Meteorological Conditions and Associated Temporal Trends in Total Non-Methane Hydrocarbon and Benzene Concentrations in the Corpus Christi Area

2008-2010 REPORT
The Neighborhood Air Toxics Modeling Project for Houston and Corpus Christi

APPENDICES A & B

Prepared for
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Appendix A

By-Site Total Non-Methane Hydrocarbon Compound (TNMHC) Analyses for the CCAQP Stations

A.0 Total Non-Methane Hydrocarbon (TNMHC) Analyses

This appendix presents a historical overview of TNMHC concentrations measured at each of the seven CCAQP monitoring stations during the June 2005 through May 2008 period. The results for each monitoring station are presented in west-to-east order of location along the Corpus Christi Ship Channel as shown in Figure 2-1 of this report (i.e., Section A.1 reports results for Solar Estates while Section A.7 summarizes the results for Port Grain). For each station, the annual, seasonal, and day of week trends are presented, followed by a summary of the local meteorological and associated large-scale weather patterns that have been observed during high TNMHC events. Surface wind back-trajectories are generated for hours characterized by high TNMHC concentrations to identify possible emissions sources at nearby industrial facilities. ***Note that all tables and figures are presented at the end of each section.***

For the purposes of TNMHC conceptual model development, high TNMHC hours are defined as those hours characterized by a TNMHC concentration of 1000 ppbC or greater. The threshold value of 1000 ppbC was selected because the 1000 ppbC threshold level, which roughly corresponds to the 98th percentile concentration for all hourly CCAQP measurements collected during the June 2005 through May 2008 period, provides a large enough dataset to allow robust statistics for the Corpus Christi area. The 1000 ppbC threshold level is lower than the 2000 ppbC threshold value currently used by the CCAQP Notification Alert Tool, which is a near real-time program that identifies possible pollution events for additional analysis in the Corpus Christi area.

NOTE: The reader is referred to Section 3.0 of the main report for an integrated summary of the major TNMHC conceptual model results across all CCAQP monitoring stations.

A.1 Solar Estates (C633) Monitoring Station

Figure A.1-1 shows the location of the Solar Estates monitoring station, which is sited along the eastern boundary of the Solar Estates residential neighborhood. CAMS 632 (FHR Easement) and CAMS 21 (TCEQ Tuloso) are located approximately 0.8 mile to the east and west-northwest, respectively, of the Solar Estates monitoring station. The Flint Hills Resources (West Plant) industrial facility, which is situated along and to the southwest of the western portion of the Corpus Christi Ship Channel, lies immediately to the north and northeast of Solar Estates on the north side of Interstate 37. The Equistar Chemicals industrial facility is located 3.0 miles to the west-southwest of Solar Estates.

A.1.1 Seasonal, Day of Week, and Diurnal Variability in TNMHC Concentrations at Solar Estates

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by month are shown in Figure A.1-2. The highest concentrations generally occur during the October through February period. The monthly 95th percentile concentration values (which roughly correspond to the 110th highest TNMHC concentration ranked by descending order) for October through February range from 372 ppbC for February to 481 ppbC for December. For the remaining months, the 95th percentile concentration values range from 214 ppbC during May to 316 ppbC during September, with a minor peak in June of 331 ppbC.

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by hour are shown in Figure A.1-3. For all metrics, the nighttime hours are characterized by the highest concentrations, with highest concentration values during the 0000 CST through 0800 CST period. A slight peak in concentrations is noted for most metrics during the 0500 CST through 0700 CST period. For all hours, the 95th percentile concentration values (which roughly correspond to the 55th highest TNMHC concentration ranked by descending order) range from 157 ppbC at 1200 CST to 488 ppbC at 0600 CST. The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by day of week are shown in Figure A.1-4. The 95th percentile concentration values (which roughly correspond to the 188th highest TNMHC concentration ranked by descending order) vary from 306 ppbC on Saturday to 381 ppbC on Tuesday.

To investigate possible seasonal differences in the diurnal profiles by day of week, Figures A.1-5 and A.1-6 present the median and 75th percentile hourly TNMHC concentrations, respectively, grouped by season. Figures A.1-5 and A.1-6 demonstrate some tendency for higher concentrations during the nighttime and especially morning hours for weekdays compared to weekend days during the Winter months. Other seasons are not characterized by consistent difference between weekdays and weekend days. Overall, Spring is characterized by relatively lower concentrations compared to the other seasons. For all seasons, highest concentration values occur during the nighttime hours with a peak in concentrations values during the 0500 CST through 0700 CST period. The morning peak occurs one hour earlier during Spring and Summer. For all seasons, the

peak hourly median concentrations vary from 75 ppbC at 0600 CST on Spring weekends to 163 ppbC at 0700 CST for Fall weekdays. The seasonal peak 75th percentile concentration values (which roughly correspond to the 48th and 19th highest TNMHC concentration ranked by descending order for weekdays and weekend days, respectively) range from 186 ppbC at 0500 CST for Spring weekends to 285 ppbC at 0600 CST on Winter weekdays.

A.1.2 TNMHC Event Duration at Solar Estates

For the purpose of investigating the duration of high TNMHC events, TNMHC events were defined as one or more consecutive hours characterized by a concentration of 1000 ppbC or greater. Table A.1-1 presents the 28 high TNMHC events (binned by duration in hours) measured at the Solar Estates monitoring station during the June 2005 through May 2008 period. Note that 23 or the 28 events are characterized by a duration of one hour.

A.1.3 Local Meteorological Conditions during High TNMHC Events at Solar Estates

Figure A.1-7 presents the median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations binned by the hourly resultant wind direction at Solar Estates. The statistical metrics demonstrate that highest concentrations occur during hours characterized by winds with northerly and easterly components, followed by a secondary peak for wind directions with southerly and westerly wind components. Minimum concentration values are noted during periods of southeasterly and south-southeasterly winds; however, the relative concentration values increase for the higher percentile ranges for these wind directions. Figure A.1-8 presents the frequency of occurrence by resultant wind direction for all hours during the June 2005 through May 2008 period and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater. The frequency of occurrence of 1000 ppbC TNMHC concentrations is far greater than the climatological frequency of occurrence for hours characterized by winds with a northerly or north-northeasterly winds. Note, for example, that north-northeasterly winds comprise 8% of all hours but account for 25% of high TNMHC hours. High TNMHC events are rare during periods of westerly winds. Although the frequency of occurrence of high TNMHC concentrations is relatively low compared to the climatological frequency of occurrence during periods of winds with a southerly component, note that hours characterized by southeasterly and south-southeasterly winds account for 13% and 8%, respectively, of all 1000 ppbC TNMHC hours.

Figure A.1-9 shows the wind component scatterplot for all hours characterized by TNMHC concentrations of 1000 ppbC or greater, grouped by time of occurrence during the 1800 CST through 0900 CST (corresponding to evening/nighttime/morning) and 1000 CST through 1700 CST (corresponding to late morning/afternoon) time periods. (Refer to Section 2.5 of this report for a discussion of how to interpret the wind component scatterplot.) Consistent with the diurnal profile shown in Figure A.1-3, high TNMHC concentrations predominate during the 1800 CST through 0900 CST time

period, and most often occur during hours characterized by either a northerly/northeasterly or southeasterly resultant wind direction.

Figure A.1-10 presents the frequency of occurrence for all hours and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater for five wind speed ranges (binned by 4 mph increments). Highest TNMHC concentrations predominate at hours characterized by wind speeds of 8 mph or less. Most hours at Solar Estates (62%) are characterized by wind speeds greater than 8 mph; however, these wind speeds are associated with only 13% of the high TNMHC events.

Figure A.1-11 presents the frequency of occurrence for all hours and for only those hours characterized by TNMHC concentrations of 1000 ppbC or greater for eight temperature ranges (binned by 10 F increments). Hours characterized by temperatures between 50 F and 70 F occurred during 28% of all hours but account for 73% of high TNMHC hours. In contrast, hours characterized by temperatures greater than 70 F account for 66% of all hours and 23% of high TNMHC hours. The tendency for 1000 ppbC TNMHC events at relatively lower temperatures is consistent with the previously shown highest frequency of occurrence of high TNMHC events during the Fall and Winter nighttime hours, which would be generally characterized by the lowest temperatures.

Figure A.1-12 presents the frequency of occurrence for all hours and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater for ten relative humidity (as a percent) ranges. High TNMHC concentrations predominate at hours characterized by high relative humidity values. Note that while 51% of all hours are characterized by relative humidity values of 70% or higher, 78% of high TNMHC concentrations occur at these relative humidity levels. Figure A.1-13 presents a scatterplot of hourly temperature versus hourly relative humidity for all days during the June 2005 through May 2008 period. Hours characterized by TNMHC concentrations of 1000 ppbC or greater are plotted in red. The highest density of all hourly observations is found along the top right portion of the scatterplot, which indicates hours characterized by relatively warm temperatures and middle to high relative humidity values. This portion of the scatterplot is representative of most days during the spring through fall period, with nighttime hours often located on the right side at relatively high humidity values and daytime hours often located to the left at the lower humidity values. Figure A.1-13 indicates the highest density of 1000 ppbC TNMHC hours occurs during temperatures between 55 F and 65 F at relative humidity values of 70% or greater, which most likely are representative of nighttime hours during the October through January period.

A.1.4 Large-Scale Weather Patterns during High TNMHC Events at Solar Estates

To investigate the large-scale weather features that predominate during high TNMHC events, 72-hour HYSPLIT back-trajectories were generated for all days during the June 2005 through May 2008 period that were characterized by one or more hours with a TNMHC concentration of 1000 ppbC or greater at the Solar Estates monitoring station. Figure A.1-14 shows the 24 back-trajectories on these highest TNMHC days. The back-

trajectories were initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface. The majority of back-trajectories are characterized by either long-range flow from the north or northeast likely associated with the passage of a cold front through South Texas or flow from the east or south over the Gulf of Mexico consistent with the large-scale circulation with the large-scale circulation around a ridge of high pressure that extends southward or westward into Texas.

Figure A.1-14 shows that about half of the long-range flow patterns prior to high TNMHC events are characterized by northerly or northeasterly flow into South Texas. Figure A.1-15 presents the surface weather map for November 19, 2006, which is characterized by a long-range trajectory that indicates winds from the north over far eastern Texas followed by northeastward flow along the coast into Corpus Christi. At upper levels on November 19th, the jet stream flowed southward from west-central Canada turning eastward over Texas. Maximum wind speeds at upper levels over Texas were in excess of 100 knots. At the surface, high pressure dominated over the western half of the US and a large high pressure ridge centered over Wyoming extended southward into Texas. At Solar Estates, winds during the afternoon and evening of November 18th were generally east-southeasterly, turning calm to light northerly on the morning of November 19th with a minimum morning temperature of 55 F. TNMHC concentrations were elevated throughout the early morning hours with a maximum concentration of 1016 ppbC at 0100 CST. Moderate to strong northeasterly by the late morning hours were associated with a decrease in TNMHC concentrations.

A review of the large-scale surface weather maps for the 24 high days characterized by maximum hourly TNMHC concentrations of 1000 ppbC or greater reveals that a high pressure ridge often extends southward, southwestward, or westward into Texas. These surface high pressure systems are often associated with cold fronts that have moved through Texas, and the weak horizontal pressure gradients over the Corpus Christi area are associated with light winds speeds and (likely) stable atmospheric conditions. More rarely, Corpus Christi is just south of a dissipating or stationary frontal system with onshore surface winds in Corpus Christi. To explore the daily evolution of surface winds in the Corpus Christi area on high TNMHC days, Figure A.1-16 presents the resultant wind direction versus the resultant wind speed for all hours during the 24 days characterized by TNMHC concentrations of 1000 ppbC or greater. During the 0000 CST through 0900 CST period, winds are characterized by a range of directions most often with a northerly or east-southeasterly component at speeds of 3-10 mph. By the late afternoon hours, most days are characterized by east-southeasterly or southeasterly winds at 10-20 mph.

A.1.5 Analysis and Summary of Solar Estates TNMHC and Meteorological Measurements

Air quality analyses were performed using the hourly TNMHC, resultant wind speed, resultant wind direction, temperature, and relative humidity measurements collected at the Solar Estates monitoring station during the June 2005 through May 2008 period. The Solar Estates monitoring station is located along the eastern boundary of the Solar Estates

residential neighborhood. The Flint Hills Resources industrial facility, which is situated along and to the southwest of the western portion of the Corpus Christi Ship Channel, lies immediately to the north and northeast of Solar Estates on the north side of Interstate 37. The Equistar Chemicals industrial facility is located 3.0 miles to the west-southwest of Solar Estates.

The highest hourly TNMHC concentrations (>= 1000 ppbC) occur most frequently during the October through February period, with a minor peak during June. Concentrations are highest during the nighttime hours with a slight tendency for peak concentrations during the 0500 CST through 0700 CST period. The majority of high TNMHC events are one hour in duration. Analyses of the diurnal profiles by season demonstrate that the nighttime and particularly morning weekday concentrations are higher compared to weekend concentrations during Winter. Other seasons are not characterized by consistent difference between weekdays and weekend days.

A wind direction analysis found that highest concentrations occur during hours characterized by winds with northerly and easterly components (especially north-northeasterly), followed by a secondary peak for wind directions with southerly and westerly wind components. Although the frequency of occurrence of high TNMHC concentrations is relatively low compared to the climatological frequency of occurrence during periods with southerly flow, hours characterized by southeasterly and south-southeasterly winds account for 13% and 8%, respectively, of all 1000 ppbC TNMHC hours. Wind speeds are most often 5 mph or less during high TNMHC events. The majority of high TNMHC concentrations occur during hours with temperatures between 50 F and 70 F with relative humidity values of 70% or higher. These temperature and relative humidity conditions are consistent with the observed nighttime peak in TNMHC concentrations during the fall and winter months, which would be characterized by relatively high relative humidity values and relatively low temperatures.

The surface weather maps on days characterized by one or more hours with maximum TNMHC concentrations of 1000 ppbC or higher often show a high pressure ridge that extends southward, southwestward, or westward into Texas. More rarely, Corpus Christi is just south of a dissipating or stationary frontal system with onshore surface winds in Corpus Christi. The diurnal variation of surface winds at the Solar Estates monitoring station on these days is often characterized by a range of morning wind directions most often northerly or east-southeasterly, followed by moderate east-southeasterly to southeasterly winds during the afternoon hours.

A.1.6 Upwind Emission Sources during High TNMHC Events at Solar Estates

The previous analyses for Solar Estates did not attempt to account for the hourly variation in atmospheric dispersion conditions. One method to provide some normalization of measured pollutant concentrations with respect to varying atmospheric dispersion conditions is to multiply the concentration by the wind speed. Figure A.1-15 presents a scatterplot of the hourly resultant wind direction (degrees) versus the product of the hourly TNMHC concentrations and the hourly resultant wind speed (ppbC-mph) for all

hours during the June 2005 through May 2008 period. Consistent with the results of previous analyses, high values of concentration-wind speed are noted at wind directions ranging from north-northwest through northeast. In addition, there are relative peaks in concentration-wind speed values for hours characterized by east-southeasterly, southeasterly, and south-southeasterly wind directions.

To identify the local emissions sources at upwind industrial facilities that may impact TNMHC concentrations at Solar Estates, the Corpus Christi Trajectory Analysis Tool was used to generate one-hour surface back-trajectories for all hours characterized by an absolute TNMHC concentration of 750 ppbC or higher. Each back-trajectory was initialized at the half-hour (i.e., midpoint) of the TNMHC one-hour averaging period. Figure A.1-18 plots the one-hour back-trajectories over a geographic map of the Solar Estates area. The highest density of back-trajectory paths indicate flow from the east-northeast that passes over the Flint Hills Resources (East Plant) industrial facility located north and east of Solar Estates. The second highest density of back-trajectories indicates generally southeasterly flow.

Routine operational activities in support of CCAQP include the near real-time investigation of local emissions sources that may have contributed to high pollution events at Solar Estates. As shown in Figure A.1-18, portions of the large Flint Hills East facility are often located in the upwind area during high TNMHC events, and are considered by UT-Austin Staff to be a likely source of emissions that have historically affected TNMHC concentrations at the Solar Estates monitoring station. With regard to other pollutants, elevated sulfur dioxide (SO_2) and H_2S concentrations have been measured during periods of southeasterly winds, and are suspected to be associated with emissions from the Sam Kane Meat Packing Plant on Leopard Street. High 1,3-butadiene concentrations that periodically affect Solar Estates have been traced to the upwind Equistar Chemicals plant during periods of (infrequent) westerly winds. Figure A.1-19 provides a zoomed map of Solar Estates and the surrounding area using Google satellite imagery.

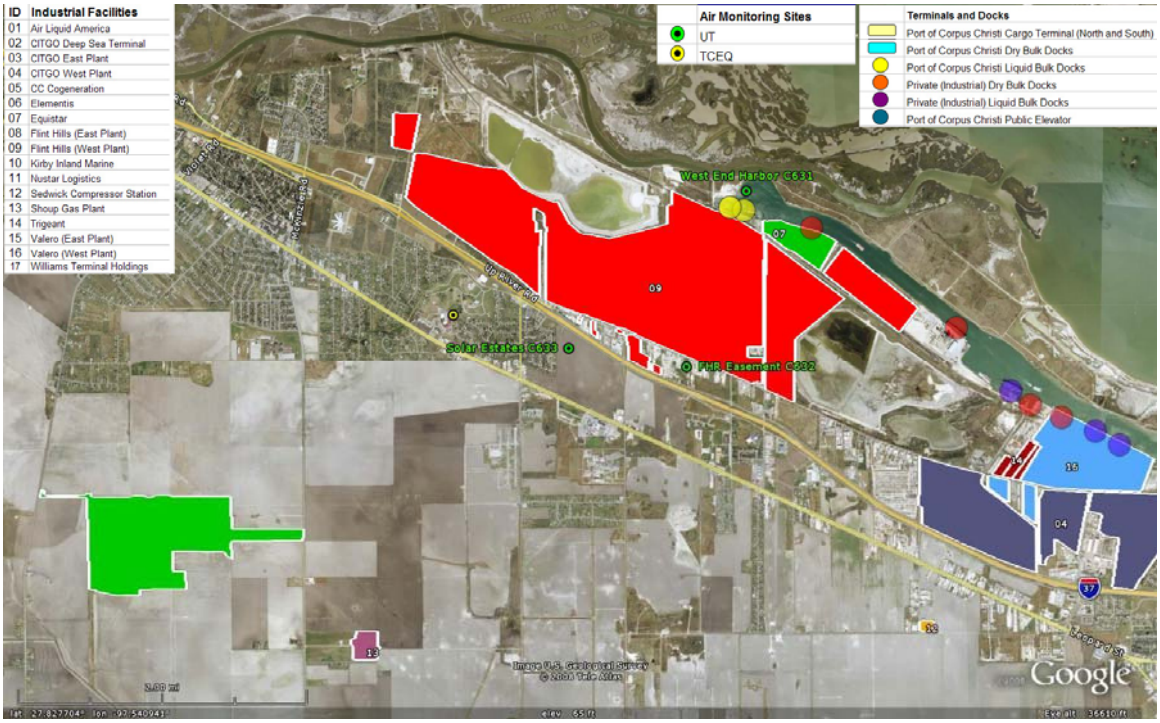

Figure A.1-1. Locations of the Solar Estates (C633) monitoring station, nearby CAMS, and surrounding industrial facilities. The Corpus Christi Ship Channel is oriented southeast to northwest near the middle of the figure.

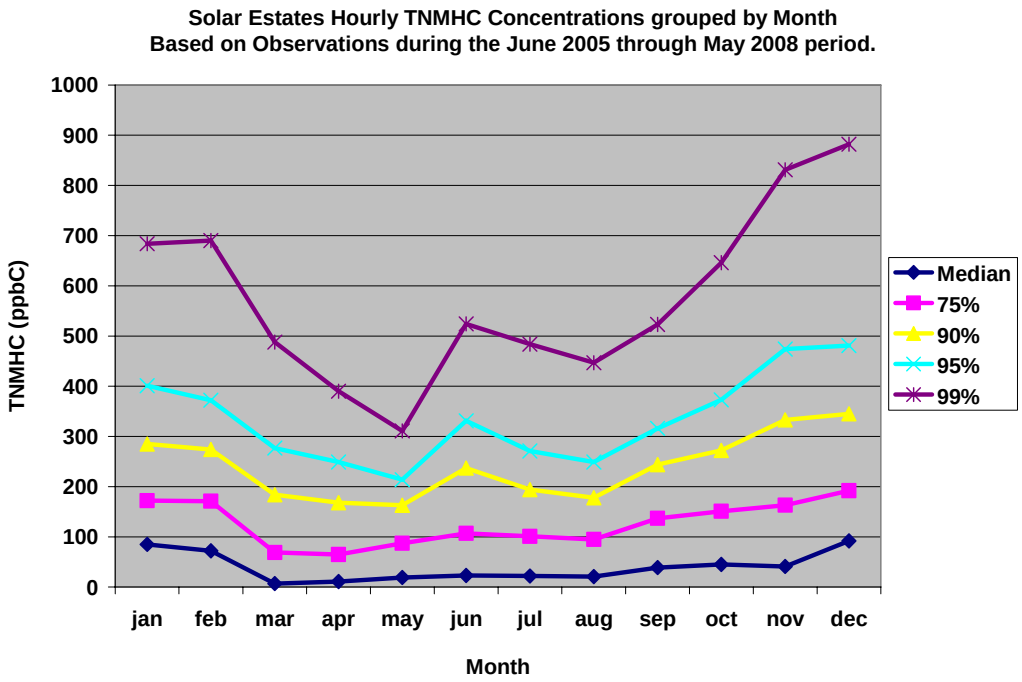

Figure A.1-2. Monthly median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

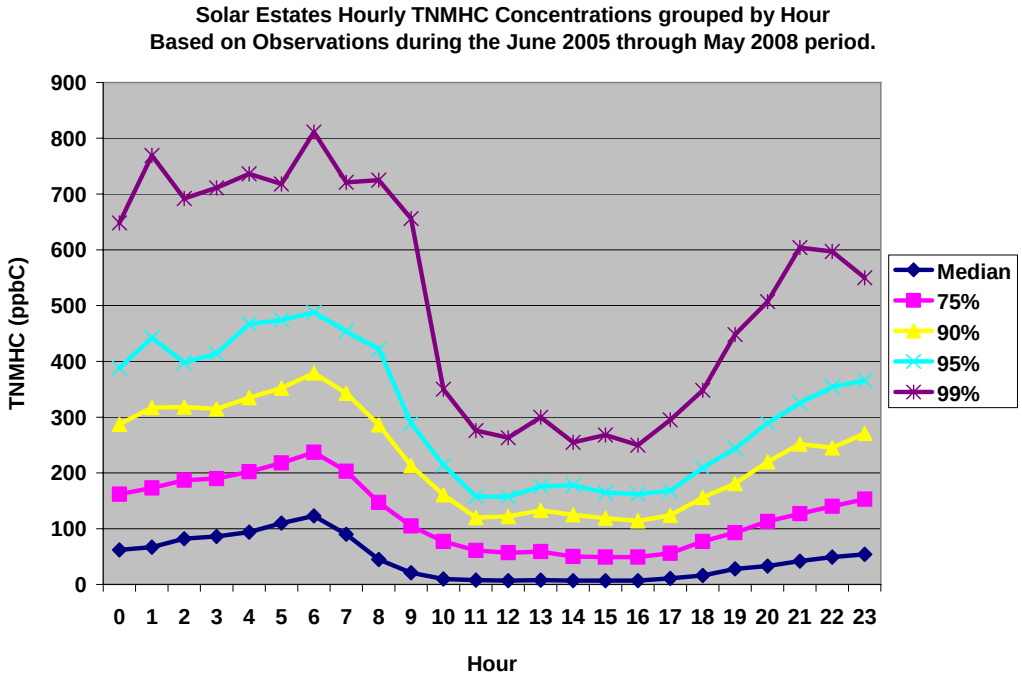

Figure A.1-3. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations at the Solar Estates monitoring station by hour based on all valid data during the June 2005 through May 2008 period.

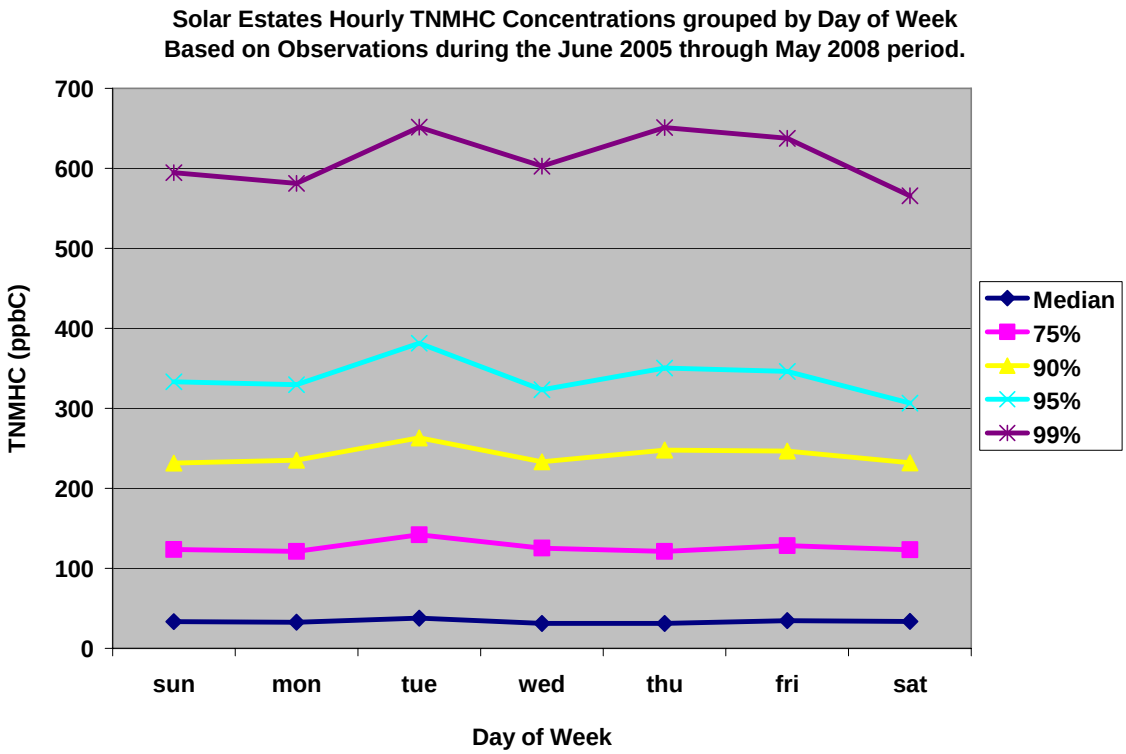

Figure A.1-4. Median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by Day of Week at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

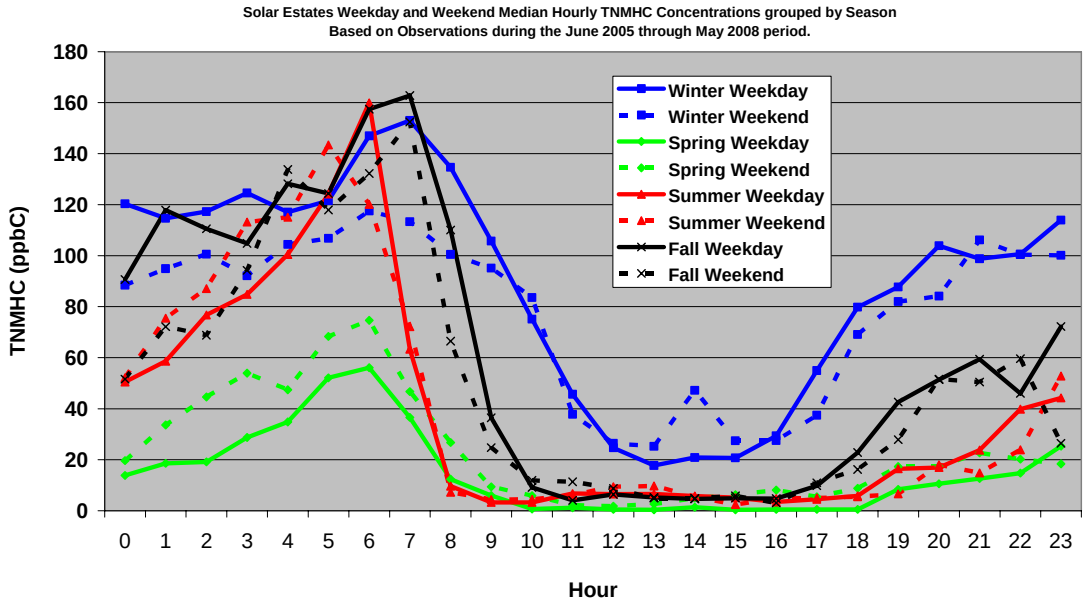

Figure A.1-5. Median hourly weekday and weekend day TNMHC concentrations grouped by season at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

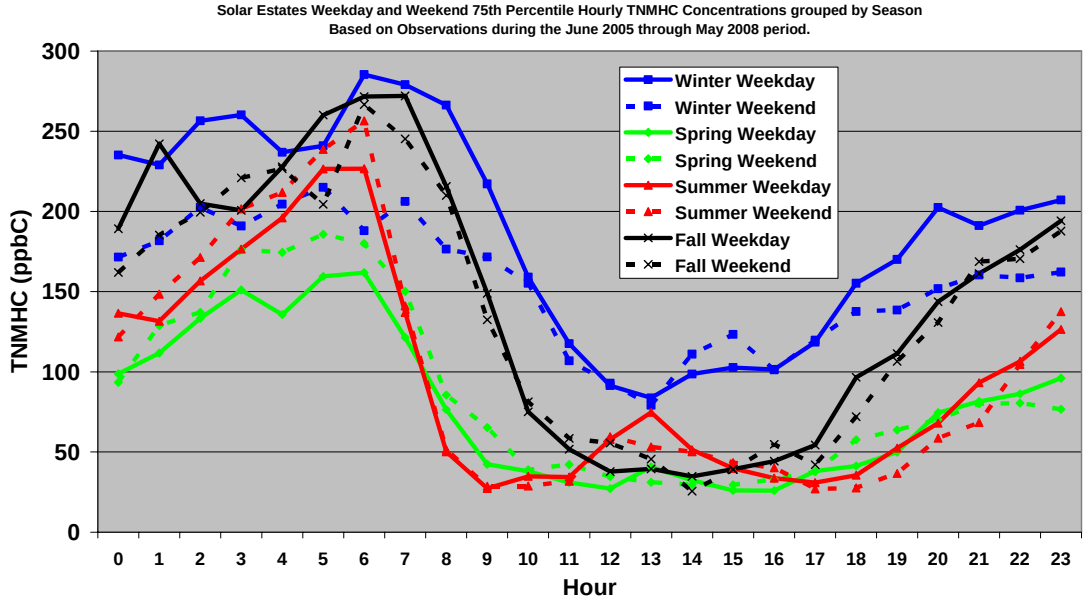

Figure A.1-6. The 75th percentile hourly weekday and weekend day TNMHC concentrations grouped by season at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

Table A.1-1. High TNMHC events at the Solar Estates monitoring station binned by duration in hours. High TNMHC events are defined as one or more consecutive hours characterized by TNMHC concentrations of 1000 ppbC or greater.

Duration of Event (hours)	Number of Events
1	23
2	2
3	1
4	1
5	0
>5	1
Total Events	**28**

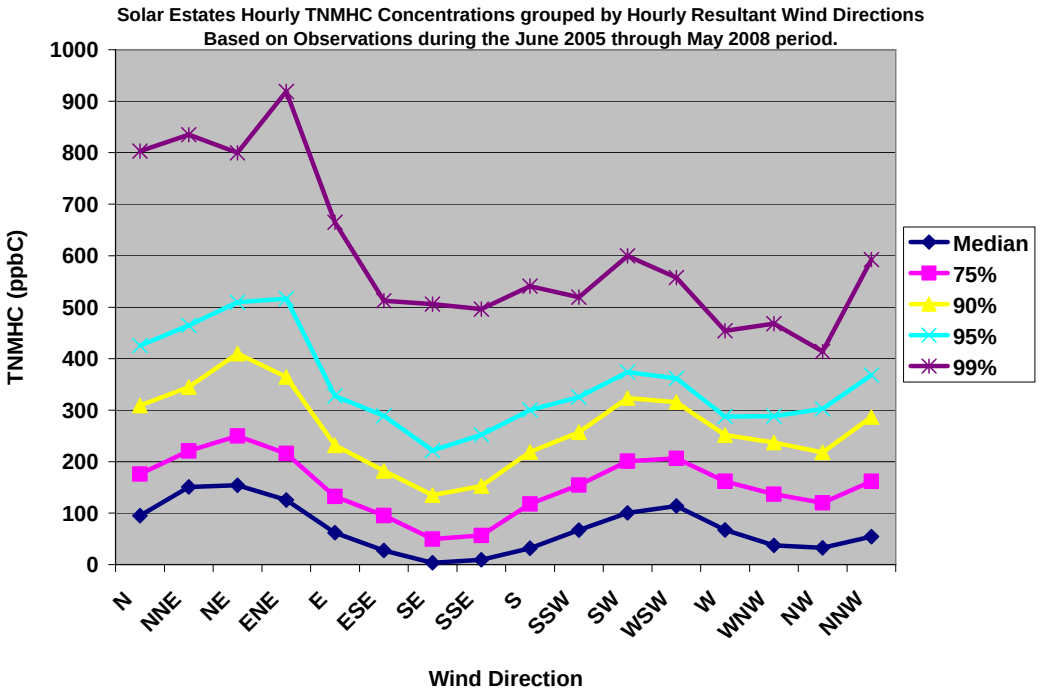

Figure A.1-7. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations grouped by hourly resultant wind direction at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

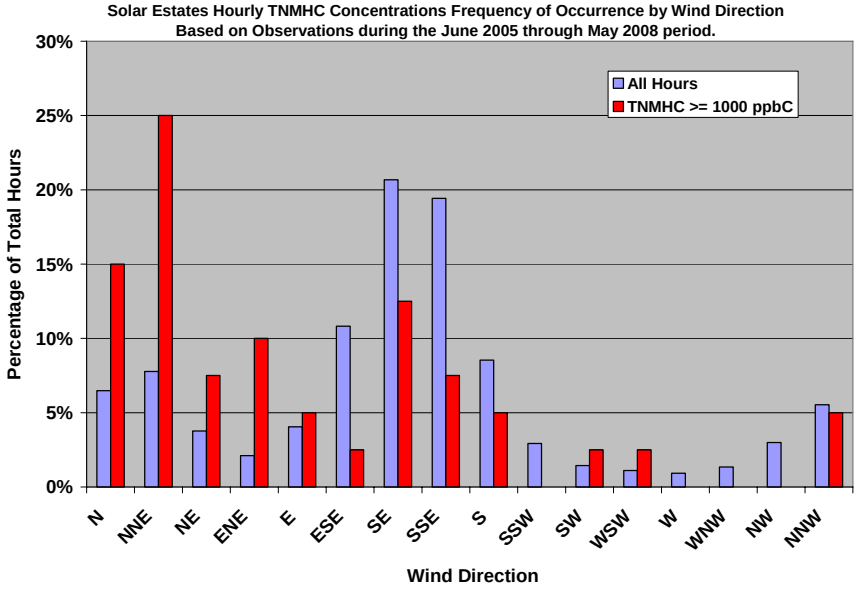

Figure A.1-8. Percentage of hours at the Solar Estates monitoring station grouped by resultant wind direction for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppb or greater. Based on all valid data during the June 2005 through May 2008 period.

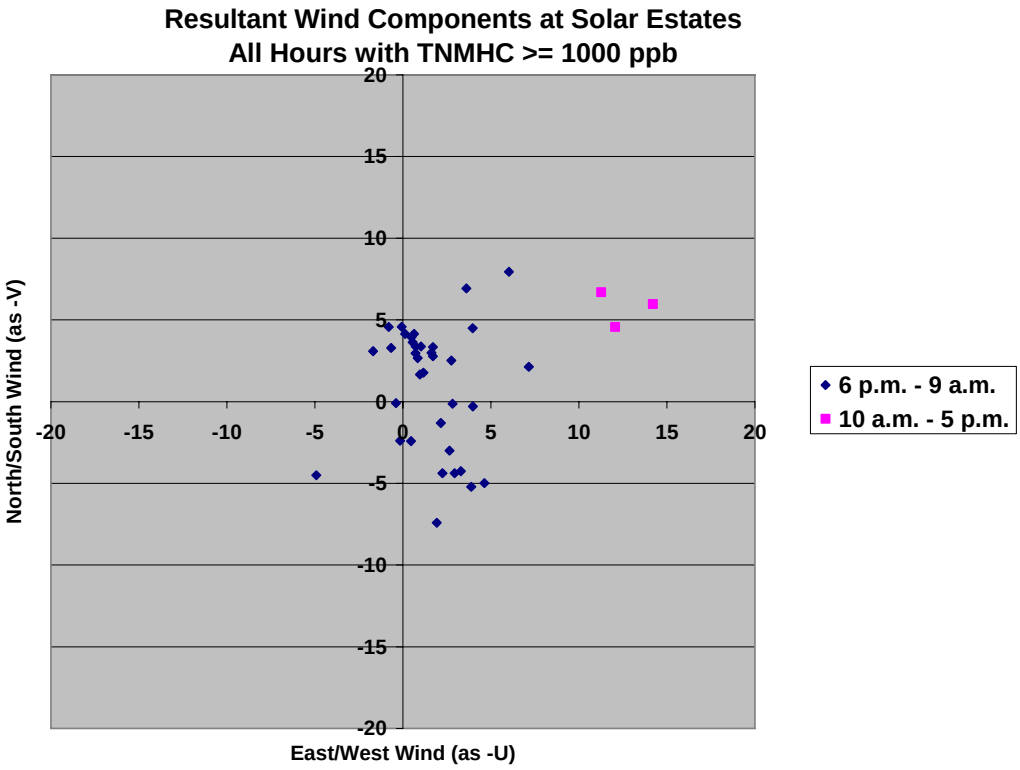

Figure A.1-9. Resultant wind component scatterplot at Solar Estates for all hours with TNMHC concentrations of 1000 ppb or greater during the June 2005 through May 2008 period. (The reader is referred to Section 2.5 for a discussion of how to interpret this figure.)

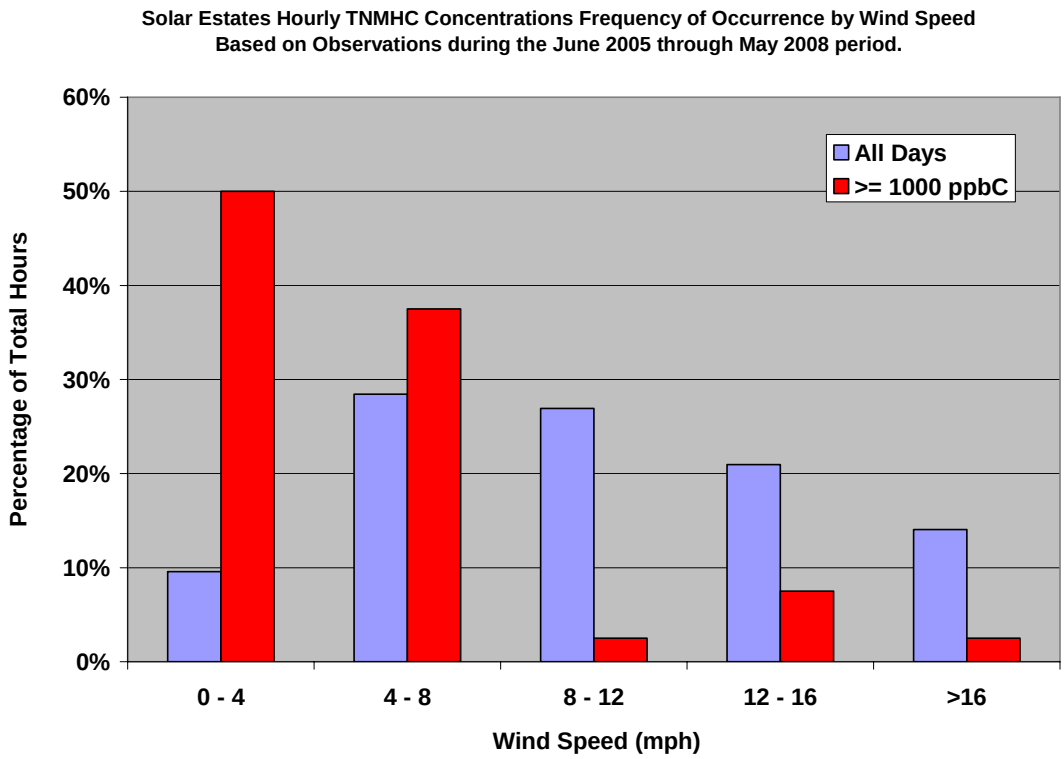

Figure A.1-10. Percentage of hours at the Solar Estates monitoring station grouped by resultant wind speed (binned by 4 mph increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

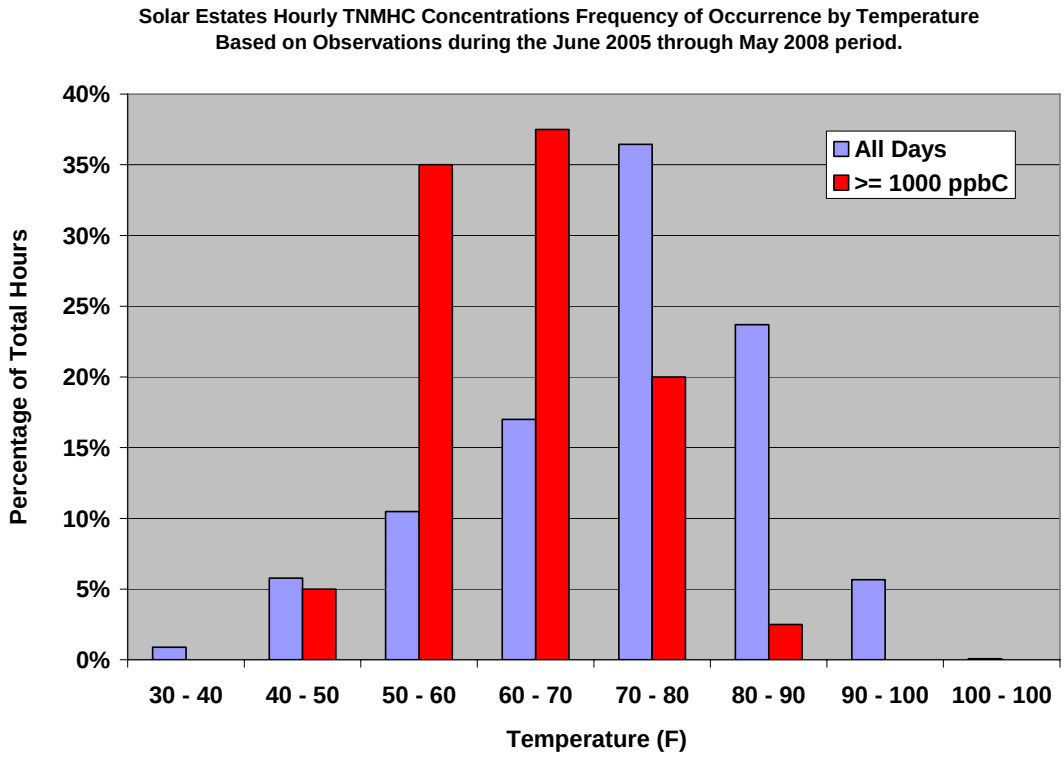

Figure A.1-11. Percentage of hours at Solar Estates monitoring station grouped by temperature (binned by 10 F increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

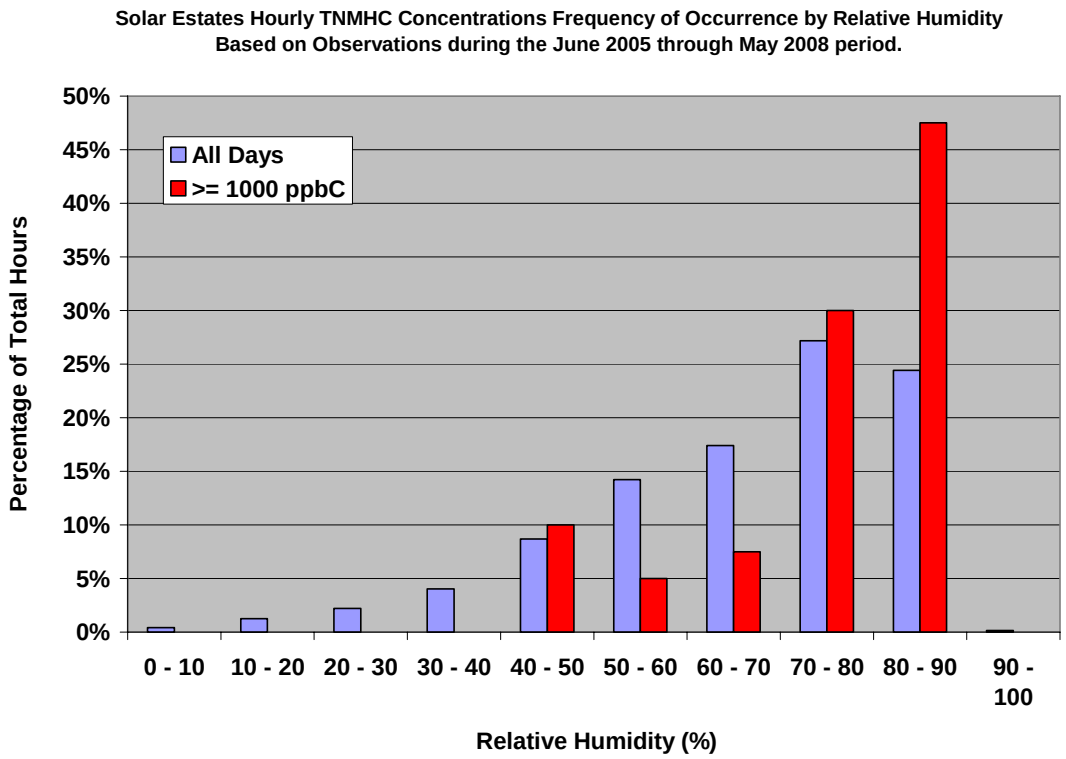

Figure A.1-12. Percentage of hours at the Solar Estates monitoring station grouped by relative humidity values (binned by 10% increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

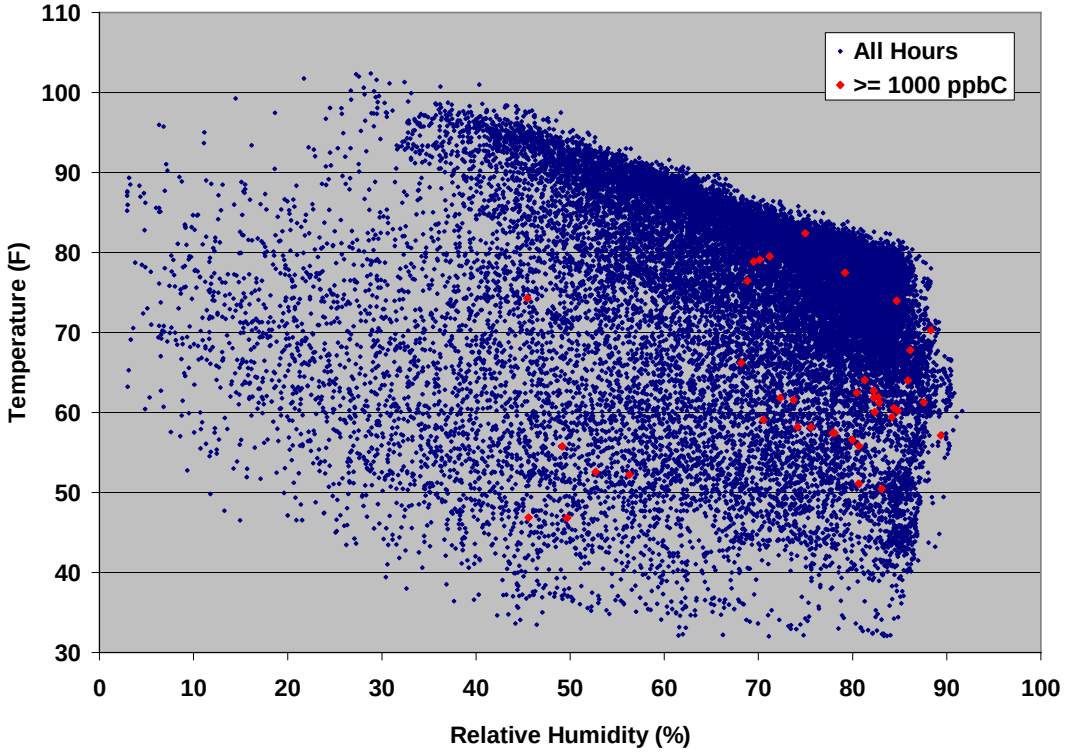

Figure A.1-13. Hourly temperature versus hourly relative humidity at the Solar Estates monitoring station for all hours during the June 2005 through May 2008 period. Hours characterized by a TNMHC concentration of 1000 ppbC or greater are highlighted in red.

72-Hour HYSPLIT Back-Trajectories for Days with Hourly TNMHC >= 1000 ppbC

Solar Estates (C633): June 2005 - May 2008

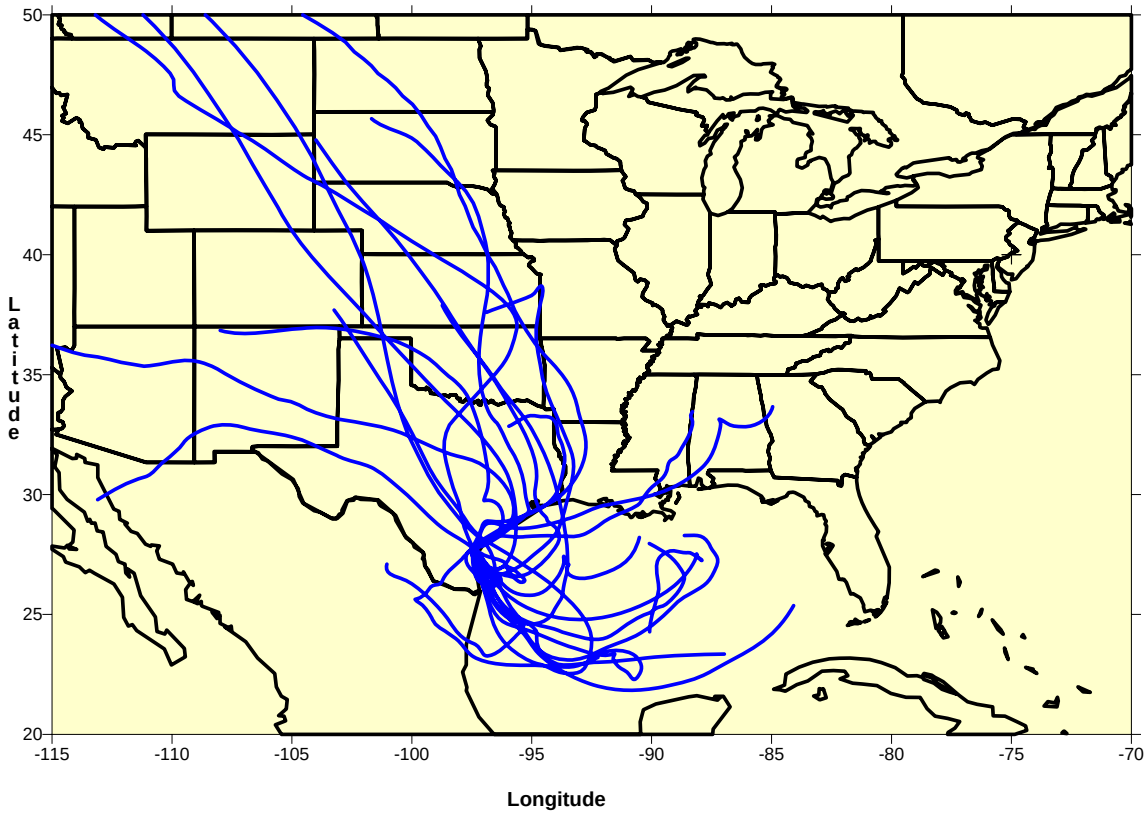

Figure A.1-14. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 24 days during the June 2005 through May 2008 period characterized by one or more hours with TNMHC concentrations of 1000 ppb or greater at the Solar Estates monitoring station.

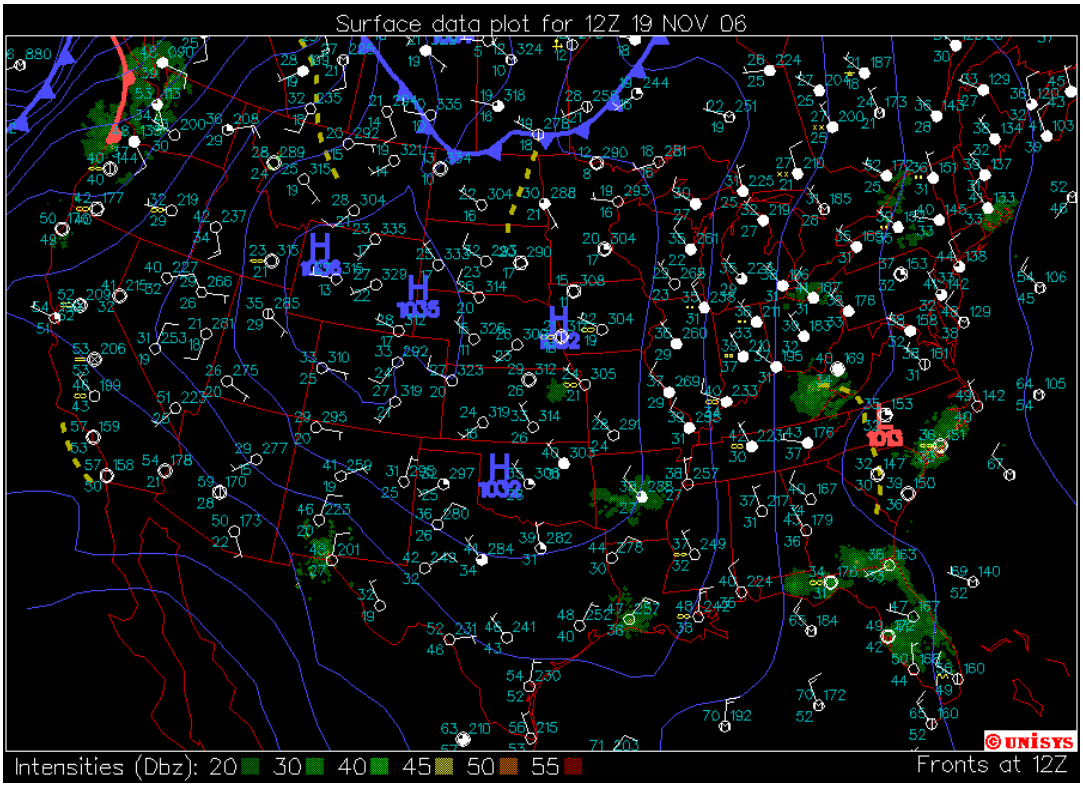

Figure A.1-15. Surface weather map at 0600 CST on November 19, 2006.

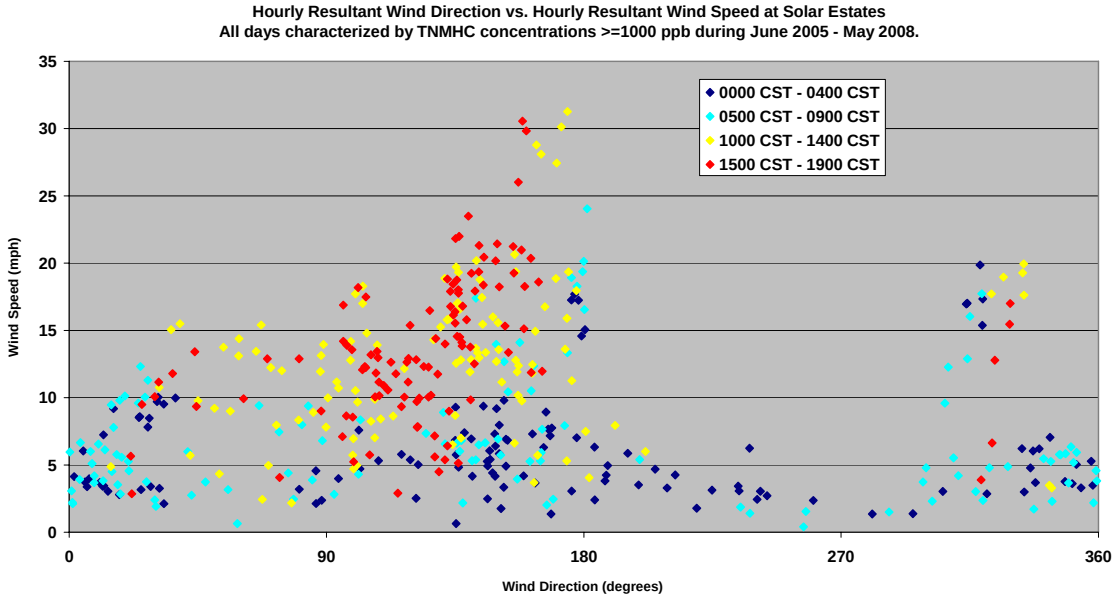

Figure A.1-16. Solar Estates resultant wind direction versus the resultant wind speed for all hours on days characterized by one or more TNMHC concentrations of 1000 ppbC or greater.

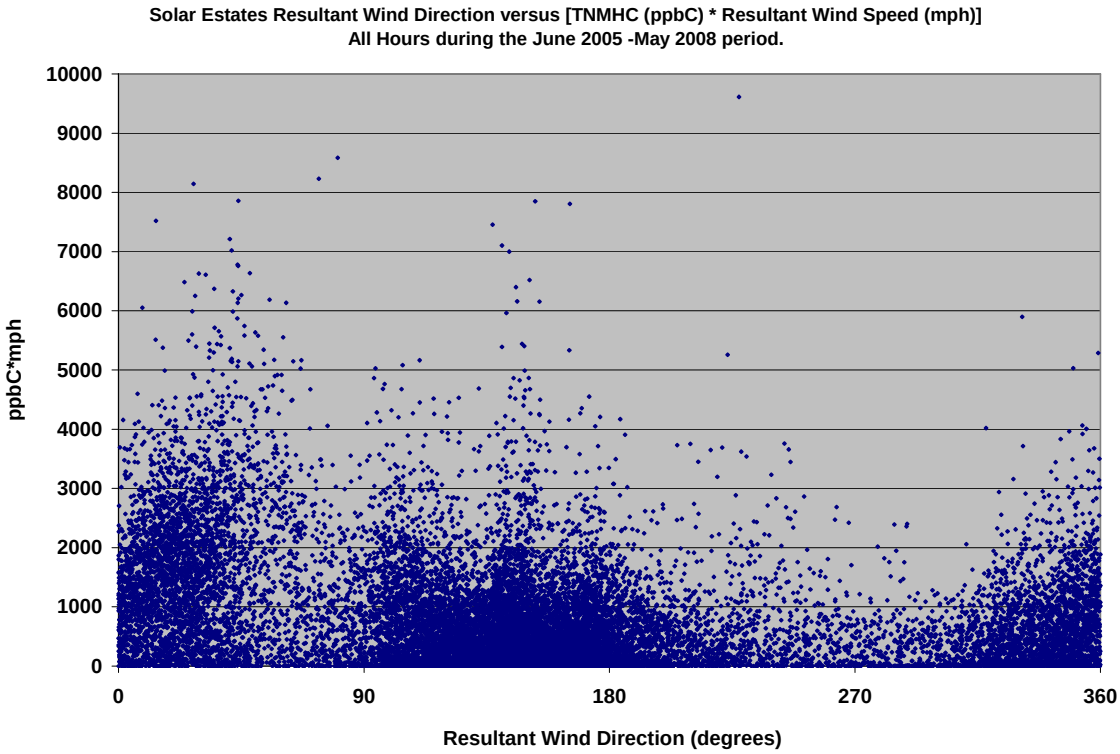

Figure A.1-17. Resultant wind direction (degrees) versus the product of the TNMHC concentration multiplied by the resultant wind speed (ppbC*mph) at the Solar Estates monitoring station for all valid hours during the June 2005 through May 2008 period. Note that the chart scale has been defined for easy visualization of high density peaks so that observations above 10,000 ppbC*mph are not shown.

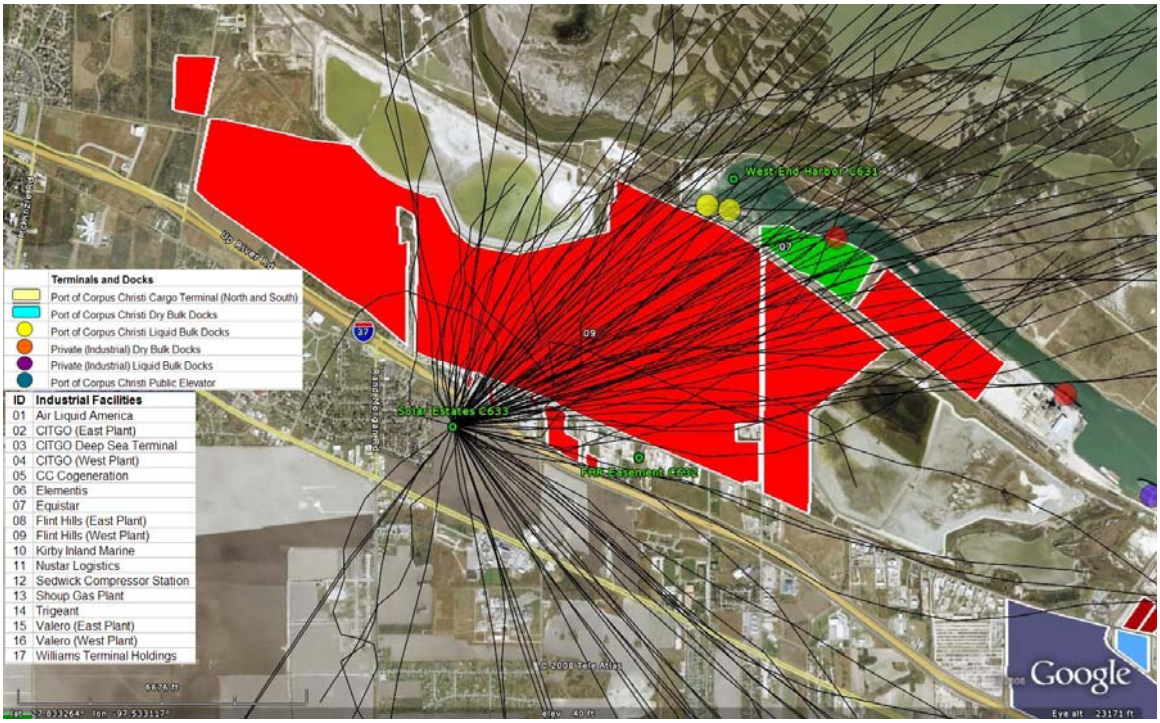

Figure A.1-18. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a TNMHC concentration of 750 ppb or greater at the Solar Estates monitoring station during the June 2005 through May 2008 period.

Figure A.1-19. Detail map of the Solar Estates monitoring station and surrounding area. Solar Estates lower left, FHR Easement lower center, West End Harbor upper right, Flint Hills (East Plant) center, Port of Corpus Christi liquid loading/unloading docks in blue oval southeast of West End Harbor, Sam Kane Meat Packing plant southeast of Solar Estates in green oval, tank battery in red circle just south of FHR Easement.

A.2 FHR Easement (C632) Monitoring Station

Figure A.2-1 shows the location of the FHR Easement monitoring station, which is sited immediately north of Interstate 37 on the south side of the Flint Hills Resources (East Plant) industrial facility. The West End Harbor and Solar Estates monitoring stations are located approximately 1.3 miles to the north-northeast and 0.8 miles to the west-northwest, respectively.

A.2.1 Seasonal, Day of Week, and Diurnal Variability in TNMHC Concentrations at FHR Easement

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by month are shown in Figure A.2-2. The 95th percentile concentration values are characterized by maximum values during the June through August period, with elevated values continuing during September through November. Minimum concentration values are noted during March, April, and May. The monthly 95th percentile concentration values (which roughly correspond to the 110th highest TNMHC concentration ranked by descending order) for the June through November period range from 1914 ppbC for October to 2816 ppbC for August. For the remaining months, the 95th percentile concentration values range from 900 ppbC during April to 1405 ppbC during February.

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by hour are shown in Figure A.2-3. For all metrics, the 1100 – 0400 CST (i.e., late night and early morning hours) are characterized by the highest values while minimum values occur throughout the daytime hours. For all hours, the 95th percentile concentration values (which roughly correspond to the 55th highest TNMHC concentration ranked by descending order) range from 391 ppbC at 1600 CST to 3344 ppbC at 0300 CST. The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by day of week are shown in Figure A.2-4. The 95th percentile concentration values (which roughly correspond to the 188th highest TNMHC concentration ranked by descending order) vary from 1644 ppbC on Monday to 2072 ppbC on Sunday.

To investigate possible seasonal differences in the diurnal profiles by day of week, Figures A.2-5 and A.2-6 present the median and 75th percentile hourly TNMHC concentrations, respectively, grouped by season. The summer weekend concentration values are higher compared to weekdays during the late night and early morning hours. During Winter, concentration values are slightly higher on weekdays compared to weekend days during the 0400 CST through 1800 CST period. Other seasons and/or times are not characterized by consistent differences between weekdays and weekend days. Overall, Figures A.2-5 and A.2-6 demonstrate a clear tendency for higher concentrations during the 2300 CST through early morning period during Summer and Fall. For all seasons, the peak hourly median concentrations vary from 204 ppbC at 0700 CST on Spring weekdays to 1266 ppbC at 0000 CST for Summer weekends. The seasonal peak 75th percentile concentration values (which roughly correspond to the 48th

and 19th highest TNMHC concentration ranked by descending order for weekdays and weekend days, respectively) range from 269 ppbC at 0200 CST for Spring weekdays to 2426 ppbC at 0200 CST on Summer weekends.

A.2.2 TNMHC Event Duration at FHR Easement

For the purpose of investigating the duration of high TNMHC events, TNMHC events were defined as one or more consecutive hours characterized by a concentration of 1000 ppbC or greater. Table A.2-1 presents the 1111 high TNMHC events (binned by duration in hours) measured at the FHR Easement monitoring station during the June 2005 through May 2008 period. The majority of events were characterized by durations of 1 hour (44% of total events) and 2 hours (23% of total events); however, longer duration events are not rare. Note that 23% of events (260 of 1111 total events) are characterized by a duration of 3 to 5 hours, with 9% (99 of 1111 total events) characterized by a duration of more than 5 hours. These latter events typically began during the evening or late night hours. About half of events greater than 5 hours in duration occurred during Summer with a majority of the remaining of events occurring during the Fall months.

A.3.3 Local Meteorological Conditions during High TNMHC Events at FHR Easement

Figure A.2-7 presents the median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations binned by the hourly resultant wind direction at West End Harbor. The statistical metrics demonstrate a clear peak in the frequency of occurrence of highest concentration values during hours characterized by a south-southeast, south, or south-southwest resultant wind directions. Concentration values also tend to be slightly elevated during periods of northwesterly winds. Figure A.2-8 presents the frequency of occurrence by resultant wind direction for all hours during the June 2005 through May 2008 period and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Note that hours with south-southeasterly and southerly winds account for 51% and 28%, respectively, of all hours characterized by TNMHC concentrations of 1000 ppbC or greater.

Figure A.2-9 shows the wind component scatterplot for all hours characterized by TNMHC concentrations of 1000 ppbC or greater, grouped by time of occurrence during the 1800 CST through 0900 CST (corresponding to evening/nighttime/morning) and 1000 CST through 1700 CST (corresponding to late morning/afternoon) time periods. (Refer to Section 2.5 of this report for a discussion of how to interpret the wind component scatterplot.) Consistent with the diurnal profile shown in Figure A.2-3, high TNMHC concentrations predominate during the 1800 CST through 0900 CST time period. The vast majority of events are characterized by south-southeasterly winds at 3 – 12 mph. In addition, high TNMHC hours sometimes occur during hours with light south-southwesterly winds or north-northwesterly winds with speeds ranging from calm to 10 mph.

Figure A.2-10 presents the frequency of occurrence for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater for five wind speed ranges (binned by 4 mph increments). Hours characterized by wind speeds less than 8 mph comprise 85% and 43%, respectively, of high TNMHC hours and all hours.

Figure A.2-11 presents the frequency of occurrence for all hours and for only those hours characterized by TNMHC concentrations of 1000 ppbC or greater for eight temperature ranges (binned by 10 F increments). High TNMHC concentrations occur at a range of temperatures between 50 F and 90 F. Hours characterized by temperatures between 70 F and 80 F account for 52% and 35% of high TNMHC hours and all hours, respectively.

Figure A.2-12 presents the frequency of occurrence for all hours and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater for ten relative humidity (as a percent) ranges. High TNMHC concentrations are mostly associated with relative humidity values greater than 70%. Hours characterized by relative humidity values above 70 % account for 83% and 50% of high TNMHC hours and all hours, respectively. Figure A.2-13 presents a scatterplot of hourly temperature versus hourly relative humidity for all days during the June 2005 through May 2008 period. Hours characterized by TNMHC concentrations of 1000 ppbC or greater are plotted in red. The highest density of all hourly observations is found along the top right portion of the scatterplot, which indicates hours characterized by relatively warm temperatures and middle to high relative humidity values. This portion of the scatterplot is representative of most days during the spring through fall period, with nighttime hours often located on the right side at relatively high humidity values and daytime hours often located to the left at the lower humidity values. Figure A.2-13 indicates the highest density of 1000 ppbC TNMHC hours occurs during temperatures between 70 F and 85 F at relative humidity values between 70% and 85%.

A.3.4 Large-Scale Weather Patterns during High TNMHC Events at FHR Easement

To investigate the large-scale weather features that predominate during high TNMHC events, 72-hour HYSPLIT back-trajectories were generated for all days during the June 2005 through May 2008 period that were characterized by one or more hours with a TNMHC concentration of 4500 ppbC or greater at the FHR Easement monitoring station. Figure A.2-14 shows the 117 back-trajectories on these highest TNMHC days. The back-trajectories were initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface. The majority of back-trajectories are characterized by long-range flow from the east, southeast, or (most often) south.

A review of the large-scale surface weather maps for the 36 days characterized by maximum hourly TNMHC concentrations of 6200 ppbC or greater revealed that a high pressure ridge often extends southwestward or westward into Texas. These surface high pressure systems are often characterized by weak pressure gradients at the surface over coastal Texas and South Texas is characterized by calm to light southeasterly morning winds and southeasterly afternoon winds. A few high TNMHC events occurred under the

influence of north-northwesterly winds associated with the passage of a cold front through the Corpus Christi area.

To explore the daily evolution of surface winds in the Corpus Christi area on high TNMHC days, Figure A.2-15 presents the resultant wind direction versus the resultant wind speed for all hours on the days characterized by a maximum hourly TNMHC concentration of 4500 ppbC or greater. During the 0000 CST through 0900 CST time period, winds are most often characterized by a south-southeasterly to south-southwesterly component. By the late morning, winds are typically east-southeasterly becoming southeasterly in the afternoon. Figure A.2-15 also shows that a limited number of days are characterized by north-northwesterly winds.

A.3.5 Analysis and Summary of FHR Easement TNMHC and Meteorological Measurements

Air quality analyses were performed using the hourly TNMHC, resultant wind speed, resultant wind direction, temperature, and relative humidity measurements collected at the FHR Easement monitoring station during the June 2005 through May 2008 period. The FHR Easement monitoring station is located immediately north of Interstate 37 on the south side of the Flint Hills Resources (East Plant) industrial facility. The Corpus Christi Ship Channel is located approximately 1.2 miles to the northeast.

The highest hourly TNMHC concentrations (>= 1000 ppbC) occur most frequently during the June through August period, with elevated values continuing during September through November. Minimum concentration values are noted during March, April, and May. Concentrations are highest during the 1100 – 0400 CST (i.e., late night and early morning hours) while minimum values occur throughout the daytime hours. The majority of high TNMHC events are characterized by durations of 1 or 2 hours (77% of total events) though longer duration events greater than 5 hours are not rare. These latter events typically began during the evening or late night hours predominantly during the Summer with a majority of the remaining of events during Fall.

The Summer weekend concentration values are higher compared to weekdays during the late night and early morning hours. During Winter, concentration values are slightly higher on weekdays compared to weekend days during the 0400 CST through 1800 CST period. Other seasons and/or times are not characterized by consistence differences between weekdays and weekend days.

A wind direction analysis indicates that the highest TNMHC concentrations show a clear peak in the frequency of occurrence during south-southeasterly and southerly winds. The majority of high TNMHC concentrations occur during hours with temperatures between 70 F and 85 F at relative humidity values between 70% and 85%. These temperature and relative humidity conditions are consistent with the observed nighttime peak in TNMHC concentrations during the Summer and Fall months, which would be characterized by relatively high relative humidity values and moderate temperatures.

The surface weather maps on the days characterized by one or more hours with maximum TNMHC concentrations of 6200 ppbC or higher often show a high pressure ridge often extends southwestward or westward into Texas. These surface high pressure systems are often characterized by weak pressure gradients at the surface over coastal Texas and South Texas is characterized by calm to light southeasterly morning winds and southeasterly afternoon winds. A few high TNMHC events occurred under the influence of north-northwesterly winds associated with the passage of a cold front through the Corpus Christi area. The diurnal variation in surface winds at the FHR Easement monitoring station shows that morning winds are most often characterized by a south-southeasterly to south-southwesterly component. By the late morning, winds are typically east-southeasterly becoming southeasterly in the afternoon.

The strong wind directionality of the highest TNMHC concentrations suggests upwind (non-mobile) emissions sources located to the south-southeast of FHR Easement.

A.3.6 Upwind Emission Sources during High TNMHC Events at FHR Easement

The previous analyses for FHR Easement did not attempt to account for the hourly variation in atmospheric dispersion conditions. One method to provide some normalization of measured pollutant concentrations with respect to varying atmospheric dispersion conditions is to multiply the concentration by the wind speed. Figure A.2-16 presents a scatterplot of the hourly resultant wind direction (degrees) versus the product of the hourly TNMHC concentrations and the hourly resultant wind speed (ppbC-mph) for all hours during the June 2005 through May 2008 period. Consistent with the results of previous analyses, a strong peak in the number of high concentration-wind speed values are noted during hours characterized by south-southeasterly winds. In addition, smaller peaks occur during periods of north-northwesterly and northerly wind directions.

To identify the local emissions sources at upwind industrial facilities that may impact TNMHC concentrations at FHR Easement, the Corpus Christi Trajectory Analysis Tool was used to generate one-hour surface back-trajectories for all hours characterized by an absolute TNMHC concentration of 3000 ppbC or higher. Each back-trajectory was initialized at the half-hour (i.e., midpoint) of the TNMHC one-hour averaging period. Figure A.2-17 plots the one-hour back-trajectories over a geographic map of the FHR Easement area. The back-trajectory paths clearly suggest an important emissions source located to the south-southeast of the monitoring station. Otherwise, back-trajectories sometimes show high TNMHC concentrations associated with flow from the south-southwest and north-northwest.

Routine operational activities in support of the CCAQP include near real-time investigation of local emissions sources that may have contributed to high TNMHC events at FHR Easement. Previous pollution event analyses have found that high TNMHC concentrations are commonly measured during hours characterized by south-southeasterly winds, which may be associated with a small tank battery and rotary rig located several hundred feet from the monitoring station. During periods of generally

northerly winds, FHR Easement is potentially affected by emissions from Flint Hills Resources (East Plant), and one case of elevated hydrogen sulfide (H_2S) was related to a reported upset at that facility. Figure A.1-18 provides a zoomed map of FHR Easement and the surrounding area using Google satellite imagery.

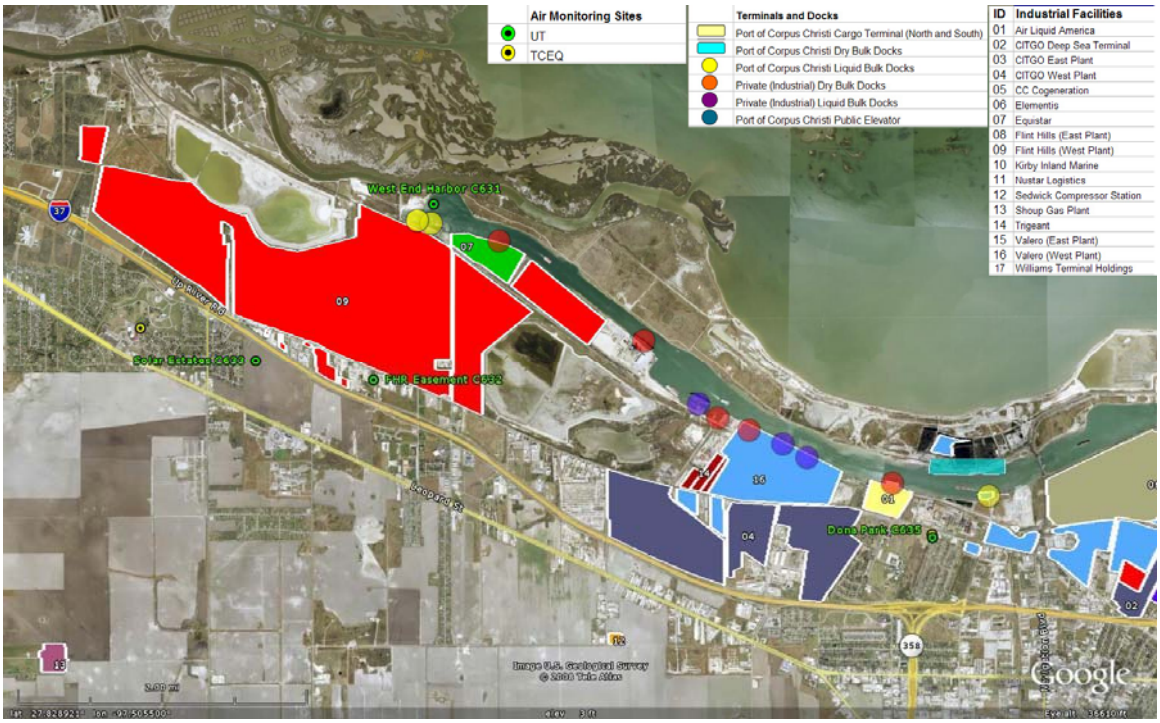

Figure A.2-1. Locations of the FHR Easement (C632) monitoring station, nearby CAMS, and surrounding industrial facilities. The Corpus Christi Ship Channel is oriented southeast to northwest near the middle of the figure.

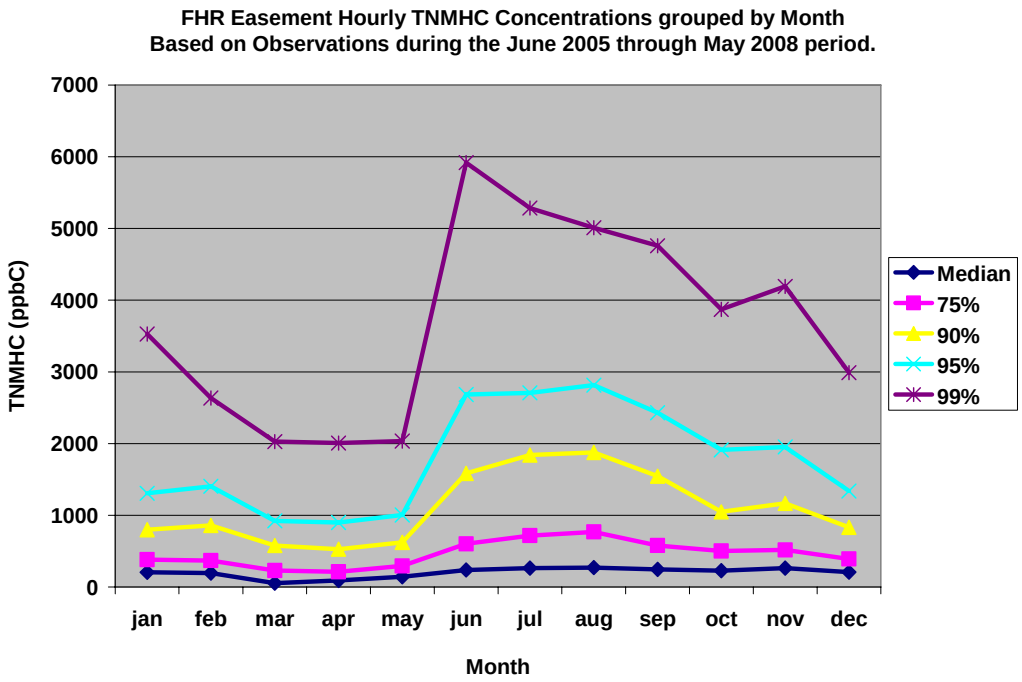

Figure A.2-2. Monthly median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations at the FHR Easement monitoring station based on all valid data during the June 2005 through May 2008 period.

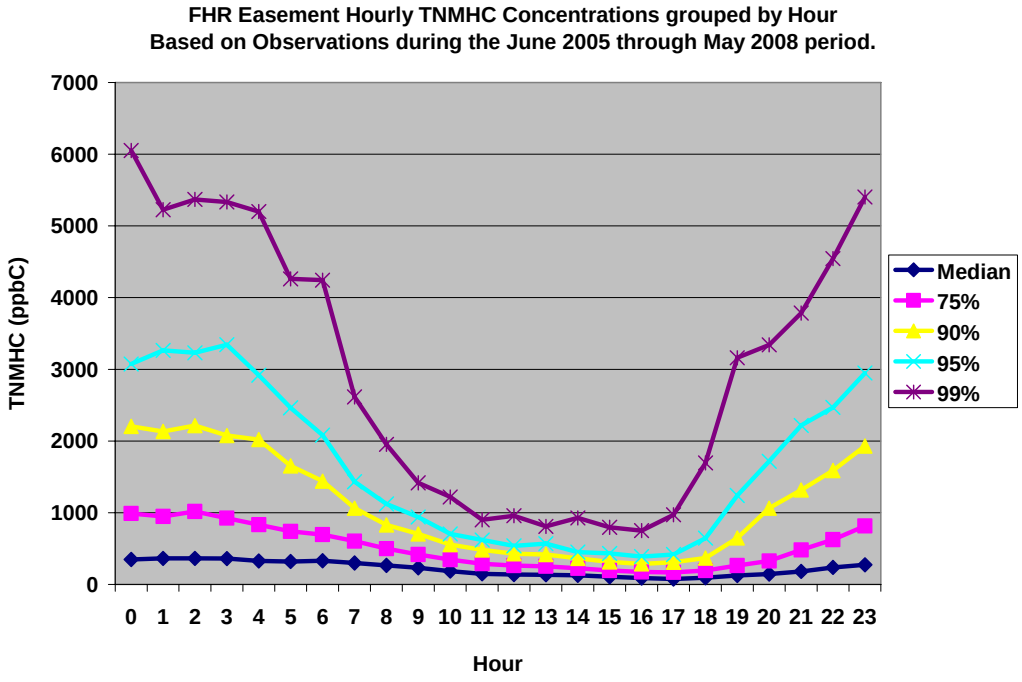

Figure A.2-3. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations at the FHR Easement monitoring station by hour based on all valid data during the June 2005 through May 2008 period.

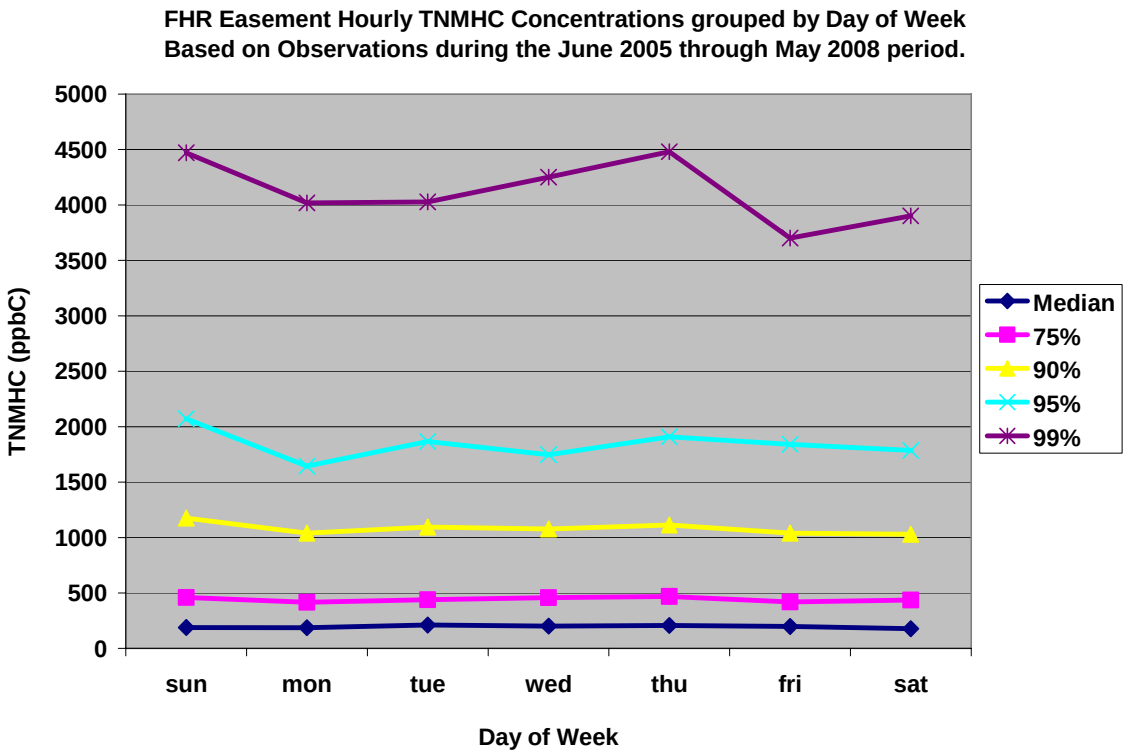

Figure A.2-4. Median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by Day of Week at the FHR Easement monitoring station based on all valid data during the June 2005 through May 2008 period.

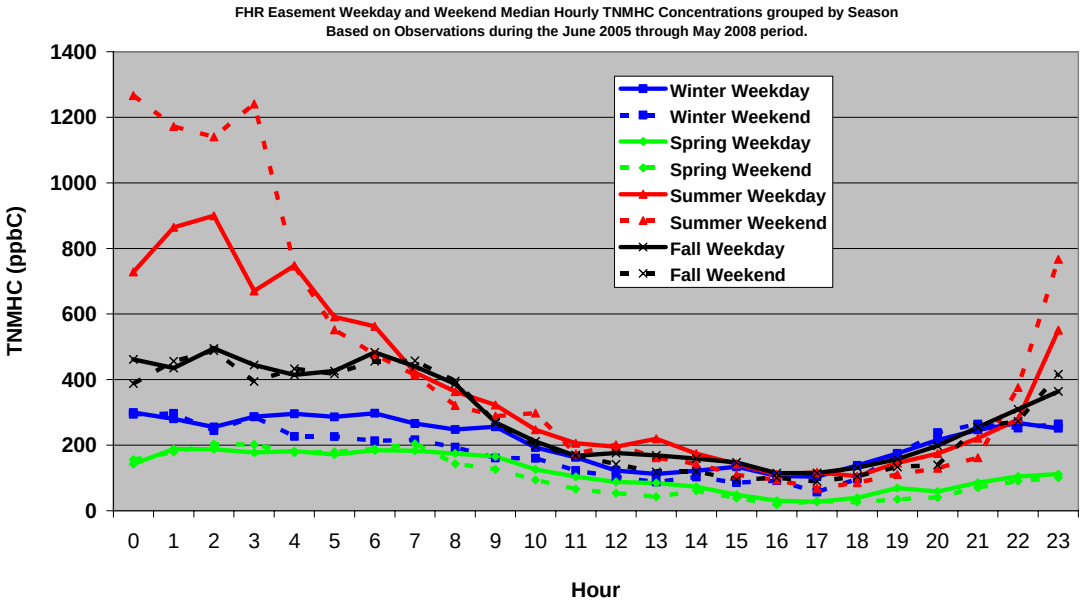

Figure A.2-5. Median hourly weekday and weekend day TNMHC concentrations grouped by season at the FHR Easement monitoring station based on all valid data during the June 2005 through May 2008 period.

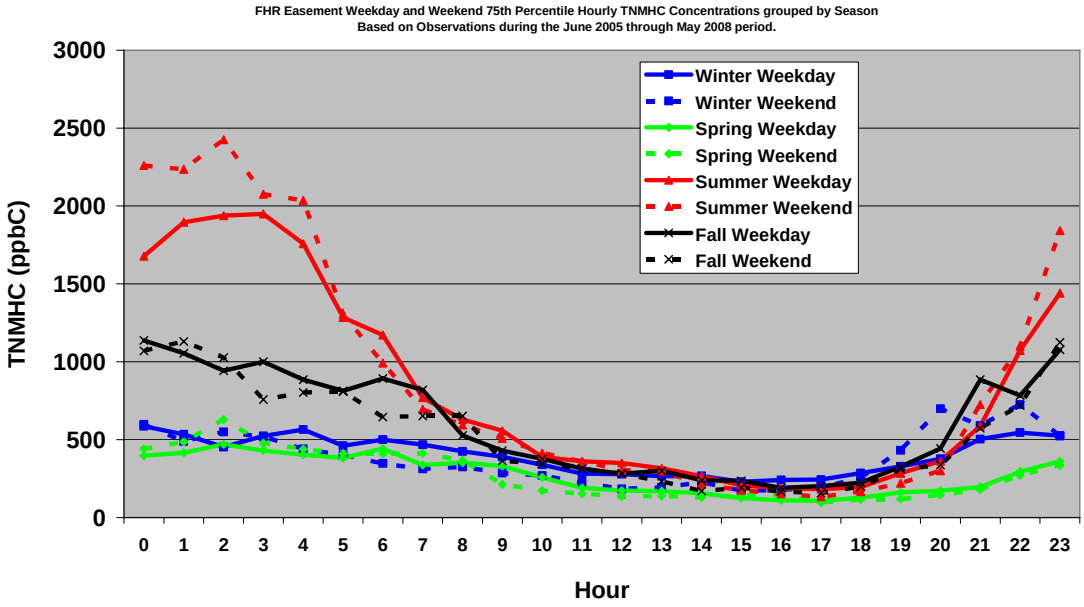

Figure A.2-6. The 75th percentile hourly weekday and weekend day TNMHC concentrations grouped by season at the FHR Easement monitoring station based on all valid data during the June 2005 through May 2008 period.

Table A.2-1. High TNMHC events at the FHR Easement monitoring station binned by duration in hours. High TNMHC events are defined as one or more consecutive hours characterized by TNMHC concentrations of 1000 ppbC or greater.

Duration of Event (hours)	Number of Events
1	493
2	259
3	121
4	89
5	50
>5	99
Total Events	**1111**

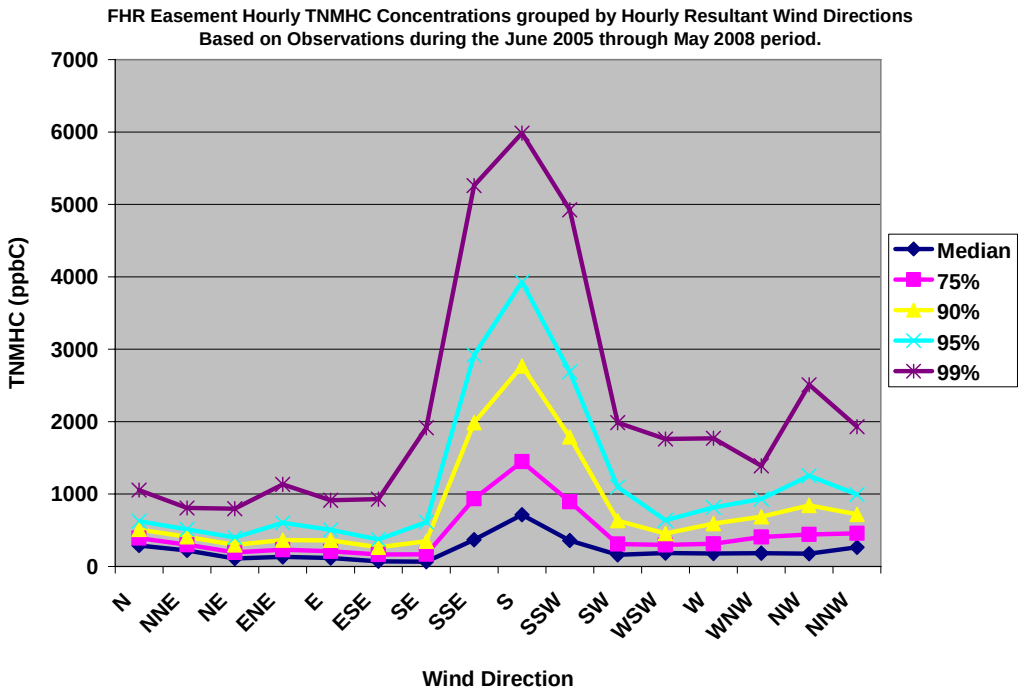

Figure A.2-7. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations grouped by hourly resultant wind direction at the FHR Easement monitoring station based on all valid data during the June 2005 through May 2008 period.

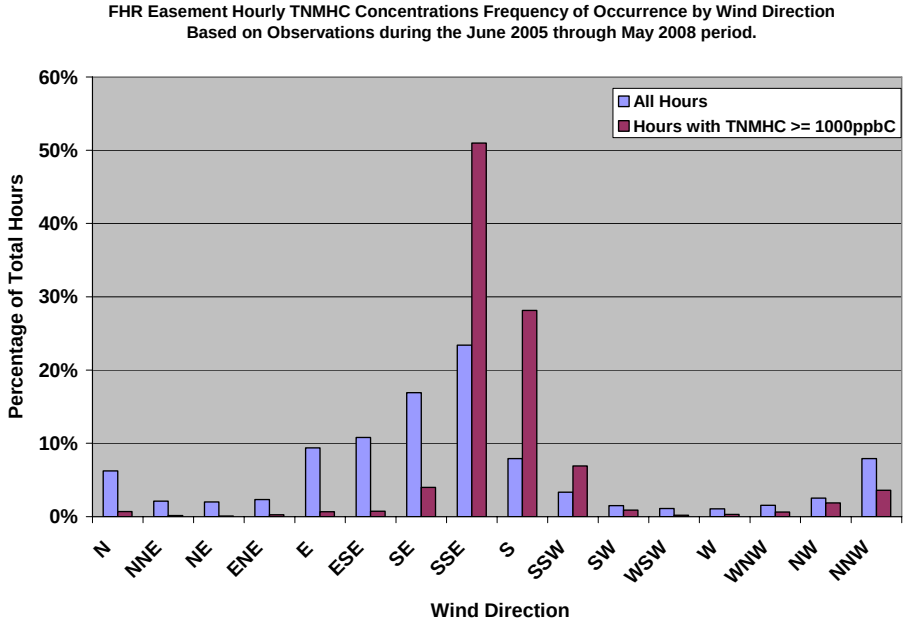

Figure A.2-8. Percentage of hours at the FHR Easement monitoring station grouped by resultant wind direction for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppb or greater. Based on all valid data during the June 2005 through May 2008 period.

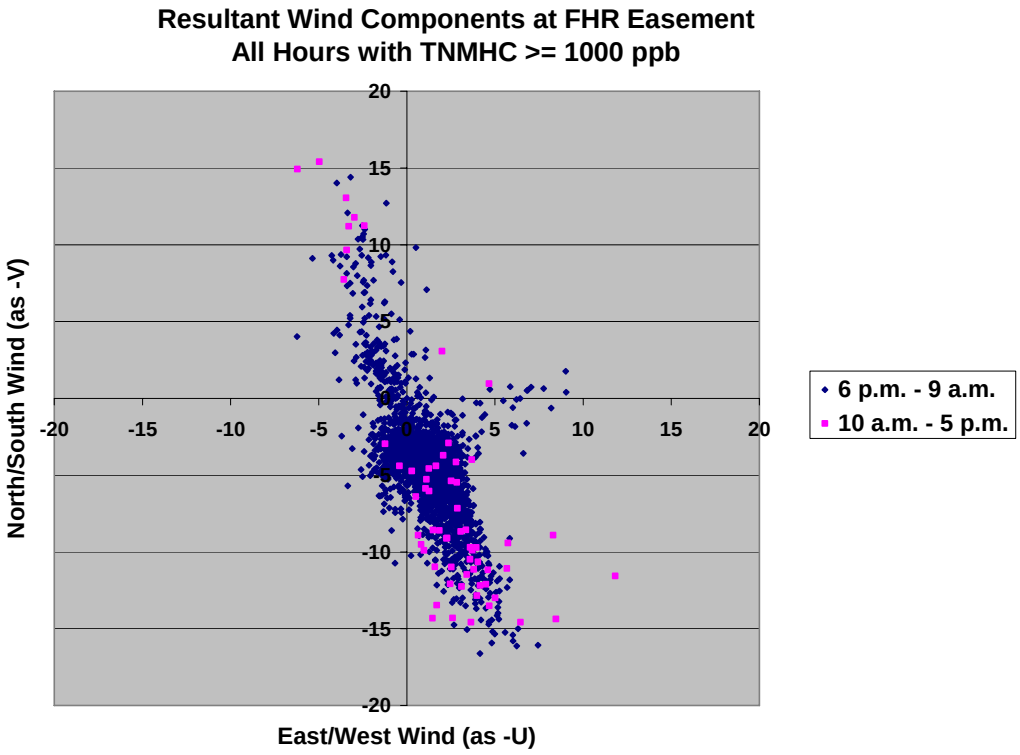

Figure A.2-9. Resultant wind component scatterplot at FHR Easement for all hours with TNMHC concentrations of 1000 ppb or greater during the June 2005 through May 2008 period. (The reader is referred to Section 2.5 for a discussion of how to interpret this figure.)

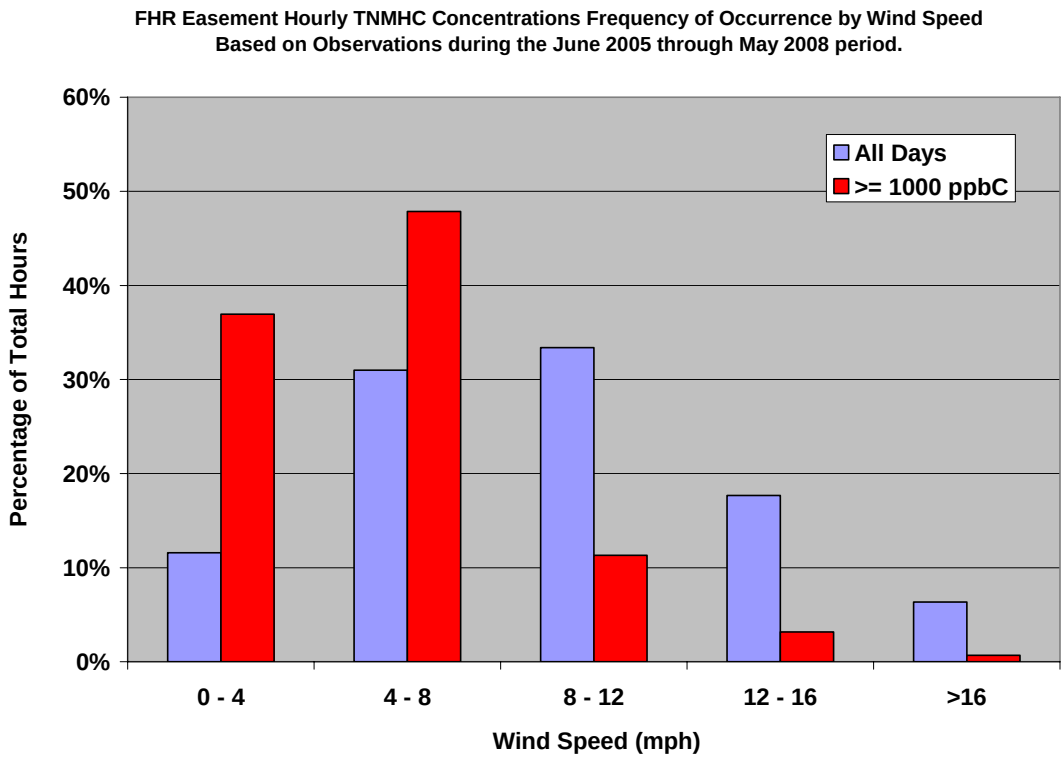

Figure A.2-10. Percentage of hours at the FHR Easement monitoring station grouped by resultant wind speed (binned by 4 mph increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

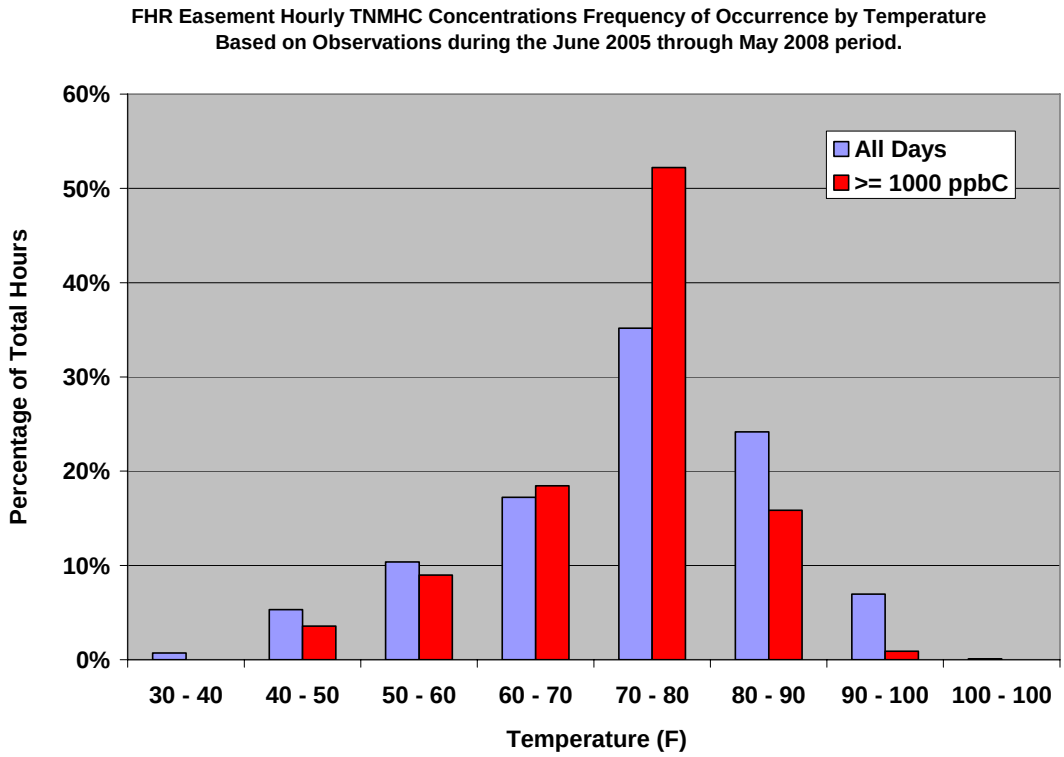

Figure A.2-11. Percentage of hours at FHR Easement monitoring station grouped by temperature (binned by 10 F increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

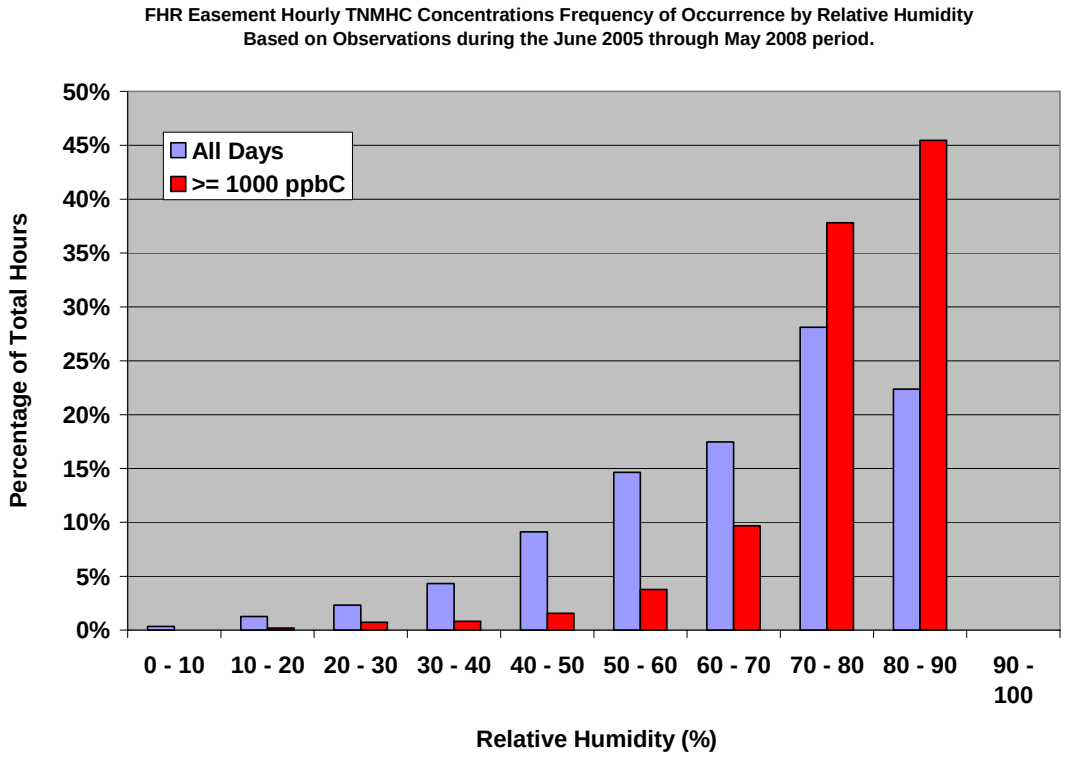

Figure A.2-12. Percentage of hours at the FHR Easement monitoring station grouped by relative humidity values (binned by 10% increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

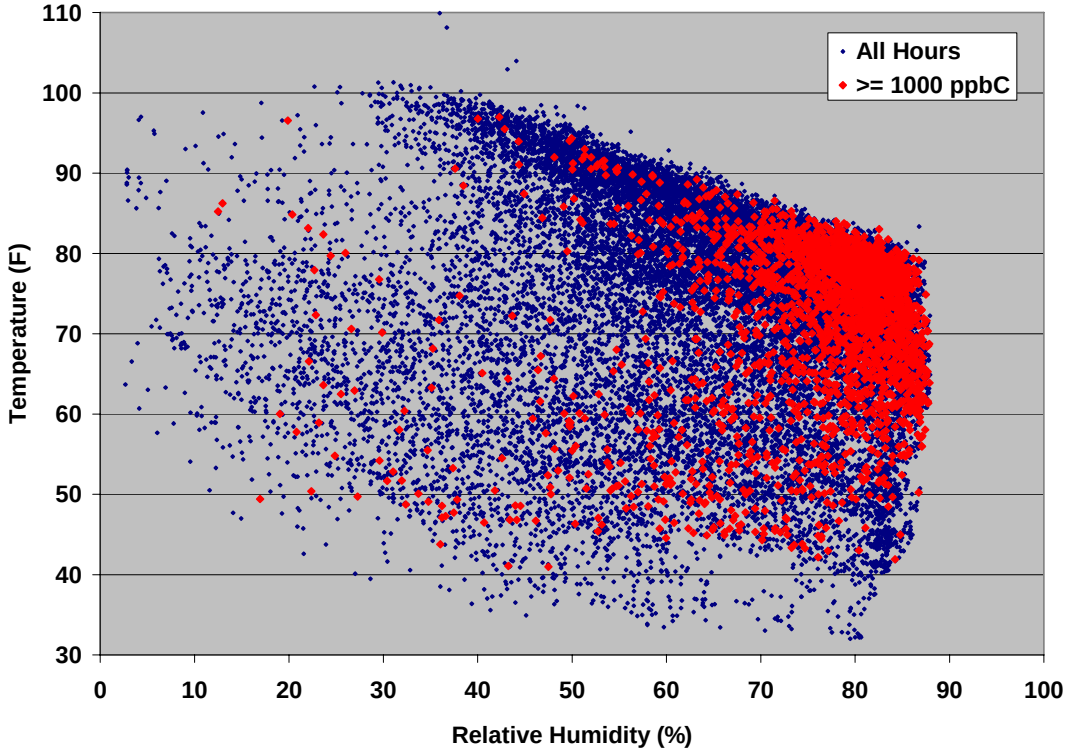

Figure A.2-13. Hourly temperature versus hourly relative humidity at the FHR Easement monitoring station for all hours during the June 2005 through May 2008 period. Hours characterized by a TNMHC concentration of 1000 ppbC or greater are highlighted in red.

72-Hour HYSPLIT Back-Trajectories for Days with Hourly TNMHC >= 4500 ppbC

FHR Easement (C632): June 2005 - May 2008

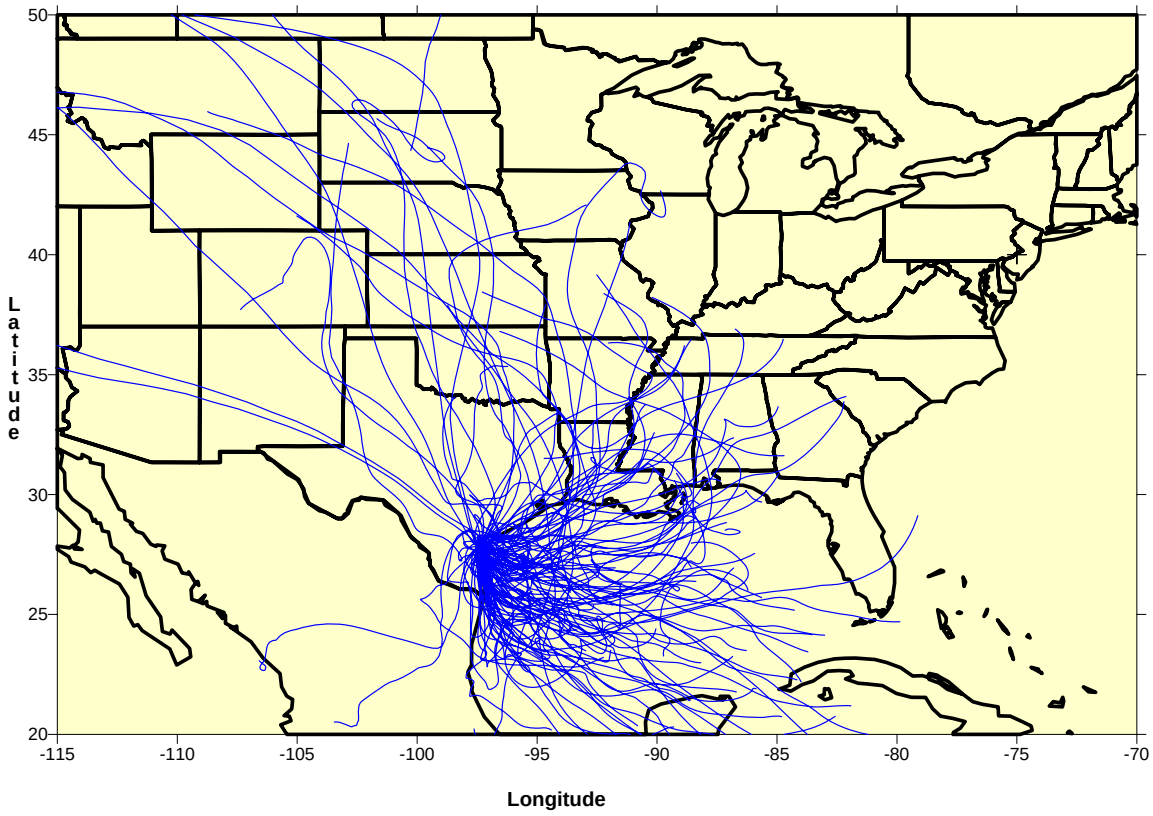

Figure A.2-14. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 117 days during the June 2005 through May 2008 period characterized by one or more hours with TNMHC concentrations of 4500 ppb or greater at the FHR Easement monitoring station.

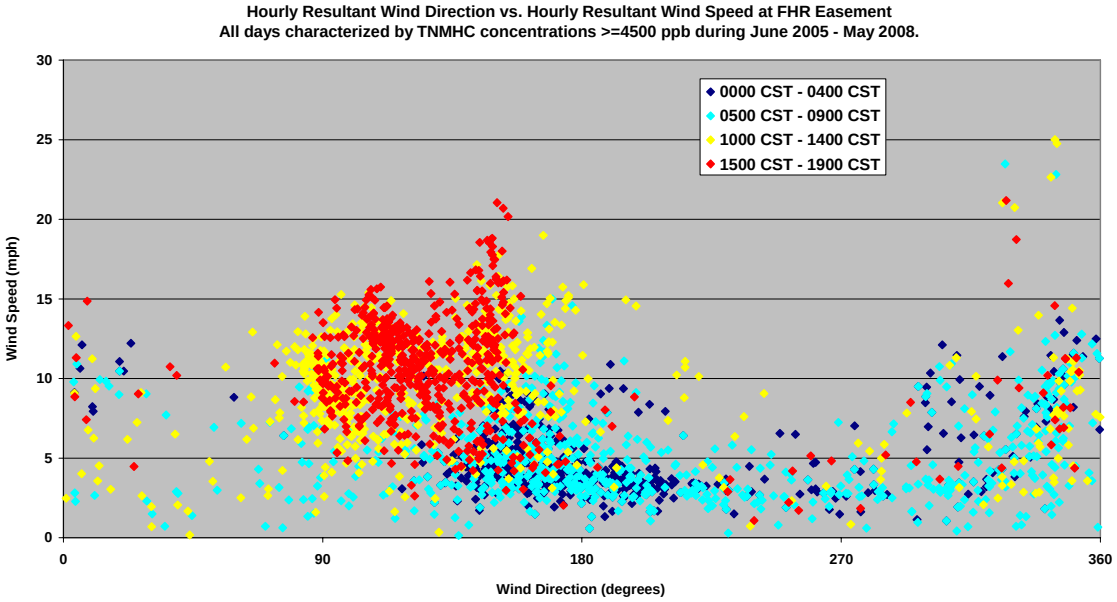

Figure A.2-15. FHR Easement resultant wind direction versus the resultant wind speed for all hours on days characterized by one or more TNMHC concentrations of 4500 ppbC or greater.

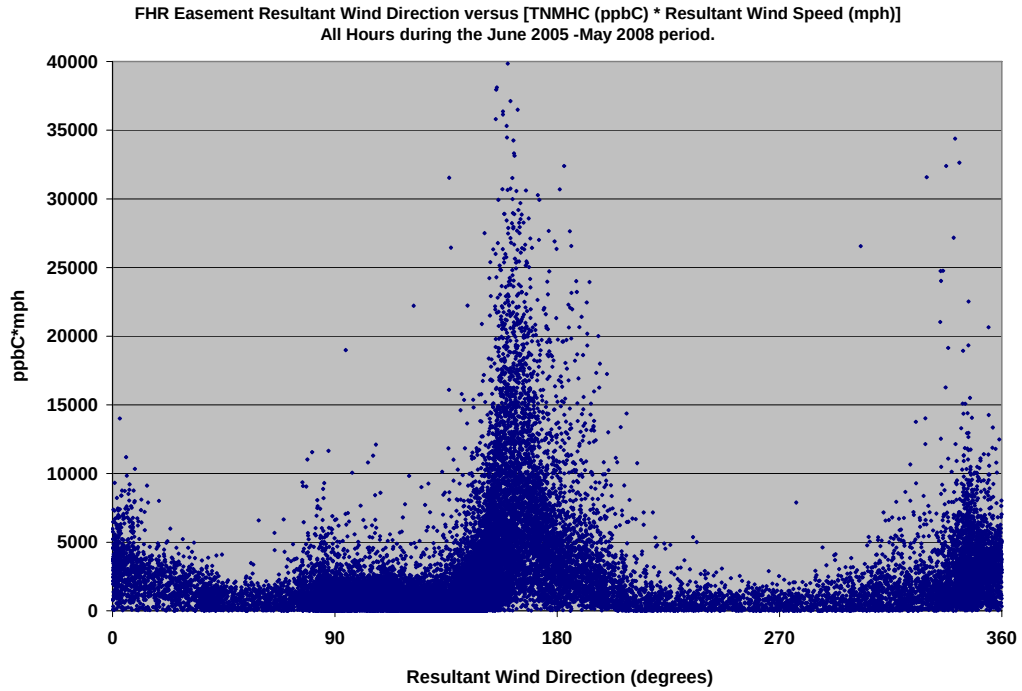

Figure A.2-16. Resultant wind direction (degrees) versus the product of the TNMHC concentration multiplied by the resultant wind speed (ppbC*mph) at the FHR Easement monitoring station for all valid hours during the June 2005 through May 2008 period. Note that the chart scale has been defined for easy visualization of high density peaks so that observations above 10,000 ppbC*mph are not shown.

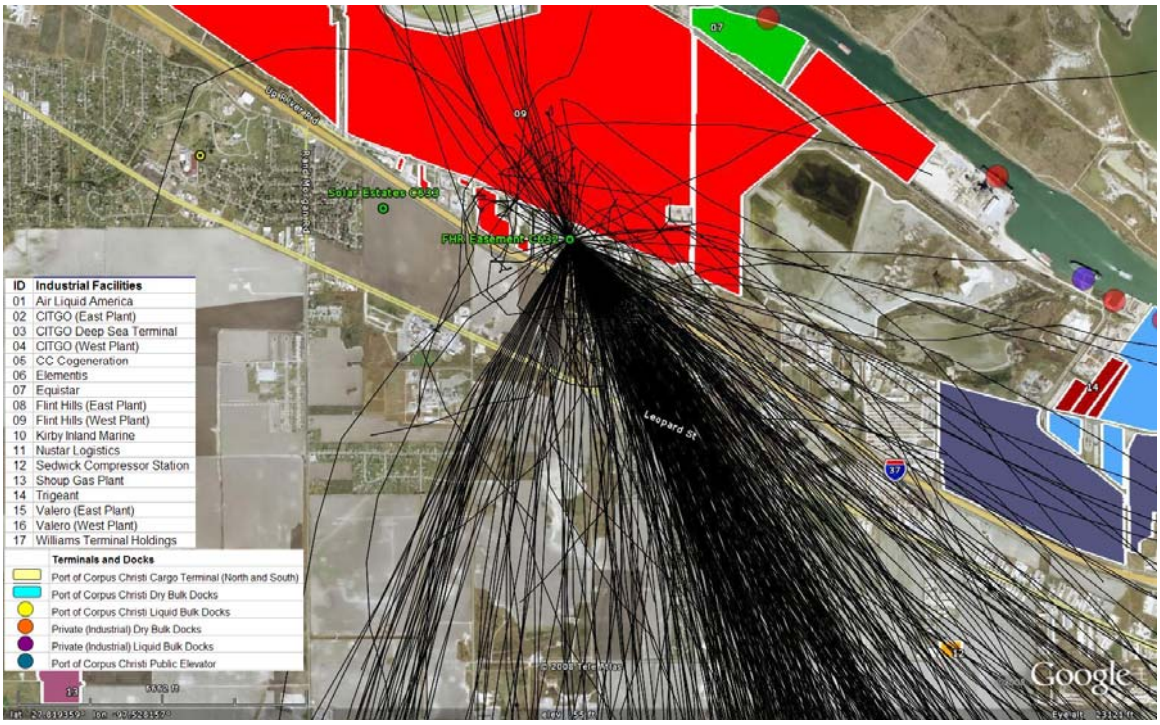

Figure A.2-17. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a TNMHC concentration of 3000 ppb or greater at the FHR Easement monitoring station during the June 2005 through May 2008 period.

Figure A.1-19. Detail map of the FHR Easement monitoring station and surrounding area. Solar Estates lower left, FHR Easement lower center, West End Harbor upper right, Flint Hills (East Plant) center, Port of Corpus Christi liquid loading/unloading docks in blue oval southeast of West End Harbor, Sam Kane Meat Packing plant southeast of Solar Estates in green oval, tank battery in red circle just south of FHR Easement.

A.3 West End Harbor (C631) Monitoring Station

Figure A.3-1 shows the location of the West End Harbor monitoring station, which is sited at the western end of the Corpus Christi Ship Channel. The Solar Estates and FHR Easement monitoring stations are located 1.3 miles and 0.8 miles to the south-southwest and southwest, respectively. The Flint Hills Resources (East Plant) industrial facility, which is situated along and to the southwest of the western portion of the Corpus Christi Ship Channel, lies south and southwest of West End Harbor. Also note that the Port of Corpus Christi bulk liquid loading/unloading docks are located immediately south of the West End Harbor monitoring station.

A.3.1 Seasonal, Day of Week, and Diurnal Variability in TNMHC Concentrations at West End Harbor

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by month are shown in Figure A.3-2. The 95th percentile concentration values are characterized by maximum values during June, with elevated concentrations throughout the latter half of the year. The monthly 95th percentile concentration values (which roughly correspond to the 110th highest TNMHC concentration ranked by descending order) for the June through December period range from 927 ppbC for June to 562 ppbC for December. For the January through May period, the 95th percentile concentration values range from 316 ppbC during May to 498 ppbC during January.

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by hour are shown in Figure A.3-3. For all metrics, the late night and early morning hours (i.e., around midnight) are characterized by the highest concentration values while minimum values occur at 1500 CST. The percentile concentration values are characterized by a smooth change during the intervening hours rather than an abrupt change between nighttime and daytime hours. For all hours, the 95th percentile concentration values (which roughly correspond to the 55th highest TNMHC concentration ranked by descending order) range from 329 ppbC at 1500 CST to 847 ppbC at 0100 CST. The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by day of week are shown in Figure A.3-4. The 95th percentile concentration values (which roughly correspond to the 188th highest TNMHC concentration ranked by descending order) vary from 608 ppbC on Saturday to 670 ppbC on Thursday.

To investigate possible seasonal differences in the diurnal profiles by day of week, Figures A.3-5 and A.3-6 present the median and 75th percentile hourly TNMHC concentrations, respectively, grouped by season. The 0000 CST through 0900 CST period is characterized by relatively higher concentrations on weekdays compared to weekends during Winter. Other seasons are not characterized by consistent differences between weekdays and weekend days. Overall, Figures A.3-5 and A.3-6 demonstrate a clear tendency for higher concentrations during the late night and early morning hours, with highest concentrations during Summer. For all seasons, the peak hourly median concentrations vary from 102 ppbC at 0200 CST on Spring weekdays to 294 ppbC at

0000 CST for Summer weekends. The seasonal peak 75th percentile concentration values (which roughly correspond to the 48th and 19th highest TNMHC concentration ranked by descending order for weekdays and weekend days, respectively) range from 200 ppbC at 0200 CST for Spring weekdays to 563 ppbC at 0300 CST on Summer weekends.

A.3.2 TNMHC Event Duration at West End Harbor

For the purpose of investigating the duration of high TNMHC events, TNMHC events were defined as one or more consecutive hours characterized by a concentration of 1000 ppbC or greater. Table A.3-1 presents the 229 high TNMHC events (binned by duration in hours) measured at the West End Harbor monitoring station during the June 2005 through May 2008 period. The vast majority of events were characterized by durations of 1 hour (60% of total events) and 2 hours (18% of total events). For the remaining events with durations of 3 hours or greater (22% of total events), just over half occurred predominantly during the late night and morning hours throughout the Summer months with the majority of the remaining events during the morning hours of November and December. However, it should be mentioned that at least one event occurred during each month of the year.

A.3.3 Local Meteorological Conditions during High TNMHC Events at West End Harbor

Figure A.3-7 presents the median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations binned by hourly resultant wind direction at West End Harbor. The statistical metrics demonstrate that highest concentration values occur during hours characterized by a southerly component. Minimum TNMHC values occur during northerly winds. Figure A.3-8 presents the frequency of occurrence by resultant wind direction for all hours during the June 2005 through May 2008 period and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater. High TNMHC concentrations strongly predominate during hours characterized by southeasterly or south-southeasterly winds.

Figure A.3-9 shows the wind component scatterplot for all hours characterized by TNMHC concentrations of 1000 ppbC or greater, grouped by time of occurrence during the 1800 CST through 0900 CST (corresponding to evening/nighttime/morning) and 1000 CST through 1700 CST (corresponding to late morning/afternoon) time periods. (Refer to Section 2.5 of this report for a discussion of how to interpret the wind component scatterplot.) Consistent with the diurnal profile shown in Figure A.3-3, high TNMHC concentrations predominate during the 1800 CST through 0900 CST time period, though daytime events are not uncommon. Wind speeds for the nighttime events most commonly range from 3 mph through 10 mph, while daytime events are generally characterized by wind speeds between 8 mph and 15 mph.

Figure A.3-10 presents the frequency of occurrence for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater for five wind speed ranges (binned by 4 mph increments). Highest TNMHC concentrations occur at a range

of wind speeds. Hours characterized by wind speeds between 4 mph and 12 mph comprise 67% of 1000 ppbC TNMHC hours compared to 58% for all hours.

Figure A.3-11 presents the frequency of occurrence for all hours and for only those hours characterized by TNMHC concentrations of 1000 ppbC or greater for eight temperature ranges (binned by 10 F increments). High TNMHC concentrations occur at a wide range of temperatures between 50 F and 100 F. Hours characterized by temperatures greater than 70 F account for 68% and 78% of all hours and 1000 ppbC TNMHC hours, respectively.

Figure A.3-12 presents the frequency of occurrence for all hours and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater for ten relative humidity (as a percent) ranges. High TNMHC concentrations occur at a wide range of humidity values. Hours characterized by relative humidity values greater than 70 % account for 58% and 64% of all hours and 1000 ppbC TNMHC hours, respectively. Figure A.3-13 presents a scatterplot of hourly temperature versus hourly relative humidity for all days during the June 2005 through May 2008 period. Hours characterized by TNMHC concentrations of 1000 ppbC or greater are plotted in red. The highest density of all hourly observations is found along the top right portion of the scatterplot, which indicates hours characterized by relatively warm temperatures and middle to high relative humidity values. This portion of the scatterplot is representative of most days during the spring through fall period, with nighttime hours often located on the right side at relatively higher humidity values and daytime hours often located to the left at the lower humidity values. Figure A.3-13 indicates the greatest density of high TNMHC hours occurs during temperatures greater than 75 F at relatively humidity values between 60% and 85%.

A.3.4 Large-Scale Weather Patterns during High TNMHC Events at West End Harbor

To investigate the large-scale weather features that predominate during high TNMHC events, 72-hour HYSPLIT back-trajectories were generated for all days during the June 2005 through May 2008 period that were characterized by one or more hours with a TNMHC concentration of 2500 ppbC or greater at the West End Harbor monitoring station. Figure A.3-14 shows the 38 back-trajectories on these highest TNMHC days. The back-trajectories were initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface. The majority of back-trajectories are characterized by long-range flow from the east, southeast, or (most often) south.

Figure A.3-14 shows that the vast majority of long-range flow patterns prior to high TNMHC events at West End Harbor are characterized by southeasterly or southerly flow over the Gulf of Mexico into South Texas. Figure A.3-15 presents the surface weather map for November 19, 2006, which is characterized by a long-range trajectory that shows southerly inflow into Corpus Christi over the western Gulf of Mexico. At upper levels, the jet stream flowed from Southern California eastward to northern Texas and northeastward to the Northeast US. This upper level trough in the jet stream was

associated with a southward moving surface front that stretched from West Texas northeastward to the Great Lakes region. As shown in Figure A.3-15, a low pressure center associated with the front was located over southwestern Oklahoma. Also at the surface, an eastward moving ridge of high pressure centered off the mid-Atlantic states stretched westward into eastern Texas. Surface winds throughout coastal Texas were generally southerly associated both with the clockwise circulation around the ridge of high pressure and in association with inflow to the surface low pressure center over southwestern Oklahoma. At the West End Harbor monitoring station, winds were 8-12 mph from the southeast throughout the night and morning hours on November 20th, with a morning low temperature of 65 F. TNMHC concentrations generally ranged between 400 ppbC and 800 ppbC throughout this period, with a maximum concentration of 2716 ppbC at 0900 CST. TNMHC concentrations remained somewhat elevated throughout the day until the cold front passed through Corpus Christi late on November 20th.

A review of the large-scale surface weather maps for the 38 days characterized by maximum hourly TNMHC concentrations of 2500 ppbC or greater reveals that a high pressure ridge often extends southwestward or westward into Texas. These surface high pressure systems are often characterized by weak pressure gradients at the surface over coastal Texas and South Texas and are associated with calm to light morning winds or moderate southeasterly winds with southeasterly winds in the afternoon. Hours with high TNMHC concentrations often occurred ahead of approaching or stationary fronts located over northern or central Texas. This latter scenario was typically characterized by surface winds with a southerly component in the Corpus Christi area.

To explore the daily evolution of surface winds in the Corpus Christi area on high TNMHC days, Figure A.3-16 presents the resultant wind direction versus the resultant wind speed for all hours during the 38 2500 ppbC TNMHC days. Note that the observations are grouped by hour. During the 0000 CST through 0900 CST time period, winds are most often characterized by either a southwesterly to westerly component (with speeds ranging from calm to 5 mph) or a southeasterly to south-southeasterly component (with speeds 4 – 14 mph). By the late morning and afternoon hours, winds are most often easterly to south-southeasterly.

A.3.5 Analysis and Summary of West End Harbor TNMHC and Meteorological Measurements

Air quality analyses were performed using the hourly TNMHC, resultant wind speed, resultant wind direction, temperature, and relative humidity measurements collected at the West End Harbor monitoring station during the June 2005 through May 2008 period. The West End Harbor monitoring station is located at the western end of the Corpus Christi Ship Channel . The Port of Corpus Christi liquid bulk loading/unloading docks are located immediately to the south. In addition, the Flint Hills Resources (East Plant) industrial facility lies to the south and southwest.

The highest hourly TNMHC concentrations (>= 1000 ppbC) occur most frequently during June, with elevated concentrations throughout the latter half of the year. The late

night and early morning hours (i.e., around midnight) are characterized by the highest concentration values while minimum values occur at 1500 CST. The vast majority of events were characterized by durations of 1 hour (60% of total events) and 2 hours (18% of total events). For the remaining events with durations of 3 hours or greater (22% of total events), just over half occurred during the late night and morning hours throughout the Summer months with the majority of the remaining events during the morning hours of November and December. However, it should be mentioned that at least one event occurred during each month of the year. The 0000 CST through 0900 CST period is characterized by relatively higher concentrations on weekdays compared to weekends during Winter. Other seasons are not characterized by consistent differences between weekdays and weekend days.

A wind direction analysis indicates that the highest TNMHC concentrations occur during hours with a southerly component, while minimum TNMHC concentrations occur during northerly winds . High TNMHC concentrations strongly predominate during hours characterized by southeasterly or south-southeasterly winds at light to moderate wind speeds. High TNMHC concentrations occur during hours characterized by a wide range of temperatures between 50 F and 100 F and a wide range of relative humidity values between 40% and 90%. Approximately half of high TNMHC hours are characterized by temperatures above 75 F with relative humidity values between 60% and 85%.

The surface weather maps on days characterized by one or more hours with maximum TNMHC concentrations of 2500 ppbC or higher often show a high pressure ridge that extends southwestward or westward into Texas. Hours with high TNMHC concentrations often occurred ahead of approaching or stationary fronts located over northern or central Texas. This latter scenario was typically characterized by surface winds with a southerly component in the Corpus Christi area. The diurnal variation of surface winds at the West End Harbor monitoring station on these days is often characterized by morning winds with either a southwesterly to westerly component (with speeds ranging from calm to 5 mph) or a southeasterly to south-southeasterly component (with speeds 4 – 14 mph). By the late morning and afternoon hours, winds are most often easterly to south-southeasterly.

The strong wind directionality of the highest TNMHC concentrations suggests upwind (non-mobile) emissions sources located to the southeast and south-southeast of the West End Harbor monitoring station.

A.3.6 Upwind Emission Sources during High TNMHC Events at West End Harbor

The previous analyses for West End Harbor did not attempt to account for the hourly variation in atmospheric dispersion conditions. One method to provide some normalization of measured pollutant concentrations with respect to varying atmospheric dispersion conditions is to multiply the concentration by the wind speed. Figure A.3-17 presents a scatterplot of the hourly resultant wind direction (degrees) versus the product of the hourly TNMHC concentrations and the hourly resultant wind speed (ppbC-mph) for all hours during the June 2005 through May 2008 period. Consistent with the results

of previous analyses, Figure A.3-17 reveals a strong peak in concentration-wind speed values for hours characterized by south-southeasterly (centered at 150 degrees) resultant wind directions.

To identify the local emissions sources at upwind industrial facilities that may impact TNMHC concentrations at West End Harbor, the Corpus Christi Trajectory Analysis Tool was used to generate one-hour surface back-trajectories for all hours characterized by an absolute TNMHC concentration of 1000 ppbC or higher. Each back-trajectory was initialized at the half-hour (i.e., midpoint) of the TNMHC one-hour averaging period. Figure A.3-18 plots the one-hour back-trajectories over a geographic map of the West End Harbor area. The back-trajectory paths clearly suggest emissions sources located to the southeast and south of West End Harbor. Importantly, the upwind area includes the Port of Corpus Christi bulk liquid loading/unloading docks. In addition, the Equistar Chemicals and Flint Hills Resources (East Plant) industrial facilities are often in the upwind region as well.

Routine operational activities in support of the CCAQP include near real-time investigation of local emissions sources that may have contributed to high TNMHC events at West End Harbor. These previous pollution event analyses suggest that elevated TNMHC concentrations have been associated with ship loading/unloading operations at the Port of Corpus Christi bulk liquid docks, particularly Oil Docks 9 and 10 located immediately south-southeast of West End Harbor. Previous analyses have also found that Flint Hills Resources (East Plant) is often upwind of West End Harbor during high TNMHC events. Figure A.1-19 provides a zoomed map of West End Harbor and the surrounding area using Google satellite imagery.

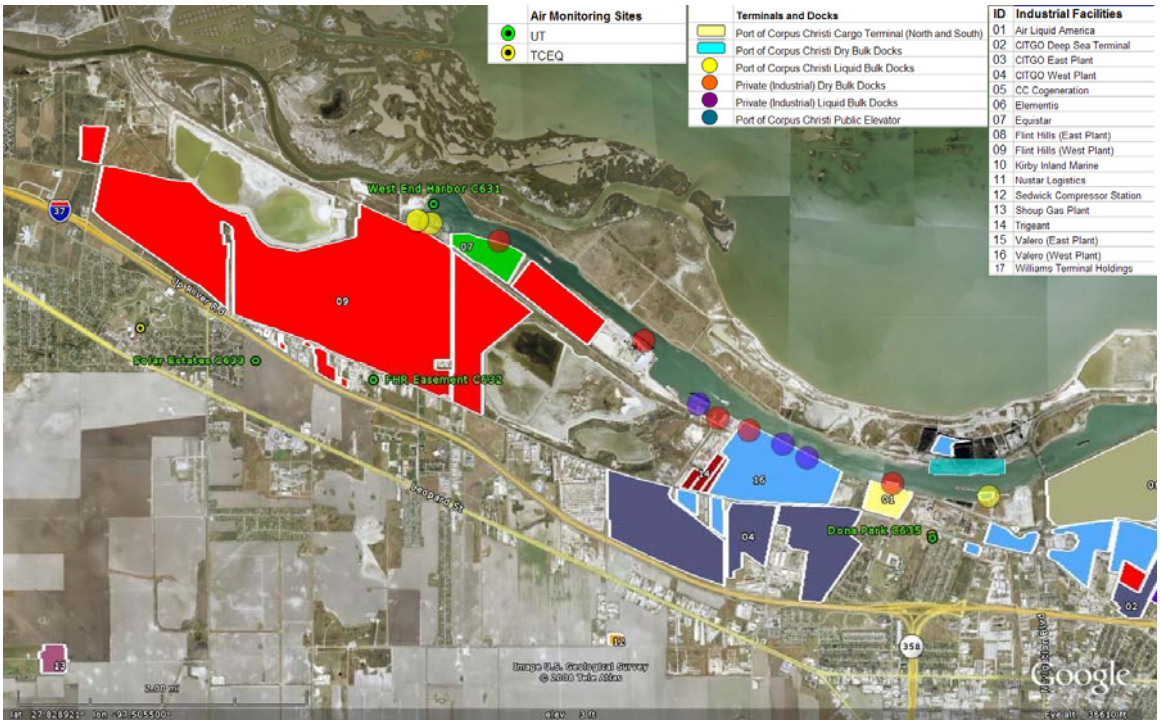

Figure A.3-1. Locations of the West End Harbor (C631) monitoring station, nearby CAMS, and surrounding industrial facilities. The Corpus Christi Ship Channel is oriented southeast to northwest near the middle of the figure.

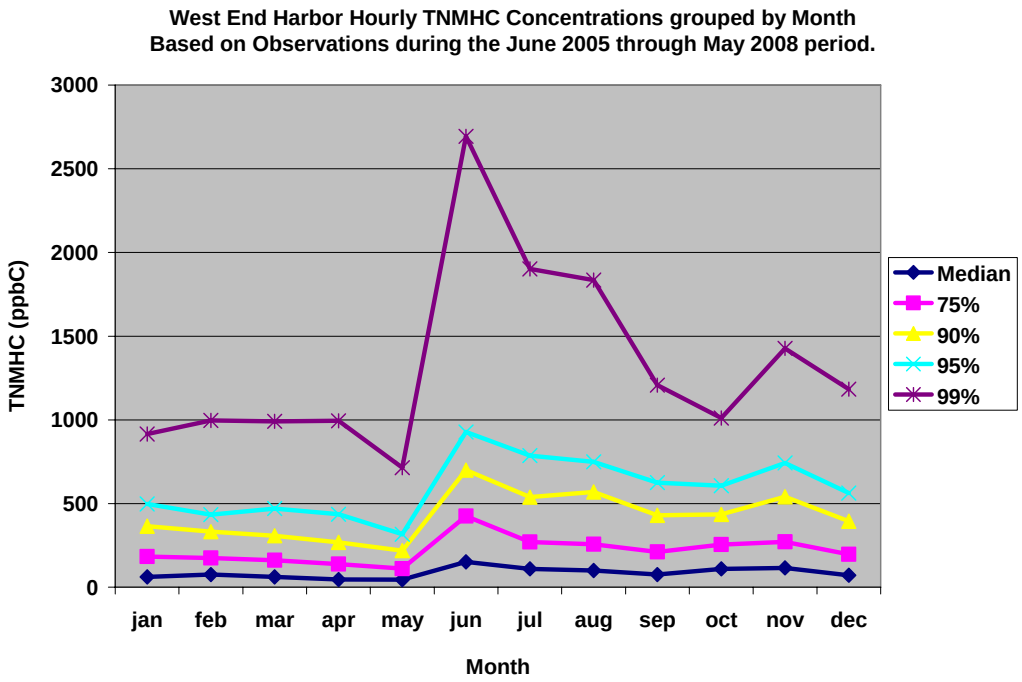

Figure A.3-2. Monthly median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations at the West End Harbor monitoring station based on all valid data during the June 2005 through May 2008 period.

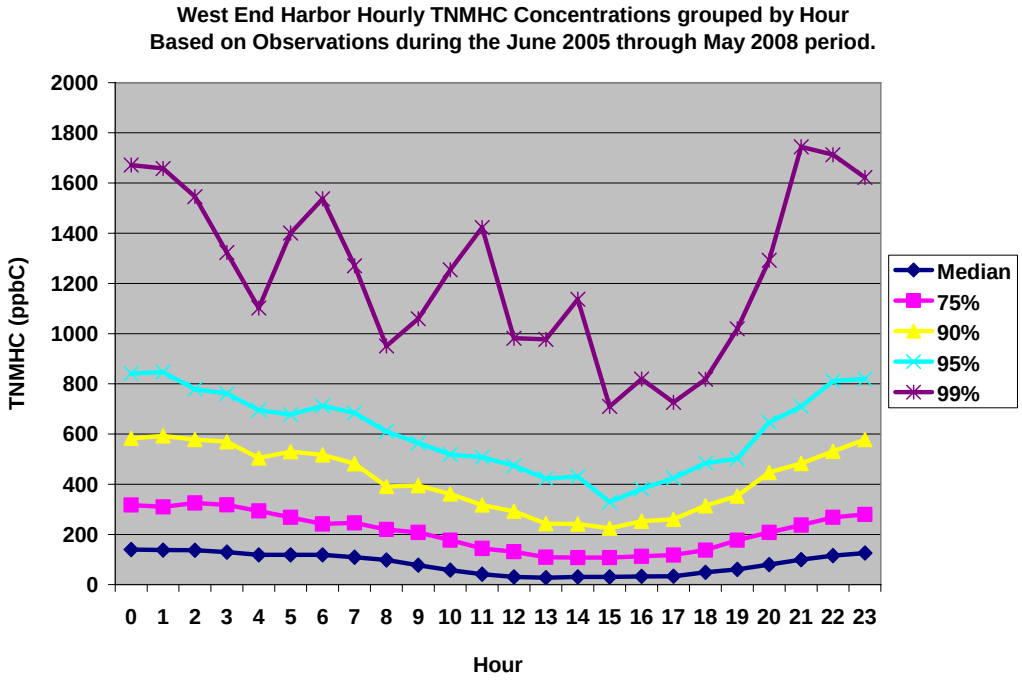

Figure A.3-3. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations at the West End Harbor monitoring station by hour based on all valid data during the June 2005 through May 2008 period.

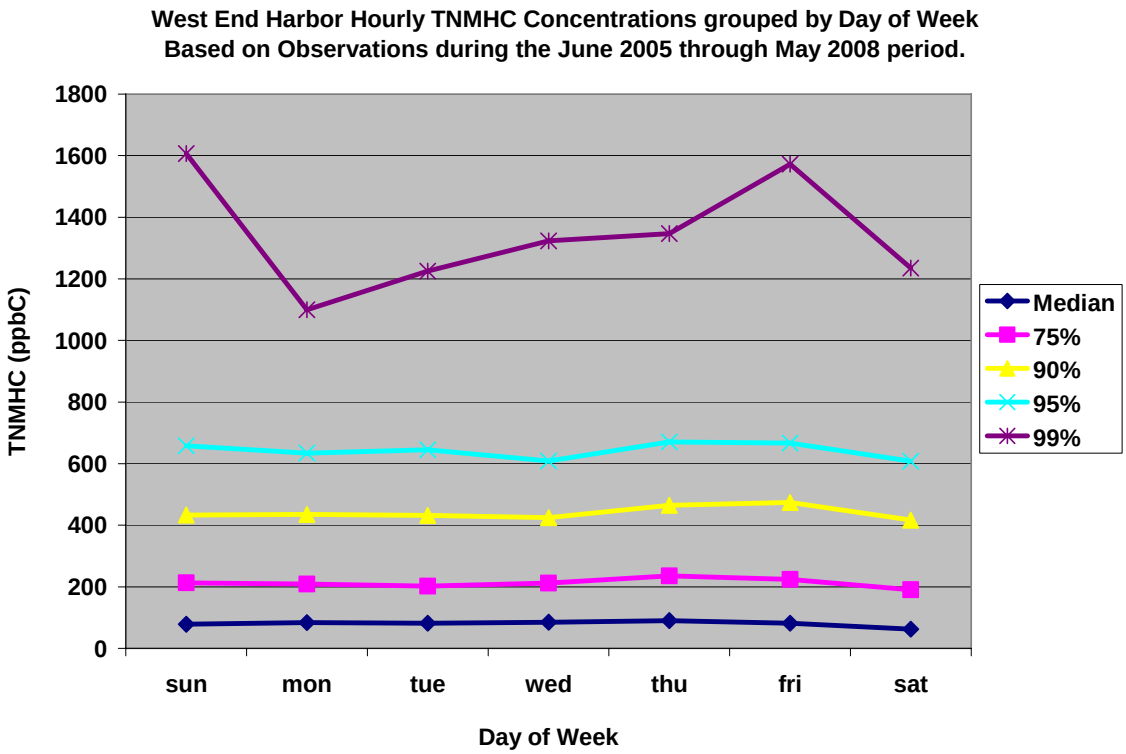

Figure A.3-4. Median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by Day of Week at the West End Harbor monitoring station based on all valid data during the June 2005 through May 2008 period.

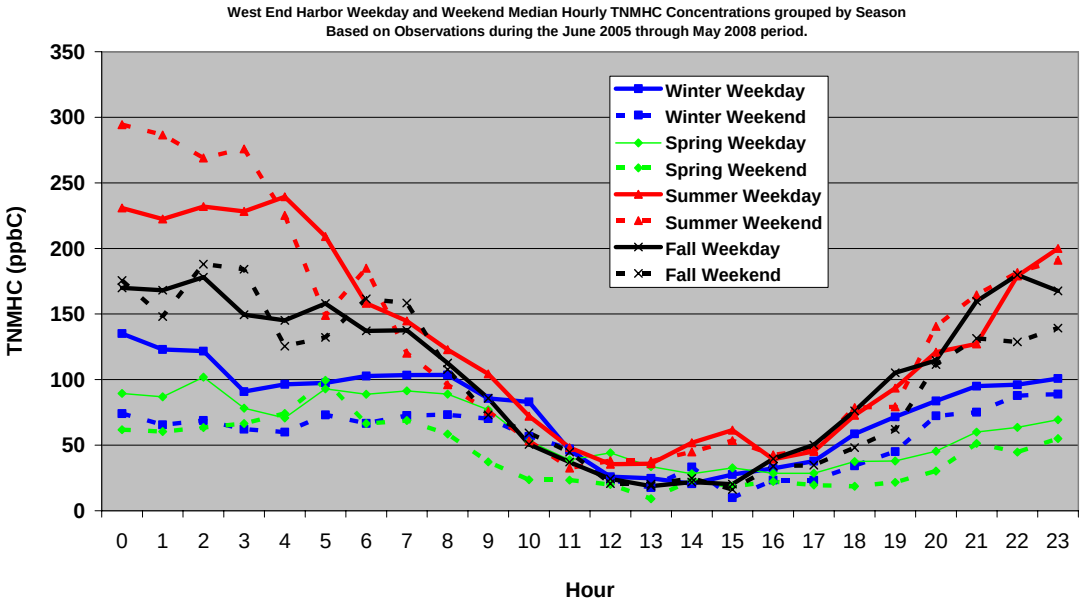

Figure A.3-5. Median hourly weekday and weekend day TNMHC concentrations grouped by season at the West End Harbor monitoring station based on all valid data during the June 2005 through May 2008 period.

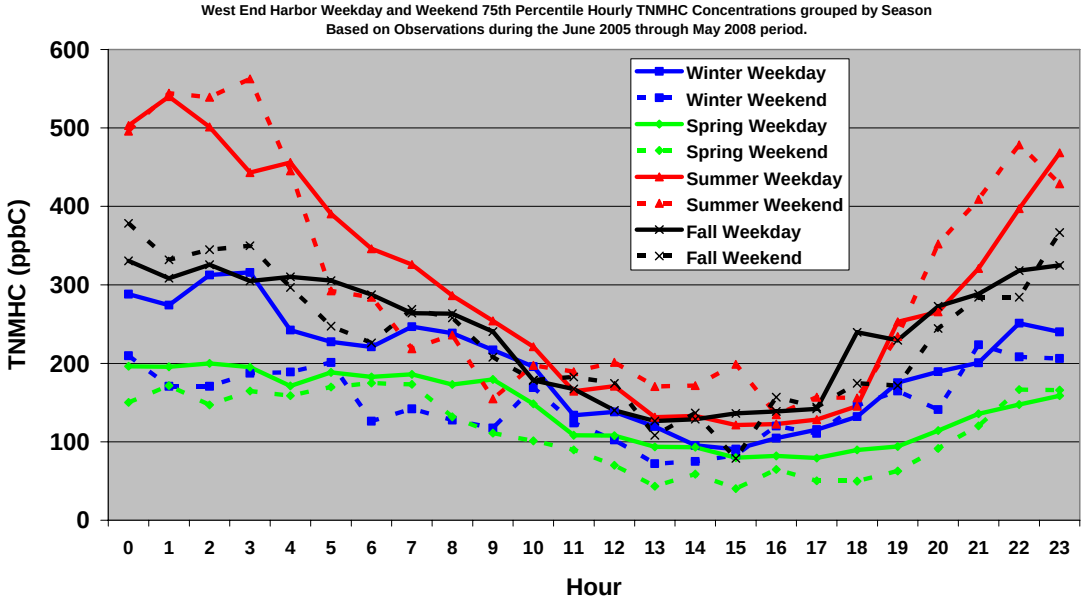

Figure A.3-6. The 75th percentile hourly weekday and weekend day TNMHC concentrations grouped by season at the West End Harbor monitoring station based on all valid data during the June 2005 through May 2008 period.

Table A.3-1. High TNMHC events at the West End Harbor monitoring station binned by duration in hours. High TNMHC events are defined as one or more consecutive hours characterized by TNMHC concentrations of 1000 ppbC or greater.

Duration of Event (hours)	Number of Events
1	138
2	41
3	25
4	7
5	5
>5	13
Total Events	**229**

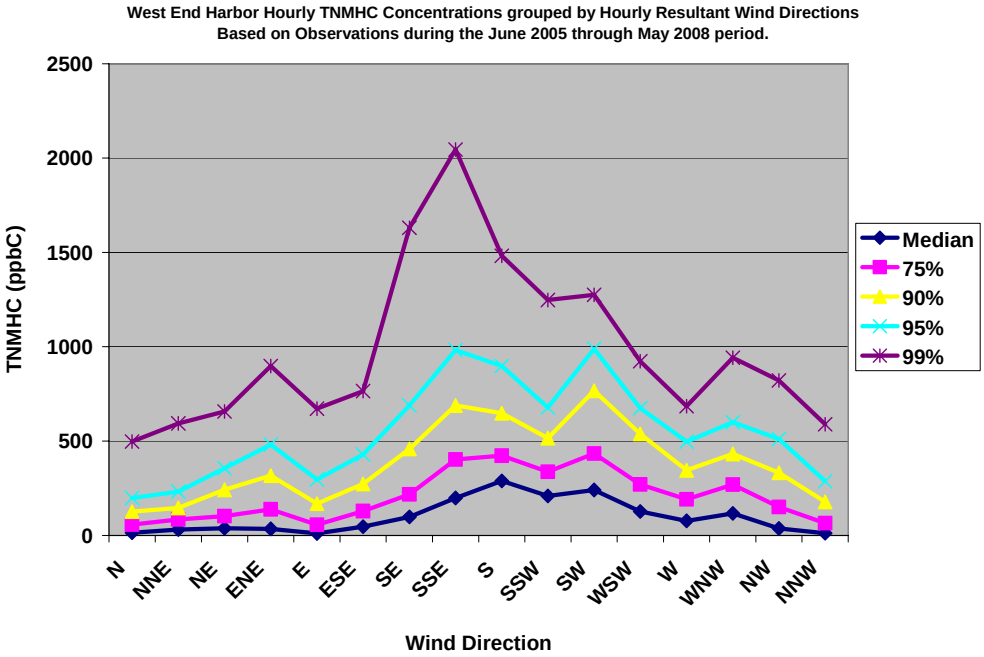

Figure A.3-7. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations grouped by hourly resultant wind direction at the West End Harbor monitoring station based on all valid data during the June 2005 through May 2008 period.

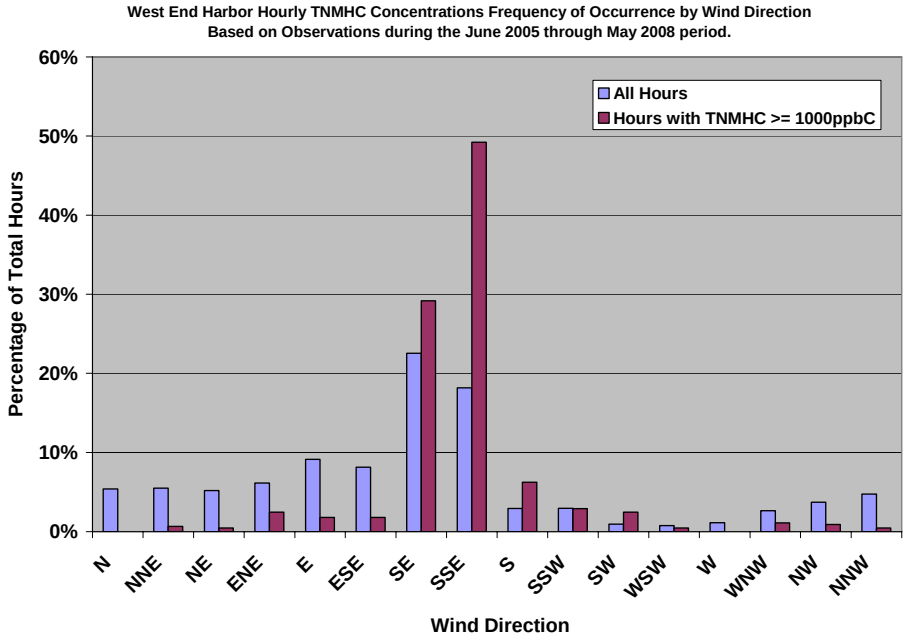

Figure A.3-8. Percentage of hours at the West End Harbor monitoring station grouped by resultant wind direction for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppb or greater. Based on all valid data during the June 2005 through May 2008 period.

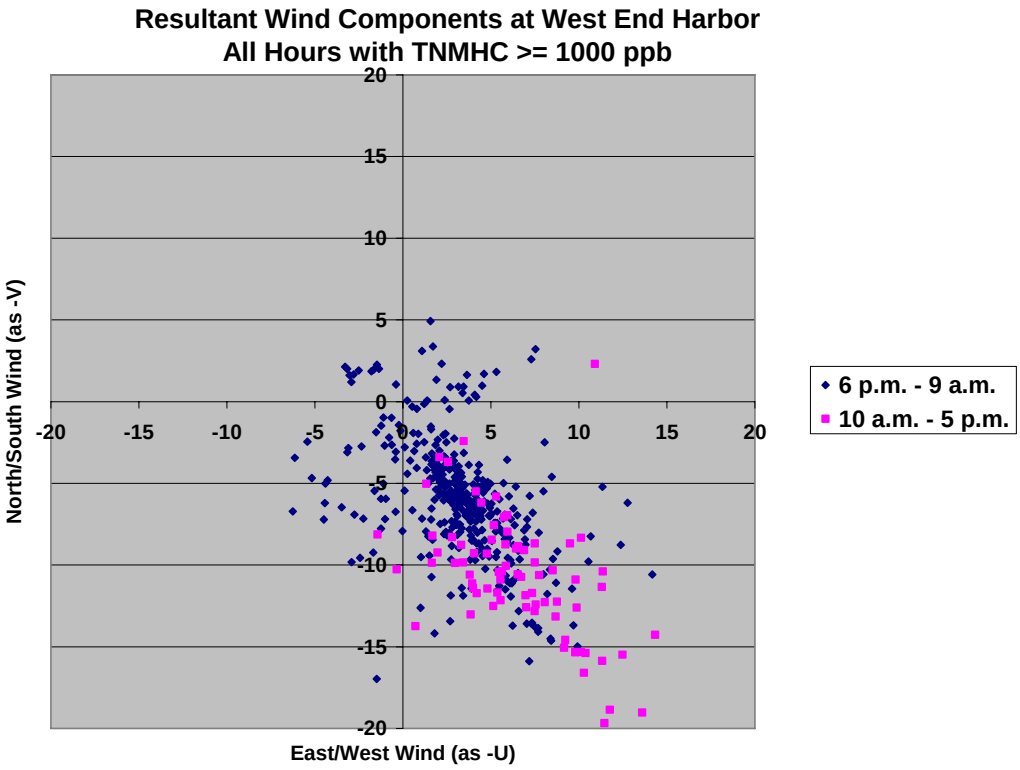

Figure A.3-9. Resultant wind component scatterplot at West End Harbor for all hours with TNMHC concentrations of 1000 ppb or greater during the June 2005 through May 2008 period. (The reader is referred to Section 2.5 for a discussion of how to interpret this figure.)

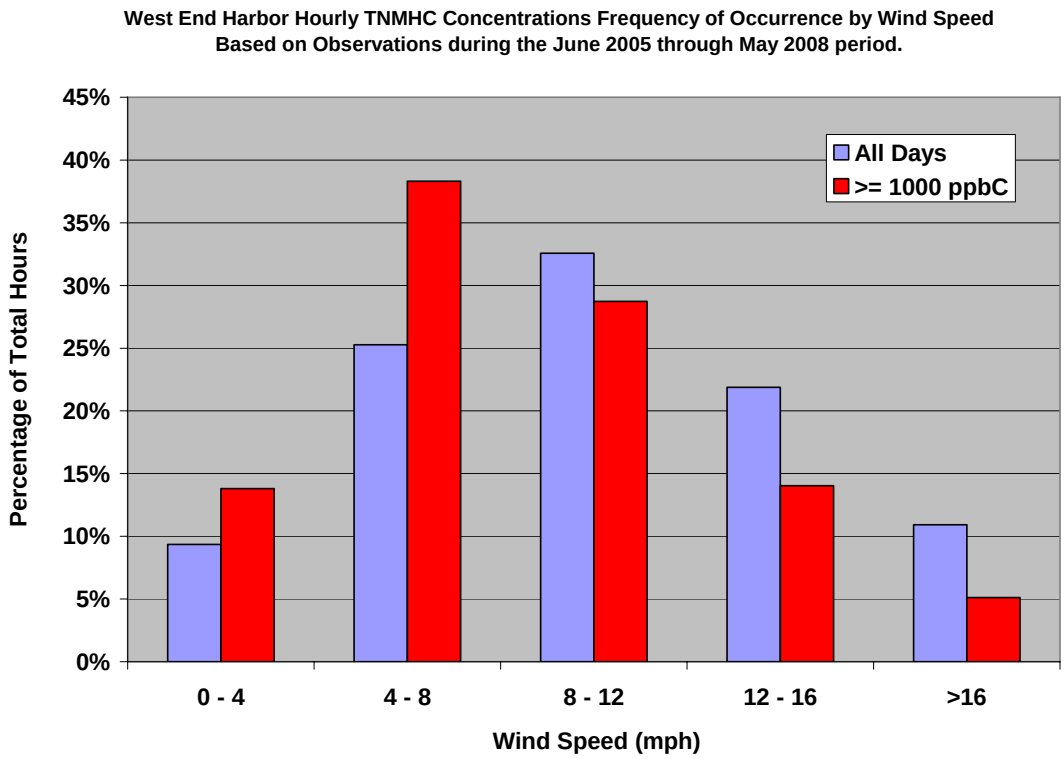

Figure A.3-10. Percentage of hours at the West End Harbor monitoring station grouped by resultant wind speed (binned by 4 mph increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

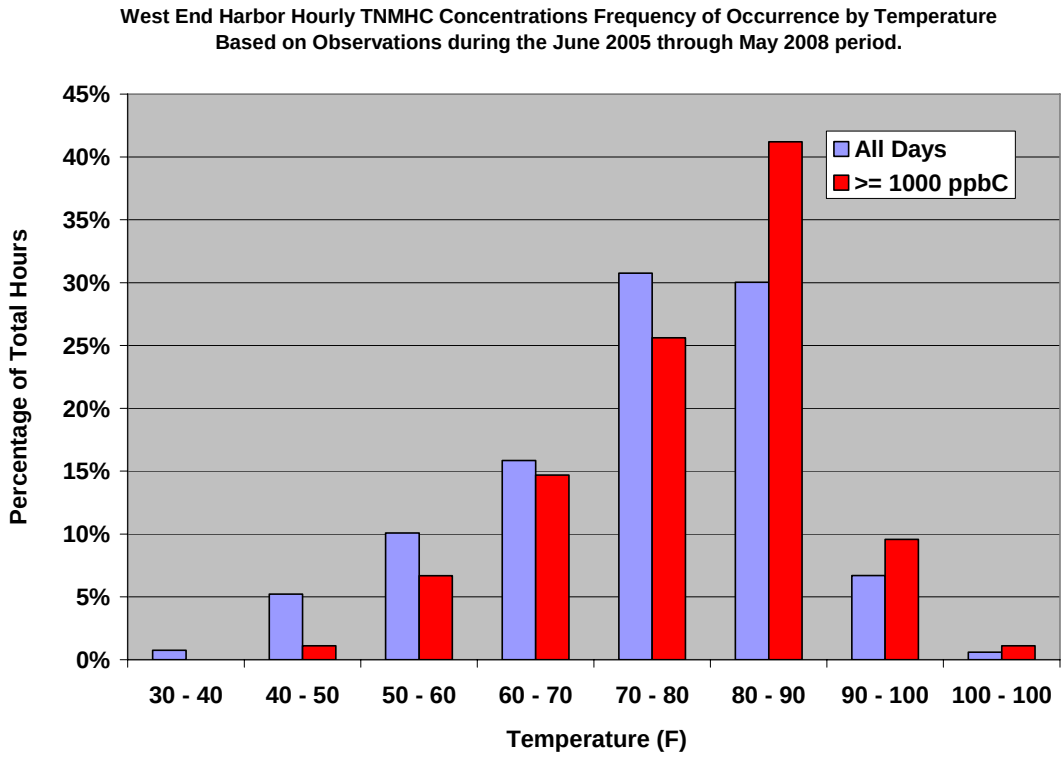

Figure A.3-11. Percentage of hours at West End Harbor monitoring station grouped by temperature (binned by 10 F increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

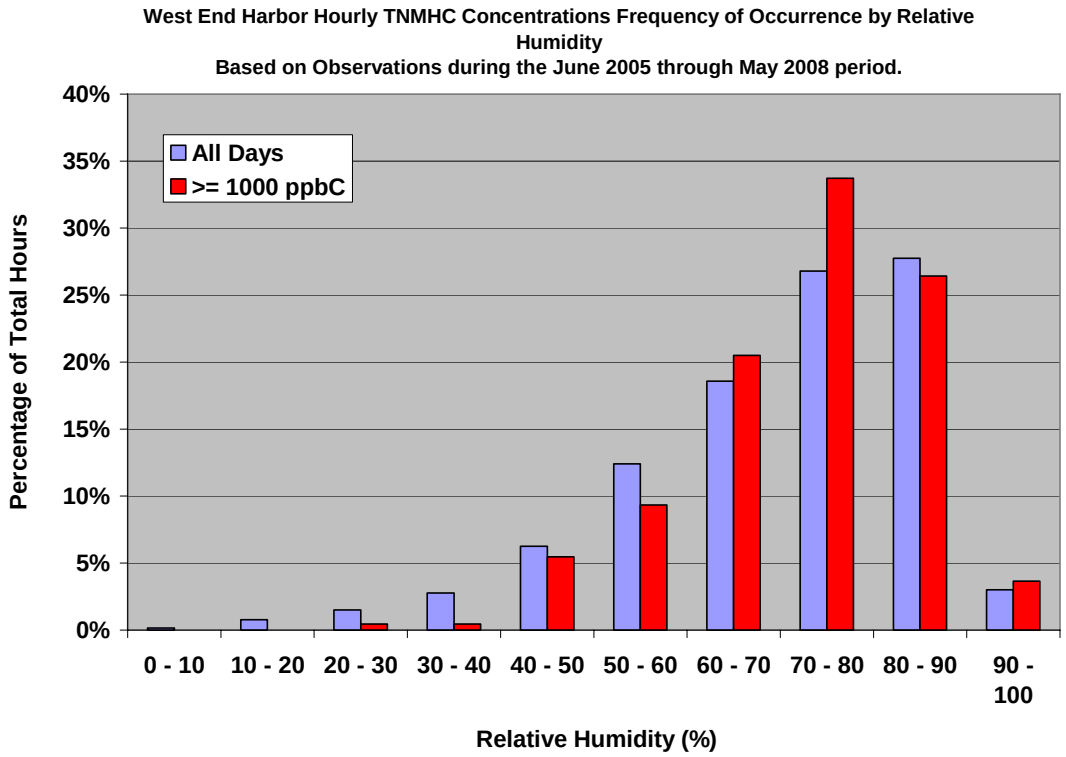

Figure A.3-12. Percentage of hours at the West End Harbor monitoring station grouped by relative humidity values (binned by 10% increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

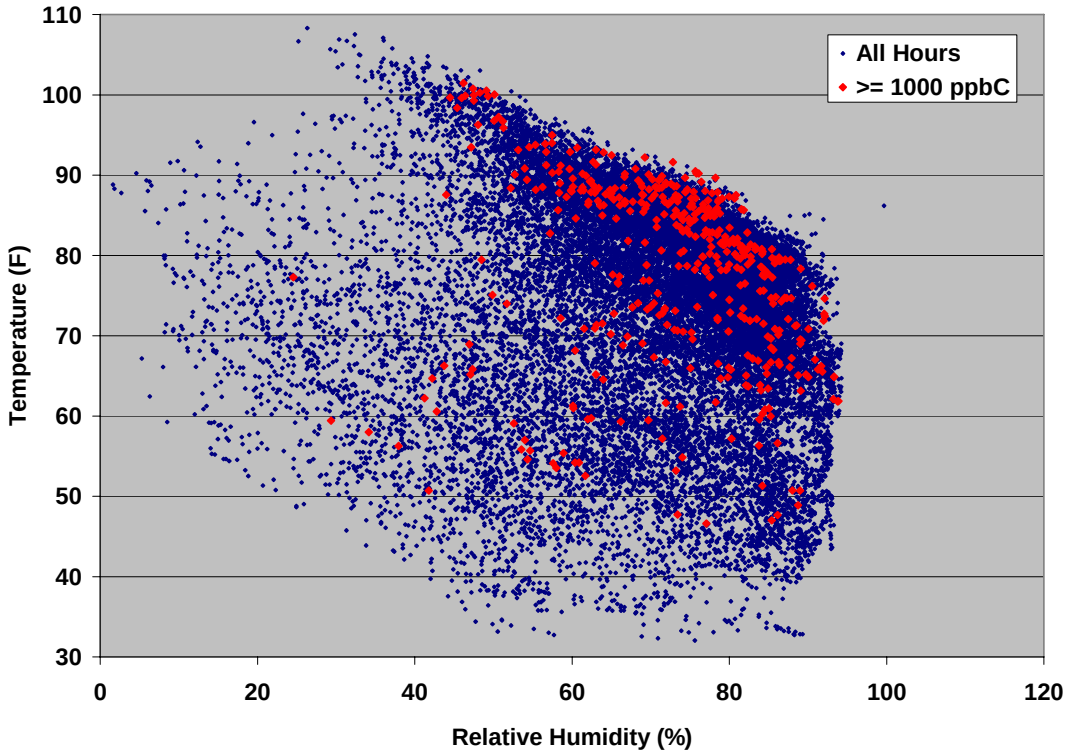

Figure A.3-13. Hourly temperature versus hourly relative humidity at the West End Harbor monitoring station for all hours during the June 2005 through May 2008 period. Hours characterized by a TNMHC concentration of 1000 ppbC or greater are highlighted in red.

72-Hour HYSPLIT Back-Trajectories for Days with Hourly TNMHC >= 2500 ppbC

West End Harbor (C631): June 2005 - May 2008

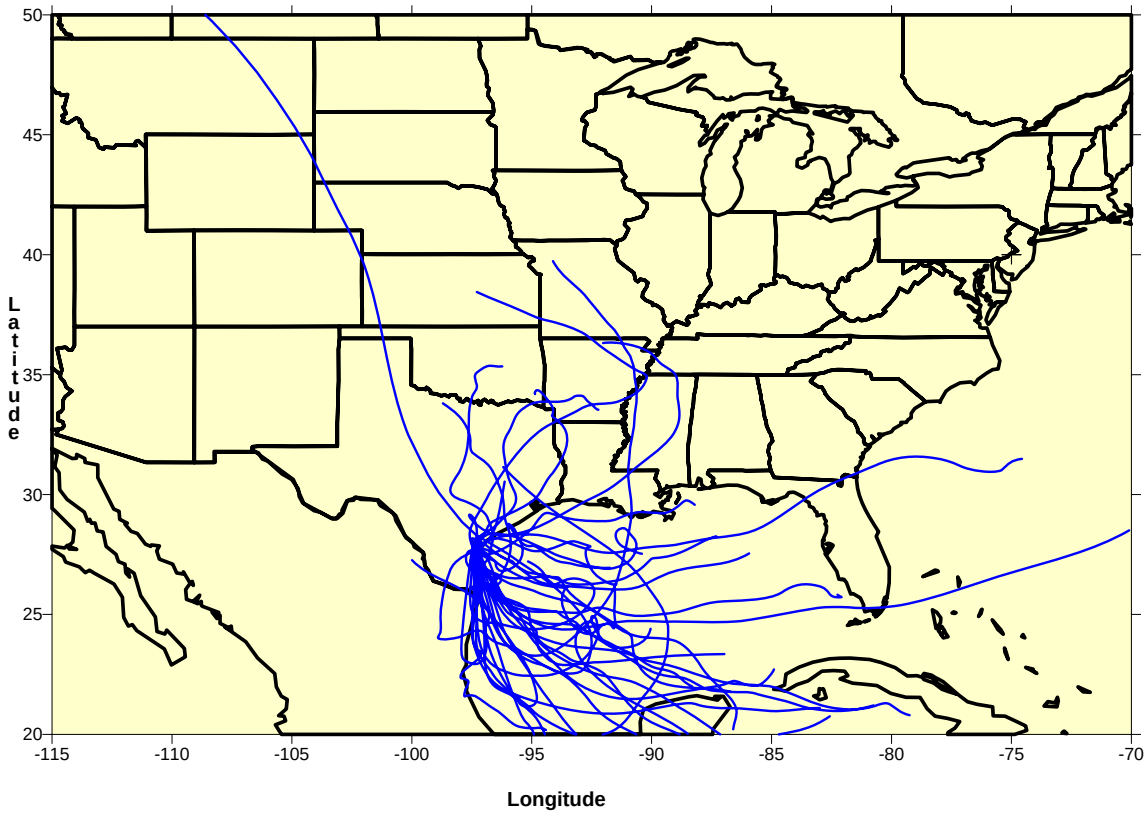

Figure A.3-14. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 38 days during the June 2005 through May 2008 period characterized by one or more hours with TNMHC concentrations of 1500 ppb or greater at the West End Harbor monitoring station.

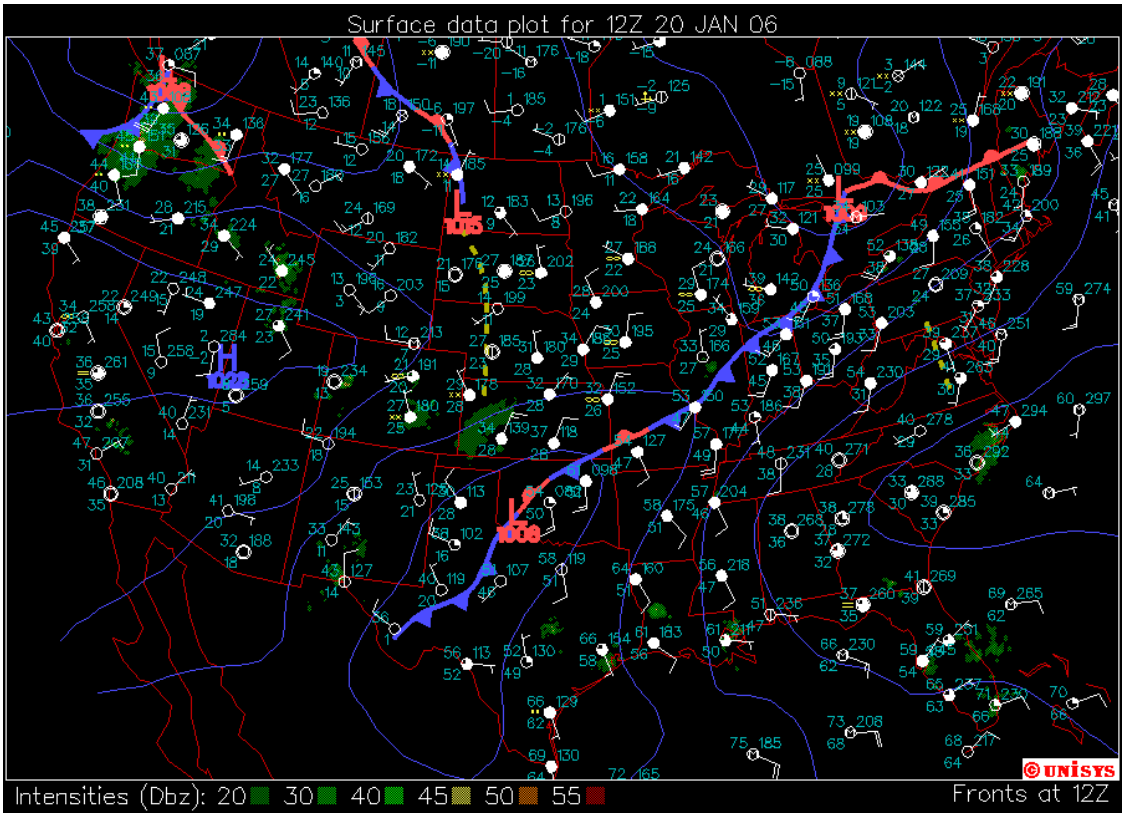

Figure A.3-15. Surface weather map at 0600 CST on January 20, 2006.

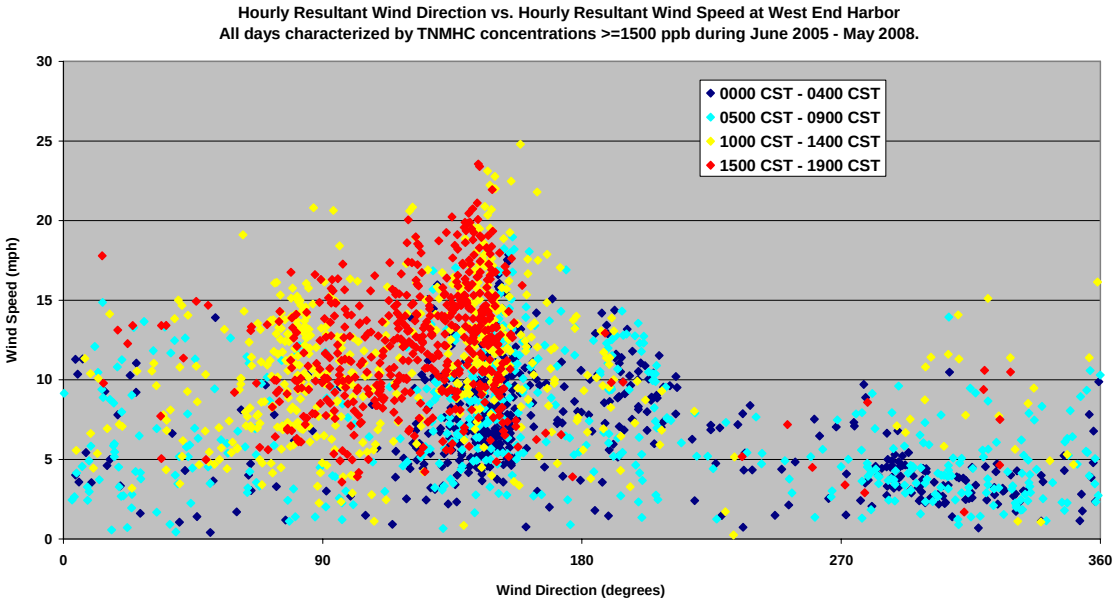

Figure A.3-16. West End Harbor resultant wind direction versus the resultant wind speed for all hours on days characterized by one or more TNMHC concentrations of 1500 ppbC or greater.

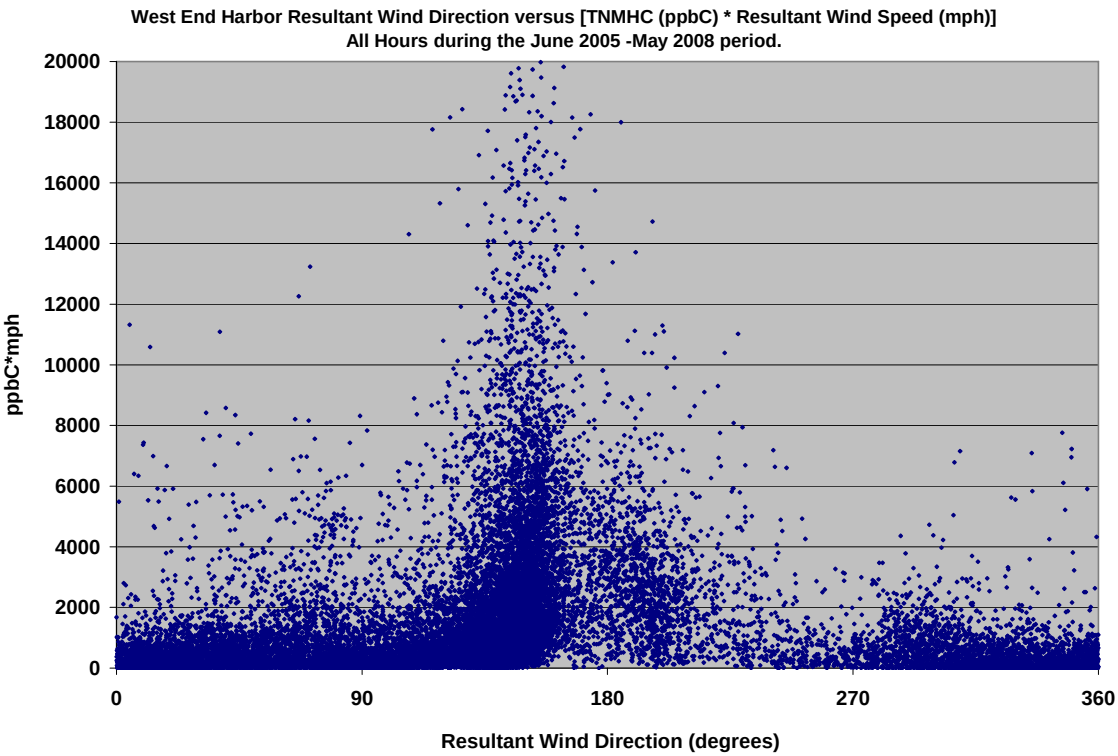

Figure A.3-17. Resultant wind direction (degrees) versus the product of the TNMHC concentration multiplied by the resultant wind speed (ppbC*mph) at the West End Harbor monitoring station for all valid hours during the June 2005 through May 2008 period. Note that the chart scale has been defined for easy visualization of high density peaks so that observations above 20,000 ppbC*mph are not shown.

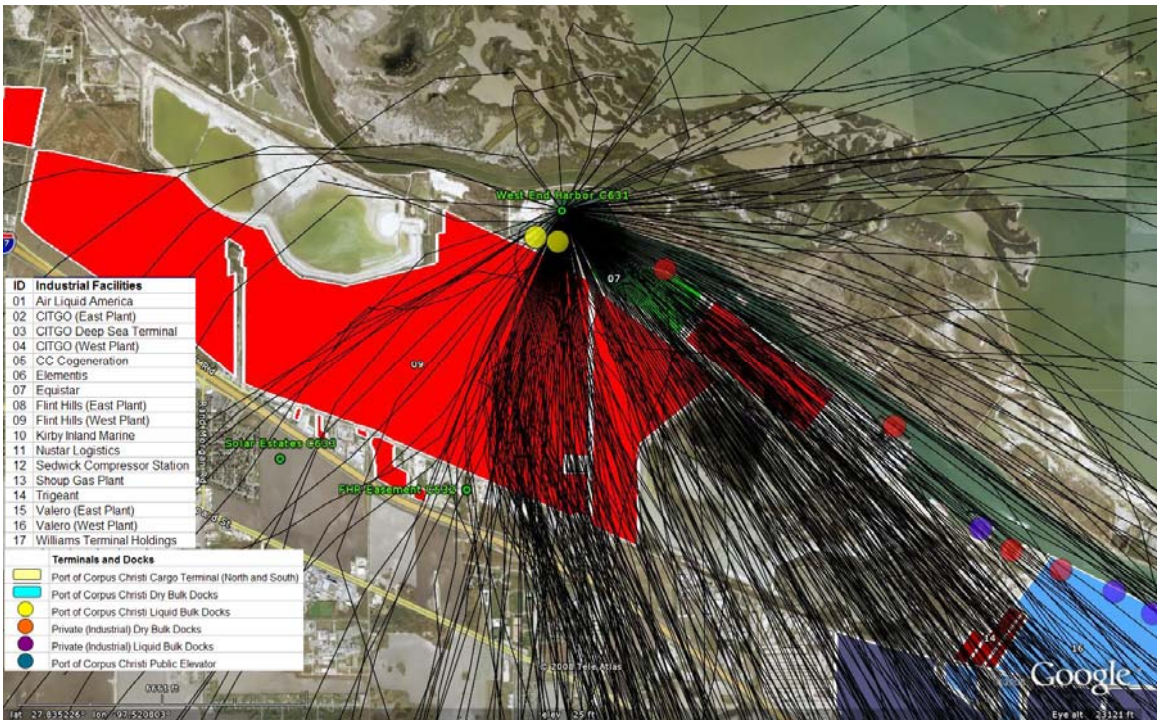

Figure A.3-18. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a TNMHC concentration of 1000 ppb or greater at the West End Harbor monitoring station during the June 2005 through May 2008 period.

Figure A.1-19. Detail map of the West End Harbor monitoring station and surrounding area. Solar Estates lower left, FHR Easement lower center, West End Harbor upper right, Flint Hills (East Plant) center, Port of Corpus Christi liquid loading/unloading docks in blue oval southeast of West End Harbor, Sam Kane Meat Packing plant southeast of Solar Estates in green oval, tank battery in red circle just south of FHR Easement.

A.4 Dona Park (C635) Monitoring Station

Figure A.4-1 shows the location of the Dona Park monitoring station, which is located on the northwestern edge of the Dona Park residential neighborhood. The Dona Park station is located approximately 0.25 miles south of the Corpus Christi Ship Channel and approximately 0.5 miles north of Interstate 37. TCEQ operates a co-located monitoring station (CAMS 199) at Dona Park. The next closest monitoring station operated by TCEQ is the Huisache monitoring station (CAMS 98) located approximately 2.2 miles to the east-southeast of Dona Park. Numerous industrial facilities are located immediately to the west (e.g., Valero and CITGO West Plants) and east (Valero East Plant, CITGO Deep Sea Terminal). These nearby industrial facilities are primarily situated between the Corpus Christi Ship Channel and the Interstate 37 corridor. In addition, ship loading/unloading operations in the nearby area include dry and liquid bulk loading/unloading docks to the northeast and northwest, respectively.

A.4.1 Seasonal, Day of Week, and Diurnal Variability in TNMHC Concentrations at Dona Park

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by month are shown in Figure A.4-2. For all metrics, elevated concentrations are noted throughout the year. The highest concentrations generally occur during the October through January and June/July time periods. The monthly 95th percentile concentration values (which roughly correspond to the 110th highest TNMHC concentration ranked by descending order) for the October through January period range from 478 ppbC for October to 602 ppbC for December. The 95th percentile values for June and July are 355 ppbC and 425 ppbC, respectively. The 95th percentile concentration values for the remaining months range from 235 ppbC during May to 379 ppbC during February.

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by hour are shown in Figure A.4-3. For all metrics, the nighttime hours are characterized by the highest concentrations, with a relative peak in concentration values during the 0500 CST through 0700 CST period. The 95th percentile concentration values (which roughly correspond to the 55th highest TNMHC concentration ranked by descending order) range from 269 ppbC at 1700 CST to 553 ppbC at 0500 CST. The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by day of week are shown in Figure A.4-4. The 95th percentile concentration values (which roughly correspond to the 188th highest TNMHC concentration ranked by descending order) vary from 376 ppbC on Sunday to 438 ppbC on Friday.

To investigate possible seasonal differences in the diurnal profiles by day of week, Figures A.4-5 and A.4-6 present the median and 75th percentile hourly TNMHC concentrations, respectively, grouped by season. Figures A.4-5 and A.4-6 demonstrate no consistent differences between weekday and weekends for any season. Overall, the Winter, Spring, and Fall seasons are each characterized by relatively higher concentrations during the nighttime hours compared to the daytime hours, with peak

concentrations during the morning. In contrast, the summer diurnal profile is characterized by similar weak peaks in TNMHC concentration values during the morning and early afternoon hours. The seasonal maximum hourly median concentrations vary from 103 ppbC at 1300 CST on Summer weekdays to 204 ppbC at 0600 CST for Fall weekends. The seasonal maximum 75th percentile concentration values (which roughly correspond to the 48th and 19th highest TNMHC concentration ranked by descending order for weekdays and weekend days, respectively) range from 212 ppbC at 0500 CST for Summer weekends to 323 ppbC at 0500 CST on Fall weekends.

A.4.2 TNMHC Event Duration at Dona Park

For the purpose of investigating the duration of high TNMHC events, TNMHC events were defined as one or more consecutive hours characterized by a concentration of 1000 ppbC or greater. Table A.4-1 presents the 93 high TNMHC events (binned by duration in hours) measured at the Dona Park monitoring station during the June 2005 through May 2008 period. The vast majority of events were characterized by durations of 1 hour (58% of total events) and 2 hours (20% of total events). For the remaining events with durations of 3 hours or greater (22% of total events), the majority occurred during the late night and morning hours throughout the November through January period.

A.4.3 Local Meteorological Conditions during High TNMHC Events at Dona Park

Figure A.4-7 presents the median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations binned by the hourly resultant wind direction at Dona Park. The statistical metrics demonstrate that relatively high concentration values occur for all wind directions except for a relative minimum in concentration values during hours characterized by south-southeasterly or southerly winds. The 95th percentile concentration values indicate highest concentrations during hours characterized by westerly and/or northerly directional components. It should be noted, however, that westerly winds are relatively rare in Corpus Christi. Figure A.4-8 presents the frequency of occurrence by resultant wind direction for all hours during the June 2005 through May 2008 period and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater. The frequency of occurrence of 1000 ppbC TNMHC concentrations is far greater than the climatological frequency of occurrence for hours characterized by winds with a northerly or westerly component. Note, for example, that north-northeasterly winds comprise 6% of all hours but account for 23% of high TNMHC hours. High TNMHC concentrations are also more likely during periods characterized by winds with a westerly component; however, these hours do not account for a particularly high percentage of 1000 ppbC TNMHC events (e.g., hours characterized by west-southwesterly, westerly, and west-northwesterly winds comprise 4.1%, 1.2%, and 4.7% of all 1000 ppbC TNMHC hours). Figure A.4-8 demonstrates that winds with a southerly component occur most frequently. Although the frequency of occurrence of 1000 ppbC TNMHC concentrations is relatively low during periods of southerly winds, note that hours characterized by east-southeasterly and southeasterly winds account for 9.9% and 6.4%, respectively, of all 1000 ppbC TNMHC hours.

Figure A.4-9 shows the wind component scatterplot for all hours characterized by TNMHC concentrations of 1000 ppbC or greater, grouped by time of occurrence during the 1800 CST through 0900 CST (corresponding to evening/nighttime/morning) and 1000 CST through 1700 CST (corresponding to late morning/afternoon) time periods. (Refer to Section 2.5 of this report for a discussion of how to interpret the wind component scatterplot.) Consistent with the diurnal profile shown in Figure A.4-3, high TNMHC concentrations predominate during the 1800 CST through 0900 CST time period. Daytime events are characterized by relatively higher wind speeds, and are mostly divided between hours characterized by north-northwesterly to northeasterly and east-southeasterly to southeasterly winds. For the nighttime events, wind speeds are generally light to calm with a majority of hours characterized by flow from the north-northeast.

Figure A.4-10 presents the frequency of occurrence for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater for five wind speed ranges (binned by 4 mph increments). Note that highest TNMHC concentrations predominate at hours characterized by wind speeds of 4 mph or less. For the lowest wind speed bin, the frequency of occurrence for all hours and for high TNMHC concentrations is 19% and 63%, respectively. Most hours at Dona Park (71%) are characterized by wind speeds between 4 and 12 mph. These wind speeds are associated with 34% of the 1000 ppbC TNMHC events.

Figure A.4-11 presents the frequency of occurrence for all hours and for only those hours characterized by TNMHC concentrations of 1000 ppbC or greater for eight temperature ranges (binned by 10 F increments). Temperatures between 50 F and 70 F occurred during 17% of all hours but account for 66% of high TNMHC hours. In contrast, hours characterized by temperatures greater than 70 F comprise 68% of all hours and 30% of high TNMHC hours. The tendency for 1000 ppbC TNMHC events at relatively lower temperatures is consistent with the previously shown highest frequency of occurrence of high TNMHC events during the Fall and Winter nighttime hours, which would be generally characterized by the lowest temperatures.

Figure A.4-12 presents the frequency of occurrence for all hours and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater for ten relative humidity (as a percent) ranges. High TNMHC concentrations predominate at hours characterized by high relative humidity values. Note that while 27% of all hours are characterized by relative humidity values of 80% or greater, 55% of high TNMHC concentrations occur at these relative humidity levels. Figure A.4-13 presents a scatterplot of hourly temperature versus hourly relative humidity for all days during the June 2005 through May 2008 period. Hours characterized by TNMHC concentrations of 1000 ppbC or greater are plotted in red. The highest density of all hourly observations is found along the top right portion of the scatterplot, which indicates hours characterized by relatively warm temperatures and middle to high relative humidity values. This portion of the scatterplot is representative of most days during the spring through fall period, with nighttime hours often located on the right side at relatively high humidity values and daytime hours often located to the left at the lower humidity values. Figure

A.4-13 indicates the highest density of 1000 ppbC TNMHC hours occurs during temperatures less than 70 F and relative humidity values of 80% or greater, which most likely are representative of nighttime hours during the October through January period. A large proportion of high TNMHC hours occurred at temperatures less than 70 F across a range of relative humidity values between 20% and 75%. These conditions are likely associated with periodic intrusions of drier and colder air following the passage of cold fronts through South Texas.

A.4.4 Large-Scale Weather Patterns during High TNMHC Events at Dona Park

Due to the labor intensiveness required to review daily weather maps, the TNMHC concentration threshold used to define high TNMHC events was increased from 1000 ppbC to 1500 ppbC to limit the number of individual days for analysis. To investigate the large-scale weather features that predominate during high TNMHC events, 72-hour HYSPLIT back-trajectories were generated for all days during the June 2005 through May 2008 period that were characterized by one or more hours with a TNMHC concentration of 1500 ppbC or greater at the Dona Park monitoring station. Figure A.4-14 shows the 38 back-trajectories on these highest TNMHC days. The back-trajectories were initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface. The majority of back-trajectories are characterized by a clockwise curvature of the long-range winds, consistent with the large-scale circulation around a ridge of high pressure that extends southward or westward into Texas. The back-trajectories shown in Figure A.4-14 can visually be classified into three general categories characterized by long-range flow from the (1) north, (2) east-northeast, and (3) south or southeast.

A.4-14 shows that about half of the long-range flow patterns prior to high TNMHC events are characterized by southerly flow into South Texas. Figure A.4-15 presents the surface weather map for December 18, 2007, which is characterized by a long-range trajectory that indicates southward flow over Southeast Texas into the west-central Gulf of Mexico followed by return flow over the Gulf of Mexico into Corpus Christi from the south. At upper levels on December 18th, zonal flow covered much of the continental US with wind speeds in excess of 100 knots over Texas. At the surface, high pressure dominated over both the western and eastern portions of the US and a high pressure ridge centered over North Carolina extended south-southwestward into the Gulf of Mexico. Corpus Christi was located on the western side of the surface ridge in a region of weak pressure gradients. At Dona Park, moderate east-southeasterly surface winds during the previous afternoon turned to light northeasterly winds during the late night and early morning hours on December 18th. The morning low temperature was 63 F with a maximum morning relative humidity of 83%. TNMHC concentrations were elevated throughout the morning at Dona Park with a peak concentration of 2903 ppbC at 0600 CST. By the afternoon, turbulent mixing by mechanical thermals likely mixed higher momentum air dominated by the large-scale flow is to the surface, and winds were southerly at moderate speeds.

A review of the large-scale surface weather maps for the 38 days characterized by maximum hourly TNMHC concentrations of 1500 ppbC or greater reveals that a high

pressure ridge often extends southward, southwestward, or westward into Texas. These surface high pressure systems are often associated with cold fronts that have moved through Texas, and the weak horizontal pressure gradients over the Corpus Christi area are associated with light winds speeds and (likely) stable atmospheric conditions. On a majority of the 1500 ppbC TNMHC days, Corpus Christi is located on the southwestern or western side of a surface high pressure ridge that extends southward over the Gulf of Mexico. To explore the daily evolution of surface winds in the Corpus Christi area on high TNMHC days, Figure A.4-16 presents the resultant wind direction versus the resultant wind speed for all hours during the 38 1500 ppbC TNMHC days. Note that the observations are grouped by hour. During the 0000 CST through 0900 CST time period, winds are most often calm to northeasterly at speeds of 7 mph or less. Less often, morning winds are southerly at 3 – 8 mph or westerly at light wind speeds. By the late afternoon hours, most days are characterized by southeasterly winds at 4-12 mph.

A.4.5 Analysis and Summary of Dona Park TNMHC and Meteorological Measurements

Air quality analyses were performed using the hourly TNMHC, resultant wind speed, resultant wind direction, temperature, and relative humidity measurements collected at the Dona Park monitoring station during the June 2005 through May 2008 period. The Dona Park monitoring station is located approximately 0.25 miles south of the Corpus Christi Ship Channel and approximately 0.5 miles north of Interstate 37, which runs east-west along the southern portion of the Corpus Christi Ship Channel. A number of industrial facilities are located immediately to the east and west of Dona Park. In addition, ship loading/unloading operations are located along the Ship Channel in the nearby area.

The highest hourly TNMHC concentrations (>= 1000 ppbC) occur most frequently during the October through January period, with a secondary peak during the months of June and July. Concentrations are highest during the nighttime hours with a peak in the frequency of occurrence during the 0500 CST through 0700 CST period. The Summer season, which is characterized by fewer high TNMHC hours compared to the Fall and Winter seasons, exhibits both an early morning and early afternoon peak in TNMHC concentrations. Across all seasons, the majority of high TNMHC events (78%) are one to two hours in duration. The remaining events greater than two hours in duration occurred throughout the late night and morning hours during the November through January period. Day of the week profiles using data from all seasons demonstrate no consistent differences between weekday and weekend day concentrations.

A wind direction analysis indicates that the highest TNMHC concentrations occurred during a range of wind directions with the exception of hours characterized by south-southeasterly or southerly winds. The frequency of occurrence of high TNMHC concentrations is far greater than the climatological frequency of occurrence for hours characterized by winds with a northerly or westerly component. The highest TNMHC concentrations (>= 1000 ppbC) occurred most often during hours characterized by winds with a northerly to northeasterly resultant wind direction at resultant wind speeds of 4

mph or less. The majority of high TNMHC concentrations occur during hours with temperatures of 70 F or less with relative humidity values of 80% or greater. These temperature and relative humidity conditions are consistent with the observed nighttime peak in TNMHC concentrations during the fall and winter months, which would be characterized by relatively high relative humidity values and relatively low temperatures.

The surface weather maps on days characterized by one or more hours with TNMHC concentrations of 1500 ppbC or greater often show a high pressure ridge that extends southward, southwestward, or westward into Texas. South Texas is often located on the southwestern or western side of a high pressure ridge that extends southward into the Gulf of Mexico. The diurnal variation of surface winds at the Dona Park monitoring station on these days is often characterized by calm to light northeasterly morning winds, followed by moderate late morning/afternoon northeasterly or south easterly winds becoming southeasterly during the late afternoon hours.

The strong wind directionality of the highest TNMHC concentrations suggests upwind (non-mobile) emissions sources located to the north-northeast of the Dona Park monitoring station. It should be noted, however, that high concentrations have been measured over a range of wind directions including east-southeasterly and those directions with a westerly component.

A.4.6 Upwind Emission Sources during High TNMHC Events at Dona Park

The previous analyses for Dona Park did not attempt to account for the hourly variation in atmospheric dispersion conditions. One method to provide some normalization of measured pollutant concentrations with respect to varying atmospheric dispersion conditions is to multiply the concentration by the wind speed. Figure A.4-17 presents a scatterplot of the hourly resultant wind direction (degrees) versus the product of the hourly TNMHC concentrations and the hourly resultant wind speed (ppbC-mph) for all hours during the June 2005 through May 2008 period. Consistent with the results of previous analyses, high values of concentration-wind speed are noted at a range of wind directions often including winds with a westerly and/or northerly resultant wind component. Relative peaks in concentration-wind speed values are noted for hours characterized by north-northeasterly (centered at 28 degrees) and northeasterly (centered at 55 degrees) resultant wind directions. Note however, that strong peaks are also noted for hours characterized by east-southeasterly (centered at 109 degrees) and southeasterly (centered at 127 degrees) resultant wind directions.

To identify the local emissions sources at upwind industrial facilities that may impact TNMHC concentrations at Dona Park, the Corpus Christi Trajectory Analysis Tool was used to generate one-hour surface back-trajectories for all hours characterized by an absolute TNMHC concentration of 1000 ppbC or higher. Each back-trajectory was initialized at the half-hour (i.e., midpoint) of the TNMHC one-hour averaging period. Figure A.4-18 plots the one-hour back-trajectories over a geographic map of the Dona Park area. The trajectory paths occur predominantly over a range of wind directions clockwise from north-northwesterly through southeasterly. During southeasterly flow,

the Markwest Javelina Holdings facility, which operates an industrial incinerator, is located in the upwind area. The Valero East Plant is often upwind of the Dona Park monitoring station during easterly to northeasterly winds. Note that the majority of back-trajectories indicate flow from the northeast counter-clockwise to the north-northwest. This latter upwind geographic area includes various dry and liquid loading/unloading dock along the Ship Channel. The back-trajectories also indicate flow from the southwest during some events, and (more rarely) from the west when the Valero and CITGO West Plants are in the upwind region.

Figure A.1-19 provides a zoomed map of Dona Park and the surrounding area using Google satellite imagery. Routine operational activities in support of the CCAQP include near real-time investigation of local emissions sources that may have contributed to high TNMHC events. Previous pollution event analyses suggest that off-gassing from petroleum coke tails pile (refer to the large black region on the north side of the Ship Channel north of the Port of Corpus Christi dry bulk loading/unloading docks shown in Figure A4.19) may impact TNMHC concentrations at Dona Park during period of northerly flow. Previous pollution event analyses suggest that emissions from the Markwest Javelina incinerator, located to the southeast of Dona Park, may be associated with high TNMHC events during periods of east-southeasterly or southeasterly winds. Previous analyses also indicate that the Valero East and (more rarely) West Plants are often in the upwind region during high TNMHC events at Dona Park. Finally, for a period during late 2007 through early 2008, winds from the northwest likely transported high TNMHC concentrations from oil and gas operations on the north side of the Ship Channel.

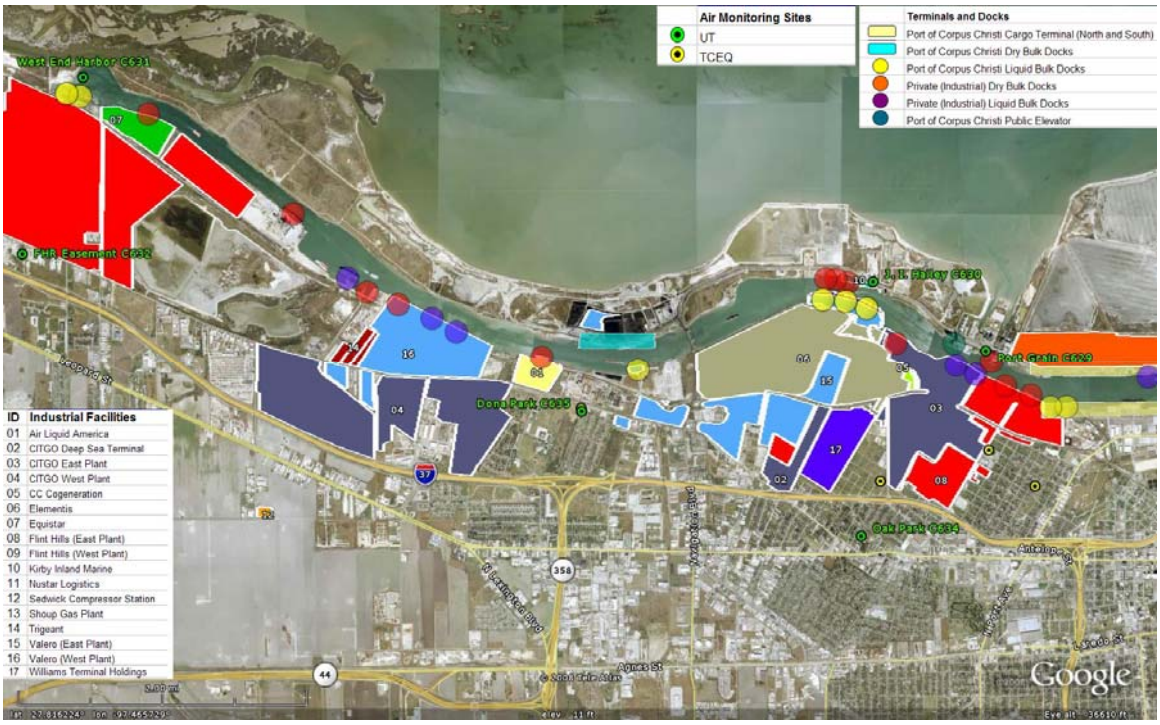

Figure A.4-1. Locations of the Dona Park (C635) monitoring station, nearby CAMS, and surrounding industrial facilities. The Corpus Christi Ship Channel is oriented east-west along the middle of the figure.

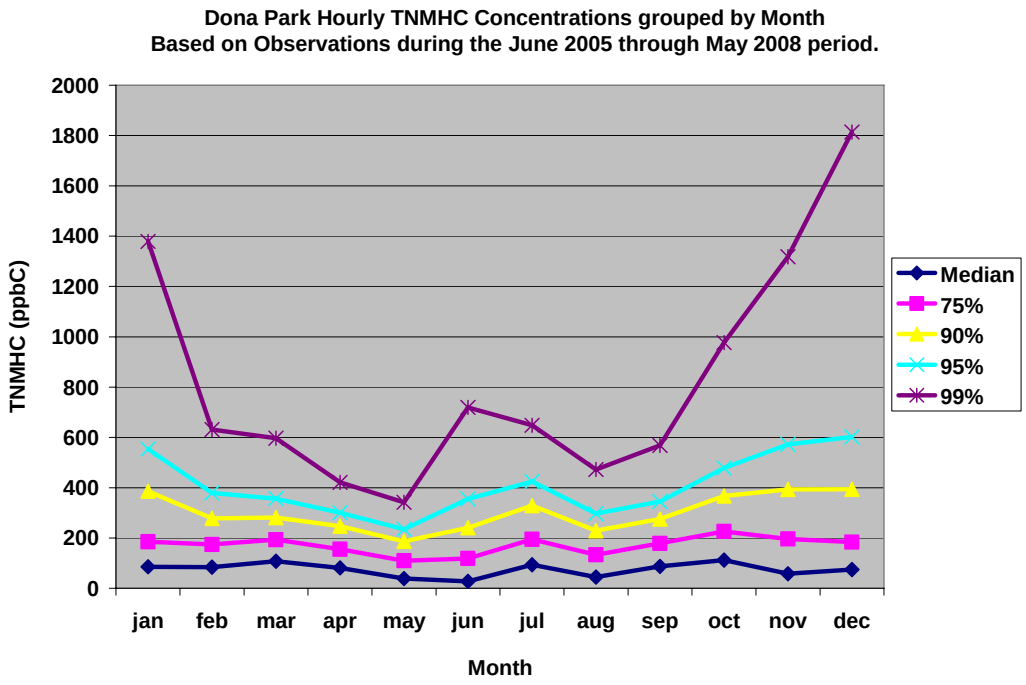

Figure A.4-2. Monthly median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations at the Dona Park monitoring station based on all valid data during the June 2005 through May 2008 period.

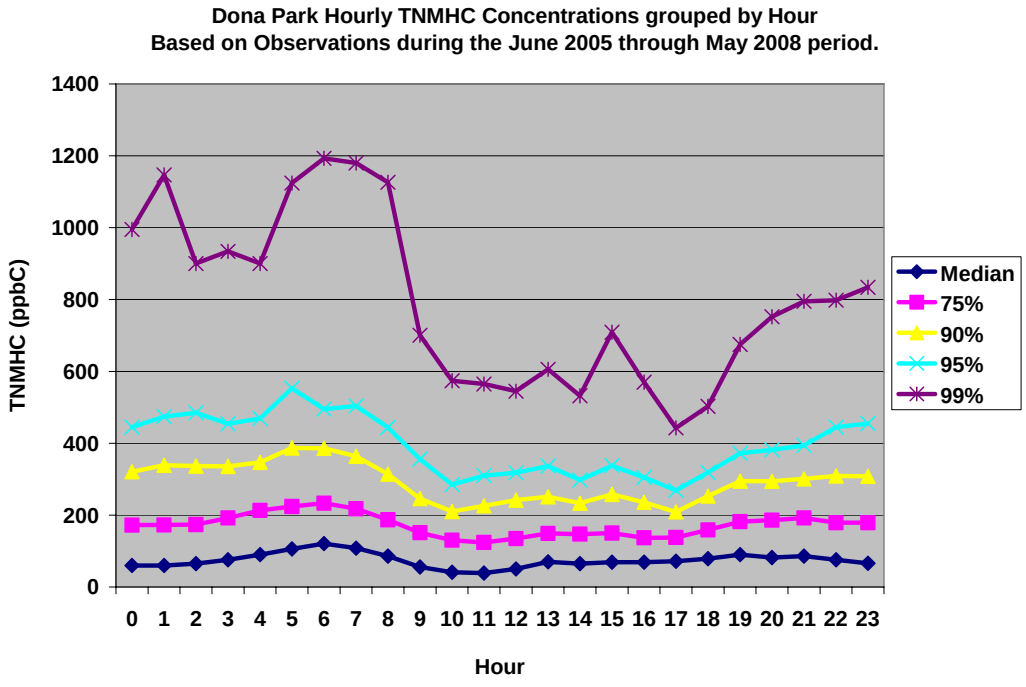

Figure A.4-3. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations at the Dona Park monitoring station by hour based on all valid data during the June 2005 through May 2008 period.

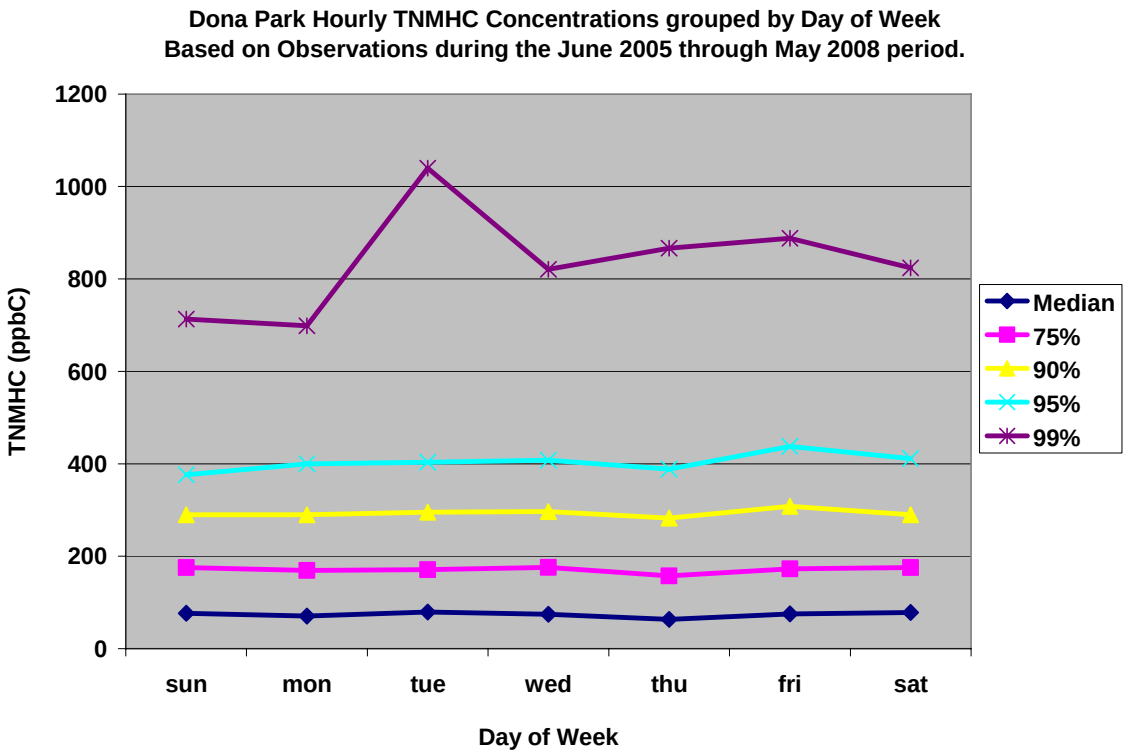

Figure A.4-4. Median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by Day of Week at the Dona Park monitoring station based on all valid data during the June 2005 through May 2008 period.

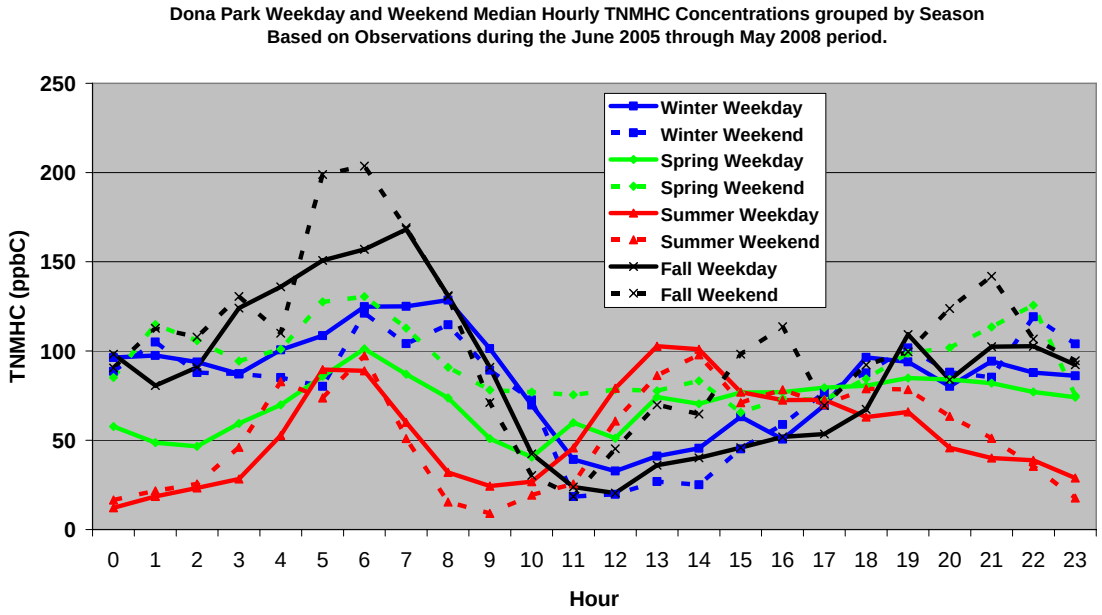

Figure A.4-5. Median hourly weekday and weekend day TNMHC concentrations grouped by season at the Dona Park monitoring station based on all valid data during the June 2005 through May 2008 period.

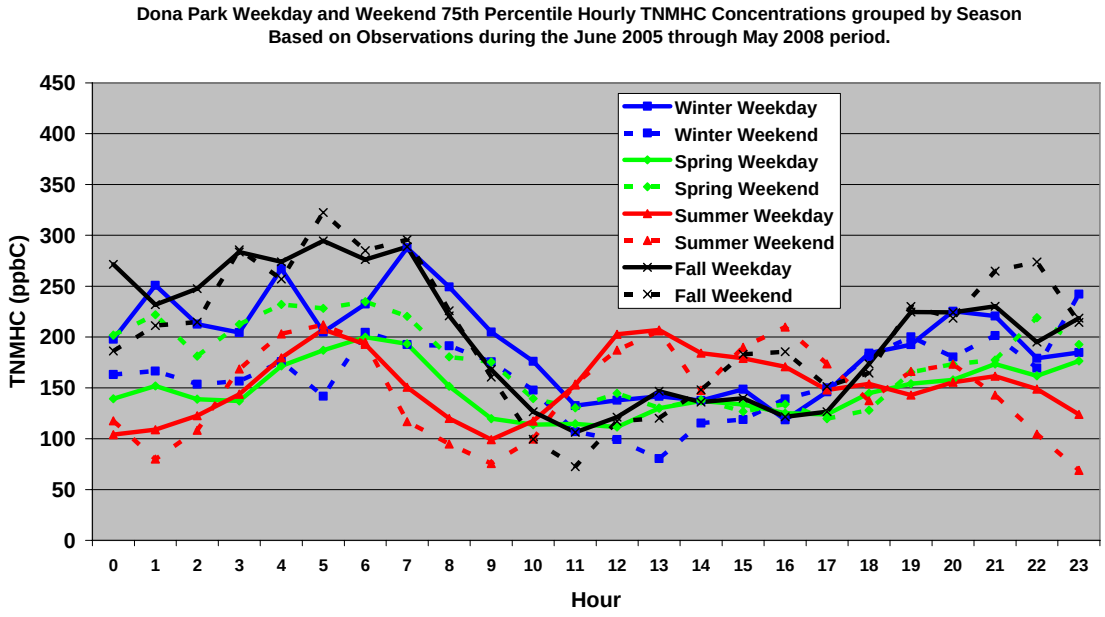

Figure A.4-6. The 75th percentile hourly weekday and weekend day TNMHC concentrations grouped by season at the Dona Park monitoring station based on all valid data during the June 2005 through May 2008 period.

Table A.4-1. High TNMHC events at the Dona Park monitoring station binned by duration in hours. High TNMHC events are defined as one or more consecutive hours characterized by TNMHC concentrations of 1000 ppbC or greater.

Duration of Event (hours)	Number of Events
1	54
2	19
3	6
4	9
5	4
>5	1
Total Events	**93**

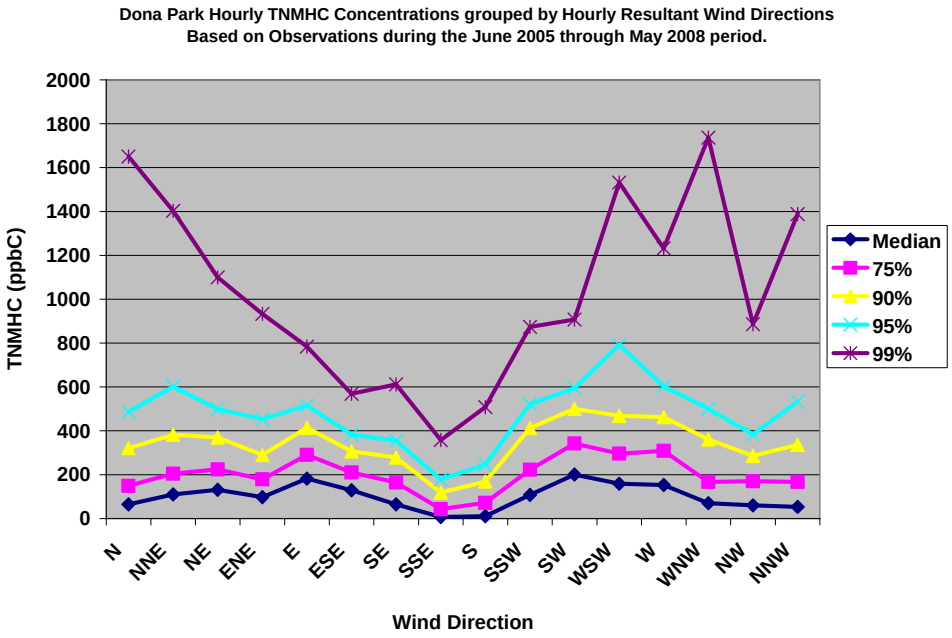

Figure A.4-7. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations grouped by hourly resultant wind direction at the Dona Park monitoring station based on all valid data during the June 2005 through May 2008 period.

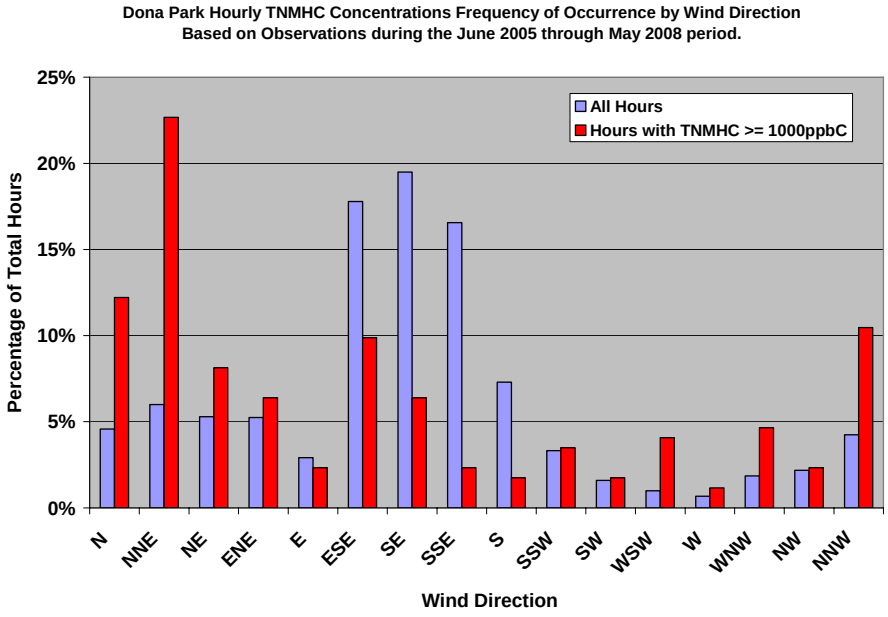

Figure A.4-8. Percentage of hours at the Dona Park monitoring station grouped by resultant wind direction for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppb or greater. Based on all valid data during the June 2005 through May 2008 period.

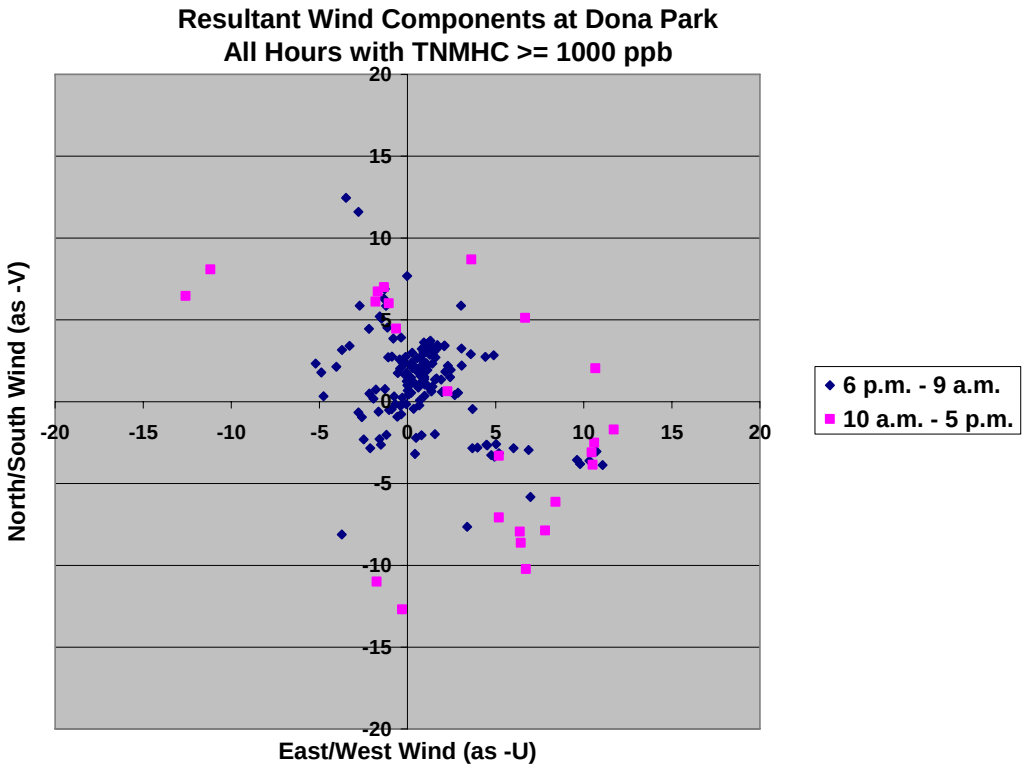

Figure A.4-9. Resultant wind component scatterplot at Dona Park for all hours with TNMHC concentrations of 1000 ppb or greater during the June 2005 through May 2008 period. (The reader is referred to Section 2.5 for a discussion of how to interpret this figure.)

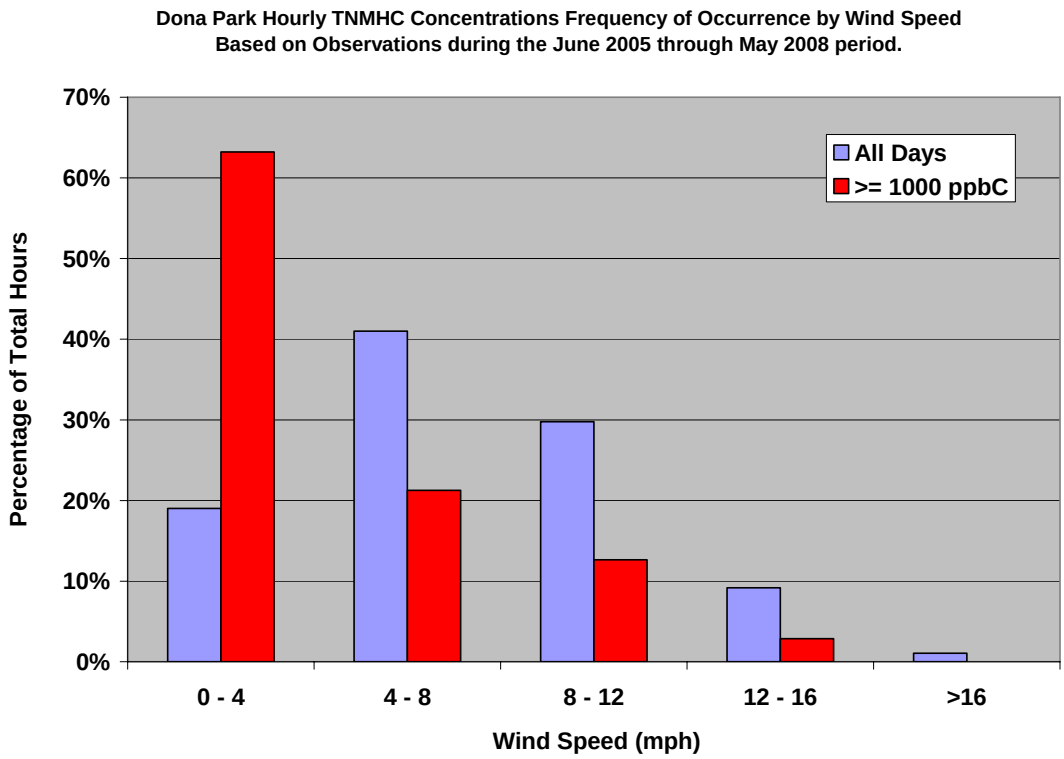

Figure A.4-10. Percentage of hours at the Dona Park monitoring station grouped by resultant wind speed (binned by 4 mph increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

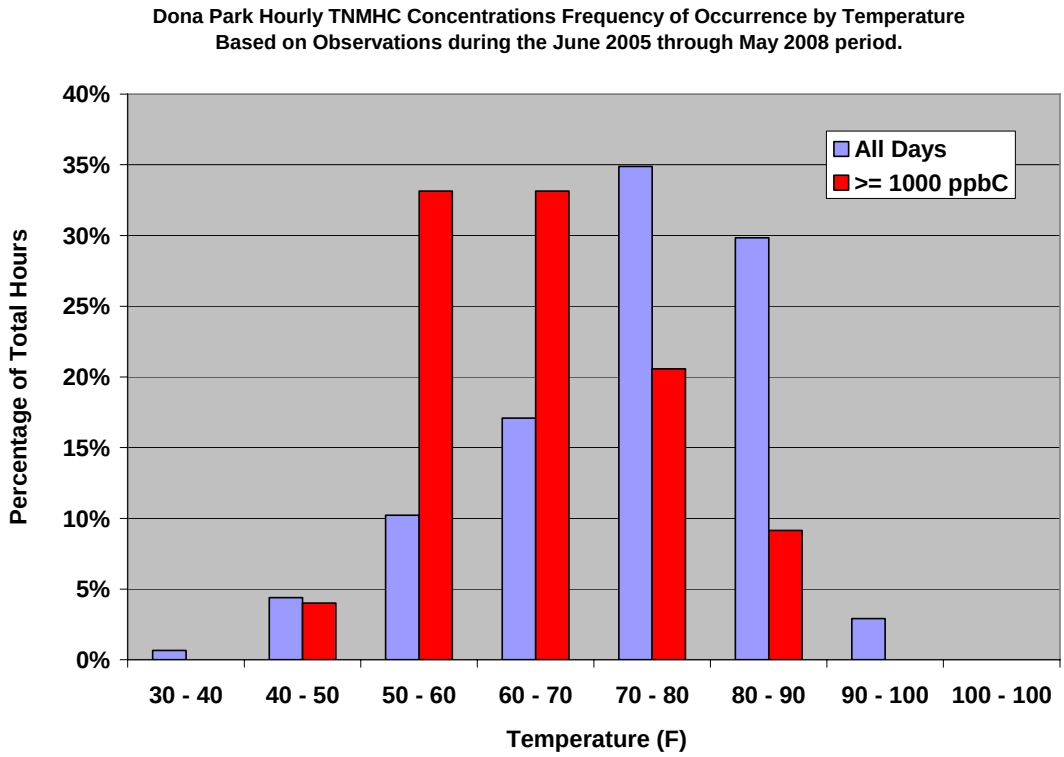

Figure A.4-11. Percentage of hours at the Dona Park monitoring station grouped by temperature (binned by 10 F increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

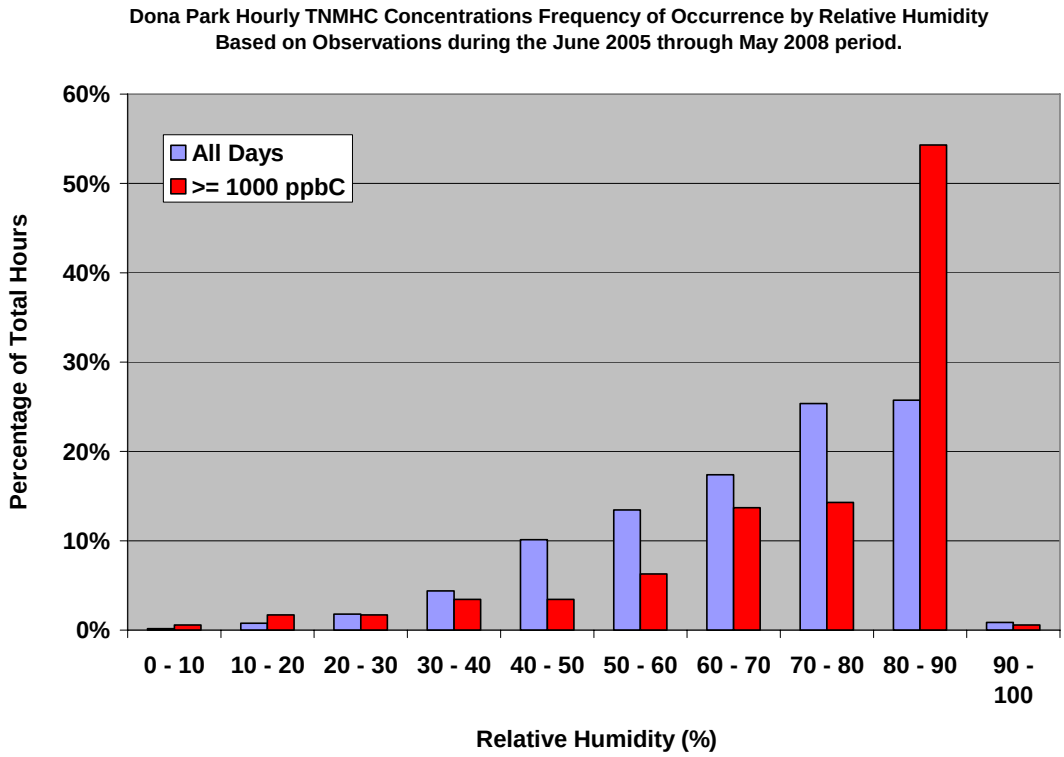

Figure A.4-12. Percentage of hours at the Dona Park monitoring station grouped by relative humidity values (binned by 10% increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

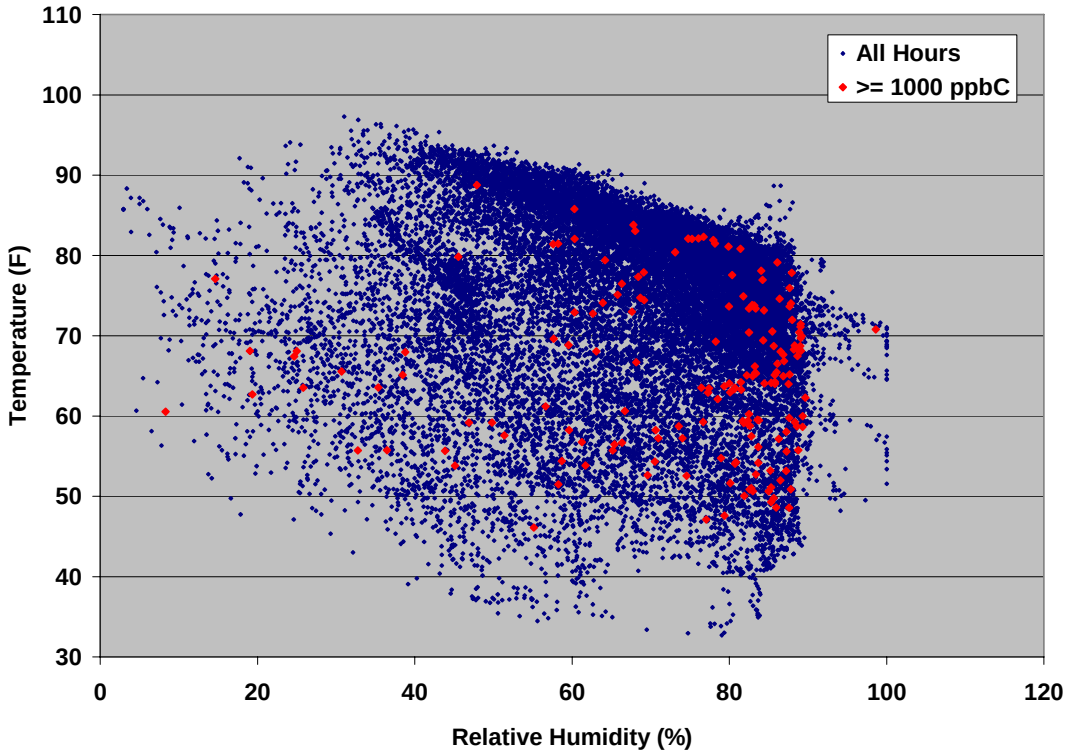

Figure A.4-13. Hourly temperature versus hourly relative humidity at the Dona Park monitoring station for all hours during the June 2005 through May 2008 period. Hours characterized by a TNMHC concentration of 1000 ppbC or greater are highlighted in red.

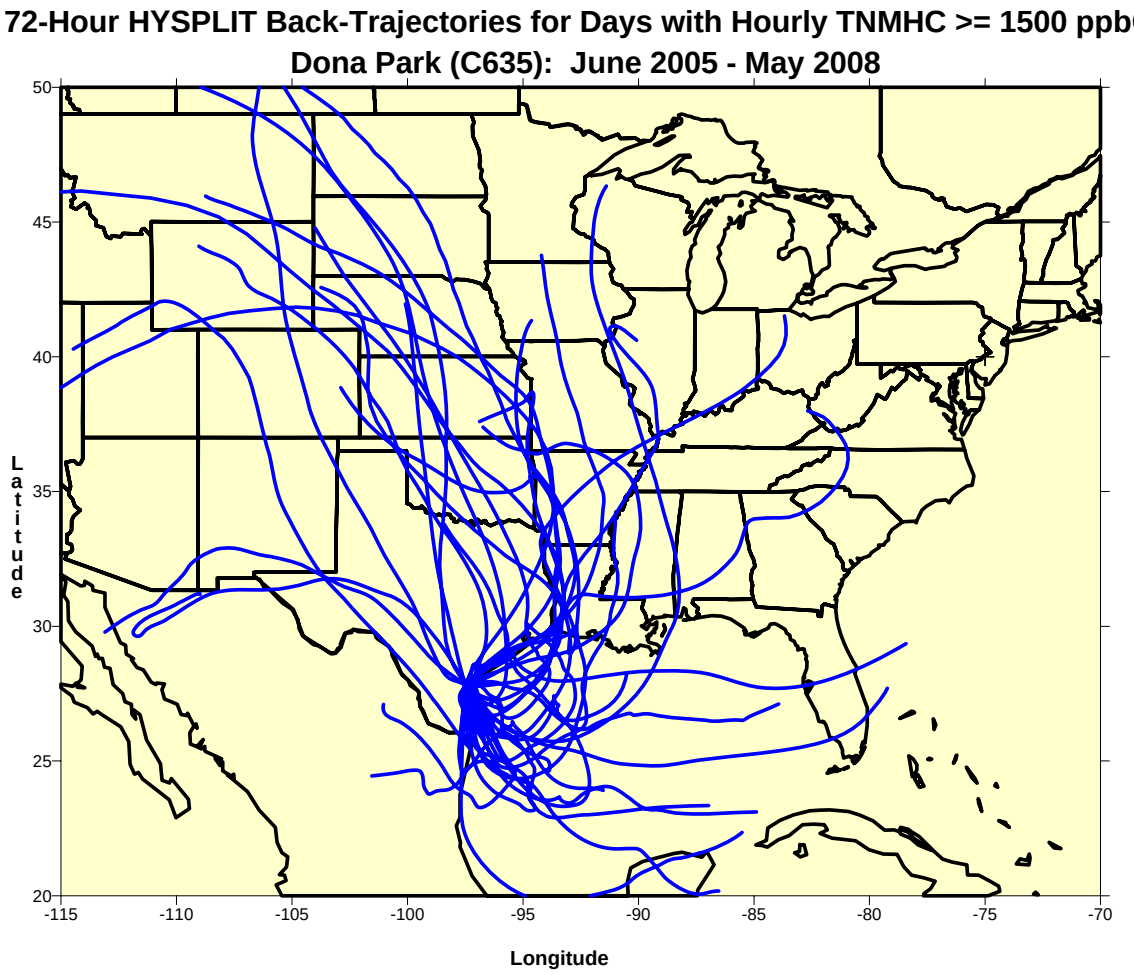

Figure A.4-14. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 38 days during the June 2005 through May 2008 period characterized by one or more hours with TNMHC concentrations of 1500 ppb or greater at the Dona Park monitoring station.

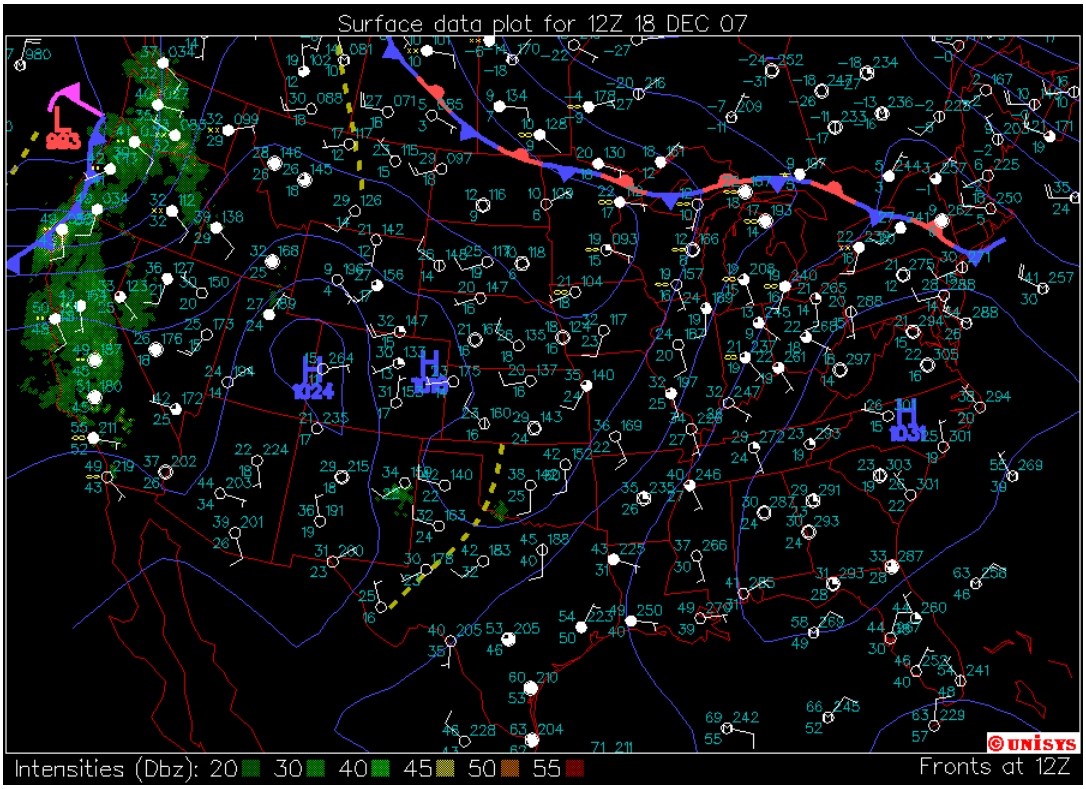

Figure A.4-15. Surface weather map at 0600 CST on December 18, 2007.

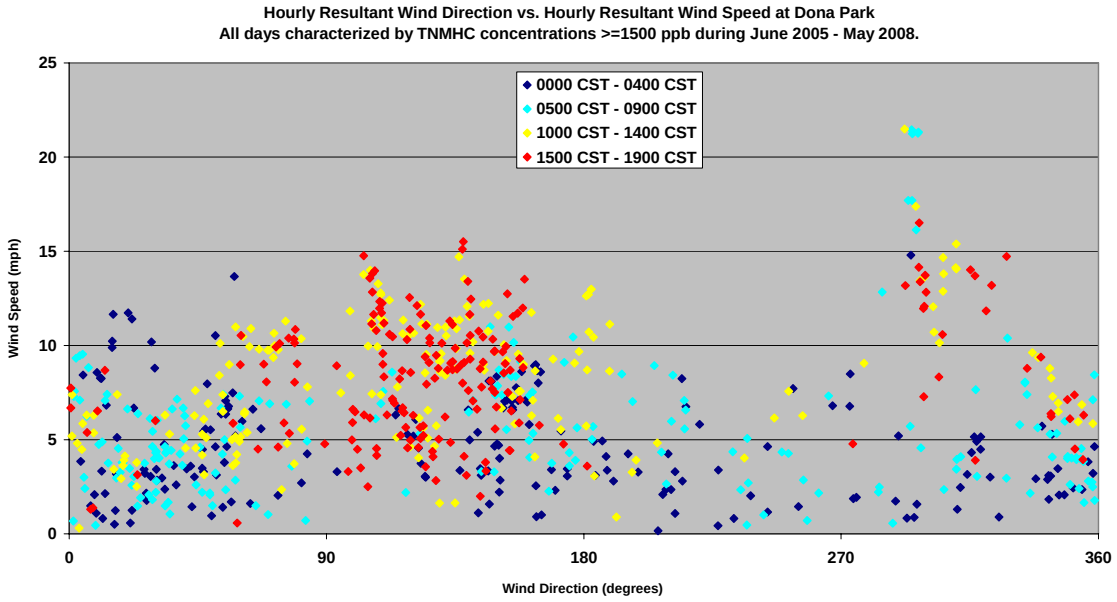

Figure A.4-16. Dona Park resultant wind direction versus the resultant wind speed for all hours on days characterized by one or more TNMHC concentrations of 1500 ppbC or greater.

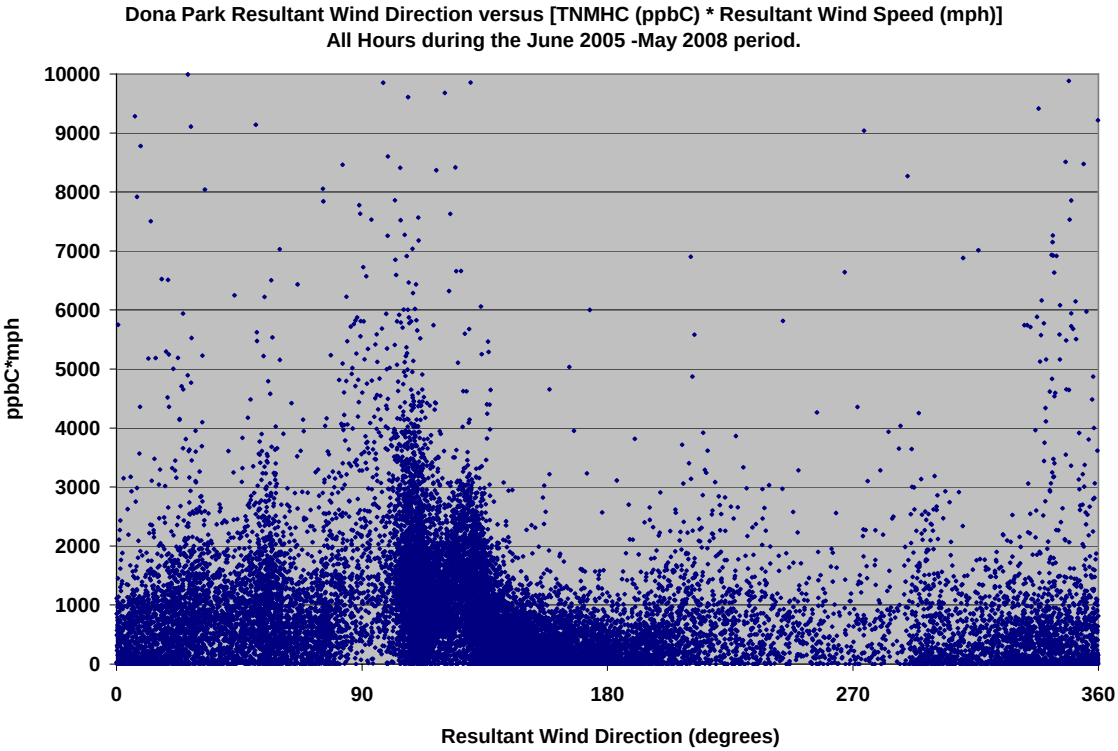

Figure A.4-17. Resultant wind direction (degrees) versus the product of the TNMHC concentration and the resultant wind speed (ppbC*mph) at the Dona Park monitoring station for all valid hours during the June 2005 through May 2008 period. Note that the chart scale has been defined for easy visualization of high density peaks so that observations above 10,000 ppbC*mph are not shown.

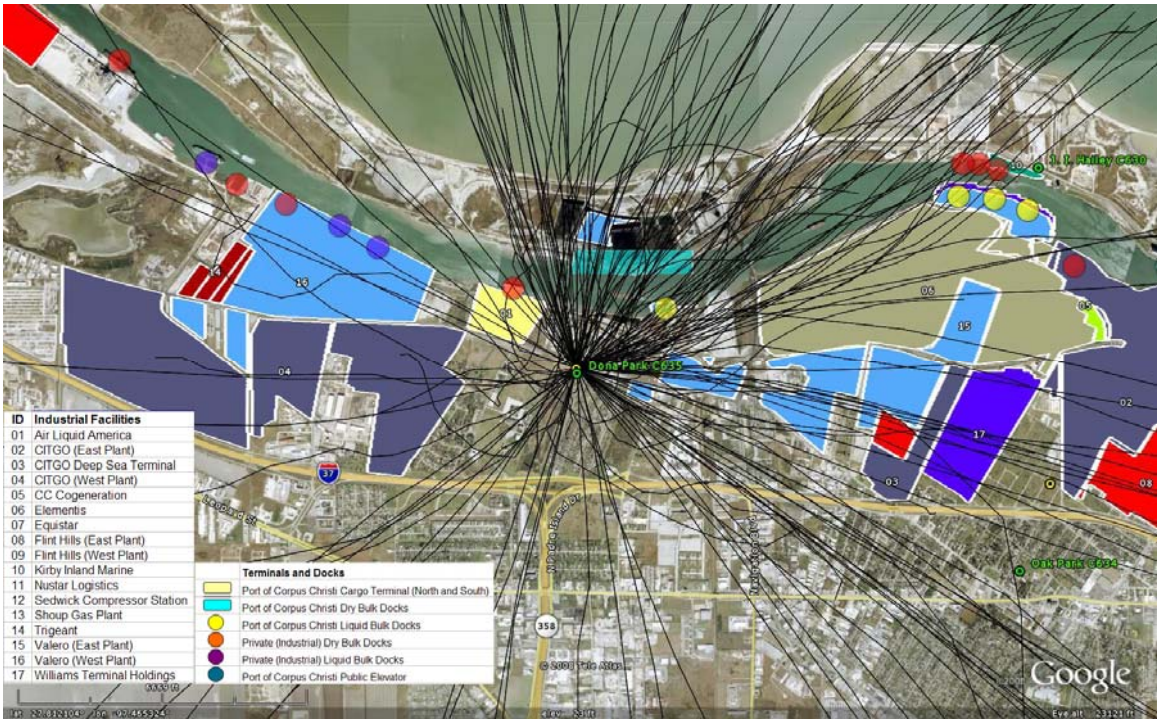

Figure A.4-18. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a TNMHC concentration of 1000 ppb or greater at the Dona Park monitoring station during the June 2005 through May 2008 period.

Figure A.4-19. Detail map of the Dona Park monitoring station and surrounding area. The Javelina incinerator is circled in red. The Valero and CITGO West Plants are located to the west of Dona Park, while the Valero East Plant is located immediately to the east of Dona Park. The petroleum coke tailings pile is characterized by the black areas located on the north side of Ship Channel. Also note various dry and/or liquid bulk loading/unloading docks along the Ship Channel.

A.5 Oak Park Recreation Center (C634) Monitoring Station

Figure A.5-1 shows the location of the Oak Park Recreation Center monitoring station (hereafter referred to as "Oak Park"). Oak Park is located in the Oak Park residential neighborhood approximately 0.25 miles south of Interstate 37. The nearest monitoring station operated by TCEQ is the Huisache monitoring station (CAMS 98) located approximately 0.5 miles to the north-northeast of Oak Park. A number of industrial facilities are located within 1.5 miles of the Oak Park monitoring station to the northwest (e.g., Valero East Plant, CITGO Deep Sea Terminal), north (e.g., Williams Terminal Holdings), and northeast (e.g., CITGO and Flint Hills East Plants). These industrial facilities are mostly to the north of Interstate 37 along the southern boundary of the Corpus Christi Ship Channel.

A.5.1 Seasonal, Day of Week, and Diurnal Variability in TNMHC Concentrations at Oak Park

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by month are shown in Figure A.5-2. For all metrics, the September through January period is characterized by the highest concentrations, with substantially lower concentrations during the months of February through August. The monthly 95th percentile concentration values (which roughly correspond to the 110th highest TNMHC concentration ranked by descending order) for September through January range from 1332 ppbC during January to 1655 ppbC for September. The monthly 95th percentile concentration values during the February though August period range from 542 ppbC during April to 812 ppbC during June.

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by hour are shown in Figure A.5-3. For all metrics, the nighttime hours are characterized by the highest concentrations, with a relative peak in concentration values during the morning hours of 0500 CST through 0700 CST. The 95th percentile concentration values (which roughly correspond to the 55th highest TNMHC concentration ranked by descending order) range from 509 ppbC at 1600 CST to 2015 ppbC at 0500 CST. The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by day of week are shown in Figure A.5-4. The 95th percentile concentration values (which roughly correspond to the 188th highest TNMHC concentration ranked by descending order) vary from 946 ppbC on Sunday to 1267 ppbC on Tuesday.

To investigate seasonal differences in the diurnal profiles by day of week, Figures A.5-5 and A.5-6 present the median and 75th percentile hourly TNMHC concentrations, respectively, grouped by season. Note that consistent and substantial differences between the weekday and weekend hourly profiles are not observed. Overall, Figure A.5-5 shows that the TNMHC hourly concentration values are lower throughout the day during Spring and Summer compared to the Fall and Winter seasons. For all seasons, the diurnal pattern is characterized by a relative peak in concentrations during the 0500 CST through 0700 CST period, with highest concentrations during Fall. During daytime hours, Winter

concentrations are relatively greater compared to those for the other seasons. The seasonal peak hourly median concentrations vary from 21 ppbC at 0700 CST on Spring weekdays to 348 ppbC at 0600 CST for Fall weekdays. The 75th percentile values (which roughly correspond to the 48th and 19th highest TNMHC concentration ranked by descending order for weekdays and weekend days, respectively) for the morning peak range from 155 ppbC at 0700 CST for Spring weekdays to 635 ppbC at 0600 CST on Fall weekdays.

A.5.2 TNMHC Event Duration at Oak Park

For the purpose of investigating the duration of high TNMHC events, TNMHC events were defined as one or more consecutive hours characterized by a concentration of 1000 ppbC or greater. Table A.5-1 presents the 177 high TNMHC events (binned by duration in hours) measured at the Oak Park monitoring station during the June 2005 through May 2008 period. The vast majority of events were characterized by durations of 1 hour (61% of total events) and 2 hours (25% of total events). For the remaining events with durations of 3 hours or greater, the majority occurred during the late night and morning hours throughout the November through January period

A.5.3 Local Meteorological Conditions during High TNMHC Events at Oak Park

Figure A.5-7 presents the median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations binned by the hourly resultant wind direction. For all statistical metrics, relative maxima in TNMHC concentrations are observed during hours characterized by north-northeasterly and northwesterly resultant wind directions. Overall, elevated TNMHC concentrations are more frequent for hours with resultant wind directions characterized by a northerly and/or westerly component. The 95th percentile concentration values (which roughly correspond to the 82nd highest TNMHC concentration ranked by descending order) are 1532 ppbC and 2314 ppbC for hours with north-northeasterly and northwesterly resultant wind directions, respectively. Figure A.5-8 presents the frequency of occurrence by wind direction for all hours during the June 2005 through May 2008 period and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater. The frequency of occurrence of high TNMHC concentrations is far greater than the climatological frequency of occurrence for hours characterized by winds with a northerly or westerly component. Note that high TNMHC concentrations occur rarely during periods of southerly or southeasterly winds despite the relatively high climatological frequency of occurrence of winds with a southerly component.

Figure A.5-9 shows the wind component scatterplot for all hours characterized by a TNMHC concentration of 1000 ppbC or greater, grouped by time of occurrence during the 1800 CST through 0900 CST (corresponding to evening/nighttime/morning) and 1000 CST through 1700 CST (corresponding to late morning/afternoon) time periods. (Refer to Section 2.5 of this report for a discussion of how to interpret the wind component scatterplot.) Consistent with the diurnal profile shown in Figure A.5-3, high TNMHC concentrations occur predominantly during the 1800 CST through 0900 CST

time period. Note that daytime events are characterized by relatively high wind speeds, and are mostly divided between hours characterized by northeasterly and northwesterly winds. For the nighttime events, wind speeds are light to calm during hours characterized by winds with a westerly component. Wind speeds vary between calm and approximately 8 mph for the northeasterly events.

Figure A.5-10 presents the frequency of occurrence for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater for five wind speed ranges (binned by 4 mph increments). Highest TNMHC concentrations predominate during hours characterized by wind speeds of 4 mph or less. For the lowest wind speed bin, the frequency of occurrence for all hours and for 1000 ppbC TNMHC hours only is 22% and 51%, respectively. Most hours at Oak Park (74%) are characterized by wind speeds between 4 and 12 mph. These wind speeds account for 26% of high TNMHC events.

Figure A.5-11 presents the frequency of occurrence for all hours and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater for eight temperature ranges (binned by 10 F increments). Hours characterized by temperatures between 70 F and 80 F account for the highest percentage (38%) of 1000 ppbC TNMHC events. Figure A.5-11 indicates that the remaining hours characterized by high TNMHC concentrations are associated with relatively low temperatures. For example, note that while hours characterized by temperatures of 60 F or lower are limited to 16% of all hours, 40% of high TNMHC concentrations occur at this temperature range. In contrast, 40% of all hours are characterized by temperatures greater than 80 F, but only 8% of high TNMHC concentrations occur at this temperature range. Note that the tendency for high TNMHC events at low temperatures is consistent with the previously demonstrated greatest frequency of occurrence of high TNMHC events during Fall and Winter nighttime hours, which would be generally characterized by relatively low temperatures.

Figure A.5-12 presents the frequency of occurrence for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater for ten relative humidity (as a percent) ranges. High TNMHC concentrations predominate at hours characterized by relatively high relative humidity values. While 48% of all hours are characterized by relative humidity values of 70% or higher, 79% of high TNMHC concentrations occur at these high humidity levels. Figure A.5-13 presents a scatterplot of hourly temperature versus hourly relative humidity for all days during the June 2005 through May 2008 period. Hours characterized by TNMHC concentrations of 1000 ppbC or greater are plotted in red. The highest density of observations is found along the top right portion of the scatterplot, which indicates hours characterized by relatively warm temperatures and mid- to high relative humidity values. This portion of the scatterplot is representative of most days during the spring through fall period, with nighttime hours located on the right side at relatively high humidity values and daytime hours located to the left at the lower humidity value ranges. As supported by previous analyses, high TNMHC concentrations occur most often during the nighttime hours during the Fall season, which correspond to the upper right portion of the scatterplot. The remainder of the scatterplot contains observations collected primarily during the Winter season at

relatively cooler temperatures. The scatter indicates a wide range of humidity and temperature values, consistent with the periodic intrusions of relatively drier and colder air in association with cold fronts that pass through South Texas. The high TNMHC concentrations in this portion of the scatterplot predominantly occur during the nighttime and early morning hours during the Winter months, and are characterized by a higher number of hours with relative humidity values less than 70% compared to the other seasons.

A.5.4 Large-Scale Weather Patterns during High TNMHC Events at Oak Park

Due to the labor intensiveness required to review daily weather maps, the TNMHC concentration threshold used to define high TNMHC events was increased from 1000 ppbC to 1500 ppbC to limit the number of individual days for analysis. To investigate the large-scale weather features that predominate during high TNMHC events, 72-hour HYSPLIT back-trajectories were generated for all days during the June 2005 through May 2008 period that were characterized by one or more hours with a TNMHC concentration of 1500 ppbC or greater at the Oak Park monitoring station. Figure A.5-14 shows the 57 back-trajectories on high TNMHC days. The back-trajectories were initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface. The majority of back-trajectories are characterized by a clockwise curvature of the long-range winds, consistent with the large-scale circulation around a ridge of high pressure that extends southward or southwestward into Texas. The back-trajectories shown in Figure A.5-14 can visually be classified into three general categories characterized by long-range flow from the (1) north, (2) east-northeast, and (3) southeast.

Figure A.5-15 presents the surface weather map for November 29, 2005, a day with an exceptionally long-range 72-hour back-trajectory that began just north of Montana. At upper levels, a southward dip in the jet stream, which flowed northward from Texas to the northeastern US, was associated with the passage of a strong cold front through Texas. The eastward-moving cold front shown in Figure A.5-15 stretches from a deep center of surface low pressure north of the Great Lakes southward through the Florida Panhandle into the Gulf of Mexico. The counterclockwise circulation around the large low pressure system combined with the clockwise flow around the surface ridge of high pressure over the southwestern US and Texas to generate widespread northerly surface winds over Texas. These northerly winds transported much colder and drier air into the state, and morning low temperatures in Corpus Christi decreased from near 60 F on November 28th to the middle 40 F range on November 29th. Surface winds measured at the Oak Park monitoring station were calm to light northwesterly in the morning followed by northeasterly in the afternoon at 5-6 mph. The calm nighttime winds were associated with elevated TNMHC concentrations throughout the morning hours at the Oak Park monitoring station, with a maximum one-hour concentration of 2659 ppbC at 0500 CST.

The second general category of long-range circulation patterns on high TNMHC days based on Figure A.5-14 is associated with long-range flow from the east-northeast into Texas. Figure A.5-16 presents the surface weather map for October 8, 2006, a day

characterized by long-range flow from the east-northeast of Corpus Christi. At upper levels, a weak low pressure trough extended from the Texas Panhandle to Southeast Texas. Note two surface cold fronts in Figure A.5-16, the first located across the Central Plains and a second stretching across central Florida westward into the central Gulf of Mexico. The passage of the cold front over Florida through Texas during the previous days was associated with the southward expansion of a large surface ridge of high pressure into Texas. Figure A.5-16 shows the high pressure ridge is centered over the northeastern US and stretches southwestward into Texas. At the Oak Park monitoring station, light morning winds from the northwest or northeast were associated with elevated TNMHC concentrations throughout the morning, with a maximum TNMHC concentration of 1513 ppbC at 0700 CST. Afternoon winds were generally easterly to east-northeasterly at 6-7 mph.

Finally, Figure A.5-17 presents the surface weather map for September 20, 2005, a day characterized by long-range winds from the southeast over the Gulf of Mexico. Clouds and showers are associated with a cold front that extends from a low pressure center north of the Great Lakes southwestward into Oklahoma. A strong center of high pressure was located at upper levels over Texas, enhancing atmospheric subsidence and maintaining generally dry conditions away from the coastal areas. A surface ridge of high pressure extends along a northeast-southwest axis from southeast Texas to the mid-Atlantic states. Temperatures in Corpus Christi ranged from the upper 70 F range in the early morning hours to the high 90 F range in the afternoon. At Oak Park, early morning winds were calm to light northwesterly in the morning followed by east-southeasterly afternoon winds at 8-9 mph. Hourly TNMHC concentrations remained elevated throughout the day with a maximum value of 1943 ppbC at 0700 CST.

A review of the large-scale surface weather maps for the 57 high days characterized by maximum hourly TNMHC concentrations of 1500 ppbC or greater reveals that a high pressure ridge often extends southward, southwestward, or westward into Texas. These surface high pressure systems are often associated with cold fronts that have moved through Texas, and the weak horizontal pressure gradients over the Corpus Christi area are associated with light winds speeds and (likely) stable atmospheric conditions. To explore the daily evolution of surface winds in the Corpus Christi area on high TNMHC days, Figure A.5-18 presents the resultant wind direction versus the resultant wind speed for all hours during the 57 high TNMHC days. Note that the observations are grouped by hour. During the 0000 CST through 0400 CST time period, the resultant wind direction is highly variable associated with calm to very light wind speeds less than 4 mph. For the 0500 CST through 0900 CST period, which includes a majority of the highest TNMHC concentrations, wind speeds vary from calm to 6 mph and the resultant hourly wind direction is most often characterized by a northerly component. By the late morning hours, turbulent mixing by convective thermals breaks through the nighttime radiation inversion, and higher momentum air dominated by the large-scale flow is likely mixed to the surface. With the deepening of the mixed layer, most days are characterized by easterly winds at 5-9 mph during the late morning hours, becoming east-northeasterly by the late afternoon.

A.5.5 Analysis and Summary of Oak Park TNMHC and Meteorological Measurements

Air quality analyses were performed using the hourly TNMHC, resultant wind speed, resultant wind direction, temperature, and relative humidity measurements collected at the Oak Park monitoring station during the June 2005 through May 2008 period. The Oak Park monitoring station is located in the Oak Park residential neighborhood immediately south of Interstate 37, which runs east-west along the southern portion of the Corpus Christi Ship Channel. A number of industrial facilities are located within a radius of 1.5 miles to the northwest, north, and northeast of Oak Park.

The highest hourly TNMHC concentrations (>= 1000 ppbC) typically occur during the September through January period. Concentrations are highest during the nighttime hours with a peak in the frequency of occurrence during the 0500 CST through 0700 CST period. The majority of high TNMHC events (86%) are one to two hours in duration. The majority of events three hours or greater in duration occurred throughout the late night and morning hours during the November through January period.

Day of the week profiles using data from all seasons demonstrate no substantial difference between concentrations measured on weekdays compared to weekends. The seasonal median hourly TNMHC concentration by day of the week does indicate a slight difference for Fall, with a median hourly concentration of 300 ppbC on weekdays compared to 350 ppbC on weekends; however, other metrics (e.g., 75^{th} percentile concentration values) by day of week reveal no consistent differences between weekday and weekend concentrations for any season.

A wind direction analysis indicates that the highest TNMHC concentrations occurred during hours with north-northeasterly or northwesterly resultant wind directions with resultant wind speeds of 4 mph or less. The majority of high TNMHC concentrations occur during hours with temperatures of 80 F or less with relative humidity values of 70% or higher. These temperature and relative humidity conditions are consistent with the observed nighttime peak in TNMHC concentrations during the fall and winter months, which would be characterized by relatively high relative humidity values and relatively low temperatures.

The surface weather maps on days characterized by one or more hours with maximum TNMHC concentrations of 1500 ppbC or higher often show a high pressure ridge that extends southward, southwestward, or westward into Texas. These surface high pressure systems often move into Texas behind cold fronts, and are typically associated with light wind speeds at the surface and (likely) stable atmospheric conditions. The diurnal variation of surface winds at the Oak Park monitoring station on these days is often characterized by calm to light northwesterly morning winds, followed by light to moderate late morning/afternoon easterly winds becoming east-northeasterly during the late afternoon hours. The clockwise rotation of the coastal wind direction has often been observed along the upper Texas coast, and is likely associated with the diurnal and

inertial components of the land and sea breeze circulations (Nielsen-Gammon et al., 2002a, 2002b; UT, 2008) that become most apparent during periods of large-scale weather patterns characterized by weak horizontal pressure gradients.

The strong wind directionality of the highest TNMHC concentrations suggests upwind (non-mobile) emissions sources located to the north-northeast and northwest of the Oak Park monitoring station. These emissions sources are likely associated with the industrial facilities located immediately north of Interstate 37.

A.5.6 Upwind Emission Sources during High TNMHC Events at Oak Park

The analyses presented previously for Oak Park did not attempt to account for the hourly variation in atmospheric dispersion conditions. One method to provide some normalization of measured pollutant concentrations with respect to varying atmospheric dispersion conditions is to multiply the concentration by the wind speed. Figure A.5-19 presents a scatterplot of the hourly resultant wind direction (degrees) versus the product of the hourly TNMHC concentrations and the hourly resultant wind speed (ppbC-mph) for all hours during the June 2005 through May 2008 period. The results are consistent with the wind direction analyses shown previously, with the highest TNMHC concentrations associated with hours characterized by north-northeasterly and northwesterly winds. In addition, note that very low concentration-wind speed values are rare during periods of north-northeasterly winds, suggesting a continuous source of emissions located in the upwind region.

To identify the local emissions sources at upwind industrial facilities that may impact TNMHC concentrations at Oak Park, the Corpus Christi Trajectory Analysis Tool was used to generate one-hour surface back-trajectories for all hours characterized by a TNMHC concentration of 1000 ppbC or higher. Each back-trajectory was initialized at the half-hour (i.e., midpoint) of the TNMHC one-hour averaging period. Figure A.5-20 plots the one-hour back-trajectories over a geographic map of the Oak Park area. The trajectory paths occur predominantly at locations found to the northwest, north, and northeast of Oak Park monitoring station. The highest density of back-trajectories to the north-northeast most often places the CITGO East Plant in the upwind area. The northerly to northwesterly back-trajectories pass over portions of the Williams Terminal Holdings, CITGO Deep Sea Terminal, and Valero East Plant industrial facilities.

Figure A.1-21 provides a zoomed map of Oak Park and the surrounding area using Google satellite imagery. Routine operational activities in support of the CCAQP include near real-time investigation of local emissions sources that may have contributed to high TNMHC events. Previous pollution event analyses have found that high TNMHC concentrations often occur during periods of northwesterly winds consistent with the transport of emissions from the Valero East Plant into the Oak Park area, or during northeasterly flow consistent with the transport of emissions from the CITGO East Plant. Oak Park is also often affected by typical urban emissions from the heavily populated areas located to the south.

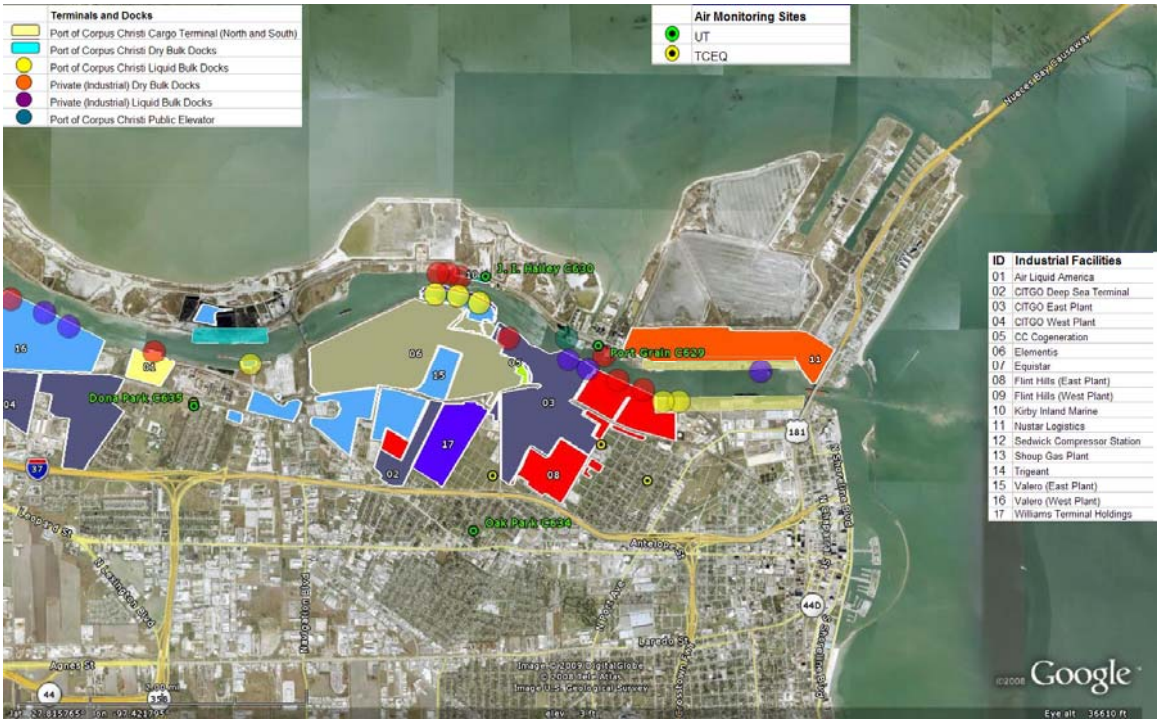

Figure A.5-1. Locations of the Oak Park (C634) monitoring station, nearby CAMS, and surrounding industrial facilities. The Corpus Christi Ship Channel is oriented east-west along the middle of the figure.

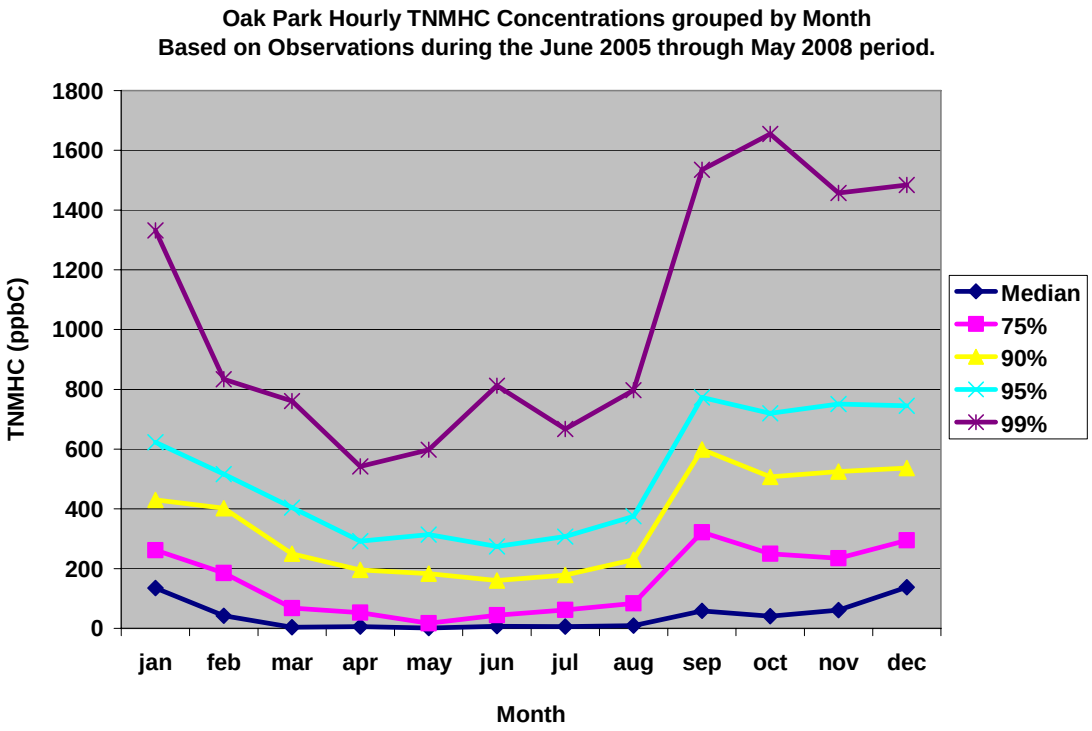

Figure A.5-2. Monthly median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

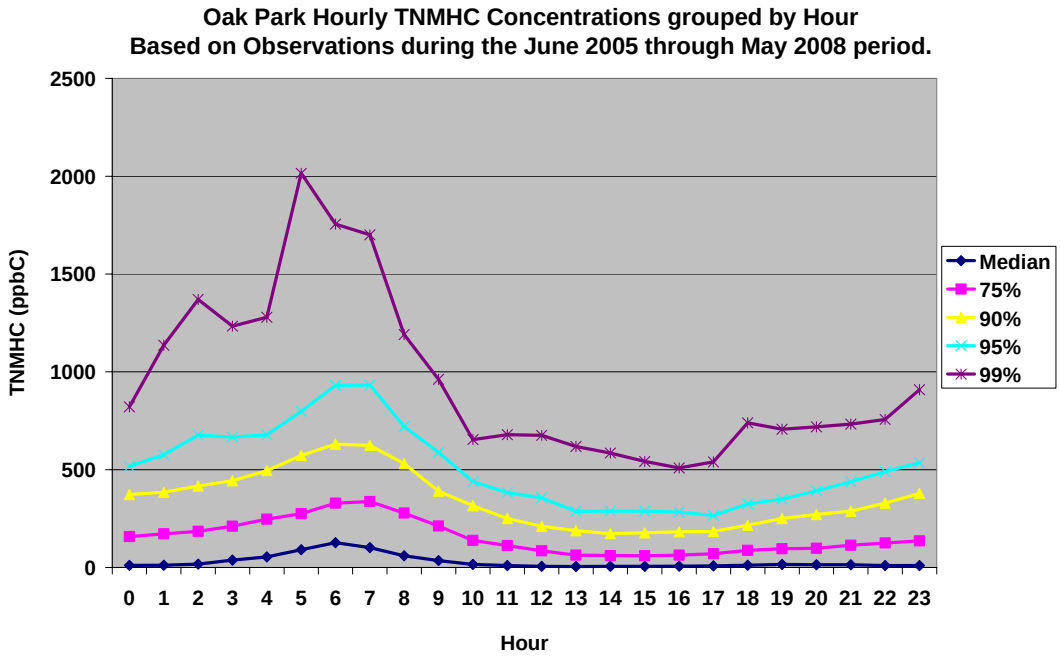

Figure A.5-3. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations at the Oak Park monitoring station by hour based on all valid data during the June 2005 through May 2008 period.

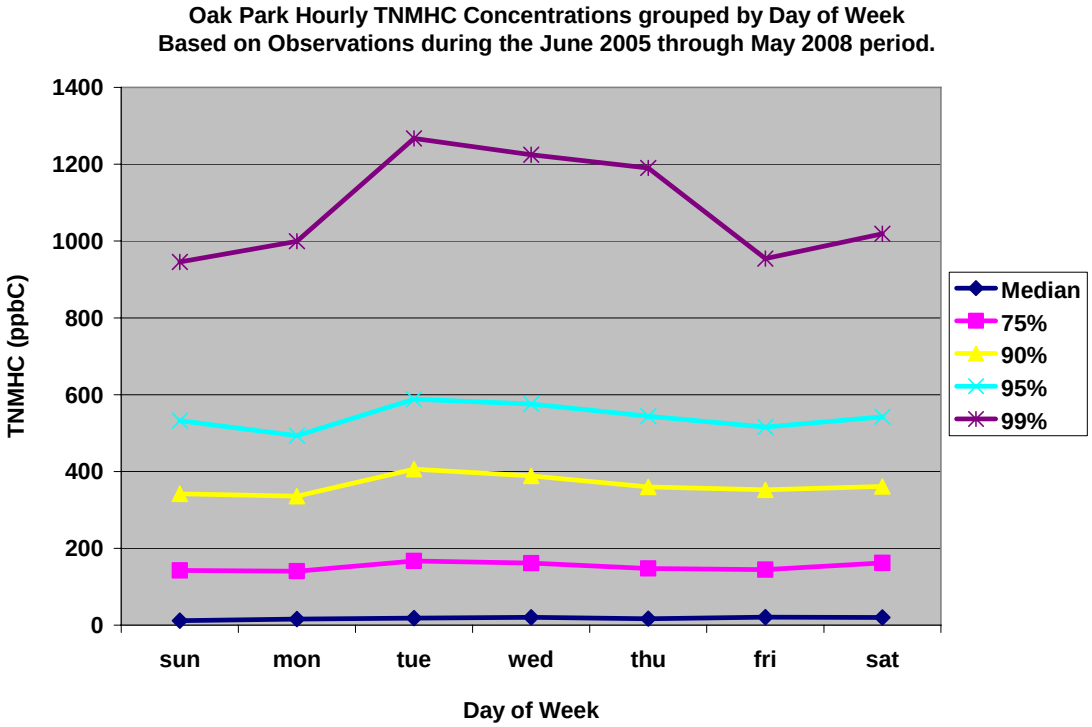

Figure A.5-4. Median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by Day of Week at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

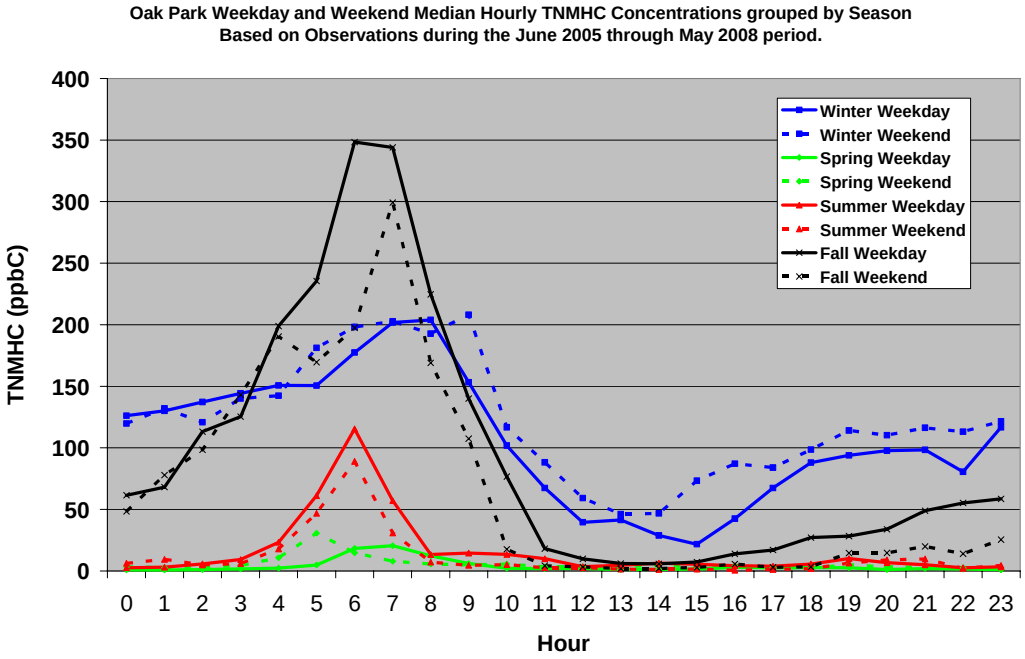

Figure A.5-5. Median hourly weekday and weekend day TNMHC concentrations grouped by season at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

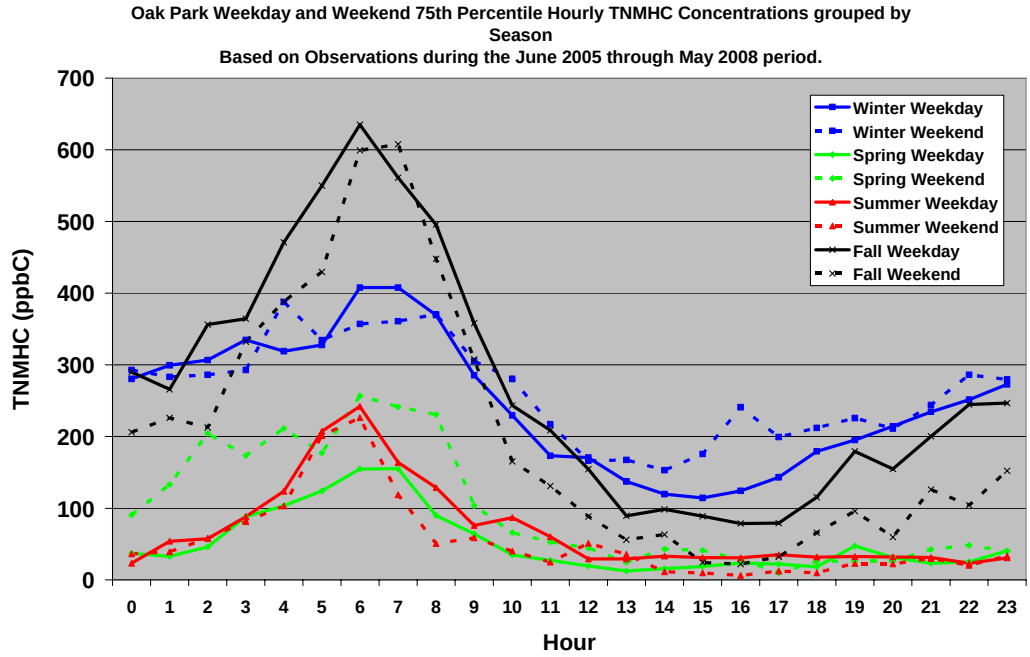

Figure A.5-6. The 75th percentile hourly weekday and weekend day TNMHC concentrations grouped by season at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

Table A.5-1. High TNMHC events at the Oak Park monitoring station binned by duration in hours. High TNMHC events are defined as one or more consecutive hours characterized by TNMHC concentrations of 1000 ppbC or greater.

Duration of Event (hours)	Number of Events
1	108
2	45
3	13
4	6
5	3
>5	2
Total Events	**177**

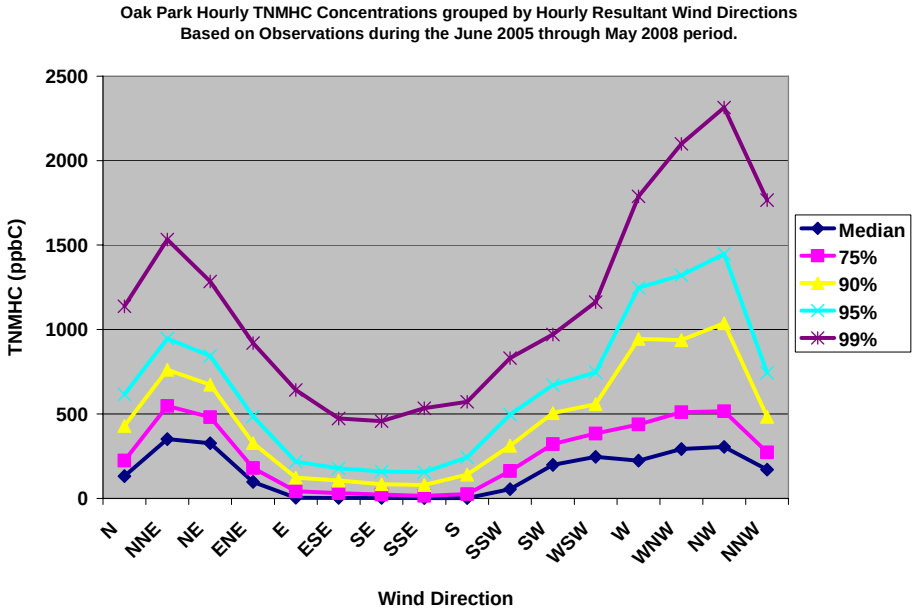

Figure A.5-7. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations grouped by hourly resultant wind direction at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

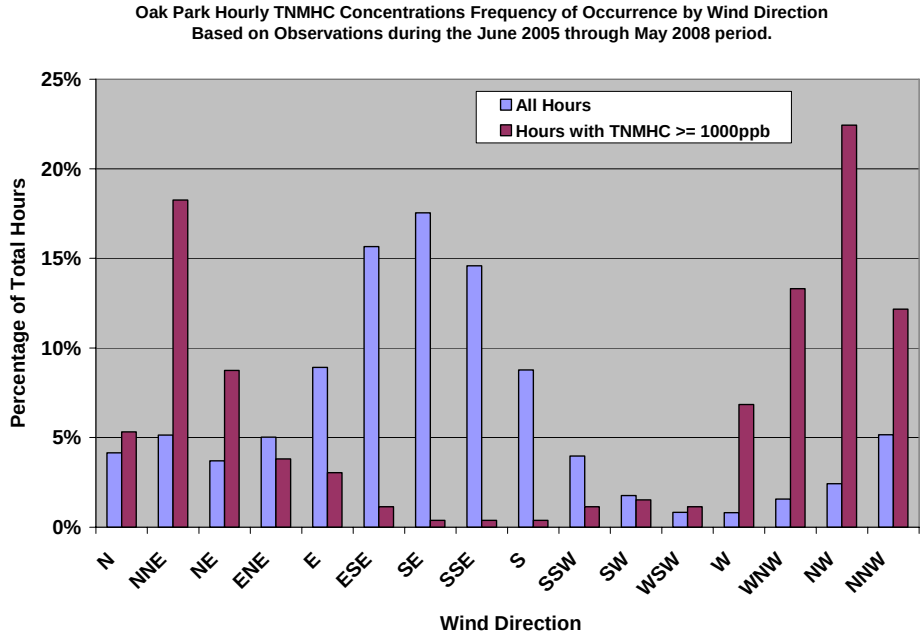

Figure A.5-8. Percentage of hours at the Oak Park monitoring station grouped by resultant wind direction for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppb or greater. Based on all valid data during the June 2005 through May 2008 period.

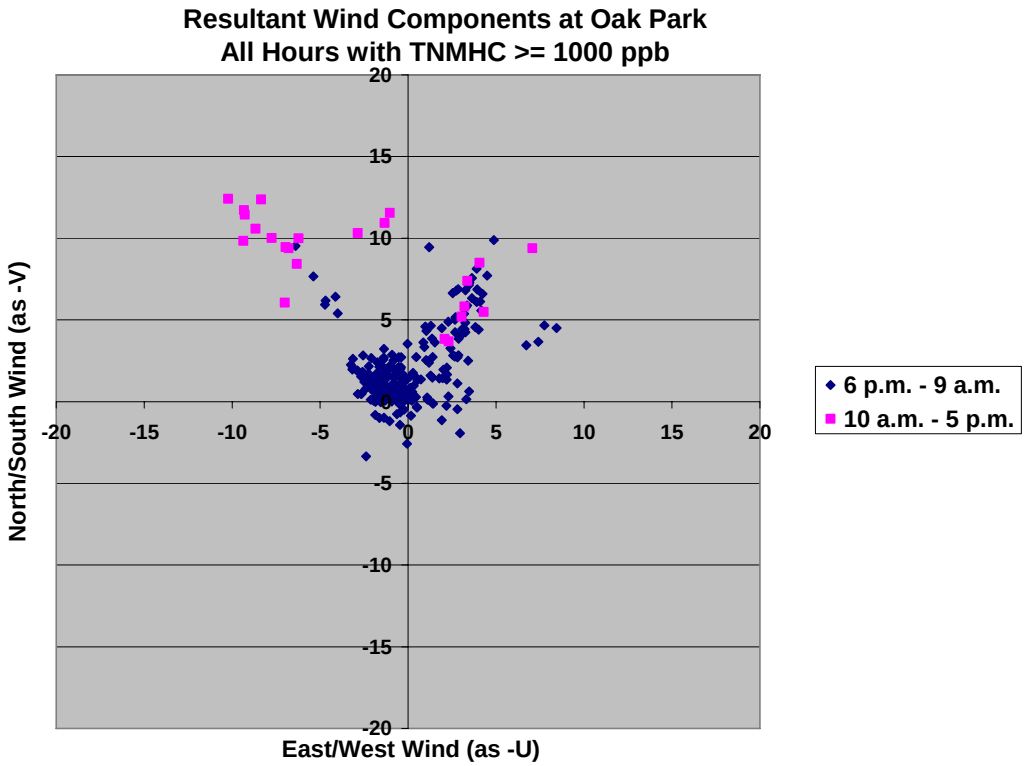

Figure A.5-9. Resultant wind component scatterplot at Oak Park for all hours with TNMHC concentrations of 1000 ppb or greater during the June 2005 through May 2008 period. (The reader is referred to Section 2.5 for a discussion of how to interpret this figure.)

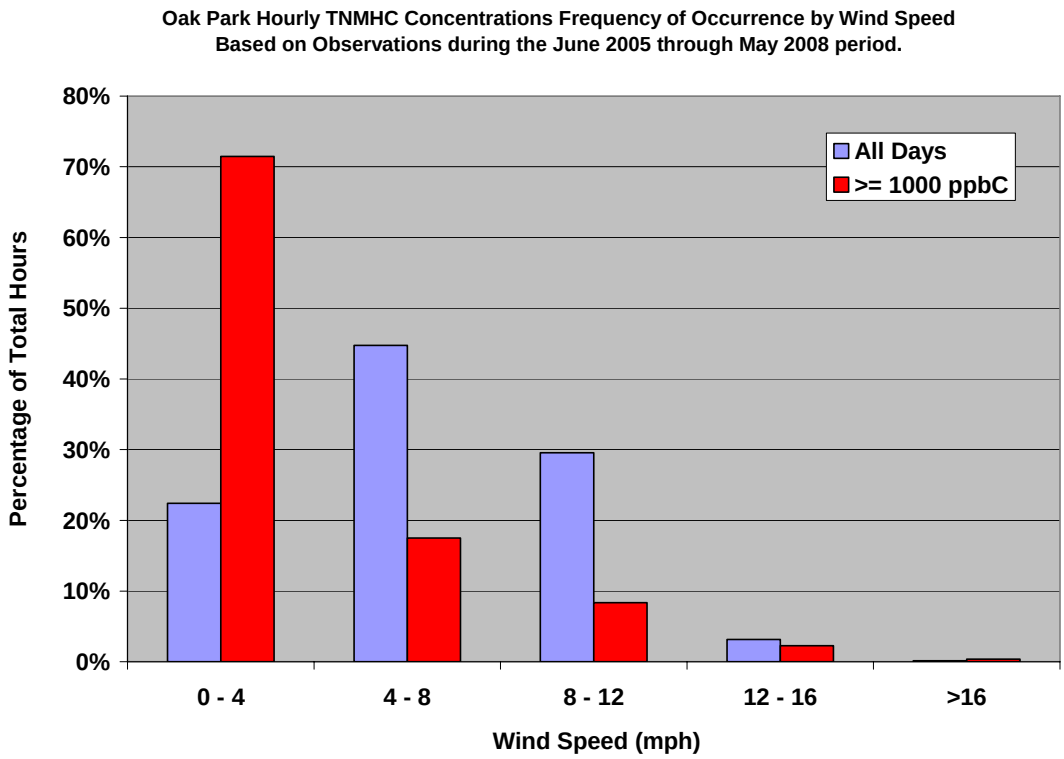

Figure A.5-10. Percentage of hours at the Oak Park monitoring station grouped by resultant wind speed (binned by 4 mph increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

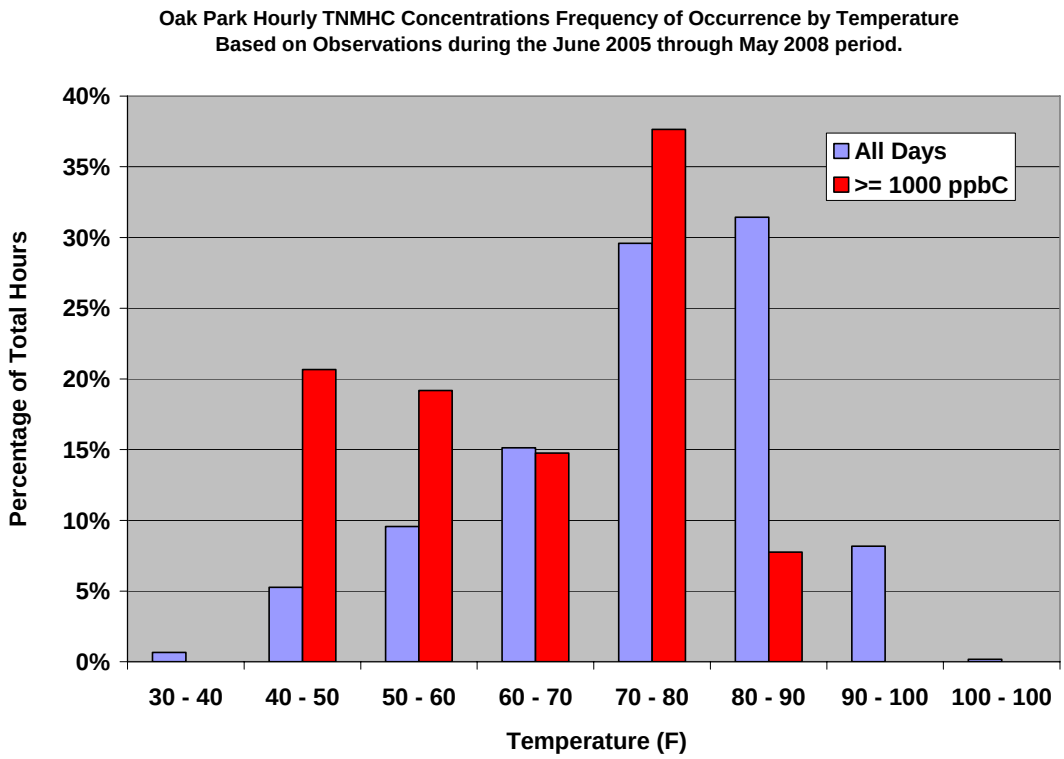

Figure A.5-11. Percentage of hours at the Oak Park monitoring station grouped by temperature (binned by 10 F increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

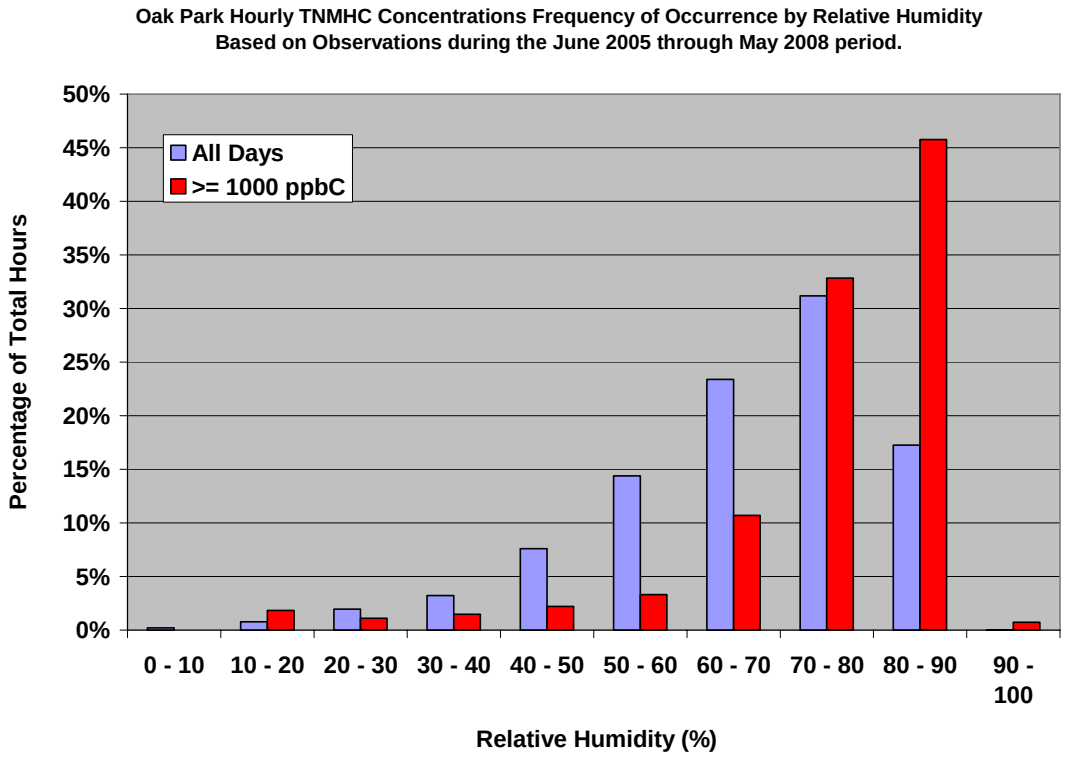

Figure A.5-12. Percentage of hours at the Oak Park monitoring station grouped by relative humidity values (binned by 10% increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

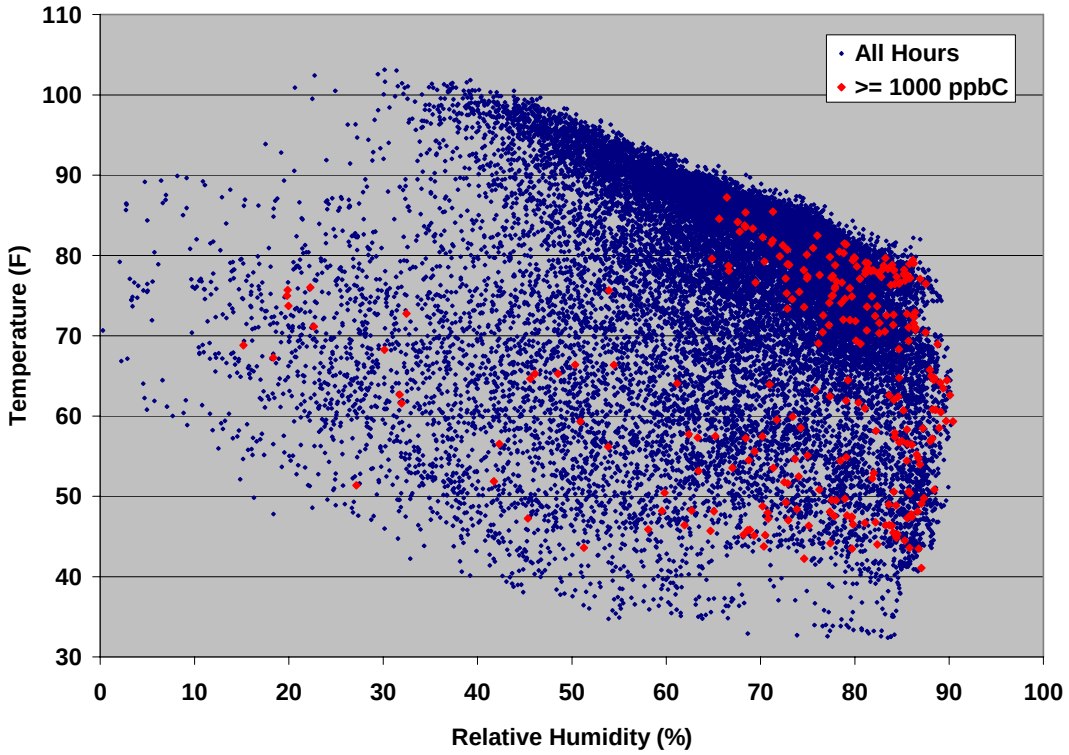

Figure A.5-13. Hourly temperature versus hourly relative humidity at the Oak Park monitoring station for all hours during the June 2005 through May 2008 period. Hours characterized by a TNMHC concentration of 1000 ppbC or greater are highlighted in red.

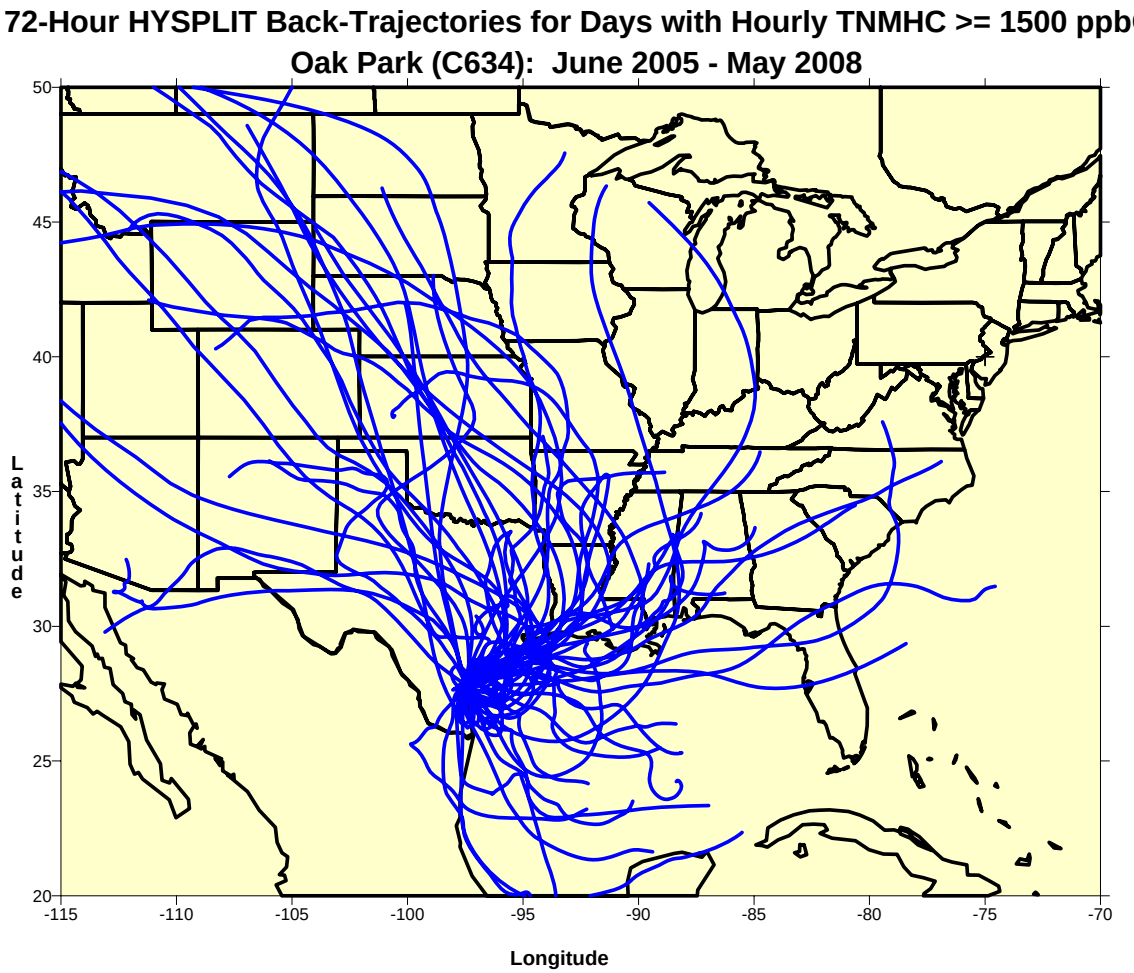

Figure A.5-14. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 57 days during the June 2005 through May 2008 period characterized by one or more hours with TNMHC concentrations of 1500 ppb or greater at the Oak Park monitoring station.

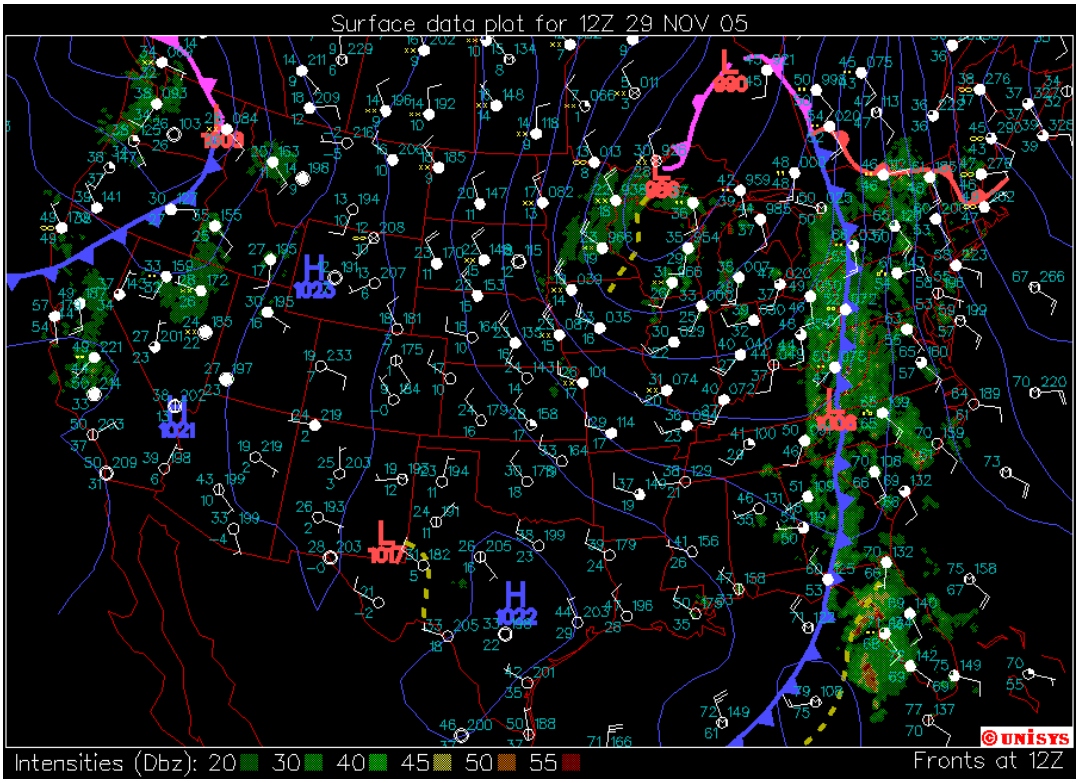

Figure A.5-15. Surface weather map at 0600 CST on November 29, 2005.

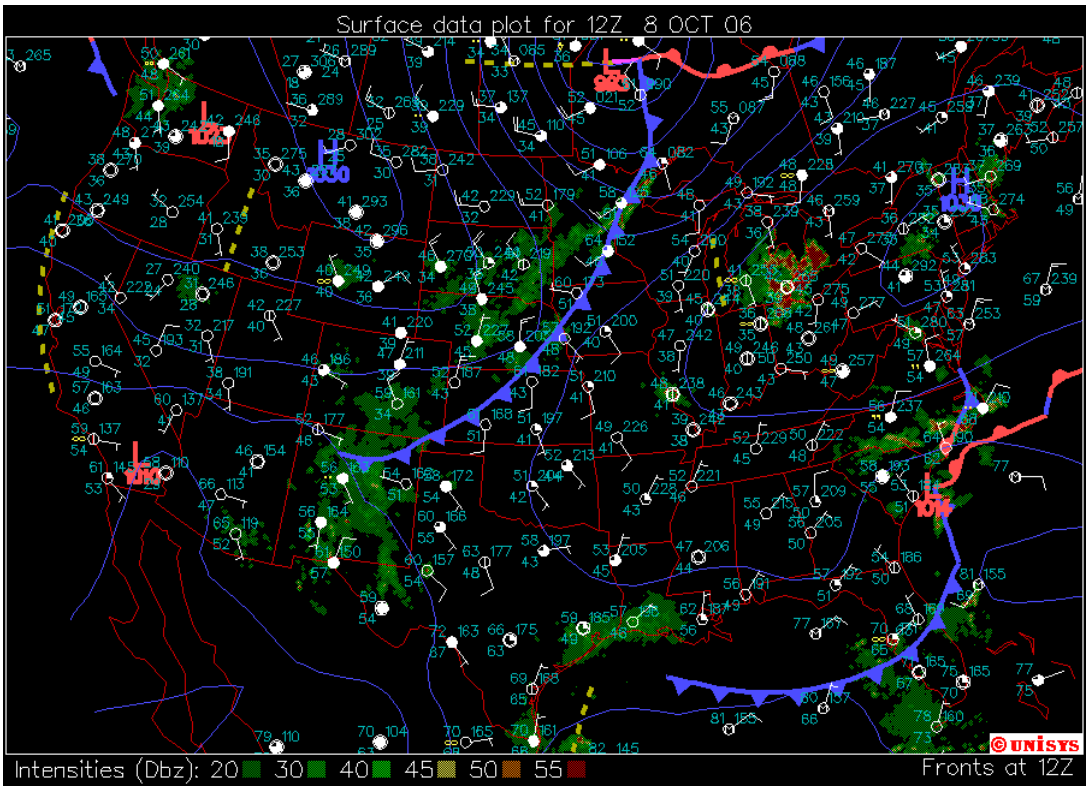

Figure A.5-16. Surface weather map at 0600 CST on October 8, 2006.

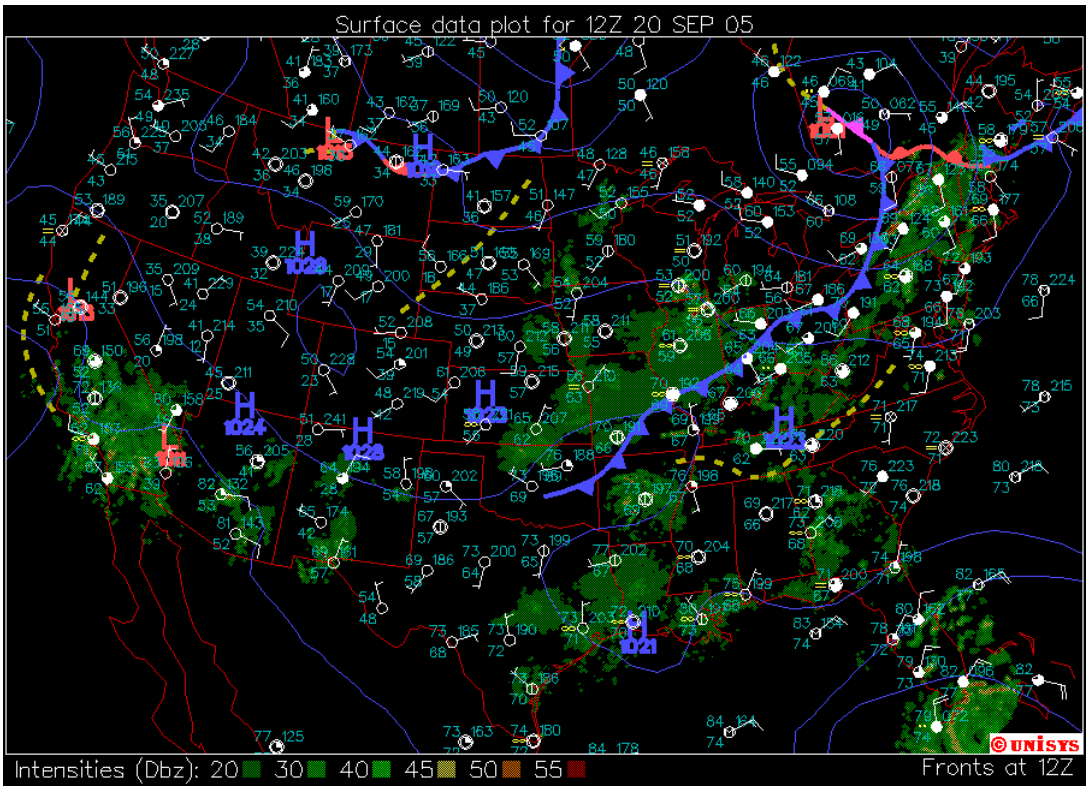

Figure A.5-17. Surface weather map at 0600 CST on September 20, 2005.

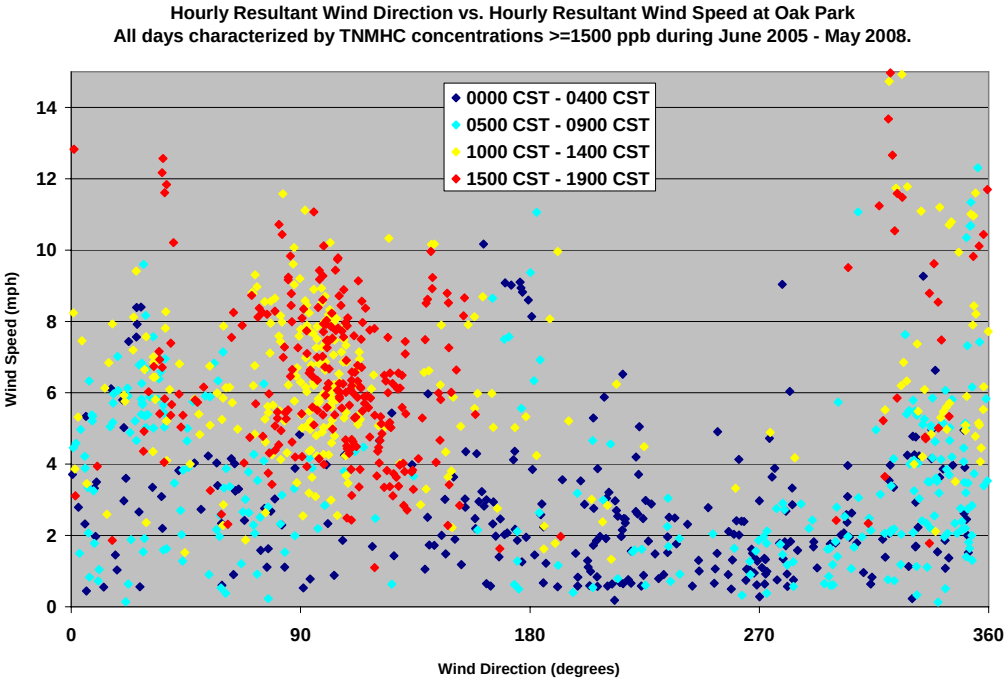

Figure A.5-18. Oak Park resultant wind direction versus the resultant wind speed for all hours on days characterized by one or more TNMHC concentrations of 1500 ppbC or greater.

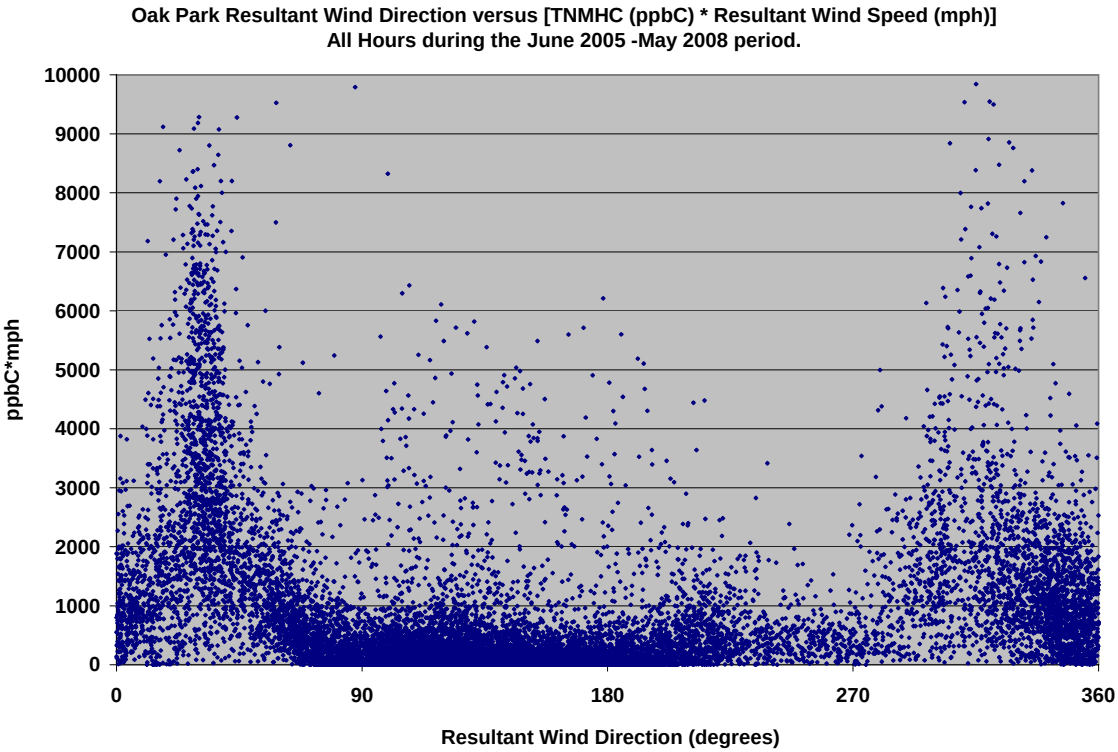

Figure A.5-19. Resultant wind direction (degrees) versus the product of the TNMHC concentration multiplied by the resultant wind speed (ppbC*mph) at the Oak Park monitoring station for all valid hours during the June 2005 through May 2008 period. Note that the chart scale has been defined for easy visualization of high density peaks so that observations above 10,000 ppbC*mph are not shown.

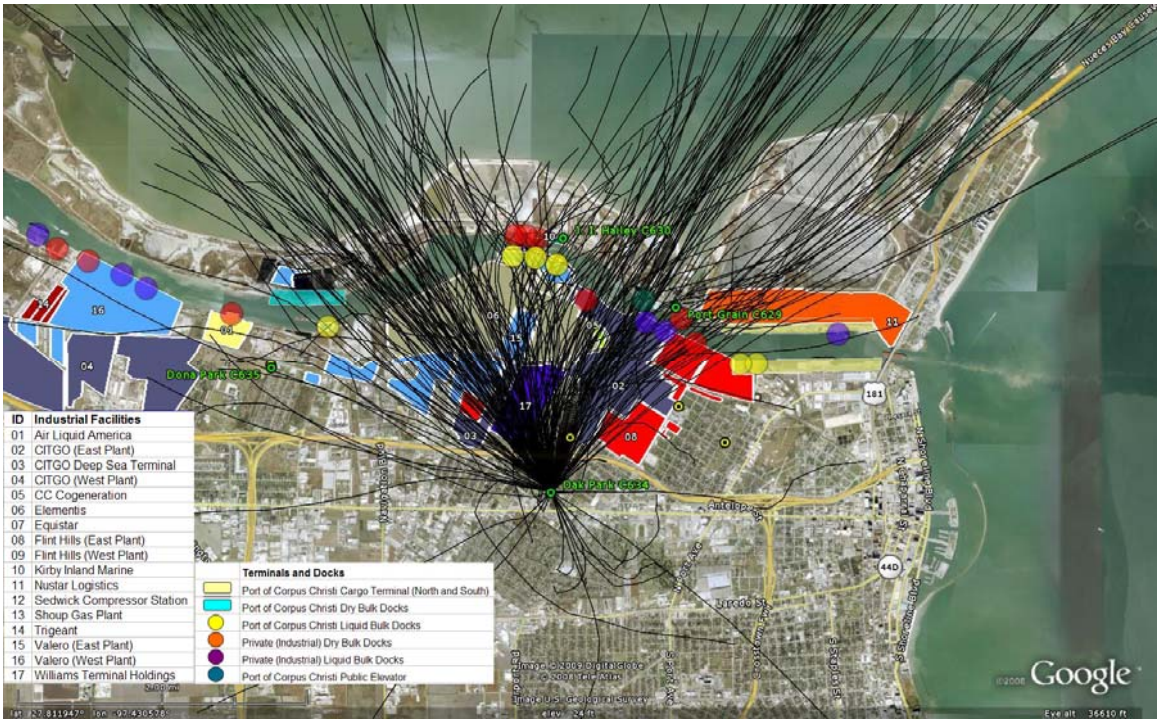

Figure A.5-20. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a TNMHC concentration of 1000 ppb or greater at the Oak Park monitoring station during the June 2005 through May 2008 period.

Figure A.5-21. Detail map of the Oak Park monitoring station and surrounding area. The J. I. Hailey and Port Grain monitoring stations are on the north bank of the Ship Channel in the upper middle and upper right corners, respectively. Note a number of industrial area associated with various facilities (e.g., refer to Figure A.5-1) are located to the northwest, north, and northeast of Oak Park. Also note the various dry and/or liquid bulk loading/unloading docks along the Ship Channel.

A.6 J. I. Hailey (C630) Monitoring Station

Figure A.6-1 shows the location of the J. I. Hailey monitoring station, which is located on the north bank of the Corpus Christi Ship Channel. The Port Grain monitoring station, also situated on the north bank of the channel, is located approximately one mile to the southeast of J. I. Hailey. Numerous industrial facilities are located nearby to the J. I. Hailey monitoring station, including Kirby Inland Marine and Elementis in the nearby area, and the CITGO and Valero East Plants on the south side of the Ship Channel. Also note that the Port of Corpus Christi bulk liquid loading/unloading docks are immediately south of J. I. Hailey along the southern bank of the Ship Channel.

A.6.1 Seasonal, Day of Week, and Diurnal Variability in TNMHC Concentrations at J. I. Hailey

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by month are shown in Figure A.6-2. For all metrics, elevated concentrations are noted throughout the year. The highest concentrations generally occur during the October through January and June through August time periods. The monthly 95th percentile concentration values (which roughly correspond to the 110th highest TNMHC concentration ranked by descending order) for the October through January period range from 607 ppbC for October to 791 ppbC for December. The 95th percentile values for June through August range from 617 ppbC for June to 719 ppbC for August. The 95th percentile concentration values for the remaining months range from 332 ppbC during April to 547 ppbC during September.

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by hour are shown in Figure A.6-3. For all metrics, the nighttime hours are characterized by the highest concentrations, with a relative peak in concentration values during the morning hours of 0300 CST through 0600 CST. For all hours, the 95th percentile concentration values (which roughly correspond to the 55th highest TNMHC concentration ranked by descending order) range from 240 ppbC at 1600 CST to 910 ppbC at 0500 CST. The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by day of week are shown in Figure A.6-4. The 95th percentile concentration values (which roughly correspond to the 188th highest TNMHC concentration ranked by descending order) vary from 535 ppbC on Saturday to 705 ppbC on Sunday.

To investigate possible seasonal differences in the diurnal profiles by day of week, Figures A.6-5 and A.6-6 present the median and 75th percentile hourly TNMHC concentrations, respectively, grouped by season. Figures A.6-5 and A.6-6 demonstrate that weekday concentrations tend to be higher compared to weekend concentrations during Winter. There are no consistent differences between weekday and weekends for the other seasons. Overall, Spring is characterized by the lowest concentrations throughout the day. For all seasons, the peak hourly median concentrations vary from 100 ppbC at 1500 CST on Spring weekends to 208 ppbC at 0700 CST for Fall weekends. The seasonal peak 75th percentile concentration values (which roughly correspond to the

48th and 19th highest TNMHC concentration ranked by descending order for weekdays and weekend days, respectively) range from 219 ppbC at 0600 CST for Spring weekdays to 387 ppbC at 0600 CST on Fall weekends.

A.6.2 TNMHC Event Duration at J. I. Hailey

For the purpose of investigating the duration of high TNMHC events, TNMHC events were defined as one or more consecutive hours characterized by a concentration of 1000 ppbC or greater. Table A.6-1 presents the 257 high TNMHC events (binned by duration in hours) measured at the J. I. Hailey monitoring station during the June 2005 through May 2008 period. The vast majority of events were characterized by durations of 1 hour (62% of total events) and 2 hours (19% of total events). For the remaining events with durations of 3 hours or greater (19% of total events), the majority occurred during the late night and morning hours throughout the October through February (approximately 65% of events) and the June through August (approximately 30% of events) periods.

A.6.3 Local Meteorological Conditions during High TNMHC Events at J. I. Hailey

Figure A.6-7 presents the median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations binned by the hourly resultant wind direction at J. I. Hailey. The statistical metrics demonstrate a strong peak in TNMHC concentration values during hours characterized by westerly winds. A secondary (lower magnitude) peak occurs for hours with northeasterly winds. Lowest concentration values are noted during easterly and east-southeasterly winds. Figure A.6-8 presents the frequency of occurrence by resultant wind direction for all hours during the June 2005 through May 2008 period and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater. The frequency of occurrence of 1000 ppbC TNMHC concentrations is far greater than the climatological frequency of occurrence for hours characterized by winds directions ranging between south-southwesterly and west-northwesterly. High concentrations occur during hours characterized by a wide range of wind directions with the notable exceptions of easterly and especially east-southeasterly, which is characterized by a frequency of occurrence of high TNMHC hours that is substantially lower than the climatological frequency of occurrence.

Figure A.6-9 shows the wind component scatterplot for all hours characterized by TNMHC concentrations of 1000 ppbC or greater, grouped by time of occurrence during the 1800 CST through 0900 CST (corresponding to evening/nighttime/morning) and 1000 CST through 1700 CST (corresponding to late morning/afternoon) time periods. (Refer to Section 2.5 of this report for a discussion of how to interpret the wind component scatterplot.) Consistent with the diurnal profile shown in Figure A.6-3, high TNMHC concentrations predominate during the 1800 CST through 0900 CST time period. High TNMHC concentrations generally occur at wind speeds less than 5 mph during hours characterized by winds with a northerly or westerly component. High TNMHC concentrations during periods of southerly or southeasterly winds are associated with resultant wind speeds that range from nearly calm to approximately 15 mph.

Figure A.6-10 presents the frequency of occurrence for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater for five wind speed ranges (binned by 4 mph increments). Note that 70% of 1000 ppbC TNMHC concentrations occur during hours with wind speeds less than 8 mph, far greater than the climatological frequency of occurrence for all hours of 27%.

Figure A.6-11 presents the frequency of occurrence for all hours and for only those hours characterized by TNMHC concentrations of 1000 ppbC or greater for eight temperature ranges (binned by 10 F increments). High TNMHC concentrations occur during hours characterized by a wide range of temperatures between 50 F and 90 F. The frequency of occurrence of 1000 ppbC TNMHC hours is relatively higher than the climatological frequency of occurrence for temperatures less than 70 F. The opposite relationship is noted for hours with temperatures greater the 70 F.

Figure A.6-12 presents the frequency of occurrence for all hours and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater for ten relative humidity (as a percent) ranges. High TNMHC concentrations can occur during hours with a wide range of relative humidity concentrations; however, the 1000 ppb TNMHC concentrations predominate at hours characterized by high relative humidity values. The frequency of occurrence of relative humidity values above 70% is 50% and 62% for all hours and high TNMHC hours, respectively. Figure A.6-13 presents a scatterplot of hourly temperature versus hourly relative humidity for all days during the June 2005 through May 2008 period. Hours characterized by TNMHC concentrations of 1000 ppbC or greater are plotted in red. The highest density of all hourly observations is found along the top right portion of the scatterplot, which indicates hours characterized by relatively warm temperatures and middle to high relative humidity values. This portion of the scatterplot is representative of most days during the spring through fall period, with nighttime hours often located on the right side at relatively high humidity values and daytime hours often located to the left at the lower humidity values. Figure A.6-13 indicates that the majority of 1000 ppbC TNMHC hours during temperatures greater than 70 F are associated with relative humidity values of 70% or greater, which most likely are representative of nighttime hours. However, note that 1000 ppb hours also occur at relatively high temperatures and low relatively humidity values suggesting daytime conditions. A large proportion of high TNMHC hours occurred at temperatures less than 70 F across a range of relative humidity values between 20% and 85%. The drier and cooler conditions are likely associated with periodic intrusions of drier and colder air following the passage of cold fronts through South Texas.

A.6.4 Large-Scale Weather Patterns during High TNMHC Events at J. I. Hailey

Due to the labor intensiveness required to review daily weather maps, the TNMHC concentration threshold used to define high TNMHC events was increased from 1000 ppbC to 3500 ppbC to limit the number of individual days for analysis. To investigate the large-scale weather features that predominate during the highest TNMHC events, 72-hour HYSPLIT back-trajectories were generated for all days during the June 2005 through May 2008 period that were characterized by one or more hours with a TNMHC

concentration of 3500 ppbC or greater at the J. I. Hailey monitoring station. Figure A.6-14 shows the 43 back-trajectories on these highest TNMHC days. The back-trajectories were initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface. The back-trajectories shown in Figure A.6-14 can visually be classified into three general categories characterized by long-range flow from the (1) north, (2) northeast, and (3) south. Note that a majority of the back-trajectories are characterized by generally southerly flow immediately prior to entering the Corpus Christi area.

Figure A.6-14 shows that a majority of the long-range flow patterns prior to high TNMHC events are characterized by southerly flow into South Texas. Figure A.6-15 presents the surface weather map for July 16, 2007, which is characterized by a long-range trajectory that shows westward flow originating near the Yucatan Peninsula (Mexico) followed by southerly flow over the west-central Gulf of Mexico into Corpus Christi. At upper levels on July 16th, Texas was on the western edge of a large ridge of high pressure oriented north-south over the western US and northern Mexico. Upper levels winds over coastal Texas were generally northerly at 25 knots. A dissipating frontal boundary over coastal Texas the previous day was associated with 0.40 in. rainfall in Corpus Christi on July 15th with moderate south-southwesterly surface winds followed by light to moderate southeasterly winds in the afternoon. By July 16th, clouds and showers continued over the eastern portion of Texas in association with the weakening frontal trough located offshore along the Texas coast. Morning low temperatures at J.I. Hailey were in the lower 80 F range. With moderate south-southwesterly winds during the nighttime hours, hourly TNMHC concentrations generally ranged between 1000 ppbC and 1500 ppbC with a maximum concentration of 4120 ppbC at 0600 CST. By the afternoon, moderate southeasterly winds were associated with dramatically lower TNMHC concentrations and maximum temperatures in the mid-80 F range.

A review of the large-scale surface weather maps for the 43 days characterized by maximum hourly TNMHC concentrations of 3500 ppbC or greater reveals that a high pressure ridge often extends southwestward or westward into Texas. These surface high pressure systems are often characterized by weak pressure gradients at the surface over coastal Texas and South Texas and are associated with calm to light northerly morning winds and southeasterly afternoon winds. High TNMHC events sometimes occurred on days with tropical cyclone activity located over the central or western Gulf of Mexico. This scenario would place Corpus Christi on the “clean” side of these tropical circulations, which is associated with light northerly flow and stable atmospheric conditions. Cold fronts often played a role in high TNMHC events. Hours with high TNMHC concentrations often occurred either following the passage of cold fronts during periods of northerly winds, or, more commonly, ahead of approaching or stationary fronts located over northern or central Texas. This latter scenario was typically characterized by surface winds with a southwesterly or southerly component in the Corpus Christi area. The presence of rain and showers over portions of Texas, including South Texas, were not uncommon during high TNMHC events. Surface centers or weak troughs of low pressure were sometimes located over Texas or northern Mexico.

To explore the daily evolution of surface winds in the Corpus Christi area on high TNMHC days, Figure A.6-16 presents the resultant wind direction versus the resultant wind speed for all hours on days characterized by maximum hourly TNMHC concentrations of 3500 ppbC or greater. During the 0000 CST through 0900 CST time period, winds are most often characterized by a westerly or northerly component (with speeds ranging from calm to 8 mph) or a southerly to south-southwesterly component (with speeds 5 – 15 mph). By the late morning, winds are often east-southeasterly with most days characterized by late afternoon southeasterly winds.

A.6.5 Analysis and Summary of J. I. Hailey TNMHC and Meteorological Measurements

Air quality analyses were performed using the hourly TNMHC, resultant wind speed, resultant wind direction, temperature, and relative humidity measurements collected at the J. I. Hailey monitoring station during the June 2005 through May 2008 period. The J. I. Hailey monitoring station is located on the north bank of the Corpus Christi Ship Channel. Numerous industrial facilities are located nearby to the J. I. Hailey monitoring station. In addition, the Port of Corpus Christi bulk liquid loading/unloading docks are immediately south of J. I. Hailey along the southern bank of the Ship Channel.

The highest hourly TNMHC concentrations (>= 1000 ppbC) occur most frequently during the October through January and June through August time periods. For all months, concentrations are highest during the nighttime hours with a peak in the frequency of occurrence during the 0300 CST through 0600 CST period. The majority of high TNMHC events (81%) are one to two hours in duration. For the remaining events with durations of 3 hours or greater (19% of total events), the majority occurred during the late night and morning hours throughout the October through February (approximately 65% of events) and the June through August (approximately 30% of events) periods. Analyses of the diurnal profiles by season demonstrate that weekday concentrations tend to be higher compared to weekend concentrations during Winter. There are no consistent differences between weekdays and weekends for the other seasons.

A wind direction analysis indicates that the highest TNMHC concentrations occur during a range of wind directions with the exception of hours characterized by easterly and east-southeasterly winds. The frequency of occurrence of high TNMHC concentrations is far greater than the climatological frequency of occurrence for all hours with northeasterly winds and for wind directions ranging between south-southwesterly and west-northwesterly at speeds of 5 mph or less. High concentrations also occur during periods of southerly or southeasterly flow at slightly greater wind speeds. High TNMHC concentrations occur during hours characterized by a wide range of temperatures between 50 F and 90 F. High TNMHC concentrations can occur during hours with a wide range of relative humidity concentrations; however, more than half of these hours are characterized by relative humidity values above 70%.

The surface weather maps on days characterized by one or more hours with TNMHC concentrations of 3500 ppbC or greater often show a high pressure ridge that extends southward, southwestward, or westward into Texas. These surface high pressure systems are often characterized by weak pressure gradients at the surface over coastal Texas and South Texas and are associated with calm to light northerly or westerly morning winds and southeasterly afternoon winds. Hours with high TNMHC concentrations often occurred either following the passage of cold fronts during periods of northerly winds, or, more commonly, during periods of southwesterly or southerly winds ahead of approaching or stationary fronts located over northern or central Texas.

The wide range of wind directions during hours with high TNMHC concentrations suggests that J. I. Hailey may be impacted by a number of emissions sources in the nearby area. This is not particularly surprising since J. I. Hailey is embedded within the industrialized Ship Channel.

A.6.6 Upwind Emission Sources during High TNMHC Events at J. I. Hailey

The previous analyses for J. I. Hailey did not attempt to account for the hourly variation in atmospheric dispersion conditions. One method to provide some normalization of measured pollutant concentrations with respect to varying atmospheric dispersion conditions is to multiply the concentration by the wind speed. Figure A.6-17 presents a scatterplot of the hourly resultant wind direction (degrees) versus the product of the hourly TNMHC concentrations and the hourly resultant wind speed (ppbC-mph) for all hours during the June 2005 through May 2008 period. Consistent with the results of previous analyses, high values of concentration-wind speed are noted at a range of wind directions, including periods of northeasterly winds or during period of winds characterized by a northerly and/or westerly component. Figure A.6-17 also reveals strong peaks in concentration-wind speed values for hours characterized by southerly (centered at 185 degrees) and, particularly, southeasterly (centered at 140 degrees) resultant wind directions.

To identify the local emissions sources at upwind industrial facilities that may impact TNMHC concentrations at J. I. Hailey, the Corpus Christi Trajectory Analysis Tool was used to generate one-hour surface back-trajectories for all hours characterized by an absolute TNMHC concentration of 1000 ppbC or higher. Each back-trajectory was initialized at the half-hour (i.e., midpoint) of the TNMHC one-hour averaging period. Figure A.6-18 plots the one-hour back-trajectories over a geographic map of the J. I. Hailey area. The back-trajectory paths are located over a wide range of directions with the general exception of to east-southeast. Visually, the trajectory paths appear densest to the southwest, south, and southeast, and for a range of directions characterized by a northerly component.

Figure A.1-19 provides a zoomed map of J. I. Hailey and the surrounding area using Google satellite imagery. Routine operational activities in support of the CCAQP include near real-time investigation of local emissions sources that may have contributed to high TNMHC events at J. I. Hailey. Previous pollution event analyses suggest that elevated

TNMHC concentrations may have been associated with work activities on above-ground pipes at a small maintenance facility located within the same unpaved parking area. In addition, J. I. Hailey has likely been impacted on numerous occasions by emissions associated with ship loading/unloading operations at the Port of Corpus Christi bulk liquid docks located directly to the south of J. I. Hailey (e.g., Oil Docks 4, 7, and 11). Previous pollution event analyses also indicate that the Valero East Plant and the CITGO East Plant are often in the upwind region during high TNMHC events.

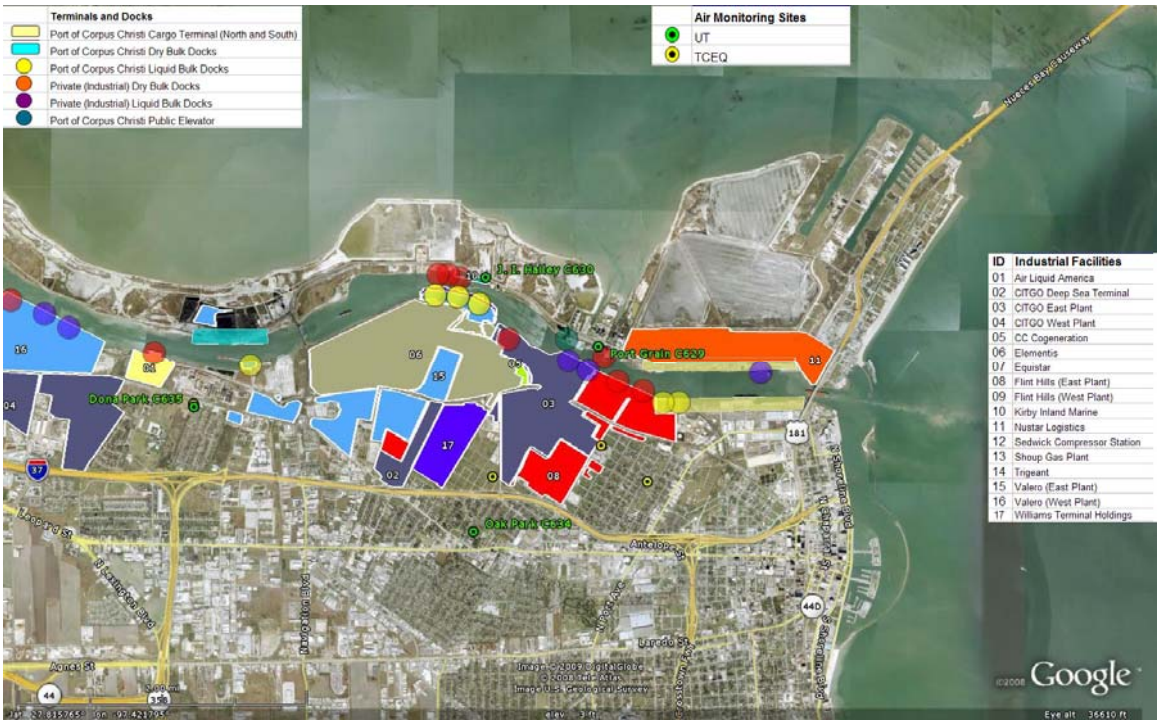

Figure A.6-1. Locations of the J. I. Hailey (C630) monitoring station, nearby CAMS, and surrounding industrial facilities. The Corpus Christi Ship Channel is oriented east-west along the middle of the figure.

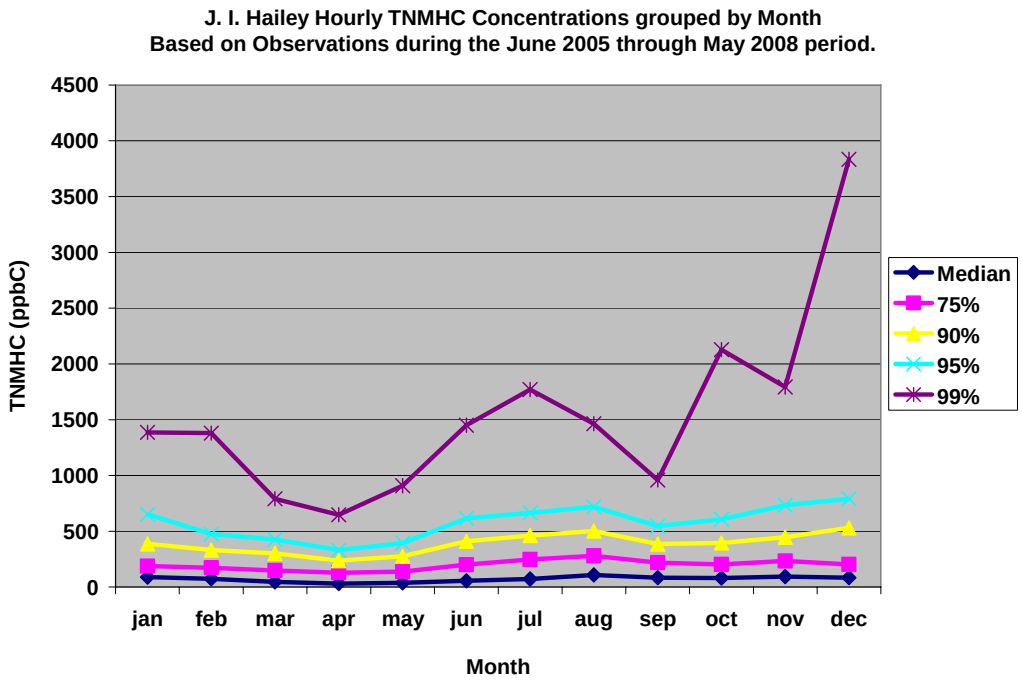

Figure A.6-2. Monthly median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations at the J. I. Hailey monitoring station based on all valid data during the June 2005 through May 2008 period.

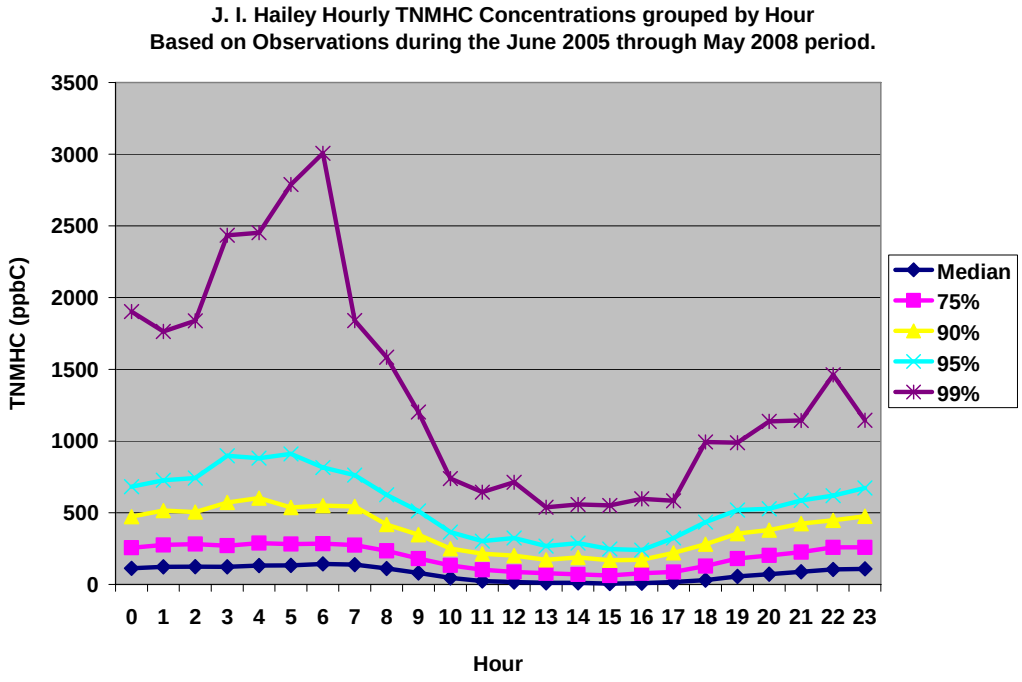

Figure A.6-3. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations at the J. I. Hailey monitoring station by hour based on all valid data during the June 2005 through May 2008 period.

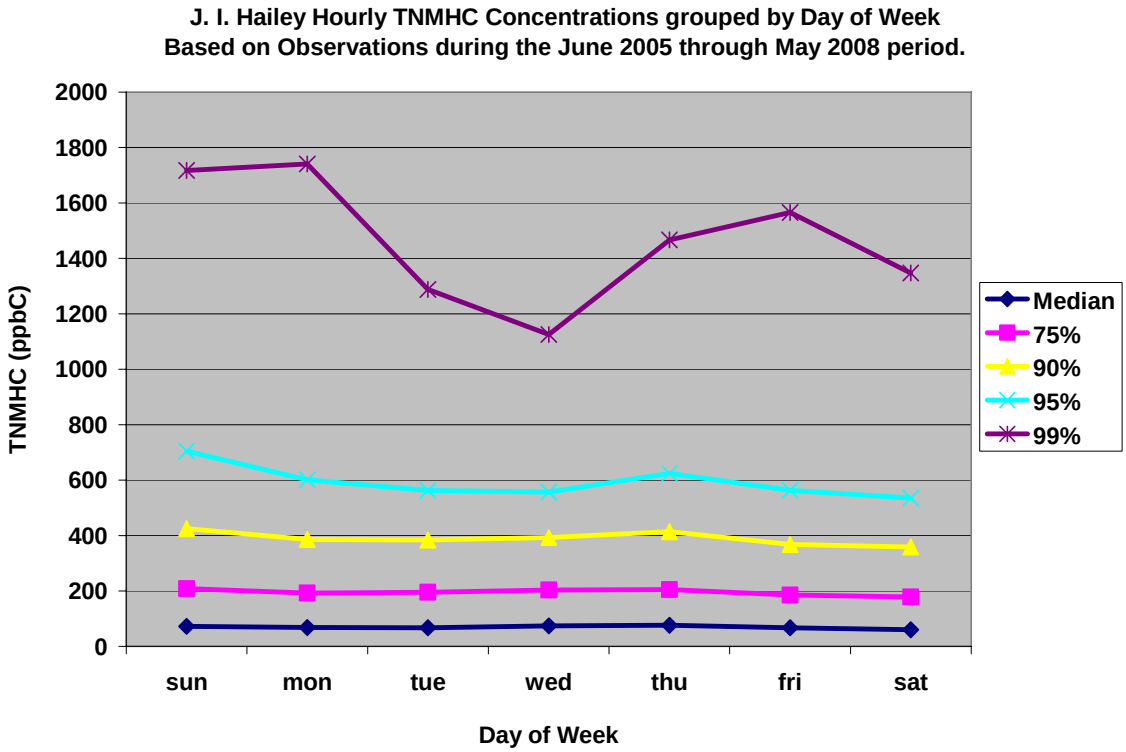

Figure A.6-4. Median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by Day of Week at the J. I. Hailey monitoring station based on all valid data during the June 2005 through May 2008 period.

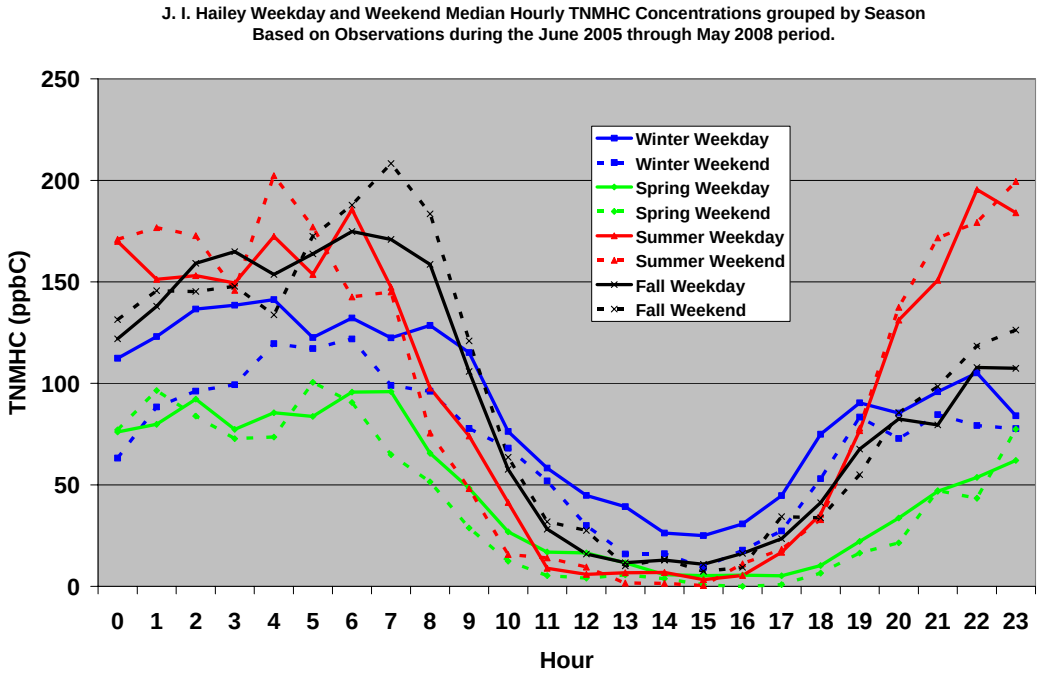

Figure A.6-5. Median hourly weekday and weekend day TNMHC concentrations grouped by season at the J. I. Hailey monitoring station based on all valid data during the June 2005 through May 2008 period.

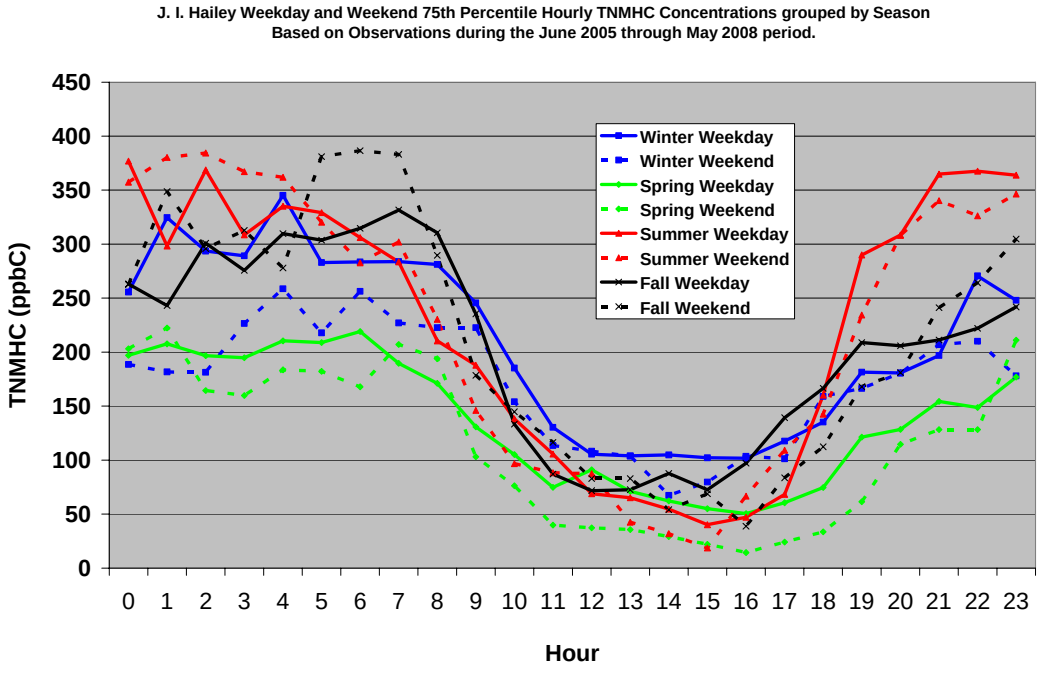

Figure A.6-6. The 75th percentile hourly weekday and weekend day TNMHC concentrations grouped by season at the J. I. Hailey monitoring station based on all valid data during the June 2005 through May 2008 period.

Table A.6-1. High TNMHC events at the J. I. Hailey monitoring station binned by duration in hours. High TNMHC events are defined as one or more consecutive hours characterized by TNMHC concentrations of 1000 ppbC or greater.

Duration of Event (hours)	Number of Events
1	160
2	50
3	18
4	17
5	7
>5	5
Total Events	**257**

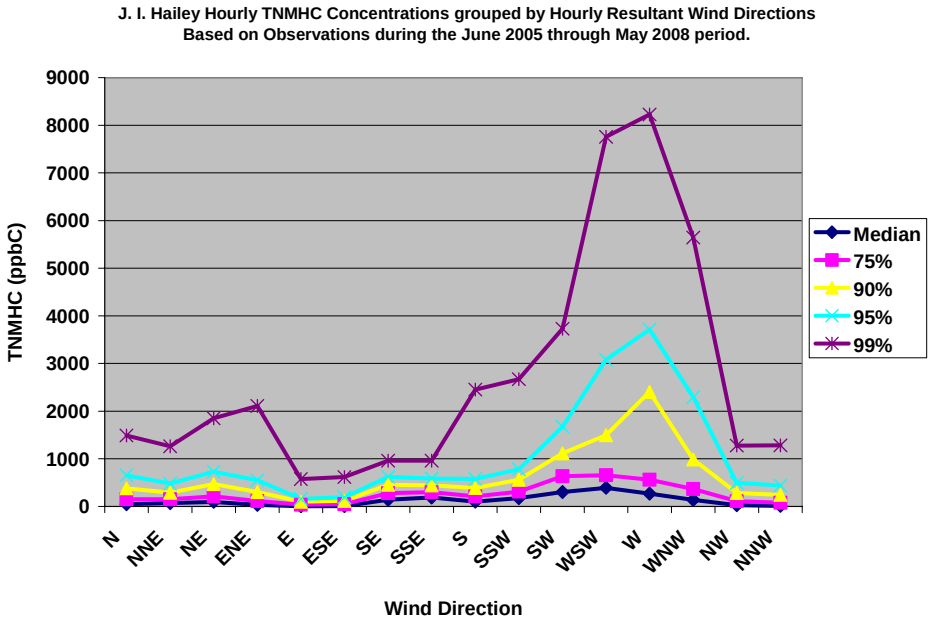

Figure A.6-7. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations grouped by hourly resultant wind direction at the J. I. Hailey monitoring station based on all valid data during the June 2005 through May 2008 period.

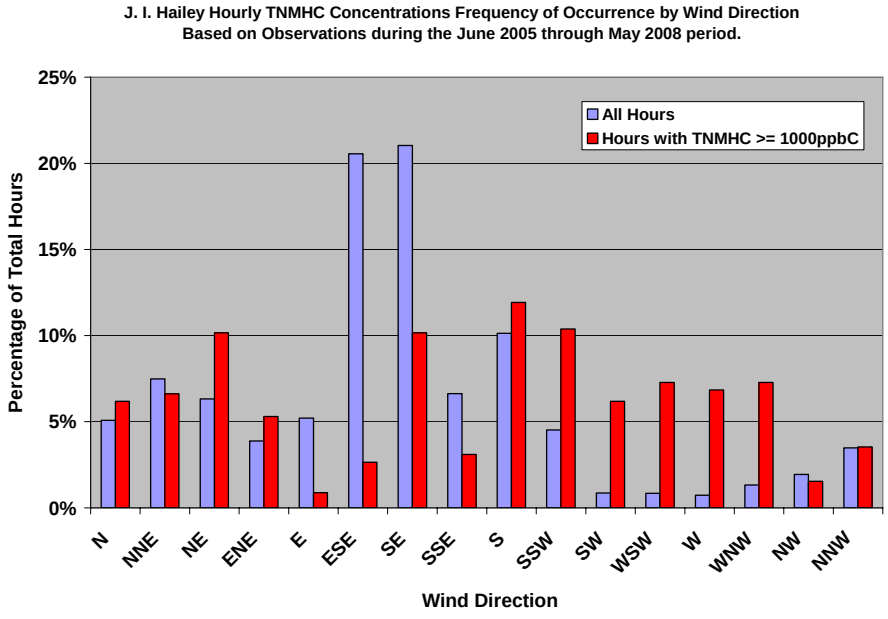

Figure A.6-8. Percentage of hours at the J. I. Hailey monitoring station grouped by resultant wind direction for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppb or greater. Based on all valid data during the June 2005 through May 2008 period.

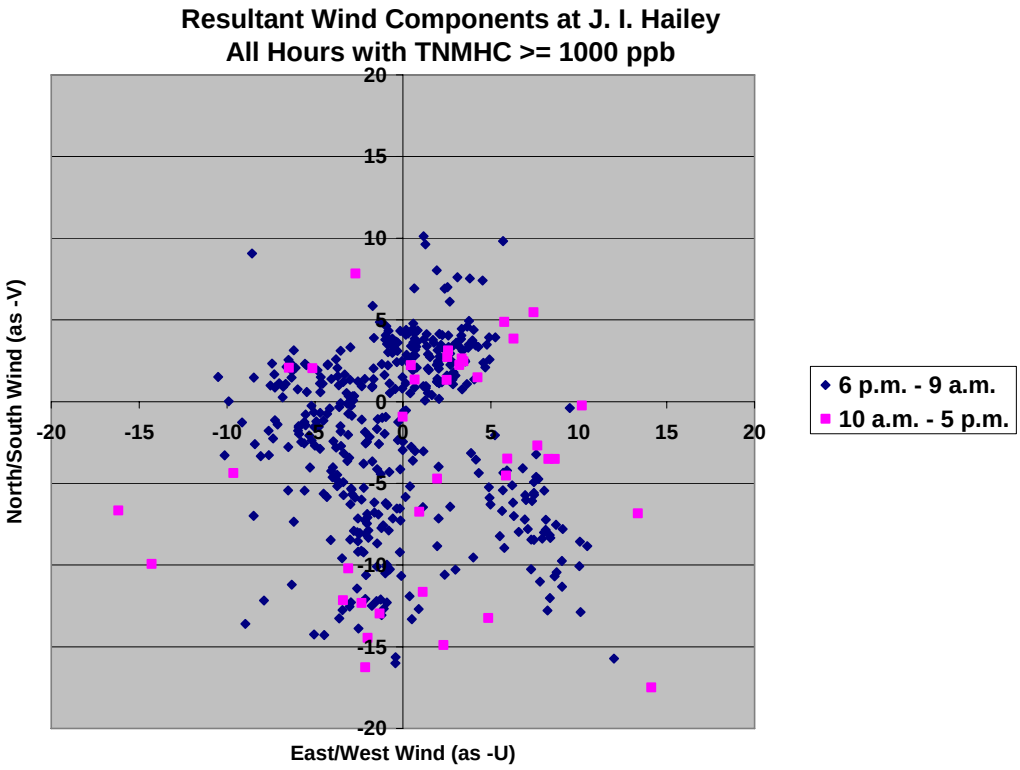

Figure A.6-9. Resultant wind component scatterplot at J. I. Hailey for all hours with TNMHC concentrations of 1000 ppb or greater during the June 2005 through May 2008 period. (The reader is referred to Section 2.5 for a discussion of how to interpret this figure.)

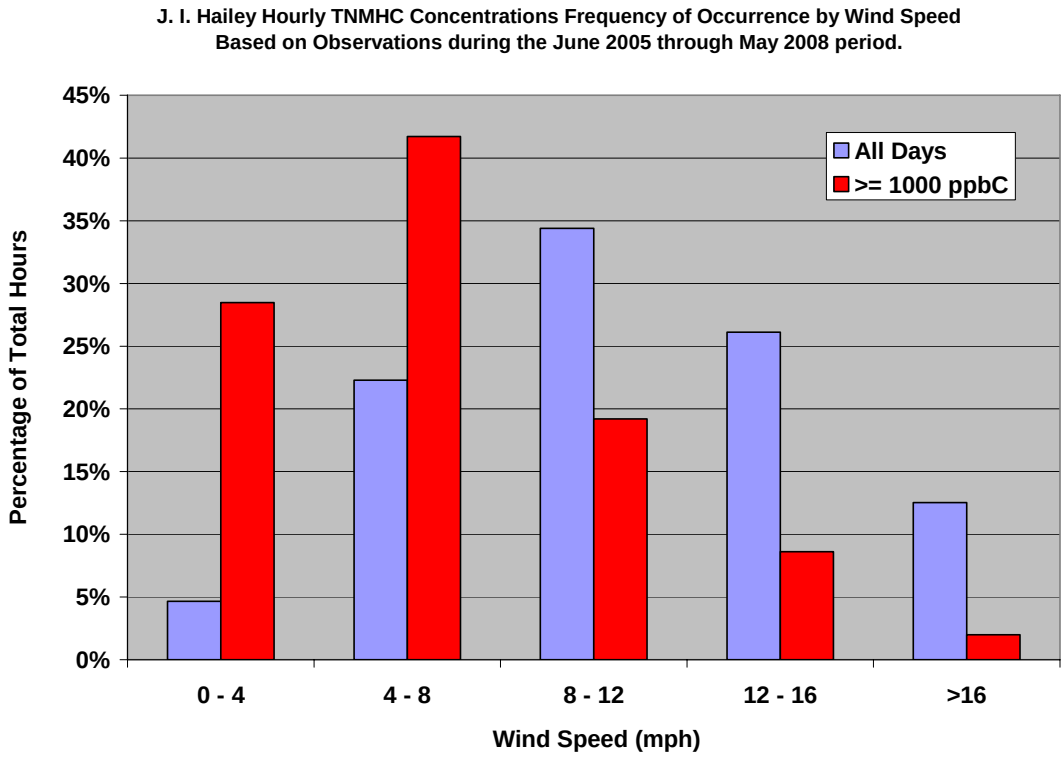

Figure A.6-10. Percentage of hours at the J. I. Hailey monitoring station grouped by resultant wind speed (binned by 4 mph increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

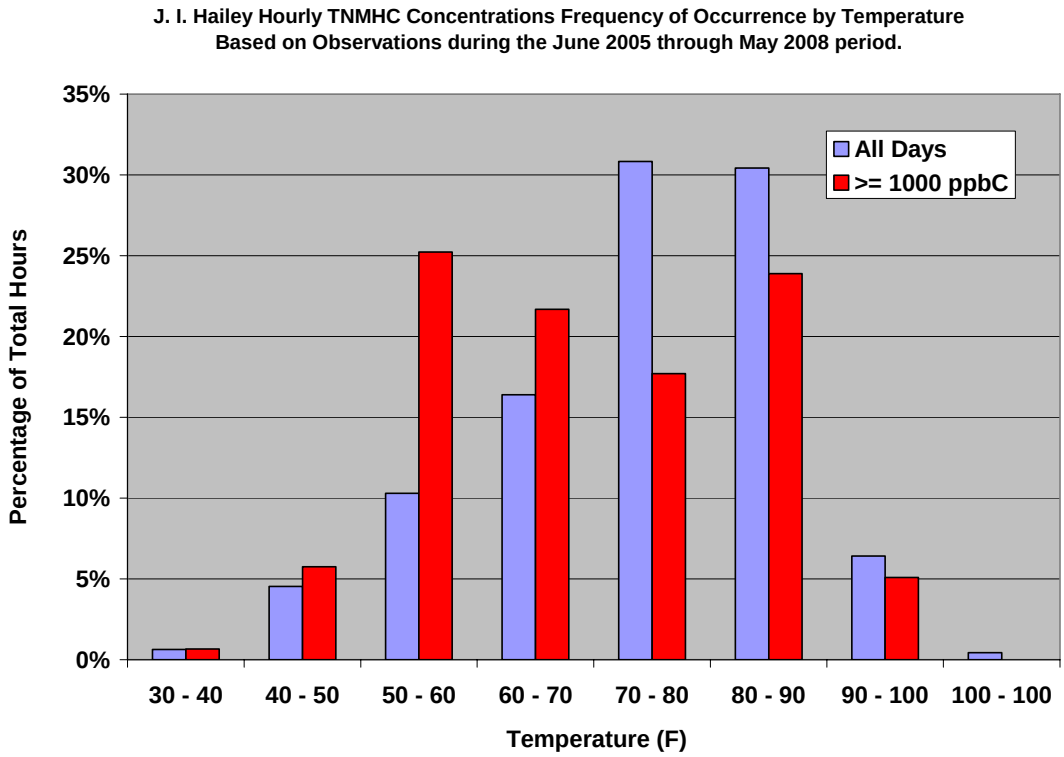

Figure A.6-11. Percentage of hours at the J. I. Hailey monitoring station grouped by temperature (binned by 10 F increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

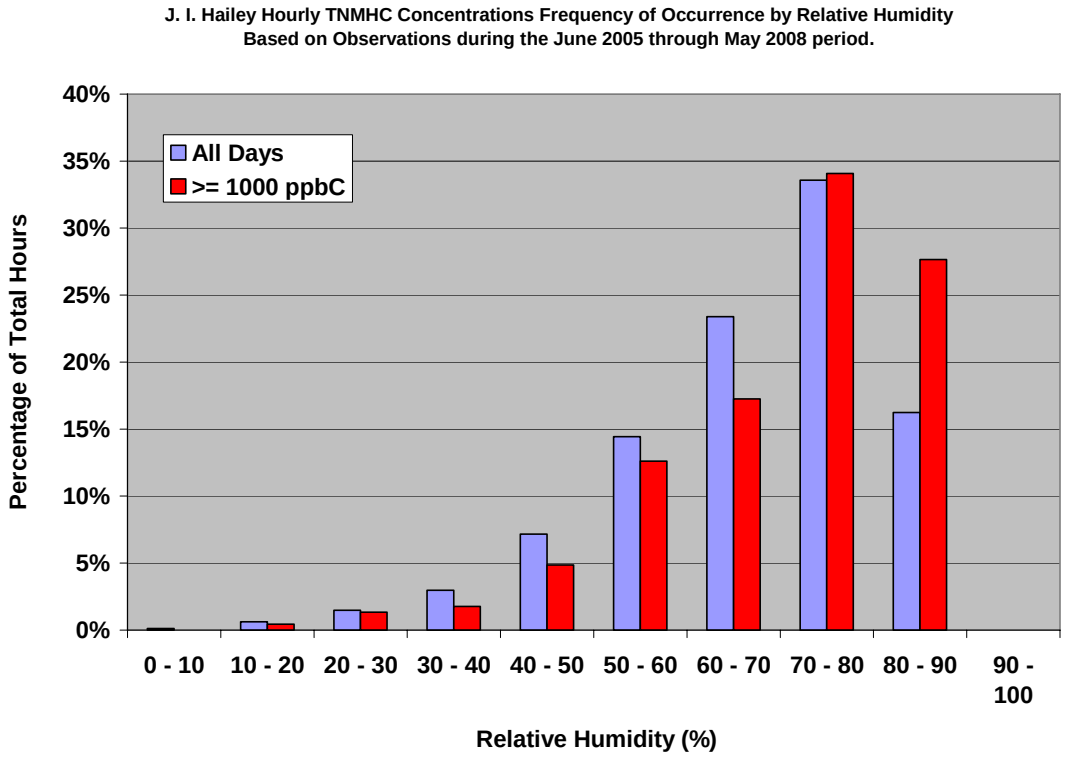

Figure A.6-12. Percentage of hours at the J. I. Hailey monitoring station grouped by relative humidity values (binned by 10% increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

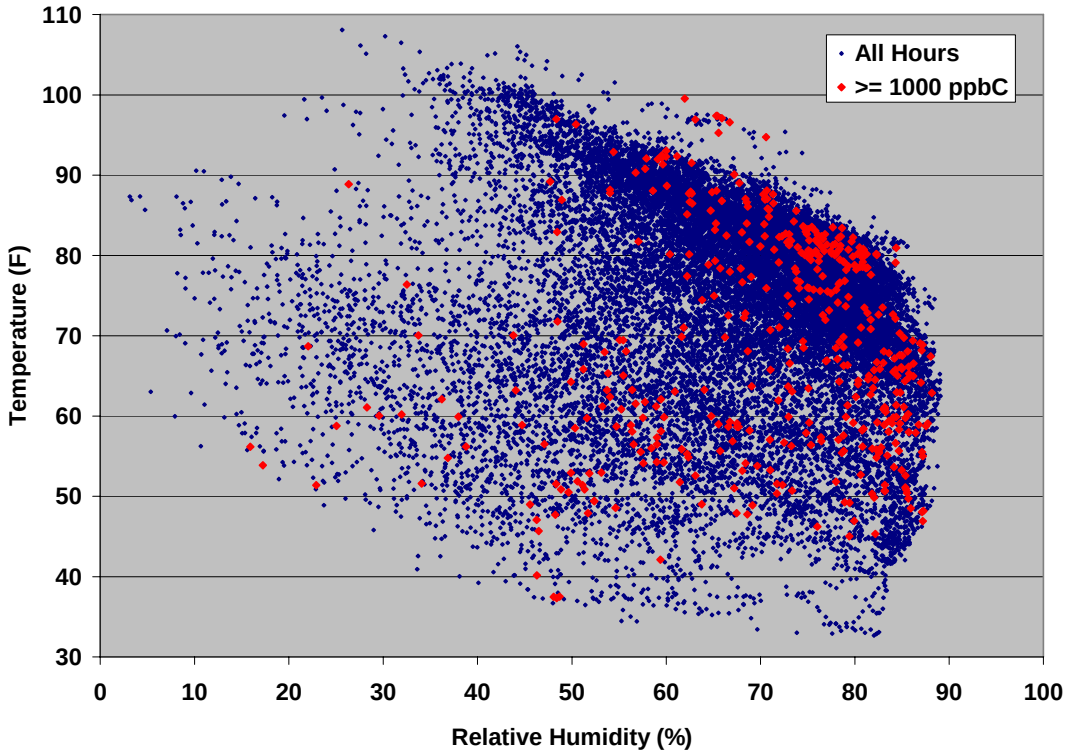

Figure A.6-13. Hourly temperature versus hourly relative humidity at the J. I. Hailey monitoring station for all hours during the June 2005 through May 2008 period. Hours characterized by a TNMHC concentration of 1000 ppbC or greater are highlighted in red.

72-Hour HYSPLIT Back-Trajectories for Days with Hourly TNMHC >= 3500 ppbC
J. I. Hailey (C630): June 2005 - May 2008

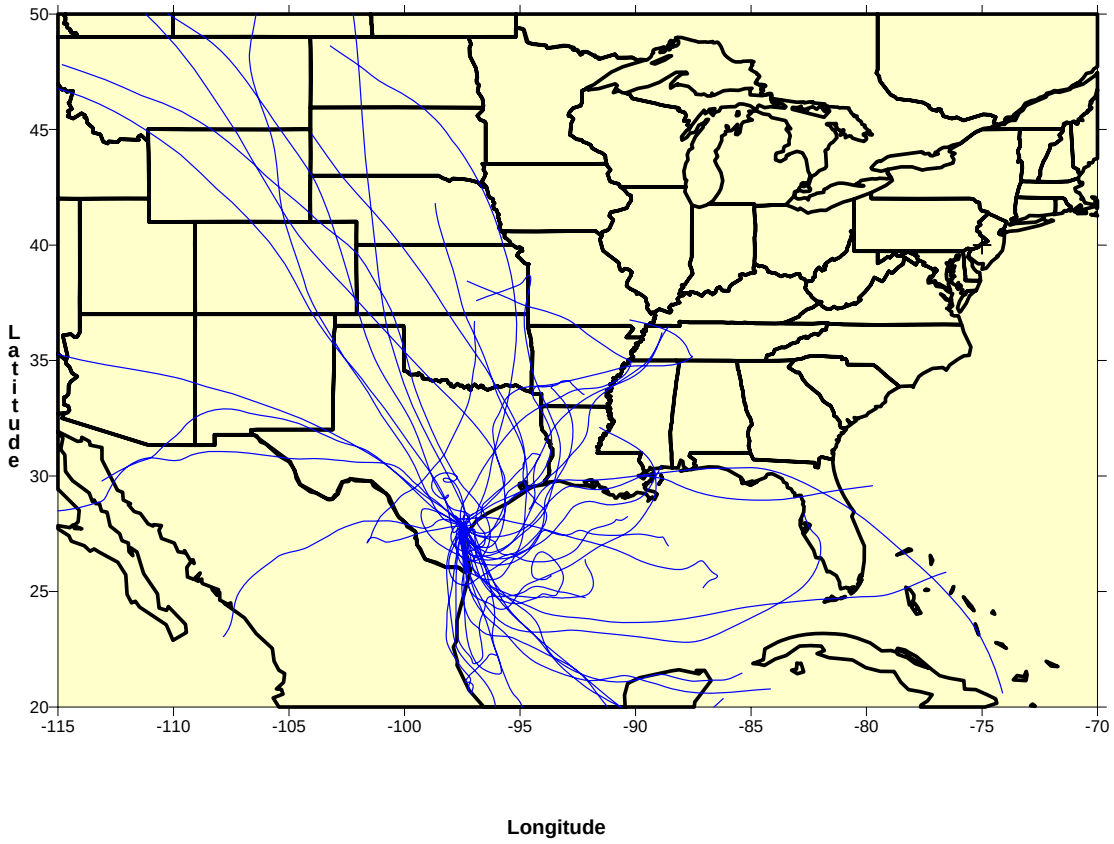

Figure A.6-14. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 43 days during the June 2005 through May 2008 period characterized by one or more hours with TNMHC concentrations of 3500 ppb or greater at the J. I. Hailey monitoring station.

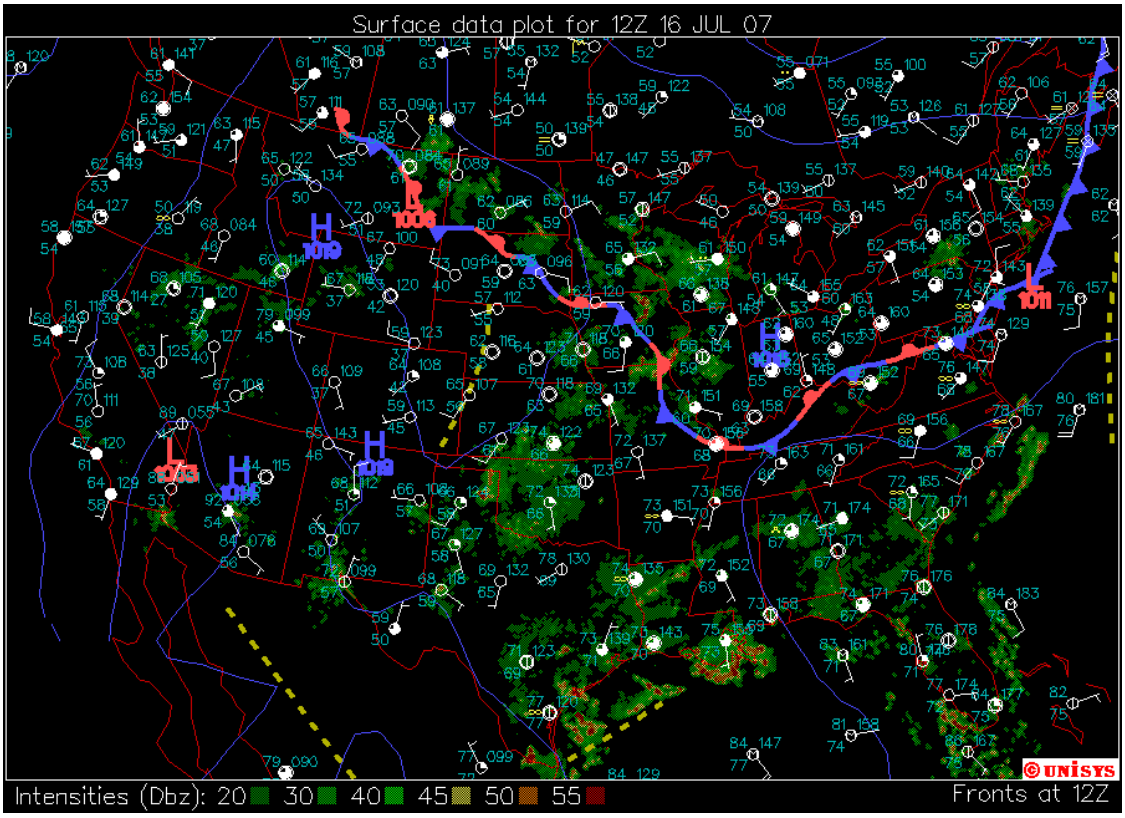

Figure A.6-15. Surface weather map at 0600 CST on July 16, 2007.

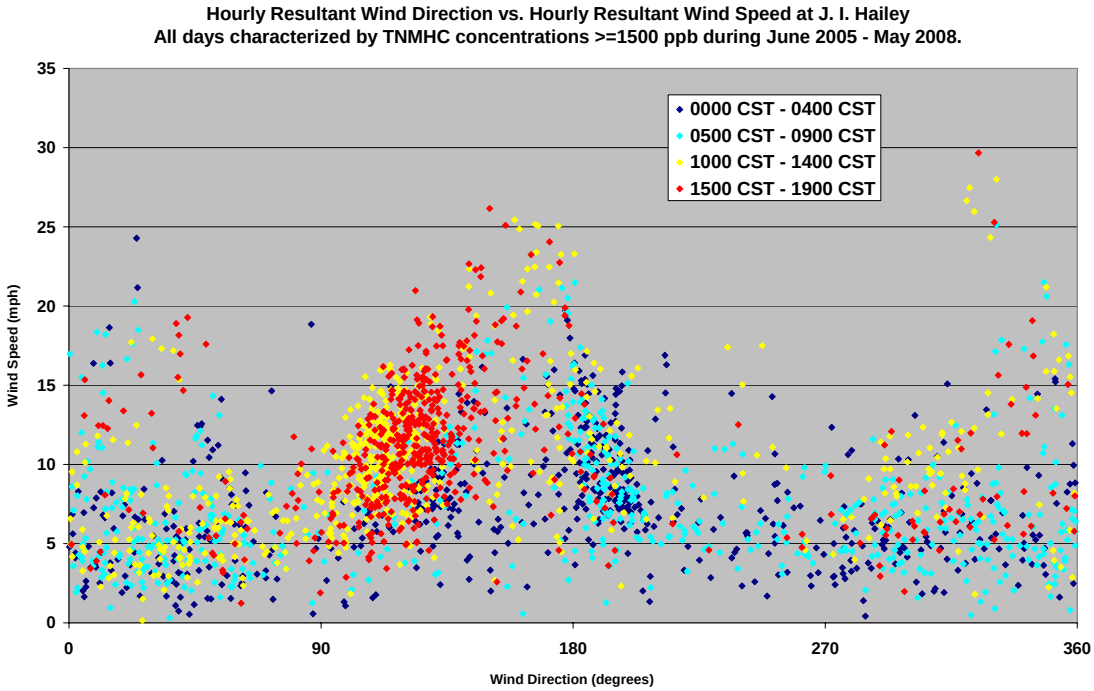

Figure A.6-16. J. I. Hailey resultant wind direction versus the resultant wind speed for all hours on days characterized by one or more TNMHC concentrations of 1500 ppbC or greater.

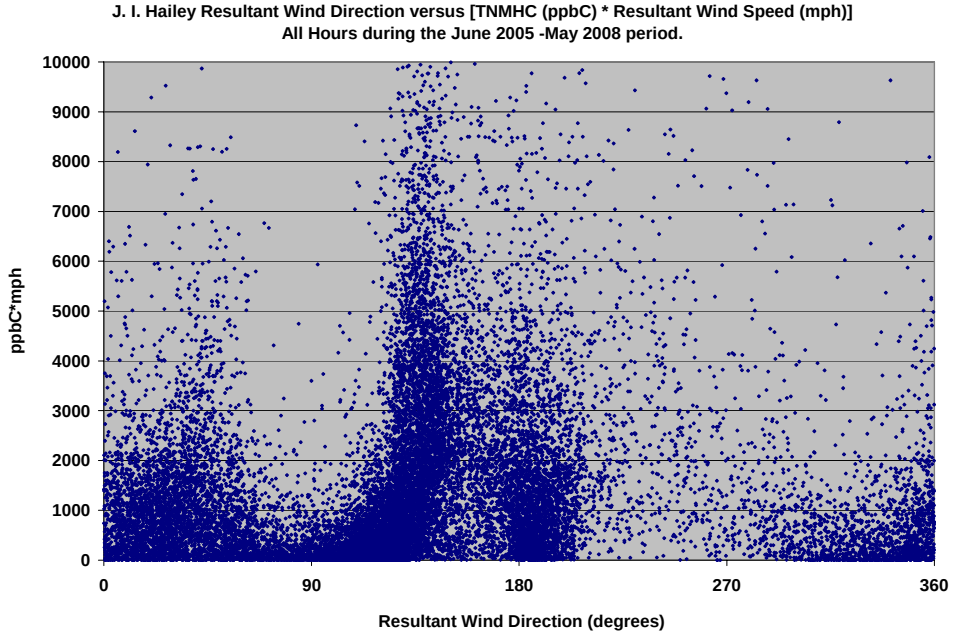

Figure A.6-17. Resultant wind direction (degrees) versus the product of the TNMHC concentration multiplied by the resultant wind speed (ppbC*mph) at the J. I. Hailey monitoring station for all valid hours during the June 2005 through May 2008 period. Note that the chart scale has been defined for easy visualization of high density peaks so that observations above 10,000 ppbC*mph are not shown.

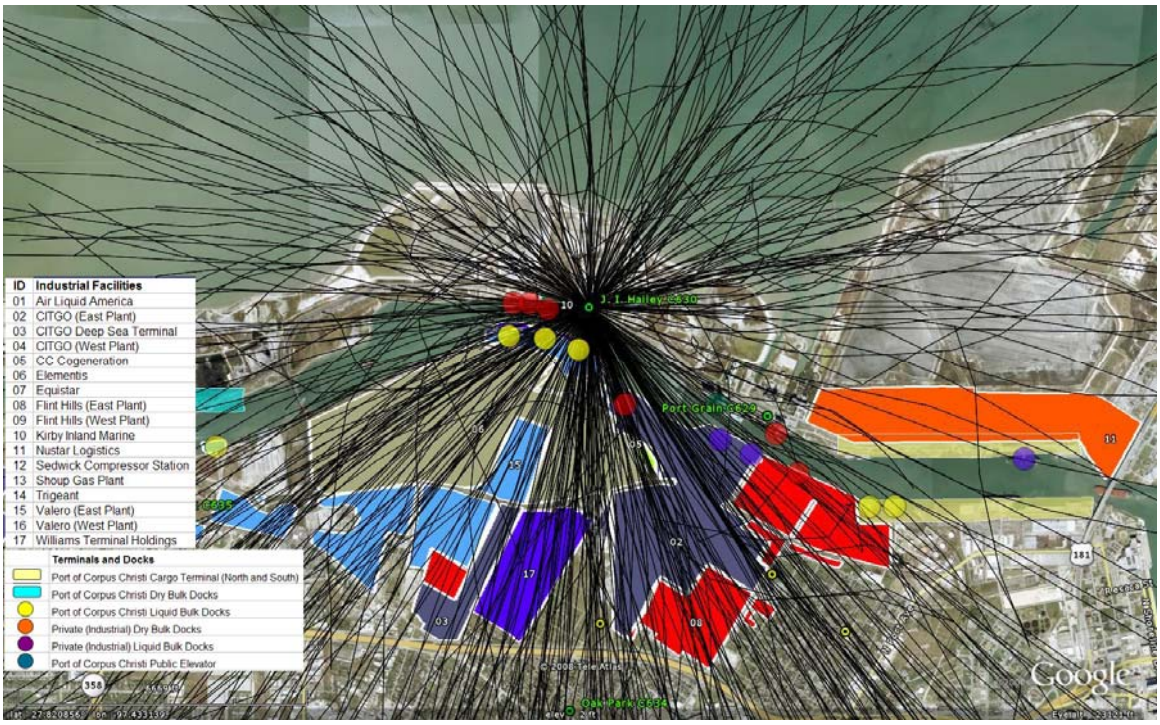

Figure A.6-18. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a TNMHC concentration of 1000 ppb or greater at the J. I. Hailey monitoring station during the June 2005 through May 2008 period.

Figure A.6-19. Detail map of the J. I. Hailey monitoring station and surrounding area. The J. I. Hailey and Port Grain monitoring stations are on the north bank of the Ship Channel in the upper middle and upper right corners, respectively. Note a number of industrial areas associated with various facilities (e.g., refer to Figure A.6-1) are located in the nearby area, including various dry and/or liquid bulk loading/unloading docks along the Ship Channel.

A.7 Port Grain (C629) Monitoring Station

Figure A.7-1 shows the location of the Port Grain monitoring station, which is located on the north bank of the Corpus Christi Ship Channel. The J. I. Hailey monitoring station, also situated on the north bank of the channel, is located approximately one mile to the northwest of Port Grain. Numerous dry and liquid bulk loading/unloading docks are located along the Ship Channel in the vicinity of Port Grain. In addition, the CITGO and Flint Hills East Plants lie just to the south of Port Grain on the opposite side of the Ship Channel.

A.7.1 Seasonal, Day of Week, and Diurnal Variability in TNMHC Concentrations at Port Grain

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by month are shown in Figure A.7-2. For all metrics, elevated concentrations are noted throughout the year. The highest concentrations generally occur during the July through January period with lowest concentrations during March, April, and May. The monthly 95th percentile concentration values (which roughly correspond to the 110th highest TNMHC concentration ranked by descending order) for the July through January period range from 439 ppbC for August to 651 ppbC for November. The 95th percentile values for the remaining months range from 195 ppbC for April to 425 ppbC for February.

The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations grouped by hour are shown in Figure A.7-3. For all metrics, the nighttime hours are characterized by the highest concentrations, with a relative peak in concentration values during the morning hours of 0200 CST through 0700 CST. For all hours, the 95th percentile concentration values (which roughly correspond to the 55th highest TNMHC concentration ranked by descending order) range from 130 ppbC at 1600 CST to 743 ppbC at 0400 CST. The median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by day of week are shown in Figure A.7-4. The 95th percentile concentration values (which roughly correspond to the 188th highest TNMHC concentration ranked by descending order) vary from 358 ppbC on Saturday to 498 ppbC on Wednesday.

To investigate possible seasonal differences in the diurnal profiles by day of week, Figures A.7-5 and A.7-6 present the median and 75th percentile hourly TNMHC concentrations, respectively, grouped by season. Figures A.7-5 and A.7-6 demonstrate that the nighttime and particularly early morning weekday concentrations tend to be higher compared to weekend concentrations during Winter. There are no consistent differences between weekday and weekends for the other seasons. Overall, Spring is characterized by the lowest concentrations throughout the day. For all seasons, the peak hourly median concentrations vary from 75 ppbC at 0600 CST on Spring weekends to 163 ppbC at 0700 CST for Fall weekdays. The seasonal peak 75th percentile concentration values (which roughly correspond to the 48th and 19th highest TNMHC concentration ranked by descending order for weekdays and weekend days, respectively)

range from 186 ppbC at 0500 CST for Spring weekends to 285 ppbC at 0600 CST on Winter weekdays.

A.7.2 TNMHC Event Duration at Port Grain

For the purpose of investigating the duration of high TNMHC events, TNMHC events were defined as one or more consecutive hours characterized by a concentration of 1000 ppbC or greater. Table A.7-1 presents the 177 high TNMHC events (binned by duration in hours) measured at the Port Grain monitoring station during the June 2005 through May 2008 period. The vast majority of events were characterized by durations of 1 hour (61% of total events) and 2 hours (25% of total events). For the remaining events with durations of 3 hours or greater (14% of total events), the majority occurred during the late night and morning hours throughout the November through January period.

A.7.3 Local Meteorological Conditions during High TNMHC Events at Port Grain

Figure A.7-7 presents the median and 75^{th}, 90^{th}, 95^{th}, and 99^{th} percentile hourly TNMHC concentrations binned by the hourly resultant wind direction at Port Grain. The statistical metrics demonstrate a strong peak in TNMHC concentration values during hours with resultant wind directions between south-southwesterly and west-northwesterly. A secondary (lower magnitude) peak occurs for hours with northerly through northeasterly winds. Figure A.7-8 presents the frequency of occurrence by resultant wind direction for all hours during the June 2005 through May 2008 period and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater. The frequency of occurrence of 1000 ppbC TNMHC concentrations is far greater than the climatological frequency of occurrence for hours characterized by winds directions ranging between south-southwesterly clockwise through northeasterly. Overall, high concentrations occur during hours characterized by a wide range of wind directions with the exceptions of easterly winds.

Figure A.7-9 shows the wind component scatterplot for all hours characterized by TNMHC concentrations of 1000 ppbC or greater, grouped by time of occurrence during the 1800 CST through 0900 CST (corresponding to evening/nighttime/morning) and 1000 CST through 1700 CST (corresponding to late morning/afternoon) time periods. (Refer to Section 2.5 of this report for a discussion of how to interpret the wind component scatterplot.) Consistent with the diurnal profile shown in Figure A.7-3, high TNMHC concentrations predominate during the 1800 CST through 0900 CST time period. High TNMHC concentrations generally occur at relatively light wind speeds during hours characterized by winds with a northerly or westerly component. High TNMHC concentrations during periods of southwesterly or southeasterly winds are associated with resultant wind speeds mostly between 5 mph and 10 mph. High TNMHC concentrations during the day are most often associated with southeasterly winds.

Figure A.7-10 presents the frequency of occurrence for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater for five wind speed

ranges (binned by 4 mph increments). Note that 71% of TNMHC concentrations greater than 1000 ppbC occur during hours with wind speeds less than 8 mph.

Figure A.7-11 presents the frequency of occurrence for all hours and for only those hours characterized by TNMHC concentrations of 1000 ppbC or greater for eight temperature ranges (binned by 10 F increments). High TNMHC concentrations occur during hours characterized by a wide range of temperatures between 50 F and 90 F. The frequency of occurrence of 1000 ppbC TNMHC hours is relatively higher than the climatological frequency of occurrence for temperatures less than 70 F. The opposite relationship is noted for hours with temperatures greater the 70 F.

Figure A.7-12 presents the frequency of occurrence for all hours and for those hours characterized by a TNMHC concentration of 1000 ppbC or greater for ten relative humidity (as a percent) ranges. The vast majority of high TNMHC concentrations occur during hours characterized by a relative humidity value of 70% or greater. Figure A.7-13 presents a scatterplot of hourly temperature versus hourly relative humidity for all days during the June 2005 through May 2008 period. Hours characterized by TNMHC concentrations of 1000 ppbC or greater are plotted in red. The highest density of all hourly observations is found along the top right portion of the scatterplot, which indicates hours characterized by relatively warm temperatures and middle to high relative humidity values. This portion of the scatterplot is representative of most days during the spring through fall period, with nighttime hours often located on the right side at relatively high humidity values and daytime hours often located to the left at the lower humidity values. Figure A.7-13 indicates that a large majority of 1000 ppbC TNMHC hours during temperatures greater than 70 F are associated with relative humidity values of 70% or greater, which most likely are representative of nighttime hours. For high TNMHC hours at temperatures less than 70 F relative humidity values are characterized by a wide range between 30% and 90%, which are often representative of drier and cooler conditions associated with periodic intrusions of drier and colder air following the passage of cold fronts through South Texas.

A.7.4 Large-Scale Weather Patterns during High TNMHC Events at Port Grain

Due to the labor intensiveness required to review daily weather maps, the TNMHC concentration threshold used to define high TNMHC events was increased from 1000 ppbC to 2000 ppbC to limit the number of individual days for analysis. To investigate the large-scale weather features that predominate during the highest TNMHC events, 72-hour HYSPLIT back-trajectories were generated for all days during the June 2005 through May 2008 period that were characterized by one or more hours with a TNMHC concentration of 2000 ppbC or greater at the Port Grain monitoring station. Figure A.7-14 shows the 38 back-trajectories on these highest TNMHC days. The back-trajectories were initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface. The back-trajectories shown in Figure A.7-14 can visually be classified into three general categories characterized by long-range flow from the (1) north, (2) east, and (3) south. Note that the vast majority of the back-trajectories are characterized by flow from the southeast and south prior to entering the Corpus Christi area.

Figure A.7-14 shows that a majority of the long-range flow patterns prior to high TNMHC events are characterized by southerly flow into South Texas. Figure A.7-15 presents the surface weather map for November 30, 2007, which is characterized by a long-range trajectory that shows eastward flow over the Gulf of Mexico followed by southerly flow over the western Gulf into Corpus Christi. At upper levels on November 30th, the jet stream was located over the northern half of the continental US and winds over Texas were zonal at 40-50 knots. A cold front that passed through Texas on the morning of November 29th was associated with light northeasterly winds in the morning and light east-southeasterly in the afternoon on November 29th, with a maximum temperature of 69 F. On November 30th, a ridge of high pressure centered over the mid-Atlantic states extended southwestward into eastern Texas. The morning low temperature was near 60 F and surface winds were light northeasterly. TNMHC concentrations were elevated throughout the morning with a maximum concentration of 2219 ppbC at 0100 CST. By the afternoon, moderate east-southeasterly winds were associated with dramatically lower TNMHC concentrations and maximum temperatures in the mid-70 F range.

A review of the large-scale surface weather maps for the 38 days characterized by maximum hourly TNMHC concentrations of 2000 ppbC or greater reveals that a high pressure ridge often extends southwestward into Texas. These surface high pressure systems are often characterized by weak pressure gradients at the surface over coastal Texas and South Texas is often characterized by calm to light morning winds and east-southeasterly afternoon winds. High TNMHC events sometimes occurred on days with tropical cyclone activity located over the central or western Gulf of Mexico. This scenario would place Corpus Christi on the "clean" side of these tropical circulations, which is associated with light northerly flow and stable atmospheric conditions. Cold fronts often played a role in high TNMHC events. Hours with high TNMHC concentrations often occurred either following the passage of cold fronts during periods of northerly winds, or ahead of approaching or stationary fronts located over northern or central Texas. This latter scenario was typically characterized by surface winds with a southeasterly component in the Corpus Christi area. The presence of rain and showers over portions of Texas, including South Texas, were not uncommon during high TNMHC events. Surface centers or weak troughs of low pressure were sometimes located over Texas or northern Mexico.

To explore the daily evolution of surface winds in the Corpus Christi area on high TNMHC days, Figure A.7-16 presents the resultant wind direction versus the resultant wind speed for all hours during the 38 high TNMHC days. During the 0500 CST through 0900 CST time period, winds are characterized by a range of wind directions most often with a westerly or northerly component. By the late morning, winds are often characterized by an easterly component becoming east-southeasterly during the late afternoon becoming southeasterly late in the day.

A.7.5 Analysis and Summary of Port Grain TNMHC and Meteorological Measurements

Air quality analyses were performed using the hourly TNMHC, resultant wind speed, resultant wind direction, temperature, and relative humidity measurements collected at the Port Grain monitoring station during the June 2005 through May 2008 period. The Port Grain monitoring station is located on the north bank of the Corpus Christi Ship Channel. Numerous dry and liquid bulk loading/unloading docks are located along the Ship Channel in the vicinity of Port Grain. In addition, the CITGO and Flint Hills East Plants lie just to the south of Port Grain on the opposite side of the Ship Channel.

The highest hourly TNMHC concentrations (>= 1000 ppbC) occur most frequently during the July through January period with lowest concentrations during March, April, and May. For all months, concentrations are highest during the nighttime hours with a peak in the frequency of occurrence during the 0200 CST through 0700 CST period. The majority of high TNMHC events (86%) are one to two hours in duration. For the remaining events with durations of 3 hours or greater (14% of total events), the majority occurred during the late night and morning hours throughout the November through January period. Analyses of the diurnal profiles by season demonstrate that the nighttime and particularly morning weekday concentrations tend to be higher compared to weekend concentrations during Winter. Other seasons (e.g., Summer and Fall) show evidence of high concentrations on weekdays compared to weekends for some metrics; however, there are no consistent differences between weekday and weekends for the other seasons.

A wind direction analysis indicates that the highest TNMHC concentrations occur during a range of wind directions with the exception of hours characterized by easterly winds. The frequency of occurrence of high TNMHC concentrations is greater than the climatological frequency of occurrence for all hours for wind directions ranging between south-southwesterly clockwise through northeasterly at wind speeds mostly less than 5 mph. High concentrations also occur during periods of southerly or southeasterly flow at slightly higher wind speeds. High TNMHC concentrations occur during hours characterized by a wide range of temperatures between 50 F and 90 F. High TNMHC concentrations can occur during hours with a wide range of relative humidity concentrations; however, a majority of these hours are characterized by relative humidity values above 70%.

The surface weather maps on days characterized by one or more hours with TNMHC concentrations of 2000 ppbC or greater often show a high pressure ridge that extends southwestward into Texas. These surface high pressure systems are often characterized by weak pressure gradients at the surface over coastal Texas and South Texas and are associated with calm to light westerly to northeasterly morning winds and east-southeasterly afternoon winds. Hours with high TNMHC concentrations often occurred either following the passage of cold fronts during periods of northerly winds, or ahead of approaching or stationary fronts located over northern or central Texas. This latter scenario was typically characterized by surface winds with a southeasterly component in the Corpus Christi area.

The wide range of wind directions during hours with high TNMHC concentrations suggests that Port Grain may be impacted by a number of emissions sources in the nearby area. This is not particularly surprising since Port Grain is embedded within the industrialized Ship Channel.

A.7.6 Upwind Emission Sources during High TNMHC Events at Port Grain

The previous analyses for Port Grain did not attempt to account for the hourly variation in atmospheric dispersion conditions. One method to provide some normalization of measured pollutant concentrations with respect to varying atmospheric dispersion conditions is to multiply the concentration by the wind speed. Figure A.7-17 presents a scatterplot of the hourly resultant wind direction (degrees) versus the product of the hourly TNMHC concentrations and the hourly resultant wind speed (ppbC-mph) for all hours during the June 2005 through May 2008 period. Consistent with the results of previous analyses, high values of concentration-wind speed are noted at a range of wind directions, including periods of northerly and northeasterly winds, and during winds characterized by a westerly component. Figure A.7-17 also reveals peaks in concentration-wind speed values for hours characterized by southeasterly and, particularly, southerly (centered at 191 degrees) resultant wind directions.

To identify the local emissions sources at upwind industrial facilities that may impact TNMHC concentrations at Port Grain, the Corpus Christi Trajectory Analysis Tool was used to generate one-hour surface back-trajectories for all hours characterized by an absolute TNMHC concentration of 1000 ppbC or higher. Each back-trajectory was initialized at the half-hour (i.e., midpoint) of the TNMHC one-hour averaging period. Figure A.7-18 plots the one-hour back-trajectories over a geographic map of the Port Grain area. The back-trajectory paths are located over a wide range of directions. Visually, the trajectory paths appear densest to the southeast, southwest, and for a range of directions characterized by a northerly component.

Figure A.1-19 provides a zoomed map of Port Grain and the surrounding area using Google satellite imagery. Routine operational activities in support of the CCAQP include the near real-time investigation of local emissions sources that may have contributed to high TNMHC events at Port Grain. Activities in the immediate vicinity of Port Grain include traffic and idling by heavy-duty vehicles loading grain from the adjacent grain storage towers. Previous pollution event analyses suggest that emissions from these heavy-duty vehicles may impact TNMHC concentrations measured at the Port Grain monitoring station. Similar to J. I. Hailey, Port Grain also may be impacted by emissions associated with ship loading/unloading operations along the Ship Channel or by emissions associated with the surrounding industrial facilities such as the Flint Hills and CITGO East Plants.

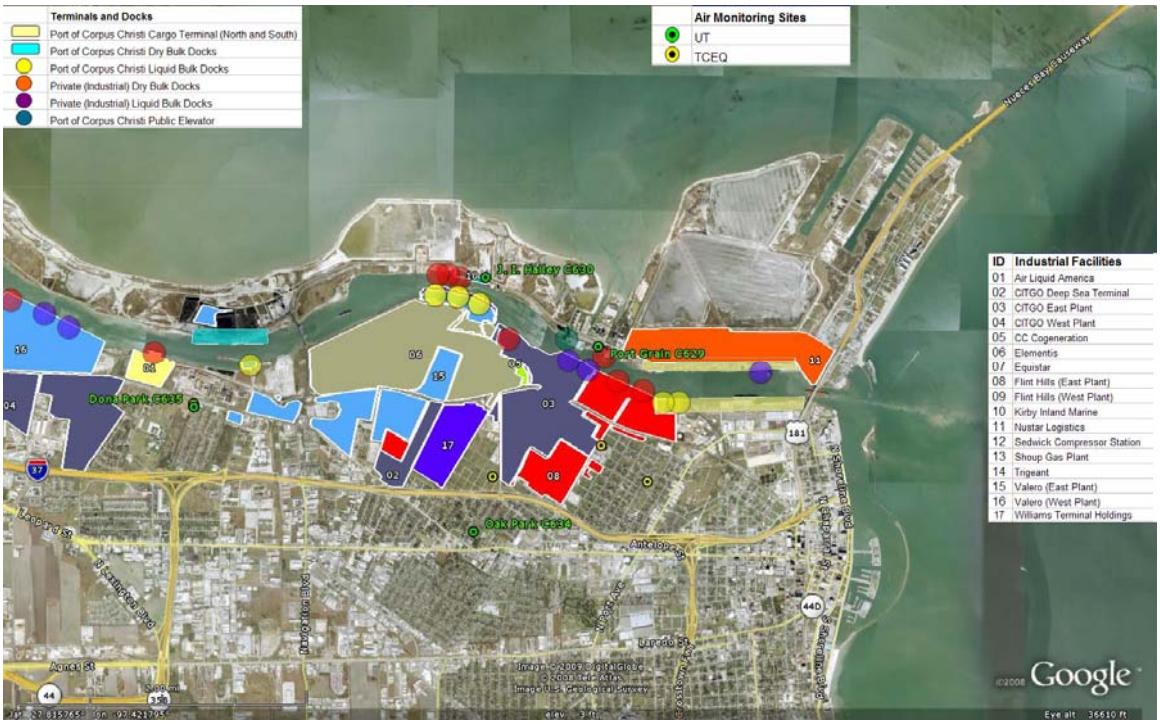

Figure A.7-1. Locations of the Port Grain (C629) monitoring station, nearby CAMS, and surrounding industrial facilities. The Corpus Christi Ship Channel is oriented east-west along the middle of the figure.

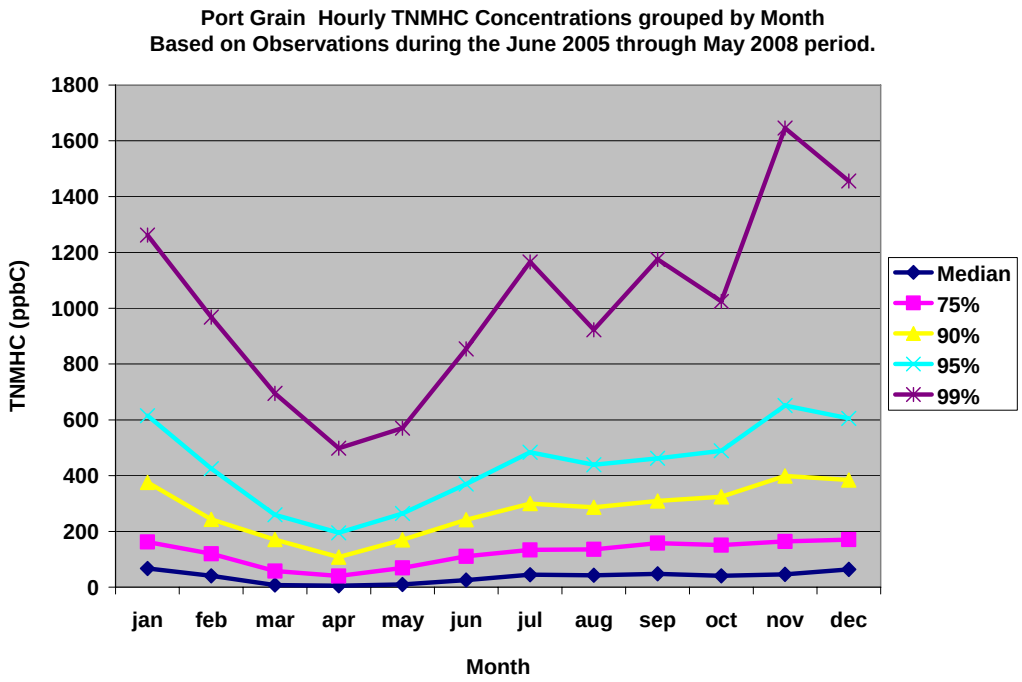

Figure A.7-2. Monthly median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations at the Port Grain monitoring station based on all valid data during the June 2005 through May 2008 period.

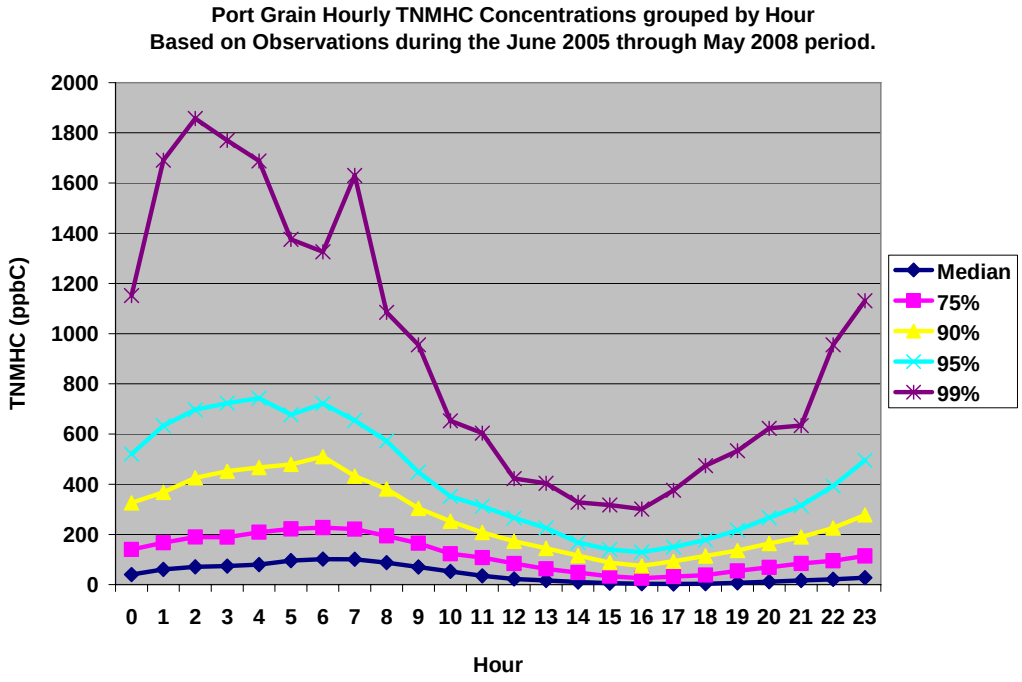

Figure A.7-3. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations at the Port Grain monitoring station by hour based on all valid data during the June 2005 through May 2008 period.

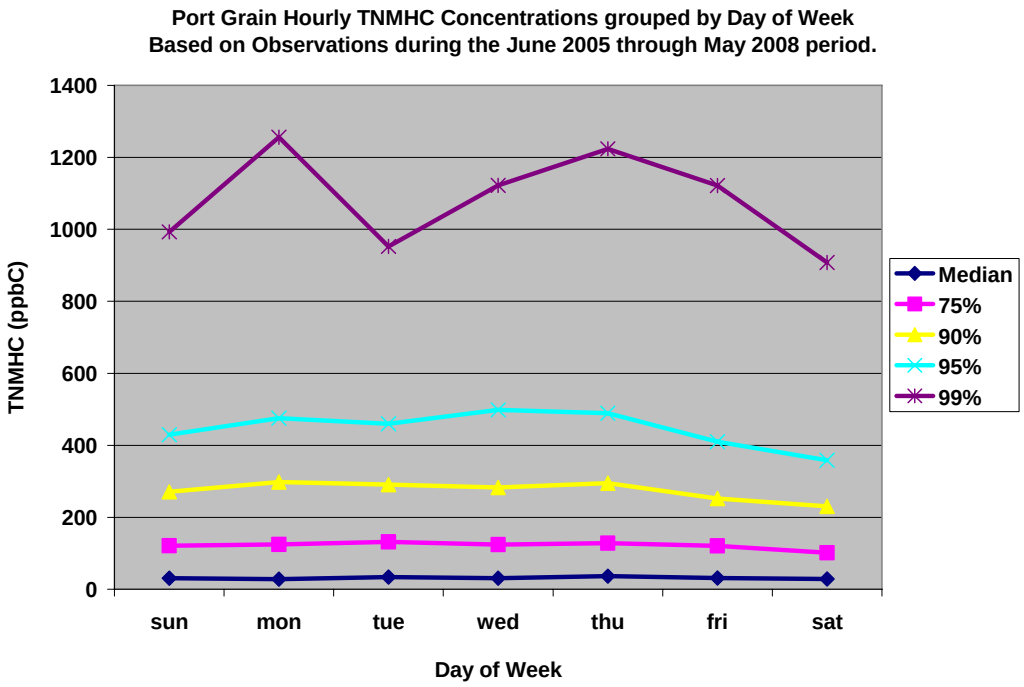

Figure A.7-4. Median and 75th, 90th, 95th, and 99th percentile hourly TNMHC concentrations by Day of Week at the Port Grain monitoring station based on all valid data during the June 2005 through May 2008 period.

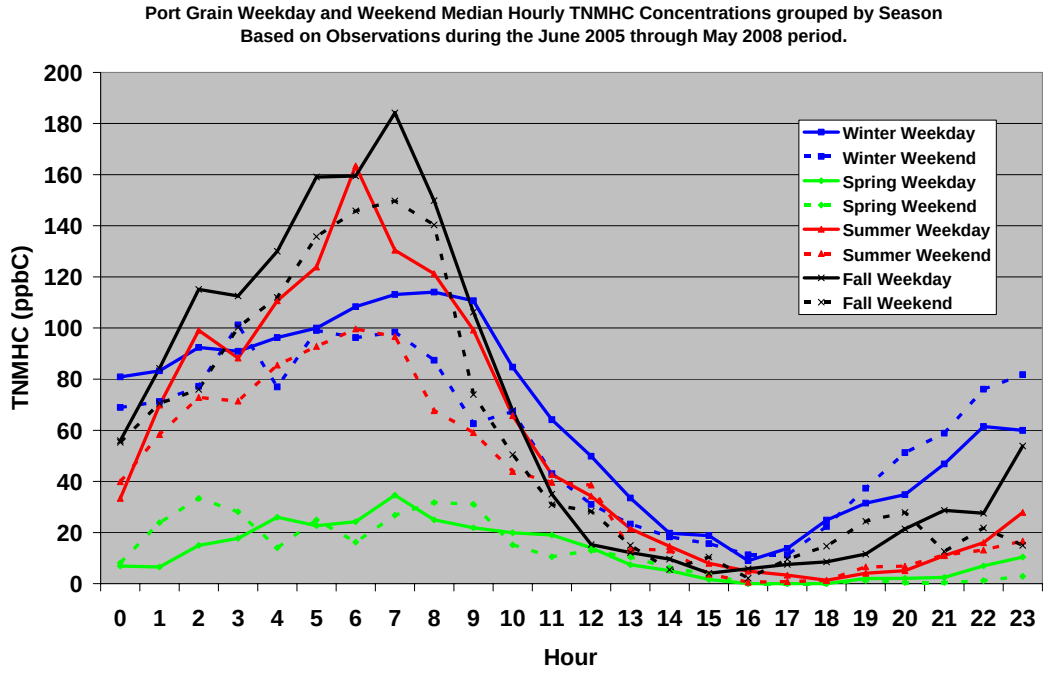

Figure A.7-5. Median hourly weekday and weekend day TNMHC concentrations grouped by season at the Port Grain monitoring station based on all valid data during the June 2005 through May 2008 period.

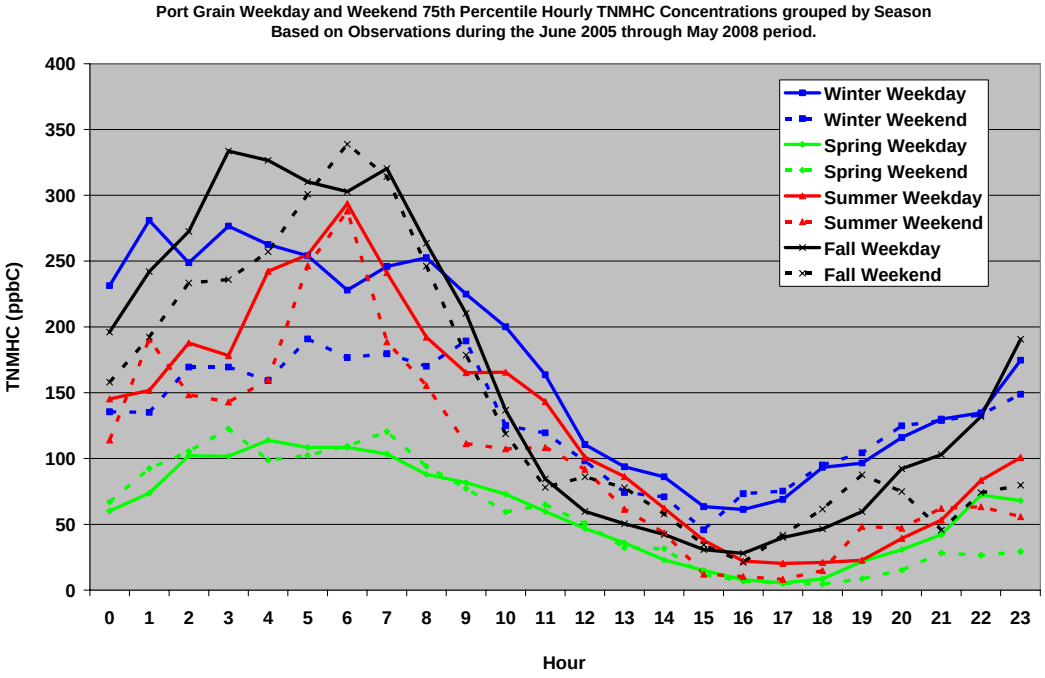

Figure A.7-6. The 75th percentile hourly weekday and weekend day TNMHC concentrations grouped by season at the Port Grain monitoring station based on all valid data during the June 2005 through May 2008 period.

Table A.7-1. High TNMHC events at the Port Grain monitoring station binned by duration in hours. High TNMHC events are defined as one or more consecutive hours characterized by TNMHC concentrations of 1000 ppbC or greater.

Duration of Event (hours)	Number of Events
1	108
2	45
3	13
4	6
5	3
>5	2
Total Events	**177**

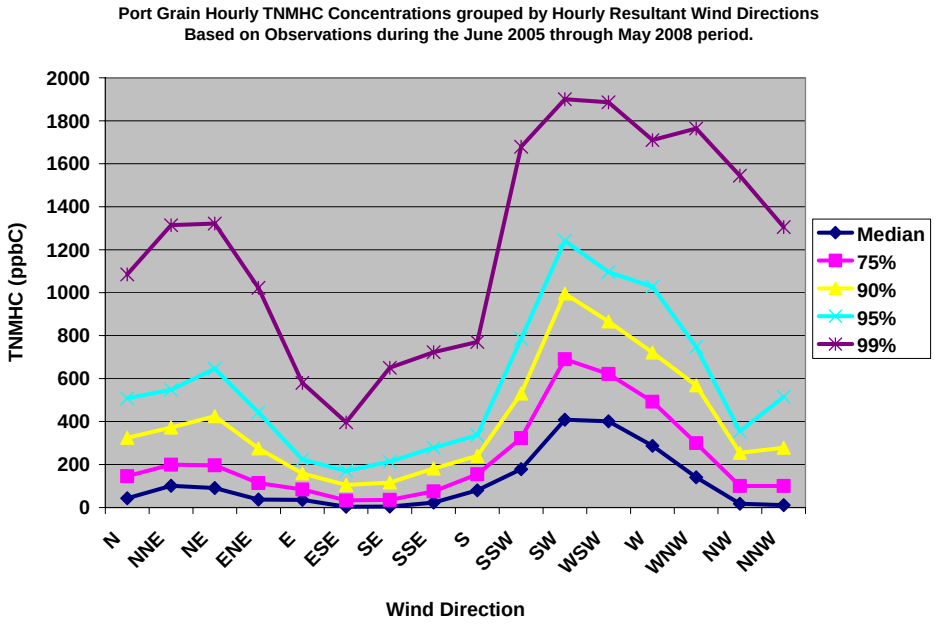

Figure A.7-7. Hourly median and 75th, 90th, 95th, and 99th percentile TNMHC concentrations grouped by hourly resultant wind direction at the Port Grain monitoring station based on all valid data during the June 2005 through May 2008 period.

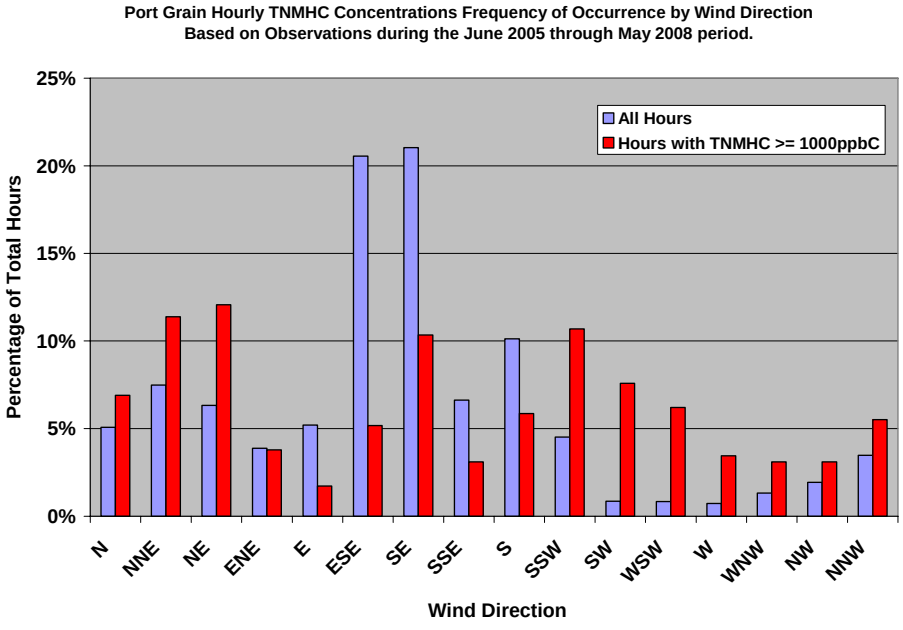

Figure A.7-8. Percentage of hours at the Port Grain monitoring station grouped by resultant wind direction for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppb or greater. Based on all valid data during the June 2005 through May 2008 period.

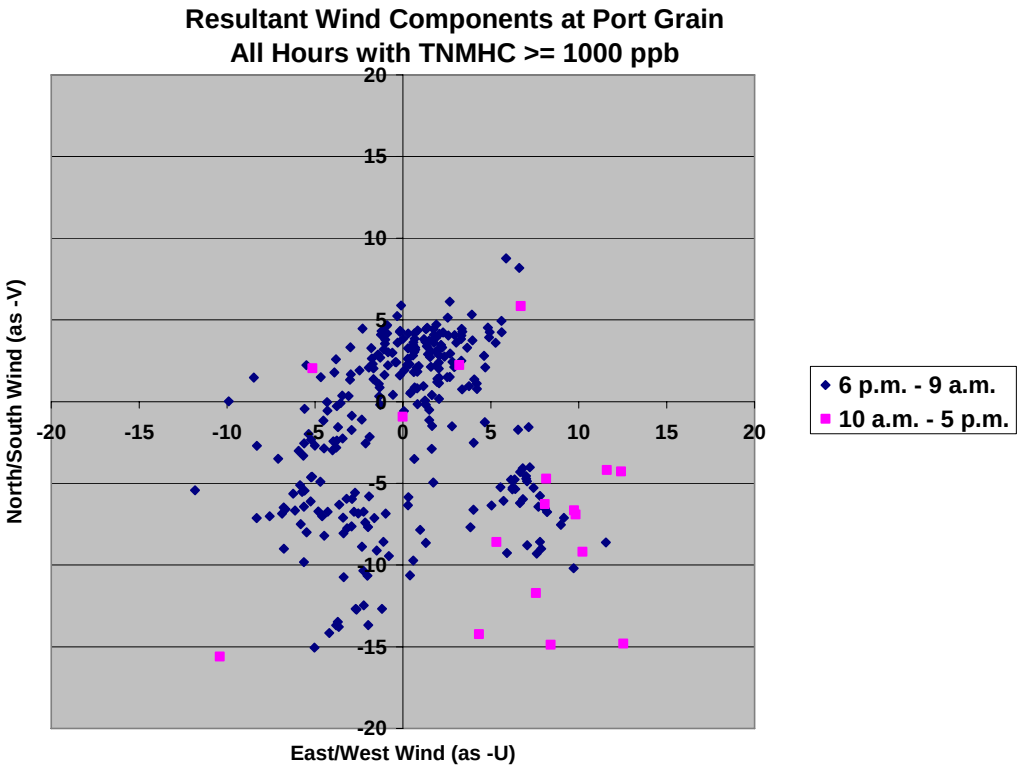

Figure A.7-9. Resultant wind component scatterplot at Port Grain for all hours with TNMHC concentrations of 1000 ppb or greater during the June 2005 through May 2008 period. (The reader is referred to Section 2.5 for a discussion of how to interpret this figure.)

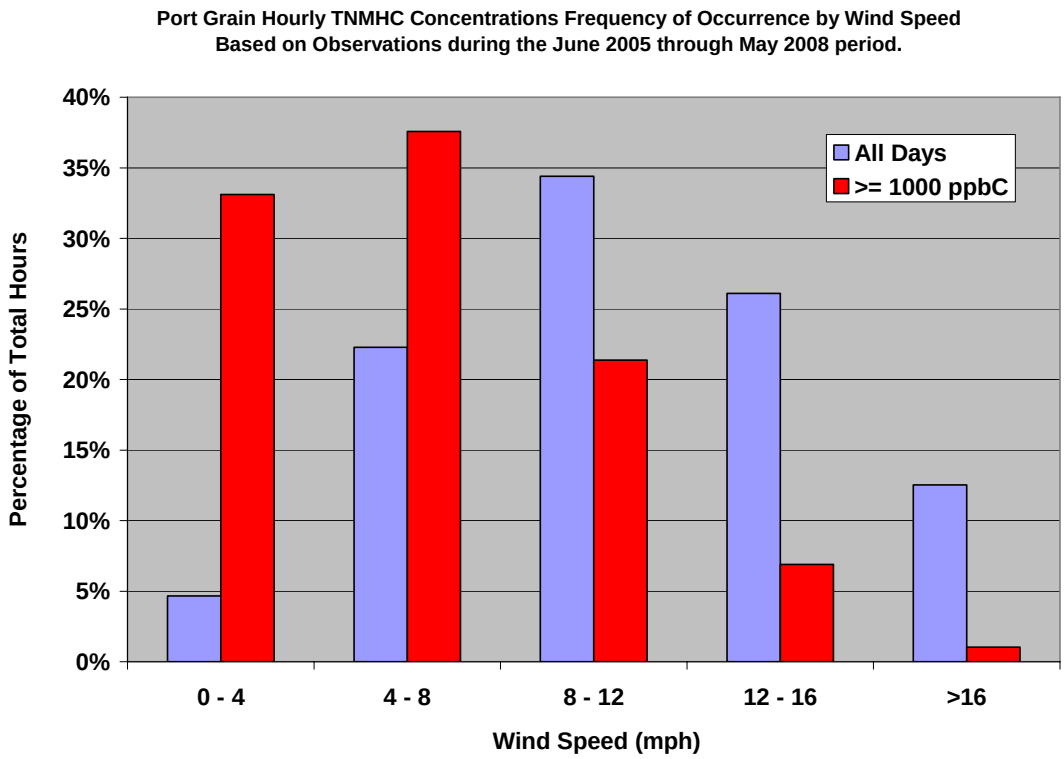

Figure A.7-10. Percentage of hours at the Port Grain monitoring station grouped by resultant wind speed (binned by 4 mph increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

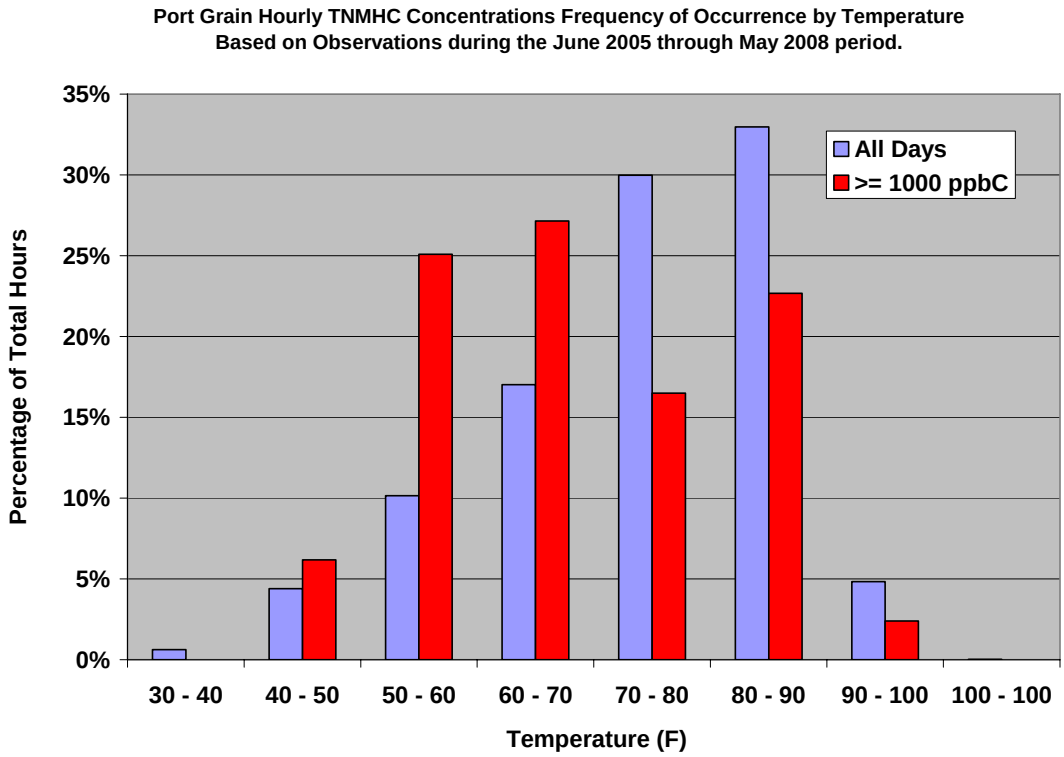

Figure A.7-11. Percentage of hours at Port Grain monitoring station grouped by temperature (binned by 10 F increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

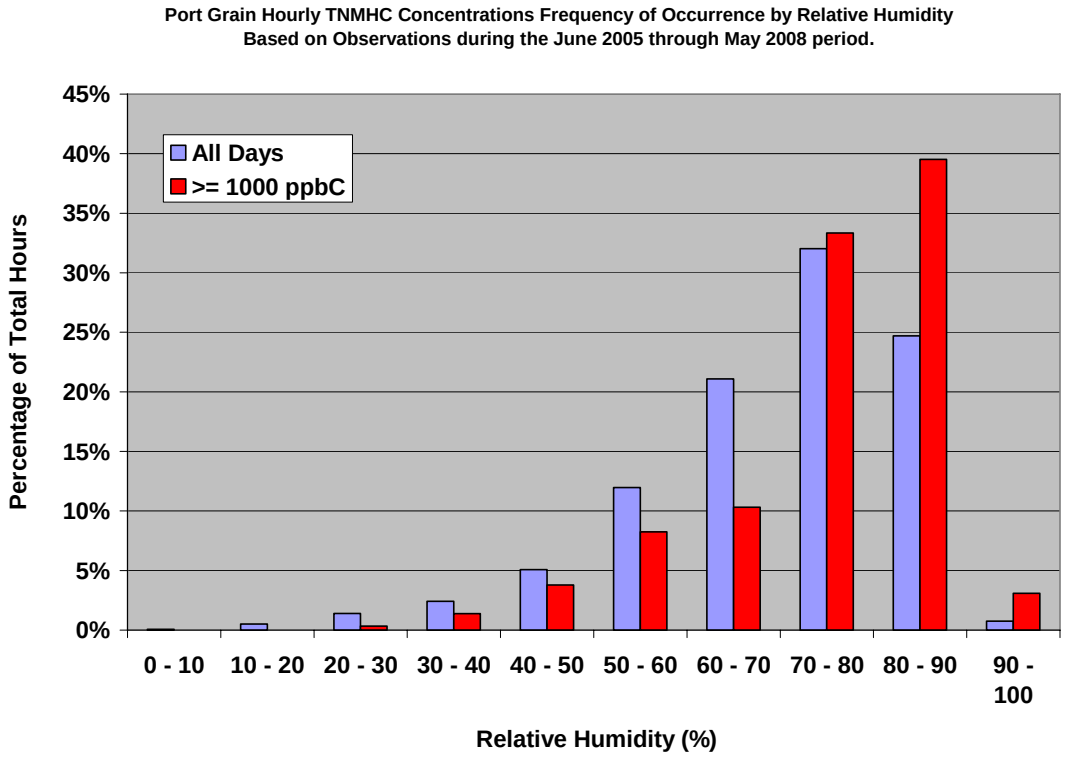

Figure A.7-12. Percentage of hours at the Port Grain monitoring station grouped by relative humidity values (binned by 10% increments) for all hours and for only those hours characterized by a TNMHC concentration of 1000 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

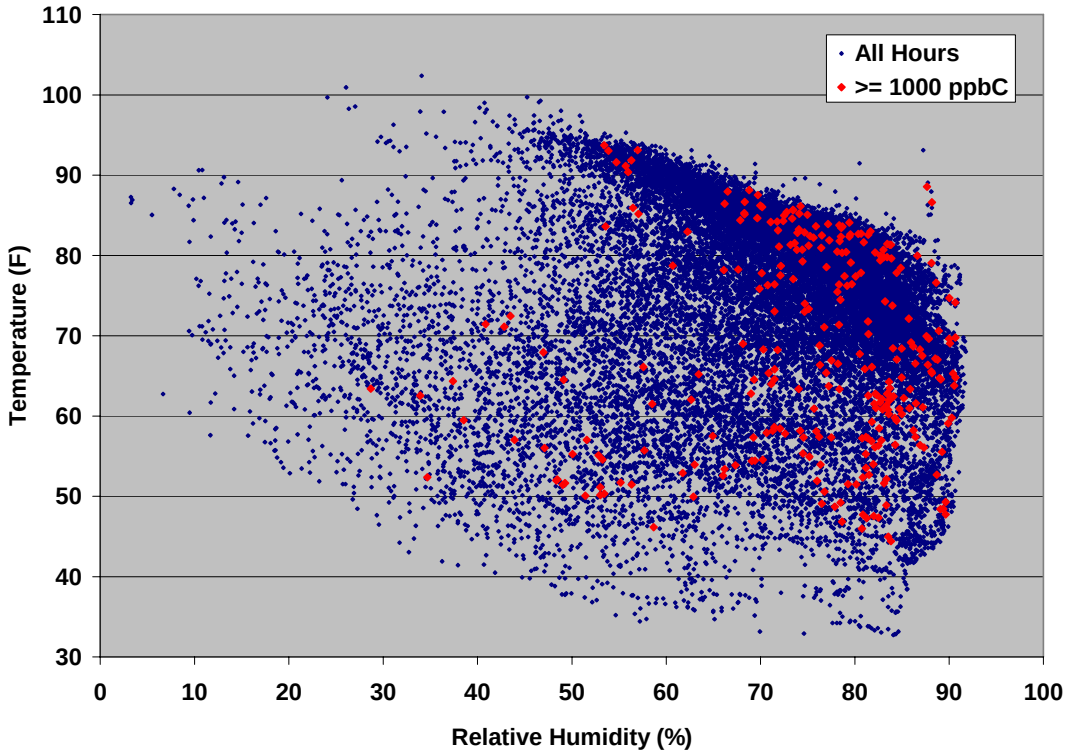

Figure A.7-13. Hourly temperature versus hourly relative humidity at the Port Grain monitoring station for all hours during the June 2005 through May 2008 period. Hours characterized by a TNMHC concentration of 1000 ppbC or greater are highlighted in red.

72-Hour HYSPLIT Back-Trajectories for Days with Hourly TNMHC >= 2000 ppbC
Port Grain (C629): June 2005 - May 2008

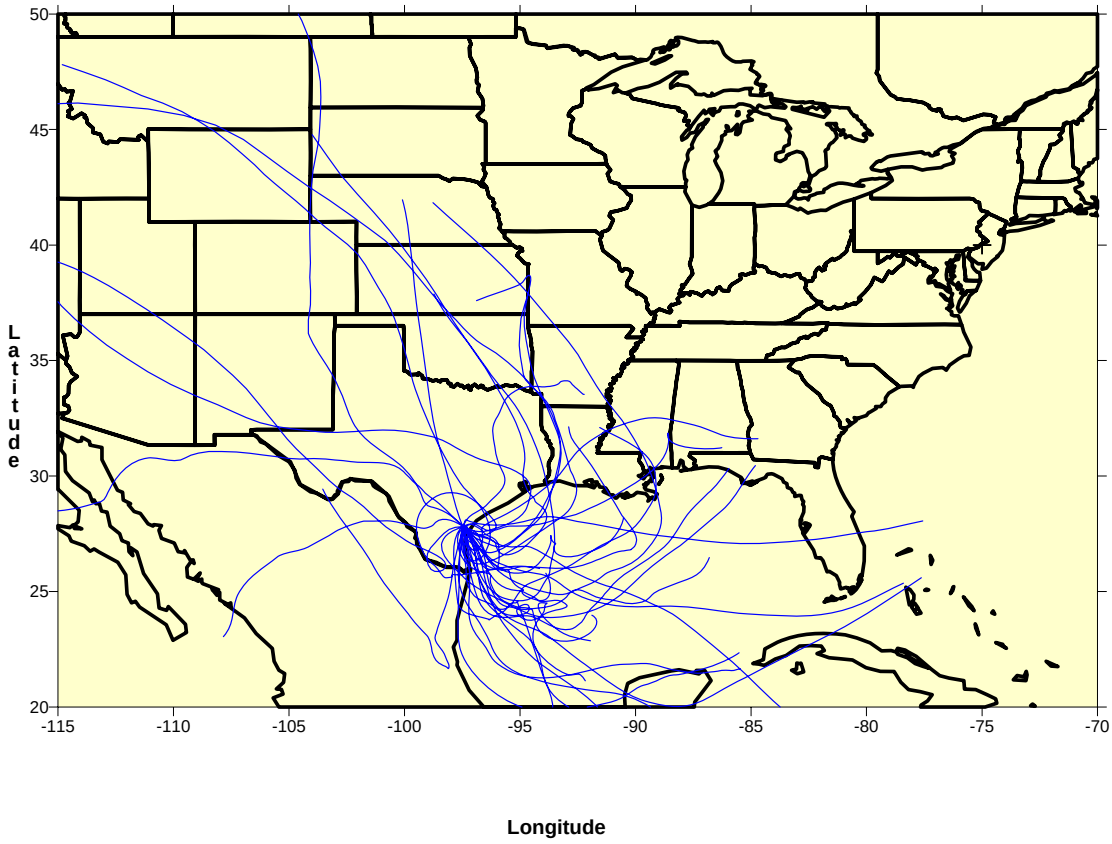

Figure A.7-14. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 38 days during the June 2005 through May 2008 period characterized by one or more hours with TNMHC concentrations of 1500 ppb or greater at the Port Grain monitoring station.

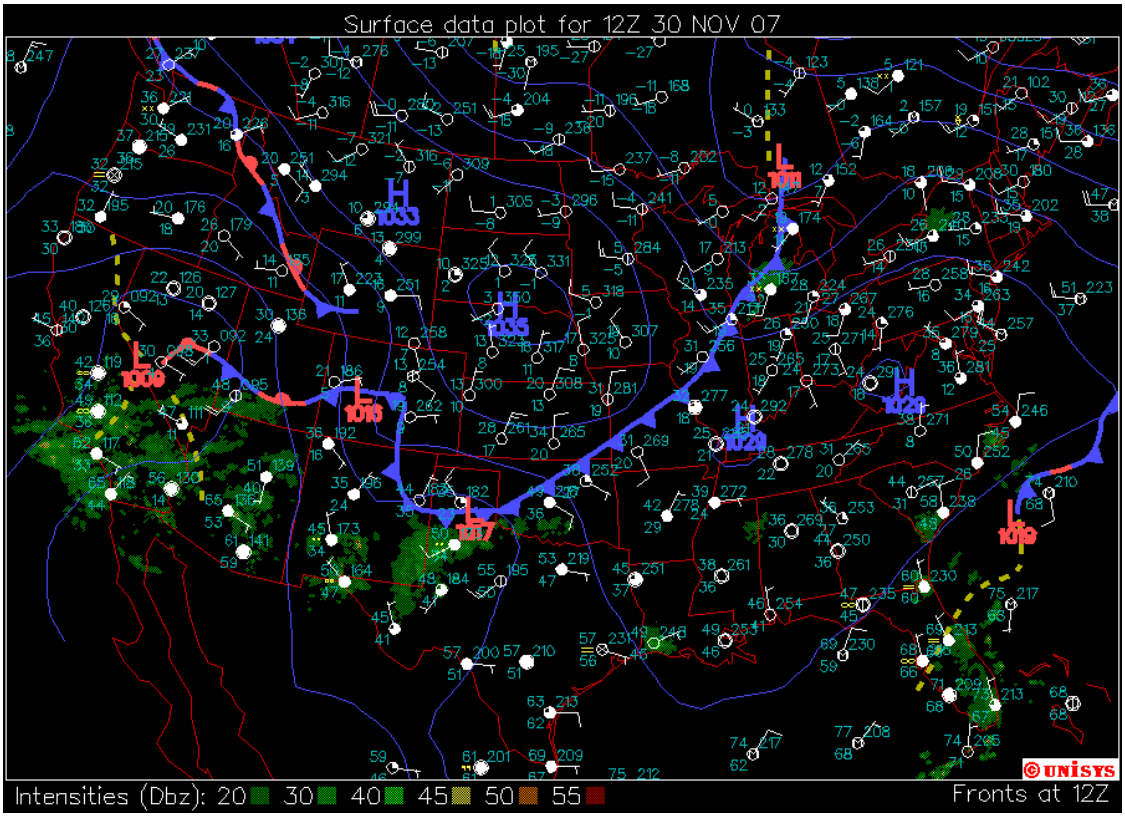

Figure A.7-15. Surface weather map at 0600 CST on November 30, 2007.

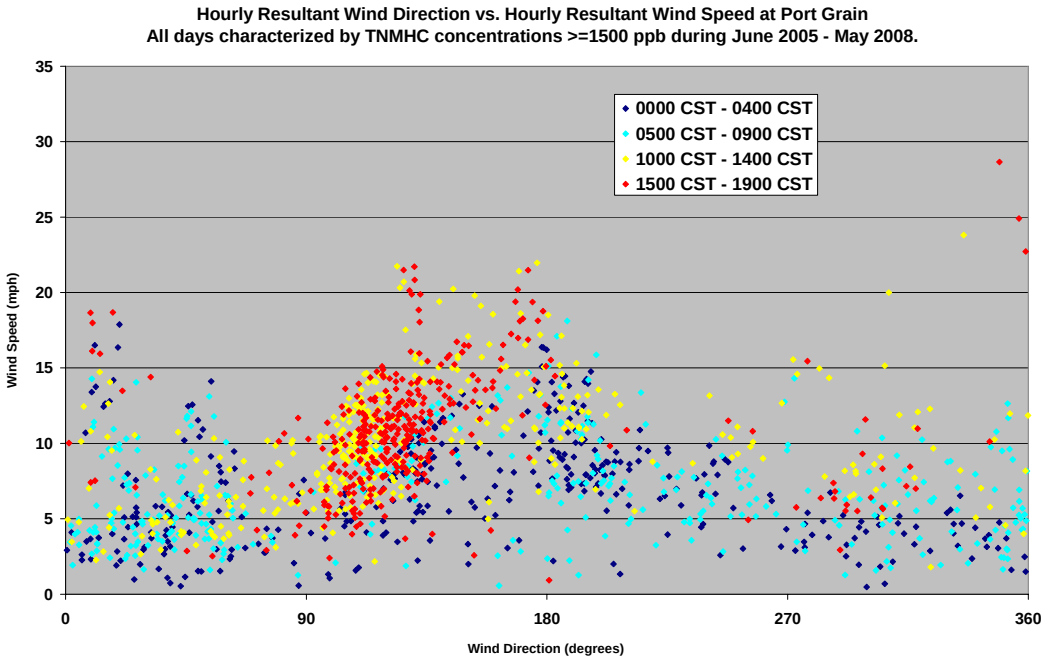

Figure A.7-16. Port Grain resultant wind direction versus the resultant wind speed for all hours on days characterized by one or more TNMHC concentrations of 1500 ppbC or greater.

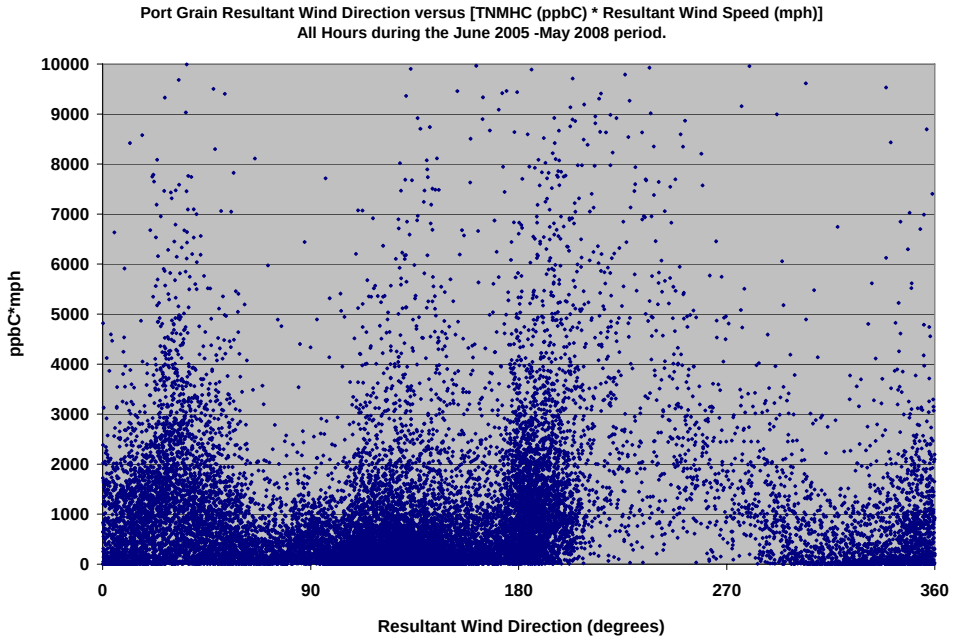

Figure A.7-17. Resultant wind direction (degrees) versus the product of the TNMHC concentration multiplied by the resultant wind speed (ppbC*mph) at the Port Grain monitoring station for all valid hours during the June 2005 through May 2008 period. Note that the chart scale has been defined for easy visualization of high density peaks so that observations above 10,000 ppbC*mph are not shown.

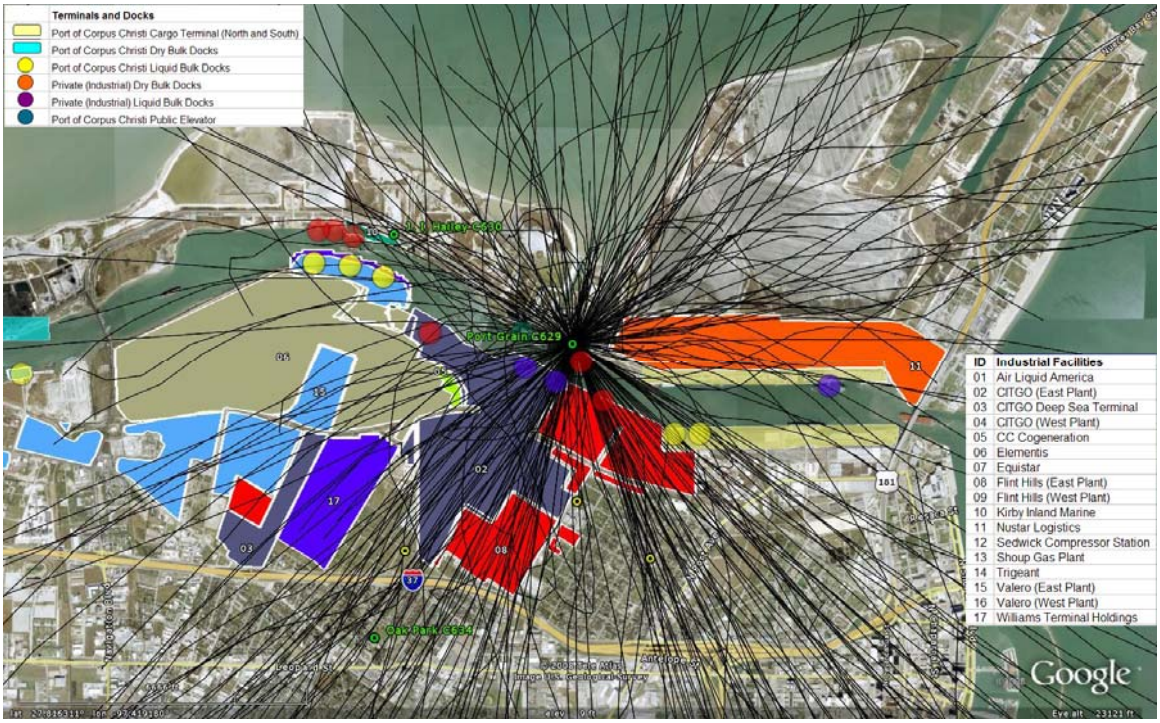

Figure A.7-18. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a TNMHC concentration of 1000 ppb or greater at the Port Grain monitoring station during the June 2005 through May 2008 period.

Figure A.7-19. Detail map of the Port Grain monitoring station and surrounding area. The J. I. Hailey and Port Grain monitoring stations are on the north bank of the Ship Channel in the upper middle and upper right corners, respectively. Note a number of industrial areas associated with various facilities (e.g., refer to Figure A.6-1) are located in the nearby area, including various dry and/or liquid bulk loading/unloading docks along the Ship Channel.

Appendix B

By-Site Benzene Analyses for the CCAQP AutoGC Stations (Solar Estates and Oak Park) and Corpus Christi CATMN Stations

B.0 Benzene

This appendix presents a historical overview of hourly benzene concentrations measured at the Solar Estates and Oak Park CCAQP monitoring stations during the June 2005 through May 2008 period. The analyses include an investigation of the annual, seasonal, and day of week trends, followed by a summary of the local meteorological and associated large-scale weather patterns that have been observed during high benzene events. Surface wind back-trajectories are generated for hours characterized by high benzene concentrations to identify possible emissions sources at upwind industrial facilities. Sections B.1 and B.2 present results for the CCAQP Solar Estates and Oak Park monitoring stations, respectively. In addition, the results of a wind direction analysis using 24-hour canister data collected during the 1993 through 2008 period by the Corpus Christi Community Air Toxics Monitoring Network (CATMN) is presented in Section B.3 provides a summary of the CATMN analyses. ***Note that all tables and figures are presented at the end of each section.***

For the purposes of benzene conceptual model development, high benzene hours are defined as those hours characterized by a benzene concentration of 30 ppbC or greater at the Solar Estates or Oak Park monitoring stations. The threshold value of 30 ppbC was selected because the 30 ppbC threshold level, which corresponds to the 99th percentile concentration for all hourly CCAQP measurements collected during the June 2005 through May 2008 period, provides a sufficient dataset to allow robust statistics for the Corpus Christi area.

The threshold concentration of 30 ppbC is well below the short-term concentration values determined by TCEQ to impact human health. TCEQ evaluates both measured and predicted (e.g., using dispersion and/or photochemical modeling) concentrations for selected air toxic compounds, including benzene, based on comparison to Effects Screening Levels (ESLs) and Reference Values (ReVs). ReVs are typically used to evaluate measured concentrations for their potential to cause health and welfare effects on sensitive human populations. ESLs are typically used in the air permitting process as comparison levels to help ensure that authorized emissions of air contaminants do not cause or contribute to air pollution. If the predicted (i.e., modeled) maximum air concentrations are below the acute (e.g., short-term or one-hour) and chronic (e.g., long-term or annual) ESLs, adverse impacts on human health and welfare are not expected. For benzene, the health-based REVs are currently set to 1080 ppbC and 516 ppbC for acute and chronic exposure, respectively. The corresponding acute and chronic ESLs for benzene are 324 ppbC and 8.4 ppbC, respectively. Note that the benzene concentration threshold value of 30 ppbC used in support of conceptual model development is 9.3% of the acute ESL value of 324 ppbC. For further information on the development of the ReVs and ESLs for benzene, the reader is referred to the TCEQ Toxicology Section's report "Benzene, Development Support Document, Final, October 15, 2007" (TCEQ, 2007).

B.1 Solar Estates (C633) Monitoring Station

Figure A.1-1 showed the location of the Solar Estates monitoring station, which is sited along the eastern boundary of the Solar Estates residential neighborhood. CAMS 632 (FHR Easement) and CAMS 21 (TCEQ Tuloso) are located approximately 0.8 mile to the east and west-northwest, respectively, of the Solar Estates monitoring station. The Flint Hills Resources (West Plant) industrial facility, which is situated along and to the southwest of the western portion of the Corpus Christi Ship Channel, lies immediately to the north and northeast of Solar Estates on the north side of Interstate 37. The Equistar Chemicals industrial facility is located 3 miles to the west-southwest of Solar Estates.

B.1.1 Seasonal, Day of Week, and Diurnal Variability in Benzene Concentrations at Solar Estates

The median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations grouped by month are shown in Figure B.1-1. The highest concentration values generally occur during the September through February period, with peak values during December. The monthly 95th percentile concentration values (which roughly correspond to the 110th highest benzene concentration ranked by descending order) for September through February range from 6.41 ppbC for February to 10.79 ppbC for December. For the remaining months, the 95th percentile concentration values range from 3.36 ppbC during April to 5.41 ppbC during August.

The median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations grouped by hour are shown in Figure B.1-2. For all metrics, the daytime hours are characterized by slightly lower concentrations compared to the nighttime hours, with peak values during the early morning hours of 0500 CST through 0800 CST. The 95th percentile concentration values (which roughly correspond to the 55th highest benzene concentration ranked by descending order) range from 4.07 ppbC at 1600 CST to 8.17 ppbC at 0600 CST. The median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations by day of week are shown in Figure B.1-3. The 95th percentile concentration values (which roughly correspond to the 188th highest benzene concentration ranked by descending order) vary from 4.76 ppbC on Sunday to 7.37 ppbC on Tuesday.

To investigate possible seasonal differences in the diurnal profiles by day of week, Figures B.1-4 and B.1-5 present the median and 75th percentile hourly benzene concentrations, respectively, grouped by season. Figures B.1-4 and B.1-5 demonstrate some tendency for higher concentrations during the nighttime and morning hours for weekdays compared to weekend days during the Fall and Winter seasons. During Spring, concentrations are generally higher on weekends compared to weekdays. For all seasons, highest concentration values occur during the nighttime hours with a peak in concentration values during the 0600 CST through 0800 CST period. The morning peak occurs one hour earlier during Spring and Summer. For all seasons, the maximum hourly median concentrations vary from 1.70 ppbC at 0200 CST on Spring weekends to 2.98 ppbC at 0700 CST on Fall weekdays. The seasonal maximum 75th percentile

concentration values (which roughly correspond to the 48th and 19th highest benzene concentration ranked by descending order for weekdays and weekend days, respectively) range from 2.88 ppbC at 0600 CST for Spring weekends to 4.85 ppbC at 0700 CST on Fall weekdays.

B.1.2 Benzene Event Duration at Solar Estates

For the purpose of investigating the duration of high benzene events, benzene events were defined as one or more consecutive hours characterized by a concentration of 30 ppbC or greater. A total of 24 events were measured at the Solar Estates monitoring station during the June 2005 through May 2008 period. No events were longer than one hour in duration.

B.1.3 Local Meteorological Conditions during High Benzene Events at Solar Estates

Figure B.1-6 presents the median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations binned by the hourly resultant wind direction at Solar Estates. The statistical metrics demonstrate that highest concentrations occur during hours characterized by winds ranging from north-northeasterly through easterly winds. The 95th percentile concentration value (which roughly corresponds to the 82nd highest benzene concentration ranked by descending order) is 15.6 ppbC for hours with a northeasterly resultant wind direction. Minimum concentration values are noted during periods of southeasterly and south-southeasterly winds. Figure B.1-7 presents the frequency of occurrence by resultant wind direction for all hours during the June 2005 through May 2008 period and for those hours characterized by a benzene concentration of 30 ppbC or greater. The frequency of occurrence of 30 ppbC benzene concentrations is far greater than the climatological frequency of occurrence for hours characterized by winds with a north-northeasterly or northeasterly wind direction.

Figure B.1-8 shows the wind component scatterplot for all hours characterized by benzene concentrations of 30 ppbC or greater, grouped by time of occurrence during the 1800 CST through 0900 CST (corresponding to evening/nighttime/morning) and 1000 CST through 1700 CST (corresponding to late morning/afternoon) time periods. (Refer to Section 2.5 of this report for a discussion of how to interpret the wind component scatterplot.) Consistent with the diurnal profile shown in Figure B.1-2, high benzene concentrations predominate during the 1800 CST through 0900 CST time period, and most often occur during hours characterized by wind speeds ranging from nearly calm to 7 mph.

Figure B.1-9 presents the frequency of occurrence for all hours and for those hours characterized by a benzene concentration of 30 ppbC or greater for five wind speed ranges (binned by 4 mph increments). Highest benzene concentrations predominate at hours characterized by wind speeds of 8 mph or less.

Figure B.1-10 presents the frequency of occurrence for all hours and for only those hours characterized by benzene concentrations of 30 ppbC or greater for eight temperature

ranges (binned by 10 F increments). High benzene concentrations occur predominantly at temperatures between 50 F and 70 F. The tendency for 30 ppbC benzene events at relatively lower temperatures is consistent with the previously shown highest frequency of occurrence of high benzene events during the Fall and Winter nighttime hours, which would be generally characterized by the lowest temperatures.

Figure B.1-11 presents the frequency of occurrence for all hours and for those hours characterized by a benzene concentration of 30 ppbC or greater for ten relative humidity (as a percent) ranges. High benzene concentrations occur at a range of relative humidity values, with about half of high benzene events occurring at hours with relative humidity values greater than 70%. Figure B.1-12 presents a scatterplot of hourly temperature versus hourly relative humidity for all days during the June 2005 through May 2008 period. Hours characterized by benzene concentrations of 30 ppbC or greater are plotted in red. The highest density of all hourly observations is found along the top right portion of the scatterplot, which indicates hours characterized by relatively warm temperatures and middle to high relative humidity values. This portion of the scatterplot is representative of most days during the spring through fall period, with nighttime hours often located on the right side at relatively high humidity values and daytime hours often located to the left at the lower humidity values. Figure B.1-12 indicates the 30 ppbC benzene hours occur at a wide range of temperature and relative humidity values.

B.1.4 Large-Scale Weather Patterns during High Benzene Events at Solar Estates

To investigate the large-scale weather features that predominate during high benzene events, 72-hour HYSPLIT back-trajectories were generated for all days during the June 2005 through May 2008 period that were characterized by one or more hours with a benzene concentration of 30 ppbC or greater at the Solar Estates monitoring station. Figure B.1-13 shows the 24 back-trajectories on these highest benzene days. The back-trajectories were initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface. The back-trajectories can generally be classified as indicating long term flow from the (1) west-northwest, (2) northeast, and (3) east. Most of the back-trajectories show long-range curvature consistent with the circulation of air around a surface ridge of high pressure that extends south or southwest into Texas.

A review of the large-scale surface weather maps for the 24 high days characterized by maximum hourly benzene concentrations of 30 ppbC or greater reveals that a high pressure ridge often extends southward, southwestward, or westward into Texas. These surface high pressure systems are often associated with cold fronts that have moved through Texas accompanied by light to moderate northerly or northeasterly surface winds in the Corpus Christi area. These high pressure systems are also often associated with weak horizontal pressure gradients over the Corpus Christi area and are associated with light winds speeds and (likely) stable atmospheric conditions. To explore the daily evolution of surface winds in the Corpus Christi area on high benzene days, Figure B.1-14 presents the resultant wind direction versus the resultant wind speed for all hours during the 24 days characterized by benzene concentrations of 30 ppbC or greater. During the 0000 CST through 0900 CST period, winds are most often northwesterly

through northeasterly at 3 – 8 mph. By the late afternoon hours, most days are characterized by east-southeasterly or southeasterly winds at 5-12 mph.

B.1.5 Analysis and Summary of Solar Estates Benzene and Meteorological Measurements

Air quality analyses were performed using the hourly benzene, resultant wind speed, resultant wind direction, temperature, and relative humidity measurements collected at the Solar Estates monitoring station during the June 2005 through May 2008 period. The Solar Estates monitoring station is located along the southeastern boundary of the Solar Estates residential neighborhood. The Flint Hills (West Plant) Resources industrial facility, which is situated along and to the southwest of the western portion of the Corpus Christi Ship Channel, lies immediately to the north and northeast of Solar Estates on the north side of Interstate 37. The Equistar Chemicals industrial facility is located 3 miles to the west-southwest of Solar Estates.

The highest hourly benzene concentrations generally occur during the September through February period during hours characterized by north-northeasterly or northeasterly winds. Concentrations are slightly higher during the nighttime hours compared to daytime hours, with peak concentrations during the 0500 CST through 0800 CST period. High benzene events (defined as one or more consecutive hours with concentrations greater than or equal to 30 ppbC) were limited to one hour in duration and 24 events were measured during the June 2005 through May 2008 period. Analyses of the diurnal profiles by season demonstrate some tendency for higher concentrations during the nighttime and morning hours for weekdays compared to weekend days during the Fall and Winter seasons. During Spring, concentrations are generally higher on weekends compared to weekdays.

High benzene events most often occurred during hours characterized by wind speeds of 8 mph or less over a wide range of temperature and relative humidity values. A review of the large-scale surface weather maps for the 24 high days characterized by maximum hourly benzene concentrations of 30 ppbC or greater reveals that a high pressure ridge often extends southward, southwestward, or westward into Texas. These surface high pressure systems are often associated with cold fronts that have moved through Texas accompanied by light to moderate northerly or northeasterly surface winds in the Corpus Christi area. These high pressure systems are also often associated with weak horizontal pressure gradients over the Corpus Christi area during periods of light winds speeds and (likely) stable atmospheric conditions.

B.1.6 Upwind Emission Sources during High Benzene Events at Solar Estates

The previous analyses for Solar Estates did not attempt to account for the hourly variation in atmospheric dispersion conditions. One method to provide some normalization of measured pollutant concentrations with respect to varying atmospheric dispersion conditions is to multiply the concentration by the wind speed. Figure B.1-15 presents a scatterplot of the hourly resultant wind direction (degrees) versus the product of the

hourly benzene concentrations and the hourly resultant wind speed (ppbC-mph) for all hours during the June 2005 through May 2008 period. Consistent with the results of previous analyses, high values of concentration-wind speed are noted during periods of northeasterly winds. In addition, there are relative peaks in concentration-wind speed values during hours characterized by easterly to east-southeasterly winds.

To identify the local emissions sources at upwind industrial facilities that may impact high benzene concentrations at Solar Estates, the Corpus Christi Trajectory Analysis Tool was used to generate one-hour surface back-trajectories for the 24 hours characterized by an absolute benzene concentration of 30 ppbC or higher. Each back-trajectory was initialized at the half-hour (i.e., midpoint) of the benzene one-hour averaging period. Figure B.1-16 plots the one-hour back-trajectories over a geographic map of the Solar Estates area. Virtually all of the back-trajectory paths indicate flow from the northeast or east over a portion of the Flint Hills Resources West Plant.

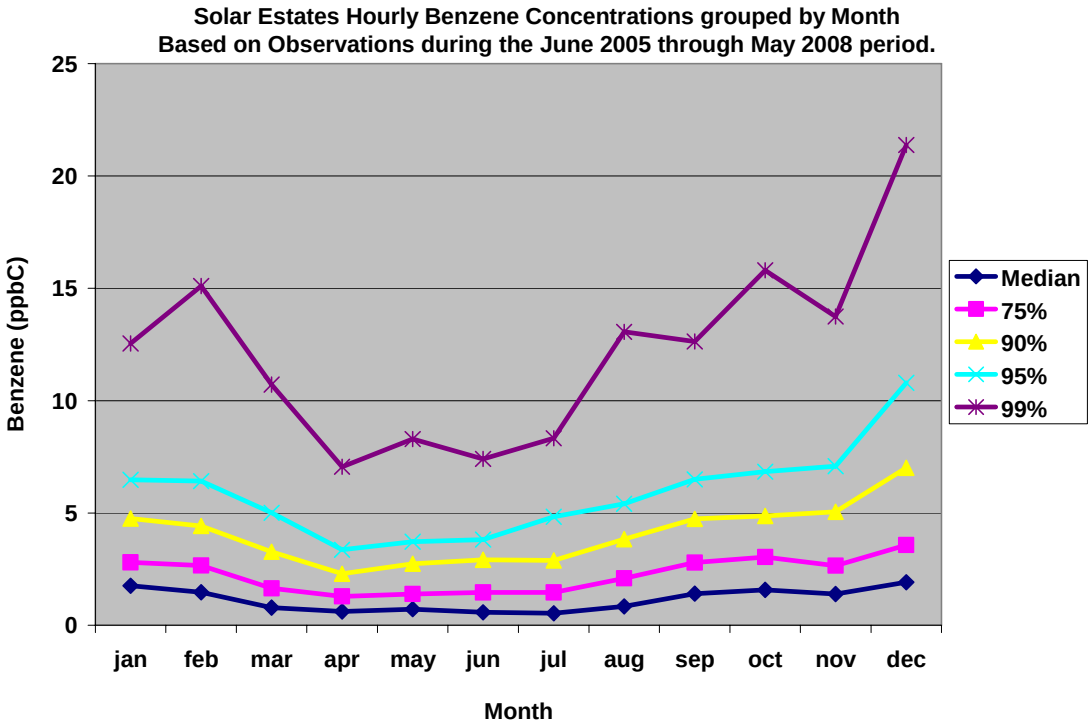

Figure B.1-1. Monthly median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

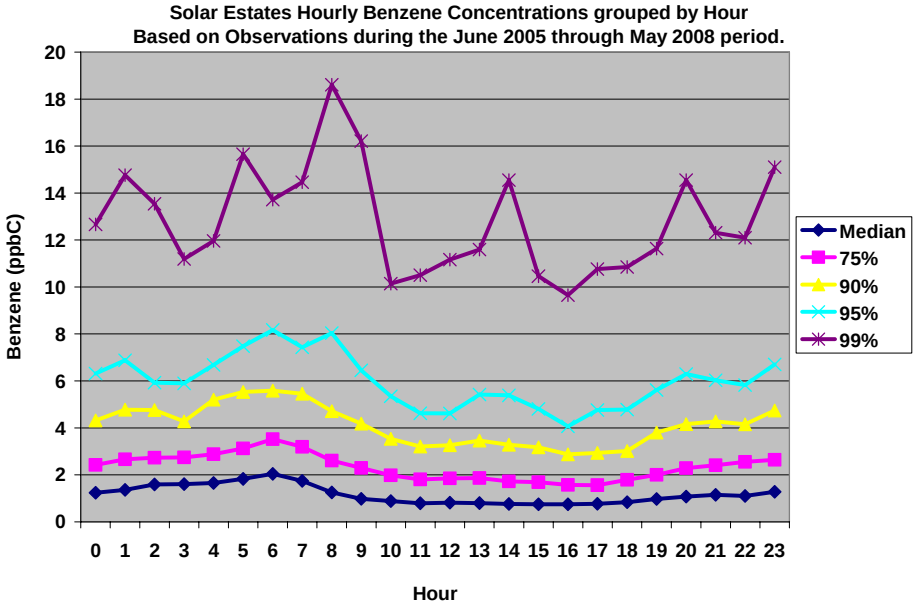

Figure B.1-2. Hourly median and 75th, 90th, 95th, and 99th percentile benzene concentrations at the Solar Estates monitoring station by hour based on all valid data during the June 2005 through May 2008 period.

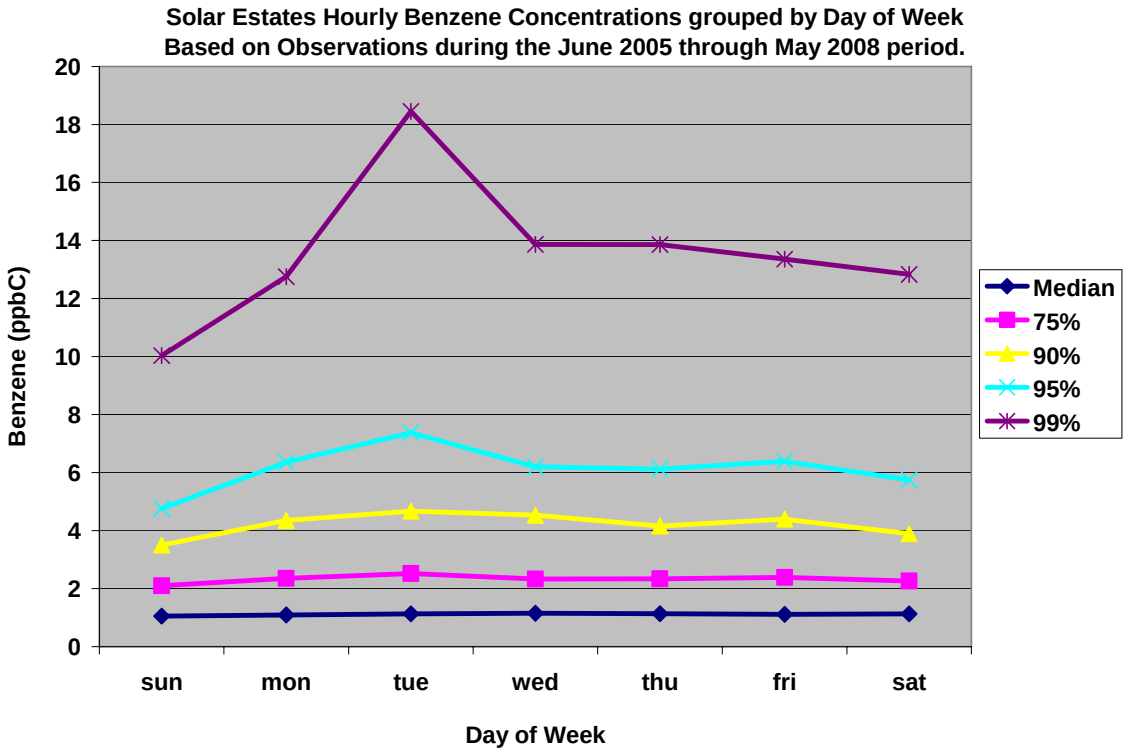

Figure B.1-3. Median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations by Day of Week at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

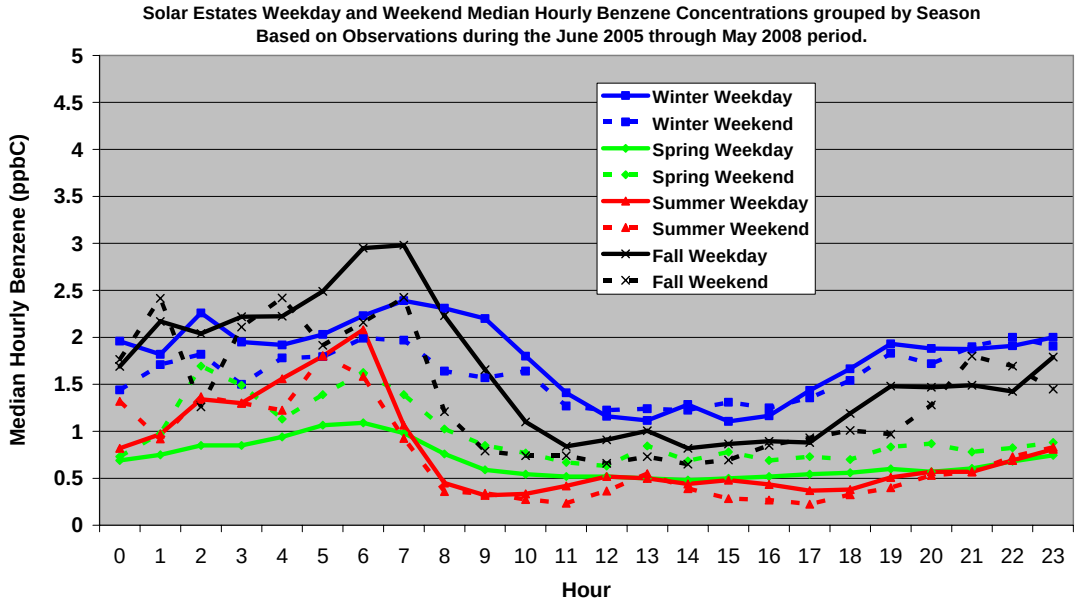

Figure B.1-4. Median hourly weekday and weekend day benzene concentrations grouped by season at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

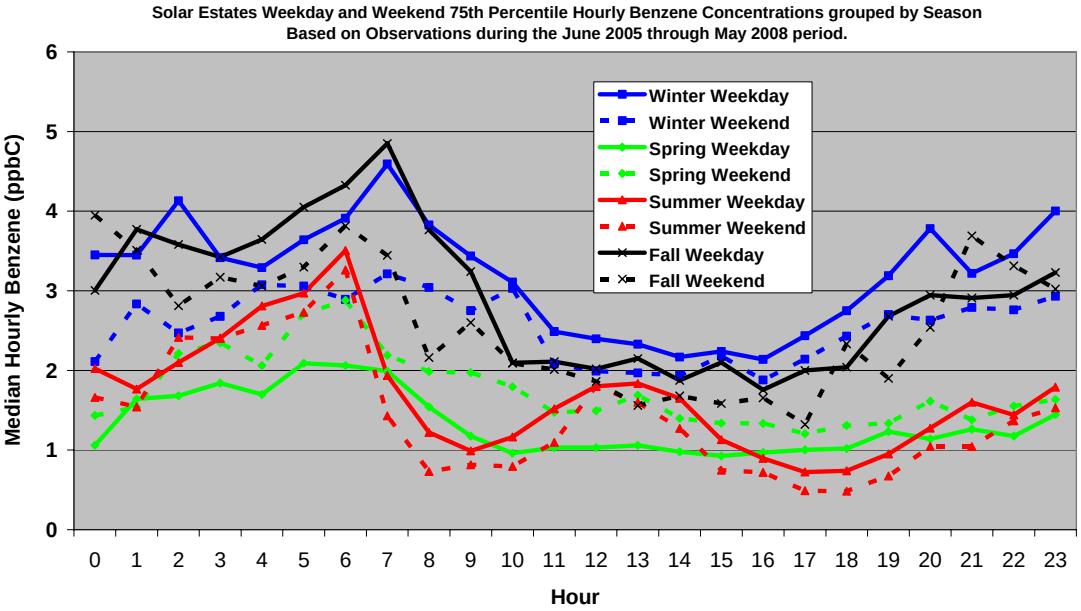

Figure B.1-5. The 75th percentile hourly weekday and weekend day benzene concentrations grouped by season at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

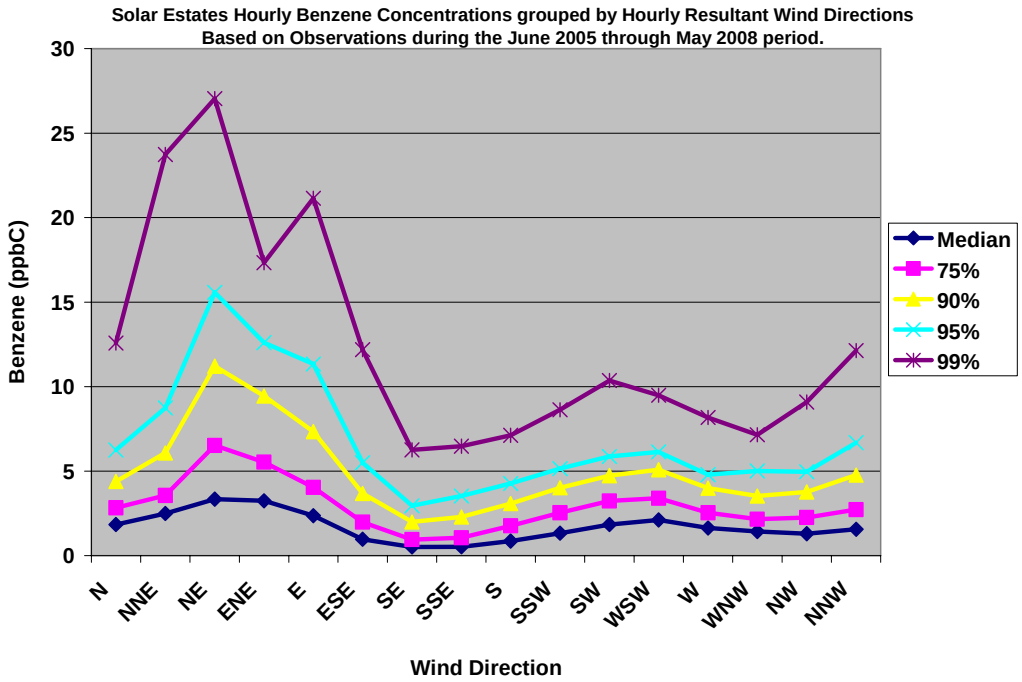

Figure B.1-6. Hourly median and 75th, 90th, 95th, and 99th percentile benzene concentrations grouped by hourly resultant wind direction at the Solar Estates monitoring station based on all valid data during the June 2005 through May 2008 period.

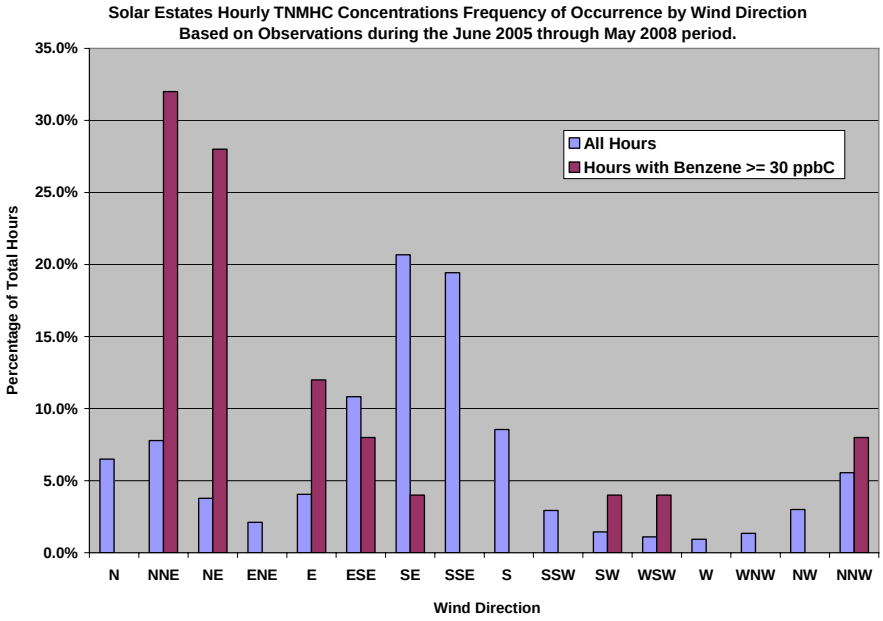

Figure B.1-7. Percentage of hours at the Solar Estates monitoring station grouped by resultant wind direction for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

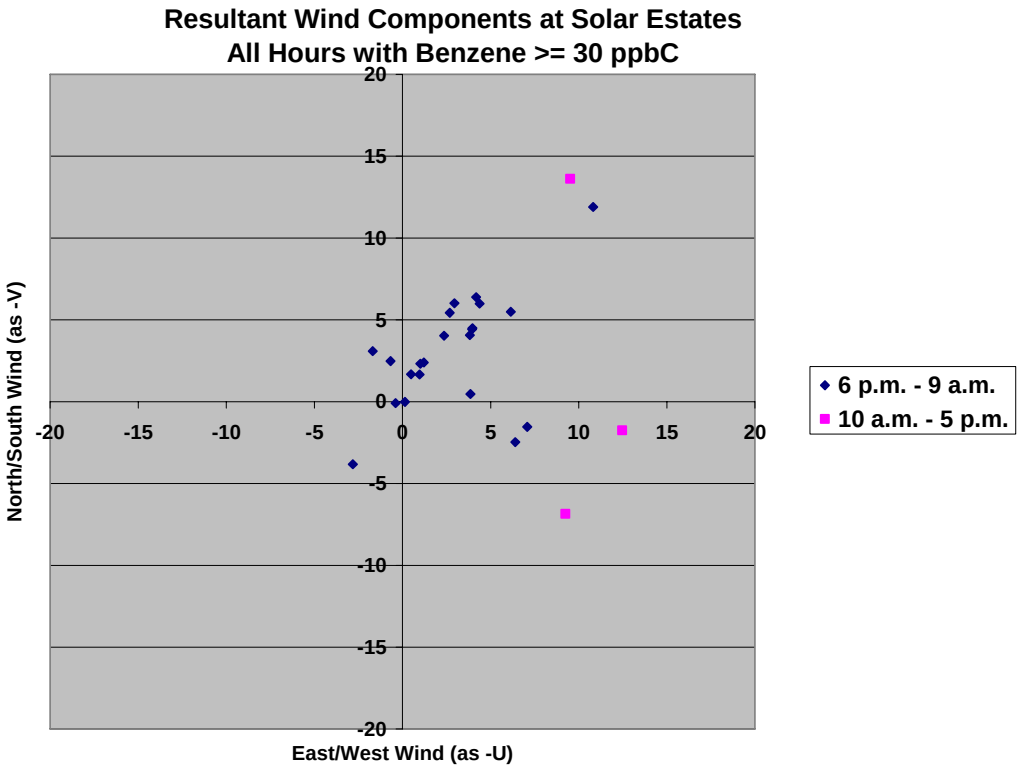

Figure B.1-8. Resultant wind component scatterplot at Solar Estates for all hours with benzene concentrations of 30 ppbC or greater during the June 2005 through May 2008 period. (The reader is referred to Section 2.5 for a discussion of how to interpret this figure.)

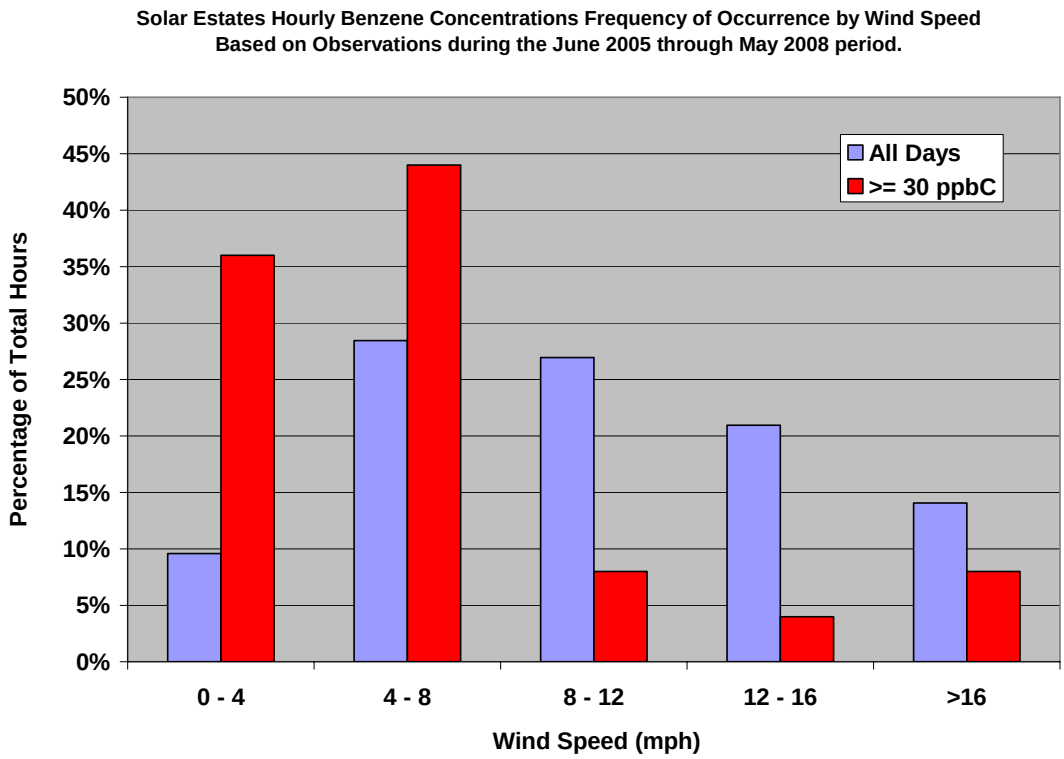

Figure B.1-9. Percentage of hours at the Solar Estates monitoring station grouped by resultant wind speed (binned by 4 mph increments) for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

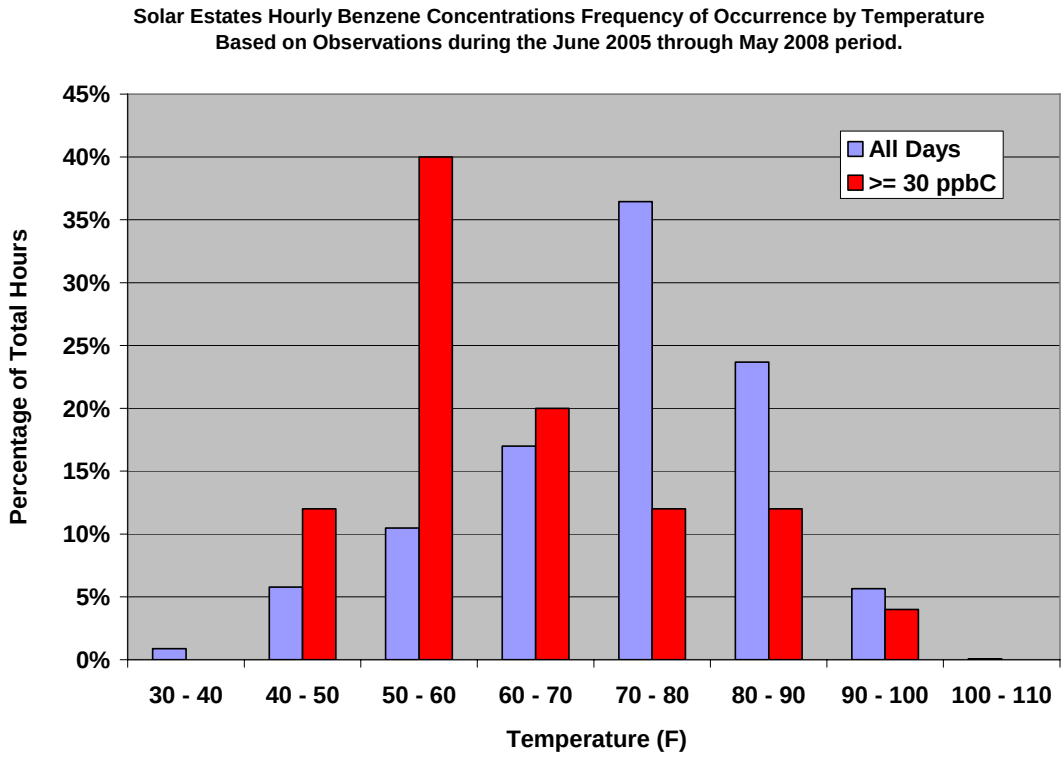

Figure B.1-10. Percentage of hours at Solar Estates monitoring station grouped by temperature (binned by 10 F increments) for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

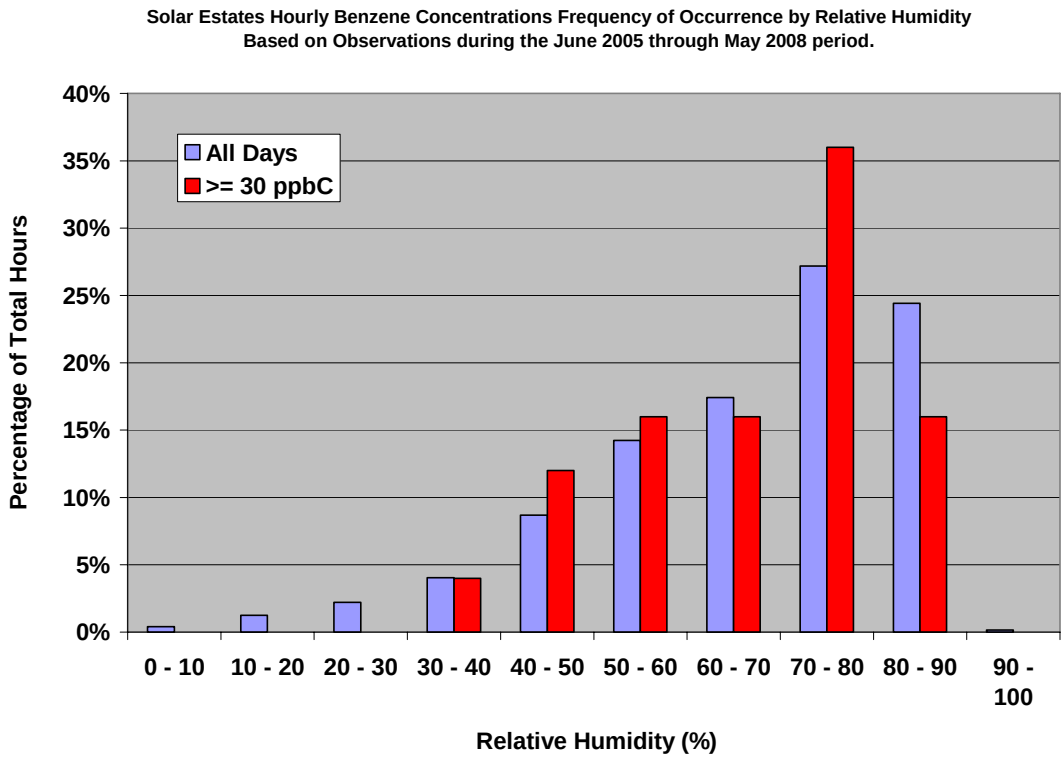

Figure B.1-11. Percentage of hours at the Solar Estates monitoring station grouped by relative humidity values (binned by 10% increments) for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

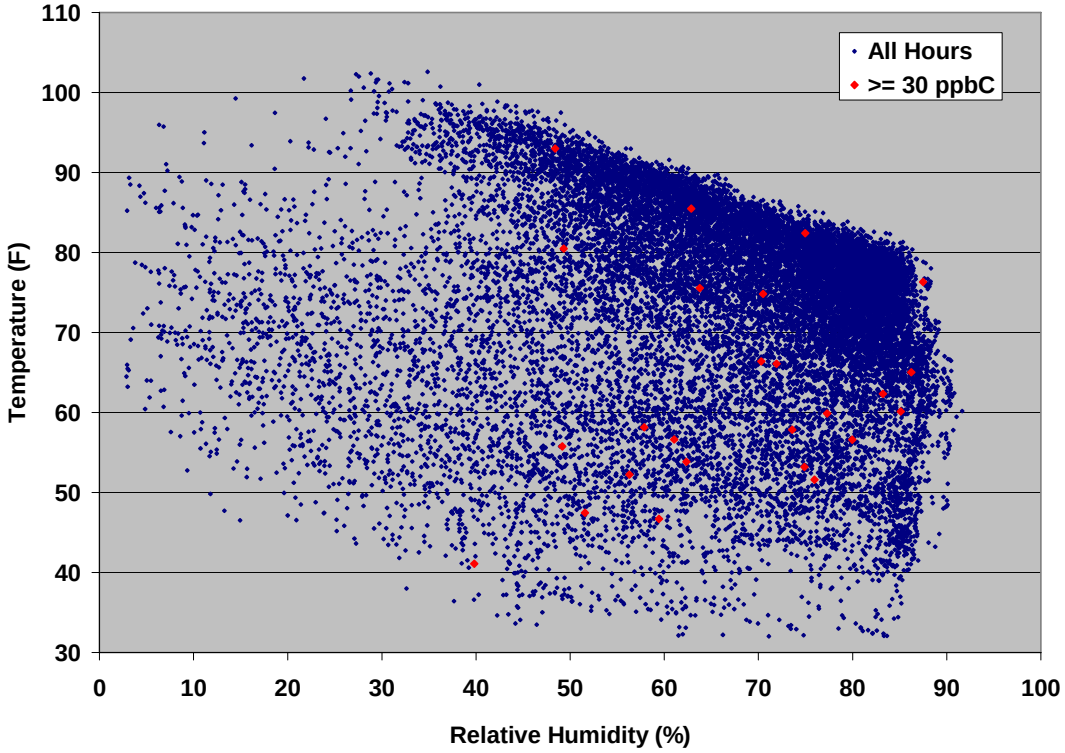

Figure B.1-12. Hourly temperature versus hourly relative humidity at the Solar Estates monitoring station for all hours during the June 2005 through May 2008 period. Hours characterized by a benzene concentration of 30 ppbC or greater are highlighted in red.

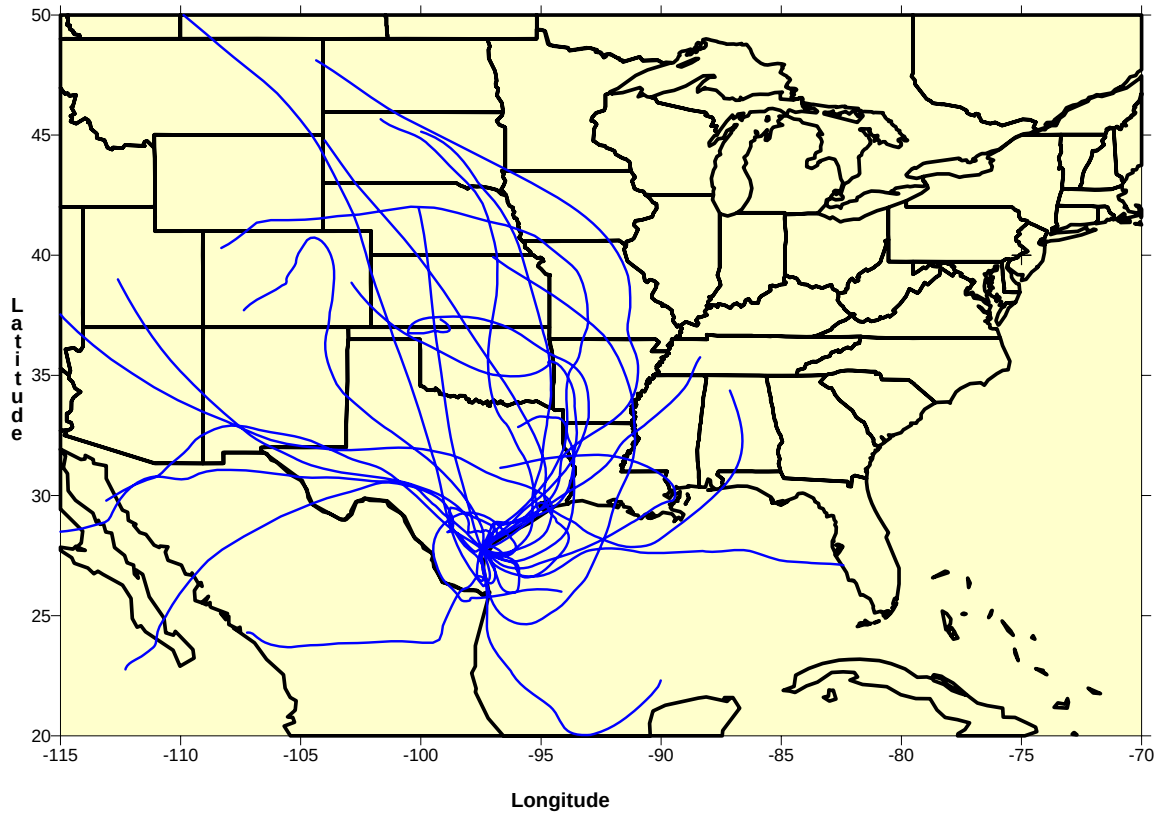

Figure B.1-13. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 24 days during the June 2005 through May 2008 period characterized by one or more hours with benzene concentrations of 30 ppbC or greater at the Solar Estates monitoring station.

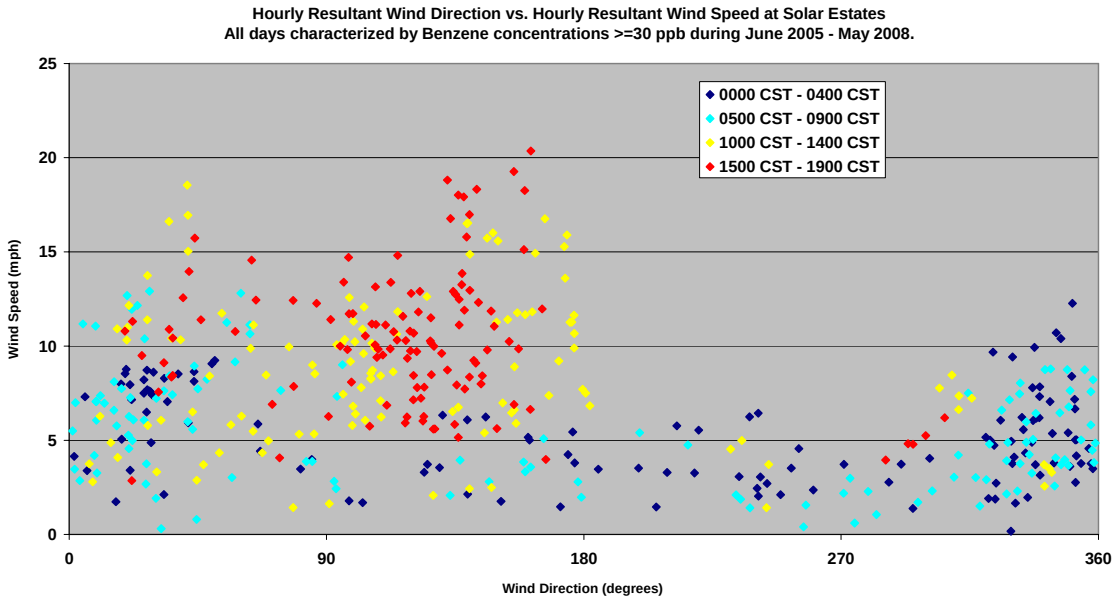

Figure B.1-14. Solar Estates resultant wind direction versus the resultant wind speed for all hours on days characterized by one or more benzene concentrations of 30 ppbC or greater.

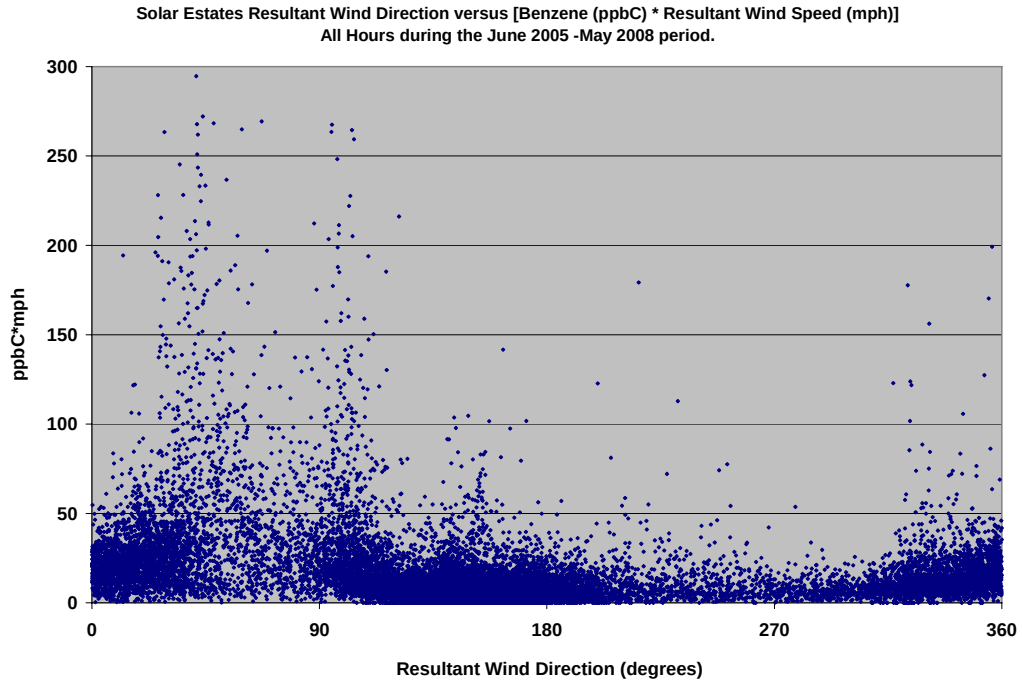

Figure B.1-15. Resultant wind direction (degrees) versus the product of the benzene concentration multiplied by the resultant wind speed (ppbC*mph) at the Solar Estates monitoring station for all valid hours during the June 2005 through May 2008 period. Note that the chart scale has been defined for easy visualization of high density peaks so that observations above 300 ppbC*mph are not shown.

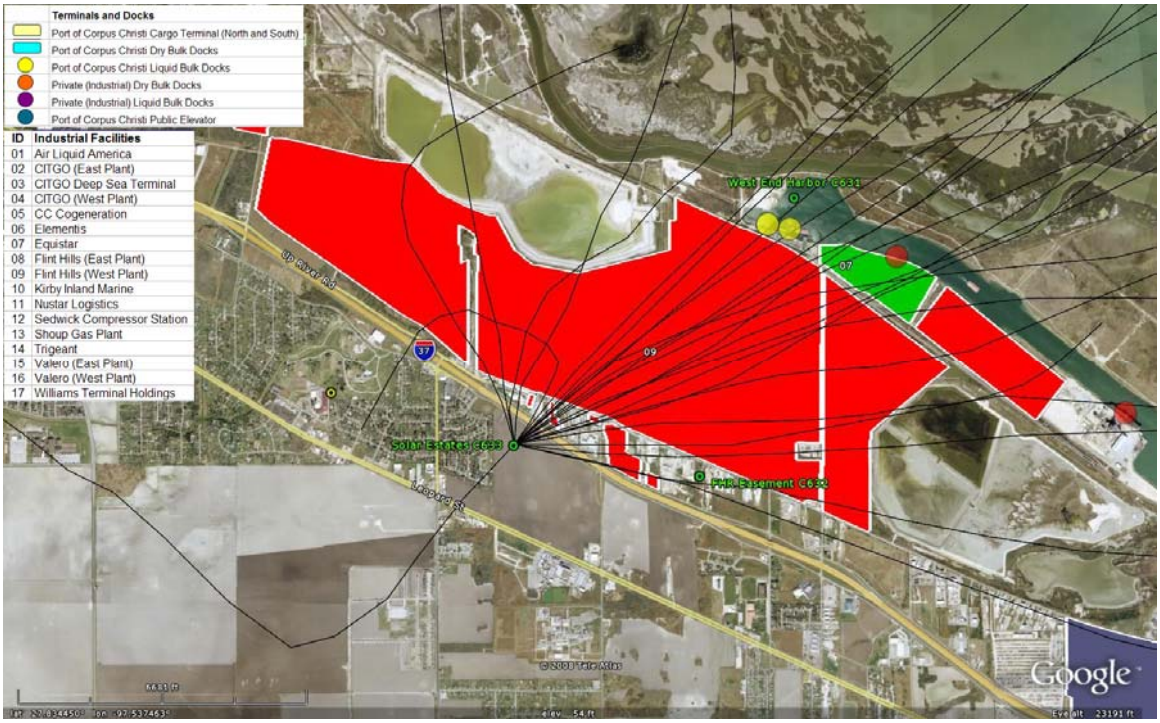

Figure B.1-16. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a benzene concentration of 30 ppbC or greater at the Solar Estates monitoring station during the June 2005 through May 2008 period.

B.2 Oak Park Recreation Center (C634) Monitoring Station

Figure A.5-1 showed the location of the Oak Park Recreation Center monitoring station (hereafter referred to as "Oak Park"). Oak Park is located in the Oak Park residential neighborhood approximately 0.25 miles south of Interstate 37. The nearest monitoring station operated by TCEQ is the Huisache monitoring station (CAMS 98) located approximately 0.5 miles to the north-northeast of Oak Park. A number of industrial facilities are located within 1.5 miles of the Oak Park monitoring station to the northwest, north, and northeast. These industrial facilities are mostly to the north of Interstate 37 along the southern boundary of the Corpus Christi Ship Channel.

B.2.1 Seasonal, Day of Week, and Diurnal Variability in Benzene Concentrations at Oak Park

The median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations grouped by month are shown in Figure B.2-1. For all metrics, the September through February period is characterized by the highest concentrations, with substantially lower concentrations during the Spring and Summer. The monthly 95th percentile concentration values (which roughly correspond to the 110th highest benzene concentration ranked by descending order) for September through February range from 19.39 ppbC during January to 27.32 ppbC for November. The monthly 95th percentile concentration values during the March though August period range from 3.58 ppbC during June to 11.40 ppbC during March.

The median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations grouped by hour are shown in Figure B.2-2. For all metrics, the nighttime hours are characterized by the highest concentrations, with a relative peak in concentration values during the morning hours of 0500 CST through 0800 CST. The 95th percentile concentration values (which roughly correspond to the 55th highest benzene concentration ranked by descending order) range from 6.73 ppbC at 1700 CST to 29.13 ppbC at 0700 CST. The median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations by day of week are shown in Figure B.2-3. The 95th percentile concentration values (which roughly correspond to the 188th highest benzene concentration ranked by descending order) vary from 12.67 ppbC on Sunday to 17.20 ppbC on Saturday.

To investigate seasonal differences in the diurnal profiles by day of week, Figures B.2-4 and B.2-5 present the median and 75th percentile hourly benzene concentrations, respectively, grouped by season. Note that consistent and substantial differences between the weekday and weekend hourly profiles are not observed. Overall, hourly benzene concentration values are substantially lower throughout the day during Spring and Summer compared to the Fall and Winter seasons. For all seasons, the diurnal pattern is characterized by a relative peak in concentrations during the 0600 CST or 0700 CST period, with highest concentrations during Fall. During daytime hours, Winter concentrations are relatively greater compared to those for the other seasons. The seasonal maximum hourly median concentrations vary from 1.03 ppbC at 0700 CST on Spring weekdays to 6.42 ppbC at 0700 CST for Fall weekdays. The 75th percentile

values (which roughly correspond to the 48th and 19th highest benzene concentration ranked by descending order for weekdays and weekend days, respectively) for the morning peak range from A.44 ppbC at 0600 CST for Summer weekdays to 14.63 ppbC at 0600 CST on Fall weekdays.

B.2.2 Benzene Event Duration at Oak Park

For the purpose of investigating the duration of high benzene events, benzene events were defined as one or more consecutive hours characterized by a concentration of 30 ppbC or greater. A total of 463 events were measured at the Oak Park monitoring station during the June 2005 through May 2008 period. These events were overwhelmingly limited to one hour in duration. The longest event was 3 hours in duration, with an additional 8 events characterized by durations of 2 hours. The majority of these events occurred during the October through December period.

B.2.3 Local Meteorological Conditions during High Benzene Events at Oak Park

Figure B.2-6 presents the median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations binned by the hourly resultant wind direction. For all statistical metrics, maximum benzene concentrations occur during hours characterized by north-northeasterly winds. Somewhat elevated benzene concentrations are also noted for hours characterized by westerly and/or northerly resultant wind components. The 95th percentile concentration values (which roughly correspond to the 82nd highest benzene concentrations ranked by descending order) are 66.2 ppbC and 35.3 ppbC for hours with north-northeasterly and north-northwesterly resultant wind directions, respectively. Figure B.2-7 presents the frequency of occurrence by wind direction for all hours during the June 2005 through May 2008 period and for those hours characterized by a benzene concentration of 30 ppbC or greater. The frequency of occurrence of high benzene concentrations is far greater than the climatological frequency of occurrence for hours characterized by winds with a north-northeasterly component. High benzene concentrations are rare during periods characterized by winds with a southerly component.

Figure B.2-8 shows the wind component scatterplot for all hours characterized by a benzene concentration of 30 ppbC or greater, grouped by time of occurrence during the 1800 CST through 0900 CST (corresponding to evening/nighttime/morning) and 1000 CST through 1700 CST (corresponding to late morning/afternoon) time periods. (Refer to Section 2.5 of this report for a discussion of how to interpret the wind component scatterplot.) Consistent with the diurnal profile shown in Figure B.2-2, high benzene concentrations predominate during the 1800 CST through 0900 CST time period; however, high values during the daytime are not rare. High benzene events during periods of northeasterly winds are most often characterized by wind speeds between 4 mph and 10 mph. High benzene events during periods of north-northwesterly winds are mostly characterized by nearly calm conditions.

Figure B.2-9 presents the frequency of occurrence for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater for five wind speed ranges (binned by 4 mph increments). As noted in Figure B.2-8, highest benzene concentrations occur at a range of wind speeds between 0 and 12 mph.

Figure B.2-10 presents the frequency of occurrence for all hours and for those hours characterized by a benzene concentration of 30 ppbC or greater for eight temperature ranges (binned by 10 F increments). High concentrations occur at a range of temperatures between 40 F and 80 F.

Figure B.2-11 presents the frequency of occurrence for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater for ten relative humidity (as a percent) ranges. High benzene concentrations occur at a wide range of relative humidity values with just over half of hours characterized by relative humidity values greater than 70%. Figure B.2-12 presents a scatterplot of hourly temperature versus hourly relative humidity for all days during the June 2005 through May 2008 period. Hours characterized by benzene concentrations of 30 ppbC or greater are plotted in red. The highest density of observations is found along the top right portion of the scatterplot, which indicates hours characterized by relatively warm temperatures and mid- to high relative humidity values. This portion of the scatterplot is representative of most days during the spring through fall period, with nighttime hours located on the right side at relatively high humidity values and daytime hours located to the left at the lower humidity value ranges. As supported by previous analyses, high benzene concentrations occur most often during the nighttime hours during the Fall and Winter seasons, which often correspond to the upper right portion of the scatterplot. Note the wide scatter of relative humidity values during high benzene events that occurred at temperatures less than 70 F, likely representative of conditions during periodic intrusions of relatively drier and colder air in association with cold fronts that passed through South Texas.

B.2.4 Large-Scale Weather Patterns during High Benzene Events at Oak Park

To investigate the large-scale weather features that predominate during high benzene events, 72-hour HYSPLIT back-trajectories were generated for all days during the June 2005 through May 2008 period that were characterized by one or more hours with a benzene concentration of 30 ppbC or greater at the Oak Park monitoring station. Figure B.2-13 shows the 190 back-trajectories on high benzene days. The back-trajectories were initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface. To isolate the highest days, Figure B.2-14 shows the back-trajectories on days characterized by one or more hours with a maximum hourly benzene concentration of 150 ppbC or greater. Figure B.2-13 indicates that days with hourly benzene concentrations of 30 ppbC or greater are characterized by a range of long-range inflow directions with the exception of west and southwest. Visually, the highest density of back-trajectory paths well outside the immediate Corpus Christi indicate flow from the north and northeast. Figure B.2-14 shows that this flow pattern accounts for about half of the 150 ppbC benzene concentration days, with a majority of the remaining days showing inflow from the south.

A review of the large-scale surface weather maps for the 17 days characterized by maximum hourly benzene concentration of 150 ppbC or greater reveals that a high pressure ridge often extends southward, southwestward, or westward into Texas. These surface high pressure systems are often associated with cold fronts that have moved through Texas, and the weak horizontal pressure gradients over the Corpus Christi area are associated with light winds speeds and (likely) stable atmospheric conditions. To explore the daily evolution of surface winds in the Corpus Christi area on high benzene days, Figure B.2-15 presents the resultant wind direction versus the resultant wind speed for all hours during the 17 highest benzene days. Note that the observations are grouped by hour. During the 0000 CST through 0400 CST time period, the resultant wind direction is calm to light southerly or westerly. During the early and late morning hours, winds are most often northwesterly through easterly at 4-10 mph. By the late afternoon, winds are most often easterly or (less commonly) northwesterly.

B.2.5 Analysis and Summary of Oak Park Benzene and Meteorological Measurements

Air quality analyses were performed using the hourly benzene, resultant wind speed, resultant wind direction, temperature, and relative humidity measurements collected at the Oak Park monitoring station during the June 2005 through May 2008 period. The Oak Park monitoring station is located in the Oak Park residential neighborhood immediately south of Interstate 37, which runs east-west along the southern portion of the Corpus Christi Ship Channel. A number of industrial facilities are located within 1.5 miles of the Oak Park monitoring station to the northwest, north, and northeast. These industrial facilities are mostly to the north of Interstate 37 along the southern boundary of the Corpus Christi Ship Channel.

The highest hourly benzene concentrations (>= 30 ppbC) typically occur during the September through February period, with lowest frequency of occurrence during May through August. Concentrations are highest during the nighttime hours with a peak in the frequency of occurrence during the 0400 CST through 0800 CST period. The majority of high benzene events (98%) are one hour in duration. Day of the week profiles using data from all seasons demonstrate no substantial difference between concentrations measured on weekdays compared to weekends.

A wind direction analysis indicates that the highest benzene concentrations occurred during hours with north-northeasterly winds most often characterized by resultant wind speeds between 4 and 10 mph, or during hours characterized by calm to light northwesterly winds. Note that 54% of hours characterized by high benzene concentrations occurred during hours with a north-northeasterly wind direction, far greater than the frequency of occurrence of north-northeasterly winds for all hours of only 5%. High benzene concentrations occurred during hours characterized by a wide range of temperatures between 45 F and 82 F with a wide range of relative humidity values between 15% and 90%. The relatively low temperatures are consistent with the occurrence of high benzene concentrations primarily during the nighttime hours during

the Fall and Winter seasons. The wide range of relative humidity values suggests that high benzene concentrations often occur during weather patterns characterized by the periodic intrusions of relatively drier air associated with westerly winds or, more often, cold fronts that move through South Texas accompanied by winds with a northerly component.

The surface weather maps on the 17 days characterized by one or more hours with maximum benzene concentrations of 150 ppbC or higher often show a high pressure ridge that extends southward, southwestward, or westward into Texas. These surface high pressure systems often move into Texas behind cold fronts, and are typically associated with light wind speeds at the surface and (likely) stable atmospheric conditions. The diurnal variation of surface winds at the Oak Park monitoring station on these days is often characterized by calm to light southerly or westerly winds during the 0000 CST through 0400 CST period, followed by northwesterly to easterly winds in the morning at 4 mph to 10 mph. By the late afternoon, winds are most often easterly to southeasterly or (less commonly) northwesterly. The clockwise rotation of the coastal wind direction has often been observed along the upper Texas coast, and is likely associated with the diurnal and inertial components of the land and sea breeze circulations (Nielsen-Gammon et al., 2002a, 2002b; UT, 2008) that become most apparent during periods of large-scale weather patterns characterized by weak horizontal pressure gradients.

The strong wind directionality of the highest benzene concentrations suggests upwind (non-mobile) emissions sources located to the north-northeast and northwest of the Oak Park monitoring station. These directions are consistent with emissions sources associated with industrial facilities located immediately north of Interstate 37.

B.2.6 Upwind Emission Sources during High Benzene Events at Oak Park

The analyses presented previously for Oak Park did not attempt to account for the hourly variation in atmospheric dispersion conditions. One method to provide some normalization of measured pollutant concentrations with respect to varying atmospheric dispersion conditions is to multiply the concentration by the wind speed. Figure B.2-16 presents a scatterplot of the hourly resultant wind direction (degrees) versus the product of the hourly benzene concentrations and the hourly resultant wind speed (ppbC-mph) for all hours during the June 2005 through May 2008 period. The results are consistent with the wind direction analyses shown previously, with the highest concentration-wind speed values associated with hours characterized by north-northeasterly and northwesterly winds. In addition, note that the very low concentration-wind speed values during hours characterized by winds with a southerly component.

To identify the local emissions sources at upwind industrial facilities that may impact benzene concentrations at Oak Park, the Corpus Christi Trajectory Analysis Tool was used to generate one-hour surface back-trajectories for all hours characterized by a benzene concentrations of 30 ppbC or higher (Figure B.2-17) and 150 ppbC or higher (Figure B.2-18). Each back-trajectory was initialized at the half-hour (i.e., midpoint) of

the benzene one-hour averaging period. The trajectory paths occur predominantly at locations found to the north-northeast and northwest of the Oak Park monitoring station. The north-northeasterly back-trajectories consistently indicate that the CITGO East Plant is in the upwind region. The northwesterly back-trajectories often indicate flow over portions of the Williams Terminal Holdings, CIGTO Deep Sea Terminal, and/or Valero (East Plant) facilities.

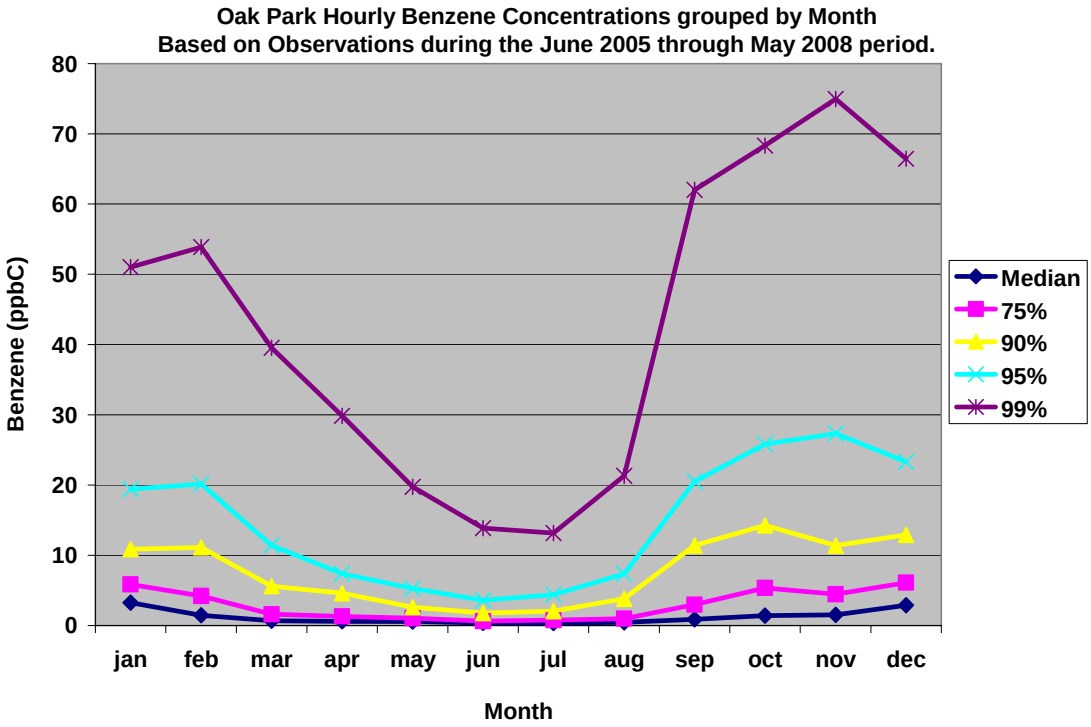

Figure B.2-1. Monthly median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

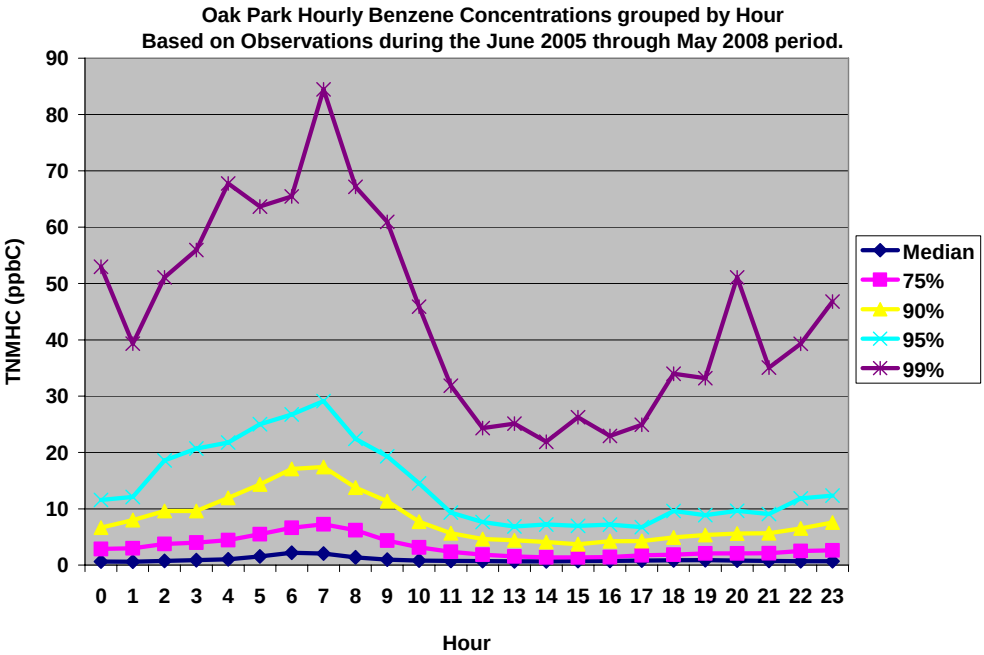

Figure B.2-2. Hourly median and 75th, 90th, 95th, and 99th percentile benzene concentrations at the Oak Park monitoring station by hour based on all valid data during the June 2005 through May 2008 period.

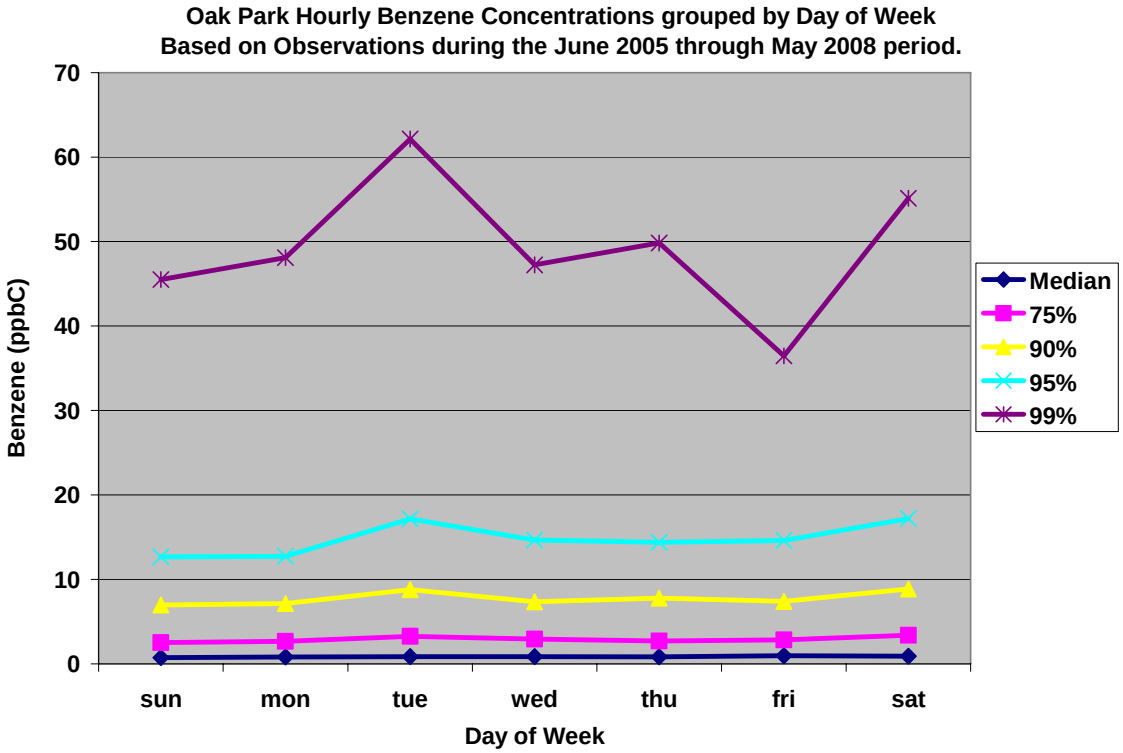

Figure B.2-3. Median and 75th, 90th, 95th, and 99th percentile hourly benzene concentrations by Day of Week at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

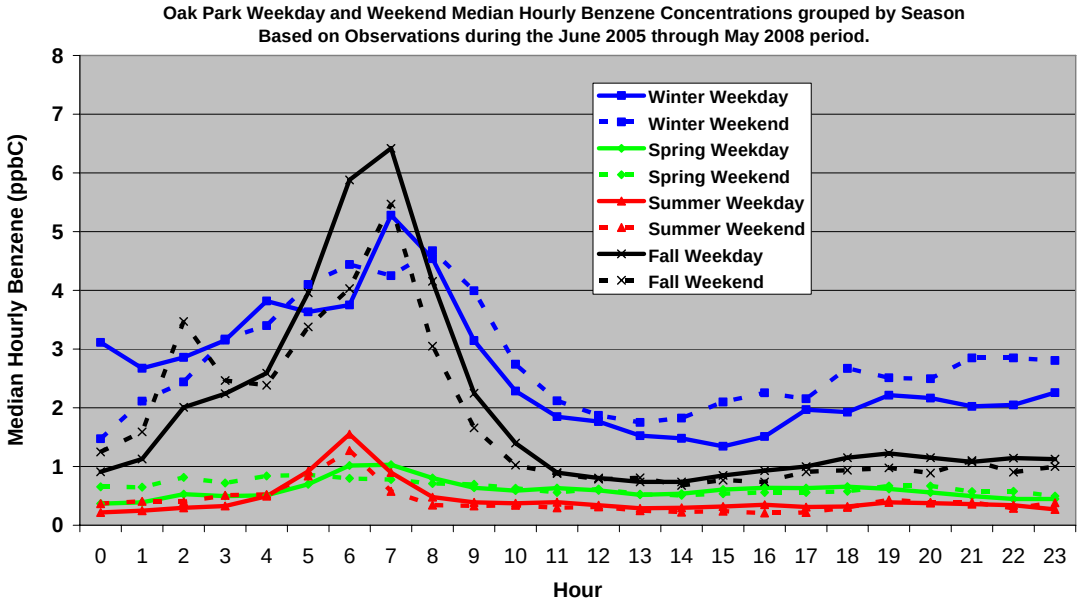

Figure B.2-4. Median hourly weekday and weekend day benzene concentrations grouped by season at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

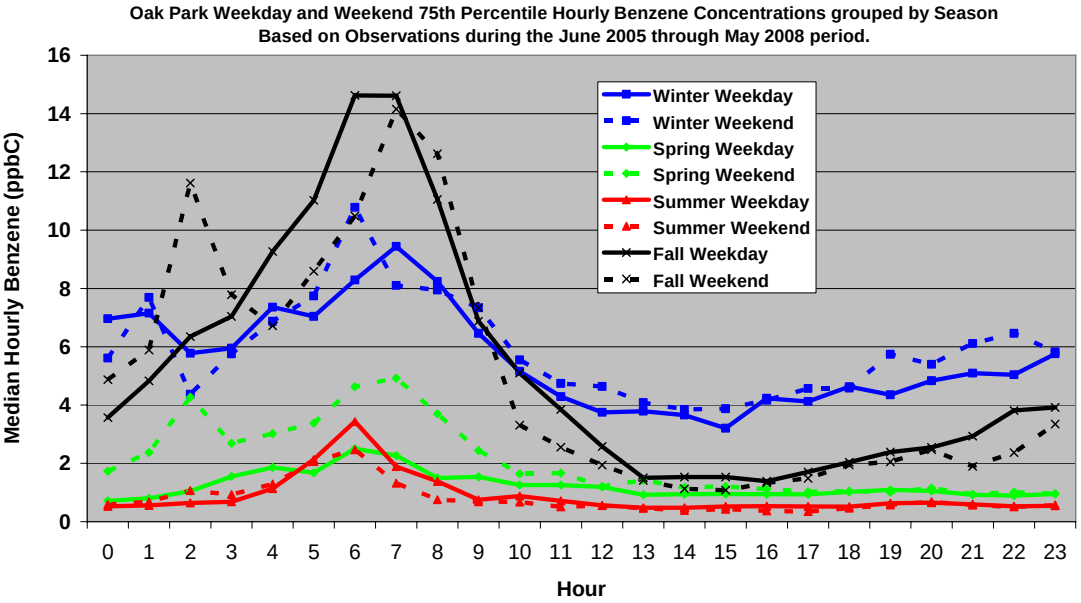

Figure B.2-5. The 75th percentile hourly weekday and weekend day benzene concentrations grouped by season at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

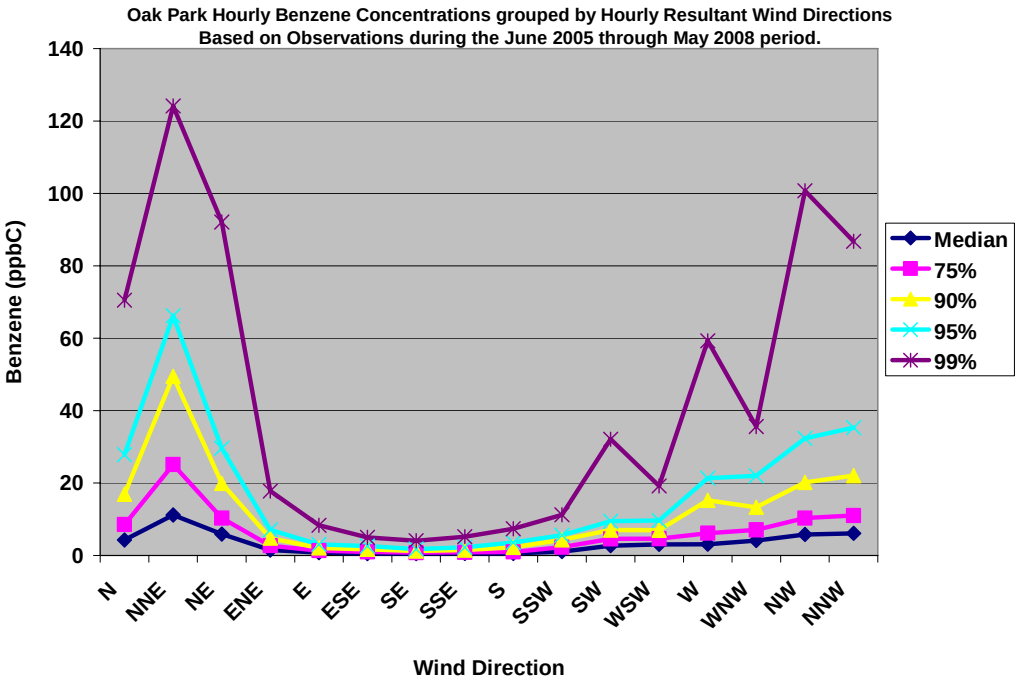

Figure B.2-6. Hourly median and 75th, 90th, 95th, and 99th percentile benzene concentrations grouped by hourly resultant wind direction at the Oak Park monitoring station based on all valid data during the June 2005 through May 2008 period.

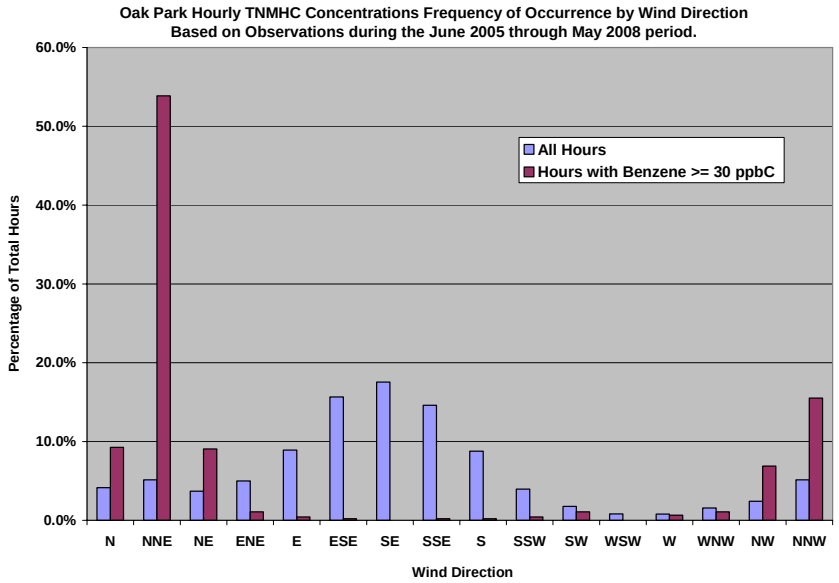

Figure B.2-7. Percentage of hours at the Oak Park monitoring station grouped by resultant wind direction for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

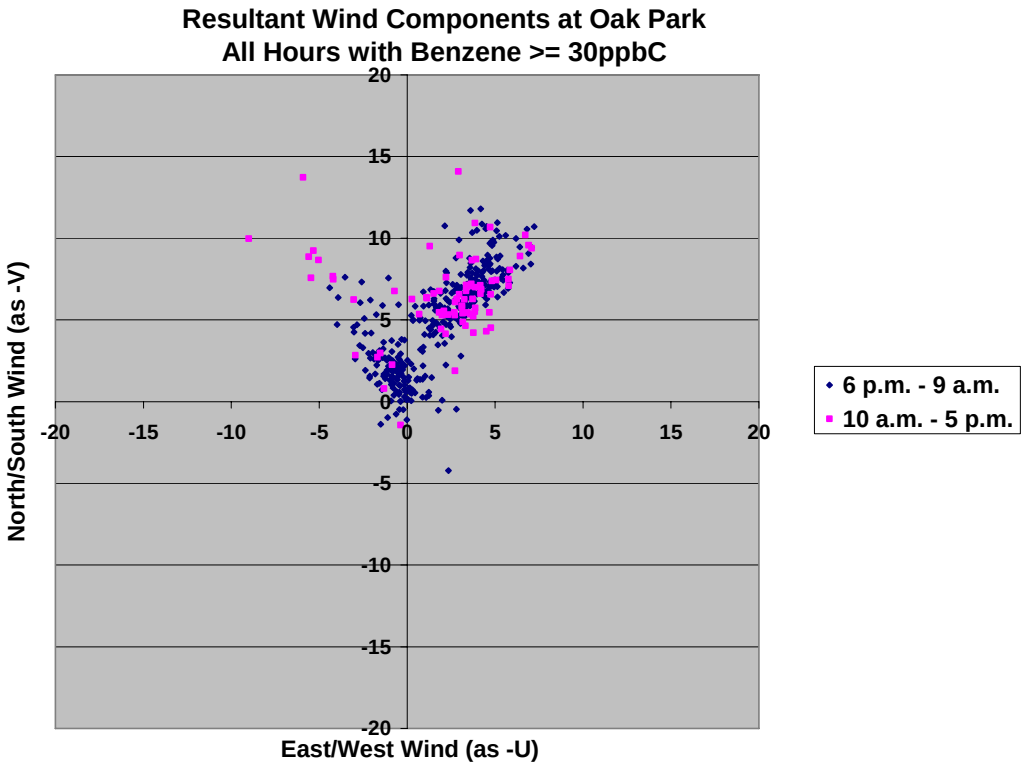

Figure B.2-8. Resultant wind component scatterplot at Oak Park for all hours with Benzene concentrations of 30 ppbC or greater during the June 2005 through May 2008 period. (The reader is referred to Section 2.5 for a discussion of how to interpret this figure.)

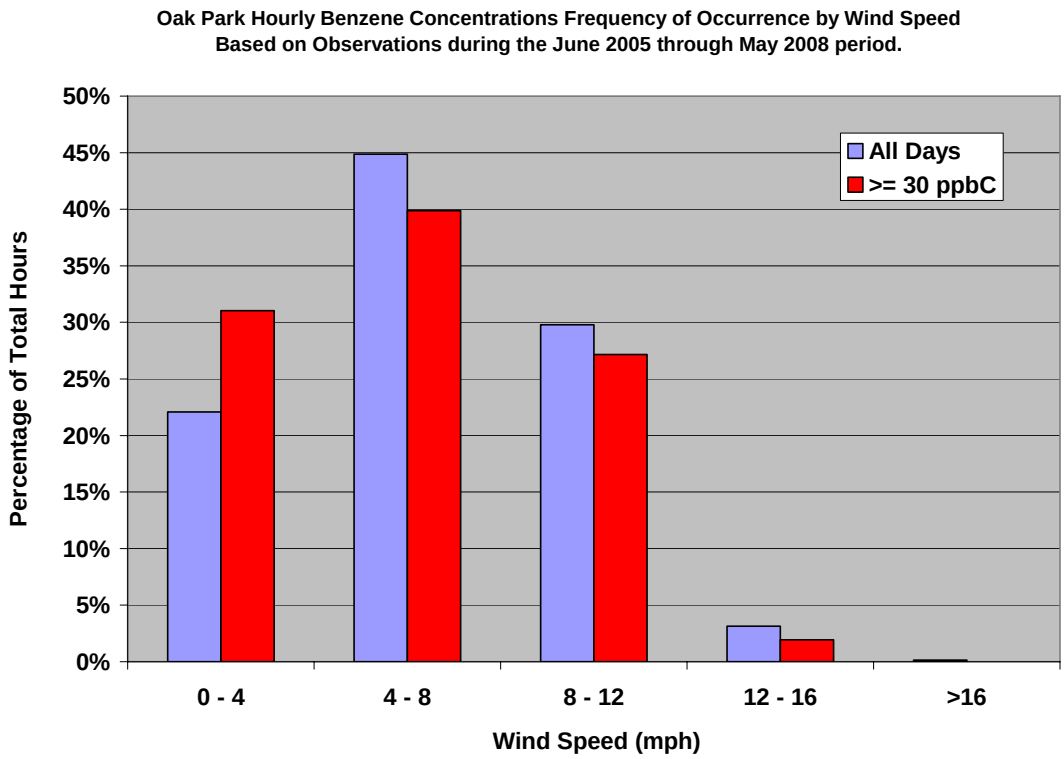

Figure B.2-9. Percentage of hours at the Oak Park monitoring station grouped by resultant wind speed (binned by 4 mph increments) for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

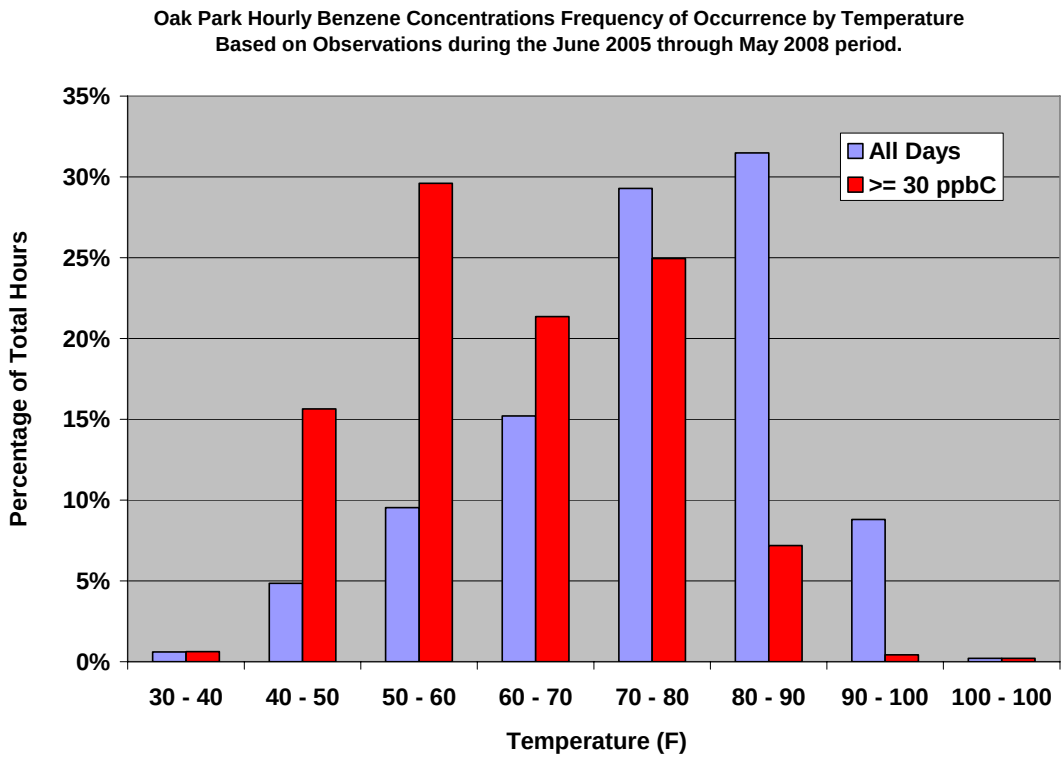

Figure B.2-10. Percentage of hours at the Oak Park monitoring station grouped by temperature (binned by 10 F increments) for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

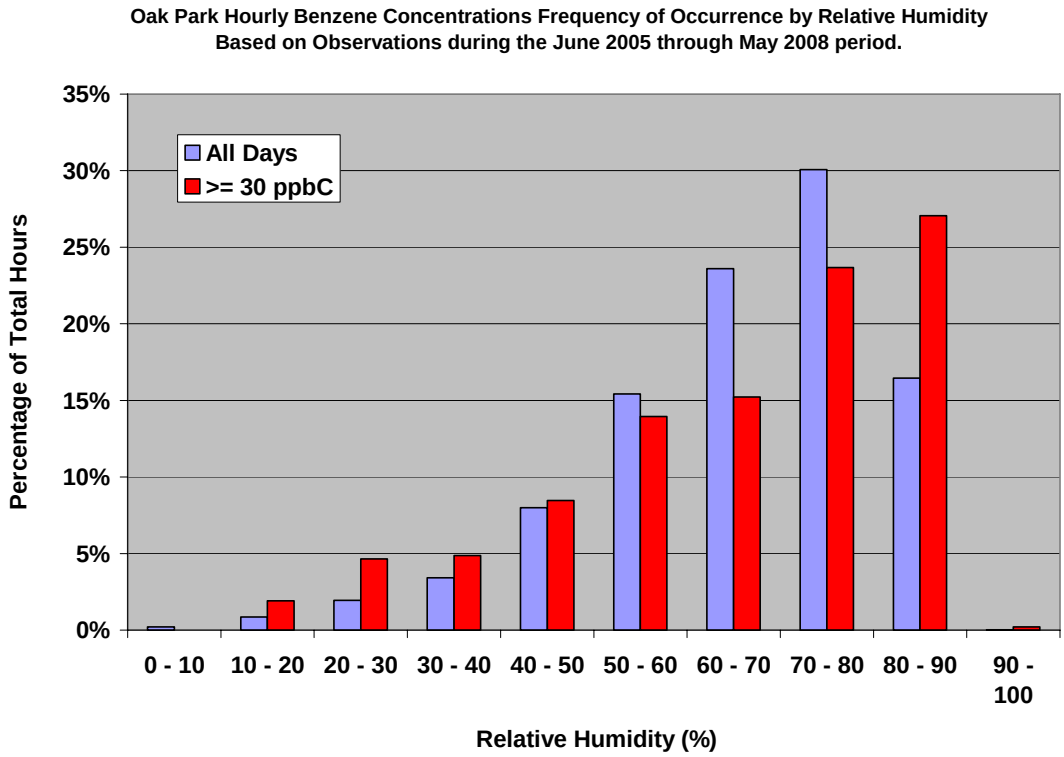

Figure B.2-11. Percentage of hours at the Oak Park monitoring station grouped by relative humidity values (binned by 10% increments) for all hours and for only those hours characterized by a benzene concentration of 30 ppbC or greater. Based on all valid data during the June 2005 through May 2008 period.

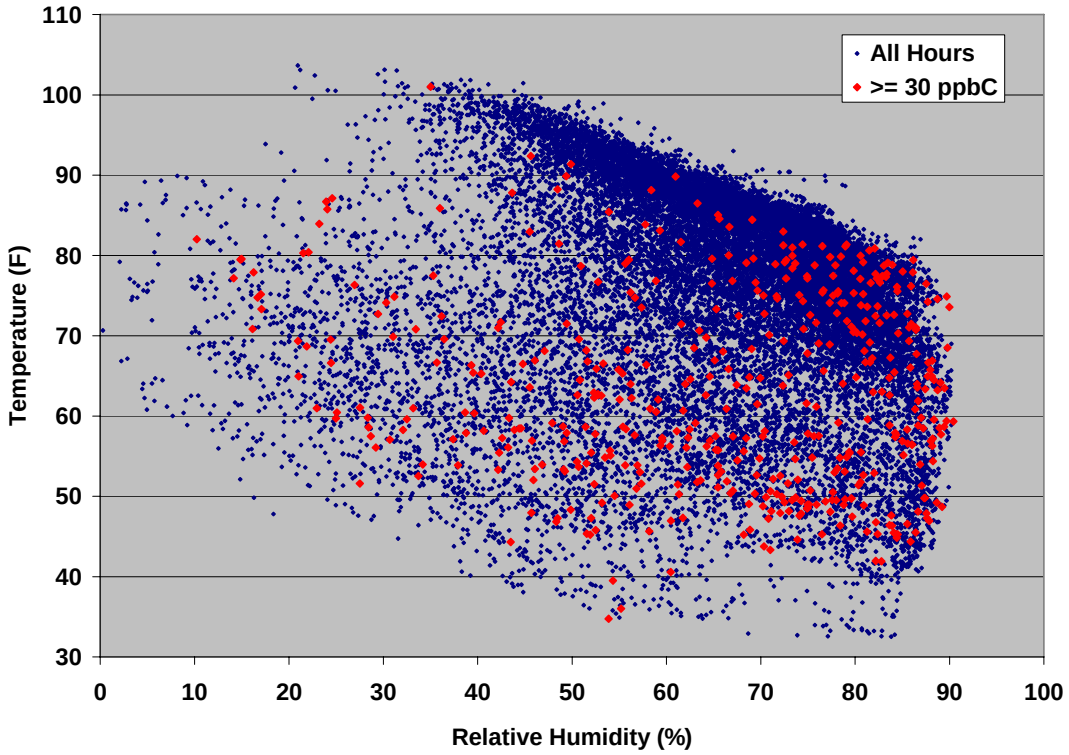

Figure B.2-12. Hourly temperature versus hourly relative humidity at the Oak Park monitoring station for all hours during the June 2005 through May 2008 period. Hours characterized by a benzene concentration of 30 ppbC or greater are highlighted in red.

72-Hour HYSPLIT Back-Trajectories for Days with Hourly Benzene >= 30 ppbC

Oak Park (C634): June 2005 - May 2008

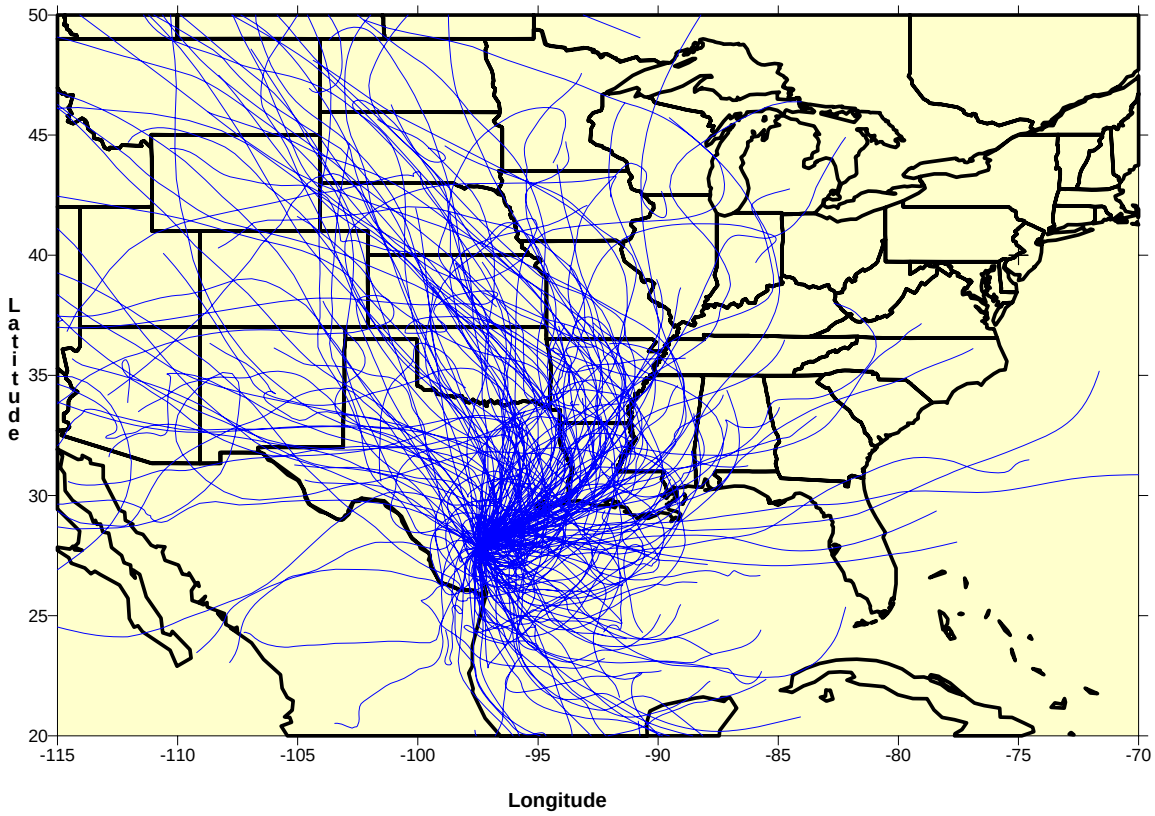

Figure B.2-13. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 190 days during the June 2005 through May 2008 period characterized by one or more hours with benzene concentrations of 30 ppbC or greater at the Oak Park monitoring station.

72-Hour HYSPLIT Back-Trajectories for Days with Hourly Benzene >= 150 ppbC

Oak Park (C634): June 2005 - May 2008

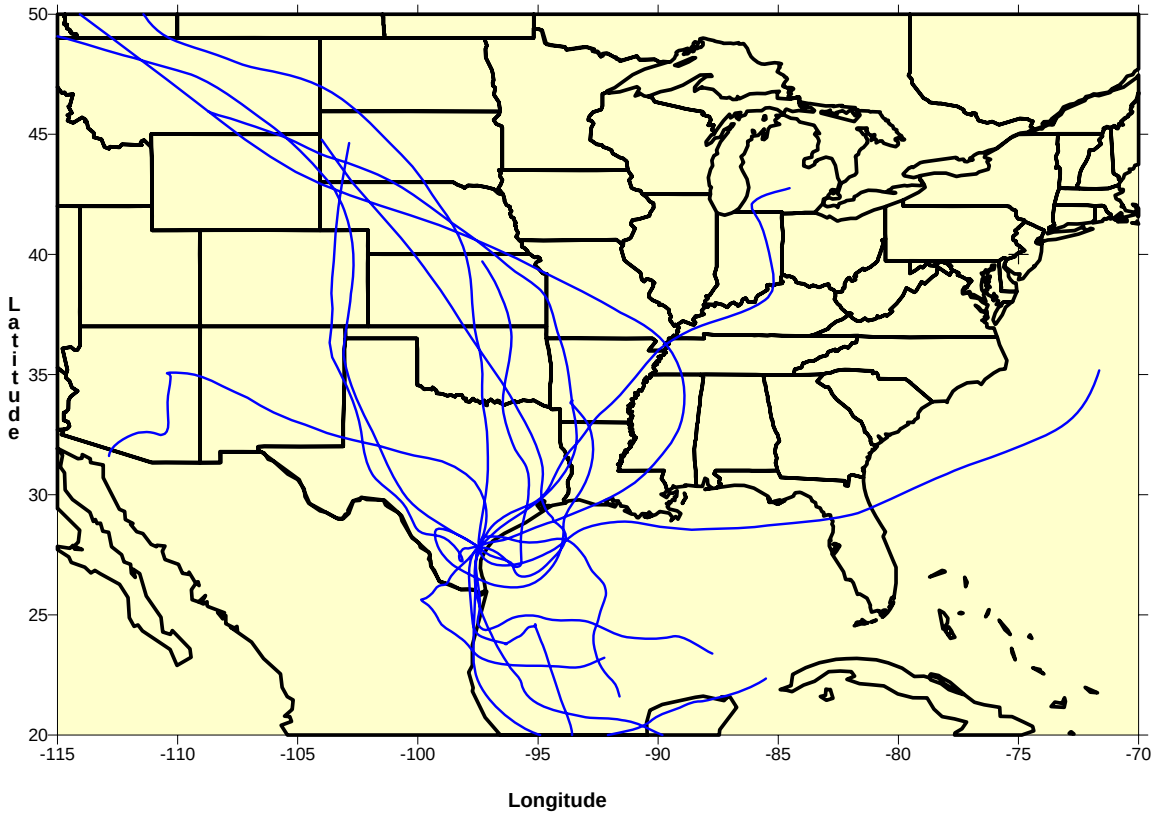

Figure B.2-14. Corpus Christi 72-Hour HYSPLIT back-trajectories initialized at a starting time of 1200 CST and a starting height of 500 meters above the surface on the 17 days during the June 2005 through May 2008 period characterized by one or more hours with benzene concentrations of 150 ppbC or greater at the Oak Park monitoring station.

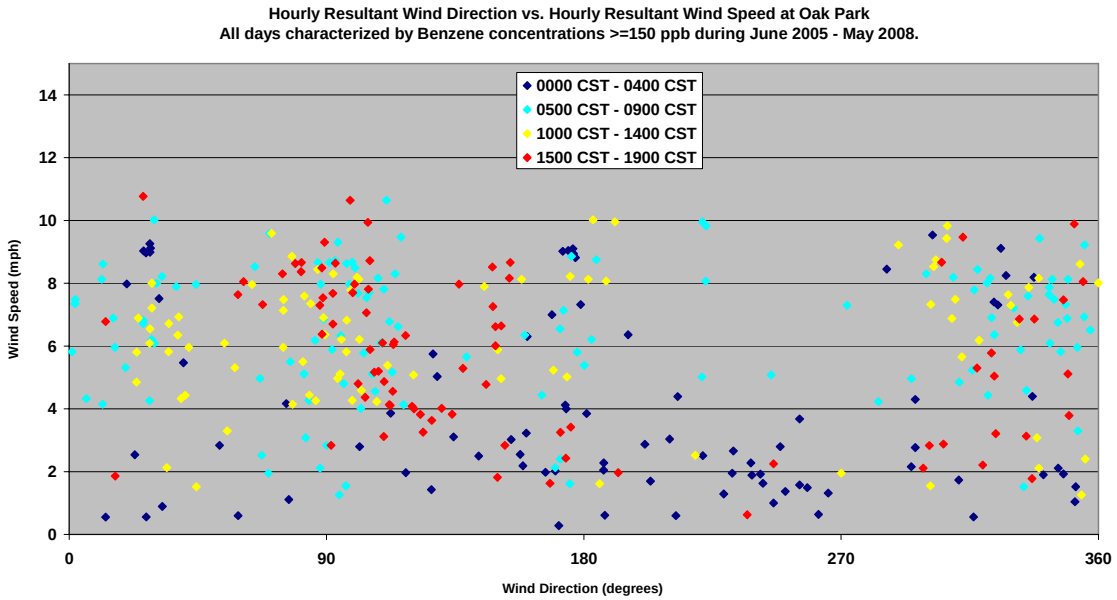

Figure B.2-15. Oak Park resultant wind direction versus the resultant wind speed for all hours on days characterized by one or more benzene concentrations of 150 ppbC or greater.

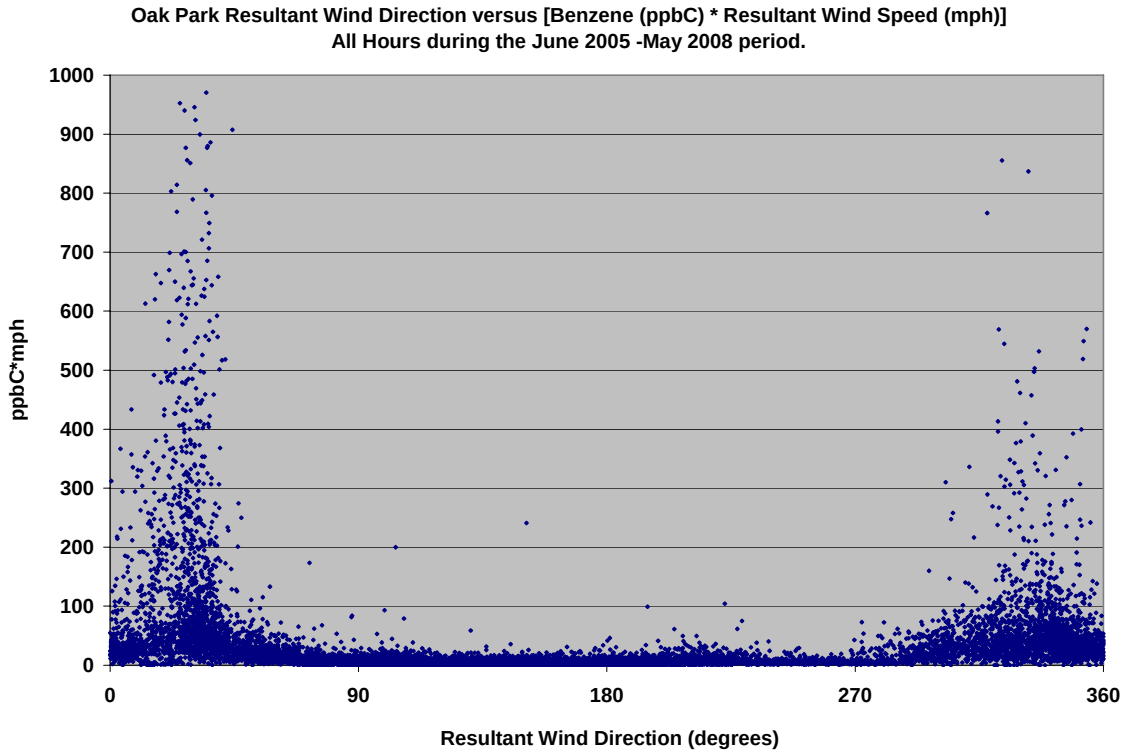

Figure B.2-16. Resultant wind direction (degrees) versus the product of the benzene concentration multiplied by the resultant wind speed (ppbC*mph) at the Oak Park monitoring station for all valid hours during the June 2005 through May 2008 period. Note that the chart scale has been defined for easy visualization of high density peaks so that observations above 1000 ppbC*mph are not shown.

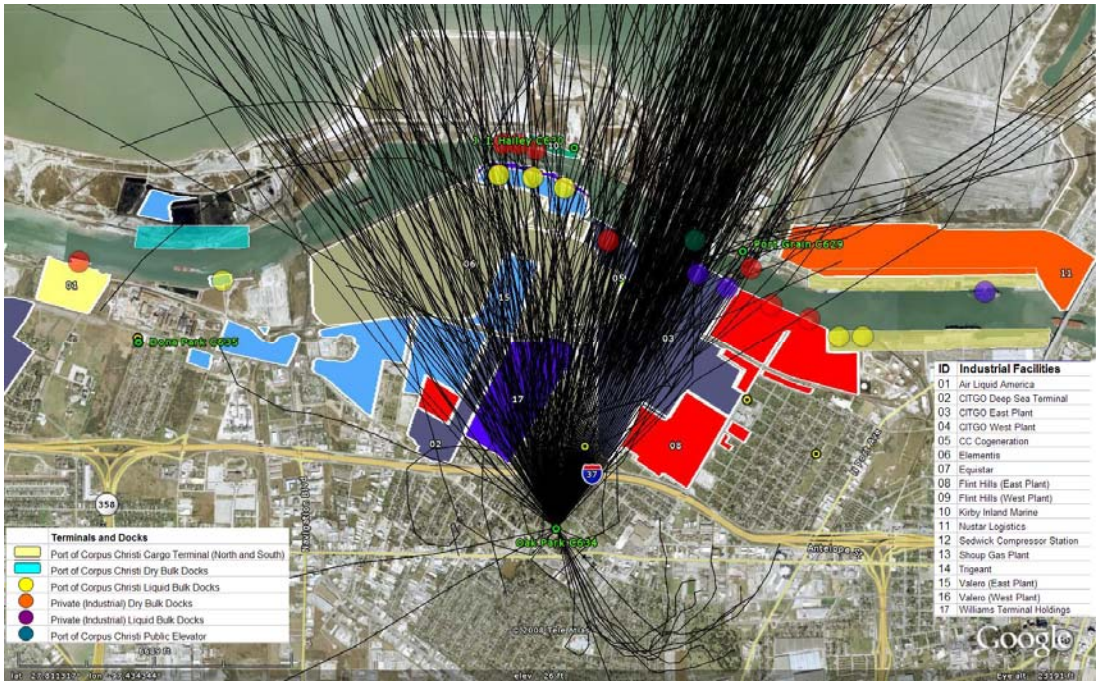

Figure B.2-17. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a benzene concentration of 30 ppb or greater at the Oak Park monitoring station during the June 2005 through May 2008 period.

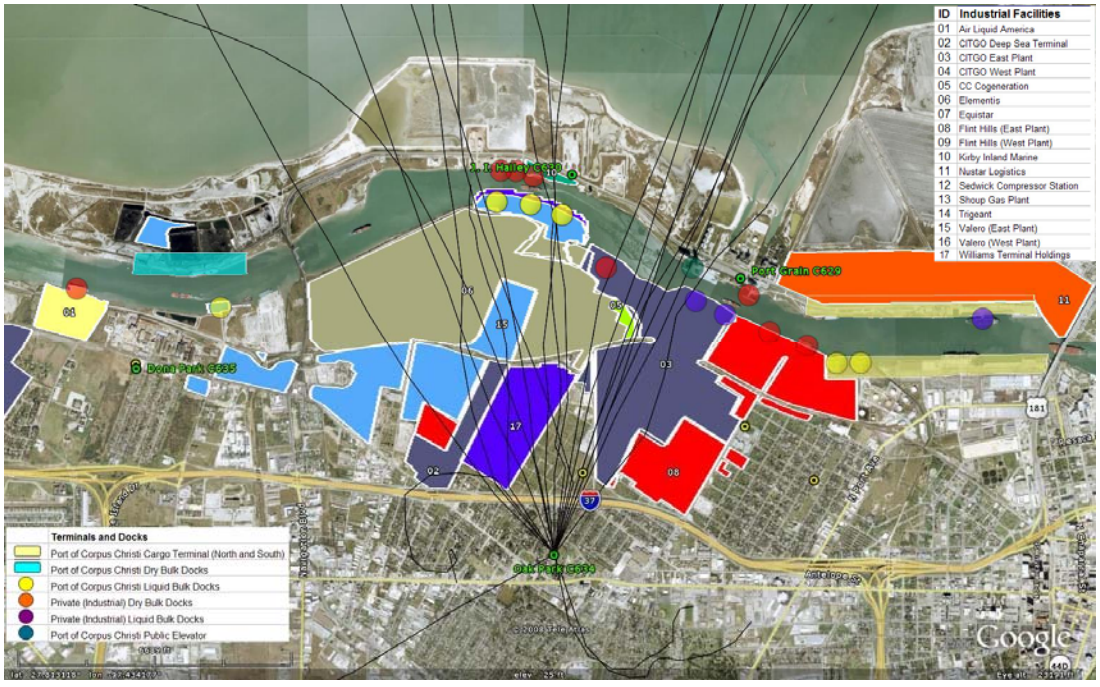

Figure B.2-18. Surface back-trajectories as generated by the Corpus Christi Trajectory Analysis Tool for all hours characterized by a benzene concentration of 150 ppb or greater at the Oak Park monitoring station during the June 2005 through May 2008 period.

B.3 Historical 24-Hour Canister Results for Benzene

Previous analyses in support of the Corpus Christi Air Quality Project have investigated the relationship between wind direction and 24-hour benzene measurements collected by the Community Air Toxics Monitoring Network (CATMN). In support of CATMN, TCEQ has collected samples at multiple monitoring stations within various Texas metropolitan areas since 1992. The samples are collected in evacuated stainless steel canisters over an integrated 24-hour period from midnight to midnight. Typically, samples are collected on an every 6th day schedule.

Table B.3-1 presents the site identification and geographic information for CATMN monitoring in the Corpus Christi area during the 1993 through 2008 period. Figure B.3-1 shows a map of the locations of these monitoring stations. Samples were collected at most locations on an every 6th day schedule with the exception of the November through April period during the years 1998 through 2005, which were characterized by every day sampling at the Huisache monitoring station. Following collection, CATMN samples are analyzed by TCEQ for target compounds in accordance with appropriate USEPA methods using gas chromatography and mass spectrometry detection. In support of previous activities for CCAQP, the archived concentration measurement results for benzene (and other compounds) for the monitoring stations shown in Table 1 were obtained by Dave Sullivan (UT-Austin Staff) for analysis.

In order to investigate the locations of possible sources of benzene emissions impacting the CATMN monitoring stations, hourly wind data at the monitoring stations shown in Table B.3-1 were retrieved for all CATMN sampling days. A resultant daily wind direction, representative of the average winds across the Corpus Christi area, was calculated based on the available CATMN hourly wind data. The 24-hour benzene concentrations at each monitoring location were merged with the daily resultant wind directions. Mean benzene concentrations were calculated as a function of wind direction. To help account for the impacts of varying wind direction over a given 24-hour period, a smoothing factor was used that incorporates a bell-shaped weighting factor applied over a 20 degree wind direction range centered on the daily resultant wind direction.

Figure B.3-2 through Figure B.3-6 presents the results for the Dona Park, Navigation, Poth, Huisache, and Hillcrest monitoring stations, respectively. The monitoring stations are presented in west-to-east order along the Ship Channel. The reader is cautioned that the results for each monitoring station are based on all available sampling data, which, as shown in Table B.3-1, are characterized by differences in the number of samples and the periods of collection. In addition, the results should be interpreted with caution since wind direction often varies substantially during a 24-hour period.

As shown in Table B.3-1, the average of all available benzene observations collected at each monitoring station varies from 2.5 ppbC at Dona Park to 12.0 ppbC at Huisache. As shown in Figures B.3-2 through B.3-6, maximum benzene concentrations by wind direction vary from 5.4 ppbC at Dona Park to 29 ppbC at Huisache. At all monitoring stations, minimum concentrations generally occur during periods of south-southeasterly

winds. Dona Park is characterized by relative peaks in average benzene concentrations during periods of northeasterly and easterly winds. Highest concentrations at the Navigation and Huisache monitoring stations show strong peaks for northeasterly winds. At Poth, highest concentrations are noted for easterly winds and over a wide range of directions characterized by a westerly component. The average benzene concentrations at Hillcrest are generally highest during periods of westerly and/or northerly winds, with a peak in concentrations during north-northwesterly winds.

To identify the possible locations of upwind emissions sources that impact benzene concentrations at the CATMN monitoring stations, directional lines were drawn at each monitoring station representing the wind directions characterized by relative maximum values in the average benzene concentrations discussed in the previous paragraph. In addition, directional lines were added for the Oak Park monitoring station based on the hourly results presented in the Appendix B.2 of this report. Figure B.3-7 presents the results over a map of the CATMN monitoring stations and the surrounding area. Based on the pattern of the directionals, two potentially important source regions are noted generally to the northeast of the Navigation and Huisache monitoring stations.

Table B.3-1. Description, period of operation, and average benzene concentrations at Corpus Christi CATMN Stations.

Monitor Name	CAMS #	AIRS ID	Operational Period	Number of Samples	Average Benzene (ppbC)
Navigation*	121	483550020	01/01/1993 - 09/29/2002	508	4.32
Hillcrest	170	483550029	11/01/1998 - 05/30/2008	693	4.68
Poth*	164	483550030	12/05/1996 - 10/02/1998	84	9.90
Huisache	98	483550032	10/26/1997 - 05/30/2008	1512	12.00
Dona Park	635	483550034	10/05/2002 - 05/30/2008	317	2.46

*Note that Navigation and Poth were not active during the 2005 through present period.

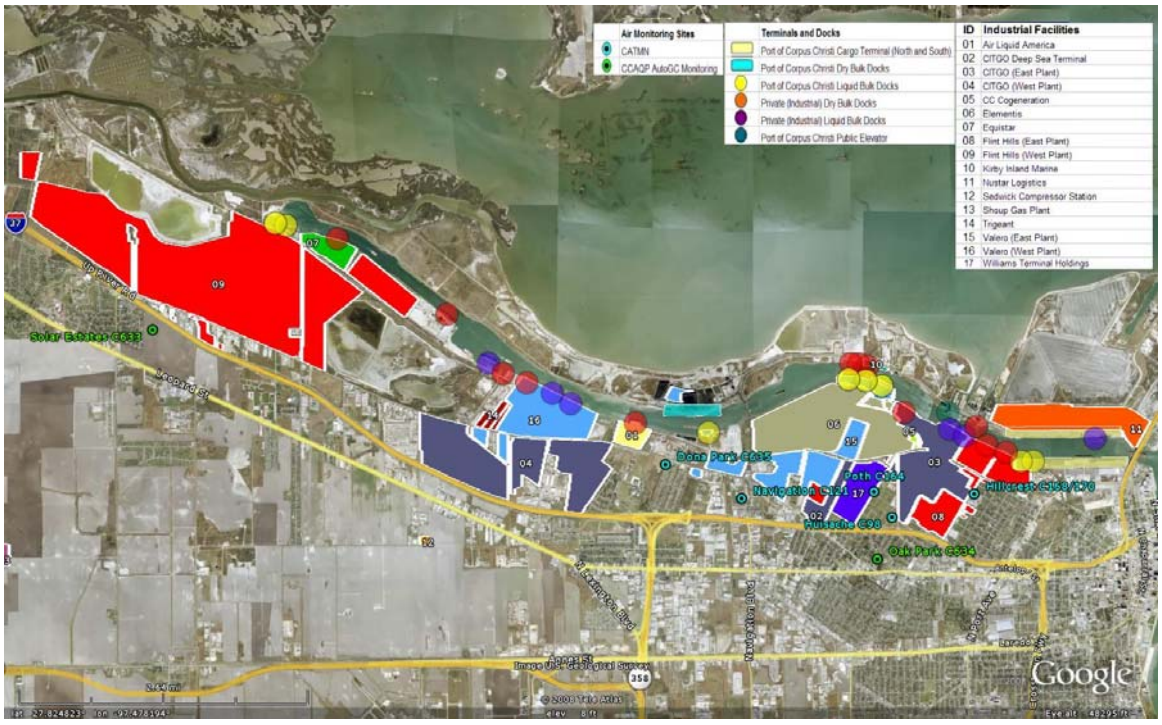

Figure B.3-1. Locations of the seven CCAQP monitoring stations. The Ship Channel is located along the middle portion of map. Figure 2-1 also shows the locations of selected industrial facilities that may impact benzene concentrations at the seven monitoring stations.

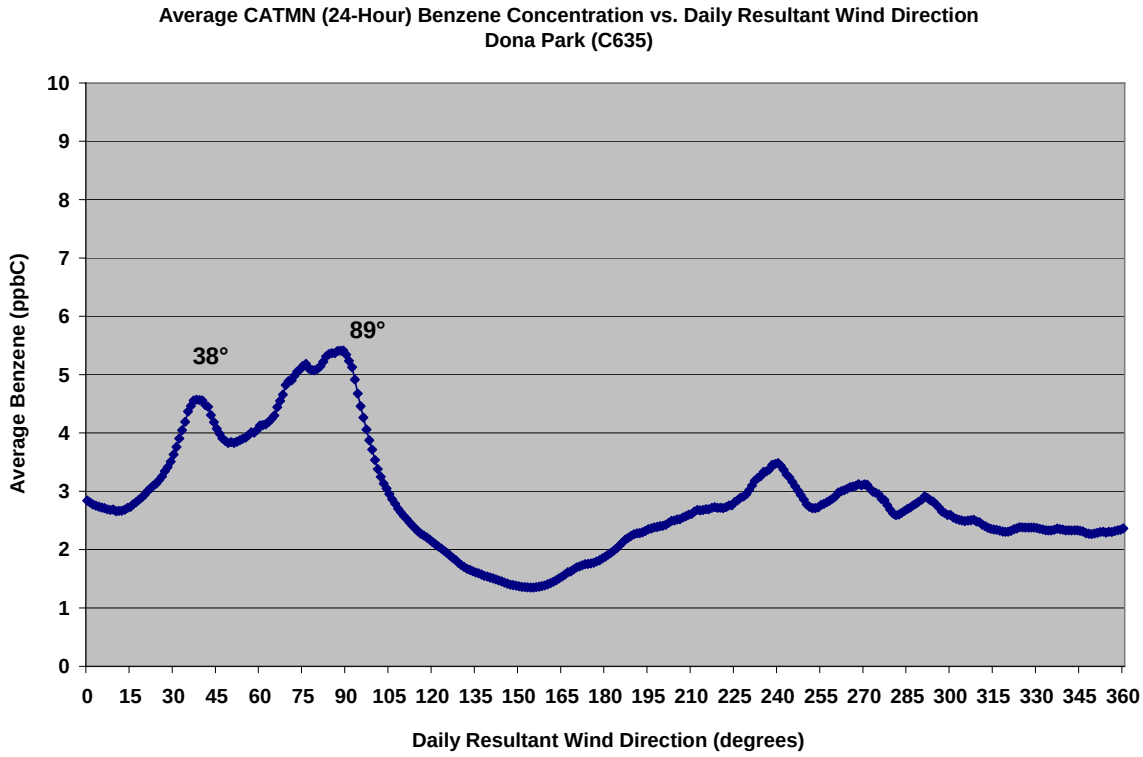

Figure B.3-2. Daily resultant wind direction, calculated from all available CATMN hourly wind data, versus the average 24-hour benzene concentrations during the October 2002 through May 2008 period at the Dona Park monitoring station. A smoothing factor over a 20 degree wind direction range centered on the daily resultant wind direction has been applied to help account for the variability in wind direction over a 24-hour period.

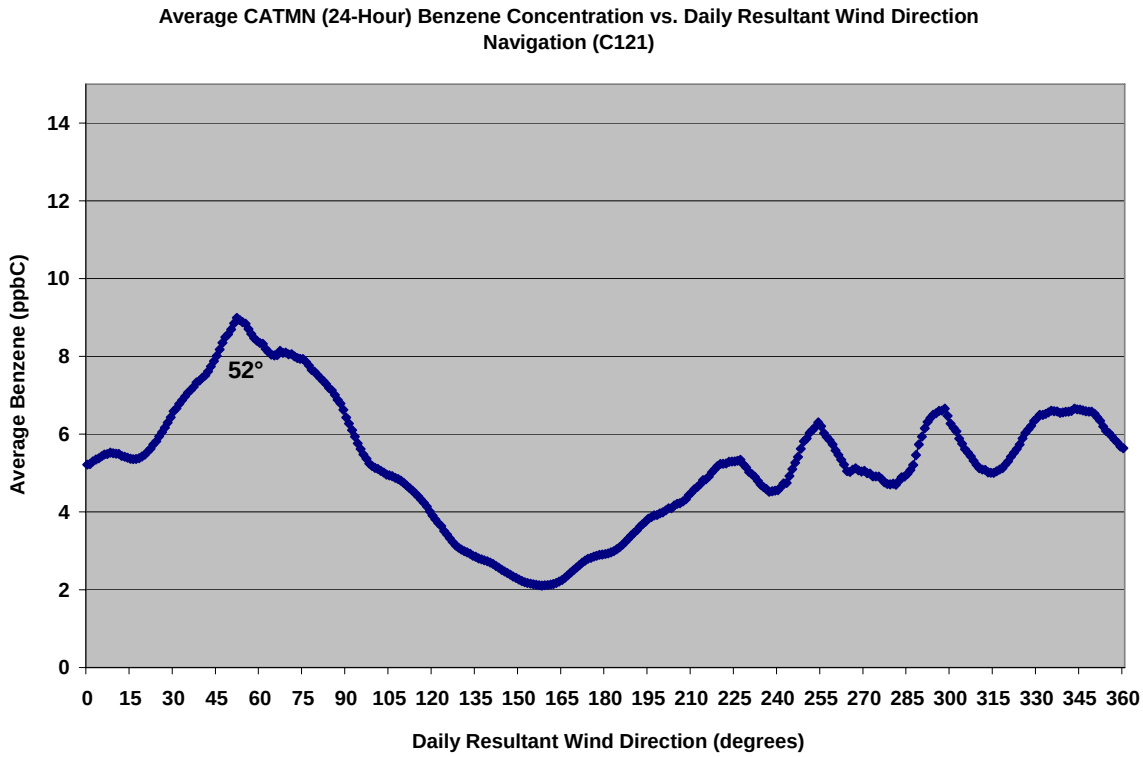

Figure B.3-3. Daily resultant wind direction, calculated from all available CATMN hourly wind data, versus the average 24-hour benzene concentrations during the January 1993 through September 2002 period at the Navigation monitoring station. A smoothing factor over a 20 degree wind direction range centered on the daily resultant wind direction has been applied to help account for the variability in wind direction over a 24-hour period.

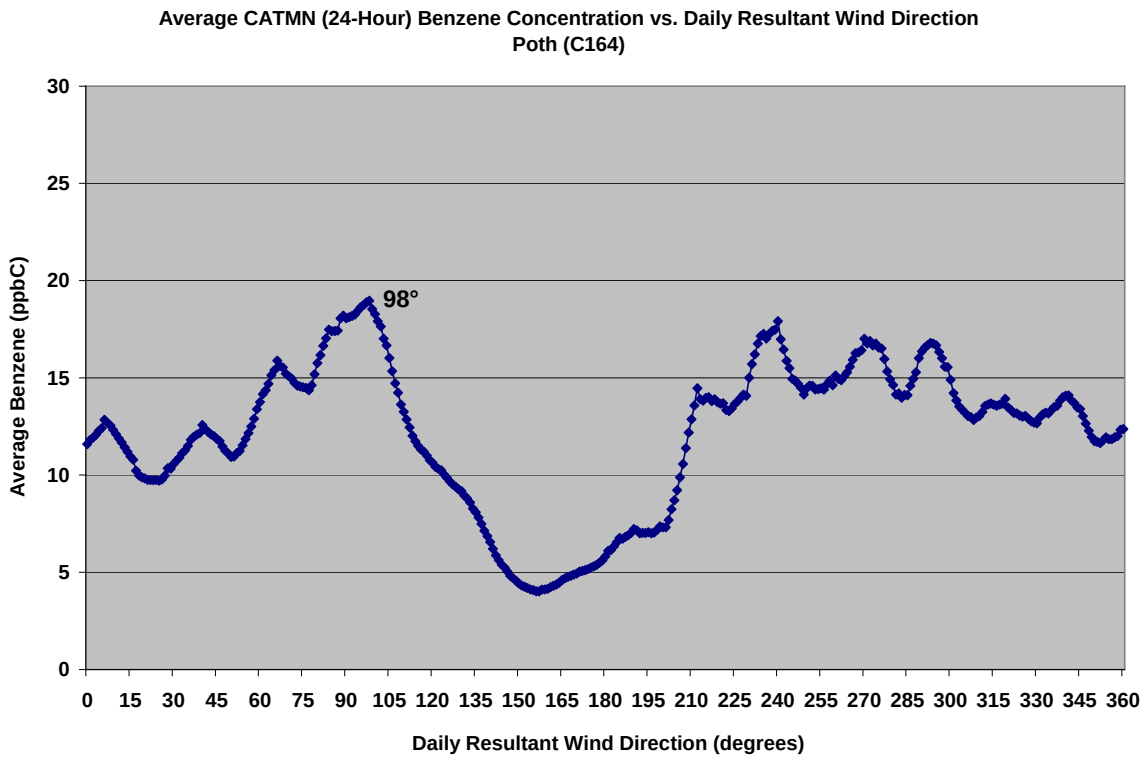

Figure B.3-4. Daily resultant wind direction, calculated from all available CATMN hourly wind data, versus the average 24-hour benzene concentrations during the December 1996 through October 1998 period at the Poth monitoring station. A smoothing factor over a 20 degree wind direction range centered on the daily resultant wind direction has been applied to help account for the variability in wind direction over a 24-hour period.

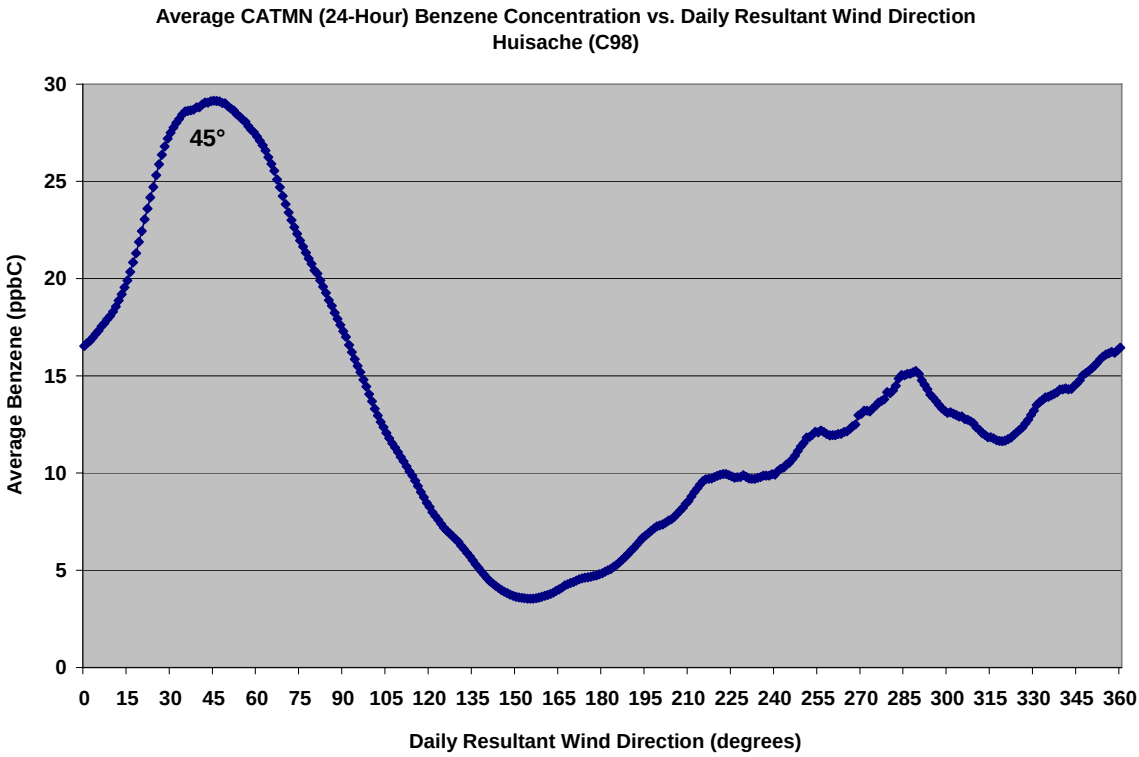

Figure B.3-5. Daily resultant wind direction, calculated from all available CATMN hourly wind data, versus the average 24-hour benzene concentrations during the October 1997 through May 2008 period at the Huisache monitoring station. A smoothing factor over a 20 degree wind direction range centered on the daily resultant wind direction has been applied to help account for the variability in wind direction over a 24-hour period.

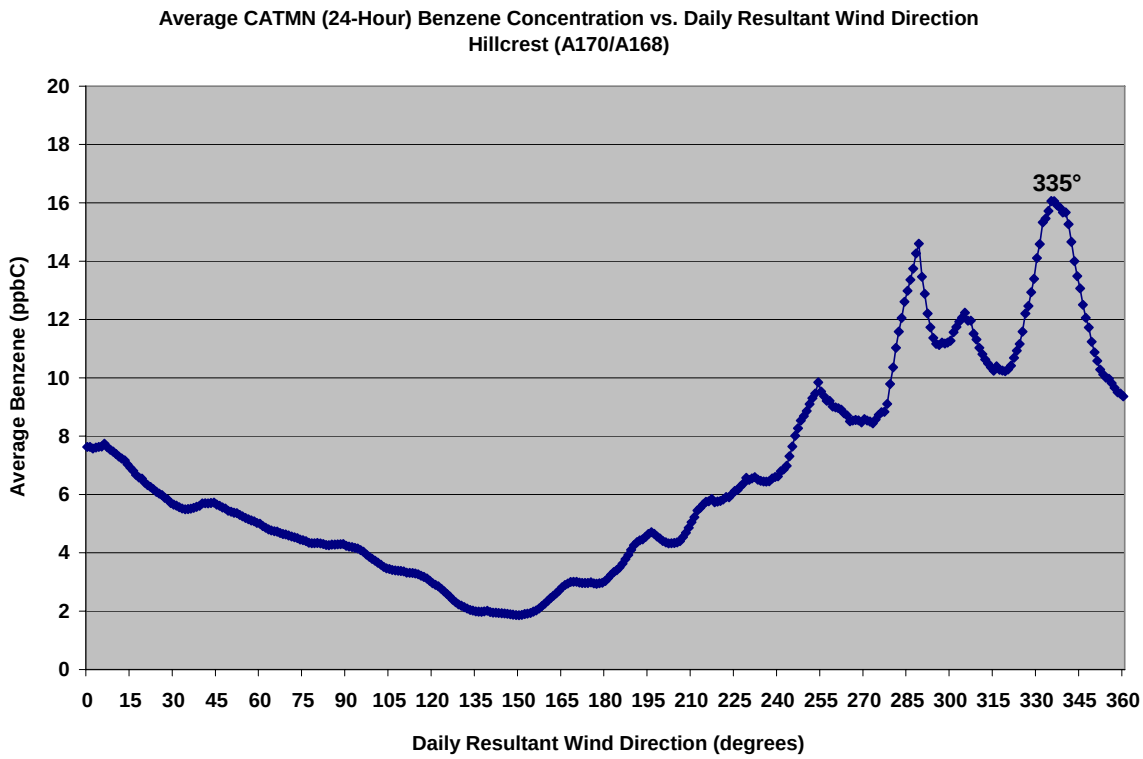

Figure B.3-6. Daily resultant wind direction, calculated from all available CATMN hourly wind data, versus the average 24-hour benzene concentrations during the November 1998 through May 2008 period at the Hillcrest monitoring station. A smoothing factor over a 20 degree wind direction range centered on the daily resultant wind direction has been applied to help account for the variability in wind direction over a 24-hour period.

Figure B.3-7. Directional lines at each of the CATMN stations representing the wind directions characterized by relative maximum values in the average benzene concentrations (as shown in Figures B.3-2 through B.3-6). Directional lines have been added for the CCAQP Oak Park monitoring station based on the wind direction results (e.g., refer to Figure B.2-15).