NETWORK OPERATION OF THE $PM_{10-2.5}$ DIFFERENCE METHOD

An Independent Study Conducted by the Jefferson County Department of Health in Birmingham, Al During 2003 and 2004

by

Robert W. Vanderpool
United States Environmental Protection Agency, 109 T.W. Alexander Drive,
Research Triangle Park, NC 27711

Randy Dillard
Jefferson County Department of Health, 1400 6th Avenue South
Birmingham, AL 35233

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1.0 Introduction

During 2003 through 2005, the U.S. EPA's Office of Research and Development conducted a series of comprehensive field studies to evaluate ambient samplers designed to measure the coarse fraction of PM_{10} (i.e., $PM_{10-2.5}$). In order to determine the inherent performance of the samplers, these multi-site evaluations were conducted under very carefully controlled conditions using three primary initiatives. First, the samplers' manufacturers were involved in all phases of the study to ensure that their respective samplers were functional; contained the latest software, hardware, and firmware revisions; and that collected sampler data was being properly downloaded, reduced, and interpreted. Second, strict operating protocols were developed for each sampler and the samplers were carefully calibrated immediately prior to each study. During the course of each 30-day field campaign, three performance audits were conducted to ensure that the samplers were holding their calibration settings within the required specifications. If a given sampler failed the performance audit, it was leak checked and recalibrated before additional tests were conducted. Third, experienced field and analytical personnel were involved in the study during all phases of the study. As a result of these initiatives, the sampler performance data obtained during these field campaigns might be viewed as "best case" and not necessarily representative of those which might be obtained by State, Local, or Tribal agencies under "real world" conditions where resources might be more limited.

In addition, the sampling sites selected for EPA's field studies were intended to evaluate the samplers in areas of relatively high $PM_{10-2.5}$ concentrations to ensure that the samplers were capable of providing accurate measurements over a wide range of concentrations. Also, coarse mode particles tended to dominate the PM_{10} aerosols at these sites thus producing relatively low $PM_{2.5}/PM_{10}$ ratios. In conjunction with the high $PM_{10-2.5}$ concentrations inherent to these sampling sites, the low $PM_{2.5}/PM_{10}$ ratios would tend to make it unlikely that zero or negative $PM_{10-2.5}$ measurements would occur. The ability of the difference method to consistently produce positive $PM_{10-2.5}$ concentration measurements, therefore, could not be adequately demonstrated during these studies. The large filter mass gains inherent to these field studies also made it difficult to assess the difference method's precision at low $PM_{10-2.5}$ concentrations.

To address these issues, EPA contacted the Jefferson County Department of Health (JCDH) in 2002 and requested that $PM_{10-2.5}$ difference method samplers (i.e., collocated designated $PM_{2.5}$ and designated low-flow PM_{10}) be independently set up and operated as part of their normal operating network. In particular, JCDH was asked to document the frequency of any negative $PM_{10-2.5}$ concentrations and report the conditions under which they occurred. Within available resources, JCDH was also asked to operate multiple difference method pairs in order to determine the precision of the difference method under typical network operating conditions. In

response to this request, JCDH evaluated difference method samplers at 7 separate network sites during 2003 and 2004. During 2004, the precision of the difference method was evaluated every 6th day at the Leeds site located in eastern Jefferson County.

This report provides a brief summary of test results obtained by JCDH during these independent efforts.

2.0 Methods

Jefferson County is located in the Birmingham-Hoover metropolitan area and has a population of approximately 660,000. Figure 1 shows a map of Jefferson County along with the location of the 7 sites selected for the 2003 and 2004 evaluation of the $PM_{10-2.5}$ difference method. The North Birmingham and Wylam sites are classified as urban neighborhood sites and are heavily impacted by a variety of nearby industries as well as by nearby interstate traffic. Located south of Birmingham, the Hoover site is classified as a suburban site and is impacted primarily by mobile emissions from HW 31 and I65. The remaining 4 sites (Providence, McAdory, Pinson, and Corner) are located 15 to 25 miles away from Birmingham and are classified as rural background sites and are generally not impacted by nearby industrial sources.

At each of the 7 sites, designated $PM_{2.5}$ samplers (BGI PQ200) were operated concurrently with designated low-flow PM_{10} samplers (BGI PQ200 with their $PM_{2.5}$ fractionators replaced by a downtube). All samplers involved in the study were operated for 24 hours on a midnight to midnight schedule. The 47 mm Teflon filters used for the designated $PM_{2.5}$ and PM_{10} samplers were conditioned and weighed at the JCDH's weighing facility in Birmingham. For each sampling event, the $PM_{10-2.5}$ concentration was calculated as the numerical difference between the measured PM_{10} concentration and the measured $PM_{2.5}$ concentration.

The difference method evaluation began at the 7 sites on January 1, 2003 and was operated on a one in 6 day schedule (with the exception of the first test of each month when field blank tests were performed) during 2003 and 2004. To assess the precision of the $PM_{10-2.5}$ difference method at low $PM_{10-2.5}$ concentrations, a collocated pair of difference method samplers began operating at the Leeds site (see Figure 1) on January 4, 2004 using the same operating and analysis procedures as those of the other 7 sites.

3.0 Results

3.1 Year 2003

Table 1 summarizes the mean $PM_{2.5}$, $PM_{10-2.5}$, and PM_{10} concentrations measured at the

7 sites during 2003. As a measure of the aerosol size distribution, the mean $PM_{2.5}/PM_{10}$ ratio was also calculated for each site.

As expected, due to their proximity to major industrial sources of air pollution, the North Birmingham and Wylam sites had the highest mean $PM_{2.5}$ and PM_{10} concentrations. The North Birmingham site was also characterized by a mean $PM_{2.5}/PM_{10}$ ratio of 0.48 indicating that, on average, coarse mode particles slightly dominated the PM_{10} mass concentration. As a result, the North Birmingham site also experienced the highest mean $PM_{10-2.5}$ concentrations.

As indicated in the table, both PM_{10} concentrations and $PM_{10-2.5}$ concentrations decreased with increasing distance from the center of Birmingham. For the Pinson, Corner, and Providence sites, the mean $PM_{2.5}$ concentration was approximately one-third of the mean $PM_{10-2.5}$ measured at the North Birmingham site. For these same sites, however, $PM_{2.5}$ concentrations were approximately 80% of the mean $PM_{2.5}$ concentration measured at the North Birmingham site. These values show that $PM_{2.5}$ aerosols are generally regionally distributed in the Jefferson County area but that high coarse mode particles concentrations are confined primarily to the areas in which they are generated. These test results, therefore, emphasize the importance of collocating $PM_{2.5}$ and PM_{10} monitors when conducting difference method calculations.

Figure 2 shows the 2003 timeline of PM_{10} and $PM_{10-2.5}$ concentrations at the site of lowest mean $PM_{2.5}$ and PM_{10} concentrations, the Providence site. In addition to having the lowest mean $PM_{10-2.5}$ concentrations, the Providence site is also of interest because its $PM_{2.5}/PM_{10}$ ratio is approximately the same mean ratio of sampling sites in the continental United States. As indicated in the timeline, very low $PM_{10-2.5}$ concentrations were occasionally observed at the Providence site in 2003. In fact, 24 of the 60 $PM_{10-2.5}$ concentrations (i.e., 40%) were less than 5 $\mu g/m^3$, with the lowest concentration being 0.6 $\mu g/m^3$. Despite these relatively low concentrations, no zero or negative $PM_{10-2.5}$ concentrations were measured at the Providence site during the 60 sampling events in 2003.

Inspection of all other 2003 site data in Table 1 revealed that low $PM_{10-2.5}$ concentrations were a fairly frequent occurrence. For all 7 sites, 116 of the 417 sampling events (i.e., 28%) resulted in a calculated $PM_{10-2.5}$ concentrations less than 5 $\mu g/m^3$. Only one negative $PM_{10-2.5}$ concentration was recorded at any of the 7 sampling sites during the 417 sampling events. This occurred on December 14, 2003 at the Hoover site where measured PM_{10} and $PM_{2.5}$ concentrations for this event were 9.16 $\mu g/m^3$ and 9.28 $\mu g/m^3$, respectively. The calculated $PM_{10-2.5}$ for this sampling event, therefore, was only -0.13 $\mu g/m^3$, and is certainly less than the detection limit of the measurement technique.

3.2 Year 2004

Table 2 summarizes the measurement results obtained at the 7 sampling sites during 2004. A comparison of Table 2 versus that of Table 1 reveals that all mean $PM_{2.5}$, $PM_{10-2.5}$, and PM_{10} concentrations at all sites were less in 2004 than during 2003. Inspection of the site $PM_{2.5}/PM_{10}$ ratios reveals that the fine fraction of PM_{10} was slightly higher at all sites in 2004 than during the previous year.

Figure 3 provides a timeline of PM_{10} and $PM_{10-2.5}$ concentrations at the Providence site for 2004. The timeline indicates that the majority of $PM_{10-2.5}$ concentrations were below 10 $\mu g/m^3$ (84%) and many were below 5 $\mu g/m^3$ (56%). As in the case of the 2003 data, however, no zero or negative $PM_{10-2.5}$ concentrations were measured at this rural sampling site. Inspection of all site data in Table 2 reveals that 147 of the 411 sampling events resulted in $PM_{10-2.5}$ concentrations less than 5 $\mu g/m^3$. Despite measured $PM_{10-2.5}$ concentrations as low as 0.3 $\mu g/m^3$, none of the 411 sampling events resulted in $PM_{10-2.5}$ concentrations which were less than or equal to 0 $\mu g/m^3$.

3.3 Precision Tests

To measure the precision of the $PM_{10-2.5}$ difference method samplers, collocated pairs of designated $PM_{2.5}$ and PM_{10} samplers were installed and operated at the rural Leeds site from Jan. 4 through Dec. 29, 2004. With the exception of the first test of every month (when field blank tests are performed), the collocated samplers were operated on a one in 6 day schedule. During 2004, this schedule produced 48 valid $PM_{10-2.5}$ data points.

Figure 4 presents a timeline of $PM_{2.5}$ concentrations measured by the two collocated $PM_{2.5}$ samplers. As indicated by the mean coefficient of variation (CV) of 2.2% during these tests, excellent intra-sampler agreement was observed for the $PM_{2.5}$ measurements. CVs ranged from a minimum of 0.0% to a maximum of 7.8%. For the 48 valid sampling events performed in 2004, both $PM_{2.5}$ FRM samplers measured a mean concentration of 15.0 $\mu g/m^3$.

A timeline of PM_{10} concentrations measured by the two collocated PM_{10} samplers is presented in Figure 5. As in the case of the $PM_{2.5}$ measurements, excellent agreement was observed between the two collocated PM_{10} samplers as evidenced by a mean CV of 2.0%. With the exception of sampling events 19 through 23, where CVs of 6% to 12% were observed, extremely close agreement was observed between the two collocated PM_{10} during all sampling events. For the 48 sampling events, the mean PM_{10} concentrations measured by Sampler 1 and Sampler 2 were 24.0 $\mu g/m^3$ and 24.4 $\mu g/m^3$, respectively.

Figure 6 presents a timeline of the $PM_{10-2.5}$ concentrations calculated for the two

difference method pairs (i.e., two sets of $PM_{2.5}$ and PM_{10} FRM samplers). Except during Runs 19-23, where the higher PM_{10} CVs naturally resulted in higher calculated $PM_{10-2.5}$ CV values, the level of agreement among the collocated difference method pairs was generally strong. Including the Run 19 through 23 data, the calculated CV for the $PM_{10-2.5}$ method was 8.1%. The mean $PM_{10-2.5}$ measured by Sampler Pair 1 and Sampler Pair 2 during 2004 were 9.2 $\mu g/m^3$ and 9.5 $\mu g/m^3$, respectively. As in the case for results obtained at the other 7 sampling sites during 2004, no zero or negative $PM_{10-2.5}$ concentrations were measured at the Leeds site.

4.0 Summary

During 2003 and 2004, the JCDH conducted $PM_{10-2.5}$ difference method sampling at 7 sites using collocated, designated $PM_{2.5}$ and PM_{10} reference method samplers. The sampling sites included two urban sites (North Birmingham and Wylam) close to industrial sources and the remaining five were designated as either suburban or rural sites. During both 2003 and 2004, $PM_{2.5}$ aerosols were more spatially distributed among the sampling sites than $PM_{10-2.5}$ aerosols. Mean $PM_{2.5}/PM_{10-2.5}$ ratios increased with increasing distance from the center of Birmingham. Temporally, mean concentrations of $PM_{2.5}$, $PM_{10-2.5}$, and PM_{10} were less at all sampling sites during 2004 than during 2003.

At the Providence site, mean $PM_{10-2.5}$ during 2003 and 2004 were measured to be 6.0 $\mu g/m^3$ and 2.9 $\mu g/m^3$, respectively. Despite the low $PM_{10-2.5}$ concentrations characteristic of this rural site, no zero or negative $PM_{10-2.5}$ values were recorded during the 115 site measurements. For all 7 sites involved in the study, only one zero or negative $PM_{10-2.5}$ concentration (-0.13 $\mu g/m^3$) was observed during the total 828 measurements made during the two year period.

Collocated reference method pairs were operated at the Leeds site during 2004 in order to determine the precision of the difference method. The intra-sampler precision between the two sets of $PM_{2.5}$ and PM_{10} samplers was excellent as indicated by CVs of 2.2% and 2.0%, respectively. The precision of the $PM_{10-2.5}$ difference method was determined to be 8.1% and mean $PM_{10-2.5}$ concentrations by the two difference method pairs during 48 sampling events was determined to be 9.2 $\mu g/m^3$ and 9.5%, respectively.

The concentration and size distribution of the ambient aerosol measured during the Birmingham tests would tend to increase the likelihood of the occurrence of negative $PM_{10-2.5}$ measurements using the difference method. Even during a routinely operating network, however, only one negative $PM_{10-2.5}$ was measured during the 1058 total measurements (including the Leeds data). In conjunction with the favorable $PM_{10-2.5}$ precision measured at the Leeds site, these test results indicate that the difference method can be successfully employed in a routine

monitoring network if proper sampling, handling, and analysis procedures are rigorously observed.

Jefferson County's evaluation of the $PM_{10-2.5}$ difference method continues at each of the 8 sampling sites and data from the first 6 months of 2005 is currently being validated and reviewed. Procurement and installation of new $PM_{2.5}$ and PM_{10} FRM samplers is underway and will enable $PM_{10-2.5}$ precision tests to be conducted at all 8 sites beginning Jan. 1, 2006.

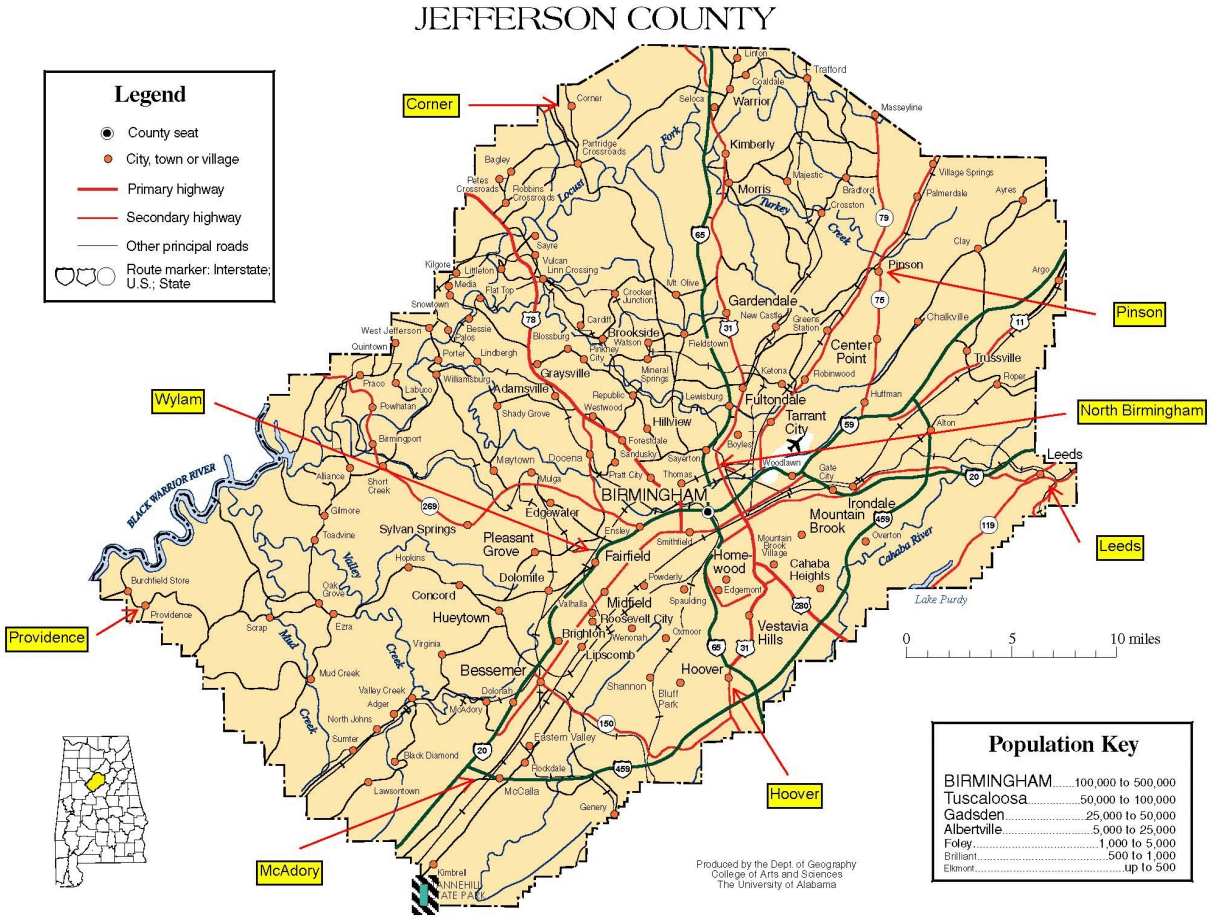

Figure 1. Map of Jefferson County, Al showing the locations of the sampling sites involved in the evaluation of the $PM_{10-2.5}$ difference method samplers.

Table 1. Summary of the Mean Site Concentrations Obtained During 2003.

Site	$PM_{2.5}$	PM_{10}	$PM_{10-2.5}$	$PM_{2.5}/PM_{10}$	Events (Total)	Events $PM_{10-2.5} \leq 5\ \mu g/m^3$	Events $PM_{10-2.5} \leq 0\ \mu g/m^3$
North Birmingham	17.3	36.1	18.7	0.48	60	3	0
Wylam	16.4	26.9	10.4	0.61	61	10	0
Hoover	14.2	21.7	7.5	0.66	60	20	1
McAdory	14.2	23.6	9.3	0.60	60	16	0
Pinson	14.0	21.0	7.0	0.67	57	24	0
Corner	14.4	21.5	7.1	0.67	59	19	0
Providence	12.6	18.6	6.0	0.67	60	24	0
				Total =	**417**	**116**	**1**

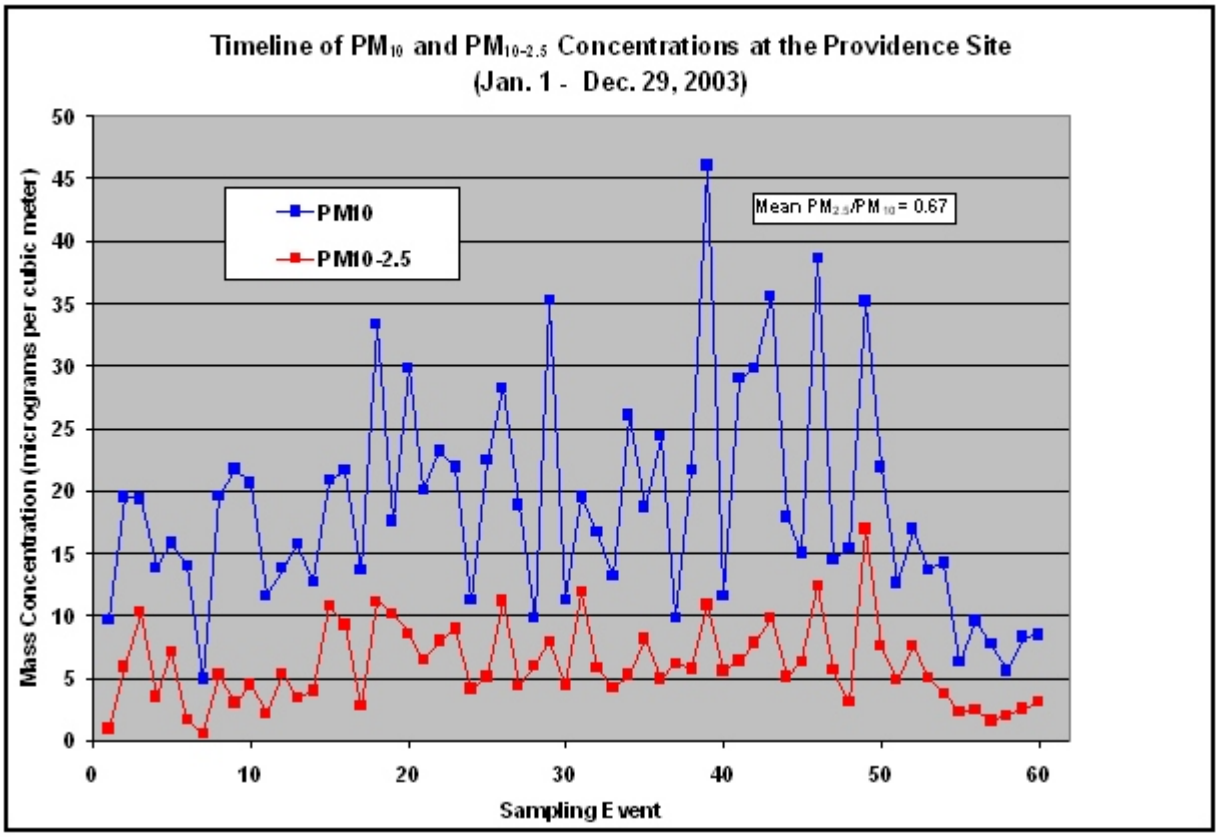

Figure 2. **Timeline of PM_{10} and $PM_{10-2.5}$ concentrations measured at the Jefferson County Providence site during 2003.**

Table 2. Summary of the Mean Site Concentrations Obtained During 2004.

Site	$PM_{2.5}$	PM_{10}	$PM_{10-2.5}$	$PM_{2.5}/PM_{10}$	Events (Total)	Events $PM_{10-2.5} \leq 5$ μg/m³	Events $PM_{10-2.5} \leq 0$ μg/m³
North Birmingham	16.2	30.7	14.5	0.53	58	6	0
Wylam	12.4	20.0	7.6	0.62	61	14	0
Hoover	11.9	17.0	5.1	0.70	59	22	0
McAdory	10.6	15.4	4.7	0.69	59	16	0
Pinson	10.2	14.4	4.2	0.71	58	28	0
Corner	9.7	14.1	4.3	0.69	61	30	0
Providence	7.7	10.6	2.9	0.73	55	31	0
				Total =	**411**	**147**	**0**

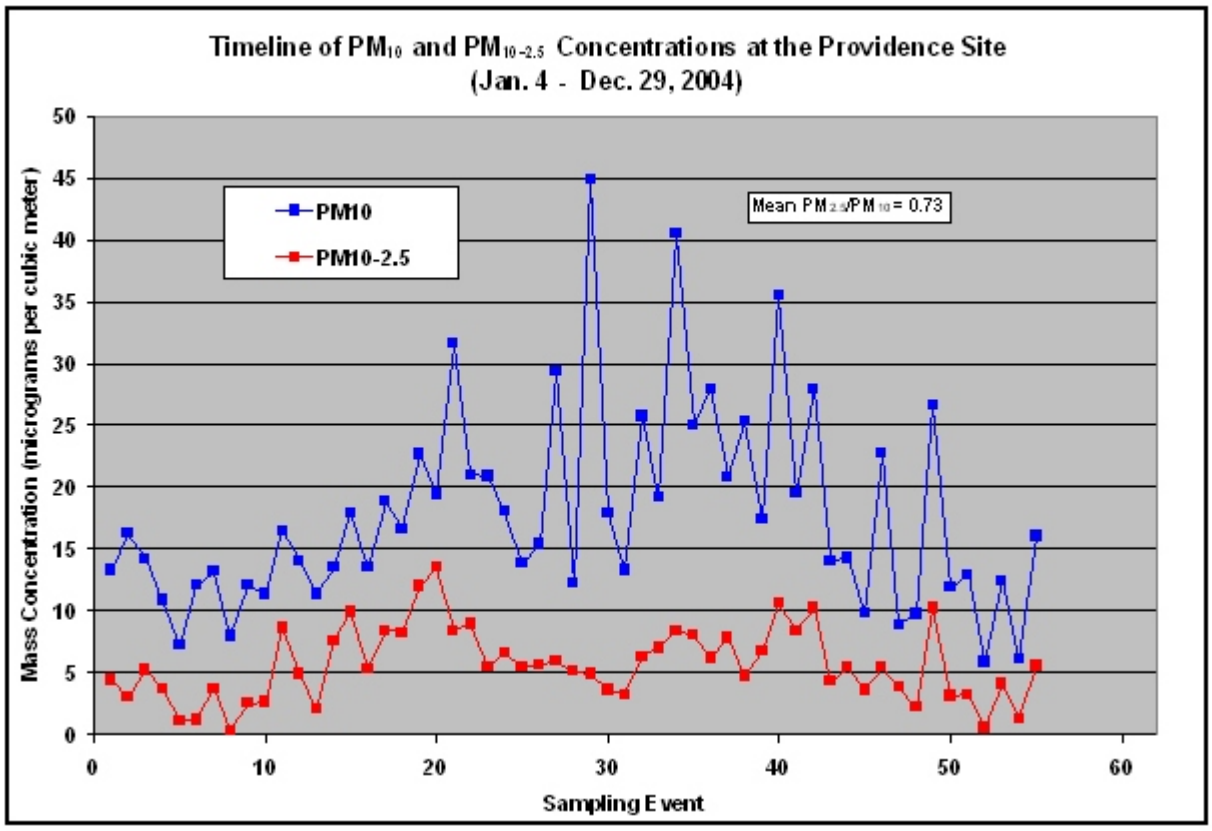

Figure 3. **Timeline of PM_{10} and $PM_{10-2.5}$ concentrations measured at the Jefferson County Providence site during 2004.**

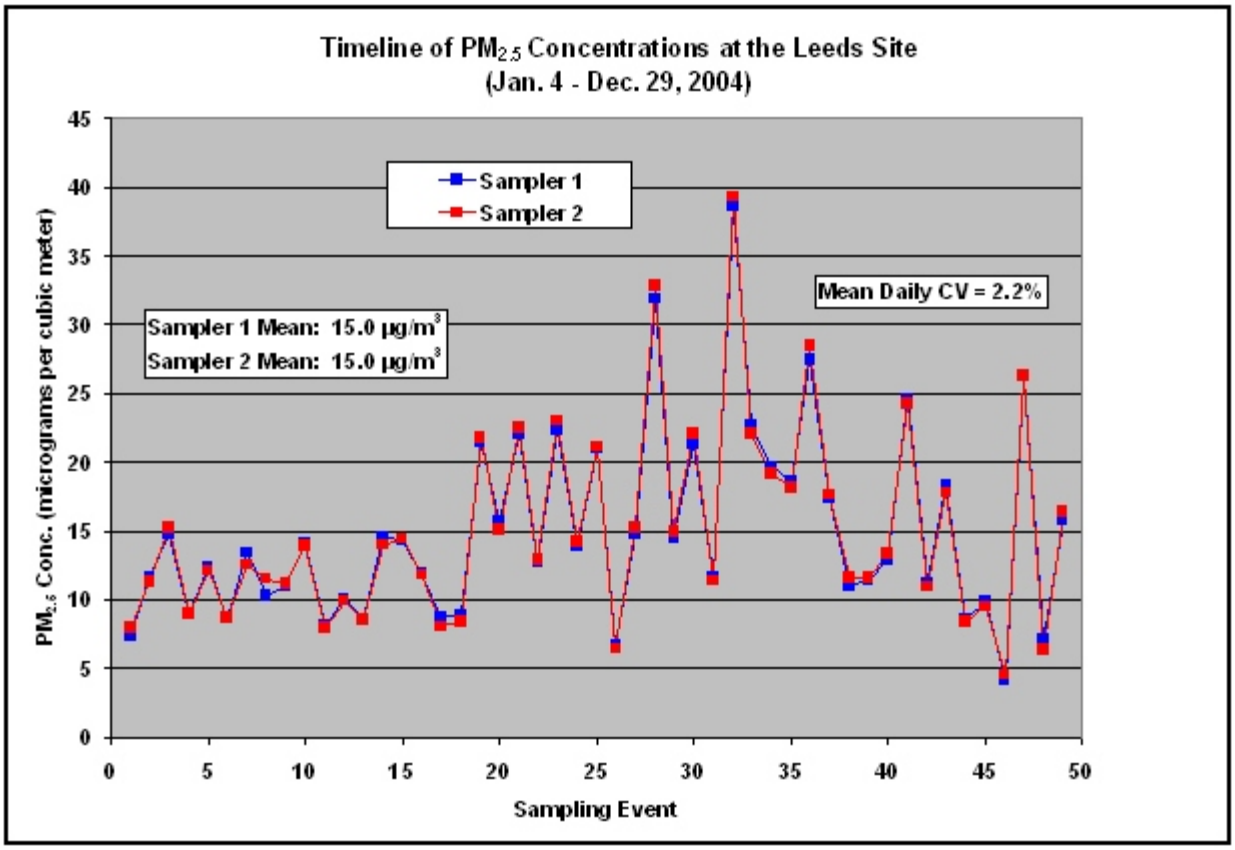

Figure 4. **Timeline of $PM_{2.5}$ concentrations measured by the two collocated $PM_{2.5}$ FRM samplers at the Leeds site during 2004.**

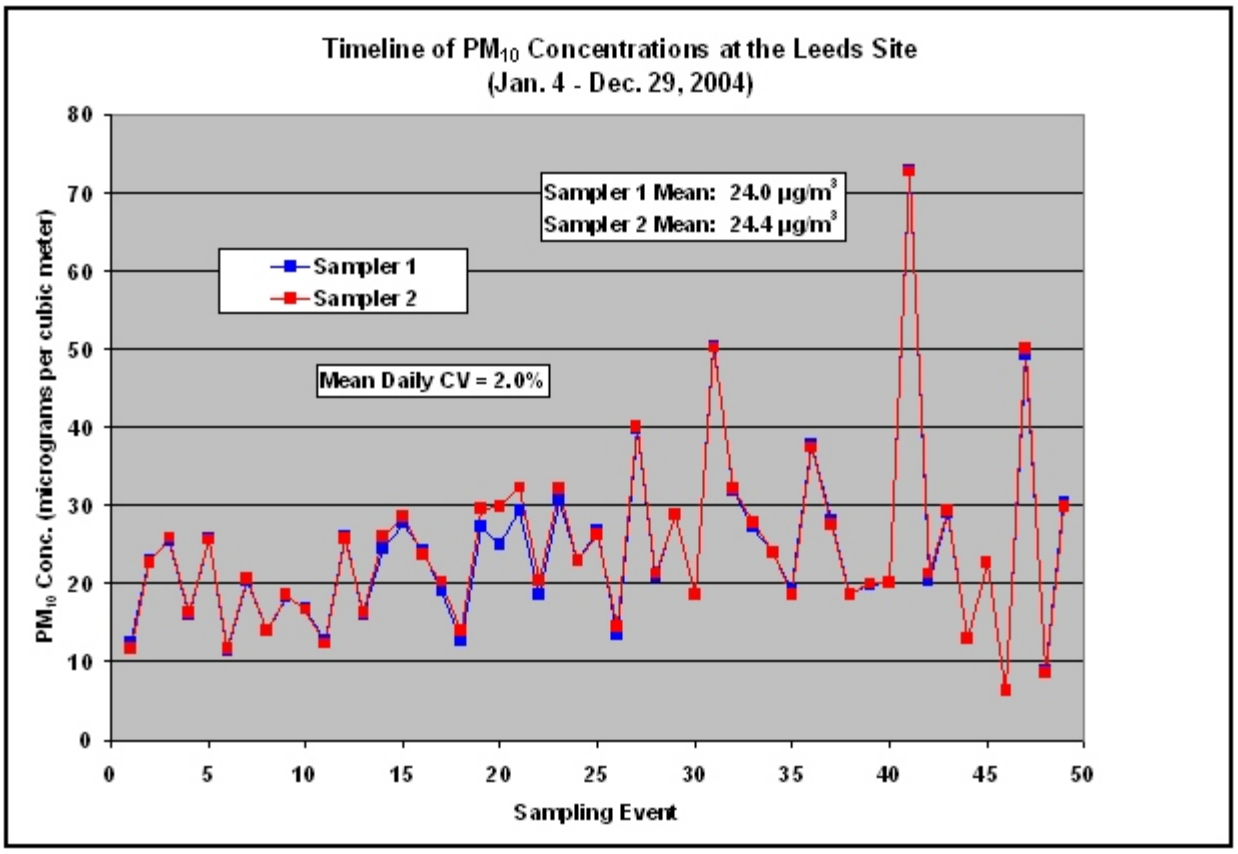

Figure 5. **Timeline of PM_{10} concentrations measured by the two collocated PM_{10} FRM samplers at the Leeds site during 2004.**

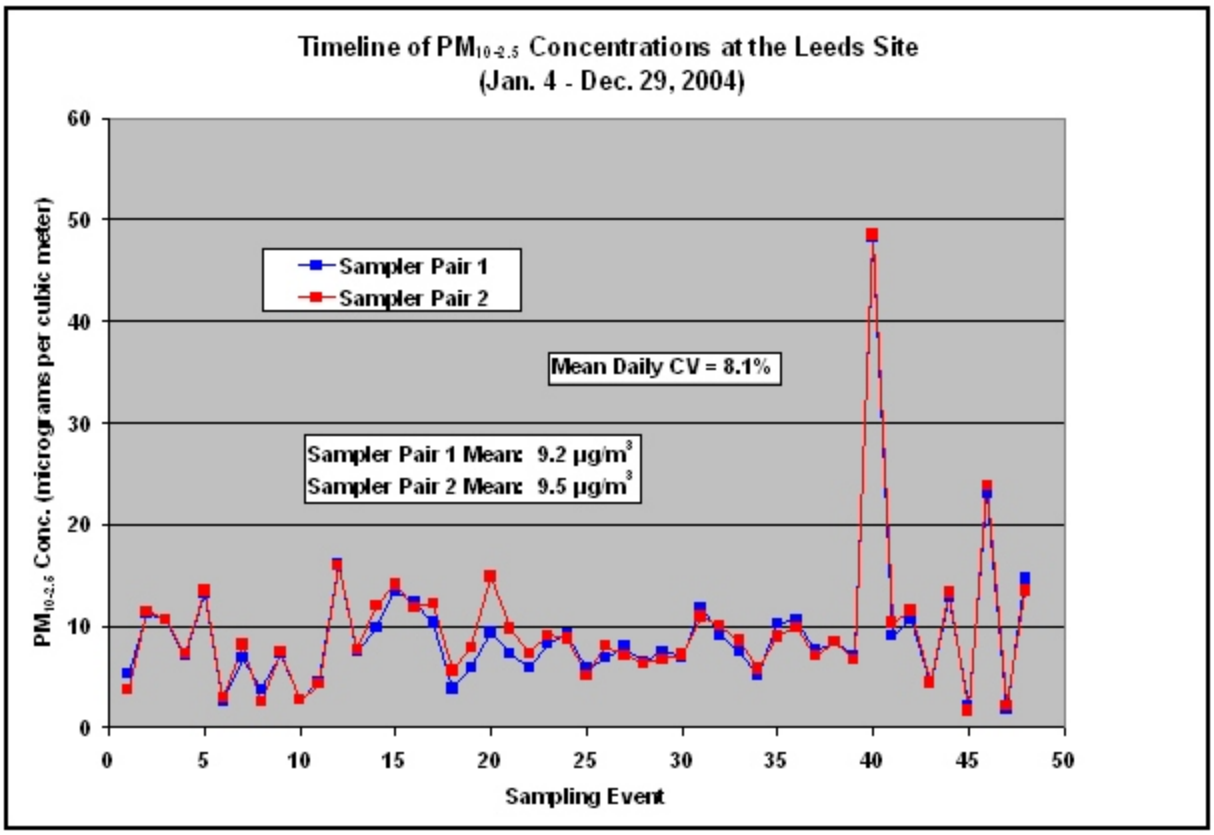

Figure 6. **Timeline of calculated $PM_{10-2.5}$ concentrations measured by the two collocated $PM_{2.5}$ and PM_{10} FRM sampler pairs at the Leeds site during 2004.**