MANHATTAN COMMUNITY BASED PARTICULATE STUDY

FINAL REPORT

EPA Contract 68D30029
Work Assignment 3-115

Prepared for:

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January 15, 1997

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1.0 INTRODUCTION

The U.S. EPA Region II conducted this study to address the concerns of the northern Manhattan communities of Harlem and Washington Heights regarding air particulate levels in their neighborhoods. The EPA Region II Office received numerous comments about particulate matter pollution levels in northern Manhattan. Community representatives expressed concern that northern Manhattan communities have higher levels of asthma than other parts of Manhattan and felt that diesel bus and truck traffic in their neighborhoods might be responsible.

The purpose of this study was to collect air quality samples of particulate matter 10 microns or less in diameter (PM10) at numerous street level locations in two communities in northern Manhattan, Harlem and Washington Heights, and at the two permanent PM10 monitoring sites, Madison Avenue in midtown and Canal Street in downtown Manhattan. In addition, samples of particulate matter 2.5 microns or less in diameter (PM2.5) were also obtained at a subset of the monitoring sites to provide information on PM2.5 levels particularly in anticipation of EPA's proposed national ambient air quality standards (NAAQS) based on PM2.5.

The study of particulate matter pollution levels in northern Manhattan was designed to provide preliminary answers to two questions:

(1) Are PM10 concentrations in northern Manhattan comparable to, less than, or greater than PM10 concentrations at reference PM10 monitoring sites in midtown and downtown Manhattan?

(2) How much variation is there in PM10 levels among community locations and, to a limited degree, to what extent do automobiles, trucks, and buses seem to contribute to PM10 concentrations?

Results will also be used to assist the State of New York in determining whether additional monitoring is warranted in these neighborhoods and, if so, where additional monitors should be located.

Representatives of the affected communities were active participants in the study from the initial meeting in June, where the project was presented to the communities and a preliminary list of sites for both Harlem and Washington Heights was selected, to the presentation of the final report, which is slated for January 1997. In a series of eight meetings to date, community representatives participated in the training given to field operators, took part in tours of potential sites for the communities, helped to select the final sites chosen, and have received preliminary data as they became available. The sites chosen for placement of samplers included locations where population exposure was likely due to vehicular emissions, where high volumes of diesel truck and bus traffic were suspected, where roadway pollutants could be trapped, and near populations with sensitive health concerns that were in proximity to high traffic locations. Undergraduate and graduate students at The City College of New York, located in the Harlem community, were used as field operators.

2.0 PM STUDY

2.1 Study Design

Air quality samples of PM10 were collected in two communities in northern Manhattan over a period of approximately 80 days during July through September 1996. Sampling was divided into two major phases, Phase 1, which focused on the neighborhoods of Harlem, and Phase 2, which focused on the neighborhoods of Washington Heights. In addition, a one-week pilot study was conducted prior to Phase 1 to try to identify and correct any equipment or logistical problems prior to starting Phase 1. For the pilot study (Phase 0), daily sampling was conducted at two sites, using two samplers per site to permit operational flexibility in servicing the sites.

During Phases 1 and 2, New York State operated its PM10 reference samplers (Sierra Andersen dichotomous samplers) on a more frequent schedule, approximately once every three days instead of once every six days. Under this schedule the reference samplers always sampled on the day required for EPA's one in six day sampling schedule. The extra sampling day was usually on the middle day (third day from the standard day) but would sometimes be shifted to the second or fourth day so that the site would not have to be serviced on a weekend. As used here, the term reference sampler means a sampler that has been designated by EPA as a Federal Reference Method or Equivalent Method for PM10 and thus has met specific design and performance specifications.

Figure 1 shows a map of Manhattan and indicates the location of the reference sites in downtown and midtown Manhattan and the general areas monitored in Phases 1 and 2. The particulate matter samplers used were saturation samplers supplied from EPA's Saturation Monitor Repository (SMR) and are described in greater detail in Section 2.2.1. Sampling was conducted midnight to midnight.

2.1.1 Phase 1

In Phase 1 of the study, which ran from July 10, 1996 through August 20, 1996, daily PM10 sampling was conducted at eight sites in the more southern neighborhoods of northern Manhattan, focusing on the neighborhoods in the Harlem/West Harlem/East Harlem communities. Sites were chosen with community involvement to represent different neighborhoods within the community and to reflect different types and levels of exposure. Figure 2 shows the locations of the eight Phase 1 community sites. Descriptions and purposes of the community and reference sites for Phase 1 are given below.

West Harlem Sites

1. 133rd Street between 12th Avenue and Broadway (bus depot and school) - On the south side of the street, on lamppost closer to 12th Avenue (PM10, PM2.5)

2. 145th Street and Broadway (truck traffic and high population density) - On the west side of Broadway between 145th and 146th Streets, center of the block (PM10)*

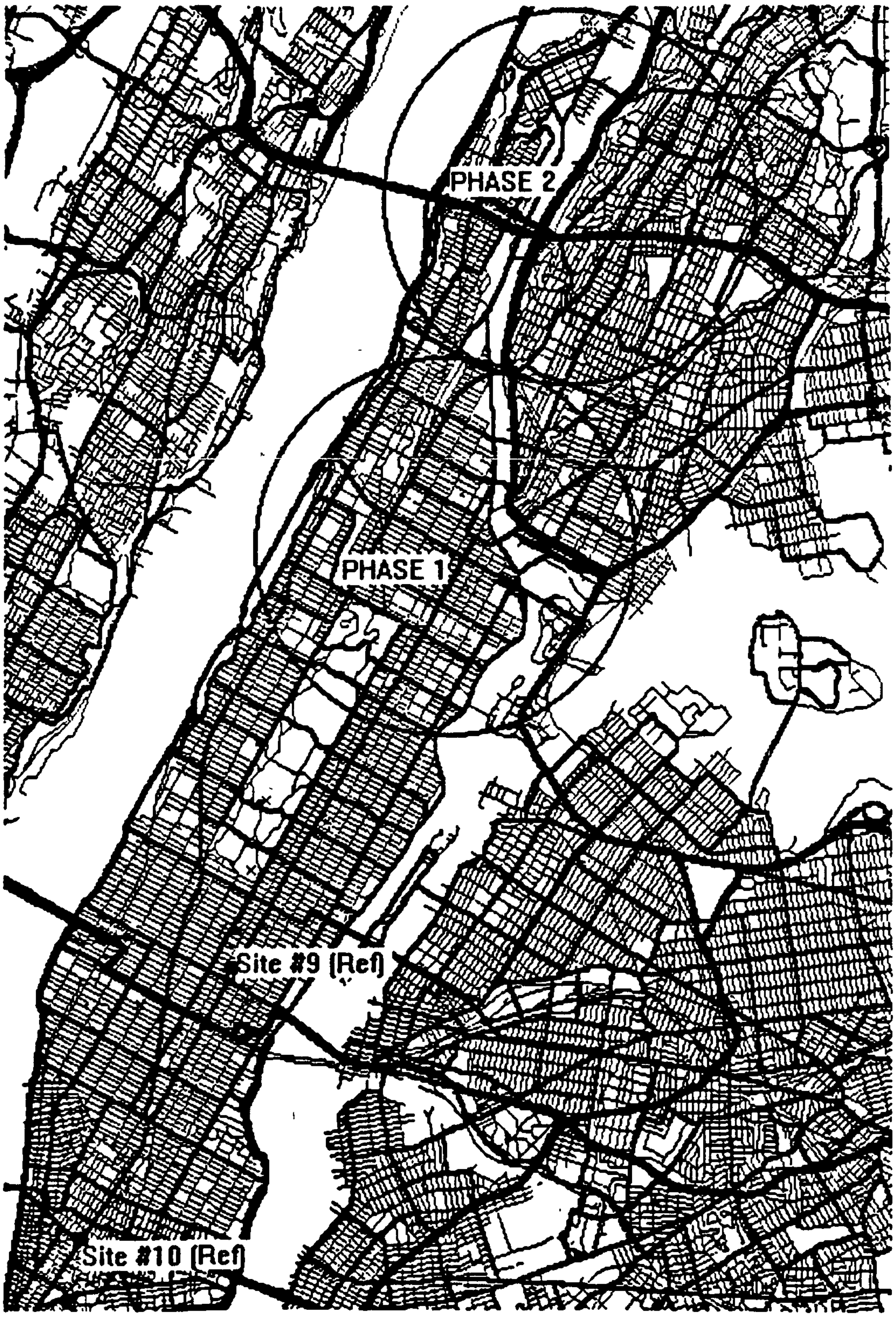


Figure 1. Locations of Reference Samplers and Areas for Phases 1 and 2

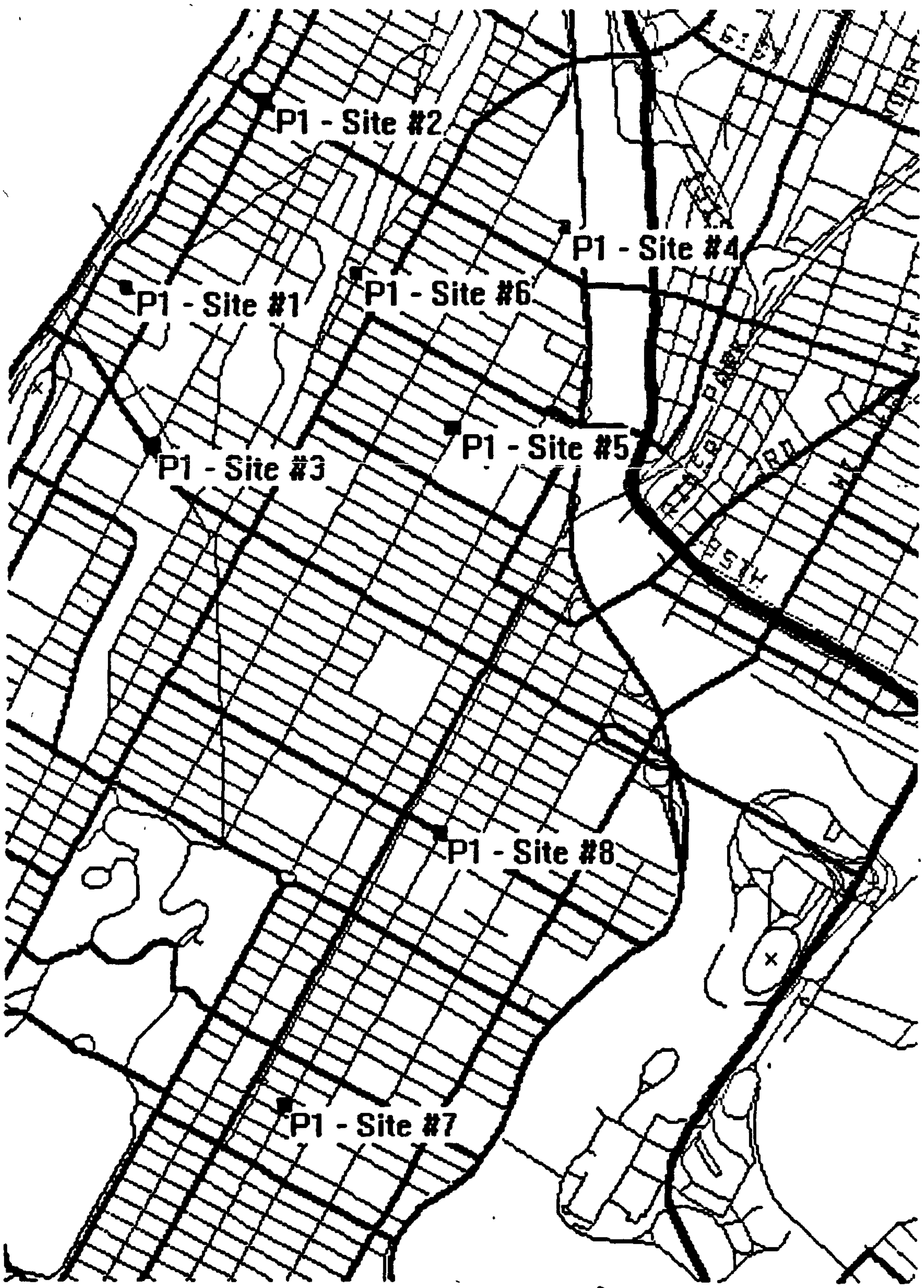


Figure 2. Site Locations for Phase 1

3. 125th Street and Amsterdam Avenue (high population density, shops, and bus and truck traffic) - On the northeast corner traffic light (PM10, PM10 collocated sampling** on reference sampler schedule)

Central Harlem Sites

4. Lennox Avenue between 147th and 148th Streets (Esplanade Gardens apartment buildings and bus depot) - On the northeast corner of 147th Street and Lennox Avenue (PM10)

5. 135th Street and Lennox Avenue (Harlem Hospital and two public schools) - On the southwest corner (PM10, PM2.5)

6. Edgecombe Avenue between 139th and 140th Streets (control site - little bus and truck traffic) - West side of Avenue, center of block (PM10)

East Harlem Sites

7. Lexington Avenue between 99th - 100th Streets (bus depot) - On the northeast corner of 100 Street and Lexington Avenue (PM10)

8. 116th Street and Lexington Avenue (high population density) - On the northwest corner of 116th Street and Lexington Avenue (PM10)

Reference Sampler Sites

9. Madison Avenue between 47th - 48th Streets (PM10, PM2.5, PM10 collocated sampling on reference sampler schedule)

10. Canal Street at Broadway (PM10, PM10 collocated sampling on reference sampler schedule)

* The sampler at this site was stolen on the first day of sampling. From July 13-25, 1996, replacement samplers were located one block east at the northwest corner of Amsterdam Avenue and 145th Street. The samplers were moved back to the original location on July 26, 1996 for the remainder of Phase 1.

** In collocated sampling, two samplers are located at a site within a few meters of one another. The duplicate measurements are used to assess the degree of mutual agreement of measurements (*i.e.*, determine precision).

Daily sampling of PM2.5 was conducted at Sites 1 and 5 in Harlem and, according to the State's sampling schedule, at reference Site 9. The PM2.5 sampling was performed as an ancillary effort by EPA to obtain information on PM2.5 concentrations and their relationship to PM10 levels in preparation for a proposed NAAQS for PM2.5.

During Phase 1 the PM10 reference samplers sampled on the following dates:

July 10, 14, 17, 20, 23, 26, 30
August 1, 4, 7, 10, 13, 15, 19

Originally, daily sampling was to be conducted at the community sites for 28 days or until the following data capture objectives were met: 15 valid data points for each site plus a minimum of 12 run days when the monitors at each location are collectively operational. However, operational and logistical problems, described in greater detail in Section 2.3, caused data to be lost and therefore the study had to be extended to 41 days in order to get enough samples to do a comparison. At a few sites, not enough data were collected.

2.1.2 Phase 2

In Phase 2 of the study, which ran from August 22, 1996 through September 30, 1996, daily sampling was initially conducted at seven sites in the more northern neighborhoods of northern Manhattan, focusing on the Washington Heights community. In addition, daily sampling at one Phase 1 site continued during this period in order to provide a data comparison between the two communities and to help account for variations in particulate matter concentrations between the two phases. Monitoring on the enhanced reference sampler schedule of approximately once every three days was also continued at the two PM10 reference sites. Figure 3 shows the locations of the eight Phase 2 community sites. The reference sites for Phase 2 were the same as those for Phase 1; the descriptions and types of sites for the community sites for Phase 2 are given below.

Washington Heights Sites

1. 181st Street and St. Nicholas Avenue (bus and truck traffic) - On northwest corner by the Chemical Bank (PM10, PM2.5)

2. 179th Street and Broadway (bus depot) - On northwest corner (PM10, PM2.5)

3. 168th Street and St. Nicholas Avenue (hospital, school and bus traffic) - On northeast corner by the school (PM10)

4. 162nd Street and Edgecombe Avenue (control site - little bus and truck traffic) - On northeast corner (PM10)

5. Dyckman Street and Sherman Avenue (bus traffic) - On northeast corner (PM10)

6. 207th Street between 9th and 10th Avenues (truck traffic) - On the north side across from Pathmark (PM10)

7. 214th Street and Broadway (bus and truck traffic) - On northwest corner (PM10)

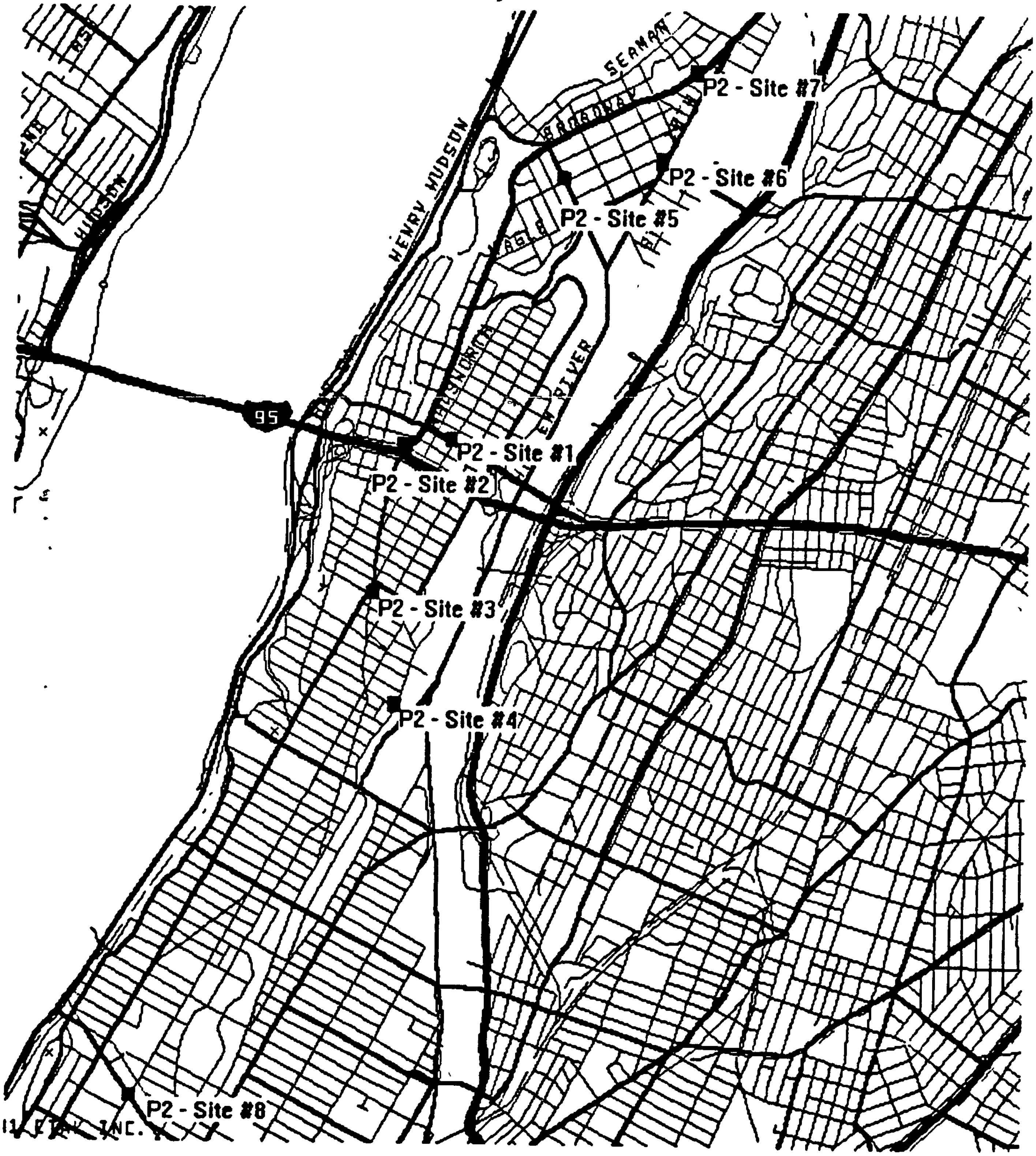


Figure 3. Site Locations for Phase 2

Harlem Site

8. 125th Street and Amsterdam Avenue (high population density, shops, and bus and truck traffic - same site as Phase 1 Site 3) - On northeast corner (PM10, PM10 quartz for carbon analysis)*

* This site was the Harlem community site with the highest particulate levels in Phase 1. It was chosen to provide additional continuity and better assess general particulate levels between the two phases of the study.

At two community sites, Sites 1 and 2, daily sampling for PM2.5 was planned, but logistical and operational problems resulted in only sporadic collection of PM2.5 data at the sites. In addition, PM2.5 data were collected at reference Site 9 on the reference sampler schedule of approximately once every three days. Two additional portable samplers were operated daily in Phase 2 (at the site carried over from Phase 1, Site 8, and at reference Site 9) to collect samples for analysis of elemental and organic carbon. Additional sampling at five sites was conducted from September 21 through September 30, 1996. This additional sampling included daily sampling for three community sites (Sites 2, 5, and 8), with sampling for elemental and organic carbon at one site (Site 8). Every third day sampling continued at the two reference sites, including sampling for elemental and organic carbon analysis at the midtown reference site (Site 9).

During Phase 2, the PM10 reference samplers sampled on the following dates:

August 22, 25, 28, 31
September 3, 6, 10, 12, 18, 24, 30

2.2 Sampling and Analysis

The following sections describe the particulate samplers, field sampling procedures, and analytical procedures for mass and carbon analysis.

2.2.1 Samplers

Saturation Samplers. The particulate samplers used in the study were saturation samplers supplied by EPA's SMR. The portable samplers are small, lightweight, and battery-operated; they are ideal for monitoring in areas where it might be difficult and expensive to establish permanent reference or equivalent samplers. The saturation sampler consists of a pump controlled by a programmable timer which can be set to make up to six runs within a 24-hour period. The portable miniVOL saturation samplers could be equipped with either a PM10 or PM2.5 impactor inlet and is designed to sample at a flow rate of 5 liters per minute (lpm) at ambient conditions.[1] Figure 4 is a diagram of a saturation sampler mounted on a utility pole. The saturation sampler, however, is not an EPA reference or equivalent method for particulate matter.

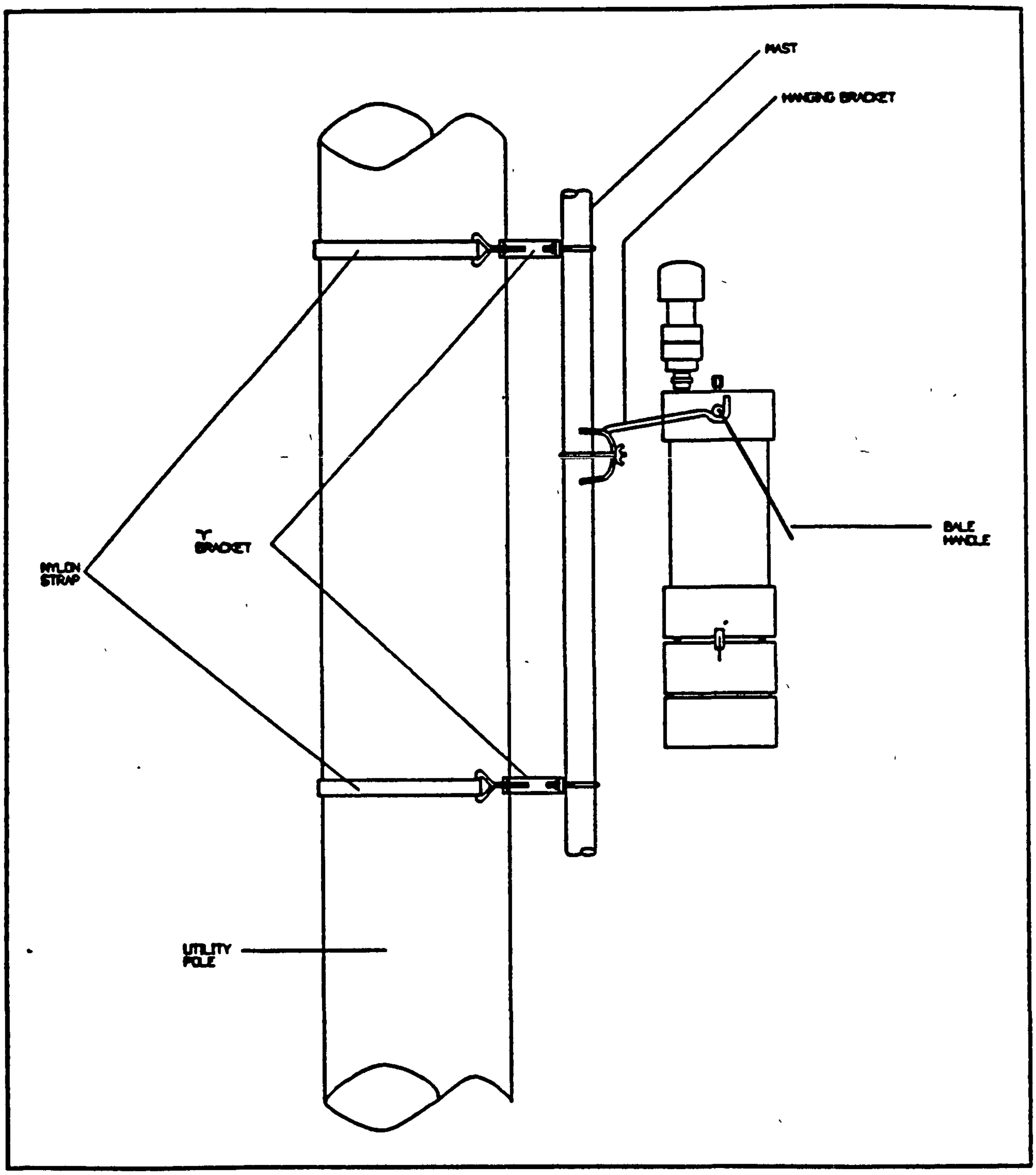


Figure 4. Diagram of Mounted Saturation Sampler

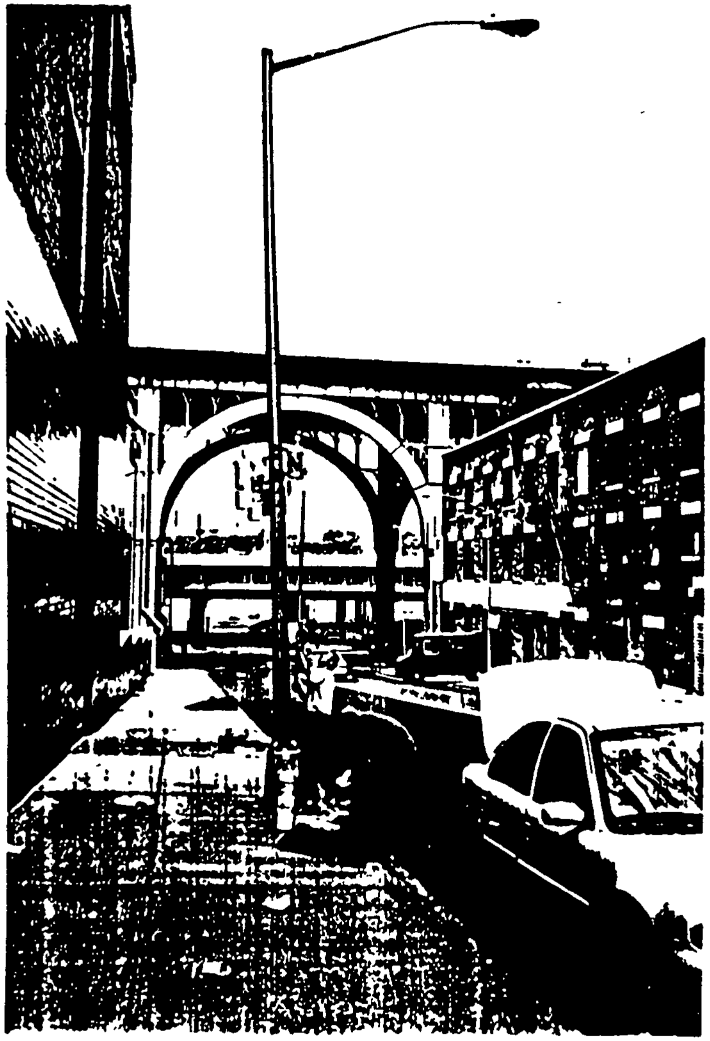
Reference Samplers. Reference samplers for PM10 were Sierra-Andersen Model 246B dichotomous samplers, which have been officially designated by EPA as equivalent samplers to the Federal Reference Method for PM10. These samplers sample at 16.7 lpm, have a PM10 inlet, and a 2.5 μm virtual impactor assembly. The sampler uses dual 37mm ringed-Teflon filters for PM2.5 and coarse (PM10-PM2.5). The sampler can thus provide measurements for PM10, PM10-PM2.5, and PM2.5, but it is only designated as an equivalent method to the Federal Reference Method for PM10 and not for PM2.5. Currently, there are no Federal Reference Method or equivalent samplers for PM2.5 because EPA has only proposed, and not promulgated, a PM2.5 standard. These reference samplers were operated by New York State personnel. The data from the reference samplers were obtained from the State by EPA Region II staff and used to assess the relative accuracy of the PM10 and PM2.5 saturation sampler data.

Sampler Placement. Ideally, the sampler inlet for PM10 and PM2.5 sampling should be at breathing height level (nominally between 1 and 2 meters). However, practical factors such as prevention of vandalism, security, and safety precautions must also be considered. Given these competing concerns, PM10 and PM2.5 sampler inlets are usually 2-7 meters above ground level. As Figure 5 indicates, the saturation samplers were usually hung from lampposts and were typically 3-4 meters above ground. Reference samplers were at ground level enclosed in wrought-iron cages with inlets about 1-2 meters above the ground. Nonetheless, the saturation samplers gave a good indication of the traffic contribution to PM10 and PM2.5. As discussed in Section 3.4.3, at the midtown Manhattan reference site, good agreement was obtained for PM10 values from the reference PM10 sampler located in the breathing zone and the saturation PM10 sampler located on a lamppost.

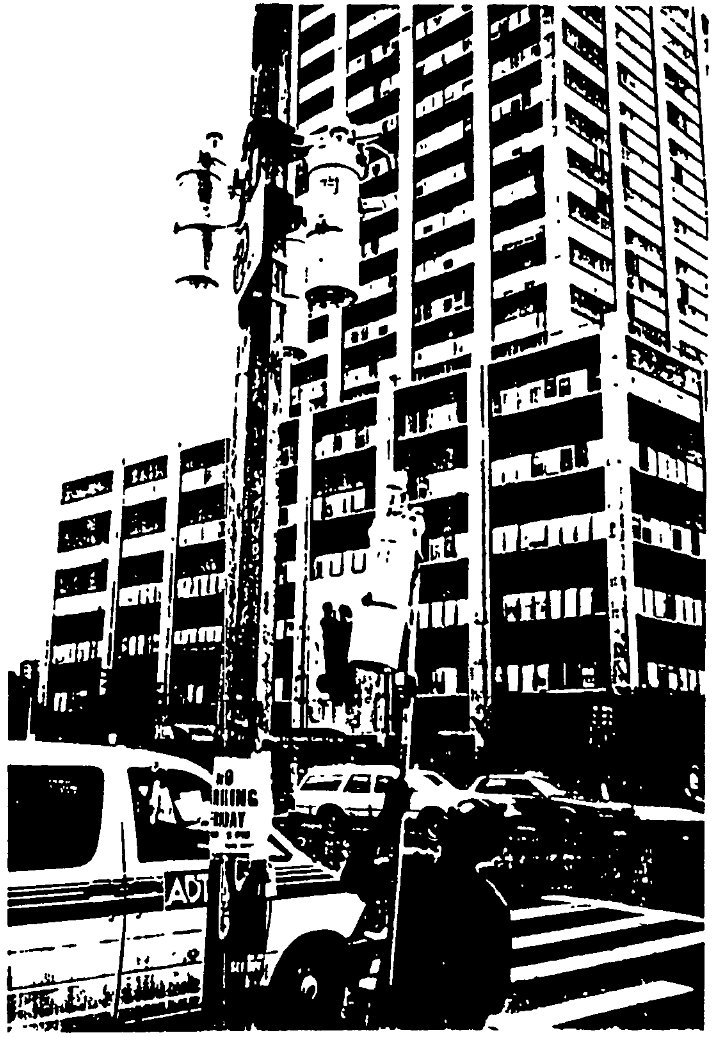
2.2.2 Sampling Procedures

The following sampling procedures were used for this study:

- Two or more samplers per site per type of particulate matter sampling (*e.g.*, PM10, PM2.5, or PM10 quartz) were generally hung from light or traffic signal posts.
- Samplers were set to run for 24-hours starting at midnight.
- Daily visits were made to sites that sampled daily.
- Each day a sampler of a particular type was reset for the next day while another sampler of the same type was running.
- A flow calibration of the samplers was conducted at the start of the study and a check of the flow calibrations was performed at the end.
- Flow points were set to achieve an actual ambient flow of 5 lpm every day prior to sampling.
- Each sampler's flow rate was checked and adjusted, if necessary, prior to and after sampling.



(a)



(b)

Figure 5. Sampler Installations at (a) Site 1 and (b) Site 5 for Phase 1

- Each sampler was checked for proper operation and damage including checks for the following:
  - battery power
  - flow rate
  - elapsed time
  - leaks
  - unusual filter conditions (such as torn or discolored filters).

- Any abnormal conditions were noted on the field forms.

During both phases, 47mm Pallflex Teflon-coated glass fiber filters were used for sampling PM10 and PM2.5 for gravimetric analysis. During Phase 2, 47mm Pallflex quartz filters were used for sampling PM10 for analysis of elemental and organic carbon. Different laboratories were used for the gravimetric and carbon analyses. Data for PM10 and PM2.5 gravimetric analyses were taken from the completed field data sheets and entered into a computerized field data management package supplied by the analytical laboratory. At periodic intervals the sampled filters, including field blanks, were sent along with copies of the field data sheets and the field data on disk to the laboratory. The quartz filters for carbon analysis were chosen after reviewing the gravimetric analysis results and sent to the analytical laboratory with a summary data sheet in hardcopy and electronic formats.

2.2.3 Analysis Procedures

Mass. The following procedures were followed for determining mass by gravimetric analysis:

- Filters for gravimetric analysis were pre- and post-weighed.

- Prior to weighing, filters were allowed to equilibrate for at least 24 hours in a control box where the relative humidity is below 50 percent (±5 percent) and the temperature is constant to within ±3°C at 15°-30°C.

- Filters were weighed with a Cahn microbalance precise to ±1 µg.

- Just before weighing, filters were passed through the field of static eliminators for a few seconds.

- Exposed filters were reweighed on the balance on which their tared weights were obtained.

- A Class M 200µg weight certified by the State Meteorology Lab, and thus traceable to National Institute for Standards and Technology (NIST), was used as a primary calibrating standard.

- Tare of the balance was checked every 20 filters (readings should be 0.000 ±2µg).

- Calibration of the balance was checked at the start and end of each filter weighing session using a 200μg Class M weight on the balance (calibration weight readings should be ±2μg of the 200μg weight).

- Three "standard" filters, arbitrarily chosen for the purpose, were weighed at the beginning of each weighing session; if the filter's weight was not within 20μg of its established value, a full-scale check-out of the balance was undertaken prior to regular filter weighing.

- Every seventh filter was reweighed by the technician; if the weight was not within 20μg of the original value, the problem was located and corrected, with all filters reweighed.

- Any blank filter weight outside the normal range of 55 to 65 mg resulted in immediate investigation.

- Three "standard" filters from a batch were weighed with each batch of filters pre-weighed and post-weighed; if the average weight of these "standard" filters changed from the pre-weighing to the post-weighing of filters due to changes in relative humidity, then a correction factor was added to/subtracted from the post-weight value.[2]

Carbon Analysis. Quartz filters were analyzed for organic and elemental carbon using a proprietary thermo-optical reflectance method. The following procedures were used:

- A section of the filter obtained by using a punch was inserted into an oven.

- The organic carbon was first volatilized at temperature steps between 300° and 550°C in a 100% helium atmosphere and then combusted at temperature steps between 550° and 700°C in an atmosphere of 1-2% oxygen in helium.

- The carbon evolved at each temperature step was converted to methane by a methanator and quantified in a flame ionization detector.

- The reflectance from the filter section was monitored using a laser from the beginning of the process and throughout the process to correct for the pyrolysis of organic material.
  - Organic carbon (OC) is the carbon that evolves before the original reflectance is reattained.
  - Elemental carbon (EC) is the carbon that evolves after the original reflectance is reattained.[2,3]

- At the end of each run, methane from a calibration loop was injected for calibration and diagnostic purposes. (The loop is calibrated by running known amounts of an organic carbon standard such as potassium hydrogen phthalate.)

- The first three runs of each day consist of an instrument blank, a carbon standard, and an EC/OC split reference standard of a previously characterized matrix deposited on a quartz filter.

- Duplicate samples were analyzed at a frequency of about one out of every 20 samples; duplicate concentrations must not vary by more than 20% relative percent difference for results greater than five times the detection limit. (Reanalysis was performed if the duplicates did not meet this criterion.[2])

Since the filters were not pre- and post-weighed, results were presented from the laboratory as micrograms per filter and were converted to $\mu g/m^3$, based on the sample flow rate using the algorithm given by the sampler manufacturer.

2.3 Operational Problems

Despite the procedures discussed in Section 2.4, some logistical, equipment, and operational problems occurred during the study that adversely affected data completeness and data quality. Although a pilot study was supposed to discover some of these problems, the samplers used in the pilot study proved to be among the most reliable and did not hint at some of the future problems. However, despite the problems encountered, the study was able to obtain sufficient data to meet its objectives.

At the start of Phase 1, three problems surfaced: (1) some samplers did not keep their original settings for 5 lpm from the field laboratory to the site locations, (2) some samplers were not sampling for the elapsed time, and (3) it was difficult to get information on the status of equipment and operations from the field operators. The first problem was quickly corrected after it was discovered during the system audit.

The second problem of too short elapsed times was corrected in some cases by adjusting the low flow cutoff threshold. However, most malfunctioning samplers could not be repaired. They eventually were replaced with other, more reliable samplers as these other samplers became available from the SMR. Considerable effort was expended in trying to diagnose and correct the problem. Defective batteries and operator error were eliminated as possible causes in a series of tests. The problem was made more difficult to solve because the samplers would seem to work in the field and SMR laboratories, but not at the site(s).

The third problem of coordination and communication difficulties was ameliorated by providing the field operators with a long-distance calling card number which they could use to report equipment problems and operations status 8 hours a day, 7 days a week.

The systems audit during Phase 1 revealed one other problem. The first sampler deployed at Site 2 was stolen on the first day of sampling. The field operators had relocated the monitoring site from Broadway between 145th and 146th streets to a location one block east at the northwest corner of Amsterdam Avenue and 145th Street. Site 2 was at this location from July 13-25, 1996, but was returned to its original location on July 26.

2.4 Quality Assurance/Quality Control

A quality assurance project plan (QAPP) was prepared and approved prior to sampling. The procedures contained in the QAPP were incorporated into standard operating procedures and followed during the study.

A variety of quality assurance/quality control (QA/QC) procedures were followed for the study.[2] Sampling and analysis QC procedures and data quality indicators are discussed in Sections 2.2 and 3.4. In addition, internal field QC checks included checks of battery power, flow rate, sampled air volume, elapsed time, leaks, unusual filter conditions, and unusual site conditions.

Field operators, who were undergraduate and graduate students at the City College of New York, were trained for two days by a senior ambient air monitoring specialist in field operations, equipment checks, field laboratory operations, recordkeeping, and site setup. A one-week pilot phase with two sites was used as a test run to identify and resolve problems. Approximately once a week, an experienced field technician would provide additional guidance to the students who were under the supervision of a Professor of Meteorology at the school. Once during each Phase, a senior QA manager conducted a systems audit of the operation and recommended and implemented corrective action on the spot.

Data were reviewed on an ongoing basis and samples were invalidated if any of the following conditions occurred:

- sampler flow rate >5.75 lpm or <4.25 lpm
- elapsed sampling time >30 hours or <18 hours
- sampled air volume >7.92 m^3 or <6.48 m^3

Data that did not meet other, more stringent criteria were labeled as suspicious. Thus, samples were labeled as suspicious if any of the following conditions occurred:

- sampler flow rate >5.5 lpm or <4.5 lpm
- elapsed sampling time >24.5 hours or <23.5 hours
- PM10 $\leq$ PM2.5

Other factors that would invalidate data included torn or damaged filters and holes in the filter.

Laboratory QC checks for gravimetric analysis included daily weighing of "standard" filters, replicate weighings of every seventh filter, checks of balance tare, and calibration after every fifth weighing. Laboratory checks for the carbon analysis included daily analysis of filter blanks, carbon standard, and OC/EC split standard and a duplicate sample analysis at a frequency of one per 20 samples or per batch, whichever is greater.

Duplicate samplers were collocated at at least two sites during each phase to assess overall precision, and one set of samplers was collocated at a reference sampler site to assess relative accuracy. During the start of Phase 1, two sites had collocated PM10 sampling, Site 3 and reference Site 9, but collocated sampling was added at reference Site 10 on July 30, 1996, to improve data completeness. All collocated sampling was chosen to correspond to the enhanced reference sampling schedule of the State, which was approximately once every three days. During the start of Phase 2, three sites had collocated PM10 sampling, Site 6 and reference Sites 9 and 10, but collocated sampling was discontinued at Site 6 after September 20, 1996.

3.0 STUDY DATA

Data were obtained for PM10 and PM2.5 concentrations during both phases of the study. In addition, data were obtained for elemental and organic carbon during Phase 2 of the study. The following sections summarize the data obtained and their data quality indicators.

3.1 PM10 Data

Table 1 summarizes the results of the final data set for PM10 for Phase 1 and includes daily summary statistics for percent complete and mean, minimum, and maximum values. Table 1 also provides similar summary statistics for each site for Phase 1. In addition, the table also provides comments about weather conditions, such as rain and stagnation conditions, that could affect PM10 levels. Table 2 provides the same information for the final data set for PM10 for Phase 2.

The data in Table 1 show that during Phase 1, 24-hour PM10 levels ranged from a low of 3 µg/m^3 (a suspicious value) at Site 6 (the control site) to a high of 122 µg/m^3 at Site 9 (a reference site). This high value was due to construction at the site and confirmed by several samplers. In general, if the exceptional value for Site 9 is omitted, Site 10, the reference site in downtown Manhattan had the highest average PM10 concentrations, 54 µg/m^3, and Site 9, the reference site in midtown Manhattan, had the next highest average PM10 concentration, 52 µg/m^3. Site 3 was the Harlem community site with the highest average PM10 concentrations, but its average concentration for the period, 40 µg/m^3, was about three-fourths that for the reference site, Site 10. Site 3 was located at the northeast corner of 125th Street and Amsterdam Avenue, a site with high population density, shops, and bus and truck traffic. Site 6, the control site, had the lowest average PM10 concentration, 28 µg/m^3. Figure 6 shows mean PM10 concentrations for Phase 1 for all days, weekdays, and weekends.

Table 2 shows that during Phase 2, 24-hour PM10 levels ranged from a low of 12 µg/m^3 (a suspicious value) at Site 4 (the control site) to a high of 79 µg/m^3 at Site 9, the midtown reference site. In general, Site 10, the downtown reference site, had the highest average PM10 concentrations, 52 µg/m^3, and Site 9, the reference site in midtown Manhattan, had the next highest average PM10 concentration, 46 µg/m^3. Site 7 was the Washington Heights community site with the highest average PM10 concentration, 36 µg/m^3, but its average concentration for the period was about two-thirds that for the reference site, Site 10. Site 7 was located at the northeast corner of 214th Street and Broadway, a site with heavy bus and truck traffic. Site 5 had the lowest average PM10 concentration, 22 µg/m^3, while Site 4, the control site, had the next lowest average PM10 concentration, 29 µg/m^3. However, due to logistical and operational problems, the sampling periods for Sites 4 and 5 did not overlap. Figure 7 shows mean PM10 concentrations for Phase 2 for all days, weekdays, and weekends.

Examination of Tables 1 and 2 shows that PM10 concentrations may vary from site to site and from day to day. During the stagnation period of June 26 through June 29, PM10 concentrations were above average at all sites. Thus, average concentrations may be misleading when different sites may have sampled for different days. Site rankings were used in an initial attempt to compensate for the difficulties of different sampling days. Tables 3 and 4 summarize

Table 1 PM10 Data (in ug/m3) for Phase 1 - Harlem Community

Day No	Day	Date	1 133rd & Broadway	2 145th & Broadway	3 125th & Amsterdam	4 Lenox & 148th	5 135th & Lenox	6 Edgecombe & 139th	7 Lexington & 99th	8 116th & Lexington	9 Madison Ave	10 Canal St.	Nact	Nexp	% Compl	Mean	Min	Max	Weather Comments
1	Wed	07/10	18		25	13		16		23			5	10	50.0	18.9	12.8	25.3	Frontal passage
2	Thu	07/11			30	22	24		25				4	8	50.0	25.4	22	30	
3	Fri	07/12	33		40				31				3	8	37.5	34.7	30.7	40.2	
4	Sat	07/13	17		16	16	17		20				5	8	62.5	17.2	15.9	19.7	Rain
5	Sun	07/14	33		43			34	38				4	10	40.0	37.0	33.3	42.8	
6	Mon	07/15	41			43	44	22	35				5	8	62.5	36.9	22.1	44.4	
7	Tue	07/16	39	29	46	29		29					5	8	62.5	34.1	28.5	45.7	
8	Wed	07/17	39		49	33	42		36		45		6	10	60.0	40.6	32.5	49	
9	Thu	07/18	48	39			47	38	44	49			6	8	75.0	44.2	38.2	48.7	
10	Fri	07/19	22			22	25	21	24				5	8	62.5	22.8	21.2	24.6	Frontal passage
11	Sat	07/20		13	19				11		21	14	5	10	50.0	15.5	10.6	20.6	
12	Sun	07/21	12		10		11	12					4	8	50.0	11.1	9.6	11.9	
13	Mon	07/22	58	26	35				26				4	8	50.0	36.3	26	57.7	
14	Tue	07/23	33	38	40	31	33	**2**		42			7	10	70.0	31.3	2.2	42.1	
15	Wed	07/24	50		53	42	47	41	43		71		7	8	87.5	49.6	41.3	70.9	
16	Thu	07/25			68	38	51		55				4	8	50.0	53.0	37.5	67.9	Rain
17	Fri	07/26	34		36	26	34	25			52	53	7	10	70.0	37.1	24.7	53	
18	Sat	07/27	11			15	17	18	18				5	8	62.5	15.9	11.2	17.9	
19	Sun	07/28	22			17	20	17	20				5	8	62.5	19.0	16.6	22.1	
20	Mon	07/29	37			35	35	30	35				5	8	62.5	34.3	29.9	36.6	
21	Tue	07/30	26			20	29	18	22		38	56	7	10	70.0	29.9	18.3	56.3	
22	Wed	07/31	27		31	15	18	16	22	7			7	8	87.5	19.3	6.7	31.3	Rain
23	Thu	08/01				28	35	**3**	39		**55**	44	6	10	60.0	34.2	3	55.1	
24	Fri	08/02	51		60	53		50	54	59			6	8	75.0	54.5	50.1	60.2	Start of stagnation period
25	Sat	08/03	69			54	63	54	64				5	8	62.5	61.0	54.1	69.2	Stagnation
26	Sun	08/04			57	62	62	47	65	44	**64**	69	8	10	80.0	58.7	43.6	69	Stagnation
27	Mon	08/05	78			70	75						3	8	37.5	74.6	70.1	78.3	Stagnation
28	Tue	08/06	77	81	86		78	64	88	88			7	8	87.5	80.3	63.5	88	Stagnation
29	Wed	08/07	79	83	89		78	69	82		93	94	8	10	80.0	83.2	69.4	93.7	Stagnation
30	Thu	08/08	38	40	47		41	34	41	43			7	8	87.5	40.3	34.2	46.5	End of stagnation period
31	Fri	08/09	**29**	48	48	36	60	34	44	47			8	8	100.0	43.2	28.8	59.5	Rain
32	Sat	08/10	20	33	23	19		21			122	31	7	10	70.0	38.4	18.5	122	
33	Sun	08/11	15	25	19	14	18	13	16	12			8	8	100.0	16.4	11.6	24.8	
34	Mon	08/12	14	24	42	26			27	12			6	8	75.0	24.3	12.2	42.4	
35	Tue	08/13	28	20	29		19		23	29	39	51	8	10	80.0	29.6	19.2	50.5	Rain
36	Wed	08/14	40	44	44	36		30	36	43			7	8	87.5	39.0	29.8	44	
37	Thu	08/15	34	38	30	31	34	30	36	39	52	55	10	10	100.0	37.9	29.7	55	
38	Fri	08/16	23	27	30	25		22	23	27			7	8	87.5	25.3	22	30.1	
39	Sat	08/17		47	49	26	48	20	47	57			7	8	87.5	41.9	20.4	56.8	
40	Sun	08/18	27		29	24		25	22	32			6	8	75.0	26.4	21.7	31.5	
41	Mon	08/19	26	29	32	23	26	22	27	32	44	72	10	10	100.0	33.3	21.9	71.6	

		1	2	3	4	5	6	7	8	9	10
All Days	Nact	35	18	31	31	29	31	34	18	12	10
	Nexp	41	41	41	41	41	41	41	41	14	14
	% Compl	85.4	43.9	75.6	75.6	70.7	75.6	82.9	43.9	85.7	71.4
	Mean	35.7	38.0	40.5	30.3	39.0	28.3	36.4	37.9	58.0	53.8
	Min	11	13	9.6	13	11	2.2	11	6.7	21	14
	Max	79	83	89	70	78	69	88	88	122	94
Weekdays	Nact	26	14	22	22	21	21	24	14	9	7
	Nexp	29	29	29	29	29	29	29	29	10	10
	% Compl	89.7	48.3	75.9	75.9	72.4	72.4	82.8	48.3	90.0	70.0
	Mean	39.3	40.5	45.0	31.5	41.7	29.4	38.3	38.4	54.3	60.6
	Min	14	20	25	13	18	2.2	22	6.7	38	44
	Max	79	83	89	70	78	69	88	88	93	94
Weekends	Nact	9	4	9	9	8	10	10	4	3	3
	Nexp	12	12	12	12	12	12	12	12	4	4
	% Compl	75.0	33.3	75.0	75.0	66.7	83.3	83.3	33.3	75.0	75.0
	Mean	25.2	29.4	29.4	27.4	32.1	26.1	31.9	35.9	69.0	38.0
	Min	11	13	9.6	14	11	12	11	12	21	14
	Max	69	47	57	62	63	54	65	57	122	69

☐ Suspicious data (boxed values, shown in bold above)

Rain noted when >= 0.25 in

Percent Complete (% Compl) = 100*(Actual Number [Nact]/Expected Number [Nexp])

Table 2 PM10 Data (in ug/m3) for Phase 2 - Washington Heights Community

Day No	Day	Date	1 181st & St. Nicholas	2 178th & Broadway	3 168th & St. Nicholas	4 162nd & Edgecombe	5 Dyckman & Sherman	6 207th & 9th Ave	7 214th & Broadway	8 125th & Amsterdam	9 Madison Ave	10 Canal St.	Nact	Nexp	% Compl	Mean	Min	Max	Weather Comments
1	Thu	08/22			49	56		51	53	61	76	71	7	10	70.0	59.4	48.5	75.9	
2	Fri	08/23			60			57	66	68			4	8	50.0	62.7	56.9	68.4	
3	Sat	08/24	37			31		33	35	34			5	8	62.5	34.0	31.3	36.9	
4	Sun	08/25	31	34	27			26	27	29	34	37	8	10	80.0	30.6	26.4	37.1	
5	Mon	08/26			37	40		41	43	44			5	8	62.5	40.8	37.1	43.8	
6	Tue	08/27	42		48			41	47				4	8	50.0	44.3	40.6	47.9	
7	Wed	08/28			36			37	38	44	61	47	6	10	60.0	43.8	35.9	61.1	
8	Thu	08/29	43		35	32		30	34	40			6	8	75.0	35.6	29.8	43.1	
9	Fri	08/30	43					26	29	29			4	8	50.0	31.8	26.3	43.2	
10	Sat	08/31	30		27	26		24		23	34	38	7	10	70.0	29.0	23.2	38	
11	Sun	09/01	28		28			27	26	28			5	8	62.5	27.5	25.6	28.4	
12	Mon	09/02	27	30	28	22		22		25			6	8	75.0	25.9	22.1	30.4	
13	Tue	09/03	43		40			38	39	42	50	58	7	10	70.0	44.4	38.4	58.4	
14	Wed	09/04	64	68	64			57					4	8	50.0	63.0	56.7	67.6	
15	Thu	09/05	54		57			52	54	57			5	8	62.5	54.8	52	56.9	
16	Fri	09/06	35	36	33	32				49	47	75	7	10	70.0	43.9	31.6	75.2	
17	Sat	09/07	37		32			34	33	40			5	8	62.5	35.2	32.2	39.6	
18	Sun	09/08	35	37	31	31		32		39			6	8	75.0	34.1	30.5	38.8	Rain
19	Mon	09/09	39		37			41	43	44			5	8	62.5	40.7	37.3	43.5	
20	Tue	09/10	47	48	44			34		50	79		6	10	60.0	50.1	34.1	78.5	
21	Wed	09/11	24		24			22	22	33			5	8	62.5	25.0	22	33.1	
22	Thu	09/12	20	21	23			20	47	32	36	61	8	10	80.0	32.5	19.7	61.3	
23	Fri	09/13	17		19			18	18	31			5	8	62.5	20.6	16.8	30.8	
24	Sat	09/14	17	24	14	16		18	18	21			7	8	87.5	18.3	13.6	24.3	
25	Sun	09/15	25		22	22		26	23	27			6	10	60.0	24.1	21.6	26.5	
26	Mon	09/16	31	38	50			27		33			5	8	62.5	35.7	26.8	49.7	
27	Tue	09/17											0	8	0.0				Rain
28	Wed	09/18	22	25	14	12		13		20	22		7	10	70.0	18.3	12.4	25	Rain
29	Thu	09/19	26		22	21		20	23	25			6	8	75.0	22.9	20.1	25.8	
30	Fri	09/20	24	27	15			19		29			5	10	50.0	22.8	14.7	29.3	
31	Sat	09/21		37						29			2	3	66.7	32.9	29.3	36.5	
32	Sun	09/22		33			30			33			3	3	100.0	31.6	29.7	32.6	Rain
33	Mon	09/23		29			18			24			3	3	100.0	23.4	17.9	28.7	
34	Tue	09/24					25			33	42	49	4	5	80.0	37.2	25.1	48.6	
35	Wed	09/25		35			16			25			3	3	100.0	25.6	16.3	35.1	
36	Thu	09/26		17			16			22			3	3	100.0	18.5	16.3	21.8	
37	Fri	09/27		23						19	36	50	4	5	80.0	32.0	19.3	49.5	
38	Sat	09/28		27			22			37			3	3	100.0	28.4	21.6	37	
39	Sun	09/29		23			27			26			3	3	100.0	25.4	22.8	27.3	
40	Mon	09/30		31			21			27	37	38	5	5	100.0	30.8	20.9	37.9	

[ ] Suspicious data — Rain noted when >= 0.25 in

		1	2	3	4	5	6	7	8	9	10
All Days	Nact	25	20	27	12	8	28	20	37	12	10
	Nexp	30	40	30	30	40	30	30	40	14	14
	% Compl	83.3	50.0	90.0	40.0	20.0	93.3	66.7	92.5	85.7	71.4
	Mean	33.7	32.1	33.9	28.5	21.9	31.6	35.8	34.3	46.0	52.4
	Min	17	17	14	12	16	13	18	19	22	37
	Max	64	68	64	56	30	57	66	68	79	75
Weekdays	Nact	18	13	21	8	5	21	15	25	10	8
	Nexp	22	28	22	22	28	22	22	28	11	11
	% Compl	81.8	46.4	95.5	36.4	17.9	95.5	68.2	89.3	90.9	72.7
	Mean	35.4	32.9	36.7	30.7	19.3	33.2	39.6	36.2	48.5	56.1
	Min	17	17	14	12	16	13	18	19	22	38
	Max	64	68	64	56	25	57	66	68	79	75
Weekends	Nact	8	7	7	5	3	8	6	12	2	2
	Nexp	8	12	12	12	12	12	12	12	3	3
	% Compl	100	58.3	58.3	41.7	25.0	66.7	50.0	100	66.7	66.7
	Mean	30.0	30.6	25.9	25.3	26.2	27.6	26.9	30.4	33.9	37.6
	Min	17	23	14	16	22	18	18	21	34	37
	Max	37	37	32	31	30	34	35	40	34	38

Percent Complete (% Compl) = 100*(Actual Number [Nact]/Expected Number [Nexp])

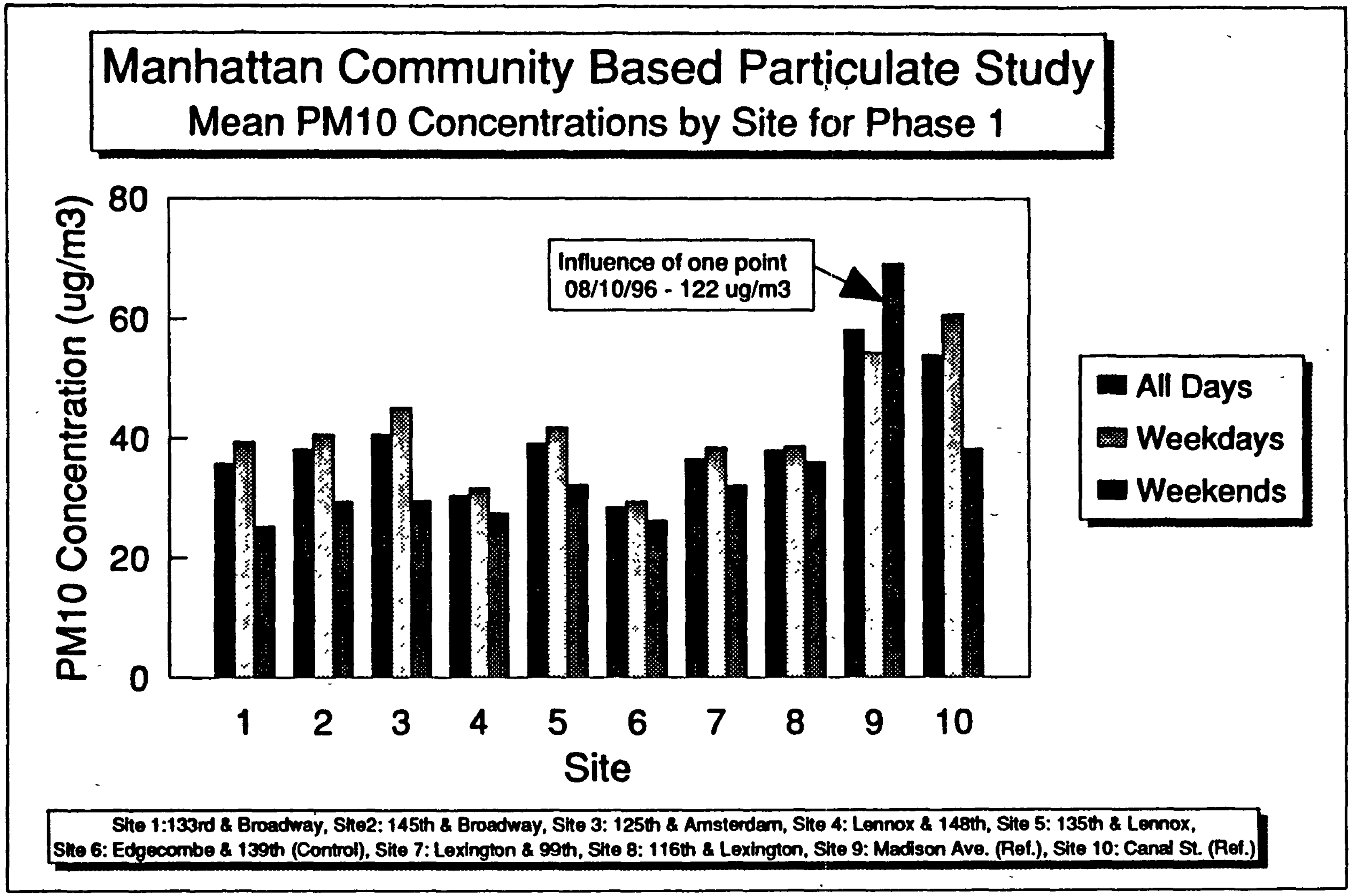


Figure 6. Mean PM10 Concentrations by Site for Phase 1

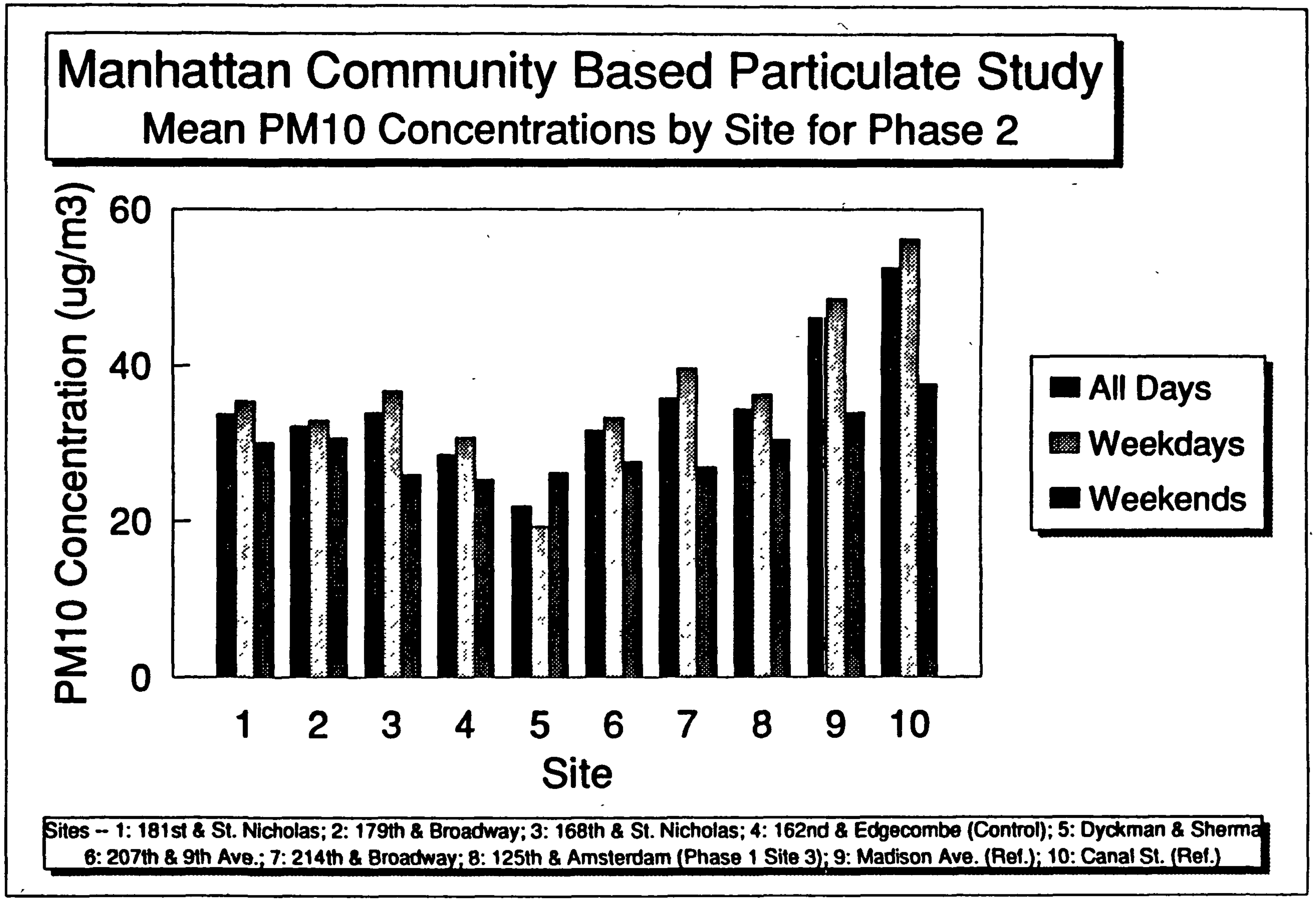


Figure 7. Mean PM10 Concentrations by Site for Phase 2

Table 3. Phase 1 Harlem Community Site Rankings

Day No	Day	Date	133rd & Broadway 1	145th & Broadway 2	125th & Amsterdam 3	Lennox & 148th 4	135th & Lennox 5	Edgecombe & 139th 6	Lexington & 99th 7	116th & Lexington 8	Madison Ave. 9	Canal St. 10	N
1	Wed	07/10	3		1	5		4		2			5
2	Thu	07/11			1	4	3		2				4
3	Fri	07/12	2		1				3				3
4	Sat	07/13	3		4	4	2		1				5
5	Sun	07/14	4		1			3	2				4
6	Mon	07/15	3			2	1	5	4				5
7	Tue	07/16	2	3	1	4		4					5
8	Wed	07/17	4		1	6	3		5		2		6
9	Thu	07/18	2	5			3	6	4	1			6
10	Fri	07/19	4			3	1	5	2				5
11	Sat	07/20		4	2				5		1	3	5
12	Sun	07/21	1		4		3	2					4
13	Mon	07/22	1	4	2				3				4
14	Tue	07/23	5	3	2	6	4	7		1			7
15	Wed	07/24	3		2	6	4	7	5		1		7
16	Thu	07/25			1	4	3		2				4
17	Fri	07/26	5		3	6	4	7			2	1	7
18	Sat	07/27	5			4	3	1	2				5
19	Sun	07/28	1			4	2	5	3				5
20	Mon	07/29	1			4	2	5	3				5
21	Tue	07/30	4			6	3	7	5		2	1	7
22	Wed	07/31	2		1	6	4	5	3	7			7
23	Thu	08/01				5	4	6	3		1	2	6
24	Fri	08/02	5		1	4		6	3	2			6
25	Sat	08/03	1			5	3	4	2				5
26	Sun	08/04			6	5	4	7	2	8	3	1	8
27	Mon	08/05	1			3	2						3
28	Tue	08/06	6	4	3		5	7	1	2			7
29	Wed	08/07	6	4	3		7	8	5		2	1	8
30	Thu	08/08	6	5	1		3	7	3	2			7
31	Fri	08/09	8	2	3	6	1	7	5	4			8
32	Sat	08/10	6	2	4	7		5			1	3	7
33	Sun	08/11	5	1	2	6	3	7	4	8			8
34	Mon	08/12	5	4	1	3			2	6			6
35	Tue	08/13	5	7	3		8		6	3	2	1	8
36	Wed	08/14	4	1	1	5		7	6	3			7
37	Thu	08/15	6	4	10	8	7	9	5	3	2	1	10
38	Fri	08/16	5	2	1	4		7	6	3			7
39	Sat	08/17		5	2	6	3	7	4	1			7
40	Sun	08/18	3		2	5		4	6	1			6
41	Mon	08/19	8	5	3	9	7	10	6	4	2	1	10
	N		35	18	31	31	29	31	34	18	12	10	
	Mean		3.9	3.6	2.4	5	3.5	5.8	3.6	3.4	1.8	1.5	
	Relative Rank		8	6	3	9	5	10	7	4	2	1	

Table 4. Phase 2 Washington Heights Community Site Rankings

Day No.	Day	Date	181st & St. Nicholas 1	179th & Broadway 2	168th & St. Nicholas 3	162nd & Edgecombe 4	Dyckman & Sherman 5	207th & 9th Ave. 6	214th & Broadway 7	125th & Amsterdam 8	Madison Ave. 9	Canal St. 10	N
1	Thu	08/22			7	4		6	5	3	1	2	7
2	Fri	08/23			3			4	2	1			4
3	Sat	08/24	1			5		4	2	3			5
4	Sun	08/25	4	2	6			8	7	5	3	1	8
5	Mon	08/26			5	4		3	2	1			5
6	Tue	08/27	3		1			4	2				4
7	Wed	08/28			6			5	4	3	1	2	6
8	Thu	08/29	1		3	5		6	4	2			6
9	Fri	08/30	1					4	3	2			4
10	Sat	08/31	3		4	5		6		7	2	1	7
11	Sun	09/01	1		1			4	5	3			5
12	Mon	09/02	3	1	2	5		6		4			6
13	Tue	09/03	3		5			7	6	4	2	1	7
14	Wed	09/04	2	1	3			4					4
15	Thu	09/05	3		1			5	3	2			5
16	Fri	09/06	5	4	6	7				2	3	1	7
17	Sat	09/07	2		5			3	4	1			5
18	Sun	09/08	3	2	5	6		4		1			6
19	Mon	09/09	4		5			3	2	1			5
20	Tue	09/10	4	3	5			6		2	1		6
21	Wed	09/11	3		2			5	4	1			5
22	Thu	09/12	8	6	5			7	2	4	3	1	8
23	Fri	09/13	5		2			4	3	1			5
24	Sat	09/14	5	1	7	6		3	3	2			7
25	Sun	09/15	3		6	5		2	4	1			6
26	Mon	09/16	4	2	1			5		3			5
27	Tue	09/17											0
28	Wed	09/18	2	1	5	7		6		4	3		7
29	Thu	09/19	1		4	5		6	3	2			6
30	Fri	09/20	3	2	5			4		1			5
31	Sat	09/21		1						2			2
32	Sun	09/22		1			3			1			3
33	Mon	09/23		1			3			2			3
34	Tue	09/24					4			3	2	1	4
35	Wed	09/25		1			3			2			3
36	Thu	09/26		2			3			1			3
37	Fri	09/27		3						4	2	1	4
38	Sat	09/28		2			3			1			3
39	Sun	09/29		3			1			2			3
40	Mon	09/30		3			5			4	2	1	5
8/22-9/30	N		25	20	27	12	8	28	20	37	12	10	
	Mean		3.1	2.1	4.1	5.3	3.1	4.8	3.5	2.4	2.1	1.2	
	Relative Rank		5	3	8	10	6	9	7	4	2	1	

the results of the site rankings for Phases 1 and 2, respectively. On any given sampling day, the site with the highest 24-hour PM10 concentration was given a rank of 1, the next highest a rank of 2, and so on. The average rank for each site during the entire study period was used to determine an overall relative rank. In each phase, Site 10 was ranked 1st and Site 9 was ranked 2nd. During Phase 1, Site 3, ranked 3rd, was the Harlem community site with the highest relative ranking, and Site 6, the Harlem community control site, was the community site ranked last. During Phase 2, Site 2, ranked 3rd, was the Washington Heights community site with the highest relative ranking, and Site 4, the Washington Heights community control site was ranked last. For Phase 2, Site 8 (which was Site 3, the highest ranked community site with a rank of 3rd, during Phase 1) was ranked 4th.

In general, average PM10 concentrations in Phase 2 were down slightly from those in Phase 1 - about 4 percent at Site 10, 12 percent at Site 9 (excluding the exceptional day), and 15 percent at Site 8 (Site 3 in Phase 1). Appendix A contains a complete set of plots of daily PM10 concentrations for each site during Phase 1. Appendix B contains the sample plots for Phase 2.

3.2 PM2.5 Data

During Phase 1, PM2.5 samplers were located at Sites 1, 5, and 9. During Phase 2, PM2.5 samplers were located at Sites 1, 2, and 9. Tables 5 and 6 summarize the data for PM2.5 during Phases 1 and 2, respectively. The tables show both PM10 and PM2.5 concentrations in $\mu g/m^3$ and the ratio of PM2.5/PM10 at each site for each day. Daily summary statistics for percent complete and mean, minimum, and maximum ratios are also given. In addition, similar statistics are provided for PM10, PM2.5, PM2.5/PM10 for each site for all days, weekdays, and weekends for each phase. Figure 8 shows daily PM10 and PM2.5 concentrations for Site 1 during Phase 1. Appendix A also shows daily PM2.5 concentrations along with PM10 concentrations for all sites having PM2.5 sampling during each phase. In addition, PM2.5 was inadvertently acquired at Site 3 for three days (July, 14, 17, and 24) during the start of Phase 1 when a PM2.5 sampler inlet was erroneously used on what was supposed to be a collocated PM10 sampler.

Table 5 shows that Phase 1 24-hour PM2.5 levels ranged from a low of 2 $\mu g/m^3$ at Site 5 to a high of 79 $\mu g/m^3$ at Site 9 (the midtown Manhattan reference site). During Phase 1, mean ratios of PM2.5/PM10 ranged from 0.75 at Site 5 to 0.83 at Site 9. Table 6 shows that Phase 2 24-hour PM2.5 levels ranged from a low of 12 $\mu g/m^3$ at Site 2 to a high of 61 $\mu g/m^3$ at Site 9. Logistical and operational problems reduced the amount of PM2.5 data that were acquired during Phase 2.

During Phase 1, mean ratios of PM2.5/PM10 ranged from 0.75 at Site 5 to 0.83 at Site 9. During Phase 2, mean ratios ranged from 0.69 at Site 1 to 0.77 at Site 2. The mean PM2.5 concentration at Site 9 decreased from 47 $\mu g/m^3$ during Phase 1 to 35 $\mu g/m^3$ during Phase 2 while the mean ratio of PM2.5/PM10 varied from 0.83 during Phase 1 to 0.75 during Phase 2. Figures 9 and 10 show daily PM2.5 concentrations along with PM10 concentrations at Site 9 for Phases 1 and 2, respectively.

Table 5. PM2 5 Data (in ug/m3) for Phase 1 - Harlem Community

			Site 1 133rd & Broadway			Site 5 135th & Lennox			Site 9 Madison Ave			PM2.5/PM10			PM2.5/PM10		
Day No	Day	Date	(10)	(2.5)	(2.5/10)	(10)	(2.5)	(2.5/10)	(10)	(2 5)	(2.5/10)	Nact	Nexp	% Compl	Mean	Min	Max
1	Wed	07/10	18	17	0.983		13					1	3	33.3	0.983	0 983	0.983
2	Thu	07/11		18		24						0	2	0 0			
3	Fri	07/12	33				24					0	2	0 0			
4	Sat	07/13	17	11	0.671	17	11	0.649				2	2	100.0	0 660	0 649	0.671
5	Sun	07/14	33				18					1	3	33 3	0 829	0 829	0.829
6	Mon	07/15	41	30	0.723	44	28	0.631				2	2	100.0	0 677	0.631	0.723
7	Tue	07/16	39				30					0	2	0 0			
8	Wed	07/17	39	32	0.818	42			45			2	3	66.7	0.808	0.798	0.818
9	Thu	07/18	48	38	0.786	47	34	0.727				2	2	100 0	0.757	0 727	0 786
10	Fri	07/19	22	18	0.817	25						1	2	50 0	0.817	0.817	0.817
11	Sat	07/20		11			9		21	16	0.782	1	3	33.3	0 782	0.782	0.782
12	Sun	07/21	12	9	0.765	11	11	0.956				2	2	100 0	0.860	0.765	0.956
13	Mon	07/22	58	25	0.435		15					1	2	50 0	0.435	0 435	0 435
14	Tue	07/23	33	28	0.848	33						1	3	33.3	0.848	0 848	0.848
15	Wed	07/24	50	44	0.878	47	39	0.819	71	57	0.805	4	2	200 0	0 848	0.805	0.889
16	Thu	07/25		44		51	42	0 814				1	2	50.0	0 814	0.814	0 814
17	Fri	07/26	34	29	0 867	34	26	0 759	52	44	0.849	3	3	100 0	0 825	0 759	0 867
18	Sat	07/27	11 [boxed]	11 [boxed]	1.009	17	13	0 764				2	2	100 0	0 887	0 764	1 009
19	Sun	07/28	22			20	17	0.838				1	2	50.0	0 838	0 838	0.838
20	Mon	07/29	37	31	0 844	35	27	0.756				2	2	100 0	0 800	0.756	0.844
21	Tue	07/30	26	21	0 801	29	15	0.533	38	26	0 702	3	3	100 0	0 679	0.533	0.801
22	Wed	07/31	27	23	0.857	18	12	0.678				2	2	100 0	0 767	0.678	0 857
23	Thu	08/01		33		35	26	0 744	55 [boxed]	68 [boxed]	1.232	2	3	66 7	0.988	0 744	1.232
24	Fri	08/02	51				41					0	2	0.0			
25	Sat	08/03	69	61	0.874	63	49	0.777				2	2	100 0	0 826	0 777	0.874
26	Sun	08/04		56		62	55	0 875	64 [boxed]	68 [boxed]	1 063	2	3	66 7	0.969	0 875	1.063
27	Mon	08/05	78			75	64	0 851				1	2	50 0	0.851	0 851	0 851
28	Tue	08/06	77	68	.0.88	78	68	0 872				2	2	100 0	0 876	0 872	0 880
29	Wed	08/07	79	66	0.838	78	59	0.764	93	79	0.846	3	3	100.0	0 816	0 764	0 846
30	Thu	08/08	38	31	0 83	41	31	0 751				2	2	100 0	0 791	0.751	0 830
31	Fri	08/09	29 [boxed]	30 [boxed]	1 035	60	48	0.805				2	2	100 0	0 920	0 805	1.035
32	Sat	08/10	20	16	0.821		14		122	41	0.339	2	3	66.7	0.580	0.339	0.821
33	Sun	08/11	15	12	0 799	18	8	0 472				2	2	100 0	0 635	0 472	0 799
34	Mon	08/12	14									0	2	0 0			
35	Tue	08/13	28	15	0.521	19	14	0.714	39	31	0.782	3	3	100 0	0.672	0 521	0.782
36	Wed	08/14	40				42					0	2	0 0			
37	Thu	08/15	34	27	0 798	34	24	0.714	52	45	0.861	3	3	100 0	0 791	0 714	0 861
38	Fri	08/16	23	18	0 779		2					1	2	50.0	0 779	0 779	0 779
39	Sat	08/17		31		48	38	0.791				1	2	50.0	0 791	0.791	0 791
40	Sun	08/18	27	24	0.892		16					1	2	50 0	0 892	0 892	0 892
41	Mon	08/19	26	20	0 781	26	19	0 720	44	37	0 828	3	3	100 0	0 776	0 720	0 828

		Site 1 (10)	Site 1 (2.5)	Site 1 (2.5/10)	Site 5 (10)	Site 5 (2.5)	Site 5 (2.5/10)	Site 9 (10)	Site 9 (2 5)	Site 9 (2.5/10)
All Days	Nact	35	33	27	29	36	25	12	11	11
	Nexp	41	41	41	41	41	41	14	14	14
	% Compl	85 4	80.5	65 9	70 7	87.8	61.0	85 7	78 6	78.6
	Mean	36	29	0.813	39	27.8	0.751	58	47	0.826
	Min	11	9 1	0.435	11	2.3	0 472	21	16	0.339
	Max	79	68	1.035	78	68 1	0.956	122	79	1.232
Weekdays	Nact	26	23	20	21	24	17	9	8	8
	Nexp	29	29	29	29	29	29	10	10	10
	% Compl	89.7	79.3	69.0	72.4	82.8	58 6	90.0	80.0	80.0
	Mean	39	31	0.806	42	30 9	0.744	54	48	0 863
	Min	14	15	0.435	18	2.3	0.533	38	26	0.702
	Max	79	68	1.035	78	68 1	0.872	93	79	1.232
Weekends	Nact	9	10	7	8	12	8	3	3	3
	Nexp	12	12	12	12	12	12	4	4	4
	% Compl	75.0	83.3	58.3	66.7	100.0	66.7	75.0	75.0	75.0
	Mean	25	24	0.833	32	21.6	0.765	69	42	0.728
	Min	11	9 1	0.671	11	8.3	0.472	21	16	0.339
	Max	69	61	1.009	63	54 6	0.956	122	68	1.063

[boxed] Suspicious data

Percent Complete (% Compl) = 100*(Actual Number [Nact]/Expected Number [Nexp])

Table 6 PM2.5 Data (in ug/m3) for Phase 2 - Washington Heights Community

			Site 1			Site 2			Site 9			PM2.5/PM10			PM2.5/PM10		
			181st & St Nicholas			179th & Broadway			Madison Ave								
Day No.	Day	Date	(10)	(2.5)	(2.5/10)	(10)	(2.5)	(2.5/10)	(10)	(2.5)	(2.5/10)	Nact	Nexp	% Compl	Mean	Min	Max
1	Thu	08/22							76	61	0.805	1	3	33 3	0 81	0 81	0 81
2	Fri	08/23		38								0	2	0 0			
3	Sat	08/24	37									0	2	0 0			
4	Sun	08/25	31	22	0.706	34			34	27	0.807	2	3	66.7	0.76	0.71	0 81
5	Mon	08/26										0	2	0 0			
6	Tue	08/27	42	23	0.55							1	2	50 0	0.55	0.55	0.55
7	Wed	08/28							61	45	0 741	1	3	33 3	0.74	0 74	0 74
8	Thu	08/29	43	33	0.761							1	2	50 0	0.76	0 76	0.76
9	Fri	08/30	43									0	2	0.0			
10	Sat	08/31	30						34	23	0.672	1	3	33.3	0.67	0.67	0 67
11	Sun	09/01	28									0	2	0.0			
12	Mon	09/02	27			30						0	2	0 0			
13	Tue	09/03	43						50	40	0.806	1	3	33 3	0 81	0 81	0.81
14	Wed	09/04	64			68						0	2	0.0			
15	Thu	09/05	54									0	2	0.0			
16	Fri	09/06	35			36			47	38	0.797	1	3	33.3	0 8	0.8	0.8
17	Sat	09/07	37									0	2	0 0			
18	Sun	09/08	35			37						0	2	0.0			
19	Mon	09/09	39									0	2	0.0			
20	Tue	09/10	47			48			79	60	0.761	1	3	33 3	0.76	0 76	0.76
21	Wed	09/11	24									0	2	0 0			
22	Thu	09/12	20			21			36	29	0.806	1	3	33.3	0.81	0 81	0 81
23	Fri	09/13	17									0	2	0 0			
24	Sat	09/14	17			24						0	2	0 0			
25	Sun	09/15	25									0	3	0 0			
26	Mon	09/16	31			38						0	2	0 0			
27	Tue	09/17										0	2	0.0			
28	Wed	09/18	22	17	0 756	25			22	18	0.811	2	3	66 7	0.78	0.76	0.81
29	Thu	09/19	26									0	2	0 0			
30	Fri	09/20	24			27						0	3	0.0			
31	Sat	09/21				37	25	0 679				1	1	100 0	0.68	0 68	0 68
32	Sun	09/22				33						0	1	0.0			
33	Mon	09/23				29						0	1	0.0			
34	Tue	09/24					33		42	16	0 37	1	3	33 3	0 37	0 37	0 37
35	Wed	09/25				35						0	1	0 0			
36	Thu	09/26				17	19	1 11				1	1	100 0	1.11	1 11	1 11
37	Fri	09/27				23	12	0.534	36	27	0 758	2	3	66.7	0 65	0.53	0 76
38	Sat	09/28				27						0	1	0.0			
39	Sun	09/29				23	17	0.75				1	1	100 0	0 75	0 75	0 75
40	Mon	09/30				31			37	32	0 872	1	3	33 3	0 87	0 87	0 87

		Site 1 (10)	Site 1 (2.5)	Site 1 (2.5/10)	Site 2 (10)	Site 2 (2.5)	Site 2 (2.5/10)	Site 9 (10)	Site 9 (2.5)	Site 9 (2.5/10)
All Days	Nact	25	5	4	25	5	4	12	12	12
	Nexp	30	30	30	40	40	40	14	14	14
	% Compl	83.3	16 7	13.3	62.5	12.5	10.0	85.7	85 7	85 7
	Mean	34	27	0.693	32	21	0.768	46	35	0.75
	Min	17	17	0.55	17	12	0.534	22	16	0 37
	Max	64	38	0.761	68	33	1.11	79	61	0.872
Weekdays	Nact	17	4	3	13	3	2	10	10	10
	Nexp	22	22	22	28	28	28	11	11	11
	% Compl	77.3	18.2	13.6	46.4	10.7	7.1	90.9	90 9	90.9
	Mean	35	28	0.689	33	22	0.822	48	37	0 753
	Min	17	17	0.55	17	12	0.534	22	16	0.37
	Max	64	38	0.761	68	33	1.11	79	61	0.872
Weekends	Nact	8	1	1	7	2	2	2	2	2
	Nexp	8	8	8	12	12	12	3	3	3
	% Compl	100	12.5	12.5	58.3	16.7	16.7	66.7	66.7	66.7
	Mean	30	22	0.706	31	21	0.715	34	25	0.739
	Min	17	22	0.706	23	17	0.679	34	23	0.672
	Max	37	22	0.706	37	25	0 75	34	27	0 807

☐ Suspicious data (boxed values: Day 28 Site 1 (10) 22, (2.5) 17; Site 9 (10) 22, (2.5) 18)

Percent Complete (% Compl) = 100*(Actual Number [Nact]/Expected Number [Nexp])

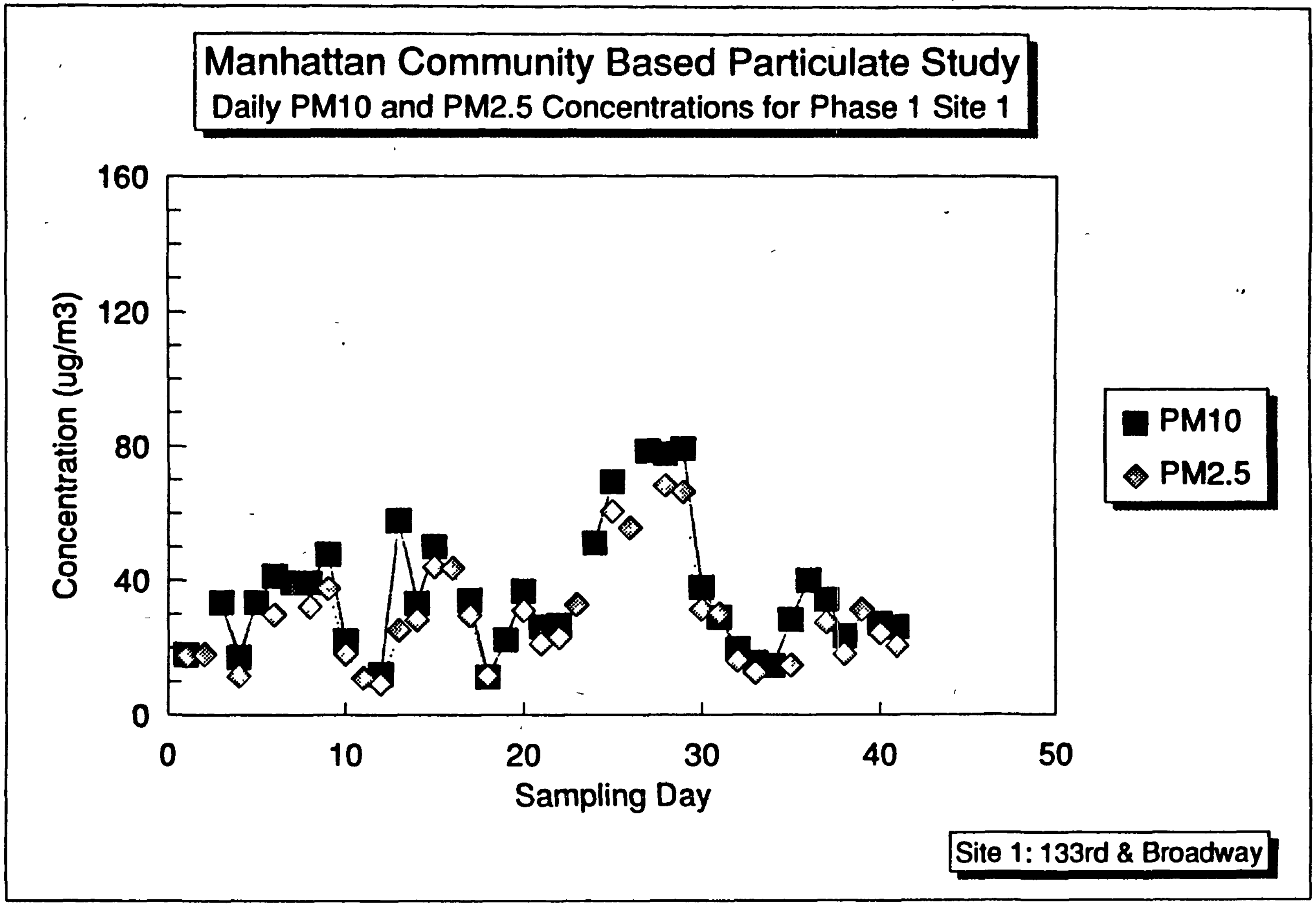


Figure 8. Daily PM10 and PM2.5 Concentrations at Phase 1 Site 1

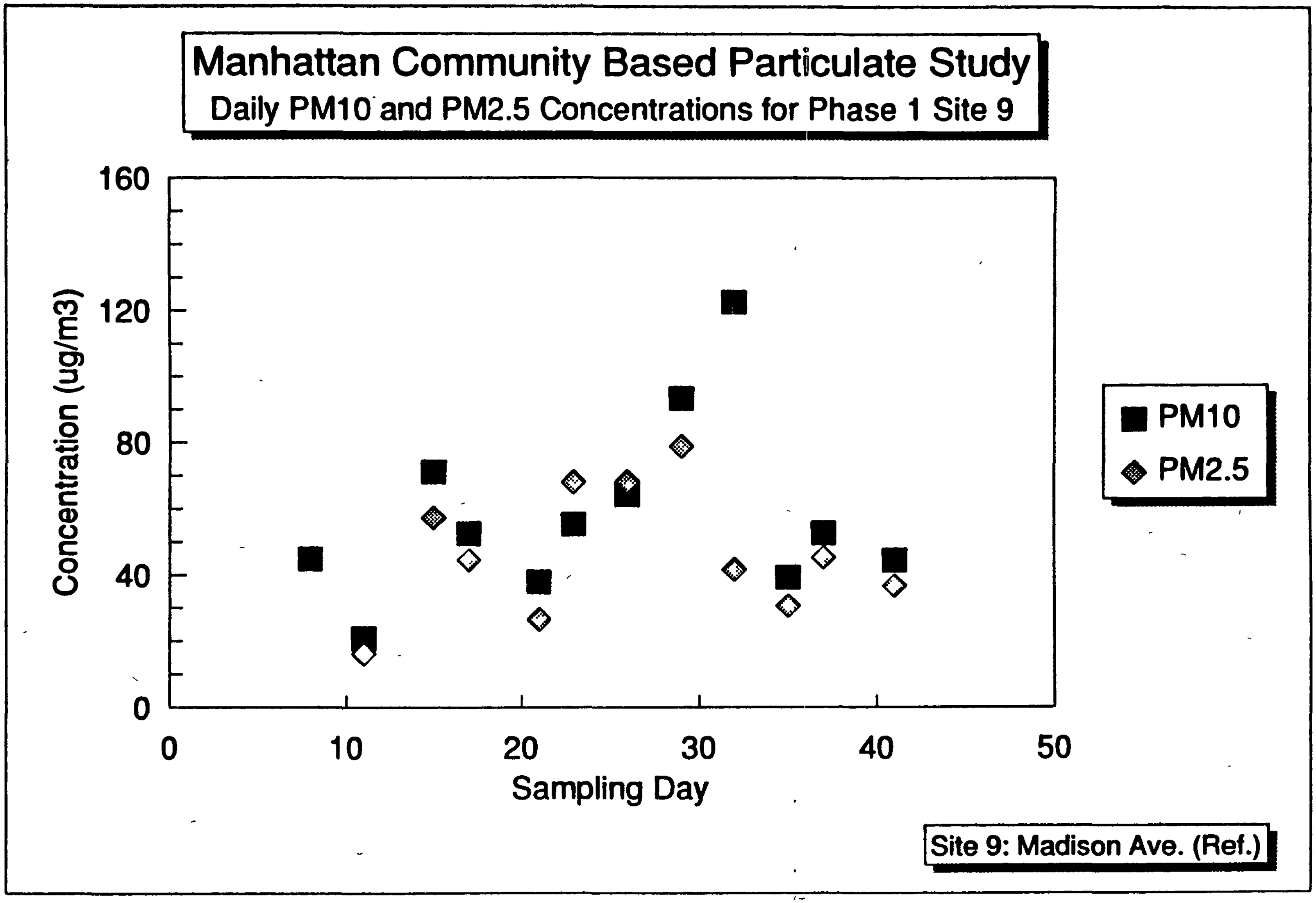


Figure 9. Daily PM10 and PM2.5 Concentrations at Phase 1 Site 9

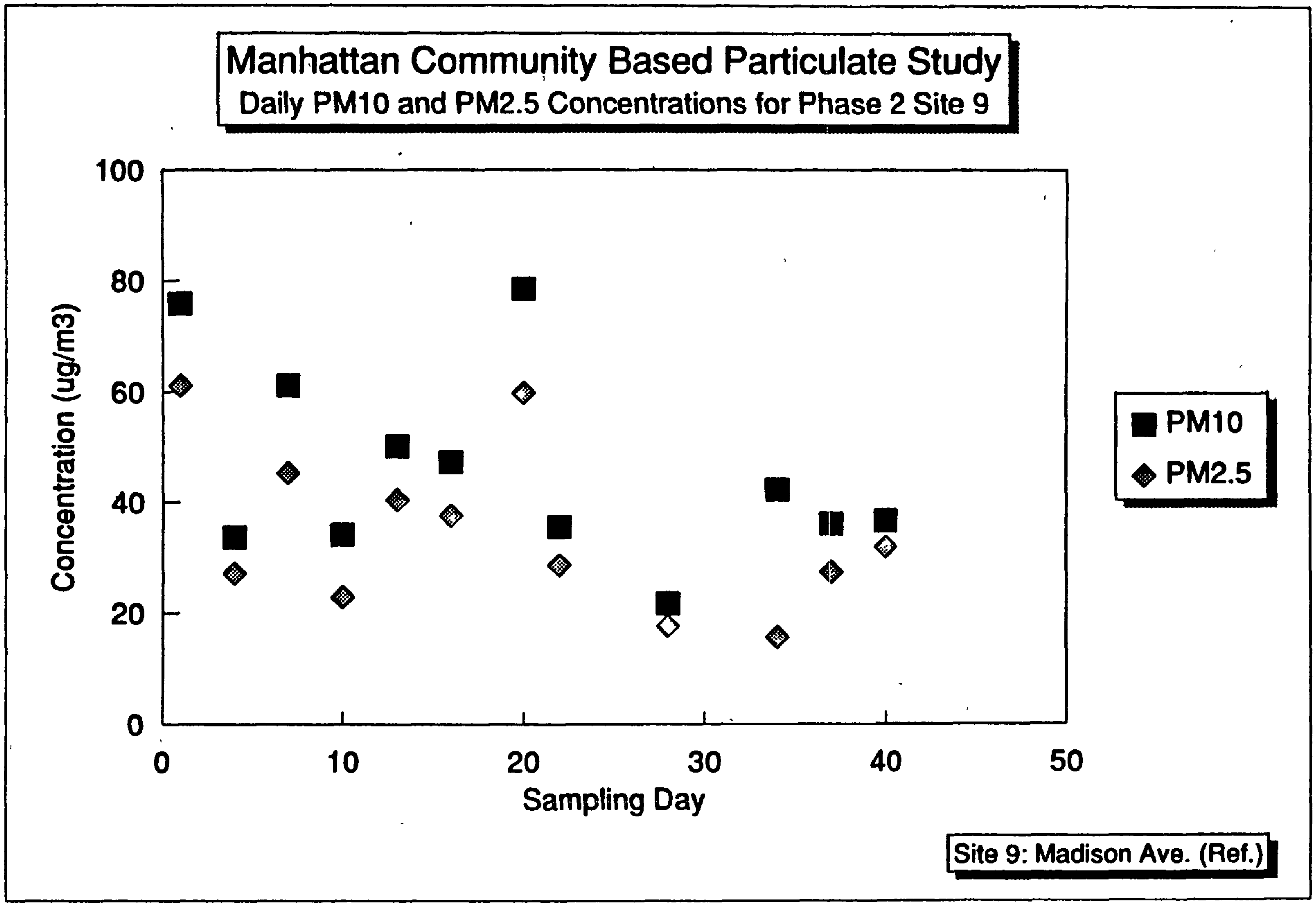


Figure 10. Daily PM10 and PM2.5 Concentrations at Phase 2 Site 9

3.3 Carbon Analysis Data

During Phase 2, PM10 samplers equipped with quartz filters were located at Sites 8 (Phase 1 Site 3) and 9 to obtain measurements of elemental and organic carbon [which together constitute total carbon (TC)] using a thermo-optical analysis method.[2,3] Daily samples were collected at Site 8 while collocated samples were taken at Site 9 on the reference sampler schedule of about once every three days. Table 7 summarizes the PM10 carbon analysis data and gives the daily measurements of PM10, EC, OC, and TC in µg/m^3 and the ratios EC/OC, EC/TC TC/PM10, and EC/PM10. In addition, it provides summary statistics for each site for all days, weekdays, weekends, and all paired values. Table 7 shows that the highest concentration of carbon occurred at Site 8 - about 8.1 µg/m^3 for OC, 19.3 µg/m^3 for EC, 25.5 µg/m^3 for TC. The ratio of EC/PM10 varied from a low of about 0.05 to a high of about 0.66 at Site 8. In general, EC was about 70 percent of TC, TC was about 50 percent of PM10, and EC was about 30 percent of PM10.

3.4 Data Quality Indicators

Two major indicators of data quality were used for study data, precision and relative accuracy. Precision is the degree of mutual agreement among individual measurements under prescribed conditions. Two aspects of precision were examined: overall precision obtained from collocated PM10 samplers and analytical precision obtained from replicate analyses of samples. Analytical precision was found to be better than overall precision.

3.4.1 Overall Precision

During Phase 1, collocated data were obtained at Sites 3, 9 and 10. Table 8 summarizes the collocated data for Phase 1. Table 8 shows that for individual sampling days, collocated precision error varied from a low of about 0.6 percent to a high of about 28 percent. The average precision error at a given site varied from a low of 1.9 percent with a standard deviation of 9.8 at Site 3 to a high of about 9.9 percent with a standard deviation of about 14.8 at Site 10. For all of Phase 1 the average precision error at all collocated sites was about 0.3 percent with a standard deviation of about 12.1. If statistics are calculated as defined in the Quality Assurance Project Plan[2] and 40 CFR Part 58, Appendix A,[4] then the 95 percent upper probability limit is 23.9 percent and the 95 percent lower probability limit is -23.4 percent.

During Phase 2, collocated data were obtained at Sites 6, 9, and 10. Table 9 summarizes the collocated data for Phase 2. Table 9 shows that for individual sampling days collocated precision error varied from a low of about 0.4 percent to a high of about 15.1 percent. The average precision error at a given site varied from a low of 1.7 percent with a standard deviation of 6.2 at Site 10 to a high of about 5.8 percent with a standard deviation of about 8.8 at Site 6. For all of Phase 2, the average precision error at all collocated sites was about -2.8 percent with a standard deviation of about 5.3. The 95 percent upper probability limit is 7.6 percent and the 95 percent lower probability limit is -13.3 percent.

Table 7 PM10 Carbon Analysis Data (in ug/m3) for Phase 2

			Site 8								Site 9 Sampler A								Site 9 Sampler B							
Day No	Day	Date	PM10	OC	EC	TC	EC/ OC	EC/ TC	TC/ PM10	EC/ PM10	PM10	OC	EC	TC	EC/ OC	EC/ TC	TC/ PM10	EC/ PM10	PM10	OC	EC	TC	EC/ OC	EC/ TC	TC/ PM10	EC/ PM10
1	Thu	08/22	61								76								76							
2	Fri	08/23	68																							
3	Sat	08/24	34																							
4	Sun	08/25	29								34								34							
5	Mon	08/26	44																							
6	Tue	08/27																								
7	Wed	08/28	44								61								61							
8	Thu	08/29	40																							
9	Fri	08/30	29	2.37	6.39	8.76	2.70	0.73	0.30	0.22																
10	Sat	08/31	23	3.90	6.11	10.0	1.57	0.61	0.43	0.26	34	7.31	9.52	16.8	1.30	0.57	0.49	0.28	34	6.70	9.82	16.5	1.46	0.59	0.48	0.29
11	Sun	09/01	28	4.90	8.30	13.2	1.69	0.63	0.47	0.30																
12	Mon	09/02	25	4.24	6.35	10.6	1.50	0.60	0.42	0.25																
13	Tue	09/03	42	0.42	1.93	2.35	4.64	0.82	0.06	0.05	60								60	5.05	9.13	14.2	1.81	0.64	0.28	0.18
14	Wed	09/04																								
15	Thu	09/05	57	6.39	12.2	19.7	1.91	0.62	0.35	0.22																
16	Fri	09/06	49	3.70	13.9	17.6	3.76	0.79	0.36	0.28	47	1.65	5.06	6.70	3.07	0.75	0.14	0.11	47	4.32	10.2	14.5	2.36	0.70	0.31	0.22
17	Sat	09/07	40	1.48	4.74	6.21	3.20	0.76	0.16	0.12																
18	Sun	09/08	39	2.19	5.69	7.88	2.59	0.72	0.20	0.15																
19	Mon	09/09	44	4.80	10.8	15.6	2.25	0.69	0.36	0.25																
20	Tue	09/10	50	1.67	4.86	6.52	2.91	0.74	0.13	0.10	79	4.45	18.8	23.3	4.22	0.81	0.30	0.24	79	6.26	16.3	22.7	2.61	0.72	0.29	0.21
21	Wed	09/11	33	6.22	19.3	25.5	3.10	0.76	0.77	0.58																
22	Thu	09/12	22	3.67	10.6	14.2	2.88	0.74	0.63	0.47	36								36	5.15	15.0	20.2	2.92	0.74	0.57	0.42
23	Fri	09/13	31	2.96	16.6	19.6	5.58	0.85	0.64	0.54																
24	Sat	09/14	21	1.85	7.35	9.20	3.97	0.80	0.45	0.36																
25	Sun	09/15	27	4.31	9.05	13.4	2.10	0.68	0.50	0.34																
26	Mon	09/16	33	2.80	8.01	10.8	2.86	0.74	0.32	0.24																
27	Tue	09/17																								
28	Wed	09/18	20	2.21	7.44	9.65	3.37	0.77	0.49	0.38	22	5.84	12.1	17.9	2.06	0.67	0.82	0.56	22	1.21	6.11	7.33	5.05	0.83	0.34	0.28
29	Thu	09/19	25	7.05	16.2	23.3	2.30	0.70	0.94	0.66																
30	Fri	09/20	29	4.76	13.0	17.7	2.73	0.73	0.61	0.44																
31	Sat	09/21	29	8.11	12.2	20.3	1.50	0.60	0.69	0.42																
32	Sun	09/22	33	7.62	11.8	19.4	1.55	0.61	0.60	0.36																
33	Mon	09/23	24	2.38	7.15	9.52	3.01	0.75	0.40	0.30																
34	Tue	09/24	33								42	8.04	14.8	22.8	1.84	0.65	0.54	0.35	42	6.42	15.0	21.4	2.33	0.70	0.51	0.35
35	Wed	09/25	25																							
36	Thu	09/26	22	1.95	5.88	7.83	3.01	0.75	0.36	0.27																
37	Fri	09/27	19	3.85	9.50	13.4	2.47	0.71	0.69	0.49	36								36	5.58	13.7	19.3	2.45	0.71	0.54	0.38
38	Sat	09/28	22																							
39	Sun	09/29	26	3.08	6.11	9.19	1.99	0.67	0.35	0.23																
40	Mon	09/30	27	4.45	12.4	16.8	2.77	0.74	0.61	0.45	37								37	7.48	17.1	24.6	2.28	0.69	0.67	0.47
8/30-9/30 All Days		Nact	30	27	27	27	27	27	27	27	9	5	5	5	5	5	5	5	9	9	9	9	9	9	9	9
		Nexp	32	32	32	32	32	32	32	32	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
		% Compl	93.8	84.4	84.4	84.4	84.4	84.4	84.4	84.4	64.3	35.7	35.7	35.7	35.7	35.7	35.7	35.7	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3
		Mean	31	3.8	9.4	13	2.7	0.7	0.5	0.3	42	5.5	12	18	2.5	0.7	0.5	0.3	42	5.4	12	18	2.6	0.7	0.4	0.3
		Min	19	0.4	1.9	2.4	1.5	0.6	0.1	0.0	22	1.6	5.1	6.7	1.3	0.6	0.1	0.1	22	1.2	6.1	7.3	1.5	0.6	0.3	0.2
		Max	68	8.1	19	25	5.6	0.8	0.9	0.7	79	8	19	23	4.2	0.8	0.8	0.6	79	7.5	17	25	5	0.8	0.7	0.5
Weekdays		Nact	20	18	18	18	18	18	18	18	9	5	5	5	5	5	5	5	9	9	9	9	9	9	9	9
		Nexp	22	22	22	22	22	22	22	22	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
		% Compl	90.9	81.8	81.8	81.8	81.8	81.8	81.8	81.8	81.8	45.5	45.5	45.5	45.5	45.5	45.5	45.5	81.8	81.8	81.8	81.8	81.8	81.8	81.8	81.8
		Mean	32	3.7	10	14	3	0.7	0.5	0.3	43	5	13	18	2.8	0.7	0.5	0.3	43	5.2	13	18	2.7	0.7	0.4	0.3
		Min	19	0.4	1.9	2.4	1.5	0.6	0.1	0.0	22	1.6	5.1	6.7	1.8	0.6	0.1	0.1	22	1.2	6.1	7.3	1.8	0.6	0.3	0.2
		Max	57	7	19	25	5.6	0.8	0.9	0.7	79	8	19	23	4.2	0.8	0.8	0.6	79	7.5	17	25	5	0.8	0.7	0.5
Weekends		Nact	10	9	9	9	9	9	9	9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Nexp	10	10	10	10	10	10	10	10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		% Compl	100	90.0	90.0	90.0	90.0	90.0	90.0	90.0	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
		Mean	29	4.2	7.9	12	2.2	0.7	0.4	0.3	34	7.3	9.5	17	1.3	0.6	0.5	0.3	34	6.7	9.8	17	1.5	0.6	0.5	0.3
		Min	21	1.5	4.7	6.2	1.5	0.6	0.2	0.1	34	7.3	9.5	17	1.3	0.6	0.5	0.3	34	6.7	9.8	17	1.5	0.6	0.5	0.3
		Max	40	8.1	12	20	4	0.8	0.7	0.4	34	7.3	9.5	17	1.3	0.6	0.5	0.3	34	6.7	9.8	17	1.5	0.6	0.5	0.3
8/30-9/30 All Pairs		Nact	27	27	27	27	27	27	27	27	5	5	5	5	5	5	5	5	9	9	9	9	9	9	9	9
		Nexp	30	30	30	30	30	30	30	30	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
		% Compl	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	81.8	81.8	81.8	81.8	81.8	81.8	81.8	81.8
		Mean	31	3.8	9.4	13	2.7	0.7	0.5	0.3	45	5.5	12	18	2.5	0.7	0.5	0.3	42	5.4	12	18	2.6	0.7	0.4	0.3
		Min	19	0.4	1.9	2.4	1.5	0.6	0.1	0.0	22	1.6	5.1	6.7	1.3	0.6	0.1	0.1	22	1.2	6.1	7.3	1.5	0.6	0.3	0.2
		Max	57	8.1	19	25	5.6	0.8	0.9	0.7	79	8	19	23	4.2	0.8	0.8	0.6	79	7.5	17	25	5	0.8	0.7	0.5

Site 8 125th & Amsterdam (Phase 1 Site 3), Site 9 Madison Ave (Ref)

Percent Complete (% Compl) = 100*(Actual Number [Nact]/Expected Number [Nexp])

Table 8. Phase 1 Overall Precision Data from Collocated Samplers

Day No.	Day	Date	Site 3 125th & Amsterdam 103	163	di	Site 9 Madison Ave. 109	169	di	Site 10 Canal St. 110	160	di	Phase 1	
1	Wed	07/10	25.3										
2	Thu	07/11	30										
3	Fri	07/12	40.2										
4	Sat	07/13	15.9										
5	Sun	07/14	42.8										
6	Mon	07/15											
7	Tue	07/16	45.7										
8	Wed	07/17	49			44.6	59.1	28					
9	Thu	07/18											
10	Fri	07/19											
11	Sat	07/20	19.4			20.6	21.9	6.12	14				
12	Sun	07/21	9.6										
13	Mon	07/22	35.3										
14	Tue	07/23	40										
15	Wed	07/24	53.1			70.9							
16	Thu	07/25	67.9										
17	Fri	07/26	36.2	32.7	-10	52.2	47.6	-9.2	53				
18	Sat	07/27											
19	Sun	07/28											
20	Mon	07/29											
21	Tue	07/30				37.6			56.3	54.3	-3.6		
22	Wed	07/31	31.3										
23	Thu	08/01				55.1			43.9				
24	Fri	08/02	60.2										
25	Sat	08/03											
26	Sun	08/04	57.1	61.2	6.93	64	69.1	7.66	69	52.7	-26.8		
27	Mon	08/05											
28	Tue	08/06	86.2										
29	Wed	08/07	88.5			93	90.9	-2.3	93.7				
30	Thu	08/08	46.5										
31	Fri	08/09	47.6										
32	Sat	08/10	23.4			122	119	-2.7	31	31.2	0.6		
33	Sun	08/11	18.8										
34	Mon	08/12	42.4										
35	Tue	08/13	28.6	28.2	-1.4	39	38.4	-1.6	50.5				
36	Wed	08/14	44										
37	Thu	08/15	29.7			52.4			55				
38	Fri	08/16	30.1										
39	Sat	08/17	49										
40	Sun	08/18	29										
41	Mon	08/19	31.9	36	12.1	44.2			71.6				
	All days			N	4		N	7		N	3	14	N
				dj	1.9		dj	3.7		dj	-9.9	0.3	D
				Sj	9.8		Sj	12.1		Sj	14.8	12.1	Sa
												23.9	U95%PL
												-23.4	L95%PL

Notes:

percent difference -- di = 200*(Yi-Xi)/(Xi+Yi)
average analyzer difference -- dj = (1/N)*SUM(di), i = 1 to N
standard deviation -- Sj = SQRT[(1/(N-1))*(SUM(di**2)-(1/N)*(SUM(di))**2)]
average of averages -- D = (1/k)*SUM(dj), j = 1 to k
pooled standard deviation -- Sa = SQRT[(1/k)*SUM(Sj**2)]
upper 95% probability limit -- U95%PL = D+1.96*Sa
lower 95% probability limit -- L95%PL - D-1.96*Sa

Table 9. Phase 2 Overall Precision Data from Collocated Samplers

			Site 6 207th & 9th Ave.			Site 9 Madison Ave.			Site 10 Canal St.				
Day No.	Day	Date	206	266	di	109	169	di	110	160	di	Phase 2	
1	Thu	08/22	50.9	48.6	-4.6	75.9	72.5	-4.6	70.8				
2	Fri	08/23	56.9										
3	Sat	08/24	33										
4	Sun	08/25	26.4			33.6	30.8	-8.7	37.1	37.7	1.6		
5	Mon	08/26	40.6										
6	Tue	08/27	40.6										
7	Wed	08/28	36.8			61.1	54.2	-12.0	47.4				
8	Thu	08/29	29.8										
9	Fri	08/30	26.3										
10	Sat	08/31	23.6			34.1	31.5	-7.9	38				
11	Sun	09/01	27.2										
12	Mon	09/02	22.1										
13	Tue	09/03	38.4	33	-15.1	50.1	49.6	-1.0	58.4	55.1	-5.8		
14	Wed	09/04	56.7										
15	Thu	09/05	52										
16	Fri	09/06		37.3		47.1	46.9	-0.4	75.2				
17	Sat	09/07	34.2										
18	Sun	09/08	31.8										
19	Mon	09/09	40.7										
20	Tue	09/10	34.1			78.5	75.7	-3.6					
21	Wed	09/11	22										
22	Thu	09/12	20			35.5	33.8	-4.9	61.3	59.2	-3.5		
23	Fri	09/13	17.8										
24	Sat	09/14	18.4										
25	Sun	09/15	26.2										
26	Mon	09/16	26.8										
27	Tue	09/17											
28	Wed	09/18	13.1	13.4	2.3	21.7							
29	Thu	09/19	20.1										
30	Fri	09/20	19.2										
31	Sat	09/21											
32	Sun	09/22											
33	Mon	09/23											
34	Tue	09/24				42.2	41.4	-1.9	48.6	50.6	4.0		
35	Wed	09/25											
36	Thu	09/26											
37	Fri	09/27				36	35.8	-0.6	49.5	55.8	12.0		
38	Sat	09/28											
39	Sun	09/29											
40	Mon	09/30				36.6	35.1	-4.2	37.9	38.7	2.1		
	All days			N	3		N	11		N	6	20	N
				dj	-5.8		dj	-4.5		dj	1.7	-2.8	D
				Sj	8.8		Sj	3.7		Sj	6.2	5.3	Sa
												7.6	U95%PL
												-13.3	L95%PL

Notes:

percent difference -- di = 200*(Yi-Xi)/(Xi+Yi)
average analyzer difference -- dj = (1/N)*SUM(di), i = 1 to N
standard deviation -- Sj = SQRT[(1/(N-1))*(SUM(di**2)-(1/N)*(SUM(di))**2)]
average of averages -- D = (1/k)*SUM(dj), j = 1 to k
pooled standard deviation -- Sa = SQRT[(1/k)*SUM(Sj**2)]
upper 95% probability limit -- U95%PL = D+1.96*Sa
lower 95% probability limit -- L95%PL - D-1.96*Sa

3.4.2 Analytical Precision

For Phases 1 and 2, analytical precision was determined by replicate weighings of clean and exposed filters. Approximately 12.2 percent of clean filters and 13.9 percent of exposed filters were reweighed. The average mass difference was about 0 µg/filter for both clean and exposed filters with a standard deviation of the mass difference of about 2 µg/filter (0.3 µg/m^3) for clean filters and 3 µg/filter (0.4 µg/m^3) for exposed filters.

For the Phase 2 carbon analysis, analytical precision was determined from the relative percent difference (RPD) of duplicate measurements.[2] Analytical precision for OC was 10.9 percent with a standard deviation of 10.1 percent, for EC it was 5.6 percent with a standard deviation of 10.9 percent, and for TC it was 7.5 percent with a standard deviation of 10.1 percent. Blank values for the carbon analysis averaged 20 µg/filter (2.8 µg/m^3) for OC, 23 µg/filter (3.2 µg/m^3) for EC, and 43 µg/filter (6.0 µg/m^3) for TC.

3.4.3 Relative Accuracy

Relative accuracy, the degree of the correctness of data, is determined from the difference between observed values and values presumed to be true. For this study, relative accuracy of the saturation samplers was obtained by comparing their PM10 and PM2.5 values with those of the PM10 reference dichotomous samplers operated by New York State, which were presumed to be "true." The results for the reference samplers were obtained from New York State. Tables 10 and 11 show the results for the comparison of saturation samplers with reference samplers at the two reference sites, Sites 9 and 10, for Phases 1 and 2, respectively. For Site 9, each table gives the relative accuracy for PM10 and PM2.5 and the ratio of PM2.5/PM10 as determined by the saturation sampler and the reference sampler. For Site 10, each table gives the relative accuracy for PM10 and the ratio of PM2.5/PM10 for the reference sampler. In addition, Appendix C gives a series of plots comparing PM10 and PM2.5 values for the saturation and reference samplers at Sites 9 and 10 for both phases of the study.

For Phase 1, the relative accuracy for PM10 was -2.7 percent with a standard deviation of 10.7 percent at Site 9 and 3.9 percent with a standard deviation of 22.7 percent at Site 10. For PM2.5 at Site 9, relative accuracy was 28.7 percent with a standard deviation of 16.9 percent. The mean ratio for PM2.5/PM10 was about 0.66 for the PM10 reference sampler at Site 9 and about 0.71 for the one at Site 10. In contrast, the PM2.5/PM10 was about 0.83 for the saturation samplers at Site 9. The ratio of PM2.5/PM10 as determined by the saturation samplers to that from the PM10 reference sampler at Site 9 averaged about 1.32.

If only valid (and not suspicious) data pairs are considered, at Site 9 relative accuracy becomes -1.5 percent for PM10 and 27 percent for PM2.5; the mean ratio for PM2.5/PM10 becomes about 0.61 for the PM10 reference sampler and 0.75 for the saturation sampler; and the ratio of PM2.5/PM10 as determined by the saturation sampler to that from the PM10 reference sampler is about 1.28.

For Phase 2, the relative accuracy for PM10 was 3.8 percent with a standard deviation of 25.9 percent at Site 9 and 12.7 percent with a standard deviation of 26.5 percent at Site 10.

Table 10. Relative Accuracy Results for Phase 1

Phase 1			Site 9 - Madison Avenue between 47th & 48th streets									Site 10 - Canal Street and Broadway				
Day No	Day	Date	Ref PM10	Sat PM10	dj PM10	Ref PM2.5	Sat PM2.5	dj PM2.5	Ref 2.5/10	Sat 2.5/10	Sat/Ref 2.5/10	Ref PM10	Sat PM10	dj PM10	Ref PM2.5	Ref 2.5/10
1	Wed	07/10	42.7			25			0.585			36.4			23.8	0.654
2	Thu	07/11														
3	Fri	07/12														
4	Sat	07/13														
5	Sun	07/14	42.1			29			0.689			47.8			33.1	0.692
6	Mon	07/15														
7	Tue	07/16														
8	Wed	07/17	54.8	44.6	-18.6	41.4			0.755			46.1			34.5	0.748
9	Thu	07/18														
10	Fri	07/19														
11	Sat	07/20	20	20.6	3.0	10.5	16	53.3	0.525	0.782	1.489	19.5	14.0	-28.2	9.6	0.492
12	Sun	07/21														
13	Mon	07/22														
14	Tue	07/23	46.9			36.7			0.783			64.8			46.9	0.724
15	Wed	07/24		70.9			57									
16	Thu	07/25														
17	Fri	07/26	50.4	52.2	3.6	37.4	44	18.4	0.742	0.849	1.144	55.2	53.0	-4.0	40	0.725
18	Sat	07/27														
19	Sun	07/28														
20	Mon	07/29														
21	Tue	07/30	38	37.6	-1.1	24.9	26	6.0	0.655	0.702	1.072	51.6	56.3	9.1	36.7	0.711
22	Wed	07/31														
23	Thu	08/01	59.5	55.1	-7.4	43.8	68	55.0	0.736	1.232	1.674	62.2	43.9	-29.4	46.6	0.749
24	Fri	08/02														
25	Sat	08/03														
26	Sun	08/04	70	64.0	-8.6	58.6	68	16.0	0.837	1.063	1.269	64.6	69.0	6.8	52.8	0.817
27	Mon	08/05														
28	Tue	08/06														
29	Wed	08/07	87	93.0	6.9	69.1	79	13.9	0.794	0.846	1.065	85.3	93.7	9.8	68	0.797
30	Thu	08/08														
31	Fri	08/09														
32	Sat	08/10	147.9	122.3	-17.3	30.3	41	36.6	0.205	0.339	1.652	28.3	31.0	9.5	19.5	0.689
33	Sun	08/11														
34	Mon	08/12														
35	Tue	08/13	37	39.0	5.4	25.9	31	17.8	0.700	0.782	1.117	45.1	50.5	12.0	34.4	0.763
36	Wed	08/14														
37	Thu	08/15	58.9	52.4	-11.0	33	45	36.7	0.560	0.861	1.536	53.8	55.0	2.2	36.6	0.680
38	Fri	08/16														
39	Sat	08/17														
40	Sun	08/18														
41	Mon	08/19	38.3	44.2	15.4	27.5	37	33.1	0.718	0.828	1.153	47.3	71.6	51.4	30.8	0.651
All Values		N	14	12	11	14	11	10	14	10	10	14	10	10	14	14
		Mean	56.7	58.0	-2.7	35.2	46.6	28.7	0.663	0.828	1.317	50.6	53.8	3.9	36.7	0.707
		Std Dev	30.9	27.3	10.7	14.8	19.5	16.9	0.16	0.23	0.24	16.4	22.0	22.7	14.4	0.08
Only Valid Pairs		N	9	9	9	8	8	8	8	8	8	10	10	10	10	10
		Mean	59.1	56.2	-1.5	32.3	39.9	27.0	0.612	0.748	1.279	51.3	53.8	3.9	37.5	0.708
		Std Dev	38.2	31.5	11.6	16.8	18.5	15.5	0.19	0.17	0.24	18.5	22.0	22.7	16.4	0.09

Notes

percentage difference – dj = 100*(Sat-Ref)/Ref

Sat/Ref 2.5/10 = (Saturation Sampler PM2.5/PM10 Ratio)/(Reference Sampler PM2.5/PM10 Ratio)

▭ = Suspicious Data

Table 11. Relative Accuracy Results for Phase 2

Phase 2 Day No	Day	Date	Site 9 - Madison Avenue between 47th & 48th streets Ref PM10	Sat PM10	dj PM10	Ref PM2.5	Sat PM2.5	dj PM2.5	Ref 2.5/10	Sat 2.5/10	Sat/Ref 2.5/10	Site 10 - Canal Street and Broadway Ref PM10	Sat PM10	dj PM10	Ref PM2.5	Ref 2.5/10
1	Thu	08/22	72.6	75.9	4.5	50.9	61.1	20.0	0.701	0.805	1.148	67.3	70.8	5.2	49 1	0.730
2	Fri	08/23														
3	Sat	08/24														
4	Sun	08/25	28.5	33.6	17.9	17.3	27.1	56 6	0.607	0.807	1.329	33.8	37.1	9.8	22 7	0 672
5	Mon	08/26														
6	Tue	08/27														
7	Wed	08/28	51	61.1	19.8	35 4	45 3	28.0	0.694	0.741	1.068	63.7	47.4	-25 6	48 4	0.760
8	Thu	08/29														
9	Fri	08/30														
10	Sat	08/31	29	34.1	17.6	15.4	22.9	48 7	0.531	0.672	1.265	24.3	38	56 4	17	0.700
11	Sun	09/01														
12	Mon	09/02														
13	Tue	09/03	46 4	50.1	8.0	28 4	40 4	42 3	0.612	0.806	1.317	48.5	58.4	20.4	32 8	0 676
14	Wed	09/04														
15	Thu	09/05														
16	Fri	09/06	42	47.2	12 4	26	37.6	44 6	0.619	0.797	1.287	68.4	75.2	9 9	47.6	0 696
17	Sat	09/07														
18	Sun	09/08														
19	Mon	09/09														
20	Tue	09/10		78.5			59 7									
21	Wed	09/11														
22	Thu	09/12		35.5			28 6						61.3			
23	Fri	09/13														
24	Sat	09/14														
25	Sun	09/15	36 1			20.2			0.560			10 6			0.6	0.057
26	Mon	09/16														
27	Tue	09/17														
28	Wed	09/18	46 7	[21 7]	-53.5	35.1	[17.6]	-49.9	0.752	0.811	1.079	29 4			20.5	0 697
29	Thu	09/19														
30	Fri	09/20										30.1			18.8	0.625
31	Sat	09/21														
32	Sun	09/22														
33	Mon	09/23														
34	Tue	09/24		42.2			15 6						48 6			
35	Wed	09/25														
36	Thu	09/26														
37	Fri	09/27		36.0			27 3						49.5			
38	Sat	09/28														
39	Sun	09/29														
40	Mon	09/30		36 6			31.9						37 9			
All Values		N	8	12	7	8	12	7	8	7	7	9	10	6	9	9
		Mean	44 0	46 0	3 8	28 6	34 6	27.2	0 634	0.777	1.21	41.8	52 4	12 7	28 6	0 623
		Std Dev.	14.2	17.6	25 9	11.7	14.9	36.2	0.08	0.05	0.11	21.0	13 6	26 5	17.0	0.22
Only Valid Pairs		N	6	6	6	6	6	6	6	6	6	6	6	6	6	6
		Mean	44 9	50 3	13.4	28 9	39 1	40.0	0.627	0.771	1.24	51.0	54.5	12.7	36 3	0 705
		Std Dev.	16 4	16 3	6.1	13.1	13 7	13.6	0.06	0.05	0 10	18 7	16 3	26 5	14.2	0.03

Notes

percentage difference – dj = 100*(Sat-Ref)/Ref

Sat/Ref 2 5/10 = (Saturation Sampler PM2.5/PM10 Ratio)/(Reference Sampler PM2.5/PM10 Ratio)

[ ] = Suspicious Data

For PM2.5 at Site 9, relative accuracy was 27.2 percent with a standard deviation of 36.2 percent. The mean ratio for PM2.5/PM10 was about 0.63 for the reference sampler at Site 9 and about 0.62 for the one at Site 10. In contrast, the PM2.5/PM10 was about 0.78 for the saturation samplers at Site 9. The ratio of PM2.5/PM10 as determined by the saturation samplers to that from the reference sampler at Site 9 averaged about 1.21.

If only valid (and not suspicious) data pairs are considered, at Site 9 relative accuracy becomes 13.4 percent for PM10 and 40 percent for PM2.5; the mean ratio for PM2.5/PM10 stays about 0.63 for the PM10 reference sampler and 0.77 for the saturation sampler; and the ratio of PM2.5/PM10 as determined by the saturation sampler to that from the reference sampler is about 1.24.

These results suggest that the relative accuracy for PM10 is fairly good overall, although the results for individual measurements may vary considerably. However, the results for PM2.5 suggest that the results for the saturation sampler are biased high by about 28 percent compared to the reference dichotomous sampler.

For the Phase 2 carbon analysis, laboratory relative accuracy was determined from analytical recovery data for standards and splits.[2] For standards, the analytical recovery was about 93.6 percent with a standard deviation of about 5.4 percent; for splits, the analytical recovery for percent OC was about 100.7 percent with a standard deviation of about 8.9 percent.

3.5 Other Data

Some data used for the data analysis in this report were obtained from other sources. As mentioned in Section 3.4, reference sampler data were obtained from New York State. In addition, meteorological data were obtained from the weather report in the *New York Times*. Due to limited resources, these meteorological data were used primarily to assess unusual conditions that might significantly impact particulate matter levels. Such conditions might include a frontal passage that results in low weekday concentrations at all sites, significant amounts of rain (≥ 0.25 inches) that could reduce particulate levels, and periods of stagnation in which particulate levels could be built up to high levels and remain high at all sites. In addition, data on daytime PM2.5 concentrations and traffic counts (automobiles, buses, trucks, and pedestrians) were obtained from Professor Patrick Kinney of the Columbia School of Public Health, who was conducting a parallel study.[5] Table 12 gives the hourly average traffic counts for four Phase 1 Harlem Community Sites (Sites 1, 3, 5, and 6). The hourly averages were taken over the period 10 a.m. to 6 p.m. and represent averages taken over two or three days. Also, the results of a 1993 study of the impact of mobile source emissions on ambient particulate levels at the midtown Manhattan reference site were used for comparison to the results obtained in this study.[6]

Table 12. Average Traffic Counts for Select Harlem Community Sites

Type of Traffic	133rd & Broadway 1	125th & Amsterdam 3	135th & Lennox 5	Edgecombe & 139th 6
Autos	288	2297	1791	153
Trucks	9	175	66	6
Buses	4	133	50	2
Pedestrians	55	1406	2095	141

Notes:

Data obtained from Prof. Patrick Kinney of Columbia University
Average traffic over 10 a.m. to 6 p.m. time period for 2 or 3 days

4.0 DATA ANALYSIS

This section builds upon the results reported in Section 3 and discusses additional summary statistics and analyses used to try to determine the answers to the two questions given in Section 1.

4.1 PM10 Summary Statistics for Each Phase by Site

Tables 1 and 2 summarize the PM10 data for Phases 1 and 2, respectively. As discussed in Section 3.1, Tables 1 and 2 show considerable variation in PM10 concentrations from site-to-site on a given day, and from day to day for a given site.

4.1.1 Phase 1

During Phase 1, mean concentrations for the sites varied from a low of 28.3 µg/m³ at Site 6 (the control site) to a high within the Harlem community of 40.5 µg/m³ at Site 3 and a high of 58 µg/m³ at the midtown Manhattan reference site. Table 1 shows that mean concentrations are, in general, higher on weekdays than on weekends when traffic is expected to be less. Site 9 is the exception since its results are skewed by the data point for Saturday, August 10, 1996, when construction at the site resulted in abnormally high PM10 concentrations.

As discussed in Section 2.3, equipment and logistical problems resulted in substantially poorer completeness than desired or expected. Table 1 shows that completeness during Phase 1 varied from day to day with a low of 37.5 percent and a high of 100 percent. Over all of Phase 1, completeness for each site varied from a low of 30 percent for Site 4 to a high of about 86 percent for Sites 9. The expected data completeness for each site was 80 percent; only three sites, Sites 1, 7, and 9, met this criterion. In a number of respects, the poor data completeness at most sites made data analysis more difficult and will be discussed in greater detail below.

Table 1 also shows that sites could exhibit significant variation in PM10 concentrations on a given day and a given site could exhibit significant variation in PM10 concentration on different days. Excluding exceptional and suspicious data, on August 19, with a mean PM10 concentration of about 33 µg/m³, PM10 concentrations varied from a low of 22 µg/m³ at Site 6 to a high of 72 µg/m³ at Site 10, the downtown reference site. On the other hand, on July 19, with a mean concentration of about 23 µg/m³, PM10 concentrations varied from a low of 21 µg/m³ at Site 6 to a high of only 25 µg/m³ at Site 5. Table 13 shows the same data as Table 1, but it reports the standard deviation and coefficient of variation (CV) of the data instead of minimum and maximum PM10 concentrations. The standard deviation is a measure of the root mean square deviation of values from the mean, and the CV is simply the standard deviation divided by the mean and expressed as a percent. Table 13 shows that from day to day, the CV varied from a low of 4.5 percent to a high of 90 percent. If days with exceptional values and suspicious data points are not considered, then CVs varied from a low of about 4.5 percent to a high of 42.3 percent. In general, the highest CVs occurred on days when the reference site samplers were sampling and the lowest CVs occurred during days with rain, frontal passages, or stagnation.

Table 13 Variability in PM10 Data for Phase 1 - Harlem Community

Day No	Day	Date	153rd & Broadway 1	145th & Broadway 2	125th & Amsterdam 3	Lenox & 148th 4	135th & Lenox 5	Edgecombe & 135th 6	Lexington & 99th 7	116th & Lexington 8	Madison Ave 9	Canal St. 10	Nact	Nexp	% Compl	Mean	Std Dev	CV
1	Wed	07/10	16		25	13		16		23			5	10	50.0	18.9	4.6	24.1
2	Thu	07/11			30	22	24		25				4	8	50.0	25.4	2.9	11.5
3	Fri	07/12	33		40				31				3	8	37.5	34.7	4.0	11.5
4	Sat	07/13	17		16	16	17		20				5	8	62.5	17.2	1.4	8.1
5	Sun	07/14	33		43			34	38				4	10	40.0	37.0	3.8	10.3
6	Mon	07/15	41			43	44	22	35				5	8	62.5	36.9	8.1	22.0
7	Tue	07/16	39	29	46	29		29					5	8	62.5	34.1	7.1	20.8
8	Wed	07/17	39		49	33	42		36		45		6	10	60.0	40.6	5.4	13.4
9	Thu	07/18	48	39			47	38	44	49			6	8	75.0	44.2	4.1	9.2
10	Fri	07/19	22			22	25	21	24				5	8	62.5	22.8	1.4	5.9
11	Sat	07/20		13	19				11		21	14	5	10	50.0	15.5	3.9	25.0
12	Sun	07/21	12		10		11	12					4	8	50.0	11.1	0.9	8.0
13	Mon	07/22	58	26	35				26				4	8	50.0	36.3	12.9	35.7
14	Tue	07/23	33	38	40	31	33	2		42			7	10	70.0	31.3	12.5	39.9
15	Wed	07/24	50		53	42	47	41	43		71		7	8	87.5	49.6	9.6	19.3
16	Thu	07/25			68	38	51		55				4	8	50.0	53.0	10.9	20.5
17	Fri	07/26	34		36	26	34	25			52	53	7	10	70.0	37.1	10.6	28.6
18	Sat	07/27	11			15	17	18	18				5	8	62.5	15.9	2.5	15.7
19	Sun	07/28	22			17	20	17	20				5	8	62.5	19.0	2.0	10.6
20	Mon	07/29	37			35	35	30	35				5	8	62.5	34.3	2.3	6.7
21	Tue	07/30	26			20	29	18	22		38	56	7	10	70.0	29.9	12.4	41.4
22	Wed	07/31	27		31	15	18	16	22	7			7	8	87.5	19.3	7.5	38.9
23	Thu	08/01				28	35	3	39		55	44	6	10	60.0	34.2	16.2	47.3
24	Fri	08/02	51		60	53		50	54	59			6	8	75.0	54.5	3.7	6.8
25	Sat	08/03	69			54	63	54	64				5	8	62.5	61.0	6.0	9.8
26	Sun	08/04			57	62	62	47	65	44	64	69	8	10	80.0	58.7	8.4	14.2
27	Mon	08/05	78			70	75						3	8	37.5	74.6	3.4	4.5
28	Tue	08/06	77	81	86		78	64	88	88			7	8	87.5	80.3	7.9	9.9
29	Wed	08/07	79	83	89		78	69	82		93	94	8	10	80.0	83.2	7.7	9.3
30	Thu	08/08	38	40	47		41	34	41	43			7	8	87.5	40.3	3.6	8.9
31	Fri	08/09	29	48	48	36	60	34	44	47			8	8	100.0	43.2	9.2	21.3
32	Sat	08/10	20	33	23	19		21			122	31	7	10	70.0	38.4	34.6	90.1
33	Sun	08/11	15	25	19	14	18	13	16	12			8	8	100.0	16.4	3.9	23.6
34	Mon	08/12	14	24	42	26			27	12			6	8	75.0	24.3	9.8	40.5
35	Tue	08/13	28	20	29		19		23	29	39	51	8	10	80.0	29.6	9.8	33.2
36	Wed	08/14	40	44	44	36		30	36	43			7	8	87.5	39.0	4.8	12.4
37	Thu	08/15	34	38	30	31	34	30	36	39	52	55	10	10	100.0	37.9	8.4	22.2
38	Fri	08/16	23	27	30	25		22	23	27			7	8	87.5	25.3	2.8	10.9
39	Sat	08/17		47	49	26	48	20	47	57			7	8	87.5	41.9	12.5	29.8
40	Sun	08/18	27		29	24		25	22	32			6	8	75.0	26.4	3.2	12.1
41	Mon	08/19	26	29	32	23	26	22	27	32	44	72	10	10	100.0	33.3	14.1	42.3

		1	2	3	4	5	6	7	8	9	10
All Days	Nact	35	18	31	31	29	31	34	18	12	10
	Nexp	41	41	41	41	41	41	41	41	14	14
	% Compl	85.4	43.9	75.6	75.6	70.7	75.6	82.9	43.9	85.7	71.4
	Mean	35.7	38.0	40.5	30.3	39.0	28.3	36.4	37.9	58.0	53.8
	Std Dev	18.3	18	18	14	19	15.7	17.9	18.8	26.1	20.9
	CV	51.2	47.4	44.5	46.1	48.7	55.3	49.1	49.7	45	38.8
Weekdays	Nact	26	14	22	22	21	21	24	14	9	7
	Nexp	29	29	29	29	29	29	29	29	10	10
	% Compl	89.7	48.3	75.9	75.9	72.4	72.4	82.8	48.3	90.0	70.0
	Mean	39.3	40.5	45.0	31.5	41.7	29.4	38.3	38.4	54.3	60.6
	Std Dev	17.3	18.6	17	12.4	17.7	16.4	17	19.4	16.6	15.6
	CV	44	46	37.8	39.4	42.5	55.8	44.3	50.4	30.6	25.8
Weekends	Nact	9	4	9	9	8	10	10	4	3	3
	Nexp	12	12	12	12	12	12	12	12	4	4
	% Compl	75.0	33.3	75.0	75.0	66.7	83.3	83.3	33.3	75.0	75.0
	Mean	25.2	29.4	29.4	27.4	32.1	26.1	31.9	35.9	69.0	38.0
	Std Dev	16.9	12.3	15.5	16.8	20.5	13.7	19.2	16.6	41.7	23
	CV	67.3	42	52.5	61.6	63.8	52.7	60.3	46.3	60.4	60.5

☐ Suspicious data (boxed values: Day 14 col 6 "2"; Day 23 col 6 "3" and col 9 "55"; Day 26 col 9 "64"; Day 31 col 1 "29")

Percent Complete (% Compl) = 100*(Actual Number [Nact]/Expected Number [Nexp])
Coefficient of Variation (CV) = 100*(Std Dev /Mean)

Table 13 also shows the variability of data at each site for Phase 1. In general, the variability at each site over the period of Phase 1 is greater than the variability among sites on a given day. During Phase 1, CVs ranged from a low of 38.8 percent at Site 10 to a high of 55.3 percent at Site 6, the control site. In general, sites with the highest mean PM10 concentrations have the lowest CVs. In general, the CVs for weekday sampling are greater than those for weekend sampling. However, Sites 2, 6, and 8 are exceptions to this observation.

The fact that the variability of data from day to day at a given site is usually greater than the variability in data from sites on a given day when coupled with the poor data completeness for some sites, makes it difficult to answer the question of which site(s) have the highest mean concentrations. As discussed in Section 3.1, one way to address this difficulty is to use relative rankings. Table 3 shows that if the mean site ranking is used as the indicator, then the site with the highest PM10 concentrations, other things being equal, should be Site 10 (the downtown reference site) followed by Site 9 (the midtown reference site) and Site 3 (the Harlem community site at 125th Street and Amsterdam Avenue). Figure 11 shows mean PM10 concentrations by type of site. Site 9, the midtown Manhattan street canyon reference site, and Site 10, the downtown Manhattan reference traffic site, look like they might violate the current PM10 annual average of 50 $\mu g/m^3$.[7] In addition, counts of daytime (10 am to 6 pm) automobile, bus, truck, and pedestrian traffic at four sites (Sites 1, 3, 5, and 6) were obtained from Professor Kinney at Columbia University and are given in Table 12. The counts were averages for several weekdays in July 1996. Average hourly automobile traffic varied from a low of 153 to a high of 2300; hourly truck traffic varied from a low of 6 to a high of 175; hourly bus traffic varied from a low of 2 to a high of 133; and hourly pedestrian traffic varied from a low of 55 to a high of 2095. Except for pedestrian traffic, all lows occurred at Site 6, the control site, and all highs at Site 3; for pedestrian traffic, the low occurred at Site 1, a bus depot site, and the high at Site 5, the Harlem Hospital site. For the period examined, the bus depot site, Site 1, only averaged 4 buses an hour.[5] In April 1993, the Desert Research Institute had the following hourly average traffic counts for the midtown Manhattan reference site, Site 9: 15 motorcycles, 1197 cars, 63 trucks, and 171 buses.[6]

4.1.2 Phase 2

During Phase 2, mean concentrations for the sites varied from a low of 21.9 $\mu g/m^3$ at Site 5 to a high within the Washington Heights community of 35.8 $\mu g/m^3$ at Site 7 and a high of 52.4 $\mu g/m^3$ at the downtown Manhattan reference site. Table 2 shows that mean concentrations are, in general, higher on weekdays than on weekends when traffic is expected to be less. Site 5 is the exception.

Table 2 shows that completeness during Phase 2 varied from day to day with a low of 0.0 percent and a high of 100 percent. Over all of Phase 2, completeness for each site varied from a low of 20 percent for Site 5 to a high of about 93 percent for Sites 6 and 8. The expected data completeness for each site was 80 percent; five sites, Sites 1, 3, 6, 8, and 9, met this criterion.

Table 2 also shows that sites could exhibit significant variation in PM10 concentrations on a given day, and a given site could exhibit significant variation in PM10 concentration on

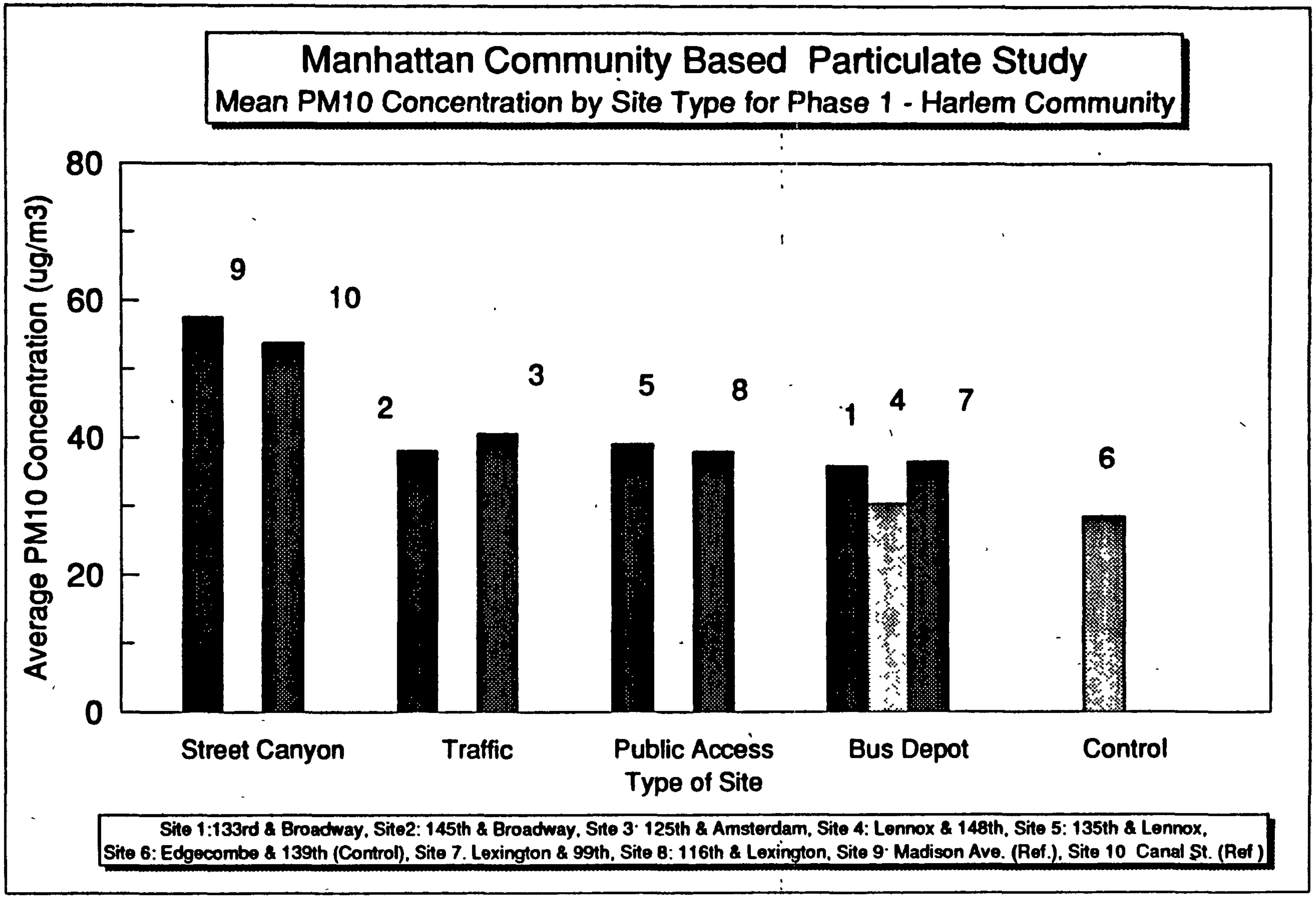


Figure 11. Average PM10 for Phase 1 Harlem Community by Site Type

different days. On September 12, with a mean PM10 concentration of about 32.5 μg/m³, PM10 concentrations varied from a low of 19.7 μg/m³ at Site 1 to a high of 61 μg/m³ at Site 10, the downtown reference site. On the other hand, on September 5, with a mean concentration of about 54.8 μg/m³, PM10 concentrations varied from a low of 52 μg/m³ at Site 6 to a high of 56.9 μg/m³ at Site 8. Table 13 shows the same data as Table 2, but it reports the standard deviation and coefficient of variation (CV) of the data instead of minimum and maximum PM10 concentrations. Table 14 shows that from day to day the CV varied from a low of 3.3 percent to a high of 43.4 percent.

Table 14 also shows the variability of data at each site for Phase 2. In general, the variability at each site over the period of Phase 2 is greater than the variability among sites on a given day. During Phase 2, CVs ranged from a low of 21.7 percent at Site 5 to a high of 40 percent at Site 3. In general, the CVs for weekday sampling are greater than those for weekend sampling.

Table 4 shows that if the mean site ranking is used as the indicator, then the site with the highest PM10 concentrations, other things being equal, should be Site 10 (the downtown reference site) followed by Site 9 (the midtown reference site) and then Site 2 (the Washington Heights community site at 179th Street and Broadway) and Site 8 (the Harlem community site with the highest ranking in Phase 1). Figure 12 shows mean PM10 concentrations by type of site. Only Site 10, the downtown Manhattan reference traffic site looks like it might violate the PM10 annual average.

4.2 Comparison of PM10 Concentrations Among Sites

For both Phases 1 and 2, the two reference sites, Site 9 in midtown Manhattan and Site 10 in downtown Manhattan, tend to have higher PM10 concentrations than any of the sites in either the Harlem or Washington Heights communities. The question is whether this difference in PM10 concentrations is significant. Two tests were used to try to assess whether the differences in PM10 concentrations between a given community site and a reference site were significant: the Student's t-test[8] and the Wilcoxon signed rank test.[9,10] For each phase, each comparison used only days when both sites being compared had PM10 values.

The Student's t-test calculates a statistic, t, which is a function of the number of pairs, their mean values, and standard deviations. If t is greater than a certain critical value t_c, then the difference in mean values is significant at a certain probability. For these tests, values of t_c were chosen to correspond to a 95 percent probability that the two means were different. The Wilcoxon signed rank test is a nonparametric test. In this test, the differences between two values is calculated and each difference is assigned a rank with 1 for the smallest difference and N for the largest difference if there are N non-zero difference pairs. The sum of all negative differences and the sum of all positive differences are then calculated. The statistic, T, is the smaller of the two sums, and is then compared to a critical value, T_c, based on the total number of pairs and the probability desired of being certain a difference is significant. If T is less than T_c, then the median of one set of data is significantly different from the other. The two tests may give different results. If there is relatively large variability among the daily values at each of two sites, but on most days one site has consistently higher (or lower) values than the other site, then

Table 14 Variability in PM10 Data for Phase 2 - Washington Heights Community

Day No	Day	Date	181st & St. Nicholas 1	179th & Broadway 2	168th & St. Nicholas 3	162nd & Edgecombe 4	Dyckman & Sherman 5	207th & 9th Ave. 6	214th & Broadway 7	125th & Amsterdam 8	Madison Ave 9	Canal St. 10	Nact	Nexp	% Compl	Mean	Std Dev	CV
1	Thu	08/22			49	56		51	53	61	76	70 8	7	10	70 0	59 4	9 7	16 3
2	Fri	08/23			60			57	66	68			4	8	50 0	62 7	4 5	7 2
3	Sat	08/24	37			31		33	35	34			5	8	62 5	34 0	1 9	5 5
4	Sun	08/25	31	34	27			26	27	29	34	37 1	8	10	80 0	30 6	3 7	12 2
5	Mon	08/26			37	40		41	43	44			5	8	62 5	40 8	2 3	5 6
6	Tue	08/27	42		48			41	47				4	8	50 0	44 3	3 0	6 9
7	Wed	08/28			36			37	38	44	61	47 4	6	10	60 0	43 8	8 8	20 0
8	Thu	08/29	43		35	32		30	34	40			6	8	75 0	35 6	4 5	12 7
9	Fri	08/30	43					26	29	29			4	8	50 0	31 8	6 7	21 0
10	Sat	08/31	30		27	26		24		23	34	38	7	10	70 0	29 0	5 1	17 6
11	Sun	09/01	28		28			27	26	28			5	8	62 5	27 5	1 0	3 8
12	Mon	09/02	27	30	28	22		22		25			6	8	75 0	25 9	3 0	11 6
13	Tue	09/03	43		40			38	39	42	50	58 4	7	10	70 0	44 4	6 8	15 3
14	Wed	09/04	64	68	64			57					4	8	50 0	63 0	4 0	6 3
15	Thu	09/05	54		57			52	54	57			5	8	62 5	54 8	1 8	3 3
16	Fri	09/06	35	36	33	32				49	47	75 2	7	10	70 0	43 9	14 3	32 5
17	Sat	09/07	37		32			34	33	40			5	8	62 5	35 2	2 7	7 8
18	Sun	09/08	35	37	31	31		32		39			6	8	75 0	34 1	3 1	9 2
19	Mon	09/09	39		37			41	43	44			5	8	62 5	40 7	2 3	5 6
20	Tue	09/10	47	48	44			34		50	79		6	10	60 0	50 1	13 7	27 3
21	Wed	09/11	24		24			22	22	33			5	8	62 5	25 0	4 1	16 6
22	Thu	09/12	20	21	23			20	47	32	36	61 3	8	10	80 0	32 5	14 1	43 4
23	Fri	09/13	17		19			18	18	31			5	8	62 5	20 6	5 2	25 2
24	Sat	09/14	17	24	14	16		18	18	21			7	8	87 5	18 3	3 2	17 3
25	Sun	09/15	25		22	22		26	23	27			6	10	60 0	24 1	2 0	8 2
26	Mon	09/16	31	38	50			27		33			5	8	62 5	35 7	7 9	22 1
27	Tue	09/17											0	8	0 0			
28	Wed	09/18	22	25	14	12		13		20	[22]		7	10	70 0	18 3	4 7	25 6
29	Thu	09/19	26		22	21		20	23	25			6	8	75 0	22 9	2 0	8 7
30	Fri	09/20	24	27	15			19		29			5	10	50 0	22 8	5 3	23 2
31	Sat	09/21		37						29			2	3	66 7	32 9	3 6	10 9
32	Sun	09/22		33			30			33			3	3	100 0	31 6	1 4	4 3
33	Mon	09/23		29			18			24			3	3	100 0	23 4	4 4	18 9
34	Tue	09/24					25			33	42	48 6	4	5	80 0	37 2	9 0	24 1
35	Wed	09/25		35			16			25			3	3	100 0	25 6	7 7	30 0
36	Thu	09/26		17			16			22			3	3	100 0	18 5	2 4	13 0
37	Fri	09/27		23						19	36	49 5	4	5	80 0	32 0	11 8	37 0
38	Sat	09/28		27			22			37			3	3	100 0	28 4	6 4	22 6
39	Sun	09/29		23			27			26			3	3	100 0	25 4	1 9	7 5
40	Mon	09/30		31			21			27	37	37 9	5	5	100 0	30 8	6 2	20 2

[box] Suspicious data

		1	2	3	4	5	6	7	8	9	10
All Days	Nact	25	20	27	12	8	28	20	37	12	10
	Nexp	30	40	30	30	40	30	30	40	14	14
	% Compl	83 3	50 0	90 0	40 0	20 0	93 3	66 7	92 5	85 7	71 4
	Mean	33 7	32 1	33 9	28 5	21 9	31 6	35 8	34 3	46 0	52 4
	Std Dev	11 4	10 7	13 6	11 1	4 7	11 8	12 7	11 5	16 8	12 9
	CV	33 9	33 3	40 0	38 8	21 7	37 3	35 6	33 5	36 5	24 7
Weekdays	Nact	18	13	21	8	5	21	15	25	10	8
	Nexp	22	28	22	22	28	22	22	28	11	11
	% Compl	81 8	46 4	95 5	36 4	17 9	95 5	68 2	89 3	90 9	72 7
	Mean	35 4	32 9	36 7	30 7	19 3	33 2	39 6	36 2	48 5	56 1
	Std Dev	12 8	12 6	14 3	13 2	3 4	13 3	13 0	13 0	17 4	11 8
	CV	36 2	38 1	39 1	42 9	17 4	39 9	32 9	35 8	36 0	21 1
Weekends	Nact	8	7	7	5	3	8	6	12	2	2
	Nexp	8	12	12	12	12	12	12	12	3	3
	% Compl	100	58 3	58 3	41 7	25 0	66 7	50 0	100	66 7	66 7
	Mean	30 0	30 6	25 9	25 3	26 2	27 6	28 9	30 4	33 9	37 6
	Std Dev	6 3	5 5	6 0	5 6	3 4	4 9	5 6	5 9	0 3	0 5
	CV	21 0	18 1	23 0	22 3	13 0	17 9	20 8	19 3	0 7	1 2

Percent Complete (% Compl) = 100*(Actual Number [Nact]/Expected Number [Nexp])
Coefficient of Variation (CV) = 100*(Std Dev /Mean)

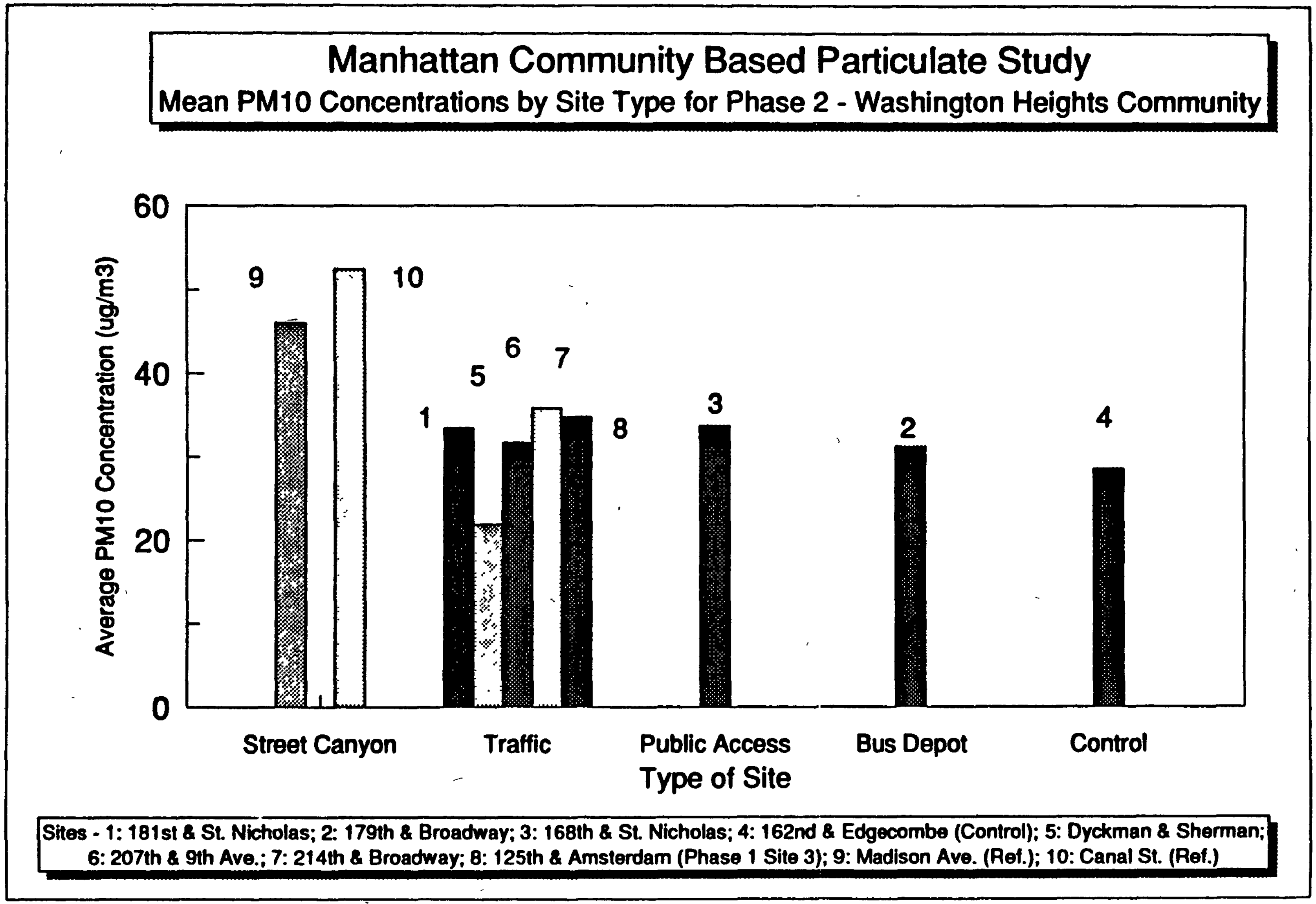


Figure 12. Average PM10 for Phase 2 Washington Heights Community by Site Type

the Student's t-test is not likely to show a significant difference while the Wilcoxon signed rank test might. On the other hand, the Wilcoxon test is not very sensitive when there are only a few paired values and cannot be used at all if the number of pairs is less than six. Thus, when there are low numbers of pairs, the Student's t-test may show a significant difference when the Wilcoxon signed test would not or could not be used.

Table 15 shows the results of assessing the differences in PM10 concentrations using these two tests. The table shows the results for each pair of sites for each phase of the study. For both phases, Sites 9 and 10 in general have significantly higher concentrations than the Harlem community sites; instances in which they do not are primarily due to having too few data pairs for the tests to be done or to be reliable. For Phase 1, Site 4 (the control site) and Site 6 in general have significantly lower PM10 concentrations than most other sites. These results are in general agreement with previous observations based on Tables 1 and 3. For Phase 2, Site 6 (the control site) in general has significantly lower PM10 concentrations than most other sites while Site 8 (the Phase 1 Site 3 Harlem community site) in general has significantly higher PM10 concentrations than the other community sites in Washington Heights. These results are in general agreement with previous observations based on Tables 2 and 4.

4.3 Comparison of Phase 1 and Phase 2 PM10 Levels

Tables 1, 2, 13, and 14 show that PM10 concentration levels were generally lower during Phase 2 compared to Phase 1. At Site 3 in Phase 1 (or Site 8 in Phase 2), PM10 concentrations averaged about 40.5 ±18μg/m^3 while for Phase 2 they were 34.3 ±11.5μg/m^3 (lower by about 15 percent). For the midtown Manhattan reference site, Site 9, the levels were 58 ±26.1μg/m^3 for Phase 1 and 46 ±16.8μg/m^3 for Phase 2, about a 21 percent decrease with the exceptional event during Phase 1 and about a 12 percent decrease if it was excluded. For the downtown reference site, Site 10, the PM10 concentrations were 53.8 ±20.9μg/m^3 for Phase 1 and 52.4 ±12.9μg/m^3 for Phase 2, about a 3 percent decrease. The decrease observed at Site 3/Site 8 is likely to be more correct since the number of PM10 concentrations obtained during each phase (31 in Phase 1 and 37 in Phase 2) was much greater at this site than the other two sites (12 for Site 9 and 10 for Site 10 during Phases 1 and 2).

4.4 PM2.5 Concentrations and the Proposed PM2.5 Standards

As discussed in Section 3.2, PM2.5 samplers were located at Sites 1, 5 and 9 for Phase 1 and at Sites 1, 2, and 9 for Phase 2. During Phase 1, Table 5 shows that mean PM2.5 concentrations varied from 28 μg/m^3 at Site 5 to 47 μg/m^3 at Site 9, while during Phase 2, Table 6 shows that they varied from 21 μg/m^3 at Site 2 to 35 μg/m^3 at Site 9. The proposed annual standard for PM2.5 is 15 μg/m^3.[11] All of the sites that sampled PM2.5 during both phases of this study would not meet the proposed standard if the mean concentrations observed were typical of those throughout the year. The proposed 24-hour PM2.5 standard is 50 μg/m^3.[11] During Phase 1, there were four exceedances of the proposed standard observed at each of the three sites while during Phase 2, there were two exceedances observed at Site 9.

The mean ratio of PM2.5/PM10 observed over all sites for both phases was 0.78. This average ratio is in agreement with values obtained earlier in Philadelphia in a 1994 study using

Table 15. Significance of Site Concentration Differences for Phases 1 and 2

Phase 1

Site	Test	1 133rd & Broadway	2 145th & Broadway	3 125th & Amsterdam	4 Lennox & 145th	5 135th & Lennox	6 Edgecombe & 135th	7 Lexington & 96th	8 116th & Lexington	9 Madison Ave	10 Canal St
1	S										
	W										
2	S	no									
	W	no									
3	S	no	no								
	W	yes	no								
4	S	no	yes	yes							
	W	yes	yes	yes							
5	S	no	no	no	no						
	W	no	no	no	yes						
6	S	no	no	yes	no	yes					
	W	yes	yes	yes	yes	yes					
7	S	no	no	no	no	no	no				
	W	no	no	yes	yes	no	yes				
8	S	no	no	no	no	no	no	no			
	W	yes	no*	no	no	no	yes	no			
9	S	yes	no	no	yes	no	yes	no	no		
	W	yes	yes*	no	yes	yes	yes	yes	**		
10	S	yes	no*	no	yes	yes	yes	no	yes	no	
	W	yes	no*	**	yes	yes	yes	yes	**	**	

Notes:

S - two-tailed Student's t-test significant at 0.05 level
W - Wilcoxon signed rank test significant at 0.05 level

* - number of pairs <=6
** - too few points for test

Phase 2

Site	Test	1 181st & St Nicholas	2 179th & Broadway	3 168th & St Nicholas	4 162nd & Edgecombe	5 Dyckman & Sherman	6 207th & 9th Ave	7 214th & Broadway	8 125th & Amsterdam	9 Madison Ave	10 Canal St
1	S										
	W										
2	S	no									
	W	yes									
3	S	no	no								
	W	yes	yes								
4	S	no	no*	no							
	W	yes	**	no							
5	S	**	no	**	**						
	W	**	no	**	**						
6	S	no	no	no	no	**					
	W	yes	yes	no	no	**					
7	S	no	no*	no	no	**	no				
	W	no	**	no	no	**	yes				
8	S	no	no	no	no	yes	no	no			
	W	no	no	yes	yes	yes	yes	yes			
9	S	no	no*	yes	no*	yes*	yes	no*	no		
	W	yes	no*	yes	**	**	yes	**	yes		
10	S	yes*	yes*	yes	no*	no*	yes	no*	yes	no	
	W	**	**	yes	**	**	yes*	**	yes	no	

saturation samplers.[12,13] As discussed in Section 3.4, PM2.5 concentrations measured by the saturation samplers appear to be biased high when compared to PM2.5 concentrations obtained from the PM10 reference dichotomous sampler used at Site 9; however, the dichotomous sampler is not a reference or equivalent sampler for PM2.5. The PM2.5/PM10 ratio determined from the dichotomous samplers appears to average about 0.66. Using the reference sampler PM2.5 data, the mean PM2.5 concentration was 35 $\mu g/m^3$ at Site 9 and 37 $\mu g/m^3$ at Site 10 during Phase 1. For Phase 2, the mean PM2.5 concentrations were 29 $\mu g/m^3$ and 29 $\mu g/m^3$ at Sites 9 and 10, respectively. All of these mean concentrations exceed the proposed annual PM2.5 standard. In addition, during the course of both phases, there were three exceedances of the proposed 24-hour PM2.5 standard observed at Site 9 and one at Site 10.

4.5 Carbon Analysis

As discussed in Section 3.3, EC was about 30 percent of PM10 while OC was about 15 percent of PM10. Elemental carbon or soot often comes from the exhaust of diesel vehicles, especially trucks and buses. Available resources did not permit a detailed source apportionment.

The two Phase 2 sites chosen for sampling carbon, Sites 8 and 9, were chosen because they were expected to have high diesel bus and truck traffic. The fraction of EC/PM10 was similar at both sites, 0.32 at Site 8 (Phase 1, Site 3) and 0.31 at Site 9, but Site 9 generally had higher PM10 concentrations. The fraction of EC/PM10 would not be expected to be as high at sites with less diesel bus and truck traffic. In addition, diesel buses and trucks also contribute to OC.

However, the observed fractions of EC/OC/TC and their percentages of PM10 are consistent with other studies at sites with heavy diesel bus and truck traffic. Desert Research Institute did perform a detailed source apportionment from data obtained at the midtown Manhattan site (Site 9), which might have higher diesel bus traffic than community sites, in 1993.[6] Using assumed profiles and a variety of particulate measurements and the Chemical Mass Balance Model (CMB) version 7, they found that the diesel contribution varied from between 31 and 68 percent of the total particulate loadings and averaged about 53 percent of ambient PM10 mass; no estimate was given of the relative contribution of trucks and buses. Automobiles were found to contribute between 0 and 21 percent with an average of about 6 percent. The total mobile source related contribution (diesel, automobile, and road dust) was responsible for about two-thirds of PM10 mass. Sea salt contributed about 6 percent and transport-related components, such as ammonium sulfate and nitrate, accounted for about 22 percent of the mass.

4.6 Unusual Events and Weather

Local weather reports were acquired to determine special weather conditions which might influence particulate matter concentrations. Weather comments were included in Tables 1 and 2 to clarify why some peculiar PM10 concentrations were observed. High PM10 concentrations on the weekend of August 3 and 4 were associated with a week-long stagnation period and low concentrations on some days were associated with periods of rain or a frontal passage.

4.7 QA/QC Results

Data quality indicators for precision and relative accuracy were discussed in Section 3.4. This section discusses how well the study met the data quality objectives (DQOs) given in the Quality Assurance Project Plan (QAPP).[2]

4.7.1 Completeness

The QAPP goal for daily completeness was 80 percent of sites for a given day. During Phase 1, that goal was met only about 37 percent of the time; the average daily completeness was about 70 percent. During Phase 2, the daily completeness goal was met only about 30 percent of the time; the average daily completeness was about 70 percent. As discussed in Section 2.3, operational and equipment problems prevented this goal from being reached.

The QAPP goal for completeness for a site for the study was 75 percent. During Phase 1, 7 of 10 sites met the goal; average site completeness was 71 percent. During Phase 2, only half the sites met the goal; average site completeness was 69 percent. The QAPP goal of 80 percent completeness for the entire study period was not met; the average completeness was about 70 percent.

4.7.2 Precision

The QAPP goal for daily overall sampling precision for saturation samplers was ±20 percent. During Phase 1, 2 out of 14 pairs did not meet the goal, but during Phase 2, all 20 sample pairs met the goal. The QAPP goal for overall sampling precision was ±15 percent for each phase and the study. That goal was met for both phases and the study. For Phase 1, it was 0.3 percent; for Phase 2, it was 2.8 percent; and for the study, it was -1.5 percent. For the carbon analysis filters, these goals for sampling precision were the same. For the carbon filters, 4 of 5 duplicate pairs exceed the 20 percent goal for OC, none exceeded it for EC, and 1 exceeded it for TC. Overall, the average sampling precision was 11.6, 1.6, and 4.6 for OC, EC, and TC, respectively.

The QAPP goal for gravimetric filter reweighings was the greater of ±20µg/filter or ±15 percent. None of the 122 exposed filters that were reweighed exceeded these criteria. In addition, all the filters met the criterion of an average percent difference within ±10 percent.

The goal for analytical precision for the carbon analysis was ±20 percent for OC/EC/TC from individual analyses of duplicate plugs and ±15 percent for all duplicates. The mean analytical precision was 11, 6, and 7.5 percent for OC, EC, and TC, respectively. Two out of five duplicate analyses for OC did not meet the 20 percent criterion; the two values were 21 and 22 percent.

4.7.3 Relative Accuracy

The QAPP goals for relative accuracy were ±20 percent for collocated reference sampler and saturation samplers for daily differences and ±15 percent for the average percent difference for each phase and the study. During Phase 1, only 1 of 21 pairs did not meet the 20 percent criterion for PM10; however, only half of 10 pairs met the criterion for PM2.5. The mean bias was about 0.5 percent for PM10 for two sites and about 28.7 percent for PM2.5 at one site. As discussed in Sections 3.4 and 4.4, there is an apparent bias in PM2.5 between the saturation samplers and reference dichotomous samplers. During Phase 2, 4 of 13 PM10 pairs and all 7 PM2.5 pairs did not meet the 20 percent criterion. The mean bias was about 7.9 percent for two PM10 sites and about 27.2 percent for the one PM2.5 site.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations fall into three main categories: (1) PM10 results and their implications for monitor siting, (2) PM2.5 results and their implications for monitor siting and future studies, and (3) issues concerning the performance of the saturation samplers.

5.1 PM10 Results and Implications

The major conclusion obtained from the results and discussion in Sections 3.1.4.1 and 4.2 for PM10 may be summarized as:

- Temporal (day-to-day) variability was greater than spatial (site-to-site) variability during both phases of the study.

- PM10 samplers in the Harlem and Washington Heights communities generally measure lower PM10 concentrations than either of the two reference sampler sites in midtown and downtown traffic locations.

- On average, community sites measured PM10 concentrations that were at most two-thirds to three fourths the PM10 levels at the reference sites.

- During both phases of the study, only the two reference sampler sites recorded PM10 concentrations that indicate a likelihood of exceeding the annual PM10 standard of 50 $\mu g/m^3$.

The highest PM10 levels seem to occur at those sites with the greatest traffic, which likely explains why the two reference sites which have higher volume of bus and/or truck traffic have higher concentration. PM10 concentrations would be expected to be high in areas with a lot of traffic, regardless of where in the city that occurs. However, similar high PM10 levels may have different impacts depending on the community. For example, some communities may have more air conditioning that would reduce the impact of ambient PM10 levels; other communities may have housing and businesses that tend to have open windows. The area around the midtown reference sampler consists of predominantly air conditioned office buildings; however, the area around the downtown reference sampler consists of small stores and apartments without air conditioning. Also, in the Harlem and Washington Heights communities residents may spend more time along heavily trafficked roads because shopping areas tend to be located along such thoroughfare.

With limited resources, it makes sense to locate the monitors at sites where the maximum PM10 concentrations are expected to occur. For Manhattan, this would mean keeping the current reference sites. Within the two communities, PM10 concentrations were relatively uniform. In Harlem, during Phase 1, the average PM10 concentration was about 36 $\mu g/m^3$ for the eight community sites with a variability among the sites of about 11 percent. The maximum concentration site was about 13 percent above the mean while the minimum concentration site was about 21 percent below the mean. If an additional site was to be located in the Harlem community, it should be in the vicinity of Site 3, the Phase 1 community site with the highest concentrations, located at 125th Street and Amsterdam Avenue. During Phase 2, the average PM10 concentration was about 31.5 μg/m^3 for all the community sites with a variability of about 19 percent. The maximum concentration was about 14 percent above the mean while the minimum concentration site was about 30 percent below the mean. If an additional site was located in the Washington Heights community, it should be in the vicinity of Site 2, located at 179th Street and Broadway, which by relative site rankings had the highest concentrations.

5.2 PM2.5 Results and Implications

Now that EPA has proposed a new PM2.5 standard,[11] the PM2.5 results from this study assume even greater significance. The major conclusions for PM2.5 may be summarized as follows:

- Many sites in both communities seem likely to fail to meet the proposed annual PM2.5 standard of 15 μg/m^3.[11]

- A few sites in both communities may also fail to meet the proposed 24-hour PM2.5 standard of 50 μg/m^3.[11]

- Most of these sites will fail to meet the proposed 24-hour and/or annual PM2.5 standards regardless of whether the reference sampler value (0.66) or saturation sampler value (0.78) is used for the PM2.5/PM10 ratio is used to estimate PM2.5 from PM10.

- PM2.5 concentrations are likely to be less at sites within the two communities than at either of the two reference sites.

A detailed quantitative estimate of the likelihood of exceeding the proposed PM2.5 standards was beyond the scope of this project. The proposed annual PM2.5 standard is based on annual averages of eligible sites within Spatial Averaging Zones. Historically, the summer season has PM10 and PM2.5 concentrations about 20 percent higher than the annual average. For the period of this study, however, the weather seemed milder, with fewer stagnation periods than normal. In general, the summer for this project would be expected to have lower particulate concentrations than the historical summer average.

The proposed 24-hour PM2.5 standard is based on the 98th percentile of 24-hour values over a 3-year period. For an everyday sampling schedule, and no missing data, one would look at the 22nd highest 24-hour value over 3 years and for every sixth day sampling, one would look at the highest 24-hour value over 3 years. For a typical year, and no missing data, one would look at the 8th highest 24-hour value for everyday sampling and at the second highest 24-hour value for once every sixth day sampling to estimate if the standard is going to be exceeded. The proposed standards give the detailed procedures for calculating the values to compare against the standards.

If the proposed PM2.5 standards are adopted, both the City and State will need to address the issue of how to control fine particulate emissions. The three likely major source categories are diesel emissions from buses and trucks, automotive emissions, and transport of secondary aerosols. A source characterization and source apportionment study will likely need to be done to address how much of the PM2.5 is attributable to these sources. Unlike previous studies, this apportionment study should cover at least an entire year to detect seasonal differences in the source characterization and apportionment and should be performed at different sites to reflect the different mix of automobile, bus, and truck traffic that was found at various sites. The highest PM10 sites in the Harlem and Washington Heights communities would be good candidate locations to be considered for such a study. A prime objective of the study should be to determine to what extent diesel emissions affect PM2.5 and to what extent control measures such as converting buses to compressed natural gas are likely to reduce ambient PM2.5 levels.

5.3 Performance of Saturation Samplers

The saturation samplers generally gave results comparable to those of the reference samplers for PM10. However, the samplers were biased about 28 percent high for PM2.5 values as determined by the dichotomous samplers used as PM10 reference samplers. The dichotomous samplers are not a reference or equivalent method for PM2.5. In a previous study in Philadelphia in 1994, the saturation samplers gave results comparable to an earlier Harvard study[14] at some of the same Philadelphia sites. The saturation samplers had determined a PM2.5/PM10 ratio of 0.76 while Harvard, using samplers of its own design, had obtained a PM2.5/PM10 ratio of 0.75.[12,13,14]

No reference or equivalent samplers for PM2.5 yet exist because EPA has only proposed, not promulgated, a PM2.5 standard and reference method. At the current time, the first prototype Federal Reference Method PM2.5 samplers are just beginning to be evaluated in the field. The SMR will soon include a set of PM2.5 saturation samplers in one of the first evaluations which is to be held at the Research Triangle Park beginning mid-December 1996. Dichotomous samplers will also be included in the evaluation. Hopefully, this evaluation will determine if PM2.5 saturation sampler measurements are comparable to the proposed FRM.

As discussed in Section 2.3, the saturation samplers had some operational problems such as failing to sample for the time set. The SMR was unable to positively diagnose a cause to account for most of the failures because of multiple component failures that affect performance. Although many samplers were checked, repaired, and checked again, they would continue to fail in the field and seem fine in the laboratory. The vast majority of failures in the field did not seem to be due to operator error, flow cutoff adjustments, or batteries. Field conditions such as vibration and electronic interference were suspected as causes, but eliminated because some samplers would operate successfully at the same sites. The SMR is continuing to completely overhaul the failed units. In addition, the SMR has prepared a series of stress tests to check the failed samplers that have been repaired.

6.0 ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of Professor Stanley Gedzelman of the City College of New York in providing space for the field laboratory and for supervising the graduate and undergraduate students serving as field operators for the study. In addition, the authors wish to thank Professor Patrick Kinney of Columbia University's School of Public Health for sharing some of his preliminary data with us.

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TECHNICAL REPORT ABSTRACT

REPORT TITLE Manhattan Community Based Particulate Study

REPORT DATE January 15, 1997

CONTRACT NO. EPA 68-D3-0029

PRIME CONTRACTOR TRC Environmental Corporation

WORK ASSIGNMENT NO./DELIVERY ORDER NO. (if applicable) WA 3-115

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PROGRAM OFFICE U.S. EPA Office of Air Quality Planning and Standards

NO. OF PAGES IN REPORT 100 pages

DOES THIS REPORT CONTAIN CONFIDENTIAL BUSINESS INFORMATION

YES ____________ NO X

REPORT ABSTRACT

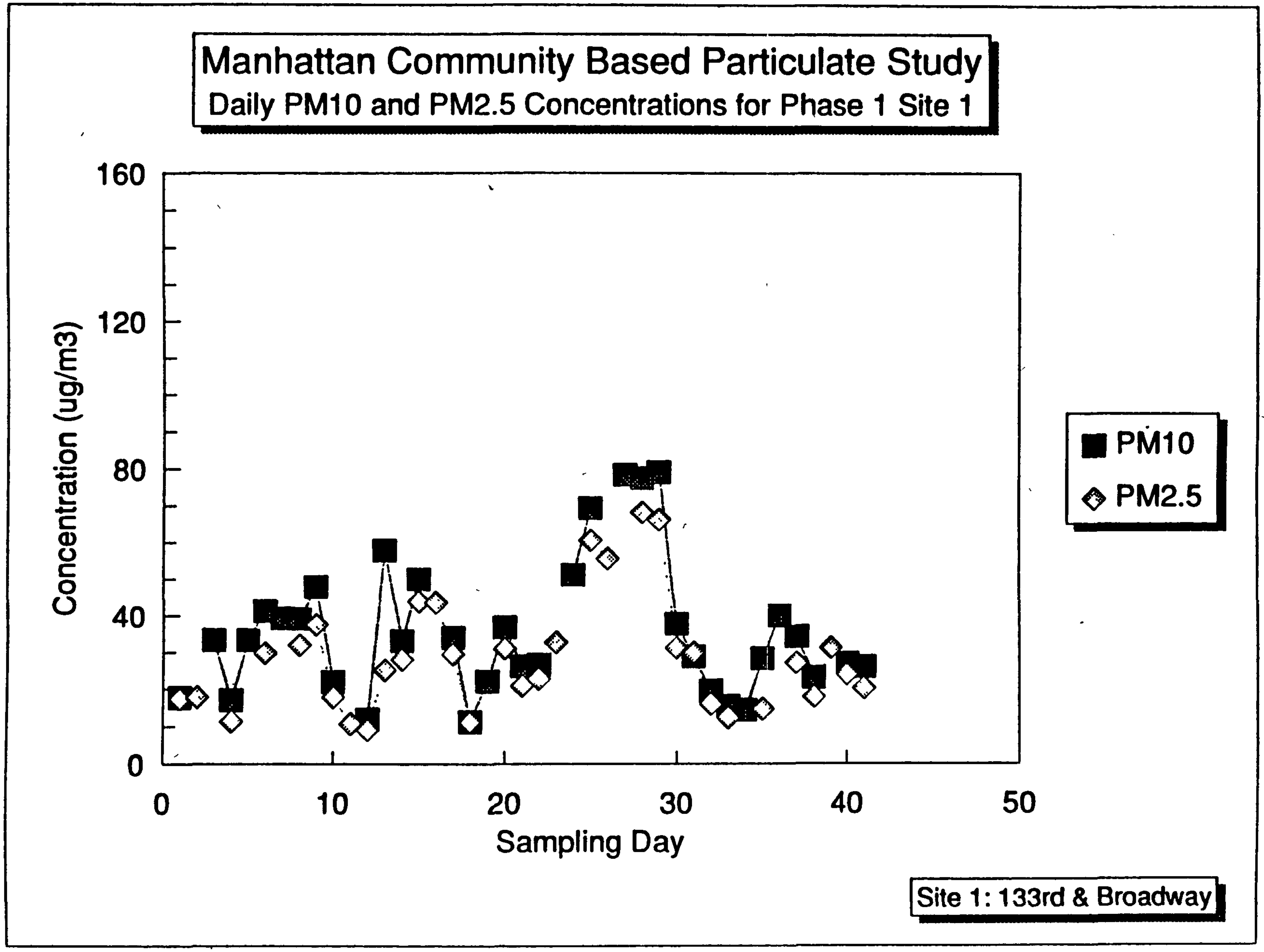
This report presents the results of a study to examine PM10 concentrations in two communities in northern Manhattan over a period of approximately 80 days during July through September 1996. Sampling was conducted using saturation samplers and was divided into two phases - the first at eight street level locations in the Harlem community and then at seven locations in the Washington Heights community (plus one continuing site in the Harlem community). During both phases, saturation samplers were located at sites in midtown and downtown Manhattan at which the State operated standard dichotomous samplers. In addition, saturation samplers were also used at a subset of sites to collect PM2.5 samples and, during Phase 2, samples for analysis of elemental and organic carbon. Temporal variability for PM10 was greater than spatial variability and the community sites generally had lower concentrations than either of the two reference sites. Based on the ratio of PM2.5/PM10 measured at reference and community sites, estimates of PM2.5 from PM10 measurements show that many sites might not meet the proposed annual and/or 24-hour PM2.5 national ambient air quality standards.

KEY WORDS/DESCRIPTORS

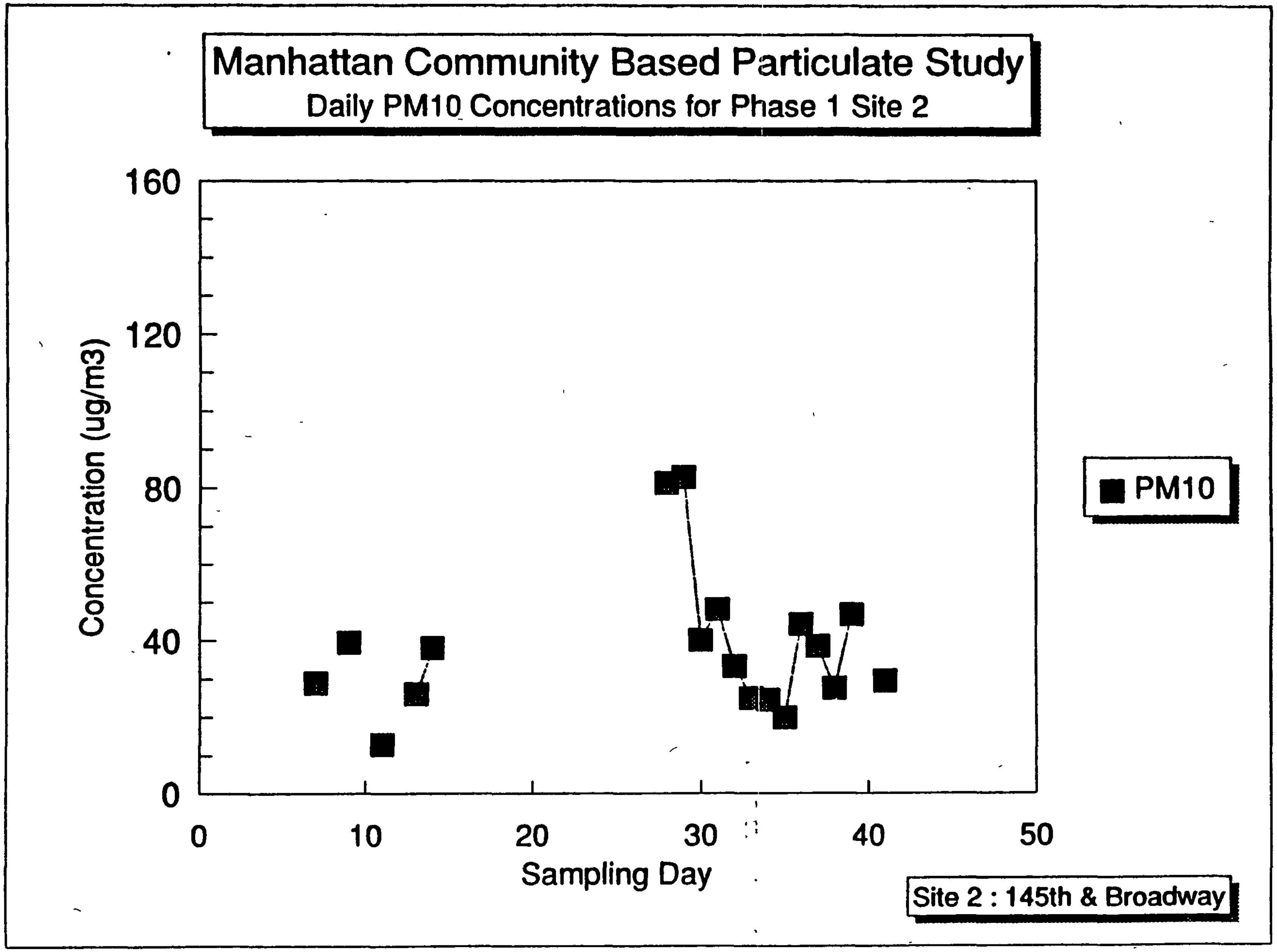
particulate matter monitoring, PM10, PM2.5, saturation sampler

APPENDIX A

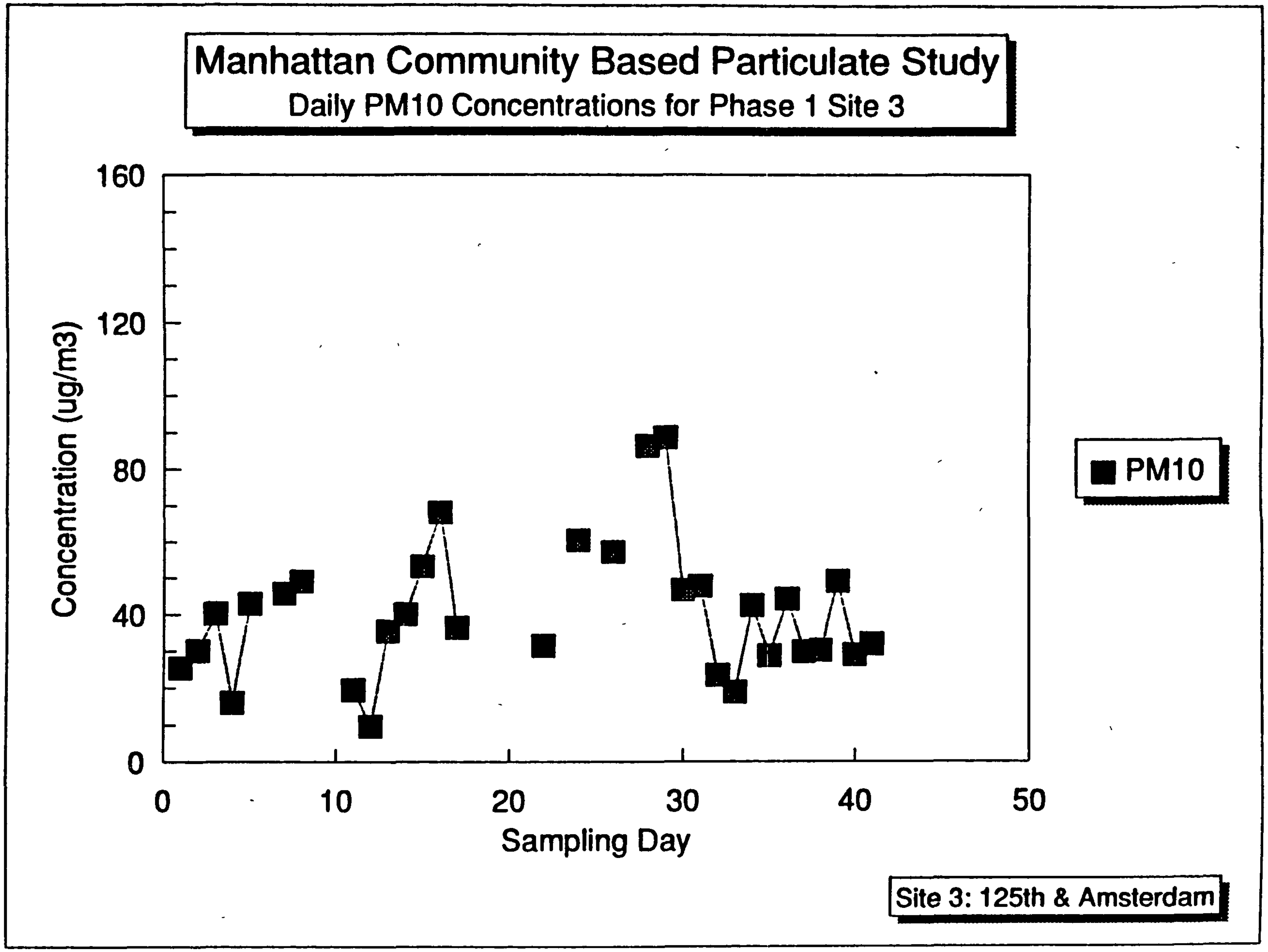
DAILY PM10 AND PM2.5 CONCENTRATIONS BY SITE FOR PHASE 1

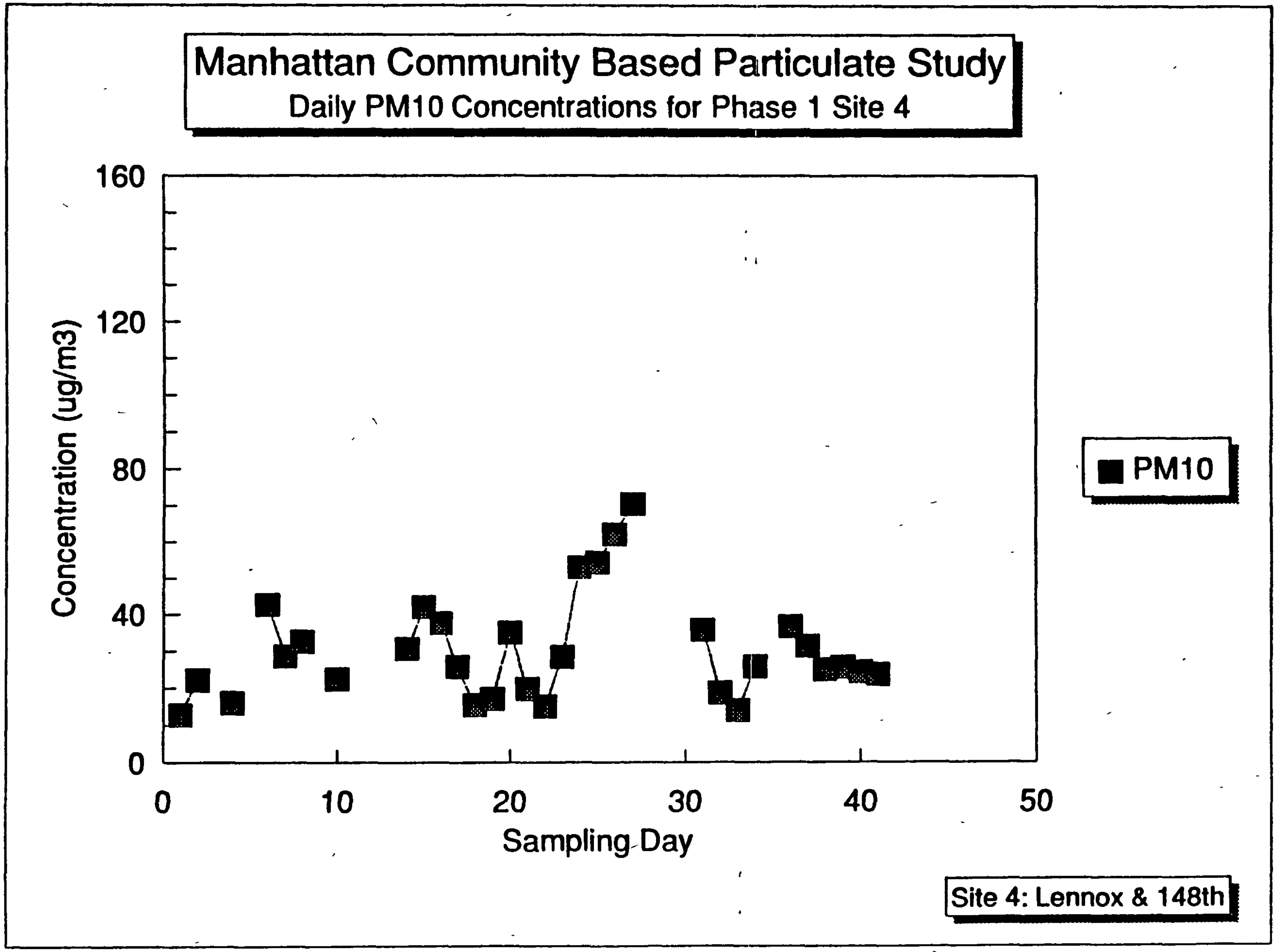


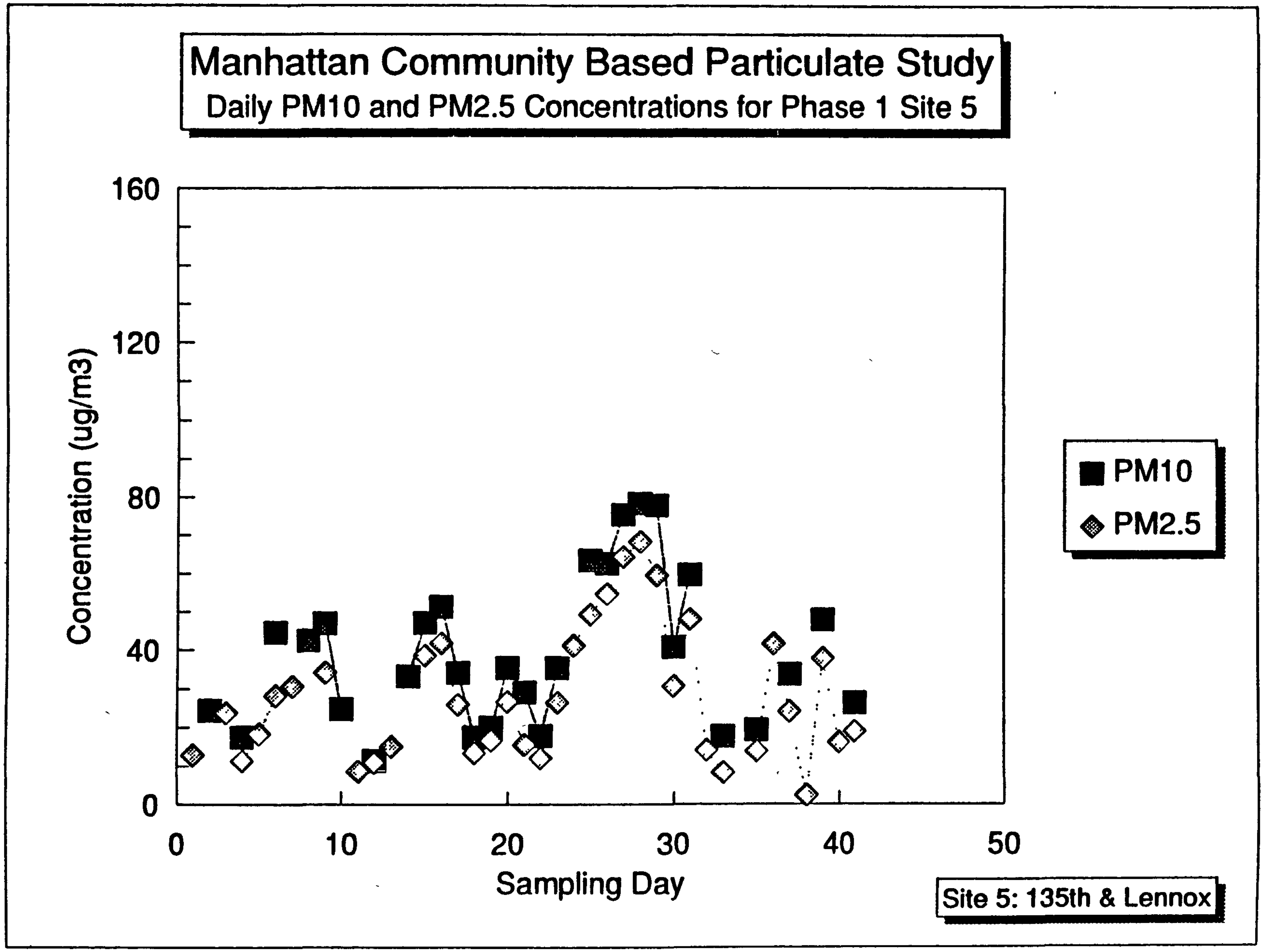
Manhattan Community Based Particulate Study
Daily PM10 and PM2.5 Concentrations for Phase 1 Site 1
160
120
80
40
0
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM10
PM2.5
Site 1: 133rd & Broadway



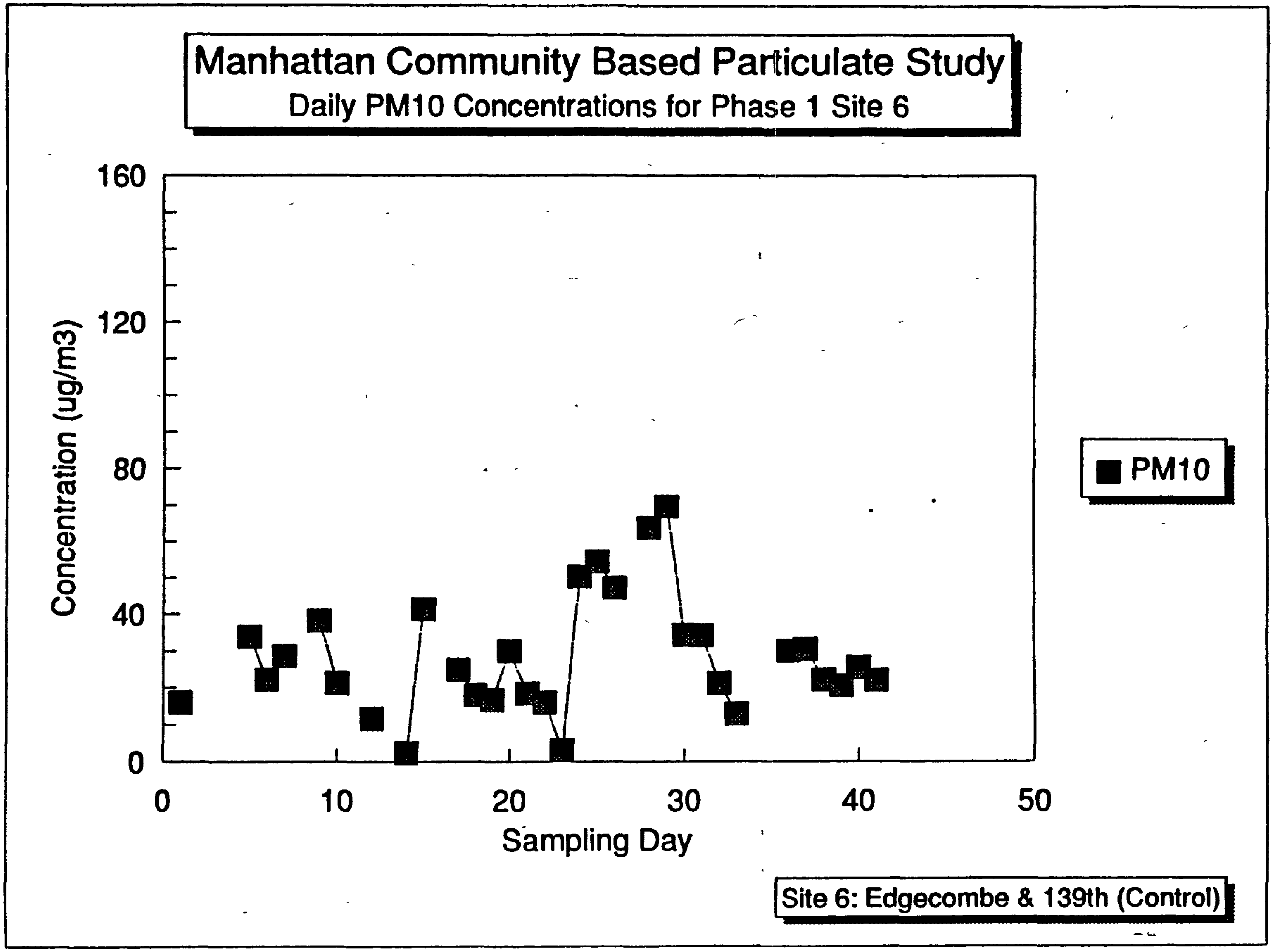
Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 1 Site 2
160
120
80
40
0
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM10
Site 2 : 145th & Broadway


Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 1 Site 3
Concentration (ug/m3)
160
120
80
40
0
0
10
20
30
40
50
Sampling Day
PM10
Site 3: 125th & Amsterdam

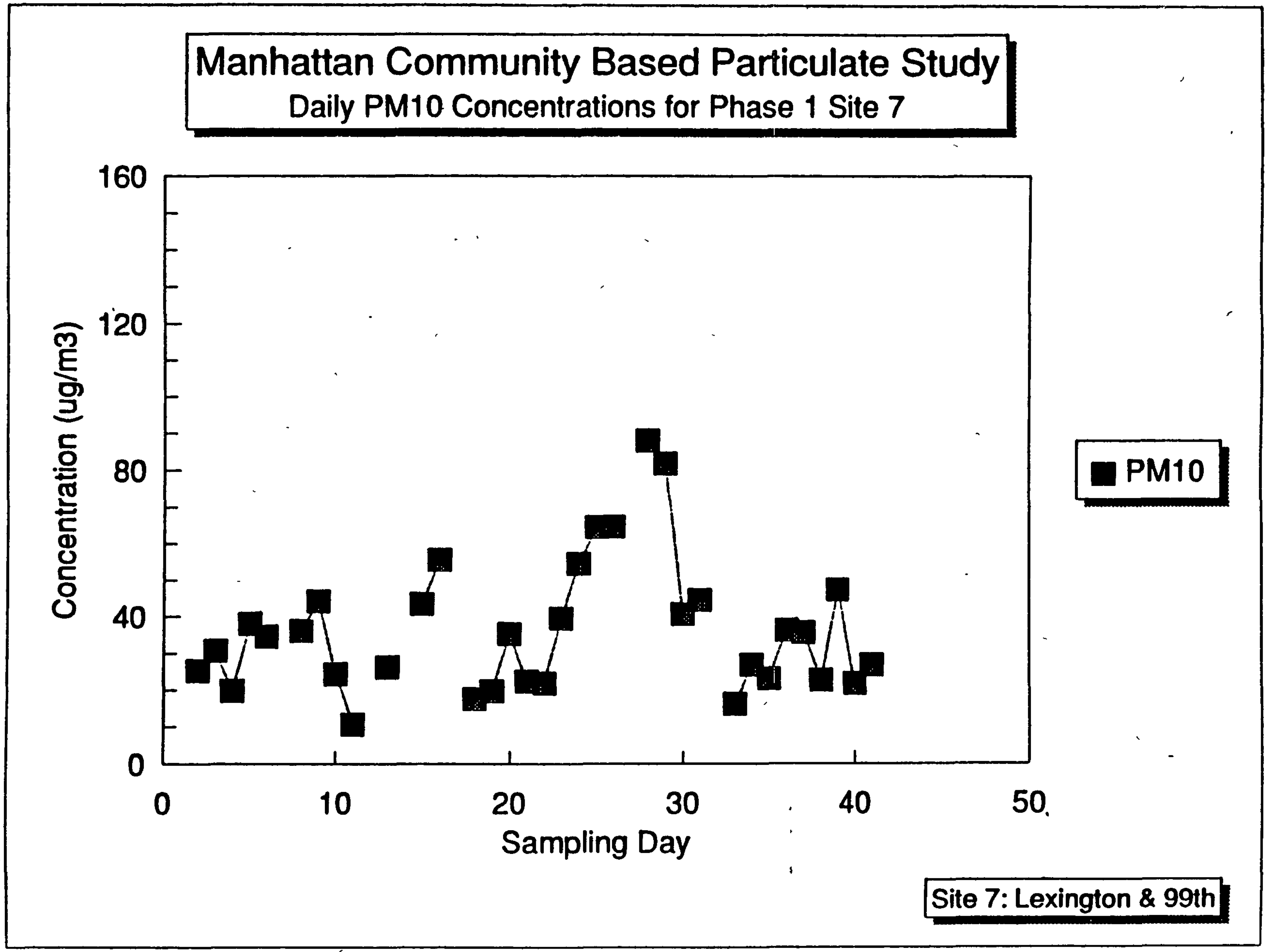

Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 1 Site 4
Concentration (ug/m3)
160
120
80
40
0
0
10
20
30
40
50
Sampling Day
PM10
Site 4: Lennox & 148th



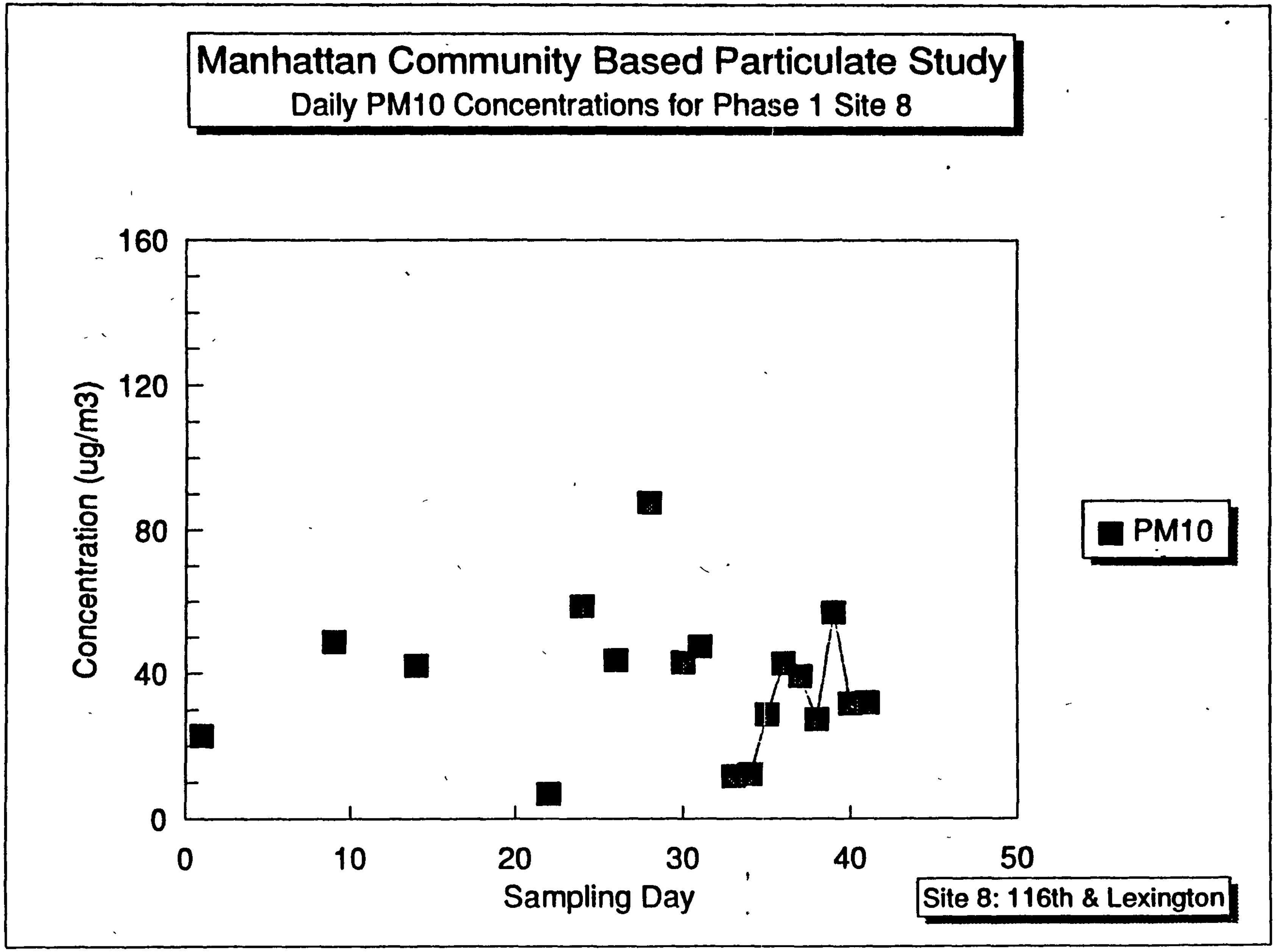
Manhattan Community Based Particulate Study
Daily PM10 and PM2.5 Concentrations for Phase 1 Site 5
160
120
80
40
0
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM10
PM2.5
Site 5: 135th & Lennox



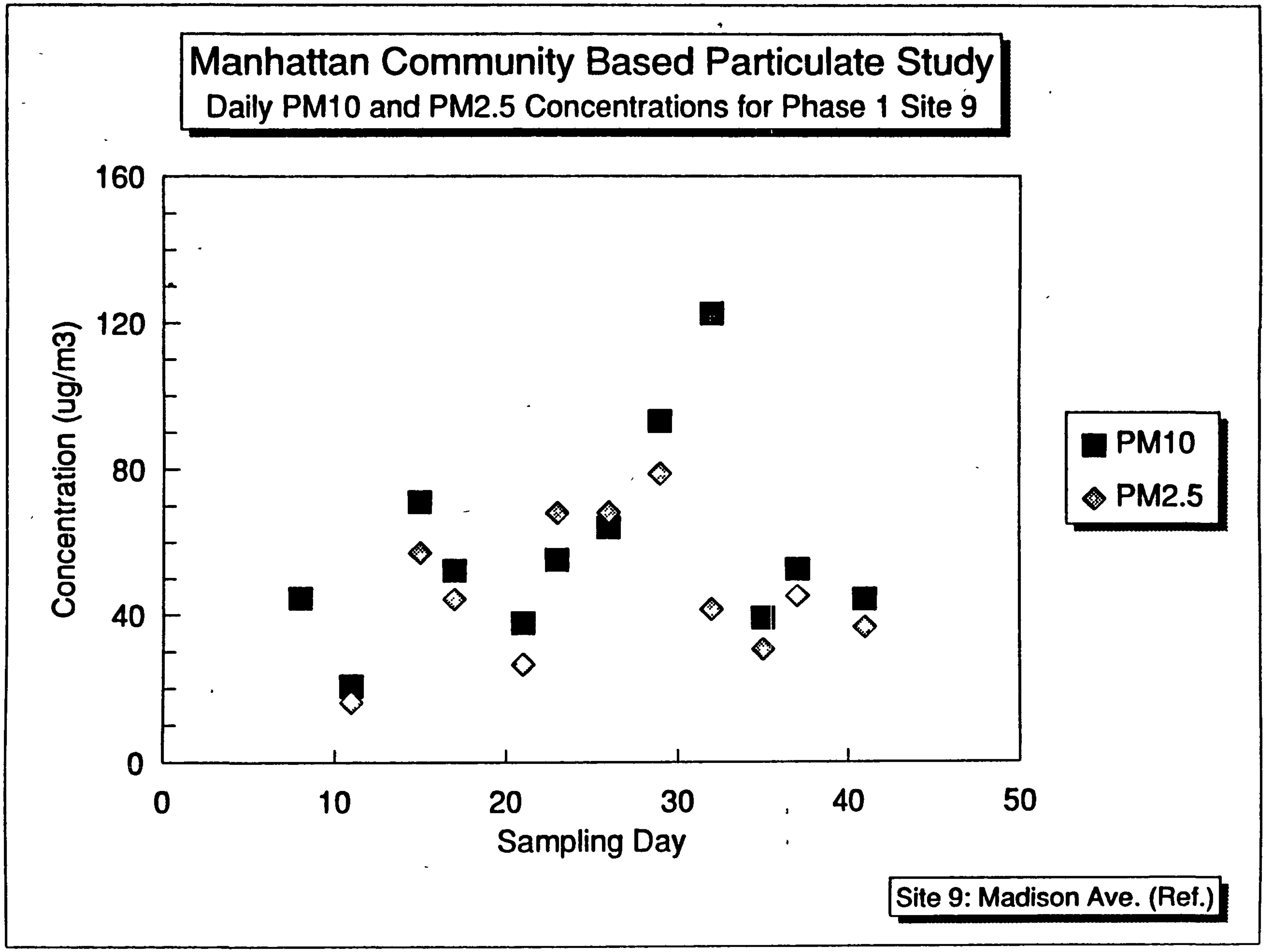
Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 1 Site 6
160
120
80
40
0
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM10
Site 6: Edgecombe & 139th (Control)

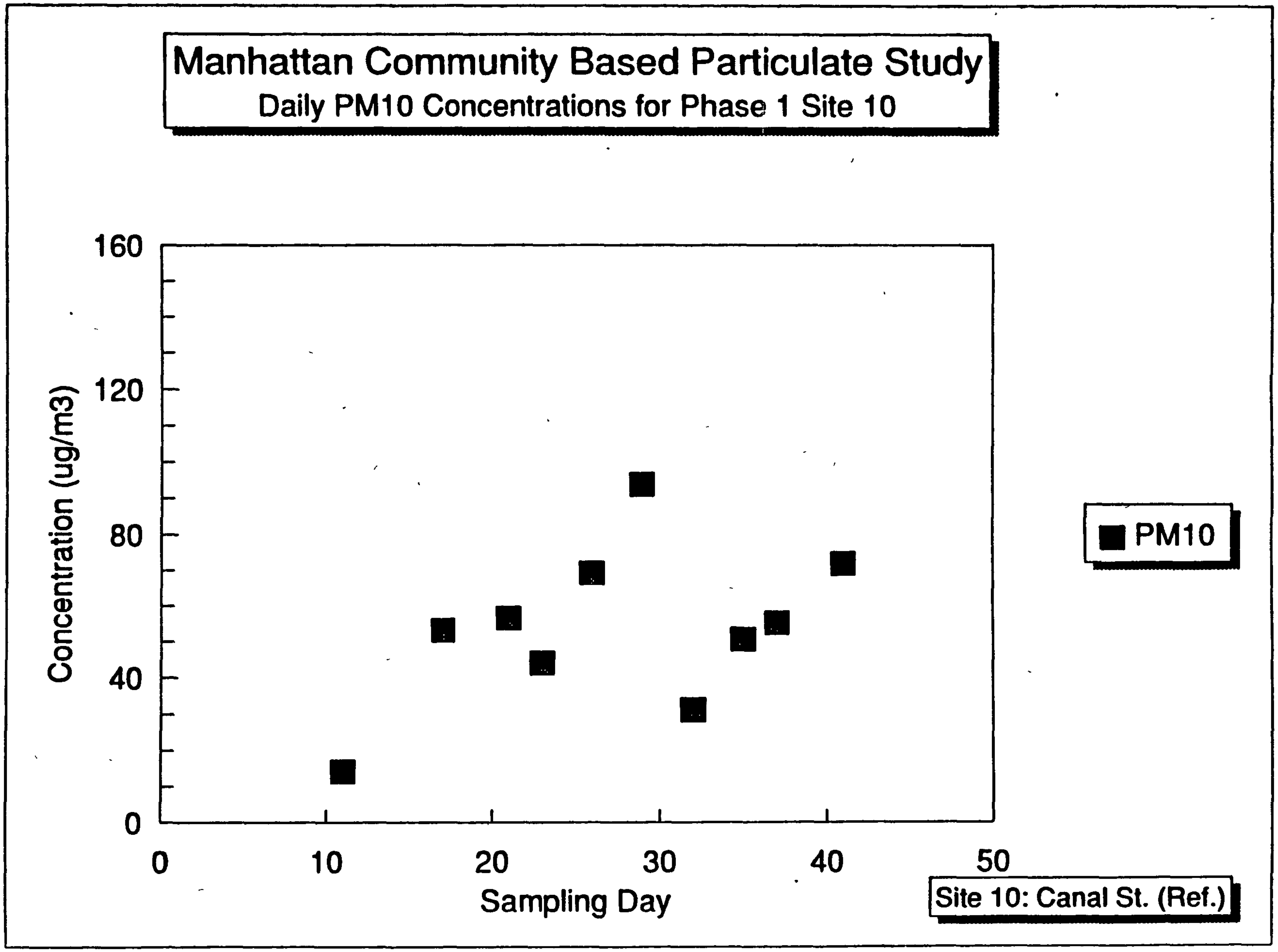


Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 1 Site 7
160
120
80
40
0
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM10
Site 7: Lexington & 99th



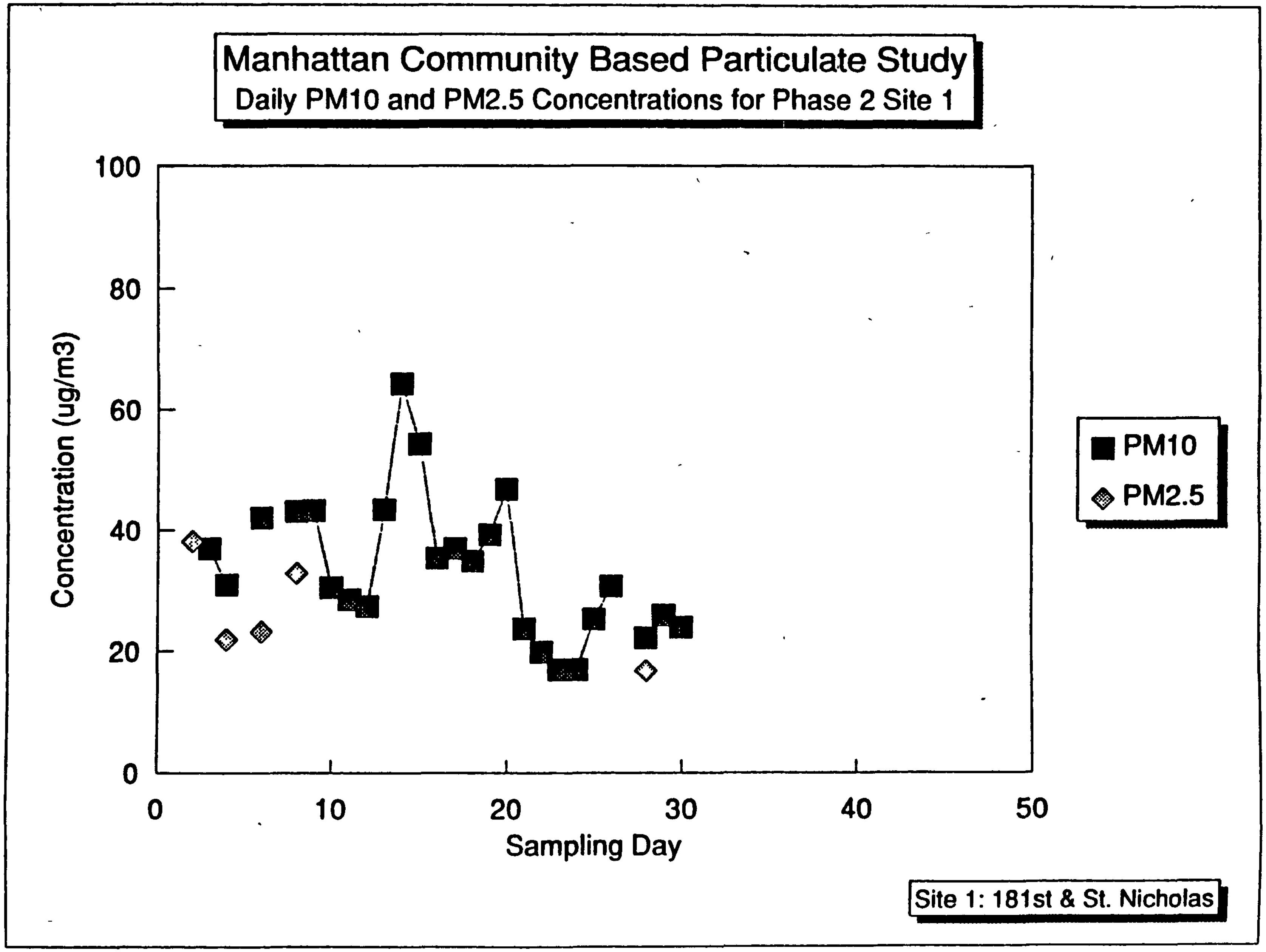
Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 1 Site 8
160
120
80
40
0
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM10
Site 8: 116th & Lexington

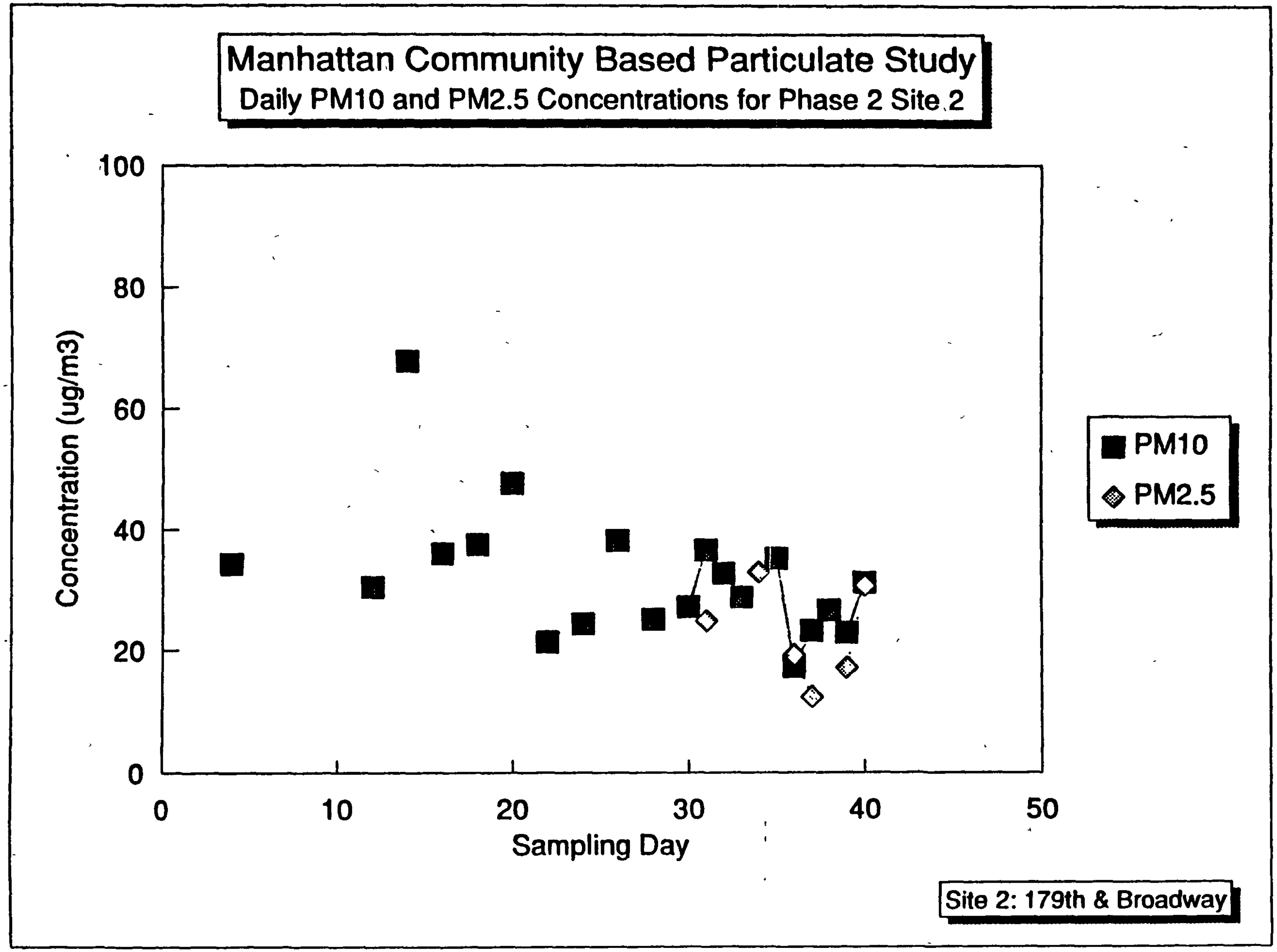

Manhattan Community Based Particulate Study
Daily PM10 and PM2.5 Concentrations for Phase 1 Site 9
Concentration (ug/m3)
160
120
80
40
0
0
10
20
30
40
50
Sampling Day
PM10
PM2.5
Site 9: Madison Ave. (Ref.)

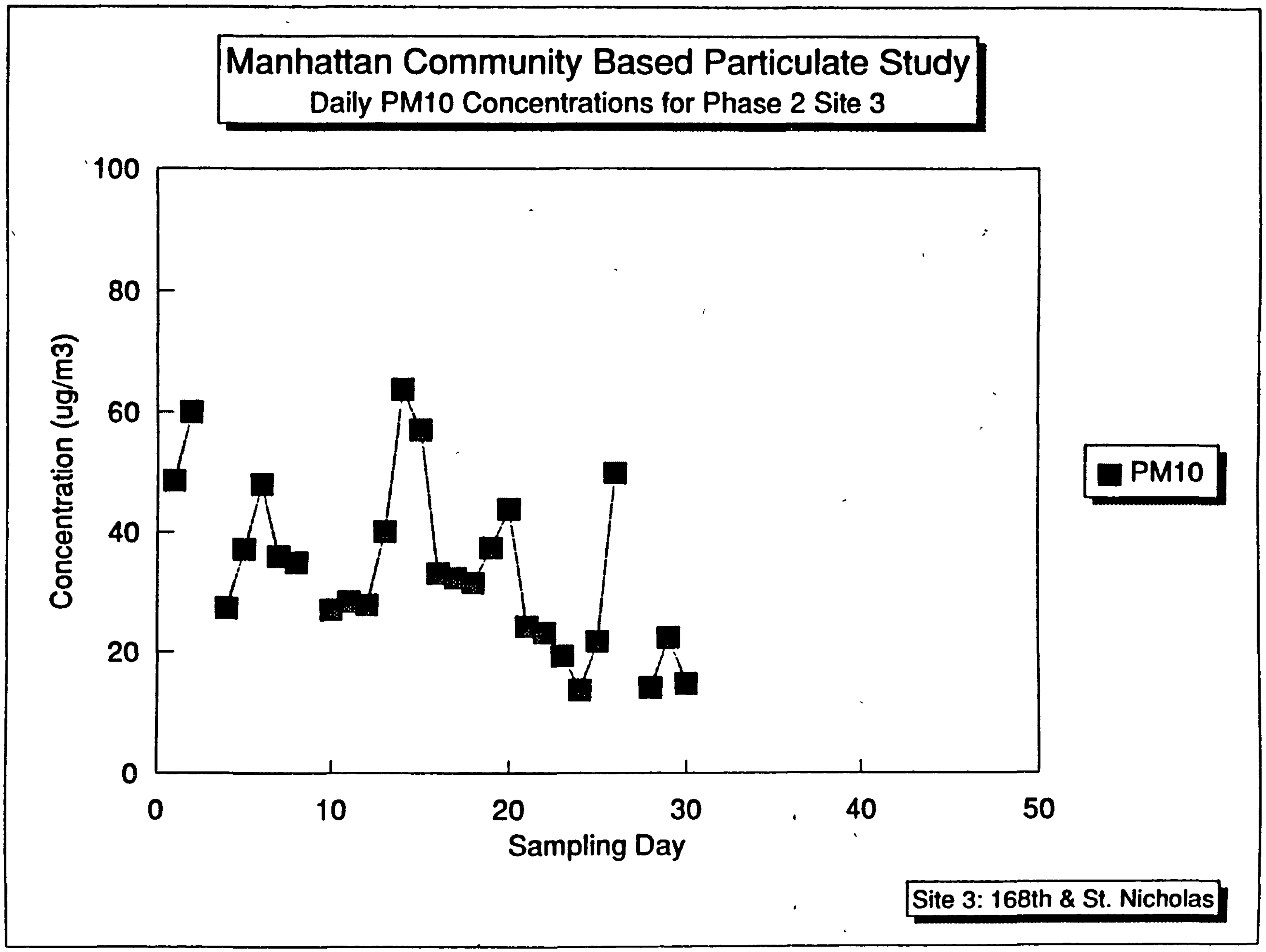

Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 1 Site 10
Concentration (ug/m3)
160
120
80
40
0
0
10
20
30
40
50
Sampling Day
PM10
Site 10: Canal St. (Ref.)

APPENDIX B

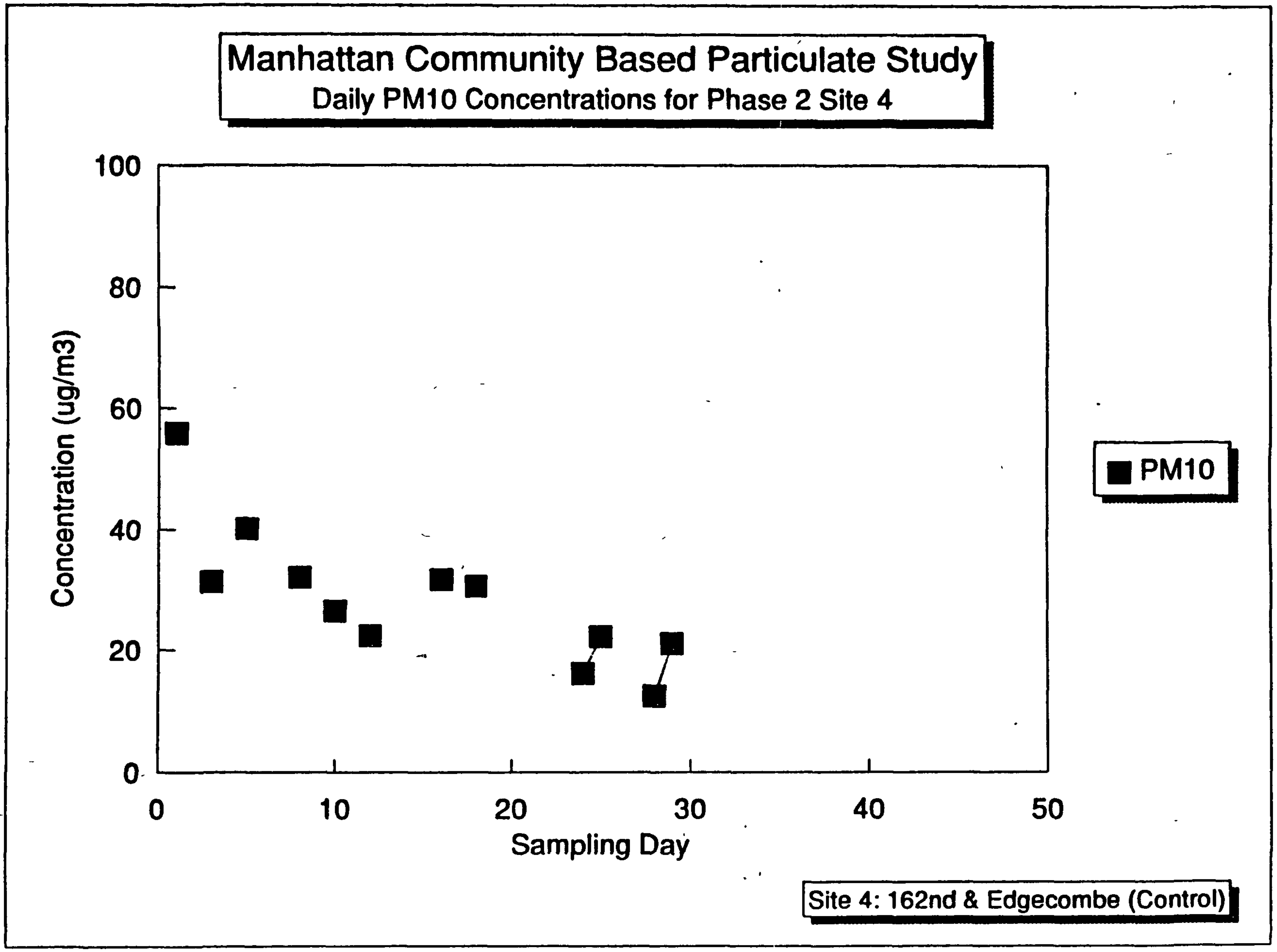
DAILY PM10 AND PM2.5 CONCENTRATIONS BY SITE FOR PHASE 2

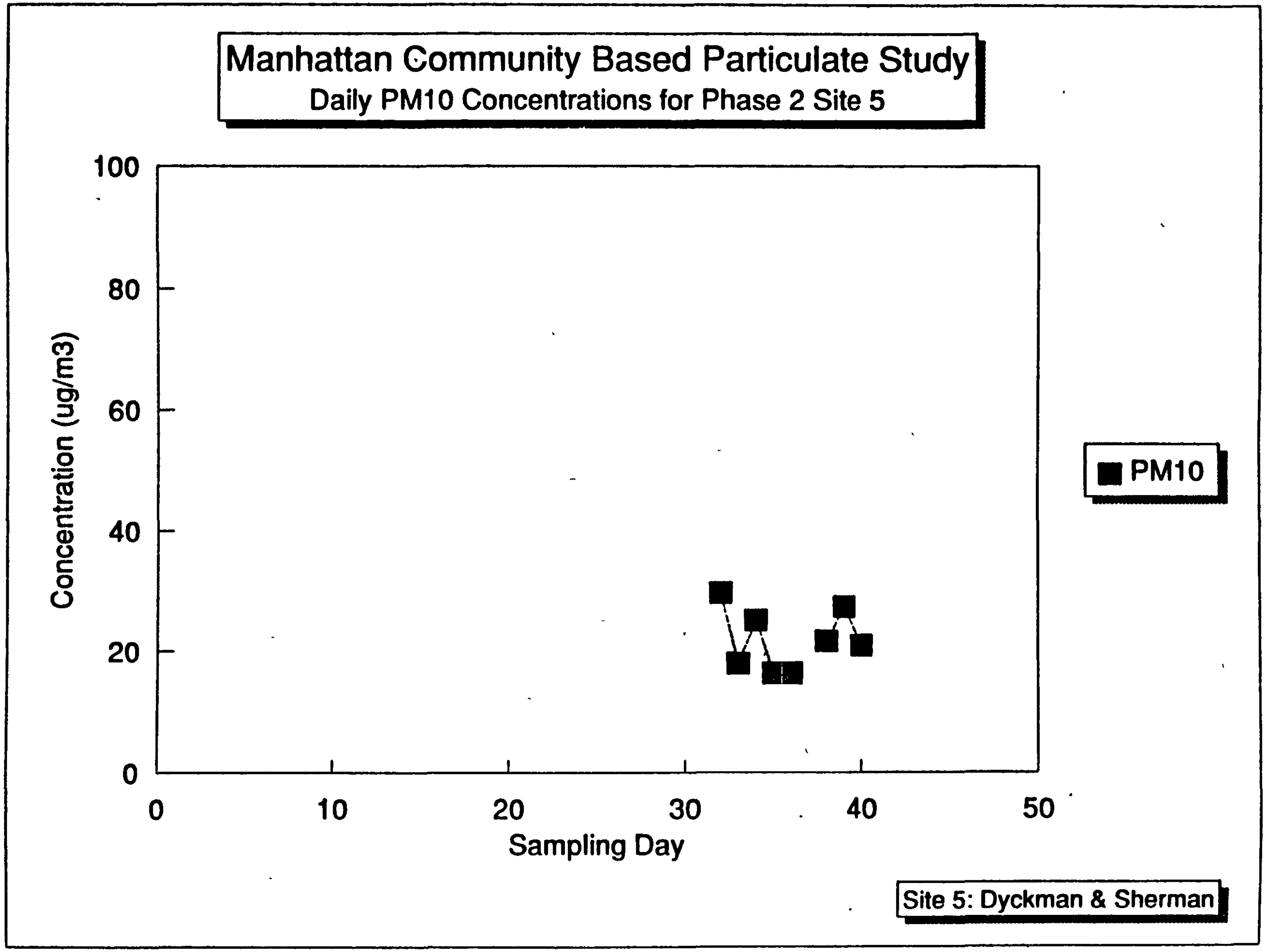

Manhattan Community Based Particulate Study
Daily PM10 and PM2.5 Concentrations for Phase 2 Site 1
100
80
60
40
20
0
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM10
PM2.5
Site 1: 181st & St. Nicholas

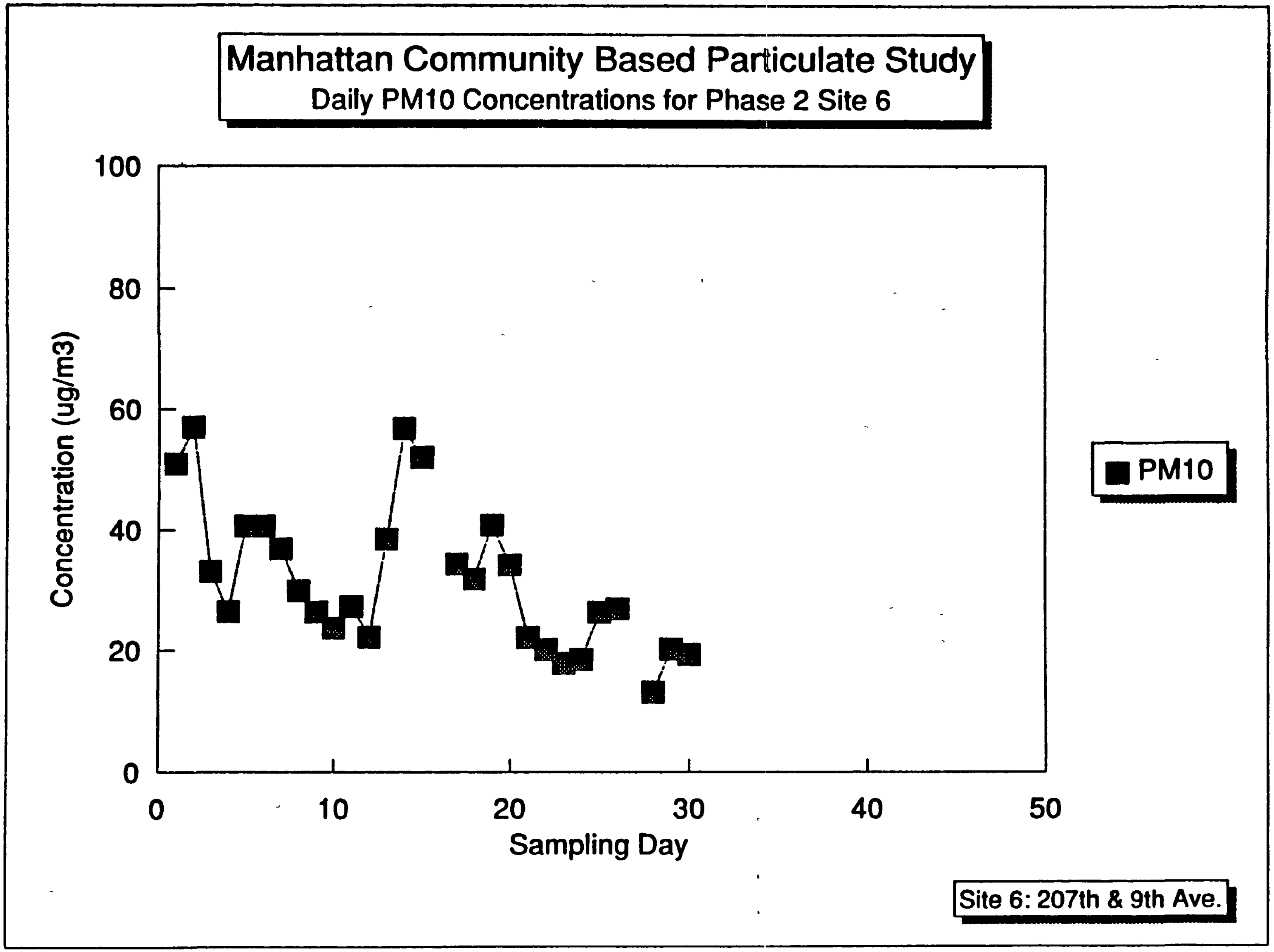

Manhattan Community Based Particulate Study
Daily PM10 and PM2.5 Concentrations for Phase 2 Site 2
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10
PM2.5
Site 2: 179th & Broadway



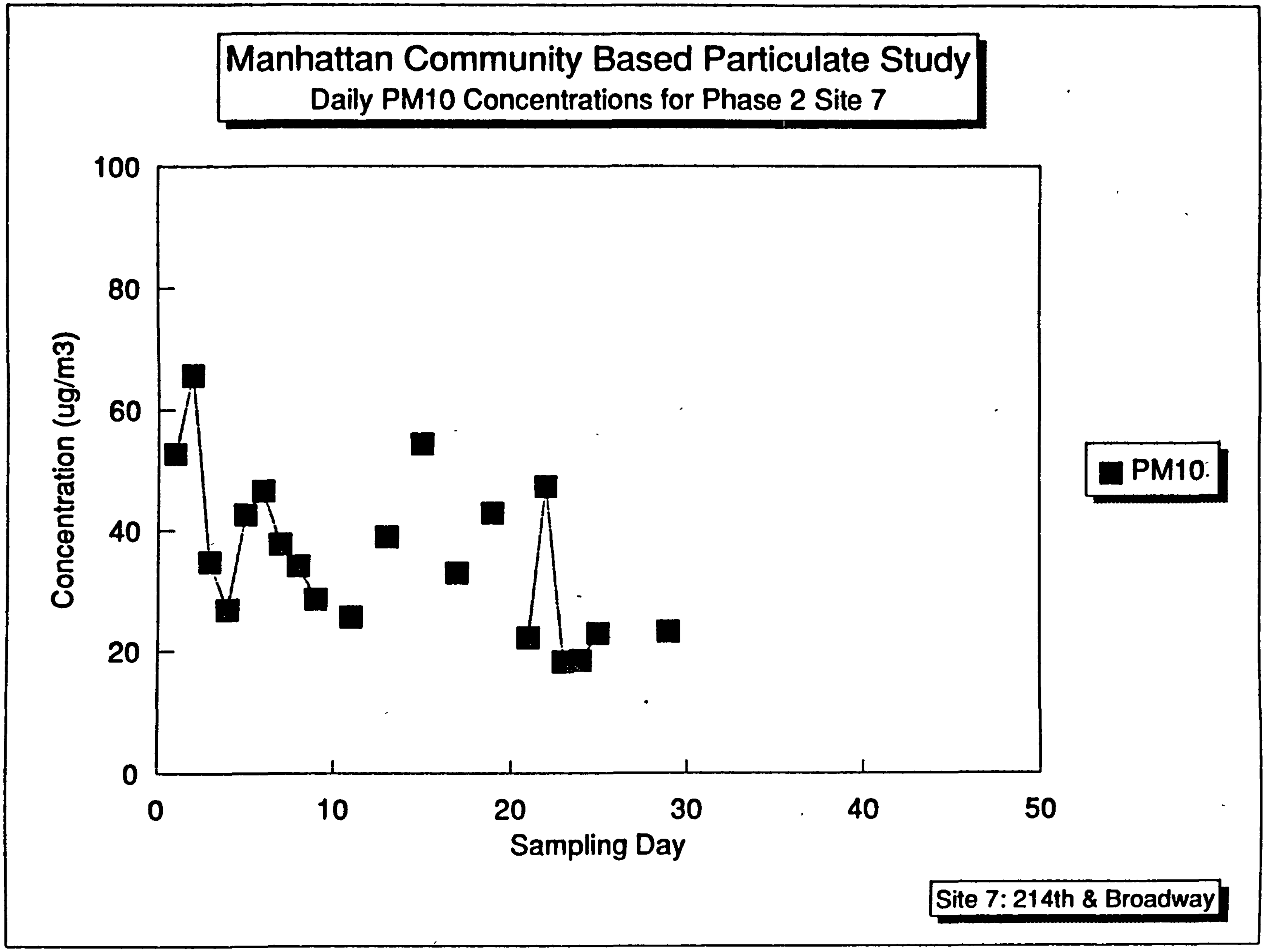
Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 2 Site 3
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10
Site 3: 168th & St. Nicholas


Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 2 Site 4
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10
Site 4: 162nd & Edgecombe (Control)

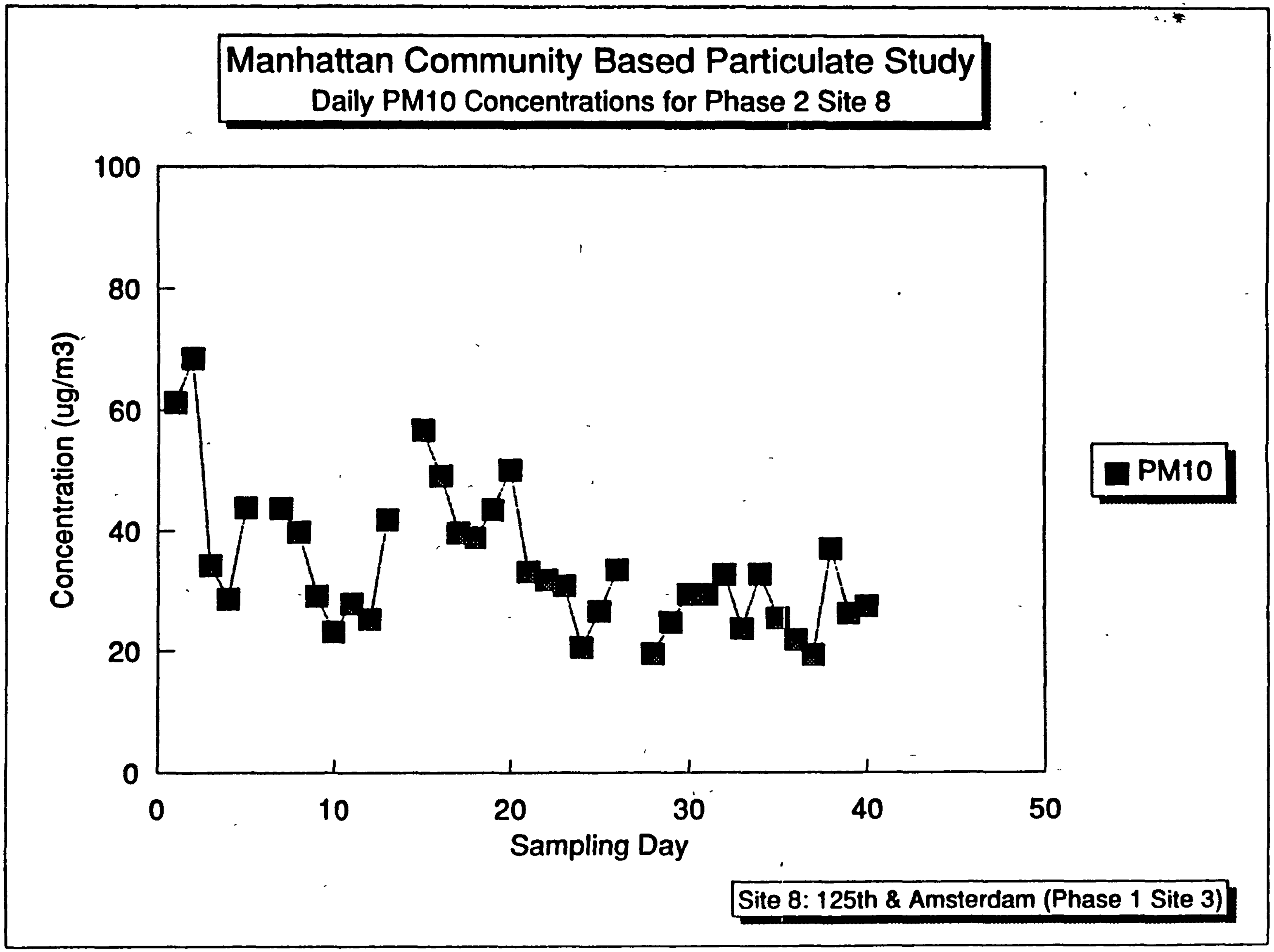

Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 2 Site 5
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10
Site 5: Dyckman & Sherman

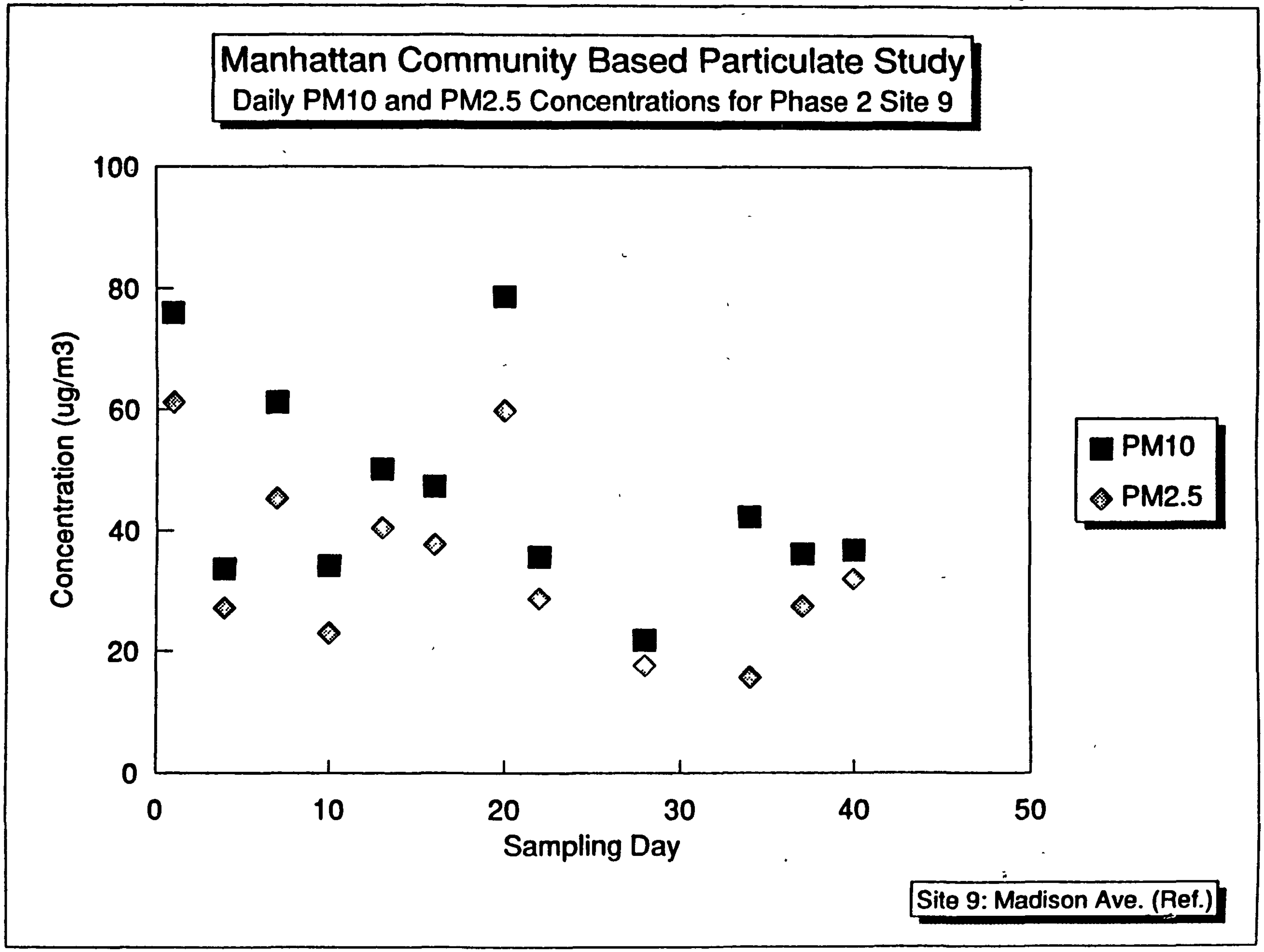


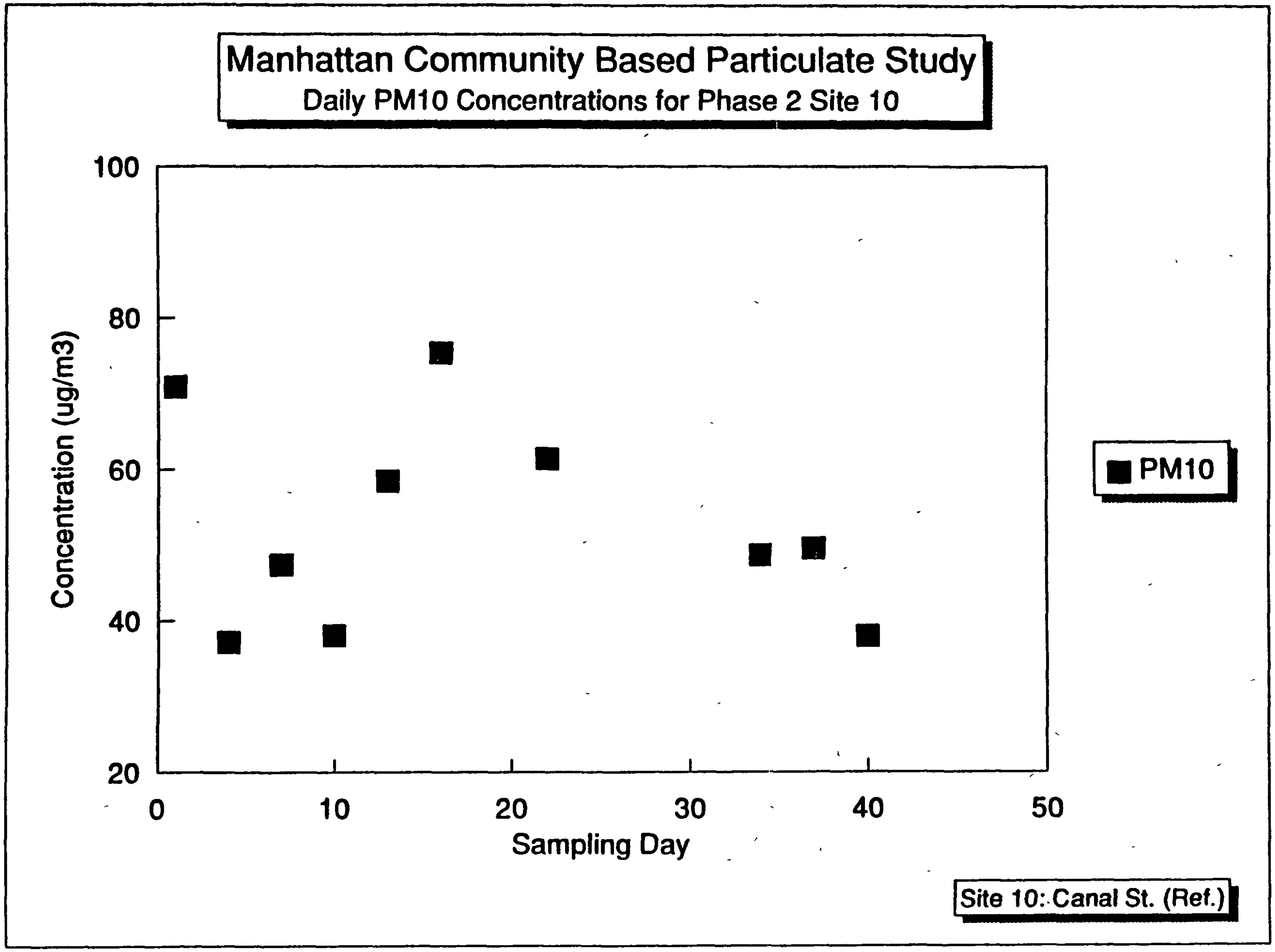
Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 2 Site 6
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10
Site 6: 207th & 9th Ave.



Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 2 Site 7
Concentration (ug/m3)
0
20
40
60
80
100
0
10
20
30
40
50
Sampling Day
PM10
Site 7: 214th & Broadway


Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 2 Site 8
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10
Site 8: 125th & Amsterdam (Phase 1 Site 3)

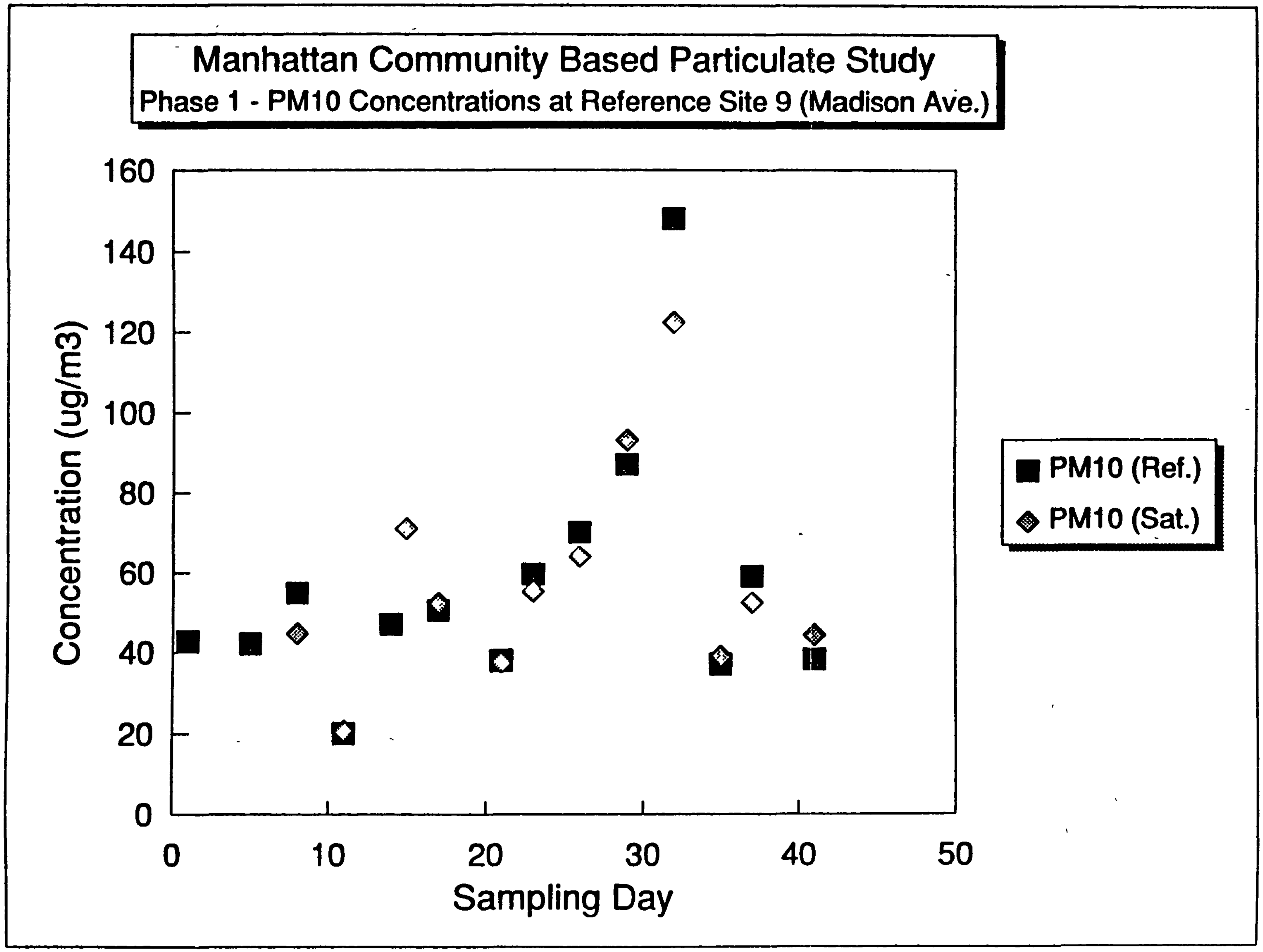

Manhattan Community Based Particulate Study
Daily PM10 and PM2.5 Concentrations for Phase 2 Site 9
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10
PM2.5
Site 9: Madison Ave. (Ref.)

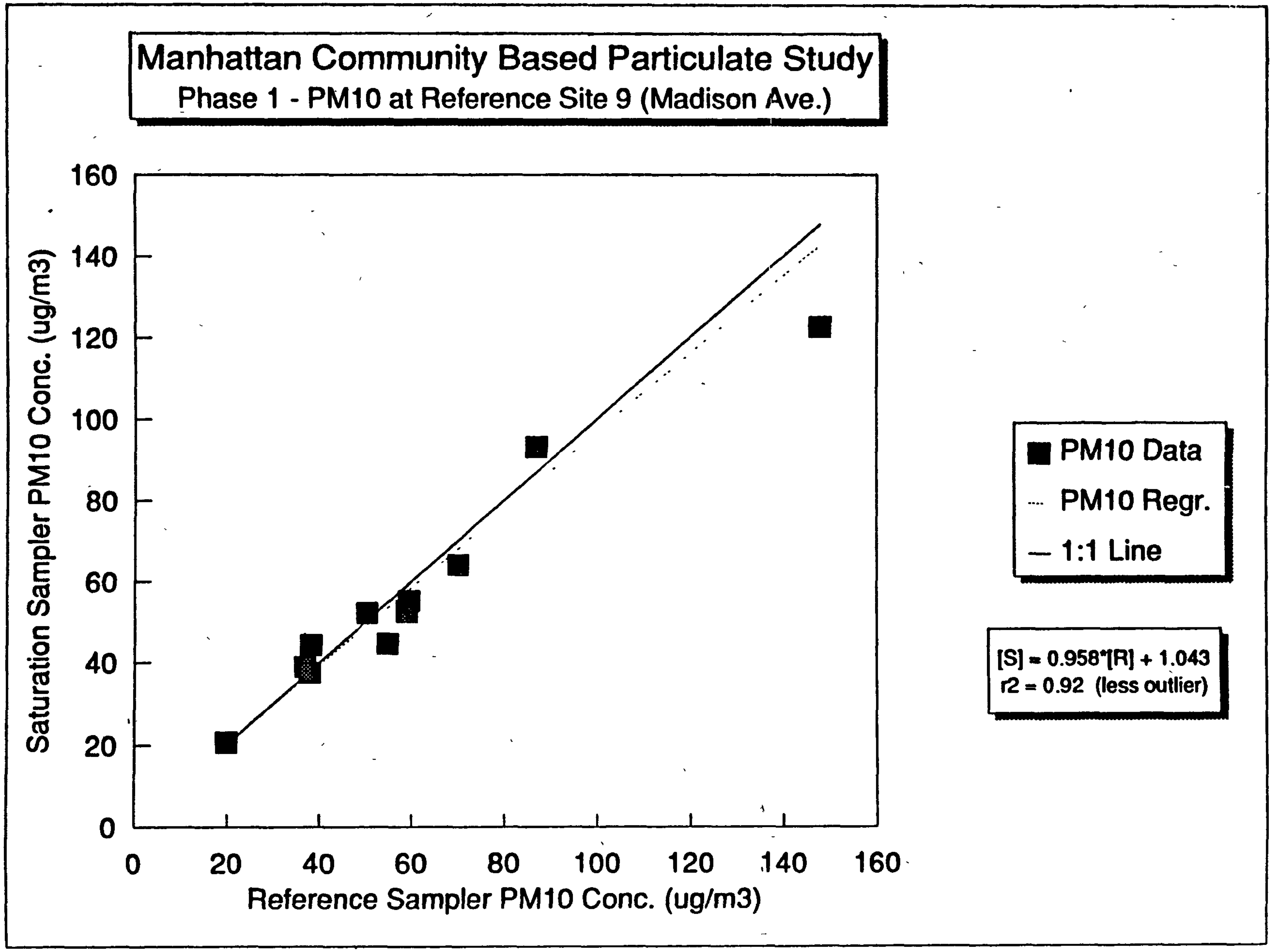


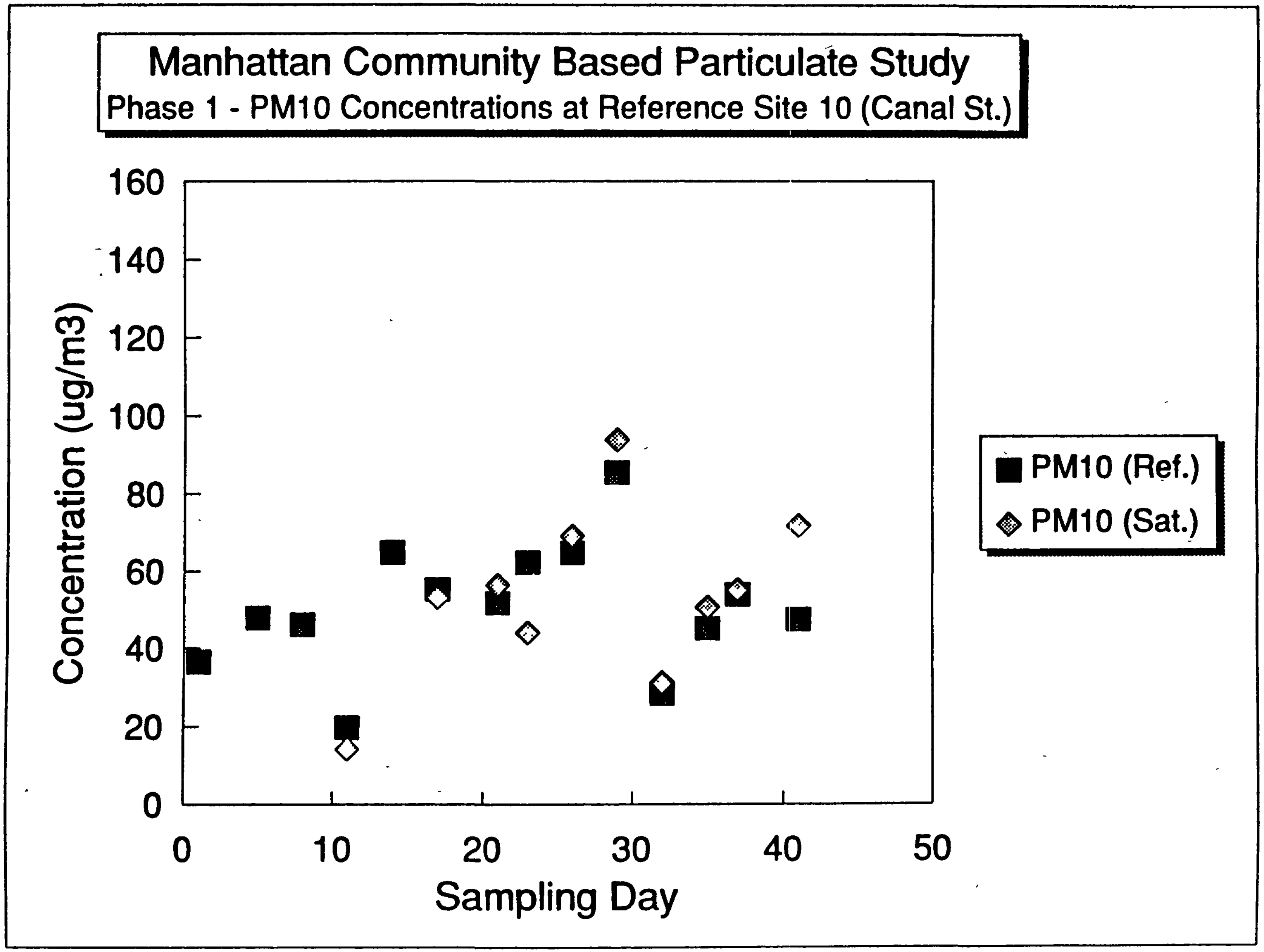
Manhattan Community Based Particulate Study
Daily PM10 Concentrations for Phase 2 Site 10
100
80
60
40
20
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM10
Site 10: Canal St. (Ref.)

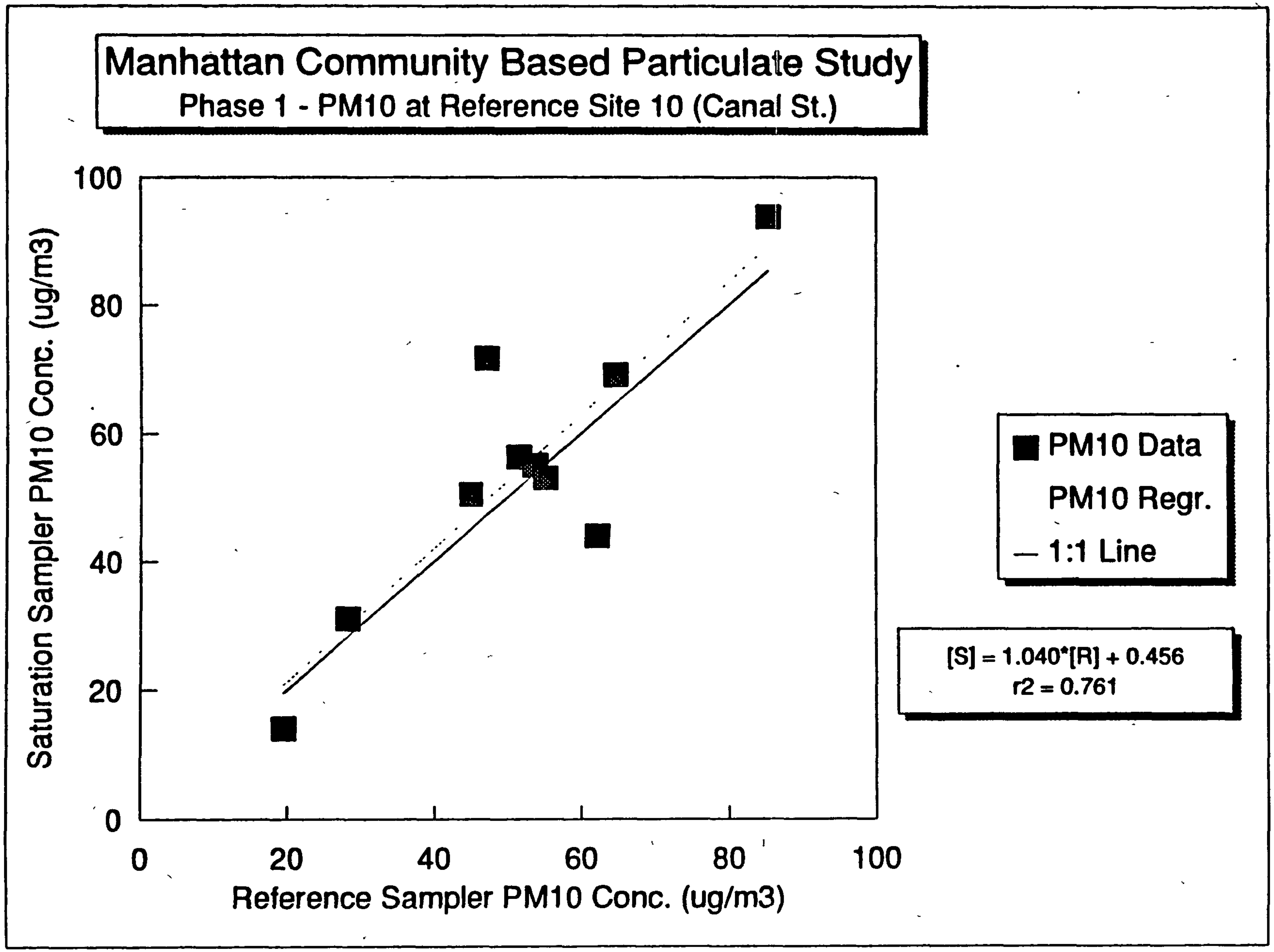
APPENDIX C

COMPARISON OF PM10 AND PM2.5 CONCENTRATIONS MEASURED BY REFERENCE AND SATURATION SAMPLERS

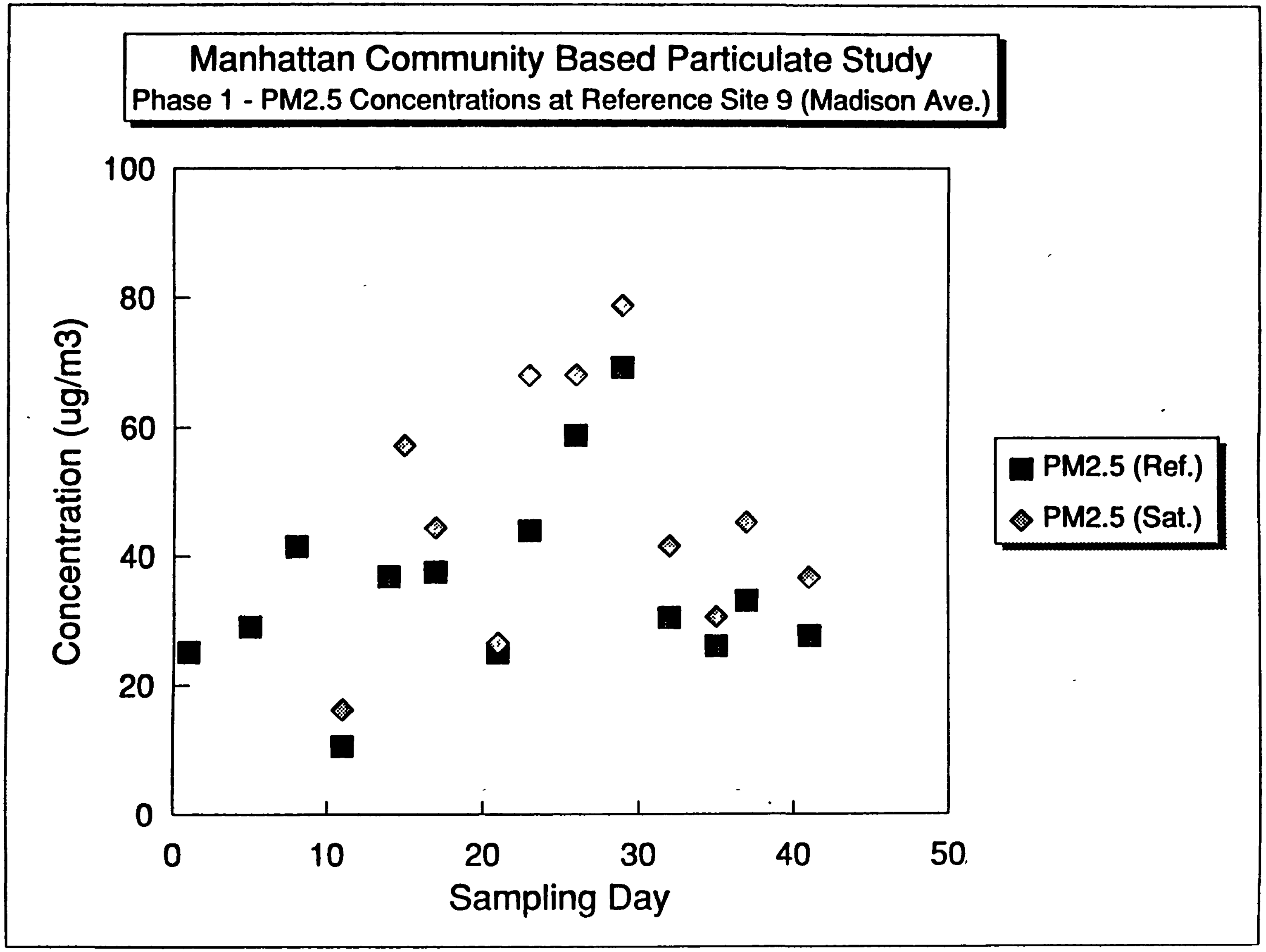

Manhattan Community Based Particulate Study
Phase 1 - PM10 Concentrations at Reference Site 9 (Madison Ave.)
Concentration (ug/m3)
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10 (Ref.)
PM10 (Sat.)


Manhattan Community Based Particulate Study
Phase 1 - PM10 at Reference Site 9 (Madison Ave.)
Saturation Sampler PM10 Conc. (ug/m3)
Reference Sampler PM10 Conc. (ug/m3)
0
20
40
60
80
100
120
140
160
PM10 Data
PM10 Regr.
1:1 Line
[S] = 0.958*[R] + 1.043
r2 = 0.92 (less outlier)

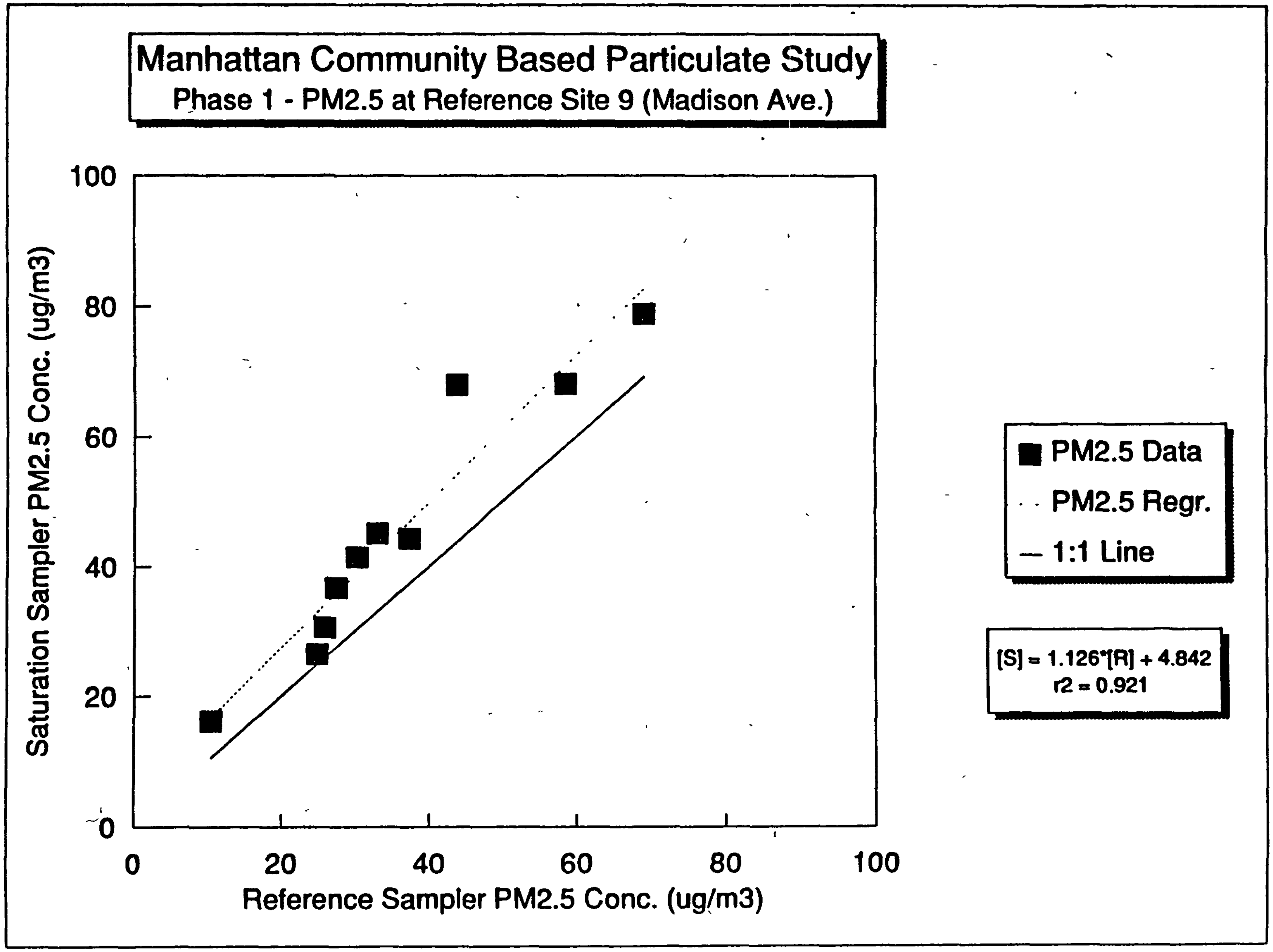

Manhattan Community Based Particulate Study
Phase 1 - PM10 Concentrations at Reference Site 10 (Canal St.)
Concentration (ug/m3)
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10 (Ref.)
PM10 (Sat.)

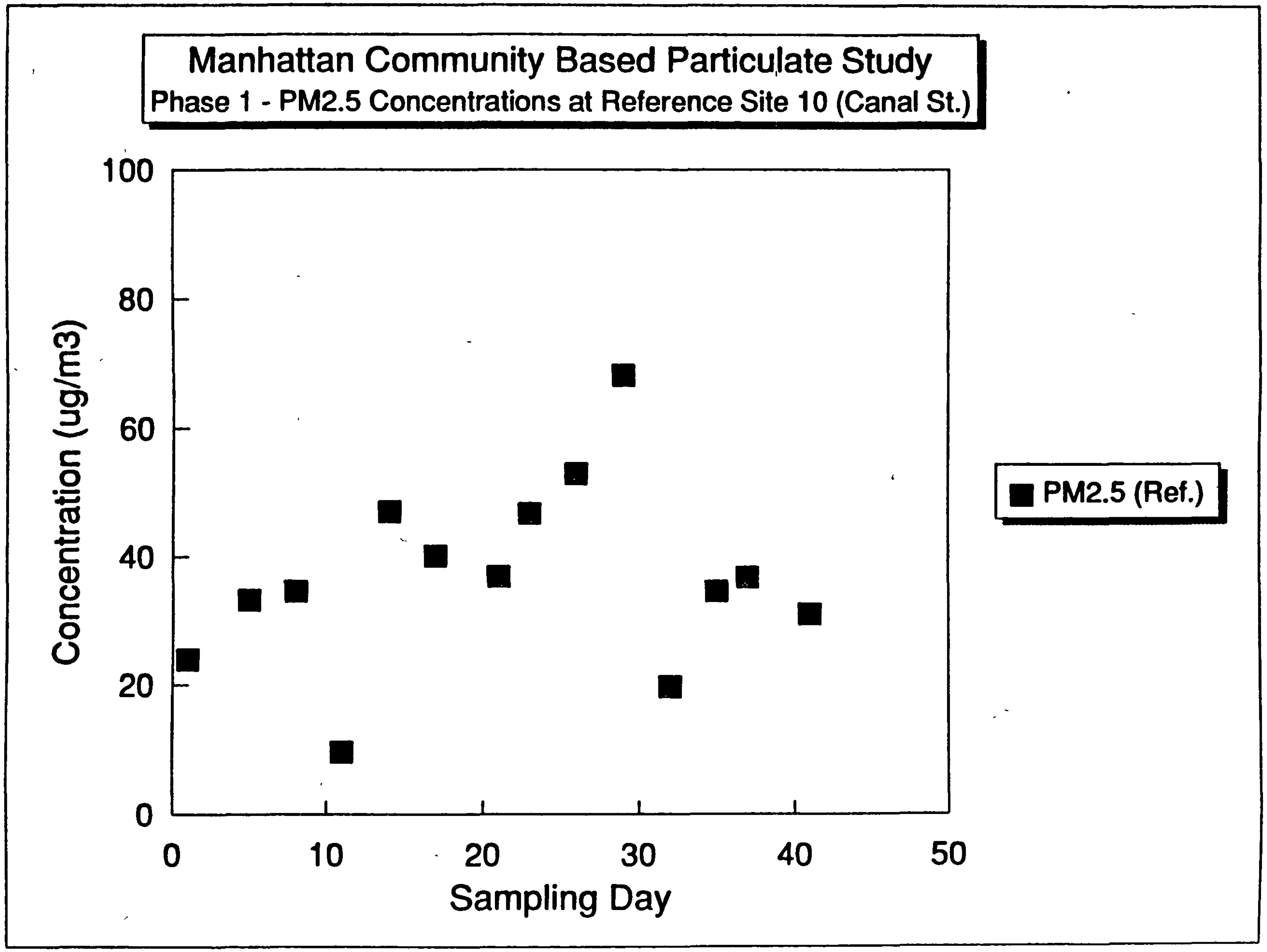


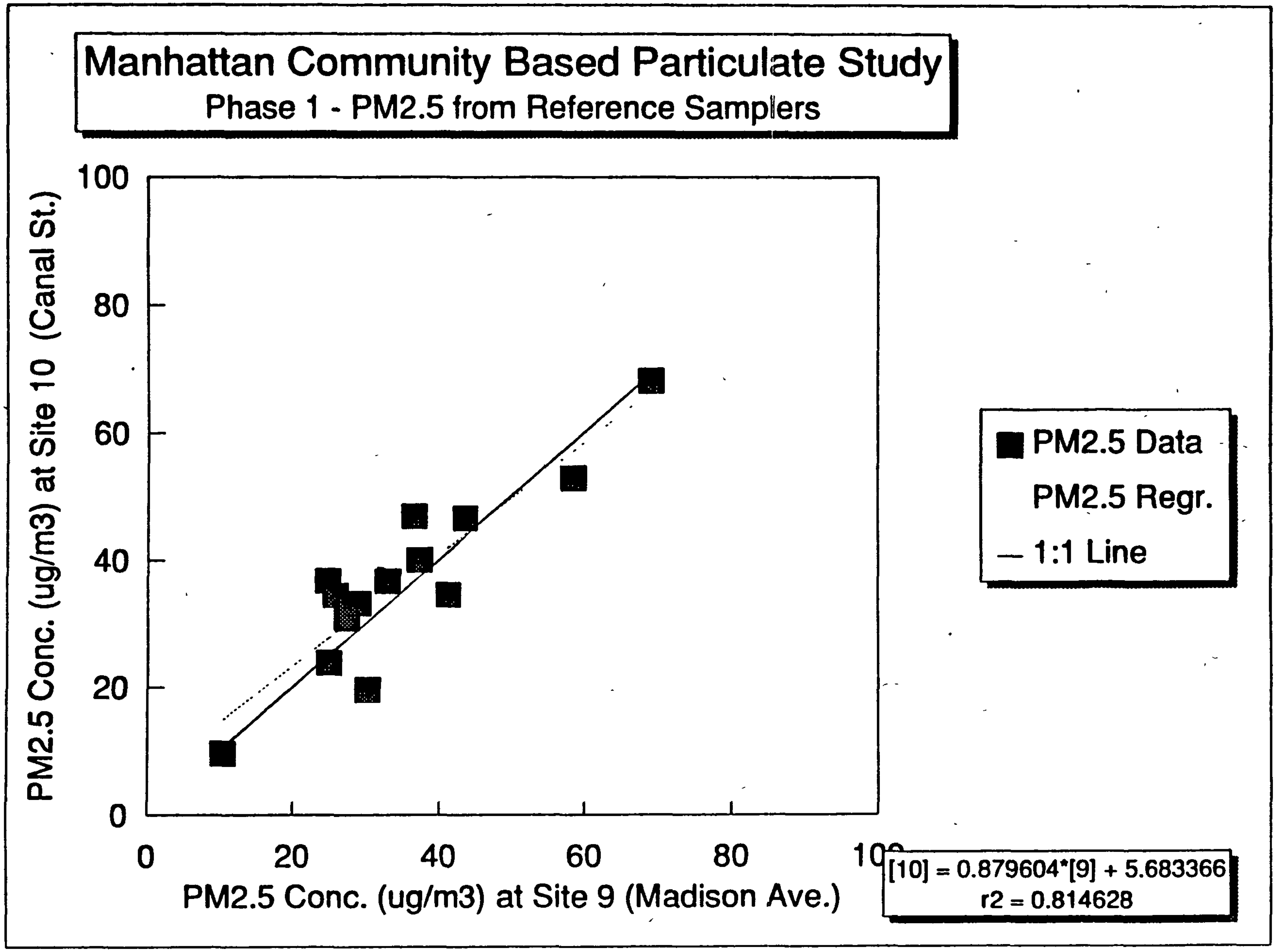
Manhattan Community Based Particulate Study
Phase 1 - PM10 at Reference Site 10 (Canal St.)
Saturation Sampler PM10 Conc. (ug/m3)
Reference Sampler PM10 Conc. (ug/m3)
0
20
40
60
80
100
PM10 Data
PM10 Regr.
1:1 Line
[S] = 1.040*[R] + 0.456
r2 = 0.761

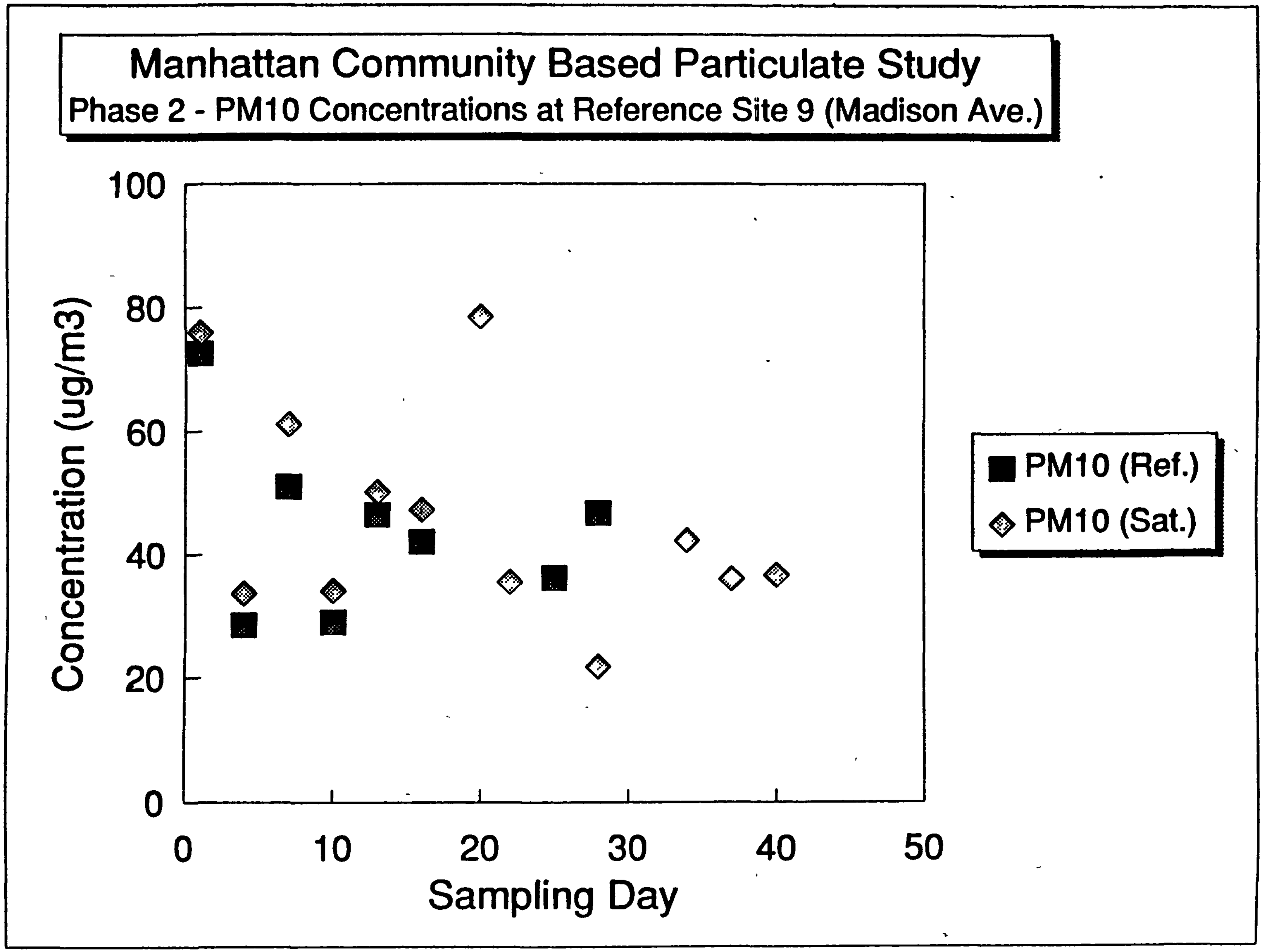


Manhattan Community Based Particulate Study
Phase 1 - PM2.5 Concentrations at Reference Site 9 (Madison Ave.)
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM2.5 (Ref.)
PM2.5 (Sat.)

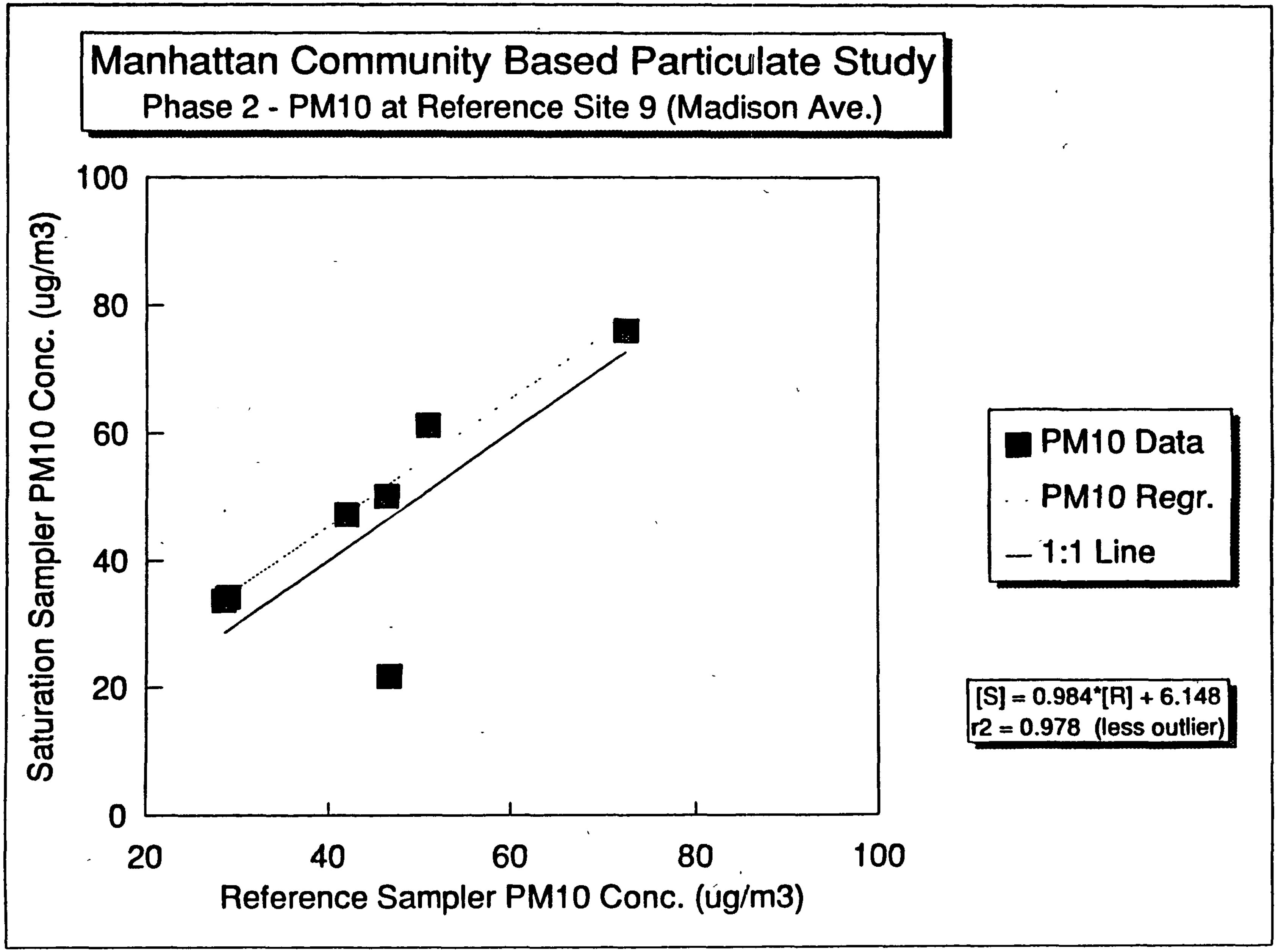

Manhattan Community Based Particulate Study
Phase 1 - PM2.5 at Reference Site 9 (Madison Ave.)
100
80
60
40
20
0
0
20
40
60
80
100
Saturation Sampler PM2.5 Conc. (ug/m3)
Reference Sampler PM2.5 Conc. (ug/m3)
PM2.5 Data
PM2.5 Regr.
1:1 Line
[S] = 1.126*[R] + 4.842
r2 = 0.921


Manhattan Community Based Particulate Study
Phase 1 - PM2.5 Concentrations at Reference Site 10 (Canal St.)
100
80
60
40
20
0
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM2.5 (Ref.)

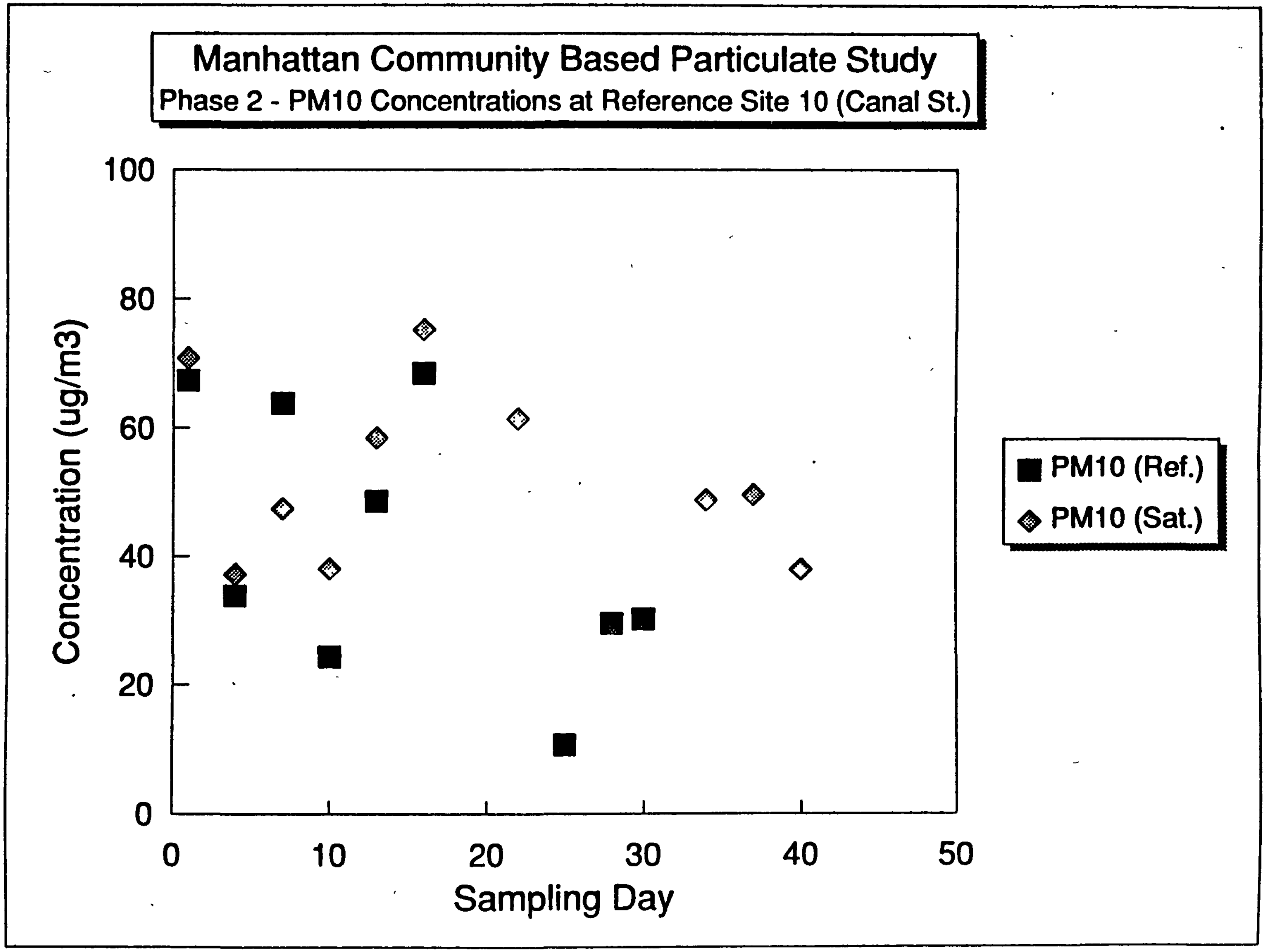

Manhattan Community Based Particulate Study
Phase 1 - PM2.5 from Reference Samplers
PM2.5 Conc. (ug/m3) at Site 10 (Canal St.)
0
20
40
60
80
100
PM2.5 Conc. (ug/m3) at Site 9 (Madison Ave.)
PM2.5 Data
PM2.5 Regr.
1:1 Line
[10] = 0.879604*[9] + 5.683366
r2 = 0.814628

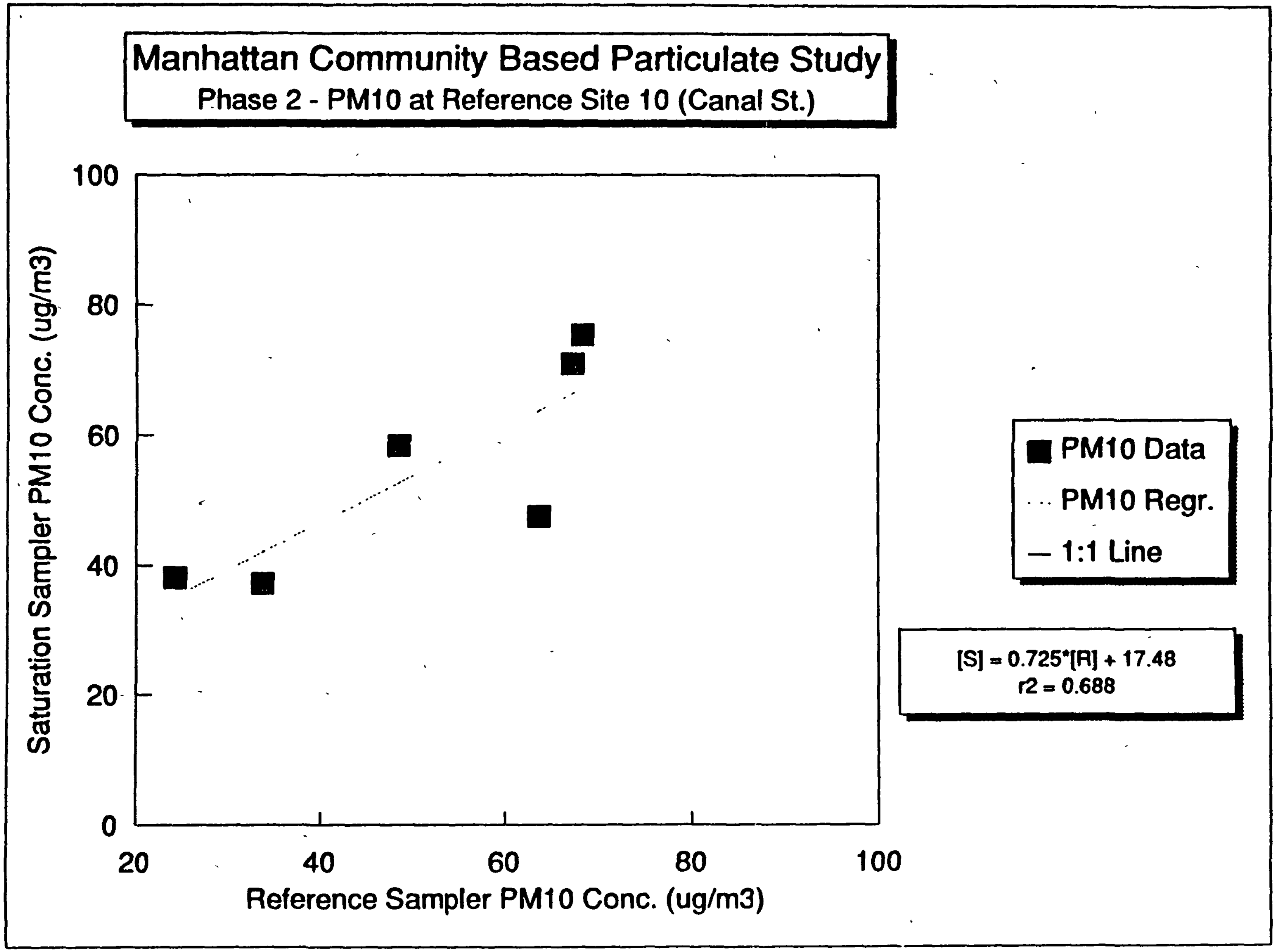


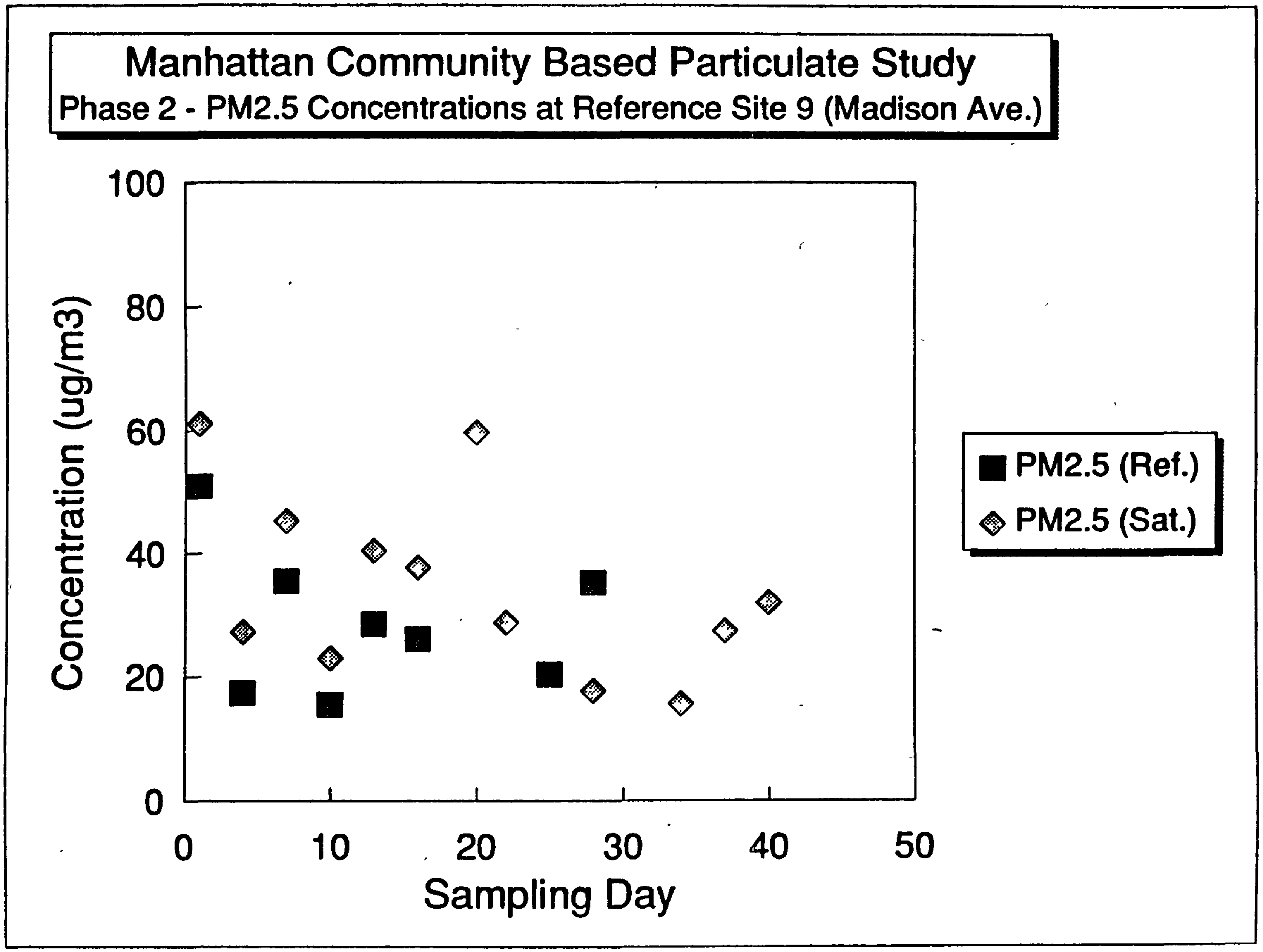
Manhattan Community Based Particulate Study
Phase 2 - PM10 Concentrations at Reference Site 9 (Madison Ave.)
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10 (Ref.)
PM10 (Sat.)

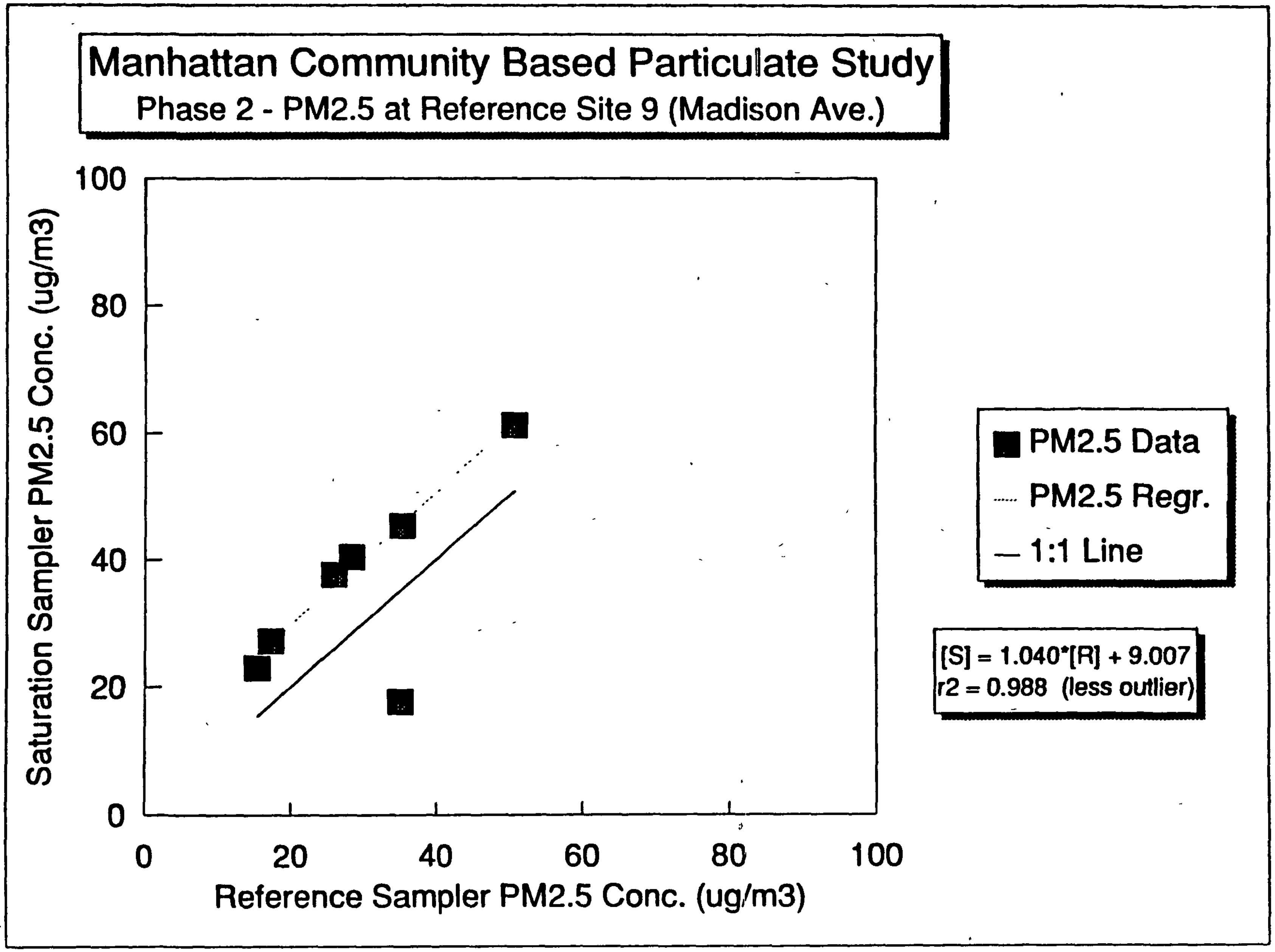


Manhattan Community Based Particulate Study
Phase 2 - PM10 at Reference Site 9 (Madison Ave.)
100
80
60
40
20
0
Saturation Sampler PM10 Conc. (ug/m3)
20
40
60
80
100
Reference Sampler PM10 Conc. (ug/m3)
PM10 Data
PM10 Regr.
1:1 Line
[S] = 0.984*[R] + 6.148
r2 = 0.978 (less outlier)

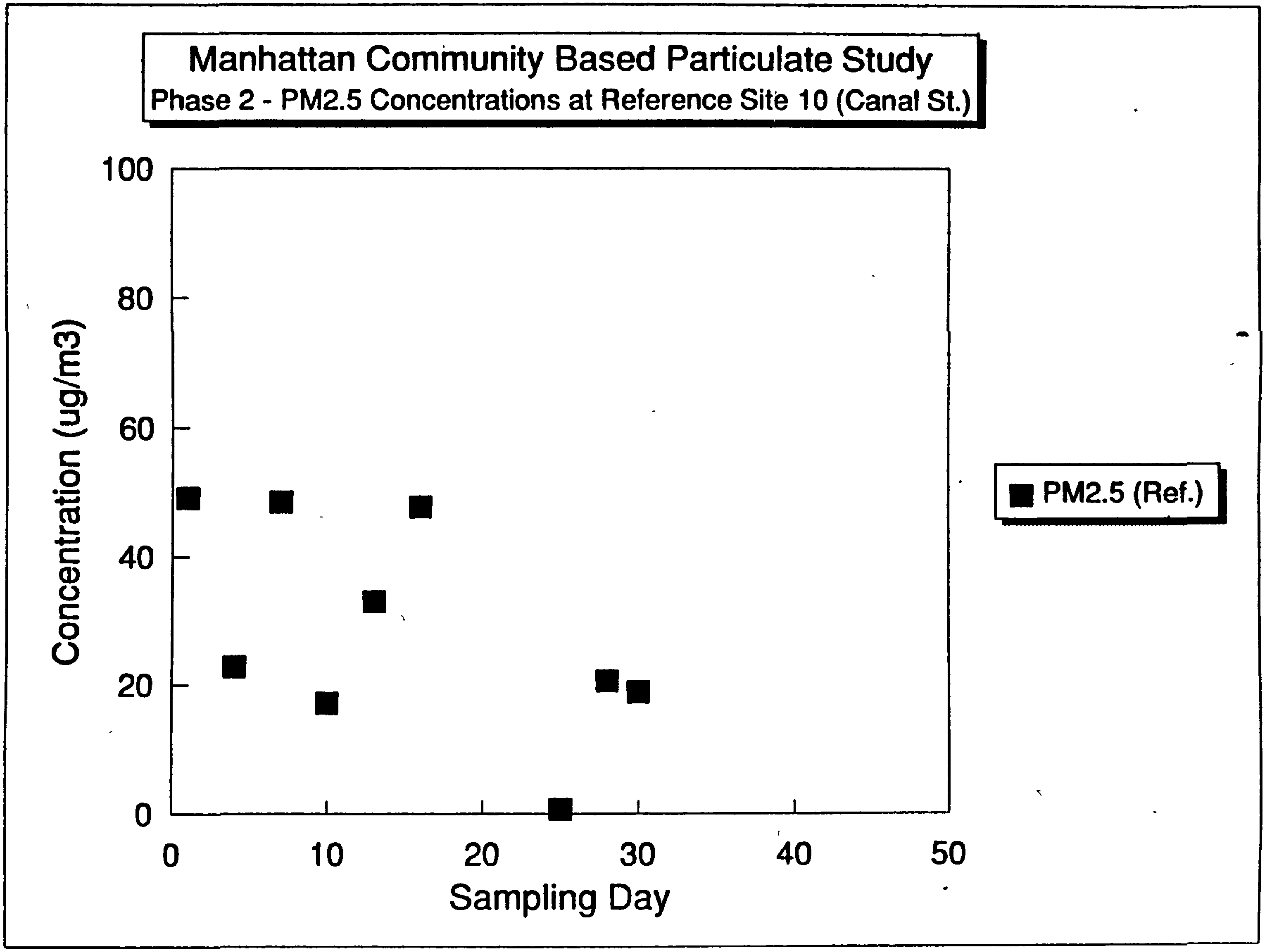

Manhattan Community Based Particulate Study
Phase 2 - PM10 Concentrations at Reference Site 10 (Canal St.)
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM10 (Ref.)
PM10 (Sat.)

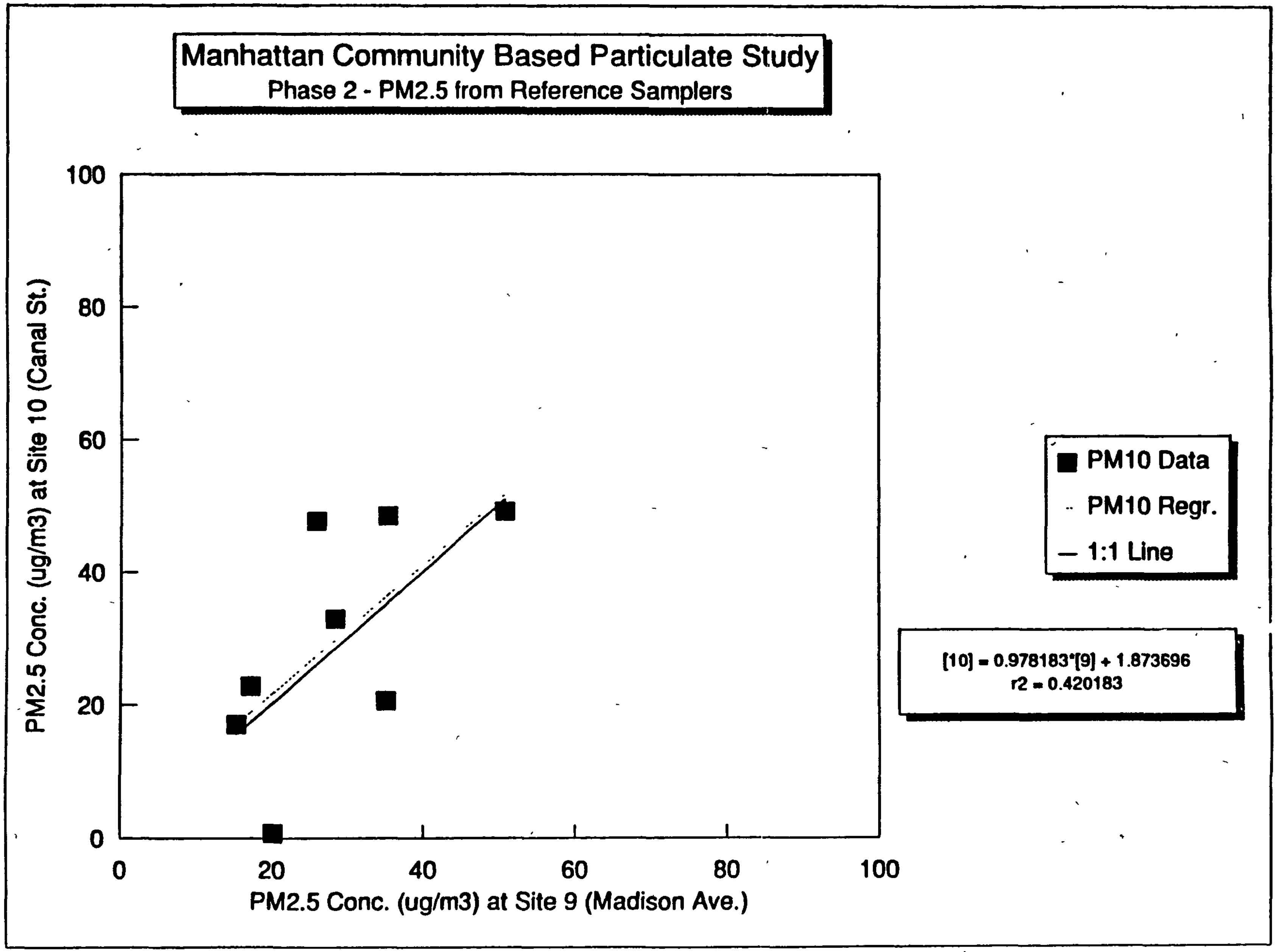

Manhattan Community Based Particulate Study
Phase 2 - PM10 at Reference Site 10 (Canal St.)
Saturation Sampler PM10 Conc. (ug/m3)
100
80
60
40
20
0
20
40
60
80
100
Reference Sampler PM10 Conc. (ug/m3)
PM10 Data
PM10 Regr.
1:1 Line
[S] = 0.725*[R] + 17.48
r2 = 0.688


Manhattan Community Based Particulate Study
Phase 2 - PM2.5 Concentrations at Reference Site 9 (Madison Ave.)
Concentration (ug/m3)
100
80
60
40
20
0
0
10
20
30
40
50
Sampling Day
PM2.5 (Ref.)
PM2.5 (Sat.)



Manhattan Community Based Particulate Study
Phase 2 - PM2.5 at Reference Site 9 (Madison Ave.)
100
80
60
40
20
0
Saturation Sampler PM2.5 Conc. (ug/m3)
0
20
40
60
80
100
Reference Sampler PM2.5 Conc. (ug/m3)
PM2.5 Data
PM2.5 Regr.
1:1 Line
[S] = 1.040*[R] + 9.007
r2 = 0.988 (less outlier)


Manhattan Community Based Particulate Study
Phase 2 - PM2.5 Concentrations at Reference Site 10 (Canal St.)
100
80
60
40
20
0
Concentration (ug/m3)
0
10
20
30
40
50
Sampling Day
PM2.5 (Ref.)


Manhattan Community Based Particulate Study
Phase 2 - PM2.5 from Reference Samplers
PM2.5 Conc. (ug/m3) at Site 10 (Canal St.)
PM2.5 Conc. (ug/m3) at Site 9 (Madison Ave.)
0
20
40
60
80
100
PM10 Data
PM10 Regr.
1:1 Line
[10] = 0.978183*[9] + 1.873696
r2 = 0.420183