

Flint Hills Air Monitoring Network Data Analysis

**Summary Report
October 7, 2004**

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Table of Contents

1.0 INTRODUCTION	1
2.0 REVIEW SUMMARY	2
2.1 Data Review/Findings.....	2
2.2.1 Health Standards and Comparison	2
2.2.3 Data Comparison to Air Quality Standards	3
3.0 CONCLUSIONS	8



Flint Hills
 STS Project 98563A
 October 7, 2004

1.0 INTRODUCTION

The Minnesota Pollution Control Agency (MPCA), as part of their state-wide air quality assessment network, currently conducts ambient air quality monitoring at four sites near the Flint Hills Rosemount petroleum refinery (facility). Table 1 summarizes which parameters are currently being monitored at each of these locations.

Table 1. Monitoring Site Summary

Parameter	Desig.	Site 420	Site 423	Site 441	Site 442
Carbon Monoxide ¹	CO	X	X		
Nitric Oxides ¹	NO _x	X	X		
Nitrogen Dioxide ¹	NO ₂	X	X		
Sulfur Dioxide ¹	SO ₂	X	X	X	X
Total Reduced Sulfur ¹	TRS			X	X
Hazardous Air Pollutants ²	HAPs	X	X	X	X
Wind Speed	WS	X	X		
Wind Direction	WD	X	X		
Temperature	Temp	X	X		

¹ Emitted from refinery in reportable quantities

² Only certain HAPs emitted from refinery in reportable quantities (see Table 3)

Each of the parameters listed above are being measured in the field on a continuous basis, except for the hazardous air pollutants (HAPs). HAPs samples are taken as 24-hour composite samples, collected once every six days. HAPs samples are sent to the MPCA laboratory where they are analyzed for a variety of specific volatile compounds.

STS Consultants, Ltd. (STS) was requested by the Flint Hills Community Advisory Council (Council) in 2002 to evaluate this monitoring network with respect to facility impacts. The fourth quarter of the calendar year 2003 has been evaluated by STS and was submitted to you on May 10, 2004. This report includes the previous data and an evaluation of the newly acquired data, first quarter of the calendar year 2004. The following six chemicals included in both evaluations are: sulfur dioxide, nitrogen dioxide, formaldehyde, carbon tetrachloride, benzene, and ethylbenzene.

Flint Hills
 STS Project 98563A
 October 7, 2004

2.0 REVIEW SUMMARY

2.1 Data Review/Findings

2.2.1 Health Standards and Comparison

In order to put these ambient air monitoring data into perspective in regards to public health impacts, a toxicity assessment for each requested, monitored chemical was first completed. This toxicity assessment involved a search of USEPA chemical toxicity databases (IRIS, 2002; HEAST, 1997), the Minnesota Department of Health's Health Risk Values (HRVs), and California EPA's Air Toxics Standards. Presented in Table 2 are the results of this search.

Listed in Table 2 are air concentrations of each chemical of concern in this study that are believed to be safe for the public to be exposed to. Acute criteria represent acceptable air concentrations of chemicals for exposure up to a one hour time period. Chronic criteria are air concentrations of chemicals that the public can be exposed to continuously throughout their entire lifetime.

Table 2: Health Criteria

Chemical	Federal Standards/Criteria ^A	State Standards/Criteria ^B	
		Acute (1)	Chronic
Nitrogen Dioxide	53	250 (CAL EPA)	
Sulfur Dioxide	500 (3); 140 (24); 31		
Formaldehyde	0.65	77	0.65
Carbon Tetrachloride	0.11	300 (CAL EPA)	
Benzene	0.41	314	0.41-1.4
Ethylbenzene	231	2,308	

^A NAAQS or RfC (ppb); carcinogens set at 10⁻⁵ risk level: (1) = 1-hour standard; (3) = 3-hour standard, (24) = 24-hour standard; criteria not identified with an exposure period are chronic standards.

^B Minnesota HRV (µg/m³)

CAL EPA = California Environmental Protection Agency

Flint Hills
STS Project 98563A
October 7, 2004

2.2.3 Data Comparison to Air Quality Standards

The first quarter of the calendar year 2004 was evaluated by STS in the same manner as the fourth quarter of the calendar year 2003. Each monitored parameter at each of the monitoring sites for this quarter was analyzed to compute standard descriptive statistics: maxima and means for annual and 1-hour averaging times (also 3-hour for SO₂), as well as the 95% confidence limits of the mean values. Also calculated was the probability (chance) that the true average of the data for each quarter would exceed the chronic health criteria for a chemical. A numerical adjustment was made to estimate the annual average for comparison to the chronic standards. Likewise, the HAPs analyses were based on 24-hour integrated samples, thus a numerical adjustment was made to adjust to the shorter averaging period. [Note: as discussed earlier in the report submitted to you on May 10, 2004, this adjustment could not completely account for the “worst” one hour-averaged concentration of each acute toxic chemical as is desirable for the acute risk analysis. Only continuous monitoring could accurately provide that data.]

The results of this descriptive analysis are summarized in Figures 1 through 5 for the two criteria pollutants, SO₂ and NO₂, and Figures 6 through 11 for the HAP chemicals. Each figure has been formatted in a similar manner. On the X-axis, the 2004 first quarter data are compared to the 2003 and 2001 values from previous studies. On the Y-axis is an air concentration range chosen to encompass both the chemical's health criterion and the maximum or calculated average of the monitoring data. Data specific to each monitor location is designed by a different symbol. The “criterion line” does not contain any symbols. The smaller graph is an expanded image of the 2004 first quarter data. The small graph has the data points affiliated with each monitoring site as well as the monitored concentration ranges (for maximum values) or the standard deviation (for averaged values).

Reading each figure is performed in an identical manner. If the monitoring data for any given year and any given monitor is less than the criterion concentration, then with respect to that chemical at that location, no risk to public health is present. For example, Figure 1 shows the three-hour averaged data for sulfur dioxide. The health criterion is 500 ppb. All of the 2004 monitoring data are below 35 ppb. Thus, it can be concluded

Flint Hills
STS Project 98563A
October 7, 2004

from these data that acute exposure to sulfur dioxide in the areas of the monitors does not present a health risk to the public. Statistical analyses of these data were performed, but not shown on this figure because the confidence interval is so small. In a separate analysis, it was determined that there is less than 0.01% chance that the true three hour-averaged sulfur dioxide concentration at these monitoring locations would actually exceed this air quality standard.

The following sections detail the analysis for each of the 12 figures.

Sulfur Dioxide 3-hour Average

Figure 1 displays the maximum three-hour averages for sulfur dioxide at the four monitored sites and compares the concentrations with a 500 ppb criterion. The maximum three-hour average was calculated from the hourly data available. Each monitoring site has a maximum and 95% upper confidence limit well below the criterion. The monitoring data are all less than 35 ppb, considerably below the USEPA standard of 500 ppb. Statistical analysis of the data indicates that there is less than 0.01% chance probability that these data would exceed this standard.

Sulfur Dioxide 24-hour Average

Figure 2 displays the maximum 24-hour averages for sulfur dioxide at the four monitored sites and compares the concentrations with a 140 ppb criterion. The maximum 24-hour average was calculated from the hourly data available. Each monitoring site has a maximum and 95% upper confidence limit of less than 5% of the criterion. The monitoring data are all less than 7 ppb, considerably below the USEPA standard of 140 ppb. Statistical analysis of the data indicates that there is less than 0.01% chance probability that these data would exceed this standard.

Sulfur Dioxide Annual Average

Figure 3 displays the average annual concentration for sulfur dioxide at the four monitored sites and compares the concentrations with a 31 ppb criterion. The quarterly average was calculated from the hourly data available and then adjusted to an annual average using a factor of 0.53. The scaled annual averages for each monitoring site and 95% confidence level are well below the criterion. The expanded view also illustrates

Flint Hills
STS Project 98563A
October 7, 2004

that the standard deviations are less than 5% of the criteria. The monitoring data all have averages less than 1.0 ppb, considerably below the USEPA standard of 31 ppb. Statistical analysis of the data indicates that there is less than 0.01% chance probability that these data would exceed this standard.

Nitrogen Dioxide 1-hour Average

Figure 4 displays the maximum one-hour averages for nitrogen dioxide at the two monitored sites that addresses this pollutant and compares these concentrations with a 250 ppb criterion. The maximum one-hour average was calculated from the hourly data available. Each monitoring site has a maximum and 95% upper confidence limit well below the criterion. The monitoring data are less than 50 ppb, considerably below the USEPA standard of 250 ppb. Statistical analysis of the data indicates that there is less than 0.01% chance probability that these data would exceed this standard.

Nitrogen Dioxide Annual Average

Figure 5 displays the annual averages for nitrogen dioxide at the two monitored sites that address this pollutant and compares these concentrations with a 53 ppb criterion. The quarterly average was calculated from the hourly data available and then adjusted to an annual average using a factor of 0.53. The scaled annual averages for each monitoring site and 95% confidence level are well below the criterion. The expanded view also illustrates that the standard deviations are less than 20% of the criteria. The monitoring data all have averages less than 10 ppb, considerably below the USEPA standard of 53 ppb. Statistical analysis of the data indicates that there is less than 0.01% chance probability that these data would exceed this standard.

Formaldehyde 1-hour Average

Figure 6 displays the maximum one-hour averages for formaldehyde at the four monitored sites and compares the concentrations with a 77 ppb criterion. The maximum one-hour average was scaled from the 24-hour averaged data available with a factor of 2.5. Each monitoring site has a maximum and 95% upper confidence limit well below the criterion. The monitoring data are all less than 2.5 ppb, considerably below the Minnesota Department of Health standard of 77 ppb. Statistical analysis of the data

Flint Hills
STS Project 98563A
October 7, 2004

indicates that there is less than 0.02% chance probability that these data would exceed this standard.

Formaldehyde Annual Average

Figure 7 displays the annual average concentrations for formaldehyde at three of the monitored sites and compares them to a 0.65 ppb criterion. No data was collected from site 420. The quarterly averages were calculated from the 24-hour averaged data available and then adjusted to an annual average using a factor of 0.53. As shown in this figure, the calculated annual averaged mean concentrations of formaldehyde, as well as their 95% confidence interval, were below the formaldehyde health criterion at each of the three monitors. Statistical analysis of the data indicates that there is less than 0.01% chance probability that these data would exceed this standard.

Carbon Tetrachloride Annual Average

Figure 8 displays the annual averages for carbon tetrachloride at the four monitored sites and compares these concentrations with a 0.11 ppb criterion. The quarterly averages were calculated from the 24-hour averaged data available and then adjusted to an annual average using a factor of 0.53. The scaled annual average for each monitoring site and its 95% confidence level are below the criterion. The expanded view illustrates that the standard deviations are less than 0.075 ppb; the averages less than 0.07 ppb. Statistical analysis of the data indicates that there is less than 0.05% chance probability that these data would exceed this standard.

Benzene Annual Average

Figure 9 displays the annual averages for benzene at the four monitored sites and compares these concentrations with a 0.41 ppb criterion. The quarterly average was calculated from the 24-hour averaged data available and then adjusted to an annual average using a factor of 0.53. The scaled annual average for each monitoring site and its 95% confidence level are below the criterion. The monitoring data all have averages less than 0.20 ppb, considerably below the Minnesota Department of Health standard of 0.41 ppb. Statistical analysis of the data indicates that there is less than 0.05% chance probability that these data would exceed this standard.

Flint Hills
STS Project 98563A
October 7, 2004

Ethylbenzene 1-hour Average

Figure 10 displays the maximum one-hour averages for ethylbenzene at the four monitored sites and compares the concentrations with a 2,308 ppb criterion. The maximum one-hour averages were scaled from the 24-hour averaged data available with a factor of 2.5. Each monitoring site has a maximum and 95% upper confidence limit well below the criterion. The monitoring data are all less than 0.25 ppb, considerably below the Minnesota Department of Health standard of 2,308 ppb. Statistical analysis of the data indicates that there is less than 0.01% chance probability that these data would exceed this standard.

Ethylbenzene Annual Average

Figure 11 displays the annual averages for ethylbenzene at the four monitored sites and compares these concentrations with a 231 ppb criterion. The quarterly average was calculated from the 24-hour averaged data available and then adjusted to an annual average using a factor of 0.53. The scaled annual average for each monitoring site and its 95% confidence level are well below the criteria. The expanded view illustrates that the standard deviations are less than 1% of the criterion. The monitoring data all have averages less than 0.04 ppb, considerably below the USEPA standard of 231 ppb. Statistical analysis of the data indicates that there is less than 0.01% chance probability that these data would exceed this standard.

Raw Monitoring Data of Volatile Organics

As requested, the raw monitoring data of the volatile organics for this latest monitoring dataset have also been provided. Figure 12 displays the 24-hour volatile organic average concentrations as measured at the four monitoring sites. No statistical analysis or comparison to health criteria were performed on this data because the 24-hour experimental time interval does not correspond to the chemicals' criteria time interval.

Summary of Results

As requested, a summary of the results from the latest monitoring dataset have also been included. Table 1 displays the chemical, time increment, criterion, and the corresponding result for the quarter.

Flint Hills
STS Project 98563A
October 7, 2004

3.0 CONCLUSIONS

Based on the results from the first quarter 2004, it was evident that the various State/Federal ambient air quality health criteria were not exceeded at any of the monitoring site locations. Thus, it can be concluded that with respect to the chemicals evaluated, the public is not at risk.

Figure 1. Sulfur Dioxide Maximum 3-Hour Average Concentration

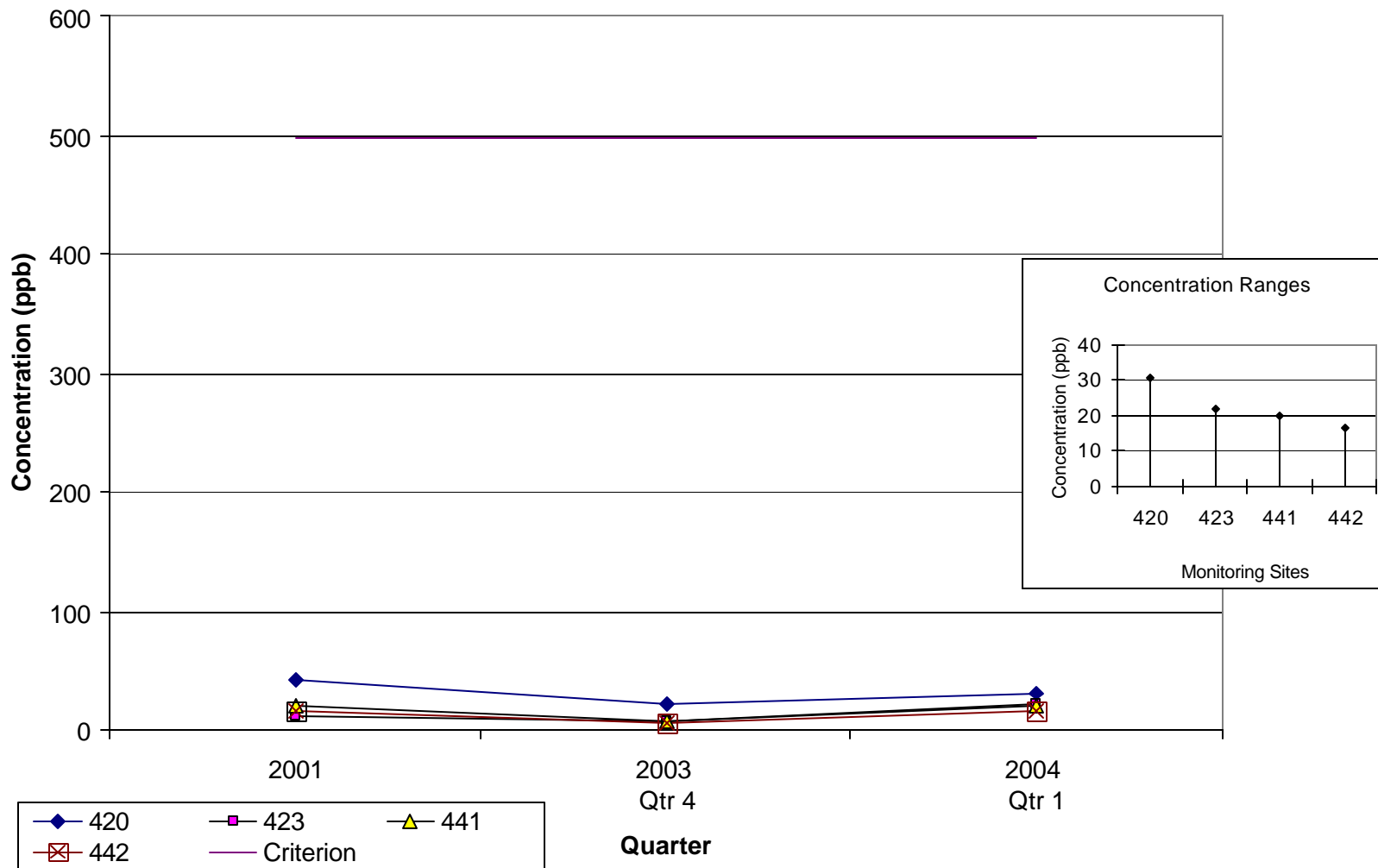


Figure 2. Sulfur Dioxide Maximum 24-Hour Average Concentration

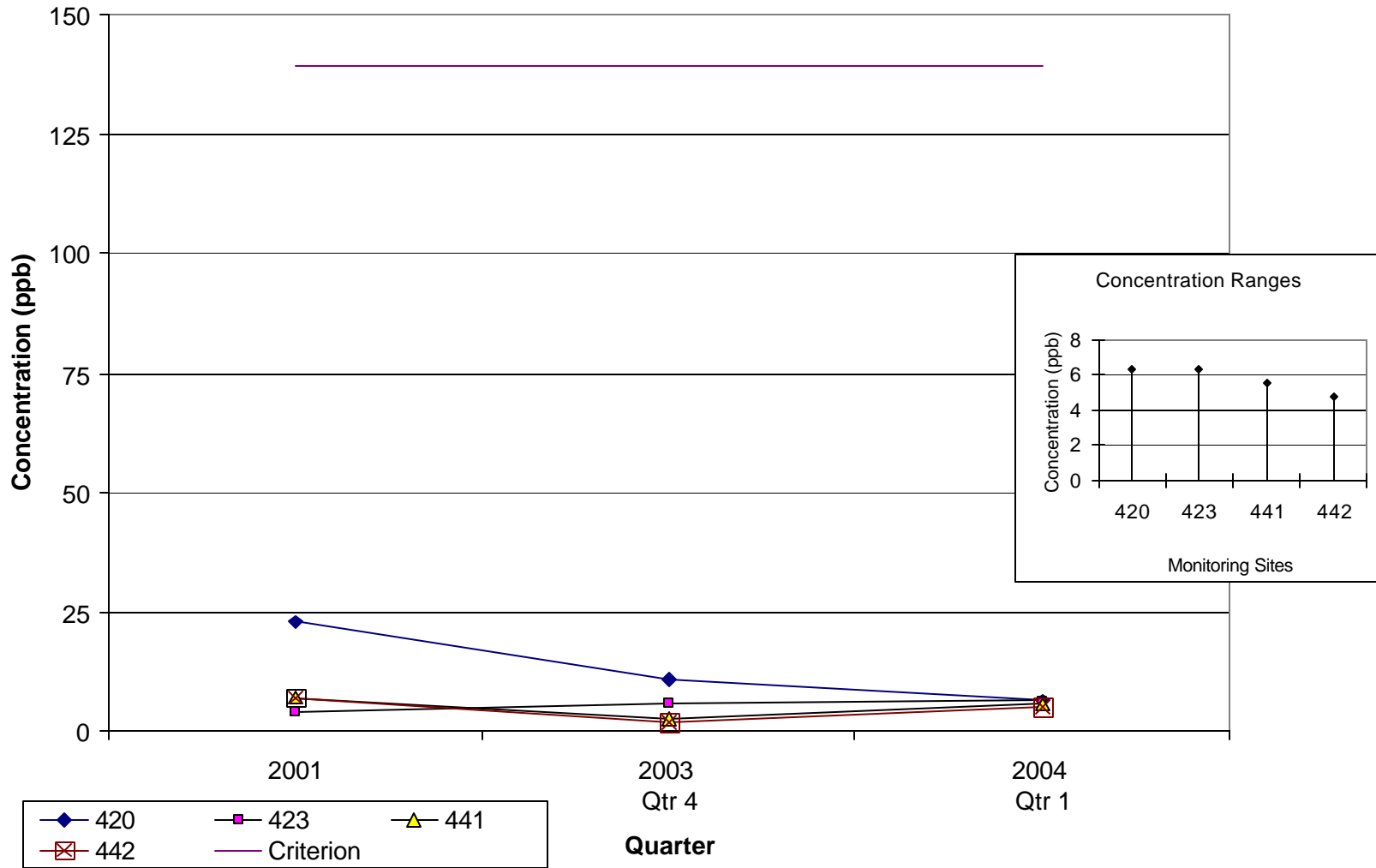


Figure 3. Sulfur Dioxide Annual Average Concentration

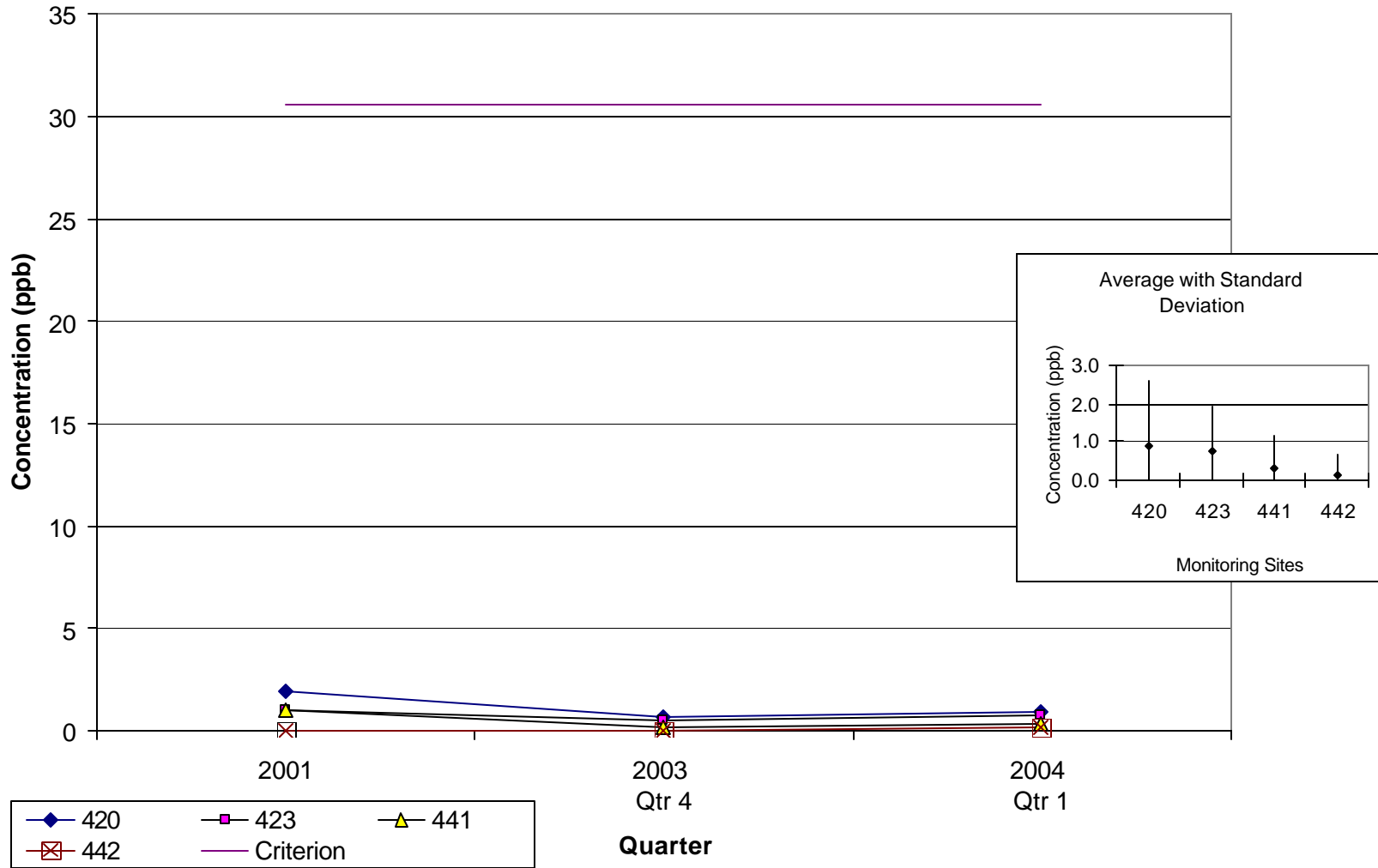


Figure 4. Nitrogen Dioxide Maximum 1-Hour Average Concentration

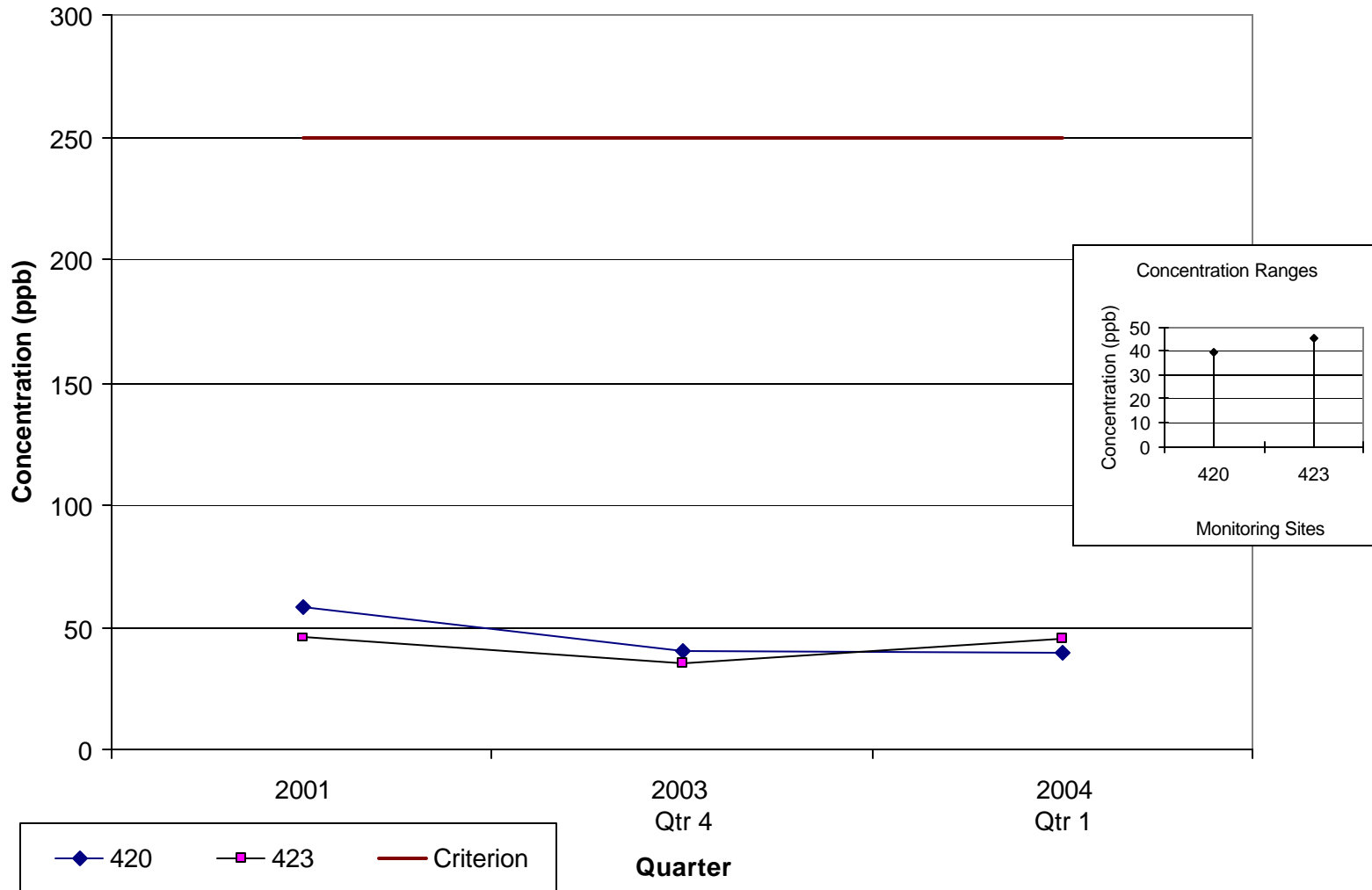


Figure 5. Nitrogen Dioxide Annual Average Concentration

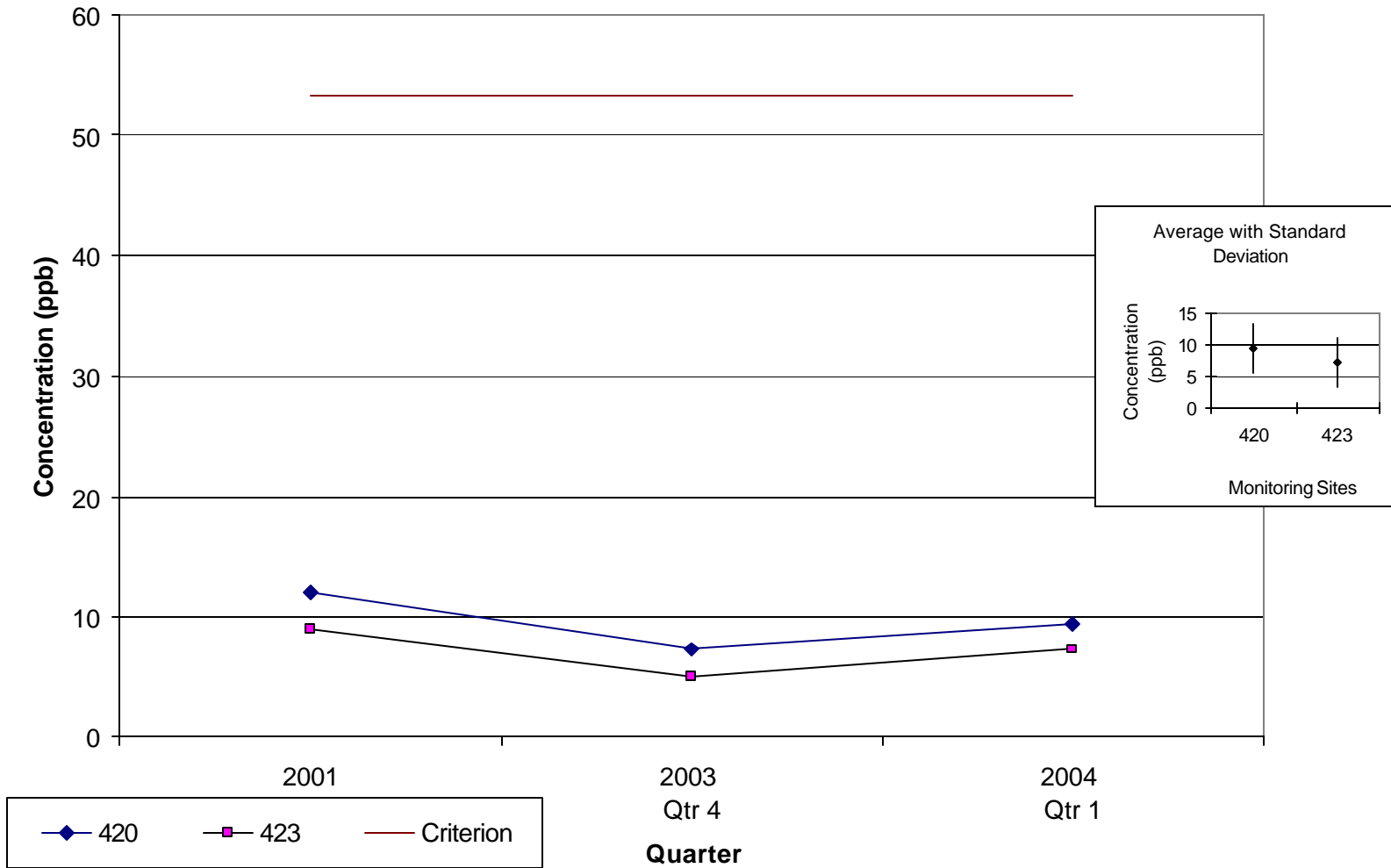


Figure 6. Formaldehyde Maximum 1-Hour Average Concentration

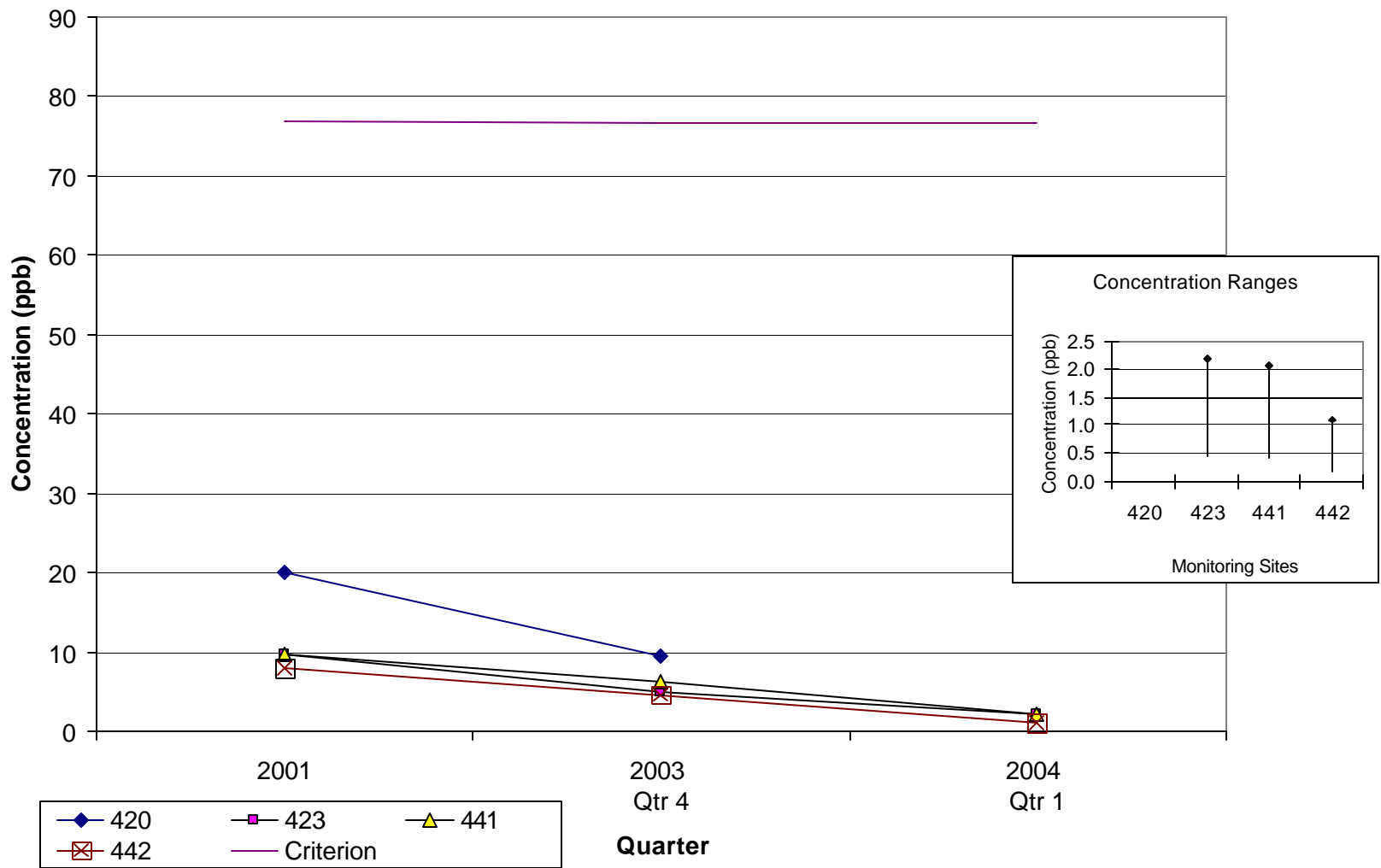


Figure 7. Formaldehyde Annual Average Concentration

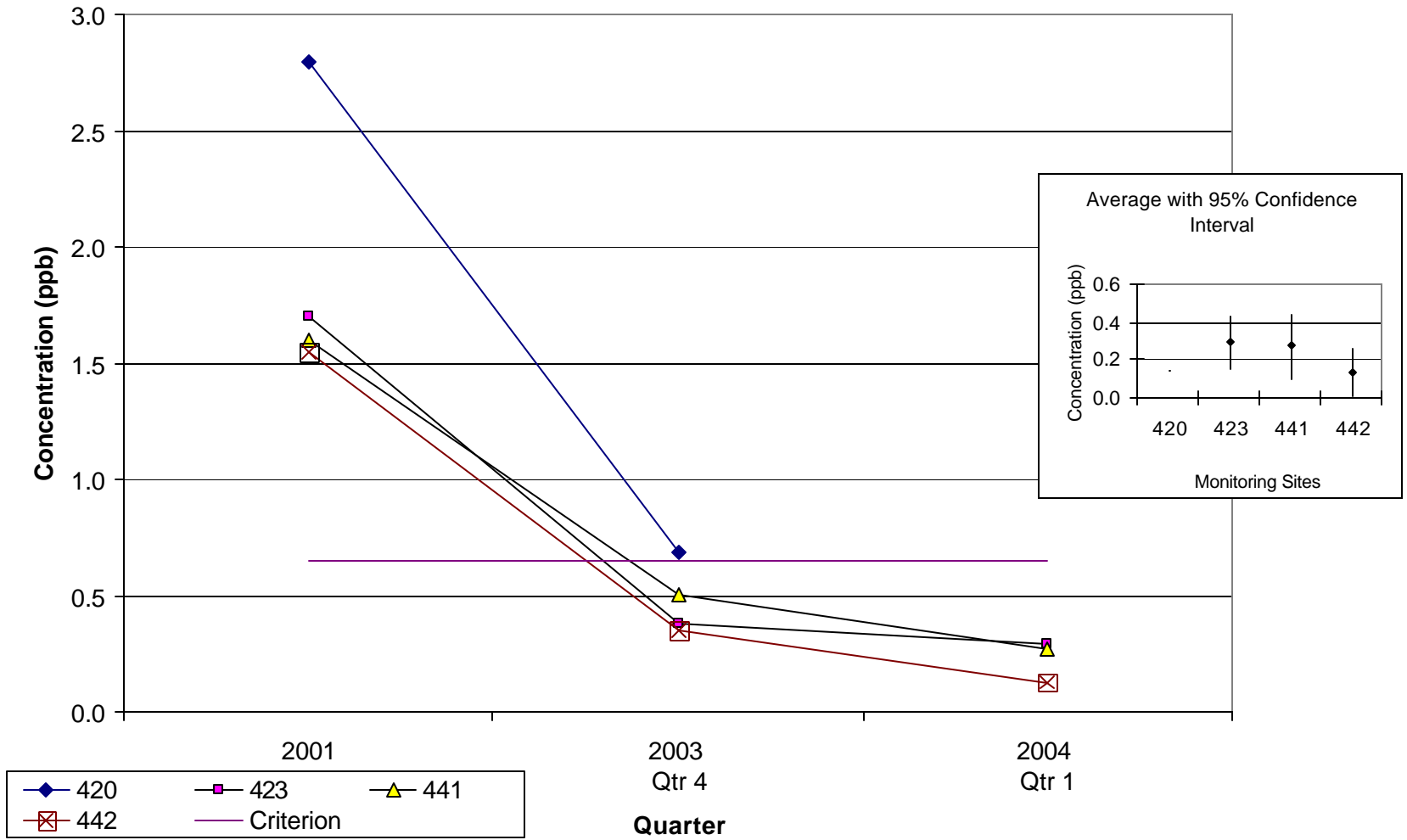


Figure 8. Carbon Tetrachloride Annual Average Concentration

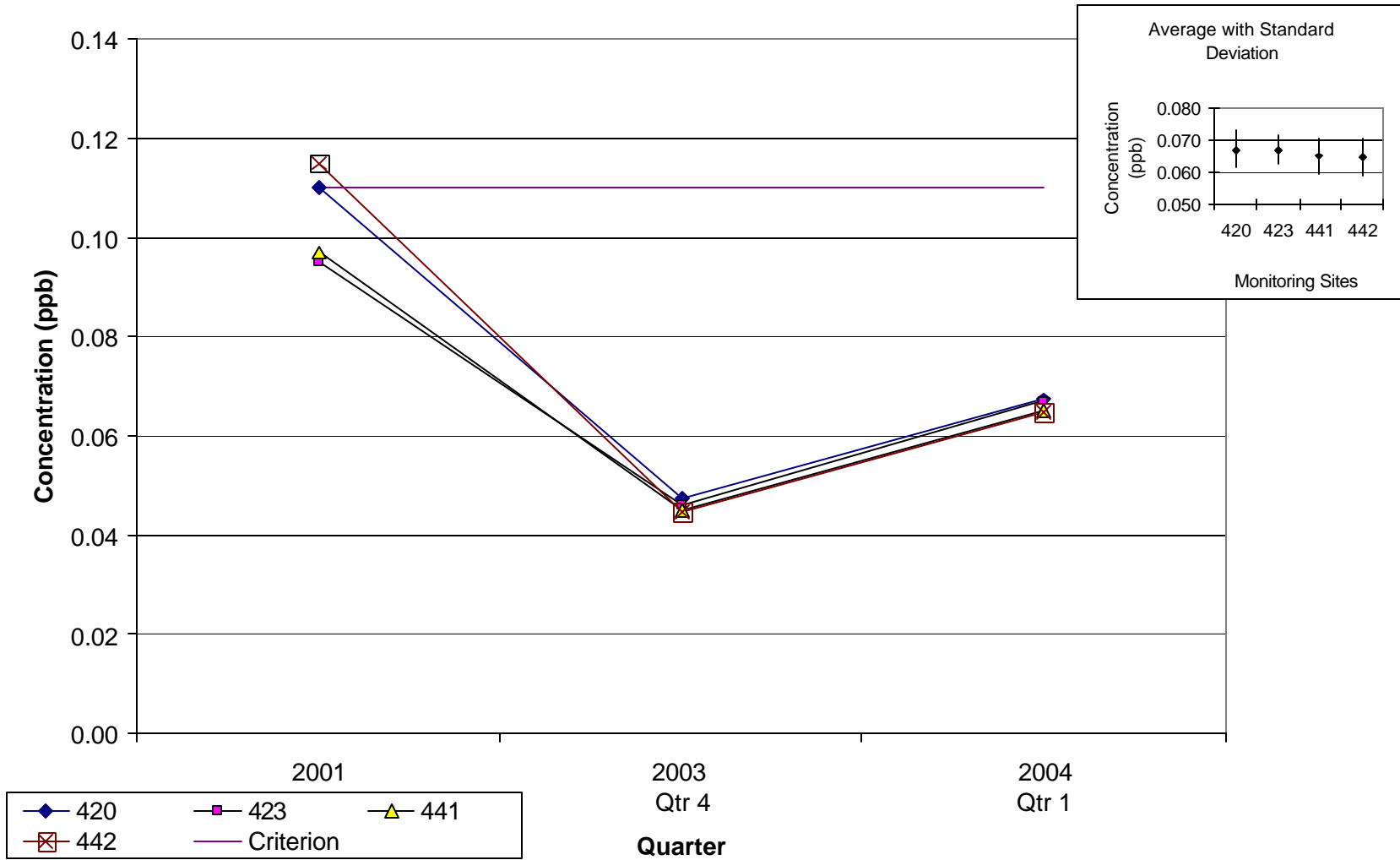


Figure 9. Benzene Annual Average Concentration

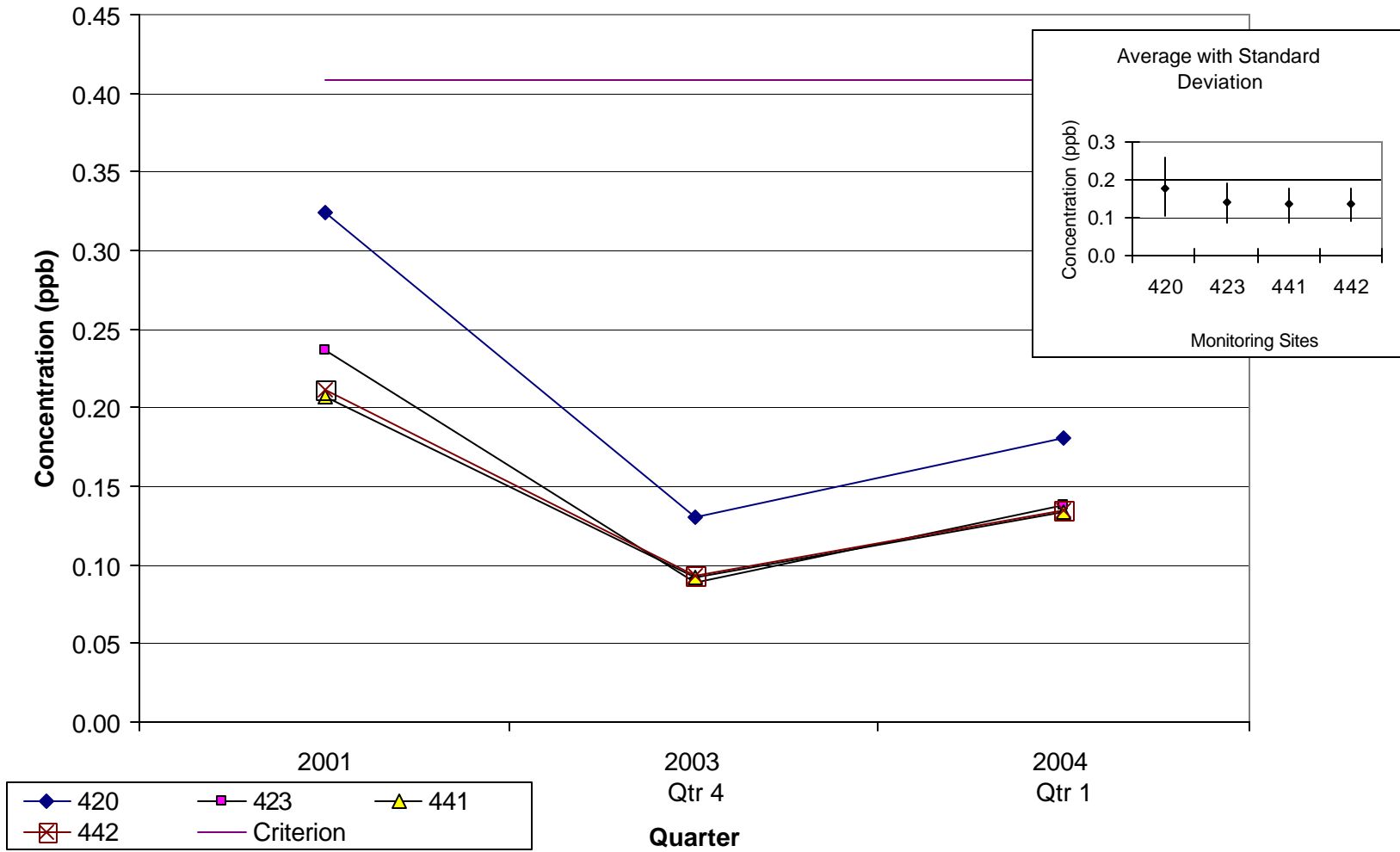


Figure 10. Ethylbenzene Maximum 1-Hour Average Concentration

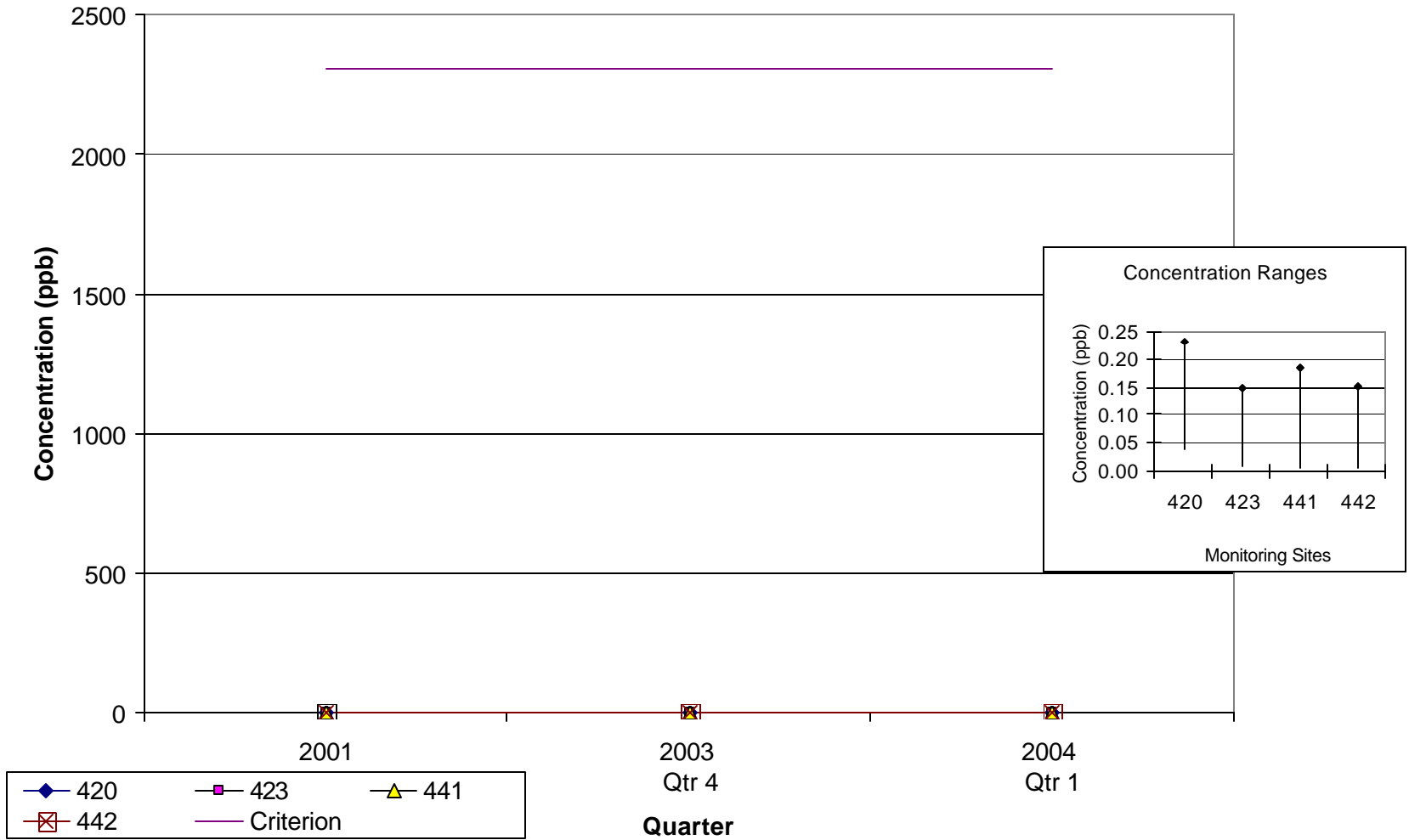


Figure 11. Ethylbenzene Annual Average Concentration

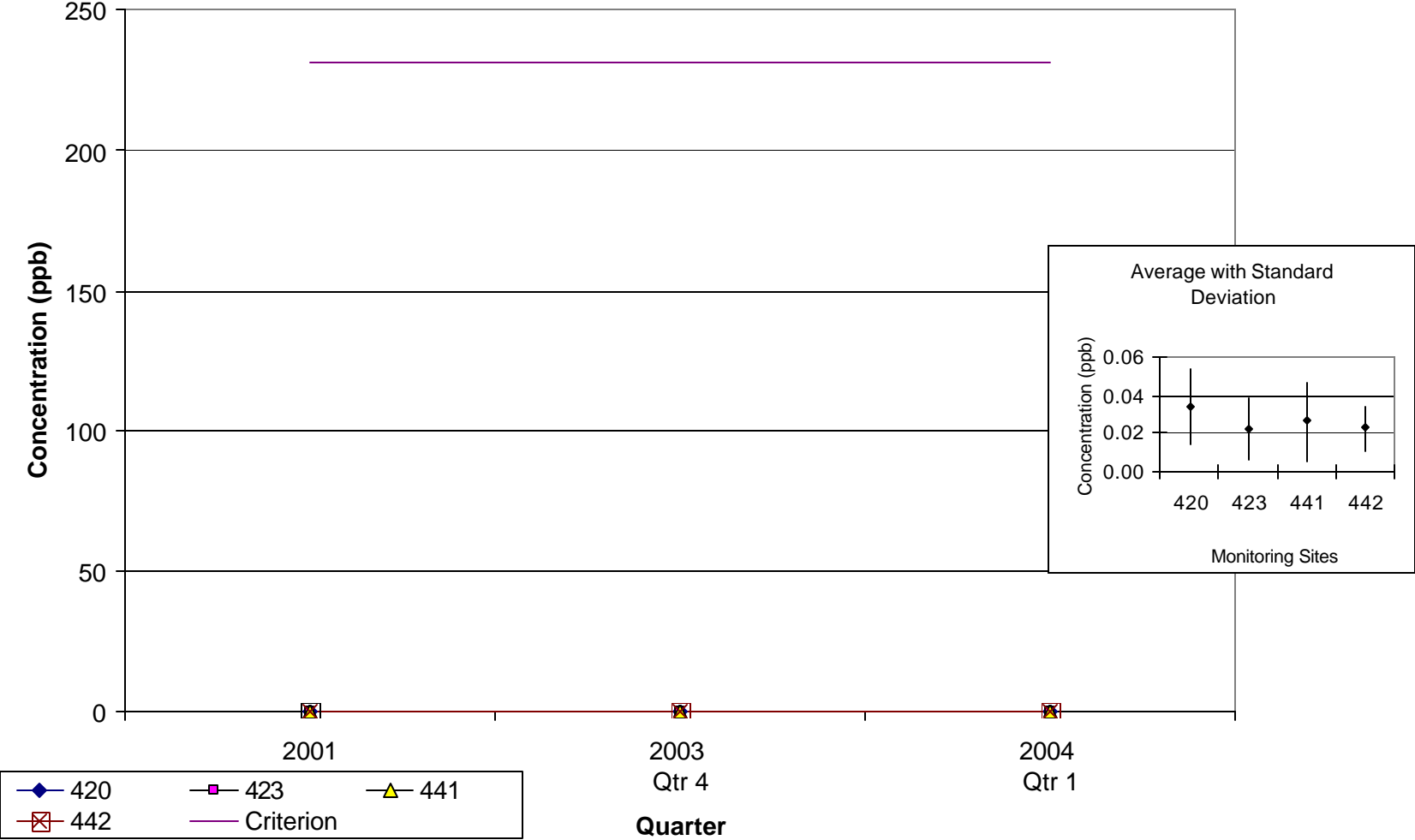
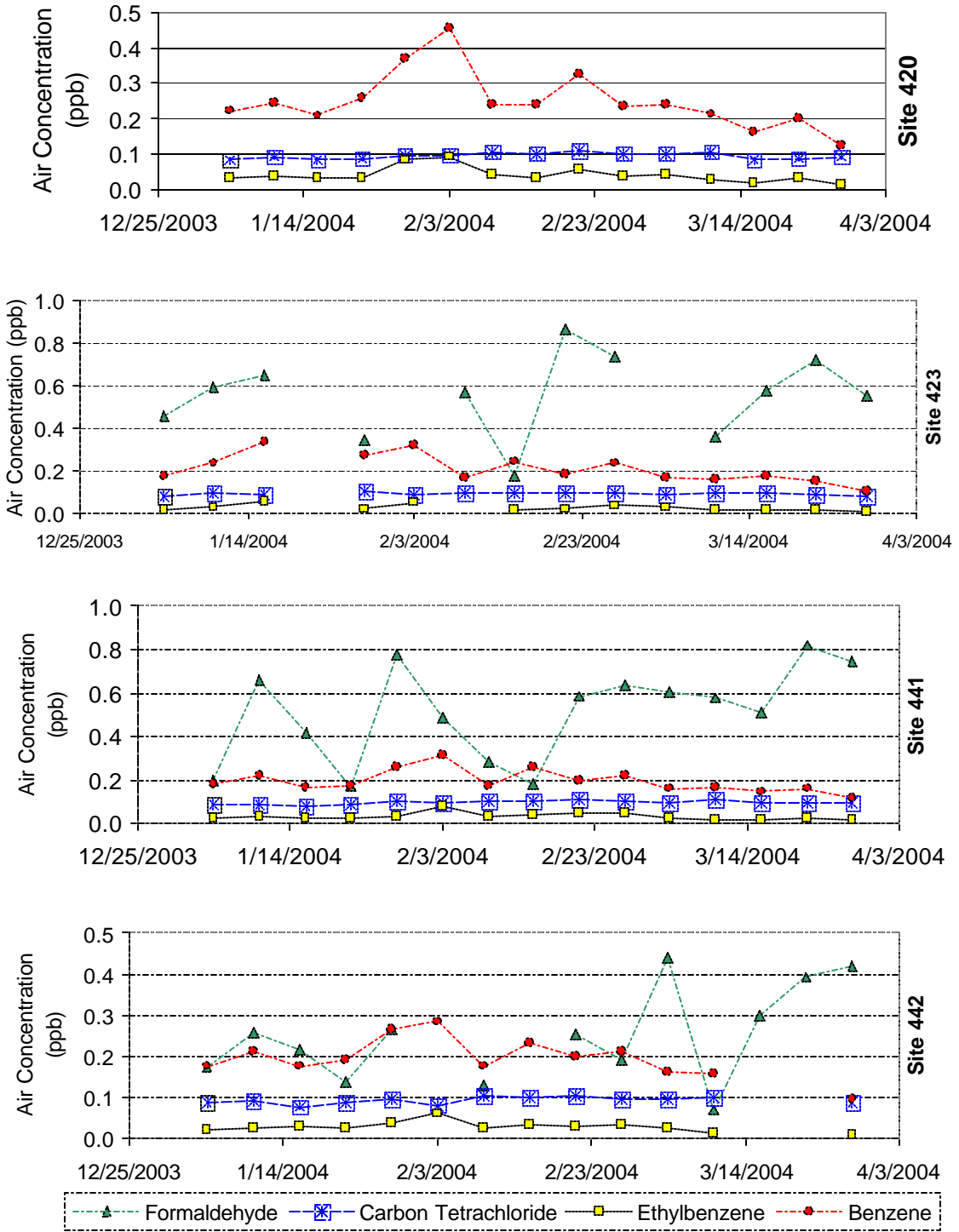


Figure 12
Raw Monitoring Data of Volatile Organics
(24-hour Average Concentrations)



**Table 1: Summary of Results
(Table 1 of 2)**

Site	Chemical	Time (scaled)	Limit (ppm)	Result (ppm) (scaled)
420	SO _x	1 hr	497	30.1
423	SO _x	1 hr	497	21.7
441	SO _x	1 hr	497	20.0
442	SO _x	1 hr	497	16.3
420	SO _x	24 hr	140	6.3
423	SO _x	24 hr	140	6.3
441	SO _x	24 hr	140	5.5
442	SO _x	24 hr	140	4.8
420	SO _x	Annual	31	0.87
423	SO _x	Annual	31	0.77
441	SO _x	Annual	31	0.33
442	SO _x	Annual	31	0.14
420	NO _x	1 hr	250	39.0
423	NO _x	1 hr	250	45.0
420	NO _x	Annual	53.5	9.5
423	NO _x	Annual	53.5	7.2
420	Formaldehyde	1 hr	77	
423	Formaldehyde	1 hr	77	2.18
441	Formaldehyde	1 hr	77	2.05
442	Formaldehyde	1 hr	77	1.10
420	Formaldehyde	Annual	0.65	
423	Formaldehyde	Annual	0.65	0.29
441	Formaldehyde	Annual	0.65	0.27
442	Formaldehyde	Annual	0.65	0.13

Continued on next page

**Table 1: Summary of Results
(Table 2 of 2)**

Site	Chemical	Time (scaled)	Limit (ppm)	Result (ppm) (scaled)
420	Carbon Tetrachloride	Annual	0.11	0.067
423	Carbon Tetrachloride	Annual	0.11	0.067
441	Carbon Tetrachloride	Annual	0.11	0.065
442	Carbon Tetrachloride	Annual	0.11	0.065
420	Benzene	Annual	0.408	0.181
423	Benzene	Annual	0.408	0.138
441	Benzene	Annual	0.408	0.134
442	Benzene	Annual	0.408	0.135
420	Ethylbenzene	1 hr	2308	0.233
423	Ethylbenzene	1 hr	2308	0.148
441	Ethylbenzene	1 hr	2308	0.185
442	Ethylbenzene	1 hr	2308	0.153
420	Ethylbenzene	Annual	231	0.034
423	Ethylbenzene	Annual	231	0.022
441	Ethylbenzene	Annual	231	0.026
442	Ethylbenzene	Annual	231	0.023