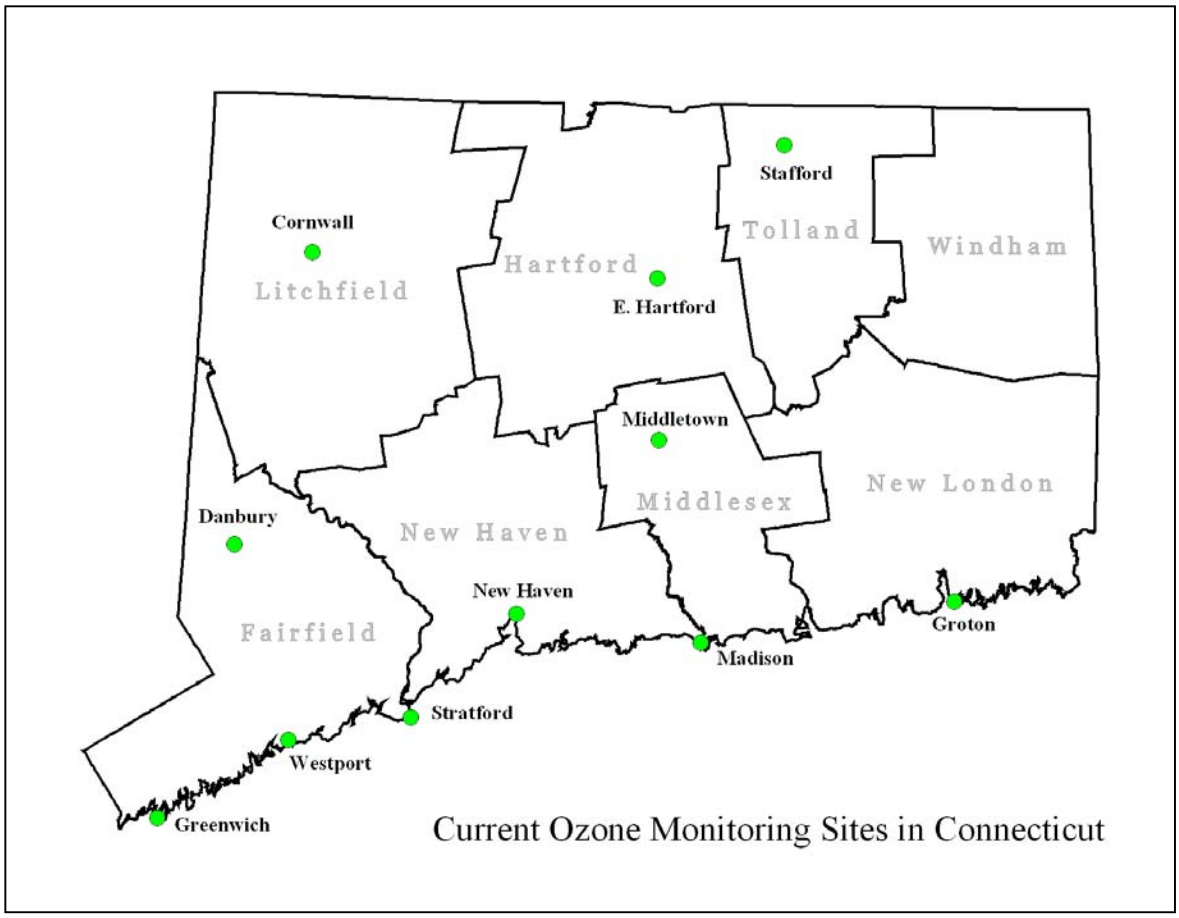
3.0 Ozone Air Quality Levels in Connecticut and Recent Trends

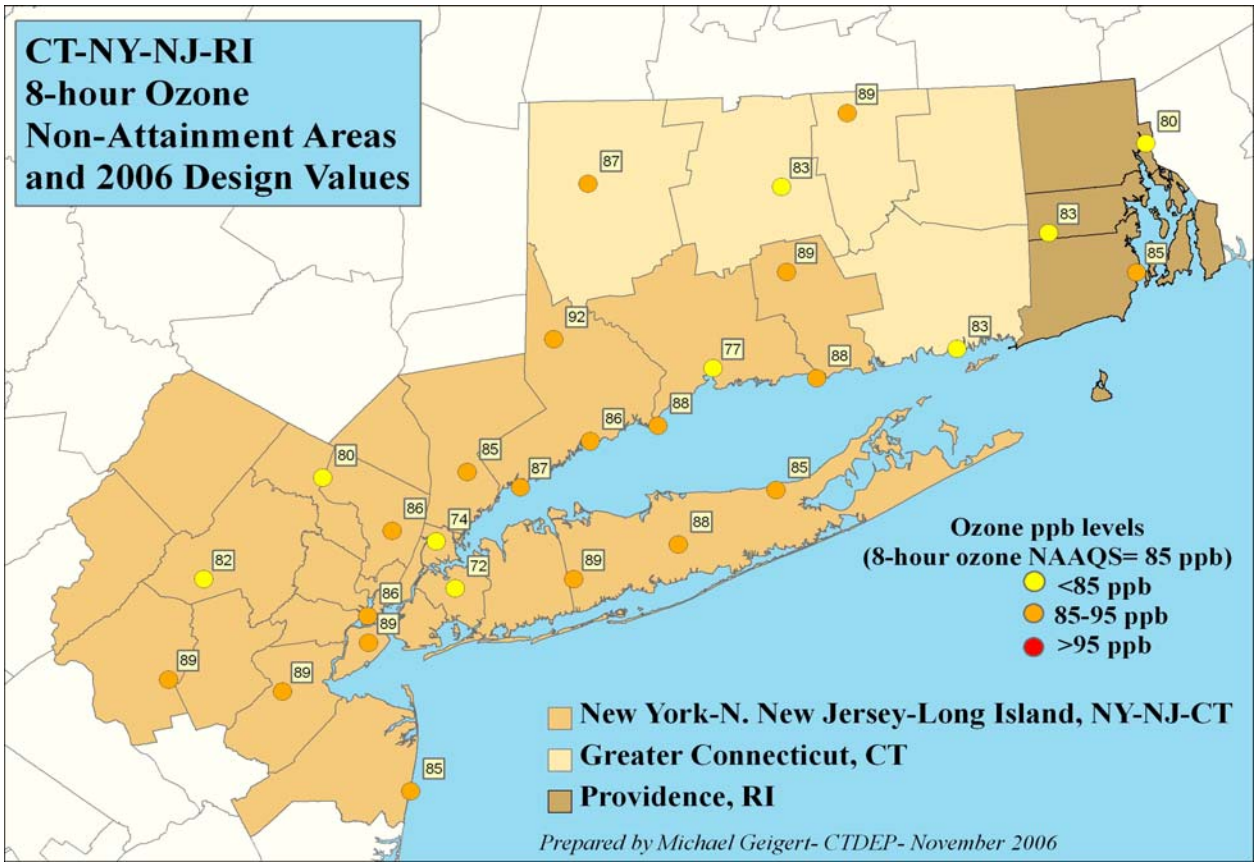
The CTDEP has been monitoring ambient ozone levels throughout the state since the early 1970s. The current network consists of the eleven sites depicted on the map in Figure 3.0.1. In addition to ozone monitoring, since 1994 Connecticut has operated up to four Photochemical Assessment Monitoring Stations (PAMS) to collect ambient concentrations of volatile organic compounds (VOCs), carbon monoxide (CO) and nitrogen oxides (NO and NO_2, which are referred to as NO_X).

Figure 3.0.1: Connecticut Ozone Monitoring Sites in 2007



The form of the 8-hour ozone standard is the three-year average of the fourth highest 8-hour ozone levels for each year. Compliance with the standard is achieved when this "design value" is less than 0.08 parts per million (which equates to 85 parts per billion, or ppb, using standard round-off convention). Figure 3.0.2 shows the 2006 design values and 8-hour ozone nonattainment area boundaries in Connecticut, New York, New Jersey and Rhode Island. Many locations throughout the area exceed the level of the standard and therefore continue to be considered nonattainment with respect to the 8-hour ozone NAAQS.

Figure 3.0.2: 8-hour Ozone Nonattainment Areas in Connecticut, New York, New Jersey and Rhode Island and Associated 2006 Design Values



3.1 8-Hour Ozone Trends

Ozone levels over the monitoring period of record have improved dramatically, corresponding to the large decreases in ozone precursor emissions from sources in Connecticut and from states upwind from Connecticut.[1]

3.1.1 Trends in Design Values

The trends in design values for each site in the Greater Connecticut and Southwest Connecticut portion of NY/NJ/CT nonattainment area are plotted in Figures 3.1.1.1 and 3.1.1.2 respectively**.** The Maximum design values in the Greater Connecticut non-attainment area have decreased by approximately 40% since the mid 1980s, from over 140 ppb to about 85 ppb in 2006. Similarly, the maximum design value in the Southwest Connecticut portion of NY/NJ/CT non-attainment area has decreased from over 155 ppb in 1983 to 90 ppb in 2006.[2]

[1] Note that the ozone data set used in the analyses in this report does not include ozone levels recorded on July 9, 2002, which have been excluded due to the influence of a northern Quebec forest fire episode. Many other states in the Northeast have similarly flagged data during this episode as an exceptional event.
[2] Note: Five sites were operational in 1983 and seven sites in 2006.

Figure 3.1.1.1: Greater Connecticut Ozone Non-Attainment Area
8-Hour Ozone Design Value Trends

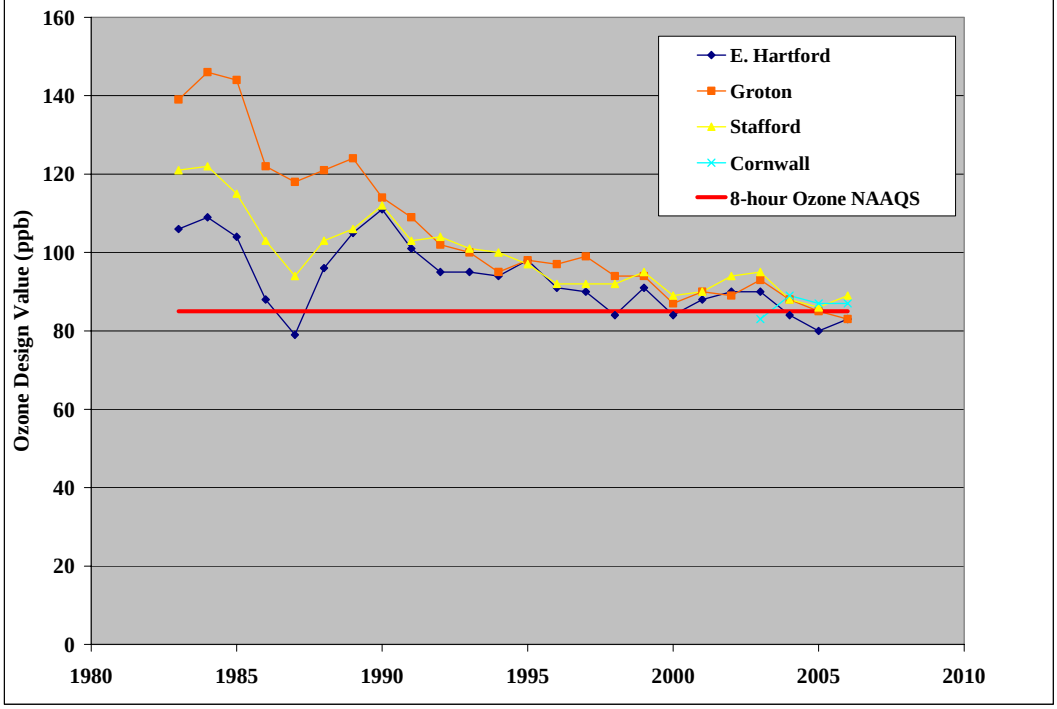
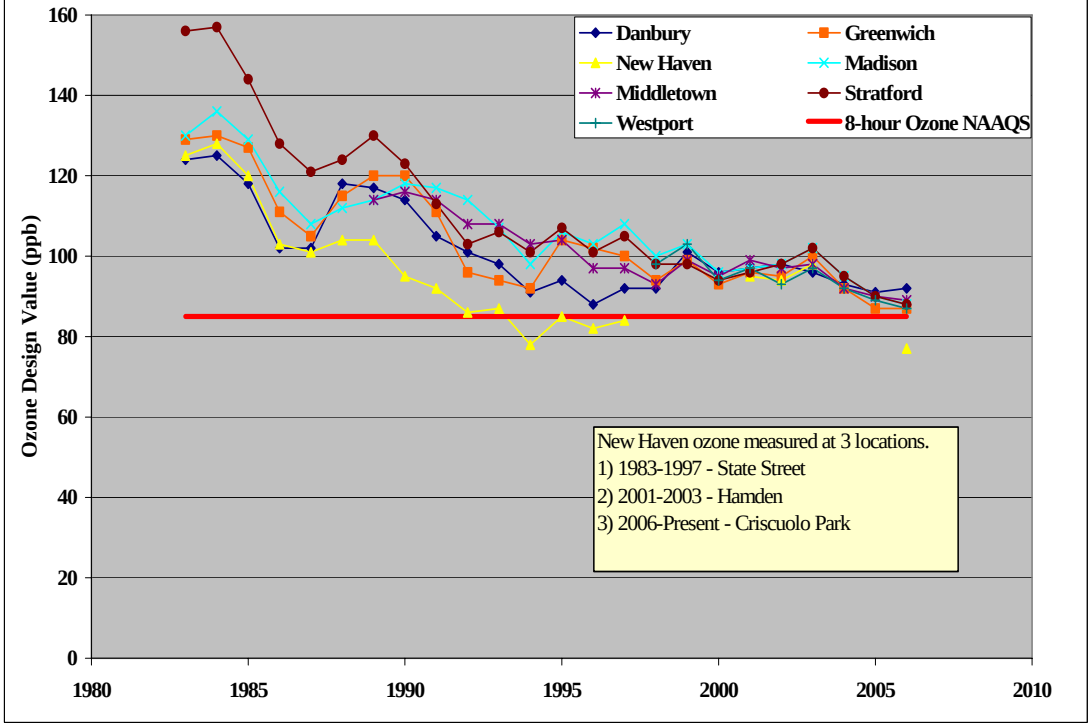
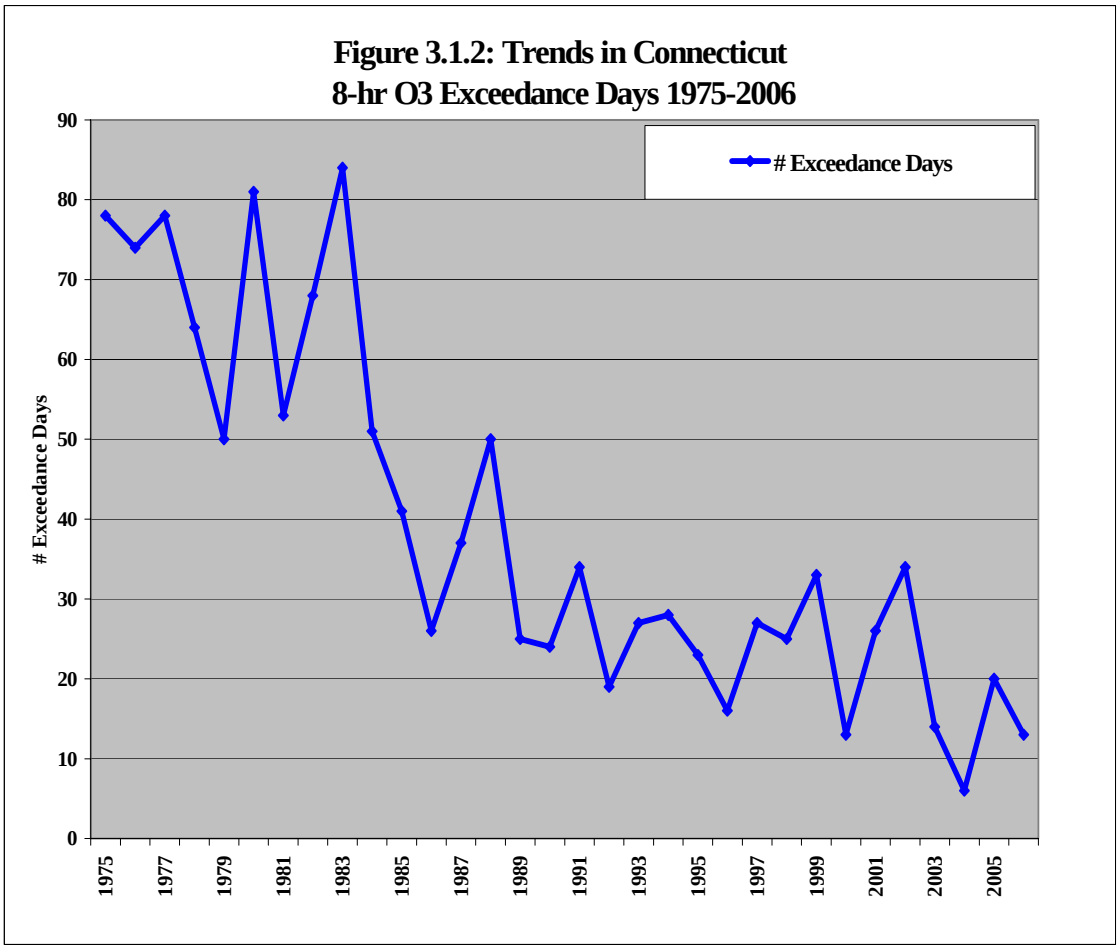


Figure 3.1.1.2: Southwest Connecticut Portion of NY/NJ/CT Ozone Non-Attainment Area
8-Hour Ozone Design Value Trends



3.1.2 Trends in Exceedance Days

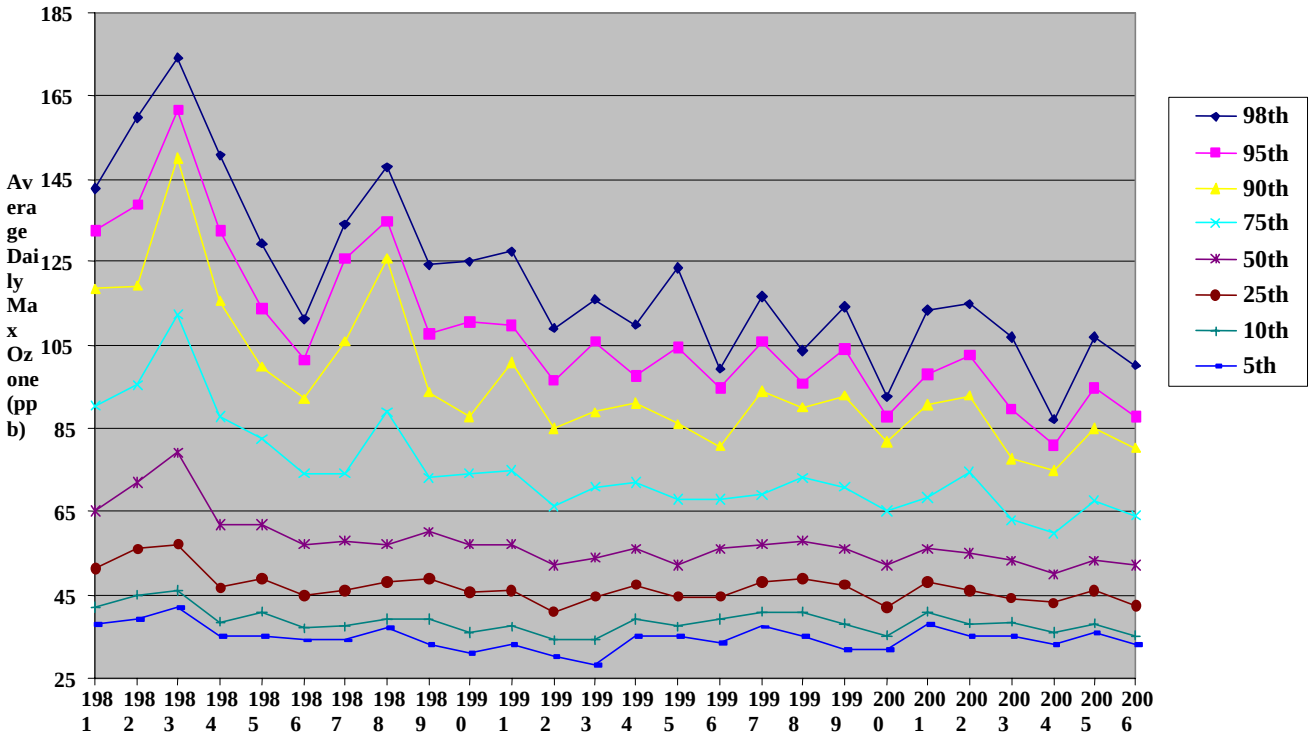
An exceedance day for the 8-hour ozone NAAQS is defined as a day, measured from midnight to midnight, on which any one or more monitors in the state record an 8-hour ozone concentration greater than or equal to 85 ppb. The statewide total number of exceedance days measured in Connecticut from 1975 through 2006 is shown in Figure 3.1.2. The number of exceedance days has decreased dramatically from a high of 84 in 1983 to 13 in 2006.



3.1.3 Trends in 8-hour Ozone Percentiles

The trends addressed previously focused on the very highest ozone concentrations measured at Connecticut monitors. Another way of looking at long-term trends is to plot the full distribution of concentrations including the lowest to the highest percentiles measured during the ozone-monitoring season. Figure 3.1.3 displays such a distribution. It shows that the trend of median values (50^{th} percentiles) and the highest percentiles of ozone levels are consistently downward for the last 25 years. For example, the 90^{th} percentile 8-hr ozone levels were as high as 150 ppb in 1983 but were only 80 ppb in 2006. Meanwhile, the lowest percentiles (representing the lowest 5 and 10 % of ozone levels) do not show a very discernable downward trend.

Figure 3.1.3: Connecticut
Average of Statewide Daily Maximum 8-Hour Ozone
Binned by Percentile for Each Year 1981 Through 2006



3.1.4 Meteorological Influences on Ozone Levels

Ozone is not emitted directly into the atmosphere, but is formed by photochemical reactions between VOCs and NO_X in the presence of sunlight. High ozone days in Connecticut occur on hot summer days, typically with surface winds from the southwest and winds aloft from the west. The photochemical reactions that produce ozone are enhanced by the long summer days and elevated temperatures (which also lead to increased levels of evaporative VOC emissions). In addition, transported ozone and precursor species are enhanced by winds coming from areas with high emissions along the Interstate-95 corridor at the surface and from Midwestern power plants aloft. Hot summers can result in several extended periods of elevated ozone production, while cooler summers are typically characterized by fewer days of elevated ozone levels.

Meteorological data from Bradley International Airport (Windsor Locks, CT) were used to examine the year-to-year relationship between the frequencies of high ozone and high temperature days in Connecticut. Figure 3.1.4.1 shows the trend from 1981 through 2006 of average of statewide daily maximum 8-hour ozone levels binned by daily maximum temperature. It shows that, the highest ozone levels occur on the hottest days (days with maximum temperatures above 90 degrees Fahrenheit) and the trend of high ozone on the hottest days is downward. The trend of ozone on days with high temperatures below 80 degrees is fairly flat.

Figure 3.1.4.1: Connecticut
Average of Statewide Daily Maximum 8-Hour Ozone
Binned by Temperature

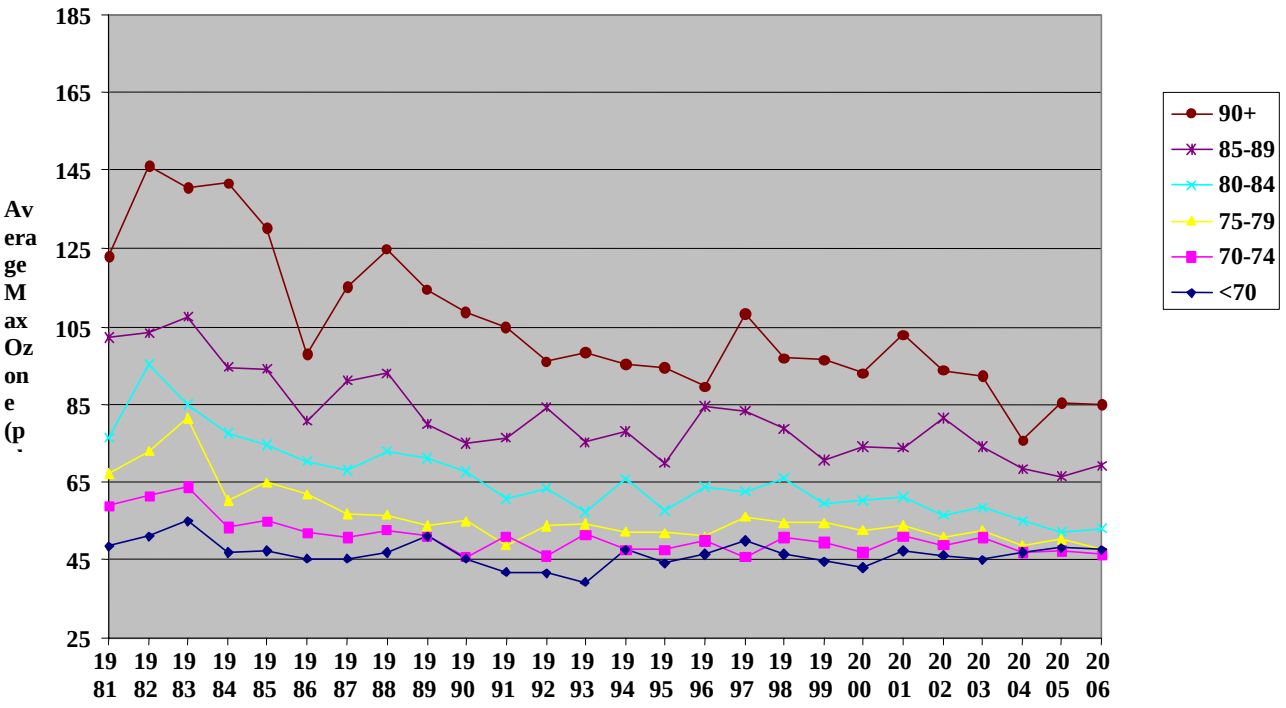
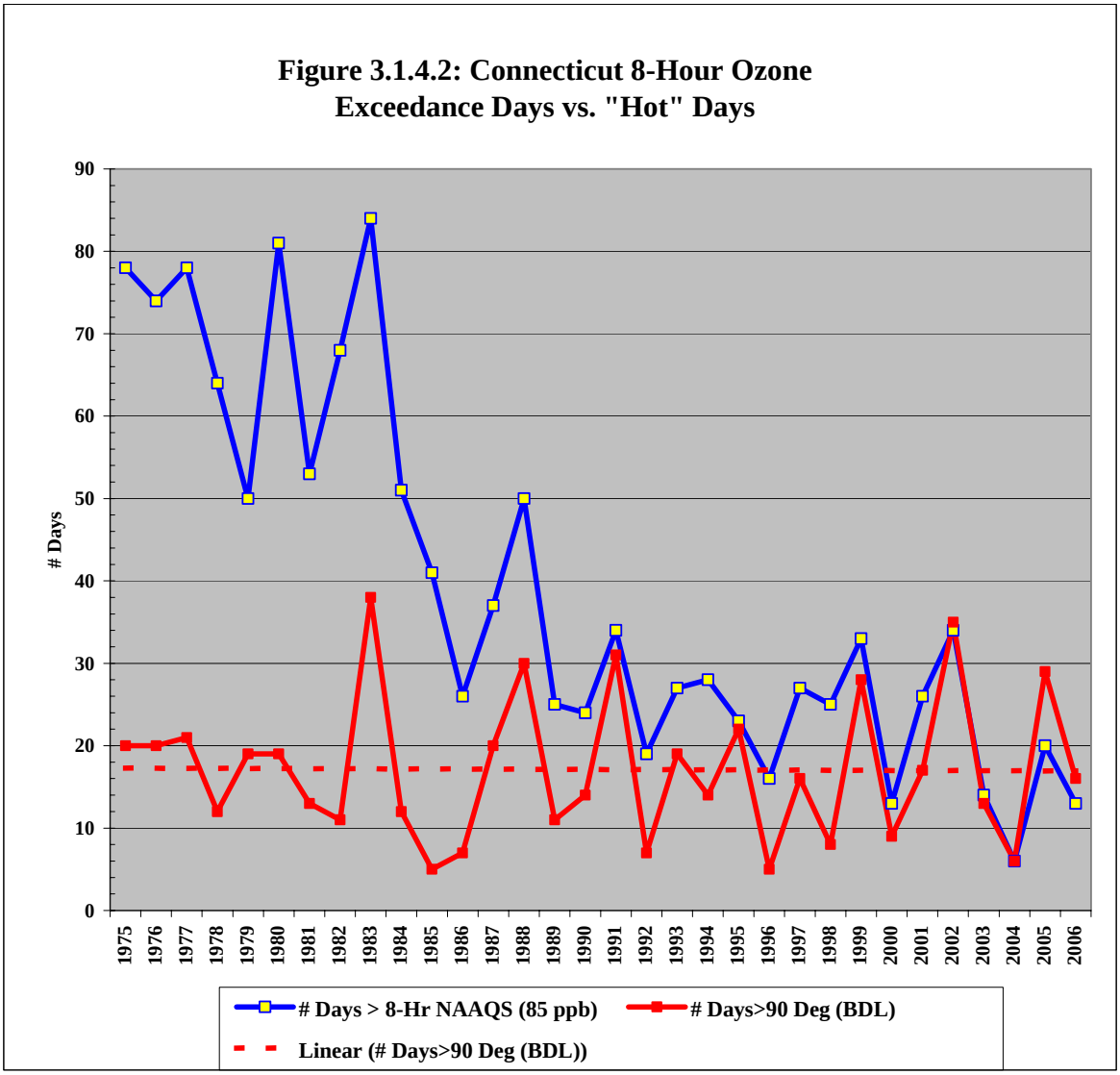


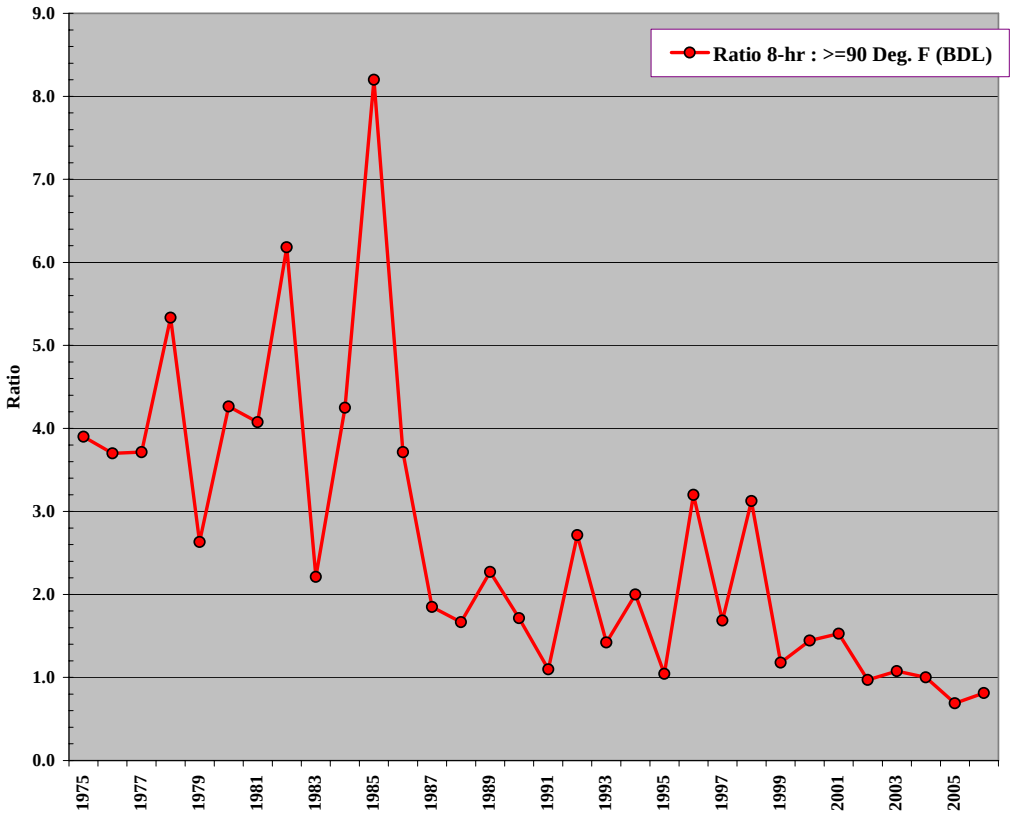
Figure 3.1.4.2 is a plot of the number of exceedance days in Connecticut for the period from 1975 through 2006 superimposed on the number of "hot" days, that is, days with maximum temperatures of 90˚F or above. Although the number of high ozone days tends to track up and down with the number of hot days, the frequency of high ozone days has decreased over time, even for years with similar numbers of hot days. Compared to the 20-year average of 17 hot days, the years 1983, 1988, 1991, 1999, 2002 and 2005 all were hot years with 28 to 38 days of 90˚F or higher temperatures. The number of exceedance days for those years, 84, 50, 34, 33, 34 and 12, respectively, exemplifies the declining trend.

Figure 3.1.4.2: Connecticut 8-Hour Ozone Exceedance Days vs. "Hot" Days



The decline in ozone exceedances after adjusting for temperature effects is shown more clearly in Figure 3.1.4.3**,** which depicts the ratio of exceedance days ("unhealthy" days) to the number of hot days for each ozone season from 1975 through 2006. There were 2.2 to 8 times more exceedance days than hot days during the first ten years of the period (1975 to 1985). Ratios subsequently decreased to levels closer to one exceedance day per each hot day through the early 1990s and have continued to decline to 1.1 or lower since 2002. In 2006, the ratio was 0.81, with 13 exceedance days versus 16 hot days during the ozone season.

Figure 3.1.4.3: Connecticut Statewide 8-Hour Ozone Standard
Ratio of "Unhealthy" to "Hot" Days through 2006



3.2 VOC and NO_X Trends

Ozone is formed when NO_X and VOCs react in the presence of sunlight. Dozens of VOC species can be present in the atmosphere influencing the ozone formation process. Section 182(c)(1) of the CAA directed EPA to promulgate rules (40 CFR 58) that would require states to establish Photochemical Assessment Monitoring Stations (PAMS) as part of their monitoring networks in serious, severe or extreme ozone nonattainment areas. CTDEP established PAMS sites during the mid-1990s that are currently operating in Westport (Sherwood Island), New Haven and East Hartford (*see* Figure 3.0.1 for locations).

PAMS data collection includes ambient concentrations of 55 VOC species, CO, NO, NO_2, and other NO_X species. The federal objectives of this program include providing a speciated ambient air database that is both representative and useful for ascertaining ambient profiles and distinguishing among various individual VOCs and characteristics of source emission impacts. In furtherance of these objectives, the Northeast States for Coordinated Air Use Management (NESCAUM) contracted with Sonoma Technology, Inc. in 2002 to collect, organize and validate

data from 2000 for all the NESCAUM PAMS sites and evaluate control program effectiveness in the NESCAUM region.[3]

Figure 3.2.1 is a plot of the average monthly NO_X concentrations from 1997 to 2005. NO_X concentrations are at their highest levels in the winter months and lowest in the summer months. The trend in NO_X concentrations during the ozone season (May to September) has been downward from 1997 to 2005.

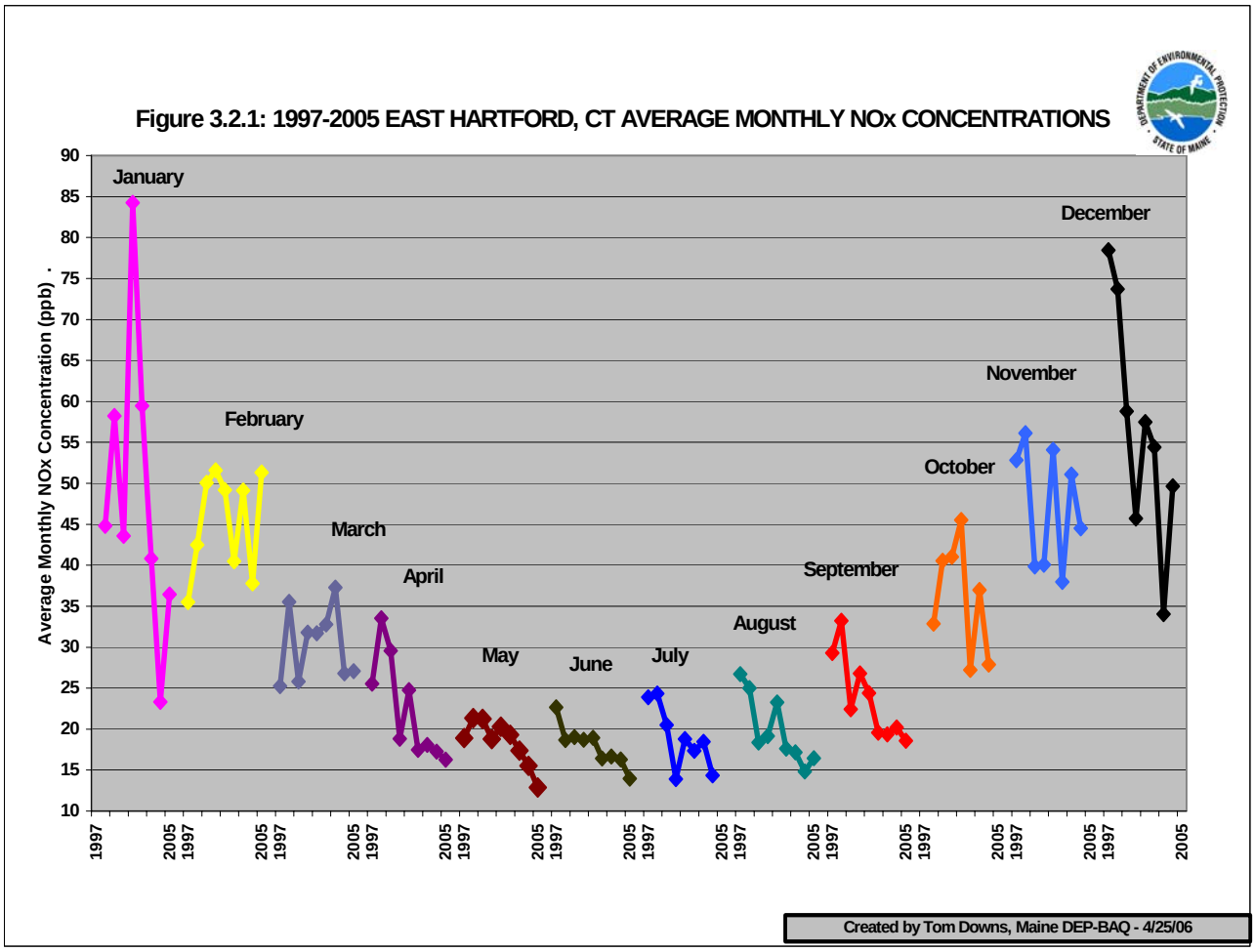
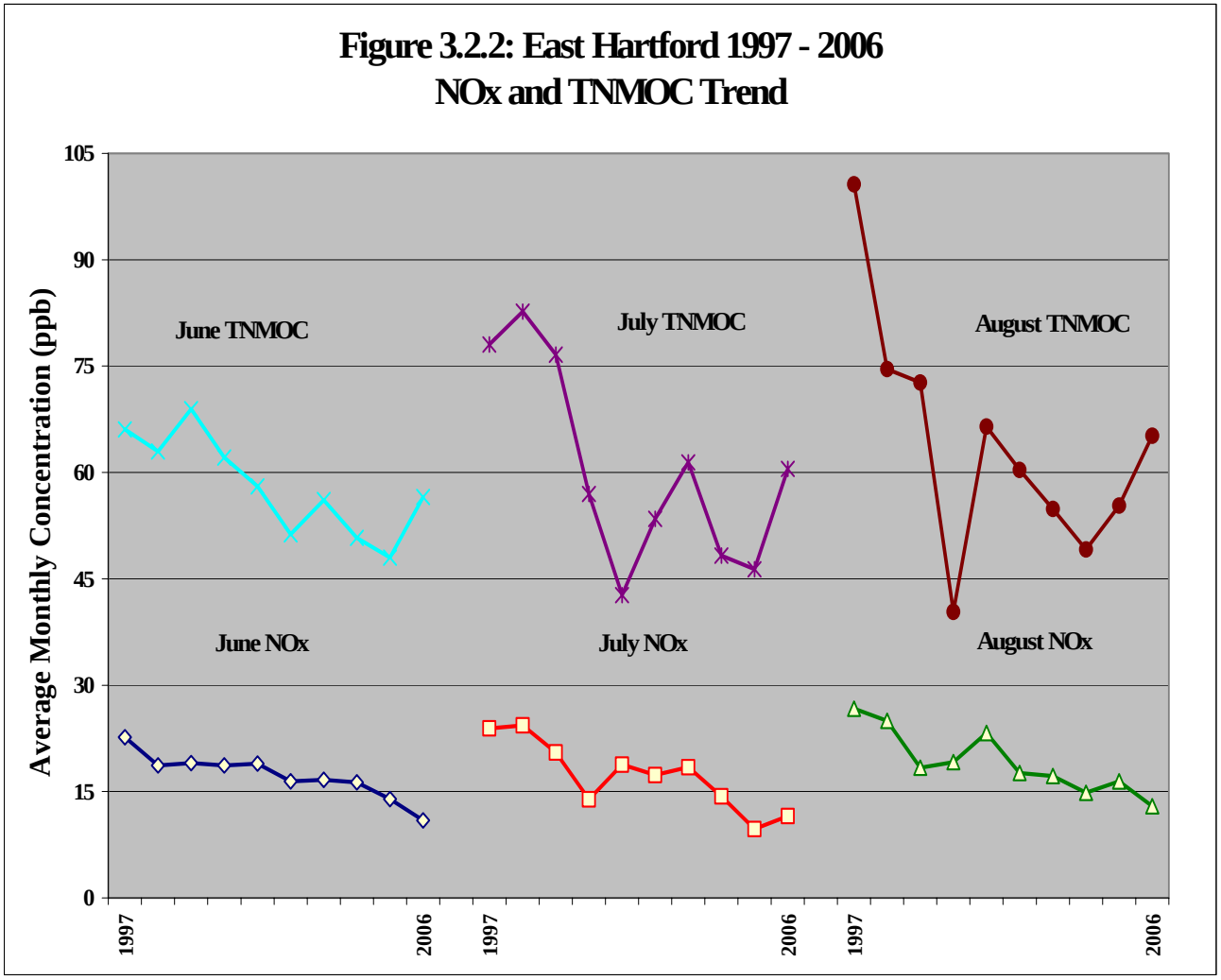


Figure 3.2.2 supplements the aforementioned analysis to include the trends of Total Non-Methane Organic Carbon (TNMOC) and NO_X from the East Hartford site for the summer months of June, July and August from 1997 to 2006. Over the eight-year period covered in the analysis, the trend shows reductions in the average monthly concentration for both NO_X and TNMOC.

[3] The results of this effort may be obtained at: http://www.nescaum.org/projects/pams/part2/index.html.



Figures 3.2.3 to 3.2.6 show the trend in NO_X and TNMOC measured at the Westport Sherwood Island and East Hartford McAuliffe Park monitoring locations where 11 and 13 years of ambient data have been collected, respectively. Over the course of data collection the concentrations of NO_X and TNMOC at each site have trended downward. It should be noted that the East Hartford site was moved closer to Route 5, a rather busy thoroughfare, prior to data collection in 1997. As a consequence, NO_X levels increased in 1997 compared to 1996 but the downward trend continued thereafter. The 95th percentile TNMOC levels for East Hartford increased in 2005 and 2006 while those for Westport showed a similar increase only in 2006.

Figure 3.2.3: East Hartford McAuliffe Park
Oxides of Nitrogen
June to August 1994 - 2006 Trend

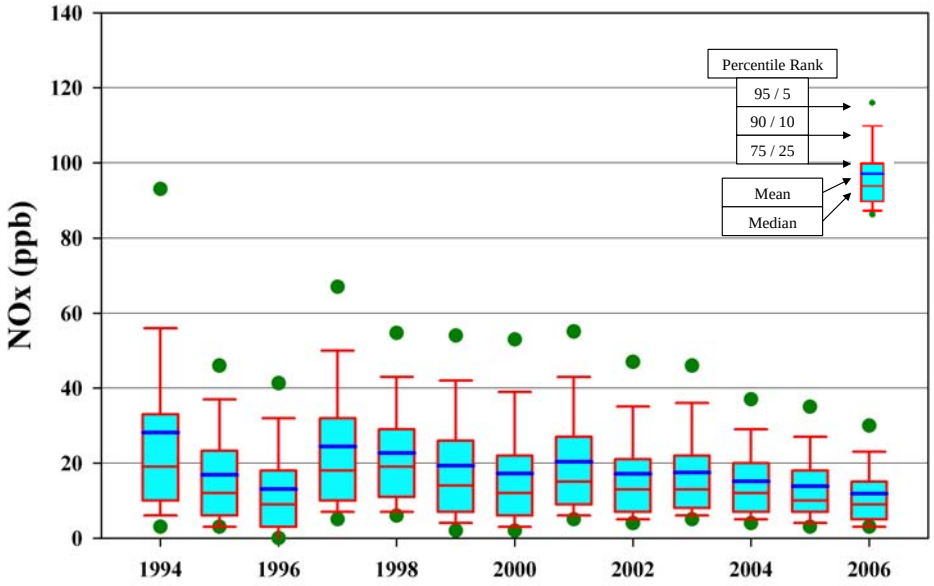


Figure 3.2.4: Wesport Sherwood Island
Oxides of Nitrogen
June to August 1996 - 2006 Trend

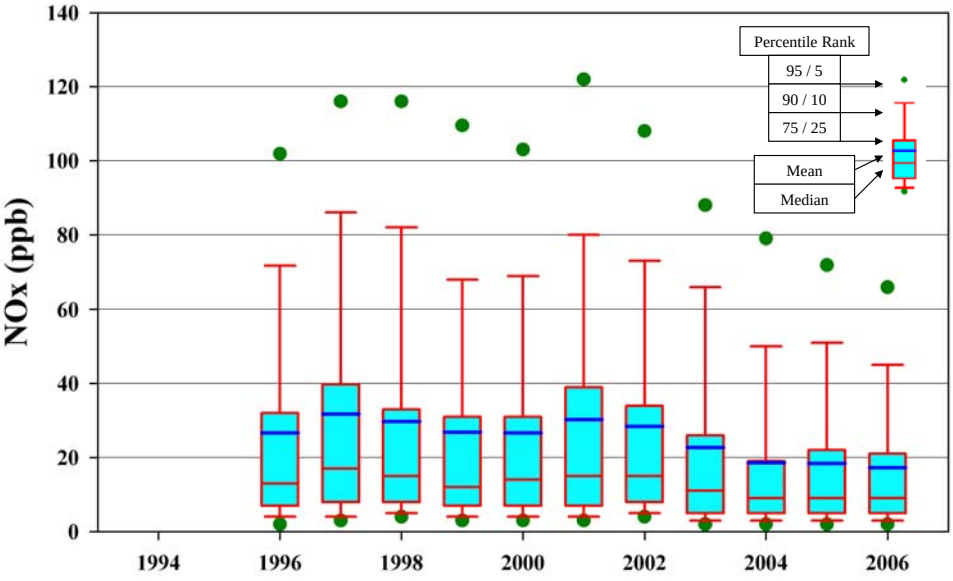


Figure 3.2.5: East Hartford McAuliffe Park
Total Non-Methane Organic Carbon
June to August 1994 - 2006 Trend

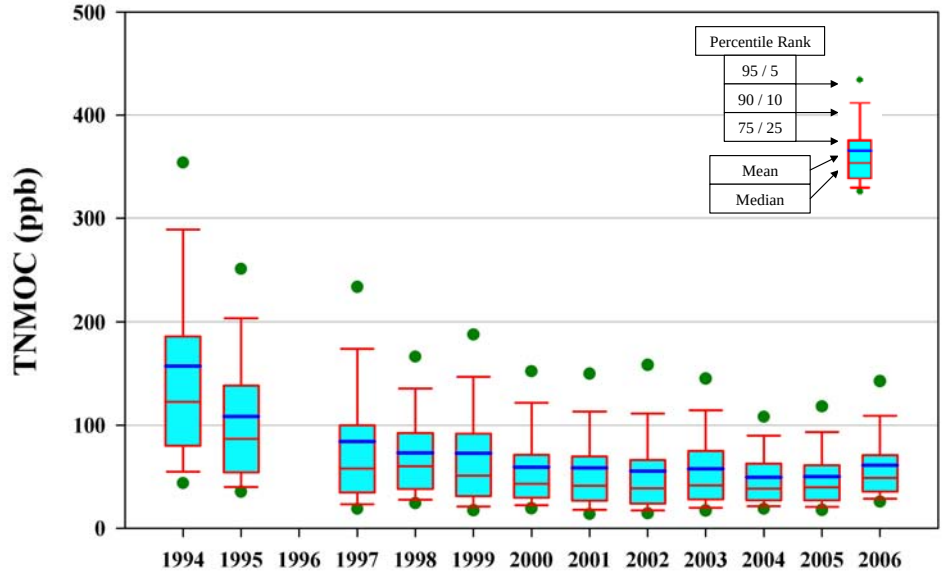
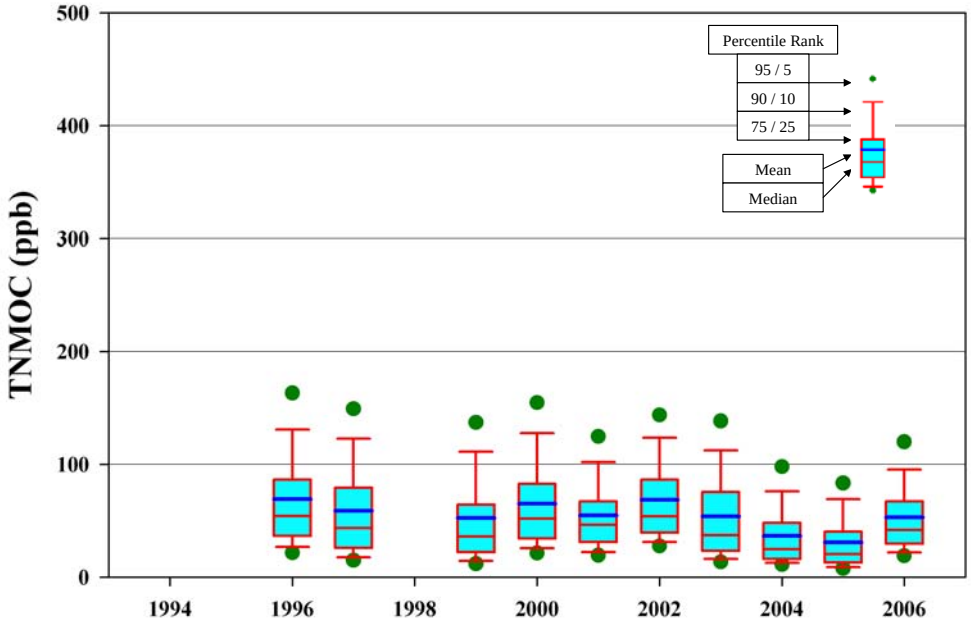
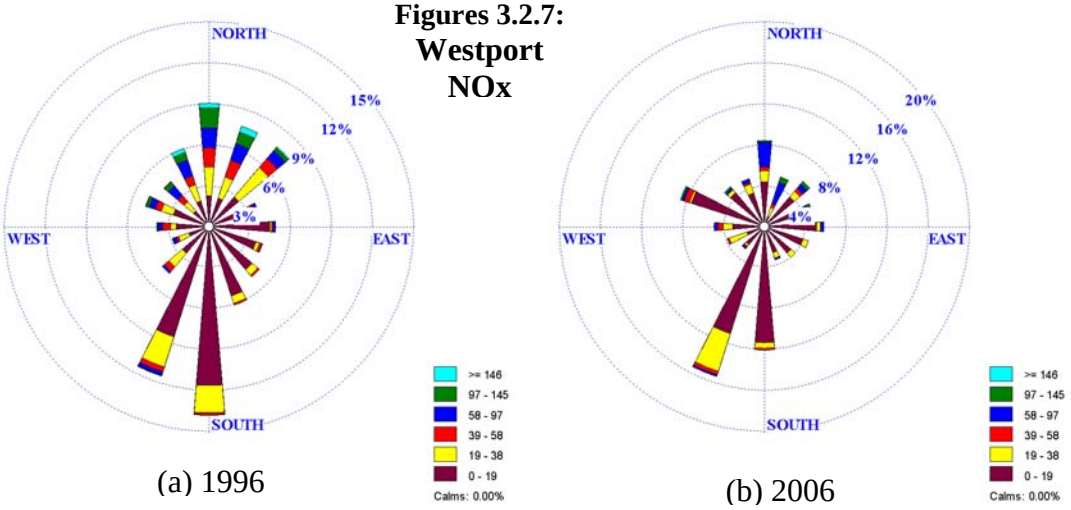


Figure 3.2.6: Westport Sherwood Island
Total Non-Methane Organic Carbon
June to August 1996-2006 Trend



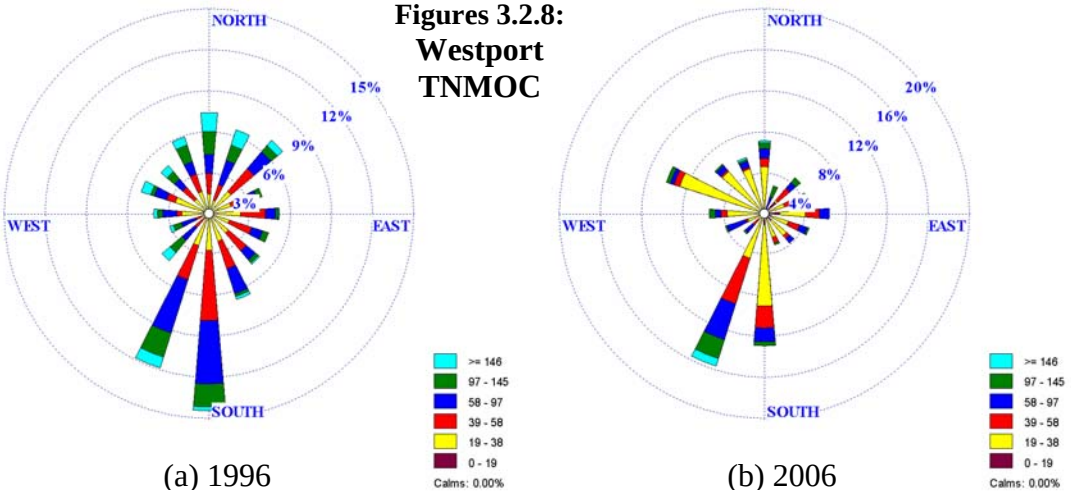
Wind rose plots of NO_X concentrations (ppb) as a function of wind direction from the Westport site in 1996 and 2006 are presented, respectively, in Figures 3.2.7 (a) and (b) below. The wind rose petals (bars) indicate the frequency that winds originated from specific directions and the color bands within each petal indicate the frequency of various NO_X concentrations. The plots show the influence of local mobile source NO_X emissions due to Interstate 95, from which the highest concentrations occur when the winds are from the Northwest to Northeast. Wind rose plots for TNMOC from the Westport site for 1996 and 2006 are presented in Figures 3.2.8 (a) and (b) below. The plots indicate that the TNMOC levels monitored in Westport are driven by dispersed, as opposed to directional-specific sources. Figures 3.2.7 and 3.2.8 also indicate that both NOx and TNMOC levels were lower in 2006 than in 1996, an indication that emission control programs are working to reduce ambient concentrations of ozone precursors.

Figures 3.2.7:
Westport
NOx



(a) 1996 (b) 2006

Figures 3.2.8:
Westport
TNMOC



(a) 1996 (b) 2006