SEMI-ANNUAL TECHNICAL PROGRESS REPORT

CONTRACT TITLE AND NUMBER	**OCTOBER 1, 2000**
Ambient $PM_{2.5}$ Sampling and Analysis	**REPORT NO:** 1
DE-AC26-98FT40456	**REPORT PERIOD:** 04/01/00-09/30/00
	ATS PROJECT NO.: 98-839-P

CONTRACTOR NAME:

Advanced Technology Systems, Inc.
639 Alpha Drive - RIDC Park
Pittsburgh, PA 15238-2819

CONTRACT PERIOD: October 1, 1998 through September 30, 2002

1 INTRODUCTION

This report summarizes observations and tentative conclusions drawn from evaluations of the data captured to date from the operation of the ambient $PM_{2.5}$ speciation sites in a geographical area encompassing southeastern Ohio, western Pennsylvania, and northwestern West Virginia. The overall goal of this program, called the *Upper Ohio River Valley Project* (UORVP), is to better understand the relationship between coal-based power system emissions and ambient air quality in the upper Ohio River Valley region through the collection of chemically resolved or speciated data.

Background

The U.S. electric-utility industry has made considerable strides in reducing emissions of SO_2, NO_X, and particulates since passage of the 1970 Clean Air Act and its subsequent amendments. For example, full implementation of Title IV of the 1990 Clean Air Act Amendments will result in an annual cap on power plant SO_2 emissions of 8.9 million tons, down from a 1990 baseline level of over 14.5 million tons. In addition, NO_X emissions during Phase I of Title IV were targeted to be reduced by 400,000 tons/yr between 1996 and 1999, whilst for Phase II the goal was for further reduction in emissions by another 1.2 million tons/year. Finally, the installation of controls on essentially the entire fleet of coal-fired boilers caused a dramatic decrease in primary particulate emissions. Particulate emissions in 1990 were less than 430,000 tons/year, compared with early-1970 emission levels that exceeded three million tons/year. However, despite such successes, emissions from coal-fired power plants continue to be targeted for further reductions in light of concerns about fine particulates, ozone, acidification, air toxics, and other environmental issues.

On July 17, 1997, the U.S. Environmental Protection Agency (EPA) revised the National Ambient Air Quality Standards (NAAQS) to address ambient air concentrations of particulate matter with an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$). The new $PM_{2.5}$ standard establishes a 24-hour average concentration limit of 65 ug/M^3 and an annual mean concentration limit of 15 ug/M^3 to protect human health from both chronic and acute effects associated with the respiration of fine particulate matter. EPA Administrator Carol Browner has stated that the promulgation of the new $PM_{2.5}$ standard, together with a revised ozone NAAQS, is "...one of the most important decisions I will make to protect public health in this country." The EPA also proposed regional haze regulations on July 31, 1997 focused on the impact of $PM_{2.5}$ on visibility impairment in Class I ("pristine") areas of the United States. More recently, EPA has announced a proposed air toxics monitoring program aimed at characterizing urban air toxic problems.

Ambient fine particulate matter originates from a wide variety of emission sources, both man-made and natural. The combustion of coal to generate electricity can produce primary $PM_{2.5}$ (e.g., fly ash, carbon soot, associated trace metals), the gaseous precursors (e.g., SO_2 and NO_X) to the formation of secondary fine particles (e.g., ammonium sulfates and nitrates), and condensible species (e.g., H_2SO_4). However, there remain numerous uncertainties regarding the linkage between coal-fired boiler emissions and the visibility and health-related impacts that have been associated with ambient fine particulates. Moreover, a recently released report by the National Academy of Sciences (NAS) recommends that there is a high-priority need to develop a better understanding of the relationship between actual personal exposure to fine particulate matter and the ambient concentrations of $PM_{2.5}$ measured at stationary outdoor monitors. In addition, the NAS recommends that these stationary monitoring efforts focus on the chemical speciation of ambient $PM_{2.5}$ to help elucidate the biologically important components and characteristics of ambient fine particulate matter.

The Fiscal Year 1998 Congressional appropriations called for the U.S. Department of Energy's Office of Fossil Energy (DOE-FE) to initiate a research program to address these technical and scientific issues from the standpoint of the potential impacts of the new standards on coal-based power systems. The overall goal of the program is to ensure that sound science and technology is available for regulatory-decision making related to the potential health and environmental impacts of ambient fine-particulate matter. This goal will be achieved through a well-focused, highly-leveraged research program that includes ambient air quality monitoring, atmospheric chemistry and pollutant formation and transport studies, source emissions characterization, and cost-effective control technology development. Where opportunities for synergism exist, the program will also address other ambient air quality issues such as ground-level ozone, mercury deposition and the impact of fine particulate matter on climate change.

The Upper Ohio River Valley Project

The fine particulate NAAQS calls for the EPA and the States to establish a nationwide network of 1,500 $PM_{2.5}$ monitoring stations starting in late 1998. The primary objective of this monitoring effort is to identify those areas of the United States that are in attainment or are not in attainment with the new standard. However, it is intended that a small, but critical, subset of these sites, will sample for a broader array of chemical species on more frequent sampling intervals to address the rigorous demands involved in air quality assessments. As part of its ambient fine particulate program, the U.S. Department of Energy's National Energy Technology Laboratory (DOE-NETL), in cooperation with key stakeholders including EPA, local and state environmental agencies, industry, and academia, has established and is operating several $PM_{2.5}$ speciation sites in the Upper Ohio River Valley.

The Upper Ohio River Valley (UORV) was chosen for this extensive fine particulate research because it mirrors an area in the eastern half of the continental United States that is not well characterized but has a high density of coal-fired electric utility, heavy industry (e.g, coke and steel making), light industry, and transportation emission sources. The UORV is also in the center of the ozone transport region which provides a platform to study interstate pollution transport issues. This region, with its unique topography (hills and river valleys) as well as a good mix of urban and rural areas, has a high population of elderly who are susceptible to health impacts of fine particulate as well as other related environmental issues (e.g., acid rain, Hg deposition, ozone). Strong local and state programs, and an excellent regional research/university system as well as world-class medical research facilities were also considered in locating this important fine particulate research program especially if subsequent health effect studies are contemplated.

Advanced Technology Systems, Inc. (ATS), with Desert Research Institute (DRI) as the subcontractor, was contracted by the U.S. Department of Energy-National Energy Technology Laboratory (NETL) in September 1998 to manage the *Upper Ohio River Valley Project* (UORVP). The location of the monitoring sites along with neighboring coal-fired plants are as shown in the map.

Two urban and two rural monitoring sites are included in the UORVP. The four sites selected were all part of existing local and/or state air quality programs. One urban site is located in the Lawrenceville section of Pittsburgh, Pennsylvania. This site is an air quality monitoring station operated by the Allegheny County Health Department. A second urban site is collocated at a West Virginia Division of Environmental Protection (WVDEP) monitoring station at the Morgantown, West Virginia airport. One rural site is collocated with the Pennsylvania Department of Environmental Protection (PADEP) at a former NARSTO-Northeast site near Holbrook, Greene County, Pennsylvania. The other rural site is collocated at a site operated by the Ohio Environmental Protection Agency (OHEPA) and managed by the Ohio State Forestry Division in Gifford State Forest near Athens, Ohio.

Project Goal and Objectives

The ***overall goal*** of this project is to investigate the ***nature and composition of fine particulate ($PM_{2.5}$)*** and its precursor gases in the Upper Ohio River valley. In the process, the UORVP will address the following ***four key scientific questions*** related to ambient fine particulate matter:

1. Are sulfates a major or minor component of Eastern $PM_{2.5}$ mass?

2. Is there a correlation between O_3 and $PM_{2.5}$ levels?

3. Is there a significant variation in $PM_{2.5}$ composition/concentration between urban and rural sites impacted by similar regional emission sources?

4. Does FRM performance provide an accurate/realistic measurement of $PM_{2.5}$ mass? (What, if any, are the influence of artifacts on measurement?)

2 EXPERIMENTAL

Overall field efforts are focused on the characterization of the chemistry of ground level urban and rural airborne particles in the Upper Ohio River Valley using measurements describing spatial and temporal variations with consideration of the production of condensed species from tropospheric reactions for at least a two-year period.

Experimental Plan

The experimental plan has been constructed to answer the major scientific questions stated above while the selection of sampling equipment and the design of the sampling schedule have been targeted to facilitate execution of the following aspects of the experimental plan:

X Compare the performance of the Federal Reference Method (FRM) for the sampling of aerosol particles over different size ranges equal to or less than 10 microns in diameter with other methods designed to account for semi-volatile components of the ambient aerosol.

X Correlate the measurement of particles with observations of ambient oxidizing or reducing gases in the Upper Ohio River Valley area to elucidate relationships between particulate characteristics and gaseous oxidizing/reducing agent producing processes under a range of meteorological and chemical conditions.

X Conduct sampling and chemical analysis of airborne particles of a sufficient number of different size ranges in order to estimate by receptor modeling the contribution of local and regional sources to ambient particulate matter with special emphasis on fine particle pollution from energy production and use of fossil fuels.

X Conduct a series of special measurements to characterize the importance of secondary production of condensed sulfur and nitrogen species (including sulfuric acid, ammonium sulfate and organic nitrates) and secondary organic species formation resulting from the accumulation of airborne sulfate and primary carbon species.

X Conduct a measurement program at ground level to establish linkages between ozone concentrations and airborne particle concentration variations.

X Conduct sufficient sampling and chemical analyses of airborne particles at both urban and rural site to establish the impact of local and regional sources.

Sampling Equipment

Table 1 presents a list of the general types of filter samplers, meteorological instruments and continuous gas monitors with sampling frequency specified as either continuous or intermittent. Tables 2 and 3 give the specific equipment utilized at each site.

To provide for comparability with stations to be set up as part of the national $PM_{2.5}$ monitoring network, the basic sampling is being conducted using $PM_{2.5}$ sequential filter-based samplers (FRM as well as DRI-SFSs). In addition, PM_{10} sequential samplers (DRI-SFSs) were installed at the Lawrenceville and Holbrook sites. The UORVP sampling protocol allows for a comparison of the PM_{10} and $PM_{2.5}$ mass and chemistry, but the emphasis of the project is on the $PM_{2.5}$ component.

The $PM_{2.5}$ samplers will also be compared with $PM_{2.5}$ monitors that will capture the semi-volatile components (e.g., semi-volatile organics and nitrates) of the aerosol, such as those that employ denuders and/or back-up filters. The comparison between the semi-volatile samplers and the FRM-based samplers will allow for a better understanding of the potential loss or gain in chemical components during ambient sampling. Moreover, speciation samplers that capture the semi-volatile species are necessary for complete characterization of ambient fine particulate matter.

The measurement of several gases that are relevant to characterizing photochemistry, or are precursors for particle formation, are also being measured. These include ozone and its precursors (NO_X, HNO_3, and NH_3) as well as sulfur dioxide (SO_2). Measurement of ambient mercury is also being carried out using a “mercury deposition network” sampler but solely at the Holbrook site.

Met-One speciation samplers (SASS) have also been installed and are operational at two sites (Lawrenceville, PA and Athens, OH). The selection of the SASS was based to a large degree on guidance provided by EPA regarding $PM_{2.5}$ speciation monitoring and the most recent equipment comparative studies conducted by the same. The SASS units have the advantage that each “canister” (filter holder) can contain a denuder followed by two in-series filters. Thus, this provides the same capabilities as the DRI Sequential Gas Samplers (SGSs).

Table 4 provides specific information on filter materials, the analytes and the analytical methods employed for the sampling and analysis effort utilizing discrete filter samplers.

Along with the discrete filter-based samplers used for intermittent sampling, continuous $PM_{2.5}$ mass measuring instruments are in operation at the Lawrenceville and Holbrook sites. Rupprecht and Patashnick (R&P) Company Tapered Element Oscillating Mass (TEOM) Balances provide continuous mass measurements of $PM_{2.5}$ and PM_{10}. Advantages in using TEOMs include being able to observe ambient particulate matter on a 24-hour per day and 7-day per week basis during non-intensive sampling periods in which filter-based units are collecting samples in only one out of every six days. Also, data resulting from the use of these units may be compared to the FRM results and those from the other filter-based instruments. Continuous measurement of $PM_{2.5}$ is expected to be a powerful adjunct to intermittent filter-based sampling.

Surface meteorological data are being collected at the Lawrenceville and Holbrook sites. Wind speed and direction, temperature, barometric pressure, relative humidity, precipitation and solar radiation sensors are operational at Lawrenceville while wind speed and direction, and temperature data are being collected at Holbrook.

Sampling and Analysis Schedule

The UORVP is arranged to obtain a base level of intermittent samples every sixth day at all the four sites. This will allow for estimates of monthly, seasonal, and annual averages that can be compared with data obtained from other EPA/state programs and with other parallel research projects in the eastern United States. To investigate the differences between months of high production of secondary particulates from atmospheric reactions, one month in the summer (1999) was used for sampling every day, with $PM_{2.5}$ material obtained on a 6-hour schedule to evaluate episodal and diurnal variations in sample composition. Sampling for particulate (ammonium) nitrate and gaseous nitrogen species, as well as ammonia, will provide data to investigate the apparent low nitrate levels found in eastern $PM_{2.5}$ catches.

For comparison with summer conditions, a one-month daily sampling period, referred to as an “intensive sampling program” or simply as an “intensive,” was performed in February, 1999 and another was carried out in mid-Winter 2000. Cool temperature conditions and low biological activity may create a trade off for ammonium nitrate production that differs from the summer months. Any sulfate production is likely to derive from minimal photochemical activity during winter, and secondary organic material is expected to be absent from particles at this time. The mid-winter particulate sampling program followed the summer sampling protocol. An intensive is projected for Summer 2000, and in lieu of Winter 2000, another is planed for Summer 2001.

Sampling commenced with intensive sampling (Winter 1999 session) at the Lawrenceville and Holbrook sites from February 17 to February 28, 1999. Intermittent sampling (every sixth day) has continued at these two sites subsequent to the intensive sampling. Intensive sampling (summer 1999 session) occurred at all the four sites from August 3 through September 12, 1999. Six-hour samples were collected daily at Lawrenceville, daily 24-hr integrated samples at Holbrook and 24-hr. integrated samples every 3rd day at the Morgantown and Athens sites. The same sampling protocol was carried out at the four sites during Winter 2000 beginning on January 12 and ending on February

18, 2000.

Quality Assurance and Quality Control

ATS is implementing the quality assurance and quality control (QA/QC) procedures and methods described in the Quality Integrated Work Plan (QIWP) for the UORVP sites. Specifically, ATS is responsible for the collection and storing of samples for subsequent chemical analysis and for the calibration and maintenance of the sampling equipment and instrumentation. ATS has overall responsibility for the analysis of samples collected at all the UORVP sites. ATS contracted DRI to analyze the collected samples following the guidance documented elsewhere. Quality assurance/quality control documentation includes filter preparation, sample collection, sample handling, sample splitting, and sample storage and transport, and sample analysis.

3 RESULTS AND DISCUSSION

The data presented below reflects the efforts from both continuous particulate measurements as well as those from discrete filter sampling monitoring. As much as was possible, comparisons were drawn between the two sampling methodologies in addition to noting observed similarities or differences between the rural and urban sites. Also of interest, at least at the initial phase of this study, were comparisons between $PM_{2.5}$ and PM_{10} levels.

Plotted in Figure 1 are $PM_{2.5}$ half-hour averages of continuous measurements obtained using the Tapered Element Oscillating Mass (TEOM) Balances from June 1, 1999 through September 9, 1999. For clarity, the individual points are not shown; only the connecting lines are presented in this figure. Data from the Lawrenceville site are shown in red, and data from the Holbrook site are given in green. It should be noted that approximately two weeks of data for the Lawrenceville site is missing in a time period starting at the end of July due to a disabling lightning strike of this equipment during a violent thunderstorm.

Immediately obvious is the fact that data from the two sites show the same trends over this three-month time period. Since one site is urban (Lawrenceville) and the other rural (Holbrook) and they are approximately 65 miles apart, we can, based on this limited number of data, infer that the minor variations in the measurements taken at a given time between the two sites may be attributed to local sources and that the overall similarity in the trending results from the more pervasive regional background $PM_{2.5}$ concentration. An interesting side note on the impact of local effects is the observation that the one measurement higher than 100 $\mu g/M^3$ occurred at approximately 10:00 PM on July 4th and only at Lawrenceville. We strongly suspect that this was due to by-products released from a local (City of Pittsburgh) Independence Day celebration fireworks display.

To quantify and graphically display the data similar to that shown in Figure 1, data were compiled for different months to reflect changing seasons. Figures 2 through 4 provide distributions of mass measurements for the two major sites for three seasons of the year. Half-hour mass average data were taken from both $PM_{2.5}$ and PM_{10} TEOM measurements. Data for each three-month season, approximately 4300 points, were sorted and plotted based on 1 $\mu g/M^3$ intervals from 0 $\mu g/M^3$ to 100

$\mu g/M^3$. These “Threshold Concentration” values were plotted on the x-axis. For each “Threshold Concentration” value, there is a corresponding “Measurement Percentile” value on the y-axis. To determine the “Measurement Percentile” value, a “Threshold Concentration” value (e.g. 33 $\mu g/M^3$) is selected. Next, the number of mass values equal to or less than 33 $\mu g/M^3$ are counted from the sorted list, divided by the total number of values, approximately 4300, and then multiplied by 100 to convert the fraction to a percent. A plot of “Measurement Percentile” values vs. the corresponding “Threshold Concentration” values gives a typical S-shaped, third order polynomial curve.

Figure 2 shows $PM_{2.5}$ TEOM data gathered at the Lawrenceville site and categorized into Summer 1999, Fall 1999 and Winter 2000 distribution curves. Although the shape of the entire curve must be considered in describing these data distributions, the “Threshold Concentration” value at the 50th “Measurement Percentile” value can be used for quick comparisons. For example, the “Threshold Concentration” value for the 50th “Measurement Percentile” for the “winter” curve is approximately 10 $\mu g/M^3$. This means that 50% of the data is below 10 $\mu g/M^3$ in concentration and 50% is above 10 $\mu g/M^3$. Therefore, 10 $\mu g/M^3$ is the median value for the data set. The corresponding 50th “Measurement Percentiles” for the “fall” and “summer” curves are approximately 12 $\mu g/M^3$ and18 $\mu g/M^3$, respectively. We can therefore infer that at Lawrenceville, $PM_{2.5}$ median values are highest in summer and lowest in winter.

Figure 3 shows Lawrenceville PM_{10} data plotted in the same manner as in Figure 2. The corresponding 50th “Measurement Percentiles” for the “winter,” “fall” and “summer” curves are approximately 18 $\mu g/M^3$, 20 $\mu g/M^3$ and 22 $\mu g/M^3$, respectively. That these three values are higher than the corresponding values in Figure 2 is not surprising, since a PM_{10} value measured at any given time and place must always be equal to or greater than that obtained from a co-located $PM_{2.5}$ measurement.

Figure 4 shows Holbrook $PM_{2.5}$ data plotted in the same manner as in Figure 2. The corresponding 50th “Measurement Percentiles” for the “winter,” “fall” and “summer” curves are approximately 9 $\mu g/M^3$, 11 $\mu g/M^3$ and 18 $\mu g/M^3$, respectively. These values are very similar to those observed in Figure 2 for Lawrenceville. This again suggests, as did the raw data in Figure 1, that the regional effects on the fine particulate captured at both the urban and rural sites have more of an impact than the effect of the local phenomena at either site.

A comparison was also drawn on the performance of the TEOMs relative to the discreet filter-based samplers. The latter included FRM as well as DRI-developed sequential filter-based samplers. Data from the 24-hr. integrated filter sampling was plotted against values obtained by integrating corresponding 24-hr. intervals on the TEOM traces. Figures 5 and 6 depict such traces for $PM_{2.5}$ data obtained for Lawrenceville and Holbrook. Evident from these traces is the good agreement between the sequential filter data and the TEOM measurements within experimental error. However, the FRM-obtained data is consistently lower than the averages from the TEOM/DRI-SFS measurements except for an anomalous occurrence at Holbrook, on June 5th, when the FRM is observed higher than the other two. We suspect this to be a sampling malfunction with the impactor allowing some PM_{10} through to the filter. There is also no statistically significant difference in the average levels determined by each of these sampling techniques except for the Holbrook June 5th data.

Figure 7 gives a breakdown of the major chemical species distribution based on thirty-six (36) six (6)-hour samples taken at the Lawrenceville site during the 1999 Winter Sampling Intensive Program. Percentage species calculations are based on the total mass as captured on the filters.
A typical **pie chart** contains the following components:

1) **Geologica**l = 1.89*Al + 2.14*Si + 1.4*Ca + 1.43*Fe (elements from XRF)
2) **Organics** = 1.4*Organic Carbon (TOR)
3) **Elemental Carbon** (TOR)
4) **Nitrate** = Nitrate (IC)
5) **Sulfate** = Sulfate (IC)
6) **Ammonium** = ammonium (AC)
7) **Trace elements** = Sum of XRF species - (Al + Si + Ca + Fe + S)
8) **Unidentified** = Total mass - sum of items (1-7)

The road salt component (**Road Salt** = 1.65*Cl (XRF) is not included. Generally this parameter depends upon location and season.

There is an unresolved mass (13%) component that was not identifiable. Elemental and organic carbon (as organics) represent 10% and 14% of the total mass, respectively, while nitrogen species in the forms of nitrate and ammonium are distributed at 18% and 14%, respectively. Sulfate accounts for a large percentage (26%) of the total mass. The geological (3%) and the trace element (2%) components are reported as determined by the X-Ray Fluorescence (XRF).

Figure 8 depicts the same major chemical species distribution based on nine (9) twenty-four (24)-hour samples for Holbrook, a rural site, compared to the urban Lawrenceville site as shown in Figure 7. There is a slightly lower unresolved mass (8%) component that was not identifiable. Elemental and organic carbon (as organics) represent 6% and 27% of the total mass respectively, while nitrogen species in the forms of nitrate and ammonium are also distributed at 7% and 14%, respectively. These ratios are significantly different from those observed for Lawrenceville. Sulfate accounts for a large percentage (33%) of the total mass and it is slightly higher than that observed at Lawrenceville. However, the geological (3%) and the trace element (2%) components are identical to those reported for Lawrenceville. More data points will need to be acquired to provide a credible base for conclusions to be drawn.

4 CONCLUSIONS

The following can be concluded from the findings discussed above:

1) The TEOM equipment is performing as well as the sequential filter samplers in accounting for ambient $PM_{2.5}$ levels;
2) The trending in the $PM_{2.5}$ levels is similar for Lawrenceville and Holbrook, which represent an urban and a rural site sixty-five miles apart;
3) The absolute median $PM_{2.5}$ levels are the same for Lawrenceville and Holbrook

4) The $PM_{2.5}$ levels appear to be impacted more by the regional than by the local effects;
5) Sulfate levels predominate in the speciation data obtained from both the Holbrook and the Lawrenceville sites during winter intensive sampling; and
6) $PM_{2.5}$ and PM_{10} mass concentration levels are consistently higher in summer than in winter, with intermediate levels being observed in the fall.

More data analysis is on-going including correlation of mass data with meteorological observations.

Table 1. Instrumentation and sampling requirements

Parameter	**Sampling Schedule**		**Comments**
	Continuous	Intermittent	
Surface meteorology (winds, temperature, relative humidity, insolation)	x		Basic data to establish meteorological conditions
FRM $PM_{2.5}$ Teflon and quartz filter		x	Gravimetric mass and organics/inorganics
FRM PM_{10} Teflon and quartz filter		x	Gravimetric mass and organics/inorganics
TEOM $PM_{2.5}$ (mass)	x		Mass concentration
TEOM PM_{10} (mass)	x		Mass concentration
Semi-volatile and filter-based sampler (speciation sampler)		x	Determination of semi-volatile inorganics and organics (e.g., NH_3, NO_3, VOCs) and other filter chemistry
Ozone	x		Provide ozone concentration and a measure of photochemical activity
Reactive nitrogen (e.g., NO_x, NO_2, NO_y)	x		Oxidant and nitrate precursors; important energy production byproduct
CO	x		Tracer for motor vehicles
SO_2	x		Tracer for coal combustion; co-factor in PM exposure

TABLE 2

SPECIFIC EQUIPMENT FOR EACH OF TWO MONITORING SITES LOCATED AT LAWRENCEVILLE, PA AND HOLBROOK, PA

UNIT	# DEPLOYED
Surface Meteorology	1
Federal Reference Method (FRM) for $PM_{2.5}$ (sequential)	1
Sequential Filter Sampler (SFS)	1
Sequential Gas Sampler (SGS) - Ammonia	1
Sequential Gas Sampler (SGS) - Nitric Acid	1
PM_{10} (sequential)	1
$PM_{2.5}$ TEOM	1
PM_{10} TEOM	1
Speciation sampler	1
Ozone (continuous analyzer)	1
Reactive nitrogen (continuous analyzer)	1
CO (continuous analyzer)	1
SO_2 (continuous analyzer)	1
Data logger/acquisition	1
Dynamic dilution calibrator	1
Portable audit sampler	1
Mini-Vol Sampler	1
Shelter and site preparation (including utility connections)	1

TABLE 3

EQUIPMENT LOCATED AT THE ATHENS, OH SITE

UNIT	**# DEPLOYED**
Sequential Filter Sampler for $PM_{2.5}$	1

EQUIPMENT LOCATED AT THE MONONGALIA, WV MONITORING SITE

UNIT	**# DEPLOYED**
Sequential Filter Sampler for $PM_{2.5}$	1

Table 4 - $PM_{2.5}$ SAMPLING AND ANALYSIS

SAMPLER	DENUDER	CHANNEL NO.	FILTER MATERIALS		ANALYSIS	
			Front	Back	Front	Back
SFS-PM2.5	(none)	A	Teflon	Quartz	Mass (Gravimetry), Elements (XRF)	Carbon (TOR)
		B	Quartz	Cellulose/NaCl	Carbon (TOR); Cl^-, NO_3^-, SO_4^{2-} (IC); NH_4^+ (AC); Na^+, K^+ (AA)	NO_3^- (IC)
SASS #72	(none)	A	Teflon	Quartz	Mass (Gravimetry), Elements (XRF)	Carbon (TOR)
		B	Quartz	Cellulose/NaCl	Carbon (TOR); Cl^-, NO_3^-, SO_4^{2-} (IC); NH_4^+ (AC); Na^+, K^+ (AA)	NO_3^- (IC)
SFS-PM10	(none)	A	Teflon	Quartz	Mass (Gravimetry), Elements (XRF)	Carbon (TOR)
		B	Quartz	Cellulose/NaCl	Carbon (TOR); Cl^-, NO_3^-, SO_4^{2-} (IC); NH_4^+ (AC); Na^+, K^+ (AA)	NO_3^- (IC)
SGS-TP	Nitric Acid	A	Quartz	Cellulose/NaCl	NO_3^- (IC)	NO_3^- (IC)
	(none)	B	Quartz	Cellulose/NaCl	NO_3^- (IC)	NO_3^- (IC)
SASS #74	Nitric Acid	A	Quartz	Cellulose/NaCl	NO_3^- (IC)	NO_3^- (IC)
	(none)	B	Quartz	Cellulose/NaCl	NO_3^- (IC)	NO_3^- (IC)
SGS-PM2.5	Ammonia	A	Quartz	Cellulose/Citric Acid	NH_4^+ (AC)	NH_4^+ (AC)
	(none)	B	Quartz	Cellulose/Citric Acid	NH_4^+ (AC)	NH_4^+ (AC)
SASS #75	Ammonia	A	Quartz	Cellulose/Citric Acid	NH_4^+ (AC)	NH_4^+ (AC)
	(none)	B	Quartz	Cellulose/Citric Acid	NH_4^+ (AC)	NH_4^+ (AC)
FRM (R&P) -a	(none)	-	Teflon	(none)	Mass (Gravimetry), Elements (XRF)	-
FRM (R&P) -b	(none)	-	Quartz	(none)	Carbon (TOR); Cl^-, NO_3^-, SO_4^{2-} (IC); NH_4^+ (AC); Na^+, K^+ (AA)	-
Portable PM2.5	(none)	-	Polycarbonate	(none)	CCSEM	-

XRF = X-Ray Fluorescence, TOR = Thermal/Optical Reflectance, IC = Ion Chromatography, AC = Automated Colorimetry, AA = Atomic Absorption,
CCSEM = Computer Controlled Scanning Electron Microscopy

FIGURE 1:
Lawrenceville & Holbrook $PM_{2.5}$ TEOMs
6/1/99 - 9/11/99

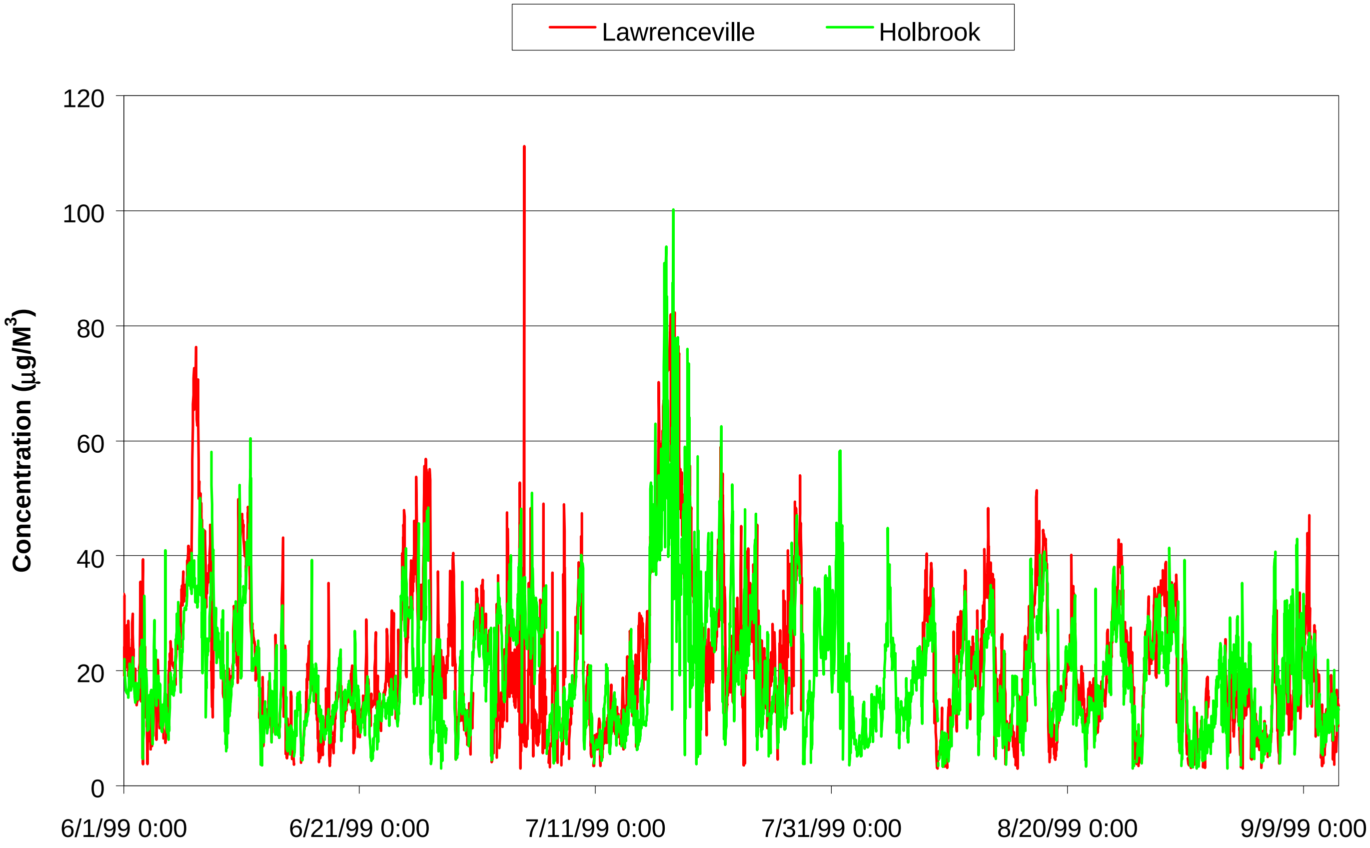

FIGURE 2:
June 1999-February 2000
Lawrenceville ($PM_{2.5}$) Data Distribution

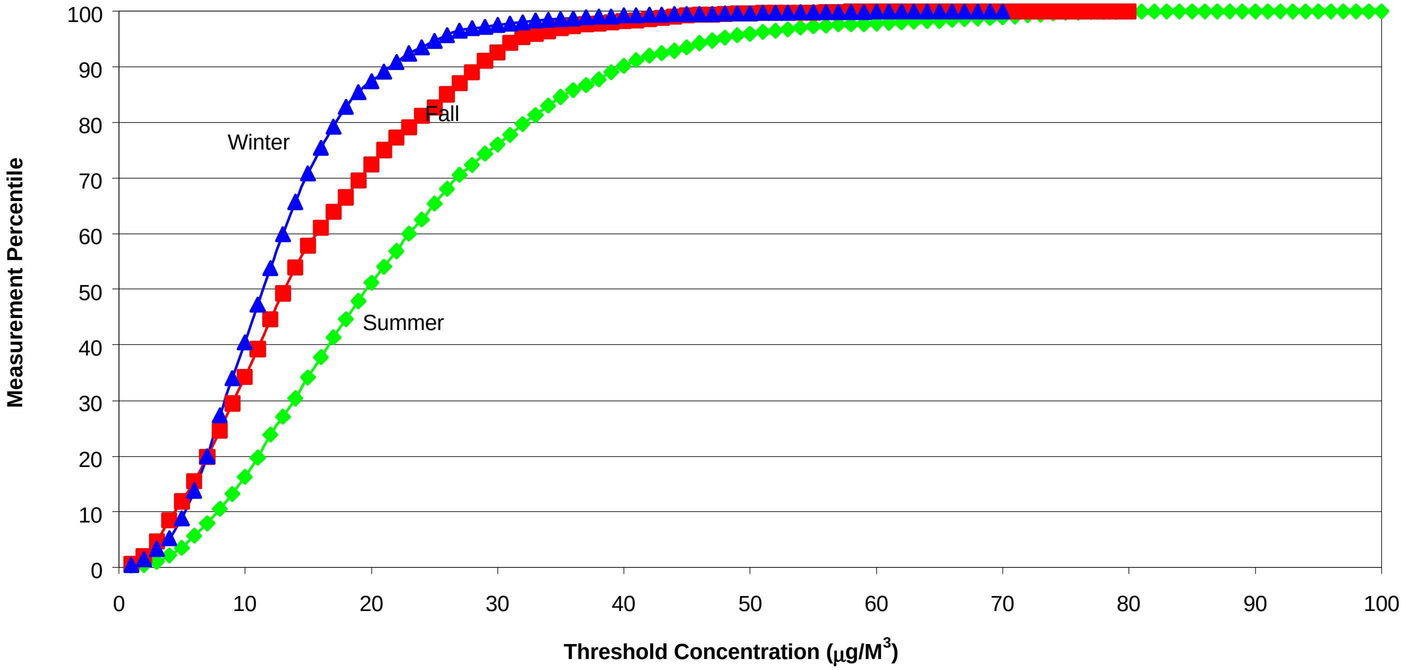

FIGURE 3:
June 1999-February 2000
Lawrenceville (PM_{10}) Data Distribution

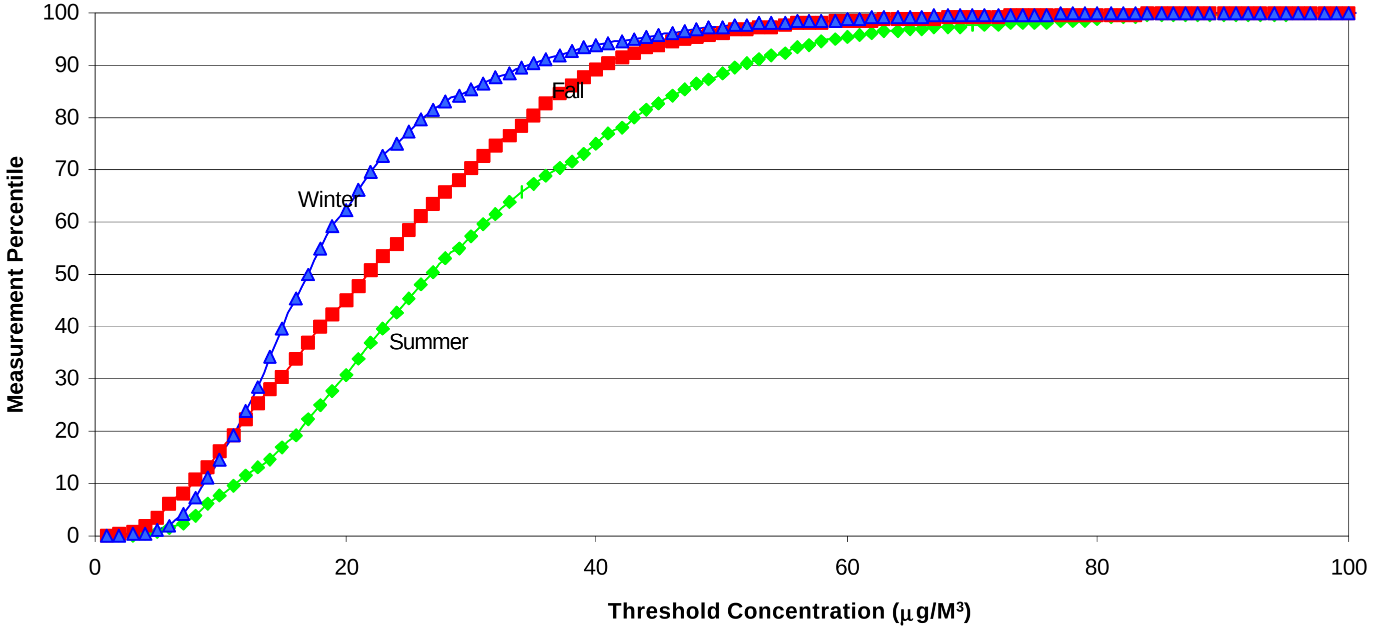

FIGURE 4:
June 1999 - February 2000
Holbrook $PM_{2.5}$ Data Distribution

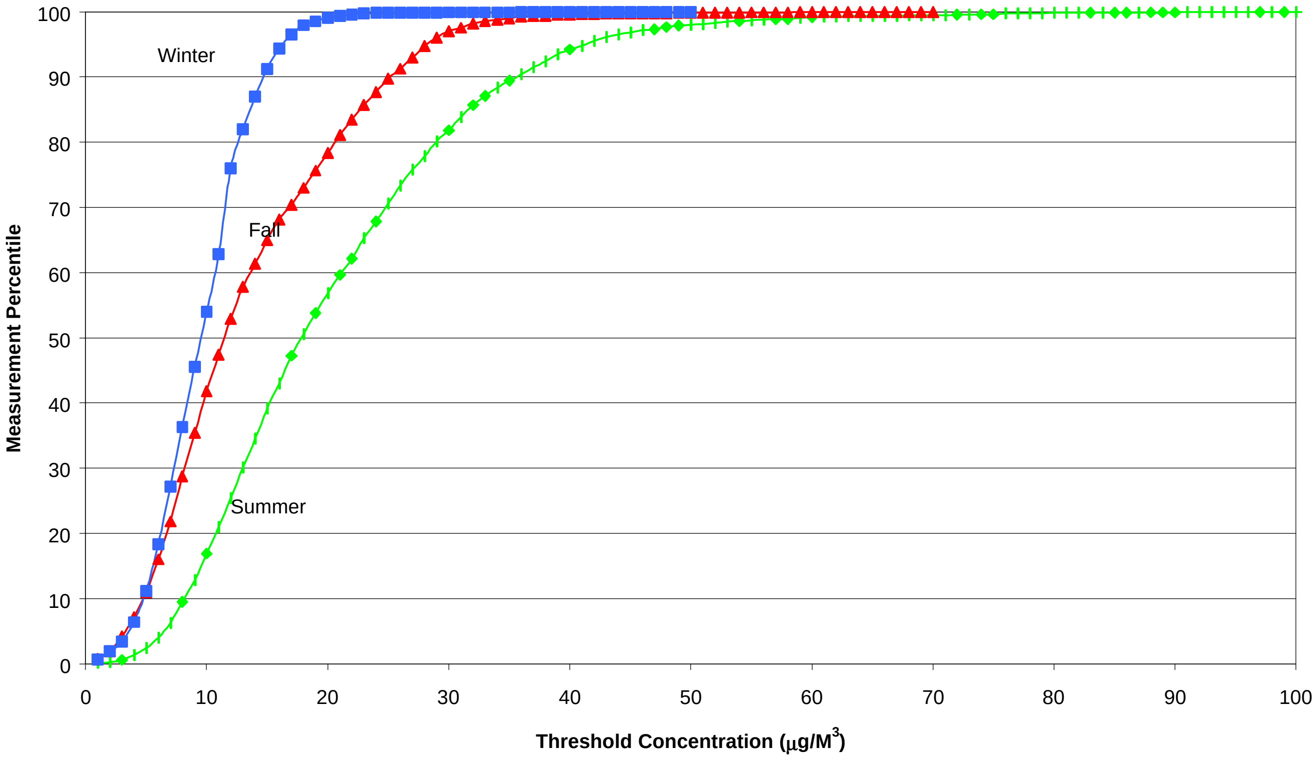

FIGURE 5:
Lawrenceville-TEOM $PM_{2.5}$, SFS $PM_{2.5}$ & FRM $PM_{2.5}$

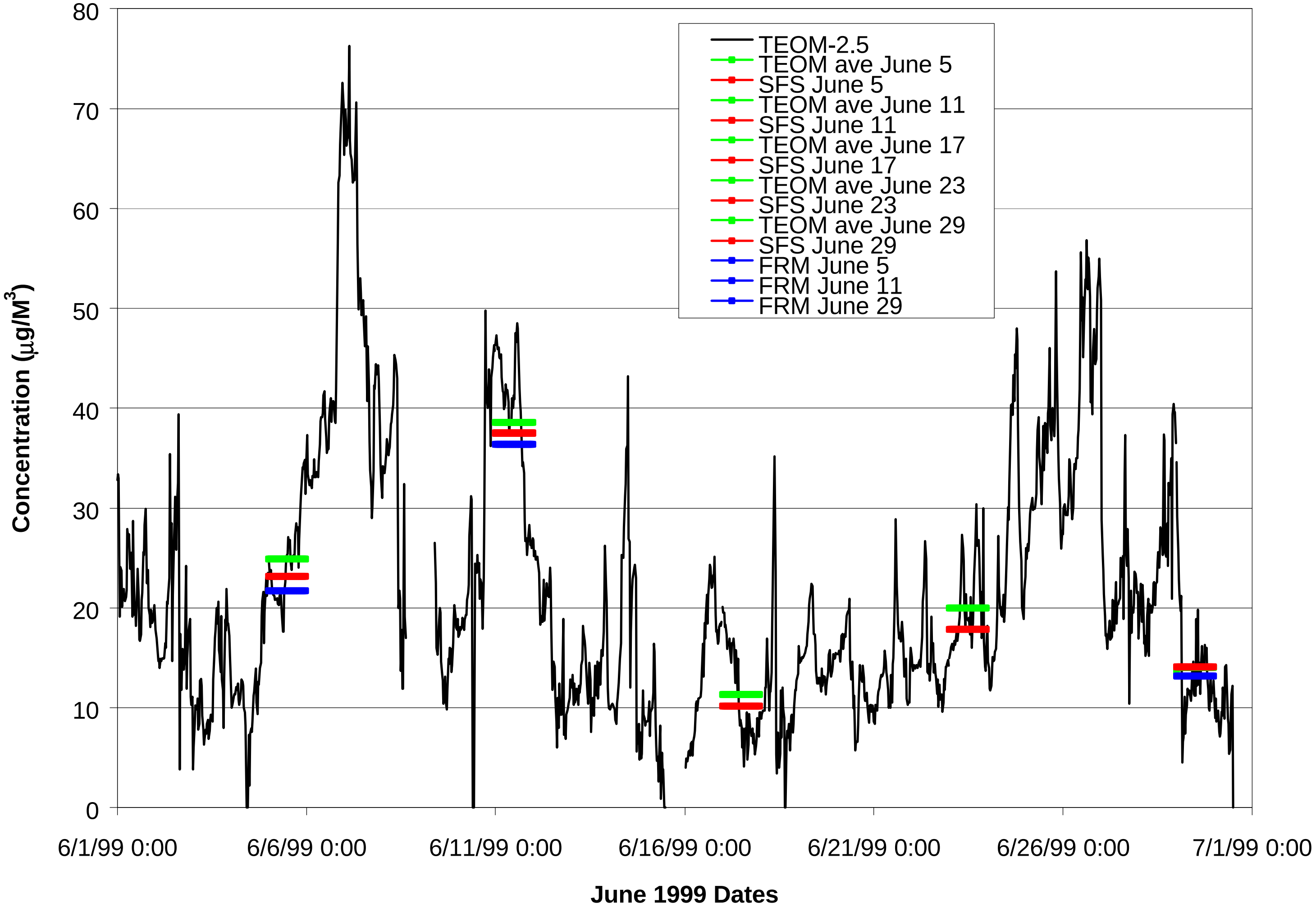

FIGURE 6:
Holbrook-TEOM $PM_{2.5}$, SFS $PM_{2.5}$ & FRM $PM_{2.5}$

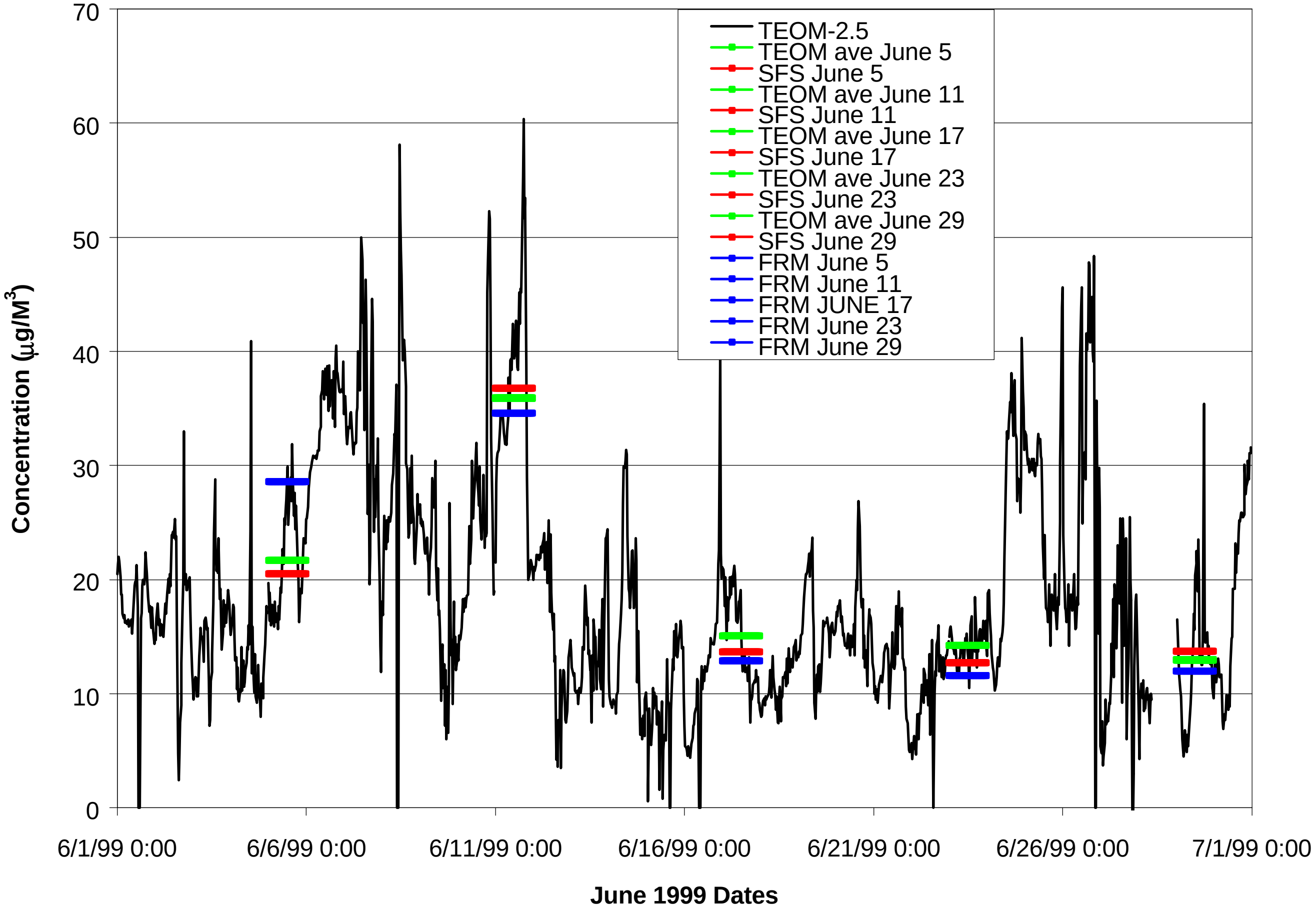

FIGURE 7:
Winter 1999
Lawrenceville
PM$_{2.5}$ Intensive Sampling Program
(36 6-Hour Samples)

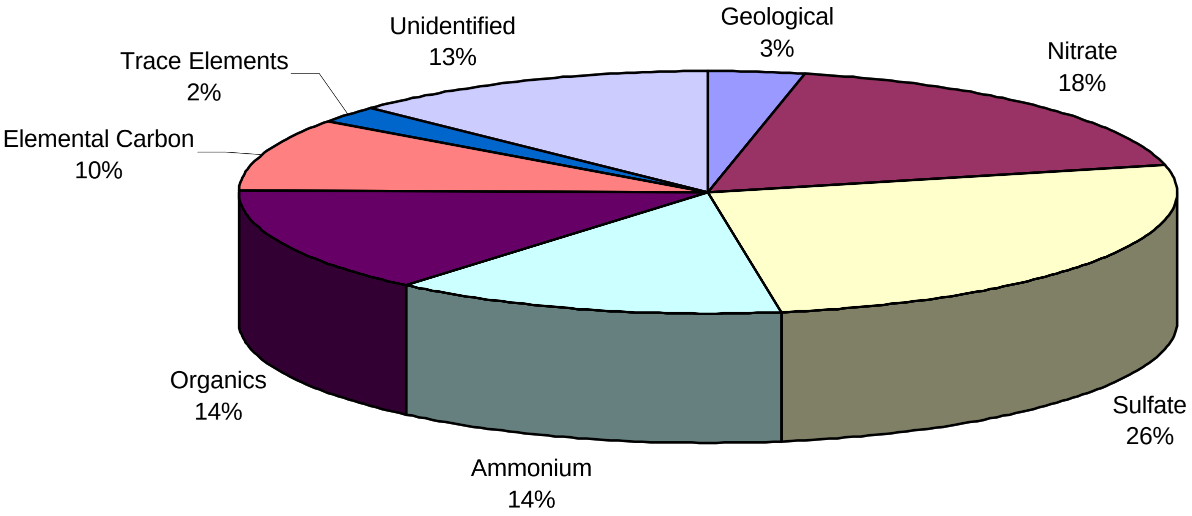

FIGURE 8:
Winter 1999
Holbrook
PM$_{2.5}$ Intensive Sampling Program
(9 24-Hour Samples)