United States
Environmental Protection
Agency

Office of Administration
and Resources Management

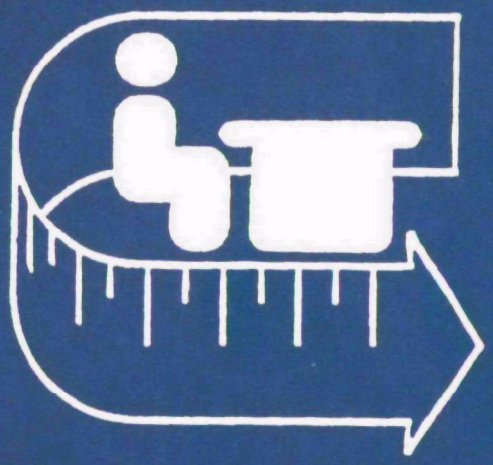
May 1990

EPA

Indoor Air Quality And Work Environment Study

EPA Headquarters' Building Volume 2

Results of Indoor Air Environmental Monitoring Study



Printed on Recycled Paper

Indoor Air Quality and Work Environment Study:

EPA Headquarters Buildings

Volume II:

Results of Indoor Air Environmental Monitoring Study

Atmospheric Research and Exposure Assessment Laboratory
Research Triangle Park, North Carolina 27711

April 1990

D I S C L A I M E R

The research described in this document has been funded in part by the United States Environmental Protection Agency and it has been subjected to Agency peer review. Mention of trade names or commercial products in this document does not constitute endorsement or recommendation for use.

ACKNOWLEDGEMENT

We wish to thank all those whose efforts contributed to the success of this study. First, we appreciate the technical support of Thomas Lumpkin, Tom Hartledge, John Wall, and Malcolm Wilkins of the Exposure Assessment Research Division and Charlie Weant and Chris Fortune of NSI Technology Services Corporation for the monitoring done at the EPA Headquarters.

We also wish to thank Joachim Pleil of the Methods Research and Development Division for the total VOC analysis and Howard Crist of the Quality Assurance Division for the QA samples. Thanks go to Roy Zweidinger and Silvestre Tejada for the aldehyde analysis.

A special thanks to Andy Lindstrom and Matt Somerville of NSI Technology Services Corporation for the statistical summaries, figures, and tables. They were very helpful in a short time frame. Thanks to Jan Parsons for her editorial review and many helpful suggestions as to format and style.

Thanks to Brian Leaderer and his staff of the John B. Pierce Foundation at Yale University for the nicotine analysis.

We would like to thank Larry Michaels and his staff for the chemical analyses of the VOC and formaldehyde badges.

Thanks go to Marie Collins and Penny Andrews of the Exposure Assessment Research Division for their assistance in preparing this report and the supplement to this report.

We appreciate the EPA management support of Gary Foley, Hugh McKinnon, Jack Puzak, Dale Pahl, David Weitzman, Julius Jimeno, Kevin Teichman, and David Smith. They have worked closely with the project team to ensure the success of this study.

We appreciate the thoughtful reviews of the drafts of this report by William Hirzy of NFFE (National Federation of Federal Employees), Kirby Biggs of AFGE (American Federation of Government Employees), and David Scott Smith and Julius Jimeno (EPA Environmental Health and Safety Division), and those who worked with them.

TECHNICAL TEAMS

This study of indoor air quality and work environment was conducted by three technical teams representing multiple organizations. It was jointly developed and carried out at EPA headquarters and the Library of Congress Madison Building under the auspices of these teams working independently of both management and unions at both EPA and the Library of Congress.

Overall project coordination was provided by two technical team leaders: Kevin Teichman at EPA and Lawrence Fine at NIOSH.

MONITORING TEAM

EPA

Ross Highsmith, Chemist
Lance Wallace, Environmental Scientist
Tom Lumpkin, Chemist
Steve Hern, Biologist
Vinson Thompson, Chemist
Ken McLauchlan, Professional Engineer*
Linda Stetzenbach, Microbiologist

NIOSH

Richard Gorman, Industrial Hygienist
Michael Crandall, Industrial Hygienist
Rebecca Stanevich, Industrial Hygienist

John B. Pierce Foundation at Yale University

Brian P. Leaderer, Environmental Scientist
Oliver J. Selfridge, Environmental Scientist

SURVEY DESIGN TEAM

EPA

Mel Kollander, Survey Statistician
Lance Wallace, Environmental Scientist
F. Cecil Brenner, Statistician

Westat

Robert P. Clickner, Statistician
Stephen K. Dietz, Statistician

NIOSH

Anne Fidler, Epidemiologist
Thomas Wilcox, Physician
Joseph Hurrell, Psychologist
Richard Hornung, Statistician

John B. Pierce Foundation at Yale University

Brian P. Leaderer, Environmental Scientist
Oliver J. Selfridge, Environmental Scientist

REPORTING AND ANALYSIS TEAM

EPA

C. J. Nelson, Statistician
Mel Kollander, Survey Statistician
Lance Wallace, Environmental Scientist
Brian Leaderer, Environmental Scientist
Rebecca Bascom, M.D.

Research Triangle Institute

Andy Clayton, Statistician
George Dunteman, Statistician

NIOSH

Anne Fidler, Epidemiologist
Joseph Hurrel, Psychologist

John B. Pierce Foundation at Yale University

Brian P. Leaderer, Environmental Scientist
Oliver J. Selfridge, Environmental Scientist

CONTENTS

Chapter		Page
	ACKNOWLEDGEMENT	iii
	TECHNICAL TEAMS	iv
	LIST OF FIGURES	vii
	LIST OF TABLES	ix
	EXECUTIVE SUMMARY	ES-1
1	INTRODUCTION	1-1
	1.1 Background and Purpose	1-1
	1.2 Study Objectives	1-4
2	BUILDING DESCRIPTION	2-1
	2.1 Building Description	2-1
	2.2 Ventilation System	2-5
3	ENVIRONMENTAL MONITORING DESIGN	3-1
	3.1 Selection of Environmental Monitoring Sites	3-1
	3.2 Environmental Monitoring Study Design	3-3
	3.3 Basis for Monitoring Environmental Pollutants	3-5
	3.4 Environmental Monitoring and Analytical Procedures	3-10
	3.5 Ventilation Evaluation	3-20
4	SUMMARY OF ENVIRONMENTAL MONITORING RESULTS	4-1
	4.1 Number of Sites and Schedule	4-1
	4.2 Real-Time Indoor Measurements	4-2
	4.3 Integrated Sampler Results	4-14
	4.4 Microbiological Contaminants	4-29
5	QUALITY ASSURANCE AND CHEMICAL ANALYSIS	5-1
	5.1 Quality Control Procedures	5-1
	5.2 Quality Control Results	5-4
6	SUMMARY OF AIR HANDLING UNIT EVALUATION RESULTS	6-1
7	REFERENCES	7-1

Appendices

A Summary Statistics for Real-Time Indoor Air Measurements A-1
B Summary Statistics for Respirable Particulate Matter B-1
C Summary Statistics for Formaldehyde and Other Aldehydes C-1
D Summary Statistics for Volatile Organic Compounds D-1
E Summary Statistics for Nicotine E-1
F Summary Statistics for Particles at Fixed Monitoring Locations . F-1
G Summary Statistics for Microbiological Contaminants G-1
H Full Scan VOC Analysis on Selected VOC Canisters H-1
I VOC and Pesticide Quality Assurance Procedures I-1

LIST OF FIGURES

Figures — Page

2.1 Photos of the Three EPA Headquarters Buildings 2-2

4.1 Plot of Temperature Maximum, Mean, and Minimum, Across Waterside Mall Sectors, Crystal City, and Fairchild by Earliest Sample Start Time 4-5

4.2 Frequency Distribution of Observed Temperatures Across Waterside Mall Sectors, Crystal City, and Fairchild . . . 4-6

4.3 Plot of Relative Humidity Maximum, Mean, and Minimum Across Waterside Mall Sectors, Crystal City, and Fairchild by Earliest Sample Start Time 4-8

4.4 Frequency Distribution of Observed Relative Humidity Across Waterside Mall Sectors, Crystal City, and Fairchild . . . 4-9

4.5 Plot of Carbon Dioxide Maximum, Mean, and Minimum Across Waterside Mall Sectors, Crystal City, and Fairchild by Earliest Sample Start Time 4-10

4.6 Frequency Distribution of Observed Carbon Dioxide Concentrations Across Waterside Mall Sectors, Crystal City, and Fairchild 4-11

4.7 Plot of Respirable Particulate Maximum, Mean, and Minimum Across Waterside Mall Sectors, Crystal City, and Fairchild by Earliest Sample Start Time 4-13

4.8 Frequency Distribution of Observed Respirable Particulate Concentrations Across Waterside Mall Sectors, Crystal City, and Fairchild 4-15

4.9 Mean Carbonyl Species Distribution Across Waterside Mall Sectors, Crystal City, and Fairchild 4-17

4.10 Mean Indoor and Outdoor VOC Concentrations and Maximum VOC Concentration Observed at the Waterside Mall, Crystal Mall, and Fairchild Buildings 4-19

4.11 Average Volatile Organic Compound Concentrations Based on All Observations Above the Limit of Quantitation at the EPA Primary Sites 4-20

4.12 Indoor and Outdoor Fixed Site Temperature and Relative Humidity 4-26

4.13 Indoor and Outdoor Fixed Site Carbon Dioxide and Respirable Particulate Concentration 4-27

4.14 Concentrations of Selected Volatile Organic Compounds and Aldehyde Species Measured at the EPA Indoor Fixed Site . . . 4-28

LIST OF TABLES

Table		Page
E.1	Number of Sites Sampled	E-9
E.2	Summary Statistics for Real-Time Environmental Measurements and Respirable Particles	E-10
E.3	Mean Values for Major Aldehydes and VOCs	E-11
3.1	Monitoring and Analytical Methodology	3-11
3.2	Analyte Limit of Detection or Limit of Quantitation	3-12
4.1	Mean Airborne Viable Fungal Concentrations by Genus	4-31
4.2	Mean Airborne Viable Human Source Bacterial Concentrations by Genus	4-32
4.3	Burkhard Spore Trap Sampling Results	4-33
5.1	Results of Duplicate Sample Analysis	5-6
5.2	Results of Repeat Sampling	5-8
6.1	Waterside Mall Air Handling Unit Evaluation	6-4

EXECUTIVE SUMMARY

1. Background

In recent years, employees of the U.S. Environmental Protection Agency (EPA) in the Washington, DC area, have reported health symptoms and discomfort concerns that have been attributed to indoor air. As a result, it was decided in 1988 to carry out a study of indoor air quality at all three EPA Headquarters buildings in the area.

Similar concerns had been expressed at the Library of Congress (LOC) Madison Building, which was to be investigated by the National Institute for Occupational Safety and Health (NIOSH). Therefore, it was decided that EPA and NIOSH would carry out a single joint investigation, using identical questionnaires and monitoring techniques as far as possible, of both the LOC Madison building and the EPA Headquarters buildings.

An interagency team of investigators consisting of EPA and NIOSH scientists was formed to direct the project. These scientists included experts in survey design, monitoring of indoor air, occupational medicine, and epidemiology. In addition, the Pierce Foundation of Yale University, whose staff is experienced in indoor air epidemiological investigations, was contracted to provide expert advice and direction to the project. A survey design firm (Westat, Inc.) administered the questionnaire, and an engineering firm (McLauchlan and Associates) was contracted to investigate the EPA building ventilation system.

The Atmospheric Research and Exposure Assessment Laboratory (AREAL) of EPA's Office of Research and Development (ORD) planned, directed, and carried out most of the monitoring performed at the EPA Headquarters buildings. Another ORD laboratory, the Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV), carried out the biological sampling and analysis.

The objectives of the study were to survey health symptoms and comfort concerns of employees; characterize the indoor air environment in selected building locations; and analyze possible associations between health or comfort symptoms and conditions in the building environment. The study results are being presented in three successive reports for each of the two building complexes involved. Volume 1 of the EPA series, released in November 1989, summarized the employees' health symptoms and comfort concerns. This report, Volume 2, summarizes the environmental measurements in the three EPA Headquarters buildings. Volume 3, to be published in the late fall of 1990, will analyze any associations between health or comfort and the building environment.

Additional information continues to be obtained by both labor and management on the quality of indoor air at EPA headquarters. The National Federation of Federal Employees Local 2050, the American Federation of Government Employees Local 3331, and EPA management have assembled a number of reports on emissions and air monitoring that document the results of independent small-scale studies conducted at EPA headquarters buildings prior to the large-scale study that is the subject of this report. This information is provided in a supplement to this report entitled "Additional EPA Headquarters Air Monitoring Information".

2. Study Design

The basic concept of the monitoring study was to measure a series of comfort and environmental variables in selected locations for a single day. Employees in those locations were to be asked about their health symptoms and comfort on that day only. About 20 locations were sampled in a day, allowing the total monitoring effort to be completed in one week (March 6-10, 1989).

An initial questionnaire was administered to all employees in the three EPA Headquarters buildings prior to monitoring. The questionnaire included a number of questions on health, comfort, and odors, as well as information

pertaining to job characteristics and the workstation environment. A supplementary questionnaire was administered to the employees on the day of monitoring that included the same questions on health, comfort and odors.

Available resources allowed for a complete set of environmental samples to be collected in 65 locations in the three EPA Headquarters buildings. These "primary sites" were supplemented by an additional set of about 50 "secondary sites", where a less complete set of environmental samples could be collected. "Special sites", selected by representatives of EPA management and each of the two unions, were sampled less frequently. The initial questionnaire was analyzed by the contractor to select rooms with high complaint levels and rooms with low complaint levels. Since only selected locations could be monitored, it was decided to sample rooms with high complaint levels preferentially (2:1). This information was not revealed to any EPA employee or any other member of the monitoring team in order to avoid possible bias.

Parameters monitored at all sites included the "comfort variables" (temperature and relative humidity), an indicator for the amount of fresh air in a space (carbon dioxide [CO_2]), an indicator of combustion emissions (carbon monoxide [CO]), and a measure of dust levels (respirable suspended particulates [RSP]). Each parameter was instantaneously monitored during three separate site visits (morning, mid-day, and afternoon) on the day monitoring was conducted. Additional variables monitored at the 65 primary sites included indicators of potential chemical contamination (formaldehyde and 27 other volatile organic compounds, or VOCs), an indicator of smoking activity (nicotine), and an integrated measurement of RSP. The formaldehyde, VOCs, and RSP measurements were integrated over a 9-h period; the nicotine measurement was integrated over the entire five-day workweek. Microbiological aerosols (bacteria and fungi) were also sampled at the primary sites and some of the secondary sites. In a few sites (about two per day), integrated air samples were collected and analyzed for 15 aldehydes and 33 pesticides. One fixed indoor site and one fixed outdoor site were established at the Waterside Mall building and was operated over all

five days, to obtain an idea of the daily variability of the environmental parameters. Measurements of airflow and other ventilation parameters were made at the 33 air handling units (AHU) serving the monitoring locations.

Quality control samples, including duplicates, blanks, and spiked controls, were collected for the VOCs. The monitoring instruments were calibrated periodically according to the study protocol. Monitoring procedures are described more fully in chapter 3 of this report and quality assurance methods in chapter 5.

3. Results

Table E-1 summarizes the total number of sites sampled at each building for each environmental parameter.

Results are presented as mean values for each of the three buildings (Table E-2): Waterside Mall (WM), Crystal Mall (CM). and Fairchild (FC). Within Waterside Mall, seven "sectors" were defined: the second and third floors of the Mall, the East and West Towers, and the Northeast, Southeast, and Southwest portions of the Mall. The following discussion presents building-wide means first, and sector means are discussed when appropriate. Tables of sector means are in the appendices. Because of the small number of samples taken in Crystal Mall and Fairchild, building-wide differences are somewhat tentative; the same statement holds for differences among sectors.

Comfort Parameters

Mean temperatures varied over a small range (from 74-77°F) at the three buildings (Table E-2). Waterside reported cooler temperatures than the other two buildings, with minimums in the low 60's. Within Waterside Mall, the East and West Towers had slightly higher mean temperatures (75°F) than the other five sectors (72-73°F Table A.8). The lowest minimum temperatures were reported in

the second floor of the mall and the Southwest sector.

Mean relative humidities were almost identical at the three buildings, about 23%. The range of values was much greater at Waterside (Table A.16): 6.2% to 54.2%, compared to ranges of about a third of that at the other two buildings. Five of the seven sectors at Waterside had mean relative humidities of 20-22%; the third floor of the Mall and Northeast sector had higher mean relative humidities of 29% and 31%, respectively.

Ventilation Parameters

Mean carbon dioxide values were highest at Fairchild (746 ppm); lower at Waterside (575 ppm); and lowest at Crystal (504 ppm). However, it should be noted that measurements at Fairchild and Crystal were made on only one day. Again, the range of values was greatest at Waterside (325-1350 ppm Table A.32). The East Tower had the highest mean CO_2 values within Waterside (695 ppm); the West Tower, with more than a hundred fewer people in the same amount of space, had the second-highest mean CO_2 level (608 ppm).

The amount of outside air supplied by 33 air handling units in the Waterside building showed a fairly wide variation between sectors. The West Tower AHUs varied from 30 to 53% outside air (Table 6.1), whereas the four East Tower units ranged from 23 to 83% outside air. Fourteen units on the second floor of the Mall ranged from 10 to 74% outside air, whereas eight units on the third floor of the Mall showed a much narrower range of 15-26%. The Southeast and Northeast sectors had similar ranges of 18-48% and 22-40% outside air, respectively. The values given are likely to be upper-bound estimates, since much depends on individual flow patterns between the supply diffuser and return within each office.

Particles

Real-time RSP measurements ranged from mean values of 9.5 $\mu g/m^3$ at Fairchild to 14.1 $\mu g/m^3$ at Waterside. Integrated samples, collected at primary sites only, ranged from 16.3 $\mu g/m^3$ at Crystal to 23.5 $\mu g/m^3$ at Waterside. The difference in real-time and integrated values is probably due to the fact that different parameters are being measured--the real-time device employs optical scattering, which depends on the aerodynamic diameter of the particles, whereas the integrating monitor measures the mass of the particles.

Instantaneous values as high as 96 $\mu g/m^3$ were observed on a few occasions and technicians' notes indicated a concurrent odor of tobacco smoke. The highest 9-h integrated average was 54.7 $\mu g/m^3$.

Nicotine

Consistent with the interpretation supplied above of the RSP measurements, only 6 of 63 nicotine badges were found to exceed the limit of quantitation (Table E.1). Two of these measurable values (out of six samples) occurred in Fairchild, and three more (out of 50) occurred in Waterside Mall.

Formaldehyde and other aldehydes

Formaldehyde mean values were very low at all buildings, ranging from 8.9 $\mu g/m^3$ to 19.3 $\mu g/m^3$. Acetone levels were similar to formaldehyde (12-28 $\mu g/m^3$), and acetaldehyde means ranged from 5 to 11 $\mu g/m^3$. Other aldehydes ranged from 0.1 to 3 $\mu g/m^3$.

Volatile Organic Compounds

Although the number of samples is small for Fairchild and Crystal (five samples each), total VOC levels showed differences in mean levels for the three

samples each), total VOC levels showed differences in mean levels for the three buildings, and Fairchild was consistently highest. For example, total VOCs as measured by flame ionization detection (FID) showed that Fairchild had mean values of 1.9 ppmC (Table D.16), compared to 1 ppmC at Waterside and 0.5 ppmC for Crystal. The same pattern appears in the sum of the 27 VOCs measured by gas chromatography-mass spectrometry (GC-MS): Mean levels were 99.4 $\mu g/m^3$ for Fairchild, 35.7 $\mu g/m^3$ for Waterside, and 28.8 $\mu g/m^3$ for Crystal. (Outdoor values for the 27 VOCs added up to 12.8 $\mu g/m^3$.)

This pattern was repeated for many individual VOCs. For example, aromatic compounds such as toluene and xylenes showed levels 3 times higher in Fairchild than the other buildings, and by larger factors compared to outdoor levels. Para-dichlorobenzene was found in all five samples at Fairchild, but in none of the five samples at Crystal and only 1 of 51 samples at Waterside. Benzene was also found in all five samples at Fairchild, but in none at Crystal and only 4 of 51 samples at Waterside.

Waterside Mall had a mean tetrachloroethylene value of 6.9 $\mu g/m^3$, compared to 3.6 $\mu g/m^3$ at Fairchild and 2.2$\mu g/m^3$ at Crystal Mall. Within Waterside Mall, the West Tower had elevated levels of tetrachloroethylene (17.4 $\mu g/m^3$ compared to levels of 2-5 $\mu g/m^3$ at other sectors). Another solvent, 1,1,1-trichloroethane was also slightly higher at Waterside (8.7 $\mu g/m^3$) than at Fairchild (6.6 $\mu g/m^3$). The East and West Towers had elevated levels of this chemical (13-15 $\mu g/m^3$ compared to a range of 2-8 $\mu g/m^3$ at the other sectors).

No samples had levels above the limit of quantitation of 4-PC (4-phenylcyclohexene), a chemical emitted from some carpets and previously found in Waterside air samples. Several air samples were analyzed for a complete spectrum of VOCs. A large number of alkanes (butane, pentane, isopentane, cyclohexanes) were identified, together with some alkylated benzenes and octahydropentalene isomers.

Pesticides

No pesticides were observed above the detection limit in any sample.

Carbon Monoxide

No elevated levels of CO were observed at any site. The highest observed value was 4 ppm, well below the EPA 8-h standard of 9 ppm.

Biological Aerosols

Overall, counts of airborne fungi taken inside the Waterside Mall, Fairchild, and Crystal City buildings were low and comparable to counts in the outdoor samples. A few samples taken in the East Tower of the Waterside Mall building contained relatively high numbers of fungi. A mycotoxin producing fungi was also isolated in low concentrations in three locations at the Waterside Mall (East Tower, Mall 2, and West Tower). Fungal spore counts were low and consisted of common airborne spores. Generally, human source bacterial counts (HSB) were low with *Staphylococcus sp.* and *Micropolyspora sp.* counts not unexpectedly higher indoors than outdoors.

Table E.1. Number of Sites Sampled at Waterside Mall (WM), Crystal Mall (CM), and Fairchild Buildings (FC)

Parameter	WM	CM	FC	TOTAL IN	TOTAL OUT
Temperature	150	17	19	186	0
Relative Humidity	150	17	19	186	0
CO	150	17	19	186	0
CO_2	150	17	19	186	14
RSP (real-time)	142	17	19	178	0
RSP (integrated)	49	5	5	59	0
VOCs	51	5	5	61	5
Aldehydes	16	2	2	20	0
Nicotine	50	7	6	63	0
Pesticides	5	2	2	9	0

Table E.2. Summary Statistics for Real-Time Environmental Measurements and Respirable Particles

Environmental Parameter	WM	CM	FC
Temperature (F)			
Mean	73.8	74.7	76.7
Standard Error	0.2	0.3	0.4
Minimum	62.0	71.5	72.0
Median	74.0	74.7	76.5
Maximum	82.5	79.5	81.0
Relative Humidity (%)			
Mean	22.8	23.3	24.4
Standard Error	0.4	0.7	0.4
Minimum	6.2	17.7	16.9
Median	21.6	24.0	23.9
Maximum	54.2	29.1	28.7
CO_2 (ppm)			
Mean	575	504	746
Standard Error	10	10	17
Minimum	325	400	525
Median	558	525	750
Maximum	1350	675	925
RSP: Real-time ($\mu g/m^3$)			
Mean	14.1	12.2	9.5
Standard Error	0.9	1.4	1.0
Minimum	0.0	2.0	1.0
Median	12.7	11.3	11.0
Maximum	96.0	32.0	21.0
RSP: Integrated ($\mu g/m^3$)			
Mean	23.5	16.3	18.5
Standard Error	1.9	1.4	4.5
Minimum	10.7	14.9	14.0
Median	21.4	16.3	18.5
Maximum	54.7	17.7	23.1

Table E.3. Mean Values for Major Aldehydes and VOCs ($\mu g/m^3$)

Chemical	WM	CM	FC	Outdoors
Aldehydes (total)	32.1	43.8	73.6	NM[a]
Formaldehyde	8.9	11.3	19.3	NM
Acetaldehyde	5.1	7.4	10.9	NM
Acetone	12.0	16.2	28.0	NM
VOCs (total of 27 targets)	35.7	28.8	99.4	12.8
Toluene	10.7	13.5	38.3	7.6
Xylenes	5.9	6.4	21.1	4.3
Methylene chloride	3.2	1.6	6.7	1.6
Tetrachloroethylene	6.9	2.2	3.6	1.7
1,1,1-trichloroethane	8.7	3.3	6.6	1.9
p-Dichlorobenzene	3.3	ND[b]	6.1	ND
Trichloroethylene	1.1	1.3	3.0	ND

[a]Not Measured

[b]Not Detected

1. INTRODUCTION

1.1 Background and Purpose

The indoor air quality of the work environment is increasingly becoming a significant factor influencing job satisfaction and office productivity. Occupants in many apparently well-designed office buildings, modern as well as newly renovated, are reporting increasing numbers of health symptoms and comfort concerns that are being attributed to the overall quality of the work environment. The most typical symptoms reported include eye, nose, and throat irritation, headaches, and lethargy.

Investigating large office buildings and relating worker concerns to indoor air quality are complex tasks. Health symptoms reported for work-related illnesses are not unique. These same symptoms are also frequently reported for common illnesses or result from other causes and exposures that are non-work related. As with individual workers, large buildings are unique. Although buildings may be comparably designed, the actual operating conditions may differ significantly. The investigative process is complicated by the influence of the building's physical characteristics (windows, building materials, etc.); the design and operation of its heating, ventilating, and air conditioning (HVAC) systems; workstation ergonomic factors; indoor sources; and outside sources. Relationships between these components must be evaluated and understood before they can be directly related to the most significant factor influencing this complex investigative process, the individual workers themselves.

In recent years, employees of the U.S. Environmental Protection Agency (EPA) Headquarters Buildings located in the Washington, DC, area, have reported numerous health and discomfort symptoms that have been attributed to the building indoor air environment. Additional information continues to be obtained by both labor and management on the quality of indoor air at EPA headquarters. The National Federation of Federal Employees Local 2050 and the American Federation

of Government Employees Local 3331 have assembled a number of emissions and air monitoring reports that document the results of independent small scale studies conducted at EPA headquarters buildings prior to the large-scale study that is the subject of this report. This information is provided in a supplement to this report entitled "Additional EPA Headquarters Air Monitoring Information".

In response to worker concerns, employees, employee unions, and management requested the EPA Office of Administration and Resource Management (OARM), Environmental Health and Safety Division (EHSD), to systematically evaluate the nature and spatial distribution of the employees' health symptoms and comfort concerns, characterize the indoor levels and spatial distribution of environmental pollutants, and where possible, relate the worker symptoms and concerns to the physical and environmental conditions of the building. EPA's Atmospheric Research and Exposure Assessment Laboratory, Office of Research and Development, Research Triangle Park, NC, was requested to assist EHSD in this investigation. The John B. Pierce Foundation at Yale University, Westat, Incorporated, and McLauchlan & Associates were contracted to assist in the development and conduct of a survey of employees and to assist in the building environmental monitoring study.

A multidimensional indoor air investigation protocol integrating participating organizational expertise was developed and implemented. A detailed employee survey questionnaire instrument was developed and administered to all EPA employees during late February and early March 1989. The questionnaire is divided into five sections. The first three sections address the spatial distribution of health symptoms and comfort concerns throughout the building. Part IV contains questions addressing job characteristics and satisfaction, as well as indicators of stress in work and nonwork activities. Part V includes demographic and other miscellaneous questions.

The survey results were summarized by worker locations and analyzed for trends and uniformity in response rates to select areas of high and low incidence

of worker health symptoms and comfort concerns for environmental monitoring and evaluation. Environmental monitoring was conducted at selected indoor and outdoor locations during March 6-10, 1989. A supplemental survey questionnaire was concurrently administered to employees located near the environmental monitors

Three reports will result from this investigation. The first report summarizes the design, conduct, and descriptive statistics of the employee survey and has been released.[1] This second report summarizes the environmental monitoring study and results. A third report comparing the employee and supplemental survey responses along with the environmental results will follow.

This report is the second of the three scheduled reports and summarizes the design, conduct, and results of the cooperative environmental monitoring study conducted in the Environmental Protection Agency Headquarters Buildings. Brief descriptions of the EPA Headquarters Buildings, including design and operating features that may contribute to overall indoor air quality, are presented in Chapter 2. Chapter 3 provides an overview of the criteria for selecting monitoring sites, the monitoring study design, the basis for the parameters monitored, and the study monitoring and analytical methodologies. Environmental monitoring study results are summarized in Chapter 4. Chapter presents quality assurance procedures and results for the monitoring study. Chapter 6 discusses the results of the evaluation of the Waterside Mall air handling units operating during the study.

A parallel investigation was conducted at the Library of Congress (LOC) James Madison Memorial Building located in Washington, DC. The EPA and LOC study objectives, protocols, survey instruments, monitoring methods, and analytical methods were similar.

1.2 Study Objectives

Four major objectives were defined for the EPA investigation:

1. Survey the nature, magnitude, and spatial distribution of health symptoms and comfort concerns.

2. Characterize selected physical, chemical, and biological aspects of the building in selected locations during the survey period.

3. Generate hypotheses from any associations observed between health and comfort effects and environmental factors while taking into account factors that would confound or modify the associations.

4. Identify areas not in compliance with standards or guidelines.

The employee survey was conducted to meet the first objective. Monitoring for selected environmental and comfort parameters was conducted during the normal working hours for one week to meet the second objective. A supplemental survey of selected workers in the vicinity of the monitoring stations was conducted simultaneously with the monitoring program. The environmental monitoring, employee survey, and supplemental survey data bases will be integrated and statistically analyzed in support of the third and fourth study objectives, and results will be provided in the third report.

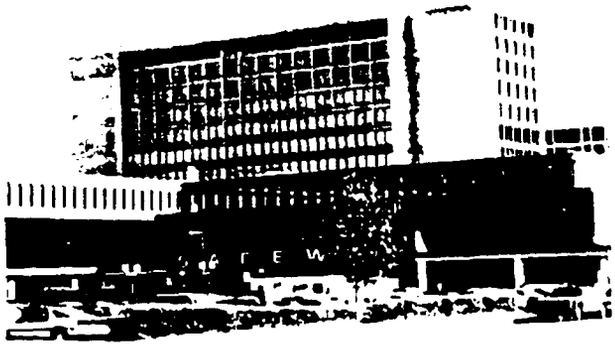
2. DESCRIPTION OF THE ENVIRONMENTAL PROTECTION AGENCY HEADQUARTERS BUILDINGS

The EPA Headquarters is housed in three separate office complexes located within a several mile radius in the Washington, DC, area: the Waterside Mall complex, the Fairchild Building, and the Crystal Mall 2 Building. Photographs of the three EPA Headquarters Building complexes are provided in Figure 2.1.

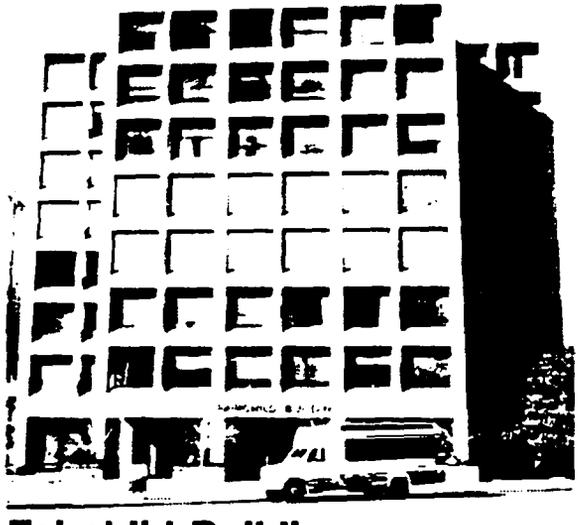
2.1 Building Description

The Waterside Mall complex (including the central four-story shopping mall and two 12-story towers (East and West)) is located at 401 M Street, S.W. The original structure was built in 1970, and EPA took occupancy in 1971-1972. Three additional structures (Northeast tower, Southeast tower, and Southwest tower) were added during the 1980s. EPA currently leases 1,004,450 ft^2 of office space, which is assigned to approximately 5100 EPA personnel. An underground parking garage (approximately 750 vehicles) is located immediately below the Waterside Mall ground floor. The first floor Waterside Mall spaces are predominately occupied by light commercial establishments such as restaurants, gift, and convenience stores. The second floor Mall, originally designed for small shops and business, has been renovated with 10-foot walls added to accommodate offices. The second floor central area office ceilings are open bay, exposed to the communal space resulting from the original mall design. The third floor was originally designed for offices with standard 8-foot enclosed ceilings. The Mall is served by four elevators and stairways, an elevator and a stairway in each corner.

The East Tower and West Tower 12-story structures are nearly identical, each being designed for general office occupancy. Four elevator shafts are located in the center of each tower. Figure-8 hallways service the half-height windowed exterior offices and the enclosed interior offices. The third floor mall is connected to the fourth floor West Tower and East Tower by the 3100



Waterside Mall



Fairchild Building

Crystal Mall 2

Figure 2.1 Photos of the Three EPA Headquarters Buildings.

hallway. All three buildings are connected by a hallway in the basement that runs beside the parking garage. The only other access between these three structures is via outdoor entrances.

Three- to five-story structures were added to three corners of the Waterside Mall complex over the years: Northeast (NE), Southwest (SW), and Southeast (SE) Malls. The first floor of the three-story SE Mall is a large grocery store, and several small businesses occupy the first floor of the three-story SW Mall. The five-story NE mall (two underground) is occupied EPA office space.

A diversity of office designs exists in the second and third floors of the Waterside Mall, especially the second floor, with 6-12 workers in each office complex. The general office design is based around a single, large, central administrative area occupied by one or more administrative personnel. Additional single-worker or two-person offices, accessible only through the central office area, complete the office design. In most cases, the attached office includes a privacy door. "Hallway" office designs observed include an initial reception area leading to a hall that services the individual office areas. Several of these "hallway" complexes are interlinked with similar office areas, which complicates the physical distinction between the end of one office area and the beginning of another. One hallway, about 100 feet long, intertwines through distinctively different renovated areas. Some small single or dual office spaces were also noted. With the exception of the few offices on the exterior north and south section, the offices do not have individual windows.

The SW Mall offices are similar in complexity to the second floor Mall offices. NE and SE Mall office areas are less complex with small central offices serving two to six individual office areas. Full or half-height windows are included in the exterior SW, SE, and NE Mall areas.

The Fairchild Building, a nine-story office building located at 499 South

Capitol Street, S.W., near downtown Washington, DC, was first occupied by EPA during the 1979-1980 time frame. Four floors (121,015 ft^2) are leased to EPA, housing approximately 850 EPA employees. The building offers no underground parking. One floor (the basement) houses an underground snack bar. The building is served by a central core elevator system. Figure-8 hallways provide access to the half-height windowed exterior and windowless interior offices located on each of the four EPA-leased floors. The majority of offices in the Fairchild building are large, multiple occupancy, open bay office areas. Half or three-quarter partitions separate work areas. The few individual or dual person offices observed exist along the exterior walls.

The Crystal Mall 2 is a 14-floor office building located at 1921-31-41 Jefferson Davis Highway, Arlington, VA. Four floors (103,019 ft^2) of office space, leased initially to EPA during 1971-1972, are assigned to approximately 560 persons. The Crystal Mall 2 building is part of a building complex which includes an underground interconnecting shopping area and a subsequently lower subground multilevel parking garage (>1000 vehicles). Central core elevators service the squared hallways that serve the exterior and interior offices. Interior offices are generally small and have only one to two occupants. Two types of exterior office areas were observed: single or dual occupant and central office areas that include a reception area interior to and servicing multiple individual offices located on the exterior wall. Offices with exterior walls included half-height windows.

The enclosed office is the prevalent workplace type for Waterside Mall (65%) and Crystal Mall 2 (84%), whereas for Fairchild, a cubicle with mid-height partitions is the most common type (65%). The next highest work place type at each building is the mid-height partitioned cubicle at Waterside Mall (19%), the open office at Crystal Mall 2 (8%), and the enclosed office at Fairchild (27%). When enclosed offices and mid-height partitions are considered together (Waterside - 85%, Crystal Mall - 91%, and Fairchild - 92%), only small differences are seen in workplace among the three buildings. Most workstation

spaces are occupied by one person or shared by two people.

2.2 Ventilation System Description and Evaluation

The ventilation system evaluation performed during the environmental monitoring period was a component of an ongoing building ventilation system analysis of the Waterside Mall HVAC systems. The specific objective of the ventilation system evaluation was to determine the ventilation rates samples were collected at selected Waterside Mall environmental monitoring sites within building zones served by specific Air Handling Units (AHUs). This information can be evaluated against the ventilation rates prescribed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers.[2]

No attempt was made to determine the instantaneous Waterside Mall total building ventilation rate, either in total outdoor cubic feet per minute (CFM) or in air changes per hour (ACH). This decision was based on the logistical problems associated with simultaneous airflow measurements at the multiple Waterside Mall complex AHUs, the outdoor intakes for which are located throughout the structure of the Waterside Mall. Tracer gas studies were not performed for this reason, also.

Resources necessary to conduct similar evaluations of the Fairchild and Crystal Mall 2 buildings were not available. Therefore, no measurements or evaluations of either the Fairchild or Crystal Mall 2 buildings AHUs were conducted during the environmental monitoring study.

The Waterside Mall complex air handling system includes 119 known AHUs which are serviced by more than one contractor. Outside air, controlled by a mechanical damper at the central unit, mixes with the return indoor air drawn through the overhead plenum in each zone to make up the supply air. The supply air is then provided at a constant volume rate to the individual offices. Thirty-six of the 119 AHUs supplying air to the monitoring locations were

examined on the same day the HVAC system was providing supply air to one or more monitoring sites.

3. EPA HEADQUARTERS BUILDINGS ENVIRONMENTAL MONITORING DESIGN

3.1 Selection of Environmental Monitoring Sites

Findings from the employee survey were used to select potential Waterside Mall sites for environmental monitoring. Rooms were selected for monitoring by using a protocol developed for this purpose. To avoid possible biasing of the results, selections were made by the contractor independent of the technical team. A detailed description of this procedure can be found in Section IV of Report I.

Briefly, a health symptom index was computed for each employee from the questionnaire responses, and a standardized mean symptom score was computed for each room in the building. Similarly, a comfort index was computed for each employee from the questionnaire responses, and a standardized mean comfort score was computed for each room in the building. Rooms were independently ranked according to the standardized health and comfort indices. Rooms were selected by Yale University and Westat for environmental monitoring; the first rooms chosen were the rooms with the highest values for both indices and the lowest values for both indices. Results of these rankings were not revealed to the monitoring team. In the selection of rooms, greater priority was given to the health symptom index than to the comfort index; and less priority was given to rooms with only one occupant.

Although the first questionnaire had been administered to the Fairchild and Crystal Mall 2 EPA employees, the data for these two buildings had not been statistically evaluated, and the health symptom and comfort indexes had not been calculated prior to the initiation of the environmental monitoring program. Therefore, the site selection process for these two buildings differed from the site selection process at the Waterside Mall complex. A list of potential sites was provided by the EHSD. This list included those locations where the employees had reported concerns over the indoor air environment and locations where no

employee concerns had been reported. Potential sampling locations were identified for each floor having EPA employees.

Each potential site was visited and evaluated for number of workers, availability of electrical and space requirements, and the presence of obvious indoor pollutant sources. At the Fairchild and Crystal Mall 2 buildings, the potential sites were also evaluated to ensure that they represented the typical EPA work areas available in the two buildings. In support of the overall study design criteria, single-worker offices and offices having obvious indoor sources (Xerox rooms, print shops, etc.) were not eligible for selection as a site for environmental monitoring. None of the rooms identified by the contractor or OARM were determined to have obvious indoor sources other than those associated with routine personal, administrative, or clerical processes.

One of the survey-identified indoor locations was selected by Yale University and Westat for monitoring throughout the entire five-day sampling period to assess possible changes over the week. In addition, an outdoor location in the middle of the Waterside Mall 3 roof was selected for monitoring on each of the five days to assess the influence of outdoor contaminants on the indoor environment.

In addition to the sites chosen in the manner described above, some special study sites were selected in two other manners:

1. To be responsive to the persons who work in the Washington, DC, area EPA Headquarters Buildings who have particular concerns about certain areas of the buildings, representatives of management and each of the two unions were asked to provide a list of sites where employees were thought to have experienced problems (either health or comfort related). These sites were compared with the list generated by analysis of the comprehensive questionnaire, and, if a site reported by management or unions was not included in that list, every effort was made to perform environmental monitoring at the suggested site. The monitoring

results from the management- and union-suggested sites are reported in special site summaries, which are separate from the monitoring results from the sites chosen with the selection procedure described above.

2. Single-person offices were not eligible for selection for environmental monitoring. However, because they are an area of concern for employees, a list of such offices was requested from management and union representatives, and environmental sampling was performed in selected offices. The monitoring results from these single-person locations are also included in the special site summaries, which are separate from the monitoring results from the sites chosen according to the selection procedure described above.

Detailed descriptions of the site selection process, including algorithms used in the ranking and selection process, are provided in Volume I.

3.2 Environmental Monitoring Study Design

Comfort and environmental parameters were monitored at selected areas with high and low (ratio 2:1) symptom and comfort index scores during routine employee working hours (between 7:00 a.m. and 5:00 p.m.) during the week of March 6-10, 1989. Four categories of monitoring locations were identified: primary, secondary, fixed, and special. Except where noted, monitoring was conducted on only one day at each primary, secondary, and special study location. Samples were collected during all five daytime sampling periods at the fixed indoor and fixed outdoor monitoring locations.

3.2.1 Primary

Extensive monitoring was conducted at each primary site to characterize the magnitude and spatial differences of the comfort and environmental parameters and included the following:

- Real-time temperature (T), relative humidity (RH), carbon monoxide (CO), carbon dioxide (CO_2), respirable suspended particulate (RSP) measurements 3 times during the monitoring period: morning, mid-day, and afternoon

- Viable and nonviable microbiological samples

- Integrated 9-h RSP, volatile organic compounds (VOCs), and passive formaldehyde samples

- Passive nicotine badges installed over the 5-day study period
- Integrated 9-h aldehyde and pesticide samples at selected sites daily

3.2.2 Secondary

Real-time T, RH, CO, CO_2, and RSP measurements were collected 3 times (morning, mid-day, and afternoon) at each secondary site.

3.2.3 Fixed

Integrated particle and VOC samples were collected daily to determine daily changes in concentrations and the influence of the outside air on the indoor air quality. Integrated aldehyde samples and real-time T, RH, CO, CO_2, and RSP measurements (morning, mid-day, and afternoon) were also made daily at the fixed indoor site.

3.2.4 Special

Viable and nonviable microbiological parameters were monitored in various components of the EPA HVAC system. When possible, individual parameters were monitored in selected areas not identified through the design criteria to support

management, union, and concerned individual worker requests.

3.3 Bases for Monitoring Environmental Pollutants

Standards for indoor air quality in office buildings do not exist. The Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health, and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards and recommended limits for occupational exposures.[3-5] The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building design criteria.[2] With few exceptions, pollutant concentrations observed in office work environments fall well below these published standards or recommended exposure limits. Scientists suspect that work-related complaints may be attributable not to individual environmental species, but to the cumulative effect resulting from exposures to low concentrations of multiple pollutants. The monitoring study protocol measured individual species concentrations to provide the data base necessary to investigate relationships between worker concerns, health symptoms, and low-level exposures to the multiple contaminants measured.

The bases for monitoring individual or classes of environmental parameters are presented in the following subsections.

3.3.1 Temperature and Relative Humidity

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. American National Standards Institute (ANSI)/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[6]

3.3.2 Carbon Monoxide

CO results from combustion source emissions, especially mobile sources. High concentrations of CO are not commonly observed in office buildings. Exceptions include buildings with parking garages or loading docks, buildings near heavily travelled roadways with improperly located HVAC vents, and buildings where internal leaks between the vehicle access areas and the work-place occur. Published CO standards range from 9 ppm for EPA's 8-h ambient standard to the OSHA permissible exposure limit (PEL) of 50 ppm for occupational environments.[3,7]

3.3.3 Carbon Dioxide

CO_2 is a normal constituent of exhaled breath and, if monitored, may be useful as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. ASHRAE's newly published ventilation standard for indoor air recommends outdoor air supply rates of 20 CFM per person for office spaces and 15 CFM per person for reception areas, classrooms, libraries, auditoriums, and corridors and provides estimated occupancy figures for each area.[2]

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 ppm). When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased. Maintaining the recommended ASHRAE outdoor air supply rates should provide for acceptable indoor air quality in the absence of unusual indoor sources.

3.3.4 Respirable Suspended Particles and Inhalable Particles

Respirable suspended particles (smaller than 2.5 μm) are associated with combustion source emissions. The greatest contributor to indoor RSP is environmental tobacco smoke (ETS). In buildings where smoking is not allowed, RSP levels are influenced by outdoor particle concentrations and by minor contributions from other indoor sources. In buildings with oil, gas, or kerosene heating systems, increased RSP concentrations associated with the heating source may be important. Inhalable particles, or PM_{10} concentrations (particles smaller than 10 μm in diameter) are a combination of combustion, soil, dust, and mechanical source particles. The larger particles are associated with outdoor particle concentrations, mechanical processes, and human activity. When indoor combustion sources are not present, indoor particle concentrations generally fall well below the EPA ambient PM_{10} standard (150 $\mu g/m^3$ averaged over 24-h).[7]

3.3.5 Volatile Organic Compounds, Formaldehyde, and Other Aldehydes

VOCs, including formaldehyde and other aldehydes, are emitted in varying concentrations from numerous indoor sources (e.g., carpeting, fabrics, adhesives, solvents, paints, cleaners, waxes, cigarettes, kerosene heaters, and other combustion heating products). Studies in newly constructed office buildings have identified hundreds of these organic compounds present in the indoor air.[8,9,10] Some organic species (e.g., formaldehyde and benzene) have been determined to be carcinogenic in animal studies. NIOSH and ACGIH have established compound specific recommended exposure limits (REL) and threshold limit values (TLV) for many organic compounds.[4,5] Total indoor VOCs and aldehyde concentrations typically exceed corresponding outdoor levels except in locations immediately impacted by industrial or combustion source emissions. In the absence of cigarette smoke, indoor combustion appliances, new building materials, new office furnishings, glues and adhesives, solvents, paints, or cleaning products, individual species concentrations are well below the corresponding TLVs. Recent laboratory studies evaluating human responses to controlled exposures to varying VOC mixtures (reference) reported test subject health symptoms similar to those reported by workers in large office buildings.[8,9,10]

The list of targeted VOCs for this study were selected on the basis of previous indoor air studies, suspected indoor sources, common occurrence in the environment, available health data, as well as the monitoring and analytical methodologies employed.[11-16]

3.3.6 Pesticides

Pesticides, a special family of VOCs, are commonly found indoors as a result of applications of household insecticides, termiticides, general purpose lawn and building insecticides, and the transport of contaminated outdoor dust. TLVs have been established for most commercially available insecticides. Indoor pesticide concentrations generally fall well below the TLVs except in situations where the pesticide may have been misapplied or misused. Pesticide exposures may result in worker symptoms similar to those observed in indoor air quality studies.

3.3.7 Nicotine

Recent reports from the Surgeon General and National Research Council have concluded that exposure to ETS may be associated with a wide range of health (e.g., lung cancer) and comfort (eye, nose, and throat irritation and odor) effects.[17-22] Vapor phase nicotine has been identified as a proxy or tracer for the presence of ETS, because it is unique to tobacco and occurs in easily measured air concentrations in indoor spaces where smoking takes place.

3.3.8 Viable and Nonviable Microbiological Contaminants

Microbiological contaminants are ubiquitous. Biological concentrations increase dramatically in the presence of warm, humid conditions, fleecy surfaces for growth, and the presence of dust, combustion aerosols, or other organic nutrients. Warm, wet areas (e.g., HVAC ducts, condensate pans, and

humidification systems) may enhance biological growth. Water-damaged ceiling tiles, walls, carpets, or other indoor surfaces can serve as excellent growth media for biologicals. However, scientists generally recommend that indoor concentrations be no higher than ambient concentrations. Microbiological contaminant exposures may result in allergic reactions and/or flu-like symptoms. The potency of the microbiological contaminant is dependent on the individual species present.

There are currently no standards to be used for interpreting the results of microbiological monitoring in indoor air. However, the ACGIH[23] states that "A situation can be considered unusual when overall levels of the bioaerosol are at least an order of magnitude (10^x) higher than those that commonly occur in control environments, or if the organism (or other bioaerosols) differ between the control environment and the complaint environment." With regard to fungi, specifically, they state, "In general, indoor levels should be lower than those outdoors, and taxa should be similar indoors and out." In mechanically ventilated interiors, fungal counts should be less than half of outdoor levels. Other researchers[24] propose four major points to consider when interpreting bioaerosol data: the presence of pathogens and toxigenic fungi (i.e., Stachybotrys atra) is unacceptable, counts of greater than 50 colony forming units (CFU)/m^3 with a single species present are of concern and should be investigated further, counts of less than 150 CFU/m^3 with a mixture of species is acceptable if no pathogens or toxigenic species are found, and counts up to 300 CFU/m^3 when Cladosporium or other phylloplane fungi are the predominant species are acceptable.

Human-source bacteria (e.g., Micrococcus and Staphyloccus) are used as surrogates for adequate ventilation because office occupants serve as the primary source of these bacteria via breathing, talking, sneezing, etc. One must consider local contaminant reservoirs and amplifiers, as well as the building's humidification system, as other possible sources of airborne bacteria. The presence of gram-negative organisms, for example, might be suggestive of

contamination from the buildings's toilet exhaust. A recommended upper limit for the "normal" indoor bacterial aerosol in subarctic homes is 4500 CFU/m^3.[24]

Although unusual in nonfarm, indoor environments, thermophilic actinomycetes have been implicated in many cases of allergic alveolitis. For this reason, some indoor air monitoring protocols include sampling for this group of organisms. Farmer's lung is the classic form of allergic alveolitis. The thermophilic species grow prolifically up to temperatures 65-70° C and their size (< 5μm) allows them to be easily dispersed. Micropolyspora faeni is considered to be the principal source of antigens in the United States.

Inhalation of either live or dead mold spores, both considered potential allergens, may cause illness and both are commonly included in indoor air monitoring protocols.

Other microorganisms such as Pseudomonas, a leaf surface organism, are more abundant outdoors.

3.4 Environmental Monitoring and Analytical Procedures

A detailed sampling and analysis protocol was developed and implemented for the EPA Headquarters Buildings study (Tables 3.1 and 3.2). The monitoring and analytical procedures used are described below:

3.4.1 Temperature and Relative Humidity

Real-time temperature and relative humidity measurements were conducted by using a Vista Scientific, Model 784, battery-operated psychrometer. Dry and wet bulb temperature readings were monitored, and the corresponding relative humidity was determined via the manufacturer-supplied curve.

TABLE 3.1 MONITORING AND ANALYTICAL METHODOLOGY

ANALYTE/ PARAMETER	COLLECTION METHOD	ANALYTICAL METHOD[a]
Temperature	Direct measurement	Psychrometer
Relative Humidity	Direct measurement	Psychrometer
Carbon Monoxide	Direct measurement	Electrochemical detector
Carbon Dioxide	Direct measurement	Infrared analyzer
Respirable and Inhalable Particles RSP/PM_{10}	Direct measurement - RSP	Light scattering
	Microenvironmental monitor - RSP	Gravimetric
	PM_{10} Dichotomous	Gravimetric
VOCs	SUMMA canister	GC/MS, GC/FID
Formaldehyde	Passive badge	Crystal growth
Aldehydes	2,4-dinitrophenylhydrazine	HPLC
Pesticides	Polyurethane foam	GC/MS, GC/ECD
Nicotine	Passive badge	GC/nitrogen detector
Viable Microbiologicals	Impaction onto agar	Incubation/ colony count
Nonviable Microbiologicals	Impaction onto greased tape	Spore count

[a]GC - gas chromatography, MS - mass spectrometry, FID - flame ionization detection, HPLC - high performance liquid chromatography. ECD - electron capture detection.

TABLE 3.2 ANALYTE LIMIT OF DETECTION (LOD) OR LIMIT OF QUANTITATION (LOQ)

PARTICULATE MATTER

Sampler	Flowrate	LOQ
Personal	1.67 L/min	10 $\mu g/m^3$
Microenvironmental	4.00 L/min	5 $\mu g/m^3$
Microenvironmental	10.00 L/min	2 $\mu g/m^3$
PM_{10} Dichotomous	16.70 L/min	2 $\mu g/m^3$

REAL-TIME MEASUREMENTS

Real-Time Parameter	Measurement Limits
Temperature	± 1 °C
Relative Humidity	± 2% RH
Carbon Monoxide	± 1 ppm CO
Carbon Dioxide	± 25 ppm CO_2
Particulate Matter	± 1 $\mu g/m^3$

FORMALDEHYDE

Passive Badge 119 $\mu g/m^3$ over 8-h exposure period

NICOTINE

Passive Badge 0.0001 $\mu g/m^3$ nicotine over 5-day period

VIABLE MICROBIOLOGICAL ORGANISMS

Impactor Sampler LOQ is seven viable organisms per cubic meter when sampling at 28 L/min for 5 min

(continued)

TABLE 3.2 ANALYTE LIMIT OF DETECTION (LOD) OR LIMIT OF QUANTITATION (LOQ) (cont'd)

ALDEHYDES

Compound	LOQ $\mu g/m^3$
Formaldehyde	0.07
Acetaldehyde	0.07
Acrolein	0.06
Acetone	0.06
Propionaldehyde	0.06
Crotonaldehyde	0.06
Butyraldehyde	0.06
Benzaldehyde	0.05
Isovaleraldehyde	0.06
Valeraldehyde	0.06
o-Tolualdehyde	0.05
m-Tolualdehyde	0.05
p-Tolualdehyde	0.05
Hexanaldehyde	0.05
2,5-Dimethylbenzaldehyde	0.05

(continued)

TABLE 3.2 ANALYTE LIMIT OF DETECTION (LOD) OR LIMIT OF QUANTITATION (LOQ)
(cont'd)

VOLATILE ORGANIC COMPOUNDS

Organic Compound	LOD ($\mu g/m^3$)	LOQ ($\mu g/m^3$)
Vinyl chloride	2.02	8.08
Vinylidene chloride	0.73	2.93
Methylene chloride	0.32	1.27
trans 1,2-Dichloroethene	0.15	0.59
1,1-Dichloroethane	0.20	0.81
cis-1,2-Dichloroethene	0.25	0.98
Chloroform	0.25	0.98
1,1,1-Trichloroethane	0.14	0.56
Carbon tetrachloride	1.71	6.85
Benzene	0.96	3.84
Trichloroethylene	0.18	0.70
Toluene	1.72	6.89
n-Octane	0.15	0.59
Tetrachloroethylene	0.24	0.95
1,2-Dibromomethane	0.38	1.53
Chlorobenzene	0.09	0.35
Ethylbenzene	0.24	0.96
p-Xylene	0.59	2.36
o-Xylene	0.25	0.99
Styrene	0.37	1.47
1,1,2,2-Tetrachloroethane	0.64	2.55
n-Decane	0.70	2.82
m-Dichlorobenzene	0.44	1.76
p-Dichlorobenzene	0.43	1.70
o-Dichlorobenzene	0.54	2.14
n-Dodecane	1.11	4.42
4-Phenylcyclohexene	1.23	4.90

(continued)

TABLE 3.2 ANALYTE LIMIT OF DETECTION (LOD) OR LIMIT OF QUANTITATION (LOQ) (cont'd)

PESTICIDES

Compound	LOD $\mu g/m^3$
Dichlorvos (DDVP)	0.93
alpha-BHC	0.02
Hexachlorobenzene	0.01
Pentachlorophenol	1.85
gamma-BHC (Lindane)	0.02
Chlorothalonil	0.02
Heptachlor	0.13
Ronnel	0.03
Chlorpyrifos	0.03
Aldrin	0.02
Dacthal	0.02
Heptachlor Epoxide	0.02
Oxychlordane	0.03
Captan	0.14
Folpet	0.09
2,4-D Butoxyethyl ester	0.46
Dieldrin	0.04
Methoxychlor	0.05
Dicofol	0.46
cis-Permethrin	0.19
trans-Permethrin	0.19
Chlordane	0.37
4,4'-DDT	0.03
4,4'-DDD	0.03
4,4'-DDE	0.03
ortho-Phenylphenol	0.09
Propoxur	0.05
Bendiocarb	0.12
Atrazine	0.12
Diazinon	0.14
Carbaryl	0.12
Malathion	0.12
Resmethrin	0.23

3.4.2 Carbon Monoxide

Real-time CO levels were determined with EPA CO exposure dosimeters, Model COED-1. This portable, battery-operated instrument monitors CO (range 1-50 ppm) via electrochemical detection with a sensitivity of 1 ppm. Instrument zeroing and calibration were performed daily prior to use with zero air and a known CO span gas (40 ppm). Confirmations were conducted throughout the instrument use period.

3.4.3 Carbon Dioxide

Real-time CO_2 levels were determined by using Gastech Model RI-411A, portable CO_2 indicators. This portable, battery-operated instrument monitors CO_2 (range 0-4975 ppm) via nondispersive infrared absorption with a sensitivity of 25 ppm. Instrument zeroing and calibration were performed daily prior to use with zero air and a known CO_2 span gas (800 ppm). Confirmations were conducted throughout the instrument use period.

3.4.4 Respirable Particles (RSP) and Inhalable Particles (PM_{10})

Real-time RSP and integrated RSP/PM_{10} concentrations were monitored by using the following methods:

1. Real-time RSP concentrations were measured by using GCA Environmental Instruments Model RAM-1 monitors. This portable, battery-operated instrument assesses changes in particle concentrations via an infrared detector, centered on a wavelength of 940 nm.Indoor air is sampled (2 L/min) first through a cyclone preselector, which restricts the penetration of particles greater than 9 μm. The air sample then passes through the detection cell. Operating on the 0-2 mg/m^3 range with a 32-s time constant yields a resolution of 0.001 mg/m^3.

2. Integrated RSP samples were collected at the primary sites by passing representative air samples (1.67 L/min) through a preweighed 37 mm Teflon filter media loaded in a Millipore cassette. The cassette flow orifices prevent the collection of large particles.

Fixed indoor site RSP and PM_{10} concentrations were measured by using two 10-L/min particle samplers, each with an independent particle size selective inlet (one RSP and one PM_{10}). The air sample enters the inlet and is directed into an acceleration jet nozzle with a diameter that is engineer-designed for maximum collection of the appropriate sample size fraction. The accelerated airstream leaves the nozzle and is focused toward a lightly oiled impaction plate. Particles larger than the design diameter fraction cannot make the critical turn and are collected on the oiled impaction plate. Particles less than or equal to the design diameter pass around the oiled plate and are collected on preweighed 37-mm Teflon filter media.

Outdoor RSP and PM_{10} concentrations were measured by using a Sierra PM_{10} dichotomous sampler (total flow 16.7 L/min). The air sample enters the inlet where particles larger than 10 μm are removed. The sample stream then passes downward into an acceleration nozzle inside the virtual impactor assembly, where particles are separated by size fraction. The RSP sample stream (15 L/min) is redirected perpendicular to the original flow direction while the coarse stream (particles 2.5-10.0 μm in diameter) continues its downward motion. The two distinct size fractions are collected independently onto preweighed 37-mm Teflon filter media.

The 37-mm Teflon filters are returned to the laboratory for gravimetric analysis following standard procedures.[25] The laboratory quality assurance weighing limits for Teflon filter media are ± 10 μg for the pre- and post-sample weighings. Primary and fixed indoor site particle collections with a net gain of less than 10 μg are considered within the experimental error and are not reported by the laboratory.

3.4.5 Volatile Organic Compounds

VOCs were collected in precleaned, evacuated (29" in. Hg) SUMMA-polished canisters by using standard EPA monitoring procedures.[26,27] Randomly selected precleaned canisters were analyzed for the target VOC compounds prior to canister shipment and sample collection. Evacuated canisters were loaded into a sampler downstream of a flow controller calibrated for an inlet flow of 8-10 cubic cm^3/min). At the beginning of the sampling period, the canister valve was opened, and the canister vacuum recorded, and the indoor air was sampled over the 9-h monitoring period (approximately a 5-L sample). At the completion of sampling, the canister final vacuum reading and time were recorded, and the valve was closed. Sampled canisters were returned to the laboratory for analysis. Representative aliquots of each canister were analyzed for targeted compounds via GC/MS. Additional aliquots were drawn and analyzed by GC/FID without a separation column for total nonmethane VOCs.[28]

3.4.6 Formaldehyde and Other Aldehydes

- Passive Formaldehyde Monitors. Passive formaldehyde badges (3M Model 3720) were installed and exposed at each primary site on the day of sampling. The badges sample formaldehyde via diffusion. At the completion of the sampling period, the badges were sealed and returned to the manufacturer for analysis via a proprietary technique to determine cumulative formaldehyde exposures.

- Aldehydes. At selected primary sites (two each day), samples for aldehyde analysis were collected by passing air (200 cm^3/min) through 2,4-dinitrophenylhydrazine-coated silica gel cartridges.[29] At the completion of the monitoring period, the cartridges were sealed, refrigerated, and shipped to the

laboratory for targeted compound analysis via HPLC.

3.4.7 Pesticides

Pesticides were collected on precleaned polyurethane foam (PUF) cartridges (4.0 L/min) at one primary site each day. At the completion of the sampling period, the PUF cartridge was sealed in aluminum foil, placed in a Teflon sealed glass jar, immediately stored on dry ice (-40 °C), and shipped to the laboratory. The samples remained frozen until extracted by the laboratory within five working days following sample collection. The sample extracts were analyzed for targeted pesticides via GC/ECD and/or GC/MS as outlined in the Non-Occupational Pesticide Exposure Study.[30]

3.4.8 Nicotine

Nicotine was collected over the entire 5-day monitoring period by using passive sodium bisulfate-coated filter media contained in Millipore cassettes. At each sampling location, the cassettes were opened, and the start time was recorded on Sunday, March 5, and Monday, March 6, prior to the initiation of the environmental monitoring study. The passive nicotine monitors sampled at a rate of 24 mL/min. Upon completion of the study, the cassettes were sealed, the ending times recorded, and the samples returned to the laboratory for analysis. The filter media was removed, extracted in heptane, and analyzed by using GC with a nitrogen-specific detector.[31]

3.4.9 Viable and Total Spore Counts

3.4.9.1 Viables

Viable microbiological samples were collected at each primary site, the fixed indoor and outdoor sites, selected locations in the HVAC system, as well as other sites where biological growth was suspected. Samples were collected, using a duplicate sampling protocol, on appropriate growth media by using

Andersen viable air samplers[32] modified to employ only the sixth stage. The Andersen sample employs inertial impaction at a flow of 1.0 CFM for organism collection into standard 100 cm^3 plastic petri dishes filled with 45 cc of the appropriate agar to ensure adequate plate to agar distance. Mesophilic fungi, human source bacteria, and thermophilic bacteria were collected on malt extract agar (MEA), trypticase-soy agar (TSA), and TSA, respectively. Samples were collected over a 5-min time period. Fungal samples were stored at room temperature. Bacterial and thermophilic samples were refrigerated. Samples were shipped to the laboratory within 2 days following collection. The mesophilic, human-source bacteria, and thermophilic samples were incubated (25, 37, and 56 °C, respectively). Fungal spores were counted after 3-5 days of incubation, whereas the bacteria samples were counted after 1-2 days of incubation. Colony types were identified initially by number, and the most common were identified by genus.

2. Nonviables

Nonviable samples (fungal spores) were collected using a Burkard recording air sampler.[33] Samples were collected for a 24-h period at four sites per day, Monday through Thursday. The indoor air passes through the sampler (10 L/min) with particles impacting on a greased tape attached to a rotating drum turning at a constant speed. Upon completion of the monitoring study, the samples were returned to the laboratory for spore counting and the determination of 8-h averaged values.

3.5 Ventilation Evaluation

Selected Waterside Mall environmental monitoring sites were matched to AHU coverage drawings. During the period when environmental monitoring was being conducted at the sites, the AHUs were visually inspected, outdoor air quantities and percentage of total supply airflows were measured, and ventilation rates were calculated for the AHU supplying air to the monitoring sites. The AHUs

operational settings were not changed to conform to minimal operating conditions as specified by the manufacturer, but were evaluated under the actual operating conditions established by the building management.

The AHUs were given a cursory inspection to determine operating condition at the time that the temperature and velocity traverse data was collected. Since insitu instrumentation or data logger equipment for the AHUs was not present, the operation status of the systems could be only visually monitored.

The AHUs were then inspected to determine the most representative location for velocity traverses. These locations are typically at the end of a long, straight duct run, prior to fittings, and as far as possible from the AHU fan. Holes were drilled in ducts for the velocity probe. The holes were drilled at a maximum of 8 in. on center, but if the duct was less than 24 in. wide, a center dimension less than 8 in. was used. The minimum number of traverse points (number of traverse holes multiplied by the number of measurements per traverse hole) was 25. In some cases, holes drilled by the Annandale Air Balancing Company (AABC) for use in AHU balancing were used for the velocity traverses. Also, at some of the AHUs, velocity traverse holes existed from prior air-flow measurements. When present, these holes were reused for the of air-flow measurements made during the environmental monitoring study.

Velocity measurements were taken using a 5/16 in. diameter pitot static probe (complying with ASHRAE specifications) and a high-precision Neotronics digital manometer (calibrated March 2, 1989). A Solomat Model MPM500E display meter with 127MS hotwire anemometer probe used in previous measurements was found to be operating erratically and not used.

The pitot tube was configured to give velocity pressure measurements. The total pressure port of the pitot tube was connected to the high-pressure side of the manometer, and the static pressure port of the pitot tube was connected to the low pressure side of the manometer. Tygon tubing was used for

connections.

The velocity pressure readings were made at predetermined intervals. The first and last readings in the traverse were taken at a distance of one-half the centerline distance between the internal readings, as recommended by AABC.

The area of the duct was based on measurements of outside duct dimension, correcting for internal lining or external thermal insulation. Air-flow, in cubic feet per minute, was determined by simple multiplication of the average velocity in feet per minute (FPM) by the duct cross sectional open area, in square feet (SF). Average velocity was determined by first converting individual velocity pressure measurements to velocity, with the following expression:

$$\text{Velocity} = 4005 * (\text{Velocity pressure}) \text{ exponential}^{0.5}$$

where velocity is in feet per minute and velocity pressure is in inches of water column.

Because of the near-sea-level elevation of Waterside Mall, pressure correction factors were not needed to account for air density differences. Air temperature correction factors published in the AABC National Standards were applied to the velocity measurements, however. Average velocity was the arithmetic average of all the corrected velocity readings for the traverses.

At certain large return air and mixed air plenums (particularly at the East and West Tower units), pitot traverses were impractical. Velocities were measured in these locations by using an Omega digital vane anemometer.

At some AHUs, there were no acceptable velocity traverse locations, primarily due to excessive turbulence in the airstream. In these cases, the dry bulb temperature method was relied upon for determination of ratio of outdoor air in the supply airstream. This ratio can be calculated with the following

expression:

$$\% \text{ Outside Air} = \frac{T_{\text{dry bulb, return air}} - T_{\text{dry bulb, mixed air}}}{T_{\text{dry bulb, return air}} - T_{\text{dry bulb, outside air}}} * 100$$

The dry bulb temperature measurements were taken with a Micronta 63-843 thermistor-type temperature meter. Because of the relatively slow response time of this probe, it was allowed to "soak" in the air-stream being measured for at least 5 min before reading. This probe was kept in a conditioned environment when not actively used for data gathering to minimize the lag in response. The measurement location for the temperature probe was selected to be as representative as possible. In the case of the mixed air, the most distant location from the point of airstream mixing was selected.

Where the airstream turbulence induced by duct work configuration precluded obtaining velocity measurements in any of the outdoor, supply, return, or mixed air ducts, the airflow rates in these ducts were calculated indirectly. The method used for calculating airstream flow rate required that at least one valid set of velocity and flow data be obtained for any one of the outdoor, supply, return, or mixed airflow streams. The unmeasured airflow streams were calculated by apportioning the percentages of flow of these air streams as determined by the dry bulb temperature data.

At some of the AHUs, multiple evaluations were made at different times of day in order to conform with the environmental monitoring schedule.

4. SUMMARY OF ENVIRONMENTAL MONITORING RESULTS

This section presents summarized data by sector collected at the three EPA Headquarters Buildings during the environmental monitoring study. These descriptive results reflect the conditions found in a generalized fashion and do not define conditions or make inferences based on specific sample data.

4.1 Number of Environmental Monitoring Sites and Monitoring Schedule

Environmental monitoring was conducted as follows: the Waterside Mall 3 locations on Monday; half of the Waterside Mall 2 locations and the Crystal Mall 2 on Tuesday; the remaining half of the Waterside Mall 2 locations and the Fairchild Building on Wednesday; the West Tower on Thursday; and the East Tower on Friday. With the exception of the microbiological contaminants, environmental monitoring was conducted at 56 primary, 61 secondary, 70 special, one fixed indoor, and one fixed outdoor sites. The distribution of environmental monitoring locations by building is shown below.

FACILITY	PRIMARY	SECONDARY	SPECIAL	TOTAL
Waterside Mall Complex	47[a]	38	67	152
Fairchild Building	5	12	2	19
Crystal Mall 2	5	11	1	17

[a] Includes the fixed indoor monitoring location.

The large number of Mall 2 monitoring locations necessitated that some environmental monitoring locations be sampled, for one or more parameters. on more than the two days scheduled for sample collection. This summary table identifies the actual number of independent sampling locations and, therefore,

may not match the number of monitoring sites reflected in other summary tables.

A total of 79 viable airborne microbiological samples were collected. Fifty-three indoor and 6 outdoor microbiological samples were collected at the Waterside Mall. Five indoor samples and one outdoor microbiological sample were collected at both the Fairchild and Crystal Mall 2 Buildings. An additional eight quality control samples were also collected at the Waterside Mall. Fourteen indoor and three outdoor Waterside Mall fungal spore samples were collected. One indoor air fungal spore sample was collected at both the Fairchild and Crystal Mall 2 buildings.

4.2 Real-Time Indoor Measurements

4.2.1 Method for Summarizing Real-time Indoor Measurements

Two summary tables are provided for each real-time parameter, one summarizing the data over the three individual buildings (Waterside Mall, Fairchild, and Crystal Mall 2) and a second summarizing the data over the various indoor sectors (Waterside Mall 2, Waterside Mall 3, Southeast Mall, Southwest Mall, Northeast Mall, West Tower, East Tower, Fairchild, and Crystal Mall 2). The data in each table was compiled by using the statistical methods discussed below.

4.2.1.1 Mean Sector Value for Single Time Period. Mean sector values for real-time measurements were calculated for each of the three monitoring time periods (morning, mid-day, and afternoon) by using individual or averaged sampling site values. If only one measurement was made for a given site in the time period, this individual value was considered the mean site value. If a sampling location other than the fixed indoor site was monitored more than once during the study for any time period, a mean site value for that time period was calculated by adding the various observations and dividing by the number of observations. The fixed indoor site data were treated slightly

differently; only the observations collected on the day the questionnaire was administered were included in the primary site data. The remaining fixed indoor site data were used in the calculation of the summary data for all sites. A mean sector value was then calculated by adding the individual mean site values for that time period and dividing by the number of sites monitored during the time period.

4.2.1.2 Average Mean Sector Values for the Entire Monitoring Day. An average mean sector value representing the parameter over the three time periods was calculated by first calculating average room values within the sector over the three time periods, adding these average room values, and dividing by the actual number of rooms monitored in the sector.

4.2.1.3 Building Means over Sectors. Building means for each of the three time periods, regardless of sector, were calculated by using the nine mean sector values (4.2.1.1, above) for the specific time period.

4.2.1.4 Grand Building Means for the Three Buildings. A grand building mean for each real-time parameter was calculated by using the three average mean sector values for the entire monitoring period (4.2.1.2, above). These summary statistics were calculated with equal weight given to each of the three buildings and may differ slightly from the values reflected in 4.2.1.5. These means may be best for comparing conditions among the three buildings.

4.2.1.5 Grand Building Means for the Nine Sectors. A grand building mean for each real-time parameter was calculated by using the nine average mean sector values for the entire monitoring period (4.2.1.2, above). These summary statistics were calculated with equal weight given to the nine sectors, therefore giving more weight to the Waterside Mall results which best describe the actual data, but may not reflect the actual relationships among the three individual buildings.

4.2.1.6 Individual Maximum and Minimum Values. The individual maximum and minimum values reflected in the real-time summary tables represent individual observations and not site mean values.

4.2.2 Temperature

Only small differences are observed in the calculated building grand mean temperatures over all sites (73.8 °F, 74.8 °F, 76.7 °F) for the three buildings (Waterside Mall, Crystal Mall 2, Fairchild, respectively) over the monitoring study (Tables A.1-A.4) with the exception of the slightly higher indoor temperatures at the Fairchild Building. Across all the Waterside Mall sectors as well as across the Fairchild Building and Crystal Mall 2 buildings, there was a general trend for mean indoor temperature (Tables A.5-A.8) to slightly increase (Figure 4.1) from morning to afternoon. The lowest temperatures (below 70 °F) were observed during the morning in Southwest Mall and Mall 2 monitoring sites. Fairchild and Crystal Mall 2 sector temperatures were consistently warmer (<5 °F). Temperature gradients between sectors and/or between buildings were small, as was the variability in mean temperature among the primary, secondary, and special study sites. Slightly less than 95% of the individual values (Figure 4.2) fell within the temperature range 70-80 °F. The largest within-day difference between the single minimum and maximum temperatures (Figure 4.1) occurred on the day following a winter storm when sampling was being conducted at Mall 2, Southwest Mall, and Fairchild Building offices. Two individual measurements were below 65 °F while six offices had individual room temperatures of ≥ 80 °F.

4.2.3 Relative Humidity

Variability in mean building RH across all sites and time periods for the three buildings (Tables A.9-A.12) was minimal (23% ± 2%), and little within-day or within-building difference was seen (Tables A.13-A.16). Mean RH tended

Figure 4.1. Plot of Temperature Maximum, Mean, and Minimum, Across Waterside Mall Sectors, Crystal City, and Fairchild by Earliest Sample Start Time

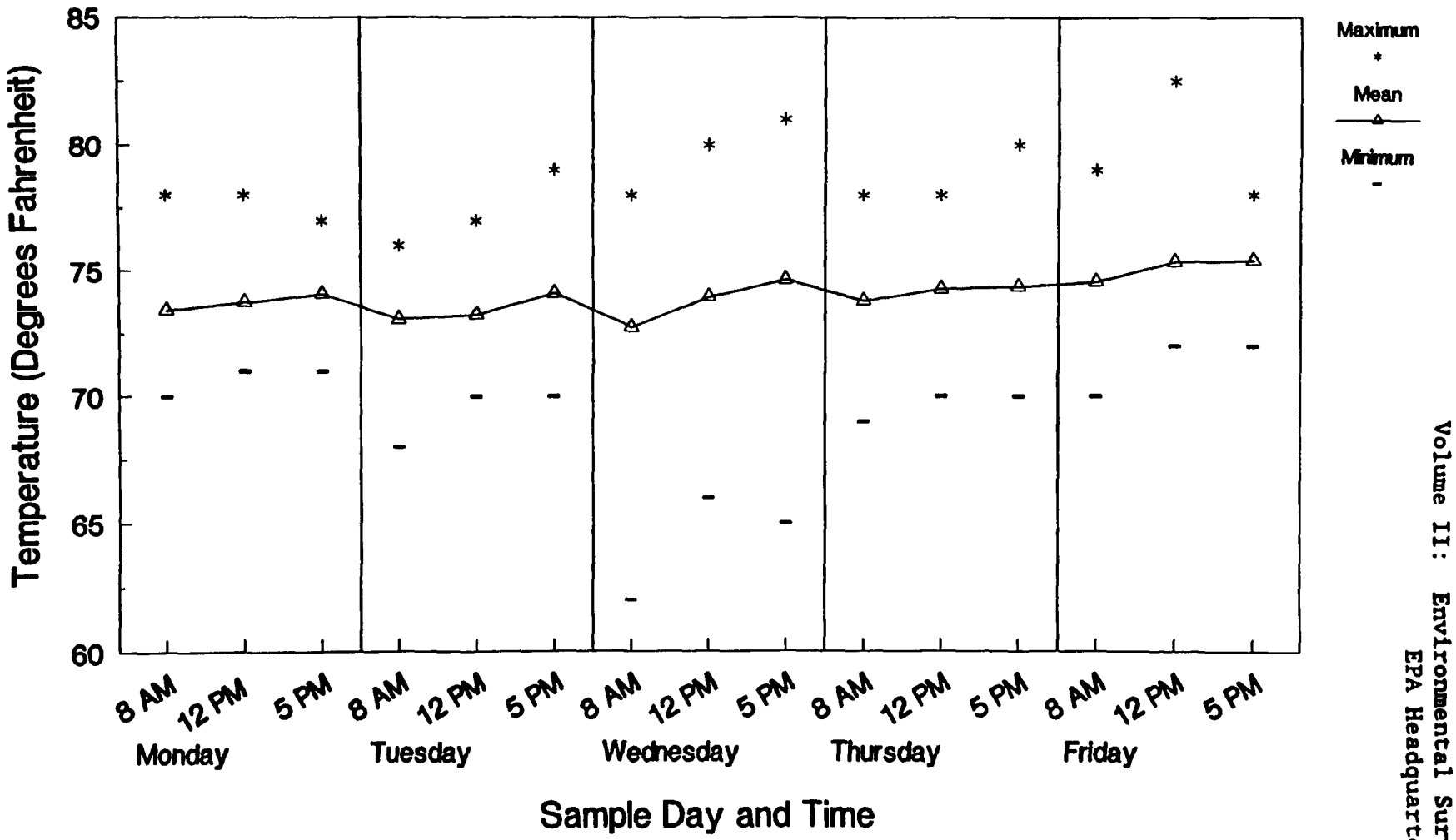
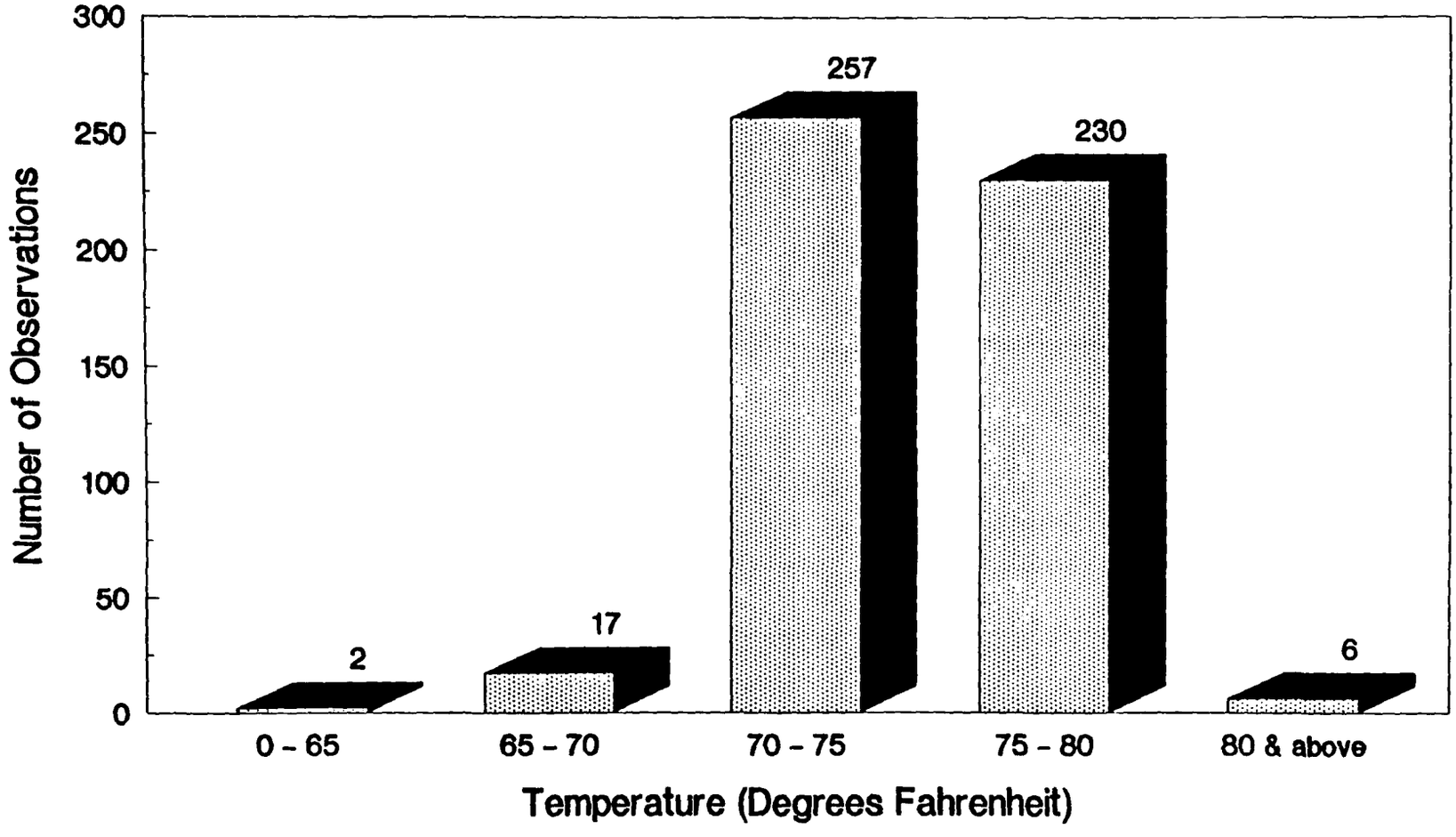


Figure 4.2. Frequency Distribution of Observed Temperatures Across Waterside Mall Sectors, Crystal City, and Fairchild



to decrease from Monday to Friday (Figure 4.3). More than 96% of the individual RH measurements (Figure 4.4) fell between 15 and 35%, generally below the recommended comfort zone. Elevated individual RHs (>50%) were measured in some monitoring locations which were noted to have an operational room humidifier and numerous plants. The maximum indoor single value of relative humidity was <55%, and several monitoring locations were noted to have RHs less than 20%. Mean Mall 3 and Northeast Mall site RHs are 5-10% higher than the other monitoring locations, and only small differences were observed between primary, secondary, and special site mean values for each sector.

4.2.4 Carbon Monoxide

CO measured did not exceed 1 ppm in any of the Crystal Mall 2 Building sites or any Waterside Mall primary or secondary monitoring sites (Tables A.17-A.24). CO <5 ppm was observed at selected Waterside Mall special sites, in particular those sites located underground in close proximity to the East Tower underground parking garage, as well as at numerous Fairchild monitoring locations. CO tended to decrease over the day at the Waterside Mall locations but increase over the day at the Fairchild Building monitoring locations.

4.2.5 Carbon Dioxide

The mean primary Fairchild Building CO_2 concentration over all time periods and sites (745 ppm) is nearly 200 ppm higher than the mean concentration reported for the Waterside Mall complex and more than 250 ppm higher than the Crystal Mall 2 CO_2 mean concentration (Tables A.25-A.28). Considering all sites and times results in small increases in mean CO_2 concentrations for the Waterside Mall (575 ppm) and Crystal Mall 2 (504 ppm) buildings, but no change in the mean Fairchild Building concentration. CO_2 tended to increase from morning to afternoon (Figure 4.5) with a grand mean of 573 ppm over all sectors and buildings (Tables A.29-A.32), a value slightly lower than the 599 ppm calculated over the three buildings. More than 93% of the individual site CO_2 measurements (Figure 4.6)

Figure 4.3. Plot of Relat... Humidity Maximum, Mean, and Minimum Across Waterside Mall Sectors, Crystal City, and Fairchild by Earliest Sample Start Time

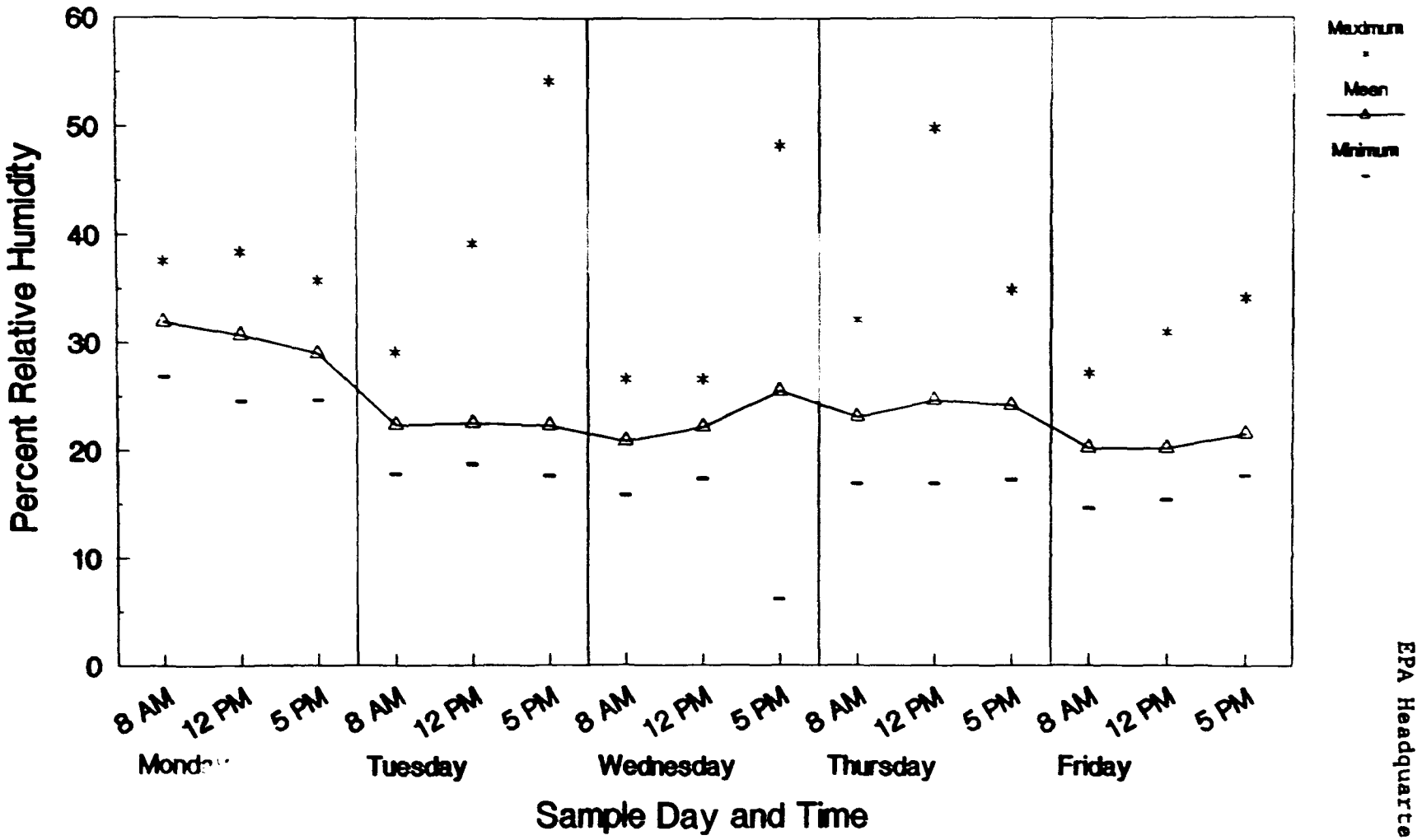


Figure 4.4. Frequency Distribution of Observed Relative Humidity Across Waterside Mall Sectors, Crystal City, and Fairchild

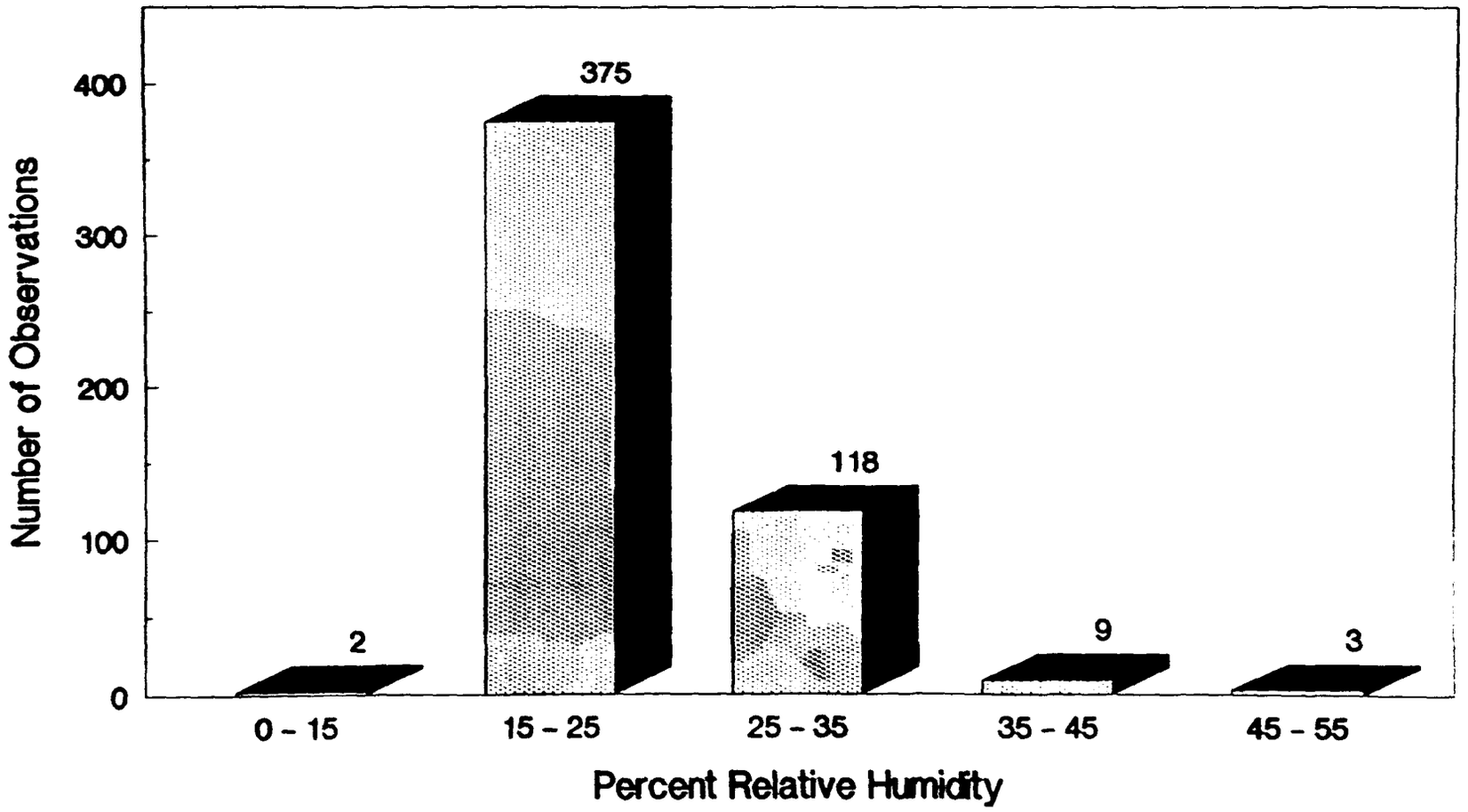


Figure 4.5. Plot of Carbon Dioxide Maximum, Mean, and Minimum Across Waterside Mall Sectors, Crystal City, and Fairchild by Earliest Sample Start Time

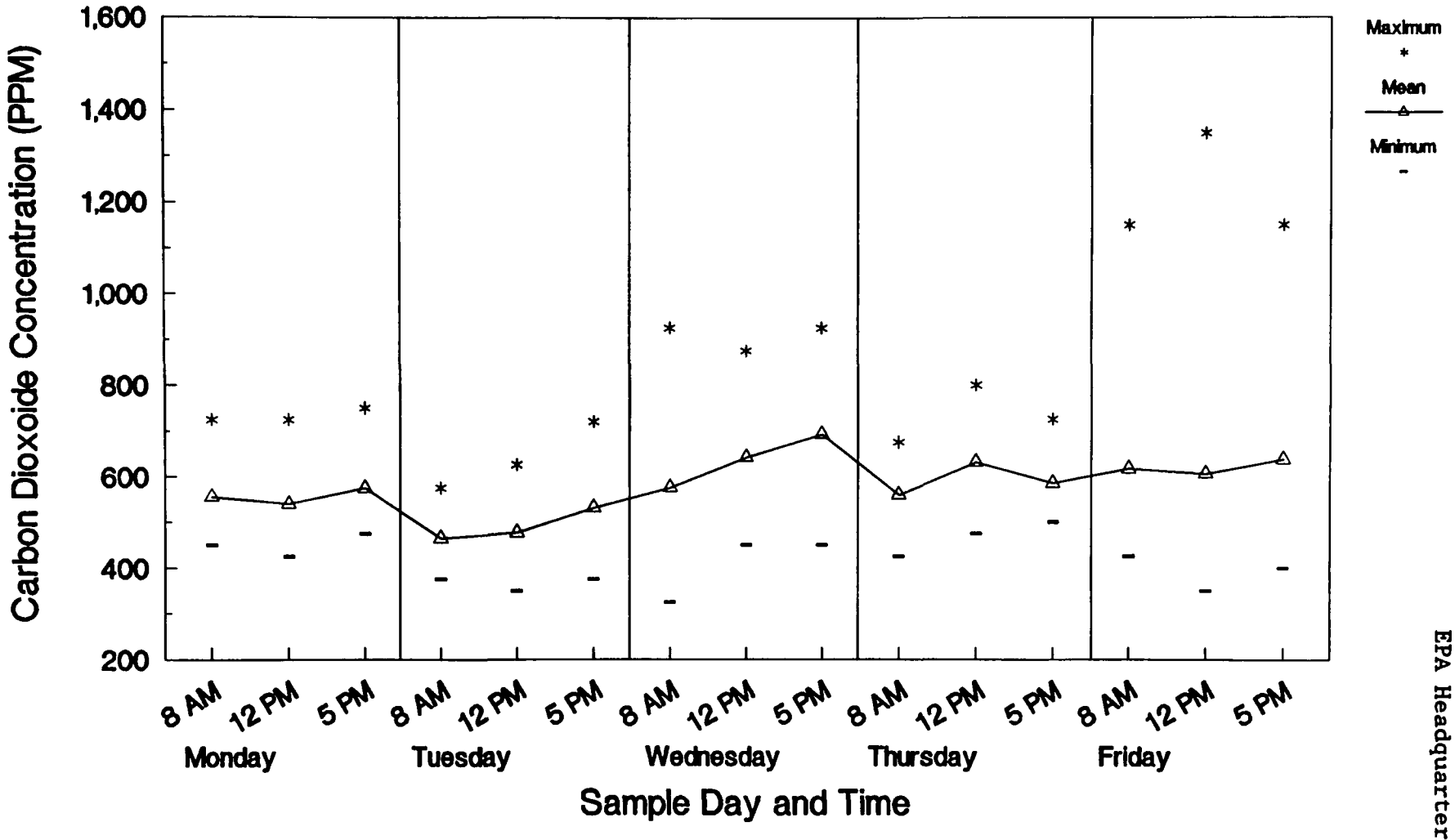
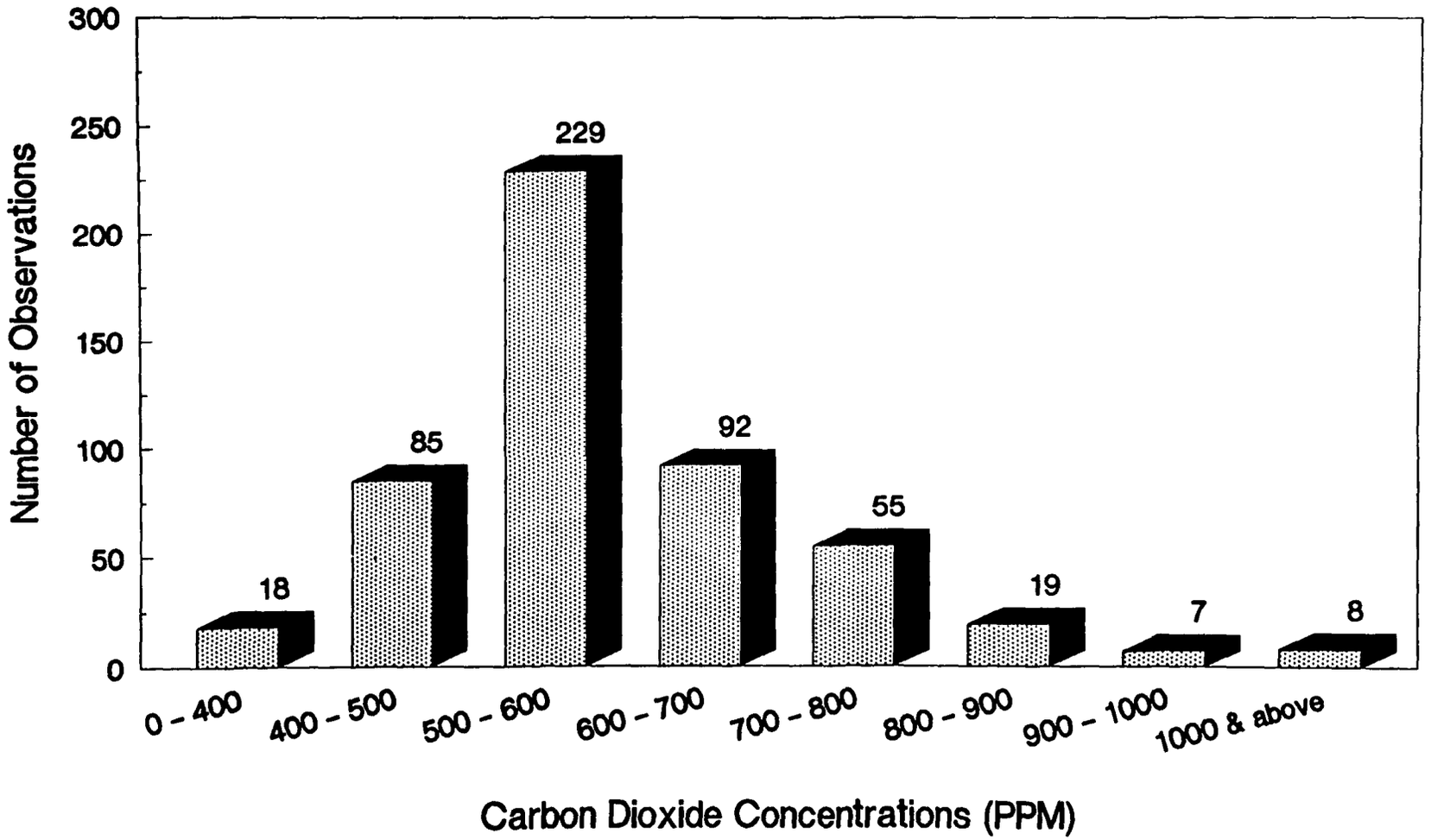


Figure 4.6. Frequency Distribution of Observed Carbon Dioxide Concentrations Across Waterside Mall Sectors, Crystal City, and Fairchild

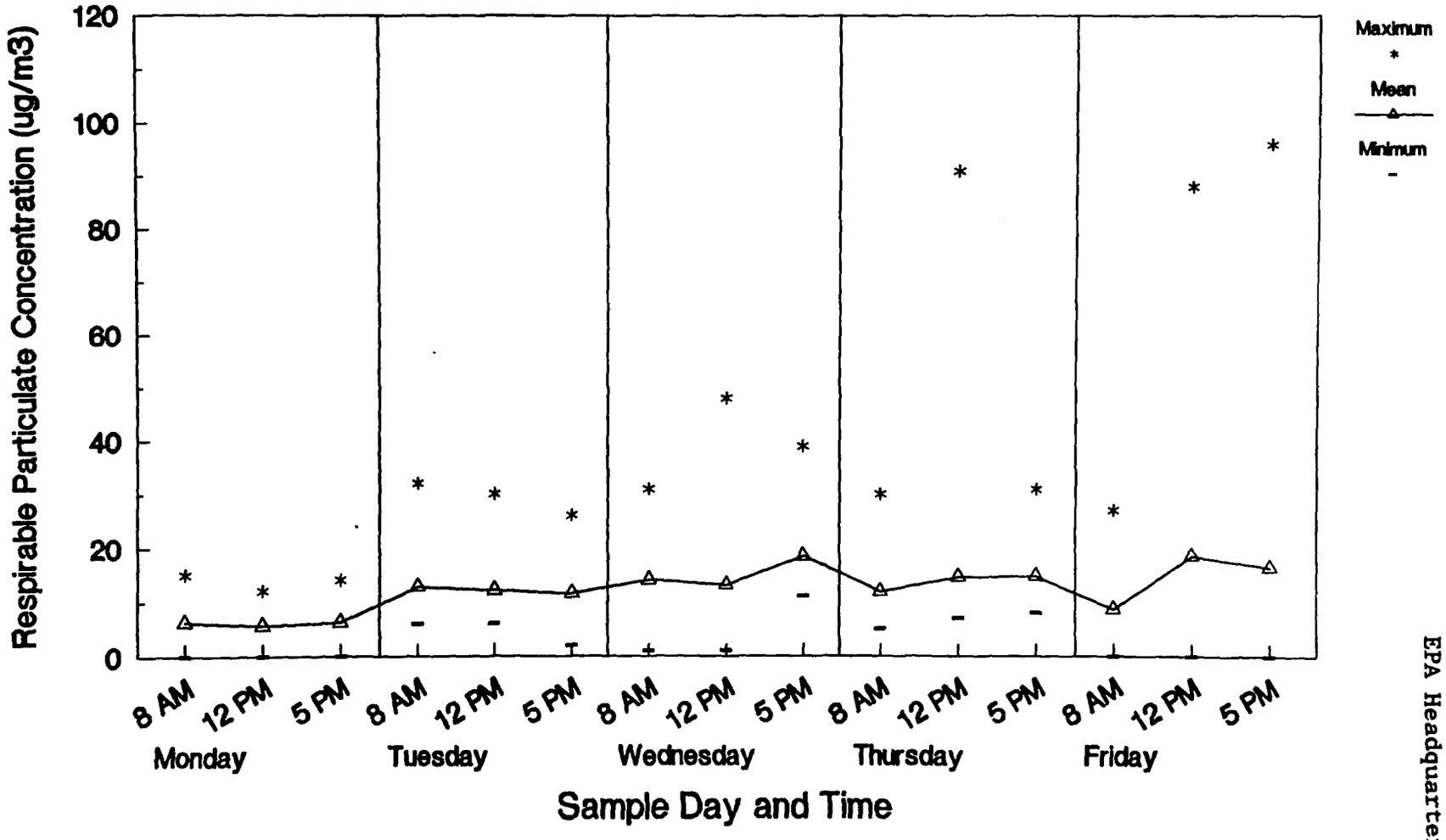


were below 800 ppm, while 34 individual values exceeded 800 ppm. Eight individual site observations (1.6%), all recorded at special monitoring sites, were greater than the ASHRAE guideline of 1000 ppm. Seven of these observations were taken in the special sites located in close proximity to the East Tower underground parking garage. CO_2 concentrations in two of these special monitoring locations were greater than 1000 ppm for all three time periods. One >1000-ppm CO_2 observation was recorded in Mall 2. CO_2 was uniformly higher in the Fairchild Building (mean = 745 ppm). However, no Fairchild single site value exceeded 1000 ppm. CO_2 was the lowest on Tuesday during the inclement weather (Figure 4.5). The largest within-day variation (Figure 4.5) occurred on Friday, when monitoring was being conducted in the East Tower as well as the Mall. The lowest mean CO_2 values were reported in the Southeast and Southwest Malls (454 and 451 ppm, respectively), and no single value in either sector exceeding 600 ppm.

4.2.6 Respirable Particulate Matter

Mean building RSP concentrations across all sites and time periods for the three buildings (Tables A.33-A.36) ranged from a low of 9.5 $\mu g/m^3$ for the Fairchild Building to a high of 14.1 $\mu g/m^3$ for the Waterside Mall complex. The mean Waterside Mall and Crystal Mall 2 special site concentrations for each building were slightly increased (3-4 $\mu g/m^3$) over the building mean values. Across all sectors and buildings (Tables A.37-A.40), mean respirable particle concentrations were less than 17 $\mu g/m^3$, and the grand mean real-time particle concentration was 12.9 $\mu g/m^3$. The Mall 3 mean concentration (6.5 $\mu g/m^3$) is <50% of the other sector means. The maximum individual value (96 $\mu g/m^3$) and the second maximum individual measurement (91 $\mu g/m^3$) were recorded at East and West Towers special sites, respectively, and were nearly double the maximum values observed at any other primary or secondary site. A review of the operator comments indicates the presence of the smell of cigarette smoke in these locations. The largest difference between within-day maximum and minimum values (Figure 4.7) occurred on Thursday and Friday, when monitoring was conducted at

Figure 4.7. Plot of Respirable Particulate Maximum, Mean, and Minimum Across Waterside Mall Sectors, Crystal City, and Fairchild by Earliest Sample Start Time



the West and East Towers, respectively, and most probably reflects cigarette smoking as noted by the field operators. More than 98% of the individual RSP values (Figure 4.8) were less than 40 $\mu g/m^3$.

4.3 Integrated Sampler Results

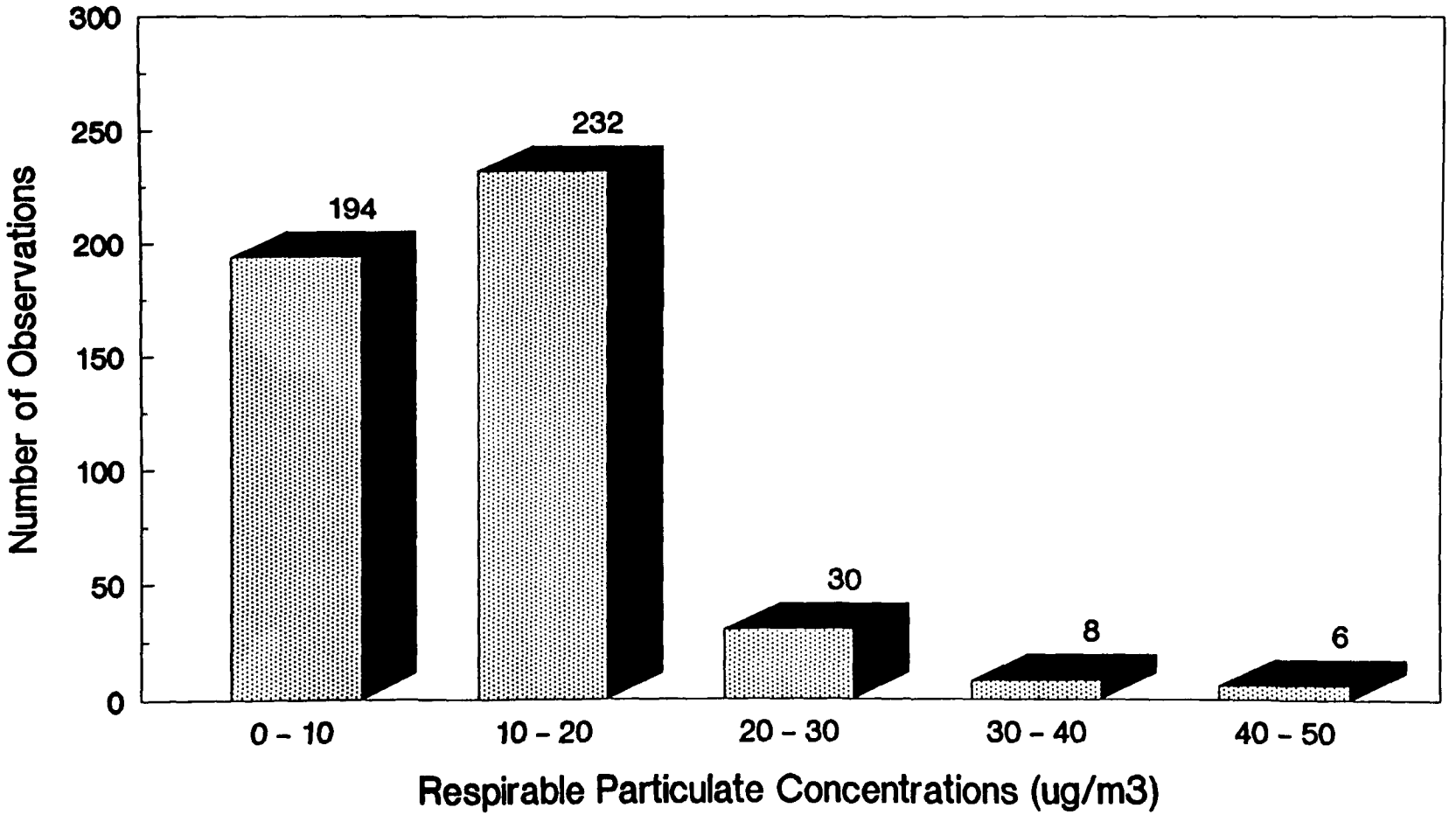
4.3.1 Method for Summarizing Integrated Indoor Measurements

Mean species concentrations for each sector were calculated by adding the individual values that were above the limit of quantitation for those samples collected from the corresponding sector monitoring sites and dividing this number by the number of samples above the level of quantitation. Trace quantities of selected VOCs, above LOD but below LOQ, were also observed when the Summa canister VOC method was used but were not included in the summarized data other than by indicating the number of trace measurements that were reported by individual species. This qualitative measurement approach indicates that through the use of the highly sophisticated mass spectrometer analytical technique, the presence of an individual species can be confirmed (i.e., if it is above the limit of detection). However, the concentration of these species is below the level of quantitation. Again, samples having trace concentrations of a specific organic compound were not used in the calculation of the sector means for that compound. Arithmetic mean concentrations for each species were calculated for individual sectors, across all buildings, and for each of the three buildings.

4.3.2 Respirable Particulate Matter (RSP)

The results of the integrated RSP samples (Table B.1) are consistently higher (5-20 $\mu g/m^3$) than the corresponding mean real-time values calculated over all monitoring sites (Tables A.36 and A.40). Integrated sampler particle means ranged from 16.3 to 27.3 $\mu g/m^3$, and the grand mean across all buildings and all sectors was 22.6 $\mu g/m^3$. Waterside Mall RSP (mean = 23.5 $\mu g/m^3$) varied only slightly among the Waterside Mall sectors but was 25-50% higher than the RSP

Figure 4.8. Frequency Distribution of Observed Respirable Particulate Concentrations Across Waterside Mall Sectors, Crystal City, and Fairchild



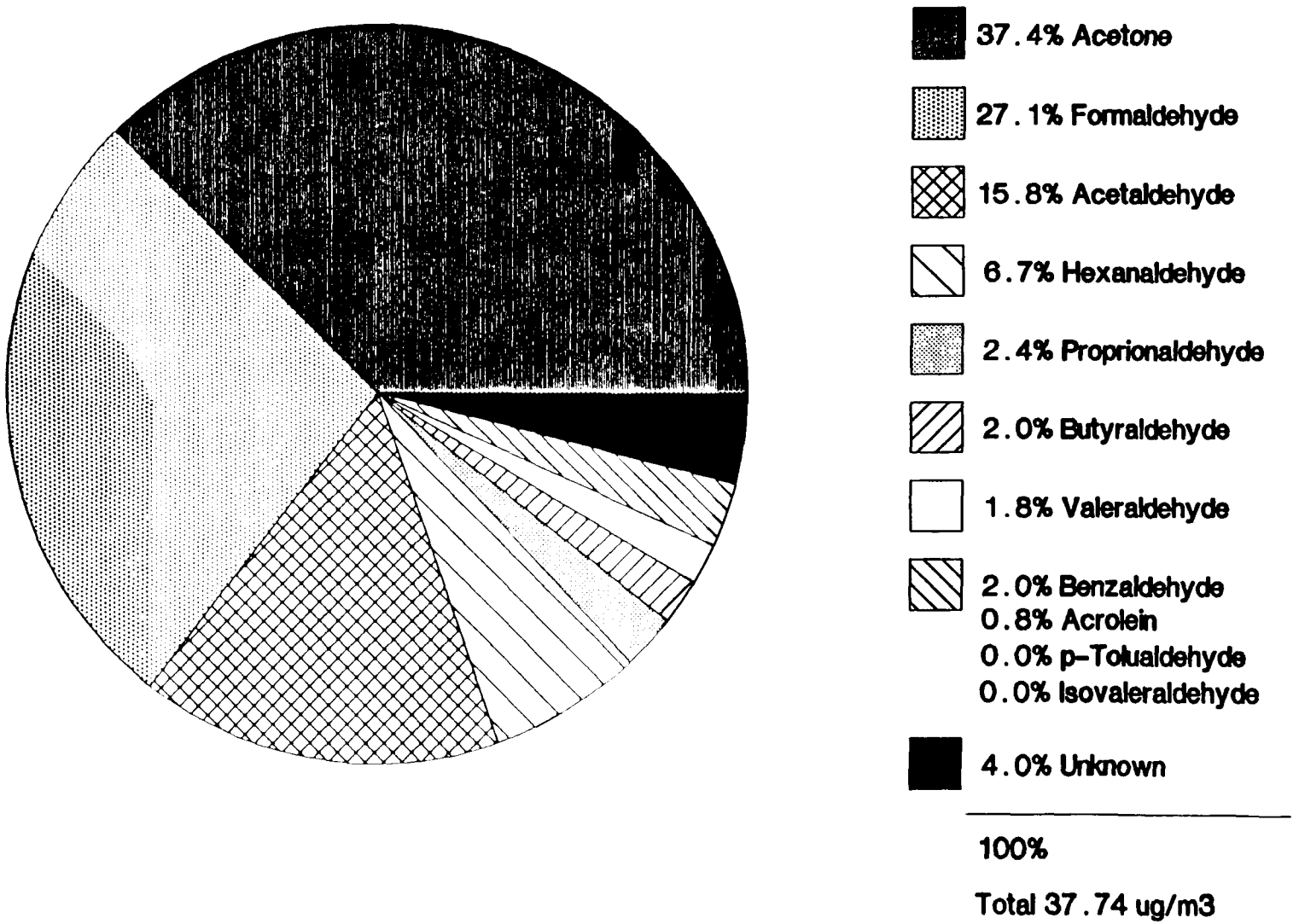
measured in the other two buildings. The highest integrated RSP measurement was 54.7 $\mu g/m^3$ in Mall 2. The difference between the integrated and real-time particle mean values most probably result from the increased sensitivity of the light-scattering method, the integrated method limit of detection, the real-time versus integrated methodology, and the omission of below LOQ values in the integrated mean. The difference in values may also have resulted from difference in the activities that occurred over the entire sampling period versus those occurring during the short time required for the real-time monitoring method. Regardless, both methods suggest that indoor EPA Headquarters buildings RSP particle concentrations are typically <50 $\mu g/m^3$.

4.3.3 Formaldehyde and Other Aldehydes

4.3.3.1 Passive Formaldehyde Badges. The results of analysis on the passive formaldehyde badges were all below the analytical limit of detection (119 $\mu g/m^3$ total over an 8-h exposure).

4.3.3.2 Integrated Aldehyde Samples. Figure 4.9 shows the mean building distribution of formaldehyde as well as other targeted carbonyls (Table C.1-C.11) having values greater than 1% of the total carbonyl concentration (mean total carbonyl = 37.7 $\mu g/m^3$). Four target carbonyls, each individually representing <2% of the total carbonyl concentration (Table C.11), were combined (<3%) and graphically represented, as was the unknown carbonyls (Table C.10) sample component (<4%). Total carbonyls measured in the Waterside Mall complex (mean total carbonyl concentration = 32.1 $\mu g/m^3$) were uniformly distributed across all Waterside Mall sectors. The Fairchild total carbonyl mean concentration (73.6 $\mu g/m^3$) is more than double the mean Waterside Mall concentration, and the Crystal Mall total carbonyl mean concentration (43.8 $\mu g/m^3$) is nearly one-third times higher than the mean Waterside Mall concentration but about half the Fairchild Building mean concentration. Individual Fairchild Building aldehyde and carbonyl species concentrations were consistently twice the corresponding species concentrations observed in the other

Figure 4.9. Mean Carbonyl Species Distribution Across Waterside Mall Sectors, Crystal City, and Fairchild



two buildings. Mean Crystal Mall 2 formaldehyde, acetaldehyde, valeraldehyde, and hexanaldehyde were also double the corresponding Waterside Mall concentrations. Across all buildings and sectors, formaldehyde (mean = 10.2 $\mu g/m^3$), acetaldehyde (mean = 6.0 $\mu g/m^3$), and acetone (mean = 14.1 $\mu g/m^3$) were the primary constituents measured, representing 27.1%, 15.8%, and 37.4%, respectively, of the mean total carbonyl sample. Nontargeted carbonyls accounted for less than 4% of the mean total carbonyl sample. Nine of the 15 targeted species (Table 3.2) were measured in all the indoor samples, and the maximumconcentrations for eight of these target compounds were observed in the Fairchild Building. Crotonaldehyde was detected only in the Fairchild Building. Butyraldehyde (mean = 0.8 $\mu g/m^3$) was nearly uniformly distributed across all sectors. Isovaleraldehyde, ortho-tolualdehyde, para-tolualdehyde, meta-tolualdehyde, and 2,5-dimethylbenzaldehyde were not detected in any indoor samples. No outdoor aldehyde samples were collected during the monitoring study.

4.3.4 Volatile Organic Compounds

Figure 4.10 summarizes the mean outdoor, mean indoor, and the maximum observed values (identified by sector) for the targeted VOCs observed above the limit of quantitation. With the exception of benzene, toluene, ethylbenzene, and the xylene isomers, indoor sources appear to be the dominant contributors for these VOCs; that is, the mean indoor concentration more than doubles the mean outdoor concentration. 1,1,1-Trichloroethane, tetrachloroethylene, toluene, and the xylene isomers were the dominant species measured across the building (Figure 4.11).

Many of the targeted chlorinated organic compounds were detected in all the indoor samples (Tables D.1-D.16). Methylene chloride (Table D.1) was detected above the limit of quantitation in 42 of the 61 indoor samples but in only two outdoor samples. The mean indoor concentration (3.6 $\mu g/m^3$) more than doubled the outdoor concentration. The mean methylene chloride concentration in the Fairchild Building (6.7 $\mu g/m^3$) was twice the Waterside Mall and four

Figure 4.10. Mean Volatile Organic Compound Concentrations Across Waterside Mall Sectors, Crystal City, and Fairchild

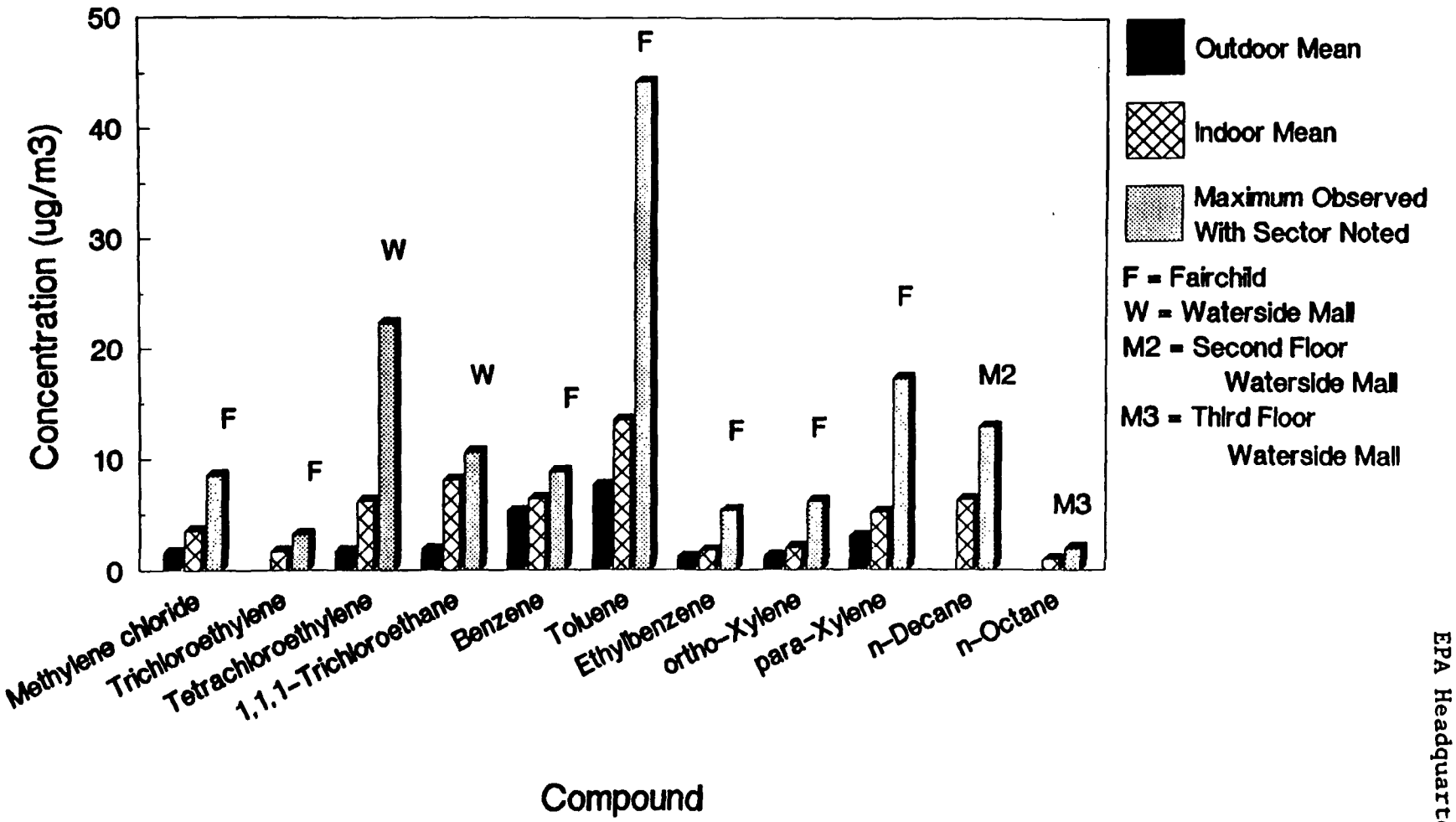
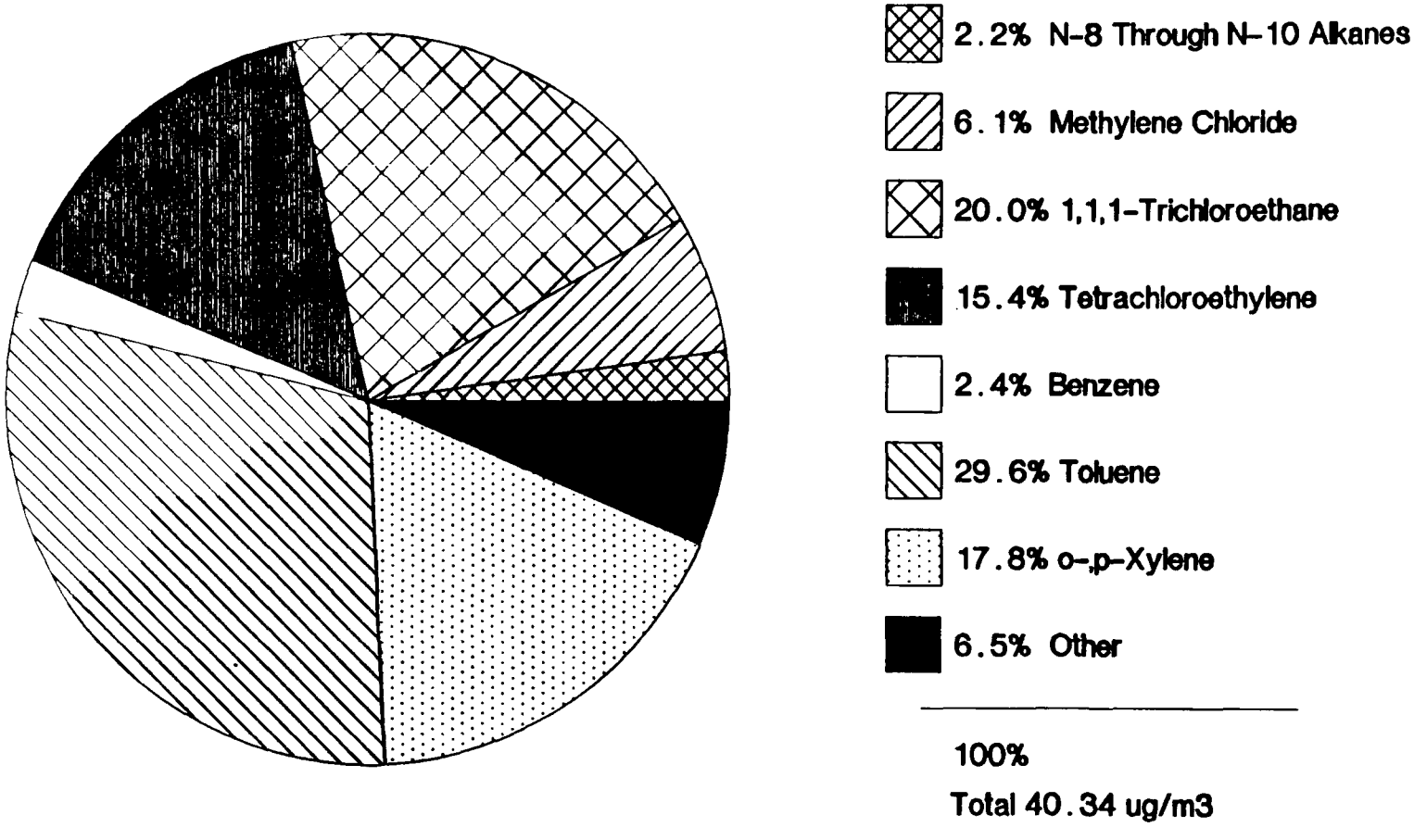


Figure 4.11. Average Volatile Organic Compound Concentrations Based on All Observations Above the Limit of Quantitation at the EPA Primary Sites



times the Crystal Mall 2 mean concentrations (3.2 and 1.6 $\mu g/m^3$, respectively). The highest and second highest concentrations (8.5 and 5.6 $\mu g/m^3$) were both observed in the Fairchild Building. Methylene chloride was quantified in nearly all the Waterside Mall samples except in the West Tower, where only 1 of the 12above-LOD samples was above the limit of quantitation. Trichloroethylene (Table D.2) was detected in 57 of the 61 indoor samples and quantified in all the Fairchild Building and Crystal Mall 2 samples. Only about 20% of the Waterside Mall samples (9) had trichlorethylene concentrations above the limit of quantitation; the majority of these samples were collected in Mall 2 and East Tower areas. The highest sector mean and individual sample concentrations were reported in the Fairchild Building (3.0 and 3.2 $\mu g/m^3$, respectively). Tetrachloroethylene (Table D.3) was quantified in all the indoor and outdoor samples, and the mean indoor tetrachloroethylene concentration (6.2 $\mu g/m^3$) was more than 3 times the outdoor concentration. The mean West Tower tetrachloroethylene concentration was more than 3 times the mean concentrations observed for the other sectors, the highest concentration (22.3 $\mu g/m^3$) being reported for that sector. The Mall 2 concentration was nearly double the remaining Waterside Mall sector means, the second highest indoor tetrachloroethylene concentration (19.1 $\mu g/m^3$) being reported for the fixed site on the day the employee questionnaire was administered. Chloroform was detected in trace concentrations below the limit of quantitation in more than two-thirds of the indoor samples as well as three of the outdoor samples. 1,1,1-Trichloroethane (Table D.4), quantified in all indoor and outdoor samples, had a mean indoor concentration (8.1 $\mu g/m^3$) 4 times the ambient concentration (1.8 $\mu g/m^3$). Mean concentrations in the West Tower and East Tower were more than double the other sectors mean concentrations. The highest concentrations were observed in the second floor Mall, East Tower, and West Tower, the highest (25.9 $\mu g/m^3$) and second highest (24.8 $\mu g/m^3$) concentrations observed in the Mall and East Tower, respectively. The Crystal Mall 2 mean (3.3 $\mu g/m^3$) was 50% of the Fairchild Building 1,1,1-trichloroethane concentration. para-Dichlorobenzene (Table D.5) was quantified in all five Fairchild Building samples (mean = 6.1 $\mu g/m^3$) and one Waterside Mall sample. Five other Waterside Mall samples

contained trace quantities of para-dichlorobenzene, whereas no Crystal Mall 2 samples contained para-dichlorobenzene above the limit of detection.

Benzene, toluene, and ethylbenzene (Tables D.6, D.7, and D.8, respectively), organics commonly associated with gasoline and other solvents, were detected in more than 85% of the indoor samples collected in the three buildings and in all outdoor samples. The mean indoor benzene concentration (6.4 $\mu g/m^3$), calculated by using the four Mall 2 and Mall 3 samples along with the five Fairchild Building samples, that had levels above the limit of quantitation, was 1 $\mu g/m^3$ higher than the ambient benzene concentration (5.3 $\mu g/m^3$). Indoor benzene concentrations in Crystal Mall 2 and the remaining Waterside Mall sectors were below the limit of quantitation. Toluene and ethylbenzene mean indoor concentrations (13.5 $\mu g/m^3$ and 1.8 $\mu g/m^3$, respectively) calculated across all sectors were nearly double the ambient concentration. The Fairchild mean toluene concentration (38.3 $\mu g/m^3$) was nearly 3 times higher than the mean concentration reported for any other sector, and the highest and second highest toluene values were reported in that building (44.3 and 34.1 $\mu g/m^3$, respectively). The Fairchild Building mean ethylbenzene concentration (4.9 $\mu g/m^3$) was triple the mean concentrations observed in the other buildings, the maximum and next-to-maximum values being observed in that building (5.4 and 4.5 $\mu g/m^3$, respectively). Few differences are observed in the toluene and ethylbenzene sector mean concentrations calculated for the Waterside Mall and Crystal Mall 2 sectors.

ortho-Xylene and para-xylene (Tables D.9 and D.10, respectively) were quantified in all but 2 indoor samples (mean = 2.0 and 5.2 $\mu g/m^3$, respectively), and both isomers observed at indoor concentrations slightly less than twice the ambient concentrations. The Fairchild Building mean concentrations for both isomers (5.6 and 15.6 $\mu g/m^3$) are nearly three times higher than the mean sector values reported for the other two buildings. The maximum observed species concentrations (o-xylene = 6.2 $\mu g/m^3$ and p-xylene = 17.3 $\mu g/m^3$) were also reported from samples collected in the Fairchild Building. The highest non-Fairchild Building isomer concentrations (3.4 and 9.2 $\mu g/m^3$, respectively) were

reported in Mall 2 samples and were 50-75% higher than the maximum concentrations reported for any of the other Waterside Mall or Crystal Mall 2 sectors. Styrene (Table D.11) was quantified in one Fairchild Building sample (1.5 $\mu g/m^3$), and trace concentrations detected in 13 other indoor samples.

N-Decane (Table D.12) was detected in 16 Waterside Mall and five Fairchild Building indoor samples but not in the Crystal Mall 2 or ambient samples. Five Mall 2 and Mall 3 samples were above the limit of quantitation (mean = 6.3 $\mu g/m^3$), and the maximum concentration (12.9 $\mu g/m^3$) was reported in the second floor Mall. n-Dodecane (Table D.13) was detected but not quantitated in two indoor samples. n-Octane (Table D.14) was detected in 60 indoor and five outdoor samples, but quantified in only 24 indoor samples. Five Fairchild Building and three Crystal Mall 2 samples were above the limit of quantitation (mean = 1.0 and 0.6 $\mu g/m^3$, respectively). Slightly higher mean n-octane concentrations were observed in the Mall 3 and Mall 2 samples (1.3 and 1.2 $\mu g/m^3$, respectively), the individual-sample highest and second highest concentrations (1.98 and 1.49 $\mu g/m^3$) also being observed in these sectors.

The sum of the targeted compounds (Table D.15) measured indoors, calculated over all sectors and all buildings by summing the concentration of the individual target compound concentrations, was more than 3 times the corresponding outdoor concentration. The sum of the targeted compounds measured indoors at the Fairchild Building was nearly 6 times the corresponding outdoor concentration and nearly 3 times the mean concentrations observed for the other two buildings. Southeast and Southwest Mall single-sample concentrations were half the other Waterside Mall sector means and approximated the ambient concentration. The highest and second highest sample sum of targeted compounds occurred in the Fairchild Building (110.4 and 94.1 $\mu g/m^3$). The highest and second highest non-Fairchild Building value was observed in a Mall 2 sample (94.1 $\mu g/m^3$) .

The qualitative measurement of total VOCs (Table D.16) also suggests that the indoor Fairchild Building VOC concentrations are nearly 6 times the ambient

VOC concentrations and more than twice the levels observed at the other two buildings. The total VOC concentration measured at the Crystal Mall 2 and Waterside Mall Buildings are approximately 2-3 times higher than the mean outdoor total VOCs concentration, and little variability between the sector means was reported in the Waterside Mall buildings.

Vinylidene chloride, carbon tetrachloride, chlorobenzene, meta- and ortho-dichlorobenzene, 1,2-dibromomethane, 1,1,2,2-tetrachloroethane, vinyl chloride, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,1-dichloroethane, and 4-phenylcyclohexene were not measured above the limit of quantitation in any indoor or outdoor sample. Trace indoor concentrations, above the LOD but below the LOQ, of chlorobenzene were found in four indoor samples, of meta-dichlorobenzene in one sample, of 1,1,2,2-tetrachloroethane in two samples, of 1,1-dichloroethane in one sample, and of 4-phenylcyclohexene in one indoor sample.

4.3.5 Pesticides

None of the targeted pesticides were observed above the limit of detection (Table 3.2) in the samples collected in the EPA Headquarters Buildings.

4.3.6 Nicotine

Above-LOQ nicotine concentrations were observed in six monitoring locations (Table E.1); one or more of these sites were located in each of the three buildings (mean = 0.13 $\mu g/m^3$). The highest nicotine concentration (0.3 $\mu g/m^3$) was observed in the Fairchild Building.

4.3.7 Fixed Indoor and Fixed Outdoor Monitoring Locations

Tables F.1-F.4 display the particulate statistics. The mean fine particle (< 2.5 μm) concentration measured over the five-day period at the fixed indoor site (8.6 $\mu g/m^3$) was slightly more than one half the corresponding outdoor fine

particle concentration (13.6 $\mu g/m^3$) or the mean Waterside Mall real-time RSP concentration (14.1 $\mu g/m^3$). The mean indoor PM_{10} measured at the fixed indoor site (19.3 $\mu g/m^3$) was slightly greater than two-thirds the corresponding mean outdoor value (27.7 $\mu g/m^3$).

Figure 4.12 and Figure 4-13 graphically show changes in T, RH, CO_2, and RSP over the entire five-day monitoring period at the fixed indoor and outdoor locations. Outdoor relative humidity was increased during the first three days of the monitoring study because of inclement weather. Outdoor temperature gradually increased over the week but remained below 40 °F through Thursday noon and below 50 °F throughout the remainder of the monitoring period. The fixed indoor site data is consistent with the mean sector values discussed above and demonstrates small day-to-day variability at this single location, with the exception of CO_2, which was lower on Tuesday, which most likely reflects the smaller number of employees present during the inclement weather period.

Figure 4.14 shows the variability of selected organic species over the five-day monitoring period at the fixed indoor site. Integrated aldehyde samples were not collected at the fixed outdoor site. Outdoor VOC concentrations (Figure 4.10) were generally consistently lower than corresponding indoor values with small daily variation in concentrations. The large increase in 1,1,1-trichloroethane concentrations on Wednesday probably results from building- or worker-related processes. Otherwise, these compounds did not vary from day-to-day.

Figure 4.12. Indoor and Outdoor Fixed Site Temperature and Relative Humidity by Earliest Sample Start Time

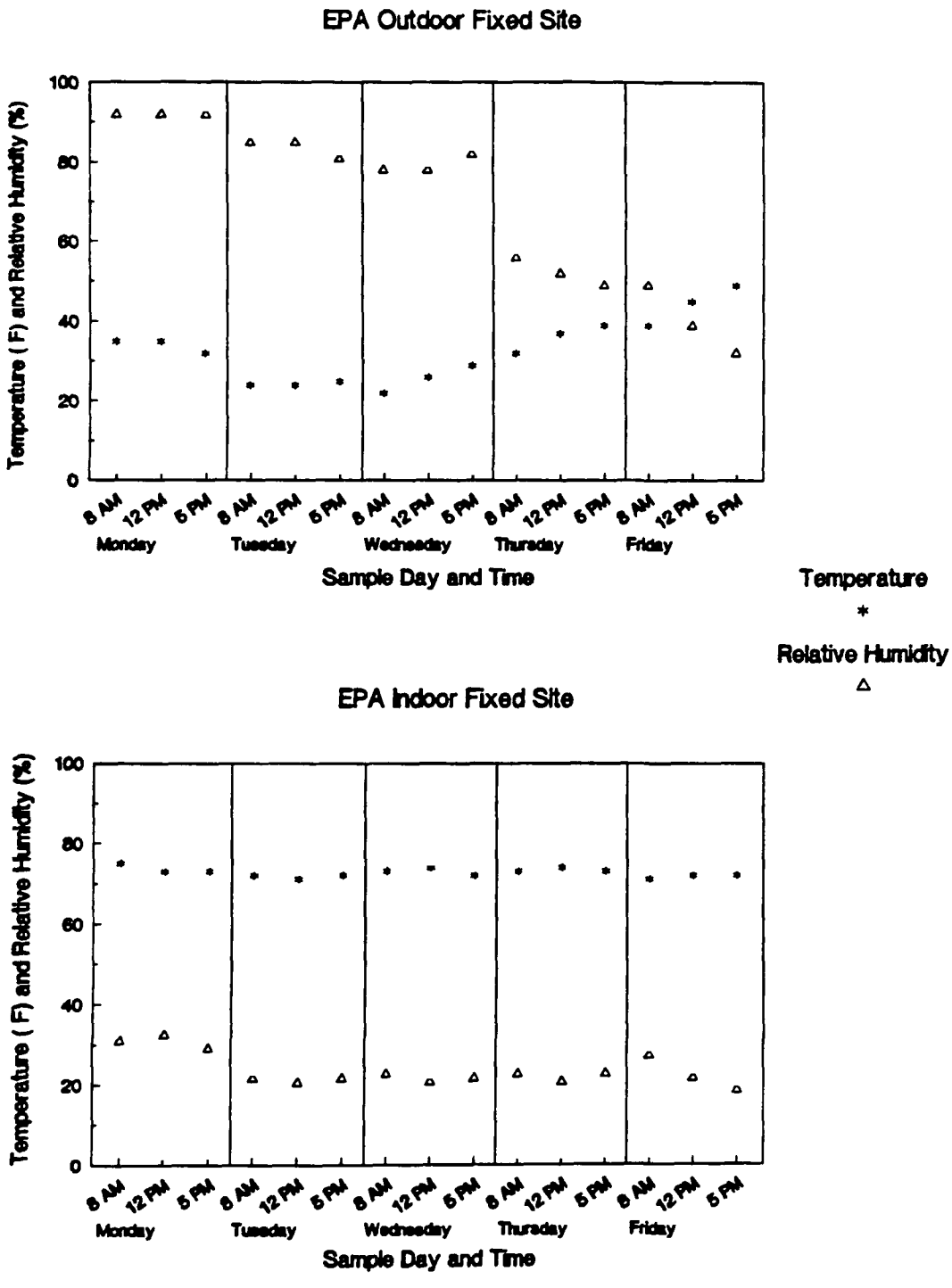
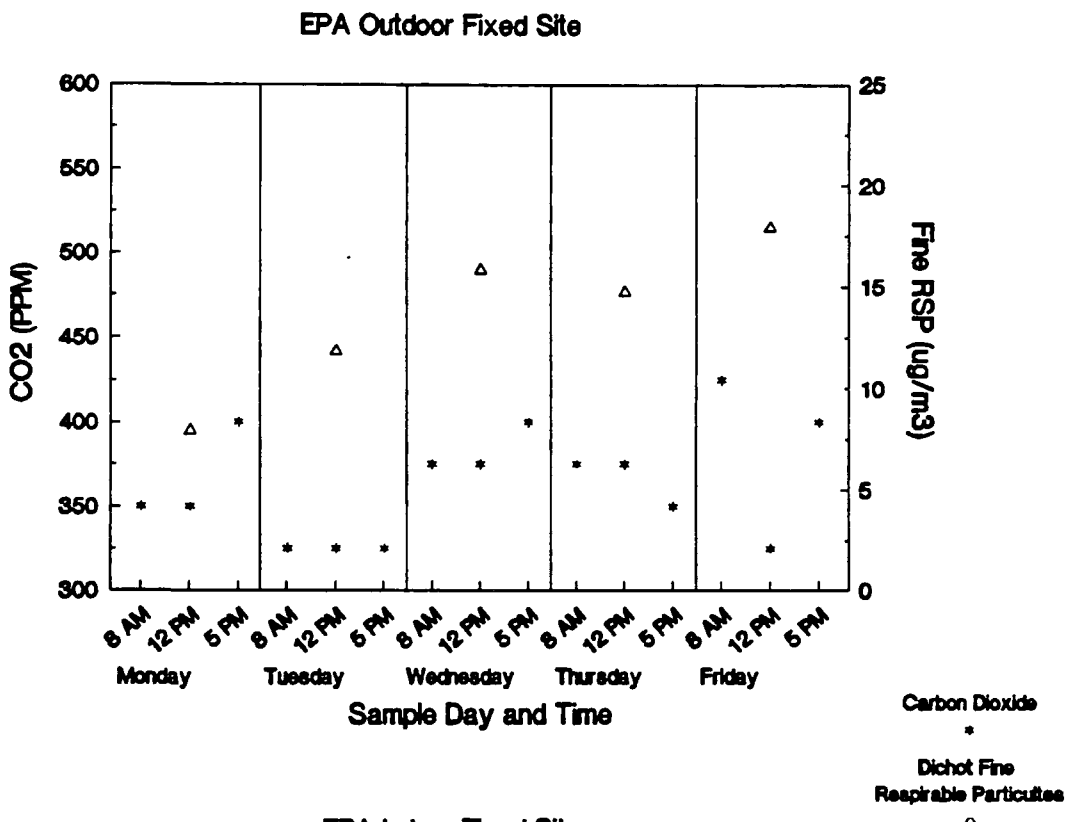


Figure 4.13. Indoor and Outdoor Fixed Site Carbon Dioxide and Respirable Particulate Concentration by Earliest Sample Start Time



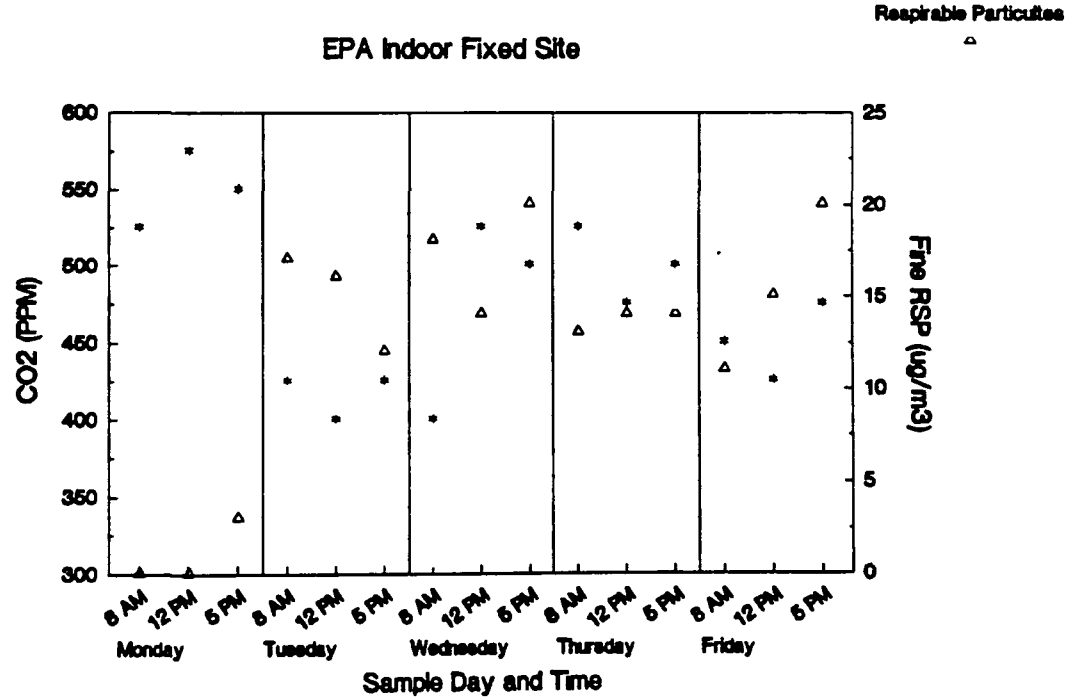
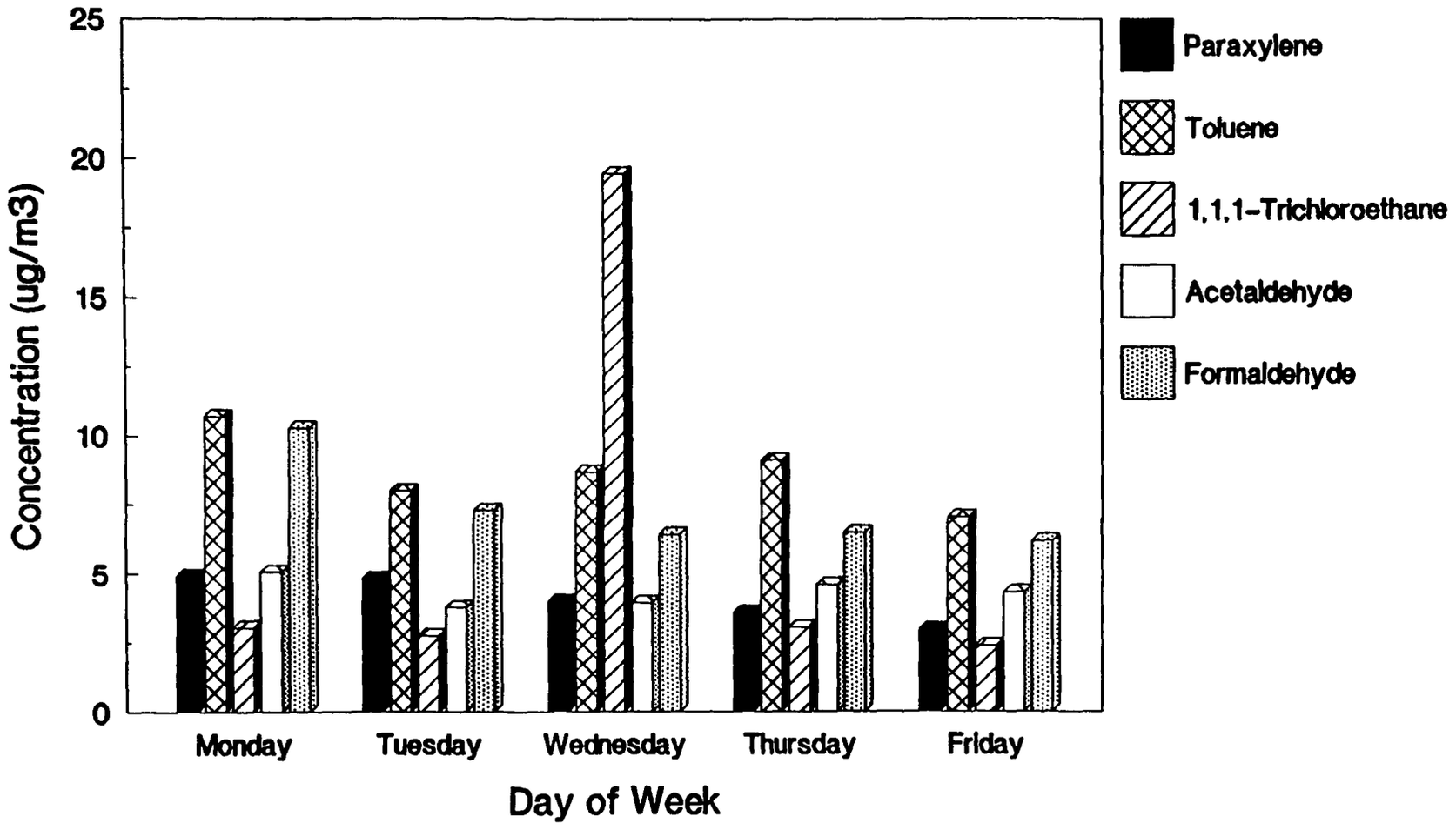


Figure 4.14. Concentrations of Selected Volatile Organic Compounds and Aldehyde Species Measured at the EPA Indoor Fixed Site



4.4 Viable and NonViable Microbiological Contaminants

4.4.1 Airborne Fungi

With the exception of the East Tower, mean viable airborne fungi (Table G.1) were low, the overall building mean concentration (28 CFU/m^3) being nearly identical to the ambient concentration (22 CFU/m^3). The mean East Tower value (130 CFU/m^3) was more than 5 times concentrations observed in the other locations. The highest single value (883 CFU/m^3) was observed in the East Tower. Table 4.1 summarizes the mean viable fungal concentrations by the major genus observed. Cladosporium were consistently identified across all sectors, and indoor concentrations were 2-10 times higher than the ambient concentration. Mean East Tower Penicillium concentrations were high in comparison to the other sectors. The high mean concentration in the East Tower resulted from a higher concentration measured in one location. Stachybotrys sp. was cultured at low concentrations from three individual indoor air samples (one East tower, one Mall 2, and one West tower).

4.4.2 Airborne Human-Source Bacteria

Over all sectors, mean human-source bacteria (HSB) concentrations (Table G.2) were low. The mean building HSB concentration (52 CFU/m^3) is slightly less than the ambient concentration (54 CFU/m^3). Table 4.2 summarizes the mean HSB concentrations by genus. Staphylococcus sp. and Micropolyspora sp. were consistently higher indoors (factor of 2-15) than in the outdoor samples.

4.4.3 Airborne Thermophilic Organisms

The mean indoor thermophilic bacteria concentration (18 CFU/m^3) was 6 times the ambient concentration (Table G.3). Mall 3 and Fairchild sector mean concentrations (27 and 24 CFU/m^3, respectively) were nearly double the other

sector mean concentrations, the highest single sample concentration (90 CFU/m^3) being observed at the Fairchild building.

4.4.4 Spores

The fungal spore counts were low and consisted of genera commonly present in the air. Table 4.3 summarizes the mean spore concentrations recorded for the three 8-h periods. With the exception of the 8 a.m. - 4 p.m. period at the West Tower, there is little difference in the concentrations reported. Although low, the East Tower and West Tower daytime concentrations are 3-4 times higher than the outdoor counts and more than 10 times higher than the concentrations observed in the other indoor sectors during normal working hours. Higher indoor than outdoor concentrations were also recorded in Mall 3 during the midnight to 8 a.m. sampling period.

TABLE 4.1. MEAN AIRBORNE VIABLE FUNGAL CONCENTRATIONS (CFU/M^3) BY GENUS

	Out	Fxd	M3	M2	OM[a]	WT	ET	CC	FC
Aspergillus	0.4		0.4	1.0		0.2	12.3	2.8	1.3
Cladosporium	1.0	10.4	2.0	3.7	7.2	5.3	6.3	4.9	5.6
Mucor	0.4	0.6							
Paecilomyces						2.1	0.3		
Penicillium	1.0	1.0	0.4	1.3	0.6	8.3	104.6	1.5	2.0
Phoma	0.3								
Rhizopus				0.1					
Sporobolomyces	0.5	0.5	0.7						
Stachybotrys				0.1		0.2	0.4		
Stemphyllium	0.1		0.6			0.2	0.3		
Verticillium						0.9			
yeast	0.4	1.3	1.0	0.2		1.9	2.0	0.5	
not identified	17.0	5.8	2.2	2.3	1.0	1.9	4.4	1.4	0.6

[a]OM = Other Mall areas (Southwest, Southeast, Northeast, etc.).

TABLE 4.2. MEAN AIRBORNE VIABLE HUMAN SOURCE BACTERIAL CONCENTRATIONS (CFU/M^3) BY GENUS

	Out	Fxd	M3	M2	OM[a]	WT	ET	CC	FC
Acinetobacter	12.0	0.8	3.7	4.1	2.8	1.0	4.4	2.5	4.0
Aeromonas			0.9	0.6			0.6	1.0	1.2
Alcaligenes				0.4	5.0				
Bacillus		9.4		4.7	2.0	3.0	0.6		
Klebsiella			0.2						
Micrococcus	4.6		3.6		7.0	20.8	9.9	3.5	19.6
Micropolyspora	2.9	45.0	26.7	15.8	7.5	10.0	14.4	8.0	24.0
Proteus	0.4		0.4						
Pseudomonas		1.0		0.4					
Serratia		2.2		3.7	1.8	0.7			
Staphylococcus	6.4	27.8	20.8	19.8	7.5	20.4	25.3	9.0	15.6
Streptococcus		1.6							1.2
not identified	4.2	4.2	1.3	11.8	11.5	1.8	1.5	7.5	

[a]OM = Other Mall areas (Southwest, Southeast, Northeast, etc.).

TABLE 4.3. BURKHARD SPORE TRAP SAMPLING RESULTS (spores/M^3 air)

Location	Period 1[a]	Period 2[b]	Period 3[c]
Outdoor	122	122	150
Fixed	44	8.8	48.3
Mall 3	36.5	103	210
Mall 2	41.5	55	7
Other Mall	64.7	40.7	9
West Tower	496	56	0
East Tower	330.5	not done	not done

[a] Period 1 - approx. 8 a.m. - 4 p.m.

[b] Period 2 - approx. 4 p.m. - midnight

[c] Period 3 - approx. midnight - 8 a.m.

5. ENVIRONMENTAL MONITORING AND ANALYSIS QUALITY ASSURANCE

5.1 Quality Control Procedures

Considerable care was taken to characterize the quality of the environmental measurements and analytical results. Time and other resource limitations necessitated that different levels of quality assurance procedures be implemented for the monitoring of individual compound classes in this field study. The most sophisticated quality assurance procedures were implemented for those species determined in the initial study design considerations to be of primary concern. The identical analytical laboratories were contracted to support both the Library of Congress Madison Building and the EPA Headquarters Building indoor air quality investigations. Because of the closeness in time for the two monitoring programs (one week) and the extensive laboratory support resources required for these two studies, the sampling media for both studies were prepared by the contractors at the same time. Likewise, the environmental and quality control samples collected from the two studies were simultaneously analyzed by the contractors.

5.1.1 Real-Time Temporal Measurements

Each instrument was calibrated in accordance with the manufacturer's specifications immediately before and after each of the three daily monitoring periods for each day sampling was conducted.

5.1.2. Integrated Samples

5.1.2.1. Respirable Particles and Inhalable Particles Duplicate low-flow (1.67 L/min) RSP samples were collected at two primary sampling locations. Only one indoor and one outdoor PM_{10} (inhalable particles) sampler were operated during the study. Therefore, no PM_{10} duplicate samples were collected. Ten percent of all the tared or final weighed filters were reweighed

by an independent operator at the conclusion of each weighing session. If the difference in independent operator weighings exceeded 10 μg for one or more individual filters, all the filters weighed during the weighing session were reweighed. External performance evaluation samples were not available for this method. The RSP and PM_{10} samplers flows were checked at the beginning and end of each sampling period.

5.1.2.2. Volatile Organic Compounds. The most sophisticated quality control procedures were implemented for VOC sampling and analysis. Grab VOC samples were collected in two locations one month prior to the monitoring study to assist in the selection of the target VOCs. The sites selected for the grab sample collection were determined on the basis of documented employee concerns recorded by EHSD. Cleaned, evacuated canisters were manually opened in the two locations and allowed to come to atmospheric conditions. The canisters were then closed and returned to the laboratory for GC/MS analysis. A full-scan analysis of these samples was conducted, and the compound peaks were identified. In addition, full-scan analysis was conducted on two integrated VOC samples collected during the monitoring study to evaluate potential changes in VOC sources before and during the monitoring period.

Numerous laboratory quality assurance procedures were implemented for VOC analysis. A series of field blanks, spiked control samples, and external performance evaluation samples was provided to characterize the quality of the VOC analysis. The laboratory also conducted duplicate analyses on selected canisters to estimate the representativeness of the aliquot removed from the canister for analysis.

Field quality assurance procedures for VOC sampling included duplicate canister sample collection at two monitoring locations. Each sampler flow controller was checked immediately before and after the monitoring period to ensure proper flow rate. Canister vacuum gauges were checked periodically (two-three times a day) to ensure proper sampler operation.

5.1.2.3. Formaldehyde and Other Aldehydes. Duplicate passive formaldehyde badge samples were collected at four monitoring locations. Duplicate integrated aldehyde samples were collected at one monitoring site. Passive and integrated sample field blanks were also collected to evaluate biases resulting from storage and shipment of the samples. Aldehyde sampler flows were checked at the beginning and end of each sampling period. External quality control samples were not available for this study.

5.1.2.4. Pesticides. Because of the limited number of available samples, duplicate pesticide samples were not collected. Field blanks were collected to evaluate potential biases resulting from storage and shipment of the samples. External quality control samples were not available for this study. Pesticide sampler flows were checked at the beginning and end of each sampling period.

5.1.2.5 Nicotine. Duplicate passive nicotine badge samples were collected at four monitoring locations. Field blanks were also collected to evaluate biases resulting from storage and shipment of the samples. External quality control samples were not available for this study.

5.1.2.6. Viable and Total Spore Counts. Duplicate samplers containing the same growth medium for the retrieval of each group of organisms (fungi, human source bacteria, and thermophilic bacteria) were operated in tandem. To minimize the effect of inherent biological variability, these duplicate plates were averaged to record the concentration of organisms at a particular site. Repeat sampling runs were also performed at randomly selected sites during the same sampling day.

Quality control of the media consisted of incubation of nonexposed plates for sterility checks and incubation of plates inoculated with an appropriate test organism for growth checks. Internal laboratory quality assurance and quality

control measures were conducted by the analytical laboratory to ensure accurate identification of the fungal and bacterial isolates and by the University of Michigan Medical Center laboratory for the accurate identification of fungal spores.

5.1.3. Other Quality Control Procedures

Additional administrative procedures were instituted by the field monitoring personnel to ensure data quality. Site environmental samples were physically inventoried against the site log sheet prior to each sampling period and rechecked by an independent operator. Computer-entered data was checked (100%) by an independent operator. At least twice each day, visual and physical checks were conducted at the primary monitoring sites to ensure that the instruments were operating. At the completion of each sampling period, a physical inventory of the site sampling log sheets, the real-time monitoring log sheets, and the samples collected at that site was conducted.

5.2 Quality Control Results

5.2.1 Real-Time Temporal Measurements

The monitors met the manufacturer's specifications prior to and following each measurement period.

5.2.2 Integrated Samplers

5.2.2.1 Respirable Suspended Particles and Inhalable Particles (PM_{10}). Duplicate personal RSP concentrations differed by 24.1% at one site (18.7 and 14.2 $\mu g/m^3$). No data is available for the second collocated sampling site, as one sample was voided by the operator as the result of a failed pump. Comparisons of the filter weighing performed by the two independent operators revealed that no filter weight exceeded the acceptable weighing limits for either

the tare or final weighing sessions.

5.2.2.2. Volatile Organic Compounds. The results of the full-scan VOC analyses conducted on the samples prior to and following the monitoring period are shown in Appendix H. Few differences are seen in the VOC peak areas between sites, and the major organic compounds identified had already been selected as targeted VOCs. Numerous alkanes and selected Freons were present in the full-scan samples. The GC scan for the field blank and the calibration standards are shown for reference.

The results of analysis on the collocated VOC canisters collected at the two sites are summarized in Table 5.1. Excellent agreement is observed for the VOCs measured at these two locations, which suggests no significant bias in the sampling and analysis procedures.

The results from laboratory duplicate analysis on selected canisters and the results of analysis on field blank, spiked, and external audit VOC samples analyses are shown in Appendix I. These data confirm the high quality of the VOC sample data reported.

The analysis of the canister samples for total VOCs using the more qualitative GC method yielded results suggesting potential sample contamination. Some of the laboratory-prepared zero air field blanks and low-VOC-concentration quality control samples had total VOC concentrations equal to or slightly above the concentrations measured in some outdoor samples. As discussed above, the canister samples were cleaned, and selected samples were analyzed by the laboratory prior to shipment for targeted VOCs only. The results of the analysis of selected "clean" canisters for the target VOCs (Appendix I) indicated this sampling medium was cleaned properly for the collection and analysis of the targeted VOCs. Only after the canisters had been shipped to the field and the study already initiated was the total VOC canister analysis included in the study protocol.

TABLE 5.1. RESULTS OF DUPLICATE SAMPLE ANALYSIS

VOLATILE ORGANIC COMPOUNDS

Organic Compound	Site 1		Site 2	
	%Diff [a]	Mean	%Diff [a]	Mean
Methylene chloride	-0.3%	3.3	NA [b]	T [c]
1,1,1-Trichloroethane	-7.4	22.4	16.2	13.1
Benzene	* [e]	*	NA [b]	T [c]
Toluene	-0.9	11.0	4.0	10.6
n-Octane	-1.0	1.0	NA [b]	T [c]
Tetrachloroethylene	-5.1	28.4	37.1	18.9
Ethylbenzene	-0.6	1.8	13.6	1.1
p-Xylene	-0.9	5.4	9.5	3.3
o-Xylene	0.0	2.5	12.4	1.4
n-Decane	1.8	9.4	NA [b]	T [c]

ALDEHYDES

Compound	Mean Blank Concentration[d] ($\mu g/m^3$)	%Diff[a]	Mean
Formaldehyde	0.92	2.1	9.0
Acetaldehyde	0.75	0.4	14.4
Acetone	1.62	-7.3	31.2
Propionaldehyde	0.29	-21.1	0.6
Butyraldehyde	0.19	56.5	0.6
Benzaldehyde	0.00	* [e]	NA
Valeraldehyde	0.00	-23.4	0.7
Hexanaldehyde	0.00	-5.1	2.1
Unknown Carbonyls	0.17	7.8	2.0
Total Carbonyls	3.93	-4.0	60.8

[a] % Difference = ((Canister 1 - Canister 2)* 100) / Canister 1.

[b] NA - Not applicable .

[c] T - Trace concentrations were measured in both canisters, above limit of detection but below limit of quantitation.

[d] Other aldehyde mean blank sample concentrations were 0.0 $\mu g/m^3$.

[e] * - Only one sample was above the limit of quantitation.

The canister GC/MS scan data was subsequently reviewed with emphasis placed on the m/z peaks located at 43 and 91, the two major peaks associated with non-aromatic and aromatic hydrocarbon identification, respectively. On the basis of the review of the m/z 43 and 91 peak areas for the seven laboratory-supplied blank samples, the cleaned canisters could be expected to contain 40-102 $\mu g/m^3$ of nontargeted nonaromatic hydrocarbons and 0-2 $\mu g/m^3$ of nontargeted aromatic hydrocarbons. The environmental sample m/z 43 and 91 peak areas suggest that nonaromatic compound concentrations ranged from 24 to 996 $\mu g/m^3$, whereas the aromatic compound concentrations ranged from 9 to 137 $\mu g/m^3$. This suggests that the non-aromatic hydrocarbons were the dominant class of hydrocarbons collected in the environmental samples.

5.2.2.3. Formaldehyde and Other Aldehydes. Analysis of the passive formaldehyde badges indicated that all the samples were below the limit of detection. Table 5-1 summarizes the mean blank aldehyde sample concentrations and the results from the analysis of duplicate aldehyde samples.

5.2.2.4. Pesticides. The results of laboratory matrix spike sample recovery data are shown in Appendix I. No individual pesticide compounds were observed in any of the individual field blank pesticide samples.

5.2.2.5. Nicotine. Duplicate passive nicotine badge samples differed by 26.9% and 10.8% at two of the four monitoring sites (mean - 5.0 $\mu g/m^3$ and 1.8 $\mu g/m^3$, respectively). Analysis of the duplicate nicotine samples collected at the other two sites were below the limit of detection.

5.2.2.6. Viable and Nonviable Microbiological Samples. No contamination was recorded on the nonexposed plates, and all of the positive growth plates supported the growth of the test organism(s).

Repeat indoor microbiological samples were collected at nine monitoring locations at a later time on the same sampling day. Table 5.2 summarizes the

results of the initial and second samples collected at these nine locations. Small differences were noted in the number of fungal and thermophilic organisms recovered between the first and second samples collected at the nine locations. Human source bacteria concentrations measured initially at two locations ("other mall" and outdoors) were more than 10 times the concentrations observed during the second sampling period (545 CFU/m^3 vs 40 CFU/m^3, and 100 CFU/m^3 vs no organisms, respectively). Stachybotrys sp. was also isolated in one of the West Tower paired samples which were collected several hours apart on the same day.

TABLE 5.2. RESULTS OF REPEAT SAMPLING (CFU/M^3)

	Fungi		Human Source Bacteria		Thermo-philes	
Location	#1	#2	#1	#2	#1	#2
Mall 3 (room A)	0	0	25	30	0	45
(room B)	0	15	10	55	35	70
average	0	7.5	17.5	42.5	17.5	57.5
Mall 2 (room C)	10	10	70	20	10	10
(room D)	5	10	10	45	20	60
(room E)	17	23	70	60	25	20
average	10.7	14.3	50	41.7	18.3	30
Other Mall	0	10	545	40	10	10
West Tower						
(room F)	15	15	100	85	10	10
(room G)	50	15	97	85	0	10
average	21.7	15	98.5	85	5	10
Outdoors	70	50	195	10	50	0

6. SUMMARY OF AIR HANDLING UNIT EVALUATION RESULTS

Thirty-six Waterside Mall air handling units were evaluated (Table 6.1), and four of these units evaluated on two different days. None of the units evaluated during this monitoring study included humidifiers. For those systems where both pitot and dry bulb measurements were made (Table 6.1), the percent outside air (% OA) determined via the pitot traverse method compares well with the corresponding dry bulb determined % OA. During the monitoring period, 10 of the AHUs delivering air to the supply air distribution ducts at the monitoring sites were operating under conditions resulting in the supply air containing less than 20% OA based on the dry bulb measurements. The % OA for the Mall 3 AHUs examined was relatively constant (range 15-25%) while the % OA being distributed during the monitoring period to Mall 2 locations ranged from 10 to 74%, the East Tower AHU % OA ranged from 23 to 83%, and the West Tower AHU % OA ranged from 30 to 53%. The test results from examining Southeast Mall AHU SE3 on two different monitoring days indicate only small differences in the operating parameters of this unit on the two days. However, the test results from the examination of two Mall 2 AHUs (unit 14 and unit 21) reveal considerable differences (18-30% difference) in the operating parameters and the % OA for these two different days.

Airflow and temperature measurement data obtained by using methods recommended in the National Standards of the Associated Air Balance Council (AABC)[34] for the AHUs evaluated during the environmental monitoring study are summarized in Table 6.1. These National Standards are universally accepted as the most rational method for obtaining accurate AHU performance data. Generally good correlation exists between the two data sets. By convention, the more conservative of the two OA measurement values is considered as the actual ventilation supply air percentage.

Each AHU which was given a cursory inspection to determine operating condition at the time that the temperature and velocity traverse data was

collected. Because the AHUs evaluated were not equipped with in situ instrumentation or data logger equipment, the operation status of the systems could only be visually monitored. The results of this inspection are summarized below.

a. The evaluated AHUs are equipped with mixed air/economizer control systems. Therefore, the outdoor air dampers were at positions determined by the automatic temperature control system based on the temperature of the outdoor air, the return air, and the mixed air. Because monitoring was conducted with the AHUs operating according to normal control sequences, no manual measures were taken to set the outside air dampers to the minimum position. Some of the outdoor air dampers were visible from the mixed air plenum. Outdoor air damper positions ranged from minimum position (i.e., no visible opening between blades, outdoor air flow-rate limited to damper leakage flow rate) to substantial opening between blades. However, the results of previous studies have shown that attempts to quantify outdoor air-flow rate on the basis of pneumatic damper actuator pressure or position of damper blades yield inconsistent and inaccurate results. The table entitled Comparison of Ventilation Percentage in Supply Air: Environmental Monitoring Period vs. Prior or Subsequent Test Date indicates the variation in ventilation air percentage which is believed to result from the automatic positioning of the outdoor air dampers (based on AHUs which have been evaluated more than once).

b. Air filters were in a condition which could be described as normally loaded; that is, there were no unusual accumulations of particulates which would result in filter damage or significant air-flow restriction.

c. All AHUs which contained chilled water cooling coils were being operated with no chilled water flow.

d. The AHUs did provide humidity control. However, no humidification equipment was installed at any of the AHUs examined during the environmental

monitoring evaluation period.

TABLE 6.1 WATERSIDE MALL COMPLEX AIR HANDLING UNIT EVALUATION

ZONE	AHU NUMBER	TEST DATE	OUTDOOR AIR, CFM	RETURN AIR, CFM	MIXED AIR, CFM	SUPPLY AIR, CFM	PITOT % OA[a]	DRY BULB % OA
EAST TOWER	ETB-1	3/10	3175	4155	n/a	7219	44.0	42.2
	S1E	3/10	n/a	n/a	58988	n/a	n/a	23.1
	S2E	3/10	n/a	n/a	68188	n/a	n/a	41.0
	S3E	3/10	n/a	n/a	30028	n/a	n/a	83.0

ZONE	AHU NUMBER	TEST DATE	OUTDOOR AIR, CFM	RETURN AIR, CFM	MIXED AIR, CFM	SUPPLY AIR, CFM	PITOT % OA	DRY BULB % OA
WEST TOWER	S1W	3/09	n/a	n/a	78765	n/a	n/a	53.3
	S2W	3/09	n/a	n/a	60742	n/a	n/a	36.5
	S3W	3/09	n/a	n/a	41208	n/a	n/a	30.4

(Continued)

TABLE 6.1 (Continued)

ZONE	AHU NUMBER	TEST DATE	OUTDOOR AIR, CFM	RETURN AIR, CFM	MIXED AIR, CFM	SUPPLY AIR, CFM	PITOT % OA	DRY BULB % OA
MALL 2	10	3/07	1068	n/a	n/a	7644	13.9	12.9
	16	3/07	6156	n/a	10241	10780	57.1	58.9
	18	3/07	n/a	n/a	13223	12936	n/a	62.1
	19	3/07	1816	5799	n/a	7562	24.0	22.9
	21	3/07	2582	9058	n/a	n/a	22.2	17.7
		3/08	n/a	n/a	19407	19048	n/a	48.9
	B	3/08	451	n/a	n/a	2255	20.0	17.5
	E	3/08	n/a	n/a	3285	n/a	n/a	15.6
	2	3/08	n/a	7190	n/a	10095	28.8	20.7
	3	3/08	n/a	9096	n/a	12366	26.4	22.6
	8	3/08	2549	n/a	n/a	11329	22.5	10.1
	14	3/08	4274	4390	n/a	n/a	49.3	55.5
		3/10	7654	4247	n/a	n/a	64.3	73.5
	15[b]	3/08	n/a	12707	n/a	27868	54.4	49.3

[b] Unit number 15 also serves the Southwest Mall

(Continued)

TABLE 6.1 (Continued)

ZONE	AHU NUMBER	TEST DATE	OUTDOOR AIR, CFM	RETURN AIR, CFM	MIXED AIR, CFM	SUPPLY AIR, CFM	PITOT % OA	DRY BULB % OA
MALL 2	18	3/08	8900	n/a	n/a	15574	57.2	51.3
	20	3/08	1597	7325	n/a	8921	17.9	16.1

ZONE	AHU NUMBER	TEST DATE	OUTDOOR AIR, CFM	RETURN AIR, CFM	MIXED AIR, CFM	SUPPLY AIR, CFM	PITOT % OA	DRY BULB % OA
SOUTH EAST MALL	SE2	3/07	n/a	3011	n/a	n/a	17.7	
	SE3	3/07	n/a	15199	n/a	n/a	n/a	48.0
		3/08	n/a	15297	n/a	n/a	42.2	
NORTH EAST MALL	2	3/09	n/a	7786	n/a	10479	25.7	22.0
	3	3/09	n/a	n/a	n/a	n/a	n/a	40.2

(Continued)

TABLE 6.1 (Continued)

ZONE	AHU NUMBER	TEST DATE	OUTDOOR AIR, CFM	RETURN AIR, CFM	MIXED AIR, CFM	SUPPLY AIR, CFM	PITOT % OA	DRY BULB % OA
MALL 3	1	3/06	n/a	11304	n/a	15809	28.5	25.3
	4	3/06	n/a	13012	n/a	16105	19.2	17.1
	5	3/06	n/a	7492	n/a	9636	22.3	21.9
	6	3/06	n/a	n/a	n/a	28440	n/a	25.5
	7	3/06	n/a	n/a	12756	12930	n/a	20.0
	9	3/06	4250	13250	n/a	17635	24.1	22.3
	12	3/06	n/a	n/a	11888	11422	n/a	15.0
	13	3/06	2275	9465	n/a	12036	18.9	19.5

[a]OA - outside air.

7. REFERENCES

1. National Institute for Occupational Safety and Health, "Indoor air quality and work environment study: Library of Congress James Madison Memorial Building volume 1 - employee survey," National Institute for Occupational Safety and Health, Cincinnati, OH, 1989.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., "Ventilation for acceptable indoor air quality," ASHRAE standard 62-1989, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, GA, 1989.

3. Occupational Safety and Health Administration. OSHA Air Contaminants - Permissible Exposure Limits. 29 CFR 1910.1000. Occupational Safety and Health Administration, 1989.

4. National Institute for Occupational Safety and Health. "NIOSH Recommendations for Occupational Safety and Health Standards, 1988", Morbidity and Mortality Weekly Report, August 26, 1988, 37 (5-7. Centers for Disease Control, Atlanta, GA.

5. American Conference of Governmental Industrial Hygienists, "Threshold Limit Values for Chemical Substances in the Work Environment Adopted by ACGIH for 1988-1989," American Conference of Governmental Industrial Hygienists, Cincinnati, OH, 1988.

6. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., "Thermal environmental conditions for human occupancy", ANSI/ASHRAE Standard 55-1981, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta,GA, 1981.

7. Fed. Regist., 1987, 52, 24634.

8. Molhave, L., Bach, B., Pedersen, O.F., "Human reactions during controlled exposures to low concentrations of organic gases and vapours known as normal indoor air pollutants," Environ. Int., 1986, 12, 167-175.

9. Bach, B., Molhave, L., Pedersen, O.F., "Human reactions during controlled exposures to low concentrations of organic gases and vapours known as normal indoor air pollutants: Performance tests," Proceedings of the 3d international indoor air quality and climate conference, World Health Organization, Stockholm, Sweden, 1984, 397-402.

10. Skov, P., Valbjorn, O., DISB, "The "sick" building syndrome in the office environment: The Danish town hall study," Environ. Int., 1987, 13, 339-349.

11. Sheldon, L.S., Handy, R.W., Hartwell, T.D., Whitmore, R.W., Zelon, H.S., Pellizzari, E.D., "Indoor air quality in public buildings: Volume I," EPA/600/S6-88/009a (NTIS PB 89-102 503/AS), U.S Environmental Protection Agency, Research Triangle Park, NC, 1988.

12. Sheldon, L., Zelon, H., Sickles, J. Eaton, C., Hartwell, T., Wallace, L., "Indoor air quality in public buildings: Volume II," EPA/600/S6-88/009b (NTIS PB 89-102 511/AS), U.S Environmental Protection Agency, Research Triangle Park, NC, 1988.

13. Pellizzari, E.D., Thomas, K.W., Smith, D.J., Perritt, R.L., Morgan, M.A., "Total exposure assessment methodology (TEAM): 1987 study in New Jersey," U.S. Environmental Protection Agency, Research Triangle Park, NC, 1989.

14. Pellizzari, E.D., Michael, L.C., Perritt, R.L., Smith, D.J., Hartwell, T.D., Sebestik, J., "Comparison of indoor and outdoor toxic air pollutant levels in several southern California communities," U.S. Environmental Protection Agency. Research Triangle Park, NC, 1989.

15. Pellizzari, E.D., Hartwell, T.D., Zelon, H. Perritt, R., Sebestik, J., Williams, W., Smith, D.J., Keever, J., Decker, C.E., Jayanty. R.K.M., Thomas, K.W., Whitaker, D.A., Michael, L.C., "Baltimore total exposure assessment methodology (TEAM) study," U.S. Environmental Protection Agency, Research Triangle Park, NC, 1989.

16. Zweidinger, R., Tejada, S., Highsmith, R., Westburg, H., Gage, L., "Distribution of volatile organic hydrocarbons and aldehydes during the IACP Boise, Idaho, residential study," Proceedings of the 1988 EPA/APCA International Symposium, 814-820, Air Pollution Control Association, Pittsburgh, PA, 1988.

17. U.S. Department of Health, Education, and Welfare, Office on Smoking and Health. Smoking and health: A report of the Surgeon General. U.S. Government Printing Office, Washington, DC, 1979.

18. U.S. Department of Health and Human Services, Office on Smoking and Health. The health consequences of smoking -- cancer: A report of the Surgeon General. U.S. Government Printing Office, Washington, DC, 1982.

19. U.S. Department of Health and Human Services, Office on Smoking and Health. The health consequences of smoking -- Chronic obstructive lung disease: A report of the Surgeon General. U.S. Government Printing Office, Washington, DC, 1984.

20. U.S. Department of Health and Human Services, Office on Smoking and Health. The health consequences of smoking -- Cardiovascular disease: A report of the Surgeon General. U.S. Government Printing Office, Washington, DC,

1983.

21. U.S. Department of Health and Human Services, Office on Smoking and Health. The health consequences of involuntary smoking: A report of the Surgeon General. U.S. Government Printing Office, Washington, DC, 1986.

22. National Research Council Committee on Indoor Air Quality, "Policies and procedures for control of indoor air quality," National Academy Press, Washington, DC, 1987, 75 pages.

23. American Conference of Governmental Industrial Hygienists, "Guidelines for the assessment of bioaerosols in the indoor environment," American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1989.

24. Miller,J.D., Laflamme, A.M., Sobol, Y., Lafontaine, P., Greenhaugh, R., "Fungi and fungal products in some Canadian houses," Int. Biodeterior., 1988, 24 (2), 103-120.

25. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, "Inhalable particulate network operations and quality assurance manual," U.S. Environmental Protection Agency, Research Triangle Park, NC, 1983.

26. Oliver, K.D., Pleil, J.D., McClenny, W.A., "Sample integrity of trace level volatile organic compounds in ambient air stored in SUMMA polished canisters," Atmos. Environ., 1986, 20, 1403.

27. Winberry, W.T., Forehand, L., Murphy, N.T., Ceroli, A., Phinney, B, Evans, A., "Compendium of methods for the determination of air pollutants in indoor air," in press, U.S. Environmental Protection Agency. Research Triangle Park, NC, 1990.

28. Winberry, W.T., Murphy, N.T., "Compendium of methods for the determination of toxic organic compounds in ambient air, Method TO-12," EPA/600/4-89/017, U.S. Environmental Protection Agency, Research Triangle Park, NC, June 1988.

29. Tejada, S.B., "Evaluation of silica gel cartridges coated in-situ with acidified 2,4-dinitrophenylhydrazine for sampling aldehydes and ketones in air," Int. J. Environ. Anal. Chem. 1986, 26, 167-185.

30. Hsu, J.P., Wheeler, H.G., Camann, D.E., Schattenberg, H.J., Lewis, R.G., Bond, A.E., "Analytical methods for detection of nonoccupational exposure to pesticides," J. Chromatogr. Sci., 1988, 26, 181-189.

31. Hammond, S.K., Leaderer, B.P., "A diffusion monitor to measure exposure to passive smoking," Environ. Sci. Technol., 1987, 21, 494-497.

32. Jones, W., Morring, K., Morey, P., Sorenson, W. "Evaluation of the Andersen Viable Impactor for single stage sampling," J. Am. Ind. Hygiene, 1985, 46(5), 294-298.

33. Nevalainen, A., "Bacterial aerosols in indoor air", National Public Health Institute, Helsinki, Finland, 1989.

APPENDIX A

Summary Statistics for Real-Time Indoor Air Measurements

TABLE A.1. PRIMARY SITE SUMMARY STATISTICS FOR TEMPERATURE (^{o} F) BY EPA BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	46	5	5	3	
	Mean	73.1	74.4	76.4	74.6	
	Std. error	0.4	0.4	0.4	1.0	
Noon	N	47	5	5	3	
	Mean	74.0	75.3	77.0	75.4	
	Std. error	0.4	0.5	0.8	0.9	
PM	N	47	5	5	3	
	Mean	74.3	76.5	77.0	75.9	
	Std. error	0.4	0.8	1.0	0.8	
Average Daily Statistics	N	47	5	5		3
	Mean	73.8	75.4	76.8		75.3
	Std. error	0.4	0.5	0.7		0.9
	Median	74.3	75.0	76.0		75.4
Individual Values	First maximum	80.0	79.5	81.0		81.0
	Second maximum	78.0	77.0	80.0		80.0
	First minimum	62.0	74.0	75.0		62.0
	Second minimum	66.0	74.0	76.0		66.0

TABLE A.2. SECONDARY SITE SUMMARY STATISTICS FOR TEMPERATURE (^{o} F) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	
AM	N	45	11	12	3	
	Mean	73.0	74.3	76.1	74.5	
	Std. error	0.4	0.3	0.5	0.9	
Noon	N	45	11	12	3	
	Mean	73.6	74.3	76.7	74.9	
	Std. error	0.3	0.4	0.5	0.9	
PM	N	42	11	12	3	
	Mean	73.9	75.3	76.6	75.3	
	Std. error	0.3	0.4	0.5	0.8	
						Grand
Average Daily Statistics	N	45	11	12		3
	Mean	73.5	74.6	76.5		74.8
	Std. error	0.3	0.3	0.5		0.9
	Median	74.0	74.3	76.7		74.6
Individual Values	First maximum	79.0	78.0	80.0		80.0
	Second maximum	78.0	77.0	79.0		79.0
	First minimum	64.0	71.5	72.0		64.0
	Second minimum	66.0	73.0	73.0		66.0

TABLE A.3. SPECIAL SITE SUMMARY STATISTICS FOR TEMPERATURE (° F) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	29	1	-	2	
	Mean	73.2	73.0	-	73.1	
	Std. error	0.5	nc[a]	-	0.1	
Noon	N	39	-	2	2	
	Mean	74.0	-	77.0	75.5	
	Std. error	0.5	-	1.0	1.5	
PM	N	29	-	2	2	
	Mean	74.2	-	77.8	76.0	
	Std. error	0.5	-	0.7	1.8	
Average Daily Statistics	N	69	1	2		3
	Mean	73.8	73.0	77.4		74.7
	Std. error	0.4	nc	0.9		1.3
	Median	74.0	nc	77.4		73.8
Individual Values	First maximum	82.5	73.0	78.5		82.5
	Second maximum	80.0	-	78.0		80.0
	First minimum	65.0	73.0	76.0		65.0
	Second minimum	65.0	-	77.0		65.0

[a] nc = not computed

TABLE A.4. PRIMARY, SECONDARY, & SPECIAL SITE SUMMARY STATISTICS FOR TEMPERATURE (^{o} F) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	
AM	N	111	17	17	3	
	Mean	73.1	74.2	76.2	74.5	
	Std. error	0.3	0.2	0.4	0.9	
Noon	N	122	16	19	3	
	Mean	73.9	74.6	76.8	75.1	
	Std. error	0.2	0.3	0.4	0.9	
PM	N	111	16	19	3	
	Mean	74.2	75.7	76.8	75.6	
	Std. error	0.2	0.4	0.4	0.8	
						Grand
Average Daily Statistics	N	150	17	19		3
	Mean	73.8	74.7	76.7		75.1
	Std. error	0.2	0.3	0.4		0.9
	Median	74.0	74.7	76.5		74.7
Individual Values	First maximum	82.5	79.5	81.0		82.5
	Second maximum	80.0	78.0	80.0		81.0
	First minimum	62.0	71.5	72.0		62.0
	Second minimum	64.0	73.0	73.0		64.0

TABLE A.5. PRIMARY SITE SUMMARY STATISTICS FOR TEMPERATURE (^{o} F) BY EPA SECTORS

Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
		Sector									
AM	N	13	10	7	12	1	1	2	5	5	9
	Mean	71.4	73.2	76.0	73.7	73.0	68.0	72.0	74.4	76.4	73.1
	Std. error	1.1	0.6	0.7	0.6	-	-	2.0	0.4	0.4	0.8
Noon	N	13	10	8	12	1	1	2	5	5	9
	Mean	72.3	73.9	76.5	74.7	72.0	71.0	73.0	75.3	77.0	74.0
	Std. error	0.7	0.5	0.4	0.6	-	-	2.0	0.5	0.8	0.7
PM	N	13	10	8	12	1	1	2	5	5	9
	Mean	72.8	74.0	76.8	75.1	74.0	73.0	72.5	76.5	77.0	74.6
	Std. error	0.7	0.6	0.3	0.8	-	-	1.5	0.8	1.0	0.6
											Grand
Average Daily Statistics	N	13	10	8	12	1	1	2	5	5	9
	Mean	72.2	73.7	76.4	74.5	73.0	70.7	72.5	75.4	76.8	73.9
	Std. error	0.8	0.5	0.4	0.6	nc[a]	nc	1.8	0.5	0.7	0.7
	Median	73.0	74.2	76.5	75.0	nc	nc	72.5	75.0	76.0	73.7
Individual Values	First maximum	76.0	77.0	78.0	80.0	74.0	73.0	75.0	79.5	81.0	81.0
	Second maximum	75.5	76.0	78.0	78.0	73.0	71.0	74.0	77.0	80.0	80.0
	First minimum	62.0	70.0	73.0	70.0	72.0	68.0	70.0	74.0	75.0	62.0
	Second minimum	66.0	71.0	75.0	70.0	73.0	71.0	71.0	74.0	76.0	66.0

[a] nc = not computed

TABLE A.6. SECONDARY SITE SUMMARY STATISTICS FOR TEMPERATURE (° F) EPA SECTORS

Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
		Sector									
AM	N	9	7	7	8	3	4	7	11	12	9
	Mean	71.8	73.9	75.5	73.9	72.2	68.3	73.3	74.3	76.1	73.2
	Std. error	0.9	0.9	0.8	0.5	0.7	2.4	0.9	0.3	0.5	0.8
Noon	N	9	7	7	8	3	4	7	11	12	9
	Mean	72.9	74.0	75.4	74.1	73.5	71.5	73.0	74.3	76.7	73.9
	Std. error	0.7	0.9	0.3	0.4	0.8	2.1	0.6	0.4	0.5	0.5
PM	N	9	7	5	8	3	3	7	11	12	9
	Mean	73.0	74.2	76.6	74.5	73.6	74.0	72.3	75.3	76.6	74.5
	Std. error	0.8	0.8	0.2	0.3	0.7	0.0	0.4	0.4	0.5	0.5

											Grand
Average Daily Statistics	N	9	7	7	8	3	4	7	11	12	9
	Mean	72.6	74.0	75.7	74.2	73.1	70.5	72.9	74.6	76.5	73.8
	Std. error	0.8	0.8	0.3	0.3	0.7	2.0	0.6	0.3	0.5	0.6
	Median	73.2	74.2	75.7	74.0	73.0	70.7	72.7	74.3	76.7	74.0
Individual Values	First maximum	76.0	78.0	79.0	77.0	76.0	77.0	76.0	78.0	80.0	80.0
	Second maximum	76.0	78.0	77.0	76.0	75.0	75.0	76.0	77.0	79.0	79.0
	First minimum	68.0	71.0	73.0	72.5	70.0	64.0	69.0	71.5	72.0	64.0
	Second minimum	69.0	71.0	74.0	72.5	71.0	66.0	70.0	73.0	73.0	66.0

TABLE A.7. SPECIAL SITE SUMMARY STATISTICS FOR TEMPERATURE (^{o} F) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	8	1	6	6	5	3	-	1	-	7
	Mean	71.4	75.0	73.3	75.3	73.2	72.7	-	73.0	-	73.4
	Std. error	1.4	-	0.8	1.0	0.8	0.3	-	-	-	0.5
Noon	N	22	1	5	4	2	5	-	-	2	7
	Mean	73.0	75.0	74.6	76.5	72.5	76.0	-	-	77.0	74.9
	Std. error	0.6	-	0.5	1.0	1.5	1.9	-	-	1.0	0.6
PM	N	15	3	6	5	-	-	-	-	2	5
	Mean	72.9	75.7	74.7	76.4	-	-	-	-	77.8	75.5
	Std. error	0.7	0.7	0.5	1.6	-	-	-	-	0.7	0.8
											Grand
Average Daily Statistics	N	30	3	7	15	6	8	-	1	2	8
	Mean	72.5	75.7	73.8	76.0	73.3	74.8	-	73.0	77.4	74.5
	Std. error	0.5	0.7	0.7	0.7	0.7	1.3	-	nc[a]	0.9	0.6
	Median	73.0	75.0	74.0	76.0	73.5	73.0	-	nc	77.4	74.3
Individual Values	First maximum	77.0	77.0	76.0	80.0	75.0	82.5	-	73.0	78.5	82.5
	Second maximum	77.0	75.0	76.0	79.0	75.0	78.0	-	-	78.0	80.0
	First minimum	65.0	75.0	70.0	71.0	71.0	72.0	-	73.0	76.0	65.0
	Second minimum	65.0	75.0	72.0	72.0	71.0	72.0	-	-	77.0	65.0

[a] nc = not computed

TABLE A.8. PRIMARY, SECONDARY, & SPECIAL SUMMARY STATISTICS FOR TEMPERATURE (° F) BY EPA HEADQUARTERS SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	27	16	20	26	8	7	9	17	17	9
	Mean	71.5	73.5	75.0	74.1	72.9	69.6	73.0	74.2	76.2	73.3
	Std. error	0.7	0.5	0.5	0.4	0.5	1.4	0.8	0.2	0.4	0.6
Noon	N	40	16	20	24	5	8	9	16	19	9
	Mean	72.8	73.9	75.6	74.8	73.1	73.5	73.0	74.6	76.8	74.2
	Std. error	0.4	0.5	0.3	0.4	0.7	1.6	0.6	0.3	0.4	0.5
PM	N	34	18	19	25	3	3	9	16	19	9
	Mean	72.9	74.3	76.1	75.2	73.8	73.8	72.3	75.7	76.8	74.5
	Std. error	0.4	0.5	0.3	0.5	0.5	0.2	0.4	0.4	0.4	0.5
											Grand
Average Daily Statistics	N	48	18	22	35	9	11	9	17	19	9
	Mean	72.4	74.1	75.4	75.1	73.2	72.8	72.8	74.7	76.7	74.1
	Std. error	0.4	0.5	0.4	0.4	0.5	1.2	0.6	0.3	0.4	0.5
	Median	73.0	74.3	75.3	75.0	73.0	73.0	72.7	74.7	76.5	74.1
Individual Values	First maximum	77.0	78.0	79.0	80.0	76.0	82.5	76.0	79.5	81.0	82.5
	Second maximum	77.0	78.0	78.0	80.0	75.0	78.0	76.0	78.0	80.0	81.0
	First minimum	62.0	70.0	70.0	70.0	70.0	64.0	69.0	71.5	72.0	62.0
	Second minimum	65.0	71.0	72.0	70.0	71.0	66.0	70.0	73.0	73.0	64.0

TABLE A.9. PRIMARY SITE SUMMARY STATISTICS FOR RELATIVE HUMIDITY (%) BY EPA BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	46	5	5	3	
	Mean	23.6	22.9	25.4	24.0	
	Std. error	0.8	1.6	0.2	0.7	
Noon	N	46	5	5	3	
	Mean	23.5	22.0	25.4	23.7	
	Std. error	0.8	1.6	0.5	1.0	
PM	N	47	5	5	3	
	Mean	24.2	21.5	27.2	24.3	
	Std. error	0.7	1.5	0.5	1.6	
Average Daily Statistics	N	47	5	5		3
	Mean	23.7	22.2	26.0		24.0
	Std. error	0.7	1.5	0.3		1.1
	Median	22.7	19.9	26.3		23.7
Individual Values	First maximum	41.6	26.8	28.7		41.6
	Second maximum	40.7	26.8	27.8		40.7
	First minimum	15.8	17.7	23.6		15.8
	Second minimum	16.5	18.7	24.6		16.5

TABLE A.10. SECONDARY SITE SUMMARY STATISTICS FOR RELATIVE HUMIDITY (%) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	
AM	N	45	11	12	3	
	Mean	22.5	23.3	22.8	22.9	
	Std. error	0.7	0.9	0.8	0.2	
Noon	N	43	11	12	3	
	Mean	24.4	23.6	23.8	23.9	
	Std. error	1.1	0.8	0.4	0.2	
PM	N	42	11	12	3	
	Mean	24.7	23.1	25.5	24.4	
	Std. error	0.8	0.7	0.5	0.7	
						Grand
Average Daily Statistics	N	45	11	12		3
	Mean	23.8	23.3	24.0		23.7
	Std. error	0.8	0.7	0.5		0.2
	Median	21.7	24.0	23.3		23.8
Individual Values	First maximum	49.9	27.8	28.7		49.9
	Second maximum	39.2	26.8	28.4		39.2
	First minimum	14.6	19.6	16.9		14.6
	Second minimum	15.8	19.7	20.3		15.8

TABLE A.11. SPECIAL SITE SUMMARY STATISTICS FOR RELATIVE HUMIDITY (%) BY EPA HEADQUARTERS BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	29	1	-	2	
	Mean	20.9	29.1	-	25.0	
	Std. error	0.5	nc[a]	-	4.1	
Noon	N	38	-	2	2	
	Mean	20.7	-	22.2	21.4	
	Std. error	0.4	-	0.5	0.8	
PM	N	29	-	2	2	
	Mean	23.7	-	22.9	23.3	
	Std. error	1.7	-	0.7	0.4	
Average Daily Statistics	N	69	1	2		3
	Mean	21.3	29.1	22.6		24.3
	Std. error	0.6	nc	0.6		2.4
	Median	20.8	nc	22.6		22.6
Individual Values	First maximum	54.2	29.1	23.6		54.2
	Second maximum	48.3	-	22.7		48.3
	First minimum	6.2	29.1	21.7		6.2
	Second minimum	15.4	-	22.2		15.4

[a] nc = not computed

TABLE A.12. PRIMARY, SECONDARY, & SPECIAL SITE SUMMARY STATISTICS FOR RELATIVE HUMIDITY (%) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	
AM	N	111	17	17	3	
	Mean	22.6	23.5	23.6	23.2	
	Std. error	0.4	0.8	0.6	0.3	
Noon	N	119	16	19	3	
	Mean	23.1	23.1	24.0	23.4	
	Std. error	0.5	0.7	0.3	0.3	
PM	N	111	16	19	3	
	Mean	24.2	22.6	25.7	24.2	
	Std. error	0.6	0.7	0.4	0.9	
						Grand
Average Daily Statistics	N	150	17	19		3
	Mean	22.8	23.3	24.4		23.5
	Std. error	0.4	0.7	0.4		0.5
	Median	21.6	24.0	23.9		23.3
Individual Values	First maximum	54.2	29.1	28.7		54.2
	Second maximum	49.9	27.8	28.7		49.9
	First minimum	6.2	17.7	16.9		6.2
	Second minimum	14.6	18.7	20.3		14.6

TABLE A.13. PRIMARY SITE SUMMARY STATISTICS FOR RELATIVE HUMIDITY (%) BY EPA SECTORS

Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
		Sector									
AM	N	13	10	7	12	1	1	2	5	5	9
	Mean	20.1	32.0	20.2	22.3	22.7	20.5	26.6	22.9	25.4	23.6
	Std. error	0.7	0.6	0.6	1.1	-	-	2.9	1.6	0.2	1.3
Noon	N	12	10	8	12	1	1	2	5	5	9
	Mean	20.9	30.0	20.1	21.5	21.6	17.3	37.4	22.0	25.4	24.0
	Std. error	0.4	0.6	0.8	0.7	-	-	3.4	1.6	0.5	2.0
PM	N	13	10	8	12	1	1	2	5	5	9
	Mean	23.7	28.8	20.7	22.9	23.7	19.6	28.6	21.5	27.2	24.1
	Std. error	1.8	0.8	0.4	1.1	-	-	1.4	1.5	0.5	1.1
											Grand
Average Daily Statistics	N	13	10	8	12	1	1	2	5	5	9
	Mean	21.5	30.2	20.4	22.2	22.7	19.1	30.9	22.2	26.0	23.9
	Std. error	0.7	0.5	0.5	0.7	nc[a]	nc	0.6	1.5	0.3	1.4
	Median	20.7	30.0	20.9	22.8	nc	nc	30.9	19.9	26.3	22.2
Individual Values	First maximum	41.6	34.0	22.7	29.6	23.7	20.5	40.7	26.8	28.7	41.6
	Second maximum	29.1	34.0	22.7	29.1	22.7	19.6	34.0	26.8	27.8	40.7
	First minimum	16.5	24.7	15.8	16.9	21.6	17.3	23.7	17.7	23.6	15.8
	Second minimum	17.2	25.7	17.9	16.9	22.7	19.6	27.1	18.7	24.6	16.5

[a] nc = not computed

TABLE A.14. SECONDARY SITE SUMMARY STATISTICS FOR RELATIVE HUMIDITY (%) BY EPA SECTORS

Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
		Sector									
AM	N	9	7	7	8	3	4	7	11	12	9
	Mean	19.9	27.7	20.2	22.3	20.2	19.2	25.9	23.3	22.8	22.4
	Std. error	0.7	3.1	1.3	0.8	0.8	1.3	1.6	0.9	0.8	1.0
Noon	N	7	7	7	8	3	4	7	11	12	9
	Mean	20.3	28.2	22.8	21.3	20.6	19.6	34.0	23.6	23.8	23.8
	Std. error	0.9	3.1	1.7	0.9	0.6	1.1	2.9	0.8	0.4	1.5
PM	N	9	7	5	8	3	3	7	11	12	9
	Mean	23.2	28.4	21.0	22.1	18.5	22.7	31.8	23.1	25.5	24.0
	Std. error	1.4	2.1	1.0	0.8	0.6	1.0	1.2	0.7	0.5	1.3

											Grand
Average Daily Statistics	N	9	7	7	8	3	4	7	11	12	9
	Mean	21.2	28.1	21.6	21.9	19.8	20.4	30.6	23.3	24.0	23.4
	Std. error	0.6	2.7	0.9	0.8	0.1	0.3	1.5	0.7	0.5	1.2
	Median	21.4	28.3	21.0	22.4	19.7	20.3	28.6	24.0	23.3	21.9
Individual Values	First maximum	39.2	38.4	30.9	26.8	22.7	23.7	49.9	27.8	28.7	49.9
	Second maximum	35.8	37.5	24.7	25.4	22.7	23.7	36.7	26.8	28.4	39.2
	First minimum	15.8	15.8	14.6	17.6	17.6	17.0	20.6	19.6	16.9	14.6
	Second minimum	16.5	15.8	17.9	17.6	17.6	17.9	22.7	19.7	20.3	15.8

TABLE A.15. SPECIAL SITE SUMMARY STATISTICS FOR RELATIVE HUMIDITY (%) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	8	1	6	6	5	3	-	1	-	7
	Mean	19.9	18.7	21.2	21.5	23.0	19.2	-	29.1	-	21.8
	Std. error	1.0	-	1.0	1.4	1.1	0.4	-	-	-	1.3
Noon	N	21	1	5	4	2	5	-	-	2	7
	Mean	20.5	18.7	24.3	18.8	20.6	19.9	-	-	22.2	20.7
	Std. error	0.5	-	0.9	0.4	0.0	1.0	-	-	0.5	0.7
PM	N	15	3	6	5	-	-	-	-	2	5
	Mean	24.5	28.5	23.9	18.5	-	-	-	-	22.9	23.7
	Std. error	3.0	2.9	1.0	0.8	-	-	-	-	0.7	1.6
											Grand
Average Daily Statistics	N	30	3	7	15	6	8	-	1	2	8
	Mean	21.6	25.0	22.8	19.8	22.2	19.7	-	29.1	22.6	22.8
	Std. error	1.4	0.8	0.8	0.7	0.9	0.6	-	nc	0.6	1.1
	Median	20.8	24.7	23.5	18.9	22.7	19.6	-	nc	22.6	22.4
Individual Values	First maximum	54.2	34.1	27.8	25.9	24.9	22.7	-	29.1	23.6	54.2
	Second maximum	48.3	26.6	26.8	24.6	24.7	21.6	-	-	22.7	48.3
	First minimum	6.2	18.7	18.7	16.9	18.7	16.8	-	29.1	21.7	6.2
	Second minimum	15.4	18.7	19.4	17.2	20.5	18.5	-	-	22.2	15.4

TABLE A.16. PRIMARY, SECONDARY, & SPECIAL SITE SUMMARY STATISTICS FOR RELATIVE HUMIDITY (%) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	27	16	20	26	8	7	9	17	17	9
	Mean	19.9	30.3	20.5	22.1	22.1	19.3	26.0	23.5	23.6	23.0
	Std. error	0.4	1.2	0.6	0.7	0.8	0.7	1.3	0.8	0.6	1.1
Noon	N	37	16	20	24	5	8	9	16	19	9
	Mean	20.6	29.1	22.1	21.0	20.7	19.9	34.8	23.1	24.0	23.9
	Std. error	0.3	1.2	0.8	0.5	0.3	0.8	2.3	0.7	0.3	1.6
PM	N	34	18	19	25	3	3	9	16	19	9
	Mean	23.8	28.8	21.8	21.7	18.9	22.0	31.1	22.6	25.7	24.1
	Std. error	1.5	0.8	0.5	0.7	1.0	0.9	1.1	0.7	0.4	1.3
											Grand
Average Daily Statistics	N	48	18	22	35	9	11	9	17	19	9
	Mean	21.5	29.1	21.6	21.1	21.5	20.0	30.6	23.3	24.4	23.7
	Std. error	0.9	0.8	0.4	0.5	0.7	0.5	1.2	0.7	0.4	1.3
	Median	20.8	28.7	21.0	21.3	20.7	19.7	30.2	24.0	23.9	21.6
Individual Values	First maximum	54.2	38.4	30.9	29.6	24.9	23.7	49.9	29.1	28.7	54.2
	Second maximum	48.3	37.5	27.8	29.1	24.7	23.7	40.7	27.8	28.7	49.9
	First minimum	6.2	15.8	14.6	16.9	17.6	16.8	20.6	17.7	16.9	6.2
	Second minimum	15.4	15.8	15.8	16.9	17.6	17.0	22.7	18.7	20.3	14.6

TABLE A.17. PRIMARY SITE SUMMARY STATISTICS FOR CARBON MONOXIDE (PPM) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	
AM	N	46	5	5	3	
	Mean	0.1	0.0	0.0	0.0	
	Std. error	0.0	0.0	0.0	0.0	
Noon	N	47	5	5	3	
	Mean	0.0	0.0	0.0	0.0	
	Std. error	0.0	0.0	0.0	0.0	
PM	N	47	5	5	3	
	Mean	0.0	0.0	0.0	0.0	
	Std. error	0.0	0.0	0.0	0.0	
						Grand
Average Daily Statistics	N	47	5	5		3
	Mean	0.0	0.0	0.0		0.0
	Std. error	0.0	0.0	0.0		0.0
	Median	0.0	0.0	0.0		0.0
Individual Values	First maximum	1.0	0.0	0.0		1.0
	Second maximum	1.0	0.0	0.0		1.0
	First minimum	0.0	0.0	0.0		0.0
	Second minimum	0.0	0.0	0.0		0.0

TABLE A.18. SECONDARY SITE SUMMARY STATISTICS FOR CARBON MONOXIDE (PPM) BY EPA BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	45	11	12	3	
	Mean	0.1	0.0	0.8	0.3	
	Std. error	0.0	0.0	0.2	0.3	
Noon	N	45	11	12	3	
	Mean	0.0	0.0	1.6	0.5	
	Std. error	0.0	0.0	0.3	0.5	
PM	N	41	11	12	3	
	Mean	0.0	0.0	2.2	0.7	
	Std. error	0.0	0.0	0.4	0.7	
Average Daily Statistics	N	45	11	12		3
	Mean	0.0	0.0	1.5		0.5
	Std. error	0.0	0.0	0.3		0.5
	Median	0.0	0.0	2.0		0.0
Individual Values	First maximum	1.0	0.0	4.0		4.0
	Second maximum	1.0	0.0	3.0		3.0
	First minimum	0.0	0.0	0.0		0.0
	Second minimum	0.0	0.0	0.0		0.0

TABLE A.19. SPECIAL SITE SUMMARY STATISTICS FOR CARBON MONOXIDE (PPM) BY EPA BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	29	1	-	2	
	Mean	0.4	0.0	-	0.2	
	Std. error	0.2	nc[a]	-	0.2	
Noon	N	39	-	2	2	
	Mean	0.1	-	3.0	1.6	
	Std. error	0.0	-	1.0	1.4	
PM	N	29	-	2	2	
	Mean	0.2	-	3.0	1.6	
	Std. error	0.1	-	1.0	1.4	
Average Daily Statistics	N	69	1	2		3
	Mean	0.1	0.0	3.0		1.0
	Std. error	0.1	nc	1.0		1.0
	Median	0.0	nc	3.0		0.1
Individual Values	First maximum	3.0	0.0	4.0		4.0
	Second maximum	3.0	-	4.0		4.0
	First minimum	0.0	0.0	2.0		0.0
	Second minimum	0.0	-	2.0		0.0

[a] nc = not computed

TABLE A.20. PRIMARY, SECONDARY, & SPECIAL SITE SUMMARY STATISTICS FOR CARBON MONOXIDE (PPM) BY EPA BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	111	17	17	3	
	Mean	0.2	0.0	0.6	0.3	
	Std. error	0.1	0.0	0.1	0.2	
Noon	N	122	16	19	3	
	Mean	0.0	0.0	1.3	0.4	
	Std. error	0.0	0.0	0.3	0.4	
PM	N	110	16	19	3	
	Mean	0.0	0.0	1.7	0.6	
	Std. error	0.0	0.0	0.4	0.6	
Average Daily Statistics	N	150	17	19		3
	Mean	0.1	0.0	1.3		0.5
	Std. error	0.0	0.0	0.3		0.4
	Median	0.0	0.0	1.7		0.1
Individual Values	First maximum	3.0	0.0	4.0		4.0
	Second maximum	3.0	0.0	4.0		4.0
	First minimum	0.0	0.0	0.0		0.0
	Second minimum	0.0	0.0	0.0		0.0

TABLE A.21. PRIMARY SITE SUMMARY STATISTICS FOR CARBON MONOXIDE (PPM) BY EPA SECTORS

Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
		Sector									
AM	N	13	10	7	12	1	1	2	5	5	9
	Mean	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	Std. error	0.0	0.2	0.0	0.0	-	-	0.0	0.0	0.0	0.1
Noon	N	13	10	8	12	1	1	2	5	5	9
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Std. error	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0
PM	N	13	10	8	12	1	1	2	5	5	9
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Std. error	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.0
											Grand
Average Daily Statistics	N	13	10	8	12	1	1	2	5	5	9
	Mean	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Std. error	0.0	0.1	0.0	0.0	nc[a]	nc	0.0	0.0	0.0	0.0
	Median	0.0	0.2	0.0	0.0	nc	nc	0.0	0.0	0.0	0.0
Individual Values	First maximum	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
	Second maximum	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
	First minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Second minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a] nc = not computed

TABLE A.22. SECONDARY SITE SUMMARY STATISTICS FOR CARBON MONOXIDE (PPM) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	9	7	7	8	3	4	7	11	12	9
	Mean	0.0	0.6	0.0	0.1	0.0	0.0	0.0	0.0	0.8	0.2
	Std. error	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.1
Noon	N	9	7	7	8	3	4	7	11	12	9
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.2
	Std. error	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2
PM	N	9	7	5	7	3	3	7	11	12	9
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.2
	Std. error	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2

											Grand
Average	N	9	7	7	8	3	4	7	11	12	9
Daily	Mean	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.2
Statistics	Std. error	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2
	Median	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Individual	First maximum	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	4.0	4.0
Values	Second maximum	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0
	First minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Second minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE A.23. SPECIAL SITE SUMMARY STATISTICS FOR CARBON MONOXIDE (PPM) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	8	1	6	6	5	3	-	1	-	7
	Mean	0.0	0.0	2.0	0.2	0.0	0.0	-	0.0	-	0.3
	Std. error	0.0	-	0.4	0.2	0.0	0.0	-	-	-	0.3
Noon	N	22	1	5	4	2	5	-	-	2	7
	Mean	0.0	0.0	0.8	0.0	0.0	0.0	-	-	3.0	0.5
	Std. error	0.0	-	0.2	0.0	0.0	0.0	-	-	1.0	0.4
PM	N	15	3	6	5	-	-	-	-	2	5
	Mean	0.0	0.0	0.8	0.0	-	-	-	-	3.0	0.8
	Std. error	0.0	0.0	0.2	0.0	-	-	-	-	1.0	0.6
											Grand
Average Daily Statistics	N	30	3	7	15	6	8	-	1	2	8
	Mean	0.0	0.0	1.3	0.1	0.0	0.0	-	0.0	3.0	0.5
	Std. error	0.0	0.0	0.2	0.1	0.0	0.0	-	nc	1.0	0.4
	Median	0.0	0.0	1.3	0.0	0.0	0.0	-	nc	3.0	0.0
Individual Values	First maximum	0.0	0.0	3.0	1.0	0.0	0.0	-	0.0	4.0	4.0
	Second maximum	0.0	0.0	3.0	0.0	0.0	0.0	-	-	4.0	4.0
	First minimum	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	2.0	0.0
	Second minimum	0.0	0.0	0.0	0.0	0.0	0.0	-	-	2.0	0.0

TABLE A.24. PRIMARY, SECONDARY, & SPECIAL SITE SUMMARY STATISTICS FOR CARBON MONOXIDE (PPM) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	27	16	20	26	8	7	9	17	17	9
	Mean	0.0	0.5	0.6	0.1	0.0	0.0	0.0	0.0	0.6	0.2
	Std. error	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.1
Noon	N	40	16	20	24	5	8	9	16	19	9
	Mean	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	1.3	0.2
	Std. error	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.1
PM	N	34	18	19	24	3	3	9	16	19	9
	Mean	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	1.7	0.2
	Std. error	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.4	0.2
											Grand
Average Daily Statistics	N	48	18	22	35	9	11	9	17	19	9
	Mean	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.0	1.3	0.2
	Std. error	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.1
	Median	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0
Individual Values	First maximum	0.0	1.0	3.0	1.0	0.0	0.0	0.0	0.0	4.0	4.0
	Second maximum	0.0	1.0	3.0	1.0	0.0	0.0	0.0	0.0	4.0	4.0
	First minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Second minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE A.25. PRIMARY SITE SUMMARY STATISTICS FOR CARBON DIOXIDE (PPM) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	
AM	N	46	5	5	3	
	Mean	535	455	730	573	
	Std. error	13	12	31	82	
Noon	N	47	5	5	3	
	Mean	575	475	705	585	
	Std. error	15	29	24	67	
PM	N	47	5	5	3	
	Mean	577	535	800	637	
	Std. error	12	17	22	82	
						Grand
Average Daily Statistics	N	47	5	5		3
	Mean	563	488	745		599
	Std. error	12	19	24		76
	Median	567	492	750		563
Individual Values	First maximum	775	575	850		850
	Second maximum	775	575	825		825
	First minimum	325	400	650		325
	Second minimum	350	425	650		350

TABLE A.26. SECONDARY SITE SUMMARY STATISTICS FOR CARBON DIOXIDE (PPM) BY EPA BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	45	11	12	3	
	Mean	531	493	744	589	
	Std. error	13	15	30	78	
Noon	N	45	11	12	3	
	Mean	567	491	710	590	
	Std. error	12	12	20	64	
PM	N	42	11	12	3	
	Mean	574	552	794	640	
	Std. error	15	16	28	77	
Average Daily Statistics	N	45	11	12		3
	Mean	557	512	749		606
	Std. error	12	14	25		73
	Median	558	525	771		557
Individual Values	First maximum	925	675	925		925
	Second maximum	775	575	900		925
	First minimum	350	425	525		350
	Second minimum	350	425	575		350

TABLE A.27. SPECIAL SITE SUMMARY STATISTICS FOR CARBON DIOXIDE (PPM) BY EPA BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	29	1	-	2	
	Mean	573	500	-	536	
	Std. error	39	nc[a]	-	36	
Noon	N	39	-	2	2	
	Mean	624	-	675	650	
	Std. error	30	-	0	25	
PM	N	29	-	2	2	
	Mean	656	-	775	716	
	Std. error	37	-	0	59	
Average Daily Statistics	N	69	1	2		3
	Mean	582	500	725		602
	Std. error	20	nc	0		66
	Median	550	nc	725		582
Individual Values	First maximum	1350	500	775		1350
	Second maximum	1150	-	775		1150
	First minimum	325	500	675		325
	Second minimum	350	-	675		350

[a] nc = not computed

TABLE A.28. PRIMARY, SECONDARY, & SPECIAL SITE SUMMARY STATISTICS FOR CARBON DIOXIDE (PPM) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	
AM	N	111	17	17	3	
	Mean	549	482	740	590	
	Std. error	12	11	23	77	
Noon	N	122	16	19	3	
	Mean	592	486	705	594	
	Std. error	12	12	14	63	
PM	N	111	16	19	3	
	Mean	597	547	793	646	
	Std. error	12	12	19	75	
						Grand
Average Daily Statistics	N	150	17	19		3
	Mean	575	504	746		608
	Std. error	10	10	17		72
	Median	558	525	750		575
Individual Values	First maximum	1350	675	925		1350
	Second maximum	1150	575	900		1150
	First minimum	325	400	525		325
	Second minimum	325	425	575		325

TABLE A.29. PRIMARY SITE SUMMARY STATISTICS FOR CARBON DIOXIDE (PPM) BY EPA SECTORS

Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
		Sector									
AM	N	13	10	7	12	1	1	2	5	5	9
	Mean	487	535	596	563	425	325	638	455	730	528
	Std. error	28	23	23	14	-	-	37	12	31	40
Noon	N	13	10	8	12	1	1	2	5	5	9
	Mean	540	500	613	660	425	500	625	475	705	560
	Std. error	31	14	21	27	-	-	0	29	24	31
PM	N	13	10	8	12	1	1	2	5	5	9
	Mean	557	543	606	610	500	500	638	535	800	588
	Std. error	31	16	19	19	-	-	37	17	22	31
											Grand
Average Daily Statistics	N	13	10	8	12	1	1	2	5	5	9
	Mean	528	526	606	611	450	442	633	488	745	559
	Std. error	27	15	16	16	nc[a]	nc	25	19	24	33
	Median	500	525	600	617	nc	nc	633	492	750	528
Individual Values	First maximum	720	675	725	775	500	500	675	575	850	850
	Second maximum	675	650	725	775	425	500	675	575	825	825
	First minimum	350	425	550	500	425	325	600	400	650	325
	Second minimum	350	450	550	500	425	500	600	425	650	350

TABLE A.30. SECONDARY SITE SUMMARY STATISTICS FOR CARBON DIOXIDE (PPM) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	9	7	7	8	3	4	7	11	12	9
	Mean	513	611	579	519	429	406	554	493	744	539
	Std. error	23	34	18	15	33	56	11	15	30	34
Noon	N	9	7	7	8	3	4	7	11	12	9
	Mean	553	611	600	584	458	481	586	491	710	564
	Std. error	31	31	15	20	55	12	20	12	20	26
PM	N	9	7	5	8	3	3	7	11	12	9
	Mean	593	661	575	559	463	483	568	552	794	583
	Std. error	50	36	21	18	26	17	17	16	28	33

											Grand
Average Daily Statistics	N	9	7	7	8	3	4	7	11	12	9
	Mean	553	627	588	554	450	452	569	512	749	562
	Std. error	32	30	16	10	33	23	15	14	25	31
	Median	533	633	588	550	479	438	575	525	771	554
Individual Values	First maximum	925	775	650	650	575	575	675	675	925	925
	Second maximum	775	750	650	650	525	500	625	575	900	925
	First minimum	425	500	525	425	350	350	525	425	525	350
	Second minimum	425	500	525	475	375	350	525	425	575	350

TABLE A.31. SPECIAL SITE SUMMARY STATISTICS FOR CARBON DIOXIDE (PPM) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	8	1	6	6	5	3	-	1	-	7
	Mean	458	775	871	596	450	375	-	500	-	575
	Std. error	36	-	91	22	16	29	-	-	-	70
Noon	N	22	1	5	4	2	5	-	-	2	7
	Mean	552	875	955	756	500	505	-	-	675	688
	Std. error	20	-	119	26	25	15	-	-	0	69
PM	N	15	3	6	5	-	-	-	-	2	5
	Mean	573	658	921	585	-	-	-	-	775	702
	Std. error	34	109	92	22	-	-	-	-	0	65
											Grand
Average Daily Statistics	N	30	3	7	15	6	8	-	1	2	8
	Mean	532	647	904	635	458	456	-	500	725	607
	Std. error	19	98	77	23	15	27	-	nc	0	54
	Median	525	575	925	625	450	475	-	nc	725	584
Individual Values	First maximum	1050	875	1350	800	525	525	-	500	775	1350
	Second maximum	875	875	1150	800	500	525	-	-	775	1150
	First minimum	350	525	550	525	425	325	-	500	675	325
	Second minimum	350	575	550	550	425	375	-	-	675	350

TABLE A.32. PRIMARY, SECONDARY, & SPECIAL SITE SUMMARY STATISTICS FOR CARBON DIOXIDE (PPM) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	27	16	20	26	8	7	9	17	17	9
	Mean	487	579	673	557	442	375	572	482	740	545
	Std. error	18	25	40	11	15	17	16	11	23	38
Noon	N	40	16	20	24	5	8	9	16	19	9
	Mean	550	566	694	651	468	498	594	486	705	579
	Std. error	15	28	45	20	31	10	17	12	14	30
PM	N	34	18	19	25	3	3	9	16	19	9
	Mean	568	602	697	589	461	483	583	547	793	592
	Std. error	20	24	46	12	25	17	18	12	19	34

											Grand
Average Daily Statistics	N	48	18	22	35	9	11	9	17	19	9
	Mean	535	581	695	608	454	451	583	504	746	573
	Std. error	14	22	40	12	14	20	15	10	17	34
	Median	529	575	631	583	475	442	583	525	750	581
Individual Values	First maximum	1050	875	1350	800	575	575	675	675	925	1350
	Second maximum	925	875	1150	800	525	525	675	575	900	1150
	First minimum	350	425	525	425	350	325	525	400	525	325
	Second minimum	350	450	525	475	375	325	525	425	575	325

TABLE A.33. PRIMARY SITE SUMMARY STATISTICS FOR REAL-TIME PARTICULATE CONCENTRATION (MG/M^3) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	
AM	N	43	5	5	3	
	Mean	10.6	9.2	10.4	10.1	
	Std. error	1.0	0.7	0.8	0.4	
Noon	N	44	5	5	3	
	Mean	10.3	10.4	12.8	11.2	
	Std. error	1.1	2.0	0.7	0.8	
PM	N	44	5	2	3	
	Mean	12.1	9.0	16.5	12.5	
	Std. error	1.2	3.3	1.5	2.2	
						Grand
Average Daily Statistics	N	44	5	5		3
	Mean	10.9	9.5	12.3		10.9
	Std. error	1.0	1.9	0.7		0.8
	Median	10.5	7.3	12.0		10.9
Individual Values	First maximum	48.0	20.0	18.0		48.0
	Second maximum	39.0	17.0	15.0		39.0
	First minimum	0.0	2.0	8.0		0.0
	Second minimum	0.0	4.0	10.0		0.0

TABLE A.34. SECONDARY SITE SUMMARY STATISTICS FOR REAL-TIME PARTICULATE CONCENTRATION (MG/M^3) BY EPA BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	41	11	12	3	
	Mean	12.7	14.4	9.3	12.1	
	Std. error	1.2	2.5	1.9	1.5	
Noon	N	41	11	12	3	
	Mean	11.3	13.1	7.2	10.5	
	Std. error	0.9	1.9	1.4	1.7	
PM	N	38	11	0	2	
	Mean	12.3	11.6	-	12.0	
	Std. error	0.9	1.7	-	0.3	
Average Daily Statistics	N	41	11	12		3
	Mean	12.1	13.0	8.3		11.1
	Std. error	0.9	1.9	1.1		1.4
	Median	12.7	11.3	7.2		12.1
Individual Values	First maximum	30.0	32.0	21.0		32.0
	Second maximum	27.0	30.0	20.0		30.0
	First minimum	0.0	3.0	1.0		0.0
	Second minimum	0.0	6.0	1.0		0.0

TABLE A.35. SPECIAL SITE SUMMARY STATISTICS FOR REAL-TIME PARTICULATE CONCENTRATION (MG/M^3) BY EPA BUILDINGS

Time	Statistic	Building: Water-side Mall	Crystal City	Fair-child	Buildings Means	Grand
AM	N	28	1	-	2	
	Mean	10.0	16.0	-	13.0	
	Std. error	1.0	nc[a]	-	3.0	
Noon	N	39	-	2	2	
	Mean	22.7	-	10.0	16.4	
	Std. error	3.1	-	7.0	6.4	
PM	N	30	-	0	1	
	Mean	19.8	-	-	19.8	
	Std. error	3.3	-	-	nc	
Average Daily Statistics	N	68	1	2		3
	Mean	17.3	16.0	10.0		14.4
	Std. error	1.7	nc	7.0		2.2
	Median	13.0	nc	10.0		16.0
Individual Values	First maximum	96.0	16.0	17.0		96.0
	Second maximum	91.0	-	3.0		91.0
	First minimum	0.0	16.0	3.0		0.0
	Second minimum	0.0	-	17.0		0.0

[a] nc = not computed

TABLE A.36. PRIMARY, SECONDARY, & SPECIAL SITE SUMMARY STATISTICS FOR REAL-TIME PARTICULATE CONCENTRATION (MG/M^3) BY EPA BUILDINGS

		Building				
Time	Statistic	Water-side Mall	Crystal City	Fair-child	Buildings Means	
AM	N	103	17	17	3	
	Mean	11.2	12.9	9.6	11.3	
	Std. error	0.6	1.7	1.3	1.0	
Noon	N	115	16	19	3	
	Mean	14.7	12.2	9.0	12.0	
	Std. error	1.3	1.5	1.2	1.6	
PM	N	105	16	2	3	
	Mean	14.3	10.8	16.5	13.9	
	Std. error	1.2	1.5	1.5	1.7	
						Grand
Average Daily Statistics	N	142	17	19		3
	Mean	14.1	12.2	9.5		11.9
	Std. error	0.9	1.4	1.0		1.3
	Median	12.7	11.3	11.0		12.2
Individual Values	First maximum	96.0	32.0	21.0		96.0
	Second maximum	91.0	30.0	20.0		91.0
	First minimum	0.0	2.0	1.0		0.0
	Second minimum	0.0	3.0	1.0		0.0

TABLE A.37. PRIMARY SITE SUMMARY STATISTICS FOR REAL-TIME PARTICULATE CONCENTRATION (MG/M^3) BY EPA SECTORS

Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
		Sector									
AM	N	13	10	7	9	1	1	2	5	5	9
	Mean	16.3	7.7	5.9	8.3	12.0	11.0	13.5	9.2	10.4	10.5
	Std. error	1.8	1.3	2.5	0.5	-	-	0.5	0.7	0.8	1.1
Noon	N	13	10	8	9	1	1	2	5	5	9
	Mean	15.8	6.8	7.5	8.7	10.0	10.0	11.5	10.4	12.8	10.4
	Std. error	2.8	1.0	3.0	0.4	-	-	0.5	2.0	0.7	0.9
PM	N	13	10	8	9	1	1	2	5	2	9
	Mean	16.8	7.6	6.5	15.3	11.0	14.0	12.5	9.0	16.5	12.1
	Std. error	2.4	1.2	2.7	2.6	-	-	0.5	3.3	1.5	1.3

											Grand
Average Daily Statistics	N	13	10	8	9	1	1	2	5	5	9
	Mean	16.3	7.4	6.4	10.8	11.0	11.7	12.5	9.5	12.3	10.9
	Std. error	2.0	1.0	2.4	0.9	nc[a]	nc	0.2	1.9	0.7	1.0
	Median	14.0	7.8	5.0	9.3	nc	nc	12.5	7.3	12.0	11.0
Individual Values	First maximum	48.0	15.0	20.0	31.0	12.0	14.0	14.0	20.0	18.0	48.0
	Second maximum	39.0	14.0	18.0	26.0	11.0	11.0	13.0	17.0	15.0	39.0
	First minimum	6.0	0.0	0.0	7.0	10.0	10.0	11.0	2.0	8.0	0.0
	Second minimum	9.0	0.0	0.0	7.0	11.0	11.0	12.0	4.0	10.0	0.0

TABLE A.38. SECONDARY SITE SUMMARY STATISTICS FOR REAL-TIME PARTICULATE CONCENTRATION (MG/M^3) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	9	7	7	4	3	4	7	11	12	9
	Mean	17.8	3.9	6.9	10.7	13.5	16.0	20.0	14.4	9.3	12.5
	Std. error	2.0	1.5	2.4	2.2	1.8	2.1	1.8	2.5	1.9	1.7
Noon	N	9	7	7	4	3	4	7	11	12	9
	Mean	13.1	8.0	7.3	10.5	10.7	12.0	16.7	13.1	7.2	11.0
	Std. error	0.8	2.9	2.6	2.8	0.4	0.8	1.1	1.9	1.4	1.1
PM	N	9	7	5	4	3	3	7	11	0	8
	Mean	15.4	9.0	6.6	10.2	13.7	10.7	17.0	11.6	-	11.8
	Std. error	1.0	2.4	2.8	1.0	2.5	0.3	1.4	1.7	-	1.2
											Grand
Average Daily Statistics	N	9	7	7	4	3	4	7	11	12	9
	Mean	15.4	7.0	7.0	10.5	12.6	13.3	17.9	13.0	8.3	11.7
	Std. error	1.0	1.8	2.5	1.9	1.1	0.9	1.3	1.9	1.1	1.3
	Median	16.4	8.0	10.3	9.3	13.3	13.2	16.3	11.3	7.2	12.6
Individual Values	First maximum	27.0	20.0	15.0	19.0	19.0	21.0	30.0	32.0	21.0	32.0
	Second maximum	26.0	20.0	14.0	17.0	18.0	17.0	24.0	30.0	20.0	30.0
	First minimum	9.0	0.0	0.0	7.0	9.0	10.0	13.0	3.0	1.0	0.0
	Second minimum	9.0	0.0	0.0	7.0	10.0	10.0	13.0	6.0	1.0	0.0

[a] nc = not computed

TABLE A.39. SPECIAL SITE SUMMARY STATISTICS FOR REAL-TIME PARTICULATE CONCENTRATION (MG/M^3) BY EPA SECTORS

Time	Statistic	Sector: Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	8	1	6	5	5	3	-	1	-	7
	Mean	14.2	2.0	5.2	7.2	13.4	9.7	-	16.0	-	9.7
	Std. error	1.8	-	1.2	0.7	0.8	0.3	-	-	-	2.0
Noon	N	22	1	5	4	2	5	-	-	2	7
	Mean	19.2	11.0	43.0	30.5	12.0	18.0	-	-	10.0	20.5
	Std. error	2.1	-	14.0	20.2	0.0	2.0	-	-	7.0	4.6
PM	N	16	3	6	5	-	-	-	-	0	4
	Mean	15.2	7.0	42.7	15.2	-	-	-	-	-	20.0
	Std. error	1.4	4.4	12.6	1.6	-	-	-	-	-	7.8
											Grand
Average Daily Statistics	N	30	3	7	14	6	8	-	1	2	8
	Mean	17.8	5.1	28.0	16.7	12.9	14.9	-	16.0	10.0	15.2
	Std. error	1.6	2.7	7.8	5.8	0.6	2.0	-	nc[a]	7.0	2.3
	Median	14.3	6.0	29.7	9.0	12.7	13.0	-	nc	10.0	15.4
Individual Values	First maximum	54.0	15.0	96.0	91.0	15.0	22.0	-	16.0	17.0	96.0
	Second maximum	54.0	11.0	88.0	17.0	15.0	21.0	-	-	3.0	91.0
	First minimum	8.0	0.0	0.0	5.0	11.0	9.0	-	16.0	3.0	0.0
	Second minimum	9.0	2.0	0.0	7.0	12.0	10.0	-	-	17.0	0.0

TABLE A.40. PRIMARY, SECONDARY, & SPECIAL SITE SUMMARY STATISTICS FOR REAL-TIME PARTICULATE CONCENTRATION (MG/M^3) BY EPA SECTORS

		Sector									
Time	Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Buildings Means
AM	N	27	16	20	18	8	7	9	17	17	9
	Mean	16.3	5.9	6.0	8.6	13.2	13.0	18.6	12.9	9.6	11.6
	Std. error	1.0	1.0	1.2	0.6	0.6	1.7	1.7	1.7	1.3	1.5
Noon	N	40	16	20	17	5	8	9	16	19	9
	Mean	17.3	6.9	16.3	14.2	11.1	15.6	15.6	12.2	9.0	13.1
	Std. error	1.4	1.1	5.0	4.9	0.4	1.7	1.1	1.5	1.2	1.2
PM	N	35	18	19	18	3	3	9	16	2	9
	Mean	16.0	7.4	17.9	14.2	13.4	11.3	16.0	10.8	16.5	13.7
	Std. error	1.1	1.1	5.6	1.4	2.5	0.3	1.3	1.5	1.5	1.1

											Grand
Average Daily Statistics	N	48	18	22	27	9	11	9	17	19	9
	Mean	17.0	6.5	13.4	13.8	12.7	14.5	16.7	12.2	9.5	12.9
	Std. error	1.0	0.9	3.4	3.0	0.5	1.4	1.3	1.4	1.0	1.1
	Median	15.7	7.5	11.0	9.3	13.0	13.0	16.3	11.3	11.0	13.4
Individual Values	First maximum	54.0	20.0	96.0	91.0	19.0	22.0	30.0	32.0	21.0	96.0
	Second maximum	54.0	20.0	88.0	31.0	18.0	21.0	24.0	30.0	20.0	91.0
	First minimum	6.0	0.0	0.0	5.0	9.0	9.0	11.0	2.0	1.0	0.0
	Second minimum	8.0	0.0	0.0	7.0	10.0	10.0	12.0	3.0	1.0	0.0

APPENDIX B

Summary Statistics for Respirable Particulate Matter

TABLE B.1 PRIMARY SITE DESCRIPTIVE STATISTICS FOR PERSONAL EXPOSURE MONITOR PARTICLE CONCENTRATION (MG/M^3) BY EPA BUILDINGS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	59	49	5	5
Number of samples above LOQ	28	24	2	2
Sample mean	22.6	23.5	16.3	18.5
Standard error of the mean	1.7	1.9	1.4	4.5
Median	21.3	21.4	16.3	18.5
Maximum	54.7	54.7	17.7	23.1
Minimum	10.7	10.7	14.9	14.0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	10	1	1	2	5	5	5
Number of samples above LOQ	6	7	7	2	1	0	0	2	2	1
Sample mean	24.6	23.8	22.6	21.2	27.3	-	-	16.3	18.5	21.5
Standard error of the mean	6.2	3.4	2.9	0.2	nc[a]	-	-	1.4	4.5	nc
Median	19.2	21.7	23.2	21.2	nc	-	-	16.3	18.5	nc
Maximum	54.7	41.4	32.7	21.3	nc	-	-	17.7	23.1	nc
Minimum	15.0	12.3	10.7	21.0	nc	-	-	14.9	14.0	nc

APPENDIX C

Summary Statistics for Formaldehyde and Other Aldehydes

TABLE C.1. PRIMARY SITE DESCRIPTIVE STATISTICS FOR FORMALDEHYDE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	10.2	8.9	11.3	19.3
Standard error of the mean	0.9	0.6	0.0	1.0
Median	10.3	8.1	11.3	19.3
Maximum	20.3	12.7	11.3	20.3
Minimum	6.2	6.2	11.3	18.3

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	6.7	11.9	9.4	10.8	-	7.6	-	11.3	19.3	7.3
Standard error of the mean	0.2	0.8	1.3	0.4	-	nc[a]	-	0.0	1.0	0.8
Median	6.9	11.9	9.4	10.5	-	nc	-	11.3	19.3	6.5
Maximum	6.9	12.7	10.8	11.5	-	nc	-	11.3	20.3	10.3
Minimum	6.4	11.1	8.1	10.3	-	nc	-	11.3	18.3	6.2

[a] nc = not computed

TABLE C.2. PRIMARY SITE DESCRIPTIVE STATISTICS FOR ACETALDEHYDE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	6.0	5.1	7.4	10.9
Standard error of the mean	0.5	0.3	0.8	0.3
Median	5.2	5.0	7.4	10.9
Maximum	11.1	7.8	8.2	11.1
Minimum	3.8	3.8	6.5	10.6

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	4.3	4.6	6.8	6.2	-	5.2	-	7.4	10.9	4.3
Standard error of the mean	0.4	0.2	1.0	0.4	-	nc[a]	-	0.8	0.3	0.2
Median	3.9	4.6	6.8	6.0	-	nc	-	7.4	10.9	4.3
Maximum	5.0	4.8	7.8	6.9	-	nc	-	8.2	11.1	5.1
Minimum	3.9	4.5	5.8	5.6	-	nc	-	6.5	10.6	3.8

[a] nc = not computed

TABLE C.3. PRIMARY SITE DESCRIPTIVE STATISTICS FOR PROPIONALDEHYDE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	0.9	0.8	0.7	2.2
Standard error of the mean	0.1	0.1	0.1	0.1
Median	0.8	0.7	0.7	2.2
Maximum	2.3	1.2	0.8	2.3
Minimum	0.5	0.5	0.6	2.0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	0.7	0.6	0.9	1.1	-	0.7	-	0.7	2.2	0.6
Standard error of the mean	0.1	0.0	0.2	0.1	-	nc[a]	-	0.1	0.1	0.0
Median	0.6	0.6	0.9	1.1	-	nc	-	0.7	2.2	0.6
Maximum	1.0	0.6	1.1	1.2	-	nc	-	0.8	2.3	0.8
Minimum	0.5	0.5	0.8	0.9	-	nc	-	0.6	2.0	0.5

[a] *nc = not computed*

TABLE C.4. PRIMARY SITE DESCRIPTIVE STATISTICS FOR BUTYRALDEHYDE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	0.7	0.7	1.1	0.9
Standard error of the mean	0.1	0.1	0.1	0.1
Median	0.8	0.7	1.1	0.9
Maximum	1.2	1.0	1.2	1.0
Minimum	0.3	0.3	0.9	0.8

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	0.6	0.5	0.8	0.9	-	0.4	-	1.1	0.9	0.6
Standard error of the mean	0.2	0.0	0.2	0.1	-	nc[a]	-	0.1	0.1	0.1
Median	0.6	0.5	0.8	0.9	-	nc	-	1.1	0.9	0.7
Maximum	0.8	0.5	1.0	1.0	-	nc	-	1.2	1.0	0.8
Minimum	0.3	0.5	0.7	0.7	-	nc	-	0.9	0.8	0.3

[a] nc = not computed

TABLE C.5. PRIMARY SITE DESCRIPTIVE STATISTICS FOR BENZALDEHYDE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	0.8	0.6	0.8	1.8
Standard error of the mean	0.1	0.0	0.2	0.1
Median	0.6	0.6	0.8	1.8
Maximum	1.9	1.0	1.0	1.9
Minimum	0.4	0.4	0.6	1.6

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	0.5	0.7	0.8	0.8	-	0.7	-	0.8	1.8	0.5
Standard error of the mean	0.0	0.0	0.2	0.0	-	nc[a]	-	0.2	0.1	0.0
Median	0.5	0.7	0.8	0.8	-	nc	-	0.8	1.8	0.5
Maximum	0.6	0.7	1.0	0.9	-	nc	-	1.0	1.9	0.6
Minimum	0.5	0.6	0.6	0.8	-	nc	-	0.6	1.6	0.4

[a] nc = not computed

TABLE C.6. PRIMARY SITE DESCRIPTIVE STATISTICS FOR VALERALDEHYDE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	18	14	2	2
Sample mean	0.7	0.5	0.7	1.9
Standard error of the mean	0.1	0.0	0.2	0.2
Median	0.5	0.5	0.7	1.9
Maximum	2.0	0.8	0.9	2.0
Minimum	0.3	0.3	0.5	1.7

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	2	2	2	3	0	1	-	2	2	5
Sample mean	0.4	0.5	0.6	0.7	-	0.4	-	0.7	1.9	0.4
Standard error of the mean	0.1	0.1	0.2	0.0	-	nc[a]	-	0.2	0.2	0.0
Median	0.4	0.5	0.6	0.7	-	nc	-	0.7	1.9	0.4
Maximum	0.5	0.5	0.8	0.7	-	nc	-	0.9	2.0	0.5
Minimum	0.4	0.4	0.4	0.6	-	nc	-	0.5	1.7	0.3

[a] nc = not computed

TABLE C.7. PRIMARY SITE DESCRIPTIVE STATISTICS FOR HEXANALDEHYDE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	2.5	2.1	3.0	5.3
Standard error of the mean	0.3	0.2	0.9	0.4
Median	2.2	2.0	3.0	5.3
Maximum	5.7	3.5	3.9	5.7
Minimum	1.1	1.1	2.2	4.8

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	1.6	1.9	2.6	2.7	-	1.1	-	3.0	5.3	2.0
Standard error of the mean	0.2	0.3	0.8	0.4	-	nc[a]	-	0.9	0.4	0.2
Median	1.8	1.9	2.6	2.5	-	nc	-	3.0	5.3	2.0
Maximum	1.9	2.2	3.4	3.5	-	nc	-	3.9	5.7	2.5
Minimum	1.2	1.6	1.8	2.2	-	nc	-	2.2	4.8	1.5

[a] nc = not computed

TABLE C.8. PRIMARY SITE DESCRIPTIVE STATISTICS FOR ACROLEIN (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	0.3	0.2	0.3	0.7
Standard error of the mean	0.0	0.0	0.0	0.0
Median	0.3	0.2	0.3	0.7
Maximum	0.7	0.4	0.3	0.7
Minimum	0.1	0.1	0.3	0.7

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	0.2	0.2	0.3	0.3	-	0.3	-	0.3	0.7	0.2
Standard error of the mean	0.0	0.0	0.1	0.0	-	nc[a]	-	0.0	0.0	0.0
Median	0.2	0.2	0.3	0.3	-	nc	-	0.3	0.7	0.2
Maximum	0.2	0.2	0.4	0.3	-	nc	-	0.3	0.7	0.2
Minimum	0.2	0.1	0.3	0.3	-	nc	-	0.3	0.7	0.1

[a] nc = not computed

TABLE C.9. PRIMARY SITE DESCRIPTIVE STATISTICS FOR ACETONE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	14.1	12.0	16.2	28.0
Standard error of the mean	1.5	1.2	1.4	1.4
Median	12.2	11.3	16.2	28.0
Maximum	29.5	25.1	17.6	29.5
Minimum	7.7	7.7	14.8	26.6

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	13.7	11.0	15.0	13.0	-	8.5	-	16.2	28.0	9.5
Standard error of the mean	5.7	0.7	3.7	0.4	-	nc[a]	-	1.4	1.4	1.2
Median	8.2	11.0	15.0	13.1	-	nc	-	16.2	28.0	8.4
Maximum	25.1	11.7	18.8	13.6	-	nc	-	17.6	29.5	14.4
Minimum	7.9	10.3	11.3	12.2	-	nc	-	14.8	26.6	7.7

[a] nc = not computed

TABLE C.10. PRIMARY SITE DESCRIPTIVE STATISTICS FOR UNKNOWN CARBONYLS (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	1.5	1.2	2.4	2.5
Standard error of the mean	0.2	0.2	0.2	0.4
Median	1.2	1.0	2.4	2.5
Maximum	3.9	3.9	2.6	2.9
Minimum	0.4	0.4	2.2	2.1

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	1.9	1.3	1.2	1.0	-	1.0	-	2.4	2.5	0.9
Standard error of the mean	1.0	0.5	0.0	0.1	-	nc[a]	-	0.2	0.4	0.1
Median	1.3	1.3	1.2	0.9	-	nc	-	2.4	2.5	1.0
Maximum	3.9	1.8	1.3	1.2	-	nc	-	2.6	2.9	1.2
Minimum	0.4	0.8	1.2	0.9	-	nc	-	2.2	2.1	0.4

[a] nc = not computed

TABLE C.11. PRIMARY SITE DESCRIPTIVE STATISTICS FOR TOTAL CARBONYLS (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	20	16	2	2
Number of samples above LOQ	19	15	2	2
Sample mean	37.7	32.1	43.8	73.6
Standard error of the mean	3.4	2.0	3.7	3.3
Median	35.3	32.2	43.8	73.6
Maximum	77.0	46.3	47.6	77.0
Minimum	22.8	22.8	40.1	70.3

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	3	2	2	3	1	1	-	2	2	5
Number of samples above LOQ	3	2	2	3	0	1	-	2	2	5
Sample mean	30.5	33.0	38.6	37.4	-	25.8	-	43.8	73.6	26.4
Standard error of the mean	6.8	0.8	7.7	1.2	-	nc[a]	-	3.7	3.3	2.4
Median	24.6	33.0	38.6	37.4	-	nc	-	43.8	73.6	24.5
Maximum	44.1	33.9	46.3	39.5	-	nc	-	47.6	77.0	36.0
Minimum	22.8	32.2	30.9	35.3	-	nc	-	40.1	70.3	22.8

[a] nc = not computed

APPENDIX D

Summary Statistics for

Volatile Organic Compounds

TABLE D.2. PRIMARY SITE DESCRIPTIVE STATISTICS FOR TRICHLOROETHYLENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	0	19	9	5	5
Sample mean	-	1.7	1.1	1.3	3.0
Standard error of the mean	-	0.2	0.1	0.1	0.1
Median	-	1.3	1.0	1.1	3.0
Maximum	-	3.2	1.8	1.8	3.2
Minimum	-	0.7	0.7	1.0	2.8
Number of trace values	3	38	38	0	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	4	0	3	1	0	0	1	5	5	0
Sample mean	1.4	-	0.9	0.7	-	-	1.0	1.3	3.0	-
Standard error of the mean	0.2	-	0.2	nc[a]	-	-	nc	0.1	0.1	-
Median	1.4	-	0.8	nc	-	-	nc	1.1	3.0	-
Maximum	1.8	-	1.3	nc	-	-	nc	1.8	3.2	-
Minimum	0.9	-	0.7	nc	-	-	nc	1.0	2.8	-
Number of trace values	9	7	5	10	1	1	1	0	0	5

[a] nc = not computed

TABLE D.2. PRIMARY SITE DESCRIPTIVE STATISTICS FOR TRICHLOROETHYLENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	0	19	9	5	5
Sample mean	-	1.7	1.1	1.3	3.0
Standard error of the mean	-	0.2	0.1	0.1	0.1
Median	-	1.3	1.0	1.1	3.0
Maximum	-	3.2	1.8	1.8	3.2
Minimum	-	0.7	0.7	1.0	2.8
Number of trace values	3	38	38	0	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	4	0	3	1	0	0	1	5	5	0
Sample mean	1.4	-	0.9	0.7	-	-	1.0	1.3	3.0	-
Standard error of the mean	0.2	-	0.2	nc[a]	-	-	nc	0.1	0.1	-
Median	1.4	-	0.8	nc	-	-	nc	1.1	3.0	-
Maximum	1.8	-	1.3	nc	-	-	nc	1.8	3.2	-
Minimum	0.9	-	0.7	nc	-	-	nc	1.0	2.8	-
Number of trace values	9	7	5	10	1	1	1	0	0	5

[a] nc = not computed

TABLE D.3. PRIMARY SITE DESCRIPTIVE STATISTICS FOR TETRACHLOROETHYLENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	5	61	51	5	5
Sample mean	1.7	6.2	6.9	2.2	3.6
Standard error of the mean	0.1	0.8	0.9	0.5	0.4
Median	1.6	3.1	3.3	1.7	3.1
Maximum	2.2	22.3	22.3	4.1	5.2
Minimum	1.4	1.5	1.5	1.6	2.8
Number of trace values	0	0	0	0	0

Sector

Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	13	10	8	12	1	1	2	5	5	5
Sample mean	5.4	3.3	2.2	17.4	1.5	2.9	2.6	2.2	3.6	5.9
Standard error of the mean	1.5	0.1	0.0	0.9	nc[a]	nc	0.3	0.5	0.4	3.3
Median	2.4	3.4	2.2	17.3	nc	nc	2.6	1.7	3.1	3.3
Maximum	19.1	3.8	2.4	22.3	nc	nc	2.9	4.1	5.2	19.1
Minimum	1.7	2.4	2.0	11.7	nc	nc	2.2	1.6	2.8	1.6
Number of trace values	0	0	0	0	0	0	0	0	0	0

[a] nc = not computed

TABLE D.4. PRIMARY SITE DESCRIPTIVE STATISTICS FOR 1,1,1-TRICHLOROETHANE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	5	61	51	5	5
Sample mean	1.9	8.1	8.7	3.3	6.6
Standard error of the mean	0.1	0.8	0.9	0.2	0.1
Median	1.9	6.3	6.7	3.1	6.5
Maximum	2.3	25.9	25.9	3.8	7.1
Minimum	1.5	2.3	2.3	3.0	6.3
Number of trace values	0	0	0	0	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	13	10	8	12	1	1	2	5	5	5
Sample mean	7.5	4.0	14.9	13.4	2.4	2.7	5.3	3.3	6.6	6.1
Standard error of the mean	2.0	0.5	2.2	0.6	nc[a]	nc	1.4	0.2	0.1	3.3
Median	3.6	3.8	15.2	13.1	nc	nc	5.3	3.1	6.5	3.0
Maximum	25.9	7.7	24.8	19.1	nc	nc	6.7	3.8	7.1	19.5
Minimum	2.7	2.3	3.9	10.6	nc	nc	3.9	3.0	6.3	2.4
Number of trace values	0	0	0	0	0	0	0	0	0	0

[a] nc = not computed

TABLE D.5. PRIMARY SITE DESCRIPTIVE STATISTICS FOR P-DICHLOROBENZENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	0	6	1	0	5
Sample mean	-	5.6	3.3	-	6.1
Standard error of the mean	-	0.6	nc[a]	-	0.4
Median	-	5.8	nc	-	6.3
Maximum	-	7.3	nc	-	7.3
Minimum	-	3.3	nc	-	5.2
Number of trace values	0	5	5	0	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	1	0	0	0	0	0	0	0	5	0
Sample mean	3.3	-	-	-	-	-	-	-	6.1	-
Standard error of the mean	nc	-	-	-	-	-	-	-	0.4	-
Median	nc	-	-	-	-	-	-	-	6.3	-
Maximum	nc	-	-	-	-	-	-	-	7.3	-
Minimum	nc	-	-	-	-	-	-	-	5.2	-
Number of trace values	4	0	0	1	0	0	0	0	0	0

[a] nc = not computed

TABLE D.6. PRIMARY SITE DESCRIPTIVE STATISTICS FOR BENZENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	2	9	4	0	5
Sample mean	5.3	6.4	4.7	-	7.8
Standard error of the mean	0.6	0.6	0.4	-	0.4
Median	5.3	6.6	4.6	-	7.7
Maximum	5.8	8.8	5.6	-	8.8
Minimum	4.7	4.0	4.0	-	6.6
Number of trace values	3	43	38	5	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-West	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	2	1	0	0	0	0	0	0	5	1
Sample mean	4.5	5.6	-	-	-	-	-	-	7.8	4.1
Standard error of the mean	0.5	nc[a]	-	-	-	-	-	-	0.4	nc
Median	4.5	nc	-	-	-	-	-	-	7.7	nc
Maximum	5.0	nc	-	-	-	-	-	-	8.8	nc
Minimum	4.0	nc	-	-	-	-	-	-	6.6	nc
Number of trace values	8	9	8	6	1	1	2	5	0	4

[a] nc = not computed

TABLE D.7. PRIMARY SITE DESCRIPTIVE STATISTICS FOR TOLUENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	2	54	44	5	5
Sample mean	7.6	13.5	10.7	13.5	38.3
Standard error of the mean	0.5	1.3	0.7	3.4	2.0
Median	7.6	9.9	9.5	10.3	35.8
Maximum	8.2	44.3	32.7	27.1	44.3
Minimum	7.1	7.0	7.0	9.3	34.1
Number of trace values	3	2	2	0	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	11	10	7	10	0	0	2	5	5	5
Sample mean	12.7	11.1	8.8	9.0	-	-	16.2	13.5	38.3	8.7
Standard error of the mean	2.3	0.4	0.2	0.4	-	-	6.3	3.4	2.0	0.6
Median	10.7	10.7	8.7	8.5	-	-	16.2	10.3	35.8	8.7
Maximum	32.7	13.6	9.5	12.0	-	-	22.5	27.1	44.3	10.7
Minimum	7.1	9.3	8.0	7.9	-	-	9.9	9.3	34.1	7.0
Number of trace values	1	0	0	0	1	0	0	0	0	0

TABLE D.8. PRIMARY SITE DESCRIPTIVE STATISTICS FOR ETHYLBENZENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	1	54	44	5	5
Sample mean	1.2	1.7	1.4	1.4	4.9
Standard error of the mean	nc[a]	0.1	0.1	0.0	0.1
Median	nc	1.4	1.4	1.4	4.9
Maximum	nc	5.4	2.8	1.5	5.4
Minimum	nc	1.0	1.0	1.4	4.5
Number of trace values	4	7	7	0	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	9	10	8	11	0	1	2	5	5	4
Sample mean	1.8	1.5	1.2	1.1	-	1.7	1.5	1.4	4.9	1.4
Standard error of the mean	0.2	0.0	0.0	0.0	-	nc	0.1	0.0	0.1	0.1
Median	1.6	1.6	1.2	1.1	-	nc	1.5	1.4	4.9	1.3
Maximum	2.8	1.7	1.3	1.4	-	nc	1.6	1.5	5.4	1.6
Minimum	1.3	1.4	1.0	1.0	-	nc	1.3	1.4	4.5	1.2
Number of trace values	4	0	0	1	1	0	0	0	0	1

[a] nc = not computed

TABLE D.9. PRIMARY SITE DESCRIPTIVE STATISTICS FOR O-XYLENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	3	60	50	5	5
Sample mean	1.3	2.0	1.7	1.8	5.6
Standard error of the mean	0.1	0.2	0.1	0.0	0.2
Median	1.2	1.7	1.5	1.8	5.5
Maximum	1.5	6.2	3.4	1.8	6.2
Minimum	1.1	1.0	1.0	1.7	5.1
Number of trace values	2	1	1	0	0

Sector

Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	12	10	8	12	1	1	2	5	5	5
Sample mean	2.0	1.9	1.4	1.4	1.0	2.0	1.7	1.8	5.6	1.6
Standard error of the mean	0.2	0.1	0.0	0.0	nc[a]	nc	0.2	0.0	0.2	0.1
Median	1.9	1.8	1.5	1.3	nc	nc	1.7	1.8	5.5	1.6
Maximum	3.4	2.2	1.5	1.7	nc	nc	1.9	1.8	6.2	1.9
Minimum	1.0	1.7	1.2	1.1	nc	nc	1.5	1.7	5.1	1.2
Number of trace values	1	0	0	0	0	0	0	0	0	0

[a] nc = not computed

TABLE D.10. PRIMARY SITE DESCRIPTIVE STATISTICS FOR P-XYLENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	4	61	51	5	5
Sample mean	3.0	5.2	4.2	4.6	15.5
Standard error of the mean	0.3	0.4	0.2	0.1	0.5
Median	2.9	4.4	4.0	4.7	15.4
Maximum	3.9	17.3	9.2	4.9	17.3
Minimum	2.4	2.5	2.5	4.3	14.4
Number of trace values	1	0	0	0	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	13	10	8	12	1	1	2	5	5	5
Sample mean	4.9	5.0	3.6	3.3	2.7	5.0	4.5	4.6	15.5	4.1
Standard error of the mean	0.6	0.2	0.1	0.1	nc[a]	nc	0.5	0.1	0.5	0.4
Median	4.9	4.9	3.6	3.3	nc	nc	4.5	4.7	15.4	4.0
Maximum	9.2	5.8	4.1	4.1	nc	nc	4.9	4.9	17.3	4.9
Minimum	2.5	4.5	3.0	2.6	nc	nc	4.0	4.3	14.4	3.0
Number of trace values	0	0	0	0	0	0	0	0	0	0

[a] nc = not computed

TABLE D.11. PRIMARY SITE DESCRIPTIVE STATISTICS FOR STYRENE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	0	1	0	0	1
Sample mean	-	1.5	-	-	1.5
Standard error of the mean	-	nc[a]	-	-	nc
Median	-	nc	-	-	nc
Maximum	-	nc	-	-	nc
Minimum	-	nc	-	-	nc
Number of trace values	0	13	10	1	2

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	0	0	0	0	0	0	0	0	1	0
Sample mean	-	-	-	-	-	-	-	-	1.5	-
Standard error of the mean	-	-	-	-	-	-	-	-	nc	-
Median	-	-	-	-	-	-	-	-	nc	-
Maximum	-	-	-	-	-	-	-	-	nc	-
Minimum	-	-	-	-	-	-	-	-	nc	-
Number of trace values	3	2	3	1	0	1	0	1	2	0

[a] nc = not computed

TABLE D.12. PRIMARY SITE DESCRIPTIVE STATISTICS FOR N-DECANE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	0	5	5	0	0
Sample mean	-	6.3	6.3	-	-
Standard error of the mean	-	1.8	1.8	-	-
Median	-	5.2	5.2	-	-
Maximum	-	12.9	12.9	-	-
Minimum	-	2.9	2.9	-	-
Number of trace values	0	16	11	0	5

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	2	1	0	0	0	0	0	0	0	2
Sample mean	8.6	2.9	-	-	-	-	-	-	-	5.8
Standard error of the mean	4.3	nc[a]	-	-	-	-	-	-	-	0.6
Median	8.6	nc	-	-	-	-	-	-	-	5.8
Maximum	12.9	nc	-	-	-	-	-	-	-	6.3
Minimum	4.3	nc	-	-	-	-	-	-	-	5.2
Number of trace values	3	3	1	4	0	0	0	0	5	0

[a] nc = not computed

TABLE D.13. PRIMARY SITE DESCRIPTIVE STATISTICS FOR N-DODECANE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	0	0	0	0	0
Sample mean	-	-	-	-	-
Standard error of the mean	-	-	-	-	-
Median	-	-	-	-	-
Maximum	-	-	-	-	-
Minimum	-	-	-	-	-
Number of trace values	0	2	1	0	1

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	0	0	0	0	0	0	0	0	0	0
Sample mean	-	-	-	-	-	-	-	-	-	-
Standard error of the mean	-	-	-	-	-	-	-	-	-	-
Median	-	-	-	-	-	-	-	-	-	-
Maximum	-	-	-	-	-	-	-	-	-	-
Minimum	-	-	-	-	-	-	-	-	-	-
Number of trace values	0	0	0	1	0	0	0	0	1	0

TABLE D.14. PRIMARY SITE DESCRIPTIVE STATISTICS FOR N-OCTANE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	0	24	16	3	5
Sample mean	-	1.0	1.0	0.6	1.0
Standard error of the mean	-	0.1	0.1	0.0	0.0
Median	-	0.9	0.8	0.6	0.9
Maximum	-	2.0	2.0	0.6	1.1
Minimum	-	0.6	0.6	0.6	0.9
Number of trace values	5	36	34	2	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	4	5	3	0	1	0	1	3	5	2
Sample mean	1.2	1.3	0.7	-	0.7	-	0.8	0.6	1.0	0.9
Standard error of the mean	0.1	0.2	0.0	-	nc[a]	-	nc	0.0	0.0	0.0
Median	1.2	1.6	0.6	-	nc	-	nc	0.6	0.9	0.9
Maximum	1.5	2.0	0.7	-	nc	-	nc	0.6	1.1	0.9
Minimum	0.8	0.7	0.6	-	nc	-	nc	0.6	0.9	0.8
Number of trace values	9	5	5	11	0	1	1	2	0	3

[a] nc = not computed

TABLE D.15. PRIMARY SITE DESCRIPTIVE STATISTICS FOR SUM OF VOCS (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	5	61	51	5	5
Sample mean	12.8	40.3	35.7	28.8	99.4
Standard error of the mean	4.0	2.9	2.1	3.4	2.8
Median	10.3	35.8	35.7	26.0	96.7
Maximum	26.7	110.4	94.1	41.8	110.4
Minimum	2.9	10.7	10.7	23.3	94.6

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	13	10	8	12	1	1	2	5	5	5
Sample mean	38.4	30.5	34.9	44.3	10.7	15.6	33.8	28.8	99.4	33.5
Standard error of the mean	6.6	1.7	2.7	2.1	nc[a]	nc	10.2	3.4	2.8	6.7
Median	27.2	29.6	35.7	44.1	nc	nc	33.8	26.0	96.7	31.7
Maximum	94.1	38.2	44.9	56.0	nc	nc	43.9	41.8	110.4	56.3
Minimum	14.5	23.6	21.4	26.0	nc	nc	23.6	23.3	94.6	17.6

[a] nc = not computed

TABLE D.16. PRIMARY SITE DESCRIPTIVE STATISTICS FOR TOTAL VOCS (PPM CARBON) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values greater than the limit of quantification (LOQ)]

Statistic	Total Outside	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	5	61	51	5	5
Number of samples above LOQ	5	61	51	5	5
Sample mean	0.4	1.0	1.0	0.5	1.9
Standard error of the mean	0.1	0.1	0.1	0.1	0.3
Median	0.3	0.8	0.8	0.5	1.8
Maximum	0.5	7.1	7.1	0.8	2.9
Minimum	0.2	0.3	0.3	0.5	1.5

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Total number of samples	13	10	8	12	1	1	2	5	5	5
Number of samples above LOQ	13	10	8	12	1	1	2	5	5	5
Sample mean	0.8	1.0	0.9	0.9	7.1	0.9	0.6	0.5	1.9	0.7
Standard error of the mean	0.1	0.2	0.1	0.2	nc[a]	nc	0.0	0.1	0.3	0.1
Median	0.8	0.8	0.9	0.7	nc	nc	0.6	0.5	1.8	0.8
Maximum	2.0	2.0	1.4	2.5	nc	nc	0.7	0.8	2.9	0.8
Minimum	0.3	0.4	0.5	0.6	nc	nc	0.6	0.5	1.5	0.4

[a] nc = not computed

APPENDIX E

Summary Statistics for Nicotine

TABLE E.1. PRIMARY SITE DESCRIPTIVE STATISTICS FOR NICOTINE (MG/M^3) BY EPA BUILDINGS AND SECTORS
[Statistics are computed only for values above the limit of quantification (LOQ)]

Statistic	Total Inside	Water-side Mall	Crystal City	Fair-child
Total number of samples	63	50	7	6
Number of samples above LOQ	6	3	1	2
Sample mean	0.1	0.1	0.1	0.2
Standard error of the mean	0.0	0.0	nc[a]	0.1
Median	0.1	0.1	nc	0.2
Maximum	0.3	0.1	nc	0.3
Minimum	0.1	0.1	nc	0.1

	Sector								
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child
Total number of samples	14	11	8	14	1	1	1	7	6
Number of samples above LOQ	1	2	0	0	0	0	0	1	2
Sample mean	0.1	0.1	-	-	-	-	-	0.1	0.2
Standard error of the mean	nc	0.0	-	-	-	-	-	nc	0.1
Median	nc	0.1	-	-	-	-	-	nc	0.2
Maximum	nc	0.1	-	-	-	-	-	nc	0.3
Minimum	nc	0.1	-	-	-	-	-	nc	0.1

[a] nc = not computed

APPENDIX F

Summary Statistics for Particles at Fixed Indoor and Fixed Outdoor Monitoring Locations

Table F.1 Fixed Site Descriptive statistics for Turner-10 particle concentration ($\mu g/m^3$)
[Statistics are computed only for values above the limit of quantification (LOQ)]

Statistic	Fixed Site
Total number of samples	5
Number of samples above LOQ	5
Sample mean	19.3
Standard error of the mean	0.6
Median	19.1
Maximum	21.5
Minimum	18.0

Table F.2. Fixed Site Descriptive statistics for Turner-2.5 particle concentration ($\mu g/m^3$)
[Statistics are computed only for values above the limit of quantification (LOQ)]

Statistic	Fixed Site
Total number of samples	5
Number of samples above LOQ	5
Sample mean	8.6
Standard error of the mean	0.9
Median	8.6
Maximum	11.2
Minimum	5.6

Table F.3. Fixed Site Descriptive statistics for coarse dichotomous particle concentration ($\mu g/m^3$)
[Statistics are computed only for values above the limit of quantification (LOQ)]

Statistic	Total Outdoor
Total number of samples	5
Number of observations	3
Sample mean	14.1
Standard error of the mean	1.0
Median	14.3
Maximum	15.6
Minimum	12.2

Table F.4. Fixed Site Descriptive statistics for fine dichotomous particle concentration ($\mu g/m^3$)
[Statistics are computed only for values above the limit of quantification (LOQ)]

Statistic	Total Outdoor
Total number of samples	5
Number of observations	5
Sample mean	13.6
Standard error of the mean	1.7
Median	14.7
Maximum	17.9
Minimum	7.9

APPENDIX G

Summary Statistics for Viable and Nonviable Microbiological Contaminants

TABLE G.1. DESCRIPTIVE STATISTICS FOR FUNGI MEASURED AT THE EPA BUILDINGS.

Statistic	Outside	Total Inside
Number of samples	7	63
Sample mean	22.14	28.25
Standard error of the mean	15.18	13.94
Median	10.0	10.0
Maximum	112.5	882.5
Minimum	0.0	0.0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Number of samples	13	12	8	12	1	1	2	5	5	5
Sample mean	11.35	8.13	129.69	22.71	2.50	10.00	17.50	11.50	9.50	19.50
Standard error of mean	2.65	1.80	107.66	9.47	nc[a]	nc	12.50	2.18	3.39	5.02
Median	10.0	7.5	18.8	16.3	nc	nc	17.5	10.0	5.0	20.0
Maximum	32.5	25.0	882.5	120.0	nc	nc	30.0	17.5	22.5	35.0
Minimum	0.0	0.0	5.0	0.0	nc	nc	5.0	5.0	5.0	7.5

[a] nc = not computed

TABLE G.2. DESCRIPTIVE STATISTICS FOR HUMAN-SOURCE BACTERIA MEASURED AT THE EPA BUILDINGS.

Statistic	Outside	Total Inside
Number of samples	7	63
Sample mean	53.6	51.5
Standard error of the mean	34.1	4.1
Median	5	45
Maximum	240	185
Minimum	5	5

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Number of samples	13	12	8	12	1	1	2	5	5	5
Sample mean	56.9	37.5	63.1	63.3	35.0	40.0	60.0	24.0	58.0	57.0
Standard error of mean	8.2	4.9	19.1	9.1	nc[a]	nc	40.0	6.4	17.3	11.2
Median	50	30	48	70	nc	nc	60	25	45	50
Maximum	120	70	185	105	nc	nc	100	40	125	100
Minimum	20	10	15	5	nc	nc	20	5	30	35

[a] nc = not computed

TABLE G.3. DESCRIPTIVE STATISTICS FOR THERMOPHILIC BACTERIA MEASURED AT THE EPA BUILDINGS.

Statistic	Outside	Total Inside
Number of samples	7	63
Sample mean	2.9	18.3
Standard error of the mean	1.5	3.0
Median	0	10
Maximum	10	140
Minimum	0	0

	Sector									
Statistic	Mall 2	Mall 3	East	West	South-east	South-west	North-east	Crystal City	Fair-child	Fixed Site
Number of samples	13	12	8	12	1	1	2	5	5	5
Sample mean	17.7	26.7	14.4	9.2	5.0	5.0	10.0	8.0	24.0	45.0
Standard error of mean	4.8	6.4	3.1	2.0	nc[a]	nc	5.0	3.0	16.7	24.6
Median	15	28	15	8	nc	nc	10	5	10	25
Maximum	60	70	30	20	nc	nc	15	20	90	140
Minimum	0	0	0	0	nc	nc	5	5	0	0

[a] nc = not computed

APPENDIX H

Results of Full-Scan VOC Analysis on Selected VOC Canisters

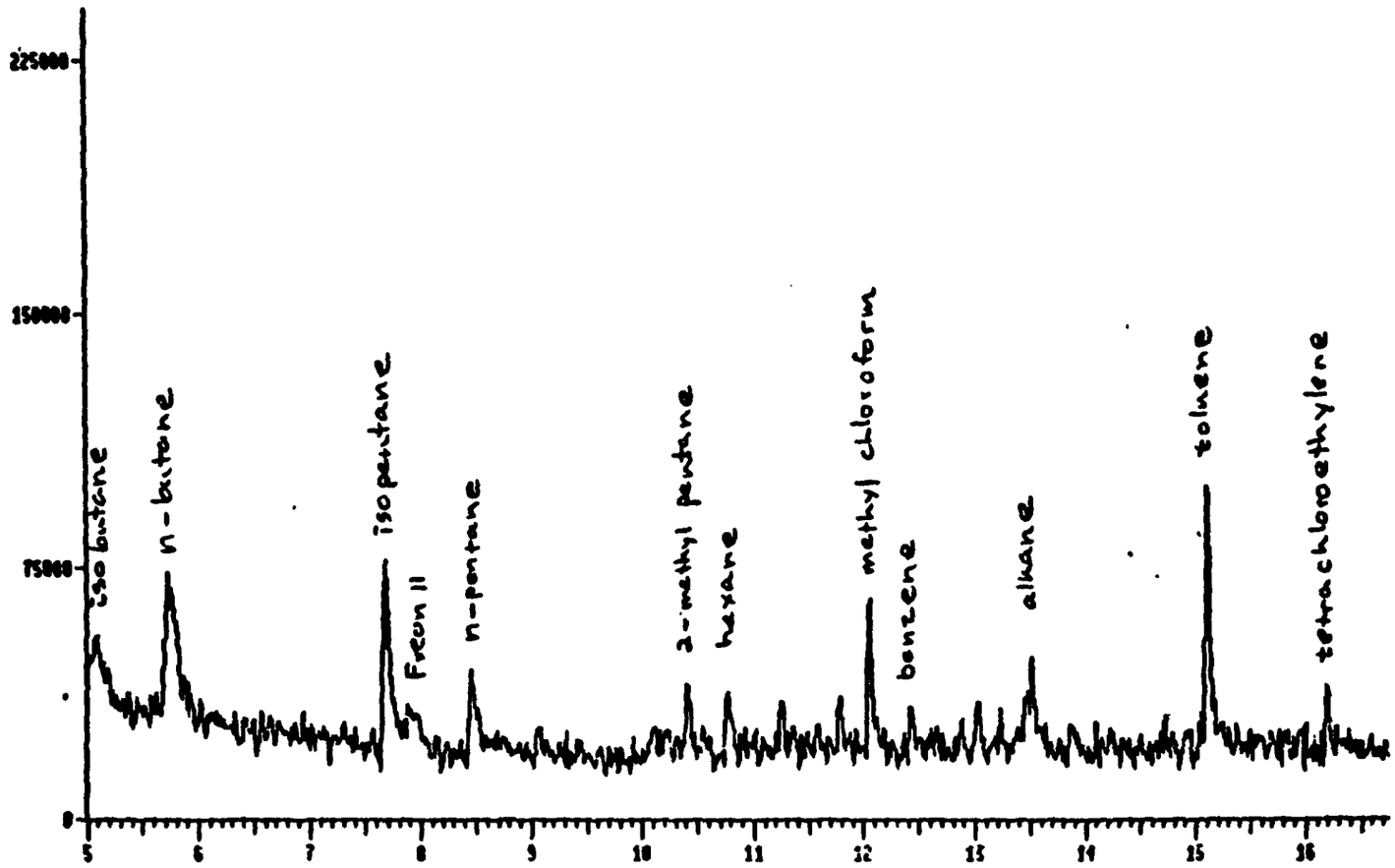


FIGURE H-1 GC/MS CHROMATOGRAM FOR EPA HEADQUARTERS' BUILDINGS SITE 1 - BEFORE MONITORING

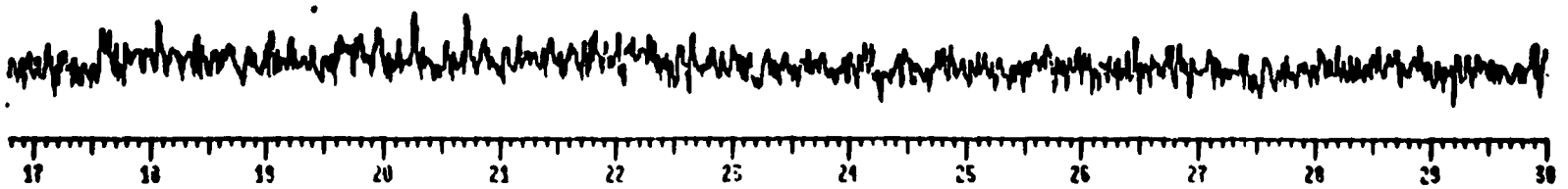


FIGURE H-1 (Continued)

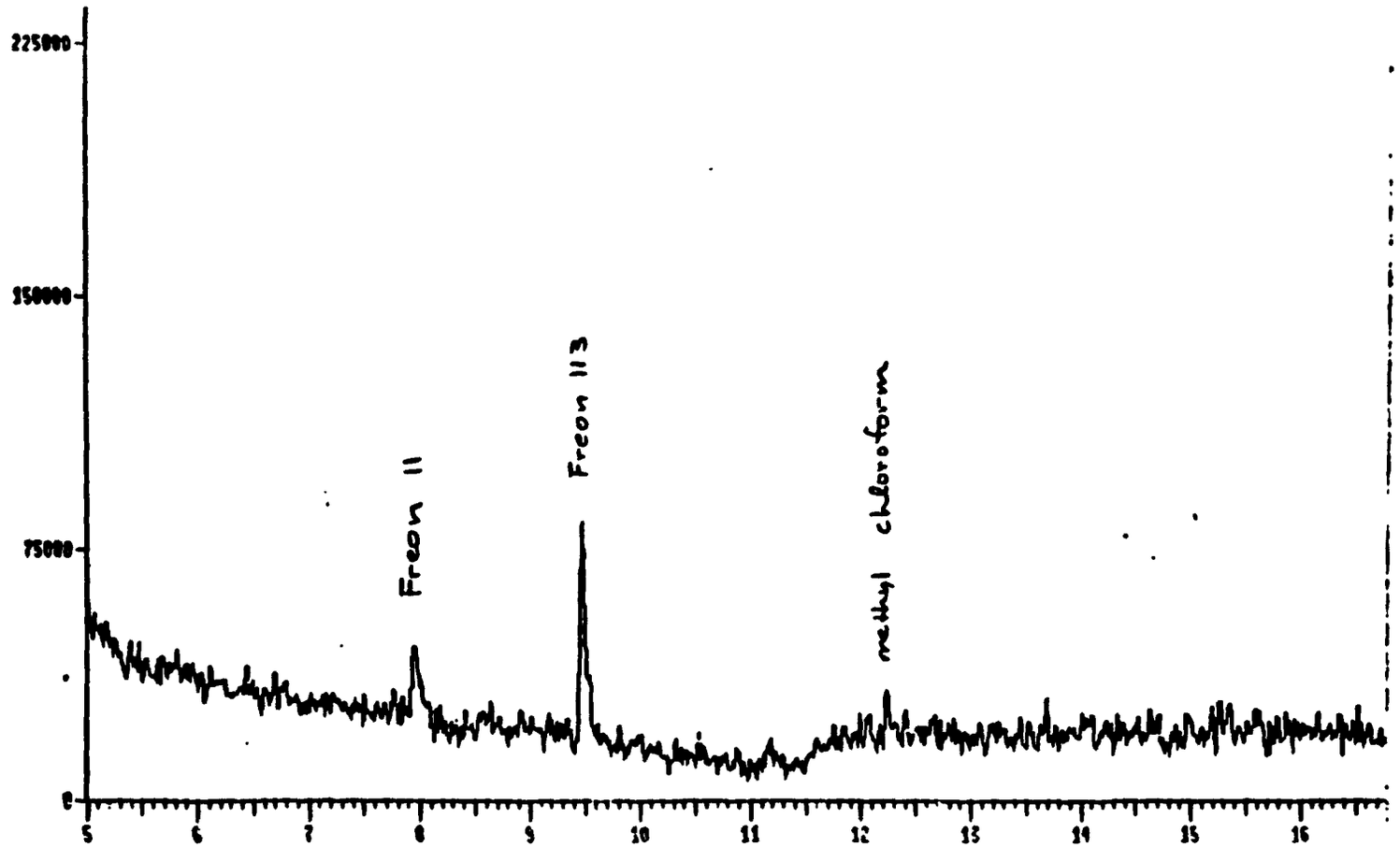


FIGURE H-2 GC/MS CHROMATOGRAM FOR EPA HEADQUARTERS' BUILDINGS SITE 2 - BEFORE MONITORING

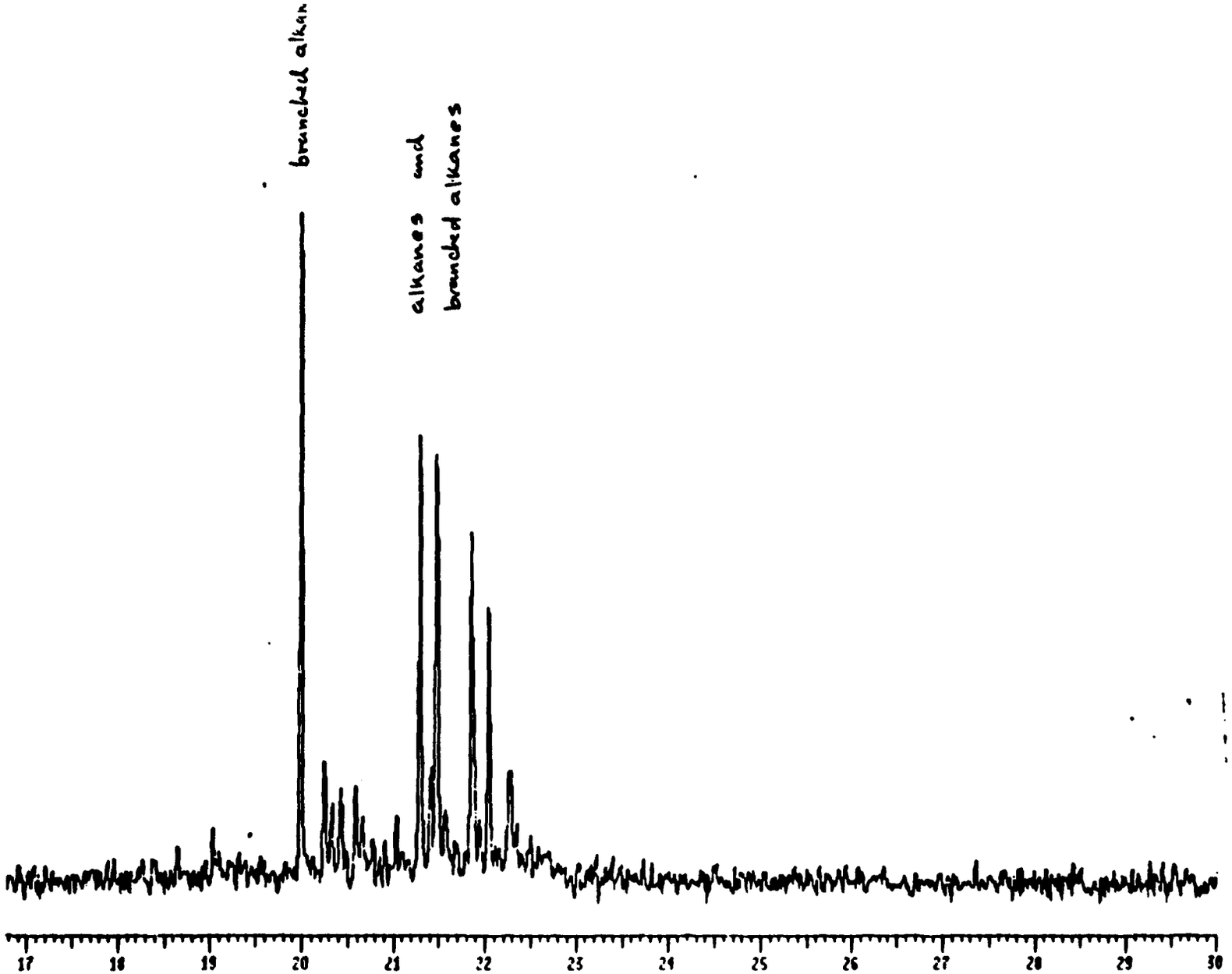


FIGURE H-2 (Continued)

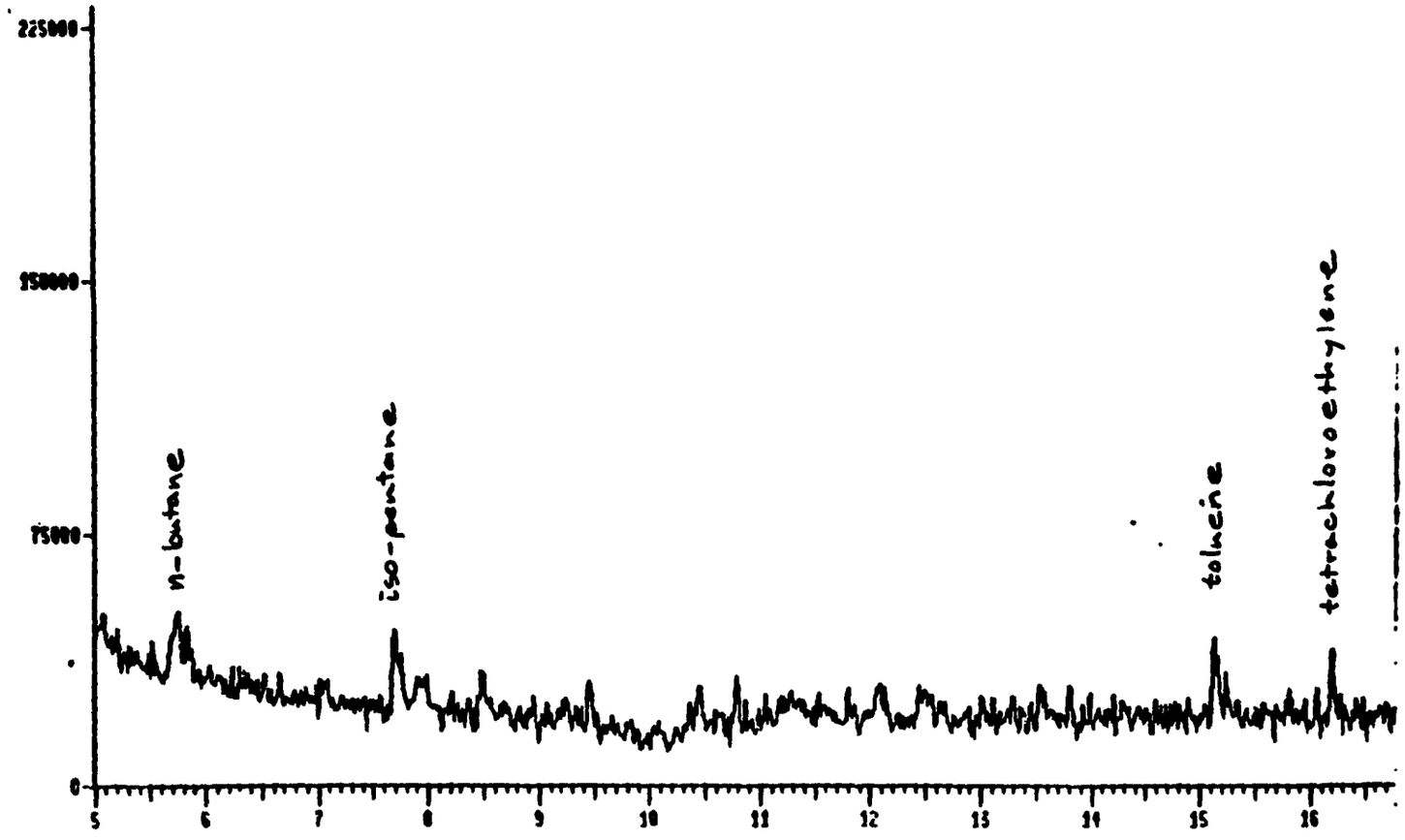


FIGURE H-3 GC/MS CHROMATOGRAM FOR EPA HEADQUARTERS' BUILDINGS SITE 3- BEFORE MONITORING

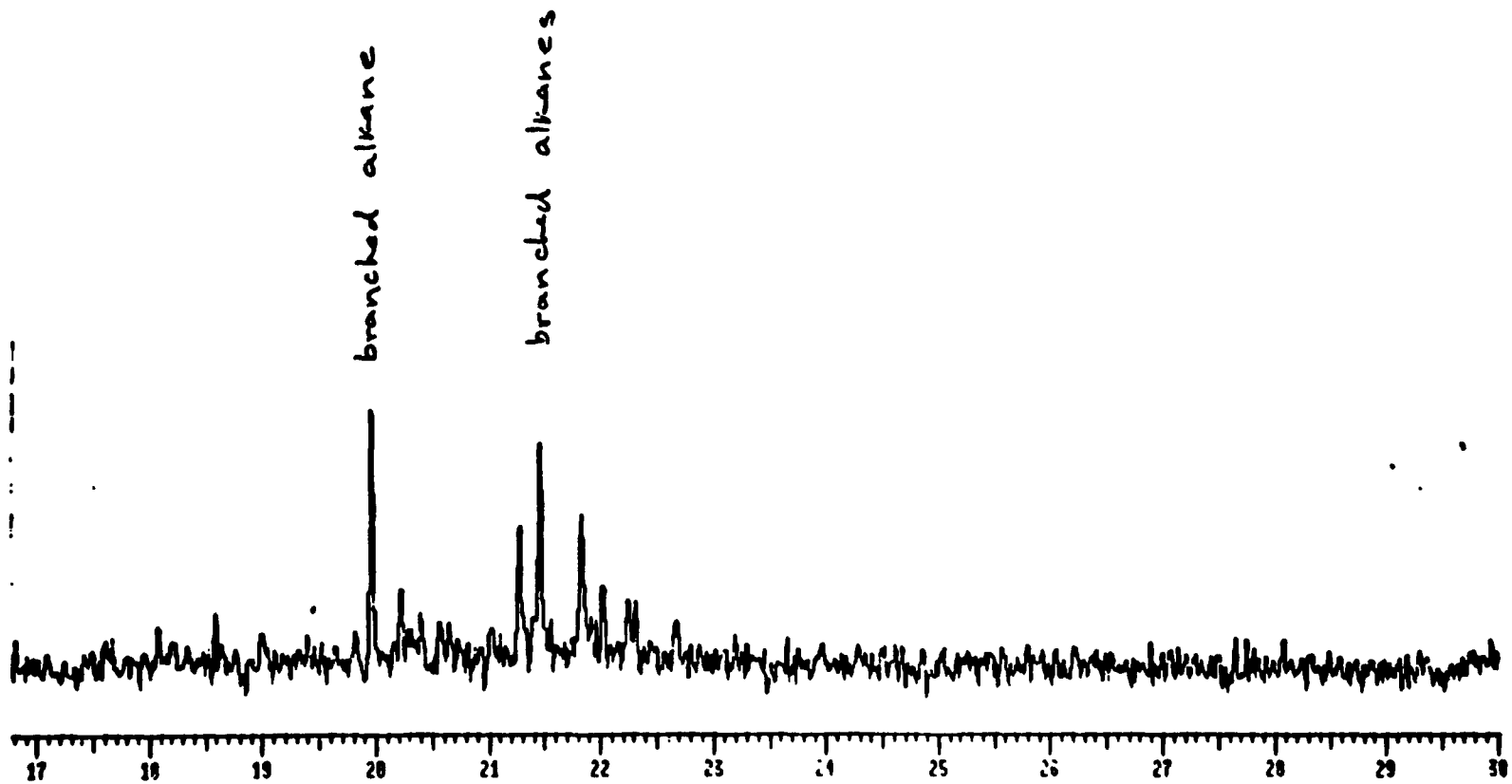


FIGURE H-3 (Continued)

FIGURE H-4 GC/MS CHROMATOGRAM FOR EPA HEADQUARTERS' BUILDINGS BLANK CANISTER - BEFORE MONITORING

FIGURE H-4 (Continued)

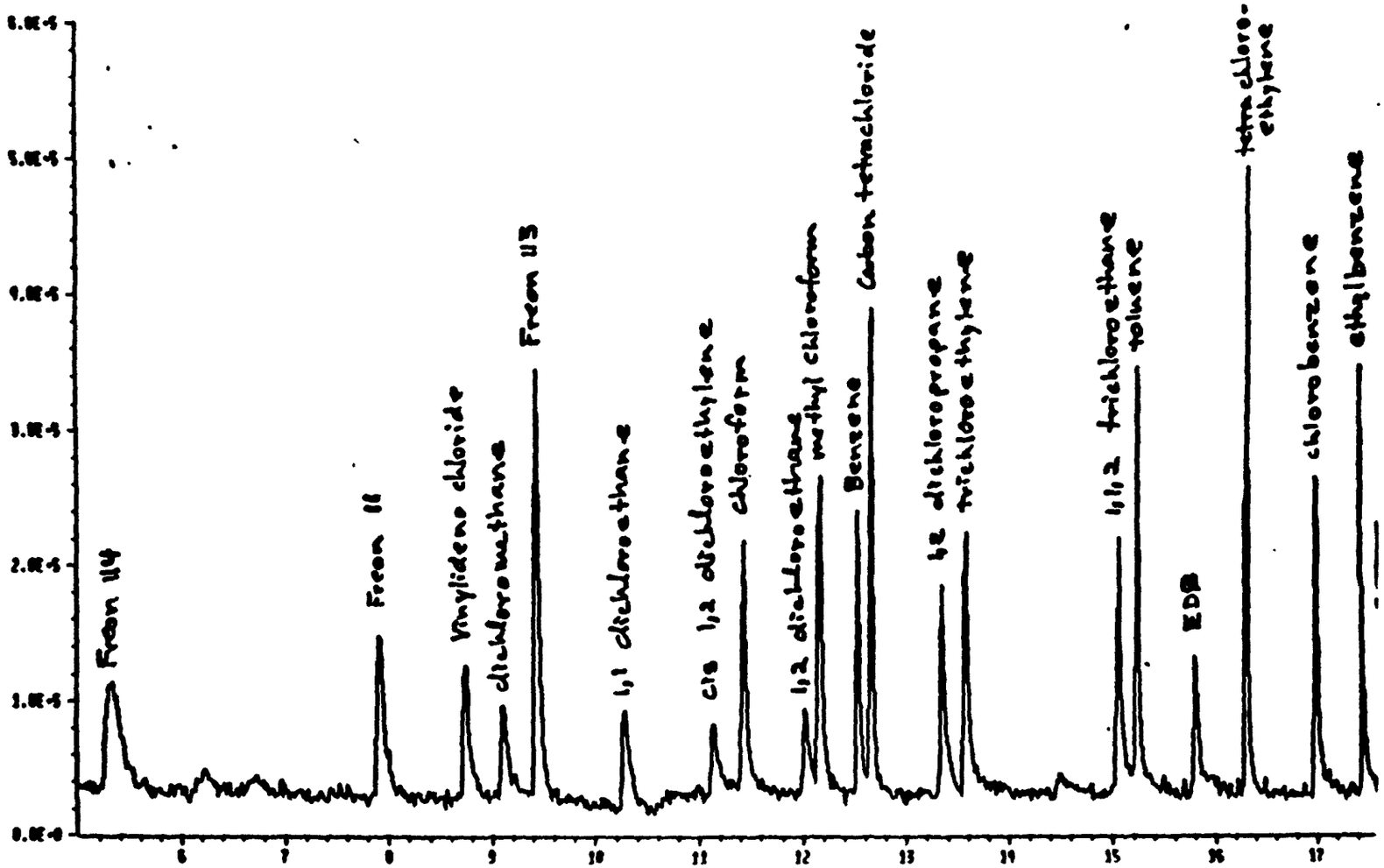


FIGURE H-5 GC/MS CHROMATOGRAM FOR EPA HEADQUARTERS' BUILDINGS CALIBRATION CANISTER - BEFORE MONITORING

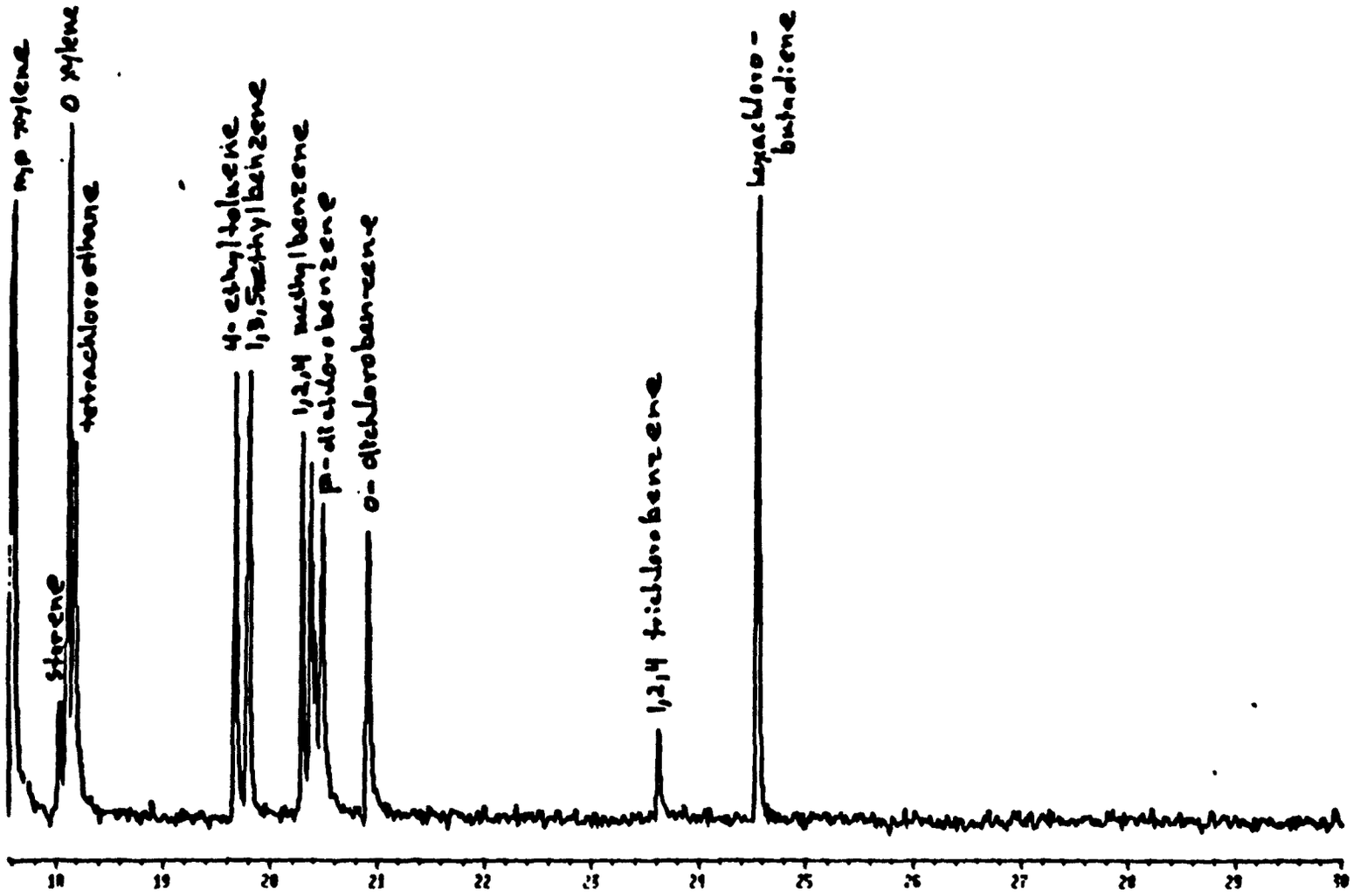


FIGURE H-5 (Continued)

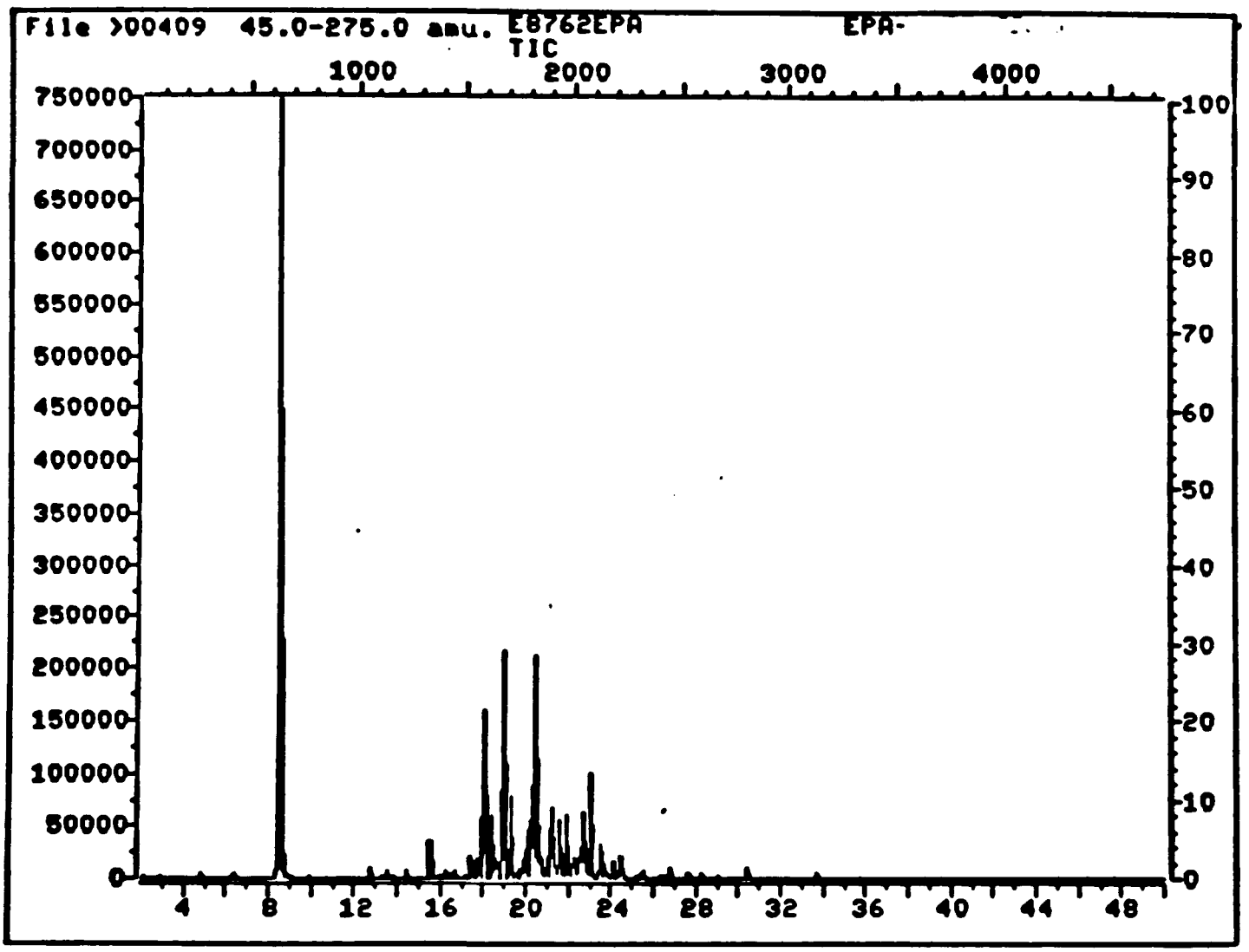


FIGURE H-6 GC/MS CHROMATOGRAM FOR EPA HEADQUARTERS' BUILDINGS SITE 4 - AFTER MONITORING

TABLE H-1. LIST OF VOC COMPOUNDS OBSERVED IN SITE 4 CANISTER

Peak No.	Retention Time (min)	Identification
1	2.03	chlorodifluoromethane
2	2.87	butane
3	4.77	C_5H_{10}
4	6.36	C_5H_8
5	8.43	methylene chloride
6	12.66	1,1,1-trichloroethane
7	12.89	C_7H_{16}
8	13.29	C_7H_{16}
9	13.81	unknown
10	15.80	unknown
11	15.90	C_8H_{18}
12	16.01	C_7H_{14}
13	17.13	unknown
14	13.55	benzene
15	14.42	n-heptane
16	15.47	methylcyclohexane
17	16.25	C_8H_{16}
18	16.61	C_8H_{16}
19	17.34	C_8H_{18}
20	17.70	C_nH_{2n+2}
21	17.97	C_8H_{16}
22	18.32	toluene
23	18.51	C_8H_{16}
24	18.59	C_8H_{16}
25	18.85	C_8H_{18} (prob. octane)
26	19.19	C_8H_{16}
27	19.34	C_9H_{18}
28	19.46	unknown
29	19.63	C_nH_{2n+2} + tetrachloroethylene
30	19.80	C_9H_{20}
31	19.93	hexamethylcyclotrisiloxane

TABLE H-1. (Continued)

Peak No.	Retention Time (min)	Identification
32	20.07	C_9H_{20}
33	20.26	C_9H_{18}
34	20.42	C_8H_{16}
35	20.56	C_9H_{18}
36	21.02	C_9H_{18} or $C_8H_{14}O$
37	21.18	C_9H_{18}
38	21.35	C_9H_{18}
39	21.56	C_9H_{20}
40	21.86	C_9H_{20}
41	21.99	octahydropentalene
42	22.22	C_9H_{18}
43	22.37	C_2-alkyl benzene + C_9H_{18}
44	22.52	C_nH_{2n}
45	22.67	dimethylbenzene + C_9H_{18}
46	22.98	n-nonane
47	23.13	$C_{10}H_{20}$
48	23.48	C_9H_{18}
49	23.62	C_9H_{18}
50	24.05	methyl octahydropentalene isomer
51	24.39	propylcyclohexane
52	25.43	$C_{11}H_{24}$
53	26.81	n-decane
54	27.62	C_3-alkyl benzene
55	28.27	$C_{11}H_{24}$ + $C_{10}H_{20}$
56	30.35	n-undecane
57	33.69	n-dodecane
58	43.45	$C_{14}H_{20}O_2$ (isomer)

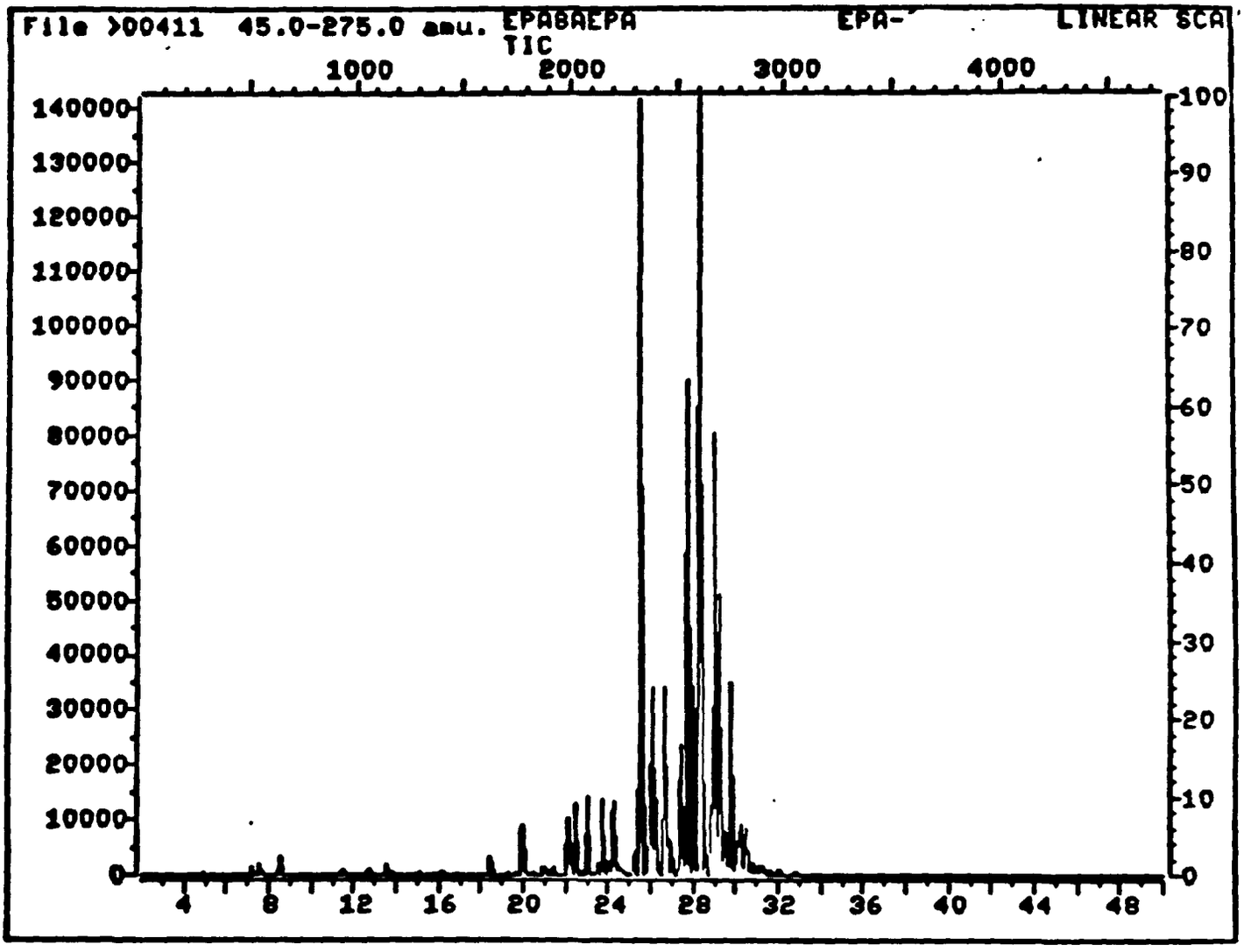


FIGURE H-7 GC/MS CHROMATOGRAM FOR EPA HEADQUARTERS' BUILDINGS SITE 5 - AFTER MONITORING

TABLE H-2 GC/MS CHROMATOGRAM FOR EPA HEADQUARTERS' BUILDINGS SITE 5 - AFTER MONITORING

Peak No.	Retention Time (min)	Identification
1	7.17	unknown (tent. acetone0
2	7.55	unknown
3	8.51	dichloromethane
4	11.38	unknown (tent. C_6H_{14})
5	12.50	unknown
6	12.67	1,1,1-trichloroethane
7	13.56	unknown (tent. benzene)
8	13.82	unknown
9	15.10	unknown
10	16.12	unknown
11	18.34	toluene
12	19.17	unknown (tent. C_nH_{2n+2})
13	19.93	hexamethylcyclotrisiloxane
14	20.93	unknown (tent. C_7H_{16})
15	21.39	unknown (tent. C_8H_{18})
16	22.05	C_nH_{2n+2}
17	22.12	C_nH_{2n+2}
18	22.21	unknown
19	22.41	C_nH_{2n+2} + ethylbenzene
20	22.69	p-xylene
21	22.96	C_nH_{2n+2}
22	23.42	unknown (tent. C_nH_{2n+2})
23	23.50	C_nH_{2n+2}
24	23.67	n-decane
25	23.98	C_nH_{2n+2}
26	24.16	$C_{11}H_{24}$
27	24.33	C_nH_{2n+2}
28	24.46	C_nH_{2n}
29	24.57	unknown (tent. C_nH_{2n+2})
30	25.16	C_nH_{2n+2}
31	25.45	$C_{11}H_{24}$

TABLE H-2 (Continued)

Peak No.	Retention Time (min)	Identification
32	25.86	$C_{11}H_{24}$
33	25.96	C_nH_{2n+2}
34	26.16	C_nH_{2n+2}
35	26.36	$C_{12}H_{26}$
36	26.66	$C_{12}H_{26}$
37	26.78	C_nH_{2n+2}
38	26.95	$C_{11}H_{24}$
39	27.41	C_nH_{2n+2}
40	27.74	C_nH_{2n+2}
41	28.04	$C_{12}H_{26}$
42	28.30	$C_{12}H_{26}$
43	28.54	C_nH_{2n+2}
44	28.77	C_nH_{2n+2}
45	28.89	C_nH_{2n+2}
46	29.02	C_nH_{2n+2}
47	29.22	C_nH_{2n+2}
48	29.39	C_nH_{2n+2}
49	29.50	C_nH_{2n+2}
50	29.73	C_nH_{2n+2}
51	29.94	C_nH_{2n+2}
52	30.08	C_nH_{2n+2}
53	30.41	C_nH_{2n+2}
54	30.75	C_nH_{2n+2}

APPENDIX I

Results of Internal and External Laboratory VOC and Pesticide Quality Assurance Procedures

TABLE I-1. BACKGROUND LEVEL EVALUATION OF CLEANED VOC CANISTERS (μg/m3)

	LOD (ng/L)	Canister Code					Mean BKGD	Range
		RTI 01483	RTI 01477	RTI 01446	RTI 01454	RTI 01478		
Vinyl chloride	2.02	0.0	0.0	0.0	0.0	0.0	0.0	
Vinylidene chloride	0.73	0.0	0.0	0.0	0.0	0.0	0.0	
Methylene chloride	0.32	1.2	0.8	0.6	0.8	0.6	0.2	0.6-1.2
trans-1,2-Dichloroethane	0.15	0.1	0.0	0.0	0.0	0.0	0.1	0.0-0.1
1,1-Dichloroethane	0.20	0.0	0.0	0.0	0.0	0.0	0.0	
cis-1,2-Dichloroethane	0.25	0.0	0.0	0.0	0.2	0.0	0.1	0.0-0.2
Chloroform	0.25	0.1	0.1	0.0	0.1	0.1	0.1	0.0-0.1
1,1,1-Trichloroethane	0.14	0.0	0.0	0.0	0.0	0.0	0.0	
Carbon tetrachloride	1.71	0.0	0.0	0.0	0.0	0.0	0.0	
Benzene	0.96	1.6	1.8	1.8	1.3	1.5	0.2	1.3-1.8
Trichloroethylene	0.18	0.0	0.0	0.0	0.0	0.0	0.0	
Toluene	1.72	0.3	0.3	0.2	0.2	0.2	0.0	0.2-0.3
n-Octane	0.15	0.0	0.0	0.0	0.0	0.0	0.0	
Tetrachloroethylene	0.24	0.3	0.2	0.3	0.2	0.0	0.1	0.0-0.3
1,2-Dibromoethane	0.38	0.0	0.0	0.0	0.0	0.0	0.0	
Chlorobenzene	0.09	0.0	0.0	0.0	0.0	0.0	0.0	
Ethylbenzene	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0
m-Xylene	0.59	0.1	0.1	0.1	0.1	0.1	0.0	0.1-0.1
p-Xylene	0.25	0.1	0.1	0.0	0.0	0.1	0.0	0.0-0.1
Styrene	0.37	0.1	0.0	0.0	0.0	0.0	0.0	0.0-0.1
1,1,2,2-Tetrachloroethane	0.64	0.0	0.0	0.0	0.0	0.0	0.0	
n-Decane	0.70	0.0	0.0	0.0	0.0	0.0	0.0	
m-Dichlorobenzene	0.44	0.0	0.0	0.0	0.0	0.0	0.0	
p-Dichlorobenzene	0.43	0.0	0.0	0.0	0.0	0.0	0.0	
o-Dichlorobenzene	0.54	0.0	0.0	0.0	0.0	0.0	0.0	
n-Dodecane	1.11	0.2	0.0	0.0	0.0	0.4	0.2	0.0-0.4
4-Phenylcyclohexene	1.23	0.0	0.0	0.0	0.0	0.1	0.0	0.0-0.1
Total Target Level	16.03	4.0	3.4	2.9	2.9	3.0	0.4	2.9-4.0

TABLE I-1. BACKGROUND LEVEL EVALUATION OF CLEANED VOC CANISTERS CONTINUED ($\mu g/m^3$)

	LOD (ng/L)	Canister Code									
		EPA 50	EPA 43	EPA 10	EPA 50	EPA 57	EPA 83	EPA 77	EPA 33A	EPA 43	EPA 1276
Vinyl chloride	2.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vinylidene chloride	0.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Methylene chloride	0.32	0.5	0.7	0.6	1.7	0.5	0.6	0.6	0.7	0.7	1.5
trans-1,2-Dichloroethane	0.15	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
1,1-Dichloroethane	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cis-1,2-Dichloroethane	0.25	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Chloroform	0.25	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.6
1,1,1-Trichloroethane	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carbon tetrachloride	1.71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzene	0.96	1.9	1.4	1.5	2.1	2.0	1.8	1.5	1.7	1.4	1.8
Trichloroethylene	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Toluene	1.72	0.1	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.5
n-Octane	0.15	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Tetrachloroethylene	0.24	0.2	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.1
1,2-Dibromomethane	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chlorobenzene	0.09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Ethylbenzene	0.24	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
p-Xylene	0.59	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
o-Xylene	0.25	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Styrene	0.37	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
1,1,2,2-Tetrachloroethane	0.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
n-Decane	0.70	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
m-Dichlorobenzene	0.44	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
p-Dichlorobenzene	0.43	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
o-Dichlorobenzene	0.54	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0
n-Dodecane	1.11	1.3	1.3	0.0	0.0	0.0	0.0	0.2	1.9	1.3	0.0
4-Phenylcyclohexene	1.23	0.4	0.8	0.1	0.0	0.1	0.0	0.0	1.2	0.8	0.0
Total Target Level	16.03	6.5	5.5	2.9	4.4	3.0	2.9	2.8	6.0	5.5	4.5

TABLE I-1. BACKGROUND LEVEL EVALUATION OF CLEANED VOC CANISTERS ($\mu g/m^3$) CONTINUED

		Canister Code								
	LOD (ng/L)	EPA 1265	EPA 37	EPA 1265	EPA 19	EPA 8917	EPA 1478	EPA 8917	EPA 5A	EPA 8710
Vinyl chloride	2.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vinylidene chloride	0.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Methylene chloride	0.32	0.7	0.6	0.5	0.6	0.5	0.7	0.6	0.8	0.6
trans-1,2-Dichloroethane	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1,1-Dichloroethane	0.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cis-1,2-Dichloroethane	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloroform	0.25	0.2	0.1	0.1	0.2	0.0	0.5	0.0	0.5	0.1
1,1,1-Trichloroethane	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carbon tetrachloride	1.71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzene	0.96	1.7	1.6	1.7	1.8	1.7	1.8	1.6	1.8	1.7
Trichloroethylene	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Toluene	1.72	0.3	0.2	0.2	0.2	0.4	0.2	0.3	0.2	0.3
n-Octane	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tetrachloroethylene	0.24	0.1	0.2	0.1	0.3	0.3	0.0	0.2	0.0	0.0
1,2-Dibromoethane	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chlorobenzene	0.09	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Ethylbenzene	0.24	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0
m-Xylene	0.59	0.1	0.0	0.0	0.2	0.2	0.1	0.2	0.1	0.2
p-Xylene	0.25	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.1
Styrene	0.37	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1
1,1,2,2-Tetrachloroethane	0.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
n-Decane	0.70	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
o-Dichlorobenzene	0.44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
m-Dichlorobenzene	0.43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
p-Dichlorobenzene	0.54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
n-Dodecane	1.11	0.0	0.0	0.0	0.2	0.4	0.0	0.3	0.0	0.0
4-Phenylcyclohexene	1.23	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Total Target Level	16.03	3.8	3.0	2.6	3.4	3.8	3.4	3.4	3.6	3.3

TABLE I-1. BACKGROUND LEVEL EVALUATION OF CLEANED VOC CANISTERS ($\mu g/m^3$) CONTINUED

	LOD (ng/L)	EPA 8754	EPA 2073	EPA 8719	Mean BKGD	Range
Vinyl chloride	2.02	0.0	0.0	0.0	0.0	
Vinylidene chloride	0.73	0.0	0.0	0.0	0.0	
Methylene chloride	0.32	1.0	0.0	0.4	0.3	0.0 - 1.7
trans-1,2-Dichloroethene	0.15	0.0	0.0	0.0	0.0	
1,1-Dichloroethane	0.20	0.0	0.0	0.0	0.0	
cis-1,2-Dichloroethene	0.25	0.0	0.0	0.0	0.0	
Chloroform	0.25	0.0	0.1	0.1	0.2	0.0 - 0.6
1,1,1-Trichloroethane	0.14	0.0	0.0	0.0	0.0	
Carbon tetrachloride	1.71	0.0	0.0	0.0	0.0	
Benzene	0.96	2.1	35.0	0.9	13.4	0.9 - 35.
Trichloroethylene	0.18	0.0	0.0	0.0	0.0	
Toluene	1.72	0.2	0.5	0.1	0.1	0.1 - 0.5
n-Octane	0.15	0.0	0.3	0.0	0.1	0.0 - 0.3
Tetrachloroethylene	0.24	0.0	0.2	0.0	0.1	0.0 - 0.3
1,2-Dibromomethane	0.38	0.0	0.0	0.0	0.0	
Chlorobenzene	0.09	0.0	0.0	0.0	0.0	0.0 - 0.1
Ethylbenzene	0.24	0.0	0.0	0.0	0.0	0.0 - 0.1
p-Xylene	0.59	0.1	0.0	0.1	0.1	0.0 - 0.2
o-Xylene	0.25	0.0	0.0	0.0	0.0	0.0 - 0.1
Styrene	0.37	0.0	0.0	0.0	0.0	0.0 - 0.1
1,1,2,2-Tetrachloroethane	0.64	0.0	0.0	0.0	0.0	
n-Decane	0.70	0.0	0.0	0.0	0.0	
m-Dichlorobenzene	0.44	0.0	0.0	0.0	0.0	
p-Dichlorobenzene	0.43	0.0	0.0	0.0	0.0	
o-Dichlorobenzene	0.54	0.0	0.0	0.0	0.0	
n-Dodecane	1.11	0.0	0.0	0.0	0.0	
4-Phenylcyclohexene	1.23	0.1	0.0	0.0	0.1	0.0 - 1.2
Total Target Level	16.03	3.6	36.1	1.5	13.3	1.5 - 36.

TABLE I-2. RESULTS OF ANALYSIS OF CANISTER FIELD BLANKS ($\mu g/m^3$)

Target Compound	FB1	FB2	FB3	FB4	FB5	FB6	FB7	Mean Blank
Vinyl chloride	0.00[a]	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vinylidene chloride	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methylene chloride	0.55	0.36	0.63	0.74	0.32	0.26	0.46	0.47
trans-1,2-Dichloroethylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,1-Dichloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cis-1,2-Dichloroethylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chloroform	0.18	0.19	0.10	0.43	0.10	0.00	0.21	0.17
1,1,1-Trichloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon tetrachloride	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Benzene	2.49	0.64	0.74	1.02	1.91	1.19	3.70	1.67
Trichloroethylene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.38	0.24	0.22	0.30	0.48	0.69	0.87	0.45
n-Octane	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.01
Tetrachloroethylene	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.04
1,2-Dibromoethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chlorobenzene	0.02	0.00	0.03	0.06	0.12	0.07	0.25	0.08
Ethylbenzene	0.03	0.00	0.04	0.04	0.12	0.10	0.25	0.08
p-Xylene	0.04	0.00	0.07	0.04	0.07	0.26	0.21	0.10
m-Xylene	0.03	0.00	0.05	0.03	0.05	0.09	0.12	0.05
Styrene	0.00	0.00	0.00	0.00	0.10	0.00	0.04	0.02
1,1,2,2-Tetrachloroethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-Decane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
m-Dichlorobenzene	0.21	0.17	0.00	0.00	0.00	0.00	0.00	0.05
p-Dichlorobenzene	0.23	0.12	0.00	0.00	0.00	0.00	0.00	0.05
o-Dichlorobenzene	0.37	0.36	0.00	0.00	0.00	0.00	0.00	0.10
n-Dodecane	3.45	3.05	0.75	0.49	0.09	0.25	0.26	1.19
4-Phenylcyclohexene	0.98	0.95	0.37	0.28	0.20	0.17	0.19	0.45

[a]0.00 = No measurable peak area.

TABLE I-3. RECOVERY OF TARGET COMPOUNDS FROM FIELD CONTROL CANISTERS ($\mu g/m^3$)

	Percent Recovery, Corrected for Background								
Target Compound	FC1	FC2	FC3	FC4	FC5	FC6	FC7	Mean	%RSD
Vinyl chloride	72	74	70	55	73	74	67	69	8.8
Vinylidene chloride	102	103	106	110	108	115	99	106	4.7
Methylene chloride	92	89	95	106	92	100	97	96	5.6
trans-1,2-Dichloroethylene	100	106	108	115	109	114	97	107	5.9
1,1-Dichloroethane	102	102	102	102	102	106	94	102	3.3
cis-1,2-Dichloroethylene	104	108	103	105	107	113	99	106	4.0
Chloroform	92	98	96	101	98	102	92	97	4.0
1,1,1-Trichloroethane	96	102	100	100	99	109	94	100	4.5
Carbon tetrachloride	105	71	108	103	0	0	110	71	65.6
Benzene	105	93	98	91	95	100	89	96	5.5
Trichloroethylene	102	106	101	104	106	113	93	104	5.2
Toluene	97	98	106	100	99	103	93	99	3.7
n-Octane	104	100	104	104	104	107	96	103	3.3
Tetrachloroethylene	100	115	104	102	100	112	100	105	5.6
1,2-Dibromoethane	107	114	114	117	110	118	115	113	3.2
Chlorobenzene	103	109	107	108	103	109	99	105	3.2
Ethylbenzene	111	109	108	111	108	110	102	108	2.7
p-Xylene	108	105	105	108	107	110	99	106	3.2
o-Xylene	117	113	109	109	107	110	102	110	4.1
Styrene	107	95	57	107	115	118	102	100	19.1
1,1,2,2-Tetrachloroethane	111	111	106	103	100	108	101	106	4.0
n-Decane	208	170	97	115	111	106	97	129	30.7
m-Dichlorobenzene	182	157	124	138	114	117	107	134	18.7
p-Dichlorobenzene	176	150	126	128	117	119	117	133	15.2
o-Dichlorobenzene	190	161	115	122	109	113	109	131	22.3
n-Dodecane	171	145	6	70	92	69	50	86	60.3
4-Phenylcyclohexene	28	25	-1	29	64	28	16	27	66.7

TABLE I-4. PERCENT RELATIVE STANDARD DEVIATION FOR DUPLICATE CANISTER ANALYSIS

	Samples		Field Controls		Field Blanks	
	N[a]	Mean %RSD	N[a]	Mean %RSD	N[b]	Mean %RSD
Vinyl chloride	-[c]	-	3	6.6	-	-
Vinylidene chloride	-	-	3	3.1	-	-
Methylene chloride	8	9.3	3	6.9	3	61.5
trans-1,2-Dichloroethane	-	-	3	4.9	-	-
1,1-Dichloroethane	-	-	3	5.7	-	-
cis-1,2-Dichloroethene	-	-	3	1.9	-	-
Chloroform	-	-	3	3.6	3	12.7
1,1,1-Trichloroethane	11	2.4	3	3.5	-	-
Carbon tetrachloride	-	-	2	5.8	-	-
Benzene	1	8.2	3	7.7	2	60.0
Trichloroethylene	1	5.4	3	2.0	-	-
Toluene	9	2.2	2	10.2	2	51.6
n-Octane	4	2.1	3	2.4	-	-
Tetrachloroethylene	11	4.5	3	11.1	-	-
1,2-Dibromoethane	-	-	3	7.9	-	-
Chlorobenzene	-	-	3	6.4	1	15.7
Ethylbenzene	10	3.2	3	2.9	1	0
p-Xylene	11	3.4	3	2.7	2	28.2
o-Xylene	11	3.1	3	2.6	2	29.5
Styrene	-	-	3	8.4	1	7.4
1,1,2,2-Tetrachloroethane	-	-	3	4.7	-	-
n-Decane	2	4.3	3	4.5	-	-
m-Dichlorobenzene	-	-	3	12.4	1	28.3
p-Dichlorobenzene	-	-	3	14.0	-	-

TABLE I-4. PERCENT RELATIVE STANDARD DEVIATION FOR DUPLICATE CANISTER ANALYSIS CONTINUED

	Samples		Field Controls		Field Blanks	
	N[a]	Mean %RSD	N[a]	Mean %RSD	N[b]	Mean %RSD
o-Dichlorobenzene	-	-	3	13.5	2	12.6
n-Dodecane	-	-	3	13.5	3	41.4
4-Phenylcyclohexene	-	-	3	63.6	3	46.8

[a]N = Number of pairs where both have measurable data.

[b]N = Number of pairs where both values are greater than 0.00

[c]- = One or both values of pair below quantifiable limit (samples, controls); one or both values 0.00 (blanks).

TABLE I-5. RESULTS OF ANALYSIS OF EXTERNAL PERFORMANCE EVALUATION VOC SAMPLES

Target Compound	Amount Spiked, ppb			
	1000 8788	8800 8711	8740 8763	8734
Vinyl chloride	4.2	3.1	1.7	2.5
Chloroform	4.0	3.0	1.6	2.4
Carbon tetrachloride	3.9	3.0	1.6	2.4
Methylene chloride	3.5	2.6	1.4	2.1
1,2-Dichloroethane	4.2	3.2	1.7	2.5
Trichloroethylene	4.4	3.3	1.8	2.6
Benzene	4.3	3.2	1.7	2.6
Tetrachloroethylene	4.5	3.4	1.8	2.7
Bromomethane	3.7	2.8	1.5	2.2
Trichlorofluoromethane	3.8	2.9	1.5	2.3
1,1,1-Trichloroethane	4.2	3.2	1.7	2.5
1,2-Dichloropropane	4.2	3.2	1.7	2.5
1,2-Dibromoethane	4.1	3.1	1.6	2.4
Toluene	4.4	3.3	1.7	2.6
Chlorobenzene	4.4	3.3	1.8	2.6
Ethylbenzene	4.0	3.0	1.6	2.4
o-Xylene	4.0	3.0	1.6	2.4

TABLE I-5. RESULTS OF ANALYSIS OF EXTERNAL PERFORMANCE EVALUATION VOC SAMPLES CONTINUED

	Results, Expressed as % Bias[a]						
Target Compound	1000	8788	8800	8711	8740	8763	8734
Vinyl chloride	-76	-55	-58	-45	-53	-29	-48
Chloroform	-15	-18	-17	-13	-12	-12	-12
Carbon tetrachloride	2.6	2.6	0.0	6.7	12	6.2	0.0
Methylene chloride	-5.7	-5.7	0.0	7.7	14	7.1	9.5
Trichloroethylene	-20	-23	-24	-18	-22	-22	-23
Benzene	-26	-19	-16	-16	-29	-18	-15
Tetrachloroethylene	-20	-24	-35	-21	-5.6	-17	-30
1,1,1-Trichloroethane	-21	-19	-22	-19	-12	-18	-16
1,2-Dibromoethane	-24	-24	-32	-26	-19	-25	-25
Toluene	-18	-23	-24	-21	-18	-18	-19
Chlorobenzene	-25	-25	-33	-27	-28	-28	-31
Ethylbenzene	-22	-25	-30	-20	-19	-25	-17
o-Xylene	-18	-20	-23	-20	-19	-19	-21

[a] $\%\text{Bias} = \frac{\text{Amount Spiked} - \text{Amount Found}}{\text{Amount Spiked}} \times 100$

TABLE I-6. PESTICIDE MATRIX SPIKE RECOVERY DATA

EXTRACTION DATE (MS-1): 03/08/89
(MS-2): 03/14/89

OCN RECOVERIES (MS-1): 98 %
(MS-2): 107%

COMPOUND	SPIKE LEVEL (ng/plug)	CONC. MS-1	% RECOVERY	CONC. MS-2	% RECOVERY	Rel. % Diff.
ALPHA-BHC	100	76.3	76	70.3	70	8
HEXACHLOROBENZENE	150	152.7	102	148.6	99	3
HEPTACHLOR	200	189.4	95	175.9	88	7
CHLORPYRIFOS	1000	838.3	84	795.7	80	5
DIELDRIN	200	190	95	181.4	91	5
PROPOXUR *	2500	2300	92	2000	80	14
DIAZINON *	2500	2500	100	1600	64	44