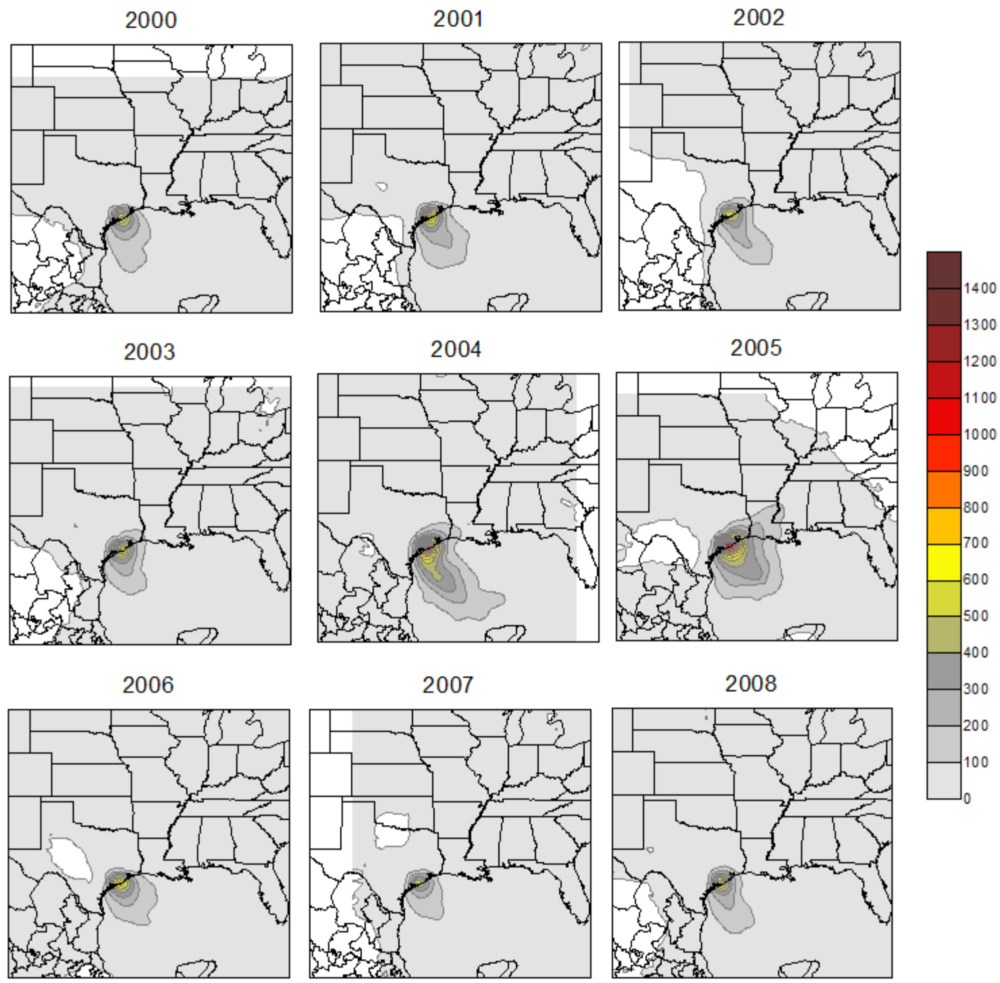


Figure 5-38: Distributions of End Points from HYSPLIT 48-Hour Back Trajectories

5.3.12 Background Ozone in Texas

Research on the meteorology of the HGB area has found that the highest background ozone transported into the HGB area predominately originates from the north and northeast (Nielson-Gammon et al., 2005). In the present analysis, two techniques are used to examine background ozone concentrations in Texas since 2000. The first technique examines the trend in ozone concentrations at four sites that can be considered background sites under certain flow conditions. The second technique examines ozone concentrations associated with different patterns of long-term backward trajectories.

Identifying appropriate background ozone monitoring sites from which to ascertain trends is complicated by local ozone, complex wind patterns, and natural variability in background ozone itself. To estimate background ozone, Nielson-Gammon et al. evaluated all monitors in the region to identify those that could be considered to be recording background ozone values. They proposed a modification of a TCEQ procedure to identify such sites.

The TCEQ procedure involves determining the direction of transport winds, then selecting a rural monitor upwind of the area in that direction. Nielson-Gammon et al. simply select as the background value the lowest of the peak eight-hour ozone values from all monitors. Unlike the

Nielson-Gammon procedure, which used gridded output of a meteorological model, this analysis follows the TCEQ approach using direct measurements of surface winds and tracking background ozone concentrations over time at selected monitors. Modifying the Nielson-Gammon procedure, the approach presented here identifies the 90th percentile values recorded at the selected monitors and examines the distribution of daily maximum ozone concentrations over time to determine whether these supposed background concentrations have increased or decreased. Both the Nielson-Gammon method and the TCEQ method may not strictly estimate background ozone, as defined above, because they do not remove any potential recirculation of pollutants generated via local emissions. Also, background ozone alone may not tell the complete story, since ozone precursors, which can react with each other and with local emissions to produce ozone, may also be present in transported air.

Four candidate monitors were selected for this analysis and are listed in Table 5-24: *Monitors Selected for Background Transport Analysis*. Two monitors, West Orange (CAMS 9) and Mauriceville (CAMS 642/CAMS 311/CAMS 665), are located east of the HGB area, adjacent to the Texas-Louisiana border, east of the BPA area; one, Karnack (CAMS 85), is located in northeast Texas near the Texas-Louisiana-Arkansas border and the Tyler-Longview-Marshall (TLM) area; and one, Hamshire (CAMS 64/CAMS 654), is located east of the HGB area, between the HGB area and the BPA area. Each of these monitors was selected for specific purposes. West Orange (CAMS 9) and Mauriceville (CAMS 642/CAMS 311/CAMS 665) were chosen because they are as close as possible to the Texas border and, thus, are useful for isolating background ozone being transported into the state from the east. Karnack (CAMS 85), in northeast Texas, is also very near the Texas border, and was selected to provide an assessment of background ozone transport from more northerly regions. The final site, Hamshire (CAMS 64/CAMS 654), was selected to aid stratification of background ozone being transported into the HGB area into a component originating outside the state, and a component contributed by the BPA area.

Table 5-24: Monitors Selected for Background Transport Analysis

Monitor	metro area	location	years	CAMS code
West Orange	BPA	TX-LA border	2000-2008	C9/A141
Mauriceville	BPA	TX-LA border	2000-2008	C642/C311/C665
Karnack	TLM	TX-LA-AR border	2001-2008	C85/AFHP303
Hamshire	HGB	between BPA and HGB	2000-2008	C64/C654

Source: TCEQ/LEADS database. Data with wind speeds less than 3 miles per hour were excluded to minimize influences from periods of stagnation which may result in over estimation of background concentrations.

To isolate ozone being transported into the state, measurements at the selected monitors were restricted by wind direction. The West Orange (CAMS 9) monitor is located less than 3 miles from the Louisiana border but is near several industrial sites. Only ozone measurements taken when winds originated from directions ranging from 30° to 90° (Figure 5-39: *Mauriceville C642/C311/C665) and West Orange (C9) Monitors*) were considered, to minimize possible influence from these sources. Thirty degrees corresponds to a north-northeast direction and 90^{o} is due east. The Mauriceville (CAMS 642/CAMS 311/CAMS 665) monitor is located ten miles from the Louisiana border, north of the West Orange (CAMS 9) monitor. This site may have some minor influence from relatively small NO_X and VOC sources. Data from this monitor was restricted to wind directions originating from 30° to 90°, similarly to West Orange (CAMS 9), to minimize any possible influence of nearby point sources.

The Karnack (CAMS 85) monitor in the TLM area is located eight miles from the Texas-Louisiana border, and roughly 20 miles from Arkansas. Measurements from Karnack (CAMS 85) were restricted to wind directions originating from 30° to 135° (Figure 5-40: *Karnack C85Monitor*), that is, from north-northeast clockwise to southeast. Though this site is not near the HGB area, it records large influxes of continental air transported from the Midwestern United States into Texas, which ultimately may raise background ozone concentrations throughout the state. Also, estimates of background ozone concentrations from Karnack (CAMS 85) can be compared to background estimates from West Orange (CAMS 9) and Mauriceville (CAMS 642/CAMS 311/CAMS 665), which is useful for corroborating estimates at these two sites, and determining the range of background ozone entering the state.

The final site under consideration is Hamshire (CAMS 64/CAMS 654), located between the HGB area and the BPA area. Ozone measurements from this site can be used to estimate background ozone concentrations transported to the HGB area when winds are from the east. These background ozone measurements are a combination of pollution transported into Texas, as well as the contribution of pollution from the BPA area. To avoid undue influence of nearby industrial sites, similar to Karnack (CAMS 85), data from Hamshire (CAMS 64/CAMS 654) are restricted to measurements obtained when winds originate from directions ranging from 30° to 135°. For the four monitors, monthly 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles of hourly ozone concentrations were calculated for the spring and summer ozone season, May through September, 2000 through 2008, except Karnack (CAMS 85) which only has data since 2001. These values are plotted in Figure 5-42: *Selected Statistics for the West Orange C9 Monitor*, Figure 5-43: *Selected Statistics for the Mauriceville C642/C311/C665 Monitor*, Figure 5-44: *Selected Statistics for the Karnack C85 Monitor*, and Figure 5-45: *Selected Statistics for the Hamshire C64/C654 Monitor*. Ninetieth percentile values are reported in Table 5-25: *Range of Monthly* 90^{th} *Percentile Daily Peak Hourly Ozone Concentrations for Subject Wind Directions*.

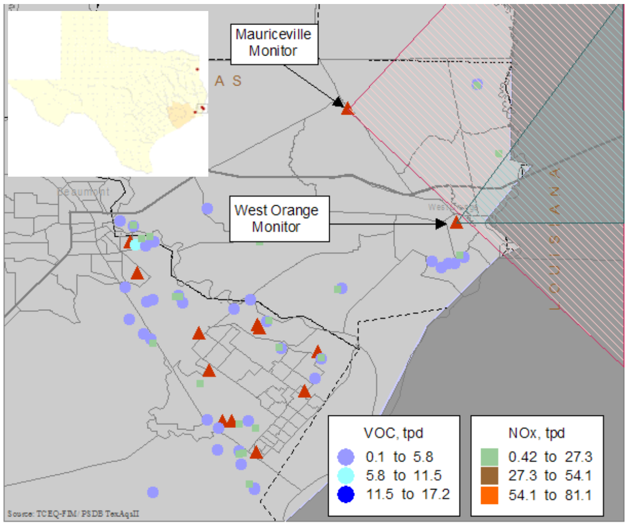


Figure 5-39: Mauriceville C642/C311/C65 and West Orange C9/A141 Monitors

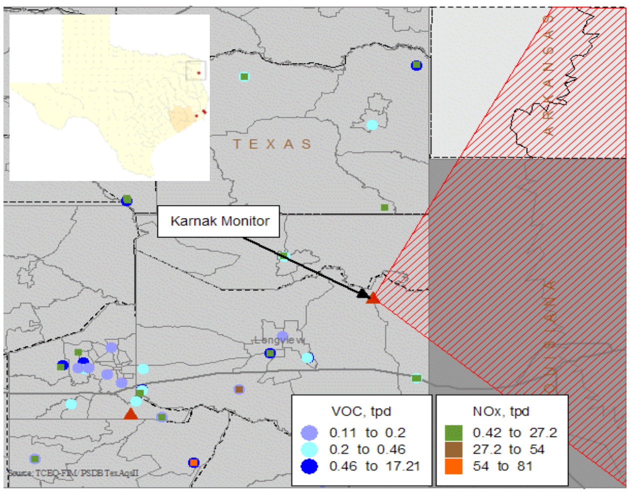


Figure 5-40: Karnack C85 Monitor

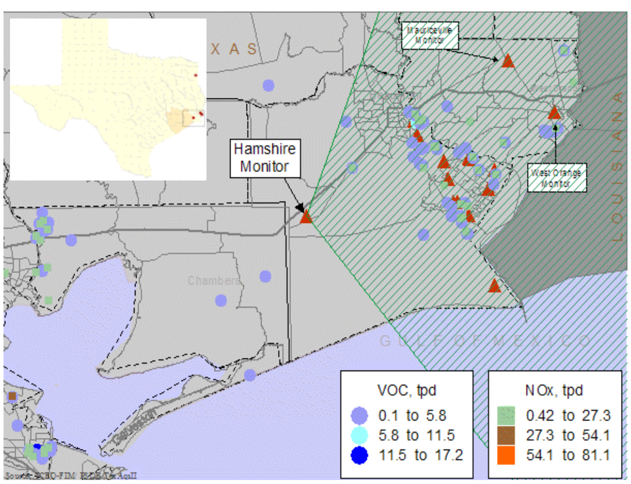


Figure 5-41: Hamshire C64/C654 Monitor

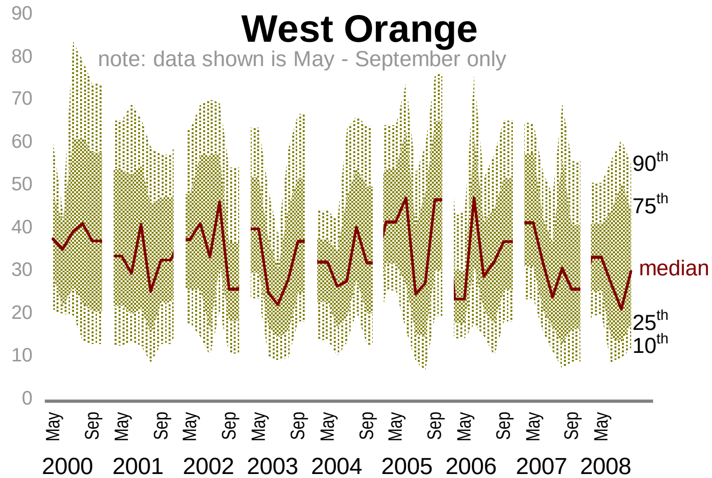


Figure 5-42: Selected Statistics for the West Orange C9 Monitor

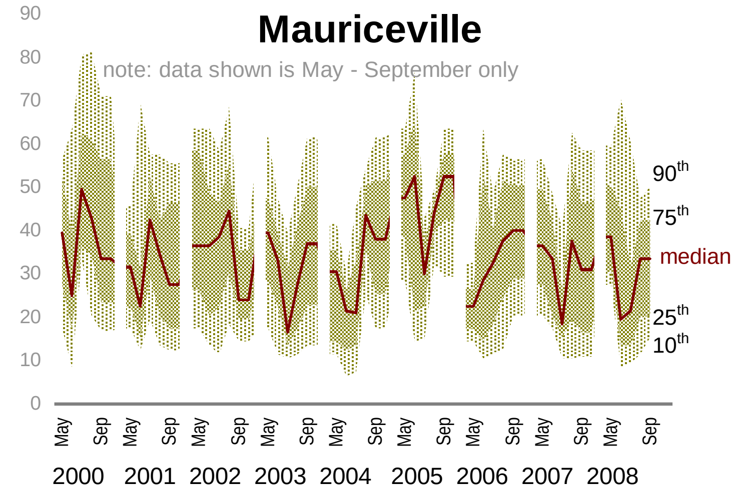


Figure 5-43: Selected Statistics for the Mauriceville C642/C311/C665 Monitor

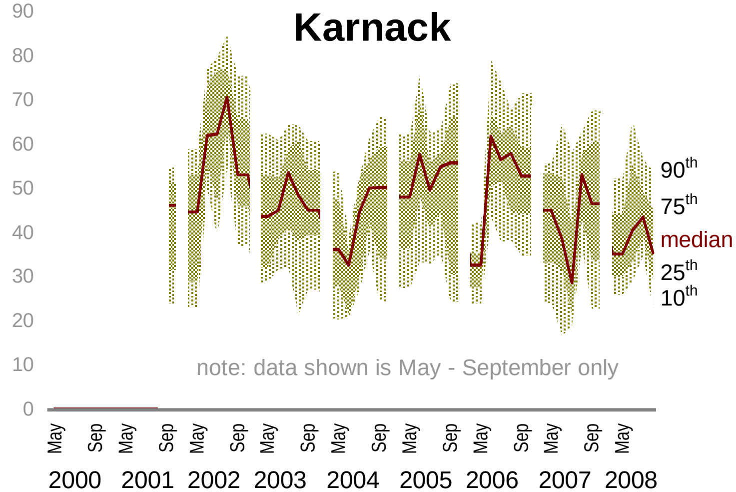


Figure 5-44: Selected Statistics for the Karnack C85 Monitor

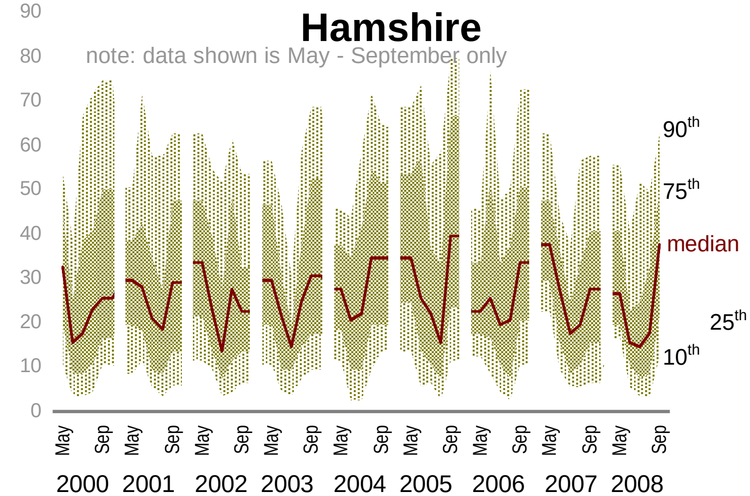


Figure 5-45: Selected Statistics for the Hamshire C64/C654 Monitor

Table 5-25: Range of Monthly 90th Percentile Daily Peak Hourly Ozone Concentrations for Subject Wind Directions

	Hamshire C64/C654		Karnack C85		Mauriceville C642/C311/C665		West Orange C9	
year	min	max	min	max	min	max	min	max
	ppb	*ppb*	*ppb*	*ppb*	*ppb*	*ppb*	*ppb*	*ppb*
2000	38	74	.	.	56	81	43	**83**
2001	50	**71**	.	54	45	69	57	68
2002	51	62	58	**84**	40	68	53	69
2003	30	**68**	60	64	39	61	38	66
2004	43	**71**	39	66	30	61	41	66
2005	55	**79**	62	75	43	76	52	75
2006	45	76	42	**78**	32	63	43	75
2007	37	62	55	67	40	62	47	**69**
2008	40	62	.	65	47	**70**	50	60
9-year period	30	79	39	**84**	30	81	38	83

Note: Though data has been restricted by wind direction to mitigate influences from nearby pollution sources, there may be unknown influences that are unaccounted for. Maximum values for each year are highlighted in boldface type.

To statistically verify whether a trend across time exists in the data, an index of date was fit to the daily peak values using ordinary least squares regression. Additional regressions were performed using an index of month against the selected percentiles of the monthly distributions. The resulting parameter estimates from these models revealed no statistically significant trend at the 5 percent significance level; however, the data likely suffer from autocorrelation, a problem common to time series data. Time series data are often not independent, but correlated with themselves across time, which complicates formal statistical estimation by biasing parameter estimates.

Rather than performing the procedures necessary to detect, measure, and correct for autocorrelation, a careful visual inspection of time series plots, presented in Figure 5-42: *Selected Statistics for the West Orange C9 Monitor* through Figure 5-45: *Selected Statistics for the Hamshire C64/C654 Monitor*, satisfies that no time trend is perceptible. These four figures plot the five selected percentiles of the monthly distributions at each monitor. While no trend is detectable, what is apparent is that ozone concentrations measured at these monitors, which have been restricted in such a way as to proxy background levels, vary substantially. Background ozone at these monitors varies as much as 35 ppb, due to meteorological effects and ozone dynamics occurring in upwind regions.

Notable in Figure 5-45: *Selected Statistics for the Hamshire C64/C654 Monitor*, hourly ozone concentrations at Hamshire (CAMS 64/CAMS 654) behave similarly to West Orange (CAMS 9) and Karnack (CAMS 85), in that there is no observable or statistically significant trend of the median or 90th percentile values. The 90th percentile value at Hamshire (CAMS 64/CAMS 654), considering directionally restricted data for May to September, 2000 through 2008, is 59 ppb. This value is in the range of values computed by Nielson-Gammon using different procedures; however, the 90th percentile can exceed 80 ppb at any of the sites, and even exceeded 90 ppb at Mauriceville (CAMS 642/CAMS 311/CAMS 665) in 2000. TexAQS II also found background ozone concentrations that exceed the 1997 eight-hour ozone NAAQS (TexAQS II Rapid Science Synthesis Team 2006).

Over the 2000 through 2008 period, the maximum 90th percentile one-hour ozone concentrations at West Orange (CAMS 9) and Mauriceville (CAMS 642/CAMS 311/CAMS 665) are 79 and 92, respectively. The maximum 90th percentile for Karnack (CAMS 85) over the 2001 through 2008 period is 81. Karnack (CAMS 85) appears to consistently measure a higher background than either West Orange (CAMS 9) or Mauriceville (CAMS 642/CAMS 311/CAMS 665). These results are consistent with estimates reported by Nielson-Gammon, et al. (2005), which also found higher background ozone concentrations during the ozone season in northeast Texas than in the HGB area.

Regression analysis was used to determine whether the 90th percentile values at West Orange (CAMS 9) and Mauriceville (CAMS 642/CAMS 311/CAMS 665) track one another, which suggests they are measuring roughly equivalent phenomena. The resulting R^2 of 0.78, which is significant at a probability level less than 0.1 percent (Table 5-26: *Parameter Estimates for Regression of West Orange C9 on Mauriceville C*642/C311/C665, indicates very strong correlation between measurements at the two sites. The scatter plot of the data is illustrated in Figure 5-46: *Scatter-plot of 90th Percentile Hourly Values at West Orange C9 and Mauriceville C642/C311/C665*. The values in the scatter plot are from May through September, 2000 to 2008. The scatter plot supports the contention that these two monitors are measuring roughly the same phenomena, under wind-restricted regimes.

Table 5-26: Parameter Estimates for Regression of West Orange C9 on Mauriceville C642/C311/C665

	intercept	slope
β estimate	4.95706	1.01251
Std. Error	0.55480	0.01421
t-statistic	8.935	71.278
Pr(>|t|)	<2e-16	<2e-16
R^2	0.78	

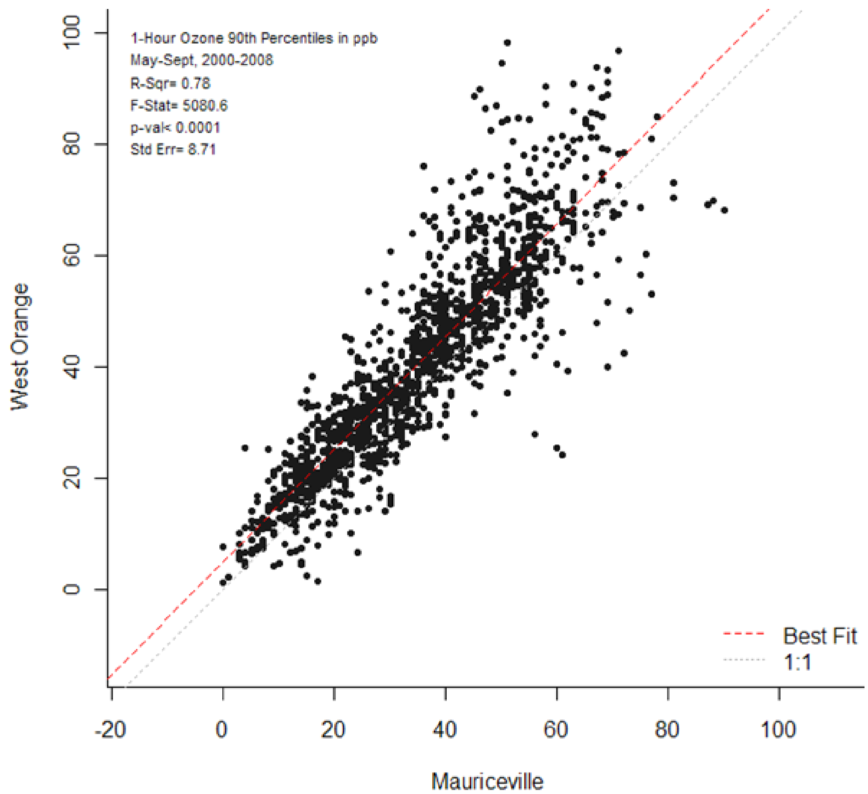


Figure 5-46: Scatter-plot of 90th Percentile Hourly Values at West Orange C9 and Mauriceville C642/C311/C665

In summary, none of the four sites used for estimating background ozone concentrations recorded a statistically significant trend. The Karnack (CAMS 85) monitoring site recorded the highest 90th percentile measurement of the four background sites, with 90th percentile ozone concentrations reaching as high as 63 ppb. Since it is farthest from the HGB area, however, the HGB area may not be strongly affected by the ozone observed at this site, at least not on the same day.

5.3.13 Air Quality Trends Conclusions

Ozone concentrations have decreased dramatically in the HGB area since the 1990s. Examination of trends in one-hour ozone, eight-hour ozone, the number of exceedances, the spatial distribution of ozone, the seasonal distribution of ozone, and the strength of ozone gradients all show substantial downward trends. The causes of the trends were investigated by examining the meteorological variations that have occurred over the years, by evaluating the local changes in ozone precursor concentrations, and by examining trends in background ozone. The analyses found that the interannual meteorological variations cannot explain the observed decreases in ozone, and that the ozone precursors are on statistically significant downward trends. In addition, the analyses have found that background ozone has not dropped substantially since 2000, suggesting that the significant ozone reductions in the HGB area are due to local emission controls, not due to background ozone decreases.

5.4 QUALITATIVE CORROBORATIVE ANALYSIS

5.4.1 Introduction

Because photochemical modeling is an evaluation tool and not an absolute prediction of future ozone concentrations, additional data must be considered in order to draw conclusions about the validity of the final predicted design value and whether the attainment demonstration satisfies the requirements of the Federal Clean Air Act (FCAA). The EPA's "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5,}$ and Regional Haze," referenced as modeling guidance in Chapter 3, *Photochemical Modeling* acknowledges that many issues cannot be accurately quantified and therefore cannot be properly included in the photochemical modeling demonstration. The qualitative corroborative analysis contains information regarding federal preemption issues and analysis of additional measures that were not included in the modeling.

5.4.2 Federal Preemption Issues

The TCEQ has limited authority to regulate certain components of the emissions inventory. The federal government has jurisdiction over on-road and non-road vehicles, ships, locomotives, and aircraft, among other sources. Since states cannot control sources that are under federal jurisdiction or located in other states, the state is limited in its ability to impose controls on all of the sources that contribute to ozone formation in a nonattainment area.

5.4.2.1 Federal Assignment

While these categories have been addressed through expeditiously implemented state incentive programs such as the Low Income Vehicle Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program (LIRAP) and the Texas Emissions Reduction Plan (TERP), future reductions are dependent on the prompt implementation of new federal engine and fuel standards for on-road and non-road vehicles, ships, locomotives, and aircraft.

5.4.3 Additional Measures

5.4.3.1 New International Marine Diesel Engine and Marine Fuel Standards for Oceangoing Vessels and Emissions Control Areas

In October 2008, the United States ratified the International Maritime Organization's (IMO) adoption of the amendments to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL) for new international marine diesel engine and marine fuel standards for oceangoing vessels (OGV). The new Annex VI Tier II and Tier III emission standards will apply to diesel engines with a power rating above 130 kilowatts (kW) (i.e., 175 horsepower) installed on marine vessels constructed on or after January 1, 2011 (Tier II), and January 1, 2016 (Tier III), or diesel engines above 130 kW that undergo a major conversion on or after those dates. The revised MARPOL Annex VI will become effective on July 1, 2010.

In March 2009, the United States submitted a request to the IMO for the creation of an emissions control area (ECA) around the nation's coastlines. If the ECA is granted, all marine diesel fuels used by OGV in the ECA will be limited to a maximum sulfur content of 1,000 ppm beginning January 1, 2015, and all new engines on OGV operating in these areas must use emission controls that achieve an 80 percent reduction in NO_X emissions beginning January 1, 2016. Table 5-27: *New MARPOL Annex VI Emission Standards for Marine Diesel Engines* lists the new emission standards for marine diesel engines with greater than 30 liter per cylinder displacement.

Table 5-27: New MARPOL Annex VI Emission Standards for Marine Diesel Engines

New MARPOL Annex VI emission standards for marine diesel engines with >30 liter per cylinder displacement			
Engine Speed (n)	NO_X Emission Standards (g/kW–hr)		
	Tier 1	Tier 2	Tier 3
N < 130 revolutions per minute (rpm)	17.0	14.4	3.4
2000 > n ≥ 130 rpm	$45.0 \times n^{-0.20}$	$44.0 \times n^{-0.23}$	$9.0 \times n^{-0.20}$
N ≥ 2000 rpm	9.8	7.7	2.0
Applicable to engines installed in vessels constructed on:	01/01/2000 – 12/31/2010	01/01/2011 - 12/31/2015	01/01/2016 and thereafter

Note: NO_X emission standards presented in grams per kilowatt hour.

In the August 28, 2009, issue of the *Federal Register* (74 FR 44442), the EPA proposed rulemaking to adopt new federal Tier 2 and Tier 3 engine standards for new marine engines above 30 liters per cylinder displacement (i.e., Category 3 marine diesel engines) that are consistent with the new MARPOL Annex VI NO_X emission standards shown in Table 5-27: *New MARPOL Annex VI Emission Standards for Marine Diesel Engines*. The EPA's proposed new Category 3 marine diesel engine standards also include new standards limiting the emissions of hydrocarbons and carbon monoxide from new Tier 2 and later Category 3 engines to 2.0 g/kW-hr and 5.0 g/kW-hr, respectfully.

The EPA regulations for marine diesel fuel and new marine engines less than 30 liters per cylinder displacement and the new MARPOL Annex VI standards for marine residual fuels and new marine diesel engines above 30 liters per cylinder displacement will apply to all OGV flagged and registered in the United States. The EPA's proposed new regulations for new Category 3 marine engines and new sulfur limits for marine diesel fuel will also apply to all OGV flagged and registered in the United States. In addition, the new MARPOL Annex VI standards will apply to all new marine diesel engines and fuels on foreign marine vessels that operate near United States coasts and ports.

The new marine diesel engine and fuel standards will provide a 96 percent reduction in sulfur in marine diesel fuels, as well as an 85 percent reduction in particulate matter emissions and an 80 percent reduction in NO_X emissions, when compared to current standards (EPA, 2009a, http://www.epa.gov/otaq/oceanvessels.htm#emissioncontrol). The cumulative effects of these new marine diesel engine and fuels standards will result in a 0.5 to 1.0 ppb reduction of ozone in the ambient air of the HGB ozone nonattainment area by 2020 (EPA, 2009b).

5.4.3.2 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 voluntary EPA program for 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 voluntary measures over three years, providing the EPA with annual updates of their progress throughout that period.

SmartWay carriers 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.

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 5 percent. 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 5 percent.

The extended periods of idling typically associated with long-haul trucks consume an average of one gallon of fuel per hour, while generating associated emissions. New technologies such as auxiliary power units (APU) and truck stop electrification (TSE) systems 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 10 percent.

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 through ongoing research, and in conjunction with the more than 2,000 companies nationwide already committed as SmartWay partners, the EPA has identified a variety of technologies and the potential fuel savings and emissions reductions from those technologies. There are 87 Texas companies that are currently SmartWay partners.

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

Partnering with the EPA Region 6 and Region 7 through this effort are the environmental and energy agencies from the 10 states along the Interstate Highway 35 (IH-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.

To achieve these objectives, the collaborative develops partnerships among international, federal, state, and local governments, as well as non-profit organizations, environmental groups, and private industries. These partnerships work together in projects along the key transportation corridors by sharing emission reduction technologies and leveraging financial resources from a variety of sources.

5.4.3.3 Control of VOC Emissions from Flash Emissions

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 underestimated, unreported, or underreported in the TCEQ emissions inventory 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 flash, generally have been underestimated, unreported, or underreported in the emission inventory. Flash emissions occur when a liquid with entrained gases goes from a high pressure to a low pressure. As the pressure on the liquid drops, some of the lighter VOC dissolved in the liquid are released or flashed. Compounds that are liquids at the initial pressure may transform from a liquid into a vapor and are also released from the liquid. As these gases are released, some of the heavier compounds in the liquids may become entrained in these gases and are emitted with the lighter VOC.

In May 2007, the commission adopted rule amendments to 30 Texas Administrative Code (TAC) Chapter 115, Subchapter B, Division 1 that revised the requirements for VOC storage tanks located in the HGB ozone nonattainment area. The revised requirements were developed to reduce VOC emissions that result from uncontrolled flash emissions at upstream oil and gas exploration and production sites and other sources of tank emissions. At the time of the rule proposal, the amount of flash emissions from minor sources was unknown.

A method for quantifying flash emissions became available around the same time. Houston Advanced Research Center Project 51C, conducted in 2006, quantified emission rates from heater-treaters (separators) and storage tank batteries, including flash and condensate tanks, associated with the upstream oil and gas industry in the Dallas-Fort Worth and HGB ozone nonattainment areas, and Jefferson County. In April 2007, the TCEQ used the results of this study to determine the flash emissions from the oil and gas production industry. However, the flash emissions were not included in the 2005 area source periodic emissions inventory (PEI) because there was not sufficient time to incorporate the emissions before the 2005 area source PEI was submitted to the EPA in May 2007. However, the updated 2005 area source emissions inventory is being used for this SIP revision. More information on this study can be found at: http://www.harc.edu/Projects/AirQuality/Projects/Projects/H051C.

The rule amendments adopted in May 2007 resulted in actual reductions to flash emissions but no credit is claimed in this SIP revision. Crude and condensate storage tanks at upstream oil and gas exploration and production sites or midstream pipeline breakout stations with uncontrolled flash emissions greater than 25 tons per year (tpy) are controlled under the rule. Since the method of calculating the emissions was based on county-level production, it is unknown at this time how many sites were over 25 tpy and were required to put on controls. Also unknown is how much flash emissions were already controlled due to economic reasons. Because of the unknown total effect of this rule, the reduction in flash emissions cannot be quantified at this time and is not included in the modeling for this SIP revision. These amendments to Chapter 115 are described in more detail in the preamble of the adopted rule (Project Number 2006-038-115-EN).

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

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

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

- 76th Texas Legislature, 1999
  - Senate Bill (SB) 7 (Regular Session)
  - House Bill (HB) 2492 (Regular Session)
  - HB 2960 (Regular Session)
- 77th Texas Legislature, 2001
  - SB 5 (Regular Session)
  - HB 2277 (Regular Session)
  - HB 2278 (Regular Session)
  - HB 2845 (Regular Session)
- 78th Texas Legislature, 2003
  - HB1365 (Regular Session)
- 79th Texas Legislature, 2005
  - SB 20 (First Call Session)
  - HB 2129 (Regular Session)
  - HB 2481 (Regular Session)
- 80th Texas Legislature, 2007
  - HB 66 (Regular Session)
  - HB 3070 (Regular Session)
  - HB 3693 (Regular Session)
  - SB 12 (Regular Session)

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

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

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

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

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

Commercial Building Codes
The THSC, Chapter 388, Texas Building Energy Performance Standards, as adopted by the 77th Texas Legislature, 2001, states in § 388.003(b) that all other residential, commercial, and industrial construction must meet the energy efficiency performance standards established in the energy efficiency chapter of the International Energy Conservation Code.

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

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

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

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

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

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

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

5.4.3.5 Clean Air Interstate Rule (CAIR)

The EPA projects that CAIR regional controls will improve air quality in the HGB area, as well as most of Texas, according to EPA's Texas CAIR Web page, http://www.epa.gov/cair/tx.html.

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

CAIR is implemented in two phases: for NO_X, Phase I covers the years 2009 through 2014 and Phase II is for the years 2015 and later; for SO_2, Phase I covers the years 2010 through 2014 and Phase II is for the years 2015 and later. The Phase I NO_X budget calculated and assigned to Texas was 181,014 tons per year, and the Phase II NO_X budget was 150,845. Because 2018 is the HGB ozone attainment year, this SIP revision incorporates CAIR Phase II (post 2014 step-down of CAIR) which provides for a Texas state-wide NO_X budget of 150,845 tons per year, or 413.3 tons per day.

See Appendix B: *Emissions Modeling for the HGB Attainment Demonstration SIP*, Section 2.3.1.2.1 for the procedural details that the TCEQ used to simulate CAIR Phase II in Texas and the regional states.

On July 11, 2008, the United States Court of Appeals District of Columbia Circuit (Court) (No. 05-1244) vacated CAIR and the CAIR Federal Implementation Plan (FIP). On December 23, 2008, the Court issued a revised opinion to remand, without vacating, CAIR to the EPA. Therefore, CAIR will remain in effect while the EPA analyzes data and conducts rulemaking to modify the program to comply with the Court's July 2008 opinion. The Court declined to impose a schedule by which the EPA must complete the rulemaking, but reminded the EPA that the Court does ". . . not intend to grant an indefinite stay of the effectiveness of this Court's decision." For more information on the ruling, see EPA's CAIR Web page, http://www.epa.gov/cair/, or the TCEQ CAIR/CAMR Web page, http://www.tceq.state.tx.us/implementation/air/sip/caircamr.html.

Any future EPA revision to the CAIR program to comply with the court's ruling may result in additional reductions.

5.4.3.6 Texas Emission Reduction Plan (TERP)

The TERP program was created in 2001 by the 77th Texas Legislature to provide grants to offset the incremental costs associated with reducing NO_X emissions from high-emitting internal combustion engines. To date the TERP program has funded over $700 million in grants for projects in Texas ozone nonattainment and near-nonattainment areas. Over $300 million of that amount has been awarded to projects in the HGB area since 2001, which will help reduce more than 66,000 tons of NO_X emissions. Of that $300 million, $5 million was awarded to the H-GAC through a third-party grant to administer additional grants in the HGB area.

Additional funds are expected to be awarded to the HGB area in subsequent grant application periods that will result in further NO_X reductions. HB 1796, 81st Texas Legislature, 2009, extended the TERP program beyond its current 2013 date to 2019, which will result in continued reductions in the significant emissions source categories of on-road and non-road engines.

5.4.3.7 Low Income Vehicle Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program (LIRAP)

SB 12, 80th Texas Legislature, 2007, enhanced LIRAP to expand participation by increasing the income eligibility to 300 percent of the federal poverty rate and increasing the amount of assistance toward the replacement of a retired vehicle. The program, known as AirCheckTexas Drive a Clean Machine (DACM), provides $3,500 for hybrids of the current or previous model year; $3,000 for cars of the current or three model years; and, $3,000 for trucks of the current or previous two model years. The retired vehicle must be 10 years or older or have failed an emissions test. In the HGB area, DACM is available to vehicle owners in five counties: Brazoria, Fort Bend, Galveston, Harris, and Montgomery. Between December 2007 and May 31, 2009, LIRAP/DACM has retired and replaced 9,330 vehicles at a cost of $28,370,520. An additional 3,949 vehicles have had emissions-related repairs at a cost of $2,136,602. The total repair and retirement/replacement funding for the HGB area since December 2007 is $30,507,122.

5.4.3.8 Clean School Bus Program

HB 3469, 79th Texas Legislature, 2005, established the Clean School Bus Program. The new program is codified in THSC, Chapter 390 and implemented through 30 TAC §§ 114.640 – 114.648.

The program is based on the EPA guidance documents, *Improving Air Quality with Economic Incentive Programs* (EPA-452/R-01-001) and *Diesel Retrofits: Quantifying and Using Their Benefits in SIPs and Conformity* (EPA-420-B-06-005). Under the economic incentive program guidance, the TCEQ is using the financial mechanism option, which is described as subsidies targeted at promoting pollution-reducing activities or products.

The Clean School Bus Program was established to provide monetary incentives for school districts in the state for reducing emissions of diesel exhaust in school buses. Eligible technologies include those approved by the EPA, certified by the California Air Resources Board, or those that the executive director finds will bring about significant emissions reductions. Some of the technologies eligible for funding under the program reduce NO_X emissions. However, the technologies mainly reduce particulate matter and reduce only negligible amounts of NO_X. The 80th Texas Legislature, 2007, provided funding for the Clean School Bus Program.

As of May 2009, the TCEQ Clean School Bus grant program has allocated $13.8 million in grants for nearly 5,000 school buses in Texas. In addition, through Supplemental Environmental Projects (SEPs), the TCEQ has also allocated over $3.5 million to third-party SEP receivers for the same kind of school bus retrofits.

5.4.3.9 81st Texas Legislature, 2009

HB 432 requires state agencies that purchase passenger vehicles or other ground transportation vehicles for general use to ensure that not less than 25 percent of new vehicles purchased during a biennium meet or exceed EPA's Tier II, Bin 3 emission standards. This bill also limits the purchase of state agency passenger vehicles or other ground transportation vehicles purchased for general use to only those vehicles that use compressed natural gas, liquefied natural gas, liquefied petroleum gas, methanol or methanol/gasoline blends of 85 percent or greater, ethanol or ethanol/gasoline blends of 85 percent or greater, biodiesel or biodiesel/diesel blends of 20 percent or greater, or electricity, including electricity to power a plug-in hybrid motor vehicle.

HB 1796 establishes a New Technology Implementation Grants (NTIG) program for facilities and stationary sources under TERP, requires the current New Technology Research and Development under TERP to be administered by the TCEQ, and extends the TERP to August 31, 2019. See Section 5.4.3.6, Texas Emission Reduction Plan (TERP), for additional information.

SB 1759 establishes a Texas Clean Fleet Program to be administered by the TCEQ, funding it with 5 percent of the 87.5 percent of the Emission Reduction Incentives Grant within TERP. The Texas Clean Fleet Program will provide grants to encourage large fleets to replace diesel-powered fleet vehicles with hybrid vehicles or alternative fuel-powered vehicles.

5.4.3.10 American Waterways Operators Tank Barge Emissions Best Management Practices

Using infrared gas imaging technology in field studies conducted in the summer of 2005, the TCEQ detected inadvertent VOC emissions from tank barges operating in the HGB area. The Louisiana Department of Environmental Quality (LDEQ) also detected inadvertent emissions from tank barges in similar field studies conducted in the same time period. In response to these field studies, the American Waterways Operators (AWO) voluntarily developed industry Best Management Practices (BMP) to reduce VOC emissions from tank barges. The BMP includes procedures to reduce VOC emissions from equipment and operations on tank barges. The recommendations are a combination of inspection, corrective action, preventative maintenance, operational, procedural, and training practices.

The BMP was reviewed by the Chemical Transportation Advisory Committee (CTAC), United States Coast Guard, LDEQ, and TCEQ. The BMP was distributed to AWO members in 2006 for implementation on a voluntary basis. In 2009, AWO reconvened the Tank Barge Emissions Working Group to review the BMP and make further improvements to the document. The improved BMP will be sent to CTAC, the Coast Guard, LDEQ, and TCEQ for review once it has been finalized by industry. While the BMP is a voluntary measure and does not impose an enforceable commitment on AWO members, the implementation of the BMP, where applicable, may contribute to reducing inadvertent VOC emissions from barges during dock operations and during transit, which will help improve the air quality in the HGB area. A copy of the 2006 BMP document is provided in Appendix J: *Recommendations for Best Management Practices to Control and Reduce Inadvertent Cargo Vapor Emissions in the Tank Barge Community*.

5.4.3.11 Local Initiative Projects

SB 12, 80th Texas Legislature, 2007, allowed the use of unexpended LIRAP funds to be used for Local Initiative Projects. These projects provide funding to LIRAP-participating counties for implementation of air quality improvement strategies through local projects and initiatives. Local Initiative Projects may include:

- expand and enhance the repair and replacement program;
- develop and implement programs to remotely determine vehicle emissions and notify the vehicle's operator;
- develop and implement projects for coordinating with local law enforcement officials to reduce the use of counterfeit state inspection stickers;
- develop and implement programs to enhance transportation system improvements; or
- develop and implement new air control strategies designed to assist local areas in complying with state and federal air quality rules and regulations.

5.4.3.12 Other Local Programs

The Houston-Galveston Area Council submitted the following programs, which were not committed to as Transportation Control Measures or Voluntary Mobile Emission Reduction Program measures, but may be implemented locally in the HGB area. For a detailed analysis of these programs, see Appendix F: *Evaluation of Mobile Source Control Strategies for the Houston-Galveston-Brazoria State Implementation Plan* (prepared by ENVIRON for the Houston-Galveston Area Council).

Scrappage and Buy-Back Plan

This measure would build on the existing LIRAP, implemented as part of the AirCheckTexas Vehicle Emissions Testing program, by increasing the number of on-road light-duty gasoline vehicles scrapped. The plan would also make separate funds available to help with the purchase of new on-road heavy-duty diesel vehicles (HDDV) to replace old, highly polluting vehicles.

Pay-As-You-Drive Insurance

Pay-As-You-Drive Vehicle Insurance, also called Distance-Based Vehicle Insurance and Mileage-Based Insurance, is a program that allows a vehicle's insurance premiums to be based directly on how many miles the vehicle is driven during the policy term. Currently, vehicle insurance is structured where high-mileage drivers are, in essence, subsidized by low-mileage drivers since all drivers are charged the same premiums after accounting for driving history related to collisions and traffic violations.

Limitations on Idling of Heavy-Duty Vehicles; Creation of Regional Government Idling Restrictions

Idling of vehicles is inherently an inefficient operation that can produce unwanted air pollutants. Idling also occurs during normal driving and other operations such as when the engine powers necessary accessories, known as power take-off, including man-lifts or concrete tumblers. It is not possible to eliminate all idling, but idle reduction programs are typically low in cost and may result in a net savings to the owner/operator of the vehicle while also reducing air emissions.

Encourage/Mandate Livable Centers

The EPA developed the Smart Growth Implementation Assistance (SGIA) program in response to communities' requests for help achieving their development goals. Through this program, the EPA provides technical assistance from private-sector experts to help communities find the best tools and resources for planning growth in ways that sustain environmental and economic progress and create a high quality of life. The Gulf Coast Institute, Main Street Coalition, and Texas A&M partnered to apply for and received an SGIA grant in 2006. While the City of Houston is not participating in the SGIA program at this time, the area has expressed interest in evaluating the potential effects of these measures on travel activity and emissions.

Enhanced Enforcement of Smoking Vehicles

This measure would encourage local law enforcement officers to enforce existing smoking vehicle laws and enable the emissions inspection status of smoking vehicles to be checked. Owners of smoking vehicles displaying a valid inspection sticker would be fined. Smoking vehicles not having a valid inspection sticker would be impounded if the sticker were found to be fraudulent.

Limitation on Idling of Heavy-Duty Construction Equipment

Idling is an inefficient use of equipment in general and generates unnecessary emissions. Idling however cannot be avoided in all cases, such as during normal work, when work is performed intermittently, and when the time to restart the engine would be considered a significant delay. This measure would seek to limit excessive idling when equipment is not required immediately. Suggested periods for limiting idling could be as little as 15 minutes maximum. Many on-road trucks have factory-installed engine shutdown systems that automatically shut down the engine after a set period, or devices could be added to existing equipment. To implement this measure, engine shutdown systems could be employed with idle timers set to a period that would not cause typical operational problems. Operator training could provide significant idle reduction perhaps beyond engine shutdown systems.

5.5 CONCLUSIONS

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

First, the photochemical grid modeling performs relatively well. Problems observed with the modeling are those that are known to exist in all photochemical modeling exercises. In spite of the known shortcomings, the model can be used carefully to predict ozone concentrations. The photochemical grid modeling predicts that the control strategy package chosen by the TCEQ can lower the ozone design values in the HGB area down to a value very near the 0.08 ppm eight-hour ozone standard. The dynamic model evaluations show that the model response to emission decreases is less than the response observed in the atmosphere, suggesting that the proposed emission controls are more likely to yield attainment of the eight-hour 0.08 ppm ozone standard than the absolute modeled design values indicate.

Second, the ozone trend analyses show that ozone has decreased significantly since the late 1990s. Meteorological variations alone cannot explain the significant downward trend. Decreases in background ozone cannot explain the downward trend either. Significant decreases in ozone precursors, however, coincide with the decreases in ozone, indicating that the ozone decreases observed in the HGB area are due to local emission controls.

Third, many additional air quality improvement measures are being adopted in the HGB area that cannot be included in the photochemical modeling analysis because they cannot be accurately quantified. These additional measures can provide additional assurance that the HGB area is on the path toward attainment.

Based upon the photochemical grid modeling results and these corroborative analyses, the weight of evidence indicates that the HGB area will attain the 1997 eight-hour ozone standard by June 15, 2019.

5.6 REFERENCES

Banta R., C. Senff, J. Nielsen-Gammon, L. Darby, T. Ryerson, R. Alvarez, P. Sandberg, E. Williams, and M. Trainer, 2005. A bad air day in Houston. Bull. of the American Meteorological Society, 86(5): 657-669.

Bao, J.-W., S. A. Michelson, S. A. McKeen, and G. A. Grell, 2005. Meteorological evaluation of a weather-chemistry forecasting model using observations from the TEXAS AQS 2000 field experiment. J. Geophys. Res. 110(D21105), doi:10.1029/2004JD005024.

Berkowitz, C. M., T. Jobson, G. Jiang, C. W. Spicer, and P. V. Doskey, 2004. Chemical and meteorological characteristics associated with rapid increases of O_3 in Houston, Texas. J. of Geophysical Research, 109:D10307, doi:10.1029/2004JD004141, 2004.

Berkowitz, C. M., C. W. Spicer, P. V. Doskey, 2005. Hydrocarbon observations and ozone production rates in Western Houston during the Texas 2000 Air Quality Study. Atmos. Environ. 39:3383–3396.

Brown, S. G., P. T. Roberts, and J. A. Roney, 2002. Preliminary characterization of 2001 event-triggered VOC and carbonyl samples. STI-900680-2188-IR. Prepared by Steven G. Brown, Paul T. Roberts, Jason A. Roney of Sonoma Technology, Inc. Prepared for Erik Gribbin, Texas Natural Resources Conservation Commission, July 17.

Brown, S. G., and H. Hafner Main, 2002. Acquisition, review and analysis of auto-GC VOC data in the Houston area, 1998-2001: Final report. STI-900670-2224-FR. Prepared by Steven G. Brown and Hilary Hafner Main, Sonoma Technology, Inc. Prepared for Erik Gribbin, Texas Natural Resource Conservation Commission, July 31. http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/da/AutoGC_VOC_Data_Houston_Final_Report.pdf

Buzcu, B., and M. P. Fraser, 2006. Source identification and apportionment of volatile organic compounds in Houston, TX, Atmos. Environ., 40:2385-2400.

Byun, D., S. Kim, B. Czader, D. Nowak, S. Stetson, and M. Estes, 2005a. Estimation of biogenic emissions with satellite-derived land use and land cover data for air quality modeling of Houston-Galveston ozone nonattainment area. J. Environ. Mgmt., 75:285-301.

Byun, D.W., Kim, S.-T., Czader, B., Cheng, F.-Y., Kim, S.-B., Percell, P., In, H.-J., Song, C.-K., Coarfa, V., and F.Ngan, 2005b. Role of modeling assumptions in the Houston midcourse review. Project H12 HRB Final Report by University of Houston for HARC, 25 February, Houston, TX, 90 pp.

Byun, D. W., S.-T. Kim, and S.-B. Kim, 2007. Evaluation of air quality models for the simulation of a high ozone episode in the Houston metropolitan area, Atmospheric Environment, 41(4): 837-853.

Camalier, L., Cox, W., and P. Dolwick, 2007. The effects of meteorology on ozone in urban areas and their use in assessing ozone trends. Atmospheric Environment 41, 7127-7137.

Chang, S., E. McDonald-Buller, Y. Kimura, G. Yarwood, J. Neece, M. Russell, P. Tanaka, and D. Allen, 2002. Sensitivity of urban ozone formation to chlorine emission estimates, Atmos. Environ. 36:4991–5003.

Chang, S., and D. Allen, 2006. Atmospheric chlorine chemistry in southeast Texas: Impacts on ozone formation and control. Environ. Sci. Technol. 40:251-262.

Chen, S., Ren, X., Mao, J., Chen, Z., Brune, W.H., Lefer, B., Rappenglück, B., Flynn, J., Olson, J., Crawford, J.H, 2009. A comparison of chemical mechanisms based on TRAMP-2006 field data, Atmospheric Environment (2009), doi: 10.1016/j.atmosenv.2009.05.027

Cheng, F.-Y. and D. W. Byun, 2008a. Application of high resolution land use and land cover data for atmospheric modeling in the Houston-Galveston metropolitan area, Part I: Meteorological simulation results, Atmos. Environ., 42:7795-7811.

Cheng, F.-Y., S. Kim, and D. W. Byun, 2008b. Application of high resolution land use and land cover data for atmospheric modeling in the Houston-Galveston Metropolitan area: Part II: Air quality simulation results, Atmos. Environ., 42:4853-4869.

Cohan, D., Y. Hu, and A. Russell, 2006. Dependence of ozone sensitivity analysis on grid resolution. Atmos. Environ., 40:126-135.

Cowling, E. and the Rapid Science Synthesis Team, 2007. Final Rapid Science Synthesis Report: Findings from the Second Texas Air Quality Study (TexAQS II). A Report to the TCEQ by the TexAQS II Rapid Science Synthesis Team, Prepared by the Southern Oxidants Study Office of the Director, North Carolina State University, Raleigh, North Carolina, August 31.

Czader, B. H., D. W. Byun, S.-T. Kim, and W. P.L. Carter, 2008. A study of VOC reactivity in the Houston-Galveston air mixture utilizing an extended version of SAPRC-99 chemical mechanism, Atmos. Environ., 42, Issue 23, Selected Papers from the First International Conference on Atmospheric Chemical Mechanisms, July, 5733-5742 pp, doi:10.1016/j.atmosenv.2008.01.039.

Daum, P.H., L. I. Kleinman, S. R. Springston, L. J. Nunnermacker, Y.-N. Lee, J. Weinstein-Lloyd, J. Zheng, and C. M. Berkowitz, 2003. A comparative study of O_3 formation in the Houston urban and industrial plumes during the 2000 Texas Air Quality Study. J. of Geophysical Research, 108:4715, doi:10.1029/2003JD003552.

Daum, P.H., L. I. Kleinman, S. R. Springston, L. J. Nunnermacker, Y.-N. Lee, J. Weinstein-Lloyd, J. Zheng, and C. M. Berkowitz, 2004. Origin and properties of plumes of high ozone observed during the Texas 2000 Air Quality Study (TexAQS 2000). J. of Geophysical Research, 109, D17306, doi:10.1029/2003JD004311.

De Gouw, J., S. Te Lintel Hekkert, J. Mellqvist, C. Warneke, E. Atlas, F. Fehsenfeld, A. Fried, G. Frost, F. Harren, J. Holloway, B. Lefer, R. Lueb, J. Meagher, D. Parrish, M. Patel, L. Pope, D. Richter, C. Rivera, T. Ryerson, J. Samuelsson, J. Walega, R. Washenfelder, P. Weibring, and X. Zhu, 2009. Airborne measurements of ethene from industrial sources using laser photo-acoustic spectroscopy, Environ. Sci. Technol., March 9, 10.1021/es802701a.

EPA, 2007. Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze, http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf.

EPA, 2009a. Oceangoing Vessels, Emission Control Area Designation, http://www.epa.gov/otaq/oceanvessels.htm#emissioncontrol, Office of Transportation and Air Quality.

EPA, 2009b. Regulatory Announcement: Proposal of Emission Control Area Designation for Geographic Control of Emissions from Ships, EPA-420-F-09-015, Figure 4: Potential Benefits of U.S. ECA Ozone Reductions in 2020, March 2009.

Esler, J. G., 2003. An integrated approach to mixing sensitivities in tropospheric chemistry: A basis for the parameterization of subgrid-scale emissions for chemistry transport models, J. Geophys. Res., 108(D20), 4632, doi:10.1029/2003JD003627.

Estes, M., S. Wharton, D. Boyer, Z. Fang, J. Smith, S. McDowell, F. Mercado, J. Neece, E. Gribbin, and J. Price, 2002. Analysis of Automated Gas Chromatograph Data from 1996-2001 to determine VOCs with largest ozone formation potential. Houston-Galveston-Brazoria Ozone SIP Revision Technical Support Document, Attachment 6, adopted by the TCEQ on December 12, 2002. 50 pp.
http://www.tceq.state.tx.us/assets/public/implementation/air/am/docs/hgb/tsd1/attachment6-agc_voc.pdf .

Fang, Z., and S. McDowell, 2003. Analysis of canister data for the Houston-Galveston and Beaumont-Port Arthur areas. Houston-Galveston-Brazoria Ozone Mid-Course Review SIP Revision, Appendix CC of Chapter 4, 15 pp.
http://www.tceq.state.tx.us/assets/public/implementation/air/sip/sipdocs/2004-05-HGB/04042sipapcc.pdf . Figures for Appendix CC:
http://www.tceq.state.tx.us/assets/public/implementation/air/sip/sipdocs/2004-05-HGB/04042sipapccfigs.zip .

Faraji, M., Y. Kimura, E. McDonald-Buller, and D. Allen, 2008. Comparison of the carbon bond and SAPRC photochemical mechanisms under conditions relevant to southeast Texas, Atmos. Environ. 42:5821-5836, doi.org/10.1016/j.atmosenv.2007.07.048 .

Fast, J. D., W. I. Gustafson Jr., R. C. Easter, R. A. Zaveri, J. C. Barnard, E. G. Chapman, G. A. Grell, and S. E. Peckham, 2006. Evolution of ozone, particulates, and aerosol direct radiative forcing in the vicinity of Houston using a fully coupled meteorology-chemistry-aerosol model, J. Geophys. Res., 111, D21305, doi:10.1029/2005JD006721.

Gego, E., C. Hogrefe, G. Kallos, A. Voudouri, J. Irwin, and S.T. Rao, 2005. Examination of model predictions at different horizontal grid resolutions, Environmental Fluid Mechanics, 5:63-85.

Gilliland, Alice B., Christian Hogrefe, Robert W. Pinder, James M. Godowitch, Kristen L. Foley, and S.T. Rao, 2008. Dynamic evaluation of regional air quality models: Assessing changes in O3 stemming from changes in emissions and meteorology, Atmospheric Environment, In Press, Accepted Manuscript, Available online February 21.

Gilman, J., W. Kuster, P. Goldan, S. Herndon, M. Zahniser, S. Tucker, A. Brewer, B. Lerner, E. Williams, R. Harley, F. Fehsenfeld, C. Warneke, and J. de Gouw. 2009, Measurements of volatile organic compounds during the 2006 TexAQS/GoMACCS campaign: Industrial influences, regional characteristics, and diurnal dependencies of the OH reactivity, J. Geophys. Res., 114, D00F06, doi:10.1029/2008JD011525.

Hafner Main, H., T. O'Brien, C. Hardy, S. Wharton, and D. Sullivan, 2001. Characterization of auto-GC data in Houston, prepared for Jim Price of the Texas Natural Resource Conservation Commission, August 31, 81 pp.
http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/da/CharacterizationAutoGCdata.pdf

Hafner, H. and S. Brown, 2003. Exploratory Source Apportionment of Houston's Clinton Drive Auto-GC 1998-2001 Data. Prepared for Erik Gribbin, Texas Commission on Environmental Quality, May 15, 144 pp. http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/da/Source_Apportionment_of_AutoGC_Data.pdf

Hardesty, M., C. Senff, R. Alvarez, R. Banta, S. Sandberg, A. Weickmann, L. Darby, Y. Pichugina, D. Law, R. Marchbanks, W. Brewer, D. Merritt, and J. Machol, 2007. Mixing heights and three-dimensional ozone structure observed by airborne lidar during the 2006 Texas Air Quality Study. AGU Fall Meeting 2007, A51G-02.

Hu D., M. Tolocka, Q. Li, and R. Kamens, 2007. A kinetic mechanism for predicting secondary organic aerosol formation from toluene oxidation in the presence of NO_X and natural sunlight. Atmos. Environ. 41:6478-6496.

Jiang, G. and J. Fast, 2004. Modeling the effects of VOC and NO_X emission sources on ozone formation in Houston during the TexAQS 2000 field campaign. Atmos. Environ. 38:5071-5085.

Jobson, B. T., C. M. Berkowitz, W. C. Kuster, P. D. Goldan, E. J. Williams, F. C. Fesenfeld, E. C. Apel, T. Karl, W. A. Lonneman, and D. Riemer, 2004. Hydrocarbon source signatures in Houston, Texas: Influence of the petrochemical industry, J. Geophys. Res., 109, D24305, doi:10.1029/2004JD004887.

Jolly, J., S. McDowell, B. Kurka, F. Mercado, J. Neece, and G. Cantú, 2003. Analyzing VOC reactivity in Houston. December 13, 2003. Houston-Galveston-Brazoria Ozone Mid-Course Review SIP Revision, Appendix GG of Chapter 4, adopted December 1, 2004, 36 pp. http://www.tceq.state.tx.us/assets/public/implementation/air/sip/sipdocs/2004-05-HGB/04042sipapgg_pro.pdf .

Jolly, J, 2003. Assessing the importance of carbonyl compounds in ozone formation in Houston-Galveston: Relative reactivities of carbonyl and hydrocarbon species. May 2003, updated May 3, 2004. Houston-Galveston-Brazoria Ozone Mid-Course Review SIP Revision, Appendix EE of Chapter 4, 13 pp. http://www.tceq.state.tx.us/assets/public/implementation/air/sip/sipdocs/2004-05-HGB/04042sipapee_pro.pdf .

Karl, T., T. Jobson, W. C. Kuster, E. Williams, J. Stutz, R. Shetter, S. R. Hall, P. Goldan, F. Fehsenfeld, and W. Lindinger, 2003. Use of proton-transfer-reaction mass spectrometry to characterize volatile organic compound sources at the La Porte super site during the Texas Air Quality Study 2000, J. Geophys. Res., 108(D16), 4508, doi:10.1029/2002JD003333, 2003.

Kemball-Cook, S., C. Emery, and G. Yarwood, 2005. Impact and role of air quality modeling assumptions in the development of revisions to the Houston State Implementation Plan for attaining the ozone air quality standard, HARC project H12.8HRB, Final Report, March.

Kim, E., S. G. Brown, H. R. Hafner, and P. K. Hopke, 2005. Characterization of non-methane volatile organic compounds sources in Houston during 2001 using positive matrix factorization, Atmos. Environ., 39:5934-5946.

Kleinman L. I., P. H. Daum, D. Imre, Y.-N. Lee, L. J. Nunnermacker, S. R. Springston, J. Weinstein-Lloyd, and J. Rudolph, 2002. Ozone production rate and hydrocarbon reactivity in 5 urban areas: A cause of high ozone concentration in Houston, Geophys. Res. Lett., 29 (10), doi:10.1029/2001GL014569.

Kleinman, L. I., P. H. Daum, Y.-N. Lee, L. J. Nunnermacker, S. R. Springston, J. Weinstein-Lloyd, and J. Rudolph, 2005. A comparative study of ozone production in five U.S. metropolitan areas, J. Geophys. Res., 110, D02301, doi:10.1029/2004JD005096.

Koo, B., G. Yarwood, and D. Cohan, 2008. Higher-Order Decoupled Direct Method (HDDM) for Ozone Modeling Sensitivity Analyses and Code Refinements, Work order 582-07-84005-FY08-07, August 31.

Langford A., C. Senff, R. Banta, R. Hardesty, R. Alvarez, S. Sandberg, L. Darby, 2009. Regional and local background ozone in Houston during TexAQS 2006, J. Geophys. Res. 114, doi: 10.1029/2008JD011687

Lelieveld, J., T. Butler, J. Crowley, T. Dillon, H. Fischer, L. Ganzeveld, H. Harder, M. Lawrence, M. Martinez, D. Taraborrelli, and J. Williams, 2008. Atmospheric oxidation capacity sustained by a tropical forest, Nature, 452, doi: 10.1038/nature06870, 10 April 2008.

Li, S., J. Matthews, and A. Sinha, 2008. Atmospheric hydroxyl radical production from electronically excited NO2 and H2O, Science, 319: 1657, doi: 10.1126/science.1151443.

Mao, J., Ren, X., Chen, S., Brune, W.H., Chen, Z., Martinez, M., Harder, H., Lefer, B., Rappenglück, B., Flynn, J., and M. Leuchner, 2009. Atmospheric Oxidation Capacity in the Summer of Houston 2006: Comparison with Summer Measurements in Other Metropolitan Studies, Atmospheric Environment, doi: 10.1016/j.atmosenv.2009.01.013

Mellqvist, J., J. Samuelsson, C. Rivera, B. Lefer, and M. Patel, 2007. Measurements of industrial emissions of VOCs, NH_3, NO_2 and SO_2 in Texas using the Solar Occultation Flux method and mobile DOAS, Final Report HARC project H-53, August 20,.http://www.tercairquality.org/AQR/Projects/H053.2005

Mellqvist, J., J. Johansson, J. Samuelsson, C. Rivera, B. Lefer, and S. Alvarez, 2008. Comparison of solar occultation flux measurements to the 2006 TCEQ emission inventory and airborne measurements for the TexAQS II, November 7, Report submitted to the TCEQ.

Morris, G., S. Hersey, A. Thompson, S. Pawson, E. Nielsen, P. Colarco, W. McMillan, A. Stohl, S. Turquety, J. Warner, B. Johnson, T. Kucsera, D. Larko, S. Oltmans, and J. Witte, 2006. Alaskan and Canadian forest fires exacerbate ozone pollution over Houston, Texas, on 19 and 20 July 2004, J. Geophys. Res., 111, D24S03, doi:10.1029/2006JD007090.

Murphy, C. F. and D. T. Allen, 2005. Hydrocarbon emissions from industrial release events in the Houston-Galveston area and their impact on ozone formation, Atmos. Environ. 39:3785–3798.

Nam, J., Y. Kimura, W. Vizuete, C. Murphy, and D. T. Allen, 2006. Modeling the impacts of emission events on ozone formation in Houston, Texas, Atmos. Environ., 40:5329-5341.

Nam, J., M. Webster, Y. Kimura, H. Jeffries, W. Vizuete, and D. T. Allen, 2008. Reductions in ozone concentrations due to controls on variability in industrial flare emissions in Houston, Texas, Atmos. Environ., 42:4198-4211, doi:10.1016/j.atmosenv.2008.01.035 .

Nielsen-Gammon, J., J. Tobin, and A. McNeel, 2005. A Conceptual Model for Eight-Hour Ozone Exceedances in Houston, Texas, Part I: Background Ozone Levels in Eastern Texas. Research report, supported by HARC, TERC, and TCEQ, HARC project H012.2004.8HRA, January 29.

Nielsen-Gammon, J. W., R. T. McNider, W. M. Angevine, A. B. White, and K. Knupp, 2007. Mesoscale model performance with assimilation of wind profiler data: Sensitivity to assimilation parameters and network configuration, J. Geophys. Res., 112, D09119, doi:10.1029/2006JD007633.

North, S. and B. Ghosh, 2009. Refining hydrocarbon oxidation mechanisms via isomeric specific radical initiated chemistry, Final Report. TCEQ tracking number 2008-93, Grant Activity No. 582-5-64593-FY08-22. 16 pp.

Osthoff, H., J. Roberts, A. Ravishankara, E. Williams, B. Lerner, R. Sommariva, T. Bates, D. Coffman, P. Quinn, J. Dibb, H. Stark, J. Burkholder, R. Talukdar, J. Meagher, F. Fehsenfeld, and S. Brown, 2008. High levels of nitryl chloride in the polluted subtropical marine boundary layer. Nature Geoscience doi: 10.1038/ngeo177, published online April 6.

Pinder, R., R. Gilliam, K. W. Appel, S. Napelenok, K. Foley, and A. Gilliland, 2009. Efficient probabilistic estimates of surface ozone concentration using an ensemble of model configurations and direct sensitivity calculations, Environ. Sci. Technol., Article ASAP, March 3, doi: 10.1021/es8025402.

Pour-Biazar, A. R. McNider, S. Roselle, R. Suggs, G. Jedlovec, D. Byun, S. Kim, C. Lin, T. Ho, S. Haines, B. Dornblaser, and R. Cameron, 2007. Correcting photolysis rates on the basis of satellite observed clouds, J. Geophys. Res., 112, D10302, doi:10.1029/2006JD007422.

Robinson, R., T. Gardiner, and B. Lipscombe, 2008. Measurements of VOC emissions from petrochemical industry sites in the Houston area using Differential Absorption Lidar (DIAL) during summer 2007, Draft. Submitted to Russell Nettles, TCEQ, by Rod Robinson, Tom Gardiner, and Bob Lipscombe of the National Physical Laboratory, Teddington, Middlesex UK TW11 0LW, February 8, 86 pp.

Ryerson, T. B., M. Trainer, W. M. Angevine, C. A. Brock, R. W. Dissly, F. C. Fehsenfeld, G. J. Frost, P. D. Goldan, J. S. Holloway, G. Huebler, R. O. Jakoubek, W. C. Kuster, J. A. Neuman, D. K. Nicks Jr., D. D. Parrish, J. M. Roberts, and D. T. Sueper, E. L. Atlas, S. G. Donnelly, F. Flocke, A. Fried, W. T. Potter, S. Schauffler, V. Stroud, A. J. Weinheimer, B. P. Wert, and C. Wiedinmyer, R. J. Alvarez, R. M. Banta, L. S. Darby, and C. J. Senff, 2003. Effect of petrochemical industrial emissions of reactive alkenes and NO_X on tropospheric ozone formation in Houston, Texas. J. of Geophysical Research, 108:4249, doi:10.1029/2002JD003070.

Sarwar, G., and P.V. Bhave, 2007. Modeling the Effect of Chlorine Emissions on Ozone Levels over the Eastern United States. J. Appl. Meteor. Climatol., 46**:**1009–1019.

Savanich, K., 2006. Ozone Exceedance Days as a Function of the Number of Monitors. Unpublished analysis for TCEQ, February.

Simon H., Y. Kimura, G. McGaughey, D. T. Allen, S. S. Brown, H. D. Osthoff, J. M. Roberts, D. Byun, and D. Lee, 2009. Modeling the impact of ClNO 2 on ozone formation in the Houston area, J. Geophys. Res., 114, D00F03, doi:10.1029/2008JD010732.

Smith, J. and J. Jarvie, 2008. Reconciling reported VOC emissions with ambient measurements, continued. Presented at Southeast Texas Photochemical Modeling Technical Committee Meeting, February 12. http://www.tceq.state.tx.us/assets/public/implementation/air/am/committees/pmt_set/20080212/20080212-smith-voc_emissions_ambient_measurements.pdf .

Smylie M., 2004. Further investigation of gas-imaging devices as an alternative to current leak detection and repair methods and the development of correlation equations for the ethylene industry. Prepared for the Texas Council on Environmental Technology, Austin, Texas, by Environ International Corporation, Mountain View, California, June 25, 145 pp.

Stuart, A. L., A. Aksoy, F. Zhang, and J. W. Nielsen-Gammon, 2007. Ensemble-based data assimilation and targeted observation of a chemical tracer in a sea breeze model, Atmos. Environ., 41:3082-3094.

Sullivan, D., 2009. Effects of Meteorology on Pollutant Trends. Final Report to TCEQ. Grant Activities No. 582-5-86245-FY08-01. Prepared by Dave Sullivan, University of Texas at Austin Center for Energy and Environmental Resources, Prepared for Kasey Savanich, for the Texas Commission on Environmental Quality, March 16.
http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/da/5820586245FY0801-20090316-ut-met_effects_on_pollutant_trends.pdf

Swall, J. and K. Foley, 2009. The impact of spatial correlation and incommensurability on model evaluation. Atmos. Environ. 43:1204-1217, doi:10.1016/j.atmosenv.2008.10.057.

Tanaka, P., D. Allen, and C. Mullins, 2003. Development of a chlorine mechanism for use in the carbon bond IV chemistry model. J. Geophys. Res., 108(D4): 4145, doi:10.1029/2002JD002432.

TCEQ, 2002. Houston-Galveston-Brazoria Attainment SIP Revision for the 1-hour ozone NAAQS, Technical Support Document, and Appendices and Attachments, December 13, 2002,
http://www.tceq.state.tx.us/implementation/air/sip/dec2002hgb.html#docs
http://www.tceq.state.tx.us/implementation/air/airmod/docs/hgmcr_tsd.html

TCEQ, 2004. Houston-Galveston-Brazoria Ozone SIP Mid-Course Review Modeling, proposed June 23, 2004, http://www.tceq.state.tx.us/implementation/air/sip/dec2004hgb_mcr.html . Modeling files available at
http://www.tceq.state.tx.us/implementation/air/airmod/data/hgb1.html#docs

TCEQ, 2006. Houston-Galveston-Brazoria 8-Hour Ozone SIP Modeling, September 21, 2006, Modeling of August 16 - September 6, 2000
http://www.tceq.state.tx.us/implementation/air/airmod/data/hgb2.html
www.tceq.state.tx.us/assets/public/implementation/air/sip/hgb/hgb_sip_2006/06027SIP_proCh2.pdf
www.tceq.state.tx.us/assets/public/implementation/air/sip/hgb/hgb_sip_2006/06027SIP_proCh3.pdf

Valari, M. and L. Menut, 2008. Does an increase in air quality models' resolution bring surface ozone concentrations closer to reality? J. Atmospheric and Oceanic Technology, 25:1955, doi: 10.1175/2008JTECHA1123.1.

Webster, M., J. Nam, Y. Kimura, H. Jeffries, W. Vizuete, and D. T. Allen, 2007. The effect of variability in industrial emissions on ozone formation in Houston, Texas, Atmos. Environ. 41:9580–9593.

Wert, B. P., M. Trainer, A. Fried, T. B. Ryerson, B. Henry, W. Potter, W. M. Angevine, E. Atlas, S. G. Donnelly, F. C. Fehsenfeld, G. J. Frost, P. D. Goldan, A. Hansel, J. S. Holloway, G. Hubler, W. C. Kuster, D. K. Nicks Jr., J. A. Neuman, D. D. Parrish, S. Schauffler, J. Stutz, D. T. Sueper, C. Wiedinmyer, and A. Wisthaler, 2003. Signatures of terminal alkene oxidation in airborne formaldehyde measurements during TexAQS 2000. J. of Geophysical Research, 108:4104, doi:10.1029/2002JD002502.

Xie, Y., and C. M. Berkowitz, 2006. The use of positive matrix factorization with conditional probability functions in air quality studies: An application to hydrocarbon emissions in Houston, Texas, Atmos. Environ., 40:3070-3091.

Xie, Y., and C. M. Berkowitz, 2007. The use of conditional probability functions and potential source contribution functions to identify source regions and advection pathways of hydrocarbon emissions in Houston, Texas, Atmos. Environ., 41:5831-5847.

Yarwood, G., T. Stoeckenius, and S. Lau, 2004. Top-down evaluation of the Houston emission inventory using inverse modeling. Project H006E.2002, Final Report to the Texas Environmental Research Consortium, available at: http://www.tercairquality.org/AQR/Projects/H006E.2002

Zamora, R. J., E. G. Dutton, M. Trainer, S. A. McKeen, J. M. Wilczak, and Y.-T. Hou, 2005. The accuracy of solar irradiance calculations used in mesoscale numerical weather prediction, Mon. Weather Rev., 133:783–792.

Zhang, F., N. Bei, J. W. Nielsen-Gammon, G. Li, R. Zhang, A. Stuart, and A. Aksoy, 2007. Impacts of meteorological uncertainties on ozone pollution predictability estimated through meteorological and photochemical ensemble forecasts, J. Geophys.Res., 112, D04304, doi:10.1029/2006JD007429.

Ziemba, L.D., Dibb, J.E., Griffin, R.J., Anderson, C.H., Whitlow, S.I., Lefer, B.L., Rappenglück, B., and J. Flynn, 2009. Heterogeneous conversion of nitric acid to nitrous acid on the surface of primary organic aerosol in an urban atmosphere, Atmospheric Environment, doi:10.1016/j.atmosenv.2008.12.024.

CHAPTER 6: ONGOING AND FUTURE INITIATIVES

6.1 INTRODUCTION

The Texas Commission on Environmental Quality (TCEQ) is committed to improving the air quality in the Houston-Galveston-Brazoria (HGB) area and continues to work toward identifying and reducing ozone precursors. Texas is investing resources into technological research and development for advancing pollution control technology, improving the science for ozone modeling and analysis, and refining quantification of volatile organic compound (VOC) emissions. Refining quantification of VOC emissions benefits SIP planning by improving understanding of ozone formation. Additionally, the TCEQ is working with the United States Environmental Protection Agency (EPA), local area leaders, and the scientific community to identify new measures for reducing ozone precursors. This chapter describes ongoing technical work that will be beneficial to improving air quality in Texas and the HGB area.

6.2 ONGOING WORK

6.2.1 Flare Task Force

In November 2008, the TCEQ formed an agency-wide task force to comprehensively evaluate all aspects of flares in Texas. The Flare Task Force is evaluating how flares factor into air quality challenges with an emphasis on air toxics and ozone. Some of the specific issues under evaluation include: different factors affecting flare performance, such as waste gas flow rates, turndown ratio, and waste gas to steam assist ratios; the adequacy of existing monitoring requirements for flares; and alternatives to flaring routine emissions. A stakeholder group associated with the Flare Task Force has been formed to solicit comment on these issues related to flares. A report for executive management is planned that will include options, considerations, and recommendations for improving our understanding and regulation of flares with the goal of improving air quality. Additional information about the Flare Task Force is available at the stakeholder Web site:
http://www.tceq.state.tx.us/implementation/air/rules/flare_stakeholder.html.

6.2.2 Technologies for Detecting VOC

6.2.2.1 Optical Gas Imaging Technology

Optical gas imaging technology offers a unique technological advancement in pollution detection capability and has proved to be highly effective in the detection of VOC emissions. An optical gas imaging system is a useful tool that assists the agency in actions such as facility investigations, reconnaissance investigations, mobile monitoring, and special projects. This technology is also useful in identifying sources of VOC emissions that are underestimated, underreported, unreported, or previously unregulated. The system also 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. 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 TCEQ uses the optical gas imaging technology as a screening tool in the following areas: offsite surveillance to identify potential sources of contaminants in response to ambient or other monitoring results; identification of sites, or areas with a specific site, where a focused investigation may be conducted; identification of potential source control strategies or to assist in an assessment of existing strategies; and identification of sources for emissions inventory issues.

6.2.2.2 Open Path Sensing Technology

Open path sensing technology allows specific pollutants to be monitored over a given distance (10 meters up to several kilometers) and generally provides very rapid measurements. Some of these techniques, such as solar occulation flux (SOF), differential absorption lidar (DIAL), and imaging differential optical absorption spectroscopy (I-DOAS) provide specific capabilities that include the ability to monitor air pollutants not only at ground level but also along a given path length in the sky, which allows measurements of specific elevated sources such as flares, vents, and storage tanks. This information coupled with meteorological measurements and modeling tools are capable, in some cases, of providing emission estimates not otherwise available. These data can be helpful in evaluating actual emissions from specific sources. These measurement techniques also have limitations or challenges that include the following.

- They are non-separatory techniques, i.e., do not physically isolate the chemical or chemicals of interest from other constituents, and as such are more prone to interference.
- They normally measure a path length average concentration or number of molecules and as such do not provide a specific concentration at any given point and can thus be difficult to compare with standards or guideline concentrations.
- They are difficult to assess from a data quality standpoint because they are an open path technology and thus have limitations for enforcement or compliance-related purposes.
- They are complex instrumentation with limited commercial availability that requires a highly experienced operator and data analyst to obtain quality data. In some cases, such as SOF and DIAL, there may be only a few operational instruments and qualified personnel in the world, which limits the ability of Texas to either acquire and operate the instrumentation or contract operation on anything but a sporadic basis.

6.2.2.3 DIAL Remote Sensing Technology

The TCEQ continued to advance the science of determining emissions from industrial sources by performing a five-week emissions monitoring study in the Texas City area during the summer of 2007. For the first time, a regulatory agency in the United States used a mobile DIAL remote sensing technology to measure emissions from industrial sources. The study, funded by the EPA and the TCEQ, focused on gathering data from industrial sources that are difficult to measure using conventional sampling techniques. The resulting scientific data and future studies will help guide future research efforts and may result in additional control measures, refined emissions models for common sources, and improved emissions inventories.

The TCEQ contracted with the National Physical Laboratory (NPL), based in the United Kingdom, to perform DIAL measurements on industrial emissions sources located in a refinery and a storage terminal near Houston during 2007.

Measurements focused on those industrial sources that are difficult to measure using conventional sampling techniques. Specifically, the study involved:

- identifying potentially under-reported industrial emissions sources;
- conducting remote sensing measurements of these sources;
- collecting process and operational data from these sources; and
- comparing emissions determined using conventional EPA-approved determination methods to the remote sensing measurements.

The NPL submitted a draft report in February 2008, which is expected to be finalized in fall 2009. An independent third party is currently comparing remote sensing measurements to conventionally determined emissions. Although these results are still being analyzed, preliminary total VOC measurements indicate that flare emissions may be underreported when emissions are determined using conventional material balance calculation methods. Additionally, preliminary results as well as other research indicate flare destruction and removal efficiency (DRE) may be reduced during certain operating conditions, such as combusting small volumes of waste gas and during flare air- or steam-assist operations.

These preliminary results indicate the need to conduct a study that determines the relationship between flare design, operation, and DRE.

6.2.2.4 Helicopter-Mounted DIAL Imaging System

The TCEQ completed field work in June 2009 to demonstrate the capabilities of a helicopter-mounted DIAL. The study's major focus will be using the DIAL to locate sources of benzene emissions from industrial facilities in the Houston Ship Channel area. The DIAL system used was developed to detect methane leaks during flyovers of gas pipelines. The system uses the infrared absorption of methane to detect leaks. The system has been used extensively and successfully to find pipeline leaks in concentrations as low as 1.7 parts per million (ppm) of methane. Instrument sensitivity has been shown in the laboratory to be approximately 100 ppm for benzene. However, with tuning and adjustments during flight measurements, the benzene sensitivity could be as low as 10 ppm. While the primary purpose of this project will be to determine the capabilities of a helicopter-mounted DIAL, results from this project could also be used to determine potentially unreported or underreported sources of benzene. Successful location of benzene sources in the surveyed areas may show the potential benefit of a full-scale survey of the entire Houston Ship Channel as well as other industrial areas. A final report is due to the agency by August 2009 and the agency final evaluation of the technology should be completed by the fall of 2009.

6.2.2.5 Flare Study

The purpose of the flare study is to measure flare emissions and collect required process and operational data in a controlled laboratory environment to determine the relationship between flare design, operation, and DRE. Direct measurement techniques of flare emissions, conceptually similar to those employed by the EPA flare studies in the 1980s, as well as remote sensing measurement techniques will be employed in the laboratory environment. Analysis of collected process and operational data will allow comparisons between traditional flare material balance emissions determinations, process stream measurements, and the emissions rates and concentrations measured by the direct and remote sensing technologies.

The TCEQ anticipates that the results of the laboratory tests will be broadly applicable, since these measurements will be conducted under controlled conditions. The TCEQ also anticipates that the tests will provide insight to operational conditions that may impact flare VOC DRE and flare combustion efficiency, such as assist rates or waste gas volumetric flow rates.

The primary study objectives include:

- assessing the potential impact of waste stream flow rate turndown on flare DRE and combustion efficiency;
- assessing the potential impact of steam/air assist on flare DRE and combustion efficiency at various operating conditions, including low flow rate conditions;
- assessing whether flares operating over the range of requirements stated in 40 Code of Federal Regulations § 60.18 achieve the assumed hydrocarbon DRE of 98 percent at varying flow-rate turndown and assist ratios as well as variable waste stream heat content; and
- identifying and quantifying the hydrocarbon species in flare plumes currently visualized with passive infrared cameras.

Field tests should be conducted during the November 2009 to March 2010 time frame, depending on approval of the final test plan and the availability of a test facility. A final report is expected during the summer of 2010.

6.2.2.6 Study of Houston Atmospheric Radical Precursors (SHARP)

An extensive field study of ozone precursors and formation was conducted in the HGB area in April, May, and June 2009 using cutting-edge measurement technology. Approximately $2 million of air quality research funds for this project were provided by the state legislature. The goal of the SHARP study is to investigate the:

- contribution of direct emissions of formaldehyde and nitrous acid from flares, stacks, and other point and mobile sources;
- importance of secondary formation of formaldehyde from the ozonolysis of olefins;
- identification of formation pathways of nitrous acid;
- ambient levels of nitryl chloride and potential impact as a ozone precursor; and
- spring and early summer ozone formation mechanisms in the HGB area.

The data from this study will be analyzed in 2009 and 2010 and used to better understand HGB area emissions and chemistry, enhance model inputs and mechanisms, and aid in the evaluation of control strategy development.

6.3 FUTURE INITIATIVES

6.3.1 Mid-Course Review (MCR)

The commission is soliciting comments on whether it is appropriate to perform a 1997 eight-hour ozone standard MCR analysis for the HGB area, and, if so, what elements should be contained in the analysis. The commission is also seeking input on the appropriate date to submit the MCR.

6.3.2 2008 Ozone National Ambient Air Quality Standard (NAAQS)

On March 12, 2008, the EPA strengthened its NAAQS for ground-level ozone from 0.08 parts per million (ppm) to 0.075 ppm. Governor Rick Perry submitted the state's recommendation regarding boundaries and designations under the federal 2008 eight-hour ozone standard to the EPA on March 10, 2009. The HGB area (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties) was included in the governor's recommended nonattainment areas. Continued efforts to reduce ozone precursors will be necessary to address this new ozone standard.

EXHIBIT 5

Evaluation of Implementation Experiences with Innovative Air Permits

Results of the U.S. EPA Flexible Permit Implementation Review

SUMMARY REPORT

Report prepared by:
EPA Office of Air Quality Planning and Standards (OAQPS)
EPA Office of Policy, Economics and Innovation (OPEI)

In consultation with:
EPA Office of Enforcement and Compliance Assurance (OECA)
EPA Office of General Counsel (OGC)
EPA Office of Policy Analysis and Review (OPAR)

With support from:
Ross & Associates Environmental Consulting, Ltd.
(Under contract to Industrial Economics, Inc.)
U.S. EPA Contract # 68-D9-9018
and
Midwest Research Institute

Table of Contents

Executive Summary

Background

In recent years, the U.S. Environmental Protection Agency (EPA) and some State and local permitting authorities recognized a change in the manufacturing landscape. This change arose in today's increasingly competitive global markets, requiring companies to respond rapidly to market signals and demand, while delivering products faster, at lower cost, and of equal or better quality than their competitors. As their market response and product development time frames shrank, companies in several industries perceived the potential administrative "friction" – costs, time, delay, uncertainty, and risk – resulting from operating under conventional air permitting approaches to increase. This raised an important question: how to provide these U.S. companies with the "flexibility" to compete effectively in global markets without decreasing environmental protection? At the same time, the EPA and others sought ways to align the regulatory framework to encourage emissions reduction and pollution prevention.

To address these challenges, the EPA and several State and local permitting authorities worked with selected companies over the past few years in the context of individual permit pilots to develop innovative approaches to air permitting. The EPA and the States launched these efforts to increase sources' operational flexibility while ensuring environmental protection and facilitating pollution prevention. Permitting authorities involved in these pilot initiatives designed permits within the existing regulatory framework to address all applicable air requirements. As interest in innovative approaches to air permitting increased, the EPA evaluated the implementation experience with "flexible" permitting techniques developed under pilot permitting efforts, such as the EPA's Pollution Prevention in Permitting Program (P4) and various State innovation initiatives. The EPA believes that careful evaluation of the implementation experience with such flexible permits can improve the effectiveness and efficiency of future efforts and help to inform evolving air policymaking activities in these areas. The EPA launched the Flexible Permit Implementation Review to meet these objectives.

What Is Flexible Air Permitting?

The term "flexible permit" is used in this report to describe air permits with conditions designed to reduce the administrative "friction" – costs, time, delay, uncertainty, and risk – experienced by sources and permitting authorities when implementing a permit or making certain changes under the permit. This is typically accomplished by allowing a source to make certain types of changes (e.g., modifications to a source's method of operation, equipment, raw materials, emission factors, or monitoring parameters) without requiring additional case-by-case permitting, provided the source meets certain criteria outlined in its operating or construction permit. Such criteria might include the maintenance of plant-wide emissions levels below enforceable caps. Over the past decade, the EPA and State and local permitting authorities have also piloted specific permitting techniques and tools to accomplish advance-approval for certain types of changes that might take place over the course of a permit term. While chosen solutions will depend on individual state permitting rules and requirements, such techniques typically include descriptions of advance-approved changes or categories of changes in the permit, procedures for testing pollution control device performance and updating emission factors or parameter values without requiring the permit to be amended or re-opened, elimination of redundant requirements by applying the most stringent applicable requirement, and provisions to explicitly encourage pollution prevention.

Flexible Permit Implementation Review Findings

The EPA launched the Flexible Permit Implementation Reviews to examine the implementation experience with innovative air permitting techniques. Under this initiative, the EPA assembled a Review Team, representing multiple EPA offices supplemented by contractor support, to conduct in-depth reviews of six pilot permits with innovative flexibility provisions and sufficient operating history. These pilot permits were developed for the following companies: 3M, DaimlerChrysler, Imation, Intel, Lasco Bathware, and Saturn. The reviews included detailed analyses of source and permitting authority experiences developing and implementing flexible air permits, based on review of information in the public record, discussions with source and permitting authority personnel, site visits to the source and permitting authorities, and verification of recordkeeping and emissions calculation requirements.

The EPA's review and analyses support the following findings for the six flexible permits covered in this review.

Finding 1: The flexible permits contain adequate measures to assure compliance with all applicable requirements.

Permitting authorities and the EPA found that the flexible permits contained monitoring, recordkeeping, and reporting mechanisms sufficient to assure that identified regulatory requirements are met and that appropriate measures are in place. The EPA Review Team did find, however, that certain topics related to renewal of flexible permits warrant further discussion and clarification. These topics include determining acceptable approaches for adjusting plant-wide emissions caps at permit renewal, and determining acceptable approaches to transition back to conventional permitting approaches if flexible permits are allowed to expire.

Finding 2: The flexible permits were considered to be enforceable by permitting authorities and EPA.

A key objective was to verify that the flexible permit provisions are enforceable by permitting authorities and the EPA. The six permitting authorities involved in the pilots all reported the ability to detect non-compliance with flexible permit conditions and to enforce the permit requirements, and expressed certainty that permit requirements could be enforced, had the need arisen. For all permits, the EPA was able to replicate the emissions calculations for selected time periods to demonstrate compliance. Permitting authorities reported that conducting inspections of sources with flexible permits is comparable to conducting inspections of sources with conventional permits.

Finding 3: The flexible permits facilitated and encouraged emissions reductions and pollution prevention.

The flexible permits contain mechanisms designed to facilitate and encourage emissions reductions and pollution prevention (P2). Five of the sources with flexible permits lowered actual plant-wide emissions during their permit terms, and the sixth source lowered its emissions per unit of production during the permit term. For example, using pollution prevention (P2), Intel lowered actual emissions of volatile organic compounds (VOCs) from 190 tons/year to 56 tons/year while increasing production. After a substantial voluntary reduction of VOC emissions from 10,000 tons/year, 3M further lowered its actual VOC emissions from 4,300 tons/year to below 1,000 tons/year. This reduction resulted primarily from increased pollution control device performance, greater use of voluntary controls, P2, and reduced production. DaimlerChrysler lowered its actual VOC emissions from 1,400 tons/year to less than 800 tons/year, primarily through P2 associated with vehicle coatings and plant solvent usage.

The plant-wide emissions caps focused organizational attention on reducing plant-wide emissions. In many cases, the advance approved change provisions reduced the administrative "friction" associated with P2 changes, making such changes more attractive for sources to undertake. The flexible permits increased internal awareness and focus on pollution prevention at the sources through explicit P2 program, reporting, and/or performance requirements.

Finding 4: Companies with the flexible permits believe that air permitting is on their critical response path.

Each of the sources with flexible permits reported that conventional permitting approaches can constrain their ability to compete effectively. The combination of increasingly globalized competition and a shift to new modes of production substantially increased the pressure to operate highly flexible, nimble, and responsive research, development, and production operations. For example, competitive pressures and computer design advances in the automotive sector have compressed the new vehicle development process from five years to less than 18 months, requiring increasingly flexible production systems and time sensitive equipment changes. For products in the semiconductor and specialty tape industries, competitive pressures frequently cause certain products to become obsolete within six to nine months, as customers' specifications change and technology evolves. Advance production concepts, such as lean manufacturing, designed to help firms compete effectively, require rapid, and often iterative, operational and equipment changes for continuous improvement of resource productivity, operational efficiency, and product quality. For these reasons, companies report that conventional case-by-case permitting actions can be problematic due to the potential delay and uncertainty of final permit actions. Companies with flexible permits identified similar needs at other facilities and are interested in pursuing flexible permits for those facilities.

Finding 5: Companies with the flexible permits utilized their flexibility provisions.

Flexibility provision utilization during the permit terms exhibited rates and types of changes consistent with the needs expressed by the companies during permit development. The actual number of changes made using advance approval and other flexibility provisions varied by source, with Intel implementing the most changes (e.g., approximately 150 to 200 equipment and operational changes per year). Other companies implemented fewer changes (e.g., more in the range of 20 or fewer changes per year), but emphasized that the relative value of making certain critical changes can be more important than the number of changes made. Some companies did not utilize all of the flexible permit provisions, but generally anticipated using the flexibility provisions in the future. The flexible permits accommodated a substantial number of advance approved changes while providing sufficient clarity in describing the advance approved changes to ensure enforceability. Additionally, flexible permits facilitated an increase in the rate and a shift in the type of changes made, when compared to what might have occurred under a conventional permit.

Finding 6: The flexible permits enhanced information sharing between the companies and permitting authorities.

The flexible permits enhanced the permitting authorities' overall understanding of company activities and emissions as compared to conventional permitting approaches. The flexible permit development process provided the permitting authorities with a clearer understanding of the maximum emissions levels anticipated during the permit terms. During permit development, companies provided more information regarding the type of changes anticipated during the permit term. This provided a more comprehensive, up-front picture of anticipated operational activities and associated environmental performance than a conventional permitting process.

During permit implementation, information about a company's specific changes under the advance approval provisions was generally comparable to information provided under a conventional permitting process. The flexible permits also required information about total source emissions and pollution prevention that is not typically required under conventional permitting.

Finding 7: The flexible permits generally provided to the public equivalent or greater information than conventional permits.

The flexible permits shifted the timing, type, and format of information made available to the public about emissions performance, operational and equipment changes, and P2 activities. The specific format, timing, and availability of certain types of information required by the flexible permits varied, particularly for advance approved changes. In all cases, the flexible permits provided more information up-front about operational changes (or categories of changes) that the sources anticipated making during the permit terms. This provided the public with an opportunity to understand and comment on the companies' anticipated changes. During permit implementation, four of the flexible permits provided equivalent or greater information for specific changes made under the advance approval provisions, although in a different format and timing than typically available under conventional permitting. In two cases, the pilot permits resulted in less information about certain changes implemented under the advance approval provisions. In the areas of total plant-wide emissions information and/or P2 information, all of the pilot permits increased the availability of information to the public for the companies' emissions and activities. For all six permits, the permitting authorities indicated that, on balance, the flexible permits improved the availability of information to the public, ensuring the flow of significant and meaningful information regarding the current status and future direction of operations and emissions.

Finding 8: The flexible permits produced or are anticipated to produce net financial benefits to companies and permitting authorities.

Companies and permitting authorities reported that the flexible permits resulted in net financial benefits or are anticipated to do so in the future. Companies and permitting authorities indicated that initial permit development costs exceeded those required to develop conventional permits because of the innovative nature of the permits and additional resources associated with developing site-specific flexible permit provisions. In each case, however, companies and permitting authorities reported that the flexibility provisions decreased, or are expected to decrease, the administrative costs of operating under the permit to more than offset the initially higher permit development costs. Companies reported that the potential opportunity costs of project delays from air permitting can be high, ranging as high as several million dollars in just a few days. In so far as flexible permits can minimize project delays, the economic benefits to companies can be correspondingly large. Permitting authorities typically reported that the additional permit development costs for flexible permits were offset by resource savings within the first three years of permit implementation.

Finding 9: Permitting authorities are generally supportive of flexible permits as an option.

The six permitting authorities involved in the flexible permits indicated that they are pleased with the environmental and administrative benefits of the permits. They believe flexible permitting techniques are useful tools to address some sources' operational flexibility needs, to foster environmental improvements through emissions reductions, and to reduce required permitting resources and backlogs for permitting. This increased permit efficiency allows the public agencies to focus resources on higher environmental management priorities. Permitting authorities expressed interest in renewing the flexible permits and expanding the use of flexible permits within their jurisdictions and believed that finalization of EPA policy and/or guidance for flexible permits should increase national interest and efficiency in expanding their use. Additionally, permitting authorities stated that various forms of EPA outreach, training, and assistance would be useful to assist permitting authorities to develop effective flexible permits.

Finding 10: Permitting authorities indicated that flexible permit provisions should be matched with a company's need for flexibility and technical capacity to implement effectively its flexible permit requirements.

Permitting authorities believe that flexible permits meet applicable requirements and are fully enforceable. However, such permits may not be appropriate for all sources. Permitting authorities believe that two critical factors should be considered when determining the appropriateness of flexible permitting for a particular company. First, the company should be able to demonstrate that it has a sufficient need for the flexibility to justify the additional up-front permitting authority time and resources required to develop flexible permit provisions for the company. Second, the company should exhibit the technical capacity to operate effectively under a flexible permit. Factors such as a source's compliance history, commitment to pollution prevention, and ability to track and manage operational changes and emissions should be considered by permitting authorities when determining the appropriateness of a flexible permit for a company.

I. Introduction

A. Project Scope and Purpose

Over the last several years, the U.S. Environmental Protection Agency (EPA) and several State and local permitting authorities worked with several companies to develop innovative approaches to air permitting. The EPA and States launched these pilots to increase operational flexibility while ensuring environmental protection. Permit developers sought to encourage and facilitate emissions reductions and pollution prevention with the flexible permits. The permits were also designed to reduce the administrative "friction" – costs, time, delay, uncertainty and risk – associated with making certain types of operational and equipment changes. Additionally, permitting authorities desired to reduce the resources needed for case-by-case applicability determinations and for the approval process of subject minor and major New Source Review (NSR) permit applications and other permitting amendments. Permitting authorities designed these "flexible permits" within the existing regulatory framework (i.e., approaches were not precluded under any relevant Federal or State regulation) to address all applicable air requirements.[1]

As interest in flexible air permitting increased, the EPA saw the need to evaluate the implementation experience with flexible permits developed under pilot efforts such as EPA's Pollution Prevention in Permitting Program (P4) and State innovation activities. Particular interest has focused on flexible permitting techniques such as plant-wide emissions limits (e.g., plant-wide applicability limits, or PALs; potential-to-emit caps).

In response to this need, the EPA launched the Flexible Permit Implementation Review to conduct in-depth reviews of six flexible permits developed since 1993. The EPA's Office of Air Quality Planning and Standards (OAQPS) initiated this effort, in partnership with EPA's Office of Policy, Economics, and Innovation (OPEI). The EPA Office of Policy Analysis and Review (OPAR), the Office of General Counsel (OGC), and the Office of Enforcement and Compliance Assurance (OECA) provided support for this effort.

The purpose of the Flexible Permit Implementation Review is to help the EPA:

- Determine whether the flexible permits work as envisioned, providing the desired operational performance improvements and environmental protection.
- Obtain more detailed and better organized information regarding these efforts.
- Improve communication of the details and results of these efforts.
- Understand how such flexible permitting approaches might be improved.
- Assess the level of environmental benefit achieved under flexible permits.
- Learn how similar flexible permit development processes can be streamlined in the future.
- Provide input, as appropriate, into the final development of corresponding EPA policy.

[1] The term "flexible permits" has been primarily used to describe permits with conditions that enable permitted sources to make certain changes (e.g., modifications to operations, equipment, raw material, emission factors, monitoring parameters) without requiring further case-by-case review and approval or permit modifications from the permitting authority. The term also encompasses those approved permit conditions which are sufficient to enable a more expedited permit revision process, but not to accomplish a full advance-approval. This report and its appendices use the terms "flexible permits," "flexible permit conditions," and "flexibility provisions" to denote permits and permit conditions that include such provisions related to advance approval. See Section D for a discussion of flexibility provisions examined by the EPA's Flexible Permit Implementation Review.

B. Structure of this Report

This report presents the EPA's findings from the Flexible Permit Implementation Review. The Executive Summary briefly addresses the review's purpose, scope, approach, and findings. The Introduction includes a more detailed account of the project purpose and scope (Section A), the structure of this report (Section B), and the review approach and process (Section C). Section D introduces the primary types of flexibility provisions that are included in the six flexible permits reviewed in this evaluation. Section E summarizes the flexibility provisions contained in the six flexible permits, and briefly discusses the sources' operations, emissions, emissions sources, and emissions control equipment. The Findings Section presents the EPA's ten major findings from this flexible permit evaluation. Each finding is explored in detail, drawing on examples from the six Permit Review Reports.

C. Review Approach and Process

The EPA's Flexible Permit Implementation Review involved detailed analysis of company and permitting authority experiences implementing six flexible air permits. To structure the six permit reviews, OAQPS developed a "Flexible Permit Review Framework" that includes specific evaluation questions grouped into eight areas of inquiry. The Flexible Permit Review Framework was developed by OAQPS in consultation with other EPA offices, including OPAR, OECA, OGC, and OPEI.

C.1 Flexible Permit Review Framework

The areas of inquiry in the Flexible Permit Review Framework are listed below. Each of the six Permit Review Reports accompanying this report are structured based on this review framework, and they include the specific questions and areas of inquiry that were addressed by the reviews.

- **Background**: This section examines background information on the permitting authority's structure, capacities, and processes; the pilot source's operations and characteristics; and the company's need for flexibility.

- **Flexible Permit Design Features**: This section examines the specific flexibility provisions contained in the permit and the terms which assure compliance with them, including monitoring, recordkeeping, and reporting requirements.

- **Public Participation and Public Perception**: This section assesses the public's participation in the development of the flexible permit through examination of the public involvement process and the record of public comments. It examines the flows of information during development and implementation of the pilot permit, and compares these to what might have been experienced under conventional permitting.

- **Implementation of Flexible Permit Provisions**: This section examines when and how flexible permit provisions were actually utilized by the source during permit implementation. It explores how the flexible permit implementation might compare to the experience under a conventional permit. This section also assesses the quality and quantity of information generated under the flexible permit and discusses any problems that were encountered.

- **Design Adequacy of the Flexible Provisions**: This section assesses whether the flexible permit design features, such as advance-approved change provisions, were adequate to assure compliance with all applicable requirements.

- **Practical Enforceability of the Flexibility Provisions**: This section assesses the ability of the source and permitting authority to determine compliance with the permit conditions and applicable requirements. It also examines the ease of inspection associated with the flexible permit.

- **Permit Costs, Environmental Benefits, and Value Added**: This section assesses the relative costs and benefits of the flexible permit to the source and permitting authority, as compared to a conventional permit. In particular, this section examines whether the permit actually provided desired flexibility to the source as well as equivalent or better environmental protection.

- **Other Issues**: This section addresses ways in which flexible permits can be improved and how the EPA can support such improvements in the future.

C.2 EPA Review Team

The EPA assembled a core Permit Review Team consisting of representatives from various EPA offices, including OAQPS, OPEI, and OECA. Ross & Associates Environmental Consulting, Ltd., under subcontract to the EPA through Industrial Economics, Inc., provided overall team coordination services and compiled review results. In addition, representatives from Midwest Research Institute, under contract to the EPA, participated in the reviews to support the EPA's evaluation of the emissions monitoring, recordkeeping, and reporting requirements and practices. At least six representatives from this group participated in each of the six individual permit reviews and associated site visits. In some cases, the EPA Review Team was supplemented by representatives from the EPA Regional Office in which the pilot permit was developed.

C.3 Permit Review Process

The Flexible Permit Review Framework was completed for each of the six flexible permits. This was accomplished through extensive off-site research, on-site visits to the source and the permitting authority, and a review process for finalizing responses to the Flexible Permit Review Framework. Prior to each site visit, preliminary responses to many of the review questions were drafted by the EPA and its contractors based on information collected through pre-site visit conference calls with each company and permitting authority. Background research also included review of the flexible permits and other publicly available records, including permit applications, public comments received during permit review or implementation, inspection reports, monitoring data summaries, compliance certifications, notices, and other records.

The on-site reviews consisted of visits to the source and the permitting authority. The EPA Review Team's one to one-and-a-half day visits were designed to collect and verify evidence and data to complete the Flexible Permit Implementation Review Reports. The EPA on-site reviews were *not* conducted as compliance audits of the sources. Rather, they assessed the company and permitting authority's experience with developing and implementing the flexible permits, so as to help improve similar permits in the future. The site visits included discussions with company and permitting authority personnel and a walk-through of the plant, as well as a detailed examination of on-site records, including monitoring data. Representatives from the permitting authority participated in the source site visits and discussions. The plant site visits were typically followed by a half-day visit of the EPA Review Team to the permitting authority offices to discuss specific aspects of the review framework relevant to the permitting authority. Company personnel did not participate in meetings and discussions at the permitting authorities.

Following each site visit, extensive steps were taken to ensure the accuracy of information catalogued in the Flexible Permit Review Frameworks. EPA contractors prepared initial drafts of the Permit Review Reports. EPA contractors conducted follow-up discussions, as necessary, with the sources and the permitting authorities to complete these draft Permit Review Reports. The EPA Review Team provided preliminary review and comment on the draft Permit Review Reports. The revised Permit Review Reports were then forwarded to the relevant company and permitting authority contacts for review and comment. Companies and permitting authorities were asked to verify the accuracy and completeness of the responses contained in the Permit Review Reports. Based on these comments, the EPA contractors worked with OAQPS and OPEI staff to finalize the six Permit Review Reports. This Summary Report was prepared by OAQPS and OPEI, with support from contractors, and was reviewed and commented on by other members of the EPA Review Team.

C.4 Flexible Permit Selection

EPA selected six pilot permits for review based on the following criteria.

- Extent of permit implementation and/or duration since permit issuance.
- Likelihood of source and permitting authority voluntary participation in the review.
- Number and type of flexibility provisions in permit.
- Unique features of flexible permit.
- Diversity of emissions and applicable requirements.
- Number of inspections completed.
- Relevance of permit to inform ongoing EPA efforts to develop policy.

Table 1.1 lists the six flexible permits selected for inclusion in the Flexible Permit Implementation Review (see end of report).

D. What Are Flexible Permit Provisions?

The term "flexible permit" is frequently used to describe pilot permits with conditions that reduce the administrative "friction" – costs, time, delay, uncertainty, and risk – experienced by companies and permitting authorities when making certain changes under the permit. Such changes could include modifications to a source's method of operation, equipment, raw materials, emission factors, or monitoring parameters. The six flexible permits examined in this review contain flexibility provisions which advance approve such changes or categories of changes. While flexible permit solutions will depend on individual state permitting rules and requirements, a variety of flexible permit provisions have been developed by the EPA and State and local permitting authorities to accomplish advance approval for a category of changes. Several types of flexible permit provisions utilized in permits reviewed in this report are summarized below.

D.1 Description of Advance-Approved Changes

The six flexible permits include descriptions that enable the advance-approval of specific changes and/or categories of changes. Advance approved change descriptions typically allow companies to make a fairly broad spectrum of modifications, eliminating the need for additional case-by-case review and approval by the permitting authority at the time the plant makes the change. Changes that trigger new applicable requirements (i.e., requirements unaddressed by the advance approval provisions) or require modifications to monitoring, recordkeeping, and reporting requirements are not advance approved. To implement advance approved changes, sources must maintain plant-wide emissions below applicable limits. In addition, they typically must submit notice to the permitting authority and maintain on-site logs providing documentation of the changes implemented under the advance approval provisions (e.g., the addition of a new emissions unit).

Some of the flexible permits contain provisions that only partially advance approve particular types of changes, providing a streamlined review and approval process. Permitting authorities believe this to be useful as an interim approach for certain types of changes and review requirements. For example, a flexible permit might advance approve a set of changes to which a source must apply best available control technology (BACT). The permit, however, could preserve the conventional process for public comment on the company's proposed BACT approach, as well as the permitting authority's opportunity to reject or comment on the proposed BACT approach at the time of the change.

D.2 Plant-wide Emissions Limits

All six flexible permits contain one or more plant-wide caps on emissions of Volatile Organic Compounds (VOC) and/or criteria air pollutants. These emissions caps typically included annual/12-month rolling limits (e.g., tons/year) and short-term limits (e.g., pounds/hour) that cover emissions from all emissions sources at a plant, including any that may be "grandfathered" under the Clean Air Act.

Emissions caps can function in different ways. First, caps can serve as a basis for ensuring new applicable requirements are not triggered. In other words, caps can be set in such a way that (as long as there is no violation of the limit) new applicable requirements will not be triggered. Potential-to-emit (PTE) caps typically establish "synthetic" minor source status for applicability purposes under one or more regulations by setting a limit on plant-wide emissions below the emissions threshold that would trigger major source status. In addition, for major sources, Plant-wide Applicability Limit (PAL) baselines are typically set at an average of the actual plant emissions for the previous two years (or another more representative period) plus 39 tons/year, an increment just under the Significant Emissions Rate (SER) for VOC emissions of 40 tons/year that would trigger major New Source Review.[2] In another variation, Oregon rules establish an annual and short-term Plant-Site Emissions Limit (PSEL) for sources in the State, based on each source's actual emissions in 1978, that is contained in the State Implementation Plan (SIP). The PSEL also functions to define the aggregate emissions level below which major NSR would not apply to changes made at the site. Short-term emissions caps, where required, also act to assure that the advance approved changes in combination with existing emissions do not adversely impact the National Ambient Air Quality Standards (NAAQS) (in attainment areas). Finally, emissions caps serve to bound the magnitude of advance approved changes so as to define them in a reasonably anticipated alternative operating scenario for title V permitting purposes. Often, when more than one cap was involved, these caps can be streamlined into one plant-wide emissions limit (i.e., combined into the most stringent form) so as to serve multiple functions at the same time.

D.3 Replicable Testing Procedures

Several of the flexible permits contain replicable testing procedures that enable sources to update the monitored parameter levels of concern (e.g., pollution control device efficiencies, emission factors), based on approved testing results, without requiring a permit modification. Permit provisions describe the replicable procedure to be used when testing and updating parameters, and the actual parameter values are documented in required correspondence between the permitting authority and company, which are maintained at the source and in the permitting authority's files along with the permit.

D.4 Applicable Requirement Streamlining

Pursuant to EPA guidance presented in White Paper Number Two, several of the flexible permits streamlined

[2] This assumes the sources is in an attainment area. SERs also differ depending on the pollutant in question.

applicable requirements to reduce permit complexity. In these instances, overlapping and redundant requirements were subsumed under the most stringent requirement(s). This technique was particularly effective when it was used as part of a "clean building" approach. A "clean building" is a separate structure or collection point within a plant site containing emissions units that are (or will be in the case of new units) routed to one or more dedicated, state-of-the-art air pollution control devices. To advance approve modifications or new unit additions in a "clean building" with respect to all technology-based requirements, the control device must assure compliance for all the advance approved changes (as well as for all unchanged existing operations in the same building) with the most stringent requirement that could apply to any of the activities being advance approved to occur within the "clean building."

D.5 Pollution Prevention Provisions

Several of the flexible permits contained explicit pollution prevention (P2) conditions designed to focus greater plant attention on P2 and to take full advantage of the P2 that often takes place when flexible permit provisions are established. These conditions ranged from P2 program development and reporting requirements to enforceable P2 performance targets.

E. Pilot Permit and Source Characteristics

While the flexible permits contain provisions to accomplish advance approval that are generally similar, each permit has a unique combination of conditions that are tailored to the company's flexibility needs, operations, and State-specific requirements. This section introduces the six flexible permits evaluated by the EPA's Flexible Permit Implementation Review. Table 1.2 highlights the key flexibility provisions in each permit (see end of report). The company operations, emissions sources, and emissions control equipment are summarized below. Detailed descriptions of source characteristics, flexible permit provisions, monitoring requirements, and other background information are available in the six Permit Review Reports.

3M Company - St. Paul, Minnesota
3M's St. Paul tape plant manufactures more than 550 specialty tape products, including automotive and medical tapes, graphics tape, offset printing tape, and foam and double-sided tapes. To produce tape products, adhesives are mixed at the plant and then applied to a tape backing, or "web", on one of 18 coaters. The coated web is fed through ovens to volatilize excess solvent from the adhesives, and is then wound into rolls and cut for packaging and shipment. VOC emissions result from volatilized solvents coming off the adhesive mixing areas and evaporation ovens and are controlled through a highly efficient regenerative thermal oxidizer (RTO). The flexible permit, issued in 1993, was needed to provide for an extensive program of renovations to maintain the long-term viability of this plant in 3M's network of plants.

DaimlerChrysler Corporation - Newark, Delaware
DaimlerChrysler's Newark Assembly Plant (NAP) began producing the Dodge Durango, a sports utility vehicle, in 1997. While vehicle production levels tend to be cyclical due to model changeovers and economic demand cycles, vehicle production in July 2001 was about 600 vehicles per day (200,000 vehicles/year). The NAP's initial flexible permit, issued in 1995, enabled the source to retool for Durango production and to construct a new vehicle coatings building adjacent to the assembly buildings. Most VOC emissions result from the various steps in the vehicle coating process (e.g., electro-coat dip tanks, paint booths, curing ovens), and are controlled through pollution prevention (P2) efforts and, to a lesser extent, by a regenerative thermal oxidizer. The NAP emits criteria pollutants (PM_{10}, SO_2, NO_x, and CO) from operation of the thermal

oxidizer, five boilers, paint curing ovens, and other combustion sources.

Imation Corporation - Weatherford, Oklahoma
Imation's Weatherford plant consists of two separate buildings. The North Building houses Printing and Publishing Division operations and manufactures products for the graphics arts and printing industries. Digital and conventional proofing systems are produced by coating thin films with colored, solvent-borne solids. The South Building contains Data Storage Division operations and produces data storage products such as computer diskettes. VOC emissions result from the solvent-borne coatings as they are mixed, applied to the film, and heated in curing ovens. Production areas are maintained with negative pressure and VOC emissions from the coaters and ovens are routed to voluntarily installed pollution control devices, including a regenerative thermal oxidizer, a catalytic oxidizer, and a carbon absorber. The pollution control equipment, two on-site boilers, and other miscellaneous combustion sources emit criteria pollutants. The design of the permit was critically needed for Imation to test new raw materials and processes in a timely manner.

Intel Corporation - Aloha, Oregon
Intel's Aloha, Oregon semiconductor fabrication plant produces semiconductor chips for use in computers and other electronic devices. An iterative sequence of steps, including application of photoresist, UV light exposure, developing, etching, rinsing with deionized water, doping, and rinsing with acid and solvent is employed to transform silicon wafers into semiconductors. Plant air emissions consist of VOCs and organic and inorganic hazardous air pollutants (HAPs) from production processes and cleaning activities, as well as criteria pollutants from on-site boilers. The flexible permit was designed to rely primarily on a campaign of P2 to advance approve a myriad of small equipment changes and process modifications.

Lasco Bathware - Yelm, Washington
Lasco's Yelm source produces fiberglass reinforced plastic (FRP) bathtubs, shower stalls, and whirlpools. The source operates a gelcoat line and an acrylic line. Coats of plastic and fiber-reinforced resins are sprayed in successive layers into molds (gelcoat line) or on preformed acrylic plastic sheets (acrylic line). Styrene emissions result from the spray booth operations. Lasco, through P2, limited its emissions per unit of production so as to allow greater overall production under its emissions cap. During the flexible permit term, Lasco also installed a regenerative thermal oxidizer to control these VOC emissions from various steps in the gelcoat line.

Saturn Corporation - Spring Hill, Tennessee
Saturn operates an integrated automotive production plant that produces a range of Saturn-brand vehicles. Production, which peaked in 1996 at 314,035 vehicles, has declined in recent years due to weakness in the subcompact car market segment. The flexible PSD permit, issued in June 2000, has enabled Saturn to retool to produce a new, fuel-efficient sport utility vehicle, the Saturn VUE™. VOC emissions result from the vehicle paint lines and the lost-foam aluminum foundry operations. VOC emissions are controlled by eleven recuperative thermal oxidizers, two regenerative thermal oxidizers, and a hybrid carbon adsorption/thermal oxidation system. Criteria pollutants arise from operation of the pollution control equipment, ovens, boilers, and other miscellaneous natural gas combustion sources. The Saturn PAL PSD permit is a hybrid permit consisting of a PSD permit for a major expansion with permitted emissions based on projected future actual emissions in combination with a PSD permit for existing emissions units with allowable emissions based on current actual emissions at the existing emissions units.

II. Findings

Drawing on information collected through the Flexible Permit Implementation Review, the EPA identified the following findings. Where appropriate, specific examples are drawn from the six individual permit implementation experiences. Readers should refer to the six Permit Review Reports for the full details of the individual permit reviews.

Finding 1: The flexible permits contain adequate measures to assure compliance with all applicable requirements.

Evaluation of the design adequacy of the flexible permits requires consideration of the objectives of the permit developers. Permitting authorities generally had two primary objectives in mind. The first was to ensure that all applicable air requirements were met. This design objective meant that the flexible permits were developed to function within the current regulatory framework without new rulemakings. The permit design teams believed that it was imperative to address all substantive requirements (e.g., technology, emissions performance, or work practice requirements) and procedural requirements (e.g., public notification, review, and comment processes; and reporting and information availability requirements). If any applicable requirement were omitted, this could necessitate obtaining construction approval and/or revising the operating permit solely to address the missing applicable requirement. This would erode most, if not all, of the potential benefits from advance approval of the other applicable requirements. The design challenge was to do so through techniques and altered administrative practices that would improve company and permitting authority operational performance and promote P2. The second design objective focused on improving the performance, or outcomes, achieved under the permit when compared with performance that would likely be experienced under a conventional permit. Specific aspects of this performance improvement goal are addressed later in this report.

All of the permitting authorities stated that the flexible permits were fully supported by current Federal and State rules. They believed that no rulemaking was required to support any of the flexible permitting efforts. While many of the flexibility techniques are not explicitly described or addressed in existing rules, the permitting authorities determined that current rules accommodated the flexible permits, since no existing regulation expressly precluded them and because the approaches did not bypass established substantive and procedural regulatory requirements.

In several cases, rule interpretations were important to enable certain flexibility provisions.

- Oregon DEQ and OAPCA representatives both reported that their ability to interpret "emissions unit" as an entire production line or building, as opposed to a specific piece of equipment or process step, was instrumental to enabling the advance approval provisions.
- DNREC determined that it had the ability to allow advance approvals in a manner consistent with construction time limit requirements.

The EPA found no evidence indicating that any air-related requirements applicable to the sources and their advance approved changes were missed during permit development. The EPA also found that the flexible permits adequately identified all requirements applicable to the advance approved changes.

The flexible permits contained adequate monitoring, recordkeeping, and reporting mechanisms to ensure that regulatory requirements are met and that appropriate measures are in place.

Permitting authorities and the EPA found that the flexible permits included monitoring, recordkeeping, and reporting (MRR) approaches that are appropriate given source operations. They also found that MRR approaches used in the flexible permits are sufficient to determine ongoing compliance with the permit conditions and applicable requirements. Table 2.1 summarizes the MRR requirements contained in the flexible permits (see end of report). Please refer to the Permit Review Reports for a more detailed discussion on the design adequacy of MRR approaches used in the six flexible permits. In several cases, the permitting authorities required enhanced MRR requirements to ensure that plant demonstration of compliance with established emissions caps was performed on a more frequent basis. These measures were partly designed to enable sources and permitting authorities to quickly identify problems or trends that could result in potential emissions cap exceedances, reducing the risk and potential severity of permit violations.

- 3M's St. Paul tape plant was required to calculate daily and rolling annual emissions totals within 41 hours of the end of each day, comparing these totals with the established VOC emissions caps.
- DaimlerChrysler was required to submit monthly reports to DNREC documenting plant-wide VOC and NO_x emissions in tons per year for the previous 12 months, as well as plant-wide daily emissions totals for the month.

In all cases, plant-wide emissions totals and calculations that demonstrated the companies' compliance with applicable emissions caps were required to be maintained on-site and were available to agency inspectors upon request. The EPA did, however, identify areas in which several of the flexible permits could be improved to ensure that specific monitoring techniques are consistent with current EPA guidance. The EPA did not find that any of these areas for improvement affected the companies' abilities to monitor actual emissions, or to ensure compliance with the emissions caps or advance approved change provisions. However, the EPA Review Team recommends that these improvements be considered in subsequent versions of the permits. Several of these recommendations are summarized below.

- Although the monitoring requirements for the VOC scrubber for Intel's Fab 4 at the Aloha plant used an appropriate methodology (i.e., operating parameter monitoring), the elements of the monitoring approach, were they relevant to the companies' ability to assure compliance, could be improved by including an operation and maintenance requirement that relates water flow rate with the flow corresponding to the optimum VOC removal efficiency, as verified through source testing.
- The EPA found that Saturn is conducting appropriate monitoring for the emissions caps, and has submitted a complete monitoring protocol to TDEC, in accordance with permit condition C.2. The EPA recommends the addition of several specific monitoring procedures and performance indicator ranges in the final Title V permit. These recommended measures are associated with monitoring of the carbon bed adsorber control equipment.
- For the Imation permit, the EPA found that continuous measurement of the air flow rate from coaters 12W and 15W and going to the catalytic oxidizer is appropriate parametric monitoring for monitoring capture efficiency. However, the permit did not identify any indicator range for this parameter (i.e., an operating range outside of which a deviation would require corrective action and reporting was not identified). Current monitoring guidance would recommend establishing such an indicator range. The periodic monitoring of capture efficiency and control device performance using inlet and outlet THC measurements was identified as an appropriate technique.

Implementation of flexible permit monitoring, recordkeeping, and reporting provisions was consistent with that envisioned and intended during permit design.

Permitting authorities reported that the sources' implementation of monitoring, recordkeeping, and reporting (MRR) requirements was consistent with that intended during permit development. They also found that the scope, timing, and availability of MRR information was sufficient for the permitting authorities to monitor companies' compliance with permit conditions and applicable requirements. In two cases, adjustments were made to clarify or alter MRR requirements during permit implementation.

- During a 1995 inspection, MPCA identified potential deficiencies in the recordkeeping approach for temperature monitoring of the thermal oxidizer emissions control device at 3M's St. Paul Tape Plant. 3M was able to demonstrate that no violations of the control device temperature level or the VOC emissions cap had occurred. 3M and MPCA clarified and agreed on an acceptable approach for recording future control device temperature readings.
- In 1996, MPCA eliminated the requirement for a ten-day advance written notice from 3M of changes implemented under permit condition 2.3.4. MPCA reported that the agency believed that the post-commencement notice for changes (submitted within two weeks of an actual change) was sufficient to provide the agency and the public with a documented record of advance approved changes actually made at the source.

Certain topics related to the renewal of flexible permits warrant further thinking to clarify acceptable approaches.

While the flexible permits operated well during the initial permit terms, companies and permitting authorities identified two areas that could benefit from further thinking and clarification. The first involves clarifying acceptable approaches for updating PALs at permit renewal. Companies and permitting authorities indicated that revising PAL levels based on the average of actual emissions for the prior two years (or some similar approach) can create disincentives for emissions reductions and P2 if the correction is too extreme. At the same time, permitting authorities and companies acknowledged that some approach for revising PAL levels at permit renewal is important to address new considerations that may have arisen, such as new applicable requirements or changes in local air quality or attainment status.

The second area involves the clarification of acceptable approaches to transition back to conventional permitting approaches if flexible permits are allowed to expire and the company or permitting authority does not wish to renew the flexibility provisions. For example, in the case of the 3M St. Paul Tape Plant flexible permit, the advance approved change provisions expired at the end of the permit term, while the plant-wide VOC emissions cap has remained in place.[3] This has raised questions regarding what level of changes (if any) would be allowed before New Source Review (NSR) would be triggered.

[3] At the time of the EPA site visit in June 2001, the 3M St. Paul Tape Plant was operating under its State air operating permit, although the advance-approval conditions in the permit expired in March 1998. The plant has submitted its Title V permit application and is awaiting its draft Title V permit.

Finding 2: The flexible permits were considered to be enforceable by permitting authorities and EPA.

A key objective of the EPA's Flexible Permit Implementation Review was to verify that company compliance with the flexible permits is enforceable in a practical manner by permitting authorities and the EPA. Permitting authorities expressed their belief that the flexible permit provisions are practicably enforceable, and the EPA agrees with these permitting authority assertions based on the findings from the reviews of the six flexible permits.

The flexible permits contain sufficient monitoring, recordkeeping, and reporting requirements to enable permitting authorities and the EPA to assure compliance.

Permitting authorities believe that the flexible permits are enforceable in a practical manner. They believe that they have the ability to detect source compliance with the flexibility provisions, as well as all applicable requirements, based on the monitoring, recordkeeping, and reporting requirements established in the permits. Permitting authorities further reported that their experiences during implementation of the permits confirmed that the flexible permits are enforceable in practice. See Finding 1 above for additional discussion of the adequacy of permit design related to monitoring, recordkeeping, and reporting requirements.

The EPA agrees with the permitting authorities' statements regarding the ability to determine company compliance with permit conditions and applicable requirements based on the findings from this review. The EPA found the monitoring, recordkeeping, and reporting information implemented by the companies for calculating emissions and determining control equipment parameter values to be sufficient to determine compliance. The EPA Review Team was able to reproduce the exact compliance values for each flexible permit using actual emissions and monitoring data (e.g., material usage data, VOC content data, control device parameter data) and established emissions calculations procedures. The EPA found that all data necessary to perform compliance verification calculations was available and well-organized at the sources.

Permitting authorities reported that conducting inspections of sources with flexible permits is comparable to conducting inspections of sources with conventional permits.

While the number of inspections conducted by permitting authorities varied, permitting authorities generally indicated that inspecting sources with flexible permits was straightforward and comparable to conducting inspections for sources with conventional permits.[4] A few permitting authorities stated that some up-front education was required of permitting authority inspectors to ensure their familiarity with the flexibility provisions in the permits. They indicated such orientation was necessary since the flexible permits contained some requirements not typically required in conventional permits, such as on-site logs of alternate operating scenarios and changes implemented under the advance approval provisions, as well as plant-wide emissions calculations.

---

[4]The number of inspections conducted of sources with flexible permits by the time of the EPA's review varied primarily based on the length of time the source had been operating under the flexible permit. Permitting authorities typically reported that they conduct annual inspections of the sources, although in some cases (e.g., MPCA's inspection of 3M's St. Paul Tape Plant) the frequency of inspections was reduced as permitting authorities focused on higher priority activities (e.g., issuance of Title V permits).

In some cases, permitting authorities indicated that the flexible permits resulted in less difficult or time-consuming inspections. This was primarily attributed to the reduced need to verify compliance with numerous requirements for specific equipment or activities that are commonly included in conventional permits (e.g., limitations on production rates for process lines, equipment, or process level emissions). Instead, inspectors were able to direct attention to ensuring compliance with the plant-wide emissions limits.

Finding 3: The flexible permits facilitated and encouraged emissions reductions and pollution prevention.

The flexible permits were designed to bring sharper attention to the current level of actual plant-wide emissions and emissions per unit of production. While the permits generally did not require actual emissions reductions during the permit term, they contained provisions to facilitate and encourage emissions reductions and P2. The permit implementation experience, supported by statements from the sources and permitting authorities, indicates that the permits were effective in facilitating emissions reductions and P2. Of the five sources which had been operating under their flexible permits for three or more years, all five accomplished a significant lowering of actual plant-wide emissions and/or emissions per unit of production. Achieving such environmental benefits was attributed by the companies to several factors, as discussed below.

Companies accomplished a significant lowering of actual plant-wide emissions and/or emissions per unit of production during their flexible permit terms.

- 3M lowered its actual VOC emissions from 4,300 tons/year to 700 tons/year due to increased pollution control device capture of VOCs, greater use of voluntary controls, P2, and reduced production.
- DaimlerChrysler lowered its actual VOC emissions from 1,165 tons/year to 776 tons/year, primarily through P2 associated with vehicle coatings and plant solvent usage.
- Lasco tested its emission factor as part of developing its flexible permit, leading to a voluntary reduction in emissions of approximately 100 tons/year prior to obtaining the flexible permit. During the permit term, Lasco implemented P2 measures and installed a thermal oxidizer to increase production while remaining under the emissions cap. These efforts resulted in per unit emissions reductions of approximately 32 percent.
- Using P2 projects, Intel lowered its actual VOC emissions over three-fold, from 190 tons/year to 56 tons/year, to become a synthetic minor source while simultaneously increasing production.
- As Saturn had only operated under the flexible permit for 13 months (at the time EPA's review was conducted), it is difficult to determine trends in VOC emissions per unit of production. VOC emissions for the first year of the flexible permit implementation were about 580 tons/year, compared with 798 tons/year in the year prior to the issuance of the flexible permit (1999).
- Imation reported that it has achieved about an 11 percent reduction in the pounds of VOC emissions generated per unit of production in 2000 when compared with 1997 baseline levels.

Companies reported that the plant-wide emissions caps focused organizational attention on reducing plant-wide emissions.

Several of the flexible permits shifted the allowable level of plant-wide emissions downward.

- The flexible permit for 3M's St. Paul Tape Plant enforceably limited VOC emissions to less than half those previously emitted by this source. With respect to actual emissions, MPCA indicated that the State of Minnesota does not have a technology requirement (such as one for best available state-of-the-art technology) as part of their State minor New Source Review program. As a result, air pollution sources are in a position to maintain their historical emissions and to increase their emissions in 39-ton increments through minor changes on an ongoing basis. Under the flexible permit in 1993, 3M became subject to an annual VOC emissions cap of 4,283 tons. Prior to the flexible permit, 3M was "grandfathered" to emit up to 65,000 tons annually. In 1988, 3M had 10,600 tons of actual VOC emissions and then voluntarily installed controls, bringing emissions down to 4,300 tons/year in 1991.
- The establishment of VOC PALs for the Saturn plant was part of a PSD permit revision process to allow approximately a doubling of production capacity. Even with a substantial increase in production capacity, the new PSD permit (including incorporation of VOC PALs) sets maximum VOC emissions at a level of about 50 percent of the allowable VOC emissions under the original, superceded PSD permit for the plant.
- Imation's flexible Title V permit extended emissions limits to the 12W coating line that was previously "grandfathered" under the Clean Air Act. Without the voluntary emissions controls that Imation installed (prior to the flexible permit), the coating line had a potential to emit (PTE) of approximately 4,000 tons/year of VOC. The permit enforceably limited VOC emissions to one site-wide cap of 249 tons/year, creating "synthetic minor" status for purposes of PSD applicability. Imation could have requested two such caps since its operations at Weatherford involved two separate sources [i.e, different operations with different Standard Industrial Classification (SIC) codes].

While limits on allowable emissions do not necessarily affect actual emissions, several of the companies reported that the emissions caps had a "focusing effect," drawing company personnel's attention to managing activities so as to minimize plant-wide emissions. They added that conventional air permits typically contain a more diffuse set of emissions limitations on specific equipment or production lines that lack this focusing effect. With company attention focused on managing plant-wide emissions levels in relation to an emissions cap, several companies reported that this created structural incentives for the companies to pursue emissions reduction opportunities that increase the margin of compliance - the difference between the emissions cap and actual emissions. First, companies indicated that emissions reductions result in larger compliance margins that typically reduce the risk of non-compliance associated with emissions cap exceedances. Second, per unit emissions reductions can create room under the cap to accommodate future production increases.

- Lasco representatives indicated that the 249 tons/year PTE cap on VOC emissions created a strong P2 and emissions reduction incentive, particularly since the source's margin of compliance was not large (e.g., actual emissions were 244.5 in 1998) and since the cap created a real production constraint.
- DaimlerChrysler representatives reported that the flexible permit conditions are easier to communicate to operations personnel since the focus on a plant-wide emissions cap and P2 is more intuitive and provides more "clarity of focus" than specific equipment or production line requirements. As a result, it has been easier to engage operations personnel in exploring and implementing P2 projects under the flexible permit. By eliminating numerous requirements on individual emissions sources at the plant, the flexible permit has also complemented DaimlerChrysler's lean manufacturing initiatives designed to reduce complexity throughout the plant.

While emissions caps, in general, can encourage emissions reductions, certain permit designs can also create disincentives for reducing emissions. As mentioned above, several companies voiced a major concern that their over-control and/or use of P2 to create emissions “head room” under an emissions cap could be lost due to five year contemporaneous “ratcheting.” A significant compliance margin between actual emissions and applicable emissions caps is desired by sources to buffer against risk of emissions cap exceedances and to accommodate production fluctuations linked to changing market demand for plant products. Companies indicated that a counter-productive “ratcheting” situation can arise if a PAL is totally adjusted downward at permit renewal to reflect recent actual emissions levels (e.g., average of prior two years actual annual emissions).

Advance approved change provisions reduced the administrative “friction” associated with P2 changes, making such changes more attractive for companies to undertake.

Advance approval provisions for selected operational, equipment, and raw material changes can significantly reduce the administrative “friction” of making changes, including delay and costs for undertaking modifications that have P2 benefits. Companies indicated that under conventional permits, administrative friction often arises from two activities. First, desired changes are typically evaluated by company environmental personnel to determine whether any regulatory requirements apply to or are triggered by the desired modification. Several companies reported that such applicability determinations are often not straightforward, and that they frequently require careful interpretation and necessitate seeking guidance or clarifications from the permitting authority. Second, changes triggering minor NSR are typically subjected to a notice of construction permitting process to seek approval from the permitting authority in advance of initiating the modification. Staff time needed to conduct applicability determinations and individual permit applications increases transaction costs for each modification. Additionally, the time frame between when the desired change is first identified and when it is reviewed and permitted can extend beyond the company’s desired implementation time frame, resulting in a disincentive to change.

Companies reported that modifications designed to improve resource productivity, process efficiency, or reduce pollution are often implemented in an iterative manner, as source personnel initiate a modification, observe and measure results, and then make further refinements to optimize system performance. This could involve trying multiple raw materials to find one with optimal product quality and emissions performance characteristics. Several companies indicated that under such iterative change processes, increased transaction costs and time delays - or even perceived uncertainty about such costs and delays - can produce significant “barriers to entry,” causing the plant to forego modifications with positive environmental outcomes that lack significant strategic, operational, or competitiveness advantages.

- For example, Intel representatives indicated that operations personnel are less willing to engage with environmental staff in exploring potential P2 opportunities if they perceive that there is a significant potential for delay or time intensive regulatory evaluations and communications. Due to the iterative nature of many P2 projects, operations personnel typically need to conduct a series of experiments on a manufacturing process to see if the changes produce the desired results. Intel indicated that many of these individual changes could be subject to individual construction permitting actions thus imposing a very jagged, stop-and-go aspect to the experimentation process. Intel indicated that, under such conditions, operations personnel might well view experimentation for purposes of pollution prevention as being too disruptive of the manufacturing process to proceed.

Even when emissions-reducing projects “pay” (e.g., exhibit a positive return on investment), increased transaction costs, time delays, and uncertainty can reduce the projects’ ability to compete effectively for internal resources and organizational attention. The net result can be environmental benefits left on the table.

Companies reported that advance approval provisions can significantly improve the attractiveness of making modifications that result in reduced emissions by reducing their transaction costs and the potential for time delays. The examples below illustrate ways in which utilization of advance approved change provisions facilitated P2 activities at several of the sources with flexible permits.

- Between 1994 and 1998, Intel's Aloha plant made at least 18 P2-related equipment and material changes, utilizing the permit's advance approval provisions, that resulted in VOC emissions reductions of over 100 tons/year.
- DaimlerChrysler's NAP has undertaken numerous P2 activities utilizing the advance-approved change provisions in their flexible permit, including steps to reduce VOC and HAP emissions from vehicle coating processes. DaimlerChrysler representatives reported that, in the absence of a flexible permit, the source might have still pursued some of these P2 initiatives, but that they may well have been delayed to coincide with permit renewal time frames due to the cost and staff resources required to secure case-by-case permit approvals. They emphasized that the flexible permits significantly reduce the regulatory friction associated with making P2 changes, increasing incentives for P2.
- Lasco representatives stated that the flexibility provisions allowed the Yelm plant to test and undertake changes that reduced styrene emissions without having to wait for conventional case-by-case permit approval. The advance approved change provisions substantially increased the likelihood that Lasco would actually research and implement such changes, due to Lasco's corporate reluctance to undertake changes that would trigger NSR permitting actions. Lasco has implemented several changes utilizing the advance approval provisions that have reduced emissions, including installation of a new putty station and expansion of emissions control capacity.

Several flexible permits increased company awareness and focus on pollution prevention through explicit P2 program, reporting, and performance requirements.

Four of the flexible permits contained explicit conditions requiring the companies to implement formal P2 programs, report on P2 performance, and/or meet certain P2 performance targets. While these companies had histories of P2 accomplishment prior to issuance of the flexible permits, the companies generally reported that the explicit P2 permit conditions served to increase the visibility of P2 among plant personnel. When combined with the new focus on managing plant-wide emissions against a cap and the relative administrative ease for accomplishing such changes under the advance approval provisions, the P2 commitments and programs have empowered some company environmental personnel to expand P2 activities.

- Intel found that the flexible permit provided clear incentives to favor P2 over new emissions control technology for meeting the required source-specific, performance-based VOC Reasonably Available Control Technology (RACT) determination (permit condition 14). The explicit focus on P2 in the permit increased environmental personnel's leverage in their efforts to engage operations personnel in exploring and implementing P2 efforts.
- The P2 performance requirement included in the DaimlerChrysler NAP's flexible permit has prompted a clear organizational focus on reducing VOC emissions associated with vehicle coating operations. DaimlerChrysler is to begin utilizing a powder clearcoat by September 2003 if it is commercially available; if not, the company is to employ P2 measures that will reduce topcoat VOC emissions to below seven pounds of VOCs per gallon of applied coating solids on a daily weighted basis until a powder clearcoat option is commercially available.
- Even though a Washington State P2 expert familiar with the RFP industry identified Lasco as a "first

in class" pollution preventer, Lasco found that the flexible permit encouraged and facilitated company efforts to pursue additional P2 opportunities. To fulfill the flexible permit's P2 program requirement (which is linked to Lasco's BACT determination for advance approved changes), Lasco instituted a "P2 Task Force" at the Yelm plant. The task force is charged with identifying P2 opportunities and coordinating P2 activities throughout the plant. Lasco representatives stated that its employees are now more cognizant of how source emissions affect the community and of the importance of P2 as a result of the flexible permit development process and the increased organizational focus on P2.

- As part of its required P2 program, Imation conducted routine P2 meetings with a cross-functional team of plant managers and personnel at the Weatherford plant. P2 training for plant employees and research and development staff further heightened organizational focus on identifying P2 opportunities. Imation representatives also reported that the formal tracking of progress towards the plant's ten percent emissions reduction goal (i.e., based on emissions per unit of production) has increased plant personnel's awareness of and attentiveness to P2.

Finding 4: Companies with the flexible permits believe that air permitting is on their critical response path.

Companies participating in the review reported that conventional permits can constrain their ability to compete effectively. Though the factors differ somewhat for each source, the companies indicated that the combination of increasingly globalized competition and a shift to new modes of production substantially increased the pressure to operate highly flexible, nimble, and responsive research, development, and production operations. In this context, conventional, case-by-case air permitting, which the companies state can cause delay and uncertainty, can act as a mission-critical bottleneck to their operations.

Global competition across multiple industry sectors has shortened product life-cycles and increased the importance of moving new products quickly from development to market.

Companies report that global competition, which intensified during the 1990s through the integration of financial markets, reductions in trade barriers (e.g., NAFTA), increased industrial development in Asia and other regions, and substantially shortened product development time frames, has exposed U.S.-based operations to more and often lower cost producers. Examples of specific company competitiveness needs include the following.

- Intel reported that it operates in a highly competitive market and needs to meet aggressive product development schedules. Intel currently introduces a new generation of semiconductor chips every 12 to 24 months, with each new product cycle supported by a major "fab revamp." These operational changes are very time sensitive, to meet product release schedules from computer and electronics manufacturers, and involve highly interdependent and sequenced steps.
- 3M management indicated that the reduction in trade barriers associated with NAFTA and other international trade agreements, combined with the overall globalization of competition and the ability of potential competitors to purchase and install rapidly "off-the-shelf" production equipment, enables other companies to reach rapidly into 3M's market share with low cost product. In this context, 3M reports that "first to market" (where a week delay can be very significant) has become a critical business success factor, particularly in specialty product markets, such as the automotive and medical sectors. 3M reported that many specialty tape products become obsolete, and are replaced by newer

products, within six to nine months of initial production.

- DaimlerChrysler indicated that its vehicle development process, in part due to advances in computer-assisted design, has decreased from five years to about 18 months, substantially reducing its ability to accommodate conventional permitting time frames while meeting product development schedules.
- Saturn indicated that the automotive market has shifted significantly in recent years, necessitating more rapid responsiveness to market demands. In this context, Saturn has recently expanded its available product line and expects further changes in the near future, each of which requires significant production line retooling and process adjustments. Saturn also indicated that the vehicle development process has significantly shortened from five years to about 18 months. Previous lead times allowed ample time, in most cases, to secure needed permits while remaining on product development and release schedules. Under the new time frames, air permitting is now on its critical path.

Advance production concepts, designed to help firms compete effectively, encourage rapid, and sometimes iterative operational and equipment changes to continuously improve resource productivity, operational efficiency, and product quality.

Production theory and techniques have undergone substantial revision with emphasis placed on continuous resource productivity improvements. This emphasis - as reflected in such advanced production concepts as Lean Manufacturing and Six Sigma - substantially influences the day-to-day operating environments at many companies. These systems are characterized by a major drive to increase the velocity of production processes (reduce the time required to transform raw materials into product), increase asset utilization and cash flow, substantially shorten research and development time frames, continually improve process yields, and respond to heightened customer expectations for quality, product features, and delivery responsiveness. Specific examples from the permit reviews include the following.

- Intel reported a need to make rapid (and sometimes iterative) process and equipment adjustments in production processes to improve yield, lower costs, reduce chemical usage, and otherwise improve operations. Many of these changes involve switching chemicals used in tools and process chemical formulations, adjusting gas flow rates, and moving or adding tools (e.g., photo lithography equipment, plasma etchers, liquid acid baths).
- 3M indicated that, in response to competitive pressures, it is involved in a major corporate-wide drive to reduce cycle times and improve asset utilization and cash flow. These initiatives require for their success an in-plant culture of continual improvement and substantial flexibility for production operations.
- Lasco indicated that the key focus in the bathtub industry is making minor product modifications on an ongoing basis (rather than launching major new products like in the semiconductor industry). In this context, Lasco's competitive strategy focuses on continually increasing material yields, which requires seeking ways to utilize less and/or increase the capture of its input materials on a per unit basis. Lasco also needed flexibility to change production lines rapidly to accommodate different product types as short-term demand fluctuated among them.
- Saturn identified factory “agility” as a key to its ability to compete within the General Motors network of plants for new product lines, citing its flexible permit (and the factory responsiveness it provided) as a critical factor in its selection to produce the L850 “world engine.”
- Imation representatives indicated that the company desired to use the Weatherford plant to experiment with and pilot new coating technologies and product recipes to respond quickly to changes

in customer demand, as well as new production innovation opportunities. These changes involve short-term experimental use of manufacturing equipment, at times requiring changes to equipment configurations and the emissions profiles of the equipment. Imation further indicated that market demands frequently require rapid process changes, including substituting or introducing new raw material, relocating, modifying or adding new equipment, and/or interchanging pollution control devices.

Companies indicated that responding effectively to increasingly industry competitiveness requires operating environments capable of responding rapidly to changing market circumstances (e.g., develop and introduce new products rapidly and adjust production to address customer requests), moving production rapidly among facilities to achieve optimal asset utilization, and generally engendering a culture of continual operational improvement. The companies indicated that this results in an operating environment where changes to equipment, operating parameters, equipment configurations, and locations are more common and are often subject to tight deadlines.

Companies report that conventional permitting can be problematic due to the potential delay and uncertainty associated with such actions.

Although some variability exists, Federal and State and local air permitting rules generally prohibit an air pollution source from constructing, modifying, reconstructing, or operating an emissions unit, stationary source, or control device without explicit approval (typically in the form of an air permit or permit modification undertaken on a case-by-case basis at the time a source desires a change). The typical process for obtaining any needed New Source Review (NSR) approval involves the following:

- Communicating the nature of prospective changes to the permitting authority and discussions to determine if NSR would apply.
- Determining all the applicable regulatory requirements that the desired change would "trigger."
- Preparing and submitting any necessary permit application providing the details of the desired change. In many cases, permitting authorities may request additional information before a source's permit application is considered to be complete.
- Reviewing the application at the permitting authority and framing a draft permit (to ensure all applicable requirements are met, air quality protection is maintained, and needed technology requirements are imposed).
- Seeking and addressing public comments on the draft permit or permit modification, if required by Federal, State, or local rules governing the applicable requirements. In some cases, this step may involve public hearings.
- Issuance of the permit or revision required to undertake the change.

Permitting authorities reported that this process can take as little as 30 days (for a minor change that does not require public comment), but can extend to six or more months depending on the type of change, environmental impacts, applicable requirements, and public concerns. A typical time frame (required or strongly suggested by agency rules) for most minor source construction permit actions is 90 to 180 days, although certain permitting authorities indicated that past or current permit back logs inhibit their ability to respond within these time frames. Some states such as Oregon have provisions that allow "minor" operational changes (as defined by their specific rules) to proceed in parallel with the permitting process. Companies indicated that they utilize this option with some hesitancy since the outcome of the review is uncertain and the consequences of failing to obtain the permit (or be subject to an unexpected requirement) can be substantial.

Companies indicated that this case-by-case permit process can introduce significant delay and uncertainty into their operational decision-making and research, development, and production activities. Although case-by-case permitting actions can impose administrative costs from applicability determinations and permit application development, companies' concerns focused on the potential opportunity costs and competitiveness costs associated with delay and uncertainty in the permit process.

Companies reported that operational change delay results from the need to obtain a permit prior to "constructing" each planned operational change (or aggregated group of changes). In the new competitive environment described by the companies, they often do not have substantial advance notice of the specific operational changes needed to address customer demands or market opportunities. As a result, the need to delay implementation of the change to meet conventional permitting requirements can lead to lost market opportunity. Companies further indicated that many of the continual resource productivity improvements they desire to undertake require experimentation and highly iterative process changes. In this context, the need to obtain a permit before each iterative step turns continual improvement into an uncertain process that operations managers are disinclined to undertake.

- Intel identified 150 to 200 changes per year that they believe would have triggered minor NSR permitting. This number of changes, combined with the Oregon DEQ approval time frame of up to 60 days per change, suggest that there would likely have been significant delay under a conventional permit. Even if few delays would have resulted in production downtime or missed market opportunities, the costs would likely have been significant under a conventional permitting scenario, as many of the changes improved the cost-competitiveness of Intel's products through resource productivity improvements. Industry estimates of the opportunity costs of production downtime and time delays run as high as several million dollars in just a few days, due to lost sales to computer makers and other factors. Intel representatives indicated that the impact of continued time delays would likely be to redirect Intel's production investment and operating facilities to locations where changes could be accommodated within existing environmental regulations (e.g., other U.S. States or to other countries where Intel operates, such as Ireland or Israel) as they had done prior to receiving their flexible permit.
- DaimlerChrysler and General Motors (Saturn's parent company) reported that they have experienced PSD review processes lasting more than 2 years.

Several of the companies indicated that uncertainty in the permitting process creates "friction" for the operational change process because it increases risk. Companies indicated that uncertainty emerges from a number of aspects of the permitting process. First, companies reported that they are at times unsure about the applicability of permitting requirements to maintenance, repair, and replacement activities. Second, future permit requirements can be unpredictable due to the discretion inherent in setting emissions limits, making technology determinations, and establishing monitoring, recordkeeping, and reporting requirements. Third, the length of the permit review and approval process can be unpredictable, due to such factors as permitting authority backlogs and the degree of public interest. According to the companies, these factors combine to make it difficult for a company to accurately estimate the time frame and cost of a permitting action and, therefore, how the need to permit will affect the financial attractiveness and overall viability of an operational change.

Companies with flexible permits stated that they have similar needs at other facilities and are

interested in pursuing flexible permits for those facilities.

The six companies reported that they have identified similar flexibility needs at other facilities, and they expressed interest in pursuing flexible permits for those facilities. For example:

- Imation's Camarillo, California source has been issued a flexible permit through the EPA's Project XL initiative, modeled in several respects on the Weatherford permit. Imation representatives stated that they believe the flexibility techniques used in the Weatherford permit would be beneficial to other Imation facilities as well.
- DaimlerChrysler pointed to a plant in the Midwest as a primary example of the company's need to expand the use of flexible permitting approaches to other facilities. The plant's eight existing permits have multiple, unit-specific technology limits, emissions limits for different time periods, and a variety of operating conditions specific to each emissions unit, for a total of 128 specific permit conditions (as compared to only 16 for the Newark Assembly Plant's permit). Since the late 1980s, the source has been addressing permit modifications and other concerns on a continuous basis. More specifically, since 1992 the plant obtained 12 permits or permit revisions, with two involving Federal NSR. Three recent amendments took, on average, over a year to complete. DaimlerChrysler believes that had the plant been operating under a flexible permit, this number of permit transactions could have been reduced to only two, saving time and money as well as facilitating timely completion of P2 activities. DaimlerChrysler representatives indicated that the company has set a goal of having flexible permits for all DaimlerChrysler facilities in the U.S. within two years. However, DaimlerChrysler reported that permitting authorities in several other States are opting to hold off on negotiating such permits until EPA guidance and/or rulemaking are complete.

Finding 5: Companies with the flexible permits utilized their flexibility provisions.

Flexibility provision utilization during the permit terms exhibited rates and types of changes consistent with the needs expressed by the companies during permit development.

All of the companies have utilized advance approval provisions contained in their flexible permits.

- As mentioned, Intel reported that the Aloha plant made an average of approximately 150 to 200 operational and equipment modifications per year during the Title V permit term that would likely have been subject to Oregon's case-by-case Notice of Construction approval process under a conventional permit. These changes, primarily associated with "fab revamps" to scale-up production of new semiconductors and iterative changes to optimize existing production processes (including P2-driven changes), were implemented using the advance approval provisions in the Title V permit.
- 3M made 34 equipment and operational changes that utilized the advance approval conditions. 3M estimated that 15 to 20 of the changes would likely have required some form of permitting action under Minnesota's conventional permitting process, with two of these changes likely having triggered at least case-by-case PSD permitting analyses. 3M indicated that the advance approval provisions accommodated all of the source's change needs (i.e., no additional construction permitting actions were necessary), enabling the company to upgrade aging equipment and improve the yield and per unit emissions performance associated with coating lines.

- DaimlerChrysler's NAP made over 90 operational and equipment changes utilizing the permits' advance approval provisions between 1995 and 2000. Advance approved modifications were made to coating system components, coatings, cleaning activities, fuel-fired sources, source locations, ventilation systems, and emissions control systems.
- Lasco made five changes during the Title V permit term (as of July 2001) that utilized the advance approval provisions. The advance approvals enabled Lasco to add two new emissions units, increase its stack height to remedy odor concerns, modify its emission factor to account for improved emissions performance, and modify its control technology without requiring case-by-case permitting actions.
- Despite only having about one year of implementation experience under its flexible permit, Saturn has made several of the changes outlined in its PSD permit application, including construction of the L850 engine line and the second assembly line in General Assembly. Saturn reported that it is likely that changes to existing emissions units have been made during the first year of the permit term (i.e., June 2000 to August 2001) that utilize the advance approval provision in permit condition B.10.1. Saturn is not required to maintain records of these changes, provided the changes meet established criteria in the permit and plant-wide emissions remain below established caps.
- Imation and Oklahoma DEQ reported that the Weatherford plant has made frequent use of the flexibility provisions that advance-approve the use of alternative raw materials. In at least four cases, this included a streamlined toxics evaluation by the State, allowing the source to rapidly implement raw material changes at the source. Imation also utilized the advance approved alternative operating scenarios for control devices and methods on three occasions.

In addition, some companies stated that the number of changes made is not the only indicator or importance to them. Equally important to them is the ability to make certain critical changes when other business factors dictate.

Companies reported that the advanced approval provisions in the flexible permits fully addressed their operational change needs. With the exception of Lasco, the companies did not need to undertake any non-advance approved construction permitting actions (e.g., minor NSR and major NSR) during their flexible permit terms (i.e., typically a 5 year period). Also, the permitting authorities indicated that the sources did not make any changes under the advance approval provisions that were not authorized under the advance approval provisions.

- Lasco was required to submit a Notice of Construction permit application and seek a Title V permit amendment to install a regenerative thermal oxidizer during the flexible permit term. This was necessary since this change was not advance approved in the permit, and since the change required new MRR requirements.

Some companies did not utilize all of the flexibility provisions in their permits, but they anticipated using these flexibility provisions in the future.

While all six companies utilized at least some of the flexibility provisions in their permits, not all flexibility provisions had been used at the time of this review (with the exception of Intel). Several sources indicated that, while they can reasonably anticipate desired operational and equipment changes (or types of changes) well in advance, the exact timing of change implementation is often influenced by multiple factors, such as changing organizational investment priorities and resources and fluctuations in customer demand. Companies typically reported that they anticipate using their unused flexibility provisions later in their permit terms or following permit renewal. For example:

- During the first 14 months under the flexible permit, Saturn did not implement the advance approval provisions which allow construction of new emissions sources (i.e., permit condition B.10.2). Saturn and TDEC anticipate that this provision will be useful in the future to accommodate changes associated with vehicle model year changeovers.
- As of December 2001, the Weatherford site had not implemented two changes that were specifically described in the advance approved minor NSR change provisions (i.e., permit condition Section H, Subsection 2, Requirement 1b and 1c). Imation indicated that the source may undertake these changes in the future.

The flexible permits appear to accommodate a substantial number of advance approved changes while providing sufficient clarity to support practical enforceability.

The permitting authorities indicated that the actual changes made under the flexible permits were fully consistent with those envisioned during permit design and that the changes were made in a manner consistent with the constraints imposed by the permits. The flexible permits vary in the degree of specificity with which advance approved modifications are described in the permits. Each of the permits, however, imposes clear boundaries for determining which changes would not be covered under the advance approval conditions. Changes triggering new applicable requirements, including new or modified MRR requirements, that were not already addressed in the permit, are subject to conventional permitting and approval procedures.

- Changes advance approved in Intel's Title V permit were clearly defined categorically and by conditions documented in the permit. For example, advance approved changes could only be made at the stationary sources comprising Emissions Unit 1 (EU1); construction of entirely new stationary sources are not covered; changes to a pollution control device are not covered; and no new applicable requirement can be triggered by an advance approved change. In addition, advance approved changes must not result in source non-compliance with the VOC RACT requirement and the source PSELs.
- 3M's flexible permit contained specific categories of changes advance approved by the permit, such as updating drive mechanisms and electrical components on coating equipment and replacing or upgrading coater ovens, provided that 3M satisfied specific requirements described in the permit (e.g., remain below emissions caps and meet applicable New Source Performance Standards). If 3M desired to make a change not specifically covered by the listed advance approved categories of changes, they would be required to proceed with a conventional permitting process for the modification, unless MPCA agreed that the change was "consistent with" the changes advance approved by the permit.
- For DaimlerChrysler, some changes made under the flexible permit were not fully advance approved, but were eligible to go through an expedited review process if all applicable requirements were met and if no public hearing was requested during the public notice period.

Several companies reported that they did feel a need to contact their permitting authority during the permit term to discuss or clarify whether a particular modification would be allowed under the advance approval provisions in their pilot permit.

- 3M indicated that on two or three occasions, they contacted MPCA to discuss planned changes that were not explicitly addressed by the permit but appeared to be covered by the "consistent with" phrasing included in the permit. In each of these instances, MPCA indicated that the planned change would not require a permitting action.

- On one occasion, Lasco filed a Notice of Construction permit application to change the venting of the regenerative thermal oxidizer (RTO). After the application was submitted, OAPCA informed Lasco that the proposed change was covered by the advance approval provisions and the application was unnecessary.

Some companies indicated the flexible permits have facilitated an increase in the rate and a shift in the type of changes made, when compared to a conventional permitting approach.

Some of the companies indicated that they would not have made certain changes, had such changes not been advance approved in their flexible permit. They typically stated that the time frames associated with conventional minor NSR and other types of air permitting, as well as uncertainty regarding the applicability of certain regulatory requirements, often creates sufficient "friction" (e.g., cost, delay, and risk) to make a proposed change unattractive. The EPA found evidence that proposed P2 changes are particularly vulnerable to being shelved under a conventional permitting approach, since they often involve iterative experimentation that could heighten regulatory transaction costs. In addition, P2 modifications often receive lower organizational investment priority unless they simultaneously address an important operational need. Advance approval provisions facilitated research and development into alternative processes. When research uncovered a promising process technique, the company could implement the change without waiting for case-by-case approval and permitting.

- Intel reported that successful pollution prevention initiatives directed at ongoing processes can be iterative in nature. The company typically conducts a series of experiments on its manufacturing process to see if the changes produce the desired results. Many of these individual changes could be subject to construction permitting actions, thus imposing a stop-and-go aspect to the experimental process. Intel indicated that, under such conditions, operations personnel might well view experimentation for purposes of pollution prevention as being very disruptive of the manufacturing process and therefore recommend that it not proceed.
- Lasco reported that the company is inclined not to make changes that have potential to trigger additional air permitting requirements, attributing this reluctance to potential costs, delay, and uncertainty associated with permitting actions. For example, Lasco installed more complex putty systems for attaching boards to the inside of bath units at other Lasco facilities to prevent the systems from triggering air permitting requirements. The advance approval provisions enabled Lasco to incorporate a new putty station design into the product production line at the Yelm site in a streamlined manner, resulting in material savings and VOC emissions reductions.

Finding 6: The flexible permits enhanced information sharing between the companies and permitting authorities.

All six permitting authorities stated that the flexible permits enhanced their overall understanding of company activities and emissions as compared to conventional permitting approaches. The flexible permits did, however, alter the timing and format of certain types of information, such as information regarding changes implemented under advance approval provisions, when compared with information available under conventional permits. In several areas, such as plant-wide emissions performance and P2 performance, the flexible permits typically required information that is not required by conventional permits.

The flexible permit development process provided permitting authorities with a clearer understanding of the maximum plant-wide emissions levels anticipated during the permit terms.

The flexible permits provided clear information regarding the maximum level of emissions that would be allowed during the permit term, in the form of established emissions caps. If a source desired to exceed its emissions cap, it would thereafter be required to undergo a major NSR permitting process that would require public comment. For example, in accepting the PTE cap of 249 tons/year of VOC emissions, Lasco had to reduce its actual emissions, providing assurances to local residents that plant-wide emissions would thereafter be held relatively steady, despite company plans to increase production during the permit term.

During permit development, companies were required to share more information regarding the type of changes anticipated during the permit term, providing a more comprehensive, up-front picture of anticipated operational activities and associated environmental performance than a conventional permitting process.

The permitting authorities believe that the flexible permit development process, through the discussions of advance approved changes, provided them with a clear advance understanding of the types of modifications that the companies anticipated during the permit term. Under a conventional permitting approach, change information would typically only be available in a more fragmented, incremental manner, as companies pursued approval to make changes on a case-by-case basis. Under the flexible approach, applicable requirements associated with each advance approved change are identified up-front in the permit, affording a long-term view of potential applicable requirements, resulting emissions control requirements, and environmental outcomes. This enabled the permitting authority to have a more comprehensive picture of changes, and associated environmental performance outcomes, that would likely occur over the permit term (e.g., 5 years).

During permit implementation, information regarding changes made by the companies using the advance approval provisions varied among the flexible permits but was generally comparable to or greater than that produced under a conventional permitting process; the flexible permits did alter the timing and format of change information, as compared to conventional permitting approaches.

Variability is evident across the six flexible permits with respect to how advance approved changes were required to be documented and reported. Most of the flexible permits required some form of notices and/or summary lists of advance approved changes made to be submitted to the permitting authority, in addition to maintenance of an on-site log of advance approved changes. At one end of the range, 3M was required to submit advance notices and post-construction notices to MPCA for each change implemented using the advance approval provisions (note: during the permit term, MPCA eliminated the advance notice requirement, streamlining relevant information into the post-construction notices). 3M was also required to submit annual summaries of advance approved changes made during the year. At the other end of the range, Intel's permit did not require the company to report information on specific changes implemented using the advance approval provisions for a given six-month period if the maximum capacity to emit for the source declined through P2 or other means during this period, when compared to the previous six-month period. Saturn's permit requires the source to register new advance approved emissions sources with TDEC, although reporting on specific advance approved changes to existing emissions sources listed in the permit is not required. Under the Intel and Saturn pilot permits, it is likely that less information on certain specific advance approved changes was available to the permitting authorities, when compared with a conventional permitting approach, in cases where such changes would have triggered the need for a NSR permit application. This assessment assumes that these advance approved changes would have been undertaken by the companies under a conventional permitting approach. The permitting authorities indicated that the information available under the flexible permits was, at a minimum, sufficient to verify compliance with all applicable requirements and to keep them appropriately informed of source activities.

Permitting authorities generally indicated that some form of recordkeeping and reporting regarding source implementation of advance approved changes is important. Inspectors with DNREC and OAPCA reported that it is helpful to have information on changes made using advance approval provisions during their inspections, whether this information was reported in advance or maintained in logs at the source.

Under a conventional permitting approach, a company typically submits a notice of construction or other such permit application to the permitting authority for approval prior to implementing a change that triggers NSR. These applications typically include specific information on proposed modifications. In addition, companies are generally required to submit a notice of completion to the permitting authority once the company has finished "construction" of the change. While the same type of change information is typically made available under a flexible permit, the timing and format of the information differs from that required under a conventional approach. First, the advance approval provisions in flexible permits provide some information at the beginning of the permit term regarding specific changes or categories of changes that are anticipated during the permit term. No such advance information is required under conventional permitting approaches. Second, under flexible permits, companies generally do not submit permit applications for individual changes, unless the changes are only partially advance approved. Instead, information on actual changes made that fit the advance approval descriptions is typically provided to the permitting authority soon after the change is implemented, typically in the form of a post-construction notice. In addition, most pilot sources operating under flexible permits are required to record information on changes made using the advance approval provisions in an on-site log that is available to agency inspectors. Third, the flexible permits frequently require some form of aggregated summary reporting on changes made using the advance approval provisions. The companies are typically required to list all advance approved changes made during a particular reporting period, such as the past month, quarter, or year. Permitting authorities indicated that the summary reporting further helps to create an aggregated picture of changes made at the source, when compared with a series of case-by-case permit applications in the agency file.

The section below discusses more detail regarding the timing, type, format, and accessibility of change information available under the flexible permits.

- 3M's permit required the company to provide written notice to MPCA for each change implemented by the plant that utilized the advance approval provisions in the permit. A written notice was due to MPCA ten days prior to beginning actual construction and a subsequent notice was required to MPCA two weeks after commencing operation. In May 1996, MPCA representatives reported that the agency believed that the post-commencement notice for changes was sufficient to provide the agency and the public with a documented record of advance approved changes actually made at the source. 3M was also required to submit an annual summary report of advance approved changes implemented during the past year.
- Imation is required to submit a notice of completion 30 days after the completion of construction of advance approved changes.

- Lasco's flexible permit required the company to submit notices of construction completion to OAPCA for each advance approved change undertaken. Lasco is also required to maintain an on-site log of changes implemented under the advance approval provisions. The permit also requires Lasco to submit a semi-annual summary of advance approved changes undertaken.
- DaimlerChrysler is required to submit monthly reports listing changes made using the advance approval provisions during the prior month. The NAP is also required to maintain an on-site log of changes made under these provisions and to submit an annual summary list of advance approved changes implemented.
- Saturn is required to register with TDEC new emissions sources constructed under the advance approval provisions of the permit. This registration includes the submission of a completed application form, a brief process description, documentation of BACT or minor source BACT (for sources below established emissions threshold levels) for the new source, and periodic monitoring parameters for any control equipment. The permit also requires Saturn to submit a plan to assess the emissions of toxic, volatile pollutants from the source within two years of permit issuance.
- Intel's permit required the company to submit a list of advance approved changes made during each six-month period, if there was a net increase in the maximum capacity to emit at the source for that period, when compared with the maximum capacity to emit for the previous six-month period. This occurred once during the five-year permit term.

Several permitting authorities reported that they received more change information from companies operating under the flexible permits than would have been available under a conventional permitting approach. These permitting authorities reported that the flexible permits encouraged sources to report on operational and equipment changes, even if these changes would not have triggered minor NSR applicability under a conventional approach. Since the advance approval provisions removed the need to make case-by-case determinations of NSR applicability for individual changes implemented during the permit term (companies only needed to determine whether the changes satisfied the advance approval criteria specified in the permit) companies tended to report more changes. For example, 3M indicated that the company viewed the permit as a valuable asset, and they indicated that they desired to protect this asset by ensuring a high level of communication with MPCA. Some permitting authorities indicated that the conventional NSR program may sometimes create disincentives for companies to report changes for which the applicability of NSR is uncertain, since such discussions with the permitting authority to determine applicability could prove time intensive and lengthy. Permitting authorities indicated that the flexible permits remove any incentive for companies to "push the interpretation" of applicability determinations in a direction that would result in less change reporting.

- MPCA representatives reported that 3M reported information on changes that would not have triggered minor NSR applicability under a conventional permitting approach, providing MPCA inspectors and the public with more information on changes implemented at the source.
- DNREC inspectors indicated that DaimlerChrysler reported information on changes beyond those that would have been required under a conventional permitting approach. The inspectors indicated that this enhanced their understanding of company activities.

During permit implementation, the flexible permits required the provision of more comprehensive and useful information on plant-wide emissions performance to permitting authorities.

Permitting authorities reported that the plant-wide emissions reporting required under the flexible permits provides more comprehensive and easy-to-understand information on actual environmental performance during the permit term. In some cases, such as for the DaimlerChrysler and 3M permits, the frequency of emissions reporting information was also greater than that typically required under a conventional permit. Even when more frequent emissions reporting was not required, however, the companies were required to maintain current emissions calculations on-site to demonstrate compliance with the established plant-wide emissions caps. The flexible permits all require companies to make these emissions calculations available to permitting authority inspectors and personnel upon request. Conventional permitting approaches typically require preparation of an emissions inventory by the source on an annual basis.

- DaimlerChrysler is required to submit monthly emissions reports to DNREC that include comprehensive, plant-wide information on VOC and NO_x emissions. The monthly frequency of these reports is greater than what would typically be available under conventional permits.
- The 3M flexible permit required the St. Paul Tape Plant to submit quarterly reports to MPCA on the source's plant-wide emissions. The permit required 3M to report on all plant emissions units, including those that had been "grandfathered" by the Clean Air Act. These previously "grandfathered" emissions units were also required to be included in the plant's emissions monitoring activities and enforceable compliance limits. MPCA indicated that daily and annual rolling totals of VOC emissions provided near "real time" information on actual plant-wide emissions.
- The Intel Title V permit retained Intel's original PSELs, pollutant-specific, plant-wide short-term and annual caps on actual emissions. Intel submitted semi-annual monitoring reports to Oregon DEQ containing semi-annual compliance certification, emissions statements, and excess emissions upset log. Since Oregon regulation required PSEL, Oregon DEQ stated that their emissions reporting was very similar to that required by other Title V facilities in the State.
- Oklahoma DEQ indicated that Imation's flexible permit requires annual emissions reporting, similar to that required under a conventional Title V permit, including annual compliance certification and an annual emissions inventory. Oklahoma DEQ indicated that the flexible permit incorporates a previously "grandfathered" source that would not have been included in compliance reporting under a conventional permit.
- Under its flexible PSD permit, Saturn is required to monitor and log monthly plant-wide emissions data which are maintained on-site and available for TDEC inspection. Saturn and TDEC indicated that plant-wide emissions reporting will be required in the forthcoming Title V permit for the source.

During permit implementation, four of the six flexible permits required companies to share information regarding P2 activities and performance with the permitting authorities. Conventional permits do not typically require companies to share P2 information with the permitting authority or public.

The flexible permits developed for Intel, Imation, and Lasco under EPA's P4 program each require the companies to implement P2 programs. The companies were required to report information on their P2 programs to the permitting authority, in addition to periodic reports on P2 activities, accomplishments, and performance. DaimlerChrysler is also required to submit routine reports documenting P2 activities.

- Imation's implementation of a P2 program is voluntary, but there is an explicit link in the permit between adoption of an approved pollution prevention program and the BACT determination for advance approved changes. Therefore, to access advance approvals that require BACT, Imation must have an approved P2 program in place, which Imation did implement during the permit term. The Lasco permit contained a similar connection between BACT and a P2 program. The flexible permit requires Imation to submit an annual P2 executive summary describing the pollution prevention activities and programs adopted on site, as well as progress against a P2 target of 10 percent per unit emissions reduction during the permit term.

- Intel was required to submit an annual P2 progress report to Oregon DEQ, and a final report at the end of the permit term.
- DaimlerChrysler is required to report annually on their P2 activities as part of the annual compliance certification.
- Lasco is required to submit an annual P2 progress report, which documents P2 techniques, goals and accomplishments. Additionally, prior to the end of the third and fifth year of the permit term, Lasco is to submit a report demonstrating compliance with the P2 Program.

Finding 7: The flexible permits generally provided to the public equivalent or greater information than conventional permits.

The EPA's examination of the public record and the availability of information to the public during the development and implementation of the flexible permits indicates that the permits shifted the timing, type, and format of information to the public on emissions performance, operational and equipment changes, and P2 activities. As discussed in Finding 6 above, the six permits vary in the specific format, timing, and availability of certain types of information required, particularly related to certain specific advance approved changes implemented under the permits. In areas such as plant-wide emissions performance and P2 information, most of the flexible permits clearly increased the availability of information to the public. In all six cases, the permitting authorities indicated that, on balance, the flexible permits improved the availability of information to the public.

During permit development, the flexible permitting efforts followed or exceeded the permitting authorities' conventional communications and public involvement procedures.

Permitting authorities indicated that the availability and flow of information to the pubic during the development of the flexible permits satisfied or exceeded all requirements associated with the agency's standard operating procedures for permit development. This procedure typically includes making the draft permit available to the public at the permitting authority offices and at a local public library, publishing notice of the draft permit and public comment opportunities in one or more newspapers, holding a public comment period (e.g., typically 30 days), and conducting a public hearing if requested by the public. Some permitting authorities also publicize draft permits on their website or through other communication mechanisms.

In four of the flexible permit development efforts, including the three permits developed under the EPA's P4 program, the permitting authorities and companies voluntarily conducted one or more public meetings (i.e., in addition to any opportunity to hold a public hearing as part of the formal review process). While these meetings were not requested by the public, the permitting authorities and companies believed that the innovative nature of the permits increased the importance of taking active steps to inform local communities about the efforts. In addition, several of the permits experienced local media coverage about the innovative nature of the permits.

- At the beginning of the flexible permit development effort in 1996, citizens of Yelm, Washington did not view Lasco as a "good cooperate neighbor" due to past odor issues. The subsequent level of information flow to the public surrounding the Lasco permit development consisted of several meetings, many public notices, and extensive communication between Lasco and OAPCA. At the end of the permit development process, the Sierra Club submitted a letter supporting Lasco's flexible permit and thanking EPA Region 10, OAPCA, and Lasco for their proactive efforts to involve the community in the permit development process.

- Companies and permitting authorities involved in the development of the Imation, 3M, and Intel flexible permits each deemed an up-front public meeting in conjunction with the public comment period to be helpful in communicating to the public about the flexible permits, due to their innovative nature. In addition, the companies and permitting authorities were interested to understand early on any potential public questions or concerns about the permits. No adverse comments were subsequently received from the public for any of these permits.

The flexible permit development process increases the availability of information to the interested public regarding anticipated changes and emissions levels, as compared to a conventional permit development process.

As discussed in Finding 6 above, the flexible permit development processes provided clear information to the public regarding the maximum level of source emissions that would be allowed over the permit term, in the form of established emissions caps. Permitting authorities indicated that the emissions cap requirements in the draft permits and communicated during public meetings (when held) provide useful information to interested members of the public. If a source desires to exceed its emissions cap, it would thereafter be required to undergo a major NSR permitting process that would require public comment. The Lasco example demonstrates how such up-front information on total allowable plant-wide emissions can increase public understanding of the permit and anticipated environmental performance. In accepting the PTE cap of 249 tons/year of VOC emissions, Lasco had to reduce its actual emissions, providing assurances to local residents that emissions would thereafter be held relatively steady, despite company plans to increase production during the permit term. This awareness allayed one of the key concerns voiced by members of the Yelm community.

During development of the flexible permits, more information was available to interested members of the public regarding the type of changes the sources anticipated making during the permit term, when compared to a conventional permit development process. As discussed in Finding 6, the permitting authorities believed that the flexible permit development process, through the discussions of advance approved changes, provided them and interested members of the public with a clear advance understanding of the types of modifications that the sources planned to make during the permit term. Under a conventional permitting approach, change information would typically only be available in a more fragmented, incremental manner, as companies pursued approval to make changes on a case-by-case basis. Under the flexible approach, applicable requirements associated with each advance approved change are identified up-front in the permit, affording a long-term view of potential applicable requirements, resulting emissions control requirements, and environmental outcomes. This enabled the permitting authority and interested members of the public to have a more comprehensive picture of changes, and associated environmental performance outcomes, that would likely occur over the permit term.

During permit implementation, the flexible permits varied in the availability of information to the public about plant-wide emissions, operational and equipment changes, and pollution prevention activities; all permitting authorities indicated that, on balance, the flexible permits enhanced the availability of information to the public as compared to information typically available under conventional permitting approaches.

During permit implementation, the flexible permits required the provision of more comprehensive and, from several of the permitting authorities' perspectives, more useful information on plant-wide emissions performance to permitting authorities. As discussed in Finding 6, permitting authorities reported that the plant-wide emissions reporting required under the flexible permits provides more comprehensive and easy-to-understand information on actual environmental performance during the permit term. In some cases, such as for the DaimlerChrysler and 3M permits, the frequency of emissions reporting information was also greater than that typically required under a conventional permit. In other cases, such as for Imation and 3M, the flexible permits required the companies to report emissions from previously "grandfathered" emissions sources in their plant-wide emissions reporting. For all the flexible permits, the reports containing information on plant-wide emissions were available to the public in the permitting authorities' files.

The EPA found that there are a variety of techniques for making information available to the public regarding changes made using the advance approval provisions. These techniques include advance notices, post-construction notices, change registration, and periodic summaries of changes made (e.g., monthly, quarterly, or annual). For changes that do not meet the advance approval provisions, or that would cause a company to increase its emissions caps, the company would be required to undergo a conventional permitting process that would include submission of required application materials and completion of required public notice and comment procedures. When combined with the information on anticipated changes identified during the permit development process, as well as information on plant-wide emissions and P2 activities, the permitting authorities believe that flexible permits ensure the flow of sufficient information to enable the permitting authorities to effectively enforce for all applicable requirements, to ensure that air quality is protected in accordance with their SIPs, and to ensure consistency with the Clean Air Act's intent to provide for effective opportunities for public input into air permitting decisions.

As discussed in Finding 6, there was variability in the reporting requirements for changes implemented using the advance approval provisions. For four of the flexible permits, including those for 3M, DaimlerChrysler, Imation, and Lasco, the EPA found that approximately equivalent information on advance approved changes made was available to the public under the flexible permits, as compared to what permitting authorities indicated would have been available under conventional permitting approaches. In these cases, the timing and format of the advance approved change information was shifted when compared to conventional permitting approaches. In general, more general information on advance approved changes was available up-front during permit development, and more detailed information on specific changes made was available in the form of notices and lists of changes made, as opposed to minor NSR construction permitting applications. In addition, MPCA and DNREC found that the companies reported changes in addition to those that would likely have triggered minor NSR permit applications under a conventional permitting approach. For the Intel and Saturn flexible permits, as discussed in Finding 6, more general information on anticipated changes was available up-front during permit development, but less information on individual changes implemented using the advance approval provisions was available during permit implementation when compared to a conventional permitting approach, assuming that these changes would have been made under a conventional permitting approach.

During permit implementation, four of the flexible permits required companies to report information regarding P2 activities and performance to the permitting authorities. This information is available to interested members of the public through the permitting authority files for these sources. P2 information would not typically be available to the public under a conventional permitting approach.

- The Imation pilot permit required the company to submit annual P2 reports to Oklahoma DEQ describing the P2 activities and programs adopted at the site, as well as progress against an established P2 target. This information is available to the public in the permitting authority's files.

- Intel was required to submit an annual P2 progress report to Oregon DEQ, and a final report at the end of the permit term. This information is available to the public in the permitting authority's files.
- DaimlerChrysler is required to report annually on their P2 activities. This information is available to the public in the permitting authority's files.
- Lasco is to submit an annual P2 progress report, which documents P2 techniques, goals, and accomplishments. Additionally, prior to the end of the third and fifth year of the permit term, Lasco is to submit a report demonstrating compliance with the P2 Program. This information is available to the public in the permitting authority's files.

Finding 8: The flexible permits produced or are likely to produce net financial benefits to companies and permitting authorities.

Companies and permitting authorities reported that the flexible permits have resulted in net financial benefits, or that they anticipate that this will be the case. Companies and permitting authorities indicated that initial permit development costs exceeded those required to develop conventional permits, due to factors related to the pilot nature of the permits, as well as to factors inherent to developing flexible permitting techniques. In each case, however, companies and permitting authorities reported that the flexibility provisions have decreased, or are expected to decrease, the administrative costs of operating under the permit sufficiently to more than offset the higher initial permit development costs.

Permit development costs for the flexible permits were significant, but these higher costs were largely attributed to the pilot nature of the permits.

Companies and permitting authorities involved in the flexible permitting efforts reported that the costs, primarily resulting from staff time devoted to development of the flexibility provisions, were greater than those typically experienced in the development of conventional permits.

- MPCA representatives estimated that about 1000 hours of MPCA staff time were devoted to development of the permit. MPCA representatives noted that a primary factor contributing to the length of the permit development was that this was the first flexible permit developed in Minnesota, as well as one of the first developed and issued in the U.S.
- The development of Lasco's flexible Title V permit spanned approximately 16 months, from initiation of discussions (e.g., P4 group discussions) until the permit was issued. However, in addition to this being a team-oriented "demonstration" project necessitating additional review and public participation (see below), this was OAPCA's first Title V permit. OAPCA representatives reported that these factors contributed to the overall length of the permit development process. In the future, OAPCA indicated that flexible Title V permits will likely take only slightly more time to develop and issue than conventional Title V permits (e.g., approximately 180 hours versus 160 hours).

Permitting authorities indicated that a substantial amount of the higher permitting costs were attributable to the pilot nature of the permits. These pilot costs stemmed partly from the need for frequent conference calls or meetings between the permitting authorities, the EPA Regional Offices, and the EPA headquarters to ensure the flexible permitting techniques would be approved by the EPA in the absence of guidance on flexible permitting. Additional costs also resulted from the fact that each of the six flexible permits were the first developed under these permitting authorities' jurisdictions, and there was limited national experience with specific flexibility provisions from which to draw upon. Permitting authorities indicated that the pilot-related transaction costs would likely be reduced significantly or eliminated if the EPA were to issue guidance and/or rulemaking that clarified the flexible permitting approaches and techniques that are acceptable to the EPA.

Some portion of the higher permit development costs, however, were associated with tailoring of flexible permitting techniques to address the specific applicable requirements, needs, and circumstances of the sources. Permitting authorities and companies indicated that these costs would be incurred in the development of any new permit containing flexibility provisions, even if the use of flexible permitting techniques becomes routine and is supported by EPA guidance or rulemaking. For example, communications between the companies and permitting authorities regarding the changes that companies' anticipate making during the permit term are typically necessary to develop advance approval provisions. Other flexible permitting techniques, such as the development of replicable operating and testing procedures and streamlining of applicable requirements, also entail more significant interactions between a company and permitting authority during permit development.

- 3M and MPCA reported that additional time was required during permit development to develop the advance approval descriptions. This involved discussions to identify the specific changes and categories of changes that 3M anticipated making during the permit term.

Companies and permitting authorities that have renewed their flexibility provisions in subsequent permits indicated that the renewal costs have been minimal, as compared to costs required under a conventional permit renewal process. While some advance approval provisions may need to be updated at permit renewal, to accommodate new change needs anticipated by the company over the subsequent permit term, this process generally requires significantly less company and permitting authority resources than were required for the initial development of flexibility provisions for the source. This means that potential financial benefits for companies and permitting authorities can be extended to subsequent permit terms.

- Oregon DEQ incorporated many of Intel's flexibility provisions into the company's subsequent synthetic minor air permit without requiring additional permitting authority resources.
- DNREC reported that it was able to incorporate the flexibility provisions in DaimlerChrysler's original pilot flexible permit into the company's Title V air operating permit without requiring resources beyond those necessary to issue a conventional Title V permit.

Companies and permitting authorities reported that they experienced financial benefits from implementation of the flexible permits that more than offset the higher up-front permit development costs.

Companies and permitting authorities reported that financial benefits arose during permit implementation from the reduced administrative costs associated with company operational and equipment changes made under the advance approval provisions. Companies indicated that the advance approval provisions reduced the staff time and resources necessary to implement changes covered by these provisions. Company personnel found that they did not need to perform detailed applicability determinations for individual changes, provided that the changes satisfied the advance approval conditions listed in the permit. Such applicability determinations for advance approved changes were performed during permit development and clarified in the permit. Companies indicated that this streamlined applicability determination process and the improved certainty related to how changes would be addressed under the permit reduced the companies' staff time needed to process changes. Further savings resulted from the companies' reduced need to prepare applications for construction permits and/or permit modifications for individual changes, due to the advance approval provisions. Companies indicated that the time necessary to complete permitting authority notifications of advance approved changes and/or to record such changes in on-site logs was significantly less than the staff time necessary to prepare permit applications under a conventional permitting approach.

- DaimlerChrysler representatives estimated that the flexible permits save the company significant staff time that would have been associated with applicability determinations and permit actions for changes made using the advance approval provisions. They estimated that approximately 505 hours of staff time were saved under the initial flexible permit. These savings are projected to increase in the future as the company makes more changes utilizing the advance approval provisions in the permit.
- Under a conventional permit, Intel would have needed to prepare approximately 150 to 200 notice of construction applications per year (that were not required under the flexible permit). Intel estimated that each application would have required an average of approximately 8 hours, resulting in 1,200 to 1,600 hours of staff time per year.
- Lasco estimated that to execute a construction permit requires approximately 50 staff hours. Additionally, to process a permit modification, Lasco would need to submit a pubic notice (with an estimated cost of $350) and to hold a public hearing (with an estimated cost of $400). For all five changes made using the advance approval provisions, Lasco estimated a cost savings of more than $20,000.

Permitting authorities also reported that they have experienced, or anticipate experiencing, administrative cost savings during permit implementation.

- MPCA representatives indicated that they view flexible permits as saving agency resources by reducing the number of case-by-case change reviews and permitting actions. MPCA estimated that each of their minor NSR permit actions (if straightforward) require an average level of effort equivalent to approximately $1,000, and 3M estimated that approximately 15 to 20 of the 34 changes undertaken likely would have required a minor permitting action. From MPCA's standpoint then, the flexible permit provided an administrative savings benefit of between $15,000 and $20,000. Further, 3M indicated at least two of their changes may have been major permit actions requiring approximately 100 hours of processing by MPCA. At $125 per hour, this would represent an additional savings to MPCA of $25,000.
- Oklahoma DEQ representatives stated that the Imation permit has saved time for DEQ personnel, enabling them to "operate more effectively" with their limited staff. They indicated that most of the time savings result from the reduced need for administrative processing of case-by-case construction permitting actions and air toxics approvals. DEQ representatives stated that they have identified at least five changes made under the advance approval provisions that would have required a permitting action under a conventional permitting approach, but that only required written notices under the flexible Title V permit. They indicated that, minus the flexibility provisions, each of these permitting actions would have required a 45-day review and approval process that could have extended well beyond that in some cases. They further indicated that this resource savings enables DEQ to focus scarce resources on inspections and other environmental and permitting priorities.
- The Intel permit saved Oregon DEQ significant staff time associated with processing notice of construction applications from Intel. Intel estimated that in the absence of the flexible permit, Oregon DEQ would have needed to process approximately 150 to 200 additional notice of construction applications per year. Even at a very low estimate of two staff hours per application, the staff time implications are significant (e.g., 300 to 400 hours).

- During the flexible permit term, Lasco made five advance approved changes that would have otherwise triggered case-by-case minor NSR permit actions. OAPCA estimated that Lasco's flexible permit saved them approximately 20 to 40 staff hours per advance approved change. The time savings includes time spent drafting a permit to construct, ensuring NAAQS compliance, modifying the Title V permit, and conducting the change-specific public review process. At $75/hour, the estimated administrative costs saved by the flexible permit for all five advance approved conditions ranges from $7,500 to $15,000.
- TDEC reported that the Saturn flexible permit has reduced agency paperwork associated with processing individual construction permit applications and permit modifications, allowing agency staff to focus on higher environmental priorities. They further indicated that the permit saved TDEC significant staff time associated with processing notice of construction applications from Saturn. The permit eliminates the need for full minor NSR permitting. Traditionally, permitting for minor NSR takes approximately 24 to 40 staff hours, plus issuance of a public notice and a town meeting or public hearing. This process has been streamlined to a State control technology review for new unit additions not subject to major BACT. TDEC representatives believe that during the life of the permit, TDEC will need to invest less hours of staff time to address the future air permitting needs associated with the Saturn plant, due to the anticipated future use of the advance approval provisions.

It should be noted that companies and permitting authorities cautioned that it is difficult to precisely estimate cost savings and financial benefits associated with flexible permit implementation, since it involves comparison with hypothetical experience under a conventional permitting approach. Companies and permitting authorities noted that the flexible permit provisions sufficiently altered the applicability determination for individual changes so as to make it difficult to retrospectively determine the precise level of effort and timing that would have been necessary to accommodate the changes under a conventional permitting approach. That said, companies and permitting authorities indicated that the estimated financial benefits identified in this report provide a reasonable approximation of the financial benefits that resulted from implementation of the flexible permits, compared to those costs that would likely have been expected had the companies been operating under conventional permits.

In additional to administrative cost savings, several companies identified financial benefits stemming from the ability to implement advance approved changes without the potential delay associated with conventional permitting time frames. Several companies indicated that this streamlined ability to implement advance approved changes improved the predictability of change implementation time frames for project planning and avoided what can be substantial opportunity costs. They further reported that this predictability and elimination of potential delay from air permitting provided important competitive advantages that enabled them to compete more effectively.

- From 3M's perspective, the flexible permit allowed the company to proceed as needed with operational change. This was critical from two perspectives: it allowed the plant to avoid acting as a bottleneck along the critical path of any particular product line that would be moving among 3M plants; and it allowed the plant to remain highly responsive to its marketplace and avoid either lost sales and/or permanent loss of market share. 3M did indicate that the changes made that potentially involved PSD permitting likely would not have been undertaken if handled on a conventional basis.
- DaimlerChrysler representatives indicated that the permit has increased the company's ability to respond to short-term changes in market demand, as well as to accommodate the tight project time lines associated with periodic model changeovers. DNREC and DaimlerChrysler representatives reported that under a conventional permitting approach, some of these changes would likely have triggered case-by-case applicability determinations and potential permitting actions that could have

extended to 6 to 9 months each.

- The advance approved changes in Intel's flexible permit likely saved the Intel Aloha plant hundreds of business days associated with making operational and process changes to ramp up production for new products, respond to market demands, and optimize production processes. Industry estimates of the opportunity costs of production downtime and time delays run as high as several million dollars in just a few days due to lost sales to computer makers and other factors. The estimated 150 to 200 changes per year[5], combined with the Oregon DEQ approval time frame of up to 60 days per change[6], indicate that there would likely have been significant delay under a conventional permitting approach. Even if few delays would have resulted in production downtime or missed market opportunities, the costs would likely have been significant, as many of the changes improved the cost-competitiveness of Intel's products. Intel representatives indicated that it is likely that the impact of continued time delays would be to redirect Intel's production investment and operating facilities to locations more conducive to change.
- Imation representatives reported that the flexibility provisions in the Title V permit enabled the company to experiment with new materials and to introduce the production of new products at the Weatherford plant with minimal delay associated with air permitting and material toxicity assessments. Under the flexibility provisions, Imation is authorized to use alternative raw materials without receiving case-by-case approval or permit modifications that typically can take two to three months, provided that they follow established procedures and ensure emissions remain below specified limits. Even for materials for which Oklahoma had not previously reviewed, DEQ agreed to complete toxicity evaluations and establish MAAC limits within 72 hours of receiving a request from Imation. Imation representatives stated that these streamlined administrative procedures for addressing Oklahoma's air toxics requirements have eliminated air permitting delay associated with raw material changes. Among other product transitions, the flexibility provisions in the Title V permit have facilitated Imation's development of digital proofing films for graphic design applications. In addition to various product quality benefits, digital proofing films also require fewer coating layers during manufacturing than conventional proofing films. This results in fewer VOC emissions from solvents per unit. While customer demand for digital proofing materials is increasing, it is likely to take several years before digital proofing technology is in widespread use, due to the cost of converting to digital proofing hardware.
- Lasco engaged in a series of advance approved changes, updated its emission factor, and voluntarily installed an RTO. These actions combined to create "head room" under Lasco's cap, which Lasco then used to increase production. Lasco indicated that typically (and as reflected by the Yelm plant's lack of operational change prior to the flexible permit and experience at other Lasco facilities) the company is very averse to making changes that trigger permitting actions. At most, they wait to undertake such changes at the time of permit renewal. Contrary to its typical corporate behavior, Lasco Yelm engaged in a series of modifications that created the opportunity to increase production from 126,045 units/year (in 1997) to 132,548 units/year (in 2000) generating a significant annual increase in profit. In 2001, after the RTO was installed, Lasco decreased emissions per unit further to 3.13 lbs./unit, allowing production to increase to 147,429 units and reducing costs associated with

---

[5]Estimates from Intel of the number of changes made per year under the flexible permit that would have triggered the need for notice of construction approval under a conventional permit.

[6]Under Oregon rules, ODEQ has up to 60 days to process notice of construction approval applications. Twenty-one days was selected as a reasonable estimate of the average actual time associated with receiving notice of construction approval from ODEQ.

styrene loss.

- Saturn indicated that the flexible permit was a principle factor in General Motors' selection of the source to manufacture the L850 engine, leading to the creation of 700 jobs. Saturn was awarded the contract primarily because it could implement the necessary changes within 24 months and accommodate future changes with minimal delay. The flexible PSD permit is enabling Saturn to add and modify coating, assembly and machining lines in a timely manner, while ensuring that best available pollution control technologies are installed and that air emissions remain under approved limits. Using a combination of the PAL emissions caps and advanced approvals, the flexible permit will allow Saturn to upgrade the plant over the next few years, with minimal delays, to produce several new vehicles, including Saturn's new fuel-efficient sport utility vehicle, the Saturn VUE™. Saturn representatives stated that the flexible permit avoids a potential NSR backlog associated with the conventional permitting process, thereby providing a competitive advantage to Saturn.

Finding 9: Permitting authorities are generally supportive of flexible permits as an option.

The permitting authorities reported that they are pleased with the benefits from the flexible permits. Additionally, they believe flexible permitting techniques are useful tools to address some companies' operational flexibility needs, to foster environmental improvements through emissions reductions, and to lessen permitting authority resource needs and backlogs associated with construction permitting, so that these public agencies can focus resources on higher environmental management priorities. Finding 10 discusses permitting authority perspectives on matching flexibility provisions with appropriate source candidates.

Permitting authorities are supportive of flexible permits, and they expressed their interest to renew the pilot flexible permits and to expand the use of flexible permits in their jurisdictions.

Permitting authorities demonstrated their support of flexible permits by retaining the flexibility provisions in the subsequent permit for the source, or by indicating their interest to do so.

- Oregon DEQ retained the advance approval provisions in Intel's synthetic minor air operating permit that replaced the Aloha plant's Title V permit in 1999.
- MPCA indicated that the agency is supportive of renewing 3M's flexibility provisions in the forthcoming Title V permit. In discussing options for the plant's Title V permitting application (under consideration by MPCA at the time of the EPA review), however, 3M management decided not to pursue such provisions due to uncertainty surrounding how the next VOC emissions limit would be defined. 3M voiced concerns that significantly lowered emissions caps could constrain the plant's ability to accommodate increased product demand or transfers of product lines from other 3M facilities.
- DNREC supported the renewal of all flexibility provisions from DaimlerChrysler's initial flexible construction and air operating permit into the plant's Title V permit, issued in October 1999.

Two permitting authorities further demonstrated their support of flexibility provisions by incorporating flexibility techniques into permits for other sources within their jurisdiction.

- MPCA reported that the agency has issued "dozens" of minor source and synthetic minor source permits that include flexibility provisions (e.g., plant-wide emissions caps and advance approval provisions) since the issuance of the 3M St. Paul Tape Plant pilot permit in 1993. MPCA also issued a permit to 3M's Maplewood, Minnesota research and development plant that included an advance approved BACT determination.

- DNREC has issued a Title V permit for DuPont's Edge Moor, Delaware plant that includes PALs and advance approval provisions, as well as several permits containing alternate operating scenarios.

Permitting authorities indicated that finalization of EPA policy and/or guidance on flexible permitting would increase their interest and efficiency in expanding the use of flexible permits.

Permitting authorities indicated that finalization of rulemaking and/or guidance related to flexible permitting is desired to provide greater clarity and certainty around the EPA's expectations. Most permitting authorities stated that, while they are supportive of flexible permitting approaches, they are somewhat hesitant to invest resources of any significant amount into new flexible permits in the absence of increased clarity regarding approaches that are acceptable to the EPA. Permitting authorities generally did not want to find themselves in a position where they have developed numerous flexible permits based on an approach or regulatory interpretation that does not correlate with the EPA's approved flexible permitting rules and/or guidance developed at some point in the future.

Several permitting authorities also noted the high transaction costs associated with developing "pilot" permits as an additional deterrent to expanding the use of flexibility techniques without EPA policy or guidance. Pilot initiatives typically demand a high level of interaction between the permitting authority, EPA Regional Offices, and various offices within the EPA headquarters to verify that the pilot approaches are acceptable. Permitting authorities indicated that EPA policy and/or guidance could reduce the amount of time spent in conference calls and meetings, and in the development of flexible permit language that does not meet the EPA's expectations, while also reducing the overall time frame for developing a flexible permit. One permitting authority believed that additional guidance was not needed for it to act but agreed with the other permitting authorities that EPA rules and/or guidance on flexible permitting might serve to improve the consistency of regulatory interpretations, expectations, and comments communicated by various EPA offices and regions.

While permitting authorities supported promulgation of EPA policy and/or guidance on flexible permitting, they hoped that any such policy would be accommodative of the approaches employed in the pilot flexible permits. In addition, DNREC representatives urged the EPA to not be overly prescriptive in any policy or guidance and to allow permitting authorities reasonable discretion in the implementation of approved flexibility techniques.

Permitting authorities stated that various forms of EPA outreach, training, and assistance would be useful to assist permitting authorities to develop effective flexible permits.

Permitting authorities and companies emphasized that the EPA could take several steps, in addition to promulgation of flexible permitting policy and/or guidance, to support the implementation of effective flexible permits. Suggestions included:

- Make documentation available regarding flexible permitting techniques. Materials should include examples of flexible permits, fact sheets on various flexible permitting approaches and tools, draft permit language related to various flexibility approaches, training materials, and other resources.
- Formalize a network of EPA flexible permitting experts who would be available to support permitting authorities interested to develop permits containing flexibility provisions.

- Conduct workshops and training sessions for EPA and permitting authority personnel who are interested to learn about flexible permitting techniques. Similar workshops or training sessions could be designed for sources to help them determine whether or not they may be appropriate candidates for flexible permitting techniques.
- Develop a tool to assist sources and permitting authorities to determine the appropriateness of flexible permitting techniques to potential source candidates.
- Develop an EPA website clearinghouse for information on flexible permitting techniques.

Finding 10: Permitting authorities indicated that flexible permit provisions should be matched with a company's need for flexibility and technical capacity to implement effectively its flexible permit requirements.

Permitting authorities indicated that while they believe flexible permitting techniques to be appropriate and beneficial for use with some companies, they may not be appropriate for all companies. They indicated that there are two critical factors that should be considered when determining the appropriateness of flexible permitting for candidate sources. First, the company should be able to demonstrate that it has a need for the flexibility. Second, the permitting authority should be confident that the source has sufficient capacity to operate effectively under a flexible permit, which typically includes additional monitoring, recordkeeping, and reporting requirements.

Permitting authorities believe that a candidate company should be able to demonstrate sufficient need for flexibility to justify the additional up-front staff time and resources needed for the permitting authority to tailor flexible permitting techniques to the source.

Permitting authorities indicated that they want to have some assurance that any additional up-front investment will result in benefits for the company, permitting authority, and/or environment before investing in the development of a flexible permit. Such need could be demonstrated by a company's ability to clearly articulate its operational change needs. Permitting authorities indicated that some companies seldom implement changes that trigger air permitting requirements, making them less appropriate candidates for flexible permits.

Permitting authorities indicated that a candidate company should exhibit the technical capacity to operate effectively under a flexible permit, as indicated by factors such as the source's compliance history, attentiveness to pollution prevention, and ability to track and manage operational changes and emissions.

Permitting authorities indicated that while they believe company compliance with flexible permits to be fully verifiable and enforceable, they believe that companies lacking sufficient capacity to operate effectively under a flexible permit could be at an increased risk of non-compliance. Additional monitoring, reporting, and recordkeeping conditions, such as the calculation of plant-wide emissions and maintenance of logs documenting operational changes and alternate operating scenarios, are typically required to assure compliance with flexible permit provisions. Permitting authorities indicated that some companies may not have sufficient capacity and capabilities to effectively meet such permit requirements on a sustained basis.

Permitting authorities stated that they view a company's past compliance history as the primary indicator of the company's capacity to operate under a flexible permit. Past patterns of compliance violations often signal that a company is not sufficiently able to handle additional monitoring, recordkeeping, and reporting requirements necessary under a flexible permit. Permitting authorities pointed to several other indicators of a company's capacity to operate effectively and in compliance under a flexible permit. These include:

- A company's capacity to track and manage operational and equipment changes.
- A company's ability to accurately monitor plant-wide emissions.
- A company's track record of communication and openness with the permitting authority.
- The presence of trained personnel at the source who understand air requirements.
- The presence of a P2 program and/or a track record of P2 accomplishment.

Permitting authorities indicated, however, that rigid criteria for determining the appropriateness of flexible permitting techniques for a company candidate, such as the complete absence of historic compliance violations, should not be established. They indicated that permitting authority personnel are accustomed to matching appropriate permitting techniques and requirements to address individual sources' applicable requirements and circumstances.

Table 1.1 Pilot Flexible Permits Evaluated in the EPA Flexible Permit Implementation Review

Source	Permitting Authority	Permit Type & Permit #	Permit Issuance	Permit Expiration
3M Company - St. Paul, Minnesota Tape Plant	Minnesota Pollution Control Agency (MPCA)	State Air Operating Permit (not a Title V permit); (Permit No. 23GS-93-OT-1)	March 4, 1993	March 4, 1998
DaimlerChrysler - Newark, Delaware Automobile Assembly Plant	Delaware Department of Natural Resources and Environmental Control (DNREC)	Construction/Operation Permit; (APC-95/0569-Construction/Operation)	September 1995	October 1999
		Title V Air Operating Permit; (AQM-003/00128)	October 1999	October 2004
Imation Corporation - Weatherford, Oklahoma Plant	Oklahoma Department of Environmental Quality (Oklahoma DEQ)	Title V Air Quality Permit; (Permit No. 97-380-TV)	June 9, 1998	June 9, 2003
Intel Corporation - Aloha, Oregon Semiconductor Fabrication Plant	Oregon Department of Environmental Quality (Oregon DEQ)	Title V Permit; (Oregon Permit No. 34-2681)	October 1995	October 1999
Lasco Bathware Corporation - Yelm, Washington Plant	Olympic Air Pollution Control Authority (OAPCA)	Title V Air Operating Permit; (Permit No. 01-97)	June 7, 1997	July 7, 2001
Saturn Corporation - Spring Hill, Tennessee Automobile Manufacturing & Assembly Plant	Tennessee Department of Environment and Conservation (TDEC)	Permit to Construct or Modify an Air Contaminant Source; (Permit No. 952233)	June 6, 2000	December 31, 2005[7]

[7]The permit expires on December 31, 2005, but the plant-wide applicability limits (PALs) extend to July 2010.

Table 1.2 Flexibility Provisions in Pilot Permits Reviewed by the EPA

Source	Key Flexibility Provisions
3M St. Paul, Minnesota	• Plant-wide emissions limits for VOC (4,596 tons/year; 30,600 lbs./day). • Advance-approvals for specified categories of renovations and other changes deemed to be "consistent with" the specified change categories. • Replicable testing procedure enabling updates to capture and destruction efficiency parameters for pollution control devices without requiring perm modifications.
DaimlerChrysler Newark, Delaware	• Plant-wide applicability limits (PALs) for NO_x (150.71 tons/year; 4.86 tons/day) and VOC (1,112.8 tons/year; 5.3 tons/day). • Advance-approvals for specified projects and categories of changes. • Case by case technology determination for significant new units. • Enforceable P2 performance requirement for topcoat emissions and P2 reporting requirements. • Replicable testing procedure for updating pollution control device parameters. • Permit conditions streamlining.
Imation Weatherford, Oklahoma	• Plant-wide PTE limit for VOC emissions (249 tons/year). • Advance-approvals for specified changes and classes of changes. • Advance-approvals for raw material changes, including streamlined determinations under State Air Toxics Program. • Alternative control device operating scenarios that provide flexibility in controlling or otherwise reducing VOC emissions. • Permit conditions streamlining, including streamlining of applicable MACT standards. • P2 Program and reporting requirements.
Intel Aloha, Oregon	• Plant Site Emissions Limits (PSELs) for VOC (190 tons/year; 8 tons/week) and CO (32 tons/year). • Potential-to-emit (PTE) limits on organic and inorganic hazardous air pollutants (HAPs). • Advance-approvals for a broad class of changes, provided no new applicable requirements and MRR requirements not covered in the permit. • Source-specific RACT limit based on units of production, designed to encourage P2. • Pollution Prevention (P2) Program and reporting requirements.
Lasco Bathware Yelm, Washington	• Plant-wide PTE limits for VOC emissions (249 tons/year; 1.71 tons/day). • Advance-approvals for categories of changes, including BACT and P2 requirements to address minor NSR requirements. • Replicable testing procedures for updating emission factors without requiring permit modifications. • P2 Program with goals and reporting requirements.
Saturn Spring Hill, Tennessee	• Variable PALs for VOC based on production (1,563 tons/year at 500,000+ vehicles per year; 198.5 tons/month). • PALs for NO_x, PM, SO, and CO (PALs are hybrids based on actual and allowable source emissions). • Advanced approvals for changes to existing emissions sources and construction of new emissions sources (with conditions). • BACT for all existing emissions units. • Case by case BACT determination for all new units. • Permit conditions streamlining.

Table 2.1 Key Emissions MRR Requirements in Pilot Permits Reviewed by the EPA

Source	Key Emissions Monitoring, Recordkeeping, and Reporting Requirements
3M St. Paul, Minnesota	• Mass balance approach to VOC emissions measurement; applies an overall control efficiency (capture and destruction) to the VOC input (derived fr material usage tracking system); parametric monitoring is conducted of selected control system operating parameters (e.g., combustion temperature exhaust gas flow). • Control device performance testing is required every two years for both capture efficiency and destruction efficiency. • Uncontrolled fugitive emissions from churn and mogul rooms measured by CEMS. • Daily calculation of VOC emissions from all emissions units (required within 41 hours) are maintained on-site. • Quarterly reporting to MPCA of daily plant-wide VOC emissions and 365-day rolling totals.
DaimlerChrysler Newark, Delaware	• Mass balance approach to VOC emissions measurement, based on EPA's "Protocol for Determining the Daily Volatile Organic Compound Emission of Automobile and Light-Duty Truck Topcoat Operations" (EPA-450/3-88-018, December 1988); parametric monitoring is conducted of selected con system (RTO) operating parameters (e.g., combustion temperature, inlet pressure); booth/oven splits, transfer efficiency, and incinerator efficiencie in calculations are based on the most recent tests completed using the protocol. • Compliance with EDP primecoat operations is demonstrated pursuant to procedures in New Source Performance Standards (40 CFR 60.393 (c)(2)) through the use of capture and control. VOC RACT standards apply to the miscellaneous metal parts coating and final repair operations and dictat compliance method. Compliance with these limits is demonstrated through the use of complying coatings or daily weighted averages. • Oven burners and miscellaneous NO_x sources use AP-42 emission factors in conjunction with monitored parameters to calculate emissions; source- emission factors were developed for the antichip, topcoat and EDP primecoat incinerators and the boilers. • Monthly reporting to DNREC of plant-wide VOC and NO_x emissions (daily, monthly, and 12-month rolling totals).
Imation Weatherford, Oklahoma	• Mass balance approach to VOC emissions measurement; parametric monitoring is conducted for all capture and control devices (RTO, catalytic oxid and carbon adsorber). • Criteria air pollutant emissions are determined using fuel type, monthly fuel usage to the boilers and oxidizers, and appropriate AP-42 emission facto • Daily and monthly calculation of VOC emissions (prorated hourly, daily, and 12-month rolling totals) are maintained on-site.
Intel Aloha, Oregon	• Mass balance approach to VOC emissions measurement; bi-monthly VOC emissions based on actual solvent monitoring; bimonthly emissions data production activity data (i.e., total surface area of wafers processed, square centimeters[cm^2]) provides the information necessary to calculate an ov emission factor (EF) for the fab. Using the recent bimonthly EF with weekly production data provides total weekly VOC emissions (tons/wk). • Criteria air pollutant emissions are determined using fuel type, monthly fuel usage to the boilers and oxidizers, and appropriate AP-42 emission facto except for Emission Unit 3 boiler's NO_x and CO emission factors which are based on manufacturer's data and verified by source test.
Lasco Bathware Yelm, Washington	• VOC emissions calculations based on raw material usage, VOC (styrene) content of the raw materials, and site-specific emission factors (pounds [lb emissions per lb. of styrene); site-specific emissions factors are based on source testing; material usage is calculated on a daily basis. • Monthly plant-wide VOC emissions are calculated each month, along with 12-month rolling totals.

Source	Key Emissions Monitoring, Recordkeeping, and Reporting Requirem
Saturn Spring Hill, Tennessee	• Mass balance approach to VOC emissions measurement, based on EPA's "Protocol for Determining th Emission Rate of Automobile and Light-Duty Truck Topcoat Operations" (EPA-450/3-88-018, Decemb conducted of selected control system operating parameters (e.g., combustion temperature, exhaust ga transfer efficiency, and incinerator efficiencies used in calculations are based on the most recent tests • Criteria air pollutant emissions are determined using monthly natural gas usage data and appropriate A • Monthly calculation of monthly and 12-month rolling plant-wide VOC emissions totals.

EXHIBIT 6

Attached are the BCCA Appeal Group's (the "Group") comments on related EPA dockets for two, related Texas SIP submittals. The Group submits these comments as a supplement to the comments on the above-numbered docket.

November 23, 2009

BCCA APPEAL GROUP COMMENTS ON EPA PROPOSED DISAPPROVAL OF TCEQ QUALIFIED FACILITY PROGRAM RULES AND GENERAL DEFINITIONS

Docket ID No. EPA–R06–OAR–2005-TX-0025
74 *Fed. Reg.* 48,450 (Sept. 23, 2009)

The BCCA Appeal Group (the "Group") submits the following comments in response to the proposed disapproval of Texas's state implementation plan ("SIP") revisions relating to Qualified Facilities and general definitions by the U.S. Environmental Protection Agency ("EPA"), published in the *Federal Register* on September 23, 2009. The Group is comprised of members with the common interests of achieving the goals of clean air and a strong economy for Texas. The Group is comprised of the following members: Air Products, L.P.; Celanese Chemicals, Ltd.; Conoco Phillips; The Dow Chemical Company; Entergy Texas, Inc.; Exxon Mobil Corporation; Lyondell Chemical Company; Texas Petrochemicals, L.P.; Valero Refining-Texas, L.P.

I. Introduction

The Group strongly supports full approval of the Qualified Facility provisions and definitions. The Texas air quality permitting program, including the Qualified Facility provisions, is stringent, comprehensive and protective of both the environment and public health.

Under Texas's integrated air permitting regime, air quality in the state is demonstrating strong, sustained improvement. Between 1999 and 2005, NO_X emissions in the Houston-Galveston area decreased from almost 1,200 tons per day, to under 600 tons per day.[1] Ozone as measured under the one-hour standard in the Houston-Galveston area has declined from 220 parts per billion ("ppb") in 1991 to 127 ppb in 2009.[2] Under the eight-hour standard, ozone in the Houston-Galveston area has declined from 119 ppb in 1991, to 84 ppb in 2009.[3] .[4] Moreover, between 1988 and 2008, there has been an 80% reduction in VOC compound indicators in the Houston area.[5] There has been a similar improvement in toxic air emissions. Between 2003 and 2008, there has been a 50% decrease in highly reactive volatile organic compounds ("HRVOCs") in the Houston area.[6] Similarly, in the Dallas-Fort Worth area, ozone as measured under the one-hour standard declined from 140 ppb in 1991 to 115 ppb in 2009.[7] Ozone for the Dallas-Fort Worth area under the eight-hour standard has declined from 105 ppb

---

[1] Susana M. Hildebrand, TCEQ Chief Engineer, *Update of Air Quality in Texas* (presented at Oct. 29, 2009 Commission Work Session, and available at TCEQ.com), 13 (attached as Exhibit 1).
[2] *Id.* at 13.
[3] *Id.*
[4] *Id.*
[5] Houston Regional Monitoring, *Annual Average Trends for VOC Indicator Compounds for HRM Network from 1988 through 2008* (attached as Exhibit 2).
[6] Houston Regional Monitoring, *Total HRVOC Network Average Concentrations: Houston Ship Channel PAMS-GC Monitoring Sites* (attached as Exhibit 2).
[7] *Id.* at 16.

in 1991 to 86 ppb in 2009 Notably, according to recent TCEQ review, all areas of Texas are in attainment for nitrogen dioxide, sulfur dioxide, and carbon monoxide.[8]

Further, the data show that stationary sources have contributed more substantial emissions reductions than any other category during the period of most dramatic air quality improvements. In the Houston-Galveston area between 1993 and 2008, NO_X emissions from stationary sources declined from 695 tons per day ("tpd"), to 156 tpd, a decrease of 539 tpd.[9] During that same period, emissions from on-road source declined from 416 tpd to 175 tpd, a decrease of 241 tpd.[10] Similarly, stationary sources made significant decreases for VOC. Between 1993 and 2009 in the Houston-Galveston area, VOC emissions from stationary sources decreased from 411 tpd, to 170 tpd, a decrease of 241 tpd.[11] On-road sources from that same period decreased from 199 tpd, to 86 tpd, a decrease of 113 tpd.[12] As the figures indicate, stationary sources in Texas have made the most significant strides in reducing emissions.

The submitted revisions strengthen a previously SIP-approved Texas program. Under the federal Clean Air Act ("CAA" or "Act"), SIP revisions are approved when those revisions do not interfere with the attainment of the National Ambient Air Quality Standards ("NAAQS"). States have the primary responsibility for developing plans for the attainment and maintenance of the NAAQS. In fact, as the Fifth Circuit recently explained:

> Although EPA is required to approve SIPs that provide for the timely attainment and subsequent maintenance of primary and secondary ambient air standards as well as satisfy other CAA general requirements, *see* 42 U.S.C. § 7410(a)(3), the EPA has no authority to question the wisdom of a State's choices of emission limitations if they are part of a SIP that otherwise satisfies the standards set forth in 42 U.S.C. §7410(a)(2).[13]

Rather, the proper test for determining whether a SIP revision can be approved is whether the revision interferes with attainment of the NAAQS (*i.e.* that the plan does not make air quality worse).[14] The last ten years have seen an unprecedented improvement in Texas air quality. The submitted revisions have been fully integrated components of the Texas air quality permitting program for all that time. Because the current SIP submittals function to *strengthen* the existing SIP, such submittal does not raise interference concerns, and should be fully approved.

II. Background on the Qualified Facilities Program

---

[8] Susana M. Hildebrand, TCEQ Chief Engineer, *Update of Air Quality in Texas* (Oct. 29, 2009), 10.

[9] *Compare* TEXAS NAT'L RES. CONSERVATION COMM'N, *Revision to the State Implementation Plan (SIP) for the Control of Ozone Air Pollution: Post-1999 Rate-of-Progress and Attainment Demonstration SIP for the Houston/Galveston Ozone Nonattainment Area*, (Dec. 2000), at 2-5 (attached as Exhibit 3); *with* TEXAS COMM'N ON ENVIRONMENTAL QUALITY, *Revision to the State Implementation Plan for the Control of Ozone Air Pollution: Houston-Galveston-Brazoria 1997 Eight-Hour Ozone Standard Nonattainment Area* (Sept. 23, 2009), at 2.3-2.5 (attached as Exhibit 4).

[10] *Id.*

[11] *Id.*

[12] *Id.*

[13] *Clean Coalition v. TXU Power*, 536 F.3d 469, 472 (5th Cir. 2008).

[14] *Galveston-Houston Assoc. for Smog Prevention v. EPA*, 289 Fed. Appx. 745, 754 (5th Cir. 2008).

A. Overview

The Texas Qualified Facility program is a minor New Source Review ("minor NSR") applicability trigger. Under the program, existing emissions units (defined in the Texas rules as "existing facilities") that employ up-to-date best available control technology ("BACT") may make physical and operational changes without a minor NSR review, so long as the changes do not result in net emissions increases above their current, protective limits.[15]

The Qualified Facilities program is statutory. All of its key provisions are laid out in the Texas Clean Air Act.[16]

The program applies to "existing facilities." A "facility" is defined as "[a] discrete or identifiable structure, device, item, equipment, or enclosure that constitutes or contains a stationary source, including appurtenances other than emission control equipment."[17] Notably, the definition of "facility" here is similar to the federal definition of "emissions unit," used in Texas's Title V program.[18]

Qualified facilities may make physical or operational changes so long as the change does not result in a net increase in allowable emission of any air contaminant or the emission of any new air contaminant. Changes that meet this criterion are not considered "modifications" subject to minor NSR review by TCEQ.[19]

The program only reaches changes to an ***existing*** facility.[20] Thus, the program does not authorize the construction of new facilities.

The Texas Legislature established the Qualified Facility program in order to provide additional incentives for sites to employ up-to-date (*i.e.*, no more than 10-year-old) BACT. Accordingly, a facility may remain a Qualified Facility only so long as it (1) was issued a permit or permit amendment or was exempted from pre-construction permit requirements no earlier than 120 months before the change will occur, or (2) uses air pollution control methods that are at least as effective as the BACT that was required or would have been required for the same class or type of facility by a permit issued 120 months before the change will occur.[21]

Status as a qualified facility is not perpetual. A facility may lose its status as a qualified facility if its permit, exemption or control method falls outside the 10-year window. "For example, if a facility obtained a permit on January 15, 1991, it would be a qualified facility on the basis of the permit until January 14, 2001, and would be eligible to have changes made under the qualified facility flexibility. After that date, the facility is no longer eligible to have

---

[15] TEXAS NAT'L RES. CONSERVATION COMM'N, *Modification of Existing Facilities under Senate Bill 1126: Guidance for Air Quality* (April, 1996), 1 (Attached as Exhibit 5).
[16] TEX. HEALTH & SAFETY CODE § 382.003(9); § 382.0512 (2009).
[17] 30 TAC § 116.10(6).
[18] 30 TAC § 122.10(8) "Emission unit--A discrete or identifiable structure, device, item, equipment, or enclosure that constitutes or contains a point of origin of air pollutants, including appurtenances."
[19] 30 TAC § 116.10(11)(E).
[20] 30 TAC § 116.10(11); §116.116(e)(5)(A).
[21] 30 TAC § 116.116(e).

changes made under the qualified facility flexibility unless the status as a qualified facility is continued or regained by a subsequent permit action or appropriate control methods."[22]

B. The Qualified Facility Program Safeguards Major NSR

TCEQ rules ensure that the Qualified Facility flexibility is not to be used to circumvent federal NSR. Section 116.117(a)(4) requires that an owner or operator wishing to use the program must document:

> [S]ufficient information as necessary to show that the project will comply with §116.150 and §116.151 of this title (relating to Nonattainment Review) and §§ 116.160-116.163 of this title (relating to Prevention of Significant Deterioration Review) . . . .[23]

Additionally, §116.117(d) states that "[n]othing in this section shall limit the applicability of any federal requirements."[24] To ensure that the regulated community understands the federal NSR safeguards, the associated TCEQ guidance document states:

> SB 1126 only revised the Texas "minor new source review" program to allow some changes to be made without a requirement to obtain a permit or other "approval" from the [TCEQ]. SB 1126 does not supersede federal requirements such as Nonattainment (NA) review and Prevention of Significant Deterioration (PSD) review of new major sources and major modifications to existing sources, which are incorporated into Chapter 116. . . . In making changes under SB 1126, owners and operators must consider the potential for these other federal and sate requirements to limit their ability to make a desired change. The owner/operator is responsible for ensuring that any change to a facility complies with all applicable regulations.[25]

TCEQ guidance also specifically states that the program does not supersede other state regulations on emissions or TCEQ's powers and duties to take action to control air pollution.

TCEQ guidance also addresses the interplay of changes under the Qualified Facility program and special conditions in the permits a facility holds. "If a change made under the qualified facility flexibility would result in the violation of a permit special condition, the permit holder must revise the permit special conditions to stay in compliance with the permit,"[26] through either the permit alteration process of 30 TAC §116.116(c) or the notification process of 30 TAC § 116.117(d). As explained above, 30 TAC § 116.117(d) states that "[n]othing in this section shall limit the applicability of any federal requirements." Thus, any changes to a facility must comply with federal NSR and PSD rules.

---

[22] TEXAS NAT'L RES. CONSERVATION COMM'N, *Modification of Existing Facilities under Senate Bill 1126: Guidance for Air Quality*, (April, 1996) 5.
[23] 30 TAC § 116.117(a)(4).
[24] 30 TAC § 116.117(d).
[25] TEXAS NAT'L RES. CONSERVATION COMM'N, *Modification of Existing Facilities under Senate Bill 1126: Guidance for Air Quality* (April, 1996), 2.
[26] *Id.* at 9.

C. The Qualified Facility Program Exceeds Federal Benchmarks for Allowables-Based Minor NSR Triggers

As outlined above, the Qualified Facility program is a minor NSR applicability trigger. As such, the program is one of the flexibility mechanisms encouraged by EPA in its 2009 Flexible Air Permitting Rule.[27] In reflecting on its decade-long flexible permit pilot program, EPA observed:

> Upon examining the provisions of their minor NSR programs, most of the States in which pilot permits were conducted . . . found that they could issue advance approvals under existing minor NSR authority for a wide spectrum of changes, provided that certain boundary conditions were established in the minor NSR permit.[28]

The Texas Qualified Facility program functions in a similar manner. However, by requiring up-to-date BACT as a requirement to use the flexibility, the Texas program is more stringent than the federal model.

Similarly, the Qualified Facility program is comparable to the proposed allowables-based minor NSR trigger in EPA's 2006 proposed Indian Country Rule. EPA proposed the Indian Country rule based on a composite of state minor NSR programs, in order to create a level playing field with the states. "[W]e seek to establish a flexible preconstruction permitting program for minor stationary sources in Indian [C]ountry that is comparable to that which applies outside of Indian [C]ountry . . . ."[29] As such, the rule represents a clear indication of the scope of statutory flexibility in crafting minor NSR tools. "[T]his proposal . . . represents how we would implement the program in Indian [C]ountry in the absence of an EPA-approved implementation plan. However, if a tribe is developing its own program, this can serve as one example of a program that meets the objectives and requirements of the Act."[30]

EPA set an allowables trigger for minor NSR in its Indian Country rule. Under EPA's rule, "a modification is defined . . . as any physical or operational change at a stationary source that would cause an increase in the allowable emissions of the affected emissions unit."[31] In justifying the allowables-based minor NSR trigger in this rule, EPA distinguished the definition of "modification" under minor NSR from that used for major NSR:

> In a recent decision, the D.C. Circuit Court of Appeals, ruled that, based on the wording of the definition of "modification" in section 111(a)(4) of the Act, the applicability of major NSR to modifications must be based on changes in actual emissions (*State of New York, et., v. U.S. EPA*, June 24, 2005). However, because the statutory basis for the minor NSR program

[27] 74 *Fed. Reg.* 51,418 (Oct. 6, 2009) at 51,423.
[28] *Id.*
[29] 71 *Fed. Reg.* 48,696, 48,700 (Aug. 21, 2006).
[30] *Id.* at 48,700-701.
[31] *Id.* at 48,701.

is section 110(a)(2)(C) of the Act, which does not define or refer to a definition of "modification," we believe that we have discretion in defining the term as we think best for the minor NSR program in Indian Country . . . .[32]

In the same fashion, Texas's Qualified Facility program uses allowables as its minor NSR "modification" trigger. Again, however, the Texas program is more stringent, as it only extends the flexibility to well-controlled facilities.

III. Group Comments on EPA's Specific Asserted Deficiencies for the Qualified Facility Program

EPA's concerns on specific aspects of the Texas Qualified Facilities program and air permitting definitions are reproduced and addressed below. Headings are for convenience only—all comments are intended to address all aspects of EPA's proposal.

A. The Definition of Facility

EPA Comment:

- *"It is our understanding of State law, that a 'facility' can be an "emissions unit," i.e., any part of a stationary source that emits or may have the potential to emit any air contaminant. A 'facility' also can be a piece of equipment, which is smaller than an 'emissions unit.' A 'facility' can be a 'major stationary source' as defined by Federal law. A 'facility' under State law can be more than one 'major stationary source.'"*

Group Response:

For purposes of the Qualified Facility program, TCEQ regulations make clear that "facility" is comparable to the federal definition of an "emissions unit." Section 116.10(6) defines a facility as:

> A discrete or identifiable structure, device, item, equipment, or enclosure that constitutes or contains a stationary source, including appurtenances other than emission control equipment. A mine, quarry, well test, or road is not a facility.[33]

Section 116.10 clearly states that the definitions contained in the section apply to all provisions contained in the Chapter.[34] Thus, the facility definition of §116.10(10)(6) expressly applies to Qualified Facility rules contained in Chapter 116.

[32] *Id.*
[33] 30 TAC § 116.10(6).
[34] 30 TAC §116.10 ("[T]he following words and terms , when used in this chapter, shall have the following meanings, unless the context clearly indicates otherwise.")

This definition is similar to the definition of "emission unit" in Texas's Title V rules. There, "emissions unit" is defined as:

> A discrete or identifiable structure, device, item, equipment, or enclosure that constitutes or contains a stationary source, including appurtenances other than emission control equipment.[35]

Under the express terms of § 116.10, the definition of "facility" is clear, and applies directly to the Qualified Facility rules.

B. Major NSR Safeguards

1. The program is not clearly limited to Minor NSR, thereby allowing new major stationary sources to construct without a Major NSR permit.

EPA Comments:

- *"Both the SIP-codified Chapter 106, Subchapter A for Permits by Rule and the SIP-codified Chapter 116, Subchapter F for Standard Permits, contain clear regulatory applicability requirements limiting their use to Minor NSR, clear regulatory requirements prohibiting their use for any project that constitutes a major modification subject to Major NSR, and clear regulatory provisions prohibiting the use of these Minor NSR permits from circumventing Major NSR. There are no similar regulatory applicability requirements, regulatory provisions prohibiting the use for Major NSR, and no regulatory provisions prohibiting circumvention of Major NSR, in the submitted Qualified Facilities State Program's rules and definitions."*

Group Response:

As outlined above, the Qualified Facility program establishes an allowables-based trigger for minor NSR. The Qualified Facility program has no effect on a permit holder's compliance obligations under the federal PSD or NNSR programs.

The CAA does not mandate a methodology for determining minor NSR applicability.

- Federal regulations that govern minor NSR programs at 40 CFR §§ 51.160-.164 do not mandate a methodology for determining minor NSR applicability.
- In 2000, the U.S. EPA's Environmental Appeals Board (EAB) confirmed that there is no "legally prescribed methodology" for the emissions test used for minor

[35] 30 TAC § 122.10(8).

NSR applicability determinations, and rejected the argument made by EPA enforcement personnel that, in the absence of an explicit minor NSR methodology in State rules, the minor NSR applicability test must be consistent with that used for federal PSD purposes.[36]

- EPA's own August 2006 proposal for minor NSR programs in Indian Country employs an "allowable-to-allowable" test to determine if a modification subject to minor NSR requirements has occurred.[37]

States have great flexibility under the CAA in determining the applicability of minor NSR requirements, and that flexibility includes the authority to use allowable emission rates in establishing whether minor NSR is triggered.

TCEQ rules articulate an overriding obligation to comply with federal NSR requirements. Section 116.117(a)(4) requires that an owner or operator wishing to use the Qualified Facility program to make a change must document

> [S]ufficient information as necessary to show that the project will comply with §116.150 and §116.151 of this title (relating to Nonattainment Review) and §§ 116.160-116.163 of this title (relating to Prevention of Significant Deterioration Review) . . .[38]

Additionally, §116.117(d) states that "[n]othing in this section shall limit the applicability of any federal requirements."[39] The current Qualified Facility rules, therefore, constrain the regulated community from making major changes without complying with major NSR requirements.

2. The program does not require that first an applicability determination be made whether the construction or modification is subject to Major NSR.

EPA Comment:

- *"We do not find any provisions in the submitted Program that require a Major NSR applicability determination for changes. The submitted Program's rules and definitions are not clear on their face that first one must determine the threshold question of whether the change is a major stationary source or a major modification subject to Major NSR."*

Group Response:

---

[36] *In re Tennessee Valley Authority*, 9 EAD 357, 461 (EAB Sept. 15, 2000).

[37] *See* 71 *Fed. Reg.* 48,695, 48,701 (Aug. 21, 2006) ("For the purposes of this rule, a modification is defined at proposed 40 CFR 49.152(d) as any physical or operational change at a stationary source that would cause an increase in the allowable emissions of the affected emissions units for any regulated NSR pollutant or that would cause the emission of any regulated NSR pollutant not previously emitted.").

[38] 30 TAC §116.117(a)(4).

[39] 30 TAC § 116.117(d).

The Group reiterates its comments from Section III.B.1 above. The overriding obligation to comply with federal NSR requirements is made explicit in TCEQ's rules. The current regulations constrain the regulated community from making major changes without complying with major NSR requirements. The clear provisions in the Texas rules safeguarding federal NSR are supported by well-developed TCEQ guidance.[40] Neither EPA's Indian Country rule, nor any of several recently SIP-approved state minor NSR rules, contain explicit language calling for a major NSR applicability determination before use of the minor NSR tools.[41] Accordingly, there are no federal requirements, nor any federally-approved analogues, for the provisions that EPA is now suggesting should exist. To the contrary, EPA's own Indian Country preamble, quoted above, notes the absence of such benchmarks. Requiring additional language in Texas would be arbitrary, and would contravene the principle articulated by the Fifth Circuit that,

> Although EPA is required to approve SIPs that provide for the timely attainment and subsequent maintenance of primary and secondary ambient air standards as well as satisfy other CAA general requirements, *see* 42 U.S.C. § 7410(a)(3), the EPA has no authority to question the wisdom of a State's choices of emission limitations if they are part of a SIP that otherwise satisfies the standards set forth in 42 U.S.C. §7410(a)(2).[42]

3. The program does not include the requirement to make Major NSR applicability determinations based on actual emissions and on emissions increases and decreases (netting) that occur within a major stationary source.

EPA Comment:

- *"[T]his submitted Program allows an evaluation using allowable, not actual emissions as the baseline to calculate the project's proposed emission increase and for many of the netting emission reduction, thereby in many case possibly circumventing the major modification applicably requirements under the Major NSR rules, rules that are based upon using actual emissions to calculate baseline emissions."*

---

40 TEXAS NAT'L RES. CONSERVATION COMM'N, *Modification of Existing Facilities under Senate Bill 1126: Guidance for Air Quality* (April, 1996).
41 ALASKA ADMIN. CODE tit. 18, §50.502, approved 72 *Fed. Reg.* 45,378 (Aug. 14, 2007); 7 DEL. CODE REGS. § 1102. Granted limited approval based on EPA's concerns about public participation provisions. 65 *Fed. Reg*. 2,048 (Jan. 13, 2000).
42 *Clean Coalition v. TXU Power*, 536 F.3d 469, 472 (5th Cir. 2008).

Group Response:

The Group reiterates its comments from Section III.B.1 above. The overriding obligation to comply with federal NSR requirements is made explicit in TCEQ's rules. Moreover, states have great flexibility under the CAA in determining the applicability of minor NSR requirements, and that flexibility includes the authority to use allowable emission rates in establishing whether minor NSR is triggered.

C. Minor NSR Approval Issues

1. The program is not clearly limited to Minor NSR thereby allowing major modification to occur without a Major NSR permit.

EPA Comment:

- *"There are no statutory and/or regulatory provisions that clearly prohibit the use of the Program for major modifications. Nor are there any statutory and/or regulatory provisions clearly limiting the use of the Program to minor modifications."*

Group Response:

The Group reiterates its comments from Section III.B.1 above. The overriding obligation to comply with federal NSR requirements is made explicit in the statute, TCEQ's rules, and guidance on the program. The current regulations and guidance, therefore, constrain the regulated community from making major changes without complying with major NSR requirements.

2. The program in not an enforceable Minor NSR Permitting program.

EPA Comments:

- *"The Program is not clear that each Qualified Facility involved in the netting transaction must submit a permit application and obtain a permit revision reflecting all of the changes made to reduce emissions (relied upon in the netting analysis) as well as reflecting the change itself that increased emissions.*"

- *"At a minimum, the State must revise its rules to make it clear that a permit application must be submitted by each participating Qualified Facility and the changes made by the participating Qualified Facilities are reflected in revised permits issued by the TCEQ."*

Group Response:

As explained above, the Qualified Facility program is a minor NSR triggering provision. Instead of a permit review, a facility must give TCEQ notification of any changes made using the program rules and must document the changes and retain that documentation at the plant site.

TCEQ guidance makes clear that the facilities involved in a change must be qualified facilities at the time the change is to occur. Any facility that is not a qualified facility at the time of the change cannot be involved in the netting analyses.[43]

In two situations, a facility must qualify with TCEQ prior to making a change, but this is not a permitting procedure. Rather a facility must be qualified by TCEQ when:

> (1) The facility is qualified on the basis of BACT, but the specific control method has not yet been approved by TCEQ as qualifying BACT, or
>
> (2) The facility does not have established allowable emissions for an air contaminant relevant to the change in a MAERT or Form PI-E document.[44]

In these two scenarios, an owner or operator must submit a Form PI-E to TCEQ justifying the BACT or the determination of allowable emissions for the air contaminants relevant to the change. TCEQ then has 45 days to review the request and either accept it or object.

Additionally, an owner or operator making a change under the program must notify TCEQ, either prior to or after the change. Post change notification must come either 30 days after the change, or in an annual report. Pre-change notification is required when, in order to achieve a result of no net increase in allowable emissions, the owner or operator makes an intra-plant trade above set limits, depending on the location of the facility from the plant's boundaries. An intra-plant trade is when an emission reductions is made at another qualified facility at the plant and is traded to the facility where the change is being made.[45]

Two important aspects of the program are implicit in the pre-change notification requirement. First, the rule only contemplates ***intra***-plant trading. Trading among different plants held by a common owner is not authorized under the program. Second, TCEQ must be notified of intra-plant trading when the amounts traded are above a set limit.

If a change implicates a permit special condition, the permit holder must revise its permit special condition using the procedures specified in Chapter 116, New Source Review.[46]

---

[43] TEXAS NAT'L RES. CONSERVATION COMM'N*, Modification of Existing Facilities under Senate Bill 1126: Guidance for Air Quality*, (April, 1996), 6.
[44] 30 TAC § 116.118.
[45] *Id.*
[46] 30 TAC § 116.116 (b)(3).

3. **The program lacks safeguards to ensure that the changes will not violate a Texas control strategy and would not interfere with attainment and maintenance of NAAQs.**

EPA Comments:

- *"The submitted Program's netting is not based upon all contemporaneous increases at the same major stationary source and not all decreases at the same major stationary source. We propose, however, to find that such an approach satisfies the minimum requirements for an approvable Minor NSR netting program as long as the ambient air is protected in the trading."*

- *"The reductions in the Program's netting are based upon the most stringent of the permitted emissions rate (which includes the highest achievable actual emission rate) or any applicable state or federal rule. Therefore, this Program's netting is not based totally on changes in actual emissions. We are proposing to find that this still is acceptable as a Minor NSR netting program as long as the ambient air is protected in the trading."*

Group Response:

Qualified Facility flexibility is only available where the change will not result in a net increase above existing BACT-reviewed levels at well controlled facilities. The program contemplates changes under existing limits that were set to protect the NAAQS and other air quality standards.

The existing Qualified Facility rules contain adequate safeguards that ensure that air quality, including NAAQS, are protected when changes are made under the program. Additionally, under the existing rules, changes are sufficiently documented and quantified so that a decrease at a facility will only be used in one netting analysis.

Section 116.117 governs the documentation and notification of changes made to qualified facility. That provision specifies that a facility making a change under the program must document the change. This documentation must include:

> (1) [Q]uantification of all emissions increases and decreases associated with the physical or operation change;
>
> (2) [A] description of the physical or operation change;
>
> (3) [A] description of any equipment being installed;

> (4) [S]ufficient information as necessary to show that the project will comply with § 116.150 of this title (relating to Nonattainment Review) and §§ 116.160-116.163 of this title (relating to Prevention of Significant Deterioration Review) and with Subchapter C of this chapter (relating to Hazardous Air Pollutants: Regulations Governing Constructed Major Sources (FCAA, § 112(g), 40 CFR Part 63)).[47]

Section 116.117 goes on to require that a facility notify TCEQ of the changes made under the program.[48]

The intersection of the requirements to document and to report the change to TCEQ means that a change may only be used in one netting analysis. Additionally, the requirement that a source document compliance with NNSR and PSD review safeguards NAAQS.

4. The program fails to demonstrate that, if viewed as an exception to the Texas Minor NSR permitting rules, it will not interfere with any applicable requirement of the Act.

EPA Comment:

- *"The submitted Program could be considered an exemption from Minor NSR. To be approvable as an exemption from the Texas Minor NSR SIP, the State must demonstrate that this exemption will not permit changes that will violate the Texas control strategies or interfere with NAAQS attainment."*

Group Response:

The Qualified Facility program is correctly analyzed as a minor NSR applicability trigger. As such, it could be viewed as an exemption to the Texas Minor NSR permitting review requirements. The existing rules, however, sufficiently prevent changes that will violate the Texas control strategies or interfere with NAAQS attainment.

Qualified Facility flexibility is only available where the change will not result in a net increase above existing BACT-reviewed levels at well controlled facilities. The program contemplates changes under existing limits that were set to protect the NAAQS and other air quality standards.

Further, as explained in Section III.B.3 above, § 116.117 requires that a modification under the program must be documented and an owner or operator specifically must show compliance with NNSR and PSD requirements.[49] The state NNSR and PSD rules exist to

[47] 30 TAC § 116.117(a).
[48] 30 TAC § 116.117(b).
[49] 30 TAC §116.117(a).

promote NAAQS attainment. The Qualified Facility provisions, therefore, incorporate Texas's control strategies, thus safeguarding the NAAQS.

IV. Substance of Asserted Deficiencies for Definitions

A. The removal of the incorporation by reference of the federal PSD definition of BACT.

EPA Comments:

- *"The 2006 submittal also removed from the State rules, the PSD SIP requirement at 40 CFR 52.21(r)(4). . . [This revision provides that] if a project becomes a major stationary source or major modification solely because of a relaxation of an enforceable limitation on the source or modification's capacity to emit a pollutant, then the source or modification is subject to PSD applies as if construction had not yet commenced."*

- *"As the mechanism in Texas for ensuring that permits contain such a requirement, the State PSD SIP must both require BACT and apply the federal definition of BACT (or one that is more stringent) to be approved pursuant to part C and Section 110(l) of the Act."*

Group Response:

Texas submitted a revision to 30 TAC 116.160(a) and a new section 116.160(c)(1) and (2) on February 1, 2006, as a SIP revision to the Texas PSD SIP. This SIP revision reorganized the earlier SIP-approved rules.

Prior to the currently-reviewed revisions, Texas had incorporated by reference certain provisions of 40 CFR 52.21. The current SIP-approved rule was adopted by the State on October 10, 2001, and EPA approved this recodified SIP rule citation on July 22, 2004.[50]

Since 1972, Texas has correctly imposed a control technology review on applications for an air quality permit.[51] Section 382.0518(b)(1) of the Texas Clean Air Act ("TCAA") requires that "the proposed facility for which a permit, permit amendment, or a special permit is sought will use at least the best available control technology, considering the technical practicability and economic reasonableness of reducing or eliminating the emissions from the facility."[52] This requirement is echoed in Section 116.111(a)(2)(C) of TCEQ's rules, which requires that "the proposed facility utilize BACT, with consideration given to the technical

[50] 69 *Fed. Reg.* 43,752 (July 22, 2004).
[51] *See* TACB, Regulation VI § I(B)(2) (July 5, 1972).
[52] TEX. HEALTH & SAFETY CODE § 382.0518(b)(1).

practicability and economic reasonableness of reducing or eliminating the emissions from the facility." [53]

The term BACT has been defined by TCEQ in strict accordance with the statutory BACT requirement in the TCAA. Specifically, 30 TAC § 116.10(3) defines BACT as "BACT with consideration given to the technical practicability and the economic reasonableness of reducing or eliminating emissions from the facility." The TCEQ has stated that this definition shall apply to all use of the term "BACT" in Chapter 116 of its rules, unless the context clearly indicates otherwise.[54]

The Texas regulations have continuously carved out 40 CFR 52.21(j), concerning control technology review, which is the federal BACT requirement, from the Texas PSD regulations. This is true from 1992 when EPA first granted authority to Texas to administer PSD permitting. As part of the 1992 approval, EPA explained why the federal control technology review requirement of Section 52.21(j) could be properly excluded by Texas under the federal Clean Air Act. EPA explained:

> This provision of the Federal PSD regulations has been excluded from the TACB Regulation VI because the TACB claims that the Texas Clean Air Act and the existing State regulations have provisions for application of BACT as stringent as the Federal requirements in reviewing the permit applications. The EPA review of the Texas Clean Air Act and Regulation VI (Sections 116.3(a)(3) through 116.3(a)(5)) *have indeed revealed that existing TACB permit requirements meet the provisions of the Federal PSD regulations* . . . .[55]

EPA then stated in the final rule approving the Texas PSD program that the federal control technology review requirement, which requires BACT for PSD applications, was "not necessary for approval of the Texas Program."[56]

The preamble to the 2006 revisions to §116.160 in which the incorporations by reference of 40 CFR 52.21 were changed, demonstrate a consistency with the approach taken by the State in the preceding years. The preamble explains the incorporation by reference of certain sections of 40 CFR 52.21 and further states, "[o]ther definitions used for the PSD program or visibility in Class I areas program are currently in [TCEQ's] rules."[57]

The appropriate BACT definition exists in Texas's rules, as demonstrated by EPA's past approval of those rules. All permits Texas has issued under the existing permitting program reflect the current TCEQ SIP-approved approach to BACT, and are valid and enforceable.

---

[53] 30 TAC § 116.111(a)(2)(C).
[54] 30 TAC § 116.10.
[55] 54 *Fed. Reg.* 52,824-25 (Dec. 22, 1989) (emphasis added).
[56] 57 *Fed. Reg.* 28,093-94 (June 24, 1992).
[57] 31 *Tex. Reg.* 519 (Jan. 27, 2006).

B. **The definition of "insignificant increases" as not requiring a permit does not meet EPA's NSR SIP requirements.**

EPA Comments:

- *"The TCAA seems to be clear that a Permit by Rule, Standard Permit, or an Exemption by Rule cannot be used for a major source or major modification. EPA is aware that in the past the State has reasonably interpreted an applied the SIP term 'insignificant' for allowing only minor modifications and minor sources. There is information; however, e.g., the State's adoption of a Permit by Rule for Startup, Shutdown, and Maintenance Emissions that belies the EPA being able to rely upon such a submittal of the relevant statutory provisions. This type of Permit by Rule cannot be construed to apply only to minor modifications and construction of minor sources. A submittal by the State of the applicable statutory sections for EPA to approve as part of the Texas SIP no longer seems sufficient in view of the issuance of this particular Permit by Rule."*

- *"With the State's issuance of the Startup, Shutdown, and Maintenance Permit by Rule that is not clearly limited to minor modifications and the continued expressions by the public, regulated entities, and government entities on the lack of clarity in the submittals' language of (A) and (B), EPA is proposing to disapprove the submittals for 30 TAC 116.10(11)(A) and (B) because they are vague and unenforceable."*

Group Response:

EPA's concerns that Texas's adoption of a Permit by Rule ("PBR") for Maintenance Start-up and Shutdown ("MSS") prevents it from approving the definition of modification of an existing facility as excluding "insignificant increase" are unfounded. TCEQ proposed that rule in December of 2005.[58] TCEQ, however, never actually adopted the rule. Consequently, it was withdrawn in July of 2006.[59] EPA's ability to rely on the state submittal of the applicable statutory sections, therefore, should not be undermined by a rule that was never adopted.

Additionally, the definition specifying that a modification of an existing facility does not include (1) an insignificant increase of an air contaminant that is authorized by one or more commission exemptions, or (2) an insignificant increase at a permitted facility[60] is not vague. As EPA recognizes, the Texas Clean Air Act clearly prevents an exemption from being used for a major source or major modification.[61] Consequently, the definition is limited to minor modifications.

V. Conclusion

The Group strongly supports full approval of existing Texas Qualified Facility provisions and the existing definitions. The Texas permitting program, including the definitions and Qualified Facility program provisions, is stringent, comprehensive and protective of both the environment and public health. The Texas SIP revisions, including Qualified Facility provisions and defined terms, further the attainment of NAAQS, and so should be fully approved.

[58] 30 *Tex. Reg.* 8,802 (Dec. 30, 2005).
[59] 31 *Tex. Reg.* 5,797 (July 21, 2006).
[60] 30 TAC §116.10(11).
[61] 74 *Fed. Reg.* at 48,465.

November 23, 2009

BCCA APPEAL GROUP COMMENTS ON EPA PROPOSED DISAPPROVAL OF TCEQ FLEXIBLE PERMIT PROGRAM RULES

Docket ID No. EPA-R06-OAR-2005-TX-0032
74 *Fed. Reg.* 48,480 (Sept. 23, 2009)

The BCCA Appeal Group (the "Group") submits the following comments in response to the proposed disapproval of Texas's state implementation plan ("SIP") submittals relating to flexible permits for air quality permitting issued by the U.S. Environmental Protection Agency ("EPA") and published in the *Federal Register* on September 23, 2009. The Group is comprised of members with the common interests of achieving the goals of clean air and a strong economy for Texas. The Group is comprised of the following members: Air Products, L.P.; Celanese Chemicals, Ltd.; Conoco Phillips; The Dow Chemical Company; Entergy Texas, Inc.; Exxon Mobil Corporation; Lyondell Chemical Company; Texas Petrochemicals, L.P.; Valero Refining-Texas, L.P.

I. Introduction

The Group strongly supports full approval of the flexible permit provisions. The Texas air quality permitting program, including the flexible permit provisions, is stringent, comprehensive and protective of both the environment and public health.

Under Texas's integrated air permitting regime, air quality in the state is demonstrating strong, sustained improvement. Between 1999 and 2005, NO_X emissions in the Houston-Galveston area decreased from almost 1,200 tons per day, to under 600 tons per day.[1] Ozone as measured under the one-hour standard in the Houston-Galveston area has declined from 220 parts per billion ("ppb") in 1991 to 127 ppb in 2009.[2] Under the eight-hour standard, ozone in the Houston-Galveston area has declined from 119 ppb in 1991, to 84 ppb in 2009.[3] There has been a similar improvement in toxic air emissions. Between 2003 and 2008, there has been a 50% decrease in highly reactive volatile organic compounds ("HRVOCs") in the Houston area.[4] Similarly, in the Dallas-Fort Worth area, ozone as measured under the one-hour standard declined from 140 ppb in 1991 to 115 ppb in 2009.[5] Ozone for the Dallas-Fort Worth area under the eight-hour standard has declined from 105 ppb in 1991 to 86 ppb in 2009.[6] Moreover, between 1988 and 2008, there has been an 80% reduction in VOC compound indicators in the

[1] Susana M. Hildebrand, TCEQ Chief Engineer, *Update of Air Quality in Texas* (presented at Oct. 29, 2009 Commission Work Session, and available at TCEQ.com), 13. (Attached as Exhibit 1)
[2] *Id.* at 13.
[3] *Id.*
[4] Houston Regional Monitoring, *Total HRVOC Network Average Concentrations: Houston Ship Channel PAMS-GC Monitoring Sites*. (Attached as Exhibit 2)
[5] *Id.* at 16.
[6] *Id.*

Houston area.[7] Notably, according to recent TCEQ review, all areas of Texas are in attainment for nitrogen dioxide, sulfur dioxide, and carbon monoxide.[8]

Further, the data show that stationary sources have contributed more substantial emissions reductions than any other category during the period of most dramatic air quality improvements. In the Houston-Galveston area between 1993 and 2008, NO_X emissions from stationary sources declined from 695 tons per day ("tpd"), to 156 tpd, a decrease of 539 tpd.[9] During that same period, emissions from on-road source declined from 416 tpd to 175 tpd, a decrease of 241 tpd.[10] Similarly, stationary sources made significant decreases for VOC. Between 1993 and 2009 in the Houston-Galveston area, VOC emissions from stationary sources decreased from 411 tpd, to 170 tpd, a decrease of 241 tpd.[11] On-road sources from that same period decreased from 199 tpd, to 86 tpd, a decrease of 113 tpd.[12] As the figures indicate, stationary sources in Texas have made the most significant strides in reducing emissions.

The submitted revisions strengthen a previously SIP-approved Texas program. Under the federal Clean Air Act ("CAA" or "Act"), SIP revisions are approved when those revisions do not interfere with the attainment of the National Ambient Air Quality Standards ("NAAQS"). States have the primary responsibility for developing plans for the attainment and maintenance of the NAAQS. In fact, as the Fifth Circuit recently explained:

> Although EPA is required to approve SIPs that provide for the timely attainment and subsequent maintenance of primary and secondary ambient air standards as well as satisfy other CAA general requirements, *see* 42 U.S.C. § 7410(a)(3), the EPA has no authority to question the wisdom of a State's choices of emission limitations if they are part of a SIP that otherwise satisfies the standards set forth in 42 U.S.C. §7410(a)(2).[13]

Rather, the proper test for determining whether a SIP revision can be approved is whether the revision interferes with attainment of the NAAQS (*i.e.* that the plan does not make air quality worse).[14] Far from "worse" air quality, the last ten years have seen an unprecedented improvement in Texas air quality. The submitted revisions have been fully integrated components of the Texas air quality permitting program for all that time. Because the current SIP submittals function to *strengthen* the existing SIP, such submittal does not raise interference concerns, and should be fully approved.

---

7 Houston Regional Monitoring, *Annual Average Trends for VOC Indicator Compounds for HRM Network from 1988 through 2008*. (Attached as Exhibit 2)

8. Susana M. Hildebrand, TCEQ Chief Engineer, *Update of Air Quality in Texas* (Oct. 29, 2009), 10.

9 *Compare* TEXAS NAT'L RES. CONSERVATION COMM'N, *Revision to the State Implementation Plan (SIP) for the Control of Ozone Air Pollution: Post-1999 Rate-of-Progress and Attainment Demonstration SIP for the Houston/Galveston Ozone Nonattainment Area*, (Dec. 2000), at 2-5 (Attached as Exhibit 3); *with* TEXAS COMM'N ON ENVIRONMENTAL QUALITY, *Revision to the State Implementation Plan for the Control of Ozone Air Pollution: Houston-Galveston-Brazoria 1997 Eight-Hour Ozone Standard Nonattainment Area* (Sept. 23, 2009), at 2.3-2.5 (Attached as Exhibit 4).

10 *Id.*

11 *Id.*

12 *Id.*

13 *Clean Coalition v. TXU Power*, 536 F.3d 469, 472 (5th Cir. 2008).

14 *Galveston-Houston Assoc. for Smog Prevention v. EPA*, 289 Fed. Appx. 745, 754 (5th Cir. 2008).

II. Flexibility in Federal Permitting Rules

A. Title V Operating Permits

For twenty years, federal air permitting regulations have consistently recognized the importance of providing operational flexibility to the regulated community. In 1990, Congress added Title V to the Clean Air Act ("CAA" or "the Act"). The Act specifies what EPA must require of states' federal operating permit programs. Specifically, state Title V programs must contain:

> Provisions to allow changes within a permitted facility . . . without requiring a permit revision, if the changes are not modifications under any provision of title I and the changes do not exceed the emissions allowable under the permit (whether expressed therein as a rate of emissions ***or in terms of total emissions***).[15]

Thus, Congress specifically envisioned emission cap permits in structuring the Title V program.

Two years later, in 1992, EPA promulgated its rules for Title V permit programs in 40 C.F.R. Part 70. In order to provide operational flexibility, EPA promulgated section 70.4(b)(12), which requires that states put in place Title V programs that allow three specific avenues for operational flexibility, including permits that establish federally-enforceable emission caps in their Title V programs. Specifically:

> The program shall require the permitting authority, if a permit applicant requests it, to issue permits that contain terms and conditions, . . . allowing for the trading of emissions increases and decreases in the permitted facility solely for the purpose of complying with ***a federally-enforceable emissions cap*** that is established in the permit independent of otherwise applicable requirements. [16]

EPA emphasized the importance of enabling plant sites to maintain operational flexibility in the preamble to Part 70. There, EPA stated:

> [I]t is possible to use the combination of several provisions in these regulations to allow for operational flexibility around federally-enforceable emission limits or caps which are more strict than otherwise required by the Act's applicable requirements. A source may request that the permit provide for emissions trading under § 70.4(b)(12)(iii), as discussed above. For example, a source could structure its permit so that the emissions caps at the permitted facility created a pool of unused emissions under the voluntary limit on the source's potential to emit. [17]

[15] CAA § 502(b)(10) (emphasis added).
[16] 40 CFR §70.4(b)(12) (iii) (emphasis added).
[17] 57 *Fed. Reg.* 32,250, (July 21, 1992) at 32,267.

At least 24 states and the District of Columbia have adopted the language of Section 70.4(b)(12) into their Title V permit programs.[18] Several of these states embraced the concept of "***federally enforceable emission caps***" that authorize emissions, not only as a title V revision trigger, but also as an authorization tool under NSR.[19] Thus, emission cap permits have deep roots outside Texas.

B. Flexible Permit Pilot Study

EPA again focused on the importance of operational flexibility when it conducted its decade-long Flexible Permit pilot study. EPA reviewed flexible emission cap permits in six states, and found that flexible permits worked well and could be used to further both environmental protection and administrative flexibility.[20] Behind the project was a recognition by both the states involved and EPA that "in today's increasingly competitive global markets," companies are required "to respond rapidly to market signals and demand, while delivering products faster, at lower cost, and of equal or better quality than their competitors."[21] EPA recognized that flexible permits could reduce the administrative "friction" of time, costs, delay, uncertainty, and risk associated with certain types of operational changes.[22]

C. Plantwide Applicability Limits

EPA recognized the advantages of emissions cap permits in promulgating its NSR reform in 1996 and 2002. In introducing the plantwide applicability limit ("PAL") concept in 1996, EPA noted:

> Rather than face complicated, piecemeal applicability decisions every time a change at a plant is contemplated, plant managers may prefer to work within an emissions cap or emissions budget, an annual emissions limit that allows managers to make almost any change anytime as long as the plant's emissions do not exceed the cap.[23]

When promulgating its final NSR reform rule in 2002, EPA reiterated the benefits of emission caps, reflecting on its experience with the flexible permit pilot project. EPA stated:

---

[18] Alabama, AL ADC 335-3-16-.05; Arkansas AR ADC 014 01 026; Washington, D.C., 20 DC ADC § 302; Delaware, DE ADC 7 1000 1130; Florida, 62 FL ADC 62-213.415; Georgia, GA ADC 391-3-1-.03; Illinois, 415 ILCS 5/39.5.12; Iowa, IA ADC 567-22.108(455B); Louisiana, LA ADC. 33-507; Mississippi, MS ADC 08 034 006; Montana, MT ADC 17.8.1224; Nebraska, 129 NE ADC Ch. 8, § 019; New Hampshire, NH ADC ENV-A 612.02; New Jersey, NJ ADC 7:27.28B(f); New York, 6 NY ADC 201-6.5; North Dakota, N.D. ADC § 33-15-14-06; Ohio, Ohio ADC § 3745-77-07; Pennsylvania, 25 Pa. Code §127.448.; Rhode Island, RI ADC 12 031 029; South Carolina, SC ADC 61-62.70; South Dakota, SD ADC 74:36:05:30; Texas, 30 TAC §122.222(c); Utah, UT ADC R307-415; Washington, WA ADC 173-401-722; West Virginia, WV ADC § 45-30-5.

[19] *See, e.g.*, New Jersey's Facility-Specific Emissions Averaging program; 7 N.J. ADMIN. CODE 27:-22.28B (2009); Oregon's Plant Site Emissions Limit program, OR. ADMIN. R. 340-222-0010, et seq. (2008).

[20] EPA OFFICE OF AIR QUALITY PLANNING AND STANDARDS & EPA OFFICE OF POLICY, ECONOMICS AND INNOVATION, *Evaluation of Implementation Experiences with Innovative Air Permits*, 4 (Attached as Exhibit 5).

[21] *Id.*

[22] *Id.* at 9.

[23] 61 *Fed. Reg.* 38,250, at 38,251 (July 23, 1996).

> Overall, we found that significant environmental benefits occurred for each of the permits reviewed. In particular, the six flexible permits established emissions cap-based frameworks that encouraged emissions reductions and pollution prevention, even though such environmental improvements were not an explicit requirement of the permits. We found that in a cap-based program, sources strive to create enough headroom for future expansions by voluntarily controlling emissions. For instance, one company lowered its actual VOC emissions over threefold in becoming a synthetic minor source (that is, 190 tpy to 56 tpy). Other companies lowered their actual VOC emissions by as much as 3600 tpy by increasing capture, by using voluntary pollution prevention and other voluntary emissions control measures, and by reducing production rates.[24]

D. EPA's Proposed Indian Country Rule

In 2006, EPA proposed an air permitting rule for Indian Country. In the preamble to that proposed rule, EPA once again expressed the importance of flexibility in air permitting programs. EPA intended the rule to be a representative template of state NSR programs that serve to provide operational flexibility while leveling the regulatory playing field:

> [W]e seek to establish a *flexible* preconstruction permitting program for minor stationary sources in Indian country that is comparable to that which applies outside of Indian country, *in order to create a more level regulatory playing field* . . . . [T]his can serve as one example of a program that meets the objectives and requirements of the Act.[25]

Moreover, the proposed rule for Indian Country contains a permit structure that embraces the emissions cap principle in the form of minor and major PALs.[26]

E. EPA's Flexible Air Permit Rule

Most recently, in October of 2009, EPA promulgated the federal Flexible Air Permitting ("FAP") Rule. Through this rulemaking, EPA incorporated changes into Title V rules that were "intended to clarify and reaffirm opportunities for accessing operational flexibility under existing regulations."[27]

In the preamble to the rule, EPA supported flexibility in air permitting. "[W]e . . . intend to support states and sources who wish to explore the flexibilities available under the existing major NSR regulations."[28] Additionally, EPA recognized that state permitting authorities have discretion to preapprove minor NSR changes. "As a general matter, the permitting authorities have authority to decide, on a case-by-case basis, the merits of granting an

[24] 67 *Fed. Reg.* 80,186, at 20, 207 (Dec. 31, 2002).
[25] 71 *Fed. Reg.* 48,696, at 48,700 (Aug. 21, 2006) (emphasis added).
[26] *Id.* at 48,727; 48,744.
[27] 74 *Fed. Reg.* 51,418 (Oct. 6, 2009).
[28] *Id.* at 51,422.

advance approval of minor NSR to a particular requesting source."[29] The final rule does not call for state Title V or NSR program revisions, but reaffirms pre-existing authority for states to craft three forms of flexible air permits. "The purpose of this rulemaking is to clarify and reaffirm opportunities within the existing regulatory framework to encourage the wider use of the FAP approaches."[30]

III. Overview of Texas Flexible Permit Program

The TCEQ's flexible permit regulations in 30 TAC Chapter 116, Subchapter G were promulgated in 1994 as a flexible mechanism to comply with State minor NSR permitting requirements. This program was established as a way to encourage facilities to install controls that would not otherwise be required in exchange for operational flexibility associated with emission caps. Under the flexible permit program, a permittee can seek pollutant-specific caps that cover certain facilities at the site. These caps are established based on the application of BACT to all of the facilities contributing to the emissions cap.[31] In exchange for this greater level of control, sites are provided with an alternative to individual facility emission limits (for the covered facilities) as long as the site complies with the emission limits set by the cap.

The flexible permit also calls for the use of individual emission limitations in certain situations.[32] Individual limits are used when it is necessary to control off-property impacts, such as impacts from air toxics, or to meet the NAAQS. Specific emission limits that an individual facility cannot exceed may also be established to ensure that federal permitting requirements are not circumvented.[33]

The flexible permit program has been quite successful in achieving emission reductions. For example, flexible permitting has resulted in a reduction of more than 25,000 tons tpy of SO_2 and more than 10,000 tpy of NO_x at a coal and petroleum coke fired power plant and a reduction of more than 4,800 tpy of SO_2 and CO from a petroleum refinery.

Issuance of a flexible permit has no impact on the permit holder's obligation to comply with federal PSD or nonattainment NSR ("NNSR") requirements. In fact, for projects that constitute major sources or modifications, TCEQ issues a major source permit (PSD or NNSR) in addition to the state flexible permit.

IV. Substance of Asserted Deficiencies

EPA's concerns on specific aspects of the Texas flexible permit program are reproduced and addressed below. Headings are for convenience only—all comments are intended to address all aspects of EPA's proposal.

A. Major NSR Safeguards

---

[29] *Id.* at 51,426.
[30] *Id.* at 51,429.
[31] 30 TAC § 116.716(a). Note, however, that a site may have an implementation period to install the new control devices. Under this period, an initial cap will be higher than the final cap, which is based on BACT.
[32] 30 TAC § 116.715(b) and 116.716(b).
[33] 30 TAC § 116.715(d).

1. The Texas definition of "modification" is not clearly at least as stringent as the definition of "modification" in EPA's Major NSR SIP rules.

EPA Comment:

- *"In evaluating Major NSR SIP revision submittals impacting ''major modifications,'' that differ from EPA's, our review is primarily guided by section 111(a)(4) of the Act that describes when a ''source'' is to be considered modified: ''The term 'modification' means any physical change in, or change in the method of operation of, a stationary source which increases the amount of any air pollutant emitted by such source or which results in the emission of any air pollutant not previously emitted.'' Texas did not submit any demonstration showing how its use of the definition ''modification'' was at least as stringent as the definition of ''modification'' in EPA's Major NSR SIP rules. In conducting our review, we particularly were mindful of the United States Court of Appeals for the District of Columbia Circuit regarding the scope and requirements of Section 111(a)(4) for determining whether a change is a ''major modification.'' See e.g., New York v. EPA, 413 F.3d 3 (D.C. Cir. 2005) (''New York I'') (evaluating EPA's 2002 revised major NSR rules and interpreting Section 111(a)(4))."*

Group Response:

TCEQ rules provide two separate "modification" definitions. Briefly, a "major modification" is a project action that triggers federal NSR review (PSD or Nonattainment).[34] In contrast the TCEQ's minor source program uses the definition of "modification of an existing facility" to determine if a proposed change triggers minor NSR review, and the scope of the change is not limited to pollutants that are federally regulated.[35] TCEQ has explicitly stated that the flexible permit rules and the definition of "modification of an existing facility" do not act as a shield for federal NSR permitting.[36]

Moreover, EPA itself distinguished the definition of "modification" under minor NSR from that used for major NSR. In the preamble to its proposed Indian Country rules, EPA explained:

---

[34] 30 TAC § 116.12(18) , defined as "a physical change or change in the method of operation of a major stationary source that causes a significant project emissions increase of a federally regulated new source review pollutant, and a significant net emissions increase of a federally regulated new source review pollutant which triggers federal review, such as PSD or nonattainment review."

[35] 30 TAC § 116.10(11), defined as "a physical change or change in the method of operation of a facility which causes an increase in the amount of any air contaminant emitted by the facility into the atmosphere or results in an emission of any air contaminant not previously emitted."

[36] Letter from Richard Hyde, Director, TCEQ Air Permits Division, to Jeff Robinson, Chief, Air Permits Division, EPA Region 6, Aug. 30, 2007 (Attached as Exhibit 6).

> In a recent decision, the D.C. Circuit Court of Appeals, ruled that, based on the wording of the definition of "modification" in section 111(a)(4) of the Act, the applicability of major NSR to modifications must be based on changes in actual emissions (State of New York, et., v. U.S. EPA, June 24, 2005). However, because the statutory basis for the minor NSR program is section 110(a)(2)(C) of the Act, which does not define or refer to a definition of "modification," we believe that we have discretion in defining the term as we think best for the minor NSR program in Indian Country . . . .[37]

Similarly, Texas has discretion in defining the term for purposes of minor NSR.

Additionally, in 2000, the U.S. EPA's Environmental Appeals Board (EAB) confirmed that there is no "legally prescribed methodology" for the emissions test used for minor NSR applicability determinations, and rejected the argument made by EPA enforcement personnel that, in the absence of an explicit minor NSR methodology in State rules, the minor NSR applicability test must be consistent with that used for federal PSD purposes.[38]

2. The program is not clearly limited to Minor NSR, thereby allowing new major stationary sources to construct without a Major NSR permit.

EPA Comments:

- *"[U]nlike the minor NSR SIP rules for Standard Permits in 30 TAC 116.610(b) and Permits by Rule in 30 TAC 106.4(a)(3) and(4), the submitted rules do not require that construction of a major stationary source or a major modification, as defined in the Major NSR SIP regulations, must meet the Major NSR permitting requirements."*

- *"If Texas truly intends for the submitted Flexible Permits State Program to apply only to minor NSR, at a minimum Texas must amend Subchapter G to include additional provisions that clearly limit its applicability to minor NSR as it did in the Texas minor NSR SIP at 30 TAC Chapter 106 for Permits by Rule and 30 TAC Chapter 116 Subchapter F for Standard Permits."*

Group Response:

A flexible permit may be used for major and minor projects under the Texas rules. The rules make clear, however, that every project for which a flexible permit is issued must also comply with federal NSR requirements. As explained above, for projects that constitute major

[37] 71 *Fed. Reg.* 48,696, at 48,701 (Aug. 21, 2006).
[38] *In re Tennessee Valley Authority*, 9 EAD 357, 461 (EAB Sept. 15, 2000).

sources or modifications, TCEQ issues a major source permit (PSD or NNSR) in addition to the state flexible permit.

The flexible permit rules distinguish between flexible permit and federal NSR requirements, and make explicit a flexible permit holder's obligation to comply with those federal NSR requirements:

- § 116.711(1) states that a flexible permit application must demonstrate that "[t]he emissions from the proposed facility, group of facilities, or account . . . will comply with all rules and regulations of the commission," which includes Division 5 (nonattainment NSR) and Division 6 (PSD) of Subchapter B.[39]

- § 116.711(8): "Nonattainment review. If the proposed facility, group of facilities, or account is located in a nonattainment area, each facility shall comply with all applicable requirements concerning nonattainment review of this chapter."[40]

- § 116.711(9): "Prevention of Significant Deterioration (PSD) Review. If the proposed facility, group of facilities, or account is located in an attainment area, each facility shall comply with all applicable requirements in this chapter concerning PSD review."[41]

- § 116.718 states that the emissions increase at a facility covered by a flexible permit that does not exceed the emission cap is insignificant *"for the purposes of state new source review under this subchapter."* The flexibility provided flexible permit holders to make physical or operational changes under the cap is limited to minor NSR.[42]

- § 116.720: "Neither operational nor physical changes authorized under this subchapter may result in an increase in actual emissions at facilities not covered by the flexible permit unless those affected facilities are authorized pursuant to §116.110 of this title (relating to Applicability)." Section 116.110 requires an applicability review that can trigger nonattainment NSR or PSD review.

In light of these safeguards, the flexible permit rules constrain the regulated community from making major changes without complying with major NSR requirements. Regulated entities are subject to clear requirements for the applicability of PSD and NNSR. Any attempts by a permittee to circumvent the federal NSR rules is properly addressed through the enforcement process, not by mandating redundant rule language as an approval condition.

3. The program does not require that first an applicability determination be made whether the construction or modification is subject to Major NSR.

[39] 30 TAC § 116.711(l).
[40] *Id.* § 116.711(8).
[41] *Id.* § 116.711(9).
[42] *Id.* § 116.718.

EPA Comment:

- *"The submitted Program fails to require that the applicability of the Major NSR requirements be evaluated prior to considering whether the construction of a new source or making a change can be authorized under a Flexible Permit."*

Group Response:

As outlined above, Texas regulations explicitly require permit holders to comply with federal NSR rules. Additionally, TCEQ rules such as § 116.150, governing New Major Source or Major Modification in Ozone Nonattainment Areas, § 116.151, governing New Major Source or Major Modification in Nonattainment Area Other than Ozone, and §§ 116.160-163 governing the Prevention of Significant Deterioration Requirements, make clear that applicants for a flexible permit are subject to an applicability demonstration for both Nonattainment review and PSD review. In light of these regulations, the Texas structure contains adequate safeguards to ensure that flexible permit applications are subject to federal NSR analyses and comply with federal NSR.

4. The Texas definition of "account" may result in an emission cap applying to multiple major stationary sources.

EPA Comments:

- *"Texas SIP defines an "account" to include an entire company site, which could include more than one plant and certainly more than one major stationary source. . . Accordingly, under a Flexible Permit, a single emissions limitation in the emission cap could apply to multiple major stationary sources."*
- *"By allowing an emission cap to be established for an account, which can include multiple major stationary sources, the submitted SIP revisions may allow a major stationary source to net a significant emissions increase against a decrease occurring outside the major stationary source, from facilities on the account's site that are covered under the Flexible Permit."*

Group Response:

TCEQ rules provide that the definition of "Account" is tied to the definition of "Site." 30 TAC 101.1(1) defines "Account":

> For those sources required to be permitted under Chapter 122 of this title (relating to Federal Operating Permits Program), all sources that are aggregated as a site. For all other sources, any combination of sources under common ownership or control and located on one or more

> contiguous properties, or properties contiguous except for intervening roads, railroads, rights-of-way, waterways, or similar divisions.[43]

Therefore, an account for any major stationary source is limited to a specific plant site. The Title V rules, specifically § 122.10(27), provide that a Site is defined as "[t]he total of all stationary sources located on one or more contiguous or adjacent properties, which are under common control of the same person . . . ." The flexible permit rules specify that only one flexible permit may be issued at an account site and a flexible permit may not cover sources at more than one account site.[44]

Moreover, the regulations governing NNSR and PSD are clear that emissions increases are evaluated on a ***project*** level rather than increases across a site. For example, §116.150 states that the NNSR netting analysis is required unless "the proposed emissions increases ***associated with a project***, without regard to decreases, is less than 5 tons per year of the individual nonattainment pollutant in areas classified . . . as Serious or Severe."[45] Similarly, § 116.160 states that "netting is required for all modification to existing major sources of federally regulated new source review pollutants, unless the proposed emissions increases ***associated with a project***, without regard to decreases, are less than major modification thresholds for the pollutant . . . ."[46]

Reading these rules together shows that they provide sufficient safeguards against a major stationary source netting a significant emissions increase against a decrease occurring outside a site using a flexible permit.

5. Lack of a program requirement for "crosswalks" from prior Minor and Major NSR permit terms.

EPA Comments:

- *"The more intricate a plan, the greater the need for detailed requirements."*

- *"[T]he lack of a program requirement for records with detailed crosswalks and of tracking and reporting requirements, one cannot determine which grandfathered units on a site are covered or not by a Flexible Permit, or which pre-existing minor NSR permitted units are covered or not by a Flexible Permit, much less which permit terms, limits, and conditions are covered, are not covered, are retained, or not."*

Group Response:

---

[43] 30 TAC § 101.1(1).
[44] 30 TAC § 116.710(a)(1) and (4).
[45] 30 TAC §116.150(c)(1).
[46] 30 TAC §116.160(b).

The flexible permit rules require special conditions and other necessary conditions, such as requirements for monitoring, testing, recordkeeping, and reporting.[47] When a flexible permit incorporates facilities that were previously authorized under an existing PSD and/or nonattainment permit, TCEQ identifies the special conditions initially contained in those federal permits with the appropriate notation (PSD), (NA), or (PSD and NA) in the conditions.[48] The permit representations are also carried forward into the flexible permit.[49]

An owner or operator can request to change the conditions contained in every Texas permit if the circumstances warrant, the applicable requirements are met, and TCEQ approves the change.[50] Consequently, the rules contemplate that a permittee may request a change in conditions from earlier-issued permits when applying for a flexible permit.[51] If such changes to representations are proposed, those changes are reviewed, and monitoring and recordkeeping requirements, consistent with any proposed changes in representations, are then added to the special conditions of the permit.[52]

For flexible permits that contain major sources authorized under existing PSD and/or nonattainment permits, the PSD and/or nonattainment permits are consolidated into the flexible permit for tracking purposes. There is no removal of control requirements, or reduction in the level of monitoring or testing.[53]

B. Minor NSR Approval Issues

1. The program is not clearly limited to Minor NSR, thereby allowing new major stationary sources to construct without a Major NSR permit.

EPA Comment:

- *"There are no statutory and/or regulatory provisions that clearly prohibit the use of the Program for major stationary sources and major modifications. Nor are there any statutory and/or regulatory provisions clearly limiting the use of the Program to minor sources and/or minor modifications. There are no provisions that prohibit the use of the Program for construction of new major stationary sources and major modifications of existing major stationary sources and minor sources."*

---

[47] 30 TAC § 116.715(c)(6) and (d).
[48] Letter from Richard Hyde, Director, TCEQ Air Permits Division, to Jeff Robinson, Chief, Air Permits Division, EPA Region 6, Aug. 30, 2007.
[49] *Id.*
[50] *See* 30 TAC §§ 116.110(b); 116.116(a)-(c).
[51] 30 TAC § 116.721.
[52] *Id.* § 116.715(c)(6).
[53] Letter from Richard Hyde, Director, TCEQ Air Permits Division, to Jeff Robinson, Chief, Air Permits Division, EPA Region 6, Aug. 30, 2007.

Group Response:

The Group reiterates the points made in Section IV.A.1 above. A flexible permit may be used for major and minor projects under the Texas rules. The rules make clear, however, that every project for which a flexible permit is issued must also comply with federal NSR requirements. As explained above, for projects that constitute major sources or modifications, TCEQ issues a major source permit (PSD or NNSR) in addition to the state flexible permit.

Texas's flexible permit rules explicitly state that sources applying for flexible permits are subject to federal NSR. The rules constrain the regulated community from making major modifications without complying with federal NSR requirements.

2. The program lacks replicable, specific, established implementation procedures for establishing the emission cap in a Minor NSR Flexible Permit.

EPA Comments:

- *"There are not specific, established, replicable procedures providing available means to determine independently, and for different scenarios, how the State will calculate a Flexible Permit's cap and/or individual emissions limitations for a company's site, plants on the site, major stationary sources on the site, a facility within a major stationary source on the site, facilities on the site, a group of units on the site, for one pollutant but not another, etc."*

- *"Because applicants can choose to establish caps or individual emission limitations for just certain pollutants rather than for all pollutants emitted from the source(s) included in the Flexible Permit, the submitted Program also must contain legally enforceable procedures for determining both the cap and individual emissions limitations for each relevant pollutant for each source and address how sources or pollutants not included in the Flexible Permit will be regulated."*

Group Response:

Under the Texas rules, an emissions cap is calculated using the maximum expected activity or operating level of a facility and the current BACT applied to each facility. In other words, the emissions cap is the sum of the well-controlled emissions of each facility under the cap.[54] Emission caps are generally calculated for each specific criteria pollutant and other pollutants as necessary or desired by the company obtaining the flexible permit. The permittee is required to meet BACT as applied to all facilities individually contributing to a particular emission cap.

[54] 30 TAC §116.716.

The flexible permit also allows for the use of individual emission limitations.[55] Individual emission limits are used when it is necessary to ensure protection of off-property impacts, such as control of air toxics, or to meet the NAAQS. Specific emission limits that an individual facility can not exceed may also be established to ensure that federal permitting requirements are not circumvented.[56]

The rules do contain an established and replicable method for determining an emissions cap. Namely, the rules require that each flexible permit involve the summing of BACT emission rates. While BACT determinations may vary between specific types of sources, the use of federal and state BACT guidance results in a replicable procedure for establishing caps.

Additionally, the rules require that an applicant indentify "each facility" to be included in the flexible permit and to identify "each contaminant for which an emission cap is desired."[57]

The flexible permits rules do not change the rule governing facilities and pollutants not addressed in a plant's flexible permit. Facilities not incorporated into a plant's flexible permit remain subject to their existing authorizations. This applies with equal force to pollutants not covered by a flexible permit. If a pollutant is not addressed by a flexible permit, the emissions of that pollutant remain subject to existing permit limits.

3. Lack of a program requirement for "crosswalks" from prior Minor and Major NSR permit terms and other requirements of the Texas SIP.

EPA Comment:

- *"We also are proposing to disapprove the submitted Program because it would allow holders of a Flexible Permit to make de facto amendments of existing SIP permits including changes in the terms and conditions (such as throughput, fuel type, hours of operation) of minor and major NSR permits, without a preconstruction review by Texas."*

Group Response:

The Group reiterates the points made in Section IV.A.4 above.

---

[55] 30 TAC §§ 116.715(b) and 116.716(b).
[56] *Id.* § 116.715(c)(1) and (d).
[57] *Id.* §116.713 (13).

4. **The program lacks the necessary more specialized monitoring, recordkeeping, and reporting (MRR) requirements required for this type of Minor NSR program.**

EPA Comment:

- *"The submitted Program lacks provisions explicitly addressing the type of monitoring requirements that are necessary to ensure that all of the movement of emissions between the emission points, units, facilities, plants, etc., still meet the cap for the pollutant, still meet the individual emissions limitations, and still meet any other applicable state or federal requirement."*

Group Response:

The Texas rules' stringent provisions for monitoring, recordkeeping, and reporting require the regulated community to monitor and submit information sufficient to safeguard environmental quality.

As explained above, TCEQ issues flexible permits with conditions on recordkeeping, monitoring, and reporting. All flexible permits require recordkeeping that contains:

> [D]ata sufficient to demonstrate continuous compliance with the emission caps and individual emission limitations contained in the flexible permit shall be maintained in a file at the plant site and made available at the request of personnel from the commission or any air pollution control program having jurisdiction. . . . This information may include, *but is not limited to*, emission cap and individual emission limitation calculations based on a 12-month rolling basis and production records and operating hours. Additional recordkeeping requirements may be specified in special conditions attached to the flexible permit.[58]

The flexible permit rules contemplate that additional recordkeeping requirements may be tailored to the type of source covered by a flexible permit. In this way, the Texas recordkeeping requirements are as stringent, if not more stringent, than federal rules.

The Group believes that a comparison of Texas's reporting requirements to the reporting requirements of the proposed Indian Country minor NSR rules highlight that the Texas requirements are as stringent, if not more stringent. That rule requires:

[58] *Id.* §116.715(c)(6) (emphasis added).

> (i) Annual submittal of reports of monitoring required under paragraph (a)(3) of this section, including the type and frequency of monitoring, and a summary of results obtained by monitoring.
> (ii) Prompt reporting of deviations from permit requirements, including those attributable to upset conditions as defined in the permit, the probable cause of such deviations, and any corrective actions or preventive measures taken. Within the permit, the reviewing authority must define ''prompt'' in relation to the degree and type of deviation likely to occur and the applicable emission limitations.[59]

Further, with respect to emission events and MSS, Texas requirements go far beyond federal benchmarks. The Texas flexible permit rules require that permit holders comply with Sections 101.201 and 101.211, which govern reporting and recordkeeping of emissions events and maintenance, startup, and shutdown reporting.[60] Section 101.201 requires that the owner or operator of a regulated entity experiencing an emissions event "shall create a final record of all reportable and non-reportable emissions events as soon as practicable, but no later than two weeks after the end of an emissions event."[61] This two-week period is even more stringent than the proposed Indian Country provision requiring "prompt" reporting of emissions events.

Section 101.201 of the Texas rules also requires that permit holders retain records both for emissions events that are reportable and those that are not reportable. The provisions for non-reportable events contain requirements similar to the proposed Indian Country rule. Those records must be maintained on-site for a minimum of five years and be made readily available upon request to commission staff or personnel of any air pollution program with jurisdiction.[62] Additionally, records on non-reportable emissions events are required to include:

> (1) the physical location of the points at which emissions to the atmosphere occurred;
> (2) the date and time of the discovery of the emissions event;
> (3) the estimated duration of the emissions;
> (4) the compound descriptive type of the individually listed compounds or mixtures of air contaminants, from all emission points involved in the emissions event, that are known through common process knowledge or past engineering analysis;
> (5) the estimated total quantities and the authorized emissions limits for those specified compounds or mixtures;
> (6) the preconstruction authorization number or rule citation of the standard permit, permit by rule, or rule, if any, governing the facilities involved in the emissions event; and the authorized emissions limits, if any, for the facilities involved in the emissions events;
> (7) the basis used for determining the quantity of air contaminants emitted;

---

[59] 71 *Fed. Reg.* 48,696 at 48,738.
[60] 30 TAC § 116.715(c)(9).
[61] *Id.* §101.201(b).
[62] *Id.*

(8) the best known cause of the emissions event at the time of recording;
(9) the actions taken, or being taken, to correct the emissions event and minimize the emissions; and
(10) any additional information necessary to evaluate the emissions event.[63]

There is, in addition, a wide array of additional Texas rules specifying MRR requirements. A cross-section of these provisions are summarized below:

- § 101.10 requires permit holders to submit emissions inventories that detail "actual emissions of VOC, NOx, carbon monoxide (CO), sulfur dioxide (SO2), lead (Pb), particulate matter of less than 10 microns in diameter (PM10), any other contaminant subject to NAAQS, emissions of all HAPs identified in FCAA §112(b), or any other contaminant requested by the commission from individual emission units within an account."[64]

- § 115.116 requires recordkeeping for specified storage tanks for VOCs. Permit holders must inspect those tanks and record, among other things, a calculation of emissions for all secondary seal gaps that exceed 1/8 inch (0.32 centimeter) where the accumulated area of such gaps is greater than 1.0 square inch per foot (21 square centimeters per meter) of tank diameter. These calculated emissions inventory reportable emissions must be reported in the annual emissions inventory submittal required by §101.10 of this title (relating to Emissions Inventory Requirements).[65]

- § 117.801 requires reporting on stack testing for NO_X emissions. These reports include data summarizing emission rates found, reported in the units of the applicable emission limits and averaging periods, the maximum rated capacity, normal maximum capacity, and actual operating level of the unit during the test (in million British thermal units, horsepower, or megawatts, as applicable), and description of the method used to determine such operating level; the operating parameters of any active nitrogen oxides (NO_X) control equipment during the test; and documentation that no changes to the unit have occurred since the compliance test was conducted that could result in a significant change in NO_X emissions.[66]

- § 111.111 requires that flare logs be kept that detail when flares are observed including the time of day and whether or not the flare was smoking. "Flare operators shall record at least 98% of these required observations."[67]

A review of all Texas MRR requirements shows that sources operating under flexible permits are subject to a thorough and rigorous MRR regime.

V. Conclusion

[63] 30 TAC §101.201(b)(2).
[64] 30 TAC § 101.10.
[65] 30 TAC §115.116.
[66] 30 TAC § 117.801.
[67] 30 TAC §111.111.

The Group strongly supports full approval of existing Texas flexible permit provisions. The Texas permitting program, including the flexible permit provisions, is stringent, comprehensive and protective of both the environment and public health. Consistent with the findings of EPA's Flexible Permit Pilot Study,[68] flexible permits in Texas have contributed to the sustained improvement of air quality in Texas. The Texas SIP revisions, including flexible permits, further the attainment of NAAQS, and so should be fully approved.

[68] EPA OFFICE OF AIR QUALITY PLANNING AND STANDARDS & EPA OFFICE OF POLICY, ECONOMICS AND INNOVATION, *Evaluation of Implementation Experiences with Innovative Air Permits*, 21.