1996

STATE OF CONNECTICUT
ANNUAL AIR QUALITY SUMMARY

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I. INTRODUCTION

The 1996 Air Quality Summary of ambient air quality in Connecticut is a compilation of air pollutant measurements made at the official air monitoring network sites operated by the Department of Environmental Protection (DEP) .

A. OVERVIEW OF AIR POLLUTANT CONCENTRATIONS IN CONNECTICUT

The assessment of ambient air quality in Connecticut is made by comparing the measured concentrations of a pollutant to each of two Federal air quality standards. The first is the primary standard which is established to protect public health with an adequate margin of safety. The second is the secondary standard which is established to protect plants and animals and to prevent economic damage. The specific air quality standards are listed in Table 1-1 along with the time and data constraints imposed on each.

The following section briefly describes the status of Connecticut's air quality for the year 1996. More detailed discussions of each of the six pollutants are provided in subsequent sections of this Air Quality Summary.

1. PARTICULATE MATTER (PM_{10})

Revision of the Particulate Matter Standard - In 1971, the federal Environmental Protection Agency (EPA) promulgated primary and secondary national ambient air quality standards for particulate matter, measured as total suspended particulates or "TSP." The primary standards were set at 260 $\mu g/m^3$, 24-hour average not to be exceeded more than once per year, and 75 $\mu g/m^3$, annual geometric mean. The secondary standard was set at 150 $\mu g/m^3$, 24-hour average not to be exceeded more than once per year. These standards were adopted by the state of Connecticut in 1972.

In accordance with sections 108 and 109 of the Clean Air Act, EPA has reviewed and revised the health and welfare criteria upon which these primary and secondary particulate matter standards were based. EPA found that a size-specific indicator for primary standards representing small particles was warranted and that it should include particles of diameter less than or equal to a nominal 10 micrometers "cut point." Such a standard would place substantially greater emphasis on controlling small particles than does a TSP indicator, but would not completely exclude larger particles from all control.

On March 20, 1984, EPA proposed changes in the standards for particulate matter based on its review and revision of the health and welfare criteria. On July 1, 1987, EPA announced its final decisions regarding these changes. They include: (1) replacing TSP as the indicator for particulate matter for the ambient standards with a new indicator that includes only those particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}); (2) replacing the 24-hour primary TSP standard with a 24-hour PM_{10} standard of 150 $\mu g/m^3$ with no more than one expected exceedance per year; (3) replacing the annual primary TSP standard with a PM_{10} standard of 50 $\mu g/m^3$, expected annual arithmetic mean; and (4) replacing the secondary TSP standard with 24-hour and annual PM_{10} standards that are identical in all respects to the primary standards. On July 7, 1993 the state of Connecticut adopted these new standards for particulate matter.

Compliance Assessment - Measured PM_{10} concentrations during 1996 did not exceed the 50 µg/m^3 level of the primary and secondary annual standards or the 150 µg/m^3 level of the primary and secondary 24-hour standards at any site. Furthermore, the 24-hour standards were not violated because the "expected number of exceedances" for the most recent 3 years at each site did not exceed one per year. The annual standards were also not violated because the "expected annual mean" for the most recent 3 years at each site did not exceed 50 µg/m^3.

2. SULFUR DIOXIDE (SO_2)

Compliance Assessment - None of the air quality standards for sulfur dioxide were exceeded in Connecticut in 1996. Measured concentrations were below the 80 µg/m^3 primary annual standard, the 365 µg/m^3 primary 24-hour standard, and the 1300 µg/m^3 secondary 3-hour standard at all monitoring sites.

3. OZONE (O_3)

National Ambient Air Quality Standard (NAAQS) - On February 8, 1979, the U.S. Environmental Protection Agency (EPA) established an ambient air quality standard for ozone of 0.12 ppm for a one-hour average. That level is not to be exceeded more than once per year. Furthermore, in order to determine compliance with the 0.12 ppm ozone standard, EPA directs the states to record the number of daily exceedances of 0.12 ppm at a given monitoring site over a consecutive 3-year period and then calculate the average number of daily exceedances for this interval. If the resulting average value is less than or equal to 1.0, (that is, if the fourth highest daily value in a consecutive 3-year period is less than or equal to 0.12 ppm), the ozone standard is considered to be attained at that site. The definition of the pollutant was also changed, along with the numerical value of the standard, partly because the instruments used to measure photochemical oxidants in the air really measure only ozone. Ozone is one of a group of chemicals which are formed photochemically in the air and are called photochemical oxidants. In the past, the two terms have often been used interchangeably. This Air Quality Summary uses the term "ozone" in conjunction with the new NAAQS to reflect the changes in both the numerical value of the NAAQS and the definition of the pollutant.

Compliance Assessment - The primary 1-hour ozone standard was exceeded at only five of the twelve DEP ozone monitoring sites in 1996 (see Table 1-2). However, nonattainment of the standard remains a fact at nearly all the sites in 1996 because the average number of annual exceedances at each site was greater than one per year over the period 1994-1996. Only the Stafford 001 and Torrington 006 sites with average exceedances of 1.0 and 0.67, respectively, were technically in compliance with the ozone standard.

4. NITROGEN DIOXIDE (NO_2)

Compliance Assessment - The annual average NO_2 standard of 100 µg/m^3 was not exceeded at any site in Connecticut in 1996.

5. CARBON MONOXIDE (CO)

Compliance Assessment - The primary 8-hour standard of 9 ppm was not exceeded at any of the five carbon monoxide monitoring sites in Connecticut during 1996. In addition, there were no exceedances of the primary 1-hour standard of 35 ppm at any site.

6. LEAD (Pb)

Compliance Assessment - The primary and secondary ambient air quality standard for lead is 1.5 µg/m^3, maximum arithmetic mean averaged over three consecutive calendar months. As has been the case since 1980, the lead standard was not exceeded at any site in Connecticut during 1996.

B. AIR MONITORING NETWORK

A computerized Air Monitoring Network consisting of an IBM System 7 computer and numerous telemetered monitoring sites was operated in Connecticut for several years. In 1985, this data acquisition system was modernized by installing new data loggers at the monitoring sites and replacing the dedicated IBM System 7 computer with a non-dedicated Data General Eclipse MV10000 computer, which was replaced in 1988 with a MV15000 model. This essentially improved both data accuracy and data capture. In April of 1996, the system was further upgraded with the purchase of state-of-the-art data loggers and PC-based charting software. In addition, the data polling functions performed by the Data General MV15000 were replaced with a primary polling and back-up system on DEC Pentium PCs.

As many as 14 measurement parameters are transmitted from a monitoring site via telephone lines to DEC PCs located in the DEP Hartford office and the DEP Windsor lab. The data are then compiled three times daily into 24-hour summaries. The telemetered sites are located in the towns of Bridgeport (3), Danbury, East Hartford (2), East Haven, Enfield, Greenwich, Groton (2), Hartford (3), Madison, Mansfield, Middletown, New Haven (2), Stafford, Stamford (2), Stratford, Torrington, Waterbury and Westport.

Continuously measured parameters include the pollutants sulfur dioxide, particulates (measured as PM_{10}), carbon monoxide, nitric oxide, total nitrogen oxides, ozone and volatile organic compounds or VOC (June through August only). Meteorological data consists of wind speed and direction, temperature, precipitation, barometric pressure, solar radiation and dew point. Other parameters used for quality assurance and troubleshooting are room temperature, calibrator oven temperature, line voltage and air flow.

The real-time capabilities of the telemetry network have enabled the Air Monitoring Unit to report the Pollutant Standards Index for a number of towns on a daily basis while continuously keeping a close watch for high pollution levels which may occur during adverse weather conditions.

The complete monitoring network used in 1996 consisted of the following:

21	Particulate matter (PM_{10}) hi-vol samplers
1	Particulate matter (PM_{10}) analyzer
5	Lead hi-vol samplers
12	Sulfur dioxide analyzers
12	Ozone analyzers
3	Nitrogen dioxide analyzers
5	Carbon monoxide analyzers
2	Automated gas chromatographs for VOC

A complete description of all permanent air monitoring sites in Connecticut operated by DEP in 1996 is available from the Department of Environmental Protection, Bureau of Air Management, Monitoring and Radiation Division, 79 Elm Street, Hartford, Connecticut, 06106-5127.

C. POLLUTANT STANDARDS INDEX

The Pollutant Standards Index (PSI) is a daily air quality index recommended for common use in state and local agencies by the U.S. Environmental Protection Agency. Starting on November 15, 1976, Connecticut began reporting the PSI on a 7-day basis, but is currently reporting the PSI on a 5-day basis for most of the year (6-day during the ozone season) with predictions for the weekends. The PSI incorporates three pollutants : sulfur dioxide, PM_{10} and ozone. The index converts each air pollutant concentration into a normalized number where the National Ambient Air Quality Standard for each pollutant corresponds to PSI = 100 and the Significant Harm Level corresponds to PSI = 500.

Figure 1-1 shows the breakdown of index values for the commonly reported pollutants (PM_{10}, SO_2, and O_3) in Connecticut. For the winter of 1996, Connecticut reported the PM_{10} PSI for the towns of Bridgeport, Burlington, Danbury, East Hartford, Enfield, Greenwich, Groton, Hartford, Meriden, Middletown, New Britain, New Haven, New London, Norwalk, Norwich, Stamford, Torrington, Voluntown, Wallingford, Waterbury and Willimantic; and reported the sulfur dioxide PSI for the towns of Bridgeport, Danbury, East Hartford, East Haven, Enfield, Greenwich, Groton, Hartford, Mansfield, New Haven, Stamford, and Waterbury. For the summer, the ozone PSI was reported for the towns of Bridgeport, Danbury, East Hartford, Greenwich, Groton, Madison, Middletown, New Haven, Stafford, Stratford, Torrington and Westport. Each day, the pollutant with the highest PSI value of all the pollutants being monitored is reported for each town, along with the dimensionless PSI number and a descriptor label to characterize the daily air quality. A descriptor label of each subsequent day's forecast is also included.

A telephone recording of the PSI is available each afternoon at approximately 3 PM, five days a week, and can be heard by dialing 424-4167. Predictions for weekends are included on the Friday recordings. For answers to specific questions, you can call a DEP representative at 424-3029 . The PSI information, as well as health effects information, is also available to the public during weekdays from the American Lung Association of Connecticut in East Hartford. The number there is 289-5401 or 1-800-992-2263.

D. QUALITY ASSURANCE

Quality Assurance requirements for State and Local Air Monitoring Stations (SLAMS), for National Air Monitoring Stations (NAMS), as part of the SLAMS network, and for Photochemical Assessment Monitoring (PAMS) are specified by the code of Federal Regulations, Title 40, Part 58, Appendix A.

The regulations were enacted to provide a consistent approach to Quality Assurance activities across the country so that ambient data with a defined precision and accuracy is produced.

A Quality Assurance program was initiated in Connecticut with written procedures covering, but not limited to, the following:

Equipment procurement
Equipment acceptance testing
Equipment installation
Equipment calibration
Equipment operation
Sample analysis
Maintenance checks
Performance audits
Data handling
Data quality assessment

Quality assurance procedures for the above activities were fully operational on January 1, 1981 for all NAMS monitoring sites. On January 1, 1983 the above procedures were fully operational for all SLAMS monitoring sites. Interim procedures have been in use for all PAMS monitoring sites since June of 1994, and are currently being refined.

Data precision and accuracy values are reported in the form of 95% probability limits as defined by equations found in Appendix A of the Federal regulations cited above.

1. PRECISION

Precision is a measure of data repeatability (grouping) and is determined as follows:

a. Manual Samplers (PM_{10})

A second PM_{10} hi-vol sampler is placed alongside the regular network sampler and operated concurrently. The concentration values from the collocated hi-vol sampler are compared to the network sampler and precision values are generated from the comparison.

b. Manual Samplers (Lead)

A second hi-vol sampler is placed alongside a regular network hi-vol sampler and operated concurrently. The concentration values from the collocated hi-vol sampler are compared to those from the network sampler, and precision values are generated from the comparison.

c. Automated Analyzers (SO_2, O_3, CO and NO_2)

All NAMS and SLAMS analyzers are challenged with a low level pollutant concentration a minimum of once every two weeks: 8 to 10 ppm for CO and 0.08 to 0.10 ppm for SO_2, O_3 and NO_2. The comparison of analyzer response to input concentration is used to generate automated analyzer precision values.

d.. Automated Analyzers (VOC)

Analyzers are challenged with a low level calibration standard every fifty hours. The standard contains all fifty-five VOC target compounds in concentrations ranging from 2.5 to 6 parts per billion carbon (ppbc). The mean measured value for each compound is used as the target value from which precision estimates are generated.

2. ACCURACY

Accuracy is an estimate of the closeness of a measured value to a known value and is determined in the following manner:

a. Manual Methods (PM_{10})

Accuracy for PM_{10} is assessed by auditing the flow measurement phase of the sampling method. In Connecticut, this is accomplished by attaching a secondary standard calibrated orifice to the hi-vol inlet and comparing the measured flow rate to the design flow rate. A minimum of 25% of the PM_{10} network samplers is audited each quarter.

b. **Manual Methods** (Lead)

Accuracy for lead is assessed in two ways:

(1) By analyzing spiked samples and comparing the known spiked-sample concentrations with the measured concentrations, and

(2) By auditing the flow, as in 2.a. above.

Accuracy measurements are obtained each quarter.

c. **Automated Analyzers** (SO_2, O_3, CO and NO_2)

Automated analyzer data accuracy is determined by challenging each analyzer with three predetermined concentration levels (four for NO_2). Each quarter, accuracy values are calculated for approximately 25% of the analyzers in a pollutant sampling network, at each concentration level. The results for each concentration of a particular pollutant are used to assess automated analyzer accuracy. The audit concentration levels are as follows:

SO_2, O_3, and NO_2 (PPM)	**CO** (PPM)
0.03 to 0.08	3 to 8
0.15 to 0.20	15 to 20
0.35 to 0.45	35 to 45
0.80 to 0.90 (NO_2 only)	

d.. **Automated Analyzers** (VOC)

The accuracy of automated gas chromatographs used for VOC analysis is determined by analyzing "blind" audit samples supplied by EPA. Audit samples contain an unknown number of VOC at unspecified concentrations. Both the analysis results and the audit gas are sent back to EPA. EPA reanalyzes the audit gas (i.e., if sufficient quantity remains) to establish stability of the mixture, and returns audit results which highlight compounds outside expected accuracy levels (typically +/-35%).

TABLE 1-1

ASSESSMENT OF AMBIENT AIR QUALITY

POLLUTANT	SAMPLING PERIOD	DATA REDUCTION	STATISTICAL BASE	AMBIENT AIR QUALITY STANDARDS			
				PRIMARY		SECONDARY	
				µg/m3	ppm	µg/m3	ppm
Particulates (PM_{10})[a]	24 Hours (every sixth day)	24-Hour Average	Annual Arithmetic Mean[b]	50[c]		50[c]	
			24-Hour Average	150[d]		150[d]	
Sulfur Oxides (measured as sulfur dioxide)	Continuous	1-Hour Average	Annual Arithmetic Mean[e]	80	0.03		
			24-Hour Average[e]	365[f]	0.14[f]		
			3-Hour Average[e]			1300[f]	0.5[f]
Nitrogen Dioxide	Continuous	1-Hour Average	Annual Arithmetic Mean[e]	100	0.053	100	0.053
Ozone	Continuous	1-Hour Average	1-Hour Average	235[g]	0.12[g]	235[g]	0.12[g]
Lead	24 Hours (every sixth day)	Monthly Composite	Weighted 3-Month Average[h]	1.5		1.5	
Carbon Monoxide	Continuous	1-Hour Average	8-Hour Average[e]	10[f,i]	9[f]	10[f,i]	9[f]
			1-Hour Average	40[f,i]	35[f]	40[f,i]	35[f]

[a] Particulate matter with an aerodynamic diameter not greater than a nominal 10 micrometers.

[b] EPA assessment criteria require 4 calendar quarters of data per year and at least 75% of the scheduled samples per calendar quarter in each of the most recent 3 years.

[c] The "expected annual mean" for the most recent 3 years.

[d] The "expected number of exceedances" per calendar year should be less than or equal to one, for the most recent 3 years.

[e] EPA assessment criteria require at least 75% of the possible data to compute a valid average. For the annual mean, 9 months of data are required, and each calendar quarter must have at least 2 months of data. Furthermore, a valid month must have at least 21 days of data, and a valid day must have at least 18 hours of data.

[f] Not to be exceeded more than once per year.

[g] Daily maximum. The expected number of days that exceed the standard is not to average more than one per year in three years at a site.

[h] State of Connecticut assessment criteria require at least 75% of the scheduled samples to compute a valid average.

[i] Units are mg/m3, not µg/m3.

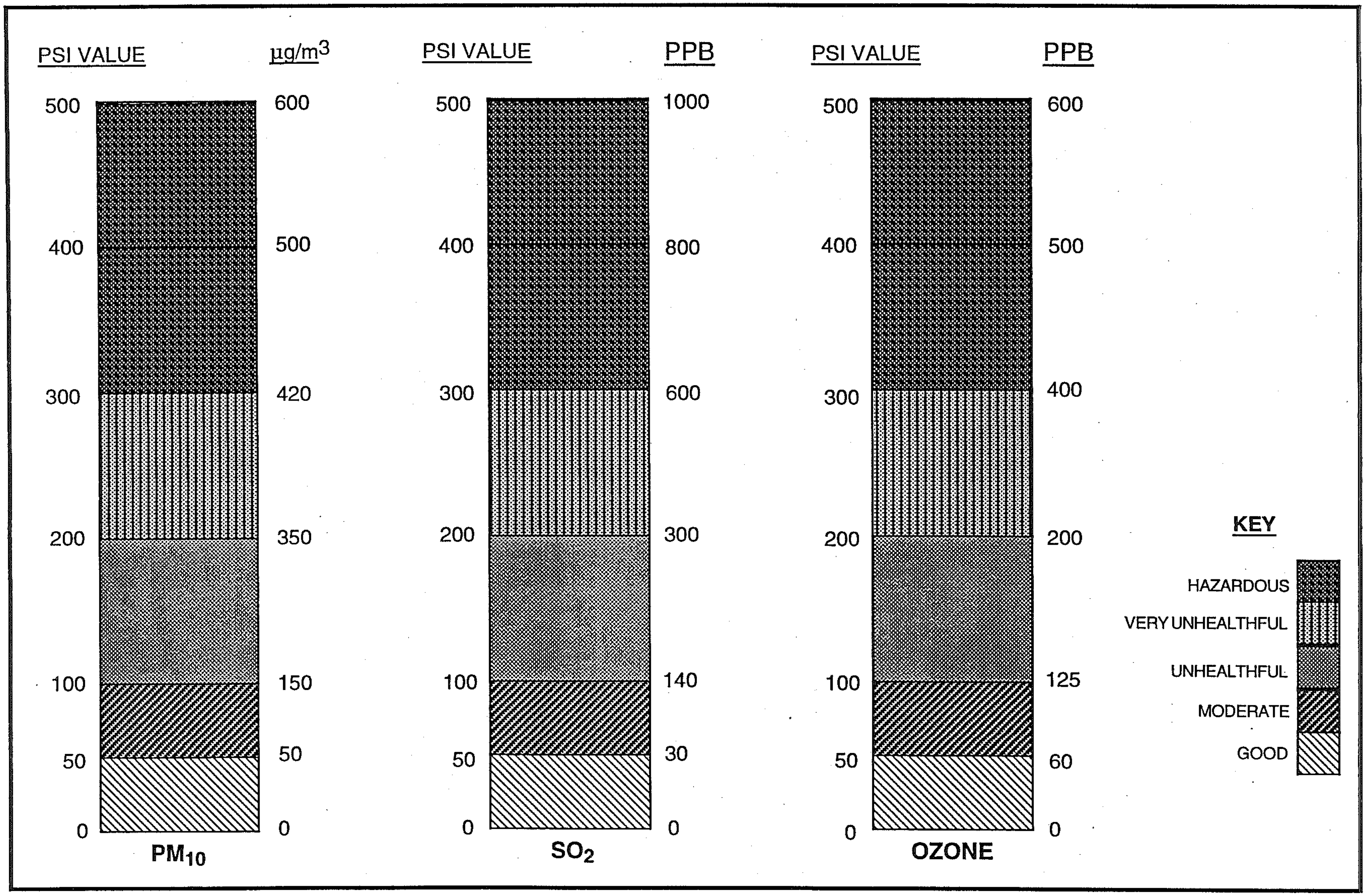
TABLE 1-2

AIR QUALITY STANDARDS EXCEEDED IN CONNECTICUT IN 1996 BASED ON MEASURED CONCENTRATIONS

		OZONE	
		Level Exceeding 1-Hour Standard (0.12 PPM)	
TOWN	SITE	Highest Observed Level (ppm)	Number of Days Standard Exceeded
Greenwich	017	0.126	1
Groton	008	0.148	1
Middletown	007	0.135	1
Stratford	007	0.126	1
Westport	003	0.138	2

FIGURE 1-1

POLLUTANT STANDARDS INDEX



II. PARTICULATE MATTER

HEALTH EFFECTS

Particulate matter is the generic term for a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. Particles originate from a variety of stationary and mobile sources. They may be emitted directly or formed in the atmosphere by transformations of gaseous emissions such as sulfur oxides, nitrogen oxides, and volatile organic substances. The chemical and physical properties of particulate matter vary greatly with time, region, meteorology and source category.

The major effects associated with high exposures to particulate matter include reduced lung function; interference with respiratory mechanics; aggravation or potentiation of existing respiratory and cardiovascular disease, such as chronic bronchitis and emphysema; increased susceptibility to infection; interference with clearance and other host defense mechanisms; damage to lung tissues; carcinogenesis and mortality.

Harm may also occur in the form of changes in the human body caused by chemical reactions with pollution particles that pass through the lung membranes to poison the blood or be carried by the blood to other organs. This can happen with inhaled lead, cadmium, beryllium, and other metals, and with certain complex organic compounds that can cause cancer.

Population subgroups that appear likely to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease, individuals with influenza, asthmatics, the elderly, children, smokers, and mouth or oronasal breathers.

REVISION OF THE PARTICULATE MATTER STANDARD

In 1971, the federal Environmental Protection Agency (EPA) promulgated primary and secondary national ambient air quality standards for particulate matter, measured as total suspended particulates or "TSP." The primary standards were set at 260 $\mu g/m^3$, 24-hour average not to be exceeded more than once per year, and 75 $\mu g/m^3$, annual geometric mean. The secondary standard, also measured as TSP, was set at 150 $\mu g/m^3$, 24-hour average not to be exceeded more than once per year. These standards were adopted by the state of Connecticut in 1972. In accordance with sections 108 and 109 of the Clean Air Act, EPA has reviewed and revised the health and welfare criteria upon which these primary and secondary particulate matter standards were based.

The TSP standard directs control efforts towards particles of lower risk to health because of its inclusion of large particles which can dominate the measured mass concentration, but which are deposited only in the extrathoracic region. Smaller particles penetrate furthest in the respiratory tract, settling in the tracheobronchial region and in the deepest portion of the lung, the alveolar region. Available evidence demonstrates that the risk of adverse health effects associated with deposition of typical ambient fine and coarse particles in the thorax are markedly greater than those associated with deposition in the extrathoracic region. EPA found that a size-specific indicator for primary standards representing small particles was warranted and that it should include particles of diameter less than or equal to a nominal 10 micrometers "cut point." Such a standard places substantially greater emphasis on controlling smaller particles than does a TSP indicator, but doesn't completely exclude larger particles from all control.

On March 20, 1984, EPA proposed changes in the standards for particulate matter based on its review and revision of the health and welfare criteria. On July 1, 1987, EPA announced its final decisions regarding these changes. They include: (1) replacing TSP as the indicator for particulate matter for the ambient standards with a new indicator that includes only those particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}); (2) replacing the 24-hour primary TSP standard with a 24-hour PM_{10} standard of 150 $\mu g/m^3$ with no more than one expected exceedance per year; (3) replacing the annual primary TSP standard with a PM_{10} standard of 50 $\mu g/m^3$, expected annual arithmetic mean; and (4) replacing the secondary TSP standard with 24-hour and annual PM_{10} standards that are identical in all respects to the primary standards. The federal standards became effective on July 31, 1987. On July 7, 1993, the state of Connecticut adopted these new standards for particulate matter.

CONCLUSIONS

Measured PM_{10} concentrations during 1996 did not exceed the 50 $\mu g/m^3$ level of the primary and secondary annual standards or the 150 $\mu g/m^3$ level of the primary and secondary 24-hour standards at any site. Moreover, the 24-hour standards were not violated because the "expected number of exceedances" for the most recent 3 years at each site did not exceed one per year, and the annual standards were also not violated anywhere because the "expected annual mean" for the most recent 3 years at each site did not exceed 50 $\mu g/m^3$.

SAMPLE COLLECTION AND ANALYSIS

High Volume Sampler (Hi-vol) - The high volume sampler resembles a vacuum cleaner in its operation, with an 8" X 10" piece of fiberglass filter paper replacing the vacuum bag. Hi-vols are equipped with retractable lids in order to eliminate the passive sampling error. The sampler normally operates every sixth day (midnight to midnight, standard time).

The matter collected on the filters is analyzed for weight in the case of the PM_{10} samplers and for both weight and chemical composition in the case of the hi-vol samplers. The chemical composition of the suspended particulate matter is determined at each hi-vol site as follows. Two standardized strips of every filter are cut out and prepared for two different analyses. In the first analysis, a sample is digested in acid and the resulting solution is analyzed for metals by means of an atomic absorption spectrophotometer. The results are reported for each individual metal in $\mu g/m^3$. In the second analysis, a sample is dissolved in water, filtered and the resulting solution is analyzed by means of wet chemistry techniques to determine the concentration of certain water soluble components. The results are reported for each individual constituent of the water soluble fraction in $\mu g/m^3$.

PM_{10} Sampler - Before 1988, Connecticut's particulate sampling network was comprised of standard high-volume (hi-vol) samplers, whose function was to measure TSP. With the promulgation of a PM_{10} standard, hi-vol samplers were needed that could screen out most particles larger than 10 microns. The samplers also had to be omnidirectional and have a constant inlet velocity so that wind direction and speed would not affect the amount of material collected.

In anticipation of a PM_{10} standard being promulgated, Connecticut installed a small number of PM_{10} samplers in 1985. The samplers, manufactured by Sierra-Andersen, were the first PM_{10} samplers on the market. These early samplers were found to have relatively high maintenance requirements and to be biased towards particles larger than 10 microns. To remedy these problems, the samplers were physically modified after 1986. In 1987, PM_{10} samplers by Wedding & Associates came on the market. These samplers replaced the Andersen samplers in the sampling network in 1988. The Wedding samplers have demonstrated lower maintenance requirements and greater precision (repeatability) and accuracy than the Andersen samplers they replaced.

The PM_{10} samplers, like the standard hi-vol samplers, operate from midnight to midnight (standard time) at least every sixth day at all sites. However, PM_{10} samplers use quartz fiber filters instead of fiberglass filters, in order to eliminate sulfate artifact formation. And the matter collected on the filter is analyzed only for weight and sulfates at the present time. The air flow is recorded during sampling. The weight in micrograms (µg) divided by the volume of air in standard cubic meters (m^3) yields the concentration of PM_{10} for the day in micrograms per cubic meter.

TEOM Sampler - Connecticut also operates real-time PM_{10} monitors that employ tapered element oscillating microbalance (TEOM) technology. The TEOM technique utilizes an exchangeable filter cartridge on the end of a hollow tapered tube. The other (wider) end of the tube is fixed. Air is passed through the filter, on which particulate matter deposits, and the filtered air passes through the tapered tube to a flow controller.

The tapered tube is maintained in oscillation. The frequency of oscillation is dependent upon the physical characteristics of the tapered tube and the mass on its free end. As particulate matter lands on the filter, the filter mass change is detected as a frequency change in the oscillation of the tube. The mass of the particulate matter is then determined directly and inertially. When this mass change is combined with the flow rate through the system, the device yields an accurate measurement of the particulate concentration in real time.

Such a continuous particulate monitoring system has advantages over manual systems like the hi-vol. Not only does TEOM technology provide more detailed information than a 24-hour average, but it also reduces the amount of labor required for these measurements, since the filter handling procedures are significantly reduced.

DISCUSSION OF DATA

Monitoring Network - In 1996, 22 PM_{10} sampling sites were operated in Connecticut (see Figure 2-1). For part of the year, the PM_{10} sampler at the Danbury 123 site employed TEOM technology. In addition, as part of the 1996 network for monitoring the airborne concentrations of lead, five hi-vol sampling sites were used to gather information on the chemical composition of TSP in the state. The locations were Bridgeport 010, East Hartford 004, Hartford 016, New Haven 018 and Waterbury 123.

Precision and Accuracy - Precision checks were conducted at three PM_{10} sampling sites which had co-located samplers. On the basis of 181 precision checks, the 95% probability limits for precision ranged from -14% to +15%. Accuracy is based on air flow through the monitor. The 95% probability limits for accuracy, based on 22 audits conducted on the PM_{10} monitoring system network, ranged from -1% to +8%. (See section I.D. of this Air Quality Summary for a discussion of precision and accuracy.)

Annual Averages - The Federal EPA has established minimum sampling criteria (see Table 1-1) for use in determining compliance with the primary and secondary annual NAAQS for PM_{10}. A site must have 75% of the scheduled samples in each calendar quarter for the the most recent 3 years. Using the EPA criteria, one finds that a determination of attainment or nonattainment of the 50 µg/m^3 primary and secondary annual standards could be obtained at 15 of the 22 PM_{10} monitoring sites in Connecticut in 1996. These 15 sites proved to be in attainment of the annual standards. A determination of attainment or nonattainment could not be obtained at Bridgeport 010, Danbury 123, Darien 001, Middletown 003, New Haven 018, New Haven 020, and Waterbury 123, where there were insufficient data at each site in at least one calendar quarter during the most recent three years. The primary reason for the loss of data at many of the these sites was the existence of defects in the filters used in the particulate samplers. Nevertheless, given the 95 percent confidence limits about the annual mean at these sites (see Table 2-1), it is likely that attainment was achieved.

A summary of annual average PM_{10} data for 1994 -1996 is presented in Table 2-1. This table also includes an indication of whether the aforementioned EPA minimum sampling criteria were met at each site for each year. If the sampling was insufficient to meet the EPA criteria, an asterisk appears next to the number of samples. Figure 2-2 illustrates the annual average PM_{10} concentrations at each site in 1996 in descending order of magnitude.

Statistical Projections - The statistical projections presented in Table 2-1 are prepared by a DEP computer program which analyzes data from all sites operated by DEP. Inputs to the program include the site location, the year, the number of samples (usually a maximum of 61), the annual arithmetic and geometric mean concentrations, and the arithmetic and geometric standard deviations. For each site, the program lists the inputs, calculates the 95% confidence limits about the annual arithmetic mean, and predicts the number of days in each year that the level of the primary and secondary 24-hour standards (i.e., 150 $\mu g/m^3$) would have been exceeded if sampling had been conducted every day. For comparison, Table 2-1 also shows the number of days at each site when the level of the primary and secondary 24-hour standards was actually exceeded, if any, as demonstrated by actual measurements at the site.

The statistical predictions of the number of days that would have seen an exceedance of the level of the 24-hour standards are based on the assumption of a lognormal distribution of the data. They indicate that more frequent PM_{10} sampling at New Haven 018 and Norwalk 014 in 1994 might have resulted in an exceedance of the 24-hour standards.

Because manpower and economic limitations dictate that PM_{10} sampling for particulate matter cannot be conducted every day, a degree of uncertainty is introduced as to whether the air quality at a site has either met or exceeded the level of the annual standards. This uncertainty can be expressed by means of a statistic called a confidence limit. Assuming a normal distribution of the pollutant data, 95% confidence limits were calculated about the annual arithmetic mean at each site. For example (see Table 2-1), at East Hartford 004 in 1994, 59 samples were analyzed and an arithmetic mean of 21.9 $\mu g/m^3$ was then calculated. The columns labeled "95-PCT-LIMITS" show the lower and upper limits of the 95% confidence interval to be 18.7 and 25.2 $\mu g/m^3$, respectively. This means that, if sampling were done every day, there is a 95% chance that the true arithmetic mean would fall between these limits. Since the upper 95% limit is less than 50 $\mu g/m^3$, one can be confident that the level of the annual standards was not exceeded at the site. However, if the upper 95% limit were greater and the lower 95% limit were less than 50 $\mu g/m^3$, then one could not be confident that the standard was not exceeded at the site. And if both the upper and lower 95% limits were greater than 50 $\mu g/m^3$, then one could assume that the level of the standards was indeed exceeded sometime during the year. These three possibilities are illustrated in Figure 2-3.

Table 2-2 summarizes the statistical predictions from Table 2-1 regarding compliance with the level of the annual air quality standards, using the 95% confidence limit criteria. The table shows that the level of the primary and secondary annual standards was probably achieved at the 19 sites that met the minimum sampling criteria in 1996. The results for previous years are also tabulated.

It should be noted that the above discussion of statistics does not affect the actual determination of attainment or nonattainment of the PM_{10} standards. The promulgated regulations specify the requirements for making an attainment determination. Those requirements, mentioned in a limited way in Table 1-1, address the projection of exceedances and the calculation and use of arithmetic means in ways that are different from the foregoing discussion.

24-Hour Averages - Figure 2-4 presents the maximum 24-hour concentrations recorded at each site. There were no PM_{10} concentrations at any site that exceeded the 150 $\mu g/m^3$ level of the primary and secondary 24-hour standards in 1996. Of the 17 sites that had sufficient data in both 1995 and 1996, 10 sites had higher maximum concentrations and 6 sites had lower maximum concentrations. The largest increase was 21 $\mu g/m^3$ at Willimantic 002; the largest decrease was 20 $\mu g/m^3$ at New Haven 018.

Table 2-3 summarizes the statistical predictions from Table 2-1 regarding the number of sites that would have seen PM_{10} concentrations exceeding the level of the 24-hour standards, if sampling had been conducted every day. In 1996, there were no such sites. The results for the preceding years are also given. In all cases, results are presented only for those sites that met the minimum sampling criteria for the year.

A determination of actual compliance with the primary and secondary 24-hour standards can be made for a site only when the minimum sampling criteria are met in each calendar quarter for the most recent 3 years. Based on these criteria, compliance was achieved at 15 of the 22 sites in 1996. A determination of compliance could not be made for the 7 sites mentioned earlier because there were insufficient data at each site in at least one calendar quarter during the most recent three years. But based upon the data that is available, it is highly improbable that an exceedance would have occurred at any of these sites.

Hi-vol Averages - Quarterly and annual averages of the chemical components from the hi-vol TSP/lead monitors have been computed for 1996 and are presented in Table 2-4. Note that the annual averages have been weighted according to the sample count.

Highest Daily Concentrations and Wind Data - On a statewide and historical basis, the highest PM_{10} concentrations occur most often on days when persistent winds out of the southwest quadrant predominate. During the fifteen year period between 1981 and 1995, 45% of the annual ten highest daily concentrations of particulate matter at each monitoring site in the state occurred when such wind conditions prevailed. This relationship between southwest winds and high particulate levels has historically been more prevalent in southwestern Connecticut.

Notwithstanding the above, many of the maximum levels at some urban sites do not occur with southwest winds, indicating that these sites are possibly influenced by local sources or transport from different out-of-state sources. Also, a large scale southwesterly air flow is often diverted into a southerly flow up the Connecticut River Valley and, for sites located there, many of the highest PM_{10} days occur when the winds are from the south.

Trends - Pollutant trends can be illustrated in a number of ways. We wish here to portray a PM_{10} trend that is both statewide in nature and relevant to one of the ambient air quality standards. Therefore, we have chosen to average the annual mean PM_{10} concentrations at a number of sites from 1989 -- the first full year of PM_{10} monitoring -- to the present (see Figure 2-5). In spite of the year-to-year changes, statewide PM_{10} levels appear to be trending downward for the eight year period.

Significant changes in annual PM_{10} levels can be caused by a number of things. Among these are simple changes of weather; changes in annual fuel use associated with conservation efforts or heating demand; the frequency of precipitation events, which wash out particulates from the atmosphere; changes in average wind speed, since higher winds result in greater dilution of emissions; and a change in the frequency of southwesterly winds, which affect the amount of particulate matter transported into Connecticut from the New York City metropolitan area and from other sources of emissions located to the southwest. In illustrating a trend, these year-to-year effects can be diminished, if not eliminated, by using a moving average of three years or more. Figure 2-6 illustrates the trend of PM_{10} using a 3-year moving average. The trend is clearly down.

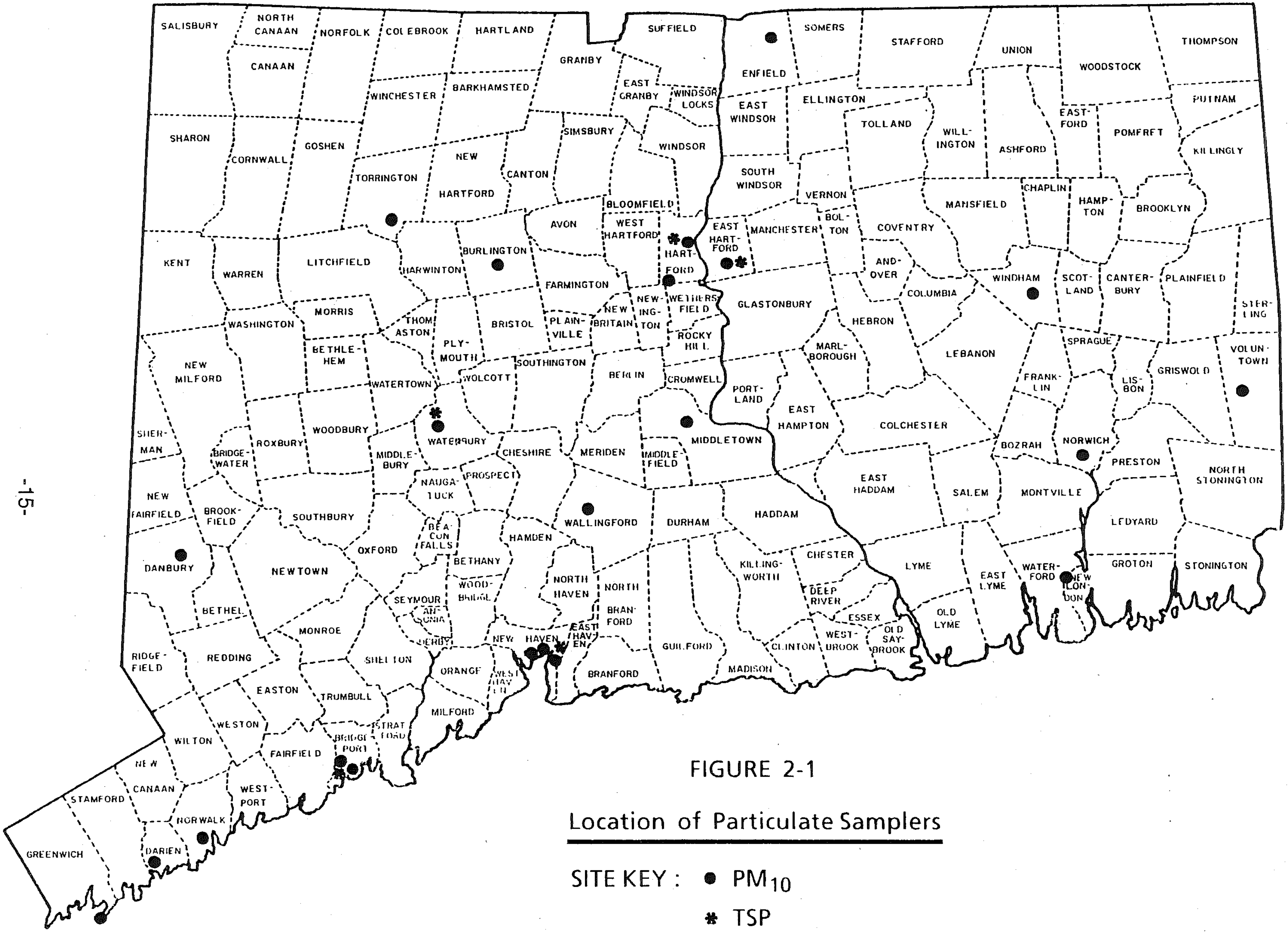


FIGURE 2-1

Location of Particulate Samplers

SITE KEY : ● PM_{10}

* TSP

- to be discontinued 1/98

TABLE 2-1

1994-1996 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	UPPER	STANDARD DEVIATION	PREDICTED DAYS OVER 150 UG/M3	MEASURED DAYS OVER 150 UG/M3
BRIDGEPORT	010	1994	50*	26.0	22.1	29.9	14.777		
BRIDGEPORT	010	1995	57	21.9	18.7	25.1	13.029		
BRIDGEPORT	010	1996	59	20.6	18.4	22.8	9.272		
BRIDGEPORT	014	1994	56	30.2	27.0	33.4	13.034		
BRIDGEPORT	014	1995	59	28.7	25.4	32.0	13.938		
BRIDGEPORT	014	1996	60	26.8	24.2	29.3	11.003		
BRISTOL	001	1994	58	18.3	15.7	20.9	10.770		
BRISTOL	001	1995	58	16.1	13.7	18.4	9.737		
BURLINGTON	001	1994	55	14.3	11.8	16.8	10.037		
BURLINGTON	001	1995	56	12.1	10.1	14.2	8.215		
BURLINGTON	001	1996	58	12.4	10.4	14.4	8.160		
— DANBURY	123	1994	52*	22.1	18.9	25.3	12.517		
DANBURY	123	1995	56*	22.0	19.2	24.8	11.403		
DANBURY	123	1996	51*	21.7	19.3	24.2	9.381		
DARIEN	001	1994	54	28.2	24.5	31.9	14.838		
DARIEN	001	1995	58	24.1	21.0	27.2	12.914		
DARIEN	001	1996	56*	23.2	20.6	25.7	10.365		
— EAST HARTFORD	004	1994	59	21.9	18.7	25.2	13.575		
EAST HARTFORD	004	1995	59	18.1	15.6	20.6	10.497		
EAST HARTFORD	004	1996	60	20.0	17.7	22.4	9.988		
— ENFIELD	005	1994	55	16.7	13.8	19.5	11.359		
ENFIELD	005	1995	60	13.9	11.8	16.0	8.893		
ENFIELD	005	1996	58	15.9	13.6	18.3	9.897		
— GREENWICH	017	1994	55	20.1	17.0	23.3	12.476		
GREENWICH	017	1995	57	17.9	15.6	20.1	9.183		
GREENWICH	017	1996	57	18.0	15.8	20.2	9.071		

* THE NUMBER OF SAMPLES IS NOT SUFFICIENT TO COMPLY WITH THE MINIMUM SAMPLING CRITERIA.

TABLE 2-1, CONTINUED

1994-1996 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

one -

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	95-PCT-LIMITS UPPER	STANDARD DEVIATION	PREDICTED DAYS OVER 150 UG/M3	MEASURED DAYS OVER 150 UG/M3
GROTON	006	1994	58	20.2	17.7	22.8	10.525		
GROTON	006	1995	57	16.8	14.2	19.3	10.317		
HARTFORD	013	1994	57	19.7	16.9	22.6	11.666		
HARTFORD	013	1995	59	16.5	14.2	18.8	9.762		
HARTFORD	013	1996	59	17.2	15.1	19.4	9.004		
HARTFORD	015	1994	52	25.6	22.1	29.1	13.492		
HARTFORD	015	1995	56	20.2	17.5	22.9	11.023		
HARTFORD	015	1996	60	21.3	18.8	23.7	10.526		
MERIDEN	002	1994	54	19.8	16.9	22.7	11.503		
MERIDEN	002	1995	59	18.4	15.9	20.8	10.351		
MIDDLETOWN	003	1994	53	21.6	18.5	24.8	12.315		
MIDDLETOWN	003	1995	55*	17.7	15.1	20.3	10.458		
MIDDLETOWN	003	1996	59	17.7	15.4	20.0	9.619		
MILFORD	010	1994	53	18.7	16.0	21.3	10.524		
MILFORD	010	1995	58	17.0	14.6	19.4	9.879		
NEW BRITAIN	012	1994	56	20.1	17.2	22.9	11.566		
NEW BRITAIN	012	1995	14*	17.6	12.2	23.1	9.626		
NEW HAVEN	013	1994	53	23.1	19.9	26.4	12.694		
NEW HAVEN	013	1995	57	20.4	17.6	23.2	11.506		
NEW HAVEN	018	1994	50*	41.2	36.0	46.3	19.444	1	
NEW HAVEN	018	1995	58	31.5	27.5	35.5	16.707		
NEW HAVEN	018	1996	58	28.2	25.3	31.1	11.963		
NEW HAVEN	020	1994	58	26.6	23.3	29.9	13.601		
NEW HAVEN	020	1995	61	22.8	20.1	25.6	11.683		
NEW HAVEN	020	1996	50*	21.0	18.1	23.8	10.647		

* THE NUMBER OF SAMPLES IN NOT SUFFICIENT TO COMPLY WITH THE MINIMUM SAMPLING CRITERIA.

TABLE 2-1, CONTINUED

1994-1996 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	95-PCT-LIMITS UPPER	STANDARD DEVIATION	PREDICTED DAYS OVER 150 UG/M3	MEASURED DAYS OVER 150 UG/M3
NEW HAVEN	123	1994	56	27.8	23.8	31.7	15.932		
NEW HAVEN	123	1995	60	21.9	19.0	24.8	12.450		
NEW HAVEN	123	1996	61	20.6	18.3	22.8	9.792		
NEW LONDON	004	1994	58	21.6	18.9	24.3	11.126		
NEW LONDON	004	1995	57	16.7	14.5	19.0	9.089		
NEW LONDON	004	1996	58	18.3	15.8	20.8	10.274		
NORWALK	014	1994	52	36.6	32.2	41.0	17.132	1	
NORWALK	014	1995	56	32.2	28.3	36.1	15.707		
NORWALK	014	1996	58	32.5	29.4	35.6	12.789		
NORWICH	002	1994	55	22.4	19.4	25.3	11.868		
NORWICH	002	1995	58	17.6	15.2	20.0	10.128		
NORWICH	002	1996	59	19.1	16.3	21.8	11.457		
STAMFORD	001	1994	51*	23.3	19.7	26.8	13.549		
STAMFORD	001	1995	59	20.8	18.4	23.3	10.412		
TORRINGTON	001	1994	57	19.2	16.3	22.1	11.835		
TORRINGTON	001	1995	60	17.2	15.0	19.4	9.248		
TORRINGTON	001	1996	59	18.1	15.7	20.5	9.955		
VOLUNTOWN	001	1994	55	15.3	12.9	17.8	9.855		
VOLUNTOWN	001	1995	56	12.6	10.4	14.9	9.153		
VOLUNTOWN	001	1996	54	14.4	11.8	17.1	10.561		
WALLINGFORD	006	1994	56	20.5	17.3	23.7	12.881		
WALLINGFORD	006	1995	59	16.9	14.6	19.3	9.860		
WALLINGFORD	006	1996	61	17.2	14.9	19.4	9.645		
WATERBURY	007	1994	53	22.7	19.3	26.1	13.306		
WATERBURY	007	1995	58	22.3	19.0	25.5	13.474		

* THE NUMBER OF SAMPLES IS NOT SUFFICIENT TO COMPLY WITH THE MINIMUM SAMPLING CRITERIA.

TABLE 2-1, CONTINUED

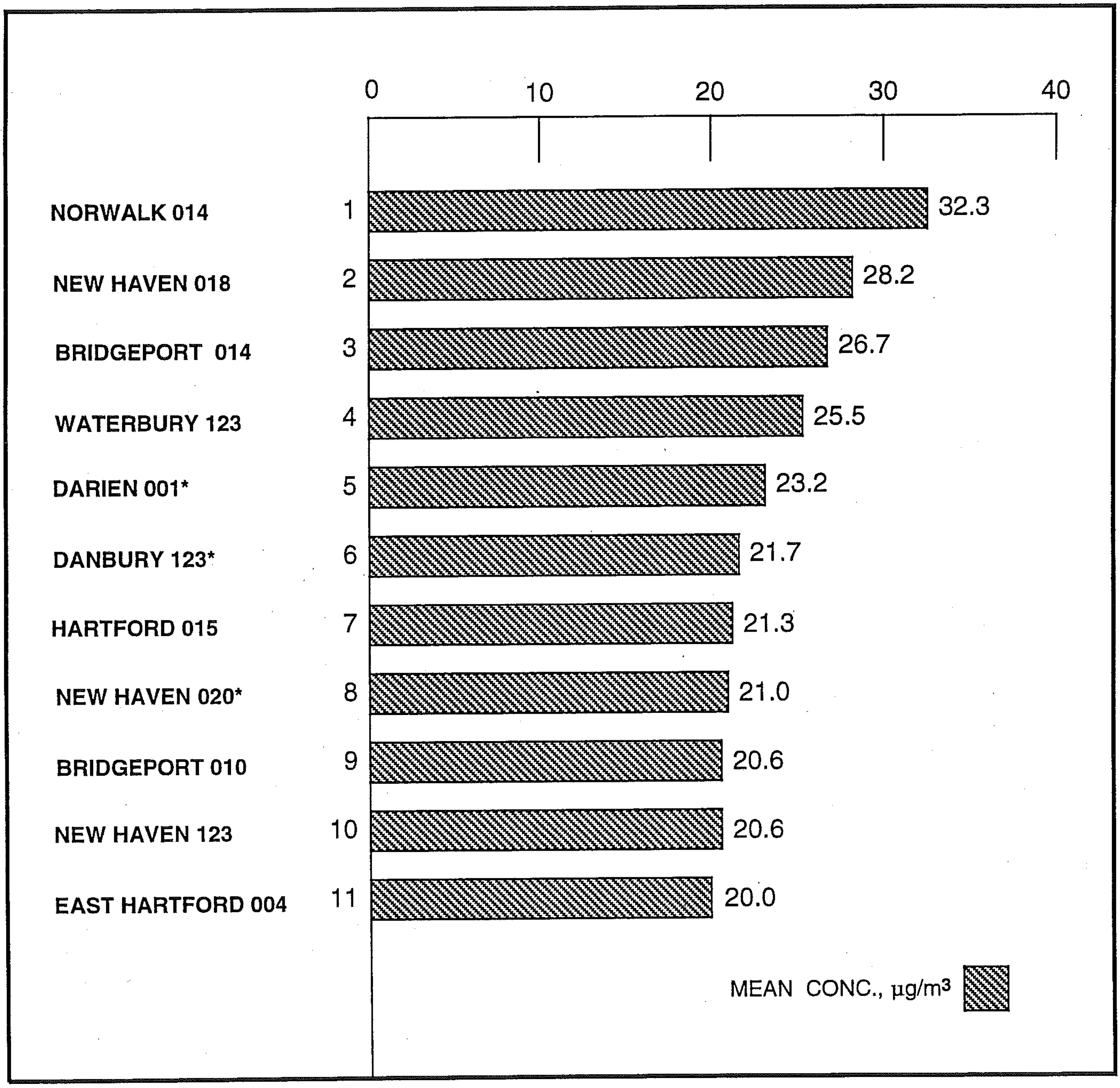
1994-1996 PM10 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMATIC MEAN	95-PCT-LIMITS LOWER	95-PCT-LIMITS UPPER	STANDARD DEVIATION	PREDICTED DAYS OVER 150 UG/M3	MEASURED DAYS OVER 150 UG/M3
WATERBURY	123	1994	54	25.0	22.0	27.9	11.701		
WATERBURY	123	1995	52*	23.8	20.4	27.1	12.990		
WATERBURY	123	1996	61	25.4	22.3	28.5	13.250		
WILLIMANTIC	002	1994	58	19.9	16.9	22.8	12.196		
WILLIMANTIC	002	1995	57	15.3	13.3	17.3	8.264		
WILLIMANTIC	002	1996	60	17.8	15.5	20.0	9.493		

* THE NUMBER OF SAMPLES IS NOT SUFFICIENT TO COMPLY WITH THE MINIMUM SAMPLING CRITERIA.

FIGURE 2-2

1996 ANNUAL AVERAGE PM10 CONCENTRATIONS



*** The site has insufficient data to satisfy the minimum sampling criteria for the year.**

FIGURE 2-2, continued

1996 ANNUAL AVERAGE PM10 CONCENTRATIONS

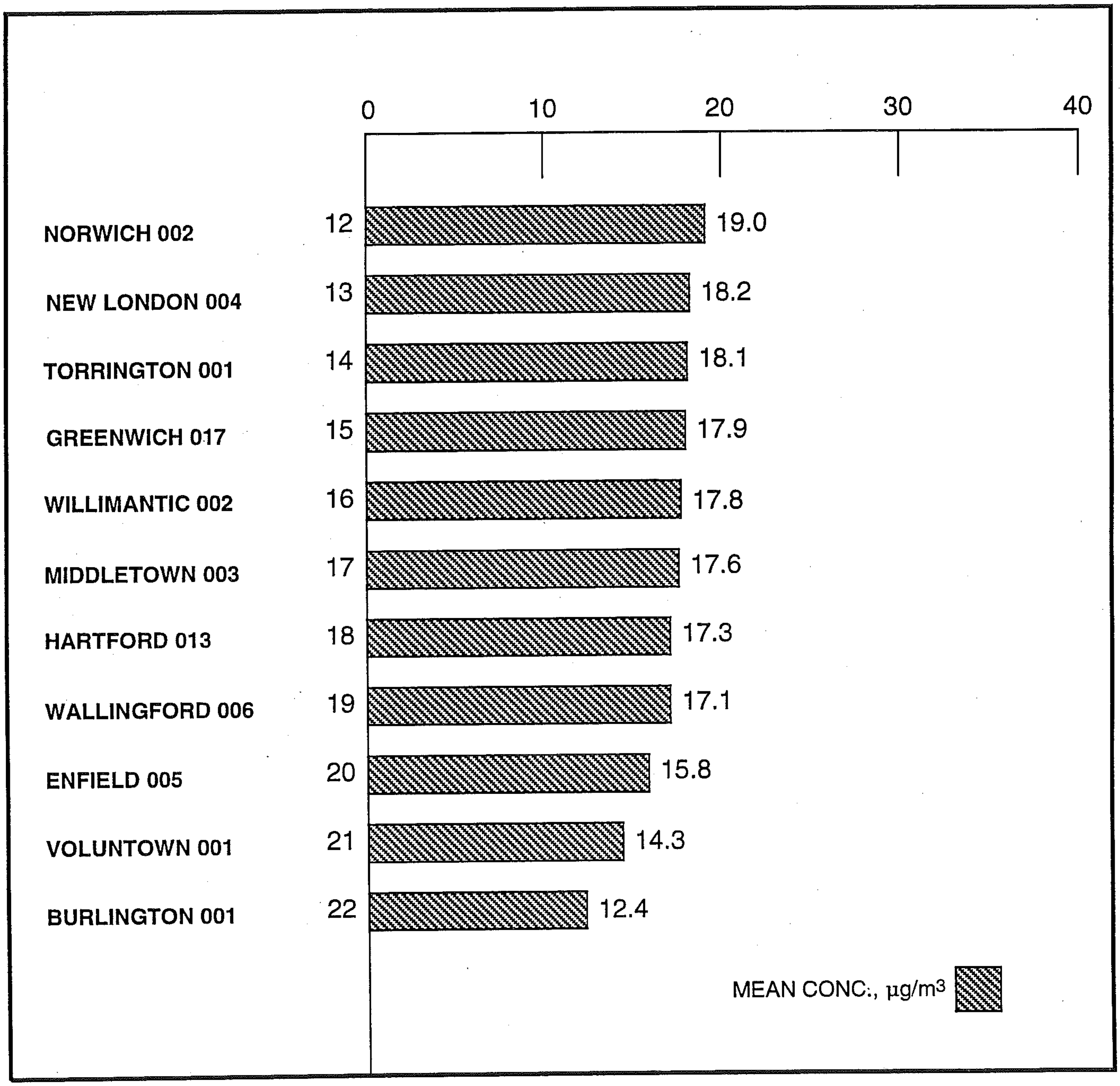
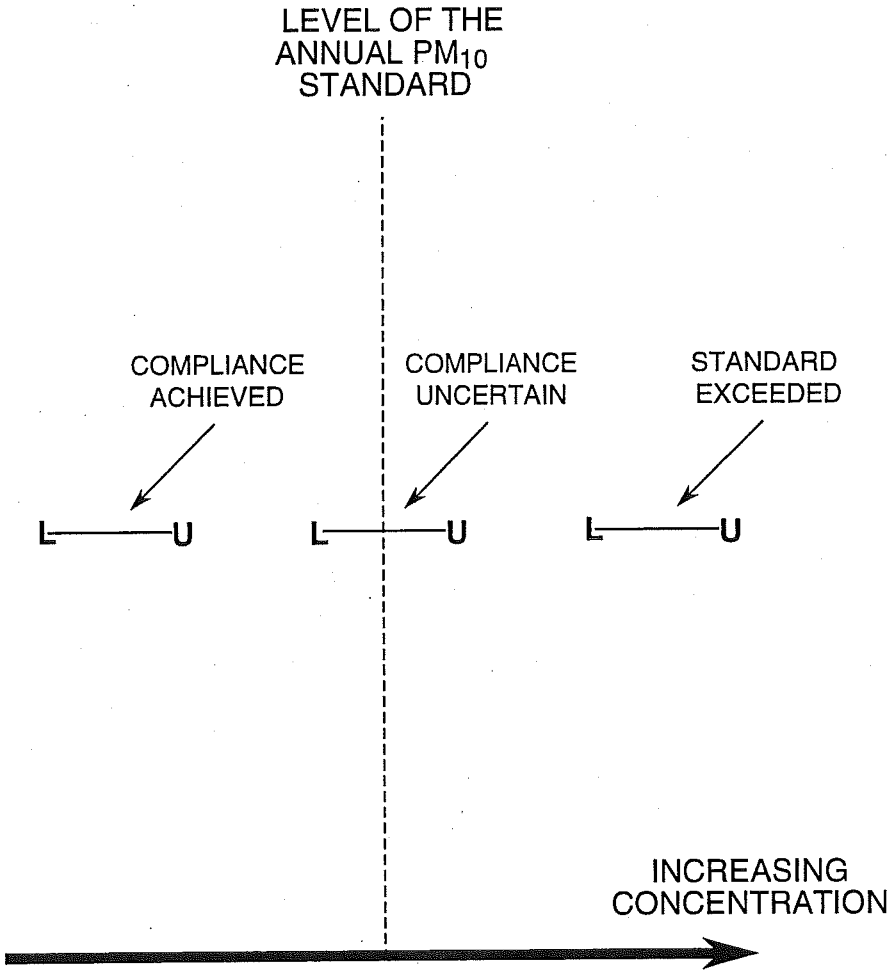


FIGURE 2-3

COMPLIANCE WITH THE LEVEL OF THE ANNUAL PM10 STANDARDS USING 95% CONFIDENCE LIMITS ABOUT THE ANNUAL ARITHMETIC MEAN CONCENTRATION



L=The lower limit of the 95% confidence interval about the annual arithmetic mean concentration.

U=The upper limit of the 95% confidence interval about the annual arithmetic mean concentration.

TABLE 2-2

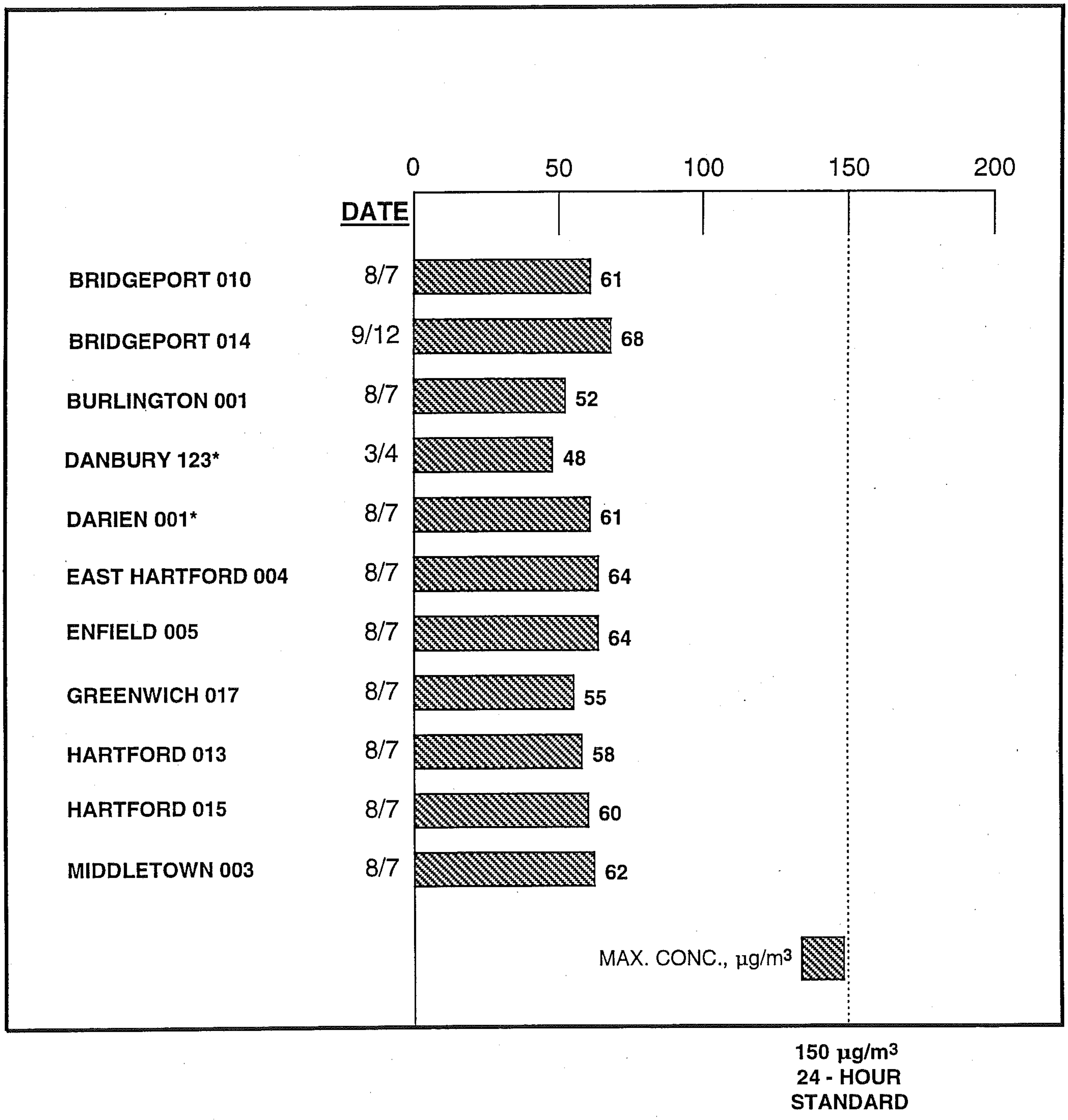
STATISTICALLY PREDICTED NUMBER OF SITES IN COMPLIANCE WITH THE LEVEL OF THE ANNUAL PM10 STANDARDS

	COMPLIANCE ACHIEVED	COMPLIANCE UNCERTAIN	STANDARD EXCEEDED
1985	2	0	0
1986	4	0	1
1987	4	0	1
1988	3	0	0
1989	40	0	0
1990	39	0	0
1991	30	0	0
1992	28	0	0
1993	23	0	0
1994	26	0	0
1995	26	0	0
1996	19	0	0

* Using 95% confidence limits about the arithmetic mean concentration at only those sites which had sufficient data to satisfy the minimum sampling criteria for the year.

FIGURE 2-4

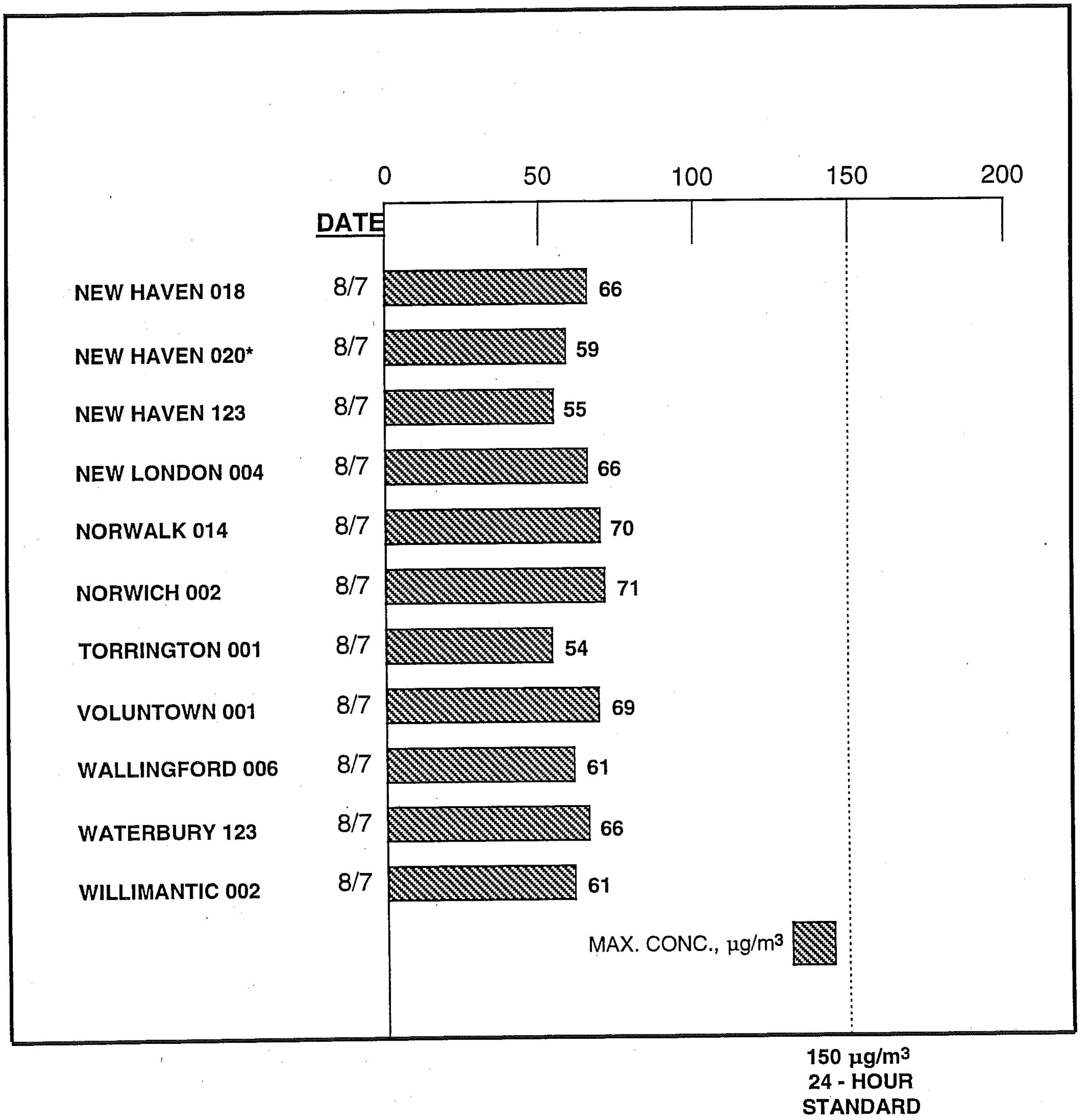
1996 MAXIMUM 24-HOUR PM10 CONCENTRATIONS



* The site has insufficient data to satisfy the minimum sampling criteria for the year.

FIGURE 2-4, continued

1996 MAXIMUM 24-HOUR PM10 CONCENTRATIONS



* The site has insufficient data to satisfy the minimum sampling criteria for the year.

TABLE 2-3

SUMMARY OF THE STATISTICALLY PREDICTED NUMBER OF PM10 SITES EXCEEDING THE LEVEL OF THE 24-HOUR STANDARDS

		SITES WITH 1 DAY EXCEEDING 150 µg/m^3	
YEAR	NO. OF SITES[1]	No. of Sites	Percentage of All Sites
1985	2	0	0%
1986	5	2	40%
1987	5	1	20%
1988	3	1	33%
1989	40	1	3%
1990	39	0	0%
1991	30	0	0%
1992	28	0	0%
1993	23	0	0%
1994	25	1	4%
1995	26	0	0%
1996	19	0	0%

---

[1] Only those sites which had sufficient data to satisfy the minimum sampling criteria for the year.

TABLE 2-4

QUARTERLY CHEMICAL CHARACTERIZATION OF 1996 HI-VOL TSP

TOWN	AREA	SITE
BRIDGEPORT	**0060**	**010**

	QUARTERLY AVG				ANNUAL AVG
	1ST	2ND	3RD	4TH	
METALS (ng/m³)					
BERYLLIUM	<.1	<.1	<.1	1.0	0.3[a]
CADMIUM	0.8	2.4	0.9	1.1	1.3
CHROMIUM	2	3	1	2	2
COPPER	80	60	70	40	60
IRON	630	560	510	370	510
LEAD	10	10	<10	10	10[a]
MANGANESE	13	13	6	6	9
NICKEL	3	4	2	5	4
VANADIUM	10	<10	<10	10	10[a]
ZINC	50	50	<10	30	30[a]
WATER SOLUBLES (ng/m³)					
NITRATE	2970	3510	3590	3100	3320
SULFATE	9320	11350	13690	12230	11790
AMMONIUM	<10	<10	90	40	40[a]
TSP (µg/m³)	49	64	53	44	53
SAMPLE COUNT	10[b]	14[b]	15[b]	14[b]	

[a] The annual average was calculated using one-half the detectable limit in quarters with the symbol "<".

[b] The sample counts were 12 for sulfate and TSP in the 1st quarter; 15 for sulfate and TSP in the 2nd quarter; 16 for sulfate and TSP in the 3rd quarter: 13 for sulfate and TSP in the 4th quarter.

TABLE 2-4, CONTINUED

QUARTERLY CHEMICAL CHARACTERIZATION OF 1996 HI-VOL TSP

TOWN	AREA	SITE
EAST HARTFORD	**0220**	**004**

	QUARTERLY AVG				ANNUAL AVG
	1ST	2ND	3RD	4TH	
METALS (ng/m³)					
BERYLLIUM	<.1	<.1	<.1	<.1	<.1
CADMIUM	0.7	0.7	0.9	1.1	0.9
CHROMIUM	2	2	<1	2	2[a]
COPPER	80	130	200	280	170
IRON	480	320	260	330	350
LEAD	10	10	<10	10	10[a]
MANGANESE	13	9	4	6	8
NICKEL	4	3	4	6	4
VANADIUM	<10	<10	10	<10	10[a]
ZINC	40	30	10	40	30
WATER SOLUBLES (ng/m³)					
NITRATE	2120	2620	2770	2540	2500
SULFATE	8480	9810	11450	11260	10370
AMMONIUM	<10	<10	100	50	40[a]
TSP (µg/m³)	44	37	31	25	34
SAMPLE COUNT	15[b]	13	13[b]	15[b]	

[a] The annual average was calculated using one-half the detectable limit in quarters with the symbol "<".

[b] The sample count was 12 for sulfate and TSP in the 1st quarter; 16 for sulfate and TSP in the 3rd quarter; 14 for sulfate and TSP in the 4th quarter.

TABLE 2-4, CONTINUED

QUARTERLY CHEMICAL CHARACTERIZATION OF 1996 HI-VOL TSP

TOWN	AREA	SITE
HARTFORD	**0420**	**016**

	QUARTERLY AVG				ANNUAL AVG
	1ST	2ND	3RD	4TH	
METALS (ng/m³)					
BERYLLIUM	<.1	<.1	<.1	<.1	<.1
CADMIUM	0.9	1.0	1.0	1.9	1.2
CHROMIUM	4	4	2	6	4
COPPER	50	60	100	70	70
IRON	1030	820	770	980	900
LEAD	10	20	20	10	20
MANGANESE	21	18	11	14	16
NICKEL	5	4	4	9	5
VANADIUM	10	<10	10	10	10[a]
ZINC	60	50	30	80	50
WATER SOLUBLES (ng/m³)					
NITRATE	2460	3100	3770	3170	3120
SULFATE	8440	9330	13430	11770	10710
AMMONIUM	<10	<10	230	100	80[a]
TSP (µg/m³)	67	63	45	42	55
SAMPLE COUNT	15	15	15	13	

[a] The annual average was calculated using one-half the detectable limit in quarters with the symbol "<".

TABLE 2-4, CONTINUED

QUARTERLY CHEMICAL CHARACTERIZATION OF 1996 HI-VOL TSP

TOWN	AREA	SITE
NEW HAVEN	**0700**	**018**

	QUARTERLY AVG				ANNUAL AVG
	1ST	2ND	3RD	4TH	
METALS (ng/m^3)					
BERYLLIUM	<.1	<.1	<.1	<.1	<.1
CADMIUM	1.6	2.4	1.2	1.3	1.6
CHROMIUM	9	6	3	5	6
COPPER	80	90	120	110	100
IRON	2880	2250	1530	1650	2100
LEAD	20	30	20	30	30
MANGANESE	58	39	24	23	36
NICKEL	19	8	6	14	12
VANADIUM	30	10	10	20	20
ZINC	170	130	70	110	120
WATER SOLUBLES (ng/m^3)					
NITRATE	2970	3390	3110	3230	3170
SULFATE	9210	10850	12210	10660	10730
AMMONIUM	<10	<10	120	130	60[a]
TSP (µg/m^3)	118	96	86	86	96
SAMPLE COUNT	15[b]	15[b]	13[b]	15	

[a] The annual average was calculated using one-half the detectable limit in the 1st and 2nd quarters.

[b] The sample count was 14 for TSP in the 1st quarter;14 for sulfate and TSP in the 2nd quarter;15 for sulfate and TSP in the 3rd quarter.

TABLE 2-4, CONTINUED

QUARTERLY CHEMICAL CHARACTERIZATION OF 1996 HI-VOL TSP

TOWN	AREA	SITE
WATERBURY	**1240**	**123**

	QUARTERLY AVG				ANNUAL AVG
	1ST	2ND	3RD	4TH	
METALS (ng/m³)					
BERYLLIUM	<.1	<.1	<.1	<.1	<.1
CADMIUM	1.2	1.5	1.5	1.4	1.4
CHROMIUM	3	4	2	3	3
COPPER	60	70	110	100	80
IRON	1200	1240	1220	1760	1350
LEAD	10	20	10	30	20
MANGANESE	25	27	24	29	26
NICKEL	7	5	5	12	7
VANADIUM	10	<10	10	20	10[a]
ZINC	80	80	60	80	80
WATER SOLUBLES (ng/m³)					
NITRATE	2380	2620	2990	2840	2690
SULFATE	9220	9330	10760	11560	10250
AMMONIUM	<10	<10	70	<10	20[a]
TSP (µg/m³)	71	81	62	--	--
SAMPLE COUNT	15[b]	15[b]	13[b]	13[b]	

[a] The annual average was calculated using one-half the detectable limit in quarters with the symbol "<".

[b] The sample count was 14 for sulfate and TSP in the 1st quarter; 13 for sulfate and TSP in the 2nd quarter; 16 for sulfate and 14 for TSP in the 3rd quarter; 14 for sulfate in the 4th quarter.

FIGURE 2-5

AVERAGES OF THE ANNUAL PM_{10} CONCENTRATIONS*

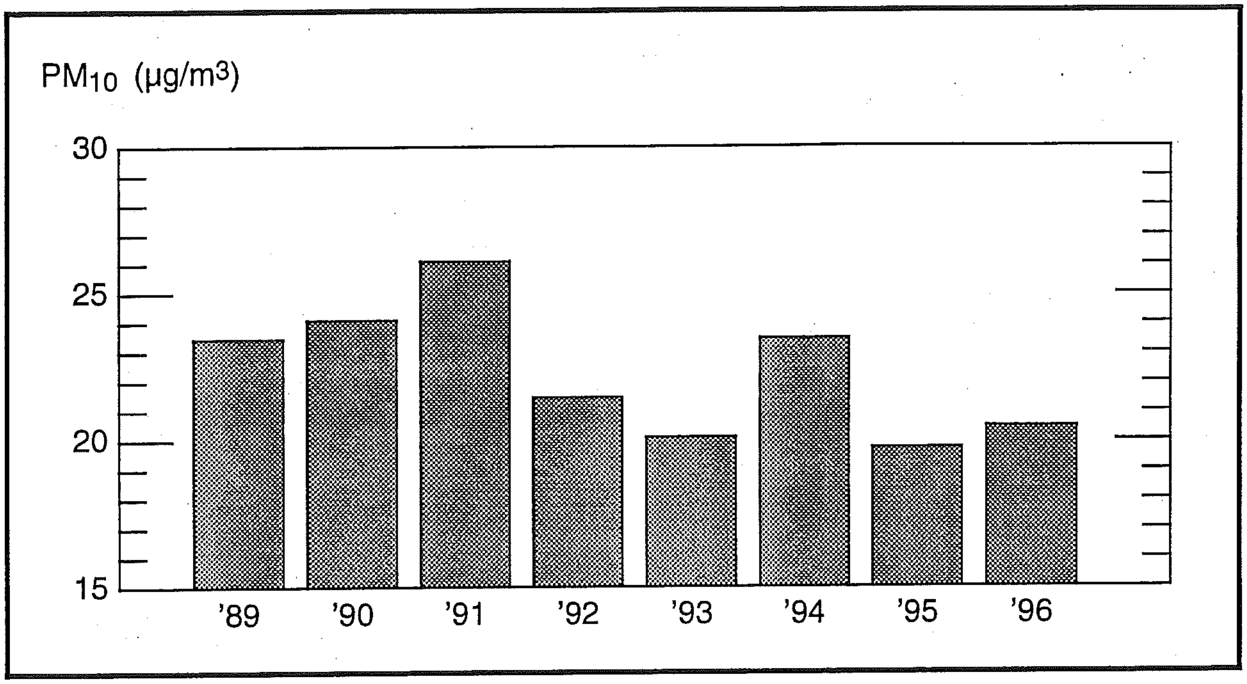
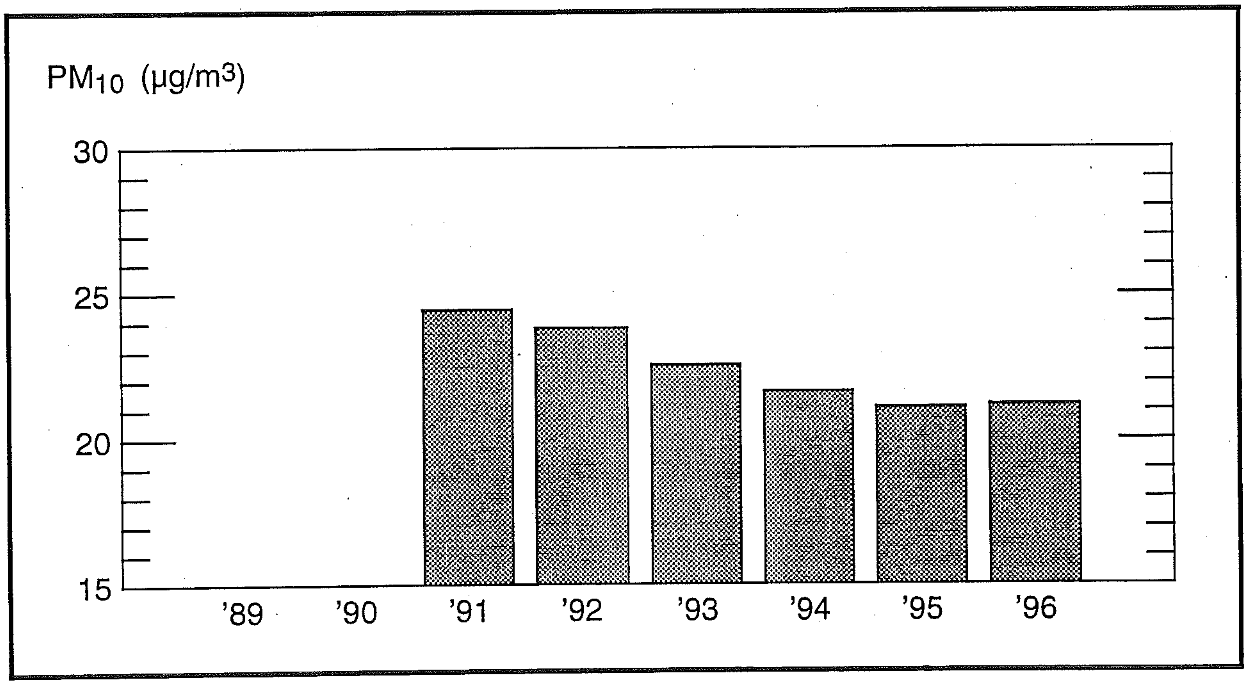


FIGURE 2-6

3-YEAR AVERAGES OF THE ANNUAL PM_{10} CONCENTRATIONS*



* At the 9 sites that met the minimum sampling criteria in each year of the eight-year period.

III. SULFUR DIOXIDE

HEALTH EFFECTS

Sulfur oxides are heavy, pungent, yellowish gases that come from the burning of sulfur-containing fuel, mainly coal and oil-derived fuels, and also from the smelting of metals and from certain industrial processes. They have a distinctive odor. Sulfur dioxide (SO_2) comprises about 95 percent of these gases, so scientists use a test for SO_2 alone as a measure of all sulfur oxides.

Exposure to high levels of sulfur oxides can cause an obstruction of breathing that doctors call "pulmonary flow resistance." The amount of breathing obstruction has a direct relation to the amount of sulfur compounds in the air. Moreover, the effect of sulfur pollution is enhanced by the presence of other pollutants, especially particulates and oxidants. The action of two or more pollutants is synergistic: each pollutant augments the other and the combined effect is greater than the sum of the effects that each alone would have.

Many types of respiratory disease are associated with sulfur oxides: coughs and colds, asthma, bronchitis, and emphysema. Some researchers believe that the harm is due not only to the sulfur oxide gases but also to other sulfur compounds that accompany the oxides.

CONCLUSIONS

Sulfur dioxide concentrations in 1996 did not exceed any federal primary or secondary standards. Measured concentrations were substantially below the 365 $\mu g/m^3$ primary 24-hour standard and well below both the 80 $\mu g/m^3$ primary annual standard and the 1300 $\mu g/m^3$ secondary 3-hour standard.

METHOD OF MEASUREMENT

The DEP Air Monitoring Unit used the pulsed fluorescence method to continuously measure sulfur dioxide levels at all 12 sites in 1996.

DISCUSSION OF DATA

Monitoring Network - Twelve continuous SO_2 monitors were used to record data in 12 towns during 1996 (see Figure 3-1):

Bridgeport 012
Danbury 123
East Hartford 006
East Haven 003
Enfield 005
Greenwich 017
Groton 007
Hartford 018
Mansfield 003
New Haven 123
Stamford 124
Waterbury 123

All of these sites telemetered their data to the central computer in Hartford three times each day (i.e., at 0700, 1400, and 2400 hours local time).

Precision and Accuracy - 657 precision checks were made on SO_2 monitors in 1996, yielding 95% probability limits ranging from -4% to +6%. Accuracy is determined by introducing a known amount of SO_2 into each of the monitors. Three different concentration levels are tested: low, medium, and high. The 95% probability limits for accuracy based on 14 audits were: low, -10% to +1%; medium, -10% to +2%; and high, -10% to +1%.

Annual Averages - SO_2 levels were below the primary annual standard of 80 $\mu g/m^3$ at all sites in 1996 (see Table 3-1). The annual average SO_2 levels decreased at five of the twelve monitoring sites and increased at six. The largest decrease was 15 $\mu g/m^3$ at Stamford 124; the largest increase was 3 $\mu g/m^3$ at Enfield 003.

Statistical Projections - A statistical analysis of the sulfur dioxide data is presented in Table 3-2. This analysis is produced by a DEP computer program and provides information to compensate for any loss of data caused by instrumentation problems. The format of Table 3-2 is the same as that used to present the statistical projections for particulate matter (see Table 2-1). Since the statistical projections are made for the 24-hour standard, the hourly SO_2 data are first converted to 24-hour block averages. These 24-hour "samples" form the basis for the annual arithmetic and geometric means and the arithmetic and geometric standard deviations employed by the DEP computer program to make the statistical projections and calculate the 95% confidence limits.

The monitored data indicate that there were no violations of the primary 24-hour SO_2 standard at any site in Connecticut in the last three years. The statistical projections confirm that no days exceeding the primary 24-hour standard of 365 $\mu g/m^3$ would have occurred during this period at any site, if sampling were complete.

The annual averages in Table 3-2 differ slightly from those in Table 3-1 due to the manner in which they were derived. The averages in Table 3-1 are based on the available hourly readings, while those in Table 3-2 are based on valid calendar day 24-hour averages. (At least 18 hourly readings are required to produce a valid 24-hour average.)

24-Hour Averages - Figure 3-2 presents the first and second high calendar day average concentrations recorded at each monitoring site in 1996. No site recorded SO_2 levels in excess of the 24-hour primary standard of 365 $\mu g/m^3$. Second high calendar day SO_2 average concentrations decreased at nine monitoring sites and increased at three monitoring sites from 1995 to 1996. The largest decrease was 18 $\mu g/m^3$ at New Haven 123, and the largest increase was 8 $\mu g/m^3$ at Waterbury 123.

Current EPA policy bases compliance with the primary 24-hour SO_2 standard on calendar day averages. Assessment of compliance is based on the second highest calendar day average in the year. Running averages are averages computed for the 24-hour periods ending at every hour. If running averages were used, assessment of compliance would be based on the value of the second highest of the two highest non-overlapping 24-hour periods in the year. There has been some contention over which average is the more appropriate one on which to base compliance. Table 3-3 contains the two highest 24-hour SO_2 readings at each site in terms of both the running averages and the calendar day averages. The first high 24-hour running averages are all higher than the first high calendar day averages by as much as 36 $\mu g/m^3$. The second high 24-hour running averages are all higher by as much as 32 $\mu g/m^3$.

3-Hour Averages - Figure 3-3 presents the first and second high 3-hour concentrations recorded at each monitoring site. Measured SO_2 concentrations were far below the federal secondary 3-hour standard of 1300 $\mu g/m^3$ at all DEP monitoring sites in 1996. Nine sites had lower second high concentrations and three sites had higher second high concentrations in 1996. The largest decrease was 64 $\mu g/m^3$ at Groton 007, and the largest increase was 30 $\mu g/m^3$ at Bridgeport 012.

Highest Daily Concentrations and Wind Data - As is the case with particulate matter, the highest SO_2 concentrations occur on days when persistent winds out of the southwest quadrant predominate.

During the fifteen year period between 1981 and 1995, 46% of the annual ten highest daily concentrations of SO_2 at each monitoring site in the state occurred when such wind conditions prevailed. This relationship is caused, at least in part, by SO_2 transport, but any transport is limited by the chemical instability of SO_2. In the atmosphere, SO_2 reacts with other gases to produce, among other things, sulfate particulates. Therefore, SO_2 is not likely to be transported very long distances. Previous studies conducted by the DEP have shown that, during periods of southwest winds, levels of SO_2 in Connecticut decrease with distance from the New York City metropolitan area. This relationship tends to support the transport hypothesis. On the other hand, these studies also revealed that certain meteorological parameters, most notably mixing height and wind speed, are more conducive to high SO_2 levels on days when there are southwesterly winds than on other days.

An examination of the available data for the period 1981-1995 also suggest another reason for maximum SO_2 days. Approximately 77% of such days occurred during the winter, and 21% occurred in late autumn. This phenomenon can be attributed to the fact that more fuel oil is burned during cold weather resulting in greater SO_2 emissions. In addition, temperature inversions, in which mixing heights are reduced, are more prevalent in autumn and winter.

In summary, high levels of SO_2 in Connecticut seem to be caused by a number of related factors. First, Connecticut experiences its highest SO_2 levels during the late fall and winter months, when there is an increased amount of fuel combustion. Second, the New York City metropolitan area, a large emission source, is located to the southwest of Connecticut, and southwest winds occur relatively often in this region in comparison to other wind directions. Also, adverse meteorological conditions are often associated with southwest winds. The net effect is that during the colder months when a persistent southwesterly wind occurs, an air mass picks up increased amounts of SO_2 over the New York City metropolitan area and transports this SO_2 into Connecticut, adding to Connecticut's own contribution to ambient levels. In addition, relatively low mixing heights are associated with warm air advection (i.e., southwest wind flow), which inhibits vertical mixing and contributes to the enhanced SO_2 concentrations. The levels of transported SO_2 eventually decline with increasing distance from New York City, as the SO_2 is dispersed and as it slowly reacts to produce sulfate particulates. These sulfate particulates may fall to the ground in either a dry state (dry deposition) or in a wet state after combination with water droplets (wet deposition or "acid rain").

Trends - The SO_2 trend over the ten year period from 1987 to 1996 is presented in Figure 3-4. The trend is clearly down in the last several years.

As was the case with the particulate matter trend, we wanted to portray an SO_2 trend that is both statewide in nature and relevant to one of the ambient air quality standards for SO_2. We chose to average the annual SO_2 concentrations at a number of sites: Bridgeport 012, East Haven 003, Enfield 005, Groton 007, New Haven 123 and Waterbury 123. These sites were the only sites that had sufficient data and valid annual averages over a twelve year period.

Annual SO_2 levels can be dramatically affected by a number of factors, some of which are annual fuel use, frequency of precipitation events, and changes in wind speed and direction. The importance of these relatively short term factors can be diminished in the portrayal of a pollution trend by means of multiple year averaging. Figure 3-5 employs a three year average of the data in Figure 3-4 and shows a smoother year-to-year transition as a result. The SO_2 trend is significantly down over the last eight years.

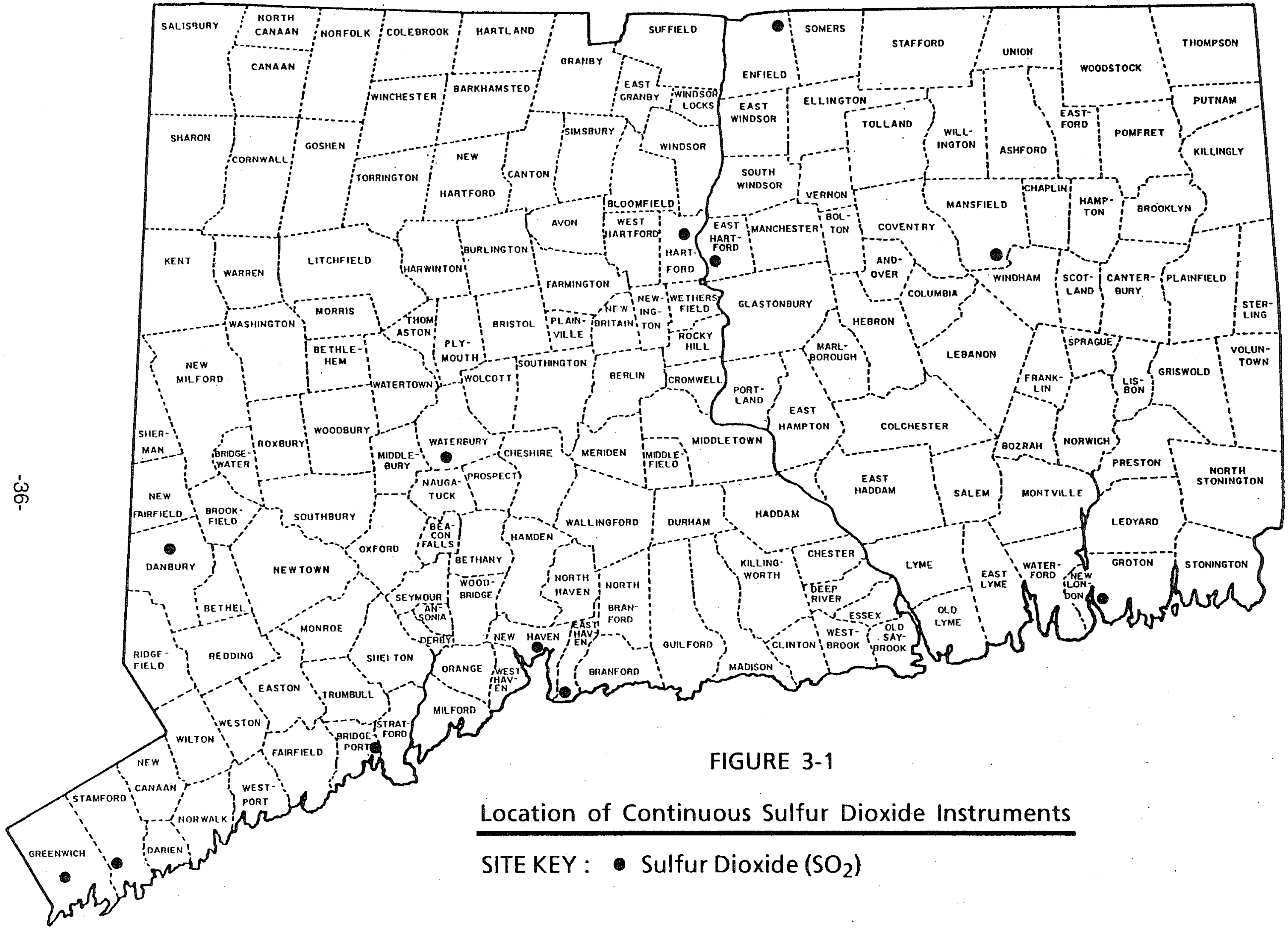


FIGURE 3-1

Location of Continuous Sulfur Dioxide Instruments

SITE KEY : ● Sulfur Dioxide (SO_2)

- to be discontinued after 1/98

TABLE 3-1

1996 ANNUAL ARITHMETIC AVERAGES OF SULFUR DIOXIDE

(PRIMARY STANDARD: 80 $\mu g/m^3$)

TOWN-SITE	SITE NAME	ANNUAL AVG ($\mu g/m^3$)
Bridgeport 012	Edison School	15
Danbury 123	Western CT State University	12
East Hartford 006	High Street	15
– East Haven 003	Animal Shelter	11
– Enfield 005	Department of Corrections	13
– Greenwich 017	Greenwich Point Park	12
– Groton 007	Fire Headquarters	12
– Hartford 018	Sheldon Street	12
– Mansfield 003	Dept. of Transportation	7
New Haven 123	State Street	19
Stamford 124	Health Department	14
Waterbury 123	Bank Street	13

TABLE 3-2

1994-1996 SO2 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

TOWN NAME	SITE	YEAR	SAMPLES	ARITHMETIC MEAN	95-PCT-LIMITS LOWER	95-PCT-LIMITS UPPER	STANDARD DEVIATION	PREDICTED DAYS OVER 365 UG/M3
BRIDGEPORT	012	1994	362	25.2	24.9	25.4	24.681	
BRIDGEPORT	012	1995	357	17.4	17.2	17.6	14.293	
BRIDGEPORT	012	1996	353	14.8	14.5	15.1	13.675	
BRIDGEPORT	013	1994	339	22.2	21.5	22.9	23.189	
BRIDGEPORT	013	1995	356	16.2	16.0	16.4	13.361	
DANBURY	123	1994	343	16.7	16.3	17.2	17.789	
DANBURY	123	1995	344	11.4	11.1	11.6	9.792	
DANBURY	123	1996	334	11.2	10.9	11.5	10.405	
EAST HARTFORD	006	1994	355	17.2	16.9	17.4	14.033	
EAST HARTFORD	006	1995	353	13.4	13.2	13.6	10.959	
EAST HARTFORD	006	1996	354	15.1	14.9	15.3	11.018	
EAST HAVEN	003	1994	360	15.6	15.4	15.8	16.644	
EAST HAVEN	003	1995	365	10.3	10.3	10.3	10.368	
EAST HAVEN	003	1996	350	10.7	10.5	10.9	10.777	
ENFIELD	005	1994	342	11.4	11.0	11.7	11.397	
ENFIELD	005	1995	359	10.3	10.2	10.4	7.265	
ENFIELD	005	1996	354	12.6	12.4	12.7	8.787	
GREENWICH	017	1994	364	14.9	14.9	15.0	12.123	
GREENWICH	017	1995	357	11.0	10.9	11.1	8.931	
GREENWICH	017	1996	355	12.3	12.1	12.4	8.684	
GROTON	007	1994	365	14.2	14.2	14.2	11.549	
GROTON	007	1995	362	12.4	12.3	12.5	8.583	
GROTON	007	1996	363	11.8	11.7	11.9	7.583	
HARTFORD	018	1994	347	18.4	18.1	18.7	14.280	
HARTFORD	018	1995	358	13.5	13.4	13.7	9.909	
HARTFORD	018	1996	363	11.7	11.6	11.8	10.004	

N.B. THE ARITHMETIC MEAN AND STANDARD DEVIATION HAVE UNITS OF MICROGRAMS PER CUBIC METER.

TABLE 3-2, CONTINUED

1994-1996 SO2 ANNUAL AVERAGES AND STATISTICAL PROJECTIONS

PREDICTED								
				ARITHMETIC	95-PCT-LIMITS		STANDARD	DAYS OVER
TOWN NAME	SITE	YEAR	SAMPLES	MEAN	LOWER	UPPER	DEVIATION	365 UG/M3
MANSFIELD	003	1994	363	11.8	11.7	11.8	7.575	
MANSFIELD	003	1995	356	7.7	7.7	7.8	5.484	
MANSFIELD	003	1996	361	7.0	6.9	7.0	5.608	
NEW HAVEN	123	1994	357	26.6	26.2	26.9	22.910	
NEW HAVEN	123	1995	354	21.2	20.9	21.5	16.612	
NEW HAVEN	123	1996	357	19.5	19.3	19.8	14.763	
STAMFORD	124	1994	357	24.9	24.5	25.4	27.204	
STAMFORD	124	1995	345	28.7	28.2	29.2	19.182	
STAMFORD	124	1996	362	14.0	13.8	14.1	12.898	
WATERBURY	123	1994	359	17.0	16.8	17.2	15.349	
WATERBURY	123	1995	358	12.3	12.1	12.4	9.324	
WATERBURY	123	1996	364	13.2	13.2	13.3	10.516	

N.B. THE ARITHMETIC MEAN AND STANDARD DEVIATION HAVE UNITS OF MICROGRAMS PER CUBIC METER.

FIGURE 3-2

1996 MAXIMUM CALENDAR DAY AVERAGE SO2 CONCENTRATIONS

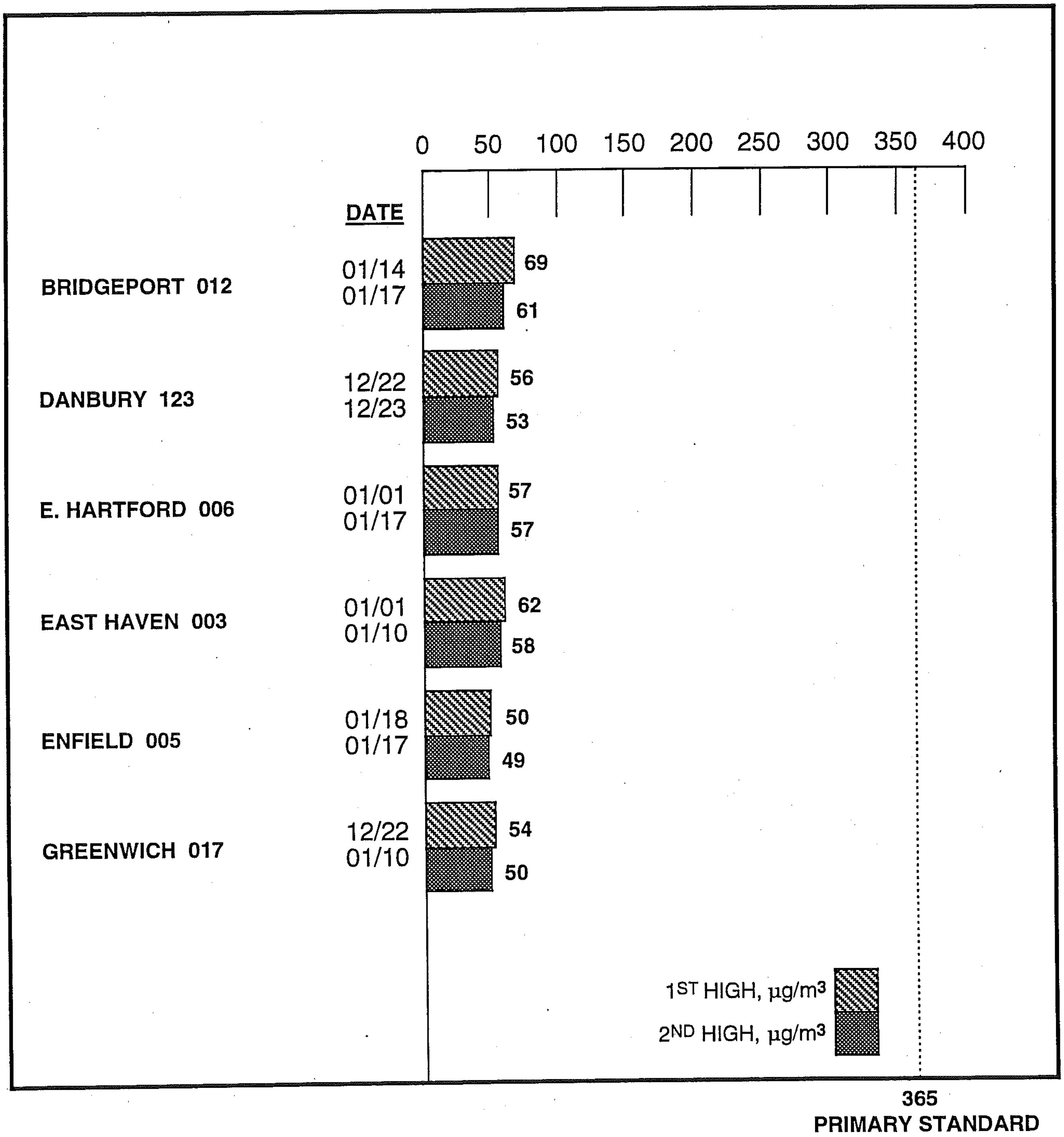


FIGURE 3-2, CONTINUED

1996 MAXIMUM CALENDAR DAY AVERAGE SO2 CONCENTRATIONS

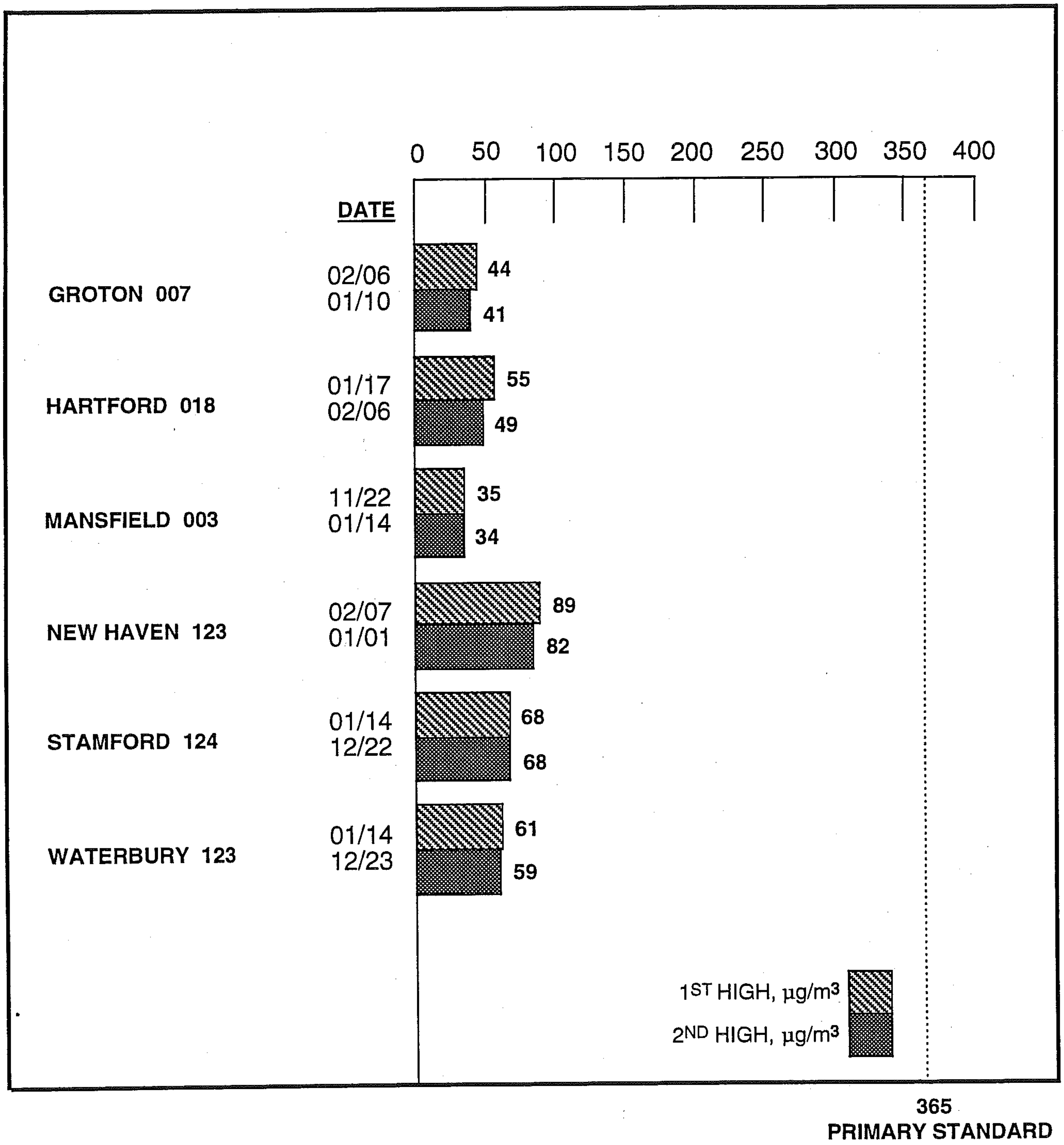


TABLE 3-3

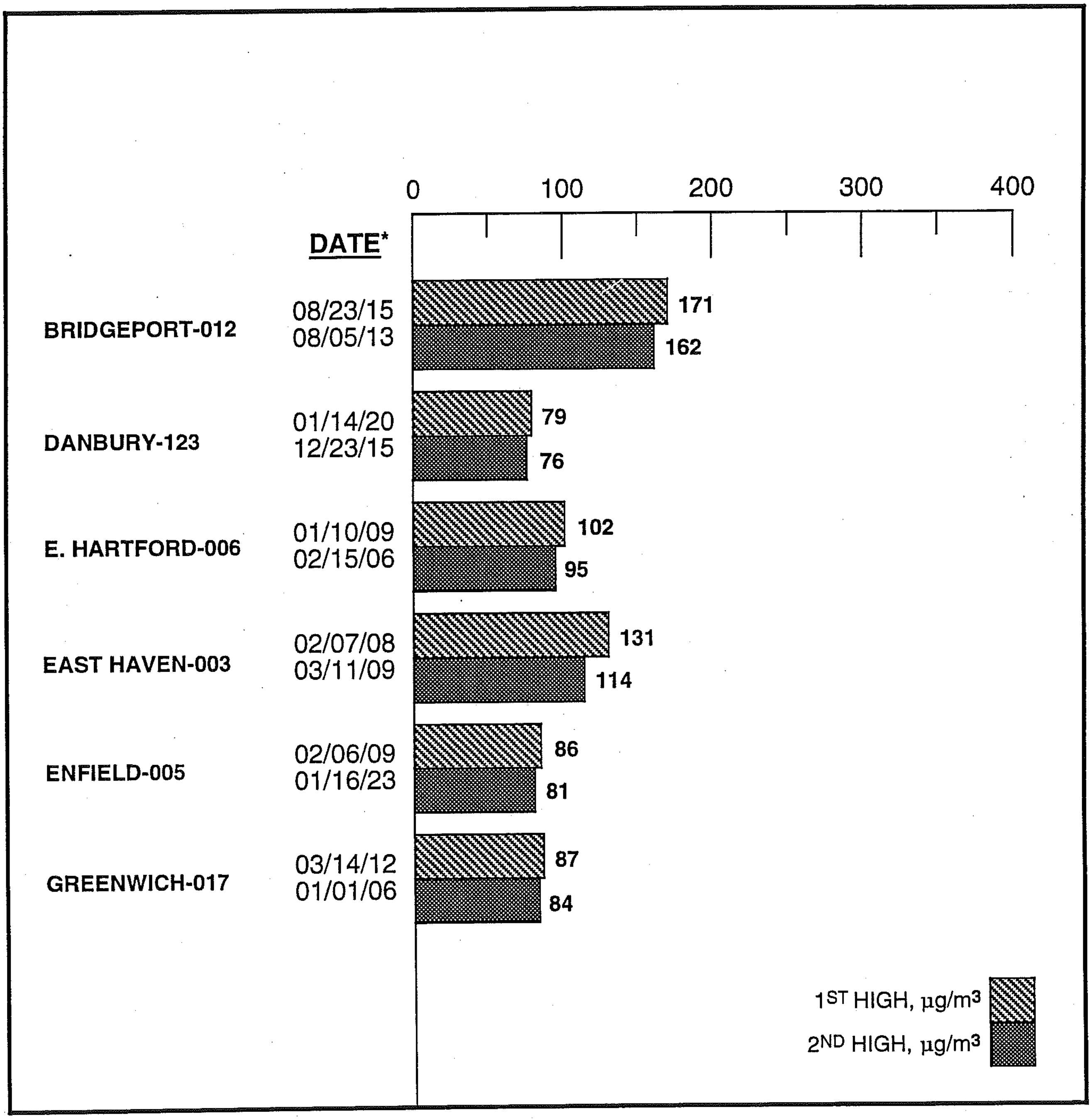
COMPARISONS OF FIRST AND SECOND HIGH CALENDAR DAY AND RUNNING 24-HOUR SO2 AVERAGES IN 1996

	FIRST HIGH AVERAGE		SECOND HIGH AVERAGE	
SITE	RUNNING 24-HOUR	CALENDAR DAY	RUNNING 24-HOUR	CALENDAR DAY
Bridgeport-012	114	69	78	61
Danbury-123	66	56	57	53
E. Hartford-006	90	57	58	57
East Haven-003	100	62	66	58
Enfield-005	58	50	56	49
Greenwich-017	71	54	63	50
Groton-007	64	44	54	41
Hartford-018	83	55	67	49
Mansfield-003	44	35	37	34
New Haven-123	136	89	113	82
Stamford-124	93	68	80	68
Waterbury-123	80	61	68	59

N.B. The averages have units of µg/m^3.

FIGURE 3-3

1996 MAXIMUM 3-HOUR RUNNING AVERAGE SO2 CONCENTRATIONS

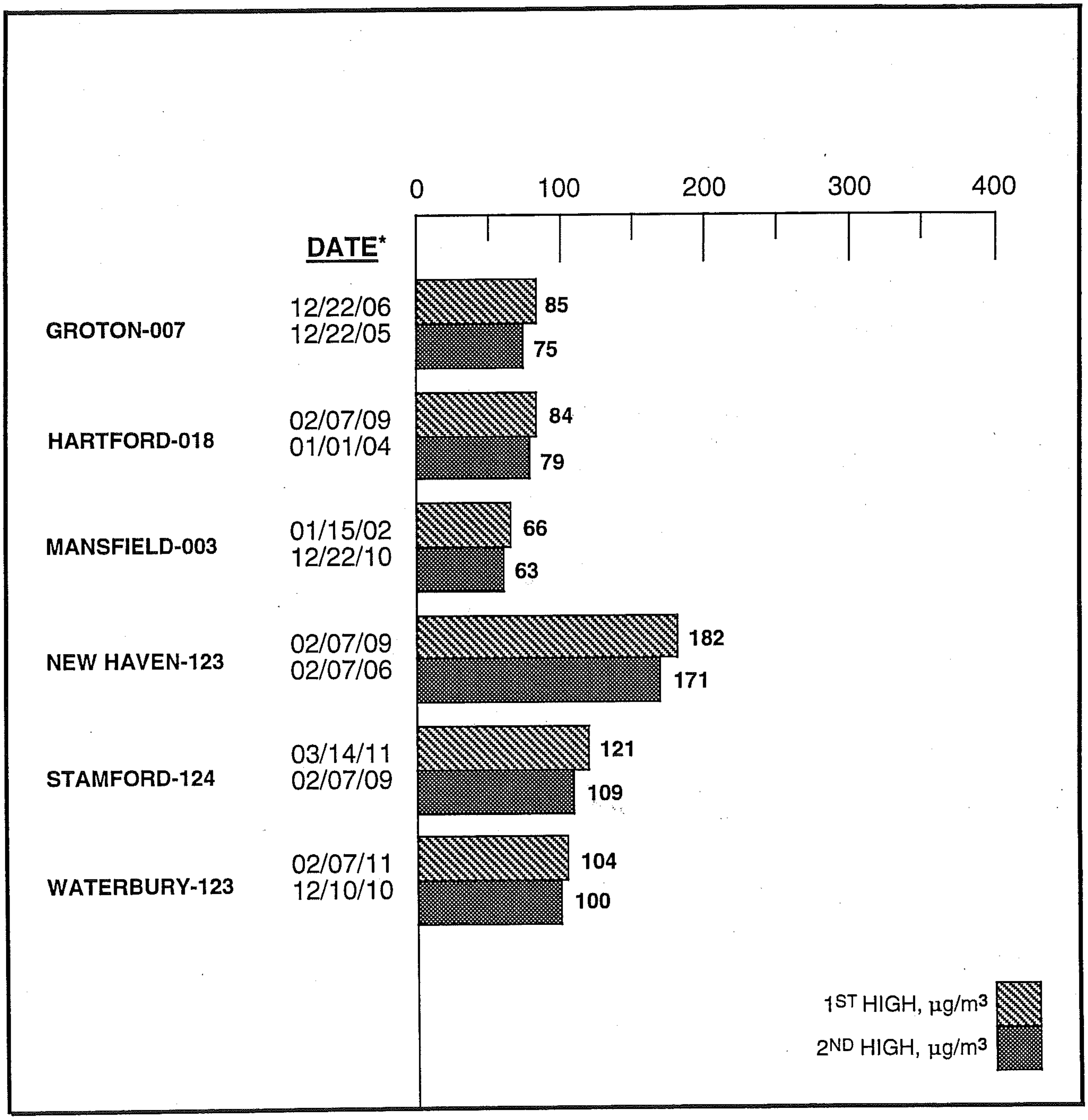


* The date is the month/day/ending hour of occurrence.

Secondary standard = 1300 µg/m^3.

FIGURE 3-3, CONTINUED

1996 MAXIMUM 3-HOUR RUNNING AVERAGE SO2 CONCENTRATIONS



* The date is the month/day/ending hour of occurrence.

Secondary standard = 1300 µg/m^3.

FIGURE 3-4

AVERAGES OF THE ANNUAL SO_2 CONCENTRATIONS AT SIX SITES

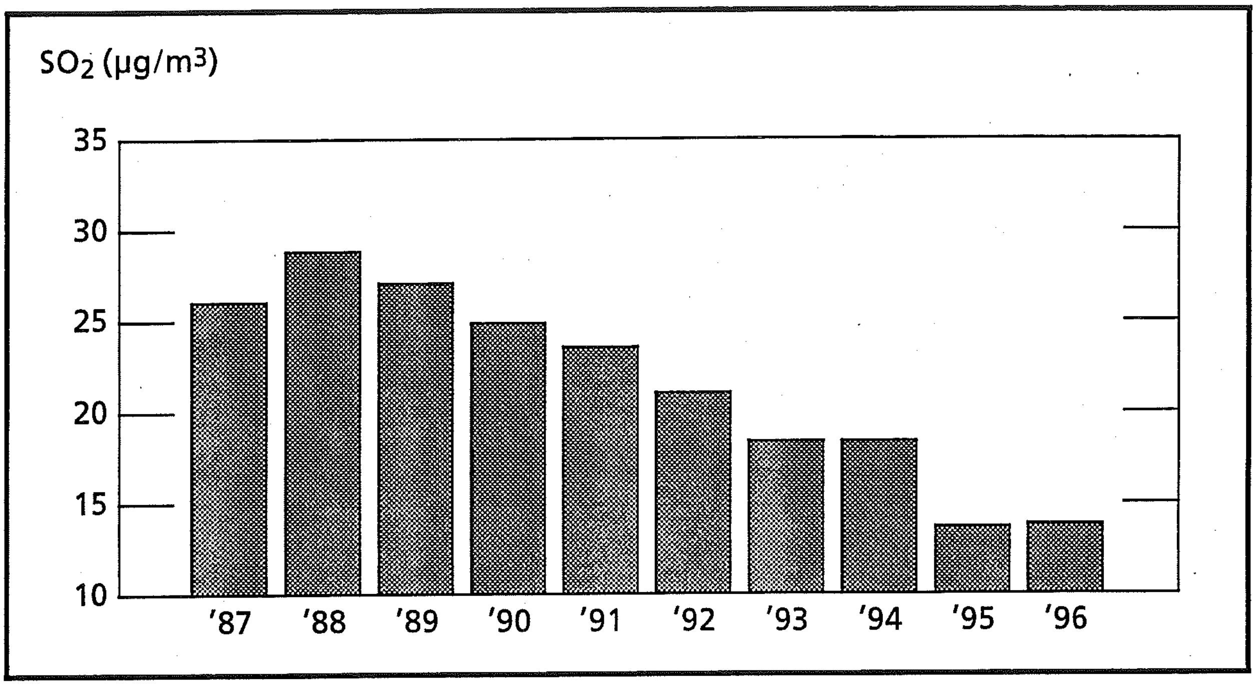
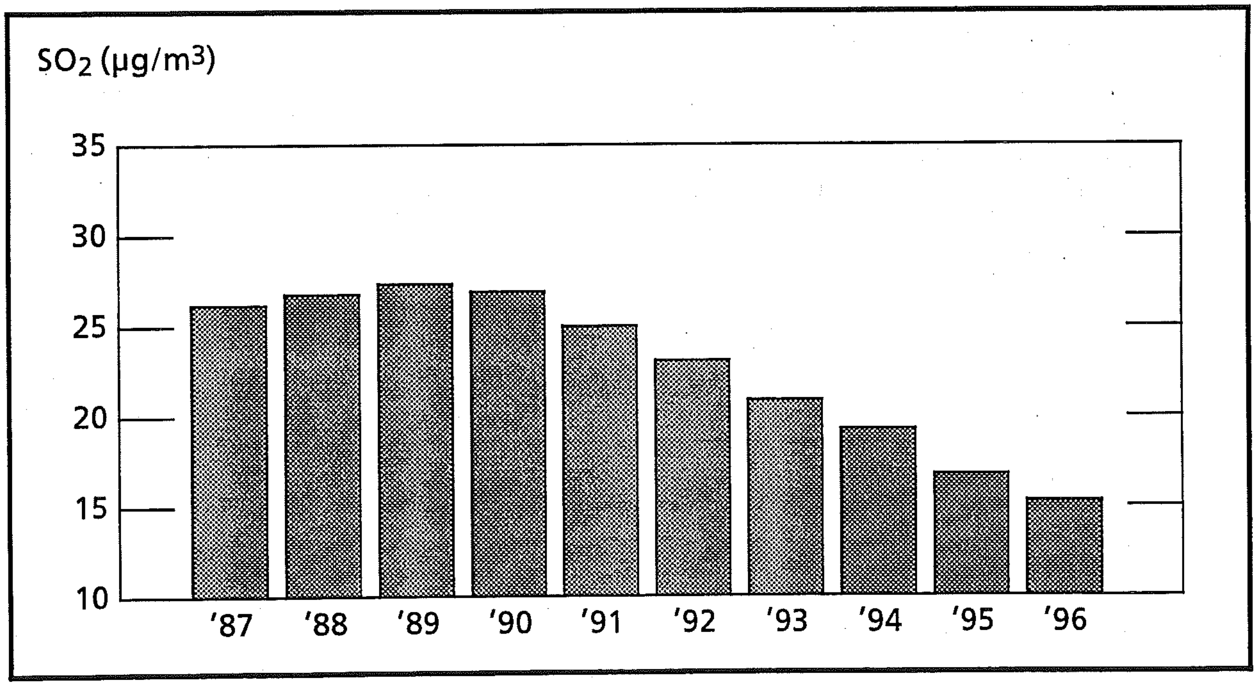


FIGURE 3-5

3-YEAR AVERAGES OF THE ANNUAL SO_2 CONCENTRATIONS AT SIX SITES



IV. OZONE

HEALTH EFFECTS

Ozone is a highly reactive form of oxygen and the principal component of modern smog. Until recently, EPA called this type of pollution "photochemical oxidants." The name has been changed to ozone because ozone is the only oxidant actually measured and is the most plentiful.

Ozone and other oxidants -- including peroxyacetal nitrates (PAN), formaldehyde and peroxides -- are not usually emitted into the air directly. They are formed by chemical reactions in the air from two other pollutants: hydrocarbons and nitrogen oxides. Energy from sunlight is needed for these chemical reactions. This accounts for the term photochemical smog and the daily variation in ozone levels, which increase during the day and decrease at night.

Ozone is a pungent gas with a faintly bluish color. It irritates the mucous membranes of the respiratory system, causing coughing, choking and impaired lung function. It aggravates chronic respiratory diseases like asthma and bronchitis and is believed capable of hastening the death, by pneumonia, of persons in already weakened health. PAN and the other oxidants that accompany ozone are powerful eye irritants.

NATIONAL AMBIENT AIR QUALITY STANDARD

On February 8, 1979 the EPA established a national ambient air quality standard (NAAQS) for ozone of 0.12 ppm for a one-hour average. Compliance with this standard is determined by summing the number of days at each monitoring site over a consecutive three-year period when the 1-hour standard is exceeded and then computing the average number of exceedances over this interval. If the resulting average value is less than or equal to 1.0 (that is, if the fourth highest daily value in a consecutive three-year period is less than or equal to 0.12 ppm) the ozone standard is considered attained at the site. This standard replaces the old photochemical oxidant standard of 0.08 ppm. The definition of the pollutant was changed along with the numerical value of the standard, partly because the instruments used to measure photochemical oxidants in the air really measure only ozone. Ozone is one of a group of chemicals which are formed photochemically in the air and are called photochemical oxidants. In the past, the two terms have often been used interchangeably. This Air Quality Summary uses the term "ozone" in conjunction with the NAAQS to reflect the change in both the numerical value of the NAAQS and the definition of the pollutant.

The EPA defines the ozone standard to two decimal places. Therefore, the standard is considered exceeded when a level of 0.13 ppm is reached. However, since the DEP still measures ozone levels to three decimal places, any one-hour average ozone reading which equals or is greater than 0.125 ppm is considered an exceedance of the 0.12 ppm standard in Connecticut. This interpretation of the ozone standard differs from the one used by the DEP before 1982, when a one-hour ozone concentration of 0.121 ppm was considered an exceedance of the standard.

CONCLUSIONS

As in past years, Connecticut experienced high concentrations of ozone in the summer months of 1996. Levels in excess of the one-hour NAAQS of 0.12 ppm were recorded at five of the twelve ozone monitoring sites. However, the 1-hour ozone standard was violated at all twelve sites because the "expected number of exceedances" for the most recent 3 years at each site exceeded one. The highest concentration was 0.148 ppm, which occurred at the Groton 008 site.

The incidence of hourly ozone concentrations in excess of the 1-hour 0.12 ppm standard was significantly lower in 1996 than in 1995 (see Table 4-1). There was a total of 90 hourly exceedances in 1995 and 7 hourly exceedances in 1996 at the eleven monitoring sites that were in operation in both years. This represents a decrease in the frequency of such exceedances from 1.7 per 1000 sampling hours in 1995 to 0.15 per 1000 sampling hours in 1996: a 91% decrease. The actual number of hours when the ozone standard was exceeded in the state decreased from 47 in 1995 to 8 in 1996.

The number of site-days on which the ozone monitors experienced ozone levels in excess of the 1-hour standard decreased from 36 in 1995 to 6 in 1996 at the eleven monitoring sites that were in operation in both years (see Table 4-2). This represents a decrease in the frequency of such occurrences from 1.64 per 100 sampling days in 1995 to 0.31 per 100 sampling days in 1996: an 81% decrease. The actual number of days on which the ozone standard was exceeded in the state decreased from 12 in 1995 to 4 in 1996.

The yearly changes in ozone concentrations can be attributed primarily to year-to-year variations in regional weather conditions, especially wind direction, temperature and the amount of sunlight. A large portion of the peak ozone concentrations in Connecticut is caused by the transport of ozone and/or precursors (i.e., hydrocarbons and nitrogen oxides) from the New York City area and other points to the west and southwest. Therefore, a decrease in the frequency of winds out of the southwest would help to explain the decrease in the number of ozone exceedances from 1995 to 1996. However, the percentage of southwest winds during the "ozone season" increased from 41% in 1995 to 46% in 1996, as is shown by the wind roses from the Stafford 001 site (Figures 4-1 and 4-2). The magnitude of high ozone levels can be partly associated with yearly variations in temperature, since ozone production is greatest at high temperatures and in strong sunlight. The summer season's daily high temperatures were lower in 1996 than in 1995. This is demonstrated by the number of days exceeding 90° F which decreased from thirteen in 1995 to one in 1996 at Sikorsky Airport in Bridgeport, and from twenty-two in 1995 to five in 1996 at Bradley International Airport. The incidence of high ozone levels is also dependent on the amount of sunlight, since sunlight is essential to the creation of ozone. According to measurements recorded at Stafford 001 site, the amount of solar radiation decreased 5.6% from 1995 to 1996, as determined by the daily mean for the months June through August. Of the meteorological parameters discussed above, both temperature and solar radiation can be seen as contributing to the decrease in ozone levels from 1995 to 1996.

The meteorological influences notwithstanding, additional and important factors contributing to the decrease in ozone concentrations over time are the continuing efforts of the EPA and the state Department of Environmental Protection to control the emissions of nitrogen oxides and hydrocarbons. Newer automobiles continue to be less polluting, and the use of reformulated gasoline, which was initiated in January of 1995, reduces vehicle hydrocarbon emissions by 15-17% and lowers the vapor pressure of gasoline in the summer months, reducing evaporative emissions. In addition, the state's inspection and maintenance program for motor vehicles, as well as the Stage I and Stage II vapor recovery requirements, also lessen the emissions of hydrocarbons into the air.

METHOD OF MEASUREMENT

The DEP Air Monitoring Unit uses UV photometry to measure and record instantaneous concentrations of ozone continuously by means of a UV absorption technique. Properly calibrated, instruments of this type are shown to be remarkably reliable and stable.

DISCUSSION OF DATA

Monitoring Network - In order to gather information which will further the understanding of ozone production and transport, DEP operated a state-wide ozone monitoring network consisting of four types of sites in 1996 (see Figure 4-3):

Urban - East Hartford, Middletown
Advection from Southwest - Greenwich, Groton, Madison, Stratford, Westport
Urban and advection from Southwest - Bridgeport, Danbury, New Haven
Rural - Stafford, Torrington

Precision and Accuracy - The ozone monitors had a total of 313 precision checks during 1996. The resulting 95% probability limits were -8% to +3%. Accuracy is determined by introducing a known amount of ozone into each of the monitors. Three different concentration levels are tested: low, medium, and high. The 95% probability limits, based on 12 audits conducted on the monitoring system, were: low, -8% to +3%; medium, -7% to +4%; and high, -6% to +3%.

1-Hour Average - The 1-hour ozone standard was exceeded at five of the twelve DEP monitoring sites in 1996, where an exceedance is defined as a concentration of 0.125 ppm or greater. Between 1995 and 1996, the maximum 1-hour concentration decreased at ten of the eleven sites that operated in both years. The largest decrease was 0.051 ppm at Madison 002; the smallest decrease was 0.012 ppm at Torrington 006. The maximum 1-hour concentration increased in 1996 at Groton 008 by 0.04 ppm over 1995. The second high 1-hour concentration decreased at all eleven sites that operated in both 1995 and 1996. The largest decrease was 0.045 ppm at both Madison 002 and Middletown 007; the smallest decrease was 0.07 ppm at Torrington 006.

The number of hours when the ozone standard was exceeded at each site during the summertime "ozone season" is presented in Table 4-1. The number of days on which the 1-hour standard was exceeded at each site is presented in Table 4-2. Figure 4-4 shows the year's high and second high concentrations at each site.

Highest Hourly Ozone Concentrations and Wind Data - As with particulate matter and sulfur dioxide, the highest ozone levels occur on days with persistent winds out of the southwest. During the fifteen year period between 1981 and 1995, 74% of the annual ten highest daily 1-hour average concentrations of ozone at each monitoring site in the state occurred when such wind conditions prevailed. This is due to the special features of a southwest wind blowing over Connecticut. One feature is that, during the summer, southwest winds are usually accompanied by high temperatures and bright sunshine, which are important to the production of ozone. Another feature of a southwest wind is that it will transport precursor emissions from New York City and other urban areas to the southwest of Connecticut. It is the combination of these factors that often produces unhealthful ozone levels in Connecticut.

There are also instances of high ozone levels on non-southwest wind days. This suggests that pollution control programs currently being implemented in this state are needed to protect the public health of Connecticut's citizenry on days when Connecticut is responsible for its own pollution.

Trends - Ozone trends can be illustrated in a number of ways by using various statistics: daily mean concentration, daily maximum concentration, number of hourly exceedances, number of daily exceedances, etc. Each has its merits. The daily maximum ozone concentration is used here as the basis for a trend analysis because (1) it represents a more robust data set than hourly or daily exceedances, and (2) a maximum concentration is more relevant to the NAAQS for ozone.

Figure 4-5 shows the unweighted average of the annual means of the maximum daily concentrations at ten ozone sites from 1987 to 1996. There is a lot of variation in the statistic from one year to the next. The importance of meteorology in the formation of ozone explains much of this variation. However, unless the effect of meteorology can be factored out, one cannot judge the effect of emission control measures on ozone production. A regression line through the data in Figure 4-5 would trend down, but the reason for this would not be evident.

The effect of meteorology on an ozone trend can be diminished by multiple year averaging. Periods of multiple years exhibit much less meteorological variability than do single years, and a trend analysis based on multiple years should more clearly reveal the effect of emission controls on ambient ozone concentrations. Figure 4-6 illustrates five year running averages of the data that is presented in Figure 4-5. With the variability of the weather minimized, it is evident that ozone is trending downward.

PHOTOCHEMICAL ASSESSMENT MONITORING STATIONS (PAMS)

Introduction - Current analyses indicate that pollutant concentrations in the United States have steadily declined over the past decade. However, many areas of the country continue to be troubled by pervasive and chronic ozone nonattainment problems. This is especially true of the northeastern United States in general and of Connecticut in particular. State and local air pollution control agencies have normally employed ozone control strategies that focus solely on reductions of volatile organic compound (VOC) emissions, which are common photochemical precursors of ozone. More recent data, however, suggest that the ozone abatement problem is more complex and requires the implementation of more varied and effective strategies.

Background - In order to meet the challenges faced by the state and local air pollution control agencies in attaining the National Ambient Air Quality Standards (NAAQS) for ozone, a more comprehensive ambient air quality database for ozone and its precursors was needed to explain the effects of ozone management strategies. To this end, the 1990 Clean Air Act Amendments (CAAA) required enhanced monitoring for ozone and oxides of nitrogen (NO_X) and monitoring for VOC in ozone nonattainment areas classified as serious, severe or extreme. In particular, the United States Environmental Protection Agency (EPA) focused attention on several pertinent issues:

(i) In addition to VOC limitations, examination of emission controls for NO_X,
(II) Expanded monitoring of ozone precursors in order to confirm emissions trends, and
(III) Creation of ambient monitoring strategies to directly measure the success of implemented ozone precursor controls.

In order to comply with the requirements of the CAAA, the EPA promulgated final amendments to the ambient air quality surveillance rules on February 12, 1993, to provide for the enhanced monitoring of ozone, oxides of nitrogen, volatile organic compounds, including carbonyls, and meteorological parameters . These rules required the affected areas to establish Photochemical Assessment Monitoring Stations (PAMS) networks in ozone nonattainment areas classified as serious, severe or extreme.

PAMS Monitoring Objectives - PAMS design criteria are site specific. Concurrent measurements of O_3, NO_X, speciated VOC, and meteorology are obtained at PAMS. Design criteria for the PAMS network are based on a selection of an array of site locations relative to O_3 precursor source areas and predominant wind directions associated with high O_3 events. Specific monitoring objectives are associated with each location. The overall design should enable characterization of precursor emission sources within the area, transport of O_3 and its precursors into and out of the area, and the photochemical processes related to O_3 nonattainment. Specific objectives that must be addressed include assessing ambient trends in O_3, NO, NO_2, NO_X, VOC (including carbonyls) and VOC species; determining spacial and diurnal variability of O_3, NO, NO_2, NO_X, and VOC species; and assessing changes in the VOC species profiles that occur over time, particularly those occurring due to the reformulation of fuels.

A maximum of five PAMS sites are required in an affected nonattainment area depending on the population of either the Metropolitan Statistical Area / Consolidated Metropolitan Statistical Area (MSA/CMSA) or nonattainment area, whichever is larger. Specific monitoring objectives associated with each of these sites result in four distinct types of site.

Type (1) sites are established to characterize upwind background and transported O_3 and its precursor concentrations entering the area and will identify those areas which are subject to overwhelming transport. Type (1) sites are located in the predominant morning upwind direction from the local area of maximum precursor emissions.

Type (2) sites are established to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions are expected to impact. In addition, these sites are suited for the monitoring of urban air toxic pollutants. Type (2) sites are located immediately downwind of the area of maximum precursor emissions and are typically placed near the downwind boundary of the central business district to obtain neighborhood-scale measurements.

Type (3) sites are intended to monitor maximum O_3 concentrations occurring downwind from the area of maximum precursor emissions. Type (3) sites should be located so that urban-scale measurements are obtained, typically 10 to 30 miles from the fringe of the urban area.

Type (4) sites are established to characterize the extreme downwind transported O_3 and its precursor concentrations exiting the area and will identify those areas which are potentially contributing to overwhelming transport in other areas. Type (4) sites are located in the predominant afternoon downwind direction from the local area of maximum precursor emissions and at a distance sufficient to obtain urban-scale measurements.

PAMS Monitoring Network - In order to comply with the federal rules requiring states to establish PAMS networks in ozone nonattainment areas classified as serious or severe (see Figure 9-1), DEP operated a PAMS monitoring network consisting of three types of sites in 1996 (see Figure 4-7):

Type (1) - Westport 003
Type (2) - East Hartford 003
Type (3) - Stafford 001

- thru 12/97 only

TABLE 4-1

NUMBER OF HOURS WHEN THE 1-HOUR OZONE STANDARD WAS EXCEEDED IN 1996

SITE	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	1996	1995
Bridgeport 013	0	0	0	0	0	0	0	1
Danbury 123	0	0	0	0	0	0	0	5
E. Hartford 003	0	0	0	0	0	0	0	4
Greenwich 017	0	0	0	0	1	0	1	9
Groton 008	0	0	0	3	0	0	3	9
Hamden Madison 002	0	0	0	0	0	0	0	26
Middletown 007	0	0	0	0	2	0	2	10
New Haven 123	0	0	0	0	0	0	0	2
Stafford 001	0	0	0	0	0	0	0	4.
Stratford 007	0	0	0	1	0	0	1	19
Torrington 006	0	0	0	0	0	0	0	1
Westport 003	0	0	0	2	1	0	3	n/a*
TOTAL SITE HOURS	0	0	0	6	4	0	10**	90

* The Westport 003 site did not exist in 1995.
** The total for 1996 without the Westport 003 site is 7.

TABLE 4-2

NUMBER OF DAYS WHEN THE 1-HOUR OZONE STANDARD WAS EXCEEDED IN 1996

SITE	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	1996	1995
Bridgeport 013	0	0	0	0	0	0	0	1
Danbury 123	0	0	0	0	0	0	0	2
E. Hartford 003	0	0	0	0	0	0	0	2
Greenwich 017	0	0	0	0	1	0	1	4
Groton 008	0	0	0	1	0	0	1	4
Madison 002	0	0	0	0	0	0	0	8
Middletown 007	0	0	0	0	1	0	1	4
New Haven 123	0	0	0	0	0	0	0	1
Stafford 001	0	0	0	0	0	0	0	2
Stratford 007	0	0	0	1	0	0	1	7
Torrington 006	0	0	0	0	0	0	0	1
Westport 003	0	0	0	1	1	0	2	n/a*
TOTAL SITE DAYS	0	0	0	3	3	0	6**	36

* The Westport 003 site did not exist in 1995.
** The total for 1996 without the Westport 003 site is 4.

FIGURE 4-1

WIND ROSE FOR JUNE- AUGUST 1995
STAFFORD 001 MONITORING SITE
SHENIPSIT STATE FOREST

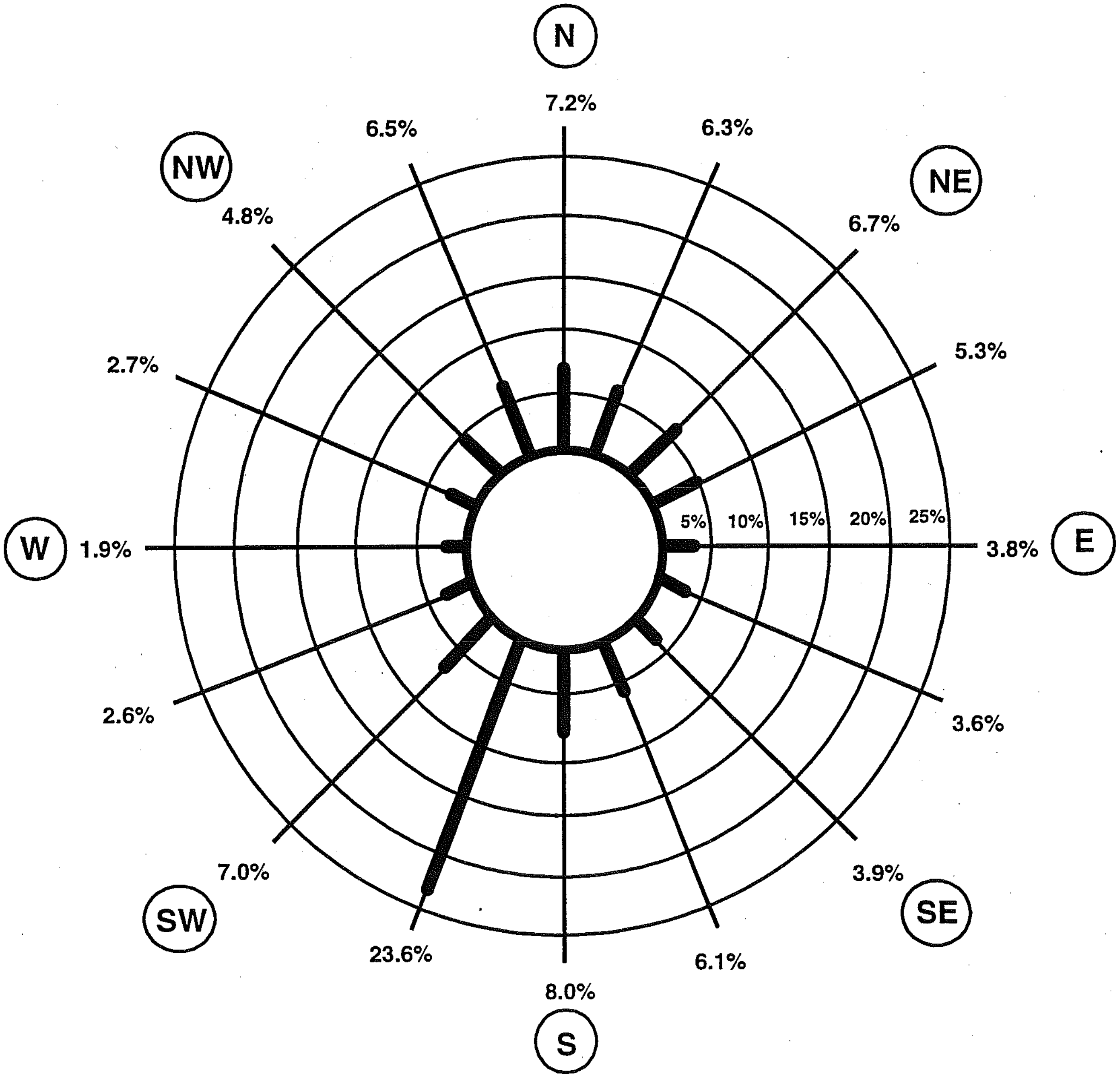
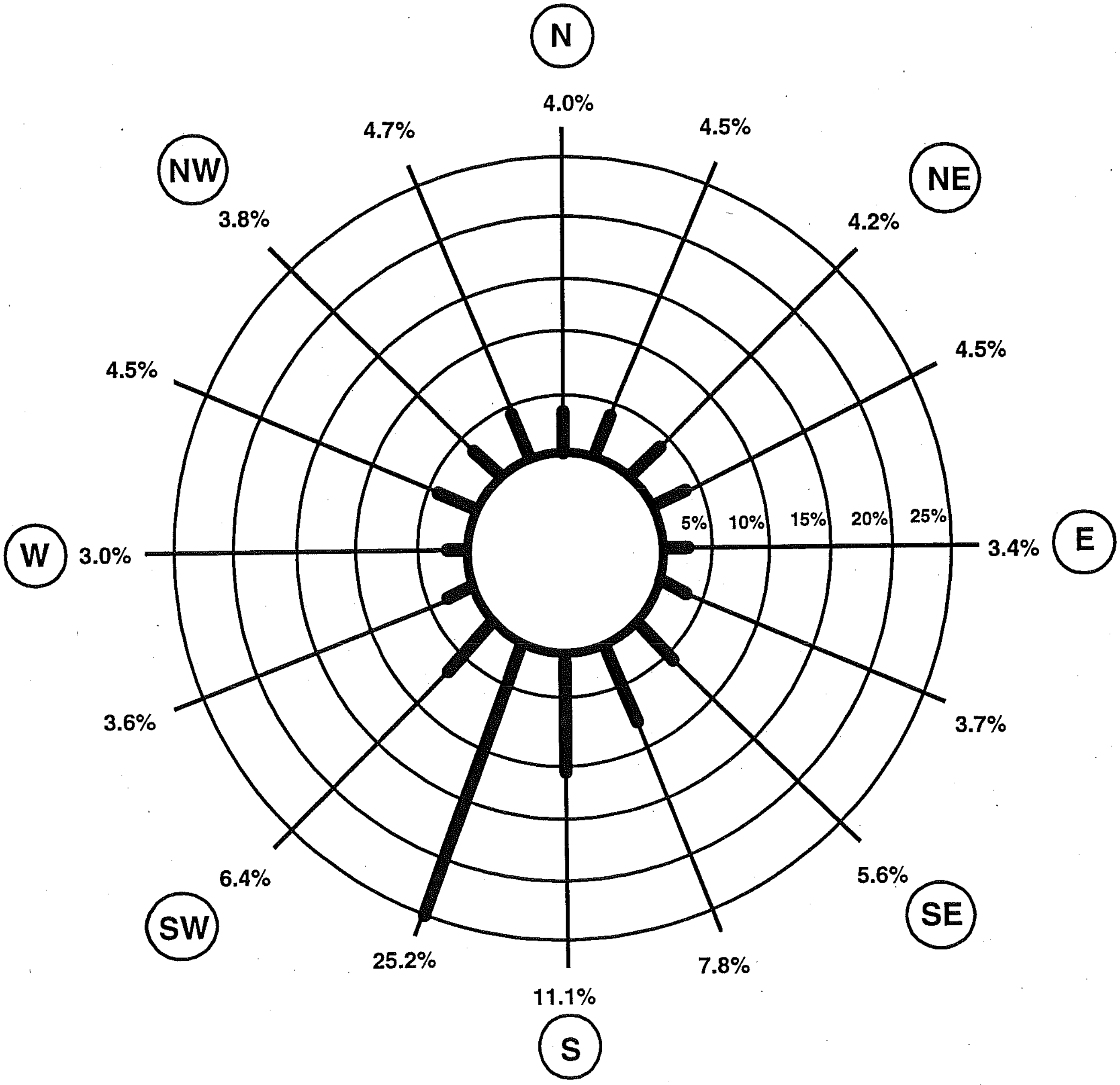


FIGURE 4-2

WIND ROSE FOR JUNE- AUGUST 1996
STAFFORD 001 MONITORING SITE
SHENIPSIT STATE FOREST



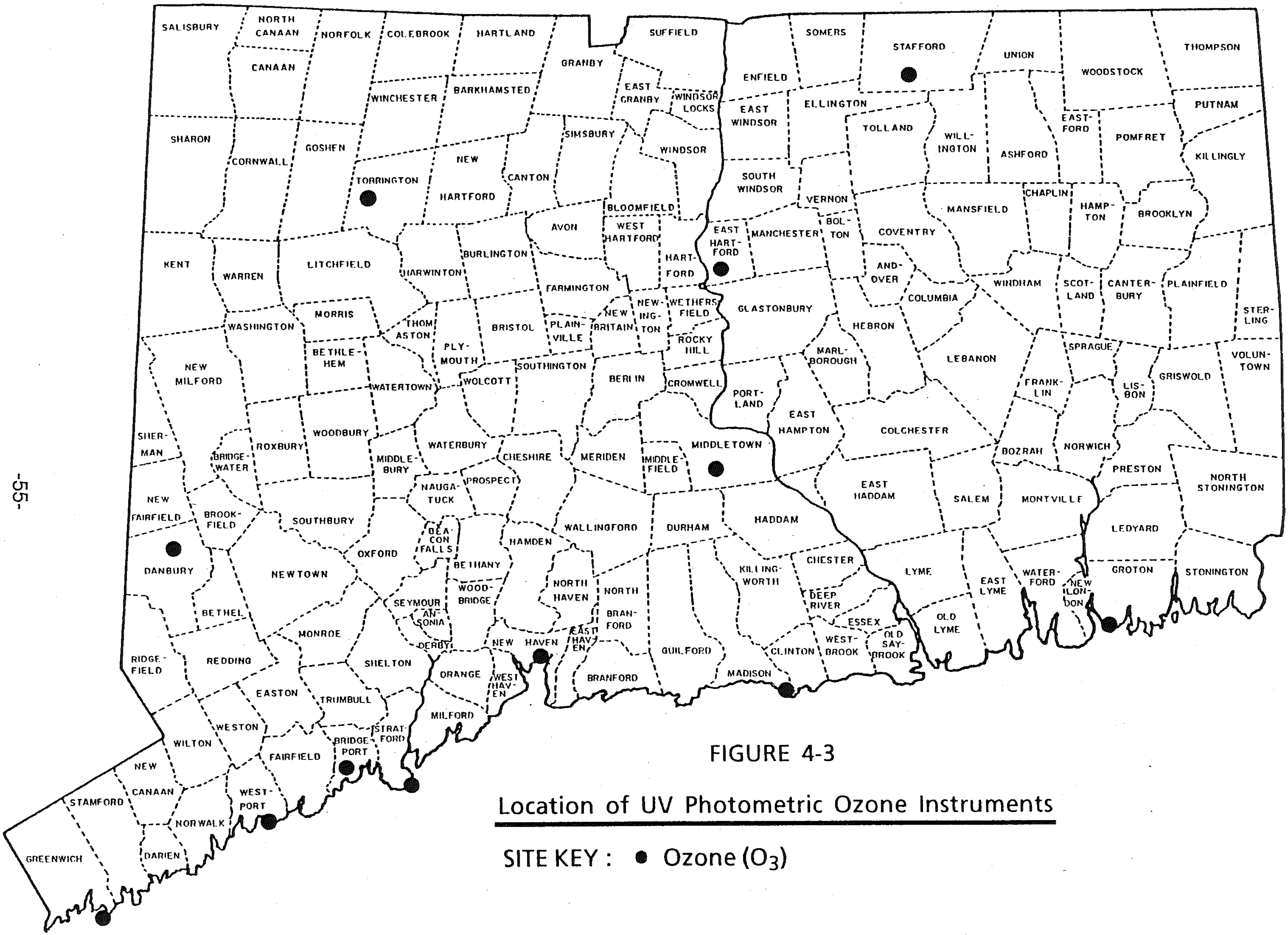


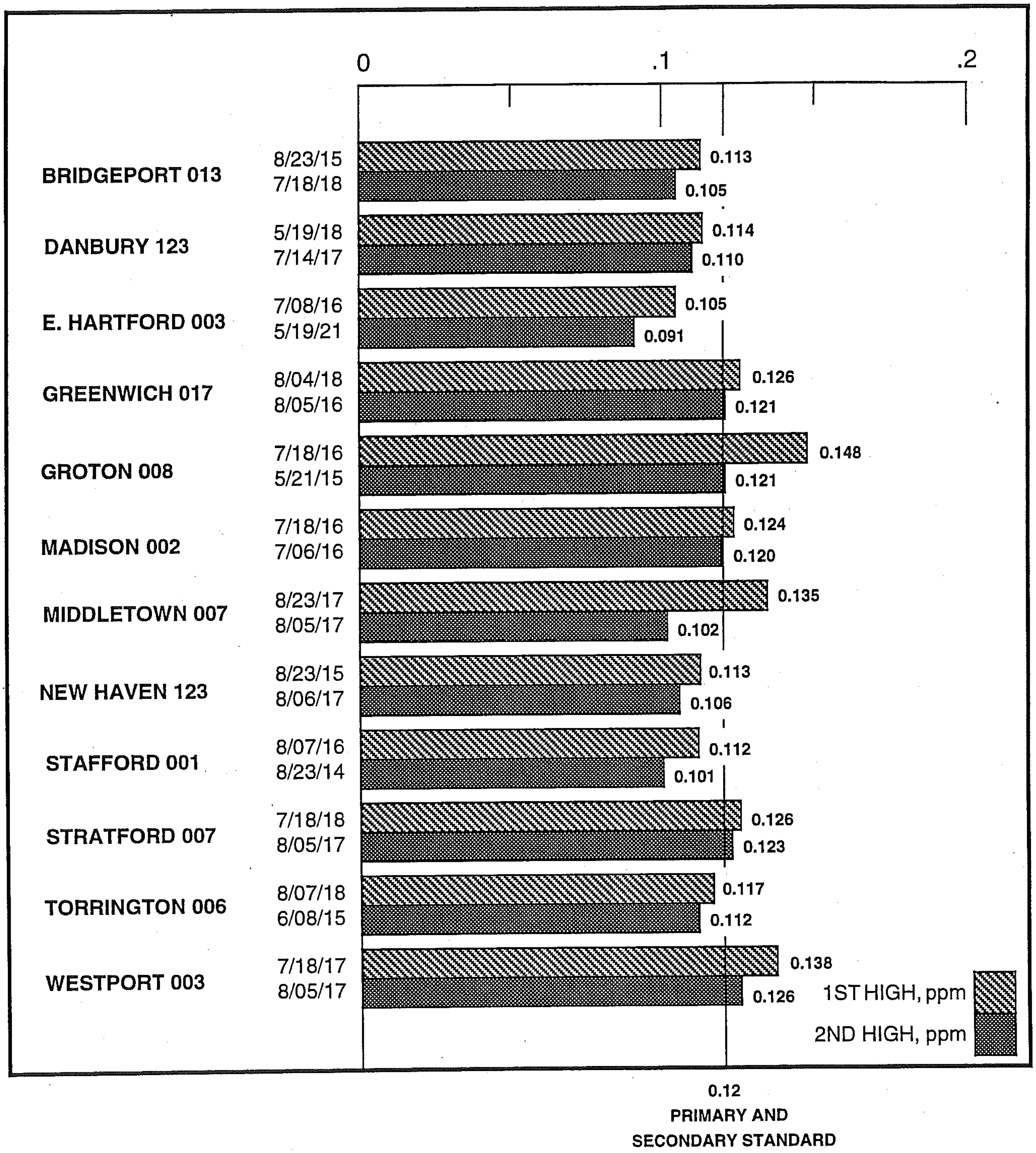
FIGURE 4-3

Location of UV Photometric Ozone Instruments

SITE KEY : ● Ozone (O_3)

FIGURE 4-4

1ST AND 2ND HIGH 1-HOUR OZONE CONCENTRATIONS IN 1996



* The date is the month/day/ending hour (standard time) of occurrence.

N.B. To be consistent with the requirements of the NAAQS for ozone, only the highest hourly concentration per day per site is considered.

FIGURE 4-5

AVERAGES OF THE ANNUAL MEAN DAILY MAXIMUM OZONE CONCENTRATIONS AT TEN SITES

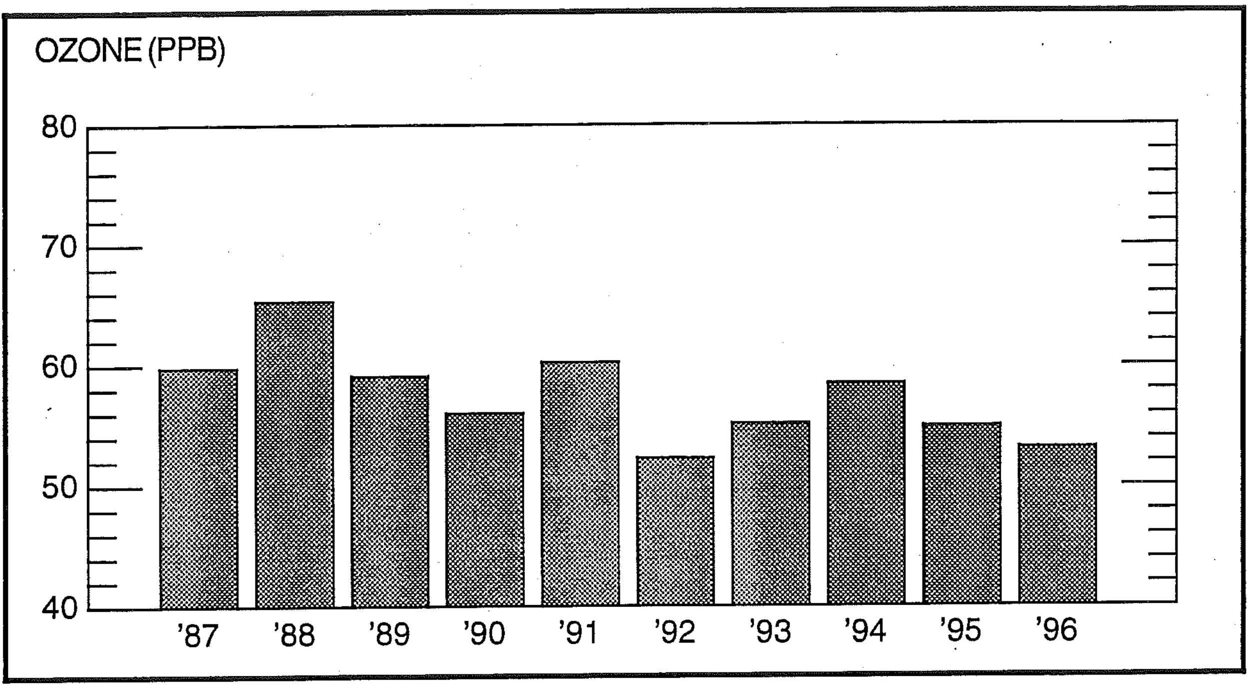
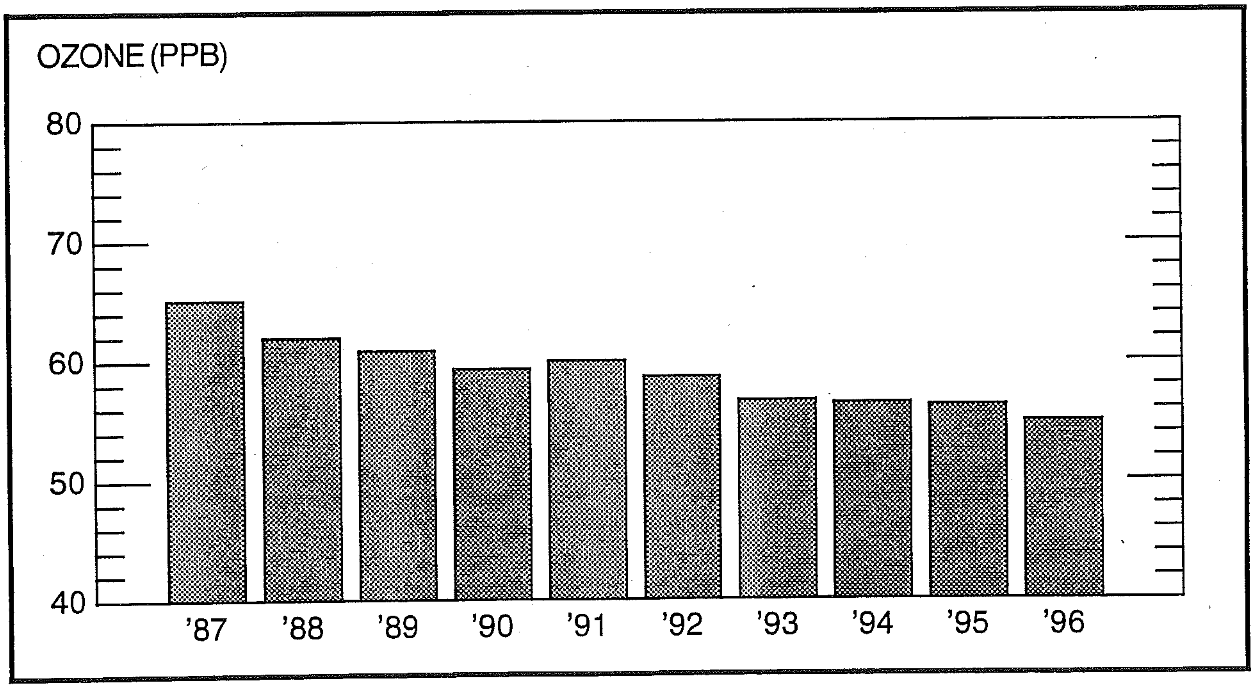


FIGURE 4-6

5-YEAR AVERAGES OF THE ANNUAL MEAN DAILY MAXIMUM OZONE CONCENTRATIONS AT TEN SITES



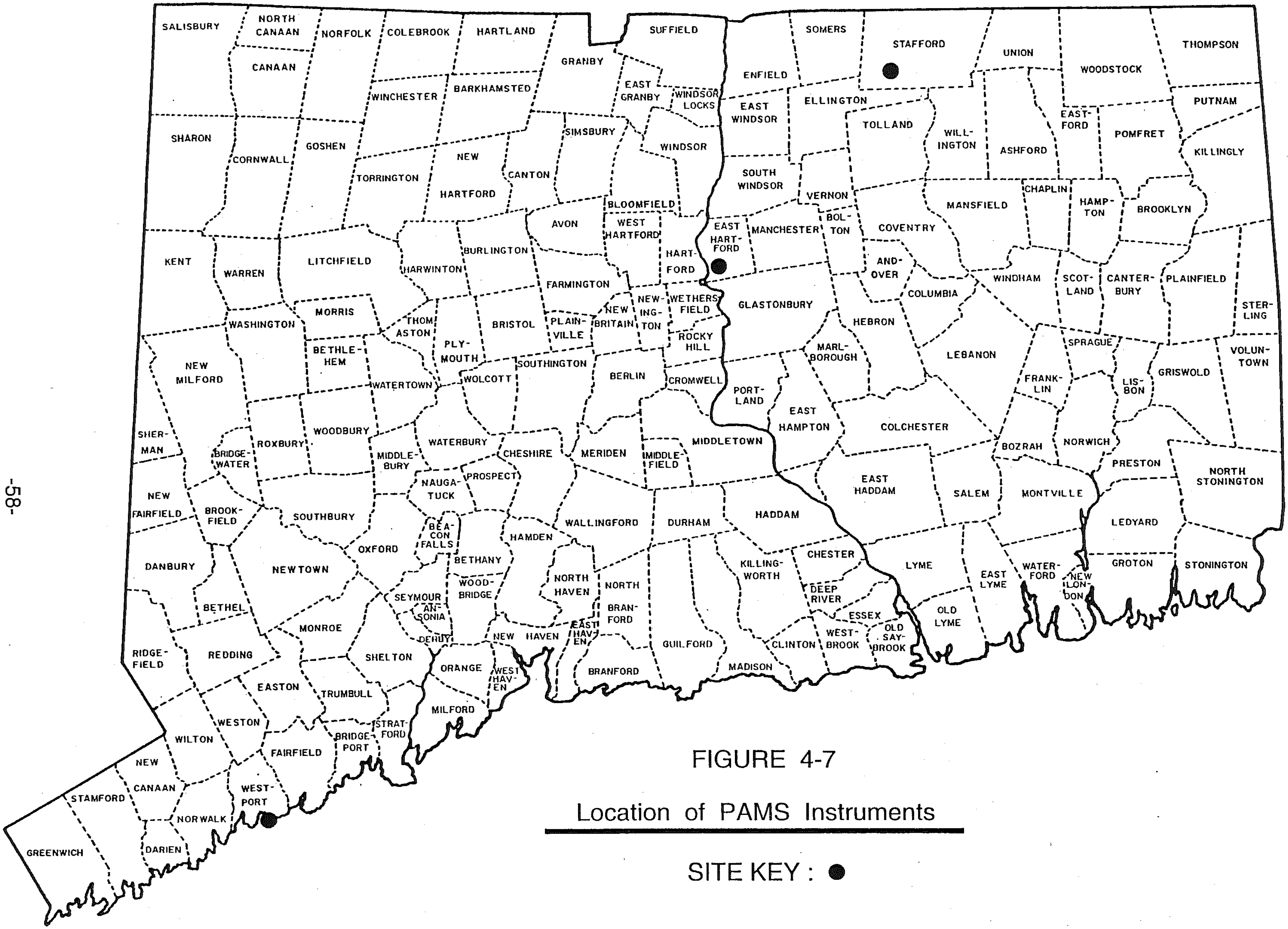


FIGURE 4-7

Location of PAMS Instruments

SITE KEY : ●

V. NITROGEN DIOXIDE

HEALTH EFFECTS

Nitrogen dioxide (NO_2) is a toxic gas with a characteristic pungent odor and a reddish-orange-brown color. It is highly oxidizing and extremely corrosive.

The presence of NO_2 in the atmosphere is accounted for by the oxidation of nitric oxide (NO) to NO_2 by means of reactions with various chemical species, principally ozone, hydroperoxyl radicals and organic peroxyl radicals. Large amounts of NO are emitted into the air by high temperature combustion processes. Industrial furnaces, power plants and motor vehicles are the primary sources of NO emissions.

Exposure to NO_2 is believed to increase the risks of acute respiratory disease and susceptibility to chronic respiratory infection. NO_2 also contributes to heart, lung, liver and kidney damage. At high concentrations, this pollutant can be fatal. At lower levels of 25 to 100 parts per million, it can cause acute bronchitis and pneumonia. Occasional exposure to low levels of NO_2 can irritate the eyes and skin.

Other effects of nitrogen dioxide are its toxicity to vegetation and its ability to combine with water vapor to form nitric acid. Furthermore, NO_2 is an essential ingredient, along with hydrocarbons, in the formation of ozone.

CONCLUSIONS

Nitrogen dioxide (NO_2) concentrations at all monitoring sites did not violate the NAAQS for NO_2 in 1996. The annual arithmetic mean NO_2 concentration at each site was well below the federal standard of 100 $\mu g/m^3$. The highest annual mean was 48 $\mu g/m^3$, which occurred at the New Haven 123 site.

SAMPLE COLLECTION AND ANALYSIS

The DEP Air Monitoring Unit used continuous electronic analyzers employing the chemiluminescent reference method to continuously monitor NO_2 levels.

DISCUSSION OF DATA

Monitoring Network - Three monitoring sites were operated in Connecticut in 1996 for the purpose of determining annual statistics for nitrogen dioxide (see Figure 5-1). The sites -- Bridgeport 013, East Hartford 003 and New Haven 123 -- were located in three urban areas near major expressways in order to obtain maximum NO_2 readings.

Precision and Accuracy - Eighty precision checks were made on the NO_2 monitors in 1996, yielding 95% probability limits ranging from -12% to +10%. Accuracy is determined by introducing a known amount of NO_2 into each of the monitors. Eight audits for accuracy were conducted on the monitoring network in 1996. Three different concentration levels were tested on each monitor: low, medium, and high. The 95% probability limits for the low level test ranged from -10% to +2%; those for the medium level test ranged from -7% to -2%; and those for the high level test ranged from -9% to 0%.

Annual Averages - The annual average NO_2 standard of 100 $\mu g/m^3$ was not exceeded in 1996 at any site in Connecticut (see Table 5-1). In addition, two of the three sites had sufficient data to compute valid arithmetic means. This permits some comparisons with the 1994 and 1995 annual averages. After a significant decrease at all three sites from 1994 to 1995, there was no discernible trend in the annual average NO_2 concentrations from 1995 and 1996.

Statistical Projections - The format of Table 5-1 is the same as that used to present the particulate matter and sulfur dioxide data, except that for NO_2 there are no 24-hour standards and, therefore, no projections of violations are possible. However, Table 5-1 gives the annual arithmetic mean of the hourly NO_2 concentrations in order to allow direct comparison to the annual NO_2 standard. The 95% confidence limits about the arithmetic mean for each site demonstrate that it is unlikely that any site exceeded the primary annual standard of 100 $\mu g/m^3$ in 1996.

Highest Hourly Concentrations and Wind Data - As was the case with particulate matter, sulfur dioxide and ozone, the highest NO_2 concentrations occur most often on days when persistent winds out of the southwest quadrant predominate. During the ten year period between 1986 and 1995, 68% of the annual ten highest hourly NO_2 concentrations at each monitoring site in the state occurred on days when such wind conditions prevailed. This is not unexpected since the NO_2 monitoring sites were deliberately located to the north and east of major expressways and interchanges, which are major sources of nitrogen oxide emissions. Moreover, high NO_2 levels coincident with southwest winds confirm the importance of pollution transport into Connecticut from the southwest.

In addition, according to National Weather Service local climatological data recorded at Bradley Airport, 75% of the high NO_2 days had at least 50% of the possible sunshine. A high percentage of the possible sunshine is interpreted to confirm the importance of photochemical oxidation in the formation of NO_2.

Trends - The weighted averages of the annual NO_2 concentrations at the three monitoring sites are illustrated in Figure 5-2. The year-to-year variation appears to be quite choppy. In spite of this, a slight downward trend in the annual NO_2 concentrations can be detected.

Given the importance of meteorology -- sunlight, in general, and southwest winds in Connecticut, in particular -- on the formation of NO_2, a trend might best be illustrated by the averaging of data over multiple years. As was the case with ozone, a trend based on multiple years of data should diminish the effect of meteorology and, thereby, reveal the effect of nitrogen oxide and hydrocarbon emission controls on ambient concentrations of NO_2. Figure 5-3 shows that the 5-year average NO_2 concentration, with the influence of meteorology minimized, has been trending downward over the past ten years.

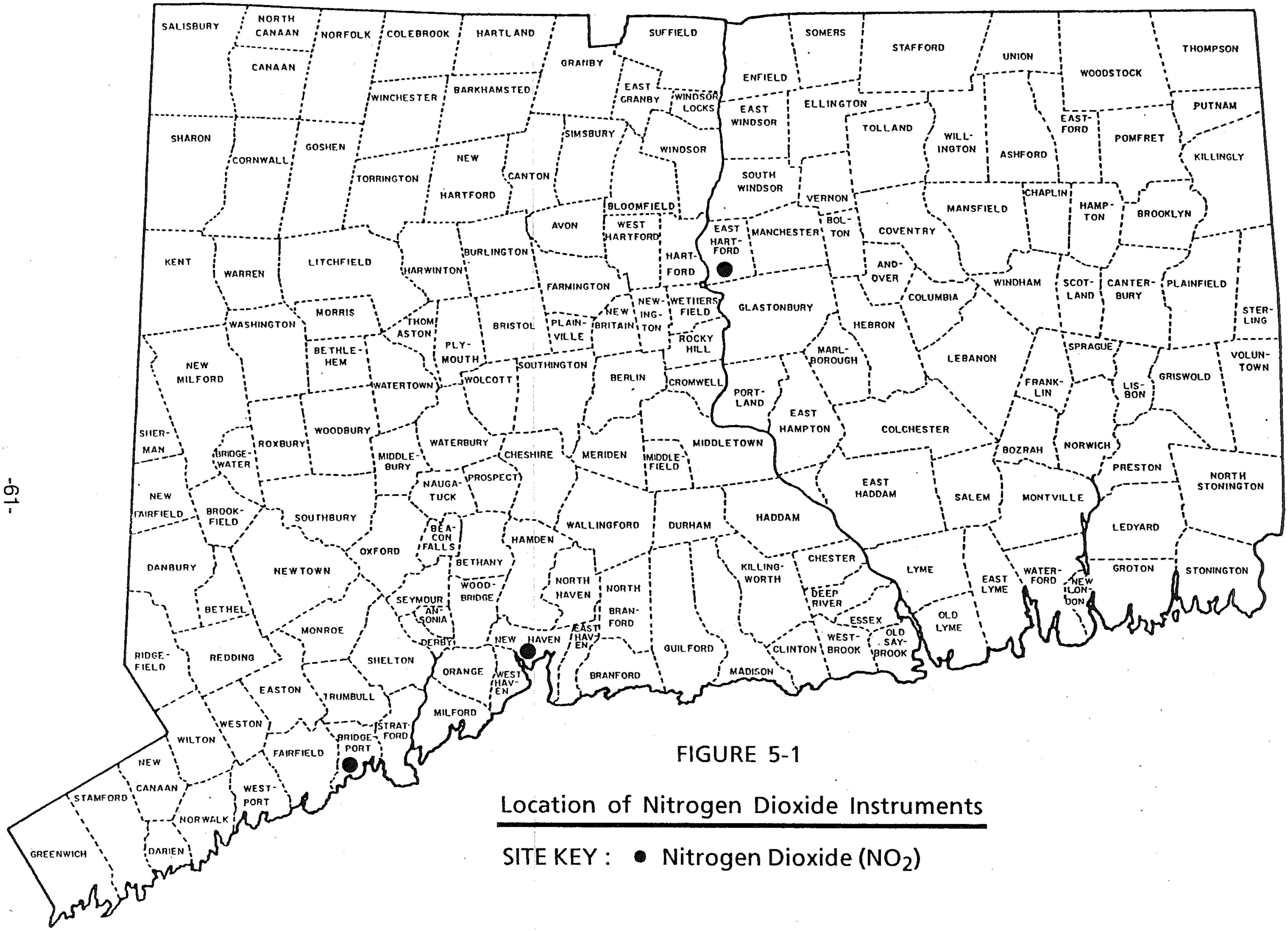


FIGURE 5-1

Location of Nitrogen Dioxide Instruments

SITE KEY : ● Nitrogen Dioxide (NO_2)

TABLE 5-1

1994 -1996 NITROGEN DIOXIDE ANNUAL AVERAGES

				Arithmetic	95-Percent-Limits		Standard
Town Name	Site	Year	Samples	Mean	Lower	Upper	Deviation
Bridgeport	013	1994	8390	49.33	49.21	49.46	28.25
Bridgeport	013	1995	8520	45.68	45.59	45.77	25.16
Bridgeport	013	1996	8119	44.23	44.09	44.38	24.66
East Hartford	003	1993	8505	34.65	34.57	34.73	22.45
East Hartford	003	1994	8355	38.25	38.12	38.37	27.04
East Hartford*	003	1996	4575	29.73	29.22	30.24	25.59
New Haven	123	1994	7694	56.48	56.26	56.70	27.80
New Haven	123	1995	8262	47.67	47.54	47.79	23.58
New Haven	123	1996	8366	48.42	48.32	48.52	22.72

* The site was shut down from July through December due to construction in the area.

N.B. The arithmetic mean and standard deviation have units of $\mu g/m^3$.

FIGURE 5-2

AVERAGE OF THE ANNUAL NO_2 CONCENTRATIONS AT THREE SITES

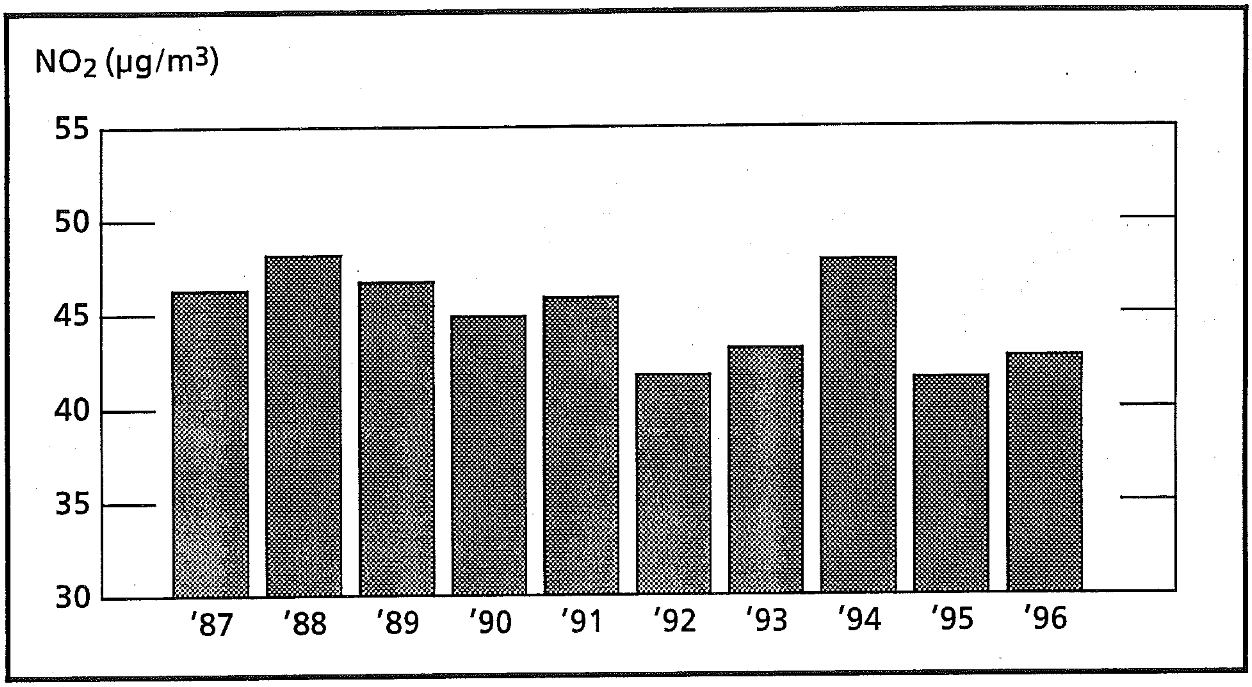
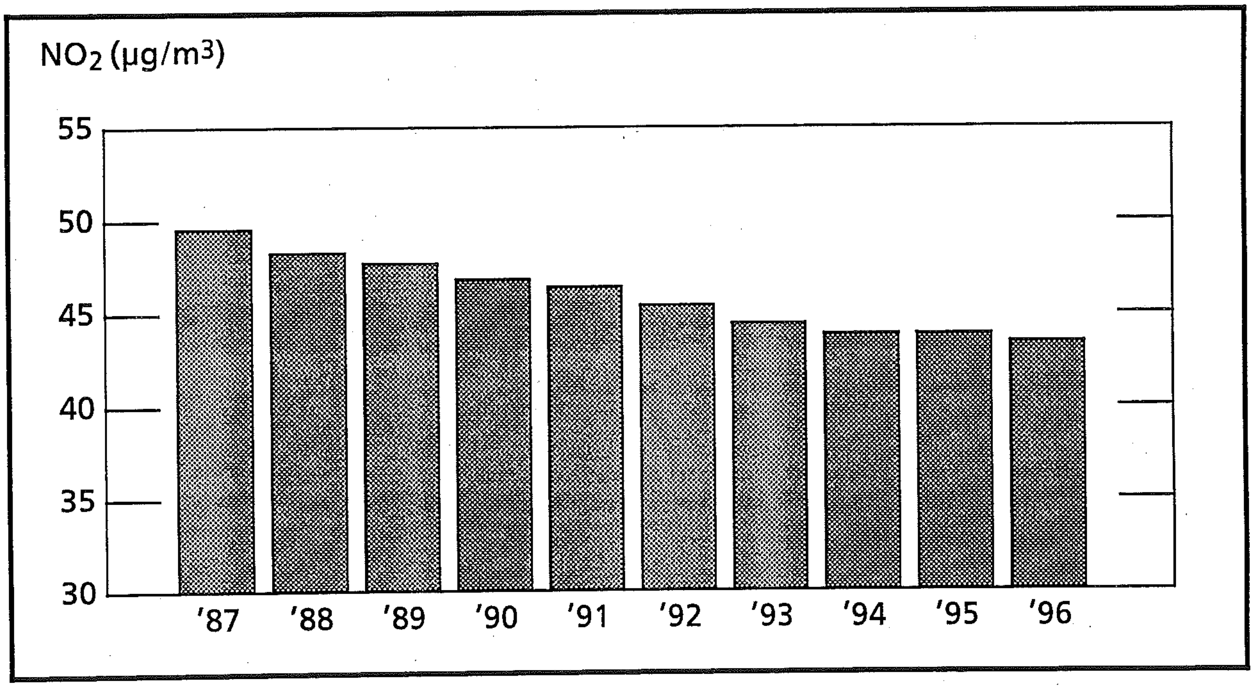


FIGURE 5-3

5-YEAR AVERAGES OF THE ANNUAL NO_2 CONCENTRATIONS AT THREE SITES



VI. CARBON MONOXIDE

HEALTH EFFECTS

Carbon monoxide (CO) is a colorless, odorless, poison gas formed when carbon-containing fuel is not burned completely. It is by far the most plentiful air pollutant. Fortunately, this deadly gas does not persist in the atmosphere. It is apparently converted by natural processes to carbon dioxide in ways not yet understood, and this is done quickly enough to prevent any general buildup. However, CO can reach dangerous levels in local areas, such as city-street canyons with heavy auto traffic and little wind.

Clinical experience with accidental CO poisoning has shown clearly how it affects the body. When the gas is breathed, CO replaces oxygen in the red blood cells, reducing the amount of oxygen that can reach the body cells and maintain life. Lack of oxygen affects the brain, and the first symptoms are impaired perception and thinking. Reflexes are slowed, judgement weakened, and drowsiness ensues. An auto driver breathing high levels of CO is more likely to have an accident; an athlete's performance and skill drop suddenly. Lack of oxygen then affects the heart. Death can come from heart failure or general asphyxiation if a person is exposed to very high levels of CO.

CONCLUSIONS

Neither the one-hour National Ambient Air Quality Standard of 35 parts per million (ppm) nor the 8-hour standard of 9 ppm was exceeded at any of the five carbon monoxide monitoring sites in Connecticut during 1996.

In order to put the monitored data into proper perspective, it must be realized that carbon monoxide concentrations vary greatly from place-to-place. The magnitude and frequency of high concentrations observed at any monitoring site are not necessarily indicative of widespread CO levels. Mobile sources contribute 83% of the CO emissions in Connecticut, and three quarters of this can be attributed to motor vehicles. Therefore, the highest concentrations occur in areas of traffic congestion. In fact, 4 of the 5 CO monitors in Connecticut are sited specifically to measure CO levels from high traffic areas. The fifth monitor (Hartford 013) is located in a populated area and represents background levels of a neighborhood scale.

As Connecticut's SIP control strategies are implemented, there should continue to be a decrease in the number of areas with traffic congestion. Also, as federal and state mandated controls continue to reduce emissions from new motor vehicles, ambient levels of CO should continue to decline.

Unlike SO_2, particulate matter, and O_3, elevated CO levels are not often associated with southwesterly winds, indicating that this pollutant is more of a local-scale, rather than a regional-scale, problem. Moreover, high CO levels tend to occur during the colder months when there are low atmospheric mixing heights, stable conditions and high CO auto emissions due to cold engine operation. Stable conditions, which are characterized by cold temperatures at the surface and warm temperatures aloft, discourage surface mixing and result in calm surface conditions. With little or no surface winds, CO emissions can accumulate to unhealthy levels.

METHOD OF MEASUREMENT

The DEP Air Monitoring Section uses instruments employing a non-dispersive infrared technique to continuously measure carbon monoxide levels. The instantaneous concentrations are electronically recorded at the site, averaged for each hour, and stored for transmission to the central computer in Hartford. Due to the relative inertness of CO, a long sampling line can be used without the danger of CO being depleted by chemical reactions within the line. The most important consideration in the measurement of CO is the placement of the sampling probe inlet -- that is, its proximity to traffic lanes.

DISCUSSION OF DATA

Monitoring Network - The network in 1996 consisted of five carbon monoxide monitors: Bridgeport 004, Hartford 013, Hartford 017, New Haven 025, and Stamford 020. They are all located in urban areas. All the sites are also located west of the Connecticut River, with three of them in coastal towns (see Figure 6-1). The Hartford 017 site was temporarily shut down in February of 1996 due to local construction work and will be reactivated when the work is completed.

Precision and Accuracy - The carbon monoxide monitors had a total of 195 precision checks during 1996. The resulting 95% probability limits were -3% to +5%. Accuracy is determined by introducing a known amount of CO into each of the monitors. Eight audits for accuracy were conducted on the monitoring network in 1996. Three different concentration levels were tested on each monitor: low, medium and high. The 95% probability limits ranged from -5% to +5% for the low level test; -7% to +3% for the medium level test; and -2% to +4% for the high level test.

8-Hour and 1-Hour Averages - An 8-hour concentration is said to exceed the standard of 9 ppm if it is equal to or greater than 9.5 ppm. No site had an exceedance of the 8-hour CO standard, which means that the 8-hour standard was not violated in Connecticut in 1996. The maximum 8-hour running average decreased from 1995 to 1996 at each of the four sites that operated for most of the two year period. The decreases ranged from 1.5 ppm at New Haven 025 to 0.9 ppm at Hartford 013. The second highest 8-hour running average also decreased at each of the four sites. The decreases ranged from 1.6 ppm at Bridgeport 004 to 0.7 ppm at New Haven 025.

As for 1-hour averages, no site in the state recorded a value exceeding the primary 1-hour standard of 35 ppm. All four sites that were in operation in both 1995 and 1996 recorded maximum 1-hour values that were lower in 1996. The decreases ranged from 2.8 ppm at Stamford 020 to 2.2 ppm at Hartford 013. The second high 1-hour values at all these sites were also lower in 1996. The decreases ranged from 2.3 ppm at Bridgeport 004 to 1.1 ppm at Stamford 020.

The maximum and second high CO concentrations at each site are presented in Table 6-1. Table 6-2 presents monthly high concentrations and the monthly average concentration at each site. Seasonal variations in CO levels can be observed using this table.

Trends - Due to the local nature of CO emissions, it is not appropriate to give an estimate of widespread CO trends. However, local CO trends can be addressed in a number of ways. Exceedances of the 8-hour standard can be tracked in order to determine if a CO problem is worsening or abating at a site. This is illustrated in Table 6-3. One can see that over the past five years the Hartford-017 site is the only monitoring site with an exceedance of the 8-hour CO standard. No exceedances were recorded at any of the other sites during this period.

Another way of illustrating local CO trends is to use running averages. Running averages have the advantage of smoothing out the abrupt, transitory changes in pollutant levels that are often evident in consecutive sampling periods and from one season to the next. Figure 6-2 shows the 36-month running averages of the hourly CO concentrations at each monitoring site. CO levels are relatively flat at Bridgeport 004, Hartford 013 and Stamford 020, and are falling at Hartford 017. Since the New Haven 025 site has only been in operation since February of 1995, it lacks sufficent data for inclusion in Figure 6-2.

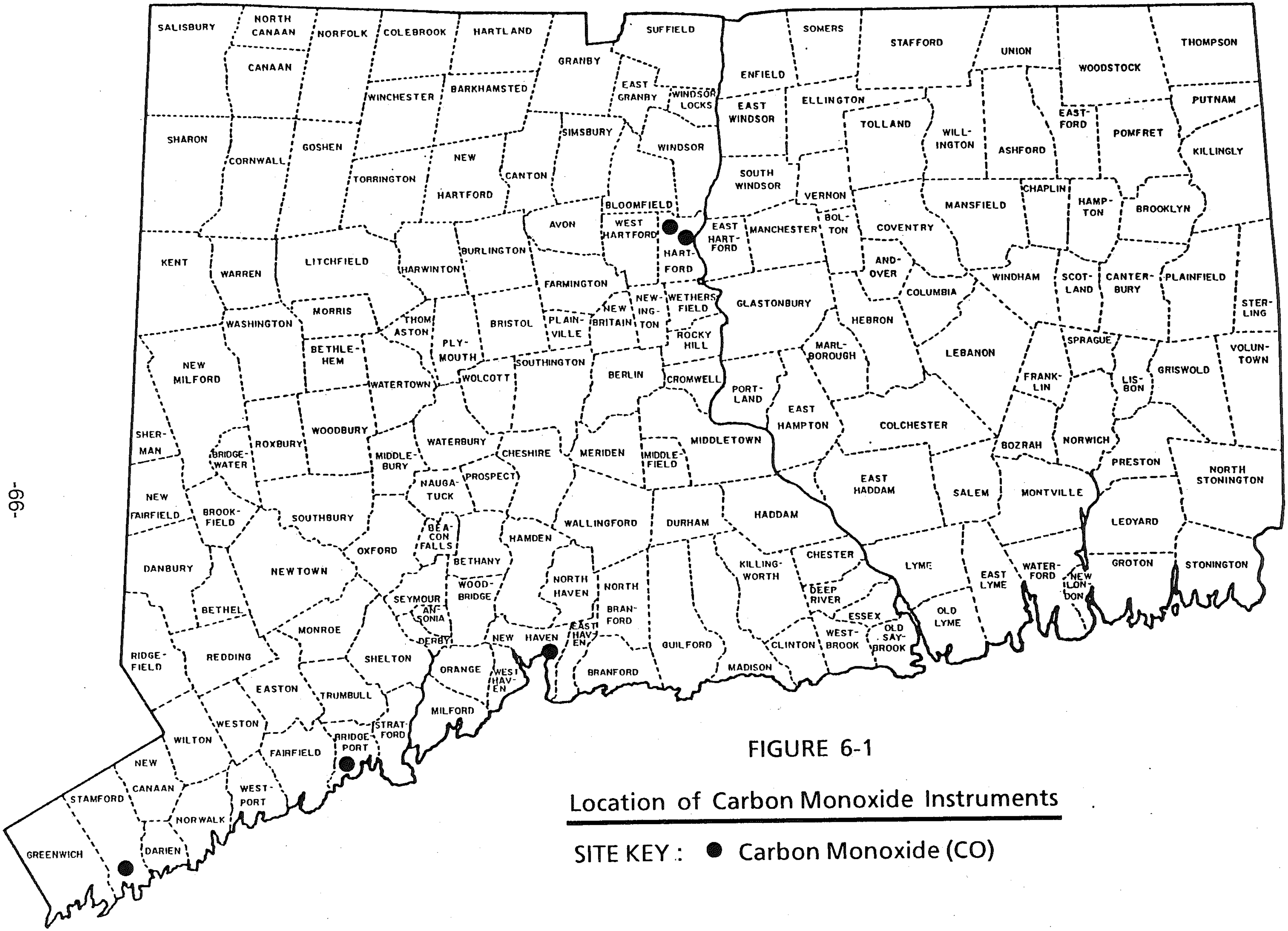


FIGURE 6-1

Location of Carbon Monoxide Instruments

SITE KEY : ● Carbon Monoxide (CO)

TABLE 6-1

1996 CARBON MONOXIDE STANDARDS ASSESSMENT SUMMARY

TOWN-SITE	MAXIMUM 8-HOUR RUNNING AVERAGE	TIME OF MAXIMUM 8-HOUR RUNNING AVERAGE[1]	2ND HIGH 8-HOUR RUNNING AVERAGE	TIME OF 2ND HIGH 8-HOUR RUNNING AVERAGE[1]	MAXIMUM 1-HOUR AVERAGE	TIME OF MAXIMUM 1-HOUR AVERAGE[2]	2ND HIGH 1-HOUR AVERAGE	TIME OF 2ND HIGH 1-HOUR AVERAGE[2]
Bridgeport 004	3.6	01/01/02	3.3	12/09/02	4.9	03/13/22	4.7	03/05/18
Hartford 013	3.9	11/17/06	3.4	03/13/04	4.3	01/10/09	4.2	02/22/22
Hartford 017[3]	5.8	01/18/21	4.1	01/19/03	9.1	01/18/18	6.9	01/18/16
New Haven 025	3.0	01/01/03	3.0	10/17/11	4.6	03/12/21	4.1	02/07/09
Stamford 020	4.3	02/16/01	4.1	03/15/14	6.7	02/07/09	6.5	03/12/21

[1] The time of the 8-hour average is reported as follows: month/day/hour (EST), specifying the end of the 8-hour period.

[2] The time of the 1-hour average is reported as follows: month/day/hour (EST), specifying the end of the 1-hour period.

[3] This site was closed down in February due to nearby construction work. The site will be reactivated when the work has been completed.

N.B. The CO averages are expressed in terms of parts per million (ppm).

TABLE 6-2

1996 CARBON MONOXIDE SEASONAL FEATURES

TOWN-SITE	AVERAGING PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Bridgeport 004	Max. 1-Hour	3.1	4.2	4.9	3.7	2.8	2.9	2.1	2.3	3.8	3.9	4.5	4.4
	Max. Running 8-Hour	3.6	2.9	3.0	1.8	1.7	2.0	1.6	1.8	2.1	2.3	2.5	3.3
	Month	1.1	1.0	0.9	0.8	0.9	1.1	1.0	1.1	1.1	1.1	1.0	1.1
Hartford 013	Max. 1-Hour	4.3	4.2	3.6	2.0	2.3	1.3	1.9	1.6	1.9	2.3	4.1	3.4
	Max. Running 8-Hour	3.0	3.1	3.4	1.7	2.1	1.2	1.4	1.1	1.6	2.1	3.9	3.2
	Month	0.9	0.9	0.9	0.6	0.6	0.6	0.7	0.8	0.8	1.0	1.1	0.9
Hartford 017*	Max. 1-Hour	9.1											
	Max. Running 8-Hour	5.8											
	Month	1.5											
New Haven 025	Max. 1-Hour	3.5	4.1	4.6	2.3	2.0	2.0	2.5	2.7	2.8	4.1	2.9	3.6
	Max. Running 8-Hour	3.0	2.9	2.7	2.0	1.5	1.6	1.5	1.7	1.9	3.0	2.5	2.6
	Month	1.0	1.1	1.0	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0
Stamford 020	Max. 1-Hour	4.6	6.7	6.5	4.5	3.7	3.0	2.6	3.0	3.8	5.4	6.2	4.3
	Max. Running 8-Hour	3.8	4.3	4.1	3.0	2.3	2.4	2.0	2.4	2.5	3.1	3.8	3.2
	Month	1.7	1.7	1.8	1.5	1.2	1.1	1.1	1.3	1.2	1.5	1.5	1.6
NETWORK	Month	1.2	1.2	1.2	0.9	0.9	0.9	0.9	1.0	1.0	1.2	1.2	1.2

* This site was closed down in February due to nearby construction work. The site will be reactivated when the work is completed.

N.B. The CO concentrations are in terms of parts per million (ppm).

TABLE 6-3

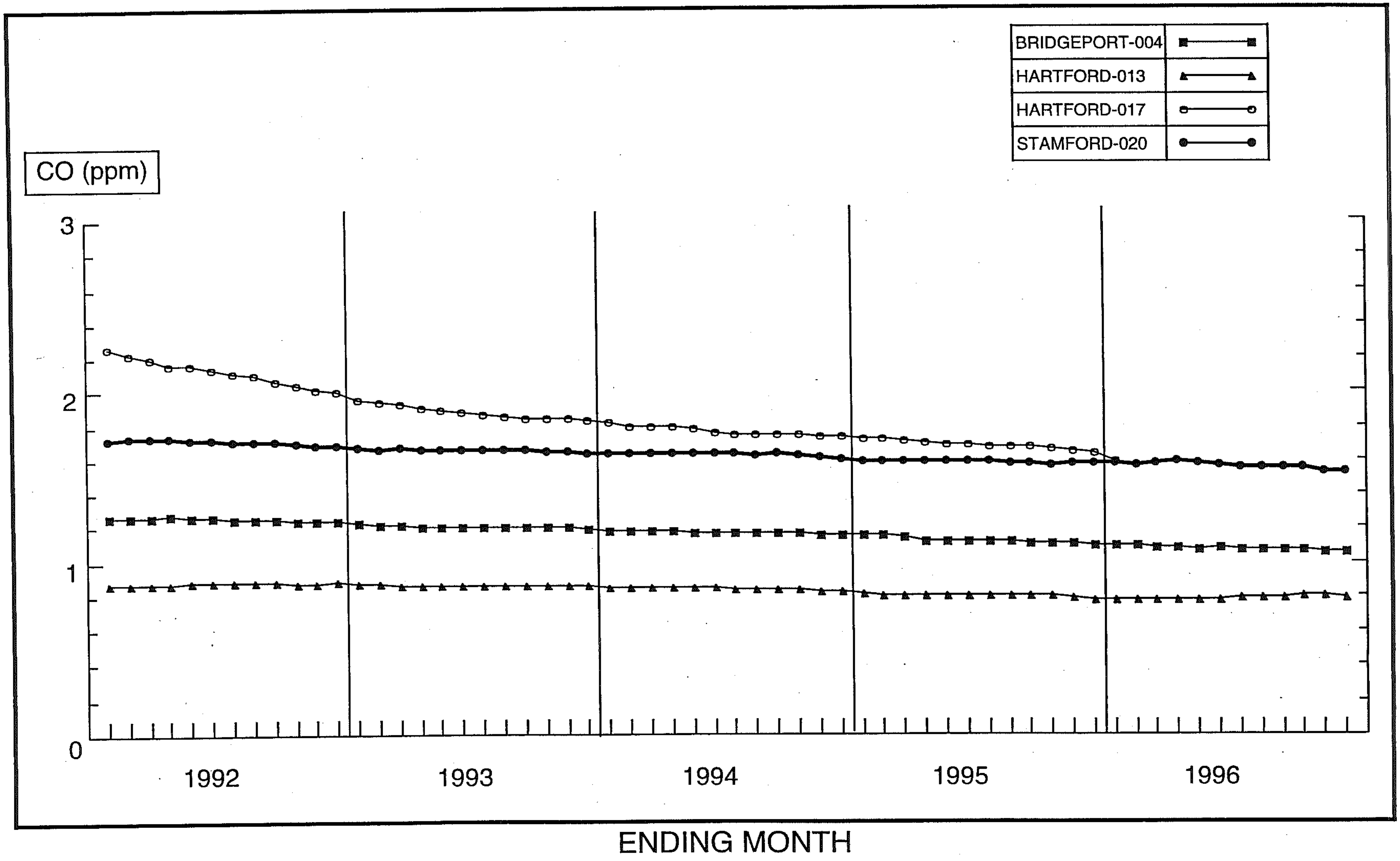
EXCEEDANCES OF THE 8-HOUR CO STANDARD FOR 1992-1996

SITE	1992	1993	1994	1995	1996
Bridgeport 004	0	0	0	0	0
Hartford 013	0	0	0	0	0
Hartford 017	1	0	0	1	0[a]
New Haven 025	0	0	0	0	0
Stamford 020	0	0	0	0	0

[a] The site was closed down in February of 1996 due to nearby construction work. The site will be reactivated when the work is completed.

FIGURE 6-2

36-MONTH RUNNING AVERAGES OF THE HOURLY CO CONCENTRATIONS



VII. LEAD

HEALTH EFFECTS

Lead (Pb) is a soft, dull gray, odorless and tasteless heavy metal. It is a ubiquitous element that is widely distributed in small amounts, particularly in soil and in all living things. Although the metallic form of lead is reactive and rarely occurs in nature, lead is prevalent in the environment in the form of various inorganic compounds, and occasional concentrated deposits of lead compounds occur in the earth's crust.

The presence of lead in the atmosphere is primarily accounted for by the emissions of lead compounds from man-made processes, such as the extraction and processing of metallic ores, the incineration of solid wastes, and the operation of motor vehicles. Nationally, in recent years, these source categories contributed 41%, 17% and 32%, respectively, of the atmospheric lead. The motor vehicle contribution, while still a large source of airborne lead emissions, has decreased significantly over the years and, since 1988, is no longer the largest source of nationwide airborne lead emissions. These emissions are in the form of fine-to-course particulate matter and are comprised of lead sulfate, ammonium lead halides, and lead halides, of which the chief component is lead bromochloride. The halide compounds appear to undergo chemical changes over a period of hours and are converted to lead carbonate, oxide and oxycarbonate.

The most important sources of lead in humans and other animals are ingestion of foods and beverages, inhalation of airborne lead, and the eating of non-food substances. From the standpoint of the general population, the intake of lead into the body is primarily through ingestion. The airborne lead settles out on crops and water supplies and is then ingested by the general population. The direct intake of lead from the ambient air is relatively small.

Overexposure to lead in the United States is primarily a problem in children. Age, pica, diet, nutritional status, and multiple sources of exposure serve to increase the risk of lead poisoning in children. This is especially true in the inner cities where the prevalence of lead poisoning is greatest. Overexposure to lead compounds may result in undesirable biologic effects. These effects range from reversible clinical or metabolic symptoms, which disappear after cessation of exposure, to permanent damage or death from a single extreme dose or prolonged overexposure. Clinical lead poisoning is accompanied by symptoms of intestinal cramps, peripheral nerve paralysis, anemia, and severe fatigue. Very severe exposure results in permanent neurological, renal, or cardiovascular damage or death.

CONCLUSIONS

The Connecticut primary and secondary ambient air quality standard for lead and its compounds is 1.5 µg/m^3, weighted 3-month average. This standard was not exceeded at any site in Connecticut during 1996.

The monitoring sites where the lead levels were highest were generally in urban locations with moderate to heavy traffic. In Connecticut, this is due to the fact that the primary source of lead to the atmosphere is the combustion of gasoline, which still contains trace amounts of lead.

Ambient lead levels in Connecticut have been extremely low for the years 1987-1996 (see figure 7-2). In comparison to the standard of 1.5 µg/m^3, the 10-year average of the statewide annual ambient lead concentrations is 0.041µg/m^3, only 2.7% of the standard. Because of this, Connecticut has decided (with EPA approval) to discontinue sampling for lead, and 1996 will be the last year for the discussion of lead data in this report.

SAMPLE COLLECTION AND ANALYSIS

The Air Monitoring Unit used hi-vol samplers in 1996 to obtain ambient concentrations of lead. These samplers are used to collect particulate matter onto fiberglass filters. The particulate matter collected on the filters is subsequently analyzed for its chemical composition. Wet chemistry techniques are used to separate the particulate matter into various components. The lead content of the particulate matter is determined using an atomic absorption spectrophotometer.

Unlike hi-vol particulate samples which are analyzed separately, the hi-vol lead sample is a composite of all the individual samples obtained at a site in a single month. That is, a cutting is taken from each filter during the month, and these cuttings are collectively chemically analyzed for lead.

DISCUSSION OF DATA

Monitoring Network - In 1996, only hi-vol samplers were operated in Connecticut to determine lead levels. There were 5 such samplers operated by the DEP in the heavily populated counties of Fairfield, Hartford and New Haven (see Figure 7-1). The samplers are situated near some of the busiest city streets and highways in order to monitor "worst-case" lead concentrations.

Much of the lead monitoring network was dismantled in 1988 due to the changeover from hi-vol to PM_{10} monitoring in the particulate matter network. By the end of that year, all but two of the hi-vol lead sampling sites were terminated: Hartford 013 and New Haven 013. By the end of 1989, the remaining hi-vol samplers were terminated and only lo-vol samplers were in use.

In 1991, the lo-vols were replaced by hi-vols. The primary reason for this has to do with data losses resulting from instrument problems or failures. With a lo-vol, an entire month of data is invalidated if an instrument fails because lo-vols operate continuously for a month. In the case of a hi-vol, instrument problems or failures result in the loss of only a single 24-hour sample.

Precision and Accuracy - Due to the very low airborne lead concentrations, precision checks yield 95% probability limits that are statistically unrealistic. Accuracy for lead can be assessed in two ways. One is by auditing the air flow through the monitors. Six audits for flow accuracy were conducted on the monitoring network in 1996. The probability limits ranged from -20% to +2%. Accuracy can also be defined as the accuracy of the analysis method. This is determined by the chemical analysis of known lead samples. On this basis, 4 audits were performed on the network. Two different concentration levels were tested: high and low. The 95% probability limits for the low level ranged from -5% to +11%; those for the high level ranged from -9% to +13%.

NAAQS - Connecticut's ambient air quality standard for lead and its compounds, measured as elemental lead, is: 1.5 micrograms per cubic meter ($\mu g/m^3$), maximum arithmetic mean averaged over three consecutive calendar months. This standard was enacted on November 2, 1981. Previously, Connecticut's lead standard was identical to the national standard: 1.5 $\mu g/m^3$ for a calendar quarter-year average. The change to a 3-month running average means that a more stringent standard applies in Connecticut, since there are three times as many data blocks within a calendar year which must not exceed the limiting concentration of 1.5 $\mu g/m^3$.

3-Month Running Averages - Three-month running average lead concentrations for 1996 are given in Table 7-1. All are significantly below the primary and secondary standard of 1.5 $\mu g/m^3$.

Trends - A downward trend in measured concentrations of lead has been observed since 1977. This is due to the increasing use of unleaded gasoline. Figure 7-2 shows that the decrease in statewide ambient average lead concentrations has been commensurate with a decrease in lead emissions from gasoline combustion from 1982 to 1989. In fact, this relationship is so close it has a correlation coefficient of 0.987 (see Figure 7-3). Reliable data on the sales of leaded gasoline in Connecticut are unavailable after 1989; so lead emissions are no longer updated in Figure 7-2, and Figure 7-3 contains only pre-1990 data.

The downward trend in airborne lead concentrations can be expected to level off when the use of leaded gasoline is finally phased out or minimized. Lead emissions will then rise and fall with the number of vehicle miles travelled (VMT's) by the population. This is due to the fact that so-called unleaded gasoline still contains a small proportion of lead.

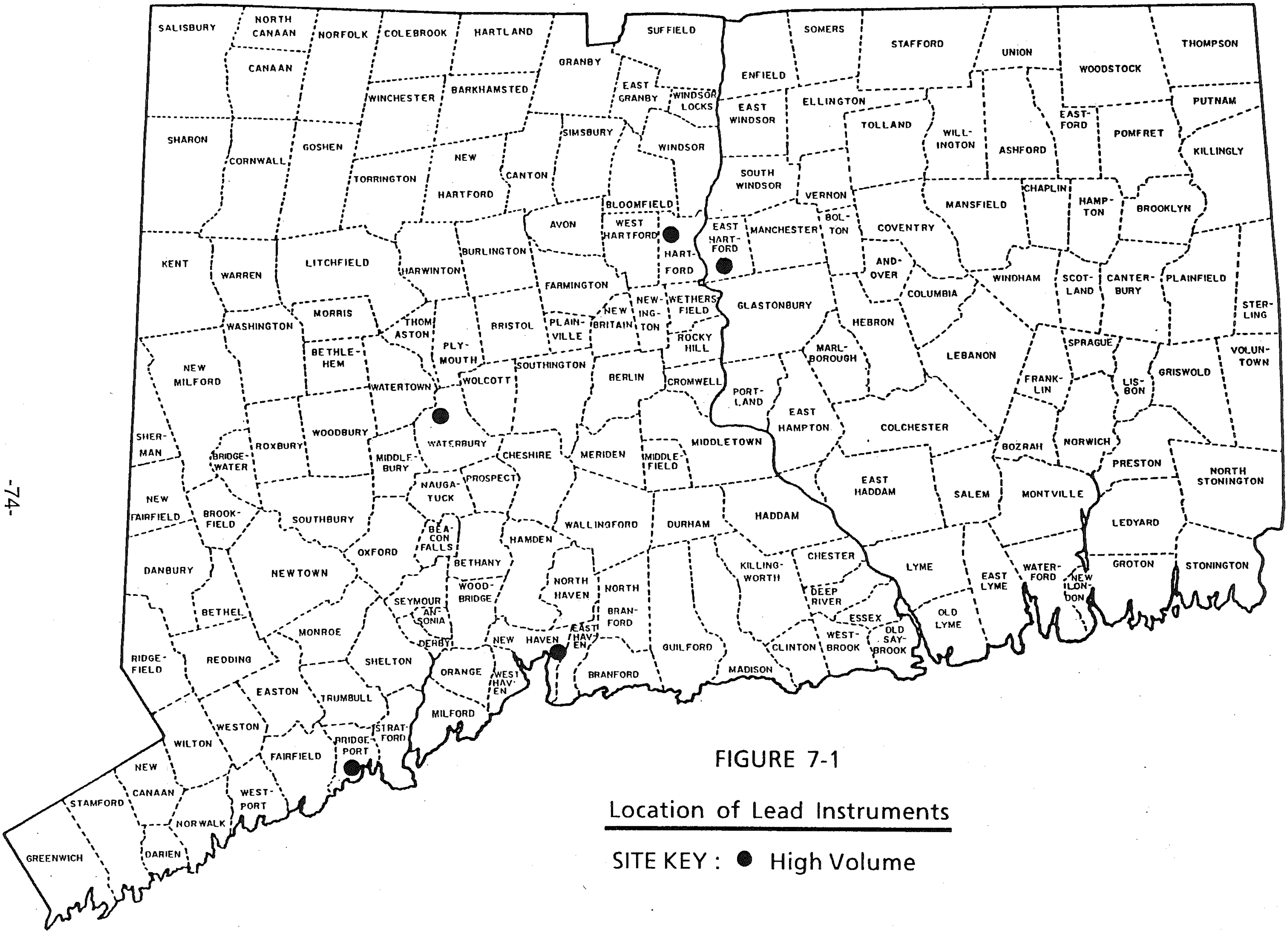


FIGURE 7-1

Location of Lead Instruments

SITE KEY : ● High Volume

TABLE 7-1

1996 3-MONTH RUNNING AVERAGE LEAD CONCENTRATIONS[a]

TOWN-SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Bridgeport 010	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.01	0.01	0.02
East Hartford 004	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Hartford 016	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.02
New Haven 018	0.04	0.08	0.08	0.09	0.06	0.05	0.04	0.03	0.03	0.03	0.03	0.03
Waterbury 123	0.03	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.04

[a] The lead concentrations are in terms of micrograms per cubic meter (µg/m³).

FIGURE 7-2

STATEWIDE ANNUAL LEAD EMISSIONS FROM GASOLINE

AND

STATEWIDE ANNUAL AVERAGE LEAD CONCENTRATIONS

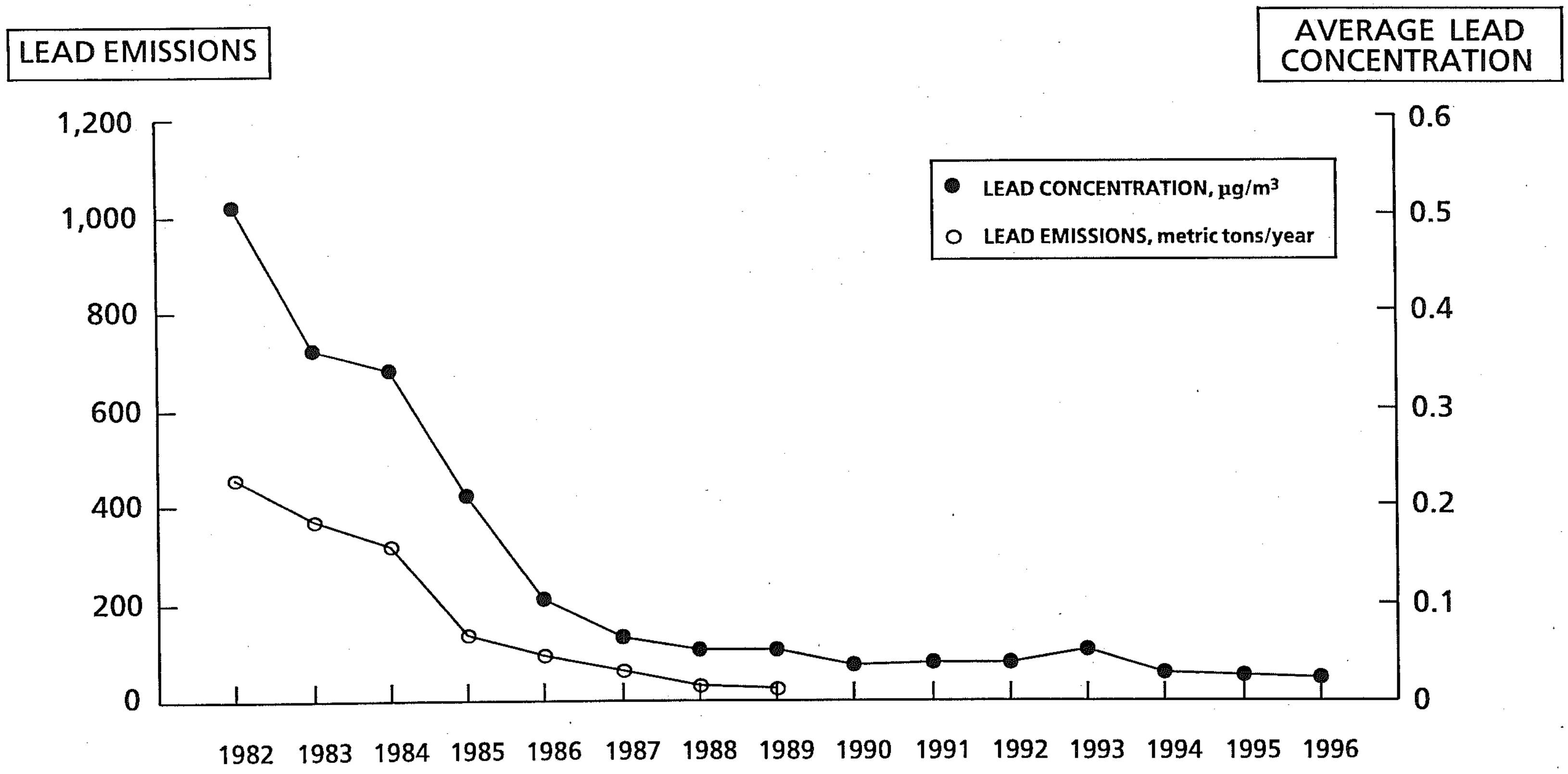
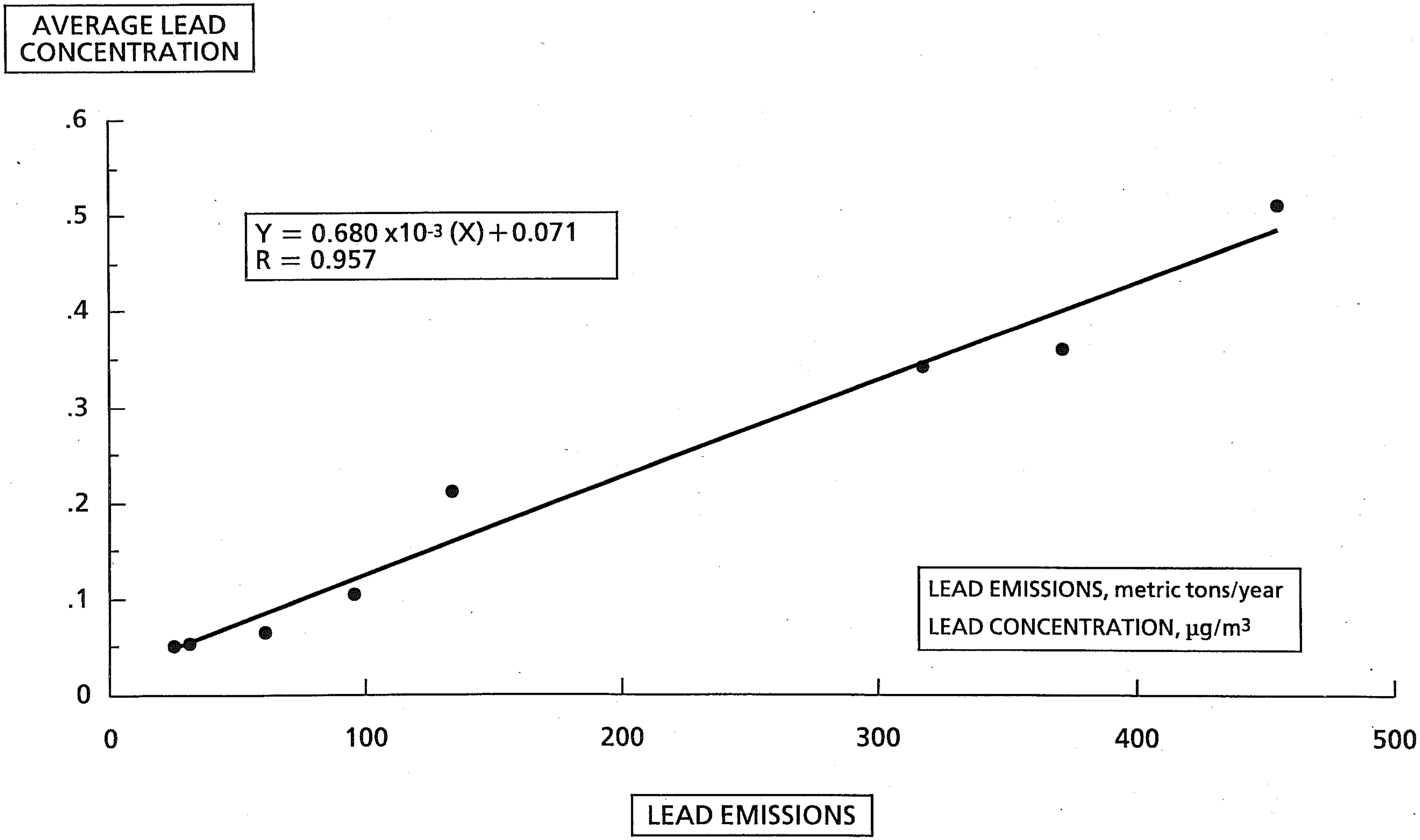


FIGURE 7-3

STATEWIDE ANNUAL AVERAGE LEAD CONCENTRATIONS

VS.

STATEWIDE ANNUAL LEAD EMISSIONS FROM GASOLINE



VIII. CLIMATOLOGICAL DATA

Weather is often the most significant factor influencing short-term changes in air quality. It also has an affect on long-term trends. Climatological information from the National Weather Service station at Bradley International Airport in Windsor Locks is shown in Table 8-1 for the years 1995 and 1996. Table 8-2 contains information from the National Weather Service station located at Sikorsky Memorial Airport near Bridgeport. All data are compared to "mean" or "normal" values. Wind speeds[1] and temperatures are shown as monthly and yearly averages. Precipitation data includes both the number of days with more than 0.01 inches of precipitation and the total water equivalent. Also shown are the number of degree days[2] (heating requirement) and the number of days with temperatures exceeding 90°F.

Wind roses for State of Connecticut monitoring sites in Greenwich and Stafford have been developed from 1996 wind measurements taken at these sites and are shown in Figures 8-2 and 8-4, respectively. Wind roses from these stations for 1995 are shown in Figures 8-1 and 8-3, respectively.

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[1] The mean wind speed for a month or year is calculated from all the hourly wind speeds, regardless of the wind directions.

[2] The degree day value for each day is arrived at by subtracting the average temperature of the day from 65°F. This number is used as a base value because it is assumed that there is no heating requirement when the outside temperature is 65°F or above.

TABLE 8-1

1995 AND 1996 CLIMATOLOGICAL DATA
BRADLEY INTERNATIONAL AIRPORT, WINDSOR LOCKS

	AVERAGE TEMPERATURE F			NO. OF DAYS WHEN MAX. TEMP. EXCEEDED 90 F			HEATING DEGREE DAYS			PRECIPITATION IN EQUIVALENT INCHES OF WATER			NO. OF DAYS WITH MORE THAN 0.01 INCHES OF PRECIPITATION			AVERAGE WIND SPEED (MPH)		
	1995	1996	Mean[a]	1995	1996	Mean[b]	1995	1996	Normal[b]	1995	1996	Mean[a]	1995	1996	Mean[b]	1995	1996	Mean[c]
Jan	32.4	25.1	26.6	0	0	0.0	1005	1227	1252	3.84	3.58	3.57	16	16	10.7	8.2	10.1	9.0
Feb	25.8	27.7	27.8	0	0	0.0	1088	1078	1050	3.24	2.86	3.17	8	13	10.2	8.8	10.4	9.5
Mar	41.1	34.3	37.1	0	0	0.0	737	944	853	1.89	2.45	3.72	8	11	11.5	7.6	8.7	10.1
Apr	46.8	49.6	48.2	0	0	0.3	539	465	489	2.60	6.29	3.76	10	13	11.2	7.0	10.8	9.9
May	58.0	58.3	59.2	0	2	1.1	224	241	194	2.63	2.98	3.69	15	13	11.8	6.3	7.8	8.8
Jun	69.3	69.3	67.9	4	1	3.6	13	19	20	1.02	2.39	3.55	9	9	11.3	4.4	7.7	8.1
Jul	76.5	71.2	72.4	12	0	8.0	0	1	0	2.58	6.97	3.46	11	11	9.8	4.9	7.6	7.3
Aug	72.1	71.9	71.0	6	2	4.8	4	2	6	3.81	1.67	3.88	5	6	9.8	4.5	5.6	7.0
Sep	62.2	62.9	63.5	0	0	1.3	130	120	96	3.15	7.53	3.64	5	15	9.4	7.0	6.4	7.4
Oct	55.8	51.1	52.9	0	0	*	283	424	397	9.46	5.25	3.22	9	13	8.5	7.7	7.2	7.8
Nov	38.1	38.1	42.0	0	0	0.0	802	802	693	4.38	4.14	3.80	14	7	11.2	8.6	7.3	8.4
Dec	27.1	35.8	30.5	0	0	0.0	1169	900	1101	2.32	5.69	3.72	10	17	11.8	9.7	7.7	8.6
YEAR	50.4	49.6	49.9	22	5	19.1	5994	6223	6151	40.92	51.8	43.18	120	144	127.3	7.1	8.1	8.5

* Less than 0.05
[a] 1905-1996
[b] 1961-1990
[c] 1961-1996

Extracted From: Local Climatological Data Charts
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Environmental Data Service

TABLE 8-2

1995 AND 1996 CLIMATOLOGICAL DATA
SIKORSKY INTERNATIONAL AIRPORT, STRATFORD

	AVERAGE TEMPERATURE F			NO. OF DAYS WHEN MAX. TEMP. EXCEEDED 90 F			HEATING DEGREE DAYS			PRECIPITATION IN EQUIVALENT INCHES OF WATER			NO. OF DAYS WITH MORE THAN 0.01 INCHES OF PRECIPITATION			AVERAGE WIND SPEED (MPH)		
	1995	1996	Mean[a]	1995	1996	Mean[b]	1995	1996	Normal[b]	1995	1996	Mean[c]	1995	1996	Mean[b]	1995	1996	Mean[d]
Jan	35.6	28.4	28.6	0	0	0.0	905	1128	1119	2.98	4.91	3.55	13	14	10.2	---	---	12.9
Feb	29.4	30.8	30.5	0	0	0.0	993	984	969	2.85	2.67	3.20	7	13	9.6	---	---	13.4
Mar	41.4	36.2	38.0	0	0	0.0	724	888	818	2.07	2.75	3.93	8	9	11.0	---	---	13.3
Apr	48.1	48.7	48.1	0	0	*	498	484	504	3.61	9.42	3.87	11	14	9.8	---	---	12.8
May	58.6	57.4	58.5	0	1	0.1	203	258	219	2.27	2.31	3.71	13	12	11.0	---	8.6	11.4
Jun	68.8	68.2	67.9	1	0	0.9	6	15	18	1.44	3.63	3.29	12	13	10.2	---	7.5	10.0
Jul	77.0	71.2	73.4	6	0	2.8	0	0	0	1.32	5.94	3.63	7	12	8.3	---	8.2	9.9
Aug	74.8	72.6	72.0	6	0	1.4	0	1	0	1.37	1.34	3.97	4	5	9.1	---	6.9	9.5
Sep	66.1	66.3	65.2	0	0	0.3	56	62	54	3.15	4.79	3.51	6	11	8.0	---	8.7	10.7
Oct	58.6	54.0	54.7	0	0	0.0	204	334	302	5.71	7.78	3.35	8	12	7.2	---	---	11.6
Nov	41.6	40.7	44.2	0	0	0.0	695	721	582	4.33	3.35	3.70	12	8	10.7	---	9.1	12.1
Dec	30.1	39.1	33.4	0	0	0.0	1075	794	952	1.94	6.47	3.63	10	19	11.4	---	9.8	12.4
YEAR	52.5	51.1	51.2	13	1	5.5	5359	5669	5537	33.04	55.36	43.34	112	142	116.5	---	---	11.7

* Less than 0.05
[a] 1903-1996
[b] 1961-1990
[c] 1904-1996
[d] 1981-1996

Extracted From: Local Climatological Data Charts
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Environmental Data Service

FIGURE 8-1

ANNUAL WIND ROSE FOR 1995
GREENWICH POINT PARK
GREENWICH, CONNECTICUT

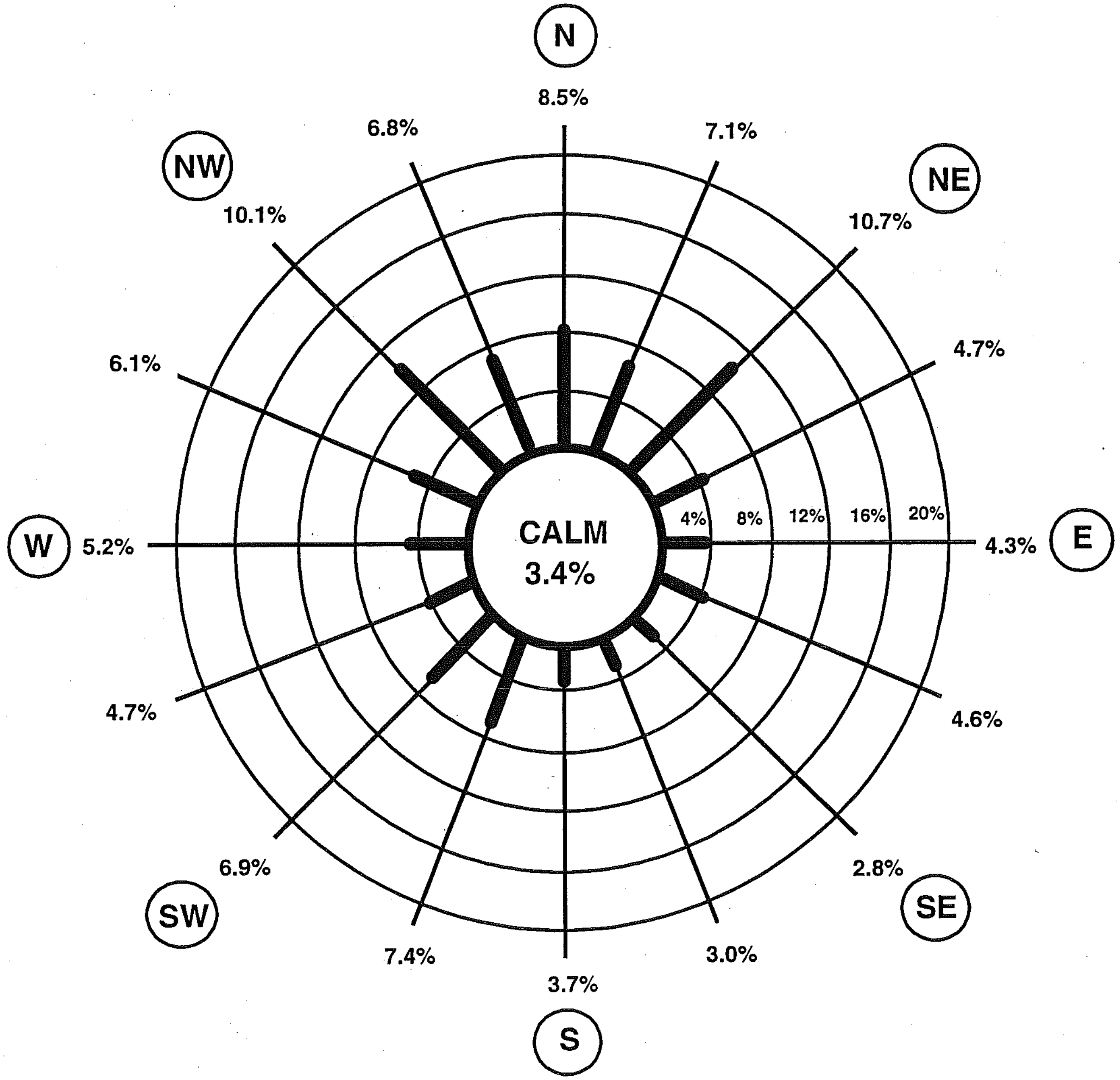


FIGURE 8-2

ANNUAL WIND ROSE FOR 1996
GREENWICH POINT PARK
GREENWICH, CONNECTICUT

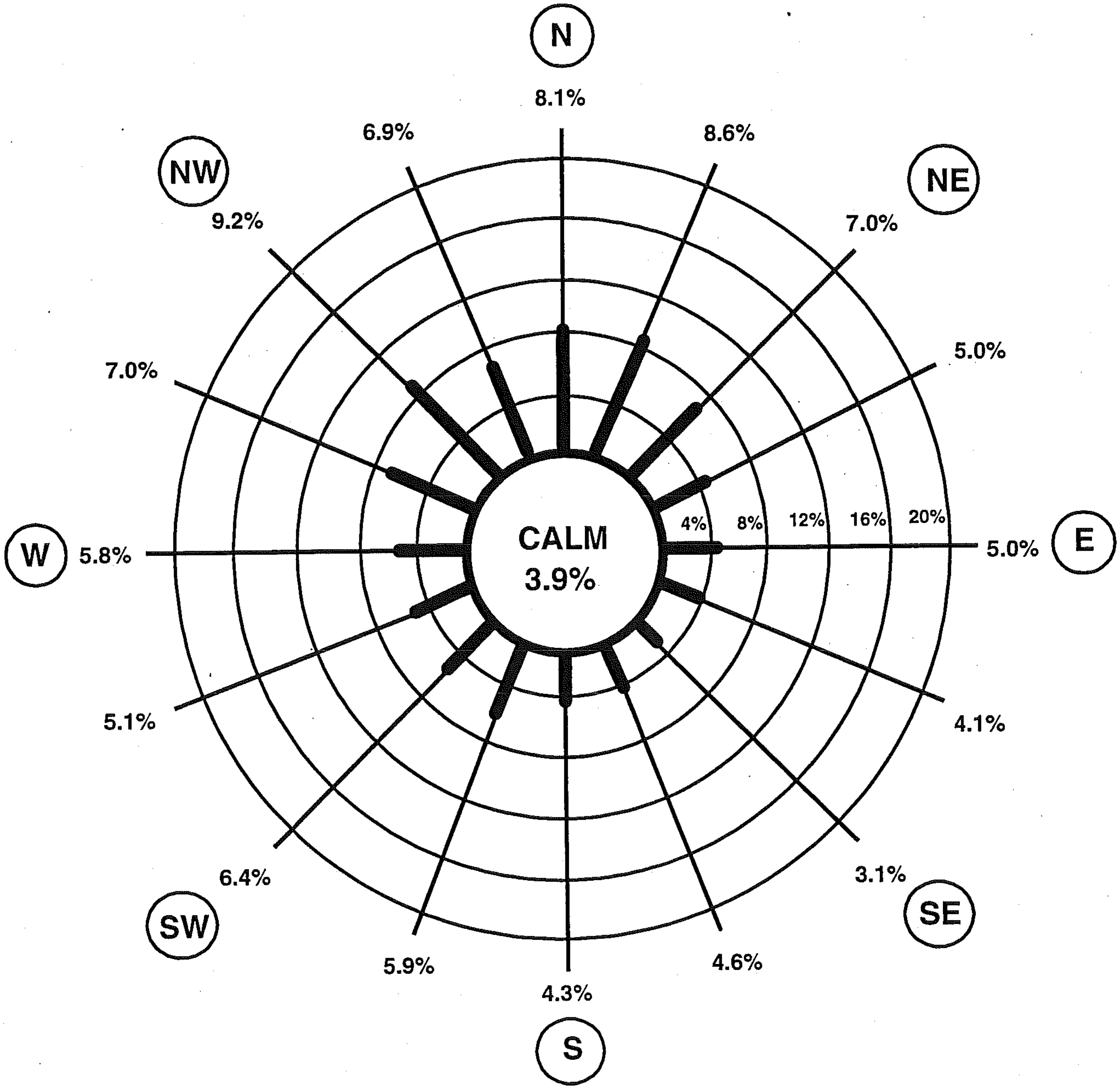


FIGURE 8-3

ANNUAL WIND ROSE FOR 1995
SHENIPSIT STATE FOREST
STAFFORD, CONNECTICUT

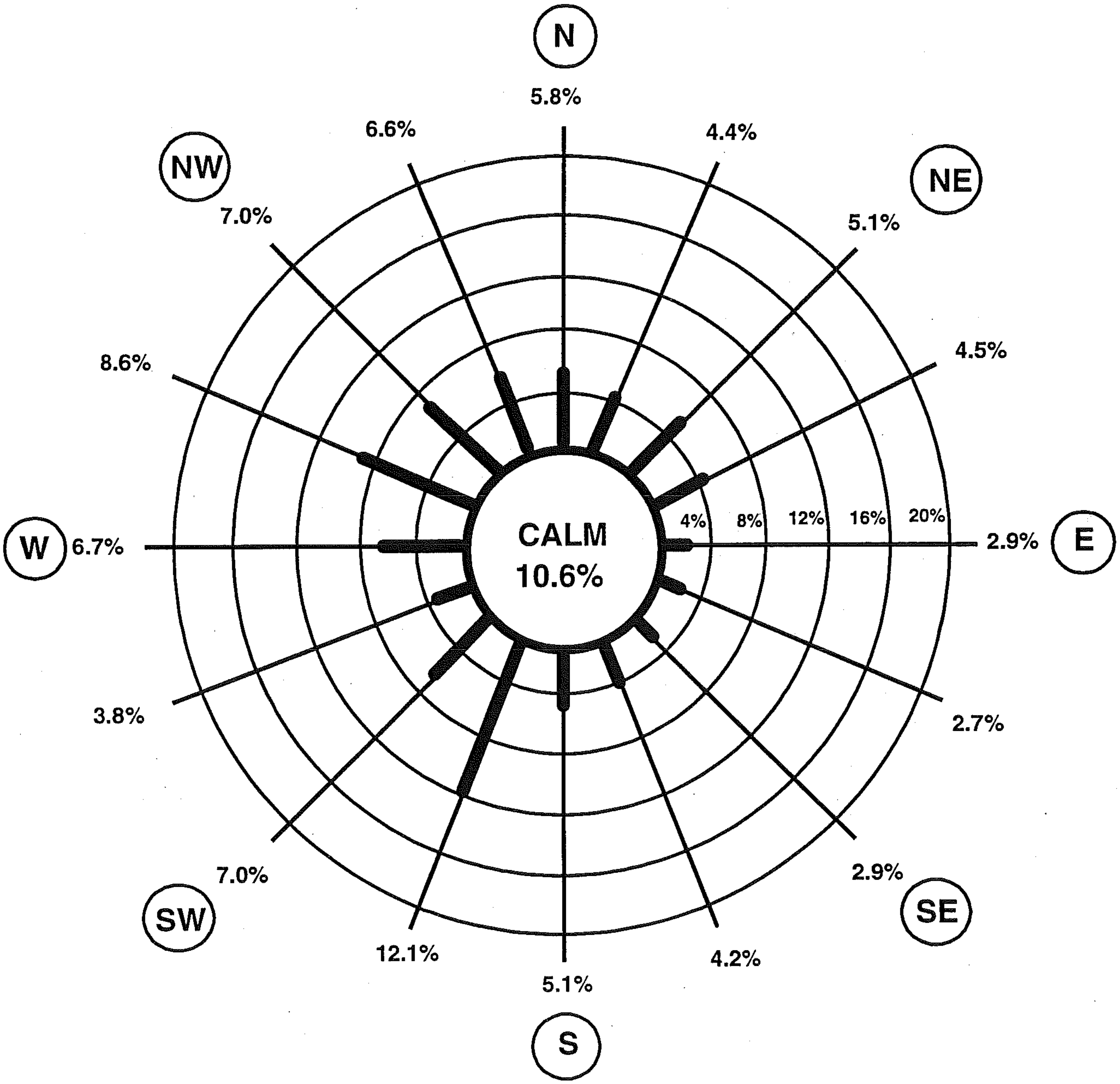
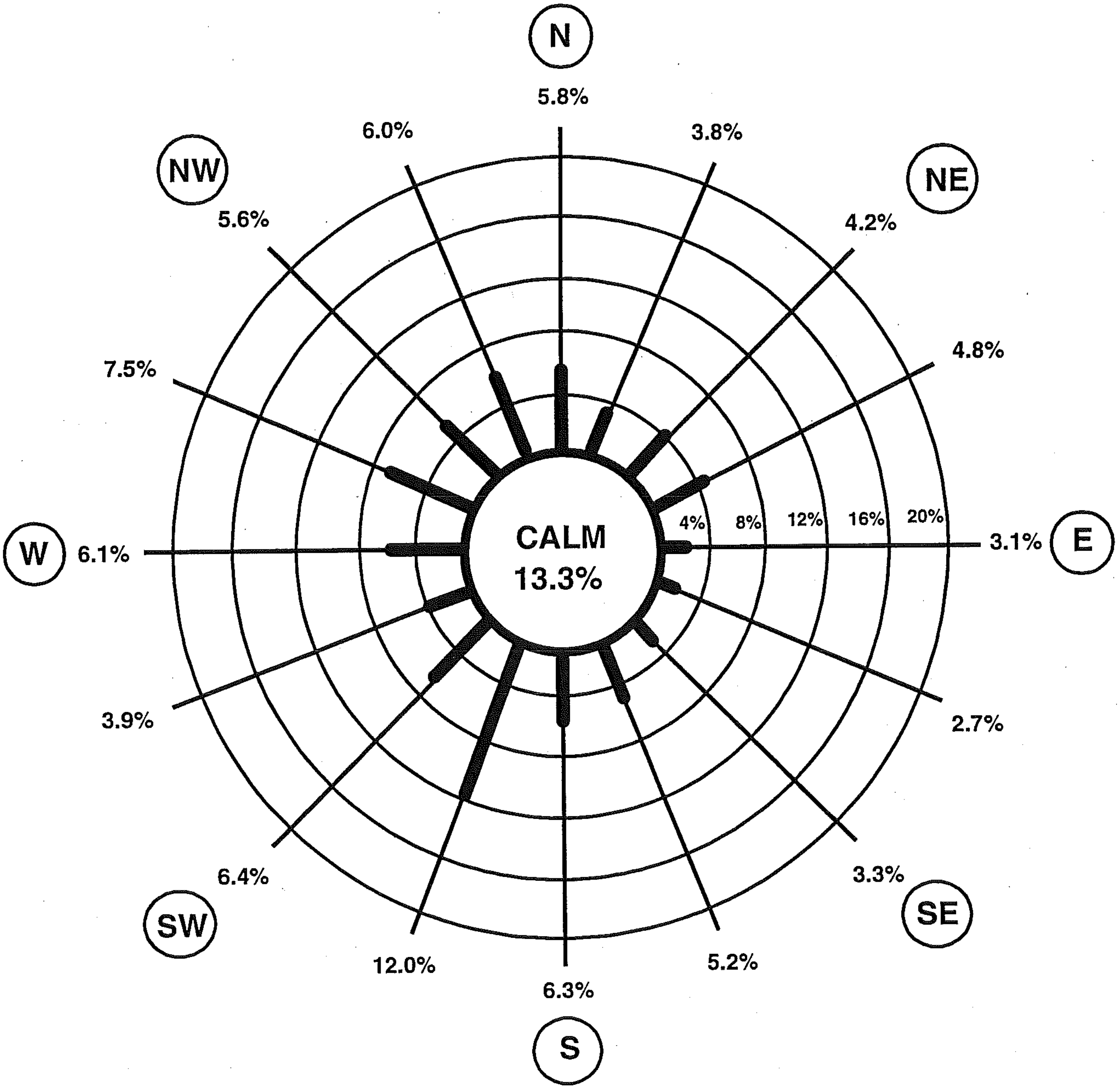


FIGURE 8-4

ANNUAL WIND ROSE FOR 1996
SHENIPSIT STATE FOREST
STAFFORD, CONNECTICUT



IX. ATTAINMENT AND NON-ATTAINMENT OF THE NAAQS IN CONNECTICUT

The State of Connecticut can be broadly designated as either attainment or non-attainment with respect to the National Ambient Air Quality Standards (NAAQS) for the following pollutants: particulate matter no greater than 10 micrometers in diameter (PM_{10}); sulfur dioxide (SO_2); ozone (O_3); nitrogen dioxide (NO_2); carbon monoxide (CO) ; and lead (Pb). The 1996 designations are:

Attainment	Non-attainment
NO_2	CO
Pb	Ozone
SO_2	PM_{10}

When the State has been designated as attainment for a pollutant, all regions of the State are in compliance with all the standards (i.e., short term and long term; primary and secondary) for the particular pollutant. This is the case for NO_2, Pb and SO_2.

When the State has been designated as non-attainment for a pollutant, one or more of the standards for the pollutant have been violated in one or more regions of the State. The non-attainment designation that is subsequently applied to a region can reflect the "degree" of non-attainment depending upon a number of factors: the air pollution history in the region; previous designation of the region as either attainment or non-attainment; lack of air pollutant monitoring in the region; inferences made based on pollutant monitoring done in adjacent or similar regions, *et al.* For example, the whole state is designated as non-attainment for ozone, but the degree of non-attainment varies between regions (see Figure 9-1). The region comprising Fairfield County (less Shelton), New Milford and Bridgewater is designated as "severe non-attainment" for ozone, while the rest of the State is designated as "serious non-attainment." The difference in the two designations is explained by higher ozone concentrations in excess of the 1-hour ozone standard in the Fairfield County portion of the NY-NJ-CT non-attainment area.

For CO, there is a mix of both attainment and non-attainment regions (see Figure 9-2). The region comprising Fairfield County (less Shelton), New Milford and Bridgewater is designated as "moderate non-attainment" primarily due to exceedances of the 8-hour CO standard in the New York / New Jersey portion of the region (not shown). The region comprising New Haven County, Bethlehem, Watertown, Woodbury, Thomaston and Shelton is designated as "unclassified non-attainment." This designation reflects the fact that although no exceedances of the CO standards have been recorded there in the recent past, the region was previously part of the New Haven -- Hartford -- Springfield Air Quality Control Region which was designated as non-attainment due to exceedances of the 8-hour CO standard recorded in the city of Hartford. The region comprising Hartford County (less Hartland), Tolland County, Middlesex County and Plymouth was redesignated as "attainment" by EPA on January 2, 1996 . This action was based on a technical analysis prepared by the Bureau of Air Management which demonstrates that the area has and will continue to maintain ambient CO concentrations levels within the air quality health standards. The two remaining regions of the State are designated as "unclassified attainment." This designation reflects the fact that although no CO monitoring has been done in these regions, their status as attainment areas can be inferred from population and traffic density data.

For PM_{10}, the entire State is designated as attainment, except for the city of New Haven (see Figure 9-3).

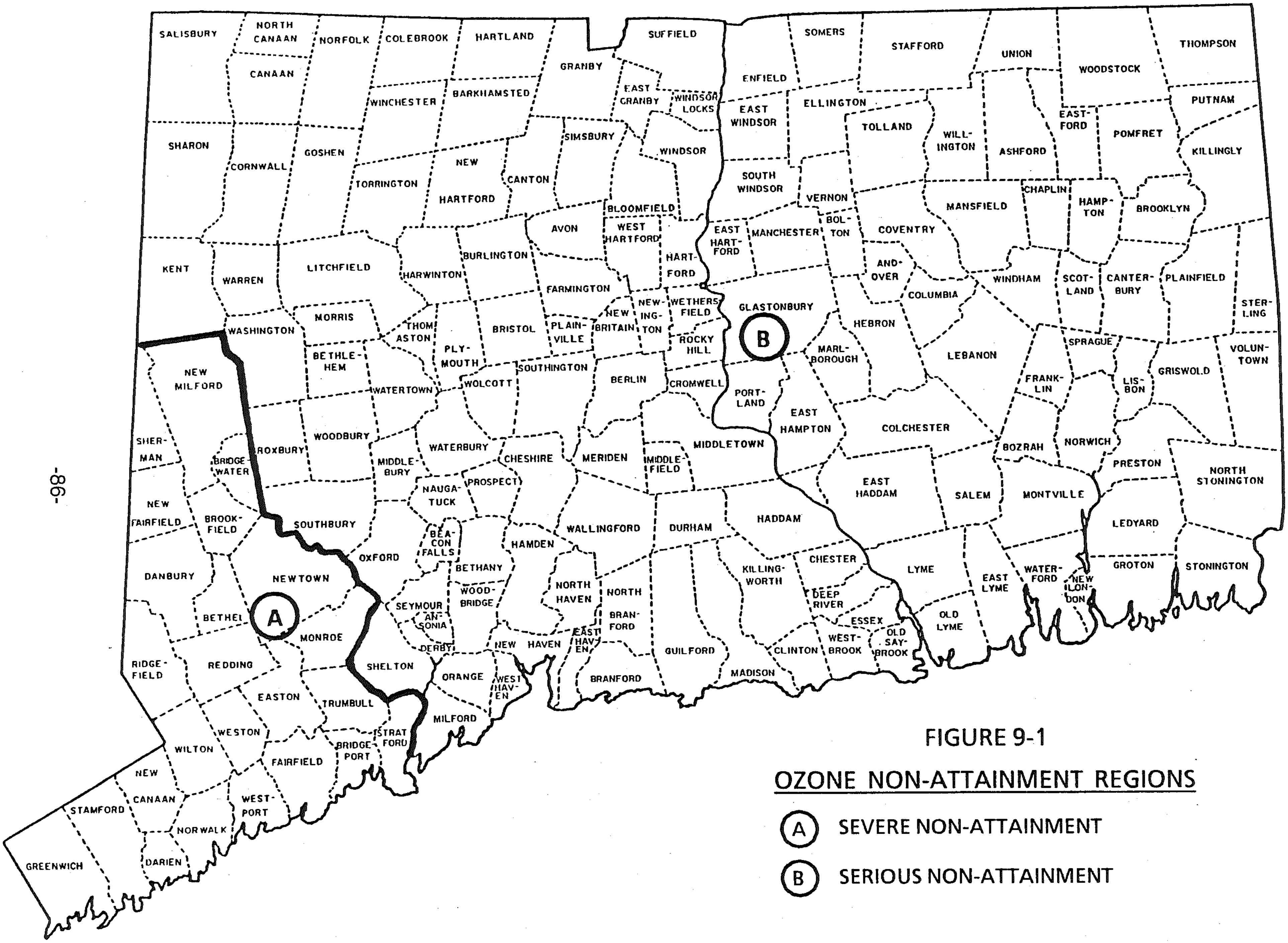


FIGURE 9-1

OZONE NON-ATTAINMENT REGIONS

Ⓐ SEVERE NON-ATTAINMENT

Ⓑ SERIOUS NON-ATTAINMENT

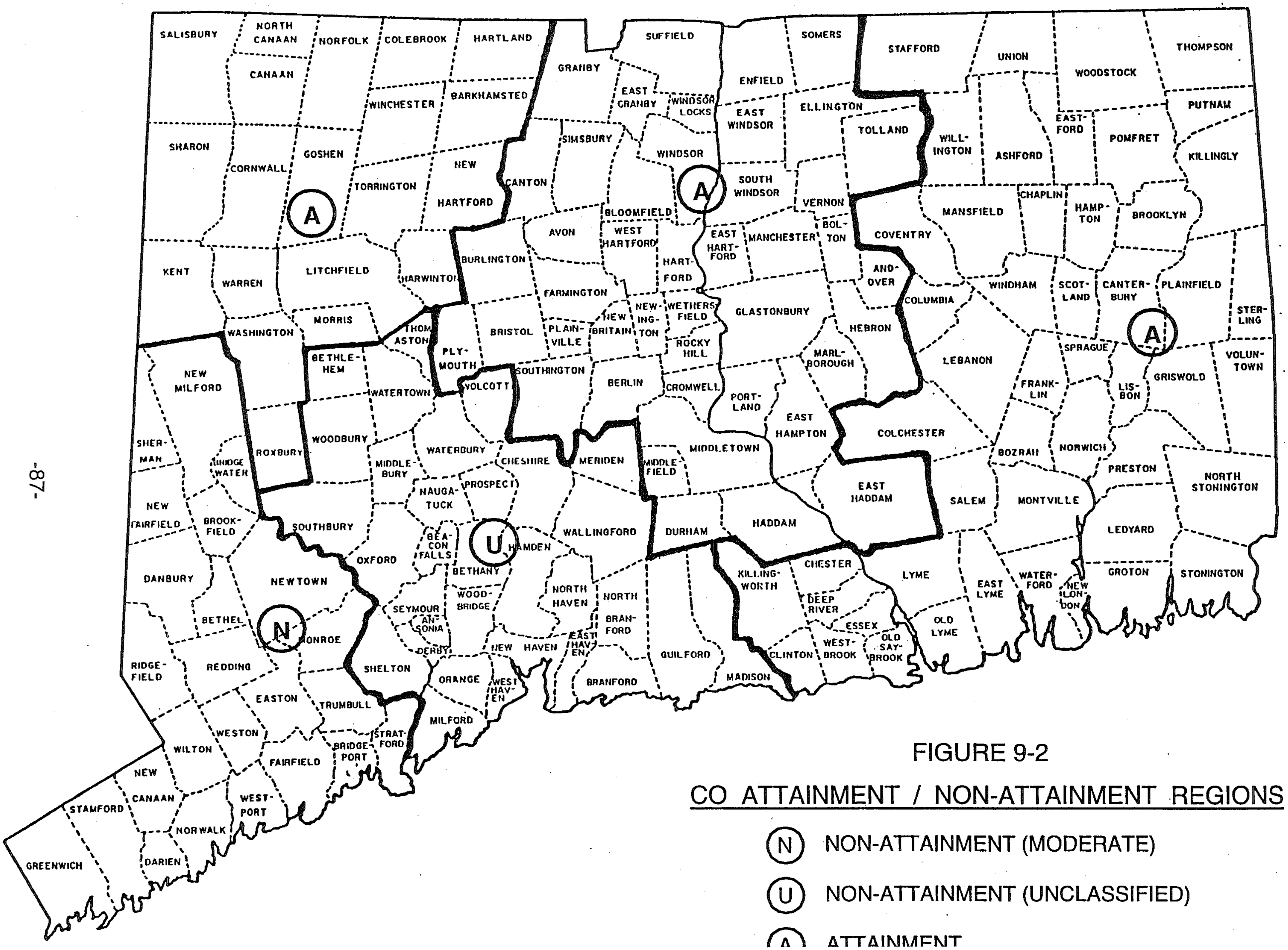


FIGURE 9-2

CO ATTAINMENT / NON-ATTAINMENT REGIONS

Ⓝ NON-ATTAINMENT (MODERATE)

Ⓤ NON-ATTAINMENT (UNCLASSIFIED)

Ⓐ ATTAINMENT

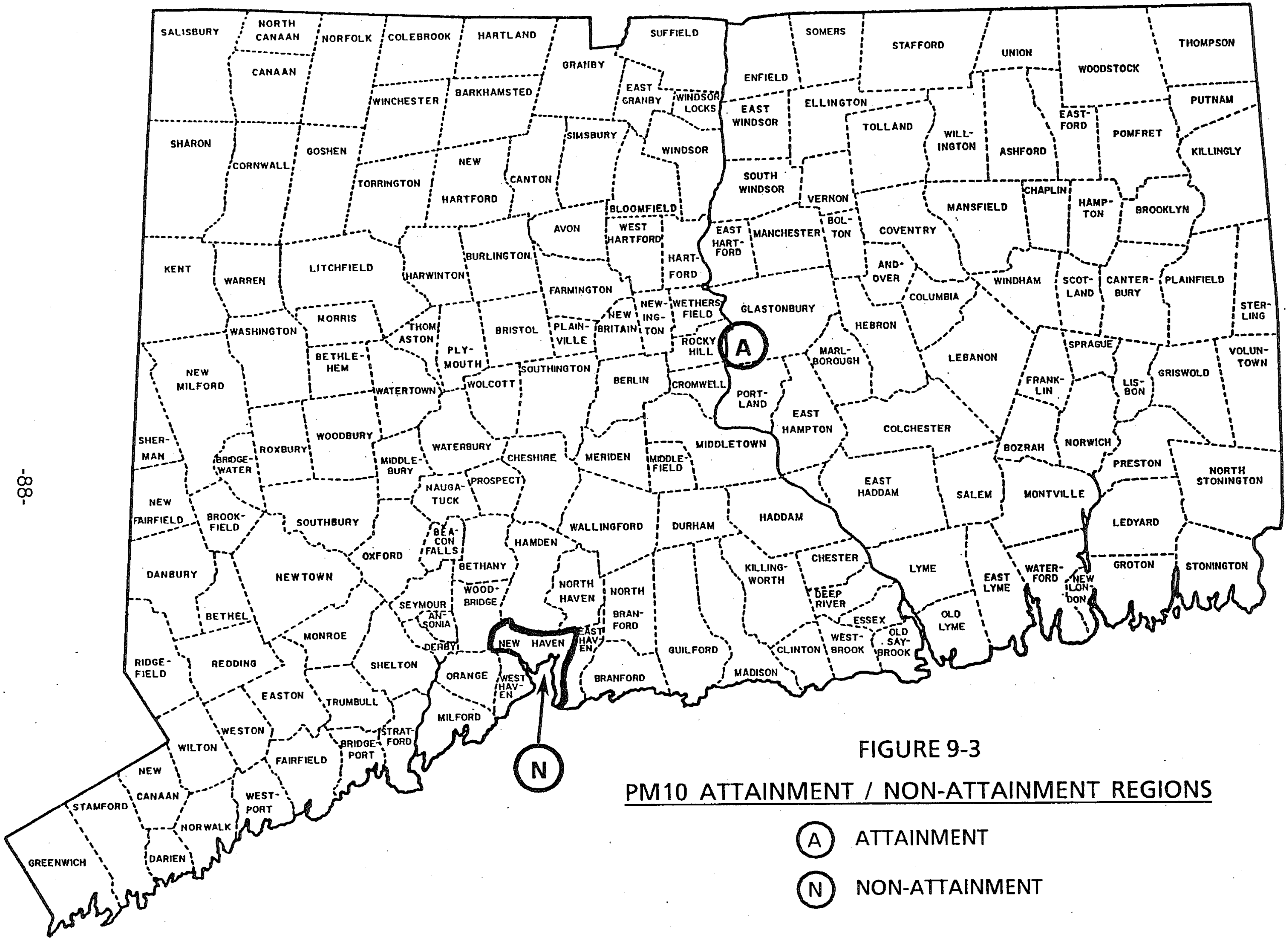


FIGURE 9-3

PM10 ATTAINMENT / NON-ATTAINMENT REGIONS

X. CONNECTICUT SLAMS, NAMS AND PAMS NETWORKS

On May 10, 1979, the U.S. Environmental Protection Agency made public its final rulemaking for ambient air monitoring and data reporting requirements in the "Federal Register" (Vol. 44, No. 92). These regulations, which can also be found in Title 40 of the Code of Federal Regulations (CFR), Part 58, Appendix A through G, are meant to ensure the acceptability of air measurement data, the comparability of data from all monitoring stations nationwide, the cost-effectiveness of monitoring networks, and timely data submission for assessment purposes. The regulations address a number of key areas including quality assurance, monitoring methodologies, network design, probe siting and data reporting. Detailed requirements and specific criteria are provided which form the framework for ambient air quality monitoring. These regulations apply to all parties conducting ambient air quality monitoring for the purpose of supporting or complying with environmental regulations. In particular, state/local control agencies and industrial/private concerns involved in air monitoring are directly influenced by specific requirements, compliance dates and recommended guidelines.

QUALITY ASSURANCE

The regulations specify the minimum quality assurance requirements for State and Local Air Monitoring Stations (SLAMS) networks and for National Air Monitoring Stations (NAMS) networks and Photochemical Assessment Monitoring Stations (PAMS) networks, which are both subsets of SLAMS. Two distinct and equally important functions make up the quality assurance program: assessment of the quality of monitoring data by statistically calculating their precision and accuracy, and control of the quality of the data by implementation of quality control policies, procedures and corrective actions, and by overseeing their proper implementation. (See Part D of Section I, Quality Assurance).

The data assessment requirements entail the determination of precision and accuracy for both continuous and manual methods. A one-point precision check must be carried out at least once every other week on each automated analyzer used to measure SO_2, NO_2, CO, O_3 and VOC. Standards from which the precision check test data are derived must meet specifications detailed in the regulations. For manual methods, precision checks are to be accomplished by operating co-located duplicate samplers. In 1996, Connecticut maintained three co-located PM_{10} samplers (Hartford 015, New Haven 123 and Waterbury 123) and one co-located lead sampler (Waterbury 123).

Accuracy determinations for automated analyzers are accomplished for SO_2, NO_2, CO, and O_3 by audits performed by an independent auditor utilizing equipment and gases which are disassociated from the normal network operations; and for VOC by audits performed by site operators utilizing blind standards. Accuracy determinations are accomplished via traceable standard flow devices for hi-vols and also spiked strip analyses for lead. During each calendar quarter, at least 25% of SLAMS network for each pollutant must be audited.

All precision and accuracy results are statistics derived through calculation methods specified by the regulations, with the data and results reported quarterly. The NAMS and PAMS networks are actually part of the SLAMS network; so the SLAMS accuracy determinations also apply to both the NAMS and PAMS networks.

The distinguishing characteristics of NAMS are: 1) the sites are located in high population, high pollution areas (i.e., urban areas); 2) only continuous instruments are used to monitor gaseous pollutants; 3) the regulations specify a minimum number and locations for them; and 4) the data are required to be reported quarterly to EPA. PAMS share most of these characteristics, except that the monitoring sites are located relative to O_3 precursor source areas and predominant wind directions associated with high O_3 events.

In order to control the quality of data, the monitoring program has operational procedures for each of the following activities:

1. Selection of methods, analyzers, and samplers,
2. Site selection and probe siting,
3. Equipment purchase, check-out and installation,
4. Instrument calibration,
5. Control checks and their frequency,
6. Control limits for control checks, and corrective actions when such limits are exceeded,
7. Preventive and remedial maintenance,
8. Documentation of quality control information, and
9. Data recording, reduction, validation and reporting.

MONITORING METHODOLOGIES

Except as otherwise stated within the regulations, the monitoring methods used must be "reference" or "equivalent," as designated by the EPA. Table 10-1 lists methods used in Connecticut's network in 1996 which were on the EPA-approved list as of September 15, 1995. Additional updates to these approved methods are provided through the "Federal Register."

NETWORK DESIGN

The regulations also describe monitoring objectives and general criteria to be applied in establishing the SLAMS, NAMS and PAMS networks and for choosing general locations for new monitors. Criteria are also presented for determining the location and number of monitors. These criteria have served as the framework for all State Implementation Plan (SIP) monitoring networks since January 1, 1984 for SLAMS and NAMS, and since February 12, 1993 for PAMS .

The SLAMS and NAMS networks are designed to meet four basic monitoring objectives which are pollutant specific: (1) to determine the highest pollutant concentration in the area; (2) to determine representative concentrations in areas of high population density; (3) to determine the ambient impact of significant sources or source categories; and (4) to determine general background concentration levels. PAMS design criteria are site specific and are based on the selection of an array of site locations. Specific monitoring objectives are associated with each location: (1) to characterize upwind background and transported O_3 and its precursor concentrations; (2) to monitor the magnitude and type of precursor emissions at the expected impact area; (3) to monitor maximum O_3 concentrations occurring downwind from the area of maximum precursor emissions; (4) to characterize the extreme downwind transported O_3 and its precursor concentrations. Proper siting of a monitor requires precise specification of the monitoring objectives, which includes a spatial scale of representativeness. The spatial scales of representativeness are specified in the regulations for all pollutants and monitoring objectives. The 1996 SLAMS, NAMS and PAMS networks in Connecticut are presented and described in Table 10-2.

PROBE SITING

Location and exposure of monitoring probes are described in Title 40 of the Code of Federal Regulations, Part 58, Appendix E. The probe siting criteria promulgated in the regulations are specific. They are also sufficiently comprehensive to define the requirements for ensuring the uniform collection of compatible and comparable air quality data.

These criteria are detailed by pollutant and include vertical and horizontal probe placement, spacing from obstructions and trees, spacing from roadways, probe material and sample residence time, and various other considerations. A summary of the probe siting criteria is presented in Table 10-3. The siting criteria generally apply to all spatial scales except where noted. The most notable exception is spacing from roadways which is dependent on traffic volume.

For the chemically reactive gases SO_2, NO_2, and O_3, the regulations specify borosilicate glass, FEP teflon or their equivalent as the only acceptable sample train materials. For VOC sampling at those SLAMS designated as PAMS, the regulations specify borosilicate glass, stainless steel, or its equivalent. Additionally, in order to minimize the effects of particulate deposition on probe walls, sample trains for reactive gases must have residence times of less than 20 seconds.

TABLE 10-1

U. S. EPA-APPROVED MONITORING METHODS USED IN CONNECTICUT IN 1996

Pollutant	Monitoring Methods		
	Reference Manual	Reference Automated	Equivalent Automated
PM_{10}	High Volume Method *[Wedding & Associates Critical Flow Hi-vol]*		Tapered Element Oscillating Microbalance *[Rupprecht & Patashnick TEOM Series 1400]*
SO_2			Pulsed Fluorescence *[Thermo Electron 43 (0.5) & Thermo Electron 43A (0.5)]*
O_3			UV Absorption *[Monitor Labs 8810 (0.5)]*
CO		Non-dispersive Infrared *[Thermo Electron 48 (50)]*	
NO_2		Chemiluminescence *[Thermo Electron 42 (1.0)]*	
Lead	High Volume Method *[General Metal Works GL 2000H]*		

( ) = Approved range in ppm

TABLE 10-2

1996 SLAMS AND NAMS SITES IN CONNECTICUT

Town	Urban Area	Site	SLAMS or NAMS	Sampling Method	Analytic Method	Operating Schedule	Monitoring Objective	Spatial Scale of Representativeness
PARTICULATE MATTER (PM_{10})								
Bridgeport	Bridgeport	010	N	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Bridgeport	Bridgeport	014	N	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
Burlington	NONE	001	S	Hi-Vol	Gravimetric	6th day	Background	Regional
Danbury	Danbury	123	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Darien	Stamford	001	N	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
E. Hartford	Hartford	004	S	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood
Enfield	MA-CT*	005	S	Hi-Vol	Gravimetric	6th day	Population	Regional
Greenwich	Stamford	017	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Hartford	Hartford	013	N	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Hartford	Hartford	015	N	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
Middletown	Hartford	003	S	Hi-Vol	Gravimetric	6th day	High Concentration	Neighborhood
New Haven	New Haven	018	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
New Haven	New Haven	020	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
New Haven	New Haven	123	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
New London	New London/ Norwich	004	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
Norwalk	Norwalk	014	N	Hi-Vol	Gravimetric	6th day	High Concentration	Micro
Norwich	New London/ Norwich	002	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Torrington	NONE	001	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Voluntown	NONE	001	S	Hi-Vol	Gravimetric	6th day	Background	Regional
Wallingford	New Haven	006	S	Hi-Vol	Gravimetric	6th day	Population	Neighborhood
Waterbury	Waterbury	123	N	Hi-Vol	Gravimetric	6th day	High Concentration	Middle
Willimantic	NONE	002	S	Hi-Vol	Gravimetric	6 th day	High Concentration	Neighborhood

* Includes Springfield, Chicopee, Holyoke in MA; East Windsor, Enfield, Suffield, Windsor Locks in CT.

TABLE 10-2, CONTINUED

1996 SLAMS AND NAMS SITES IN CONNECTICUT

Town	Urban Area	Site	SLAMS or NAMS	Sampling & Analytic Method	Operating Schedule	Monitoring Objective	Spatial Scale of Representativeness
				CARBON MONOXIDE			
Bridgeport	Bridgeport	004	S	NDIR	Continuous	High Concentration	Micro
Hartford	Hartford	013	N	NDIR	Continuous	Population	Neighborhood
Hartford	Hartford	017	N	NDIR	Continuous	High Concentration	Micro
New Haven	New Haven	025	S	NDIR	Continuous	High Concentration	Micro
Stamford	Stamford	020	S	NDIR	Continuous	High Concentration	Micro
				SULFUR DIOXIDE			
Bridgeport	Bridgeport	012	S	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Bridgeport	Bridgeport	013	N	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Danbury	Danbury	123	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
E. Hartford	Hartford	006	N	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
East Haven	New Haven	003	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
Enfield	MA - CT*	005	S	Pulsed Fluorescence	Continuous	Background	Regional
Greenwich	Stamford	017	S	Pulsed Fluorescence	Continuous	Background	Urban
Groton	New London/ Norwich	007	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
Hartford	Hartford	018	N	Pulsed Fluorescence	Continuous	Population	Neighborhood
Mansfield	NONE	003	S	Pulsed Fluorescence	Continuous	Population	Neighborhood
New Haven	New Haven	123	N	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Stamford	Stamford	124	S	Pulsed Fluorescence	Continuous	High Concentration	Neighborhood
Waterbury	Waterbury	123	S	Pulsed Fluorescence	Continuous	Population	Neighborhood

* Includes Springfield, Chicopee, Holyoke in MA; East Windsor, Enfield, Suffield, Windsor Locks in CT.

TABLE 10-2, CONTINUED

1996 SLAMS AND NAMS SITES IN CONNECTICUT

Town	Urban Area	Site	SLAMS, NAMS or PAMS	Sampling & Analytic Method	Operating Schedule	Monitoring Objective	Spatial Scale of Representativeness
				NITROGEN OXIDES			
Bridgeport	Bridgeport	013	S	Chemiluminescent	Continuous	High Concentration	Neighborhood
E. Hartford	Hartford	003	S/P	Chemiluminescent	Continuous	High Concentration	Neighborhood
New Haven	New Haven	123	S	Chemiluminescent	Continuous	High Concentration	Neighborhood
Stafford	NONE	001	P	Chemiluminescent	Continuous	Maximum Ozone	Regional
Westport	Norwalk	003	P	Chemiluminescent	Continuous	Upwind Concentration	Regional
				OZONE			
Bridgeport	Bridgeport	013	N	Chemiluminescent	Continuous	Population	Neighborhood
Danbury	Danbury	123	S	Chemiluminescent	Continuous	High Concentration	Urban
E. Hartford	Hartford	003	N	Chemiluminescent	Continuous	Population	Neighborhood
Greenwich	Stamford	017	S	Chemiluminescent	Continuous	High Concentration	Urban
Groton	New London/ Norwich	008	S	Chemiluminescent	Continuous	High Concentration	Urban
Madison	NONE	002	S	Chemiluminescent	Continuous	High Concentration	Urban
Middletown	Hartford	007	N	Chemiluminescent	Continuous	High Concentration	Urban
New Haven	New Haven	123	N	Chemiluminescent	Continuous	Population	Neighborhood
Stafford	NONE	001	N/P	Chemiluminescent	Continuous	High Conc. /Max. Ozone	Urban / Regional
Stratford	Bridgeport	007	N	Chemiluminescent	Continuous	High Concentration	Urban
Torrington	NONE	006	S	Chemiluminescent	Continuous	High Concentration	Urban
Westport	Norwalk	003	P	Chemiluminescent	Continuous	Upwind Concentration	Regional
				VOC			
E. Hartford	Hartford	003	P	Chemiluminescent	Continuous	Max. Concentration	Neighborhood
Stafford	NONE	001	P	Chemiluminescent	Continuous	Maximum Ozone	Regional
Westport	Norwalk	003	P	Chemiluminescent	Continuous	Upwind Concentration	Regional

TABLE 10-2, CONTINUED

1996 SLAM, NAMS AND PAMS SITES IN CONNECTICUT

Town	Urban Area	Site	SLAMS or NAMS	Sampling Method	Analytic Method	Operating Schedule	Monitoring Objective	Spatial Scale of Representativeness
					LEAD			
Bridgeport	Bridgeport	010	S	Hi-Vol	Atomic Abs.	6th day	High Concentration	Middle
E. Hartford	Hartford	004	N	Hi-Vol	Atomic Abs.	6th day	Population	Neighborhood
Hartford	Hartford	016	N	Hi-Vol	Atomic Abs.	6th day	High Concentration	Micro
New Haven	New Haven	018	S	Hi-Vol	Atomic Abs.	6th day	High Concentration	Middle
Waterbury	Waterbury	123	S	Hi-Vol	Atomic Abs.	6th day	High Concentration	Middle

TABLE 10-3

SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal[a]		
PM_{10}	Micro		>2	2 - 7	1. The sampler should be > 20 meters from the dripline and must be 10 meters from the dripline when any tree acts as an obstruction. 2. The distance from the sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler, except for street canyon sites.[b] 3. There must be unrestricted air flow 270 degrees around the sampler, except for street canyon sites. 4. No furnace or incineration flues should be nearby.[c] 5. The spacing from roads varies with traffic[d], except for street canyon sites which must be from 2 to 10 meters from the edge of the nearest traffic lane.
	Middle, neighborhood, urban and regional		>2	2 - 15	1. The sampler should be > 20 meters from the dripline and must be 10 meters from the dripline when any tree acts as an obstruction. 2. The distance from the sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler.[b] 3. There must be unrestricted air flow 270 degrees around the sampler. 4. No furnace or incineration flues should be nearby.[c] 5. The spacing from roads varies with traffic.[d]

TABLE 10-3, CONTINUED

SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal[a]		
Pb	Micro		>2	2 - 7	1. The sampler should be > 20 meters from the dripline and must be 10 meters from the dripline when any tree acts as an obstruction. 2. The distance from the sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler.[b] 3. There must be unrestricted air flow 270 degrees around the sampler, except for street canyon sites. 4. No furnace or incineration flues should be nearby.[c] 5. The sampler must be 5 to 15 meters from a major roadway.
	Middle, neighborhood, urban and regional		>2	2 - 15	1. The sampler should be > 20 meters from the dripline and must be 10 meters from the dripline when any tree acts as an obstruction. 2. The distance from the sampler to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler.[b] 3. There must be unrestricted air flow 270 degrees around the sampler. 4. No furnace or incineration flues should be nearby.[c] 5. The spacing from roads varies with traffic.[d]

TABLE 10-3, CONTINUED

SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal[a]		
SO_2	All	3 - 15	>1	>1	1. The probe should be > 20 meters from the dripline and must be 10 from the dripline when a tree acts as an obstruction. 2. The distance from the inlet probe to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the inlet probe.[b] 3. There must be unrestricted air flow 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building. 4. No furnace or incineration flues should be nearby.[c]
O_3 or VOC	All	>1	>1	3 - 15	1. The probe should be > 20 meters from the dripline and must be 10 from the dripline when a tree acts as an obstruction. 2. The distance from the inlet probe to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the inlet probe. 3. There must be unrestricted air flow in an arc of at least 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building.[e] 4. The spacing from roads varies with traffic.[d]

TABLE 10-3, CONTINUED

SUMMARY OF PROBE SITING CRITERIA

Pollutant	Spatial Scale	Distance from Supporting Structure (meters)		Height Above Ground (meters)	Other Spacing Criteria
		Vertical	Horizontal[a]		
CO	Micro	2.5 - 3.5	>1	>1	1. The probe must be >10 meters from the street intersection and should be at a midblock location. 2. The probe must be 2 to 10 meters from the edge of the nearest traffic lane. 3. There must be unrestricted airflow 180 degrees around the inlet probe.
	Middle neighborhood	3 - 15	>1	>1	1. There must be unrestricted airflow 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building. 2. The spacing from roads varies with traffic.[d]
NO_2	All	3 - 15	>1	>1[f]	1. The probe should be > 20 meters from the dripline and must be 10 from the dripline when a tree acts as an obstruction. 2. The distance from the inlet probe to an obstacle, such as a building, must be at least twice the height the obstacle protrudes above the inlet probe.[b] 3. There must be unrestricted air flow in an arc of at least 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building.[e] 4. The spacing from roads varies with traffic.[d]

[a] When the probe is located on a rooftop, this separation distance is in reference to walls, parapets, or penthouses located on the roof.

[b] Sites not meeting this criterion would be classified as middle scale.

[c] Distance is dependent upon height of furnace or incineration flue, type of fuel or waste burned, and quality of fuel (sulfur and ash content). This is to avoid undue influences from minor pollutant sources.

[d] Distance is dependent upon traffic ADT, pollutant, and spatial scale.

[e] In addition, for PAMS the predominant wind direction for the period of greatest pollutant concentration must be included in the arc.

[f] 3-15 for PAMS

XI. PUBLICATIONS

The following is a partial listing of technical papers and study reports dealing with various aspects of Connecticut air pollutant levels and air quality data.

1. Bruckman, L., ***Asbestos: An Evaluation of Its Environmental Impact in Connecticut***, internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, March 12, 1976.

2. Lepow, M. L., L. Bruckman, R.A. Rubino, S. Markowitz, M. Gillette and J. Kapish, ***"Role of Airborne Lead in Increased Body Burden of Lead in Hartford Children,"*** Environ. Health Perspect., May, 1974, pp. 99-102.

3. Bruckman, L. and R.A. Rubino, ***"Rationale Behind a Proposed Asbestos Air Quality Standard,"*** paper presented at the 67th Annual Meeting of the Air Pollution Control Association, Denver, Colorado, June 9-11, 1974, J. Air Pollut. Cntr. Assoc., 25: 1207-15 (1975).

4. Rubino, R.A., L. Bruckman and J. Magyar, ***"Ozone Transport,"*** paper presented at the 68th Annual Meeting of the Air Pollution Control Association, Boston, Massachusetts, June 15-20, 1975, J. Air Pollut. Cntr. Assoc.: 26, 972-5 (1976).

5. Bruckman, L., R.A. Rubino and T. Helfgott, ***"Rationale Behind a Proposed Cadmium Air Quality Standard,"*** paper presented at the 68th Annual Meeting of the Air Pollution Control Association, Boston, Massachusetts, June 15-20, 1975.

6. Rubino, R.A., L. Bruckman, A. Kramar, W. Keever and P. Sullivan, ***"Population Density and Its Relationship to Airborne Pollutant Concentrations and Lung Cancer Incidence in Connecticut,"*** paper presented at the 68th Annual Meeting of the Air Pollution Control Association, Boston, Massachusetts, June 15-20, 1975.

7. Lepow, M.L., L. Bruckman, M. Gillette, R.A. Rubino and J. Kapish, ***"Investigations into Sources of Lead in the Environment of Urban Children,"*** Environ. Res., 10: 415-26 (1975).

8. Bruckman, L., E. Hyne and P. Norton, ***"A Low Volume Particulate Ambient Air Sampler,"*** paper presented at the APCA Specialty Conference entitled "Measurement Accuracy as it Relates to Regulation Compliance," New Orleans, Louisiana, October 26-28, 1975, APCA publication SP-16, Air Pollution Control Association, Pittsburgh, Pennsylvania, 1976.

9. Bruckman, L. and R.A. Rubino, ***"High Volume Sampling Errors Incurred During Passive Sample Exposure Periods,"*** J. Air Pollut. Cntr. Assoc., 26: 881-3 (1976).

10. Bruckman, L., R.A. Rubino and B. Christine, ***"Asbestos and Mesothelioma Incidence in Connecticut,"*** J. Air Pollut. Cntr. Assoc., 27: 121-6 (1977).

11. Bruckman, L., ***Suspended Particulate Transport in Connecticut: An Investigation Into the Relationship Between TSP Concentrations and Wind Direction in Connecticut***, internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, December 24, 1976.

12. Bruckman, L. and R.A. Rubino, ***"Monitored Asbestos Concentrations in Connecticut,"*** paper presented at the 70th Annual Meeting of the Air Pollution Control Association, Toronto, Ontario, June 20-24, 1977.

13. Bruckman, L., ***"Suspended Particulate Transport,"*** paper presented at the 70th Annual Meeting of the Air Pollution Control Association, Toronto, Ontario, June 20-24, 1977.

14. Bruckman, L., ***"A Study of Airborne Asbestos Fibers in Connecticut,"*** paper presented at the "Workshop in Asbestos: Definitions and Measurement Methods" sponsored by the National Bureau of Standards/U.S. Department of Commerce, July 18-20, 1977.

15. Bruckman, L., ***"Monitored Asbestos Concentrations Indoors,"*** paper presented at The Fourth Joint Conference of Sensing Environmental Pollutants, New Orleans, Louisiana, November 6-11, 1977.

16. Bruckman, L., paper presented at the Joint Conference on Applications of Air Pollution Meteorology, Salt Lake City, Utah, November 28 - December 2, 1977.

17. Bruckman, L., E. Hyne, W. Keever, ***"A Comparison of Low Volume and High Volume Particulate Sampling,"*** internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, 1976.

18. ***"Data Validation and Monitoring Site Review,"*** (part of the Air Quality Maintenance Planning Process), internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, June 15, 1976.

19. ***"Air Quality Data Analysis,"*** (part of the Air Quality Maintenance Planning Process), internal report issued by the Connecticut Department of Environmental Protection, Hartford, Connecticut, August 16, 1976.

20. Bruckman, L., ***"Investigation into the Causes of Elevated SO2 Concentrations Prevalent Across Connecticut During Periods of SW Wind Flow,"*** paper presented at the 71st Annual Meeting of the Air Pollution Control Association, Paper #78-16.4, Houston, Texas, June 25-29, 1978.

21. Anderson, M.K., ***"Power Plant Impact on Ambient Air: Coal vs. Oil Combustion,"*** paper presented at the 68th Annual Meeting of the Air Pollution Control Association, Paper #75-33.5, Boston, MA, June 15-20, 1975.

22. Anderson, M.K., G. D. Wight, ***"New Source Review: An Ambient Assessment Technique,"*** paper presented at the 71st Annual Meeting of the Air Pollution Control Association, Paper #78-2.4, Houston, TX, June 25-29, 1978.

23. Wolff, G.T., P.J. Lioy, G.D. Wight, R.E. Pasceri, ***"Aerial Investigation of the Ozone Plume Phenomenon,"*** J. Air Pollut.8 Control Association, 27: 460-3 (1977).

24. Wolff, G.T., P.J. Lioy, R.E. Meyers, R.T. Cederwall, G.D. Wight, R.E. Pasceri, R.S. Taylor, ***"Anatomy of Two Ozone Transport Episodes in the Washington, D.C., to Boston, Mass., Corridor,"*** Environ. Sci. Technol., 11-506-10 (1977).

25. Wolff, G.T., P.J. Lioy, G.D. Wight, R.E. Meyers, and R.T Cederwall, ***"Transport of Ozone Associated With an Air Mass,"*** In: Proceed. 70 Annual Meeting APCA, Paper 377-20.3, Toronto, Canada, June, 1977.

26. Wight, G.D., G.T. Wolff, P.J. Lioy, R.E. Meyers, and R.T.Cederwall, ***"Formation and Transport of Ozone in the Northeast Quadrant of the U.S.,"*** In: Proceed. ASTM Sym. Air Quality and Atmos. Ozone, Boulder, Colo., Aug. 1977.

27. Wolff, G.T., P.J. Lioy, and G.D. Wight, ***"An Overview of the Current Ozone Problem in the Northeastern and Midwestern U.S.,"*** In: Proceed. Mid-Atlantic States APCA Conf. on Hydrocarbon Control Feasibility, p. 98, New York, N.Y., April, 1977.

28. Wolff, G.T., P.J. Lioy, G.D. Wight, R.E. Meyers, and R.T.Cederwall, ***"An Investigation of Long-Range Transport of Ozone Across the Midwestern and Eastern U.S.,"*** Atmos. Environ. 11:797 (1977).

29. Bruckman, L., R.A. Rubino, and J. Gove, ***"Connecticut's Approach to Controlling Toxic Air Pollutants,"*** paper presented at the STAPPA / ALAPCO Air Toxics Conference, Air Toxics Control: An Environmental Challenge, Washington, D. C., October 15-17, 1986.

30. Wackter, D.J., and P.V. Bayly, ***"The Effectiveness of Emission Controls on Reducing Ozone Levels in Connecticut from 1976 through 1987,"*** paper presented at the APCA Specialty Conference on: The Scientific and Technical Issues Facing Post-1987 Ozone Control Strategies, Hartford, Connecticut, November 17-19, 1987.

31. Wackter, D.J., ***"Sensitivity Analysis of Ozone Predictions by the Urban Airshed Model in the Northeast,"*** paper presented at the Air Pollution Control Association Conference on VOC and Ozone, Northampton, MA, November 1-2, 1988.

32. Leston, A.R., J. Catalano, K. Crossman, R. Pirolli, N. Rowe, G. Hunt and B. Maisel, ***"The Connecticut Department of Environmental Protection's Evaluation of Pre/Post Operational Dioxin Monitoring Conducted at Four Resources Recovery Facilities,"*** paper presented at the Dioxin '91 Conference, RTP, North Carolina, Sept., 1991.

33. Leston, A.R., and W. Ollison, ***"Estimated Accuracy of Ozone Design Values: Are They Compromised by Method Interference?,"*** In: Proceed. A&WMA's Conference "Troposheric Ozone: Nonattainment and Design Value Issues," Boston, Massachusetts, October 27-30, 1992.

34. Leston, A.R., and S.A. Bailey, ***"Preliminary Report on Establishing a Prototype PAMS Site in the Urban Northeast,"*** In: Proceed. A&WMA's 86th Annual Meeting & Exhibition, Denver, Colorado, June 14-18, 1993.

35. Hartman, R.M., and A. Leston, ***"Use of an OPSIS Open Path Monitor for Ambient Aldehyde Monitoring,"*** In: Proceed. A&WMA's Conference "Optical Sensing for Environmental and Process Monitoring," McLean, Virginia, November 7-10, 1994.

36. Main, H.H., Roberts, P.T., Leston, A.R., and P. Brunelli, ***"Data Validation of PAMS Auto-GC Data: Lessons Learned,"*** In: Proceed. A&WMA's Conference "Measurement of Toxic And Related Air Pollutants," RTP, North Carolina, May 7-9, 1996

XII. ERRATA

During the preparation of this Air Quality Summary, a number of errors were discovered in previous editions of this document. For the benefit of the reader, the corrections are presented below:

- Regarding the 1995 edition of the Air Quality Summary,

  1. On page 29, in Table 2-3, the data for 1994 should be 25,1 and 4%, instead of 26, 0 and 0%.
  2. On page 44, in Figures 2-5 and 2-6, the y-axis divisions of 0, 5, 10 and 15 should by replaced with 15, 20, 25 and 30.
  3. On page 53, in Table 3-2, the date of the 2nd high calendar day SO_2 concentration at the Groton 007 site should be listed as 03/08, not 08/46.
  4. On page 82, in Figure 5-2, the label at the top identifying the units of measurement is incorrect. The proper units for the concentrations shown are parts per million, not micrograms per cubic meter

- Regarding the 1994 edition of the Air Quality Summary,

  1. On page 14, in the second paragraph under **24-Hour Averages**, the second sentence should read: In 1994, there was one such site, Norwalk 014.
  2. On page 29, in Table 2-3, the data for 1994 should be 25,1 and 4%, instead of 26, 0 and 0%.