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Indoor - Outdoor Carbon Monoxide Pollution Study

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Indoor - Outdoor Carbon Monoxide Pollution Study

by

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ACKNOWLEDGEMENT

An acknowledgement is hereby given to the Environmental Protection Agency, New York Department of Air Resources, Management of the Washbridge Apartments, New York State Housing Authority and the New York Port Authority, without whose cooperation and assistance this study could not have been completed.

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INTRODUCTION

The considerable interest which exists today on the part of architects, urban planners and others in air rights buildings for dwellings, schools and offices, is a natural consequence of the fact that 60 - 70% of the downtown areas of many major American cities consist of paved roadways. The high value of land in such areas makes the concept of buildings, which span these roads, economically attractive. It is clear however, that the impact of traffic generated air pollutants on the air quality within such buildings requires assessment to be sure that the health of the occupants is not endangered. In order to make such an assessment, the Air Pollution Office of the U. S. Environmental Protection Agency contracted with the General Electric Company in May of 1970 to make an intensive study of air quality and traffic relationships inside and outside of two buildings in New York City. One of these buildings was an air rights, high rise, apartment dwelling, known as the Washington Bridge Apartments, which straddles the Trans Manhattan Expressway near the approach to the George Washington Bridge. The second building was chosen to provide a comparison between an air rights building and a more conventional high rise structure located on a canyon - like street in midtown Manhattan. This second structure was a twenty story office building located at 264 West 40th Street, just east of Eighth Avenue

The basic objective of the study was to gather and analyze a large statistical data base of carbon monoxide, hydrocarbons, particulates and lead concentrations inside and outside each building at different levels above the roadways and to relate these concentrations to the wind, temperature and traffic conditions which occurred at each site. The study was designed to obtain sufficient data to determine if a significant difference in the relationships between pollutant levels and environmental parameters was observable between the two sites. It also was structured to explore whether or not these pollutant/environmental relationships changed as a function of building heating and non-heating seasons.

Fulfillment of these requirements necessitated continuous and simultaneous monitoring of the pollutants, meteorological variables and traffic flow rate and velocity for approximately five months at each site. The monitoring period at each site was selected to provide data on the pollutant levels during both the heating and non-heating seasons. It was necessary for the General Electric Company to establish an air pollution laboratory within each test building to perform this continuous 24 hour a day seven days a week monitoring. The laboratory was equipped with the necessary instrumentation to measure and record data from sensing devices positioned at carefully selected locations in and about the building.

Carbon monoxide concentrations were measured with non-dispersive, infra-red instruments distributed by Intertech Corporation. Hydrocarbon measurements were made with Beckman, Inc., flame ionization detectors. Wind speed, wind azimuth and elevation and sigma azimuth and elevation were measured with MRI vector vanes. Traffic speed and volume were measured with General Signal Company, ultrasonic sensors mounted above each lane of the roadways. Particulate measurements were made with high volume and tape samplers. Lead concentrations were determined from the high volume samples by atomic absorption.

It will be realized that the enormous quantity of data implied by the above brief description could not be managed by manual methods in any reasonable time period. For this reason, the problem of converting the continuously gathered analog sensor data into hourly averages was handled by a small hybrid computer (i.e., part analog and part digital) which had been designed and developed at GE prior to this contract and which was constructed and used under the contract. This device, known as the Mean Data Calculator, accepted over 40 channels of continuously input analog data, calculated hourly averages for each such channel, converted the hourly averages to ASCII digital form and provided these digital outputs on punched paper tape while simultaneously printing the hourly averages on an ASR 33 teletypewriter. The teletype was connected by phone line to an identical teletype and tape punch in the APO in Cincinnati. The 24 hourly averages for each sensor were transmitted by this telemetry link to Cincinnati once each day. The paper tapes were used to enter the hourly averages into the GE 605-635 batch process computer system in Philadelphia for further processing.

The General Electric Company would like to acknowledge the assistance of the New York City Department of Air Resources, and the New York City Department of Transportation Administration in arranging site access and permits, and the assistance of the New York Port Authority in mounting the traffic sensors at the George Washington Bridge Site.

The work was performed under Contract CPA 70-77 entitled "Indoor-Outdoor CO Study." This document is the final report describing the study and its results.

1.1 Conclusions

Concentration levels of the four pollutants studied, i.e., carbon monoxide, hydrocarbon, total particulates and lead and the outdoor/indoor relationships of these pollutants are influenced by four factors. These are:

1. Traffic conditions
2. Non-traffic related sources
3. Meteorological conditions
4. Site Configuration

Both the traffic and non-traffic related sources in combination with the meteorological variations determine the hourly and average levels of each of the four pollutants.

1.1.1 Pollutant Sources

Carbon monoxide concentrations at both sites are clearly traffic generated. At the air rights structure, the Trans Manhattan Expressway is the prime CO source. CO increases with increasing traffic flow rate and decreases with increasing traffic velocity. At the canyon site, CO levels are determined jointly by 40th Street traffic and traffic on adjacent streets whose rush hour peaks occur at different times than the 40th Street peaks.

Hydrocarbon concentrations at the air rights structure are the result of Trans Manhattan Expressway traffic and cooking facilities in the apartments. The effect of these cooking facilities on internal hydrocarbon levels, especially when used by tenants on the 32nd floor for heating purposes, was verified by experimenters on site during the study. At the 40th Street site, paint spraying activities on the third floor which normally occurred during the early evening hours, effectively masked the contribution of traffic to the daily average hydrocarbon level. However, variations in hydrocarbons at the 3rd floor outdoor location of this site between 5 and 6 PM from day to day show a similar correlation with CO as seen at the air rights structure. Thus area traffic contributes to, but does not primarily establish, the hydrocarbon level at the canyon site.

The major particulate source at the air rights site is the building chimney. This source overshadows the traffic generated particulates. Similarly, no particulate/traffic relationship is discernible at the 40th Street site. It is apparent, however, that the source at this site is external to and south and west of the canyon structure.

Lead concentrations at the air rights structure originate outside the base of the building. Daily variations at outdoor locations strongly indicate that Trans Manhattan Expressway traffic is the major lead source at that site. At the 40th Street site, the paint spraying activities control lead concentration.

1.1.2 Meteorological Conditions

Concentrations of each pollutant at a given building location vary directly as a function of the wind angle between the source of the pollutant and the location involved. Traffic generated CO is transported from the roadway to the low levels of the buildings by road level winds. Outdoor CO rising from the base of the building is dispersed by roof winds which blow parallel or perpendicular to the building face under study study. However, these outdoor CO concentrations are not dissipated when roof winds blow from behind the building.

Non-traffic related pollutants, such as particulates, are primarily influenced by roof level winds. As these pollutants settle downwards, they combine with traffic generated particulates. Road winds then distribute the particulates from both sources. Apparent seasonal changes in particulate levels at all locations are the result of changes in wind direction and not related to temperature.

Wind direction, speed and turbulence influence outdoor concentrations. Wind direction is the most significant meteorological variable. Indoor concentrations are affected by the meteorological variations primarily through the change in outdoor concentrations.

Outdoor hydrocarbon concentrations increase with increases in outdoor temperature levels both on an average temperature basis and a diurnal cycle. It is possible that differential hydrocarbon concentrations are influenced by outdoor/indoor temperature differentials.

Building ventilation, while not a true meteorological parameter, definitely influences indoor concentrations. This is particularly noticed at the 40th Street site where indoor concentrations generally are higher for all pollutants during the non-heating season. Open windows decrease the time lag between outdoor and indoor concentrations at a given floor and prevent the entrapment of pollutants within the building. This suggests that the inversion in CO levels seen between the 23rd and 32nd floors of the air rights structure is partially due to the increased ventilation within the 23rd floor room by the room air conditioner used at that location

1.1.3 Site Configuration

Pollutant levels are affected by site configuration in several ways.

1. The vertical profile of wind from roof to ground level was different at each of the two sites. At the air right structure, road level winds were often coaxial with roof level winds but frequently oppositely directed. This suggests that a vortex is sometimes present. At the canyon structure road winds were generally were limited to westerly and southerly directions regardless of roof level direction.
2. At the air rights structure the relative levels of carbon monoxide between the median strip of the Trans Manhattan Expressway and the 3rd floor level of the building for any given hour are random. Their relationships are determined by the traffic flor rate in the eastbound and westbound lanes and the relative road level wind direction between the roadway lanes and the CO measurement point. The outdoor CO level, at a constant vertical distance above the roadway, therefore will vary from the 178th Street side to the 179th Street side as a function of both road wind angle and magnitude of traffic in the two sets of lanes. As a result

average CO concentrations at any point at the 3rd floor building elevation are significantly lower than median strip average concentrations.

At the canyon site, the relative levels of CO between road concentrations and those at the 3rd floor location for any given hour are linear regardless of wind direction. The predominantly westerly road winds carry traffic generated pollutants along the canyon, effectively eliminating any reduction in concentrations parallel to the road. As a result average 3rd floor CO concentrations are only slightly lower than road level concentrations.

3. Pollutants generated at road level diffuse as a function of vertical distance. Both sites display typical exponential reductions in CO concentrations from the bottom to top floors at the outdoor locations. Indoor concentrations also decrease with height; however, these indoor CO levels reduce more slowly than outdoor concentrations. Pollutants which enter the buildings at low elevations become entrapped within the buildings. They disperse upwards and outwards, when outdoor concentrations are lower than indoor concentrations. The pollutants rising internally increase at upper floors when the upward diffusion path is blocked
4. The configuration of the roadway involved influences the pollutant level transported to the outside of the buildings adjacent to the roadway. Traffic generated pollutants on the Trans Manhattan Expressway are entrapped within the intermittent span beneath the air rights buildings. This causes higher road level CO concentrations at the ends of the span than midway between the two covered

sections. Therefore, air rights structures may be exposed to higher CO concentrations than buildings at equal distances from open highways.

1.1.4 Summation

Seasonal variations of all pollutant levels do occur at given locations of the buildings studied. These variations primarily are the result of seasonal changes in prevailing wind direction and associated changes in site temperature. However, since the pollutant levels were monitored only on one side of each building, the average concentration levels for the pollutant identified herein are significant only to the locations monitored and to the particular months of monitoring at each site. Concentration differences attributed to "heating" and "non-heating" seasons will differ at other locations on a given floor of a building or adjacent buildings as a function of the location of the particular pollutant source and the relative wind angle. Building locations which are located 180° apart from the particular pollutant source at each site will vary in opposite directions as the prevailing wind changes. Further seasonal differences may occur if the prevailing winds at the sites are significantly different for the four calendar seasons.

With the above in mind, the following conclusions are drawn relative to the pollutants examined during this study.

Carbon Monoxide

Carbon monoxide concentrations at all outdoor and indoor locations result from automotive emissions on roadways in the site vicinity.

On-roadway concentration levels increase linearly with increase in traffic flow rate and decrease with traffic velocity.

CO concentration gradients across a roadway vary as a function of traffic conditions in all lanes of the road and the wind conditions close to the road.

CO concentration gradients from a roadway to a building vary as a function of the horizontal distance and the road level wind direction between the high volume traffic lanes and the building vary. Winds from the high volume lanes to the building increase concentrations at the building.

Average concentrations at the base of the building reflect on-roadway average concentrations but are lower in proportion to the horizontal and vertical distances from road level. These distances create finite response time lags at the building to changes in traffic conditions, which vary as a function of road level wind speed, direction and turbulence.

There is an appreciable reduction in both peak and average carbon monoxide levels between "on-roadway" locations and adjacent buildings at the air rights site but not at the canyon site. As a result there is no significant difference in CO levels along the outside walls and inside the two structures.

Concentrations indoors at the building base vary with outdoor concentrations. Indoor concentrations lag changes in outdoor CO levels. It is suspected that this time delay is a variable that is a function of both wind conditions as seen at the building and the direction of change in outdoor concentrations.

Average concentrations inside and outside the buildings reduce exponentially with height above ground level. The rate of change with height is essentially constant outdoors for both heating and non-heating seasons. However, indoors the decay in average concentrations with height is greater during the non-heating season than during the heating season. This variation is the result of changes in the roof wind angle from the non-heating to the heating season.

Indoor concentrations normally are lower than outdoor concentrations at all heights above the roadway when outdoor concentrations are high. Conversely, indoor concentrations are higher than outdoor concentrations when outdoor concentrations are low.

Hydrocarbons

Hydrocarbon concentrations result from automotive emissions on roadways adjacent to the two sites and non-traffic related emissions internal to the buildings.

Internal hydrocarbon emissions at the 40th Street site obscure traffic generated hydrocarbons at all building elevations. However, at the Washington Bridge Apartments air rights site, Trans Manhattan generated hydrocarbons influence concentrations at building locations close to the roadway. These traffic generated concentrations at both sites decrease with height until overshadowed by internal emissions.

Diurnal changes in site temperature produce diurnal changes in hydrocarbons at outdoor locations. Since diurnal temperature is out of phase with diurnal traffic, hydrocarbon/traffic correlations are distorted by temperature much of the day.

Concentrations at both sites generally are higher indoors than outdoors. Differential concentrations at all heights above the base of the buildings vary as a function of indoor concentrations.

Seasonal increases in site temperature appreciably increase the outdoor hydrocarbon levels close to road level. Since daily average temperature change as a function of calendar season, these hydrocarbon/traffic correlations change with calendar time.

Differential concentrations at the Trans Manhattan site are influenced by site temperature. Since indoor temperatures were not monitored, it is not definite whether the temperature effect is outdoor temperature or differential temperature between inside and outside locations.

1.2 Suggested Guidelines for Urban Planners

The data obtained in this study indicates that the pollutant level internal to buildings is greatly influenced by traffic and the height above the traffic and by "stack effects" internal to the buildings. Accordingly, the following guidelines are suggested:

1. Special attention be observed to seal the lower floors of new guildings to exclude traffic generated CO. The specific number of floors to be sealed should be determined from forecast data on traffic volume on predominant adjacent highways.
2. Where possible, major entrances into buildings should be located such that prevailing road winds blow parallel to them. Building sides which face major urban roadways should be as tight as possible.
3. Air rights structures should be designed to provide ample spacing between buildings to permit dilution. This spacing should be based upon forecast data on traffic volume and speed, and the length of covering over the highway.
4. Consideration should be given, when long sections of a high traffic volume expressway are covered, to force ventilation systems which exhaust pollutants from the "tunnels" beneath air rights structures

at heights above their roof levels.

5. Convection paths internal to buildings should be minimized. Elevator shafts could be under a slight positive pressure from an air source drawn from the outside of the building approximately 1/2 the height of the building. (This assumes that 1/2 the height is higher than the level indicated in guideline 1)
6. Elevator control rooms at roof level should be force ventilated to the roof to reduce the entrapment of pollutants in tall buildings.
7. Internal pollutant sources, such as parking garages within the building, etc., be force ventilated outside the building, parallel to and over the center of the highway over which the building is constructed. The pressure at the exhaust point should be inversely proportioned to the horizontal distance from the nearest receptor.

1.3 Recommendations for Future Research

1. Segregations of the collected data on a heating vs. non-heating season basis produced two statistical perturbations which should be avoided in the future. These are:
   a. The relative sample sizes are significantly different. Non-heating seasonal hourly averages are biased considerably more by random data than are heating season averages.
   b. The change of time from Daylight Savings to Standard time, and vice versa, distorts heating season diurnal data for meteorological factors such as wind speed and temperature. Peak and valley hourly averages are inadvertently smoothed by the one hour shift.

   Future studies of "seasonal" effects should be divided at the time of changing from Standard to Daylight time.

2. Segregation of the data on the basis of weekdays and weekends produced distortions in diurnal profiles for traffic and traffic related pollutants for both periods. Traffic patterns vary on holidays which occur on Monday thru Fridays. Saturday and Sunday traffic profiles are different. While this doesn't affect the pollutant/traffic relationships significantly, it distorts the relationships of meteorological and traffic related data. Similarly variations in internal pollutant sources which are related to building usage are lost by the segregation process used.

   Different groupings of days in future studies, might strengthen correlation of the many variables influencing pollutant levels.

3. The absence of temperature data at all indoor locations and intermediate locations outdoors precluded any evaluation of the effect of differential temperature on outdoor/indoor pollutant relationships. Future studies of outdoor/indoor pollutants should include this temperature data.

SECTION 2.0

SUMMARY

This section summarizes the study of the Indoor-Outdoor Carbon Monoxide Pollution Relationships associated with two high rise structures within New York City. Section 2.1 provides a brief description of the test program conducted at the two sites. A brief description of each of the sites is presented in Section 2.2. Highlights of the study results for both sites are given in Section 2.3; Sections 2.4 and 2.5 expand these highlights for the two sites.

2.1 Brief Test Program Description

Data necessary to determine the impact of traffic generated pollution on typical multi-storied buildings was gathered for approximately five months at each site. The site locations and data collection periods are tabulated below.

Site	Location	Data Collection Period
1	Washington Bridge Apts. Trans Manhattan Expressway	Sept. 9, 1970 - Jan 14, 1971
2	264 West 40th Street	Feb. 11, 1971 - June 20, 1971

Each of the two sites was instrumented to measure the concentration levels of four pollutants, i.e., carbon monoxide, hydrocarbons, particulates and lead at selected locations. The pollutant levels were measured both inside and outside the buildings under study and at different elevations above the adjacent roadways. Traffic volume and velocity and meteorological parameters, such as wind velocity and direction and prevailing temperatures, were recorded as necessary inputs to the analysis. Section 3.0 provides a detailed description of the instrumentation used at each site.

Continuous readings were taken of the carbon monoxide and hydrocarbon levels and of the traffic and meteorological parameters. These data were averaged to obtain a single value for each hour of the day. Each days worth of data was categorized into "heating" and "non-heating" seasons. This was done by determining the days when the average daily road level temperature was below or above 65°F. Both "heating" and "non-heating" seasons were further subdivided into "weekdays" and "weekends." Averages were taken, on a diurnal basis, for the resultant four data groupings. The 24 hourly averages were then averaged to obtain a total value for the variables for each of the four data groups. The processed data for these variables is included in two Appendices, one for each site.

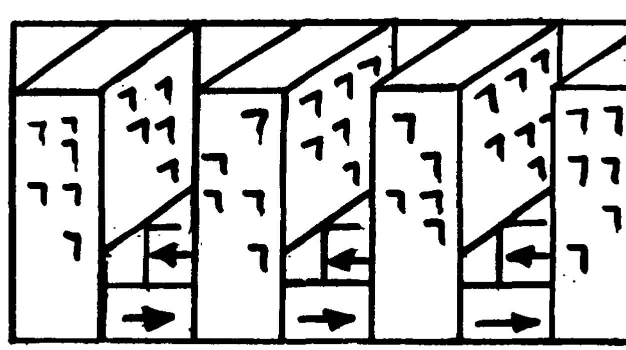
Particulate and lead samples were taken for continuous 24 hour periods at random times throughout the monitoring period at each site. This "daily" data is presented in tabular form in Sections 5.1 and 5.2 of this report.

Three analytical approaches were used to examine the seasonal impact on pollutant levels. These are: the daily average levels for the heating versus non-heating season, the level recorded from day to day for the 24 hour period used to collect particulate samples, and the levels recorded from day to day for the peak traffic hour of 5-6 pm. The techniques involved in the latter two approaches are described in further detail in Section 5.0.

2.2 Brief Site Description

2.2.1 Site 1 - Washington Bridge Apartments

2.2.1.1 Configuration



The Washington Bridge Apartments site consists of a series of air rights, high rise, apartment buildings which straddle the Trans Manhattan Expressway. Two of these buildings, between St. Nicholas and Wadsworth Aves., look down upon the highway.

The 12 lane highway is some 35 feet below street level with poured concrete walls along it sides, and carries a constant flow of traffic on its way to and from the George Washington Bridge. The configuration simulates a series of tunnels or intermittent spans with the open section between the two air rights structures. The 32 story aluminum clad building on the east edge of the exposed highway was the high rise apartment evaluated.

2.2.1.2 Meteorological Conditions

Data monitoring at Site 1 was started late in the summer and continued for a five month period to the middle of January. All "non-heating" days occurred prior to October 16. Some early October and all days after October 15 make up the "heating" season. Thus the majority of data on pollutants collected at the air rights structure is for the heating season. Detail meteorological data was not obtained during the first month of monitoring, so some "non-heating" season description is not available. However, as shown in the following table, the "non-heating" season generally was milder than the "heating" season.

Roof Level				Road Level			
Wind Speed (mph)	Prevailing Wind Direction In Degrees	Wind Turb. (Sig. Elev.) / (Sig. Azi.)	Temp. °F	Wind Speed (mph)	Prevailing Wind Direction In Degrees	Wind Turb. (Sig. Elev.) / (Sig. Azi.)	Temp °F
Heating Season							
9.33	325°	11.3° / 25.1°	39.2	5.74	215°	11.2° / 21.2°	41.6°
Non-Heating Season							
4.69	190°	10.7° / 29.4°	63.1	3.82	130°	9.1° / 17.2°	65.5

Wind direction, and other associated meteorological variables, are influenced by calendar seasons and the configuration of the air rights structure and the adjacent buildings. Since data was collected at this site during the

2nd half of the year, the general weather changed from summer to winter conditions. Wind direction, as measured at the building roof level shifted from the south to the west and north. Site temperatures showed a gradual decline from moderate to below freezing conditions. These trends are shown on Figure 2.2-1 which shows the daily average data for these two meteorological parameters for the 24 hour periods in which particulate samples were collected. In general, more turbulent roof winds occurred when the roof wind blew from the northwest and northeast.

At road level, wind speed and turbulence generally reflected those factors as recorded at the roof level. Road level wind direction followed roof level direction the majority of time but frequently blew 180^{o} from roof winds. No data was taken to define the height above ground level at which this roof to road direction shifted.

The roof to road temperature difference, or temperature lapse, was basically determined by the roof level wind angle. High temperature lapses were recorded, as seen on the northwest side of the building, when the roof wind blew from behind the building from the southeast. Temperature lapse decreased as the wind shifted to blow towards the building face under study.

The meteorological conditions at the Washington Bridge Apartments are discussed in more detail in Section 5.1.1.3 of this report. As shown therein, the general dependency of wind speed, wind turbulence, temperature and temperature lapse on roof wind direction complicates the identification of the effect of these meteorological variables on pollutants. It is felt that since these latter variables are basically controlled by wind direction, wind direction is the major meteorological variable.

2.2.1.3 Traffic Conditions

The 12 lane Trans Manhattan Expressway displayed typical traffic characteristics for a two-way urban roadway. Weekdays showed a daily

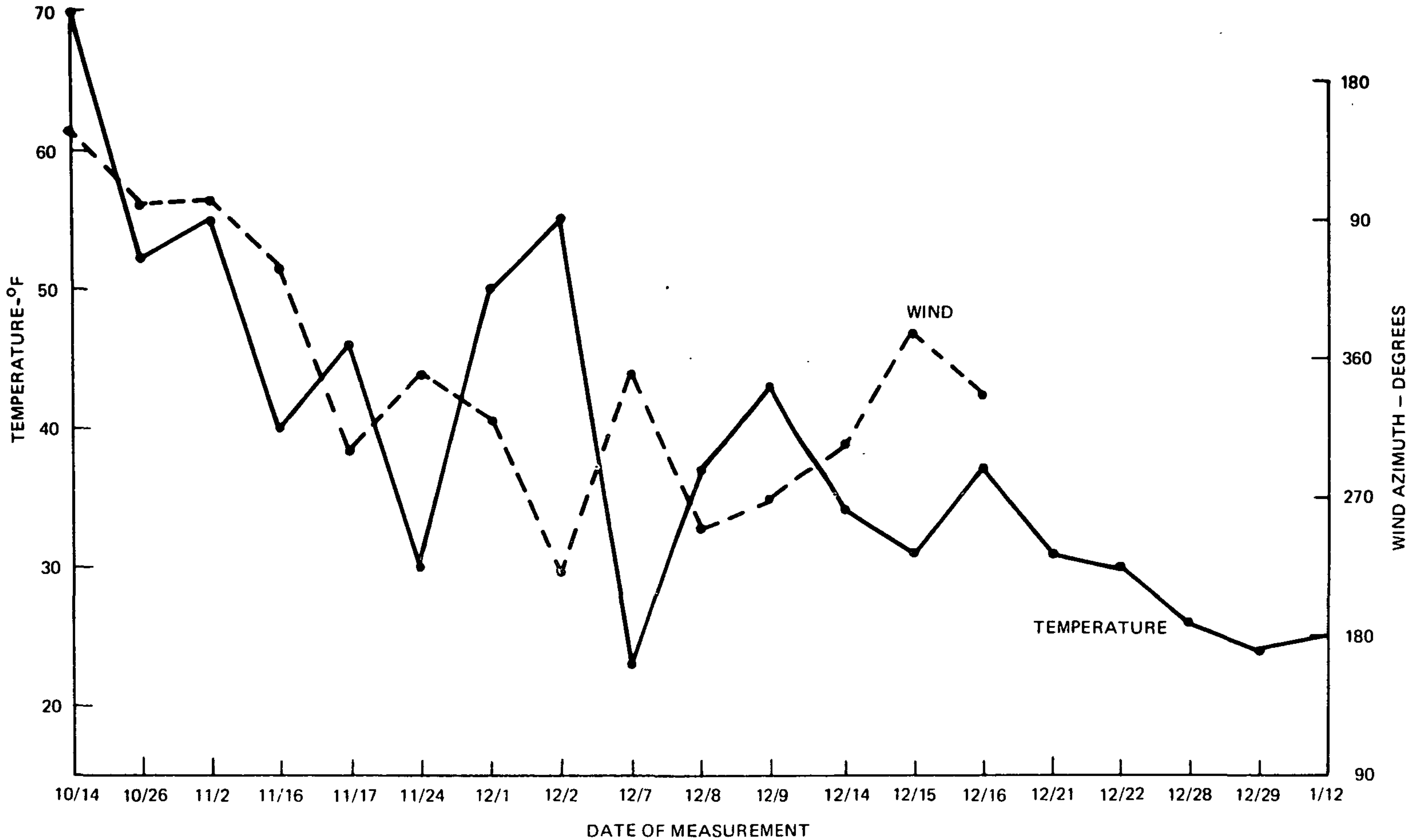


Figure 2.2-1. Temperature and Wind Direction - Road Level - Site 1

minimum traffic flow rate during the early morning hours and dual peaks reflecting the morning and evening rush hours as shown on Figure 2.2-2. Weekends were marked with the early morning low and a single peak traffic flow rate about 5 pm, see Figure 2.2-3. Average weekday traffic, as shown in the following table, was slightly higher during the non-heating season.

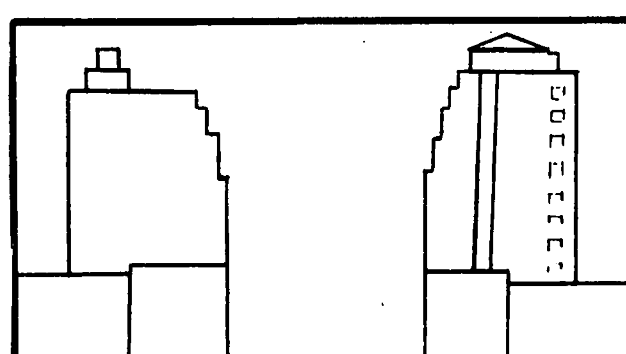
Avg. Traffic Volume (24 Hr. Avg.)	Peak Traffic For 1 Hr. (Veh/Hr.	Hour of Highest Flow Rate	Flow Rate	Avg. Traffic Vehicle Velocity (mph)
Heating Season				
6669	14198	5-6 pm	11990	46.2
Non-Heating Season				
6884	14328	5-6 pm	12510	47.1

Traffic velocity on the expressway is inversely related to the existing traffic flow rate. Velocity is higher for periods of low traffic volume and lower for high volume conditions. Slightly higher velocities were recorded during peak traffic conditions during the non-heating season than for comparable heating season traffic peaks, as shown on Figure 2.2-4.

2.2.2 Site 2 - West 40th Street

2.2.2.1 Configuration

The 40th Street site consists of two older type brick buildings on opposite sides of West 40th Street, just east of Eighth Ave. Smaller structures were located on either side of the facing buildings. The three lane road-



way between the buildings handles one way east bound traffic. Normally, curb side parking restricted traffic to a single lane. The 20 floor building

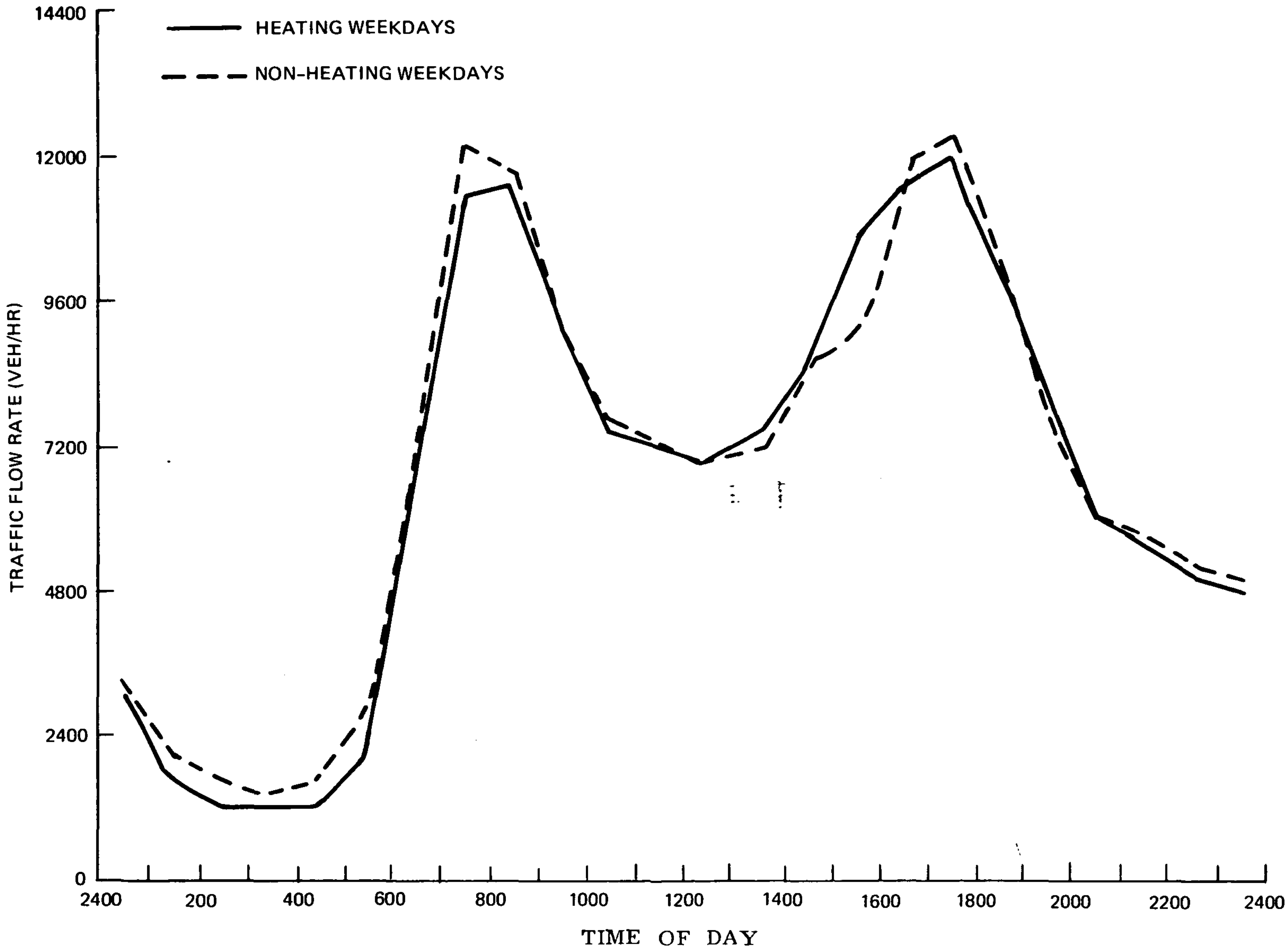


Figure 2.2-2. Weekday Traffic Flow Rate On Trans Manhattan Expressway

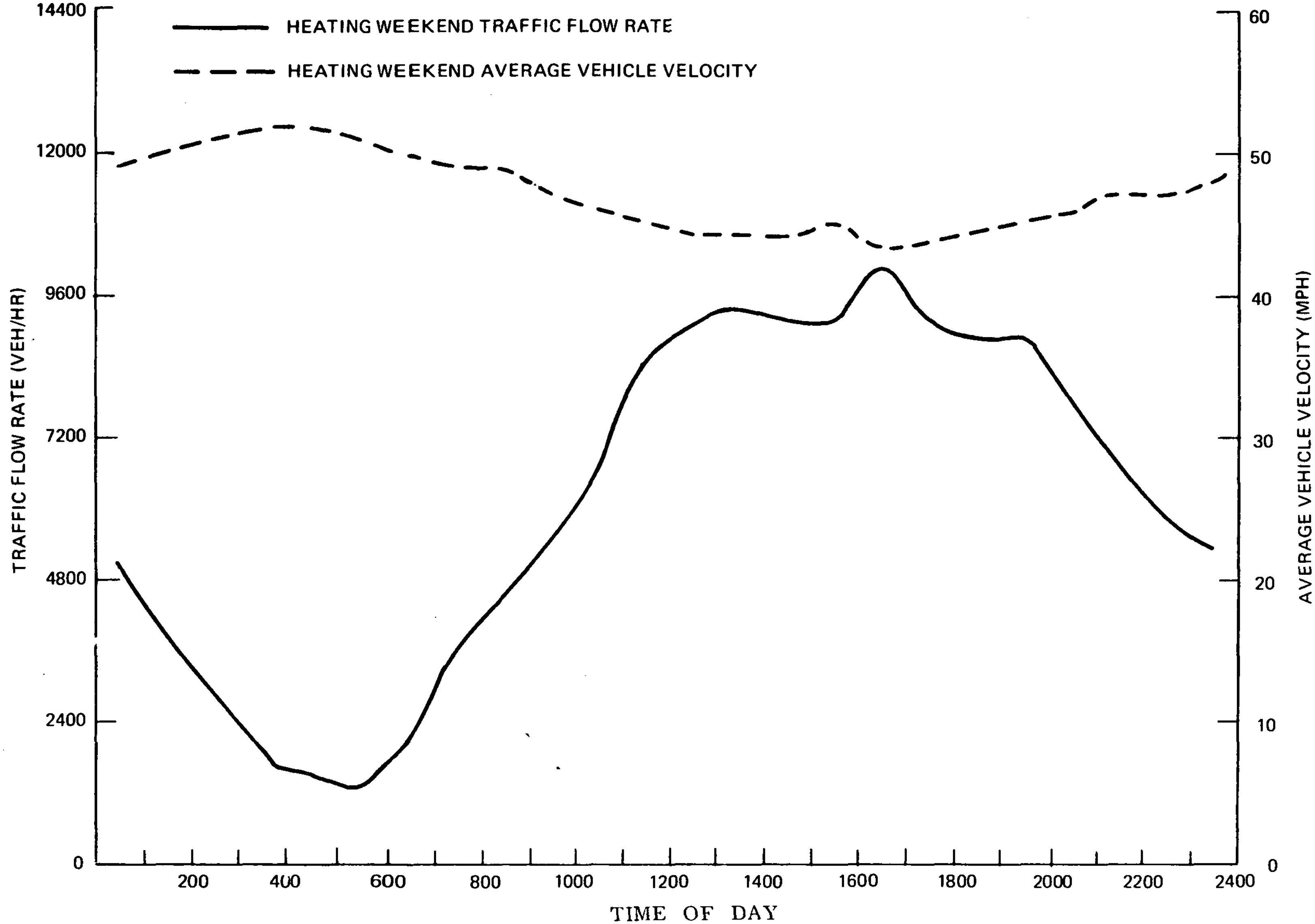


Figure 2.2-3. Weekend Traffic Characteristics On Trans Manhattan Expressway

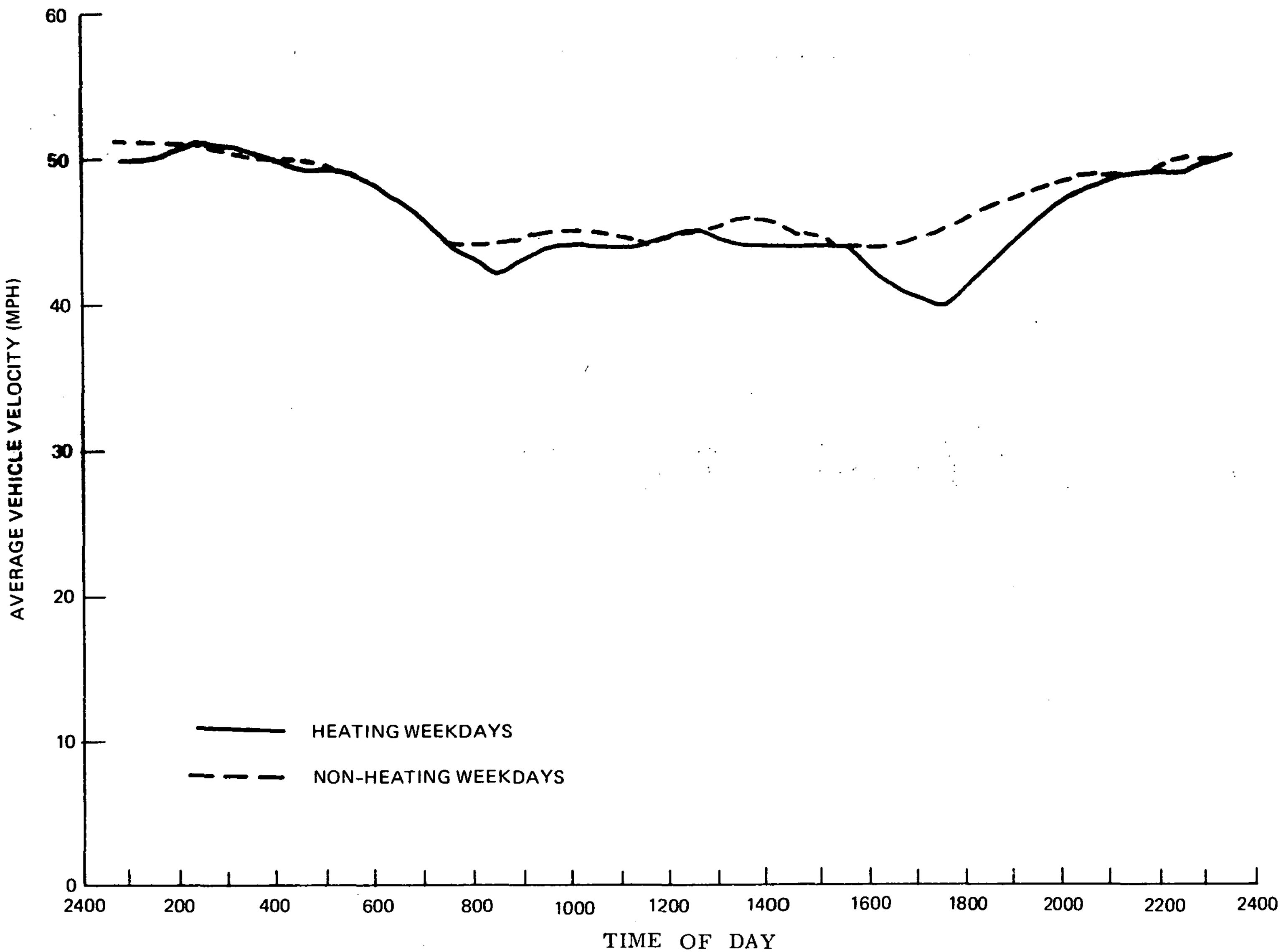


Figure 2.2-4. Weekday Traffic Velocity On Trans Manhattan Expressway

on the south side of 40th Street was the test building.

2.2.2.2 Meteorological Conditions

The data monitoring period at site 2 started in mid-winter and ended in early June. All "non-heating" days occurred after May 10. The "heating" season comprised all days prior to then plus several other May and June days. Again the heating season data on pollutants exceeds the non-heating season data.

Since the five month period of data collection at the canyon structure involved the spring season, daily temperatures at the site displayed a general increase from winter to summer, as shown in the following tabulation.

Roof				Roadway			
Wind Speed (mph)	Prevailing Wind Direction In Degrees	Wind Turb. (Sig. Elev.) / (Sig. Azi.)	Temp. °F	Wind Speed (mph)	Prevailing Wind Direction In Degrees	Wind Turb. (Sig. Elev.) / (Sig. Azi.)	Temp. °F
Heating Season							
5.24	255°	10.2° / 18.1°	47.2	4.09	285°	8.4° / 13.4°	50.1
Non-Heating Season							
3.84	200°	8.7° / 12.8°	72.0	2.55	135°* 285°*	7.2° / 8.9°	73.6

* Wind direction followed bimodal frequency distribution.

Prevailing winds at the roof level of the test building showed a shift from westerly to southerly quadrants as monitoring progressed.

Road wind direction generally followed roof winds from the west and south showing the same seasonal effect, see Figure 2.2-5. However, easterly roof winds were translated to westerly road winds resulting in predominantly westerly road winds

Wind speed decreased at both roof and road levels as the roof wind shifted from the west to east. This generally followed the seasonal weather moderation.

Temperature lapse at this site decreased as the general site temperature increased. This change appears independent of roof wind angle.

The meteorological conditions at the 40th Street site are discussed in more detail in Section 5.2.1.3 of this report. Roof wind again is the dominant meteorological factor, especially since road wind basically flows west to east in the same direction as West 40th Street

2.2.2.3 Traffic Conditions

The traffic pattern on West 40th Street was essentially alike on weekdays and weekends for both the heating and non-heating seasons, as shown on Figures 2.2-6 thru -9. Minimum traffic conditions occurred in the early morning hours. The traffic flow rate increased during the AM rush hour to reach a peak level about midday. The weekday peak is significantly higher than the weekend peak and occurs earlier in the day. Weekday traffic was slightly greater during the non-heating season than in the heating season as shown below

Avg. Traffic Volume (24 Hr. Avg.)	Peak Traffic For 1 Hr. (Veh/Hr.)	Hour of Highest Flow Rate	Flow Rate	Avg. Traffic Velocity (mph.)
Heating Season				
357	888	10-11 am	582	15.0
Non-Heating Season				
369	894	10-11 am	638	15.5

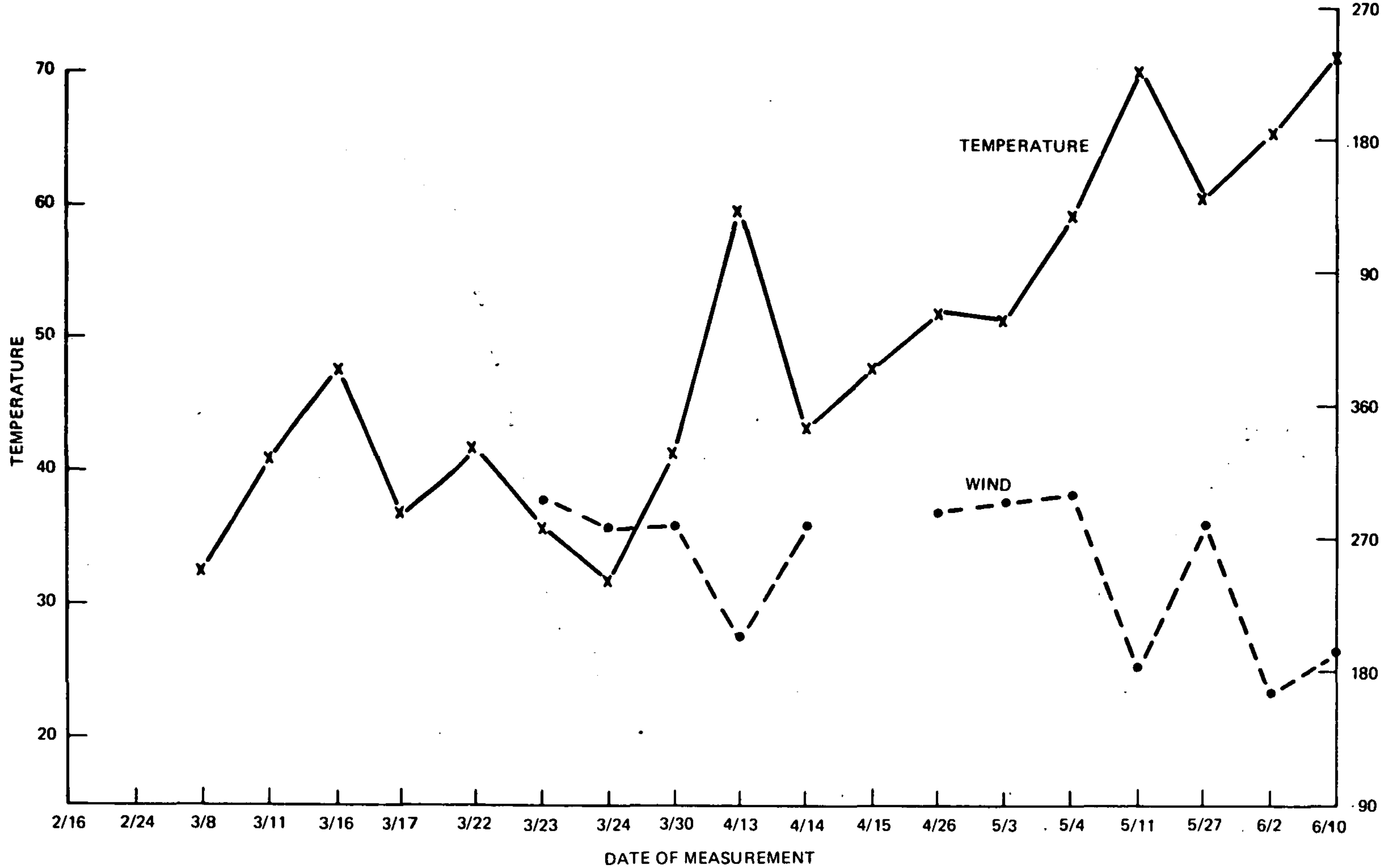


Figure 2.2-5. Temperature & Wind Direction - Road Level - Site 2

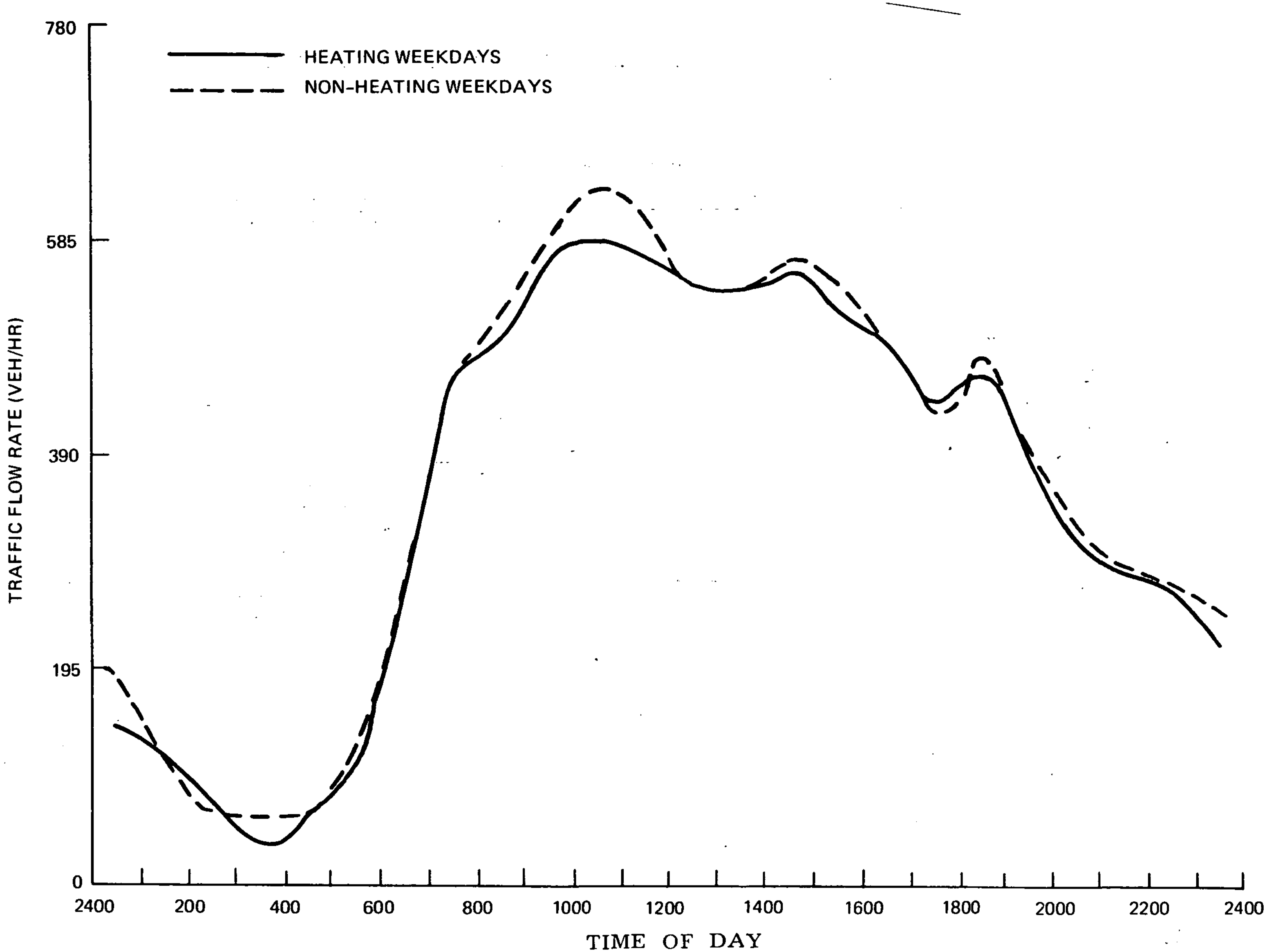


Figure 2.2-6. Weekday Traffic Flow Rate On West 40th Street

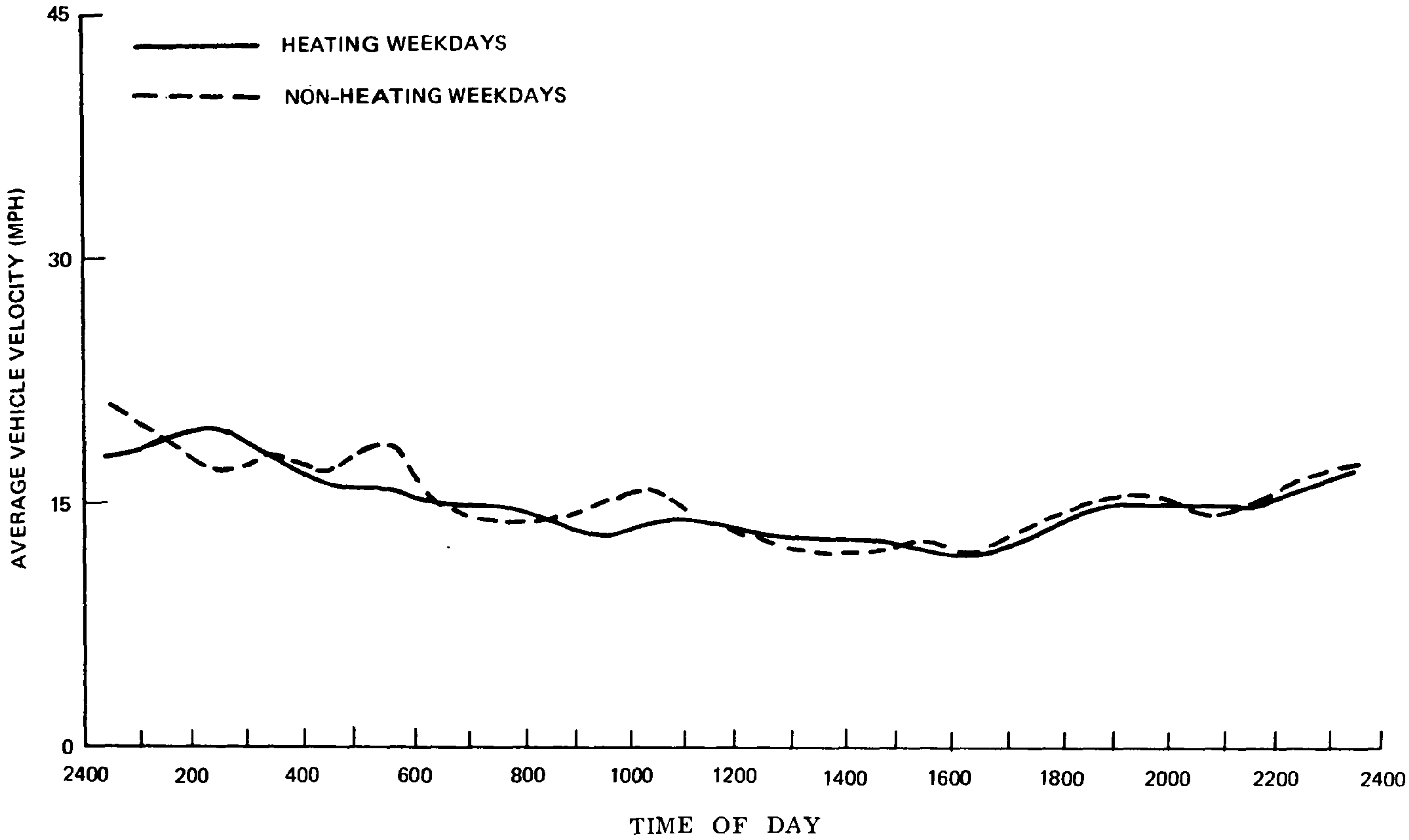


Figure 2.2-7. Weekday Traffic Velocity On West 40th Street

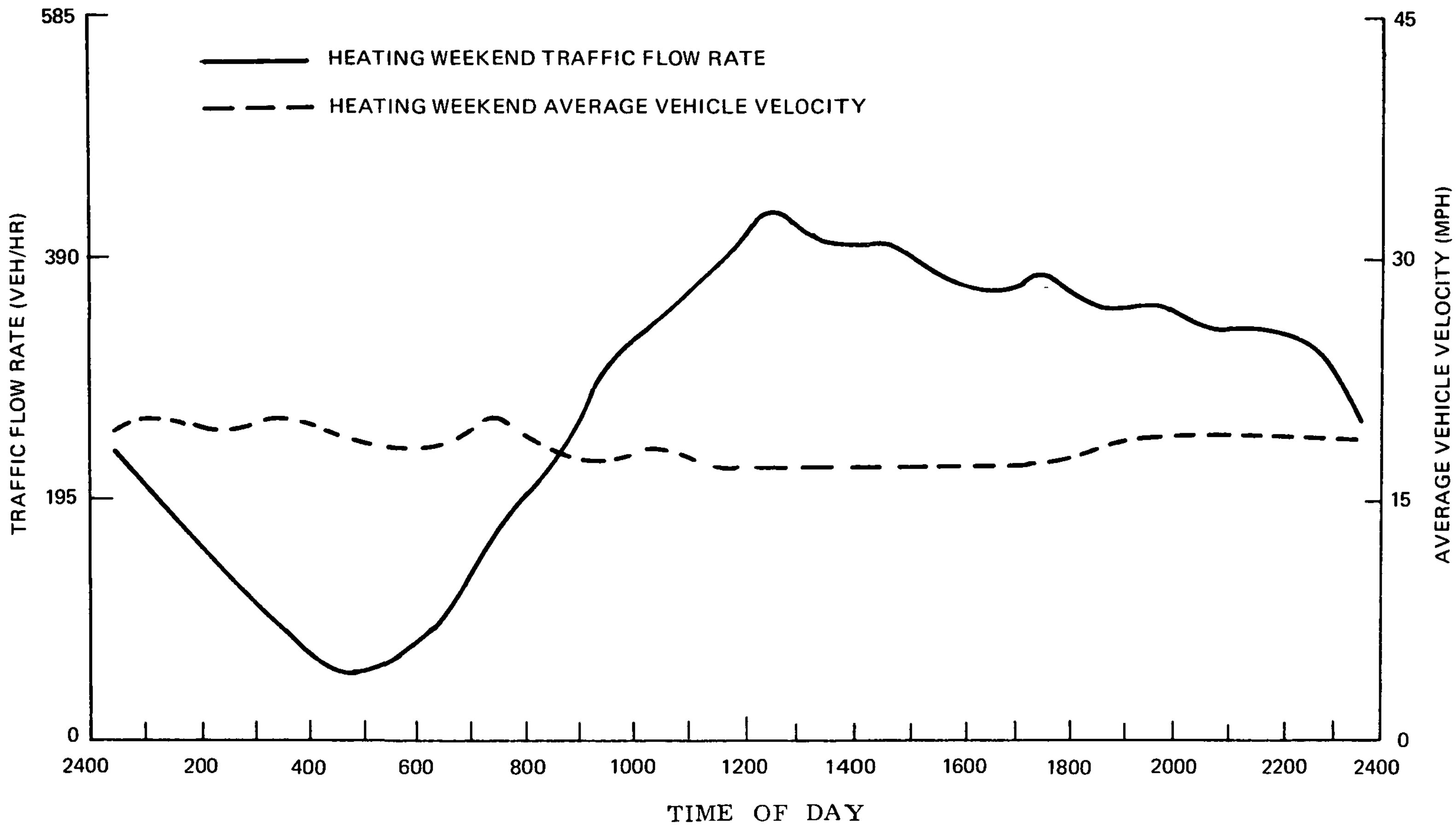


Figure 2.2-8. Heating Weekend Traffic Characteristics On West 40th Street

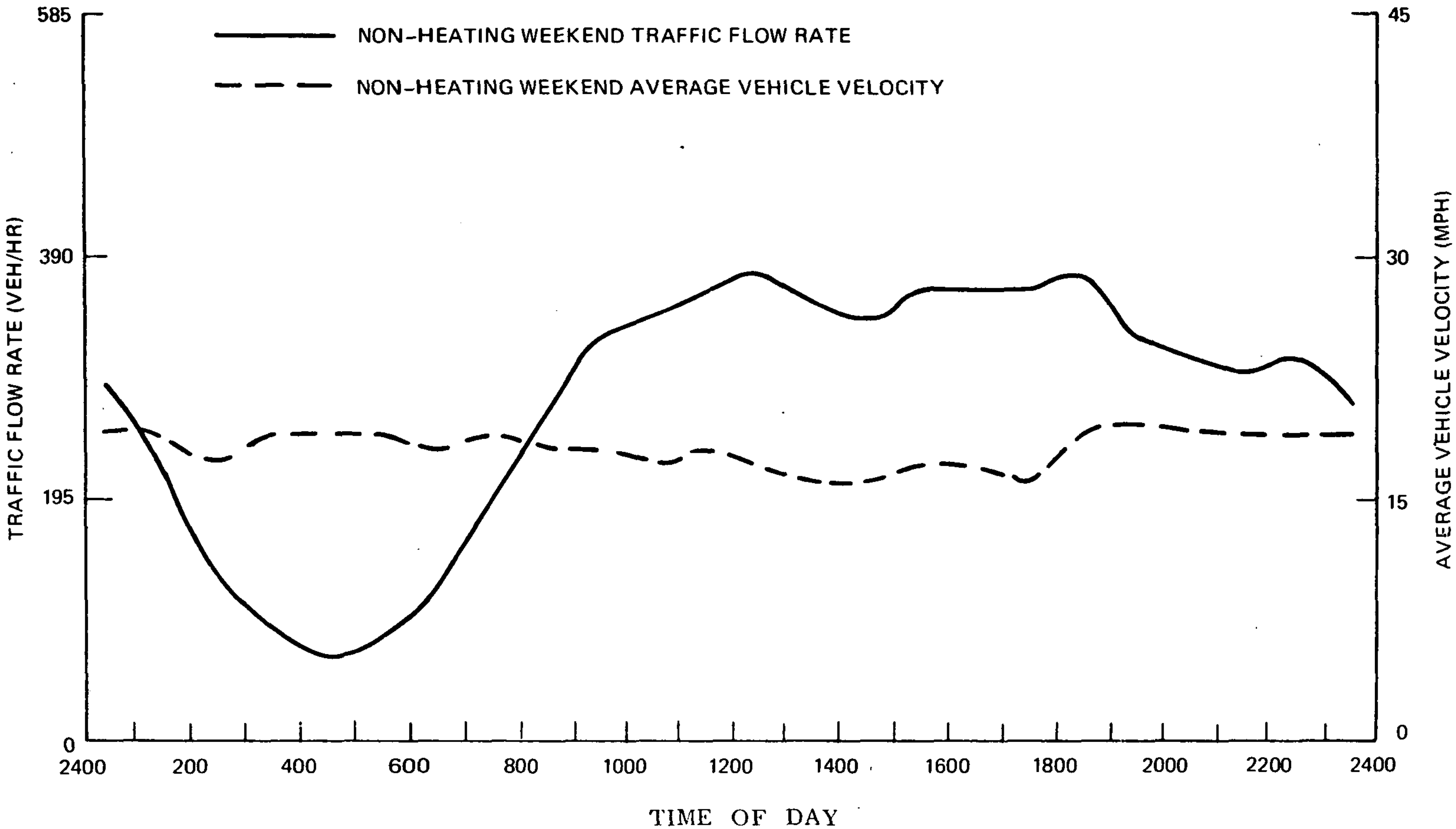


Figure 2.2-9. Non Heating Weekend Traffic Characteristics On West 40th Street

West 40th Street traffic velocity displayed typical sensitivity to traffic flow rate. Higher velocities occurred during low traffic volume periods and lower velocities during the daylight hours of high traffic volume. Average traffic velocity was slightly higher during the non-heating season than recorded for the heating season.

2.3 Highlights

This section presents significant highlights concerning the four pollutants explored during this Indoor/Outdoor Pollution Study. A more detailed summary is provided on these pollutants on a site basis in Section 2.4 and 2.5. In depth analyses are presented in Sections 5.1 and 5.2

2.3.1 Carbon Monoxide Concentration

The average carbon monoxide concentrations at the two sites decay exponentially with height above road level. The decay is essentially the same at the two sites at heights greater than 30 feet above road level. Figures 2.3-1 and -2 show the smoothed verticle CO profiles for the two sites respectively for the outdoor and indoor locations monitored.

CO concentrations at low building elevations generally are higher outdoors than indoors indicating that CO levels at both sites are a function of traffic generated carbon monoxide. At the Washington Bridge Apartments site, the outdoor CO levels at all heights closely follow Trans Manhattan Expressway traffic volume. Outdoor CO at the 40th Street site displays diurnal variations which are characteristic of a two-way street. The weak CO/traffic correlation suggests that CO generated by traffic on 8th Avenue and parallel streets contribute to the carbon monoxide level at this site.

Concentrations at all building locations at both sites follow CO levels as seen close to the road level on a time-delayed basis. Indoor concentrations at all building levels are directly influenced by the outdoor concentrations at the location involved. Generally these indoor concentrations lag outdoor concentrations. Outdoor concentrations usually are higher than indoor concentrations during periods of increasing area traffic and lower during decreasing traffic conditions. Outdoor concentrations generally are higher than indoor con-

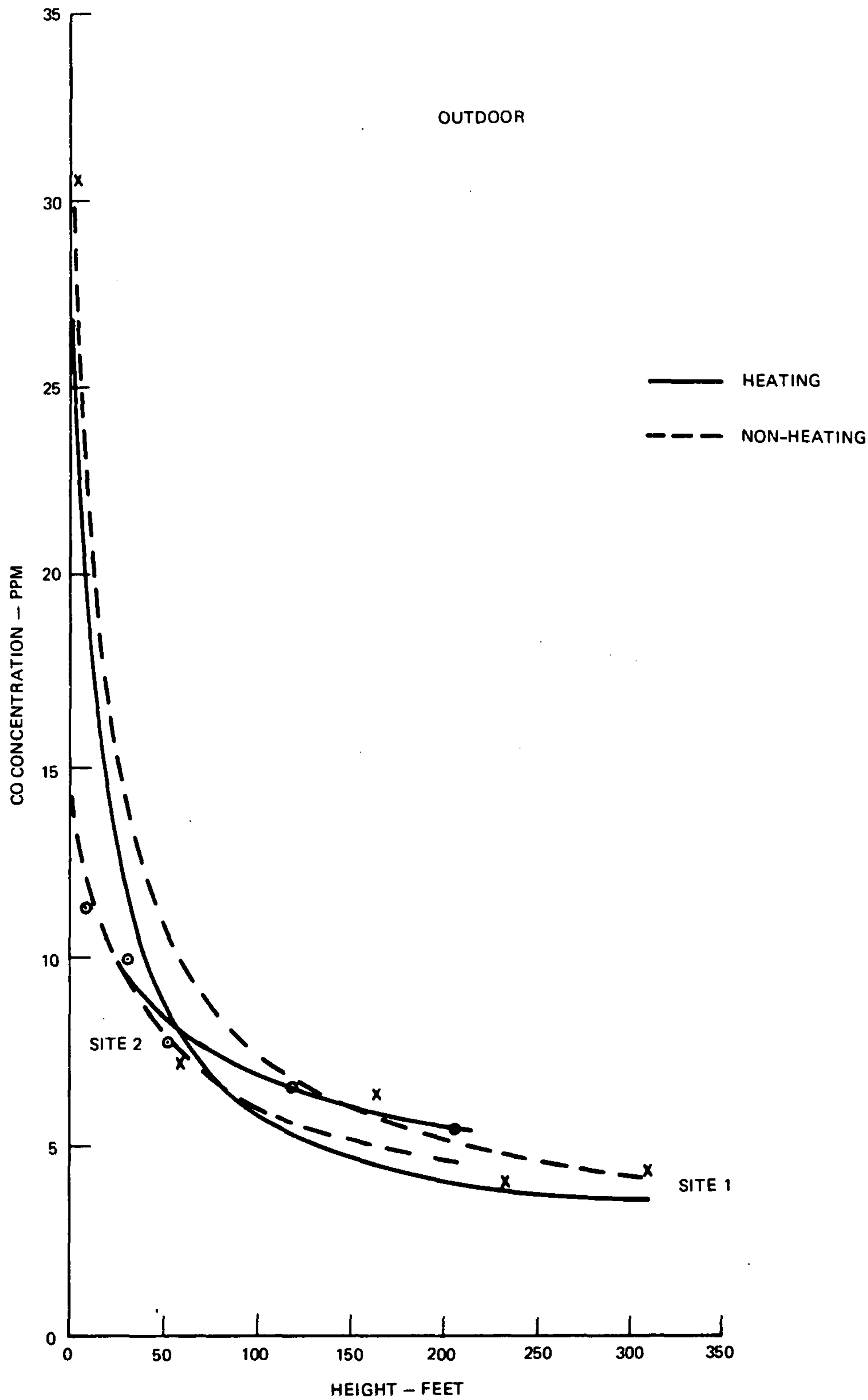


Figure 2.3-1. Vertical Outdoor CO Profile - Both Sites

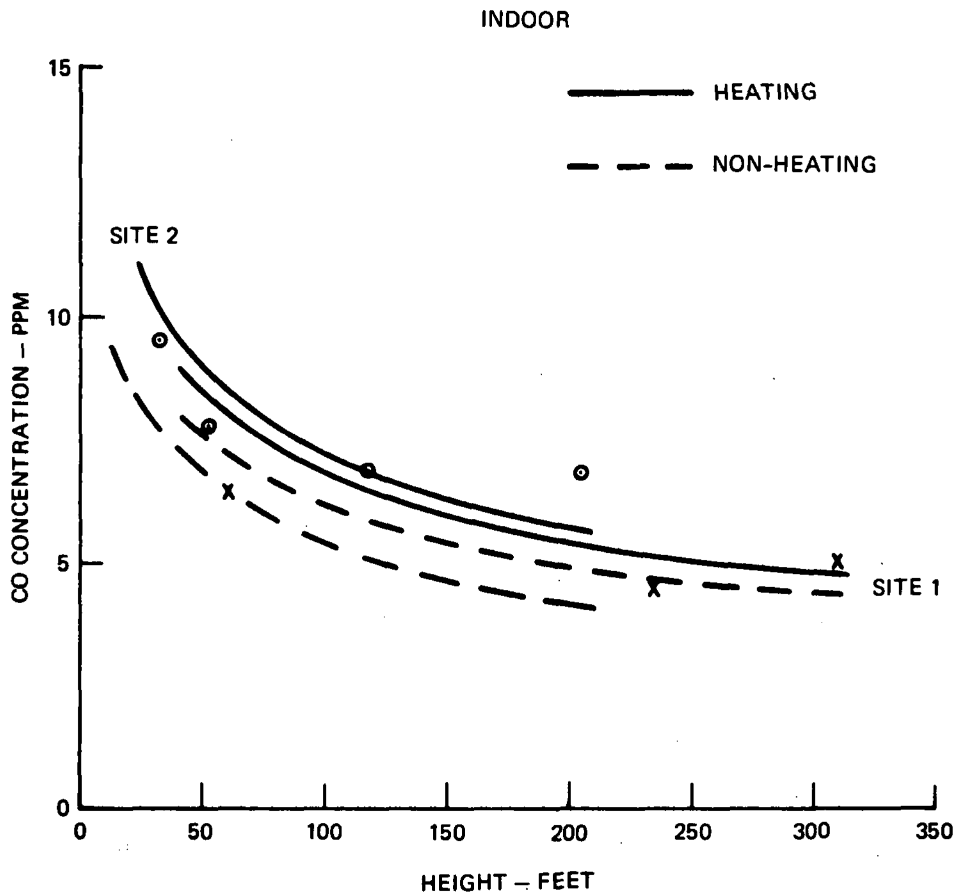


Figure 2.3-2. Vertical Indoor CO Profile - Both Sites

centrations when the outdoor concentrations are high. However, indoor concentrations normally are higher than outdoor concentrations when outdoor concentrations are low.

Outdoor concentrations, as measured at the building locations, are influenced by wind direction at each site. Road level winds which blow from the CO source towards the monitoring locations produce high concentration levels at the buildings. Concentrations decrease as the wind shifts away from this worst case condition. Roof level winds similarly modify CO levels at the upper floors of both buildings.

Average levels indoors generally are higher than outdoor concentrations at heights greater than 100 feet above the road surface. This situation is more pronounced during the heating season than during the non-heating season, as shown on Figures 2.3-3 and -4, and indicates an entrapment of CO within the building.

2.3.2 Hydrocarbon Concentrations

The average hydrocarbon concentrations at the two sites generally are higher indoors than outdoors. This situation is present during both the heating and non-heating seasons at all building locations regardless of vertical distance from road level with the sole exception of the 3rd floor level at the Washington Bridge Apartments during the non-heating season, as shown on Figures 2.3-5 and -6.

Average concentrations at the Washington Bridge Apartments are lower close to the roadway than at the top floor. The reverse is true at the 40th Street site. Hydrocarbon concentrations at the Washington Bridge Apartments site display a general correlation with Trans Manhattan Expressway traffic volume. There is no hydrocarbon/traffic relationship at the 40th Street Site. Cooking facilities, which were used for heating purposes at the 32nd floor of the air rights structure caused the high internal hydrocarbon levels on that floor. Paint spraying internal-

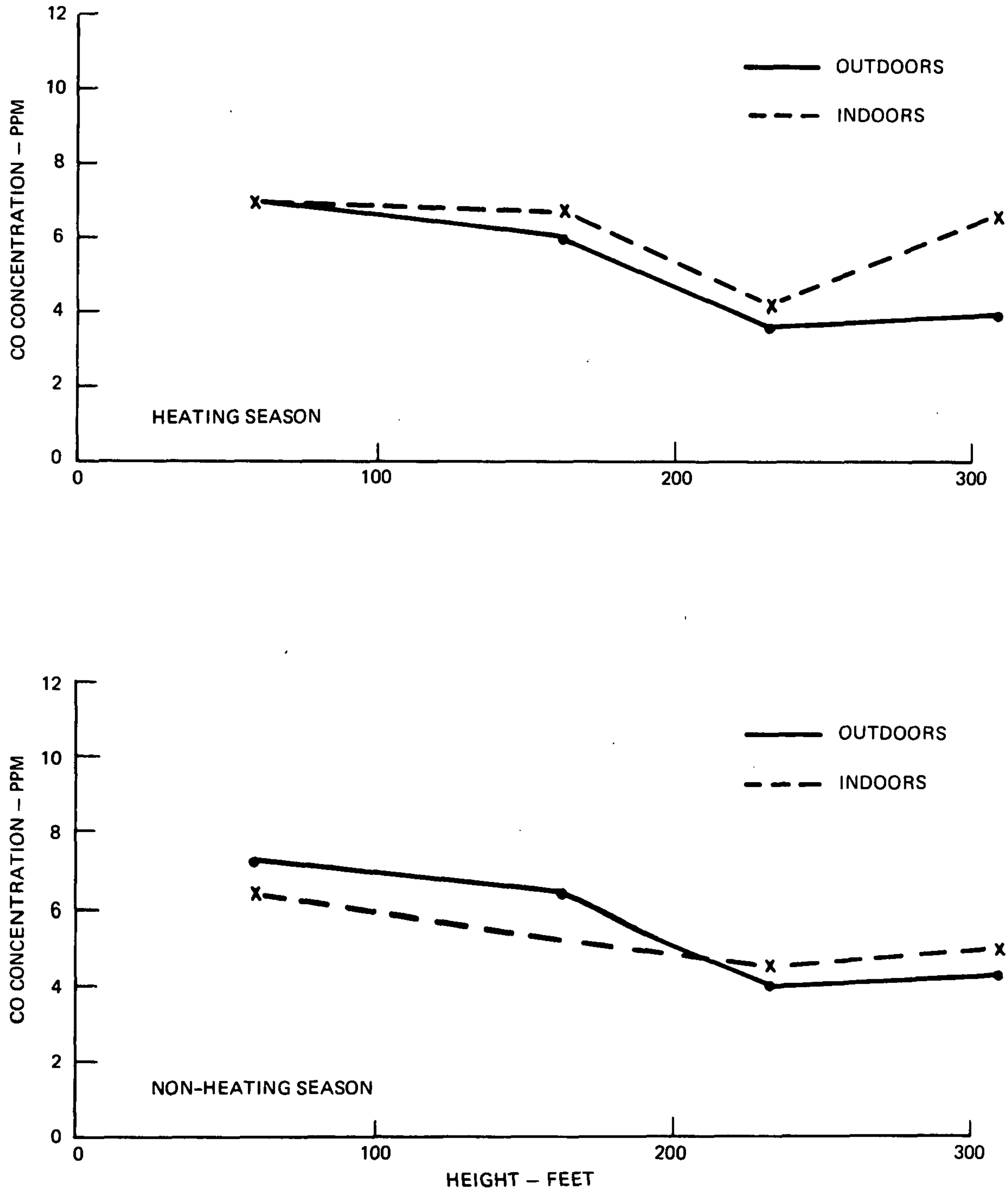
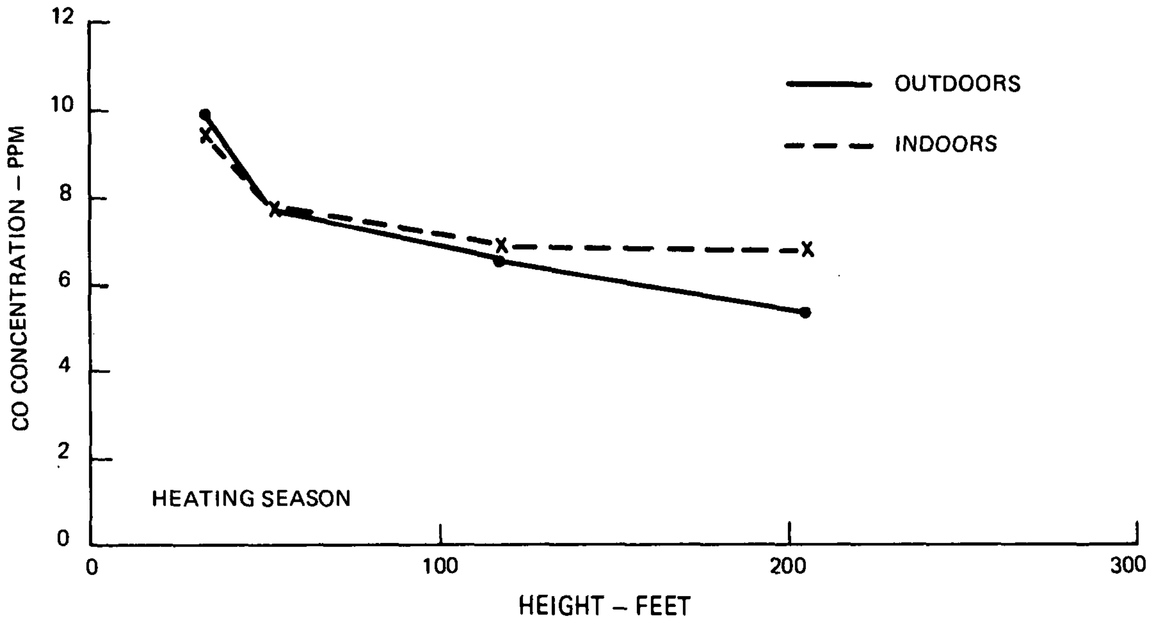


Figure 2.3-3. Average Outdoor/Indoor CO Profile - Site 1



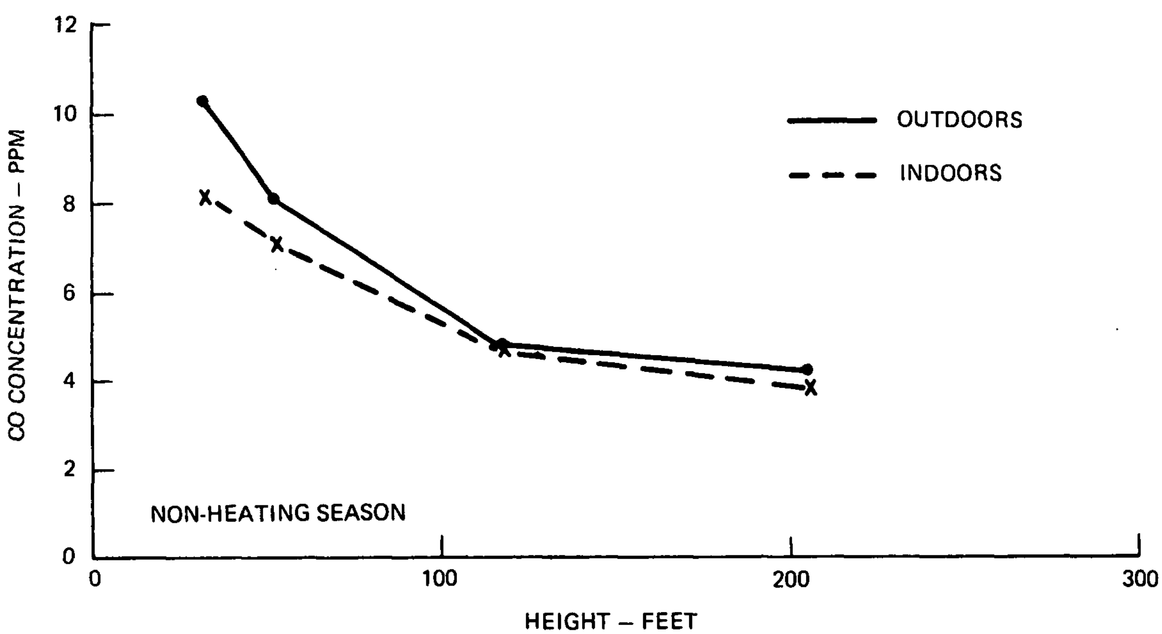


Figure 2.3-4. Average Outdoor/Indoor CO Profile - Site 2

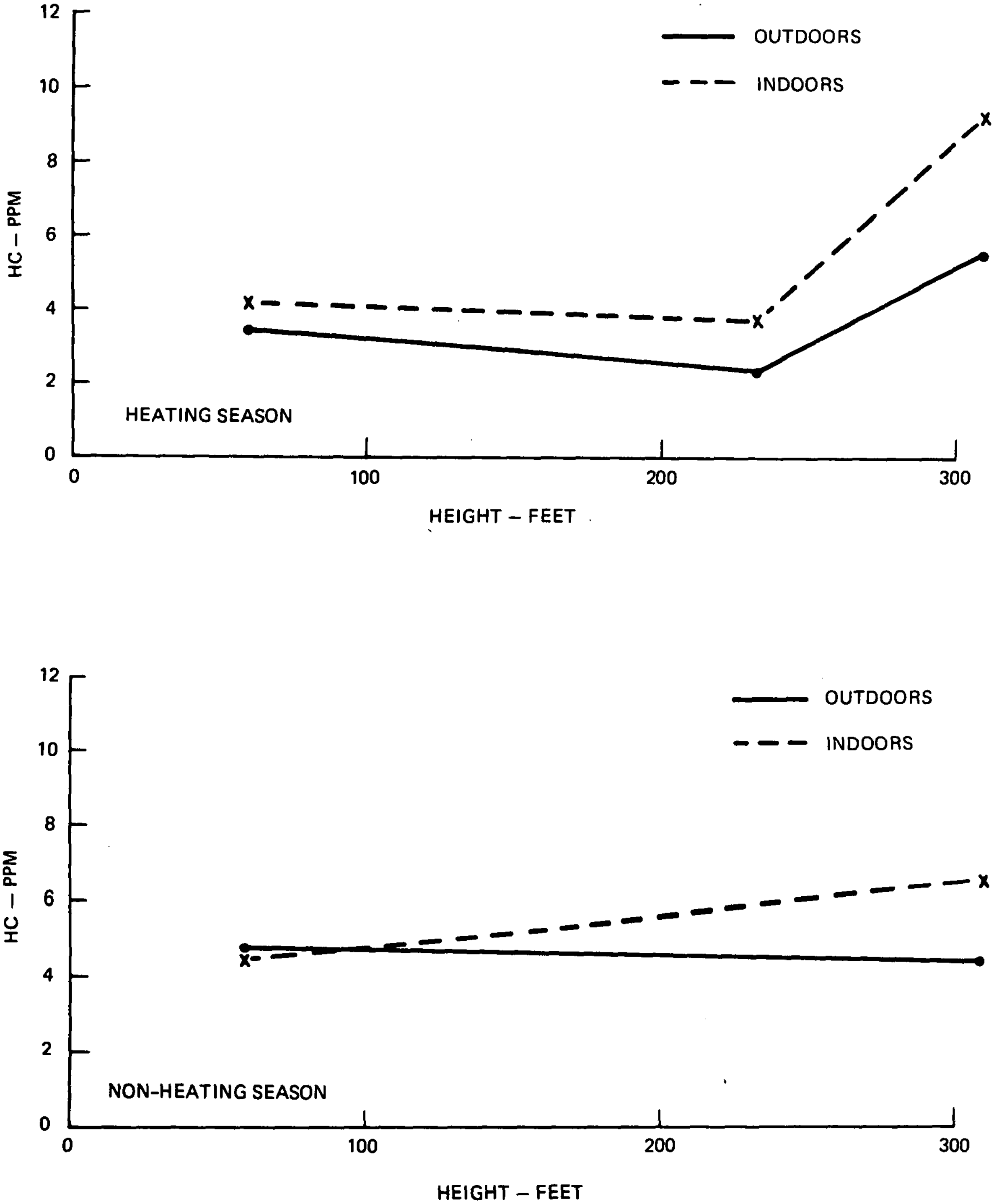
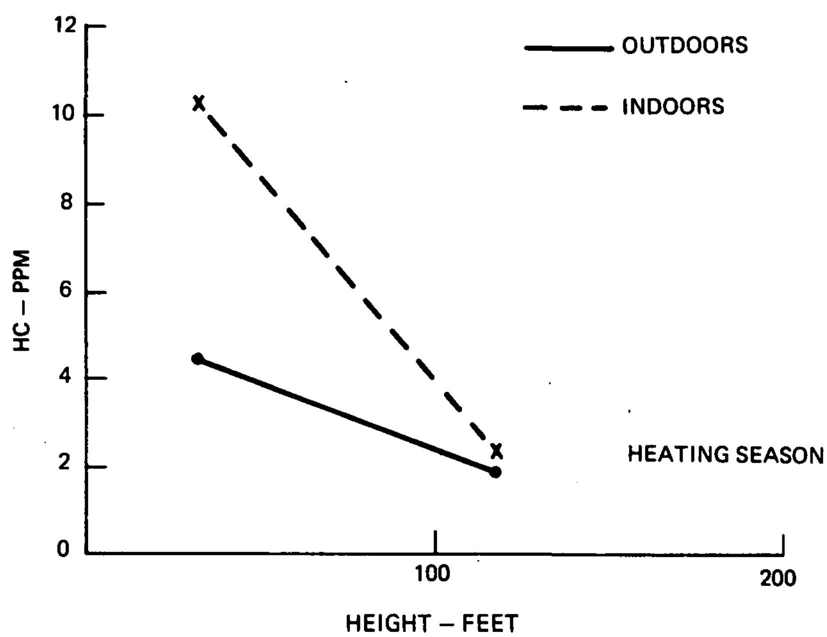


Figure 2.3-5. Average Outdoor/Indoor HC Profile - Site 1



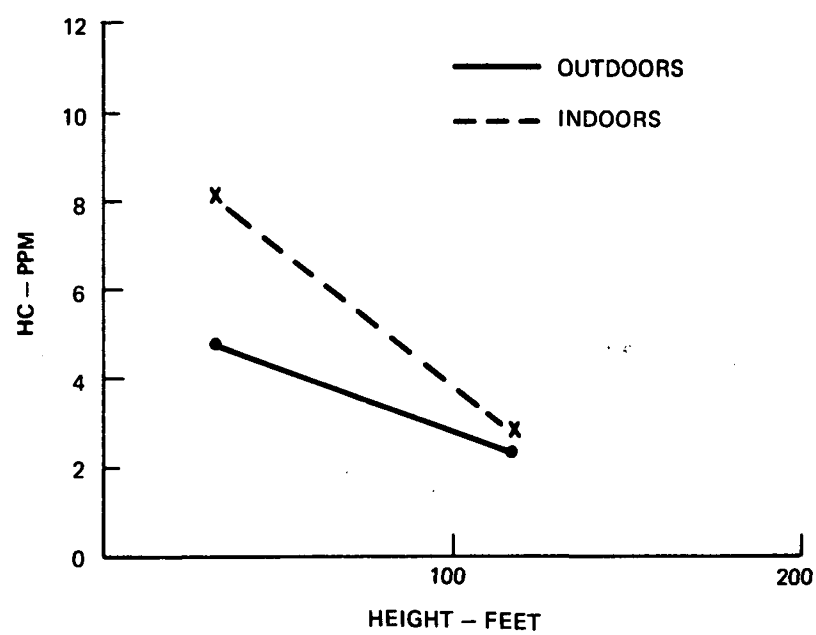


Figure 2.3-6. Average Outdoor/Indoor HC Profile - Site 2

ly at the 3rd floor level of the 40th Street site produce the abnormally high 3rd floor concentrations at that site.

With the exception of the 3rd floor location at Site 1, outdoor hydrocarbon levels are established by internal levels. The outdoor/indoor differentials vary proportionately with indoor concentrations and randomly with outdoor hydrocarbons.

Site temperature changes significantly affect outdoor hydrocarbon concentrations at Site 1. This is most noticeable during the non-heating season at the 3rd floor location. These outdoor concentrations are high during midday and decrease to their minimum at the low temperature hour of the day. Similar temperature effects are noticed at all the floors during the heating season, however, the change due to temperature variations is less.

2.3.3 Particulate Concentrations

The total particulate concentrations at the two sites vary on a daily basis. These daily variations are controlled primarily by roof and road level wind directions. No direct correlation of particulates with traffic volume exists at either site.

Indoor particulate levels are significantly lower than outdoor concentrations at both sites. Daily variations are larger at the outdoor locations than indoors. The major particulate source at the Washington Bridge Apartments is the chimney which exhausts to the outdoors slightly above the roof. The 40th Street source is to the south and west of the building.

Since prevailing winds at roof level of each site vary as a function of the time of the year, the general shift in roof winds creates a seasonal change in measured particulates. Figure 2.3-7 shows the average particulate concentrations (excluding the basement boiler room at the Washington Bridge Apartments) at the two sites plotted as a function of height from the roadway surfaces for both outdoor and indoor locations.

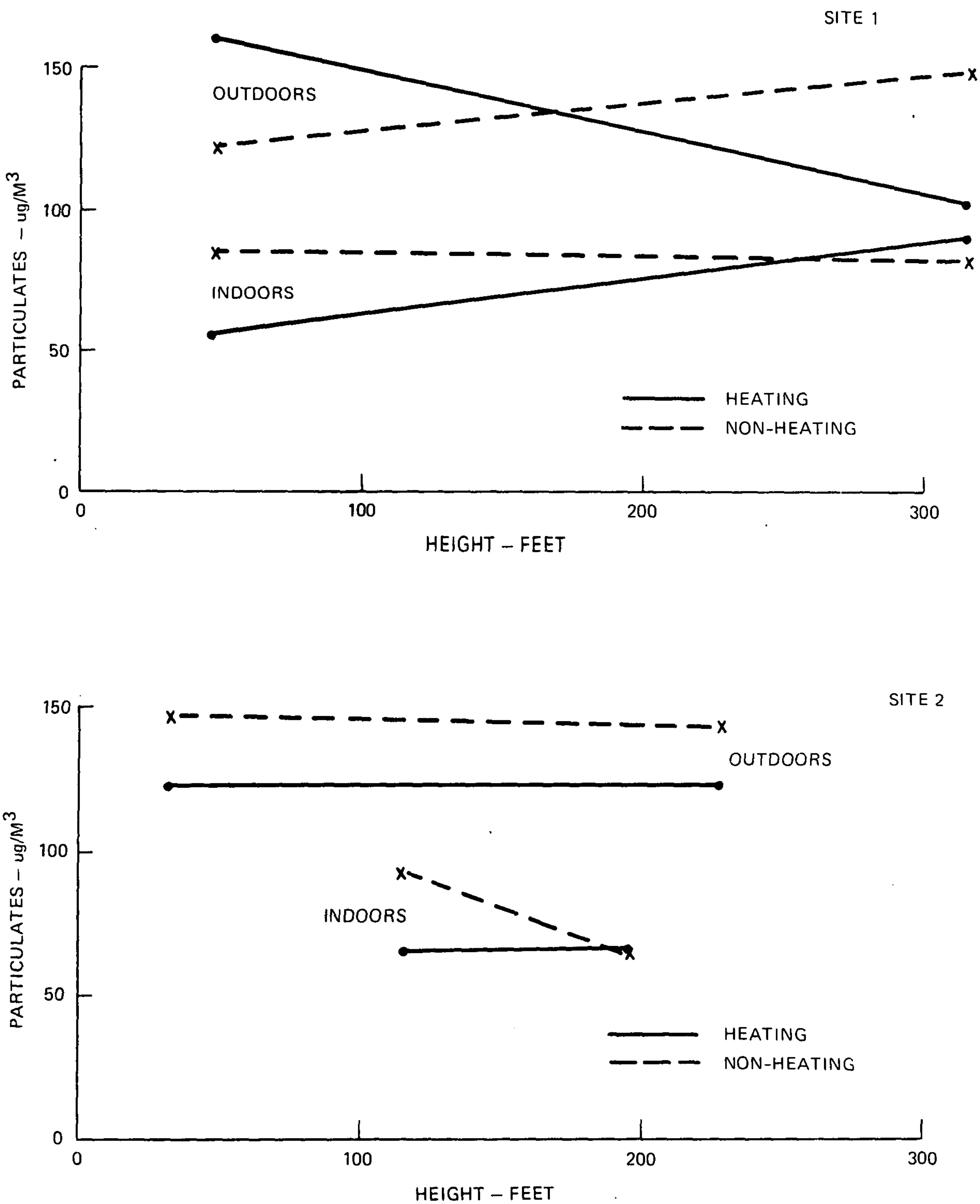


Figure 2.3-7. Average Outdoor/Indoor Particulate Profiles - Both Sites

At Site 1, the seasonal shift in wind direction produces opposite effects on average outdoor and indoor concentrations. During the heating season, maximum particulate concentration was recorded on the outside of the second floor balcony. This outside concentration decayed rapidly to the roof elevation. Indoor concentrations increased with vertical distance. During the non-heating season, outdoor concentration increase with height while indoor concentration decrease from the second floor to roof locations.

Daily variations in roof level concentrations, and outdoor/indoor particulate differential levels are completely dependent on roof wind angle between the chimney and the two roof level samplers. Simularly outdoor differentials between the roof and 2nd floor levels also vary as a function of wind angle.

At site 2, the particulate concentrations show no change with height at the outdoor locations. However, the average level is higher during the non-heating season. Indoor concentrations show the same increase from heating to non-heating season at the 11th floor level but not at the 18th floor. This anomaly is entirely due to the fact that the 18th floor location was a sealed room and the particulate sampler was essentially isolated from daily variations in outdoor concentration levels.

2.3.4 <u>Lead Concentrations</u>

The lead concentrations at the two sites also show a daily variation which is basically related to wind direction. No direct correlation of lead with traffic volume is evident at either site.

Indoor lead concentration levels are generally lower than outdoor concentrations at both sites at comparable heights above road level. Concentrations measured close to road level show greater daily variations than those measured at greater heights. While a direct lead/traffic relationship is not identifiable at the Washington Bridge Apartments, it is evident that road and roof winds transport traffic generated lead from the Trans Manhattan Expressway to the air rights structure. The contribution of traffic to lead concentrations at the 40th Street site is totally obscured by the paint spraying activity within the building.

The shift in prevailing winds with calendar time at Site 1 produces a alightly different effect on lead concentrations than seen for particulates. As shown on the upper diagram of Figure 2.3-8, outdoor concentrations always decrease from 2nd floor to roof level while indoor concentrations are generally unchanged. The difference is basically due to the ground level origin for lead and the roof level source for particulates.

At the 40th Street site, lead concentrations show a larger change in the 3rd floor outdoor and 11th floor indoor levels between the heating and non-heating seasons than seen at higher elevations. This is expected since the internal source was located on the 3rd floor.

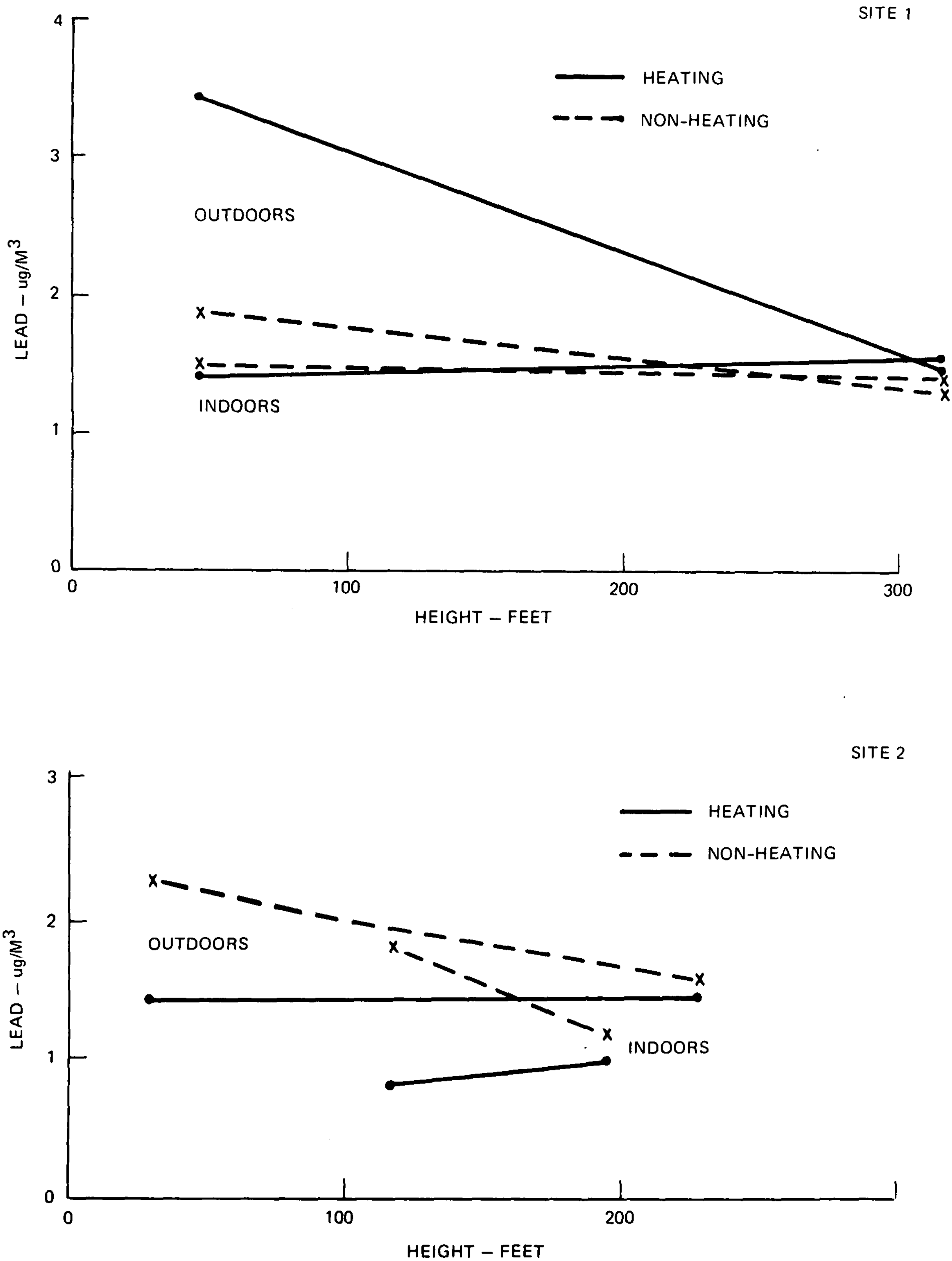


Figure 2.3-8. Average Outdoor/Indoor Lead Profiles - Both Sides

2.4 Summary of Site 1 Results

Three sources of pollutants are identifiable at the Washington Bridge Apartments. These are: traffic on the Trans Manhattan Expressway, cooking facilities in the apartments on the upper floors and the building chimney which exhausts slightly above roof level. These pollutant sources contribute to the pollution level both outdoors and indoors at this air rights sight. The pollution concentration level at individual locations in and about the building are controlled by these emission sources and wind currents from the roof to road level.

The average pollution levels varied significantly from road level to roof level at both indoor and outdoor locations. Outdoor carbon monoxide and hydrocarbon levels generally were higher during the non-heating season than for the heating season. This trend, however, does not hold at indoor locations nor for the particulate and lead concentration levels. The average levels for each of the pollutants at all measurement locations on weekdays are shown in Tables 2.4-1 and -2.

The average hourly carbon monoxide and hydrocarbon levels displayed diurnal variations which closely followed diurnal traffic patterns. The diurnal variations of the two pollutants respond differently, however, to diurnal changes in site temperature. As can be seen from Figure 2.4-1, which presents 3rd floor outdoor diurnal CO and hydrocarbons and diurnal traffic and site temperature, both pollutants respond to rush hour traffic peaks. The afternoon hydrocarbon peak, however, is significantly distorted by diurnal temperature changes. Midday hydrocarbon levels are higher due to increasing site temperature. The evening peak is lowered by the reduction in site temperature which occurs approximately two hours before the traffic peak. There is a slight time delay between CO and traffic peaks, reflecting the time for traffic generated CO to

TABLE 2.4-1
CARBON MONOXIDE
WEEKDAY MEASUREMENTS
SITE 1

	3' - Median		3' - North		3rd Floor		15th Floor		23rd Floor		32nd Floor	
	Ave. ppm	Peak ppm	Ave. ppm	Peak ppm	Ave. ppm	Peak ppm	Ave. ppm	Peak ppm	Ave. ppm	Peak ppm	Ave. ppm	Peak ppm
	Ex. Pri	Ex. Sec	Ex. Pri	Ex. Sec	Ex. Sec.	Ex. Sec.	Ex. Sec.	Ex. Sec.	Ex. Sec.	Ex. Sec.	Ex. Sec.	Ex. Sec.
Heating Season												
Outside	27.7	92	24.9	112	7.0	33	6.0	35	3.6	36	3.9	23
	91.4	26.6	95.4	23.1	23.6	0	13.5	0	4.2	.1	3.0	0
Inside	NA	NA	NA	NA	7.0	29	6.7	21	4.2	19	6.6	28
	NA	NA	NA	NA	23.1	0	18.7	0	4.1	.1	19.7	0
Non-Heating Season												
Outside	30.6	75	31.1	72	7.2	28	6.4	29	4.0	20	4.3	19
	97.9	38.5	97.9	39.7	20.3	0	16.5	0	3.9	0	3.6	0
Inside	NA	NA	NA	NA	6.4	23	NA	NA	4.5	19	5.0	17
	NA	NA	NA	NA	15.2	0	NA	NA	5.1	0	2.9	0

Ex. Pri. = Frequency exceeding 9 ppm averaged over 8 hour period
Ex. Sec. = Frequency exceeding 35 ppm over 1 hour period

TABLE 2.4-2
HYDROCARBONS - PARTICULATES - LEAD
WEEKDAY MEASUREMENT
SITE 1

Hydrocarbon

	3rd Floor Ave ppm / peak ppm	23rd Floor Ave ppm / peak ppm	32nd Floor Ave ppm / peak ppm
Heating Season			
Outside	3.4 / 15	2.4 / 10	4.5 / 9
Inside	4.1 / 28	3.7 / 28	9.2 / 21
Non-Heating Season			
Outside	4.8 / 10	N/A / N/A	4.5 / 8
Inside	4.5 / 11	N/A / N/A	6.5 / 18

	Mean Particulate Concentration ug/M^3				Mean Lead Concentration ug/M^3			
	2nd Fl	Roof	Tower	Boiler Room	2nd Fl	Roof	Tower	Boiler Room
Heating Season								
Outside	160.9	102.9	N/A	N/A	3.45	1.47	N/A	N/A
Inside	56.1	90.4	69.1	112.9	1.42	1.58	1.71	4.0
Non-Heating Season								
Outside	122.1	148.6	N/A	N/A	1.89	1.30	N/A	N/A
Inside	85.1	82.5	N/A	N/A	1.51	1.42	N/A	N/A

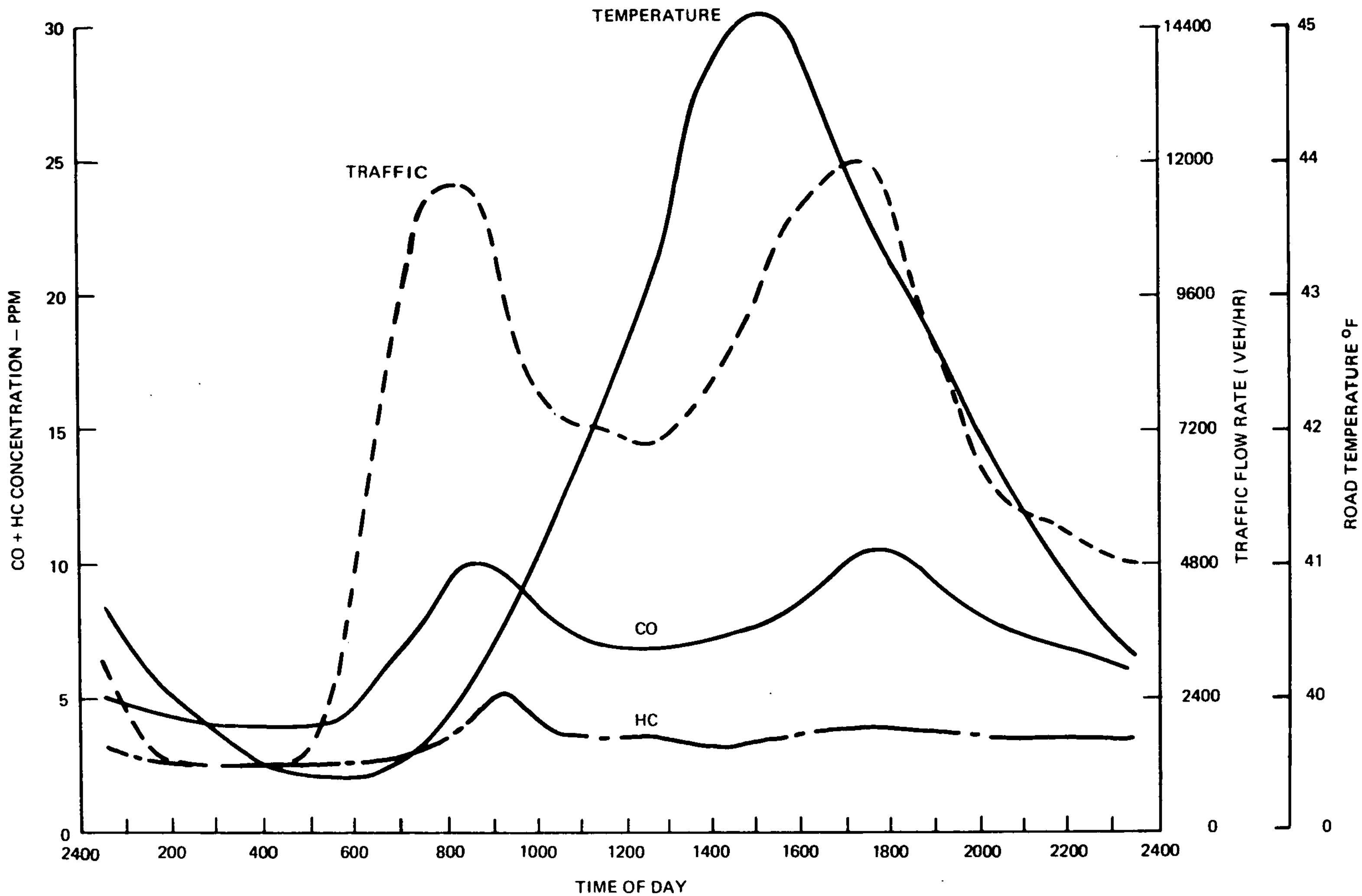


Figure 2.4-1. Diurnal Traffic Temp., & CO & HC - 3rd Floor - Heating Weekdays - Site 1

disburse from the Trans Manhattan Expressway to the lower floors of the air rights structure.

As previously presented in Section 2.2.1.3, there is a significant variation in the diurnal traffic patterns on weekdays and weekends. Also minor differences were noted in traffic flow rate and velocity between the heating and non-heating seasons. However, both the small variation in traffic parameters between seasons and the marked change in diurnal traffic for weekdays and weekends are directly reflected in changes in the carbon monoxide concentration measured at the median strip of the Trans Manhattan Expressway. This CO/traffic relationship appears constant regardless of the day of the week or season of the year. Similarly, the average carbon monoxide and hydrocarbon concentrations, as measured at the 3rd floor outdoor location at the air rights structure, are linear with traffic flow rate. These median and 3rd floor pollutant relationships to Trans Manhattan traffic using diurnal data, are shown on Figure 2.4-2.

No diurnal data is available for total particulate or lead concentrations. However, daily data for these two pollutants fail to indicate a pollutant/traffic relationship.

The relative concentration levels of the four pollutants, as measured at the 2nd and 3rd floor outdoor locations for those days on which particulate samples were obtained, is shown in Figure 2.4-3. (Carbon monoxide and hydrocarbon concentrations are given as hourly averages to permit comparison with data in Tables 2.4-1 and -2. Particulates and lead are plotted in daily concentration levels.) It will be noted that while there are similarities in the variations of the pollutant levels, the pollutants do not vary uniformly. In general, both carbon monoxide and total particulates increased during the data collection period. Hydrocarbons and lead increased during the early months and then decreased. These differences in general trends reflect the change in

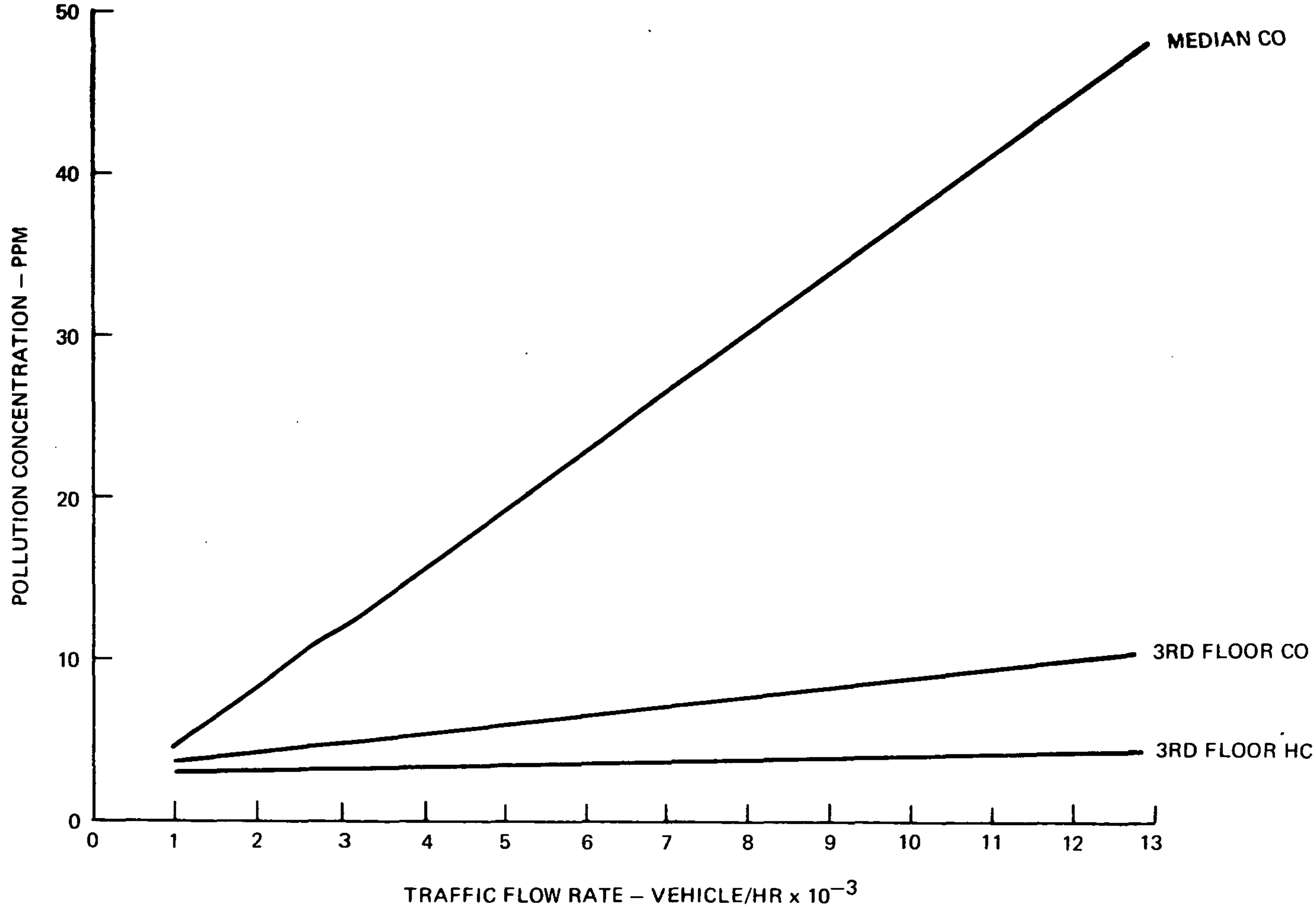


Figure 2.4-2. Hydrocarbon & CO Concentrations vs. Traffic Flow Rate - Heating - Weekdays - Site 1

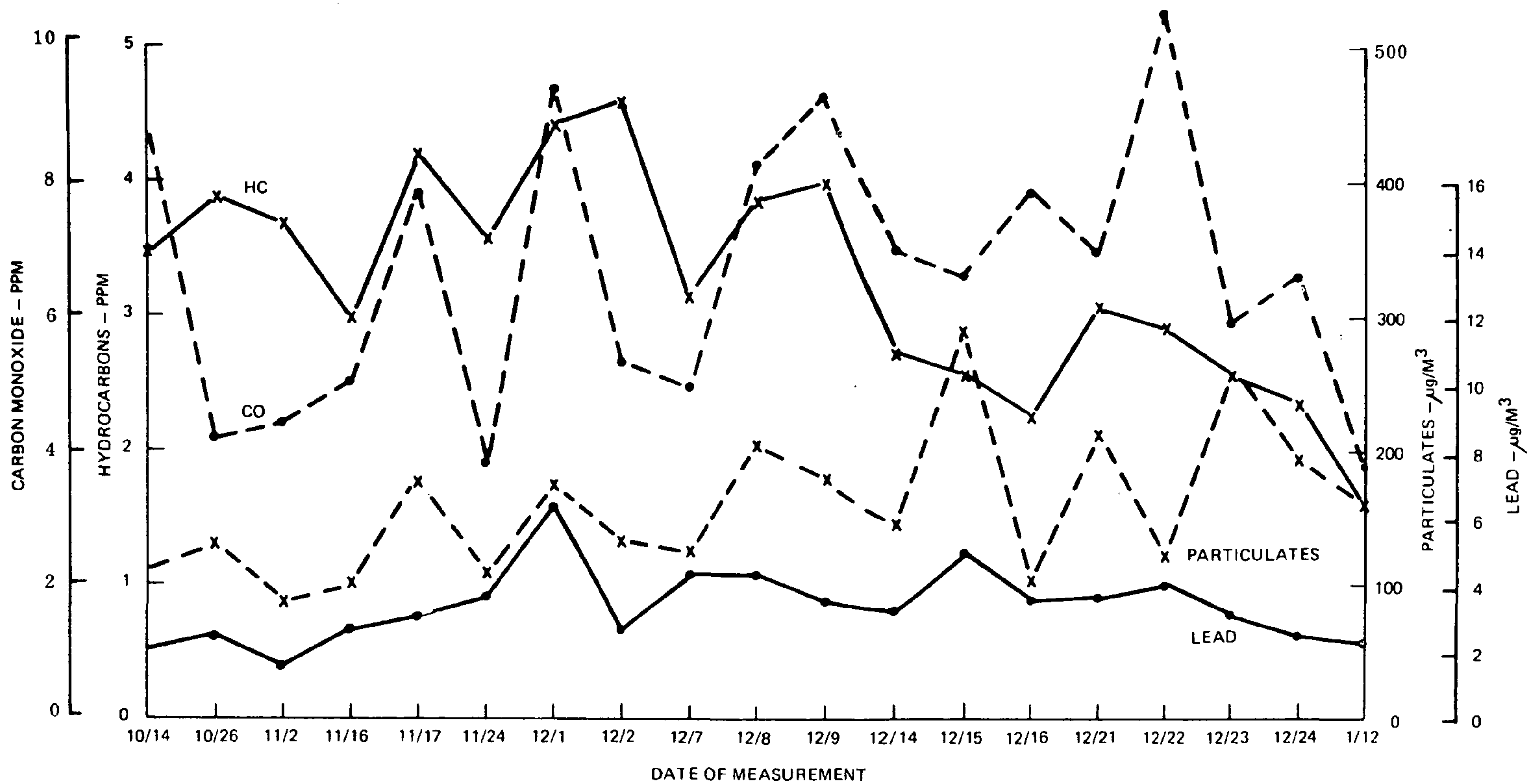


Figure 2.4-3. Pollutants - 2nd & 3rd Floors - Outdoors - Site 1

meteorological conditions; i.e., site temperature and wind direction, throughout the 5 months monitoring period. A comparison of the hydrocarbon concentration curve with the daily temperature levels shown on Figure 2.2-1 again shows the reduction in hydrocarbon concentrations with a decrease in site temperature.

Wind azimuth and the relative location of the sampling location to the pollutant source both influence the concentration levels of the four pollutants. Figures 2.4-4 and -5 show the daily concentration levels as a function of the road level wind azimuth angle. CO and HC concentrations are high for road winds from 270° which blow Trans Manhattan generated pollutants towards the sampling location at the N. E. corner of the air rights structure. These pollutants are low for winds from the N. E. Particulate and lead concentrations are high for road winds from 15° and 245°; directions which carry these pollutants across the face of the building. Wind perpendicular to the building, from 300°, reduce these pollutant concentration levels.

It will be noticed from the constant temperature lines on the four curves, that hydrocarbon concentrations are significantly lower on low temperature days than any of the other pollutants. (The data for these curves are included in Section 5.1).

Figure 2.4-6 shows the relationship between daily average hydrocarbon and CO concentrations and daily levels of lead and total particulates for the selected days.

Since the average levels of the four pollutants at the 2nd and 3rd floor outdoor locations and traffic flow rate on these selected days are very close to the averages during the heating season, as shown in the following tabulation, it is felt that the date for these selected days properly represents the total monitoring period.

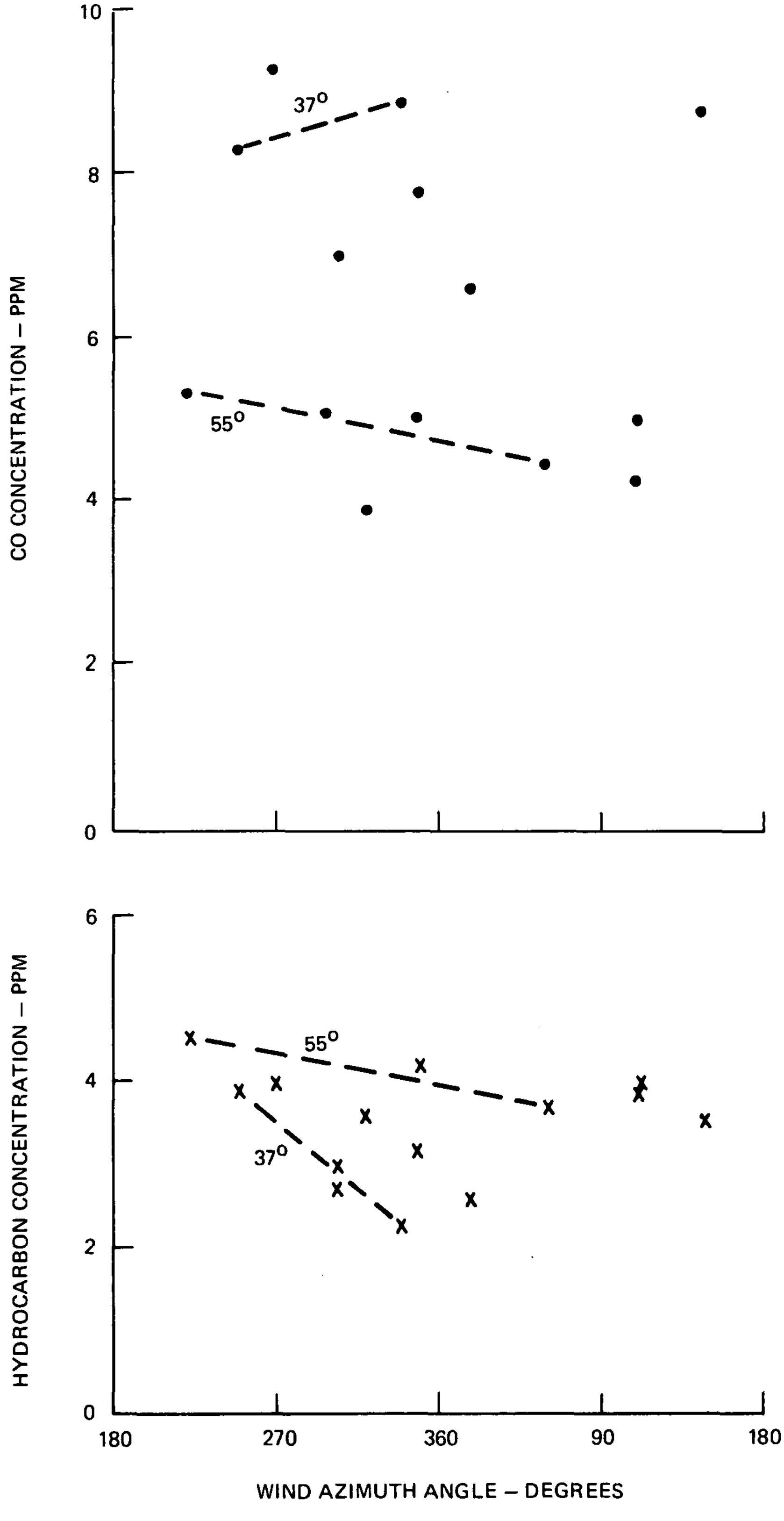
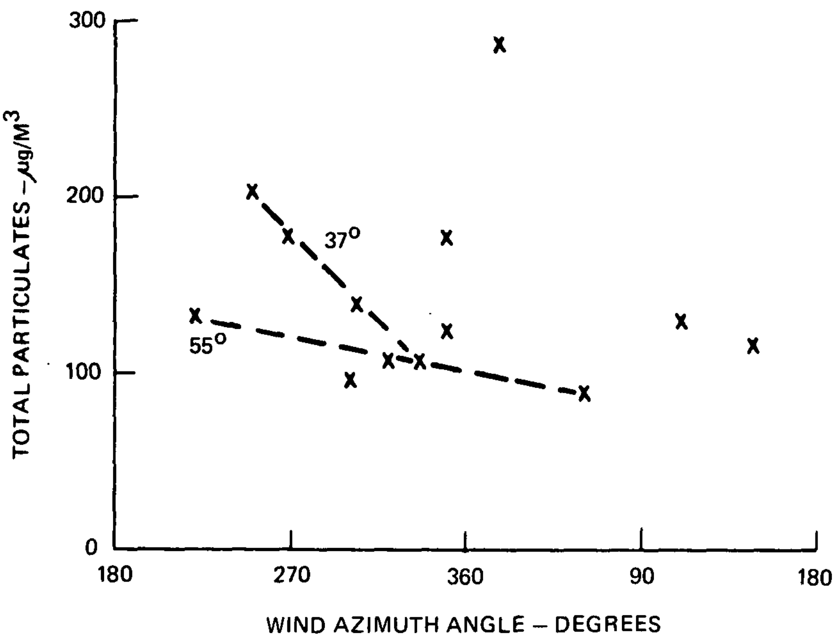


Figure 2.4-4. CO & HC Concentrations vs. Road Level Wind - Site 1



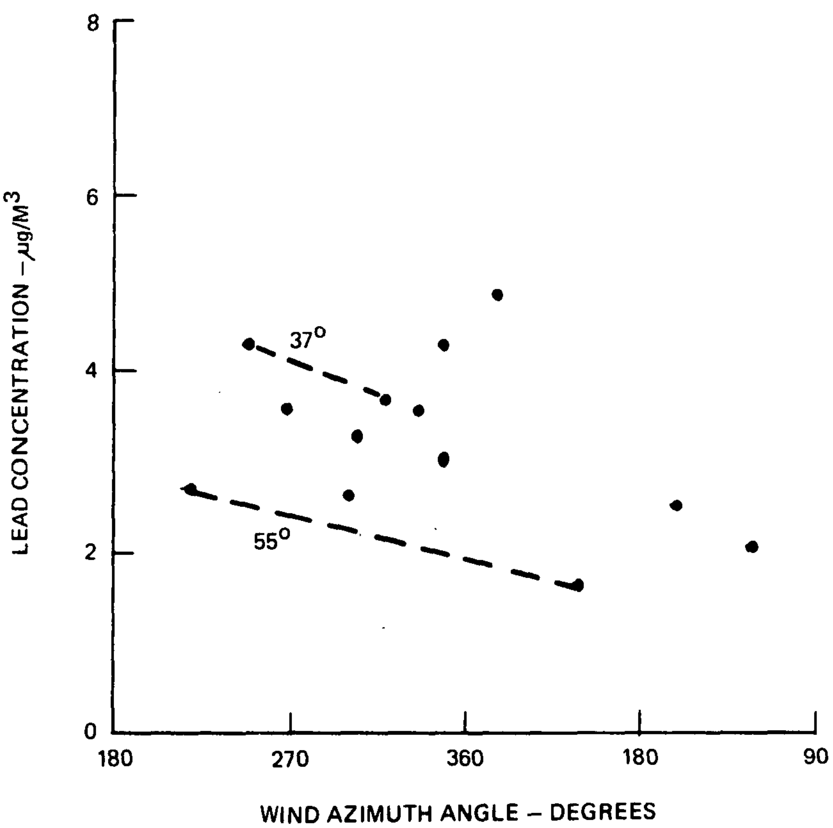
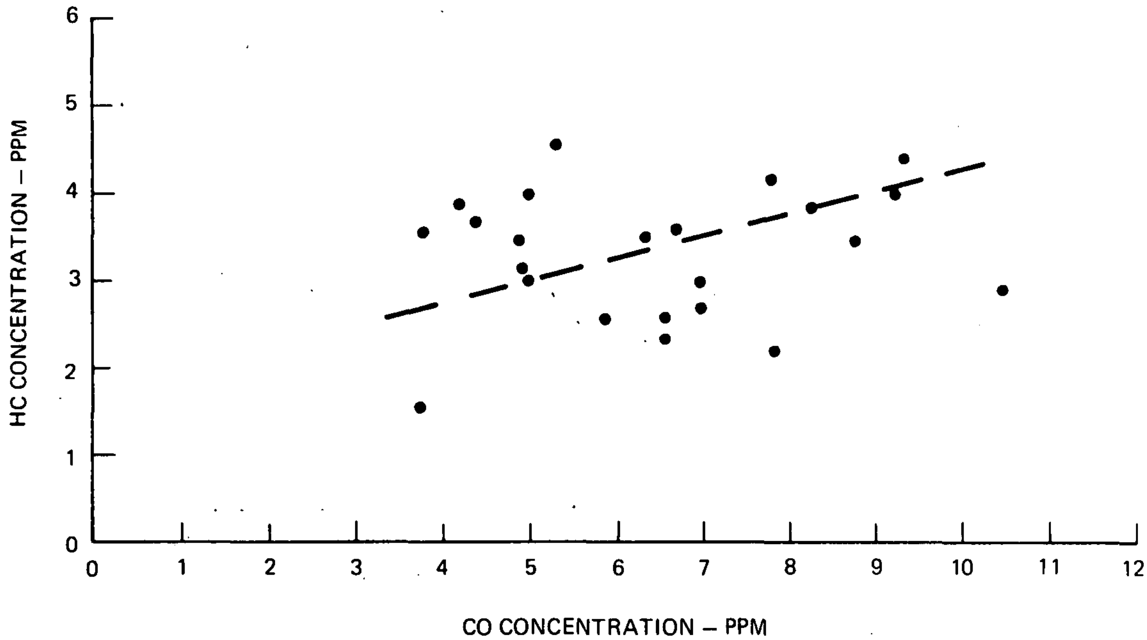


Figure 2.4-5. Particulates & Lead Concentrations vs. Road Level Wind - Site 1



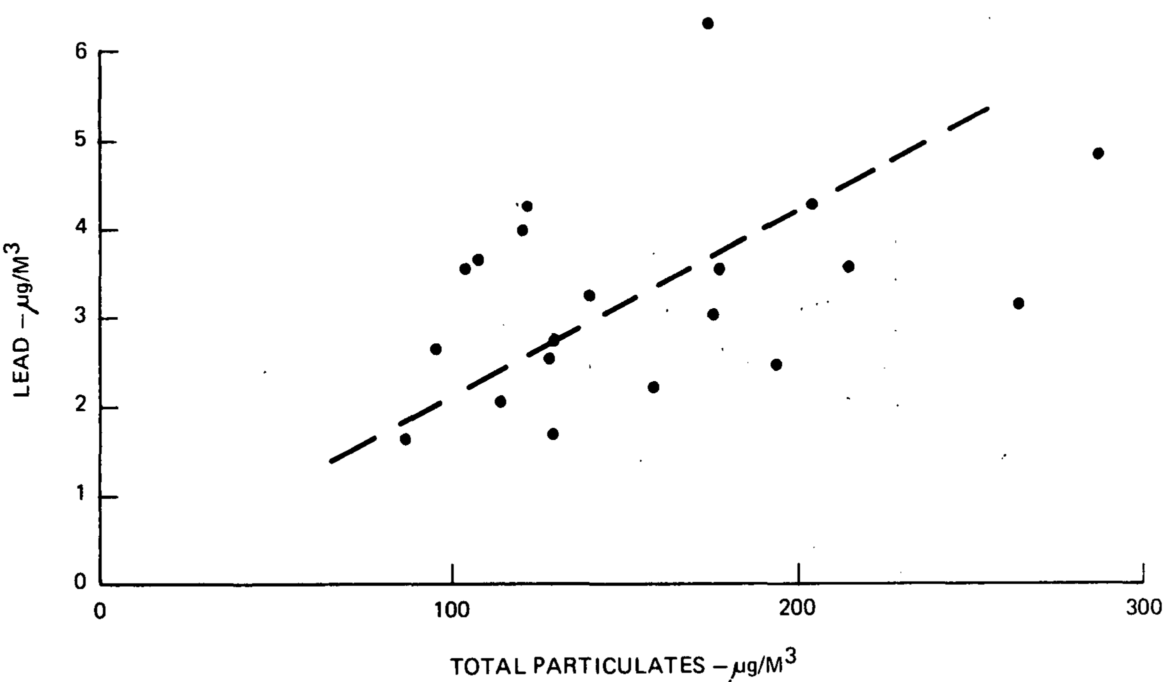


Figure 2.4-6. Pollutant Relationships - Daily Data - Site 1

	CO	HC	Part.	Lead	Traffic
	ppm		ug/M^3		Veh/Hr
Heating Season Daily Ave.	7.0	3.4	161	3.5	6670
Selected Days 24 Hr. Ave.	6.5	3.3	157	3.3	6590

2.4.1 Carbon Monoxide

CO measurements at this site were made at five elevations; 3 ft. above road level, 3rd floor, 15th floor, 23rd floor and 32nd floor. Because of the time of starting the program, September 25, 1970, sparse CO data was taken during the non-heating season. One hundred days of CO measurements were taken during the heating season and only 9 days of measurements during the non-heating season.

The Federal Criterion of 9 ppm was exceeded over 90% of all hours 3 ft. above the road level with the 35 ppm one hour average being exceeded over 20% of the time. At the third floor level the 9 ppm standard was exceeded over 20% of the time both outdoors and indoors. Above these levels the frequencies are as shown in Table 2.4-1.

Hourly average CO measurements taken at the 3 ft. level show a good correlation with the traffic characteristics. The diurnal CO weekday profiles have a double-peaked configuration (morning and afternoon maxima) which have a close phase relationship to the traffic flow rate. The daily average CO concentrations, both outdoor and indoor, show an exponential decay, with the greatest decrease between the ground level and 3rd floor probes. The general decay profile up to and including the 23rd floor is quite representative of that related to a live source. For this site, therefore, traffic is a major source of the CO as measured at the lower and intermediate elevations.

The CO measurements at this site were higher during weekdays as compared to weekends, consistent with the traffic volumes. Concentrations outdoors were always higher during the non-heating season than during the heating season. This is also consistent with higher traffic conditions during the non-heating season. However, indoor concentrations during the non-heating season were lower at the 3rd and 32nd floors than those occuring during the heating season. Indoor average concentrations at all elevations were comparable to outdoor averages for both seasons with the exception of the 32nd floor during the heating season.

CO concentrations at all building locations, indoors and outdoors, displayed diurnal characteristics representative of the diurnal traffic flow rate for both weekdays and weekends. That is, weekday CO profiles were double-peaked while weekend CO profiles had a single peak late in the day. There were significantly different time delays between traffic peaks and CO peaks at the various building elevations suggesting that other factors beside traffic influence CO concentration at the various building elevations, especially indoors. As for the general trend, we see an indoor/outdoor pattern of highly permeable walls, low concentration gradient across the wall and definite indications that the building acts as an entrapping receptor.

The difference in time delay between CO and traffic peaks is partially due to height above the roadway, different upward paths internally and externally and to different meteorological conditions indoors and outdoors. These factors modify the response time of CO concentrations to changes in traffic flow rate. This can be seen from Figure 2.4-7 which portrays the diurnal CO concentrations at the 3rd floor outdoor and 32nd floor indoor locations against diurnal traffic flow rates. (The numbers 24, 1, 2, etc., represent the hour of the day.) CO levels lag changes in traffic flow rates for both increasing and decreasing traffic conditions. 32nd floor lag is greater.

Indoor CO concentrations, as measured on both heating and non-heating weekdays, increase linearly with the outdoor concentration at all building levels.

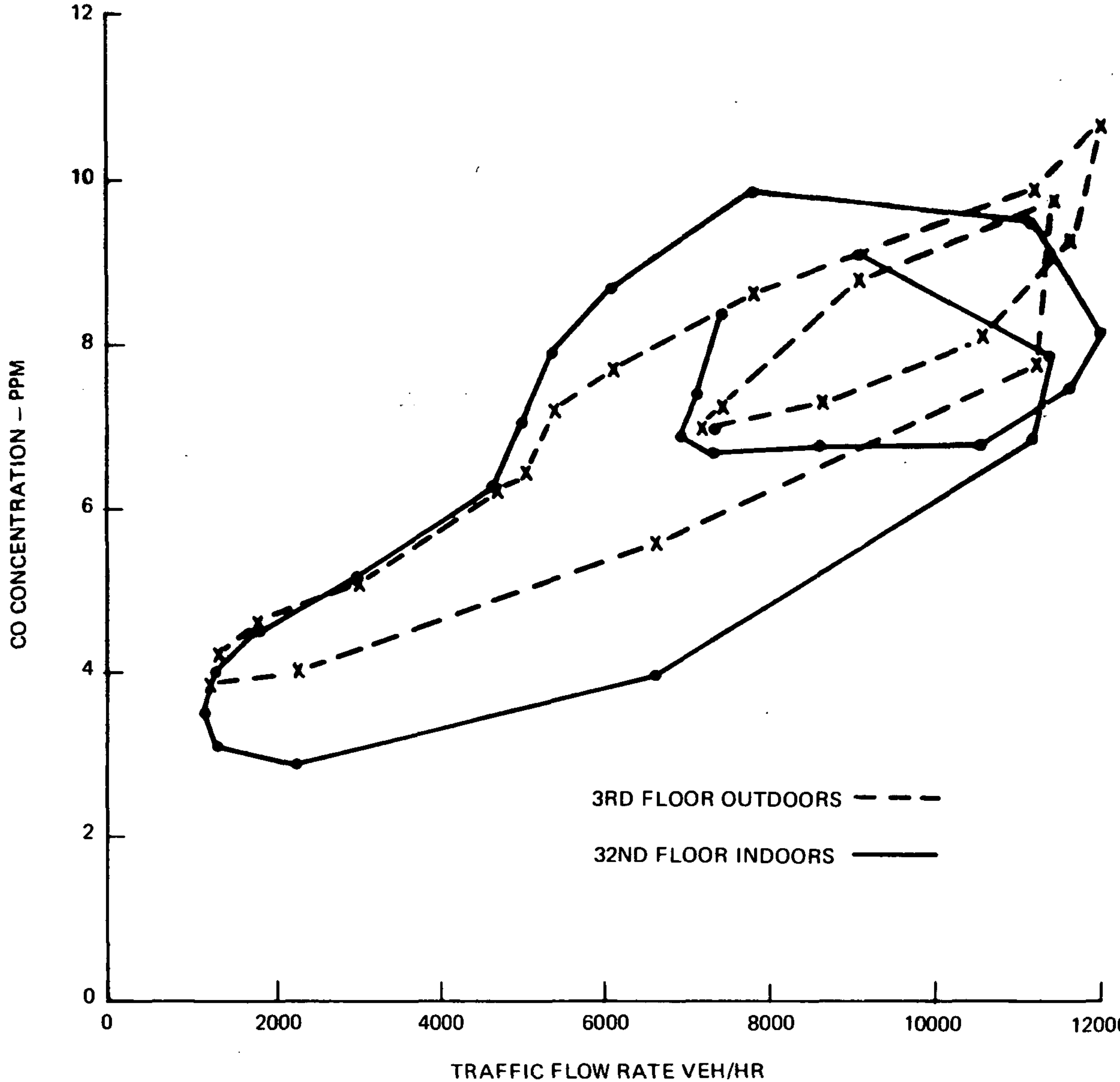


Figure 2.4-7. Diurnal CO vs. Diurnal Traffic - Site 1

The indoor/outdoor relationships are slightly different at each floor, as shown on Figure 2.4-8. Indoor CO at the 23rd floor is lower than 3rd floor indoor CO. However, 32nd floor CO indoors is higher than the 3rd floor concentration. This "inversion" duplicates the phenomena noted for the daily average CO concentrations.

The outdoor/indoor differential relationships also increase as a function of outdoor CO level at the respective floors. Again an "inversion" occurs between the 23rd and 32nd floors. Figure 2.4-9 shows the average O/I relationships for both heating and non-heating weekdays. These O/I relationships are influenced by outdoor temperature as shown on Figure 2.4-10. The differentials become positive, i.e., outdoor CO higher than indoor CO, at lower outdoor CO levels at high temperature than at low site temperature. Since no temperature measurements are available to define indoor temperatures, it is assumed that indoor temperatures generally are higher than outdoor temperatures, especially at the higher floors during the heating season. It is felt that the resultant differential temperature contributes to the variation in outdoor/indoor relationships at the different floors.

As previously mentioned, the Trans Manhattan Expressway is the major source of CO at this site. Road and roof level winds distribute the Trans Manhattan Expressway generated CO in the open area between the two air rights buildings and the buildings along 178th and 179th Streets. Median strip CO level varies as a function of road wind direction and the traffic flow rate in the east and west bound lanes. Road wind that blow across the high volume traffic lanes toward the median produce high median CO levels. Winds blowing high volume traffic generated CO away from the median produce low median CO readings.

It should be noted that the other meteorological parameters, wind speed, wind turbulence and temperature lapse contribute to variations in median strip CO. However, these parameters generally vary as a function of wind direction. The contribution of these parameters are small in comparison to the

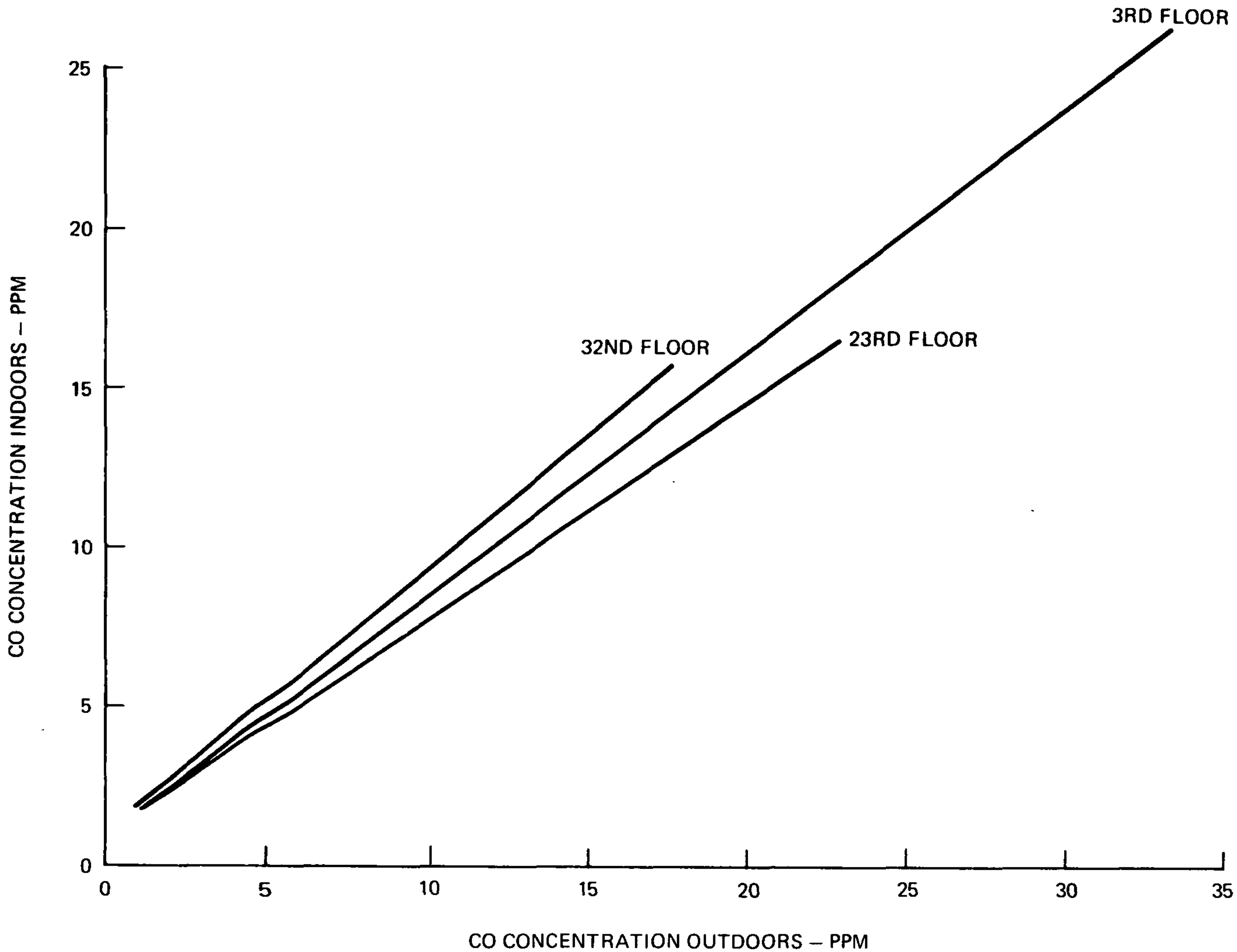


Figure 2.4-8. Indoor vs. Outdoor CO Concentrations - Site 1

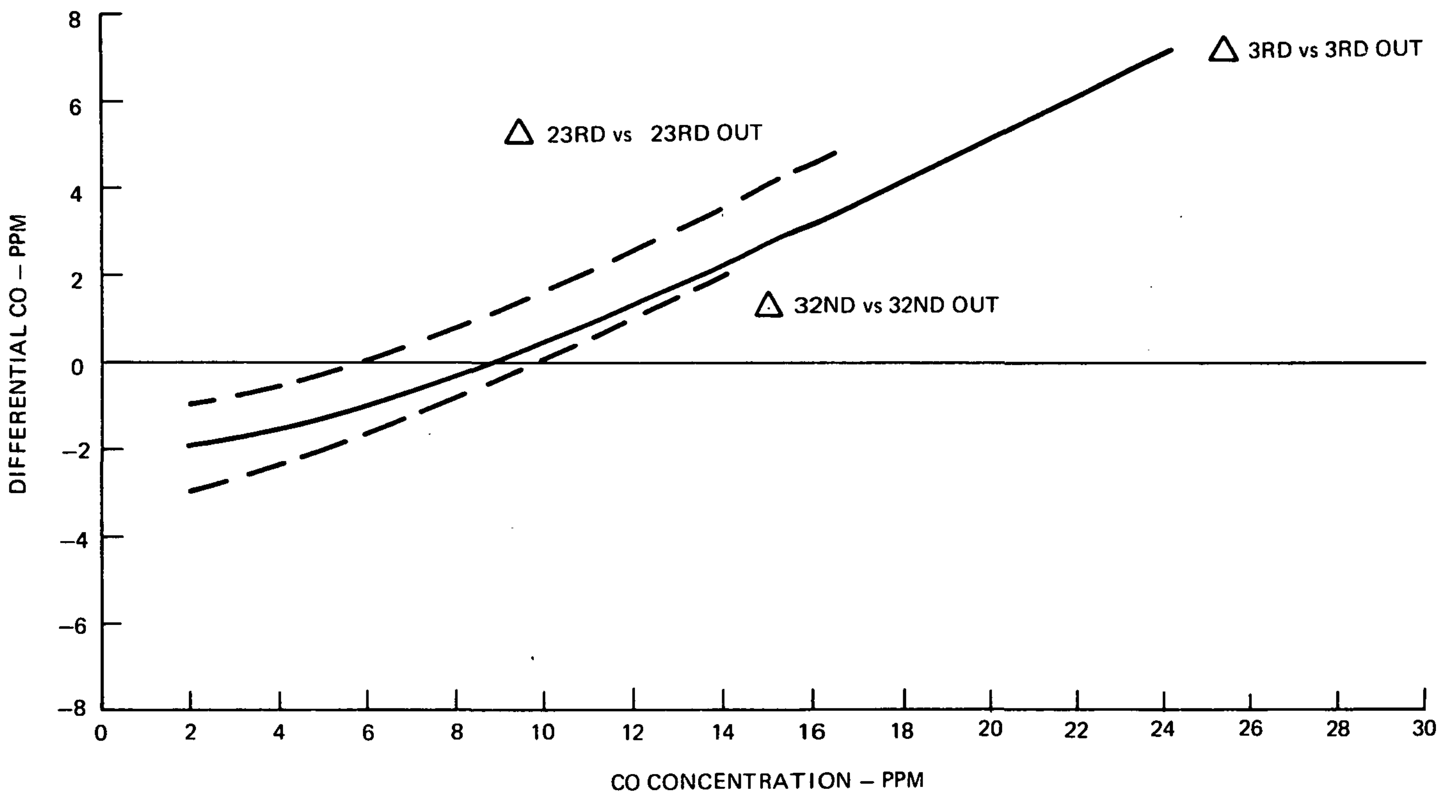


Figure 2.4-9. Differential CO vs. Outdoor CO - Various Floors - 6 pm - Weekdays - Site 1

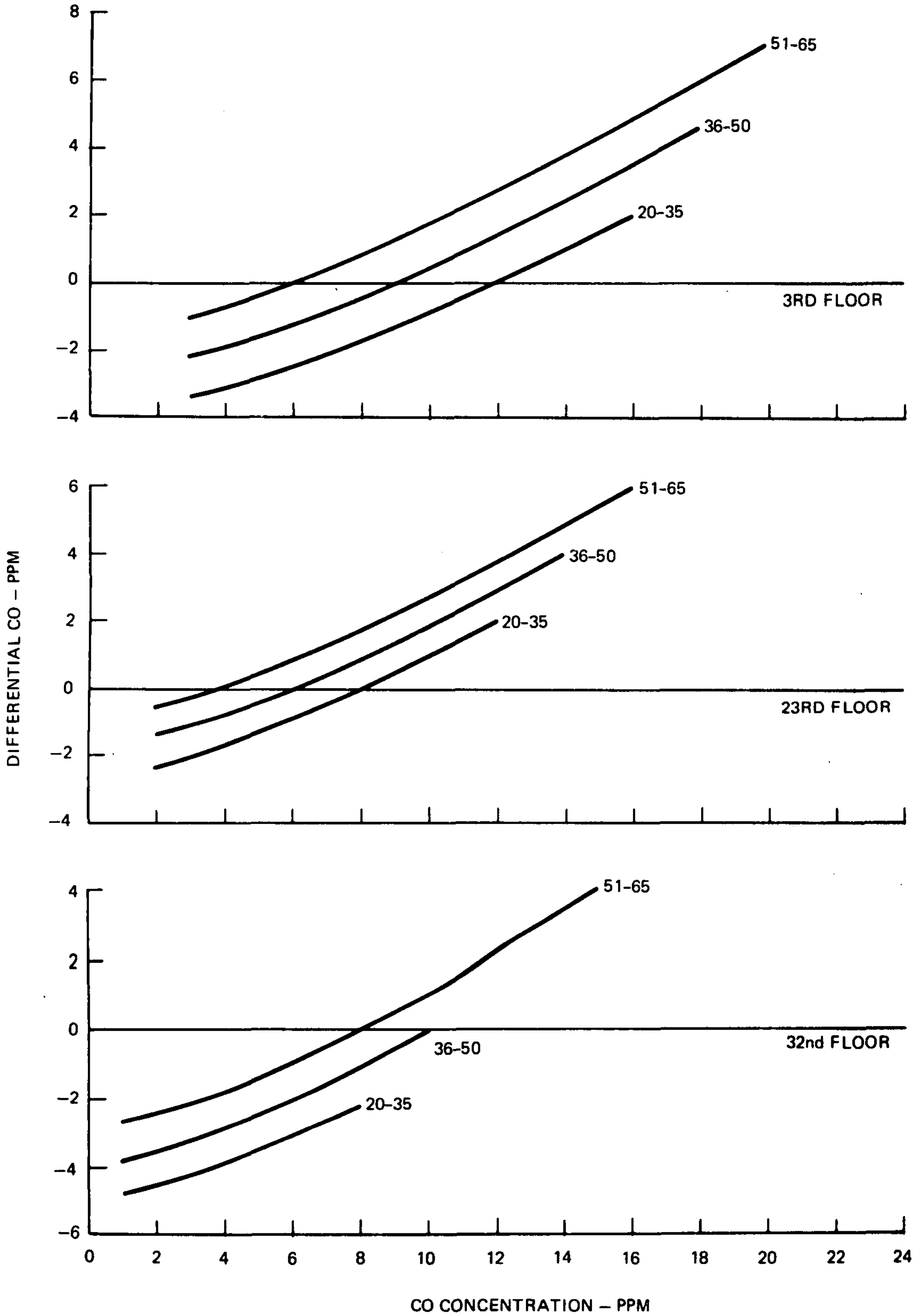


Figure 2.4-10. Differential CO vs. Outdoor CO & Site Temperature - Site 1

effect produced by changes in wind direction.

CO levels at any particular time as seen at the N. E. corner of the air rights buildings, both inside and outside, vary as a function of road wind direction and the volume of traffic on the Trans Manhattan Expressway. Highest building concentrations occur when high traffic flows west bound and the road wind blows directly at the sampling location from the west bound lanes. N. E. corner concentrations reduce when traffic and meteorological conditions vary from this "worst case" condition.

Average concentrations at the 3rd floor outdoor location are significantly lower than average median strip CO levels. The unusually large decay in concentration between the ground level and the third floor probe can be explained, at least in part, by noting that the probes at the third floor are set back over a deck configuration which precludes a line of site visibility between those probes and the traffic induced pollutants as they are dispersed upward.

Concentrations at the upper floors are strongly influenced by concentrations at the immediate lower floors and by the roof wind direction. High outdoor concentrations, and positive outdoor/indoor relationships, occur at both the 23rd and 32nd floors when the roof wind blows from behind the building towards the open space between the two air rights buildings. Roof winds from 300^{o} to 60^{o}, which blow towards the N. E. corner, produce low outdoor concentrations and negative indoor/outdoor relationships. It is felt that the CO concentrations rising from the Trans Manhattan Expressway are partially blown away and partially blown into the air rights structure by the northerly roof winds. The CO concentration levels react differently between floors at outdoor and indoor locations as a function of roof wind direction. This is explained in greater detail in Section 5.1.1.3.6

2.4.2 Hydrocarbons

Measurements were conducted at three elevations, the 3rd floor, for a period of time at the 32nd floor and at the 23rd floor. It was discovered early in the heating season that the 32nd floor apartment showed unusually high hydrocarbon levels because of very significant internal sources. Accordingly, these probes were moved to the GE leased apartment at the 23rd floor on November 23, 1971. Therefore, no non-heating season hydrocarbon data was take at the 23rd floor.

The diurnal curves of hydrocarbon concentration vs. traffic flow rate do not show an obvious correlation. The plots of concentration vs. traffic flow rate and speed, however, suggest a cause-effect relationship between concentrations measured outside the building and traffic emissions. This indication is strongest at the third floor and decreases with height. Diurnal temperature variations which, as shown on Figure 2.4-1, are time phase differently than diurnal traffic variations are the cause for this lack of correlation.

Meteorological parameters, rather than traffic conditions, appear to be the most significant factors in determining the hydrocarbon concentrations at the 3rd floor outdoor location of the air rights structure. Road wind direction and wind speed influence the amount of hydrocarbons transported from the Trans Manhattan Expressway to the base of the building. Outdoor hydrocarbons vary with road temperature, as shown on Figure 2.4-11. 3rd Floor indoor concentrations are random with outdoor temperature.

In general, hydrocarbon concentrations are higher at indoor locations than at outdoor locations. Concentrations indoors increase with outdoor concentrations. The relationship between indoor and outdoor hydrocarbons increases from the non-heating season to the heating season. Similarly, indoor hydrocarbon concentrations increase with respect to outdoor concentrations for both

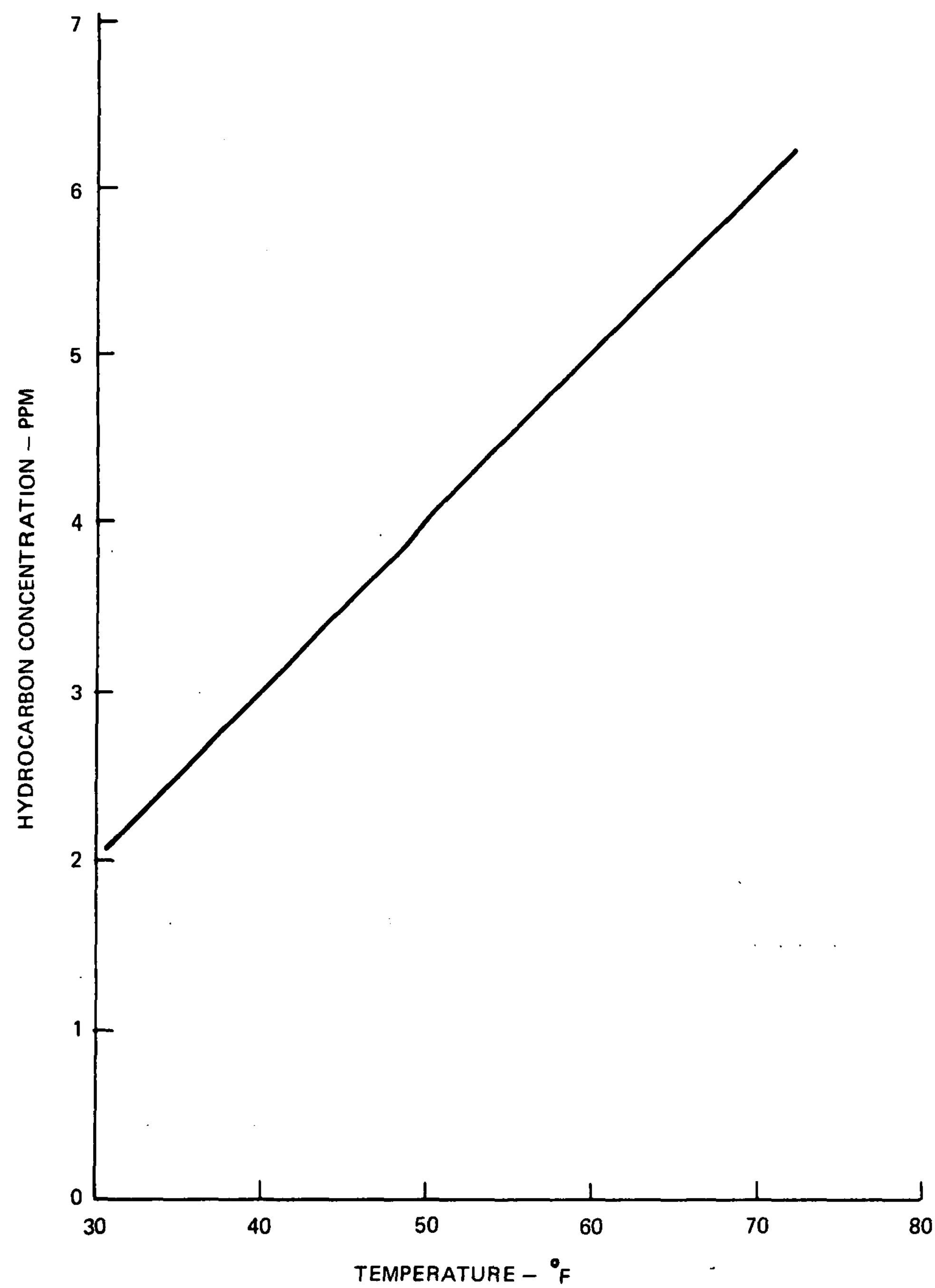


Figure 2.4-11. 3rd Floor Hydrocarbon Outdoors vs. Road Temperature - Site 1

seasons with height above the roadway. Figure 2.4-12 shows these indoor/outdoor relationships.

Differential hydrocarbon concentrations, outdoors to indoors, primarily are determined by indoor concentrations as presented on Figure 2.4-13. (The O/I differential when plotted against outdoor hydrocarbons displays a similar but significantly more random relationship. This may be caused by greater temperature variations outdoors than indoors.) As expected, the differential to indoor concentration relationships change with height above the roadway and from non-heating to heating seasons, indicating a strong temperature effect. Only the 3rd floor differential during the non-heating season displays positive levels, i.e., high outdoor hydrocarbons.

There are strong indications that internal sources contribute to the high indoor concentrations at the 32nd floor. Test personnel noticed that use of cooking stoves increased indoor concentrations significantly and we know that the family in the 32nd floor apartment complained of insufficient heat and frequently used the oven and stove to obtain additional heat. The similarity of 32nd floor O/I differential to indoor concentrations, shown on Figure 2.4-13 for both heating and non-heating seasons, suggest the high indoor hydrocarbons leak outwards to control the outdoor concentrations as measured right outside the apartment window.

The outdoor concentrations are responsive to diurnal traffic and temperature changes as shown on Figure 2.4-14 and -15 which show the vertical gradient between floors. Both figures show the rise and fall in 3rd floor hydrocarbon between 8 and 10 AM due to the morning rush hour traffic peak. This is followed by a secondary rise due to the increase in outdoor temperature.

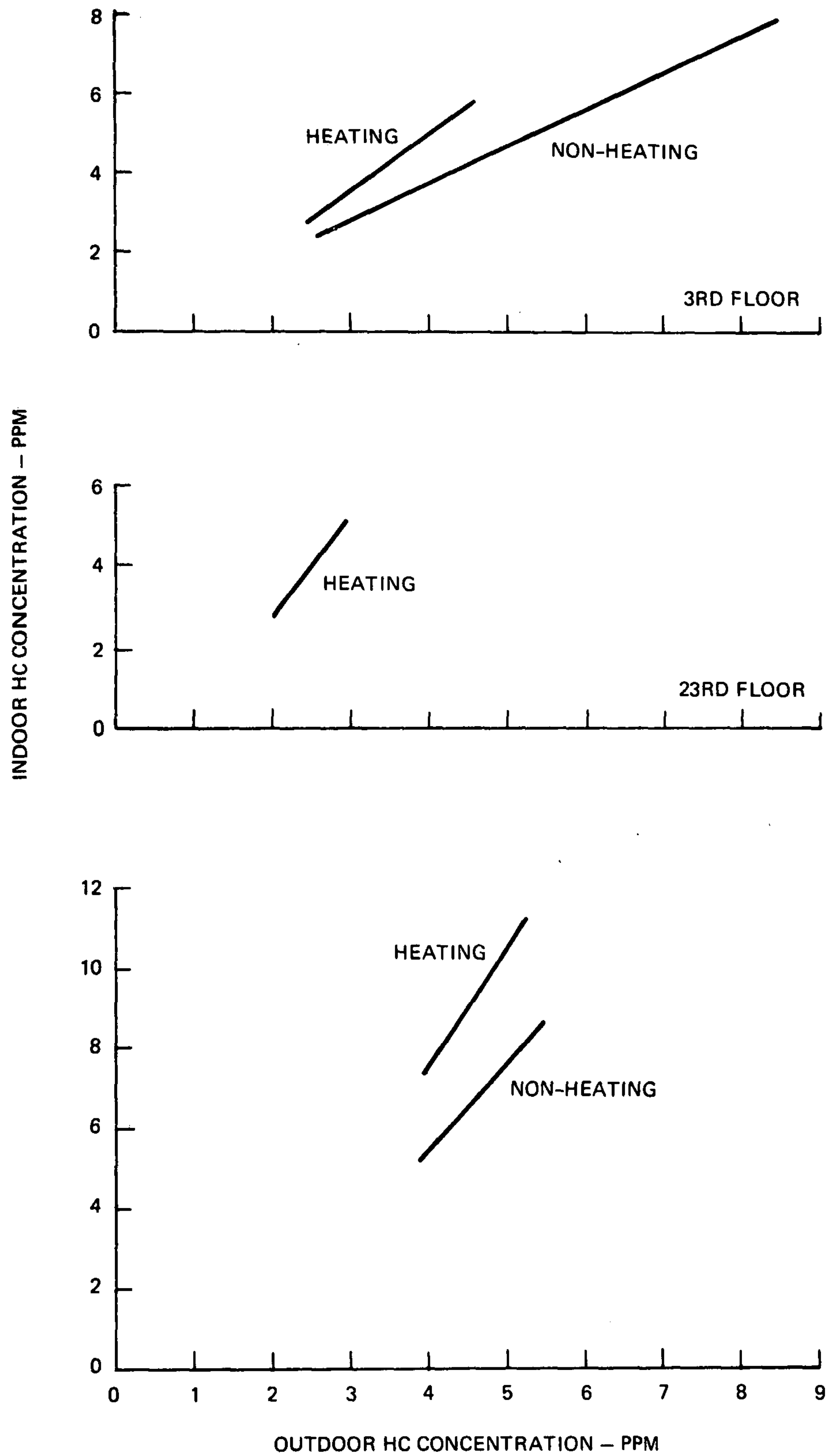


Figure 2.4-12. Indoor vs. Outdoor HC Concentration @ Floor - Diurnal Average - Site 1

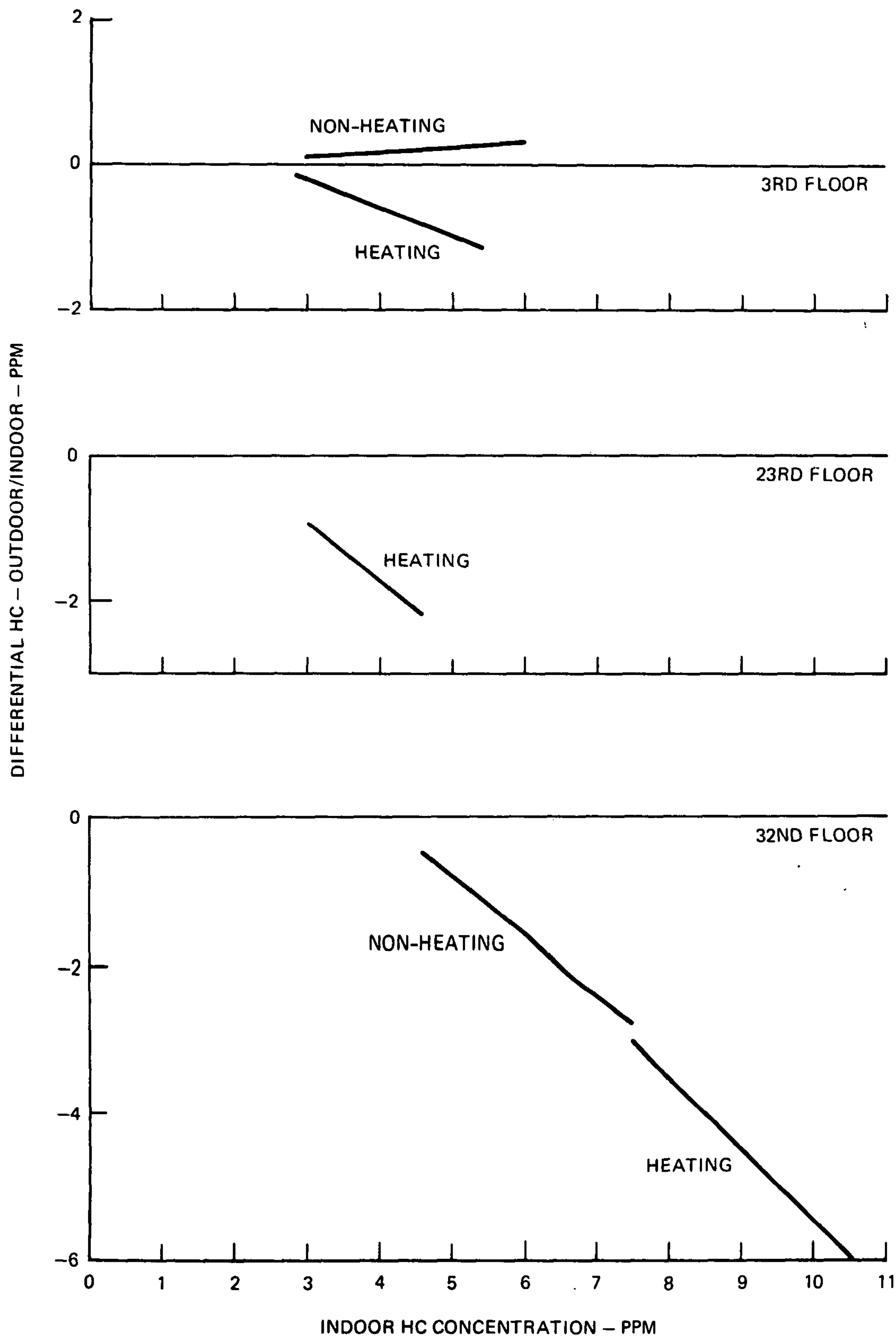


Figure 2.4-13. O/I HC Diff. vs. Indoor HC @ Floor - Diurnal Averages - Site 1

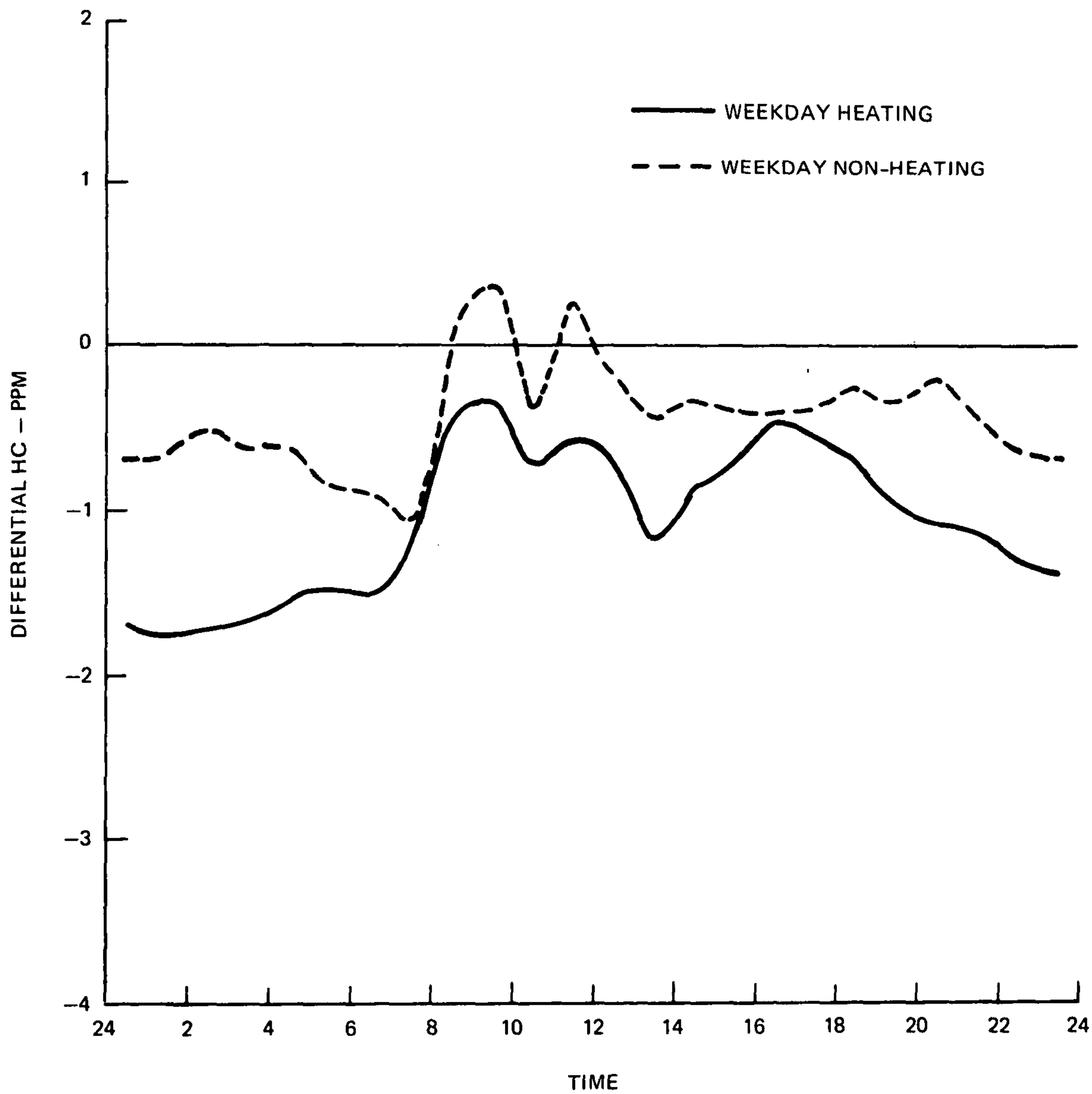


Figure 2.4-14. Diurnal Hydrocarbon Differential 3rd - 32nd Floor - Outside

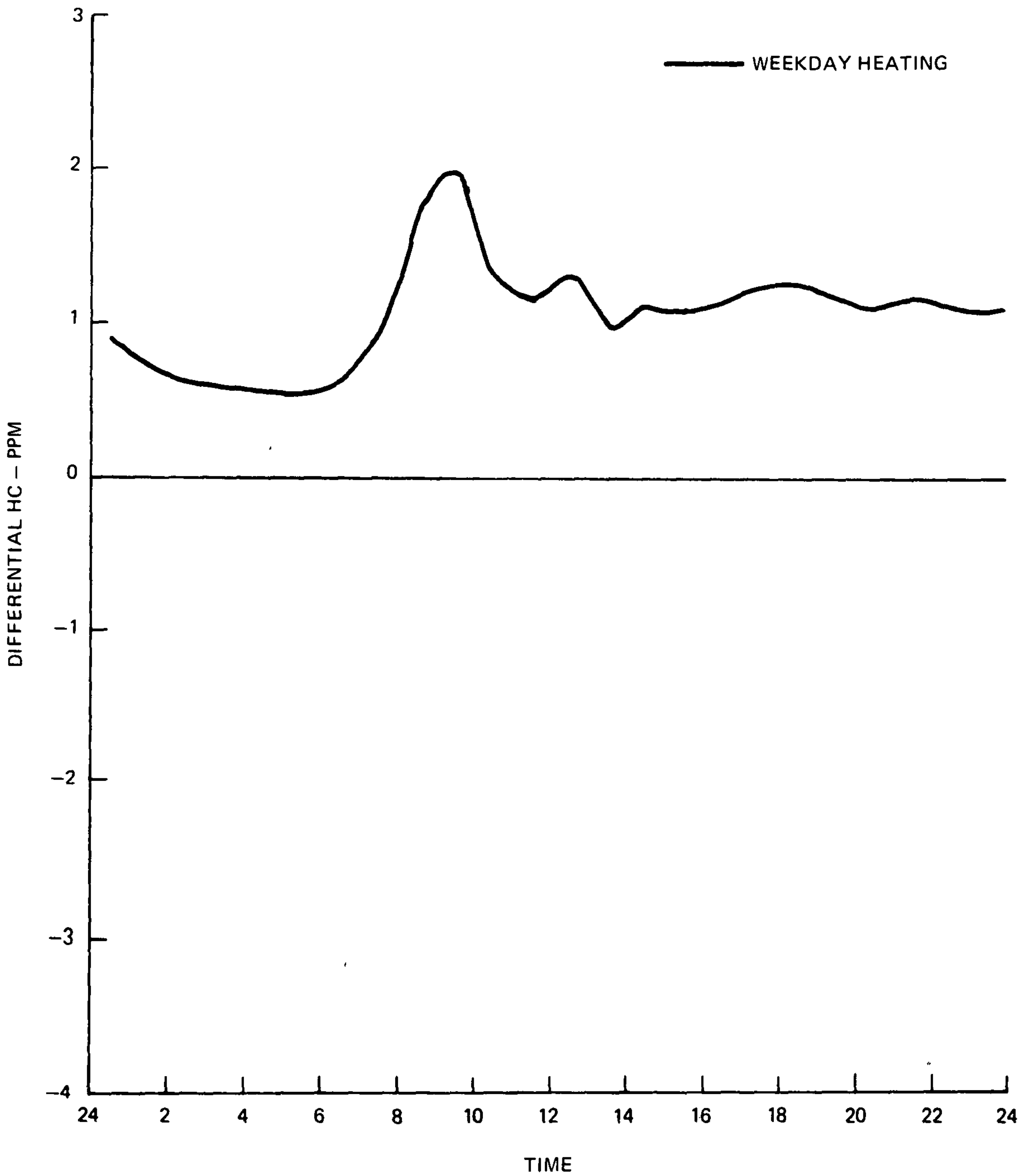


Figure 2.4-15. Diurnal Hydrocarbon Differential 3rd - 23rd Floor - Outside

2.4.3 <u>Particulate Concentration</u>

Approximately 90 particulate samplings were taken at the Washington Bridge Apartments between September 10, 1970 and January 12, 1971. The data was collected at two outdoor locations and four indoor locations. The data collected was organized according to heating and non-heating seasons. The mean values along with the concentration ranges from all the 24 hour samplings (excluding those inside the tower) are summarized in Tables 1 and 2 below.

Table 1 - Total Particulates, ug/M^3 (Mean Values)

	Outside		Inside		
	2nd Fl.	Roof	2nd Fl.	Roof	Boiler Rm.
Heating	160.9	102.9	56.1	90.4	112.9
Non-Heating	122.1	148.6	85.1	82.5	

Table 2 - Particulate Concentration Ranges - ub/M^3

	Outside		Inside		
	2nd Fl.	Roof	2nd Fl.	Roof	Boiler Rm.
Heating	86.6-287.6	50.3-243.6	29.4-105.6	57.4-142.4	75.9-184.8
Non-Heating	115.2-129.1	104.7-192.5	79.5- 90.7	82.5	

At this site, the particulate concentrations outside the test building were significantly higher than the inside particulate concentrations. The outside mean particulate concentration was 133.6 ug/M^3 while the inside was only 82.0 ug/M^3. This trend was shown during both heating and non-heating seasons. Both inside and outside particulate concentrations fluctuated greatly on a day to day basis indicating that daily changes in variables were of utmost significance.

During both seasons, the particulate concentration inside and outside the building exceeded the national primary ambient air standard of 260 ug/M^3 for particulates over a 24 hour sampling period only on December 14 and 28. The secondary standard of 150 ug/M^3 was exceeded outside nine out of a possible 20 days during the heating season. During the non-heating season, the secondary standard was exceeded outside once out of two days. The inside particulate concentrations for both seasons exceeded the secondary standard only once, on December 8 in the boiler room.

There was also no direct correlation between total particulates and traffic volume passing the test building. The poor correlation indicated that the total particulate concentrations are a function of other variables.

Concentration close to the roadway displayed a gradual change in level from the beginning to the end of the monitoring period. Second floor outdoor concentrations increased with time, while both 2nd floor indoor and boiler room particulate levels decreased. Roof level concentrations, however, varied independently with calendar time.

While the shift in particulate levels at the three ground level sampling locations indicates a temperature influence, graphical analysis showed that roof wind direction is the prime controlling factor at all locations.

Roof level particulates primarily originate from the building chimney. Both outdoor and indoor concentrations vary as the roof wind rotates about the chimney exhaust. Outdoor concentrations are high when the roof wind blows from 270° (from the chimney towards the outdoor sampler) and low at 90°. Indoor concentrations are the reverse.

Ground level particulates also vary as a function of roof level angle suggesting that chimney exhaust is the major particulate source. However, road wind angle and temperature also influence the concentrations at both the 2nd floor and boiler room locations.

At the roof level, the particulate differential outdoors to indoors is controlled by the roof wind angle. The outdoor differential from roof to 2nd floor is established by roof wind in essentially the same manner. These differential relationships are shown in the upper diagrams of Figure 2.4-16.

At the ground level, the indoor differential from the boiler room to the 2nd floor location also responds to roof wind. Second floor differential,

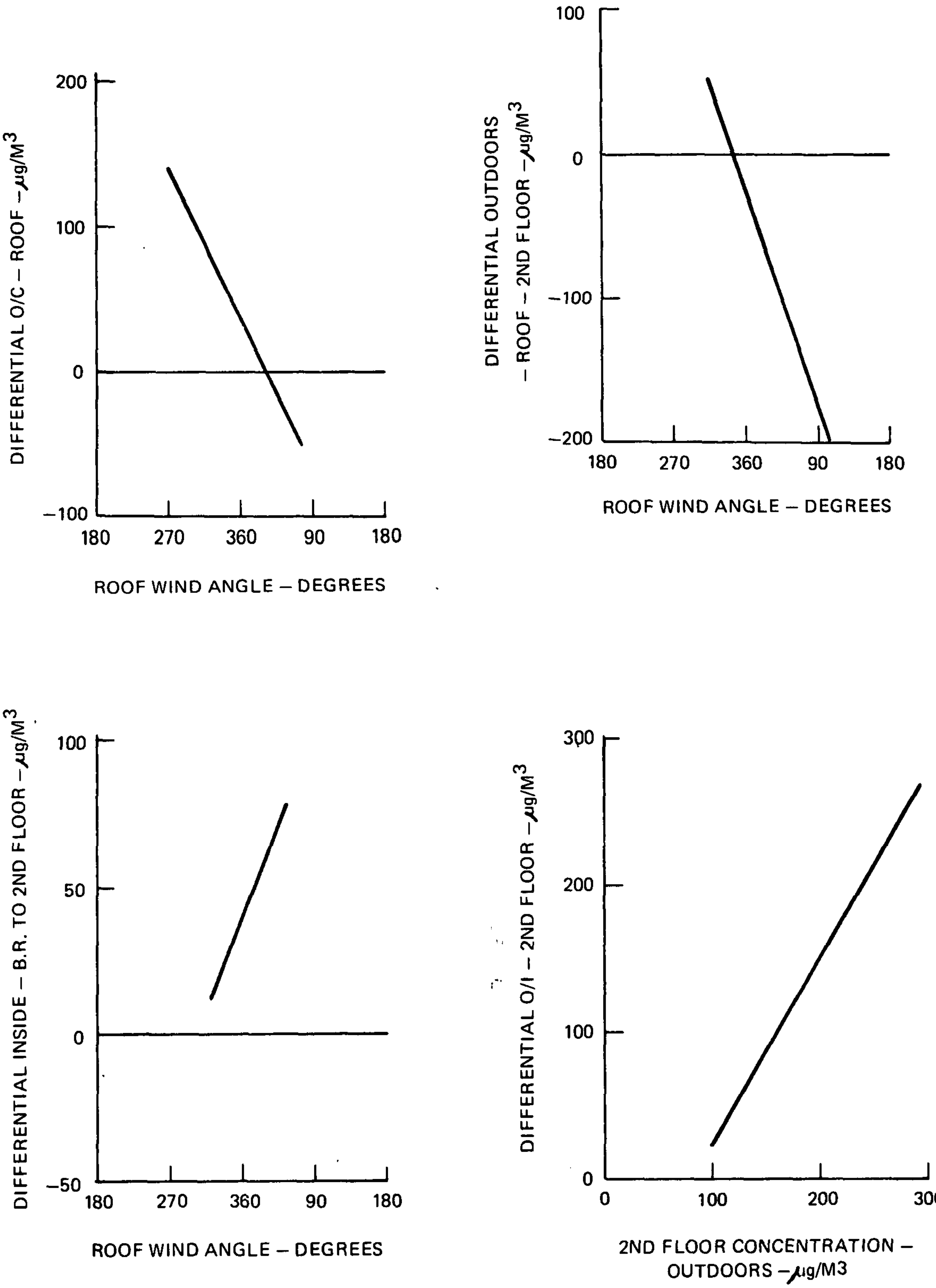


Figure 2.4-16. Particulate Differential Relationships - Site 1

outdoor to indoor, however, is basically a function of the particulate level at the outdoor location. The lower diagrams of Figure 2.4-16 show these relationships.

In summary, the building chimney is the major source of particulates at the air rights structure. The chimney exhaust is disbursed by the roof wind and settles to the ground level. Road winds then further distribute these and road generated particulates.

2.4.4 Lead Concentrations

All total particulate samples collected at the Washington Bridge Apartments site were analyzed for lead content using an atomic absorption technique. The results are summarized according to mean values and concentration ranges as shown in Tables 1 and 2.

Table 1 - Lead Concentration, ug/M^3 (mean values)

	Outside		Inside		
	2nd Fl.	Roof	2nd Fl.	Roof	Boiler Room
Heating	3.45	1.47	1.42	1.58	3.999
Non-Heating	1.89	1.30	1.51	1.42	-
		% Lead (mean values)			
Heating	2.30	1.53	2.40	1.77	3.60
Non-Heating	1.57	0.98	1.74	1.10	-

Table 2 - Pb Concentration Ranges

Heating	1.61-6.35	0.52-2.68	0.38-3.29	0.72-2.25	2.61-5.87
Non-Heating	1.69-2.09	1.18-1.41	1.05-1.96	1.42	
		% Lead Ranges			
Heating	1.20-2.50	0.73-3.10	1.20-5.40	0.60-3.90	2.90-4.80
Non-Heating	1.31-1.82	0.61-1.35	1-32-2.16	0.47-1.73	-

The lead concentrations at the 2nd floor outside and boiler room locations were significantly higher than at the other four sampling positions. The similarity of lead concentration in the boiler room to that outside the second floor indicates a common source, probably at ground level. Concentrations varied significantly from day to day at all three locations close to the roadway. However, roof level concentrations generally displayed less fluctuation. Concentrations increased at all locations from the beginning of the monitoring program to reach their peak levels about December 1. Lead levels decreased after that date to approximately the same values measured at the beginning of the monitoring period. This reversal is primarily due to the shift in wind direction from east, through north and to the west and then back to the north. This wind change was previously shown on Figure 2.2-1.

Examination of the average lead concentrations for both heating and non-heating seasons showed the vertical concentration, 2nd floor to roof, decreased with height outdoors. Indoor concentrations, however, increased with height from the 2nd floor to roof level.

Roof level lead concentrations do not originate, as seen for total particulates, from the building chimney. Both outdoor and indoor concentrations vary with the roof wind angle in the same fashion. Concentrations are high at both locations when the roof wind blows from 270° and low for roof winds from 90° as shown in the upper diagrams of Figure 2.4-17. The roof level outdoor/indoor differential is basically random with roof wind angle. Similarly roof to 2nd floor differentials, both outdoors and indoors are random with both roof and road level wind directions.

Second floor concentrations do not display a definite relationship to wind angle. However, it appears that the outdoor concentration and the outdoor/indoor differential peak when the road wind blows from approximately

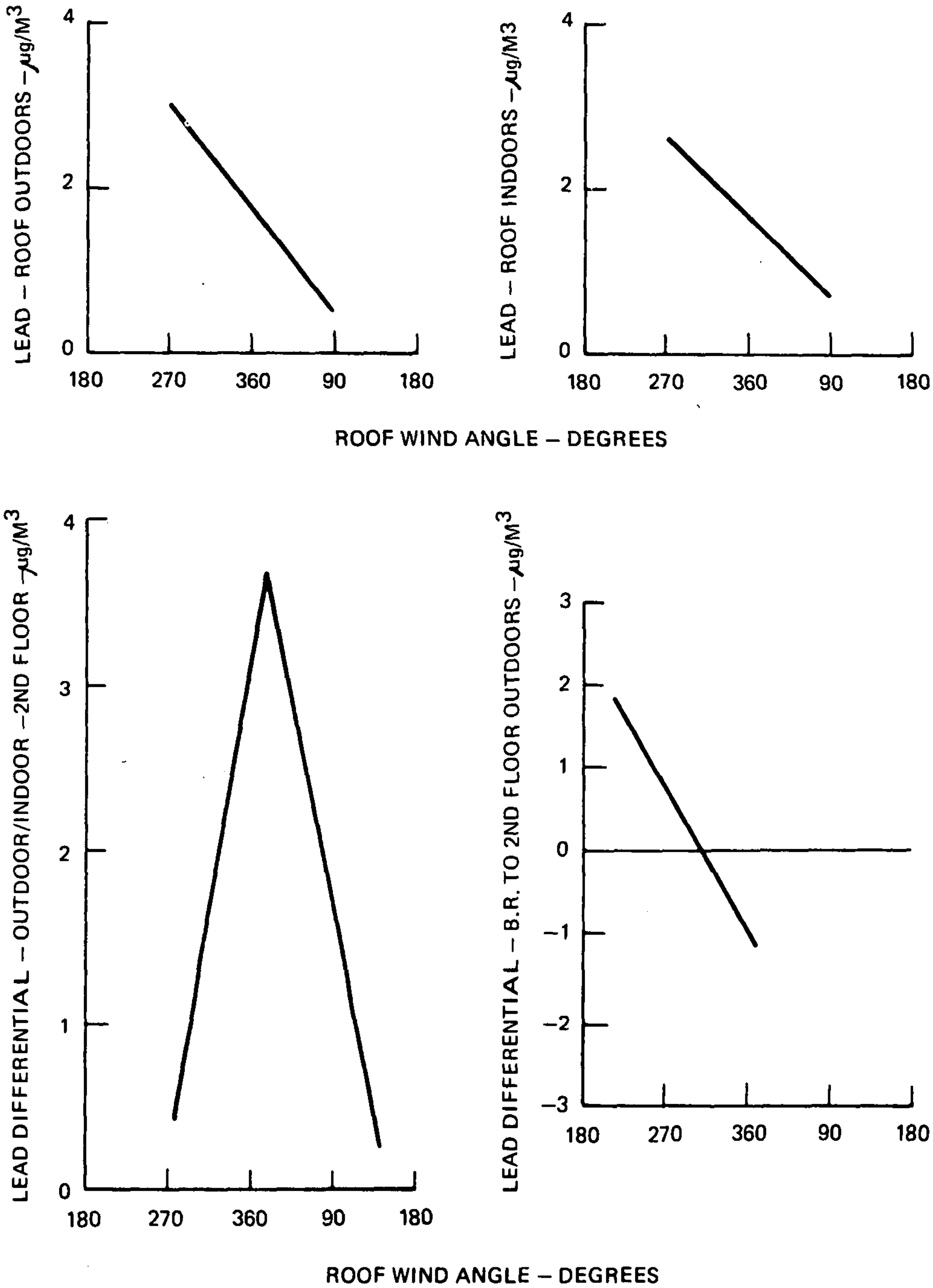


Figure 2.4-17. Lead Differential Relationships - Site 1

20° and drops rapidly as the wind shifts in either direction. Road wind also controls the differential between the boiler room and the 2nd floor outdoor location in the same fashion. These relationships are shown in the lower diagrams of Figure 2.4-17.

The average percent lead was found to be higher at the low level locations than at roof level. Daily lead percentages fluctuated more than the lead concentration at all sampling locations. In general, higher percentages occurred for road and roof wind angles of 300°. These factors strongly indicate that the Trans Manhattan Expressway is a major source of lead at the air rights structure.

Figure 2.4-18 presents comparative plots of the lead and lead percentage differentials as a function of roof wind direction. Both the roof level outdoor/indoor and roof to 2nd floor indoor differentials respond to roof wind in opposite fasions, further suggesting that the lead source is ground originated and total particulates emanate at roof level.

In summary, traffic is the major source of lead at this site. Road and roof winds distribute the lead. Since the major particulate source is non-traffic related, the percentage of lead at any sampling location varies as a function of the total particulates and roof and road wind direction.

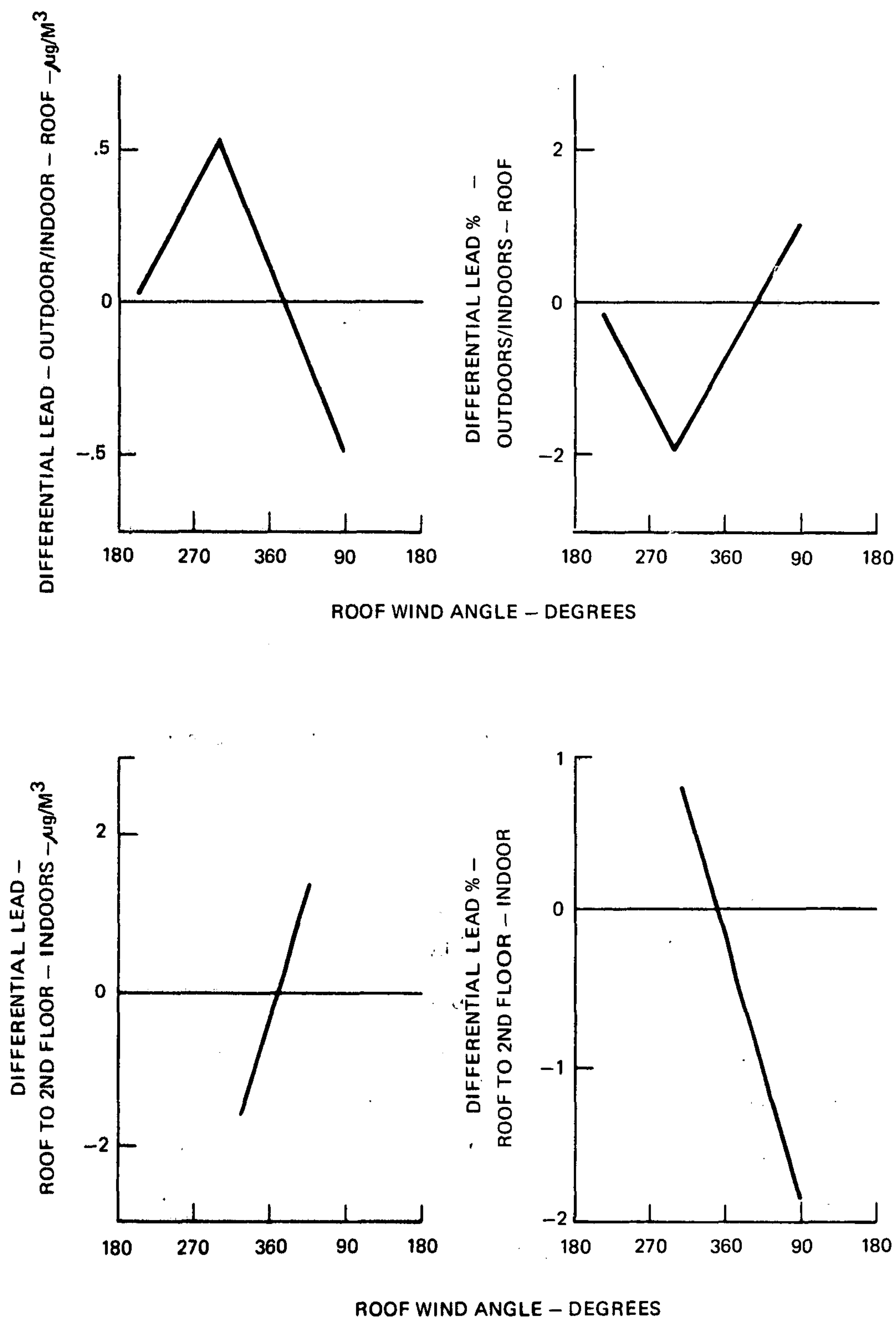


Figure 2.4-18. Lead and % Lead Differential Relationships - Site 1

2.5 Summary of Site 2 Results

The pollution levels at the West 40th Street site are generated by three sources. These are: traffic on West 40th Street, sources internal to the building and sources in the general area to the south and west of the building. These three sources influence the pollution levels both outdoors and indoors. The concentration levels at individual locations are established by these sources and wind currents at the site.

The average carbon monoxide and hydrocarbon concentrations decreased significantly from road to upper floor levels for both seasons and at both indoor and outdoor locations. However vertical distance generally did not affect total particulate and lead concentrations. All four pollutants displayed large differences between indoor and outdoor concentrations. The average levels for the four pollutants on weekdays for both the heating and the non-heating seasons are listed in Table 2.5-1 and -2. It will be noticed that while indoor carbon monoxide and hydrocarbons levels were generally higher than outdoor levels during the heating season, only hydrocarbons were higher indoors during the non-heating season.

Neither carbon monoxide nor hydrocarbon average hourly levels displayed diurnal variations which decisively indicate their relationship to 40th Street traffic patterns. From Figure 2.5-1 it can be seen that weekday traffic profile is characteristic of a one way street while CO closely portrays a two way roadway. The diurnal CO peaks occur slightly later in the day than typical for morning and evening rush hour times, indicating that traffic generated CO from adjacent streets contributes to the carbon monoxide levels at this site. Hydrocarbons appear to be totally independent of 40th Street traffic. While there is a slight suggestion that site temperature influences the hydrocarbon diurnal profile from 4 AM to 4 PM, the lack of response to both traffic and temperature reductions in the latter part of the day strongly indicates the presence of a non traffic related hydrocarbon source.

TABLE 2.5-1

Carbon Monoxide
Weekday Measurements
Site 2

	9' South		9' North		3rd Floor		5th Floor		11th Floor		19th Floor	
	Ave. ppm	Peak ppm	Ave. ppm	Peak ppm	Ave. ppm	Peak ppm	Ave. ppm	Peak ppm	Ave. ppm	Peak ppm	Ave ppm	Peak ppm
	Ex. Pri.	Ex. Sec.	Ex. Pri.	Ex. Sec.	Ex. Pri.	Ex. Sec.	Ex. Pri.	Ex. Sec.	Ex. Pri.	Ex. Sec.	Ex. Pri.	Ex. Sec
Heating Season												
Out-side	11.2	46.6	11.2	51.2	9.9	45.0	7.7	33.8	6.6	25.8	5.4	24.6
	59.3	1.1	62.1	0.4	47.5	0.4	28.0	0	20.4	0	7.8	0
In - side	NA	NA	NA	NA	9.5	34.5	7.8	25.3	6.9	25.3	6.8	30.7
	NA	NA	NA	NA	47.6	0	29.2	0	20.2	0	17.4	0
Non Heating Season												
Out-side	11.2	39.4	10.8	37.8	10.3	37.3	8.1	35.2	4.8	21.1	4.2	18.3
	55.8	0.5	60.4	0.2	48.8	0.2	36.0	0.2	8.4	0	1.4	0
In - side	NA	NA	NA	NA	8.2	30.0	7.1	22.1	4.7	15.6	3.8	13.4
	NA	NA	NA	NA	33.0	0	28.3	0	5.2	0	1.2	0

Ex. Pri. = Frequency exceeding 9 ppm averaged over 8 hr. period

Ex. Sec. = Frequency exceeding 35 ppm over 1 hr. period

TABLE 2.5-2
HYDROCARBONS - PARTICULATES - LEAD
WEEKDAY MEASUREMENTS
SITE 2

HEATING SEASON

	3RD FLOOR Ave ppm	3RD FLOOR Peak ppm	11TH FLOOR Ave. ppm	11TH FLOOR Peak ppm
OUTSIDE	4.5	14.3	1.9	7.9
INSIDE	10.4	34	2.4	15.5

	MEAN PARTICULATE CONCENTRATION ug/M³		MEAN LEAD CONCENTRATION ug/M³	
	3RD FLOOR	ROOF	3RD FLOOR	ROOF
OUTSIDE	123.2	123.9	1.42	1.45
	11TH	18TH	11TH	18TH
INSIDE	65.7	66.8	0.81	0.98

NON-HEATING SEASON

	3RD FLOOR Ave ppm	3RD FLOOR Peak ppm	11TH FLOOR Ave. ppm	11TH FLOOR Peak ppm
OUTSIDE	4.8	11.7	2.4	6.8
INSIDE	8.1	30.9	2.8	13.1

	MEAN PARTICULATE CONCENTRATION ug/M³		MEAN LEAD CONCENTRATION ug/M³	
	3RD FLOOR	ROOF	3RD FLOOR	ROOF
OUTSIDE	147.1	144.1	2.25	1.57
	11TH	18TH	11TH	18TH
INSIDE	92.9	64.0	1.81	1.17

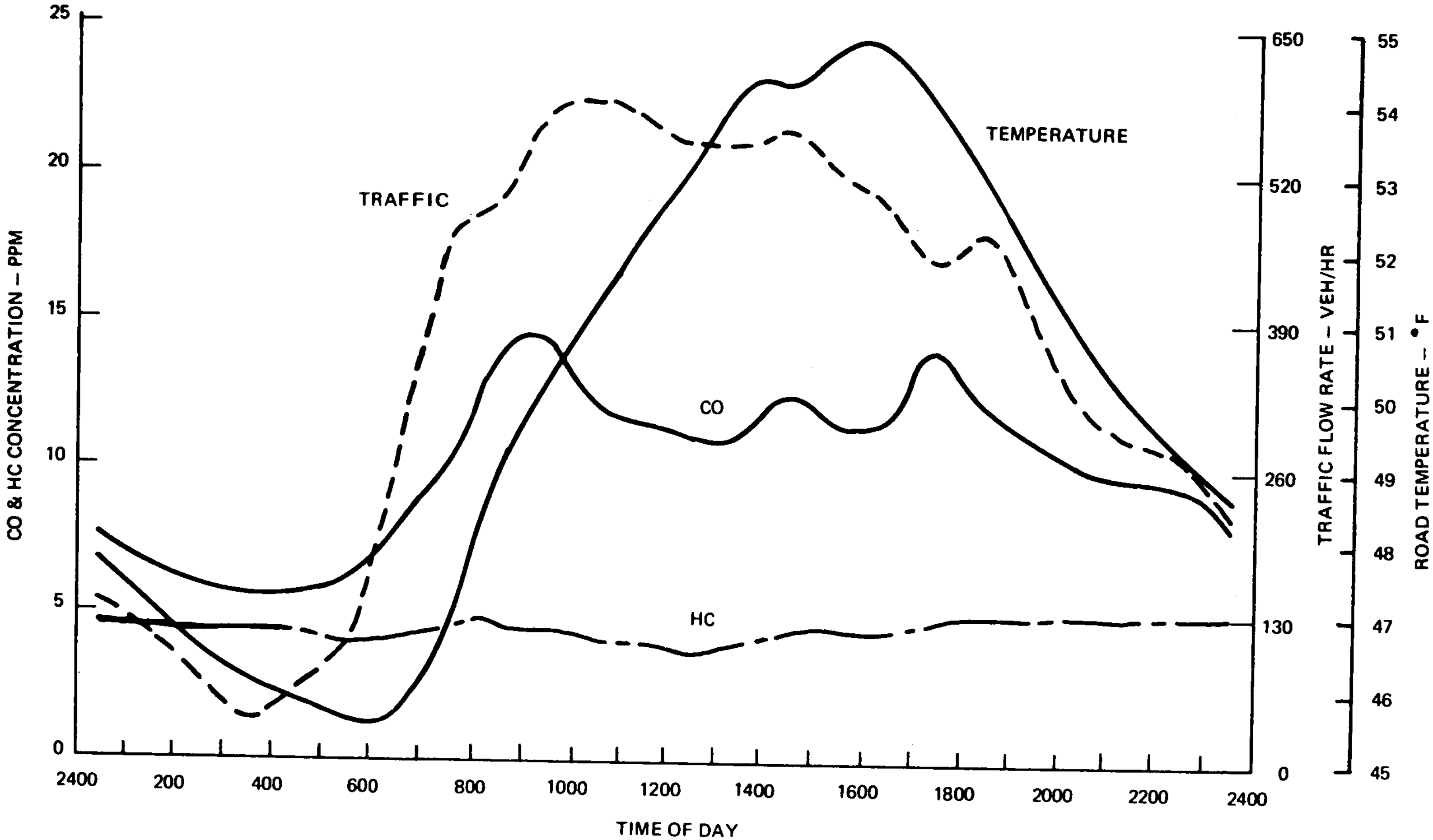


Figure 2.5-1. Diurnal Traffic. CO & HC - 3rd Floor - Heating Weekday - Site 2

Since West 40th Street is a one way street, the general shape of the diurnal traffic parameters are basically the same weekdays and weekends. Weekday traffic is somewhat higher than that on weekends for both the heating and non-heating seasons. The correlation between traffic on 40th Street and both CO and hydrocarbons is considerably weaker than seen at the Trans Manhattan Expressway site. As shown on Figure 2.5-2, the averaged diurnal data for CO at road level and the 3rd floor outdoor locations display similar linear relationships to traffic flow rate while hydrocarbon is independent.

The relative concentration levels of the four pollutants as measured at the two different outdoor locations at the 3rd floor level for the days of particulate sampling is shown on Figure 2.5-3. Generally the four pollutants show very similar fluctuations on a day to day basis during the monitoring period, but little or no change in level from the start to the end of the program. Since, as previously shown on Figure 2.2-5, site temperature generally rises during the monitoring period, the apparent differences in 3rd floor outdoor pollution levels between the heating and non-heating seasons are indicative of daily rather than seasonal variations.

Road level wind direction and the location of the pollutant sampler both influence the 3rd floor outdoor concentration levels. Figures 2.5-4 and -5 show the relationship of the four pollutants to road level wind. The variation in concentration level is small for all pollutants for westerly winds which blow along 40th Street. Higher, and more randon, levels occur for southerly winds. As shown by the constant temperature lines, much of this randomness is the result of a general increase in site temperature.

Figure 2.5-6 shows the relationship between daily averages of the two sets of pollutants. The relationships are comparable to those seen at the Trans Manhattan Expressway site.

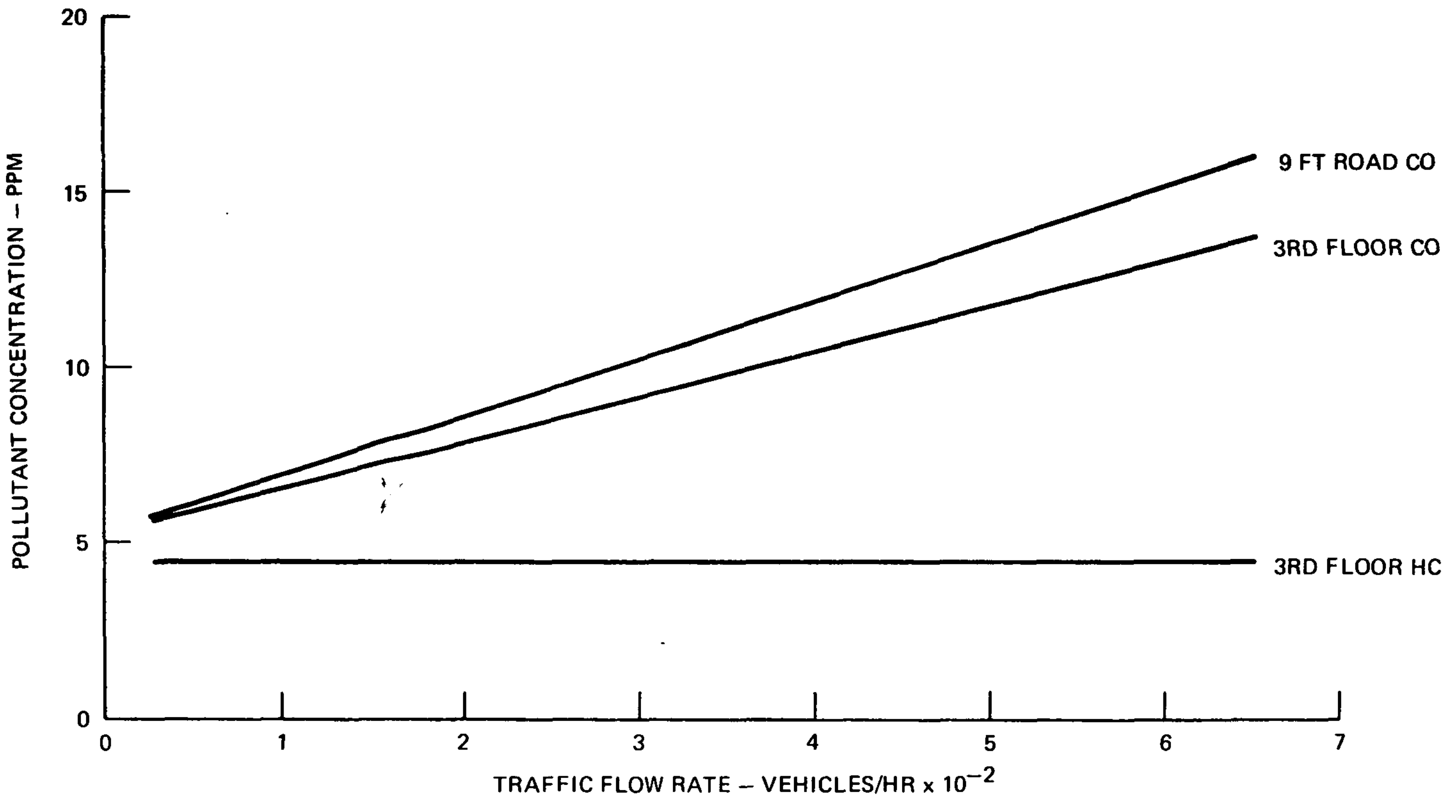


Figure 2.5-2. HC & CO Concentrations Vs. Traffic Flow Rate - Heating Weekdays - Site 2

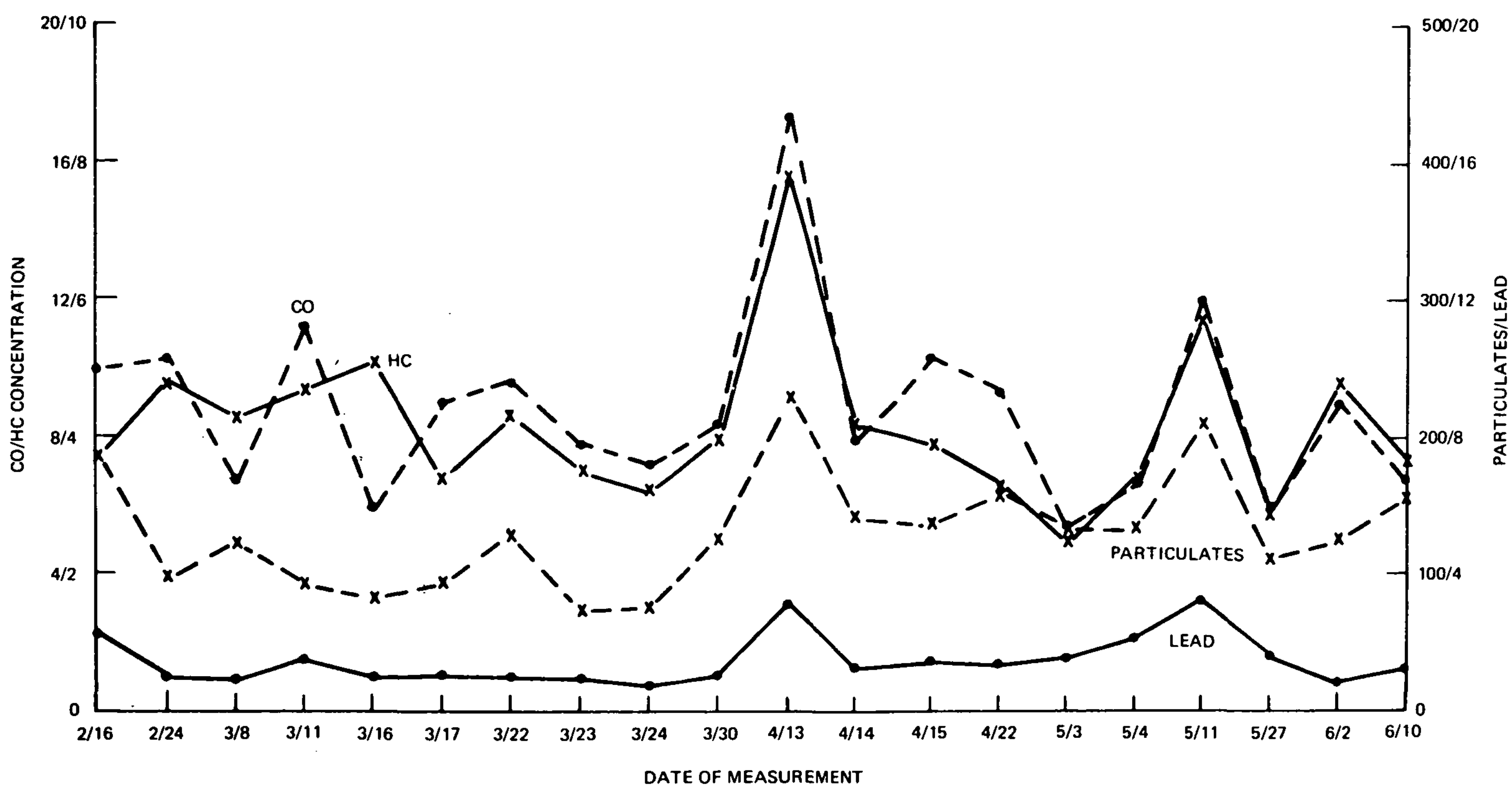


Figure 2.5-3. Pollutants - 3rd Floor Outdoors - Site 2

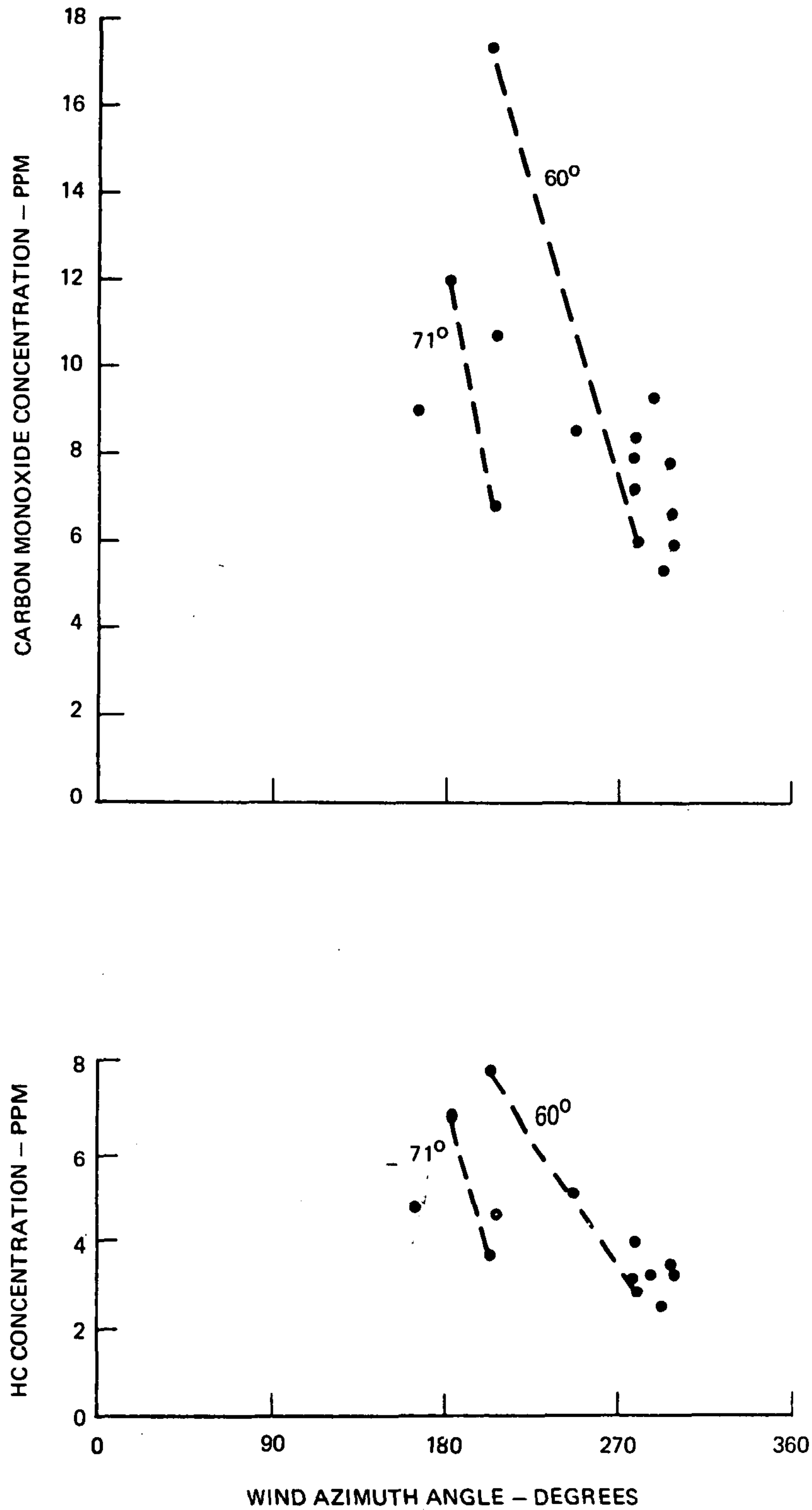


Figure 2.5-4. CO & HC Concentration Vs. Road Level Wind - Site 2

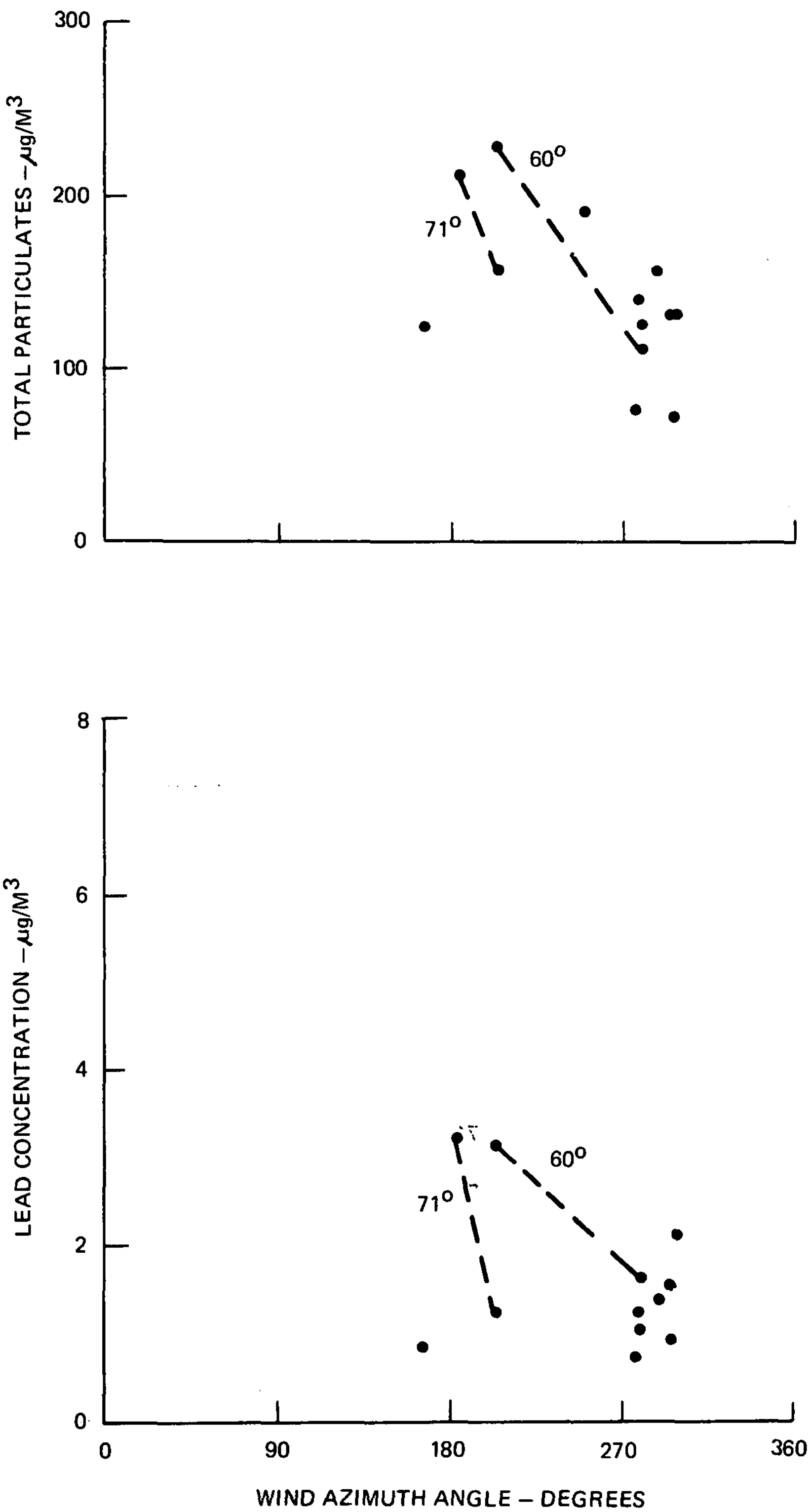


Figure 2.5-5. Particulates & Lead Concentration Vs. Road Level Wind - Site 2

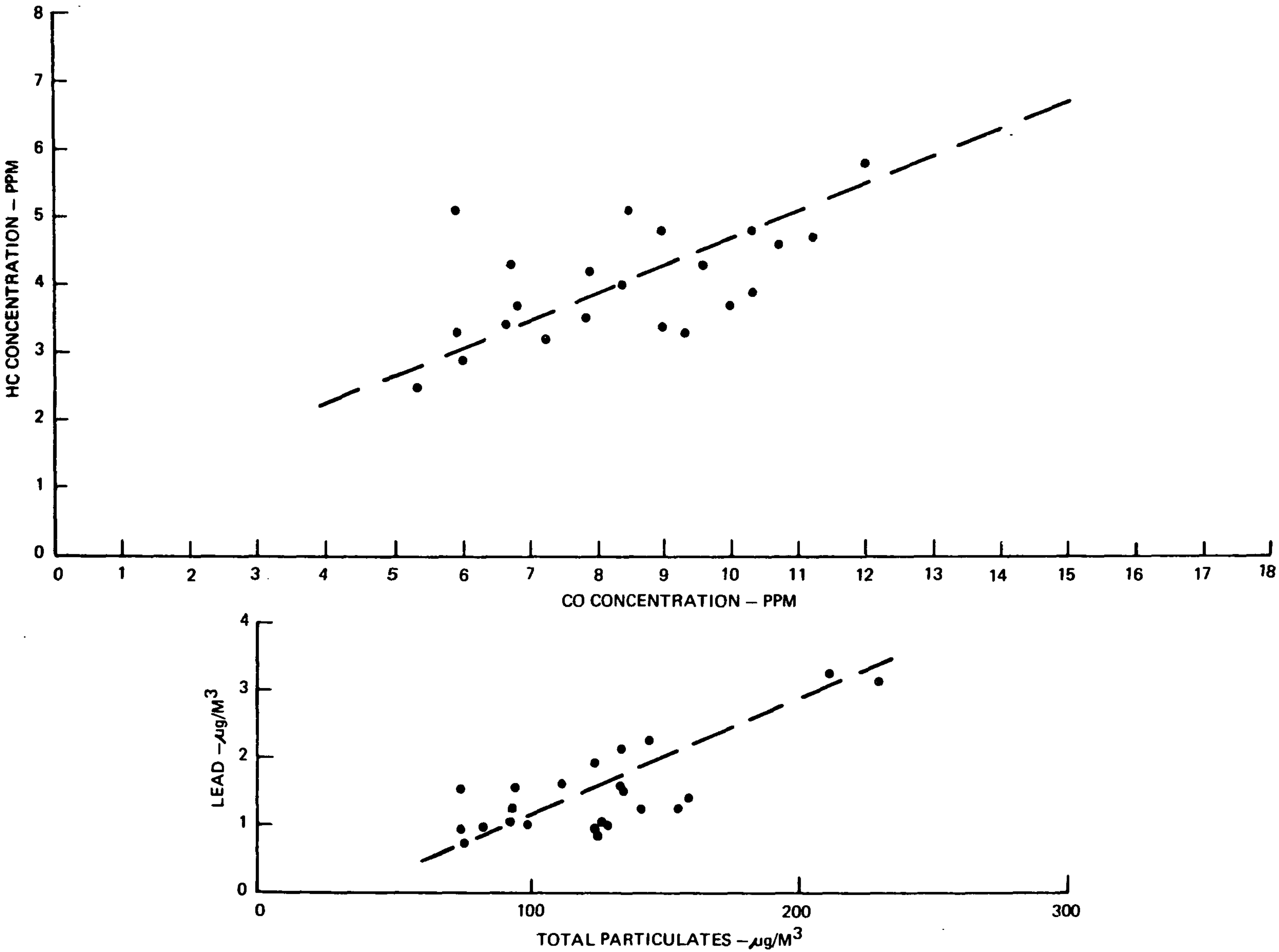


Figure 2.5-6. Pollutant Relationships - Daily Data - Site 2

The averages of 3rd floor pollutants for the two analytical approaches are shown below. These averages are essentially alike.

	CO	HC	Part	Lead	Traffic
	ppm		ug/m³		Veh / Hr.
Heating Season Daily Ave.	9.9	4.5	123	1.4	357
Selected Days 24 Hr. Ave.	8.8	4.2	129	1.5	353

2.5.1 Carbon Monoxide

CO measurements were made at the 40th Street site at five elevations; 9 ft. above road level, 3rd floor, 5th floor, 11th floor and 19th floor. 106 days of CO measurements were taken during the heating season and 32 days data was obtained during the non-heating season.

The primary Federal Standard of 9 ppm was exceeded approximately 60% of all monitoring hours at the 9 ft. level. The secondary standard of 35 ppm one hour average was only exceeded 1% of the time at that level. The primary standard was exceeded by lesser percentages at the various building locations as shown in Table 2.5-1.

Hourly average CO measurements taken at the 9 ft. level show a general correlation with 40th Street traffic characteristics. However, the weekday diurnal CO profiles have a double peaked configuration which do not correspond to the single peaked diurnal traffic flow rate profile. The CO peaks do correspond with double valleys in the weekday 40th Street traffic velocity diurnal curve. Similarly the weekend traffic and CO diurnal profiles do not peak simultaneously. It is therefore evident that other traffic, probably on 8th Avenue, contributes to the CO concentrations at this canyon-like site.

The vertical concentration decay is exponential from the 9ft level to the 19th floor both outdoors and indoors and during both heating and non-heating seasons. At road level, the concentration gradient across the road is negligible during the heating season. The average CO level on the north side of the road is slightly lower than that on the south side during the non-heating season when the general wind flow is from the south and perpendicular to 40th Street. Concentrations at the various building levels show diurnal profiles very similar to those at street level but at generally lower magnitudes. The outdoor concentrations display reasonable correlation with traffic between 6 PM and 8 AM. However, as shown on Figure 2.5-7, the CO/traffic relationship during the midday period is significantly different

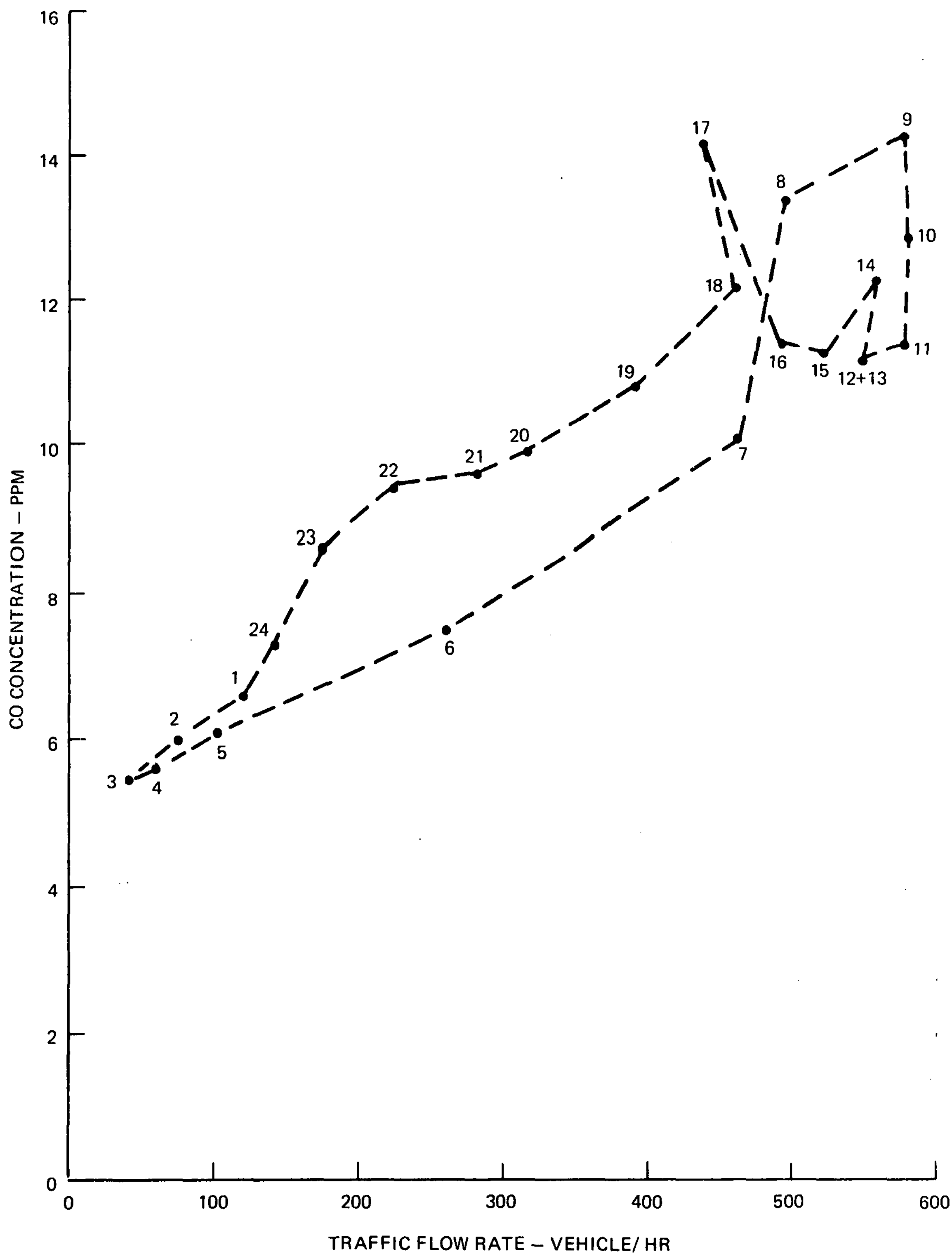


Figure 2.5-7. Diurnal CO 3rd Floor Outdoors Vs. Diurnal Traffic - Site 2

from that seen at the Trans Manhattan Expressway site.

The indoor concentrations at each building floor increase essentially linearly with outdoor concentrations at that floor. The 40th Street structure displays the same characteristic of greater indoor concentrations per outdoor concentration at the upper floor. This is indicated on Figure 2.5-8.

The outdoor/indoor differential relationships at this site vary as a function of outdoor CO levels. The average heating weekday conditions are displayed on Figure 2.5-9. The O/I differential relationship at each floor is modified by site temperature. Appreciably higher differentials, lower indoor concentrations, occur with increases in site temperature. The change with temperature, as shown on Figure 2.5-10, appears greater than seen at the air-rights structure.

In winter, the density difference between heated indoor air and cold outdoor air provides the force which controls the indoor-outdoor pollution relationship. In summer, the wind provides this control. The effect in winter may be likened to a "stack." Cold air enters lower floors to replace rising warm air which leaks out through roof openings and open windows on the upper floors. The entering air carries relatively high CO concentrations into the building from ground level on 40th Street. These concentrations rise through the building with the thermally induced circulation, receiving relatively little dilution compared to the turbulent mixing occurring outdoors. Interior sources such as oil-fired boilers and open gas flames may also provide some small contribution. This type of circulation in the building accounts for equal indoor-outdoor concentrations at the lowest floor and higher indoor concentrations at upper floors. It also accounts for the phase lag between indoor and outdoor concentrations at the upper floors because the vertical transport within the building through elevator shafts and the like would tend to be slower than the free transport and diffusion occurring outdoors.

Carbon monoxide levels were lower indoors during the non-heating season due to the influence of a different circulation regime. During this season, the

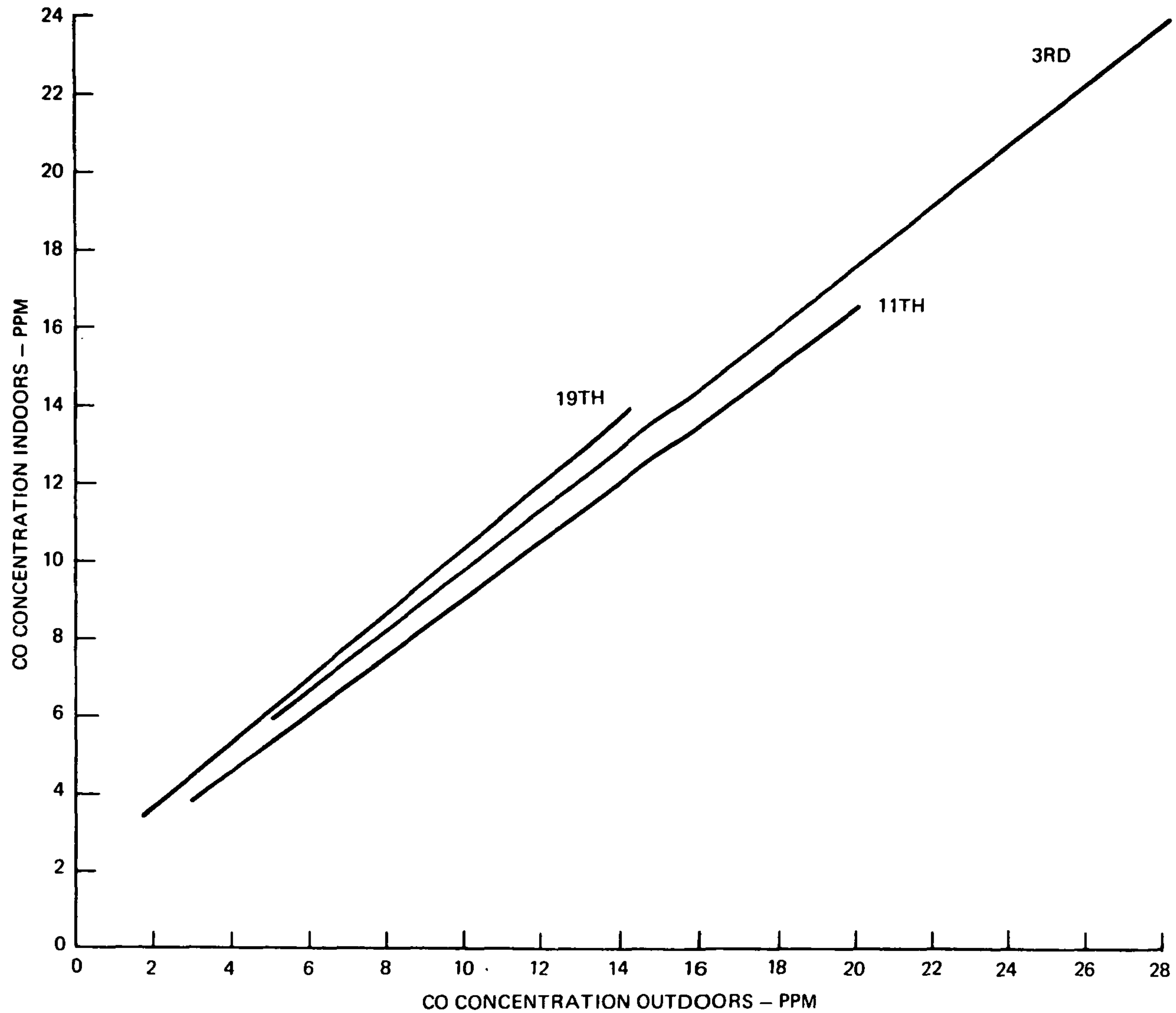


Figure 2.5-8. Indoor Vs. Outdoor CO Concentration - Site 2

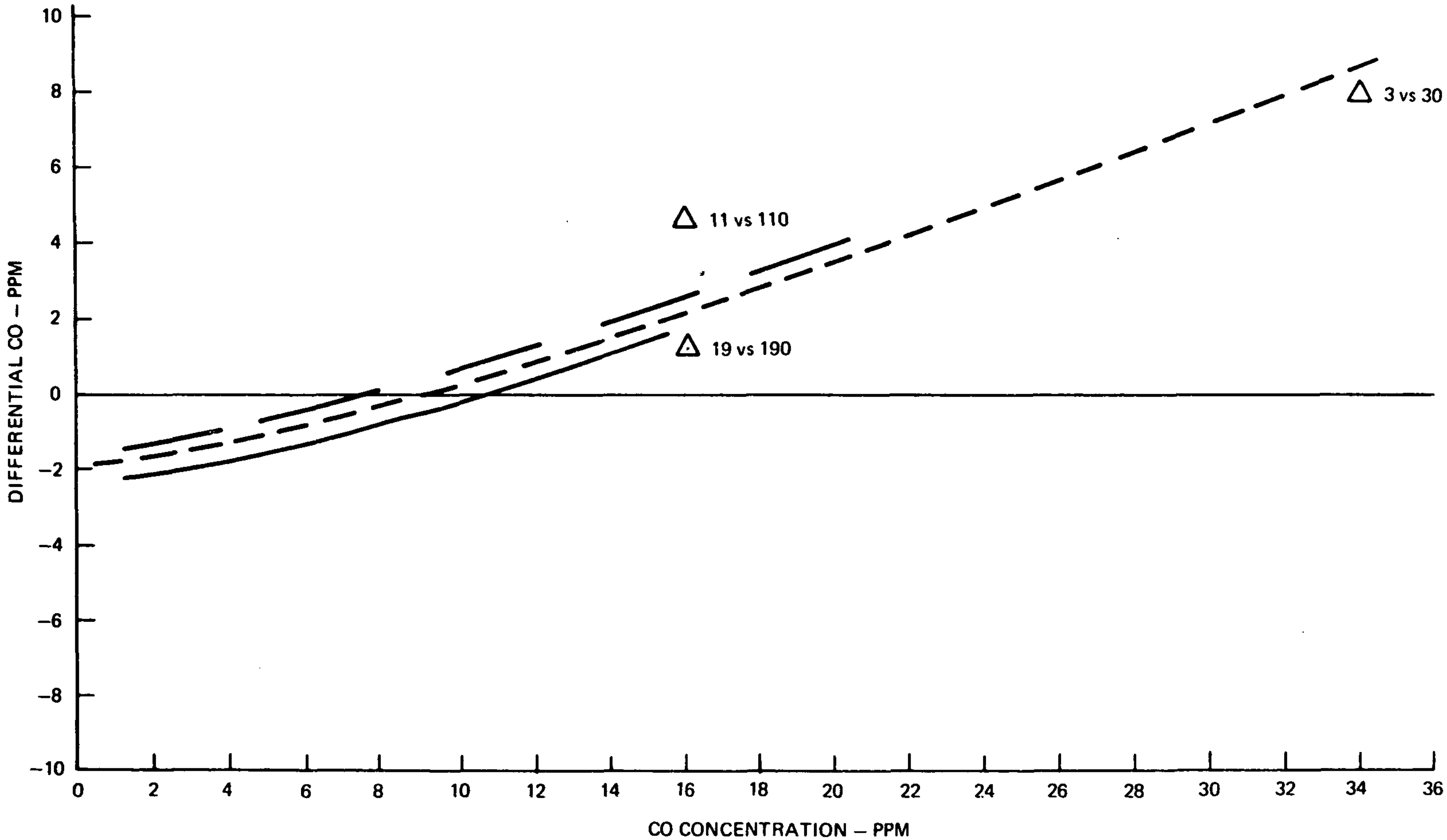


Figure 2.5-9. Differential CO Vs. Outdoor CO - Various Floors - 6 pm - Heating Weekdays - Site 2

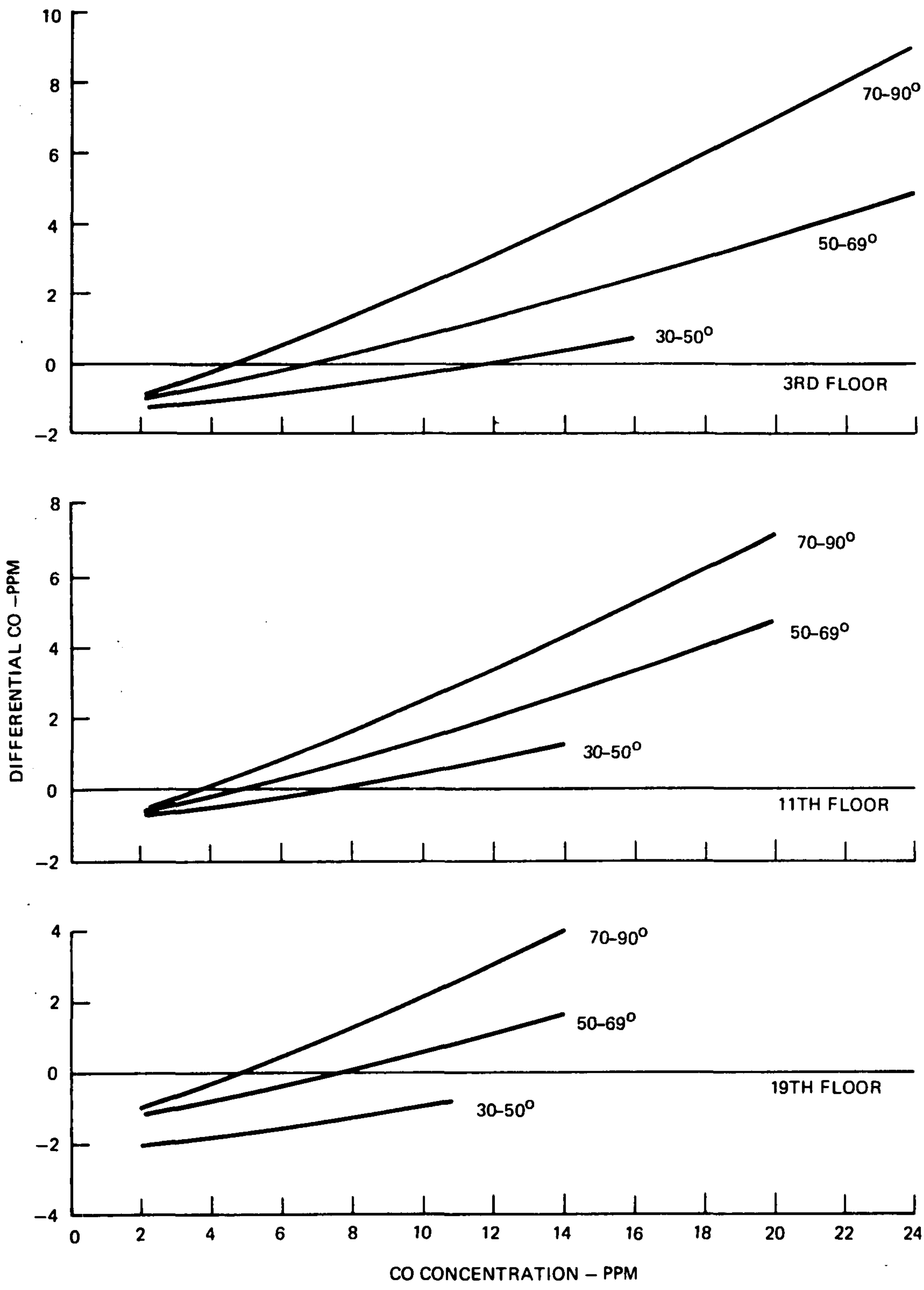


Figure 2.5-10. Differential CO Vs. Outdoor CO & Site Temperature - Site 2

windows were open, the prevailing wind was from the south, and the building was generally at the same temperature as its surroundings. The probes within the building received contributions only from relatively distant upwind sources. The probes outdoors on the north face of the building received contributions directly from 40th Street. The pressure gradient force at the north face of the building prevented any 40th Street generated CO from entering the building. The lack of a "stack effect" during warm weather precluded the entrance of large amounts of CO-laden air at lower floors as was the case in the winter.

2.5.2 Hydrocarbons

Hydrocarbon concentrations were measured at the 3rd and 11th floor levels of the structure on West 40th Street.

Average hydrocarbon concentrations were always higher indoors than outdoors at all days of the week. Indoor hydrocarbon concentrations at the third floor were strongly affected by a paint spraying operation. Diurnal variations in concentrations were generally small ($\leq$ .5ppm) except for the third floor indoors. In the vertical, indoor hydrocarbon concentrations decreased by a factor of approximately 4 from the third floor to the eleventh. Outdoor concentrations decreased by a factor of approximately 2.

Hydrocarbon concentrations at the 11th floor, indoor and outdoor and at the 3rd floor outdoor were slightly less on weekends. Weekend indoor concentrations at the 3rd floor increased during the heating season.

At the 3rd floor, indoor concentrations were independent of outside hydrocarbons. However, 11th floor hydrocarbons increased linearly with outdoor concentrations. Differential concentrations at both floor are controlled by indoor hydrocarbons. Figure 2.5-11 shows these relationships for both floor for the heating and non-heating seasons.

The large internal hydrocarbon source at this site obscures the effect of traffic emissions at the 3rd floor level. The correlation, at the 11th floor, with traffic parameters is so slight that no firm conclusion can be made.

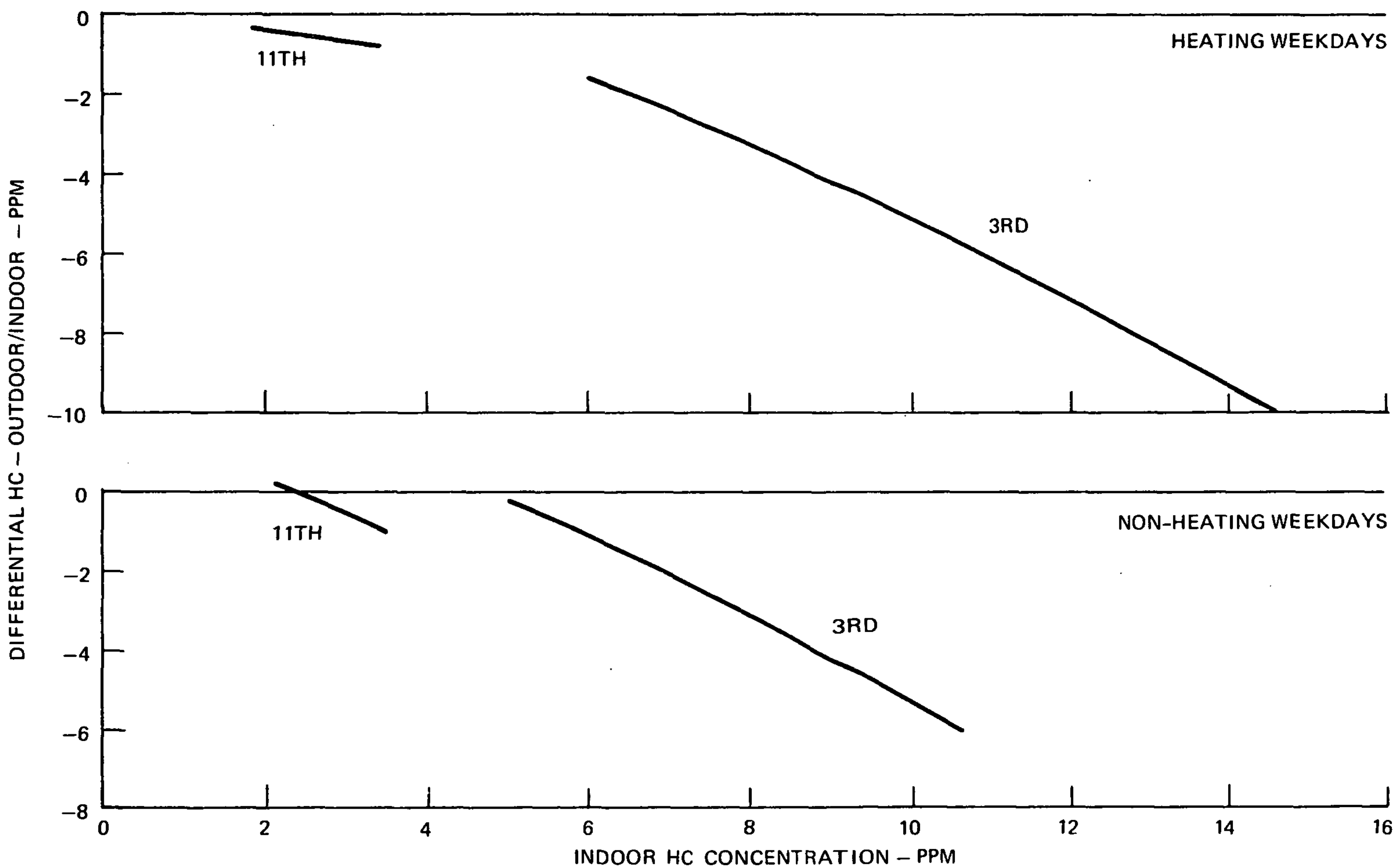


Figure 2.5-11. HC Diff. Vs. Indoor HC @ Floor - Diurnal Averages - Site 2

2.5.3 Particulate Concentration

In order to define the particulate concentrations at the 264 W. 40th Street site, four high volume air samplers were utilized. Two of the samplers were placed outside the building while two others were placed inside. Approximately one hundred (100) particulate samplings were taken during the period between February 16, 1971 and July 14, 1971, at the test building at 264 W. 40th Street. The data collected was organized according to heating and non-heating seasons. The mean values along with the concentration ranges from all the 24 hour samplings are summarized in Tables 1 and 2 below.

Table 1 - Total Particulates, ug/M^3 (Mean Values)

	Outside		Inside	
	3rd Fl.	Roof	11th Fl.	18th Fl.
Heating	123.2	123.9	65.7	66.8
Non-Heating	147.1	144.1	92.9	64.0

Table 2 - Particulate Concentration Ranges - ug/M^3

Heating	73.6-229.8	75.6-229.8	27.9-109.3	23.1-143.0
Non-Heating	74.0-212.0	71.9-213.5	59.5-128.0	34.2-105.7

At the 264 W. 40th Street site, the particulate concentrations outside the test building were significantly higher than the inside particulate concentrations. This trend was shown during both heating and non-heating seasons. Both inside and outside particulate concentrations fluctuated greatly on a day to day basis indicating daily changes in variables such as wind speed, air turbulence, traffic volume, and other influencing parameters were of utmost importance.

During both seasons, the particulate concentration inside and outside the building never exceeded the national primary ambient air standard of 260 ug/M^3 for particulates over a 24-hour sampling period. The secondary standard of 150 ug/M^3 was exceeded outside six out of a possible 18 days during the heating season. During the non-heating season, the secondary standard was exceeded outside three out of six sampling periods. The inside particulate concentrations never exceeded the secondary standard for both seasons.

There was also no direct correlation betwween total particulates and traffic volume passing the test building. The poor correlation indicated that the total particulate concentration outside was a function of other variables, only one of which was traffic volume.

Concentrations at all four locations remained essentially constant throughout the monitoring program. The outdoor concentrations were consistantly higher than indoor concentrations and varied in identical patterns. Indoor concentrations generally fluctuated together but somewhat differently than the outdoor concentrations. This indicated the suspended particulates did not vary with height at least up to the roof level (227 ft.). Inside the building, the amount of suspended articles was substantially lower. The building had a filtering effect on the incoming particles, the efficiency of which was probably a function of the relative particle size distribution outside. The larger particulates, which were continuously being generated and circulated outside were probably restricted to a great extent from entering the building. Any large particles that did enter the building probably settled quickly in the absence of sufficient internal air turbulence. The smaller particles, such as lead, easily entered the building due to its "leaky" construction. A decrease in the number of particles, along with the building's ability to selectively filter out the more weighted particles, caused the concentration of particulates inside to drop significantly. During the heating season, when the doors and windows were closed, the mean particulate concentration remained fairly constant within the building. Concentration variations inside the building were probably a function of the outside particulate concentration and the amount of air movement inside at the particular levels. During the summer months when the windows and doors at the 11th floor were kept open for ventilation, the mean particulate concentration inside at that level increased significantly. Since the 18th floor area was a storage room, where the air circulation was minimal, the particulate concentration showed no appreciable seasonal variation. The mean concentration at the 18th floor was almost identical to the mean concentration at the 11th floor during the heating season indicating that the particulate concentration remained fairly constant with height inside the building when the doors and windows were not open. Any particulates generated inside were considered small when compared to those filtering in from the outside.

Outdoor concentrations increased as temperature increased and as the roof wind shifted to the south. Since these two meteorological factors are directly related at this site, accurate identification of the major factor was not possible. It is felt, however, that wind direction was more influential. Both 3rd floor and roof outdoor particulates are high for wind from 180° and low for west winds as shown on the upper diagram of Figure 2.5-12. Indoor concentrations appear to be random with both roof and road wind direction.

Differential concentrations, outdoors and from outdoor to indoor locations, respond to wind direction as shown on the lower diagrams of Figure 2.5-12. Indoor differentials between the 11th and 18th floors again are random.

2.5.4 Lead Concentrations

All total particulate samples collected at the 264 W. 40th Street site were analyzed for lead content using an atomic absorption technique. The results are summarized according to mean values and concentration ranges as shown in Tables 1 and 2.

Table 1 - Lead Concentration ug/M^3 (Mean Values)

	3rd Fl.	Roof	11th Fl.	18th Fl.
Heating	1.42	1.45	0.81	0.98
Non-Heating	1.78	2.26	1.81	1.44

% Lead (Mean Values)

	3rd Fl.	Roof	11th Fl.	18th Fl.
Heating	1.15	1.23	1.45	1.53
Non-Heating	1.27	1.62	1.91	2.19

Table 2 - Pb Concentration Ranges

	3rd Fl.	Roof	11th Fl.	18th Fl.
Heating	0.75-3.13	0.76-2.46	0.25-1.28	0.59-1.57
Non-Heating	0.87-3.25	1.29-3.44	0.56-3.47	0.37-3.28

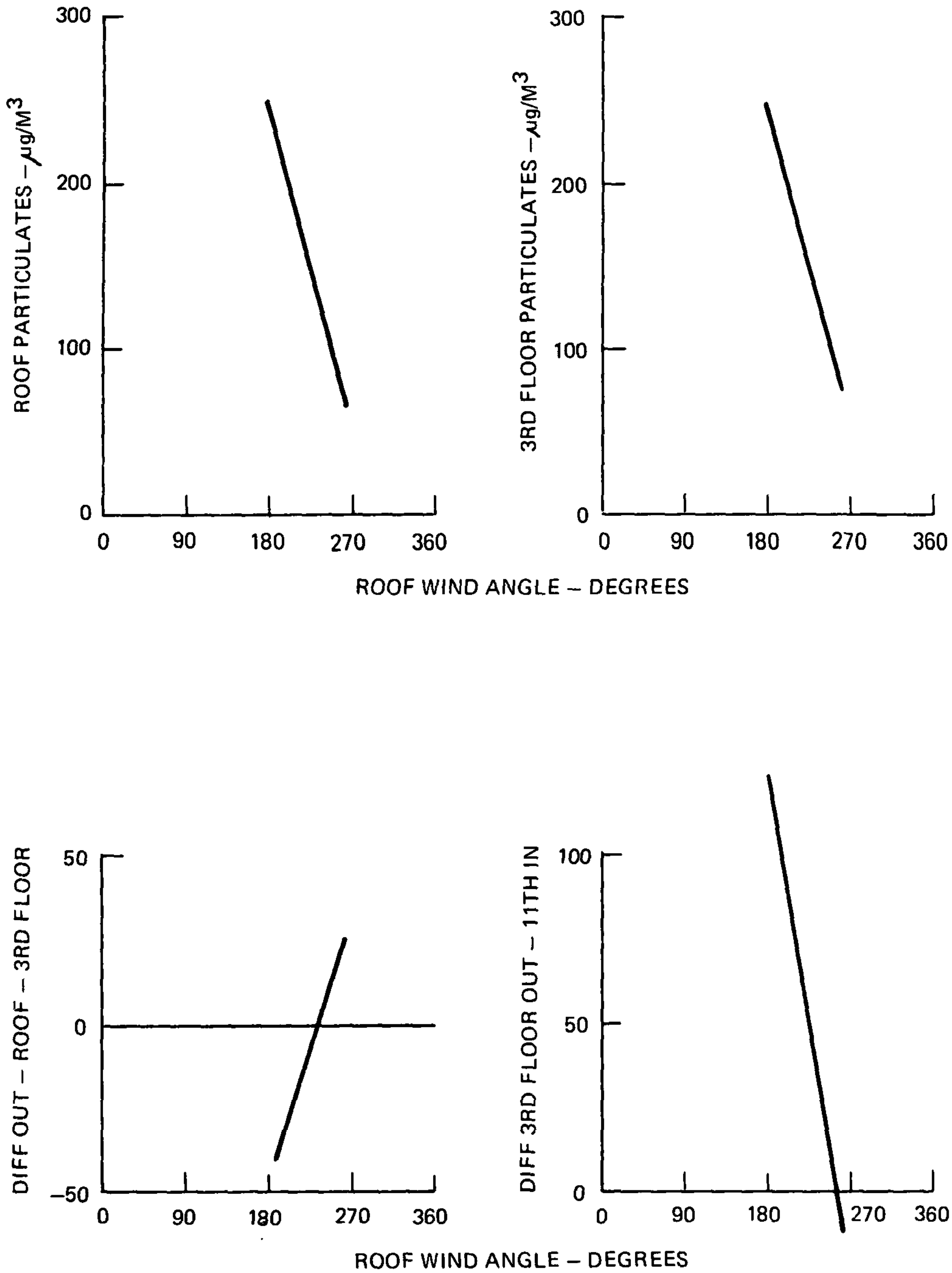


Figure 2.5-12. Particulate Differential Relationships - Site 2

% Lead Ranges

Heating	0.78-1.64	0.71-2.43	0.35-3.72	0.43-3.31
Non-Heating	0.70-2.09	0.91-2.97	0.95-3.70	0.71-3.10

The average lead concentration was higher during the non-heating season than for the heating season both inside and outside the test building. The concentrations inside and outside fluctuated widely from day to day during both seasons. These variations in lead level are directly relatable to increase in site temperature and changes in the wind direction. There was no correlation between lead concentration and traffic flow on West 40th Street.

Outside the building, there was essentially no change in concentration with height during the heating season, however, the non-heating season concentration increased with height. Inside the building , the heating season produced a slight concentration increase with height. The non-heating season, however, showed a substantial decrease with height within the building. This anomaly is caused by a single days data for the two outdoor locations on June 2 and inclusion of 18th floor data for two non-heating season days for which there is no comparable 11th floor data (shown on Table 5.2.4.1). Elimination of these data results in non-heating season averages and seasonal differentials as follows:

	Outside		Inside	
	3rd Fl.	Roof	11th Fl.	18th Fl.
Non-Heating	2.25	1.57	1.81	1.17
Diff. Non-Heating to Heating	.83	.12	1.00	.19

Using these figures, lead concentrations at both lower level locations are higher than those at upper level locations and show a larger variation from the heating to non-heating seasons. The high level locations show a small seasonal change in lead. Relative concentrations, both indoors and outdoors, reverse with height between the heating and non-heating seasons.

Adjusting the percent lead non-heating season averages for the same questionable data produces the following:

	Outside		Inside	
	3rd Fl.	Roof	11th Fl.	18th Fl.
Non-Heating	1.73	1.45	1.91	2.01
Diff. Non-Heating to Heating	.58	.22	.46	.48

The seasonal change outdoors, using these figures, is larger at the 3rd floor than at roof level and greater than either indoor locations. The indoor percentage change from the heating to non-heating season is essentially equal at both locations.

The larger variation in lead and lead percent at the 3rd floor outdoor location distinctly indicates the major lead source is traffic related. The general randomness of lead concentration levels with respect to both road level and roof level winds shown in Section 5.2.4, suggests that there are many sources, i.e., adjacent streets, which contribute to the area level.

SECTION 3.0
STUDY PROGRAM AND METHODOLOGY

A study was performed to determine the air quality, traffic and meteorological relationships as seen inside and outside two buildings in New York City. One of these buildings was an air rights apartment dwelling which straddles the TransManhattan Expressway near the George Washington Bridge. The second structure was a twenty story office building located on West 40th Street, just east of Eighth Avenue.

3.1 General Methodology

Data defining these relationships was obtained by an air pollution laboratory set up within each test building. This laboratory provided the capability of sensing, measuring, and recording carbon monoxide, hydrocarbons, traffic, and meteorological data. Each of these parameters was continuously monitored for a total of 130 days at both sites. This data was collected on punched paper tape in the form of averages using a GE developed Data Converter and recorded on strip chart recorders as a back-up and permanent record. A general schematic of the entire sampling system is shown on Figure 3.1-1. Total particulate and lead concentration samples were collected on a 24 hour basis periodically throughout each monitoring period.

3.1.1 Carbon Monoxide Measurement

In this study, carbon monoxide was measured using an infrared analysis technique. The measuring principle of the CO analyzer makes use of the specific radiation absorption band of carbon monoxide in the infrared range. A total of five carbon monoxide analyzers (Intertech Corp., Princeton, N.J.), were used in this study. The instrument was usually operated on the 0 to 100 ppm CO range and had the capability of measuring concentrations of less than 1 ppm CO in the sampled gas. The inherent zero and span drift for the instrument was $\leq$ 2% of full scale per week. Nitrogen gas (zero grade) and standard carbon monoxide in nitrogen were used to calibrate each CO instrument. All the calibration

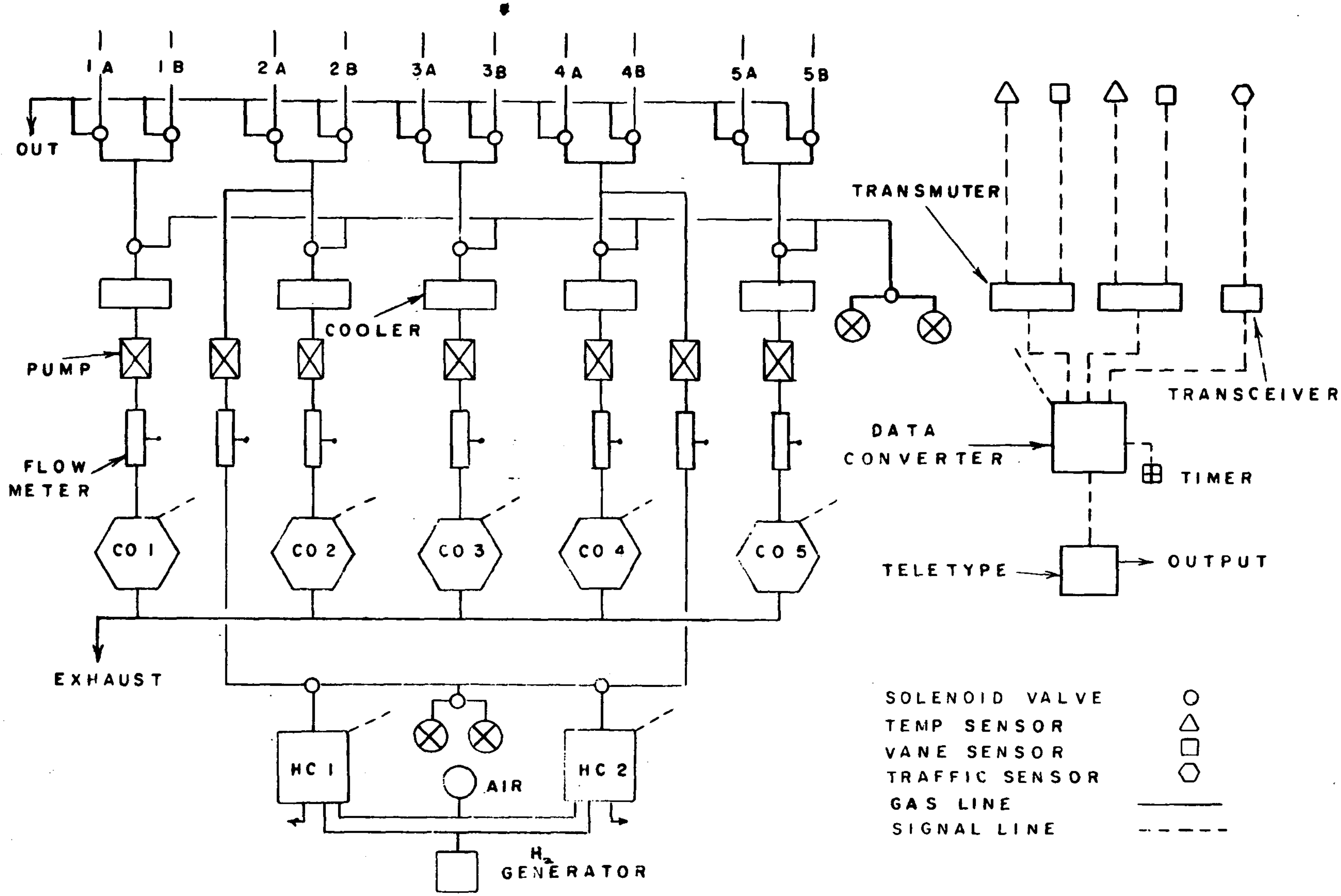


Figure 3.1-1 General Schematic of Sampling System

gases used in this study were supplied by Air Products and Chemical, Inc., of Emmaus, Pa. For each of these standard gases, a detailed chemical assay was provided by the vendor to assure for component purity and concentration accuracy. All analyzers were calibrated daily (except weekends) to insure maximum accuracy. All interfering water bands and particulate matter were either removed by filtration or kept constant by condensing coolers during the analysis. Since the infrared measuring techniques used in the carbon monoxide determination is sensitive to water vapor it was important to maintain the water concentrations constant during the analyses. Both sample and calibration gas were passed through a condensing coil which reduced the water vapor content to a dewpoint below ambient temperature.

At each site, a total of ten sampling probes were positioned near the roadway and at various levels relative to the building under evaluation. Through these probes, the air from the various locations was sampled. Each CO analyzer was equipped with a pump which alternately pulled air from one of two probe locations. The sampled gas was directed through electrically controlled solenoid valves which were controlled by means of a digital clock built directly into the Data Converter. From these valves, the gas flowed either to a CO analyzer or was exhausted to the outside. The exhaust gases were vented to the outside at a place where their relative concentrations would not interfere with the ambient CO concentrations being sampled. A high capacity pump was connected to the exhaust system in order to keep the sampling lag time to a minimum and to insure that all instruments were supplied with a fresh sample.

3.1.2 Hydrocarbons Measurement

Hydrocarbon concentrations at both sites were measured by a flame ionization method of detection. Two analyzers (Beckman Instruments, Model

Number 400-FID , Fullerton, Calif.) were used to measure total hydrocarbons from four different probe locations at each site. By means of solenoid switching and the utilization of specific probes, CO and HC concentrations from a specified level could be measured simultaneously. The instrument full scale sensitivity had an adjustable range of 1 ppm to 2% CH_4. The electronic stability of each instrument at maximum sensitivity was 1% of full scale. The reproducibility was 1% of full scale for successive identical samples. All concentrations were expressed as ppm CH_4, since methane was the particular hydrocarbon present in the calibration gas. Each analyzer was equipped with its own flow regulator and particulate filter. Fuel was provided by means of a hydrogen generator while the clean combustion air was obtained from gas cylinders. Two different calibration gas concentrations were used to define the linear calibration range of the instrument (usually 0 to 20 ppm).

3.1.3 Traffic Measurement

Ultrasonic traffic sensors were used to measure the volume and average speed of vehicles at each of the test sites. The sensing equipment (General Railway Company, N.J.) included one sensing head for each traffic lane which was electrically connected to a remote transceiver. Each traffic head was positioned ~18 feet above the middle of each traffic lane. Inside each head was a transmitter and a receiver assembly. The transmitter directed an ultrasonic signal down to the roadway which was reflected back and sensed by the receiver. The remote transceiver was used to calibrate and set the sensitivity of each sensing unit. Calibration of the unit was defined as setting the timing of a series of electrical gates. The time lapse between transmission and signal return would determine whether the signal would be picked up by the receiver or not. Normally, with no vehicle in the detection zone, the signal would not be sensed. However, if a vehicle did pass into the zone of detection, the signal was reflected off the vehicle instead of the roadway, thus reducing the time of reflection. Since the electrical gate was calibrated to be open for this time period, the vehicle would be sensed (counted).

Velocity measurement was obtained by assuming an average vehicle length and calibrating the time of detection for various speeds. Thus, a detection time vs. speed relationship was obtained. The General Electric Data Converter integrated all detection times on an hourly basis. By dividing this integrated velocity component by the hourly vehicle count, one obtained average hourly velocity readings.

3.1.4 Wind Measurements

In order to define the wind parameters and their effects on the normal pollution diffusion characteristics, two three-dimensional vector vanes were installed at two different locations at each site. The Mark III vector vane sensor (Meteorology Research Inc., Altadena, Calif.) was selected for this study because of its special design features which allowed for maximum accuracy, low thresholds, and fast responses. The vector vane sensor, its associated transmuter and output recorder were utilized to sense, measure and record such variables as wind velocity, wind azimuth and wind elevation at each point of sensor installation. In addition to these measurements, standard deviation (sigma) values for the azimuth and elevation were automatically computed.

The wind speed output was an analog voltage generated by an ultralinear solid state tachometer circuit driven by a pulse signal from the vector vanes light chopper. Using this sensor, wind speeds up to 80 mph could be accurately recorded. Elevation potentiometers in the vane itself allowed for wind angle measurement from -60 to 60° from the horizontal. A dual azimuth potentiometer measured the wind direction over a full 540°. A transmuter, by means of a shielded cable, provided a linearized 0 - 5 volts DC positive voltage to the data system for each of the five wind parameters measured.

3.1.5 Particulate Measurement

Hi Volume Air Samplers (General Metal Works, Cleves, Ohio) were used to define the total particulate and lead concentrations at each site. Ambient air was drawn by a pump through a weighed filter paper for a period of 24 hours. A calibrated flowmeter measured the air flow rate through the filter at the beginning and at the end of the sampling period. An average flow volume over the sampling period was calculated from these two readings. After the sampling period, the filter was again weighed. The difference between the initial and final filter weight was the total weight of particulate collected for 24 hours. This total weight of particulates divided by the volume of air sampled, gave a weight/ m^3 of particulate matter in the sampled air. The filter, along with the deposits, was later analyzed for lead using an atomic absorption technique.

3.1.6 Temperature Measurement

The lapse rate was calculated at each site by taking a temperature measurement at ground level and at the top of each test building. The sensor itself was a very sensitive thermistor enclosed in a highly reflective radiation shield. The thermistor was electrically connected to a transmuter inside the laboratory and measured temperatures with a sensitivity of $\pm 0.1°F$.

3.2 Data Editing and Processing

The processed data from the air rights structure site and the canyon structure site are found in Appendices A and B respectively. Each appendix is divided into four sections. The four sections are: (1) Traffic Data and Statistics, (2) Hydrocarbon Data and Statistics, (3) Carbon Monoxide Data and Statistic, and (4) Meteorological Data and Statistics.

The Traffic Data and Statistics Section of Appendix A contains flow rate and velocity information for the vehicular traffic on both the eastbound and westbound lanes of the Trans-Manhattan Expressway beneath the air rights structure. Information on the total traffic flow rate, which is the sum of the two directional traffic flow rates, is also presented as well as information on the average velocity of all vehicular traffic on the Expressway for each hour period. If one or both of the directional traffic flow rates for an hour were missing, the total traffic flow rate for that hour was not calculated. The average vehicle velocity was calculated by summing the products of the traffic flow rate and average vehicle velocity for each direction and then dividing by the total traffic flow rate. If, for an hour period, either the average vehicle velocity or traffic flow rate data for one direction was missing, the average vehicle velocity for all the vehicular traffic in that hour period was not calculated.

The Traffic Data and Statistics section of Appendix B contains flow rate and velocity information for the vehicular traffic on the center lane and on the two outer lanes of South 40th Street in front of the canyon structure. The total traffic flow rate and average vehicle velocity data for all lanes is also presented. Because approximately 85% of the vehicles on South 40th

Street in front of the canyon structure travelled in the center lane, the center lane traffic flow rate was taken as the total traffic flow rate when traffic flow rate data from the outer lanes was missing. If the center lane traffic flow rate data was missing, then the total traffic flow rate was considered missing. Similarly, the average vehicle velocity for the center lane was taken as the average vehicle velocity for all lanes if the data from the outer lanes was missing, but if the center lane vehicular velocity data was missing, then the vehicle velocity average from the outer lanes was taken as the average vehicle velocity for all lanes.

The data acquired at each site for each traffic parameter was classified on the basis of when the data was taken, either on a weekday or weekend, and also on the basis of whether the day was a heating day (the mean temperature for the day was less than 65°F) or a non-heating day (the mean temperature for the day was 65°F or higher). All the data for a particular parameter in each classification is presented in tabular form. A "-1.00" entry means that no data was acquired for that parameter during the indicated time period and a "-2.00" entry means that the data that had been acquired has been judged inaccurate for some reason and hence was omitted from the table and all statistical calculations. The mean, median, and standard deviation of all values in the table for each hour period appears at the bottom of the table. The 24 hourly means and standard deviations were then plotted to show the diurnal variation in that particular traffic parameter. Following the diurnal curve plot is a frequency of occurrence table, a percent frequency of occurrence histogram plot, and a cumulative percent frequency of occurrence histogram plot.

The data from the Hydrocarbon Data and Statistics section of Appendix A and B was again classified on the basis of when the data was taken, on a heating or non-heating day and on a weekday or weekend. The classification and sampling location is printed above each table or graph in the section. All data in each classification acquired at each sampling location is presented in tabular form with a "-1.00" entry indicating no data was acquired during the indicated sampling period and a "-2.00" entry indicating inaccurate data was acquired. The mean, median, and standard deviation of each column of data is presented at the bottom of each column and the diurnal variations of the means and standard deviations are plotted on the graph following the data table. A frequency of occurrence table, a percent frequency of occurrence histogram, and a cumulative percent frequency of occurrence histogram are shown on the succeeding two pages. In the next two graphs the 24 hourly means that are shown at the bottom of the data table are plotted against the 24 hourly means of the total traffic flow rates in the same classification and also against the 24 hourly means of the average vehicle velocities in the same classification. An "X" on the graph indicates that more than one point has been plotted at that particular location. The two graphs are omitted in Appendix A for the non-heating weekends since there was no accurate non-heating weekend traffic data acquired at the air rights structure site. For the data taken at a sampling location inside the air rights or canyon structure, there is an additional graph showing the diurnal variation in the difference between the outdoor and indoor means of the hydrocarbon data for each classification.

The Carbon Monoxide Data and Statistics section has the same format as the Hydrocarbon Data and Statistics section with one exception. For the carbon monoxide data in each classification there is a list of the occurrences when the average carbon monoxide concentration for an 8-hour period exceeded 9 parts per million. The percent of the time that the 9 PPM value was exceeded is also shown as is the percent of the time that the average CO concentration for a one-hour period exceeded 35 PPM. This additional information is presented after the graphs of the CO concentrations vs. the traffic flow rates and the CO concentrations vs. the average vehicle velocities.

The temperature and wind parameter data acquired at the two sites is presented in essentially the same format in the Meteorological Data and Statistics section as the traffic flow rate and vehicle velocity data was presented in the Traffic Data and Statistics section. Where the mean, median, and standard deviation would be meaningless, as in the case of the wind elevation angle, they are omitted. In addition, missing lapse rate values and missing values of the wind elevation angles are shown as a "-98.00" or a "-99.00" instead of a "-1.00" and "-2.00" as was used previously to indicate missing or inaccurate data. If all data for a particular meteorological parameter was missing for some classification, only the table of values which indicate missing data is presented, since the additional tables and graphs would be extraneous.

SECTION 4.0

SITE DESCRIPTION AND ENVIRONMENTAL CONDITIONS

4.1 Site 1 - Air Rights Structure - Trans-Manhattan Expressway

4.1.1 Site Description

The Bridge Apartments complex consists of four hi-rise apartment buildings each being built directly over the Trans-Manhattan Expressway in upper New York City. Located on one of the highest points on Manhattan Island, these 32-story aluminum-clad structures are among the tallest apartment buildings ever built in the city. This 12-lane expressway is a direct artery connecting Upper Manhattan and the Bronx with New Jersey by means of the George Washington Bridge. At various points, exit and entrance lanes also provided service to the expressway. There were a total of six lanes flowing in each direction. They could be thought of as being four sets of three lanes. Each set of three lanes had flow patterns similar to or different from the adjacent sets of lanes. At any moment, one set of lanes could be traveling freely while the other set (in the same direction) could be very congested. There was a slight upward grade in the west-bound lanes. Narrow medial strips divided each set of three lanes. During the day, a large volume of traffic flows beneath the Bridge Apartment complex producing an appreciable amount of pollution at the roadway level. The degree to which this concentrated pollution source affects residents at each of the indoor-outdoor apartment levels deserves some serious attention. An evaluation of this site as to various indoor-outdoor pollution concentrations should provide some direction to future planinng of similar housing complexes.

In this study, only a portion of the entire apartment complex was under evaluation. The actual test area included two apartment buildings, the included vent area, the roadway below, and all surrounding construction bounded by West 178th St. and West 179th St. between St. Nicholas and Wadsworth Avenues. Three different views of the site under test are shown in Figures 4.1-1, 4.1-2 and 4.1-3. The open vent area between the buildings provided an open exposure to the traffice pollution on the expressway below. One-way traffic also flowed parallel to the expressway on 178th and 179th St. and perpendicular to the expressway on St. Nicholas Avenue at the ground level of the building. These streets often carried heavy traffic volumes, whose associated pollution levels were also of direct concern to this study. Surrounding each building at the 2nd floor level, was located a building loggia consisting of a park and play facilities. During the summer months, children played in this secluded area because it was situated above street level and offered complete privacy and safety away from the stree traffic. This balcony area surrounded the entire building and was approximately 180 feet wide and 29 feet deep. Beneath the building was located a parking garage for the residents of the apartment building.

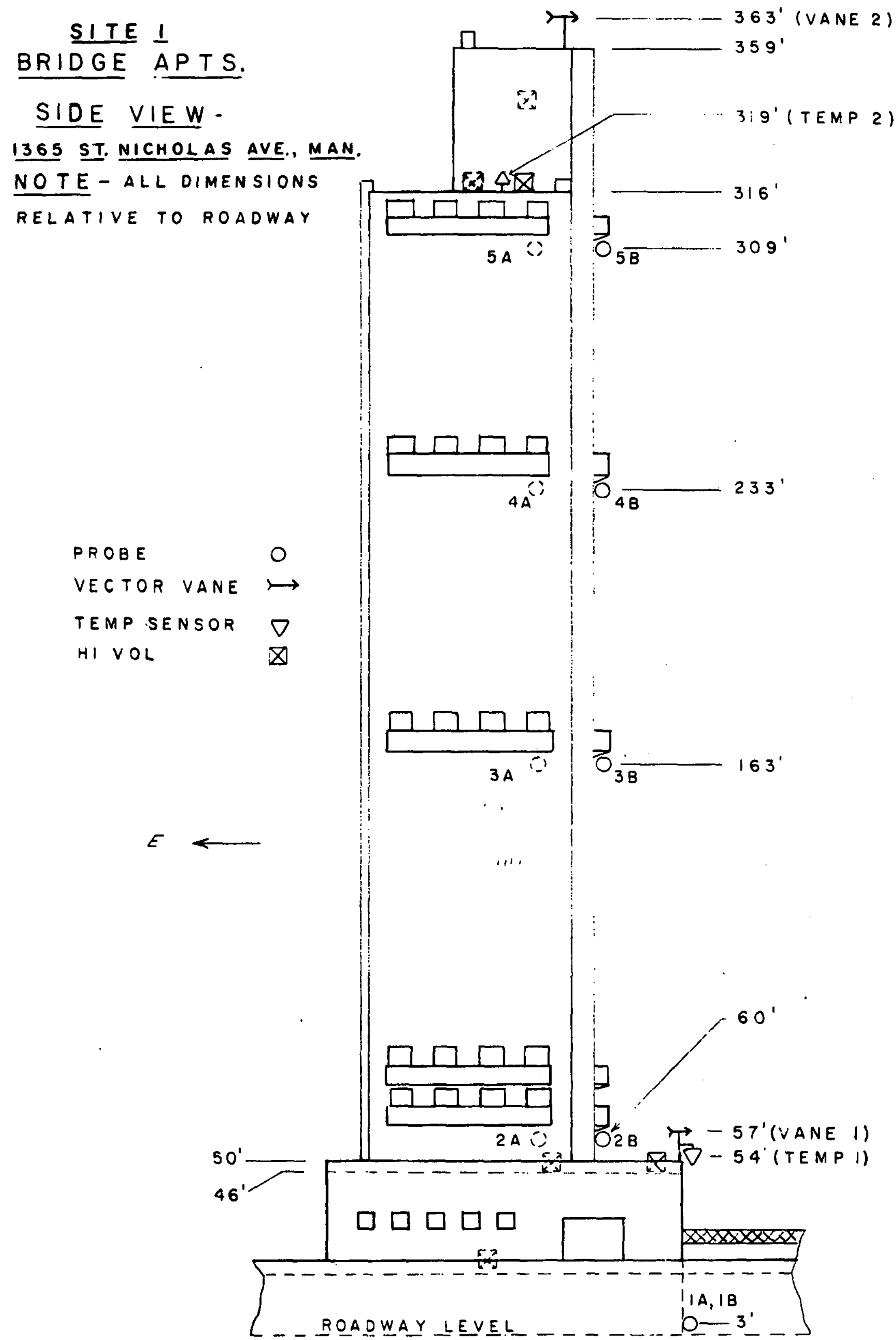


Figure 4.1-1 - Site 1 Side View

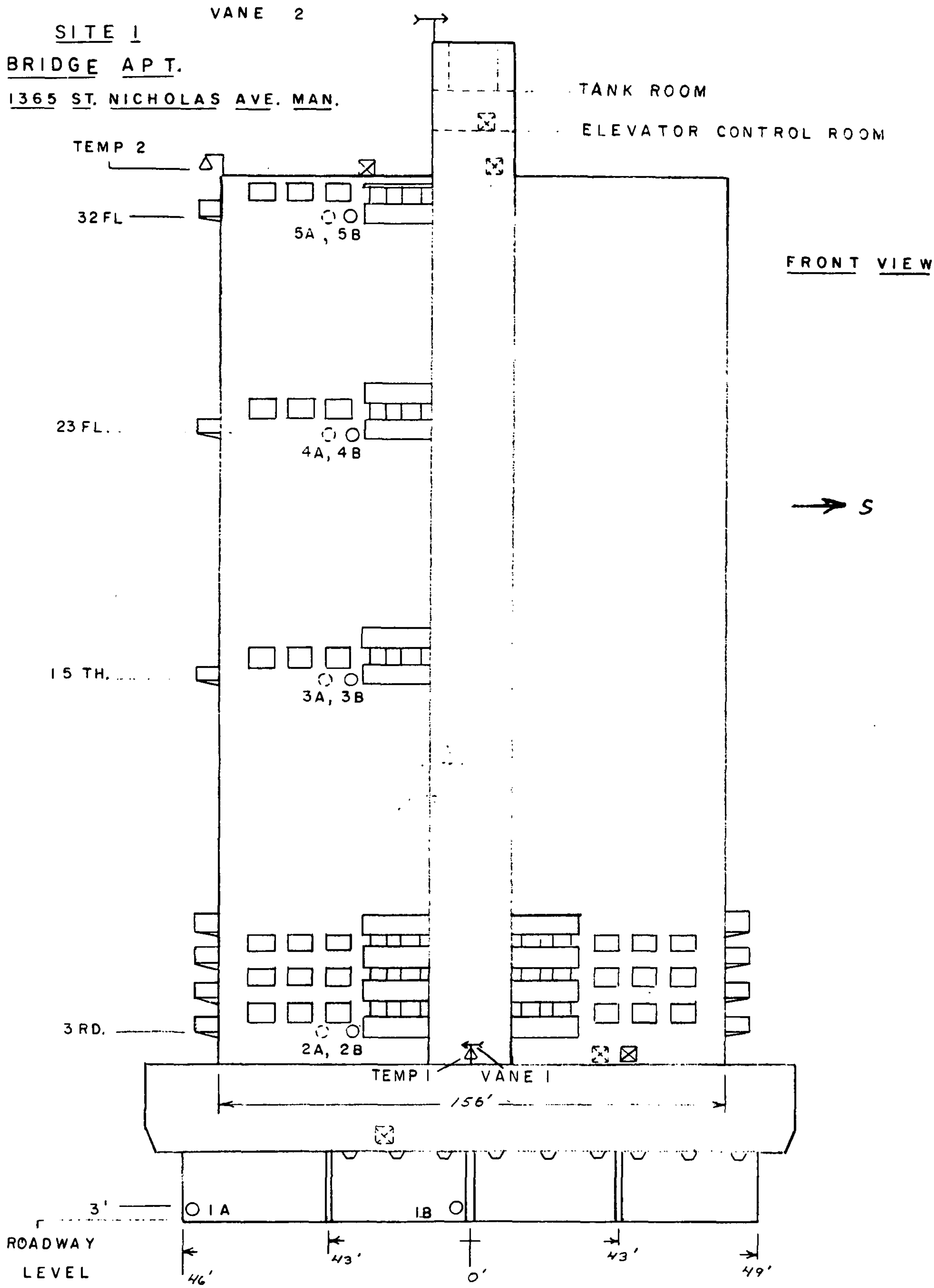


Figure 4.1-2 - Site 1 - Elevation View

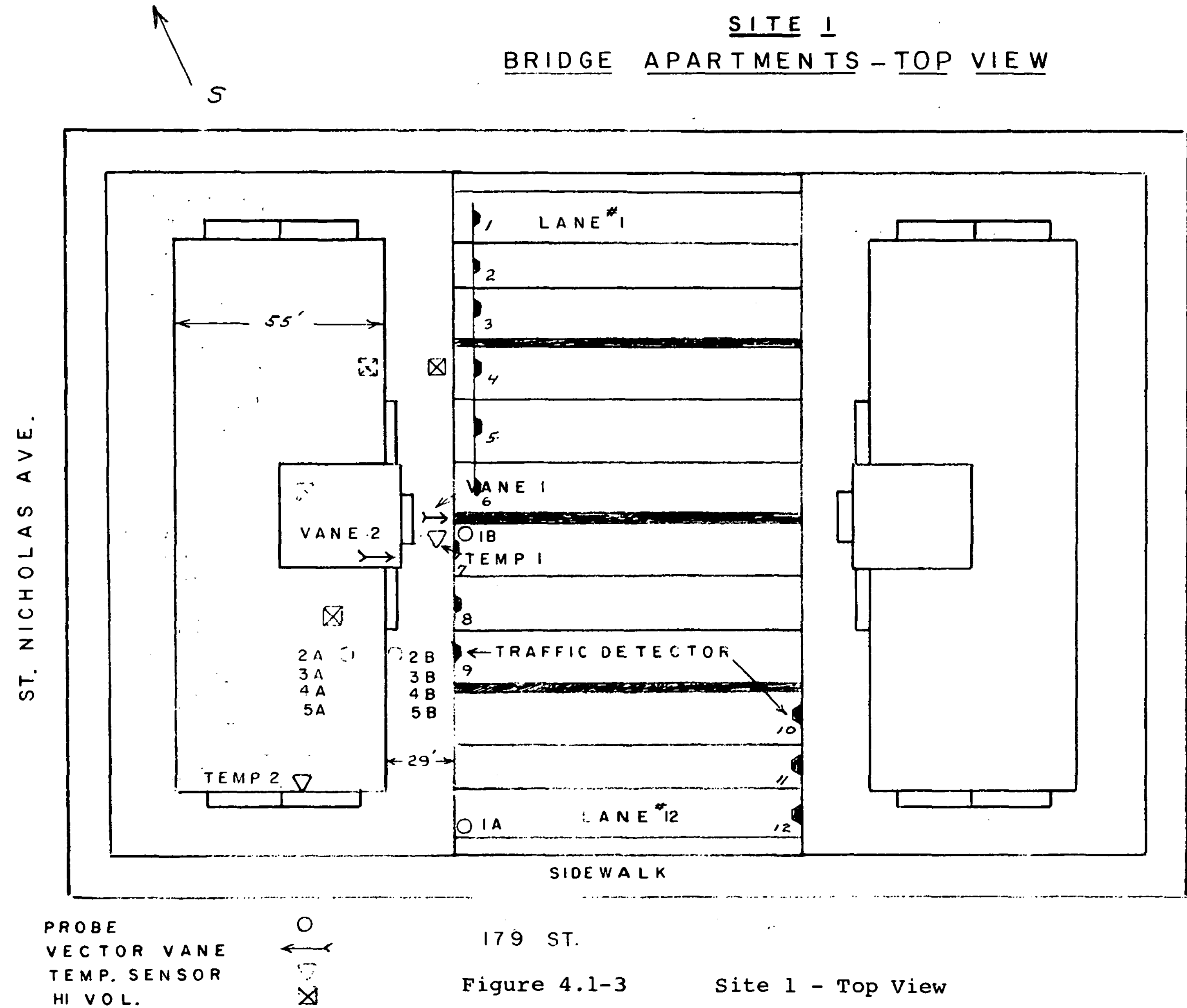


Figure 4.1-3 Site 1 - Top View

The building is of modern construction whose highest point rises 359 feet above the roadway and displays a 156 ft. frontage facing the open vent area. Four apartments face the vent area on 30 of the 32 floor levels. The first two floors are non-residential. A total of 120 apartments having a total of 240 windows and 60 doors were of direct and indirect concern to this study. The apartment units, which were of direct concern to this study, were designated as being either "R" or "N" apartments. The "R" units at each level were three-bedroom corner apartments having balconies on the north side of the building. These apartments each have three windows facing the open vent area. These same apartments had two windows and one door leading to the balcony on the northern building face. The "N" units were studio apartments having a balcony, one door, and one window facing the open vent area. All "R" and "N" apartments were of similar layout as shown in Figure 4.1-4. There were 60 additional apartment units on the southern part of the building (also facing the vent area) which were of similar designs and were of lesser concern to the study.

Since the apartment complex is of relatively new construction, the number of possible leak entrances into the building was small. Open doors and windows and thru wall air conditioning would define the relative permeability of the building. Building exhaust ventilation was provided from the roof by several blowers and each apartment was provided with a thru wall air conditioning option. However, since the exhaust blowers were down for repairs, the building was not provided with this exhaust ventilation capability for the duration of

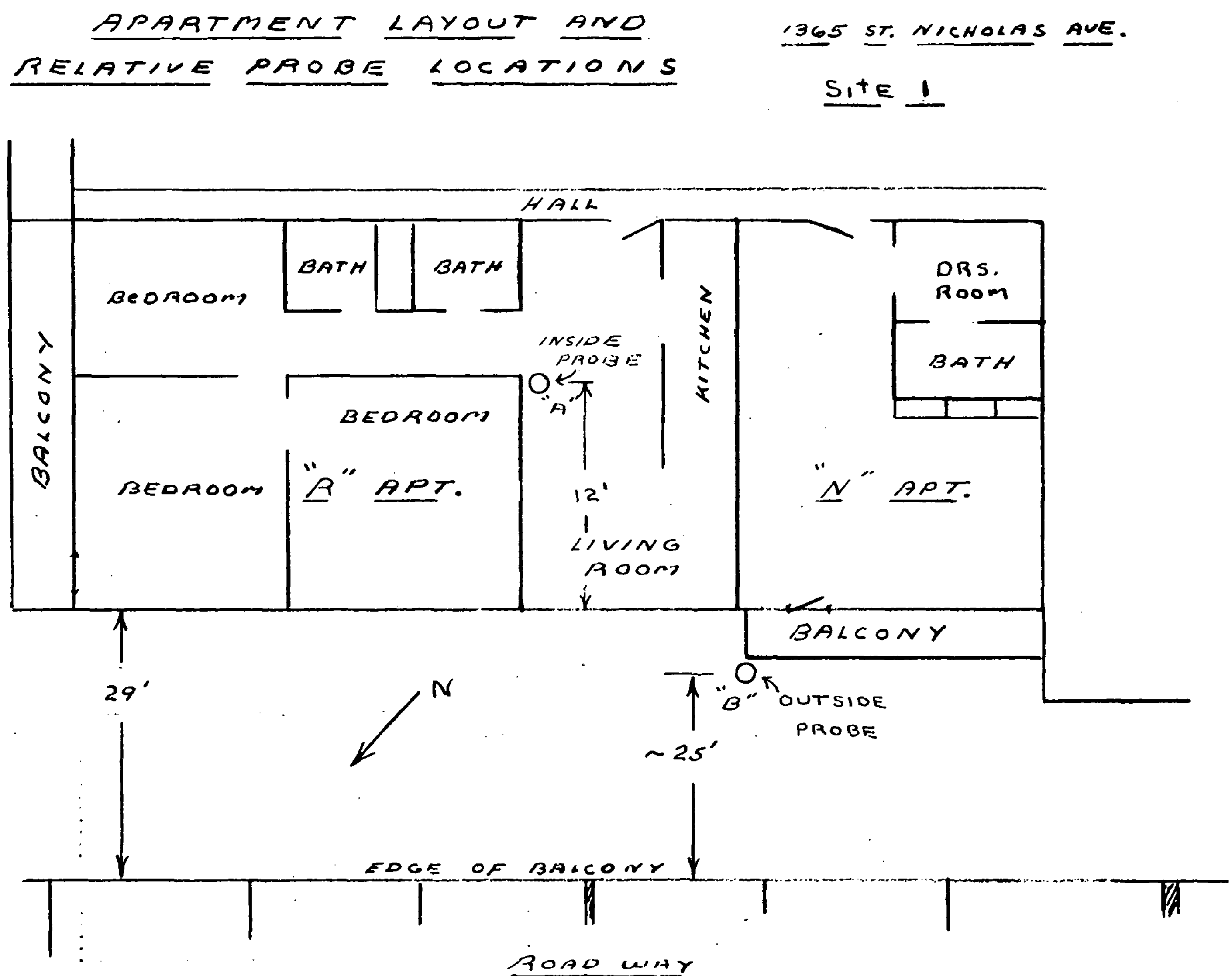


Figure 4.1-4 Site 1 - Apartment Layout

the study. All apartments which were monitored during this study did not have air conditioning except for the General Electric air pollution laboratory on the 23rd floor. On each floor of the building was located a trash shoot which led directly to the common incinerator located at the street level. Each building is equipped with a flue-fed incinerator. In this configuration, the flue serves a dual purpose; to provide a means of feeding the refuse deposited at the various floors to the storage/combustion chamber in the cellar; and also to convey the products of combustion to the roof. Generally speaking, the incinerator should not be expected to be an indoor source of CO contamination because during operation the flue is under moderate negative pressure. Moreover, on November 25, 1970, the system was converted from incineration to compaction, thereby eliminating any potential source problems. The building was centrally heated (oil-hot water) by four large furnaces in the basement.

4.1.2 Site Instrumentation

4.1.2.1 Carbon Monoxide and Hydrocarbons

A total of 10 probes were used, as shown on Figure 4.1-1, -2 and -3, to map and define pollution concentrations at the various levels at this site. Probing in the form of tubes extended from the intake manifold of the laboratory on the 23rd floor to the various indoor-outdoor locations on the western face of the test building. Both carbon monoxide and total hydrocarbon concentrations were sampled by these probes, as indicated in the table below.

Probe Designation	Pollutant		Distance from Roadway
1A	Roadway - CO		3 ft (no. wall)
2A	Inside CO	Inside HC	60 "
3A	" " **		163 "
4A	" "	Inside HC **	233 "
5A	" "	" " **	309 "
1B	Roadway - CO		3 " (median strip
2B	Outside CO	Outside HC	60 "
3B	" "		163 "
4B	" "	Outside HC **	233 "
5B	" "	" " **	309 "

* Permission to locate probe inside was not obtained until partway thru monitoring period. Probe was mounted outdoors adjacent to 3B until 11/4/70.

** Hydrocarbon samples were obtained from probes 5A and 5B from beginning of monitoring until 11/19/70. Probes 4A and 4B were sampled from 11/21/70 to end of monitoring.

As indicated, two carbon monoxide probes were positioned at the roadway, each at a level of 3 feet. One probe was placed along the north wall down along the roadway while a second probe was positioned at the median strip at the geometric center of the 12 lanes. Both probes were located in a plane perpendicular to the roadway at the point where the west-bound traffic lanes exited from beneath the building. Sampling from these two probes should define the highest

CO concentrations measured at the site and should represent the total CO emissions at the apparent source. There were no probes positioned adjacent to the east-bound lanes since all apartments monitored were located on the northwest sector of the building and the majority of the CO would probably evolve from the traffice moving in the west-bound direction.

As was shown on Figure 4.1-4, all outside readings at the various levels were measured adjacent to the "N" (studio) apartment balconies. The indoor measurements were taken inside the three bedroom (R) apartments.

4.1.2.2 Total Particulates and Lead

Total particulates were measured at a total of six different locations. Two high volume air samples were utilized to measure total particulates and lead concentrations outside the test building. One sampler was placed on the balcony while another sampled from the roof. Inside, Hi Vols initially were placed in the second floor community room and in the 32nd floor stairwell. These instruments were moved during the monitoring program to the boiler room and the elevator control shelter area respectively. All Hi Vols were operated simultaneously for periods of 24 hours in order to obtain total particulates and % lead concentrations in the air in and about the test building.

4.1.2.3 Traffic

A total of 12 ultrasonic traffic detectors were used to obtain data on traffic volume and speed. One traffic head was positioned over each of the 12 traffic lanes. The southernmost lane traveling east was designated as being lane #1 whle the northernmost lane was considered lane #12. Traffic detectors #1 thru #6 were mounted on an overhead traffic sign structure approximately 6 feet away from the sign itself. Detectors #7 thru #9 were placed on the east wall of the vent area and detectors #10 thru #12 were placed on the west wall of the vent area. Each detector was positioned parallel to the roadway at an 18 ft. level. All signal wires were routed to a central transceiver center (located on the balcony) from which additional wires traversed up the building to the laboratory area. A total hourly volume and average velocity measurement was obtained for each direction of traffic.

4.1.2.4 Meteorological

Two precise temperature measurements were continuously monitored at two different levels. One temperature sensor (Temp 2) was placed on a support pole (8 ft. off building) on the northwest corner of the building roof. The other temperature (Temp 1) sensor was positioned 8 ft. high off the edge of the balcony directly in the plane of the median strip of the roadway below. Both temperature sensors provide valuable data as to relative stability of the air mass surrounding the test building.

Two vector vanes described the wind parameters at the site. Vane #2 was positioned 4 ft. above the highest portion of the building and defined the general wind patterns at the site. A second vector vane (Vane #1) was placed on the same pole supporting Temp #1, 11 ft. off the balcony, and described the traffic derived and micrometeorological wind patterns between the buildings.

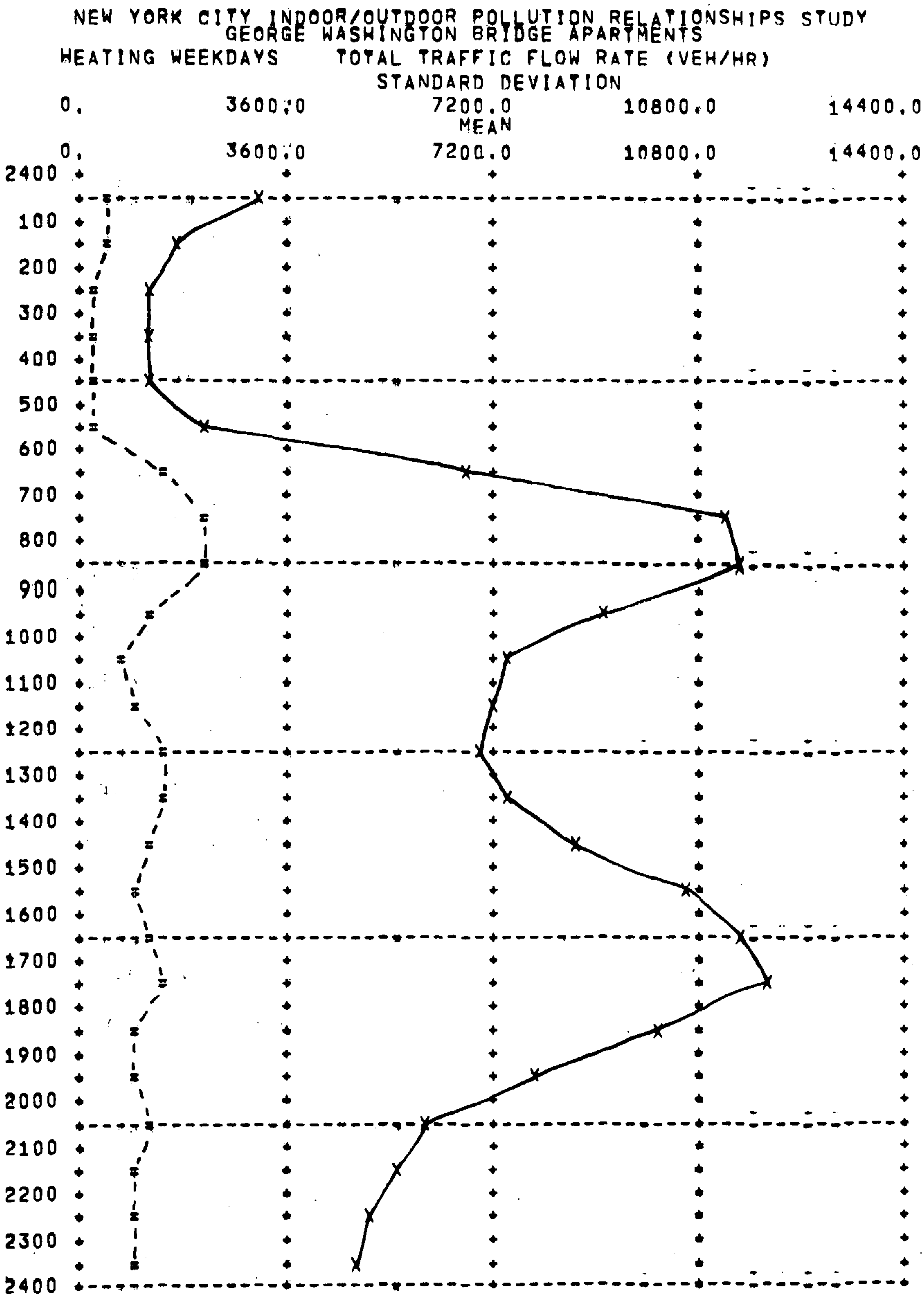
4.1.3 Traffic Characteristics

Traffic flow rates and velocities measured on the Trans-Manhattan Expressway during both the heating and non-heating seasons were essentially the same. While traffic conditions varied throughout the total monitoring period, these variations are not related to "heating" and "non-heating" season categories. The minimum traffic flow rate for the total period was 585 vehicles per hour. The maximum was 14,328 vehicles per hour. In general vehicle velocities were greater than 45 mph when the traffic flow rate was less than 7200 vehicles per hour and 45 mph or less when the traffic flow rate was greater than 7200 vehicles per hour.

Traffic conditions throughout the total period were bascially the same for each day on weekdays. Saturdays, Sundays and holidays had their own characteristic traffic patterns.

4.1.3.1 Weekday Traffic

Weekday traffic during the heating season displayed typical diurnal characteristics as shown on Figures 4.1-5 and 4.1-6. Figure 4.1-7 and 4.1-8 show the non-heating season diurnal traffic parameters.


NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS
TOTAL TRAFFIC FLOW RATE (VEH/HR)
STANDARD DEVIATION
0.
3600.0
7200.0
10800.0
14400.0
MEAN
0.
3600.0
7200.0
10800.0
14400.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
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1900
2000
2100
2200
2300
2400

FIGURE 4.1-5

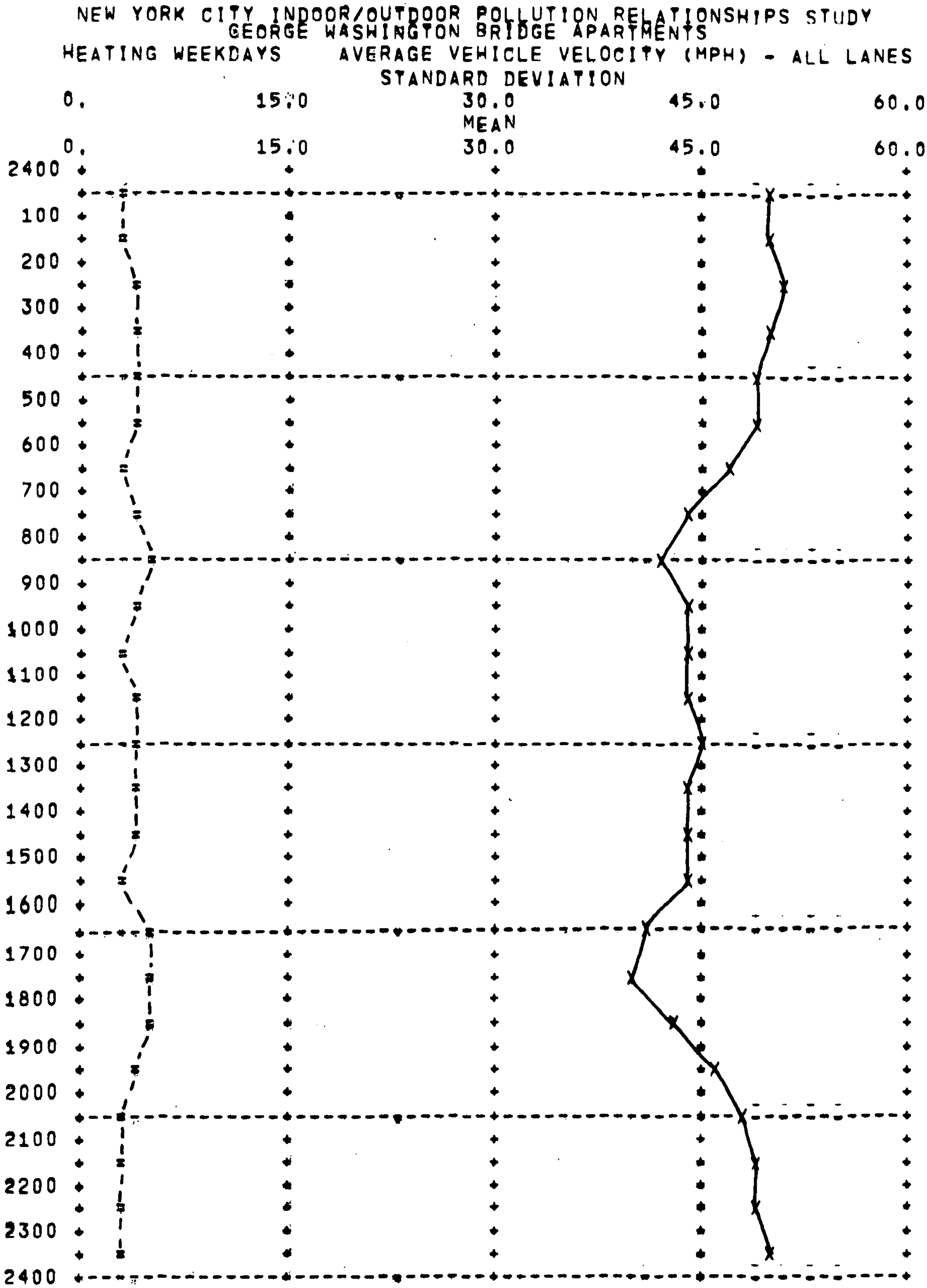

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS
AVERAGE VEHICLE VELOCITY (MPH) - ALL LANES
STANDARD DEVIATION
0. 15.0 30.0 45.0 60.0
MEAN
0. 15.0 30.0 45.0 60.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

FIGURE 4.1-6

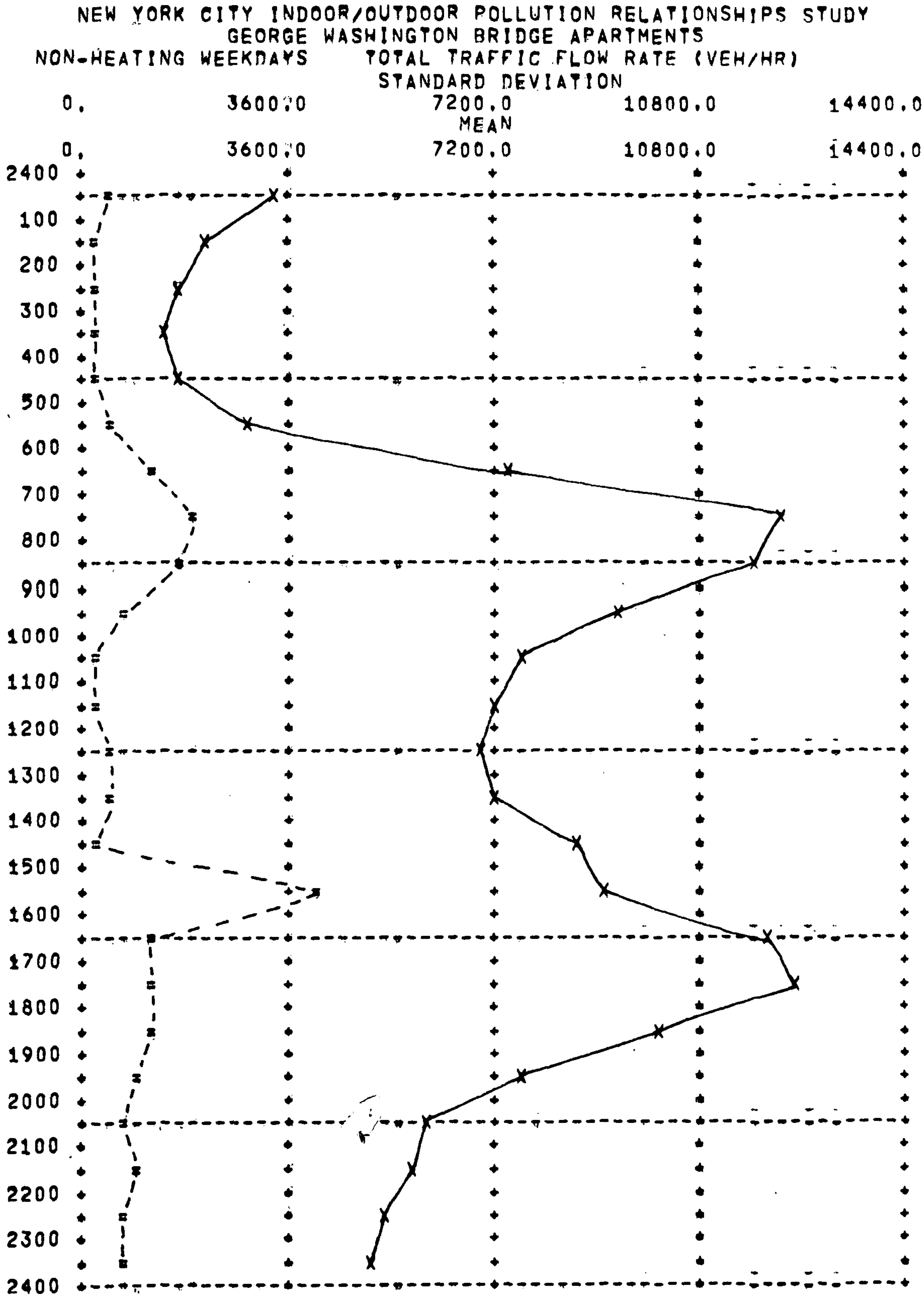
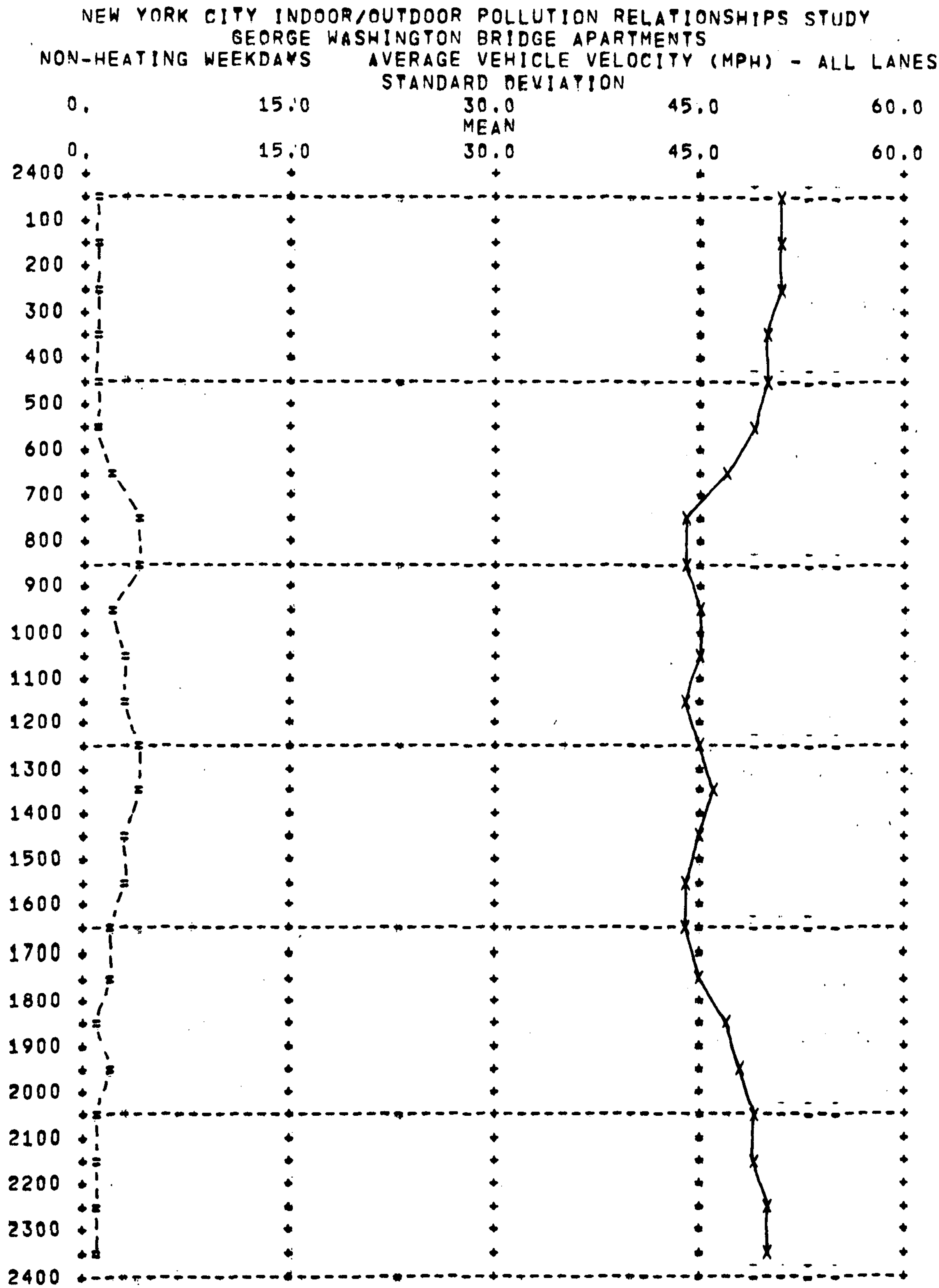

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
NON-HEATING WEEKDAYS
TOTAL TRAFFIC FLOW RATE (VEH/HR)
STANDARD DEVIATION
0. 3600.0 7200.0 10800.0 14400.0
MEAN
0. 3600.0 7200.0 10800.0 14400.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

FIGURE 4.1 -7


NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
NON-HEATING WEEKDAYS AVERAGE VEHICLE VELOCITY (MPH) - ALL LANES
STANDARD DEVIATION
0. 15.0 30.0 45.0 60.0
MEAN
0. 15.0 30.0 45.0 60.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
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2200
2300
2400

FIGURE 4.1-8

Minimum traffic flow for both seasons occured in the early morning hours. The traffic flow rate was highest during the morning and evening rush hour periods. Mid-day traffic dipped to approximately 2/3 of the morning peak. The numerical differences between the heating and non-heating duirnal traffic characteristics is primarily caused by the difference in data sample size. ie 55 days for the heating season and 6 days for the non-heating season.

4.1.3.2 Weekend Traffic

Weekend traffic during the heating season was highest during the afternoon and early evening. No morning rush hour occured. The daily minimum again occured in the early morning but several hours later than for weekdays. Figures 4.1-9 and 4.1-10 show the diurnal traffic flow rate and velocity profiles for the heating season. Insufficient non-heating season data is available to provide comparable profiles.

4.1.4 Meteorological Conditions

Meteorological characteristics at the air - rights site are relatively undisturbed by other nearly obstacles. The four George Washington Bridge Apartment Buildings were, by far, the tallest buildings were, by far, the tallest buildings in the area rising to about 300 feet. Other nearby buildings averaged less than 60 feet.

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKENDS   TOTAL TRAFFIC FLOW RATE (VEH/HR)

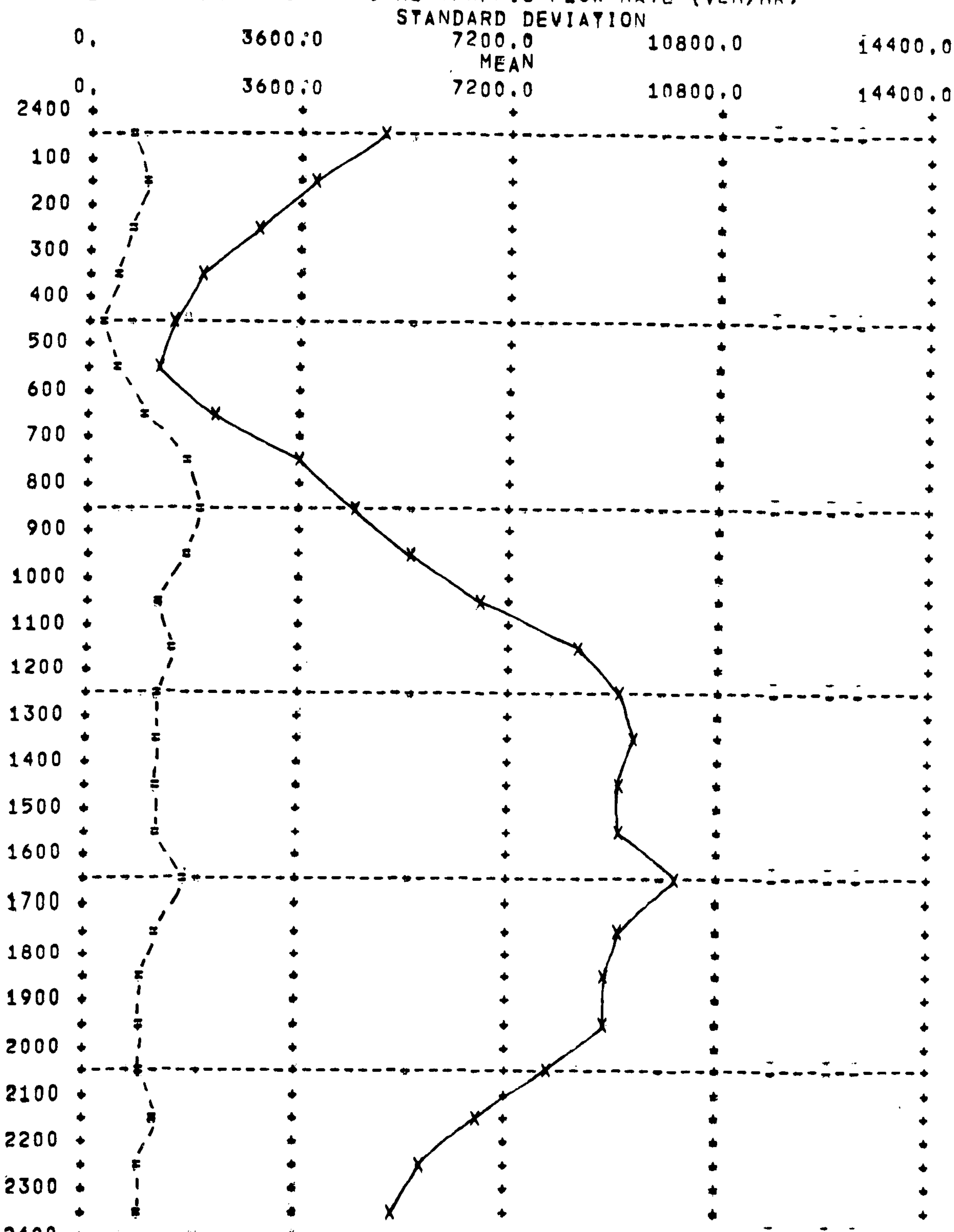
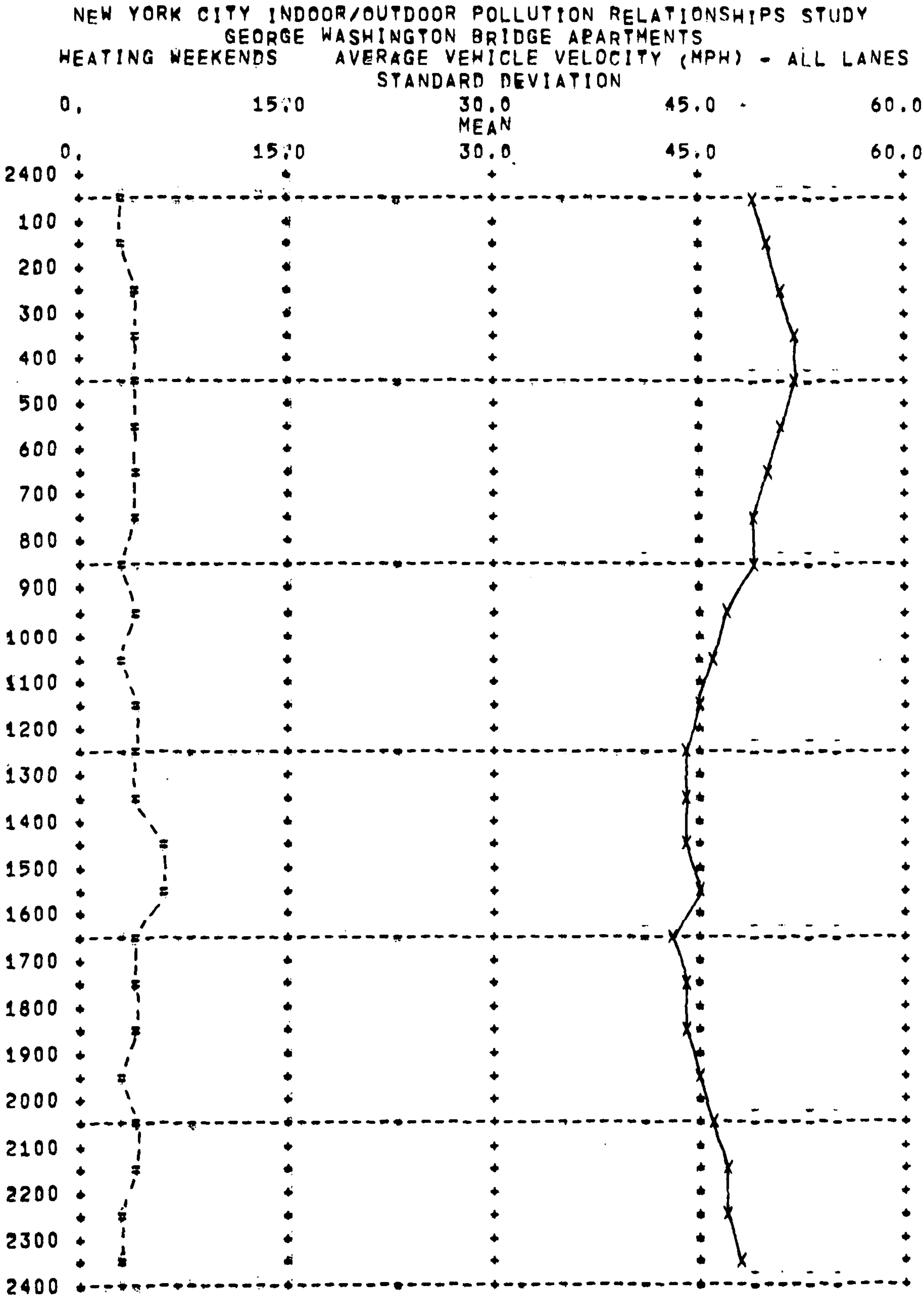


FIGURE 4.1-9


NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKENDS AVERAGE VEHICLE VELOCITY (MPH) - ALL LANES
STANDARD DEVIATION
0. 15.0 30.0 45.0 60.0
MEAN
0. 15.0 30.0 45.0 60.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
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1600
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2200
2300
2400

FIGURE 4.1-10

The upper floors of the structure were sheltered from the general wind flow by the other apartment buildings, but only very slightly. However, the roof level measurements themselves were almost completely unaffected by the presence of the other three buildings since they were taken an additional 40 feet above the rooftop. Other meteorological data (wind and temperature) was taken on a second floor balcony approximately 29 feet from the nearest building wall (see figure 4.1-1). The data collected at this lower location was influenced by the proximity of the building.

The highest average hourly wind speed recorded on the roof of the air - rights structure was 45 mph from 190° (North = 0°) between 12 and 1 PM on 10/2/70. The wind speed on the second floor balcony also recorded its highest average hourly level at that time, registering 23 mph from 199° . This correspondence between wind at the two levels of measurement did not hold throughout the monitoring period. For example, the second highest roof level wind speed was 32 mph from 84° , between 8 and 9 PM on 12/16/70. However, the balcony (road) level wind at that time blew from 313° and only recorded 7 mph.

The heating and non-heating seasons were characterized by the roof wind azimuth direction as shown in the table below. It can be seen that during the heating season, the roof wind blew from 120 - 239° only 5.8% of the time. This wind however blew from 120 - 239° for 83%

Wind Azimuth Angle-degree

Loc	Season	0-59	60-119	120-179	180-239	240-299	300-359
Roof	Heating	28.3	21.5	3.4	2.4	10.5	33.8
	Non-Heating	5.0	9.0	25.0	58.0	1.0	2.0
Road	Heating	17.1	18.4	11.3	25.7	8.8	18.6
	Non-Heating	6.9	1.5	42.7	34.4	4.6	9.9

of the time during the non-heating season. While the wind direction at road level during the non-heating season shows general correspondence with roof level wind direction, the heating season wind conditions are significantly different. Apparently there is no fixed relationship between roof and road level wind directions. Average wind speeds at the two locations characteristically were lower at road level for both seasons.

Average Wind Speed-mph

Loc	Heating	Non-Heating
Roof	9.3	4.7
Road	5.7	3.8

Diurnal variation of wind speed on the roof on weekdays during the heating season is shown in figure 4.1-11. The apparent peak of 2000 hours is not real but is caused by a few abnormal readings. The diurnal plot of the turbulence parameter, sigma azimuth, is shown in

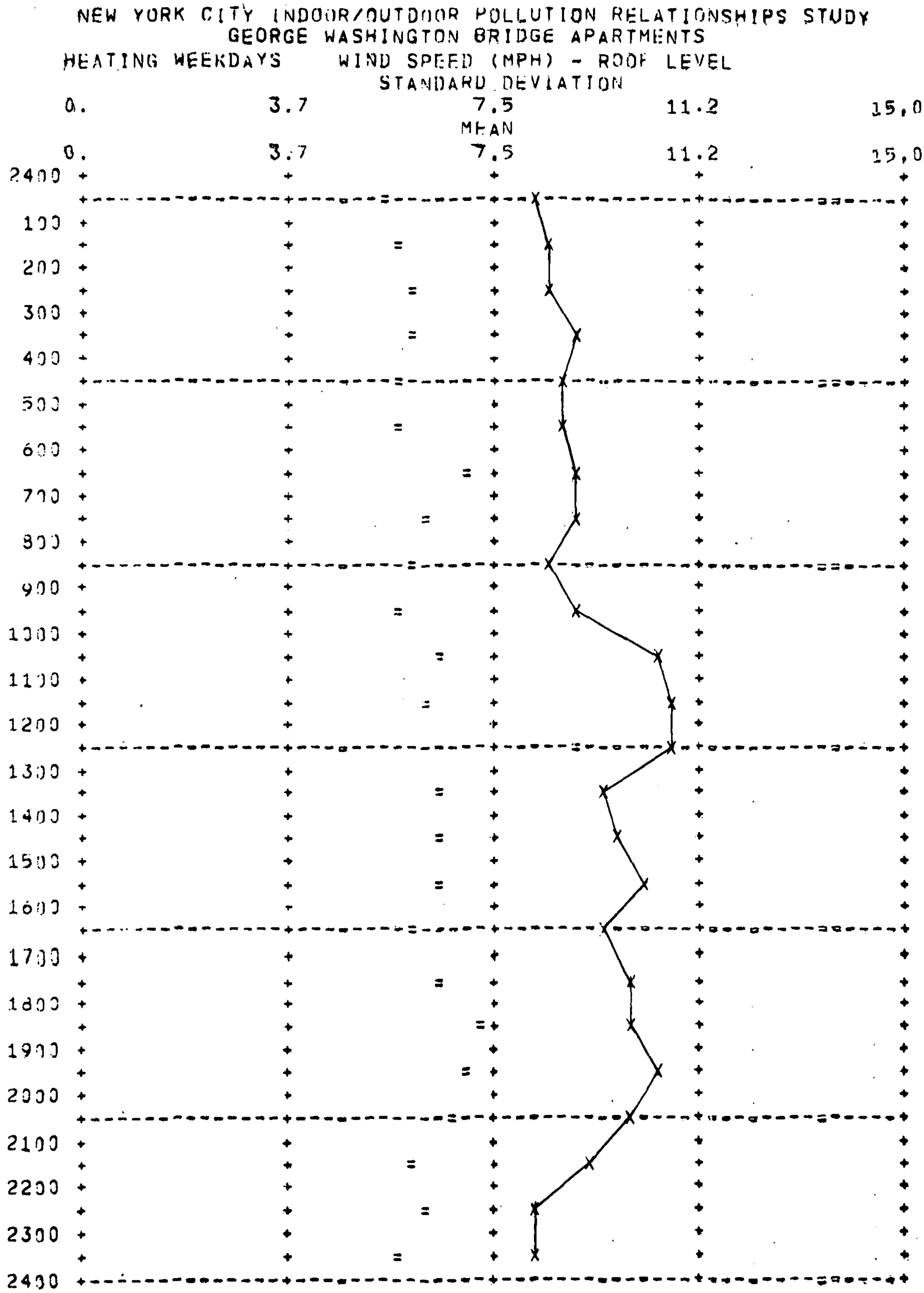

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS
WIND SPEED (MPH) - ROOF LEVEL
STANDARD DEVIATION
0. 3.7 7.5 11.2 15.0
MEAN
0. 3.7 7.5 11.2 15.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

Figure 4.1-11

figure 4.1-12. At road level, the same parameters have considerably lower values (Figures 4.1-13 and 4.1-14). This is due to normal velocity decrease with height coupled with a sheltering effect of nearby walls and other objects. Diurnal temperature curves are presented in figures 4.1-15 (roof sensor) and 4.1-16 (ground level sensor). As may be seen from these plots, the average daily temperature range for this site was small. Duirnal variations of meteorological parameters for heating weekends are essentially the same and are not shown.

As expected the only significant difference in diurnal characteristics between the heating and non-heating seasons is the temperature level. The average temperature at the road level was 2.4° higher than that at roof level for both heating and non-heating seasons, as seen from the following table.

Average Temp - degrees F

Loc	Heating	Non-Heating
Roof	39.2	63.1
Road	41.6	65.5

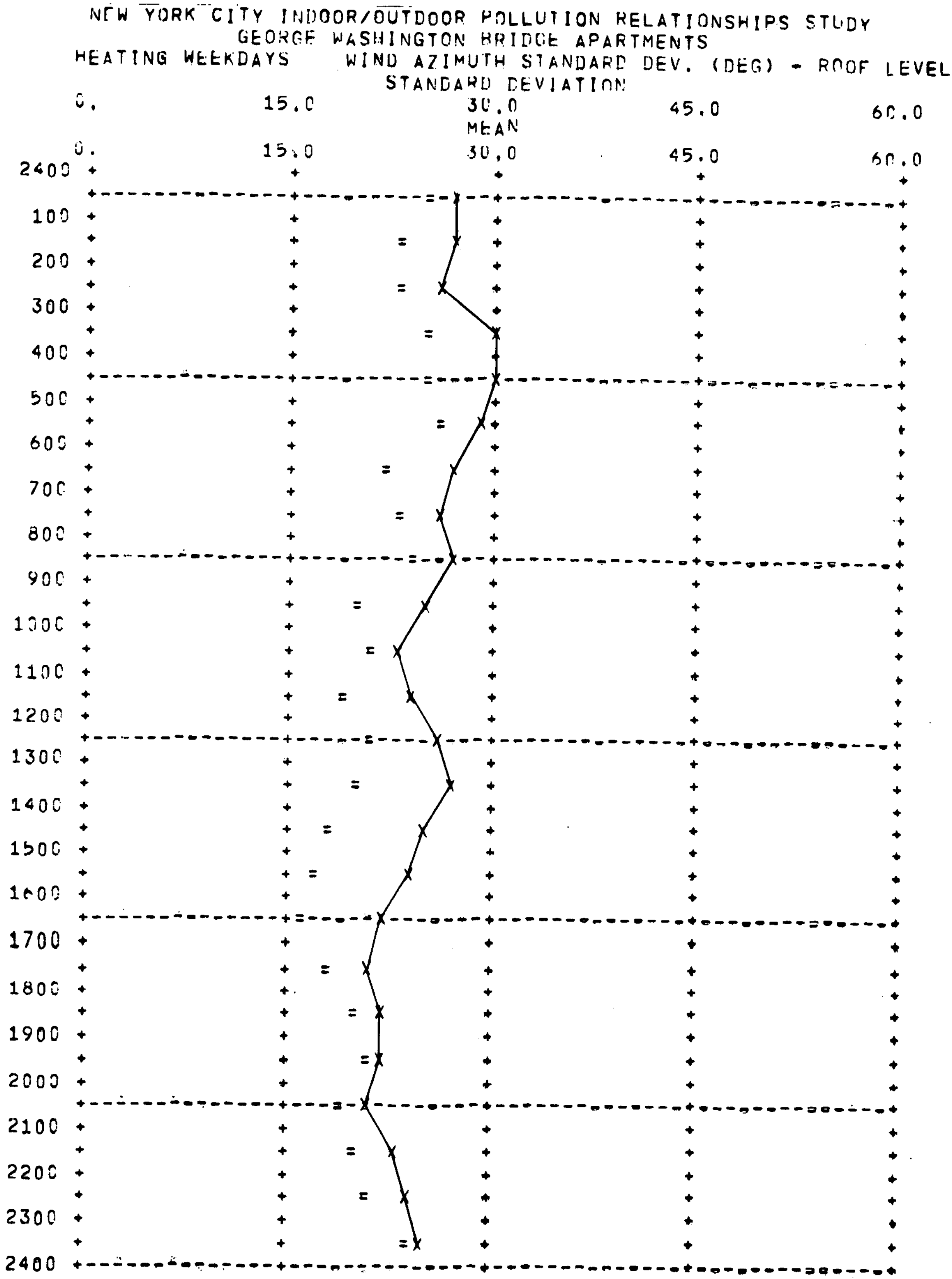

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS WIND AZIMUTH STANDARD DEV. (DEG) - ROOF LEVEL
STANDARD DEVIATION
0. 15.0 30.0 45.0 60.0
MEAN
0. 15.0 30.0 45.0 60.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

Figure 4.1-12

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS WIND SPEED (MPH) - ROAD LEVEL

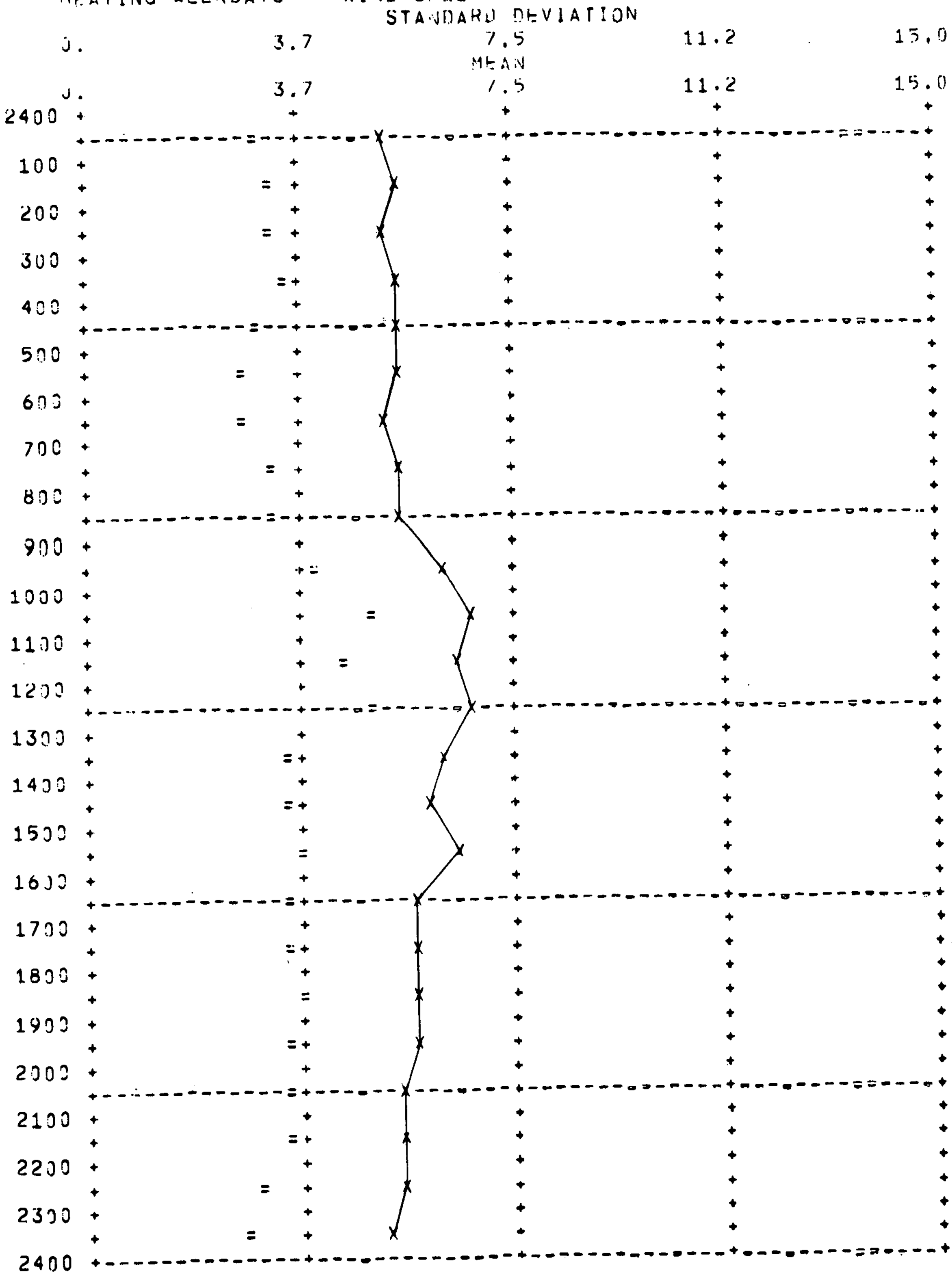


Figure 4.1-13

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS WIND AZIMUTH STANDARD DEV. (DEG) - ROAD LEVEL

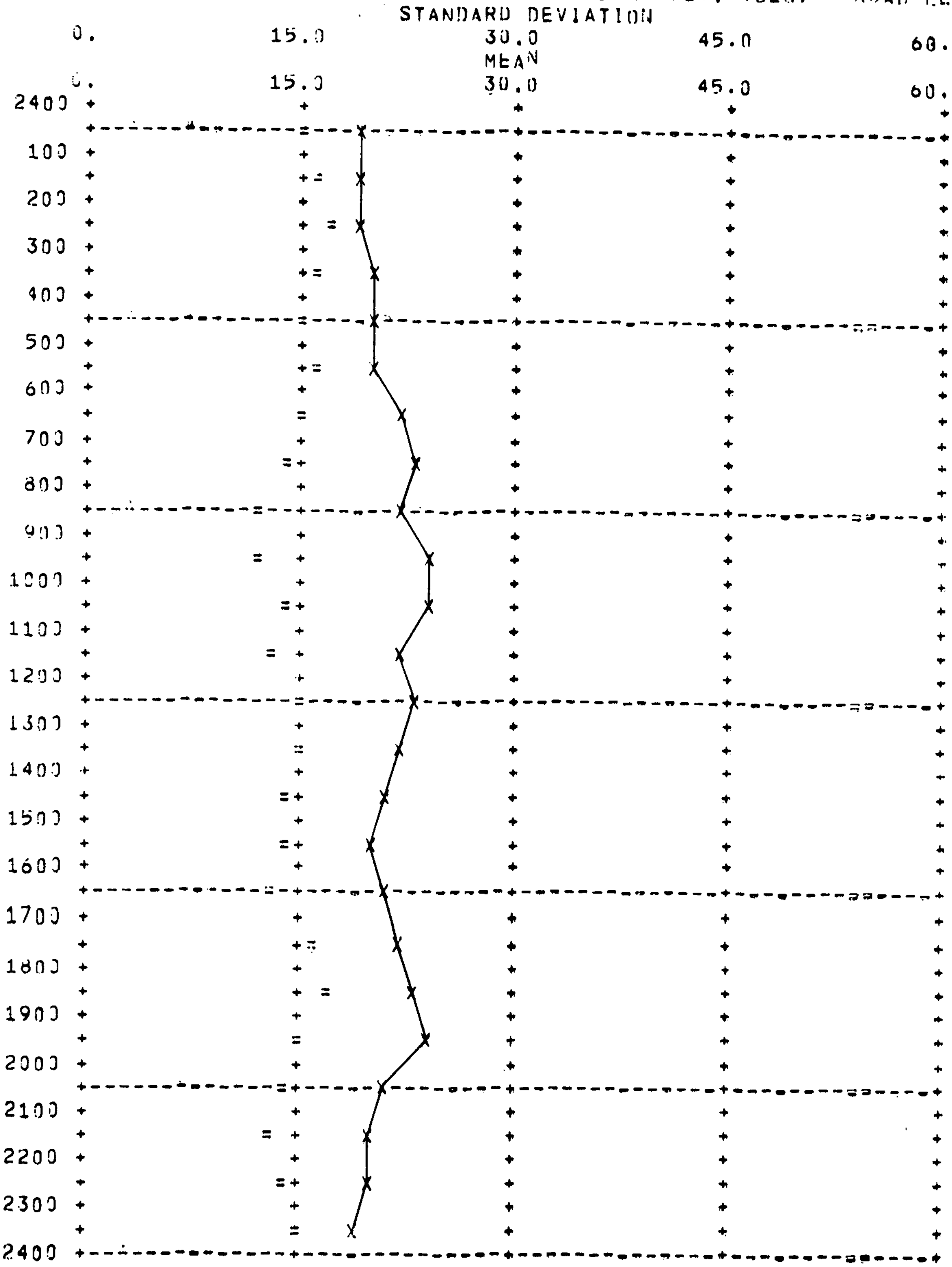


Figure 4.1-14

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS TEMPERATURE (DEG. F) - 319 FT. ABOVE ROAD

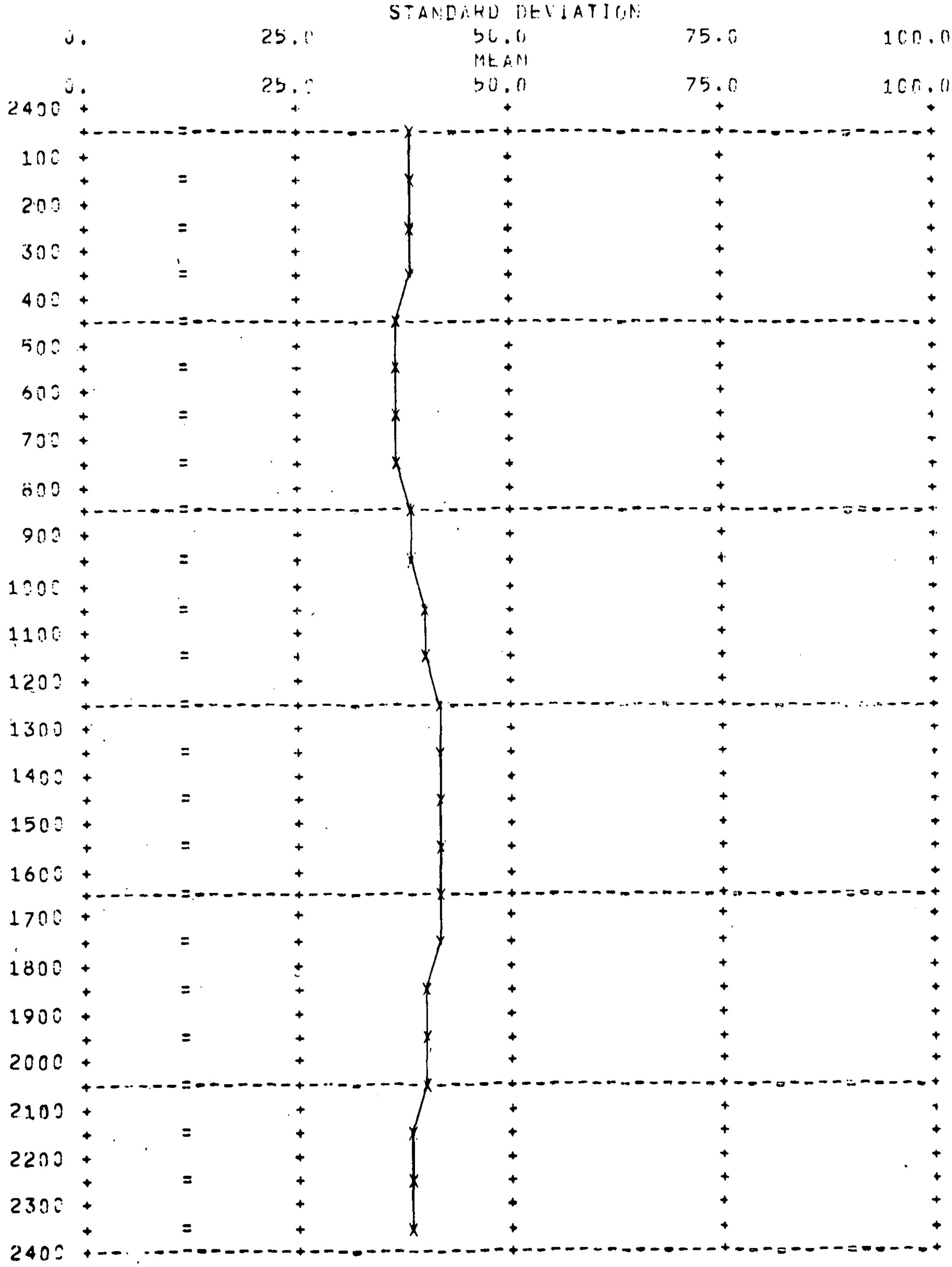


Figure 4.1-15

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS TEMPERATURE (DEG. F) - 54 FT. ABOVE ROAD

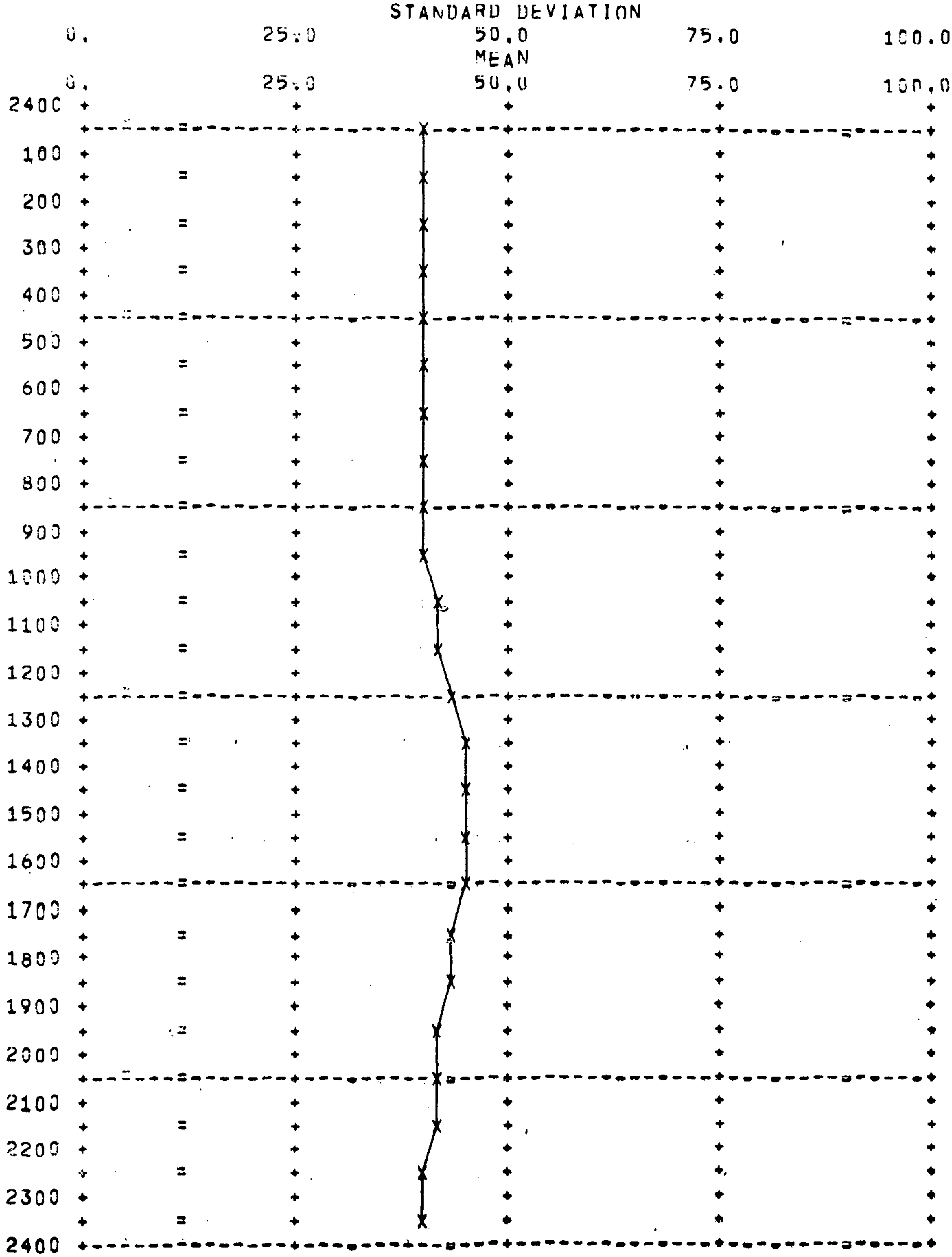


Figure 4.1-16

4.2 Site 2 - Canyon Structure - West 40th Street

4.2.1 Site Description

In the heart of New York City's garment district, a large volume of slow moving urban traffic creates a high pollution source potential. Within the buildings in the surrounding area is located a variety of small business activity. Here many people work and carry on their daily business exposing themselves to pollution concentrations which may or may not be harmful. In order to provide valuable information as to the pollution levels to which these working people are being exposed, a typical commercial building was selected to be the focal point of an air pollution study.

The building selected for the canyon structure test site was located at 264 W. 40th St. in mid-Manhattan. The building was situated on the south side of 40th St. approximately 105 ft. east of the edge of the building line on 8th. Avenue. The structure rose 251 ft. above the street, having a frontage span of 65 ft. This building was an older type brick structure and was considered ideal in which to check indoor-outdoor pollution relationships due to its "leaky" construction. In conjunction with a similar building across the street, the test building formed the narrow canyon-like formation. The building across the street was of similar construction and dimensions. A large parking garage bounded the test building on the east, while a hotel was on the west. The building across the street was bounded by another parking garage and a smaller office building. All adjacent buildings were shorter and formed a canyon which was not as deep or pronounced. The face of the test building was 13 ft. from the roadway and rose 149 ft. perpendicular to the street after which a series of steps occurred (ex. the face of the 19th floor was offset back 9 feet from the face at the 11th floor). Site drawings and important site dimensions are shown in Figures 4.2-1, 4.2-2 and 4.2-3.

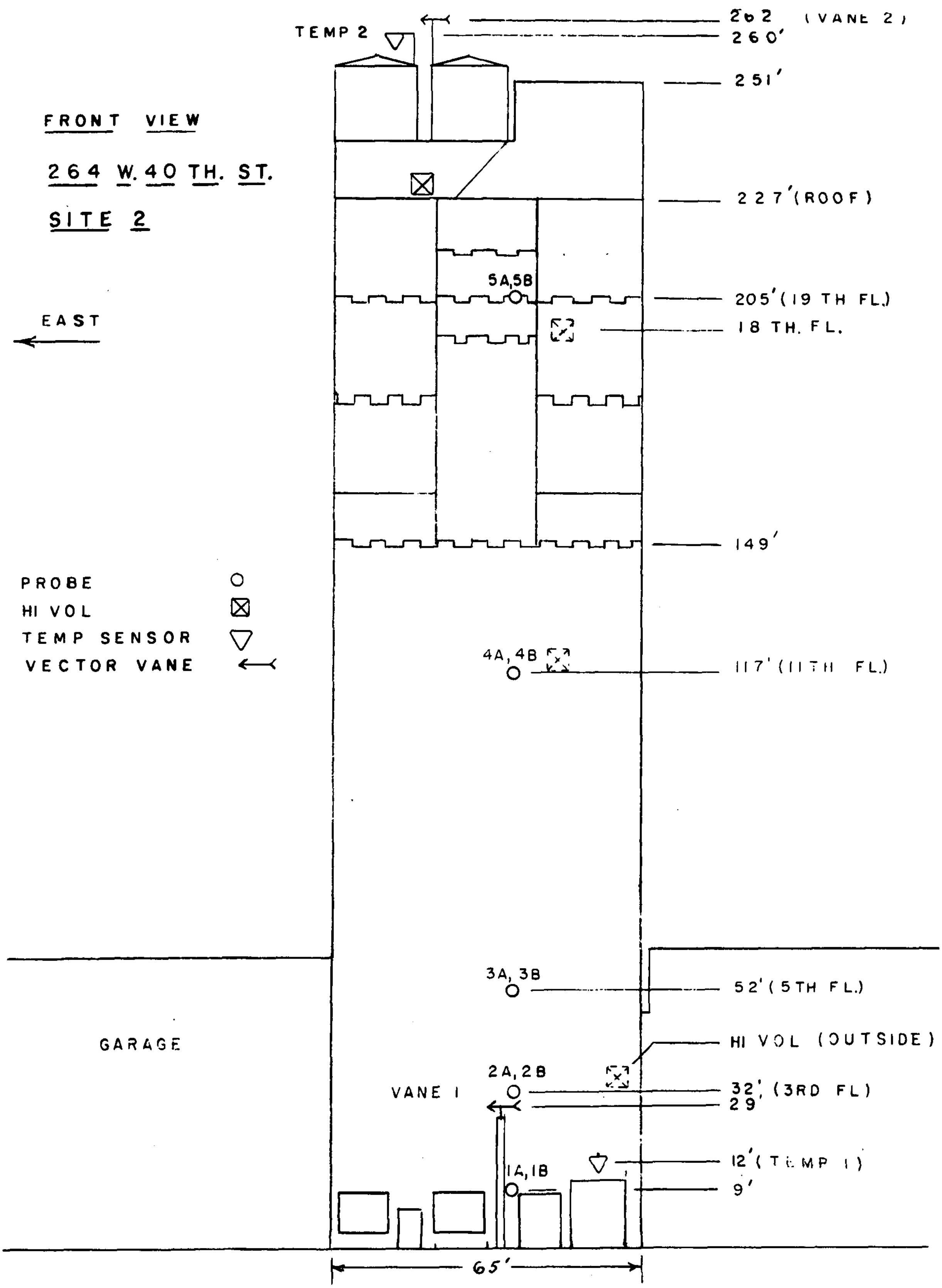


Figure 4.2-1 Site 2 - Front View.

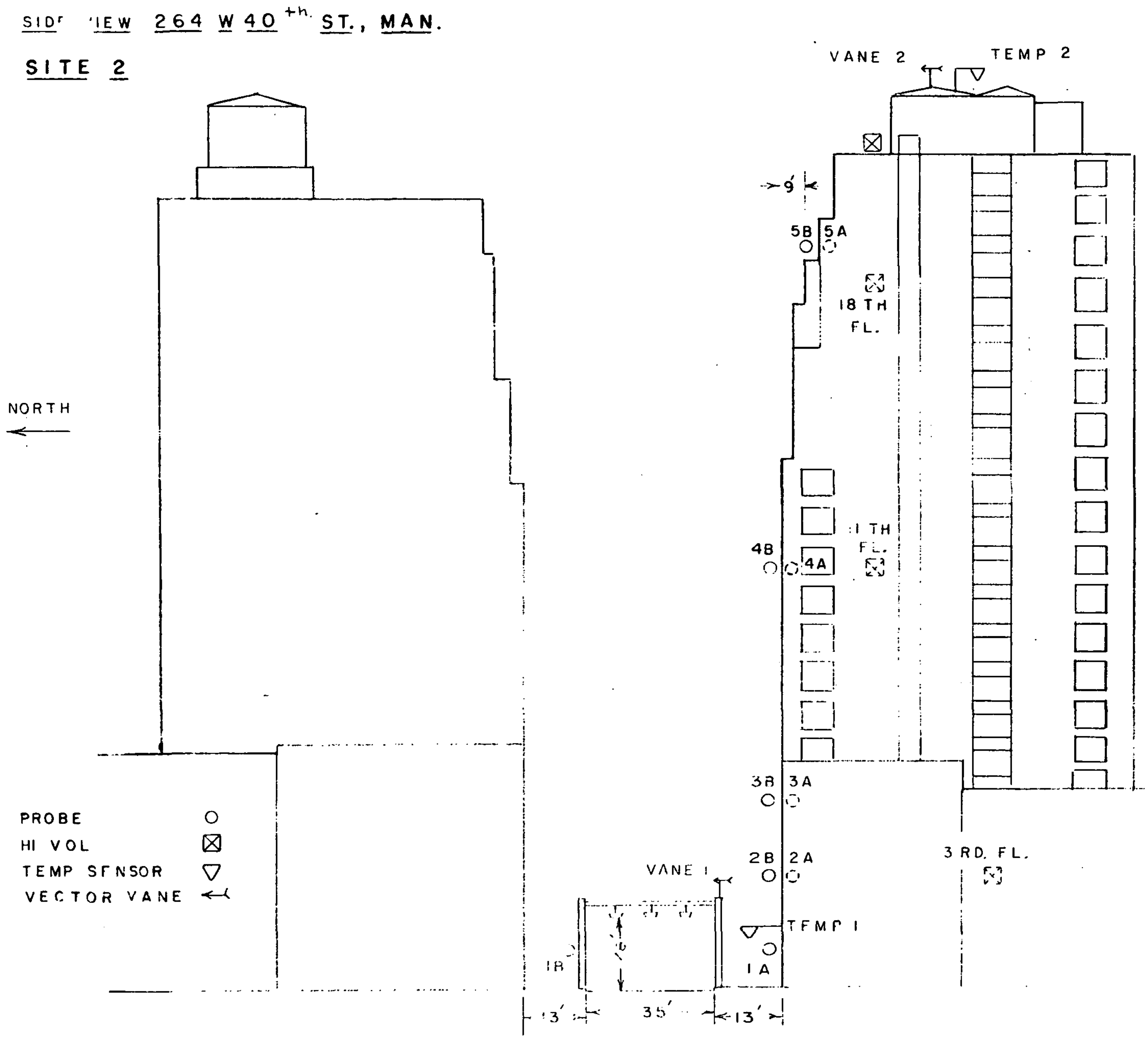


Figure 4.2-2 Site 2 Side View

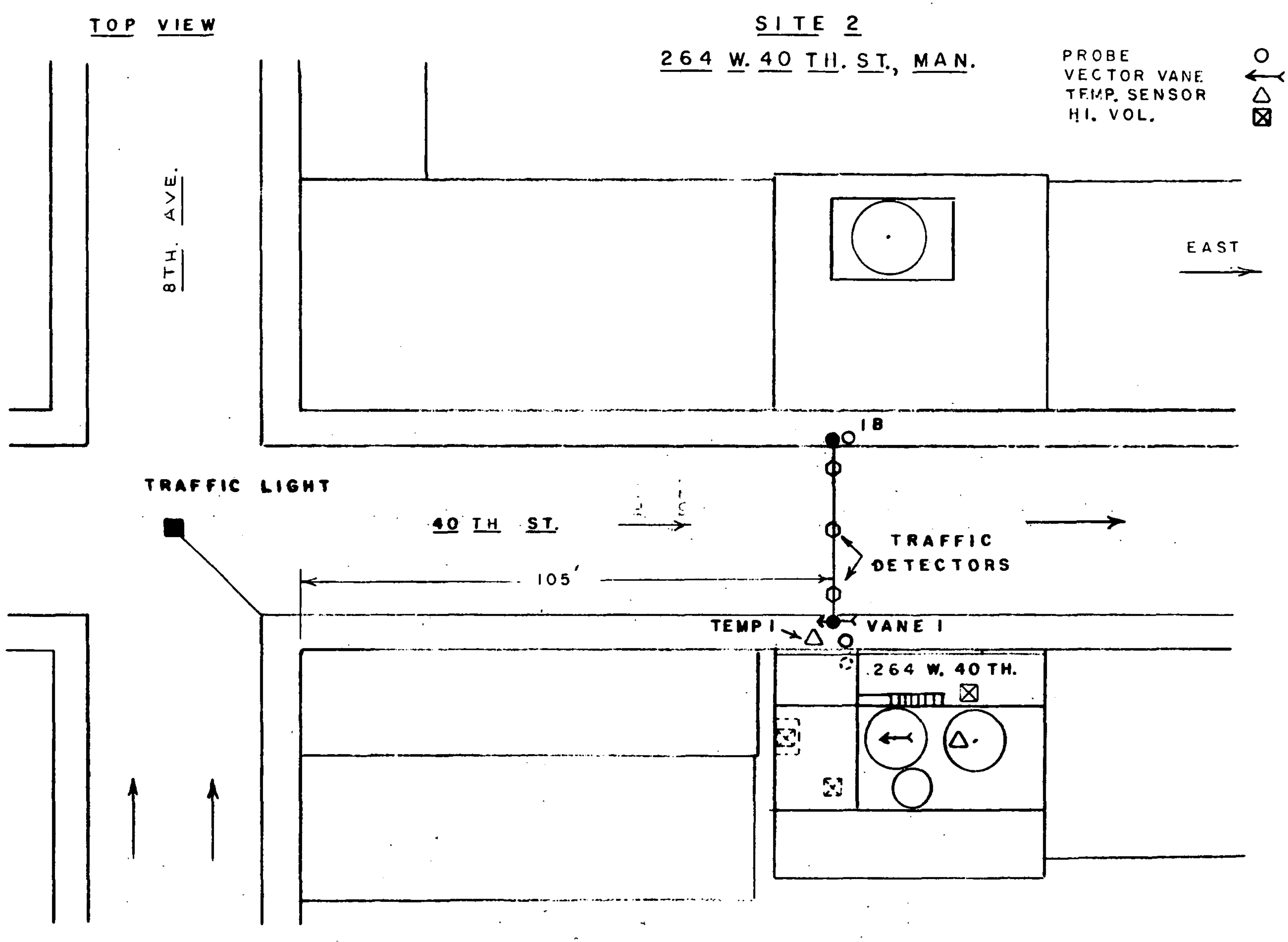


Figure 4.2-3 Site 2 - Top View

A total of 177 windows faced 40th St., while 28 upper level windows were exposed to 8th Avenue. Windows were located at each floor level and were fairly evenly spaced across the face of the building. There were two entrances into the main part of the building, one being a public entrance and the other being a service entrance. Both entrances led to elevators which serviced the 20 floors within the building. A small fabric shop was located at the first floor level with its own entrance on 40th St. On the west face of the building at each level above the second floor were located external cement balconies connecting the working area within the building with an enclosed fire stairwell. These doors leading from each balcony to the inside of the building were kept open at times for ventilation, introducing possible entrances for incoming pollution. Because of the number of windows, doors, and general building construction, many possible leak-entrances were available which allowed pollution to diffuse and circulate throughout the building. The building was heated with oil (hot water) and was not centrally air-conditioned. Most of the ventilation, especially during the summer months, was achieved by opening doors and windows.

Inside the building were many small business firms manufacturing such items as clothing, buttons, buckles, display fountains, etc. On other floors were printing concerns, fabric and metal casting companies, storage spaces, and other areas involving small business operations. Each of the above businesses paid for its own trash removal, thus eliminating incineration in the building.

All traffic passing by the test building originated from either right-turn traffic off 8th Avenue (one way north) or from cross-over traffic on

40th St. (one way east). Heavy commuter traffic exiting from the Lincoln Tunnel flowed directly onto 40th St. making it a major artery into the city. A traffic light (located at the intersection of 40th and 8th Ave.) determined to some extent the volume of traffic flowing at any particular time but overall traffic volume can be considered relatively independent of the visual stop-go condition of the traffic light. Steady traffic flows regardless of the state of the light. Ideally, 40th St. handled a maximum of three lanes of one-way traffic. Traffic patterns, however, did not allow for maximum traffic flow. During the working day, vehicles parked along the curb forced all traffic to pass single file up the middle of 40th St. At night, when the street was completely free of all parked vehicles, traffic again followed the geometric center of the street out of driver personal preference. Traffic flow patterns involving more than one lane of traffic occurred but not as frequently and usually took an unpredictable haphazard pattern.

4.2.2 Site Instrumentation

4.2.2.1 Carbon Monoxide and Hydrocarbons

Five different gas sampling levels relative to the street were monitored to investigate the indoor-outdoor pollution concentrations at this site. Two sampling probes were placed at each level, one inside and one outside, providing a total of 10 samplings. All probes placed inside the building were positioned as far from the windows as possible in order to best define the pollution concentrations within. Both carbon monoxide and total hydrocarbon concentrations were sampled by these probes as indicated in the table below.

Probe Designation	Pollutant		Distance from Roadway
1A	Roadway - CO x		9 Feet - Test Building
2A	Inside - CO	Inside HC	32 Feet
3A	Inside - "		52 Feet
4A	Inside - "	Inside HC	117 Feet
5A	Inside - "	" "	205 Feet
1B	Roadway - CO x		9 Feet - North Side
2B	Outside CO	Outside HC	32 Feet
3B	Outside CO		52 Feet
4B	Outside CO	Outside HC	117 Feet
5B	Outside CO	" "	205 Feet

The air pollution laboratory was located on the 11th floor.

X Monitoring started on 2/18/71. Probe on north side of street not installed until 3/15/71.

The roadway CO concentrations was characterized using two probes, each at the 9 ft. level. One of the probes (1B) was positioned on the wooden pole on the north side of 40th St. while the other probe (1A) was attached to the face of the test building. An average of the two probes might best define the CO concentrations at the roadway. Two other sampling probes were positioned inside and outside at the 3rd floor level (32 ft.). The outside probe (2B) was secured outside the window at that level. The inside probe (2A) was positioned approximately 15 ft. inside a small women's clothing factory. Probes 3A and 3B were positioned at the 5th floor (52 ft.). A small print shop was located at this level. At the 117 ft. level (11th floor) probe 4A was inside and 4B was located outside. Business activity on this floor included a dress maker shop and a manufacturer of auto travel bags. The highest level checked for CO was the 19th floor, Probe 5A was positioned in an area involved in the manufacture of buckles for women's shoes and dresses. Probe 5B was placed outside at this level. Large drums of oil coated buckles were often stored on this floor.

Hydrocarbon concentrations were measured at three different indoor-outdoor elevations. The 3rd, 11th and 19th floors were monitored for total hydrocarbons by utilizing the CO probing and incorporating a switching technique using solenoid valving. Thus the CO and HC concentrations from the desired levels would be monitored simultaneously. High HC concentrations were expected from various levels due to the oil drums on the 19th floor, spraying of decorative fountains on the 3rd, painting of the various floors during the study, and other factors which introduced high hydrocarbon concentrations inside the building which were not traffic derived.

4.2.2.2 Total Particulates and Lead

Particulates were measured at various levels inside and outside the test structure. Since the High Volum Air Sampler produced excessive noise, a problem arose as to where the units could be positioned. One Hi Vol sampler was placed on the roof of the test building while another was positioned on the outside balcony on the third floor. Two inside samplers were positioned on the 11th and 18th floors. These four air samplers measured the total particulate matter and relative lead concentrations at the various locations about the test building.

4.2.2.3 Traffic

Three ultrasonic traffic detectors were utilized to measure hourly vehicular traffic volumes and speeds. Two steel cables were positioned between wooden poles located on each sidewalk adjacent to 40th St. to support the three traffic sensors. One sensor was placed directly above the geometric center of the street while the other two sensors were positioned 6 ft. out from the curb. Most of the traffic was counted by the center traffic sensor, while the adjacent sensors picked up any irregular non-typical patterns that occurred. Since the majority of vehicles passed through the detection zone of the center detector, average speed for the flowing traffic was defined by the speed measurement of that detector.

4.2.2.4 Meteorological

Two vector vanes were utilized to measure and evaluate the wind parameters at this site. One vane (vane #1) was positioned at the top of the traffic pole on the south side of 40th Street, 29 feet above the roadway. All measurements recorded from this vector vane were considered to be the summation of both natural and traffic derived wind components. A second vane was placed 262 ft. above the street, higher than any portion of the building. Since the test building was the tallest structure in the nearby area, wind measurements recorded from this vane characterized the general overall wind parameters at the site.

In order to calculate the local temperature lapse rate which indicated the stability of the micrometeorological condition present at the site, two very accurate temperature sensors were utilized. One sensor was placed above the building adjacent to vane #2 at a distance of 260 ft. from the street level. Another temperature sensor was positioned 4 ft. off the face of the building, 12 ft. from the sidewalk. This temperature sensor (Temp #1) measured the temperature near ground level.

4.2.3 Traffic Characteristics

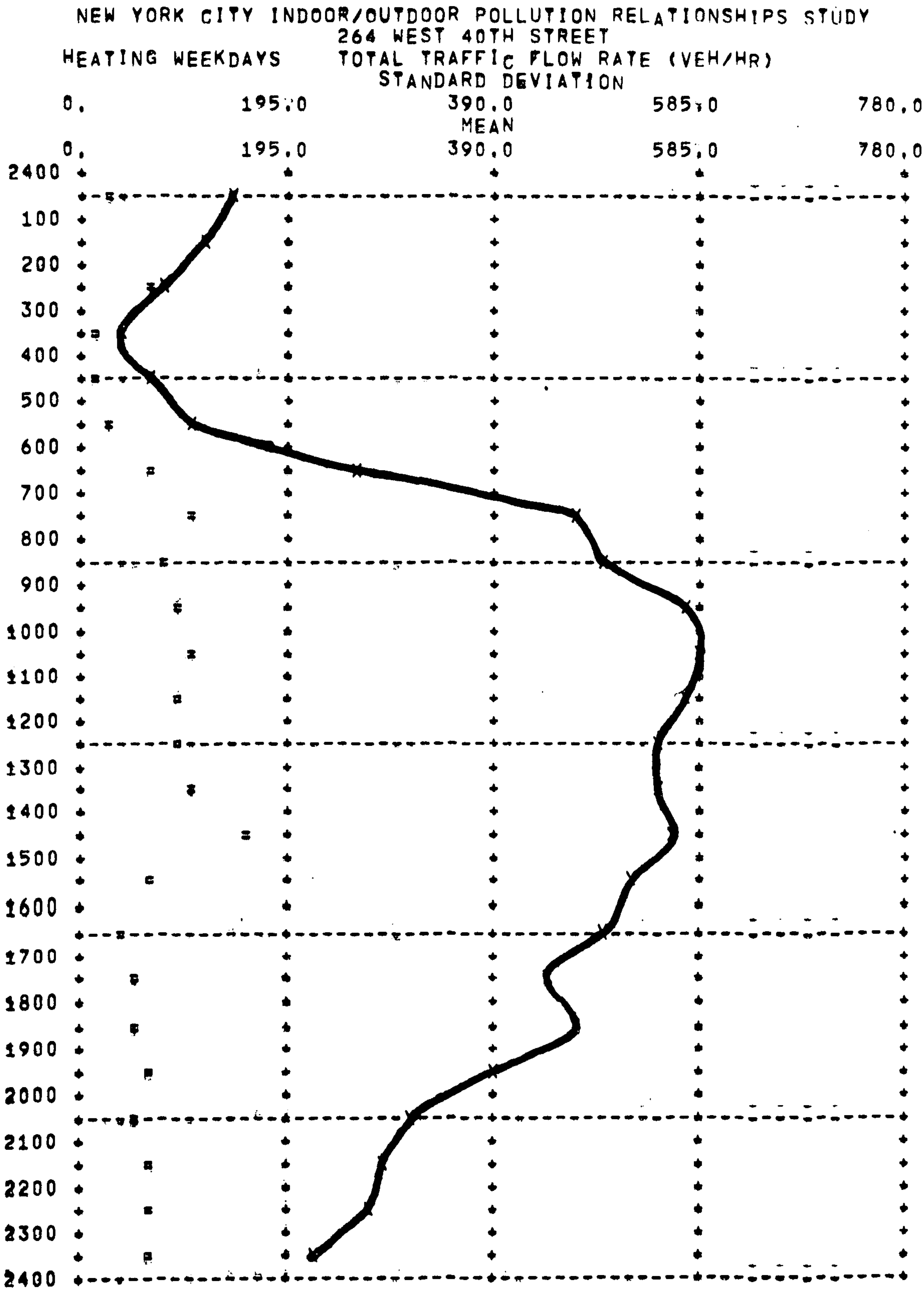
Traffic flow rates and velocities measured on West 40th Street were essentially the same during the heating and non-heating seasons.

The minimum traffic flow rate for the total period was 23 vehicles per hour. The maximum was 938 vehicles per hour. The average vehicle velocities for the individual hours ranged from 5 mph to 39 mph. Average vehicle velocities were less than 15 mph when the average traffic flow rate exceeded 455 vehicles per hour. Average vehicle velocities were greater than 15 mph when the average traffic flow rate was less than 455 vehicles per hour.

Traffic conditions on weekdays throughout the total monitoring period were basically the same for each day. Weekend traffic generally was lower than for weekdays.

4.2.3.1 Weekday Traffic

Weekday traffic during the heating season produced the diurnal characteristics shown on figures 4.2-4 and 4.2-5. Non-heating season diurnal weekday traffic conditions are very similar as shown on figures 4.2-6 and 4.2-7. It should be noted that twice as many days data (51 days) is available for the heating season than for the non-heating season (26 days). Minimum traffic flow for both seasons occurred in the early morning hours. Traffic rose sharply during the morning rush hour. Peak traffic, however, occurred between 9 and 11 A.M. Traffic decreased from this peak, except for a short period of time during the evening rush hour, to the early morning low.


NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS
TOTAL TRAFFIC FLOW RATE (VEH/HR)
STANDARD DEVIATION
0. 195.0 390.0 585.0 780.0
MEAN
0. 195.0 390.0 585.0 780.0
2400
100
200
300
400
500
600
700
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900
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1100
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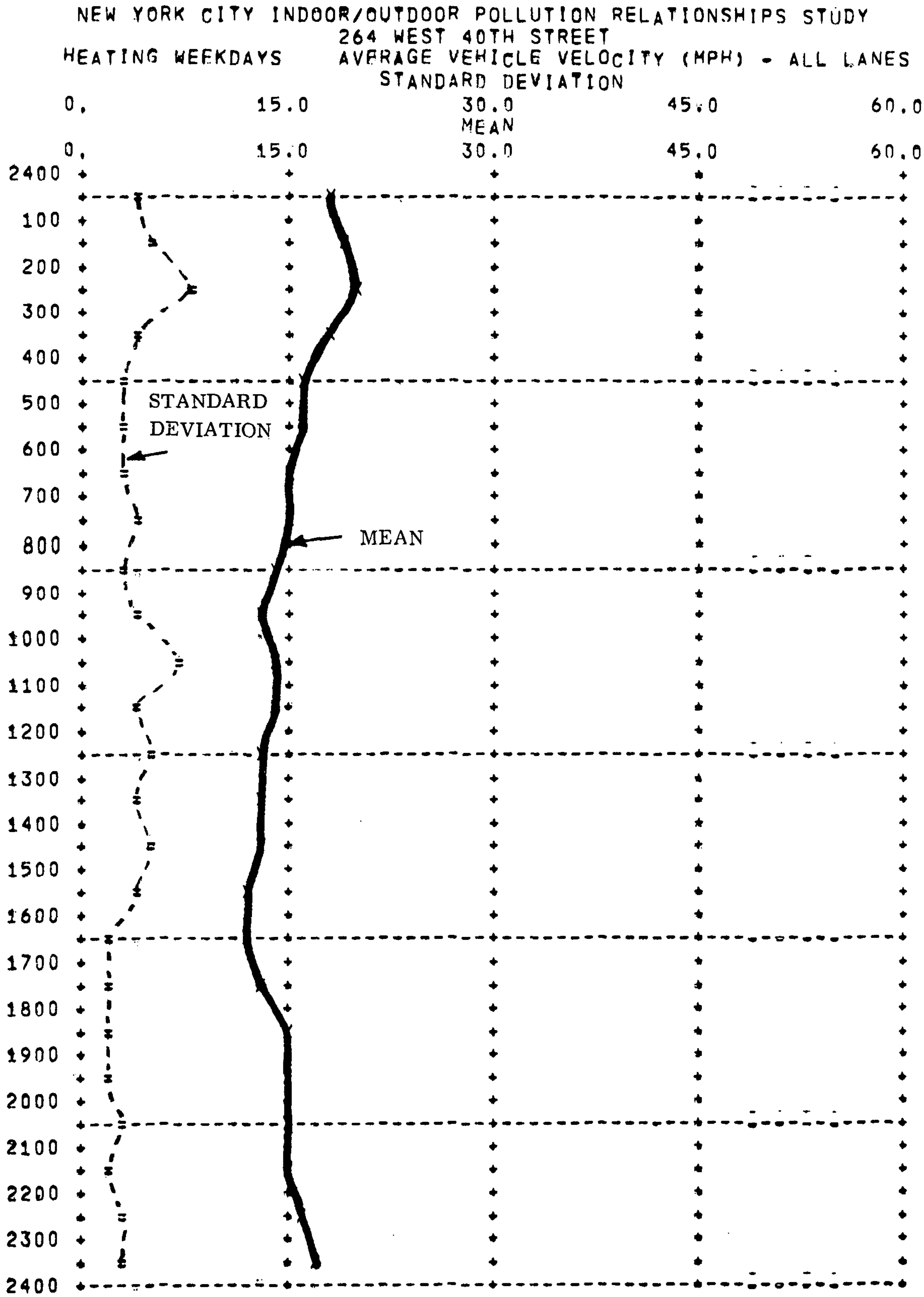
Figure 4.2-4



NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS
AVERAGE VEHICLE VELOCITY (MPH) - ALL LANES
STANDARD DEVIATION
0. 15.0 30.0 45.0 60.0
MEAN
0. 15.0 30.0 45.0 60.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
STANDARD DEVIATION
MEAN

FIGURE 4.2-5

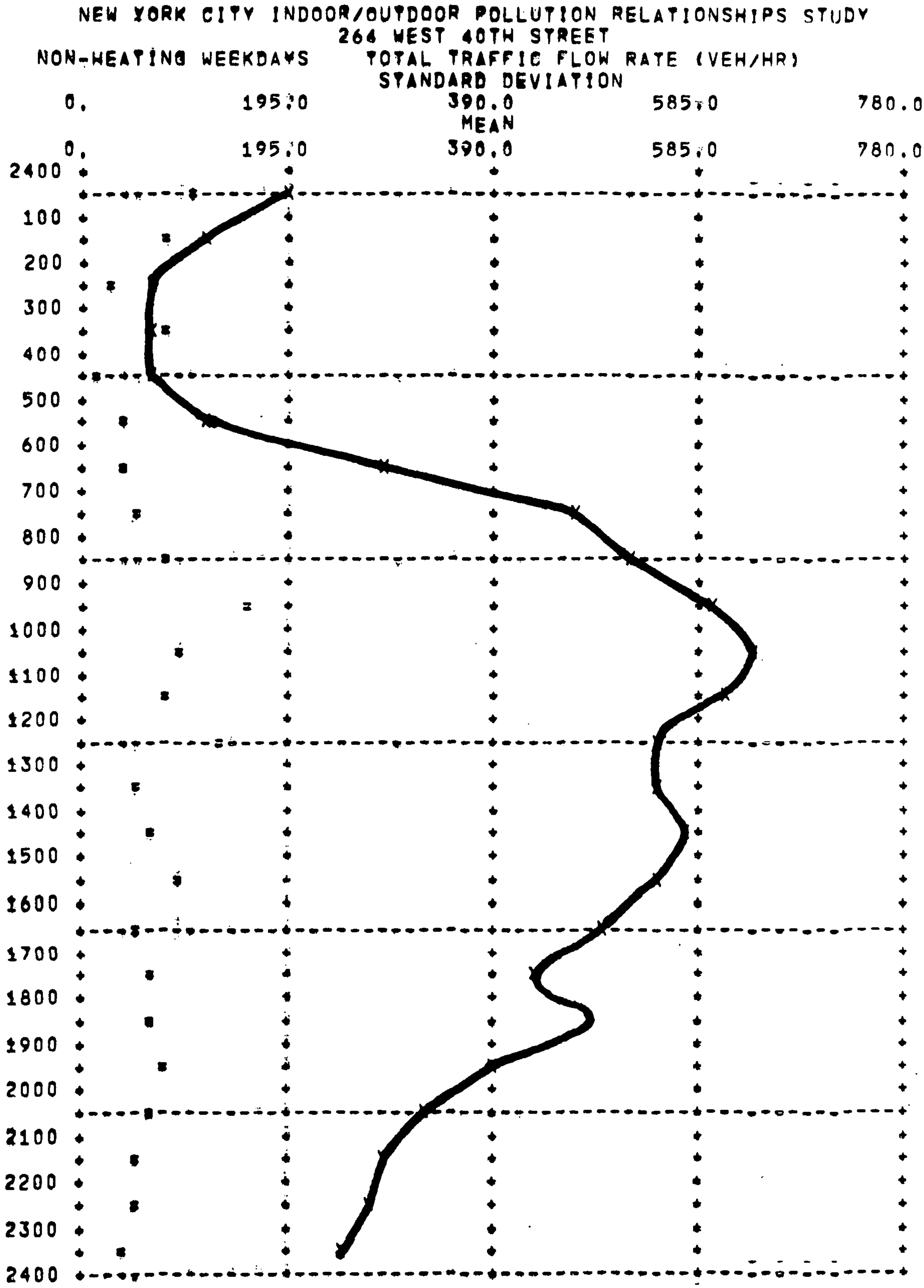
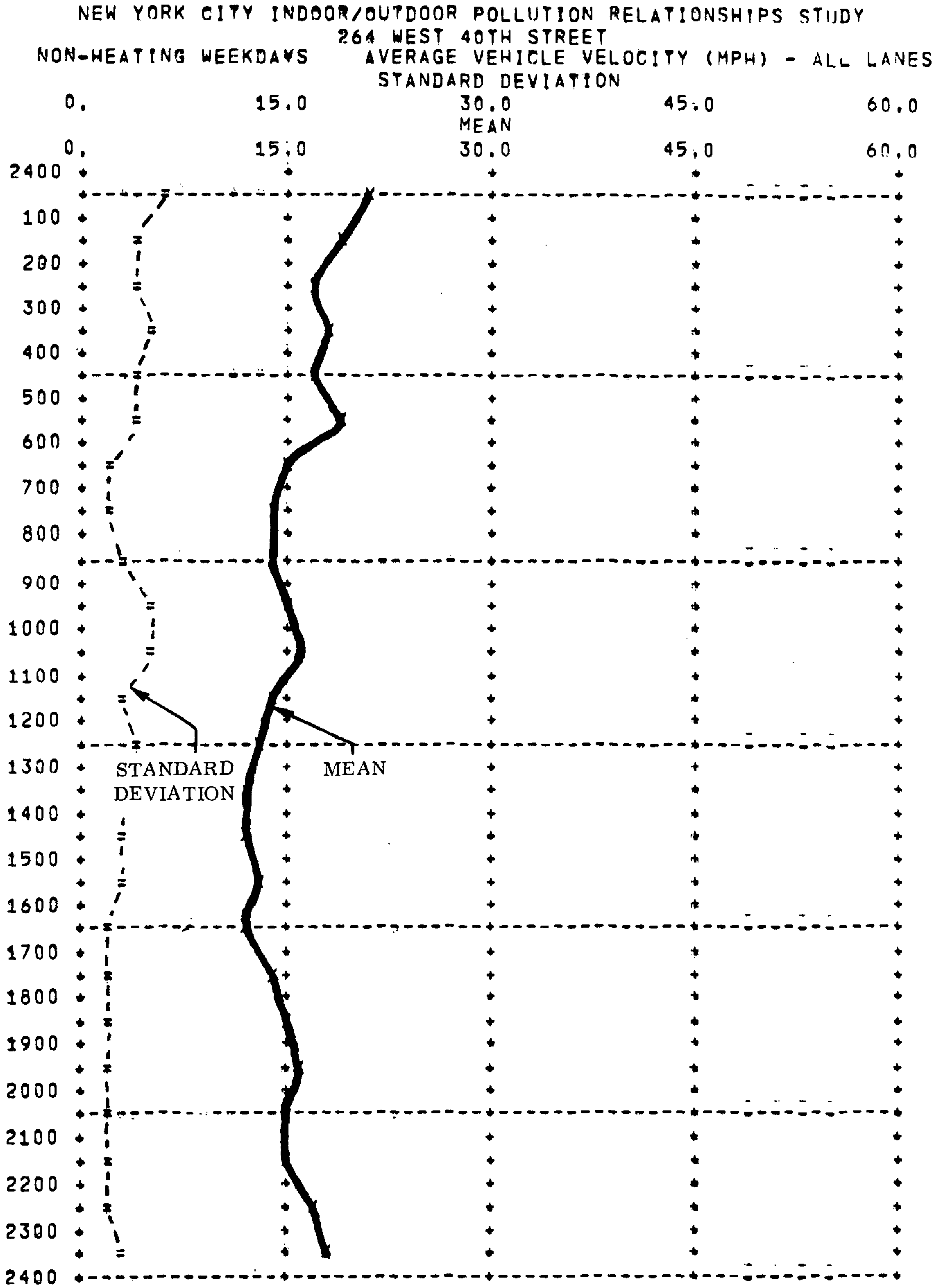

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS
TOTAL TRAFFIC FLOW RATE (VEH/HR)
STANDARD DEVIATION
0.
195.0
390.0
585.0
780.0
MEAN
0.
195.0
390.0
585.0
780.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

FIGURE 4.2-6



NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS AVERAGE VEHICLE VELOCITY (MPH) - ALL LANES
STANDARD DEVIATION
0. 15.0 30.0 45.0 60.0
MEAN
0. 15.0 30.0 45.0 60.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
STANDARD DEVIATION
MEAN

FIGURE 4.2-7

4.2.3.2 Weekend Traffic

Weekend traffic during the heating season was highest at noon-time as shown on figure 4.2-8. No morning rush hour was present. The daily low occured a couple of hours later than typical on weekdays. Average traffic velocities, as shown on Figure 4.2-9, were higher than for weekdays.

Figures 4.2-10 and 4.2-11 show the diurnal traffic flow rate and velocity profiles for non-heating weekends. These curves represent only 8 days of data while the heating weekend data covers 22 days. It is felt that the slight difference between the seasonal data is a reflection of the difference in data sample size.

4.2.4 Meteorological Conditions

The area near the canyon street site was structurally more congested than the air-rights site. Many nearby buildings were almost as tall as the structure used for monitoring. At a distance of only a few blocks, other buildings were considerably taller than this. Circulation patterns in the vicinity of the canyon site are, therefore, extremely complex. The highest wind speed recorded at this site was 20 mph at the roof level between the hours of 2 AM and 5 AM on April 7, 197. Wind azimuth, during this period, was basically from 40^{o}. The road level winds however were blowing from 280^{o} at this time at approximately 5 mph. There was no discernible reduction in pollution levels during these hours.

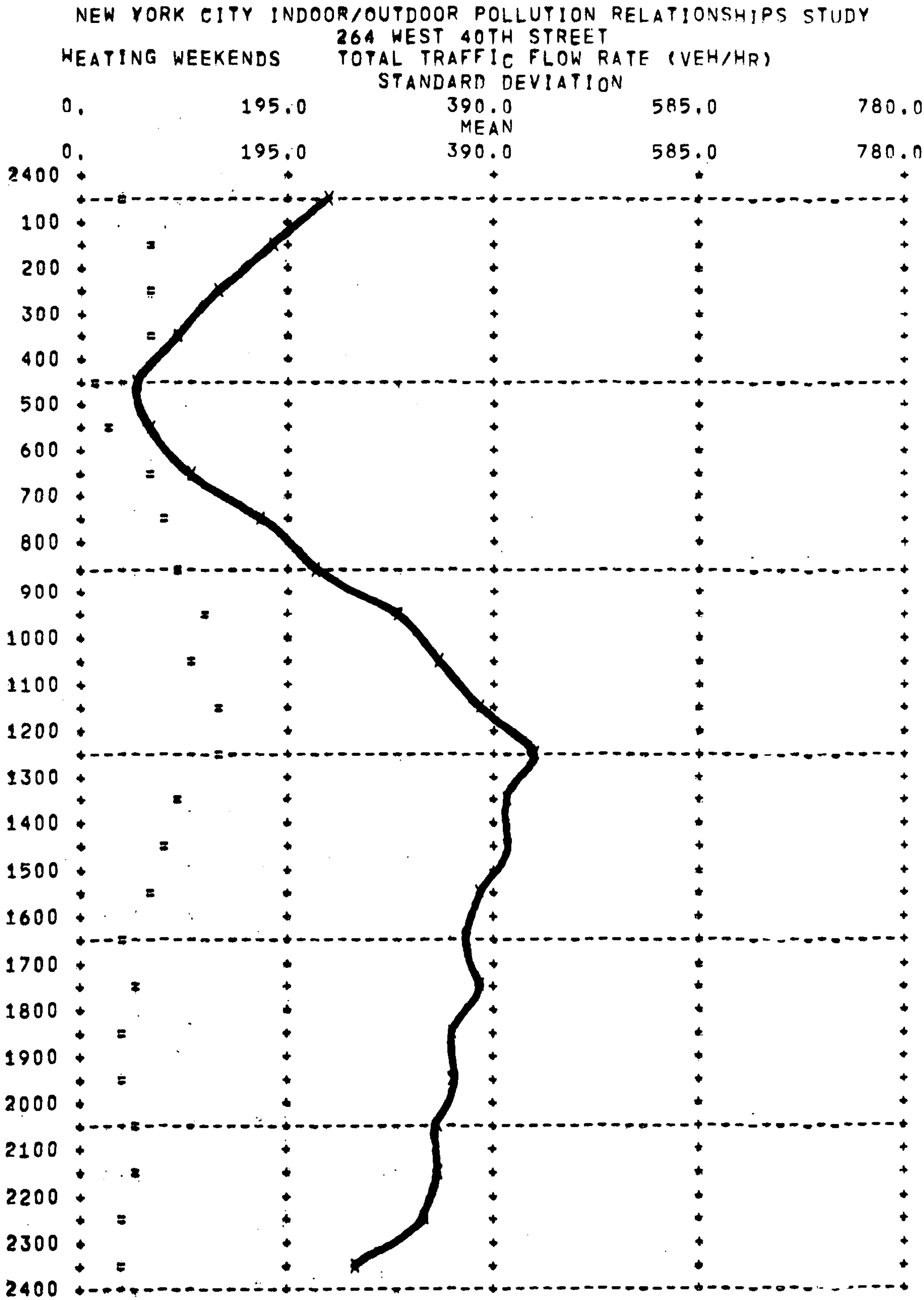

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKENDS
TOTAL TRAFFIC FLOW RATE (VEH/HR)
STANDARD DEVIATION
0. 195.0 390.0 585.0 780.0
MEAN
0. 195.0 390.0 585.0 780.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

FIGURE 4.2-8

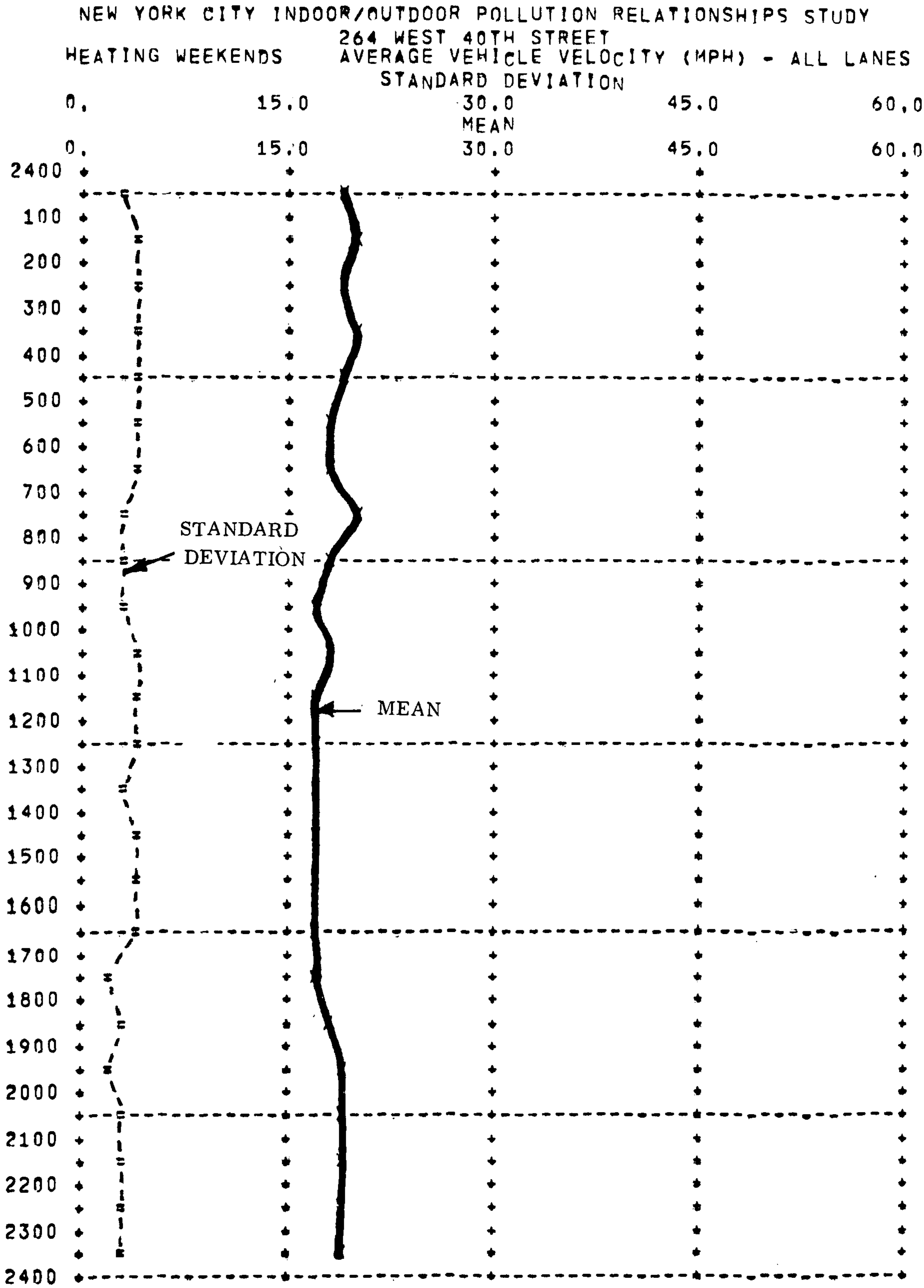
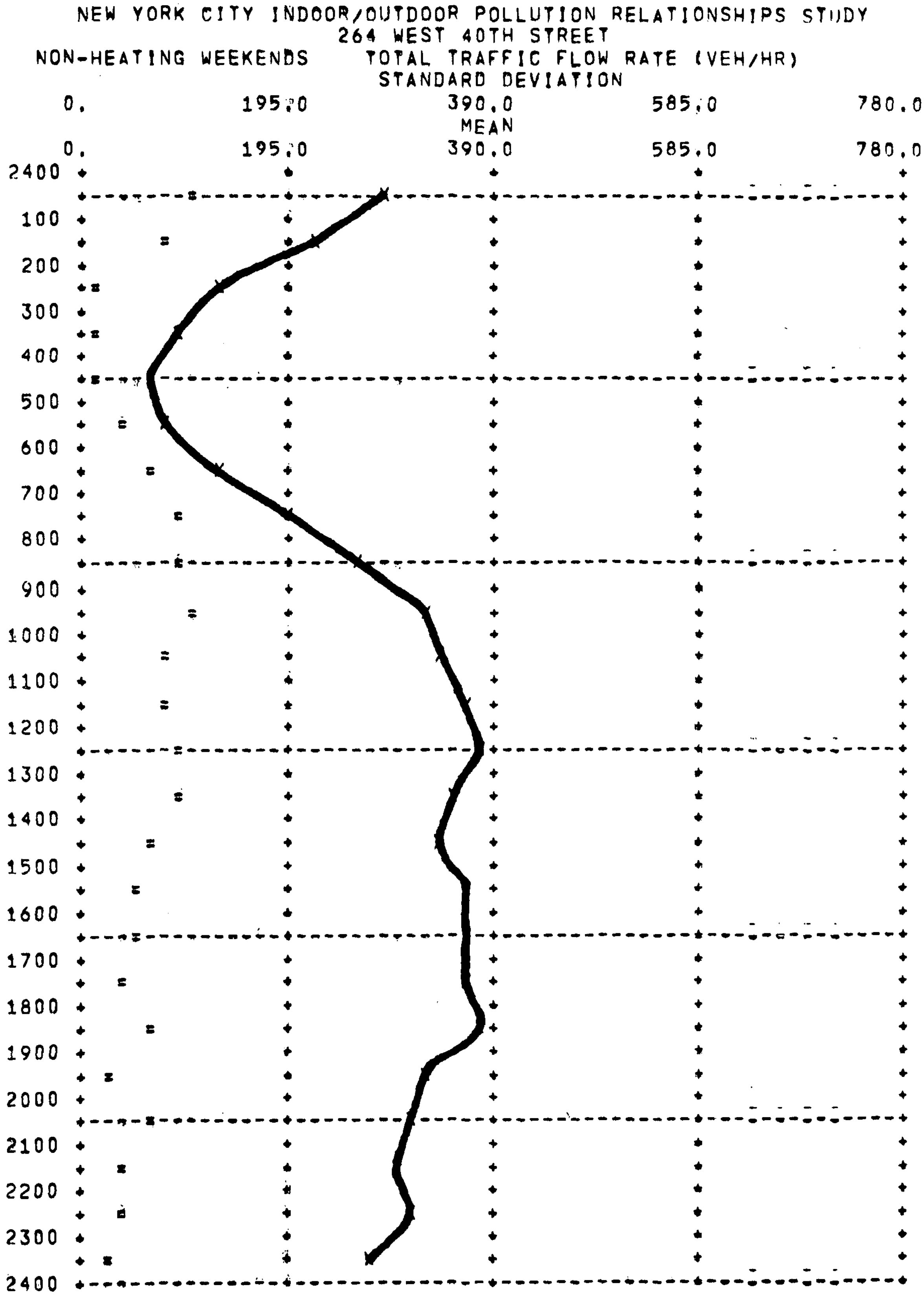

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKENDS
AVERAGE VEHICLE VELOCITY (MPH) - ALL LANES
STANDARD DEVIATION
0.
15.0
30.0
45.0
60.0
MEAN
0.
15.0
30.0
45.0
60.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
STANDARD DEVIATION
MEAN

FIGURE 4.2-9



NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKENDS
TOTAL TRAFFIC FLOW RATE (VEH/HR)
STANDARD DEVIATION
0. 195.0 390.0 585.0 780.0
MEAN
0. 195.0 390.0 585.0 780.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

FIGURE 4.2-10

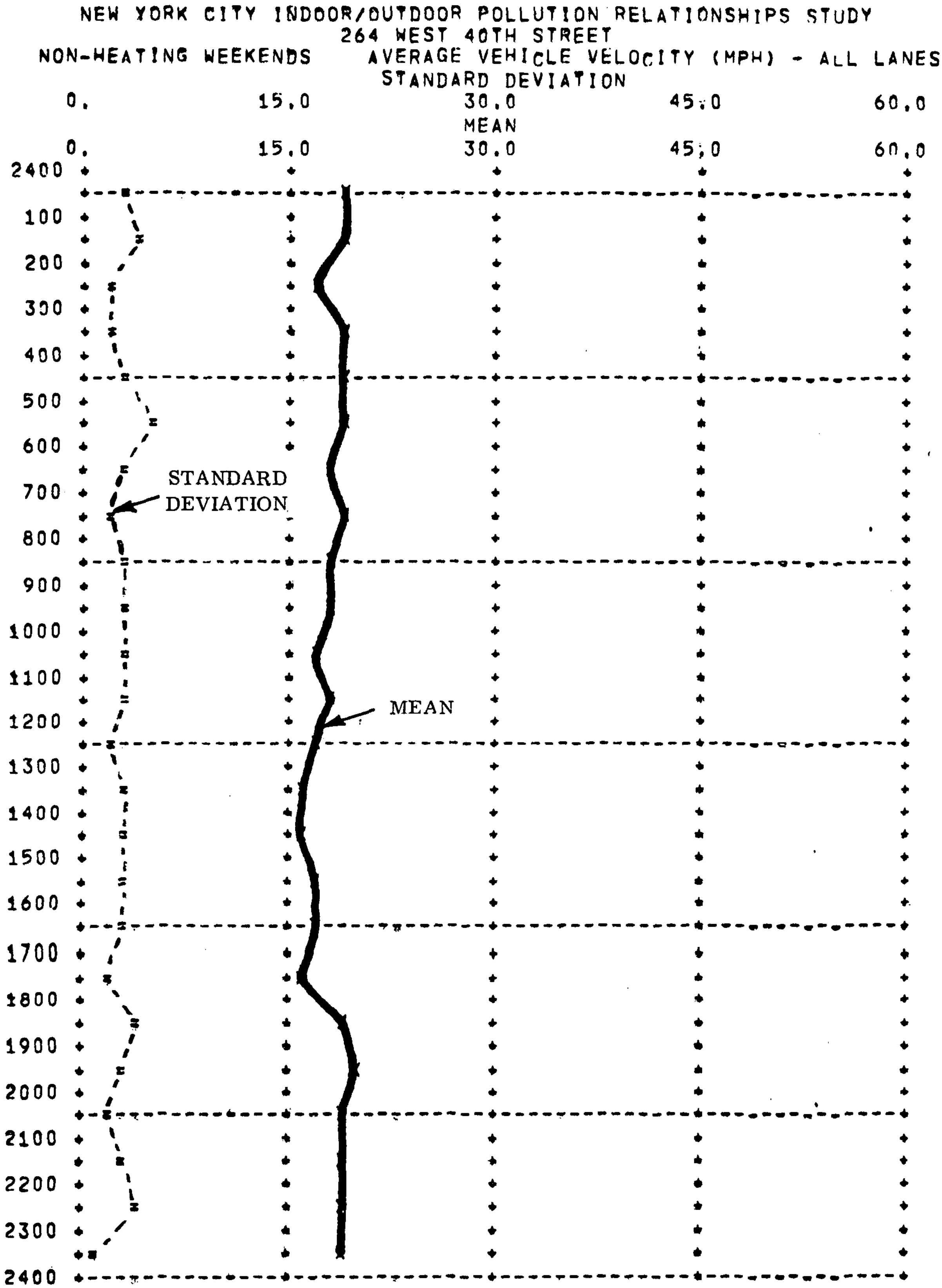

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKENDS
AVERAGE VEHICLE VELOCITY (MPH) - ALL LANES
STANDARD DEVIATION
0. 15.0 30.0 45.0 60.0
MEAN
0. 15.0 30.0 45.0 60.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
STANDARD DEVIATION
MEAN

FIGURE 4.2-11

The heating and non-heating seasons were characterized by the roof wind azimuth direction as shown in the table below. It can be

		Wind Aximuth - degrees					
		0-59	60-119	120-179	180-239	240-299	300-359
Loc	Season						
Roof	Heating	8.1	14.7	21.0	23.5	32.4	0.2
	Non-Heating	6.9	11.9	23.2	44.8	13.2	0
Road	Heating	0	0.7	17.4	8.7	61.1	11.9
	Non-Heating	0	0.6	31.6	17.6	40.2	10.1

seen that during the heating season, the roof wind blew from 120-239° for 44.5% of the time and from 240-299° for 32.4% of the time. This wind, however, blew from 120-239° for 68.0% of the time during the non-heating season and only 13.2° of the time from 240-299°. Road level winds were predominately from 240-299° during the heating season. Non-heating season road level winds were fairly evenly distributed between 120-239° and 240-299°.

Diurnal variation of the roof level wind speed at the canyon site is shown in figure 4.2-12. The maximum occurs near 6 PM and the minimum near 6 A.M. Velocities are considerably reduced from those recorded at the air-rights structure. The turbulence parameter, sigma azimuth, as recorded at roof level shows a good range

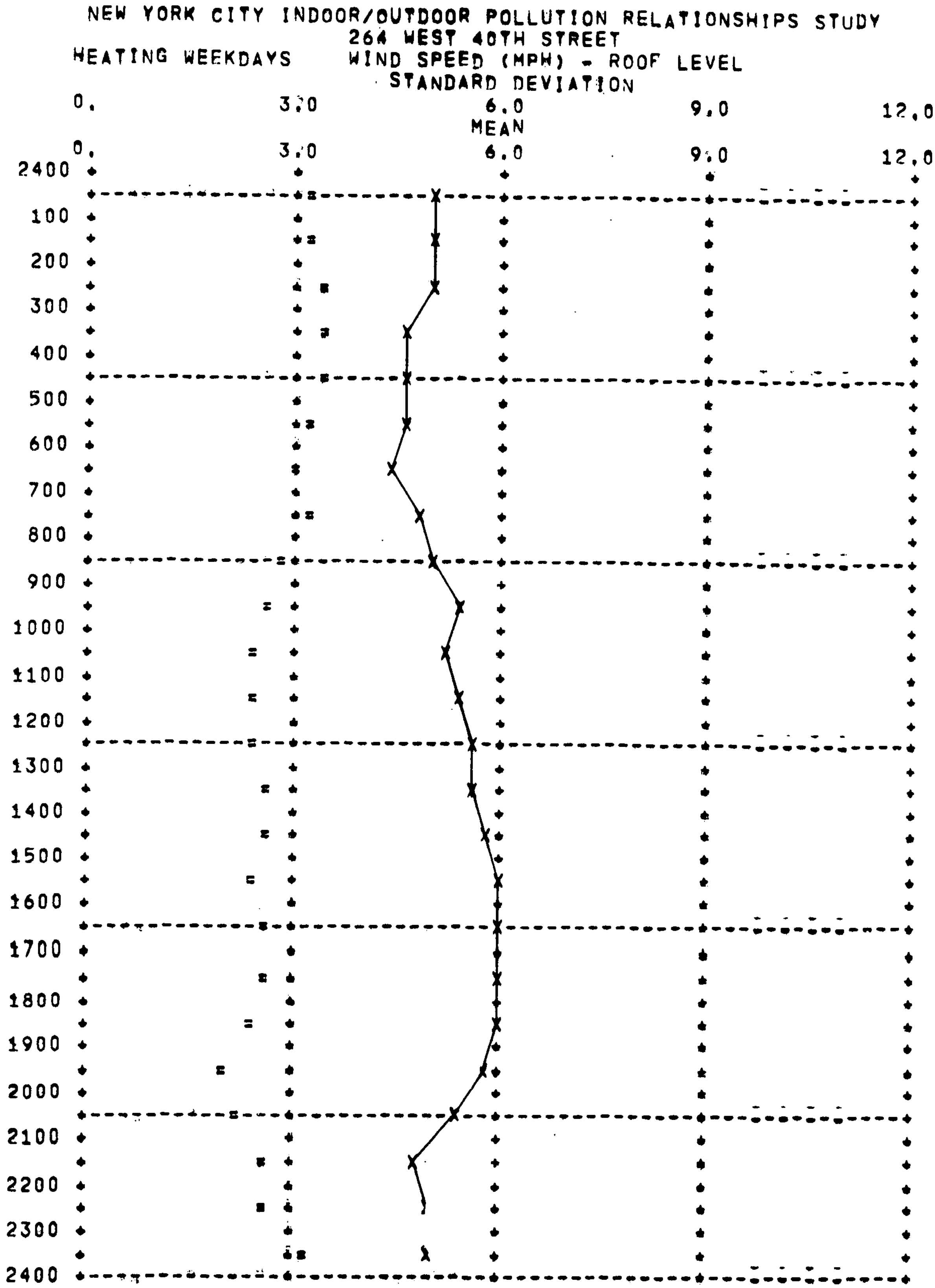

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS
WIND SPEED (MPH) - ROOF LEVEL
STANDARD DEVIATION
0. 3.0 6.0 9.0 12.0
MEAN
0. 3.0 6.0 9.0 12.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

Figure 4.2-12

of values with the minimum occurring at 5 AM and the maximum near 5 PM (Figure 4.2-13). The curve is considerably smoother and shaped more as would normally be expected of a meteorological parameter than the air rights sigma azimuth curve. Wind speed at road level (Figure 4.2-14) is reduced about 1 mph from the roof level averages as shown in the following table.

Loc	Heating	Non-Heating
	Average Wind Speed - mph	
Roof	5.2	3.8
Road	4.1	2.6

Turbulence is also reduced at street level (Figure 4.2-15). There is no evidence of traffic-induced turbulence in the data. This is expected since vehicle velocity was very low and the amount of congestion quite high. Diurnal temperature ranges, although still rather small at 12°F, were almost twice the magnitude of those encountered at the air-rights structure (Figure 4.2-16 and 4.2-17). The heating season mean temperature of near 50°F was approximately 11°F warmer than the heating season mean for the air-rights location as shown in the table below.

Average Temp degrees F

Loc	Heating	Non-Heating
Roof	47.2	72.0
Road	50.1	73.6

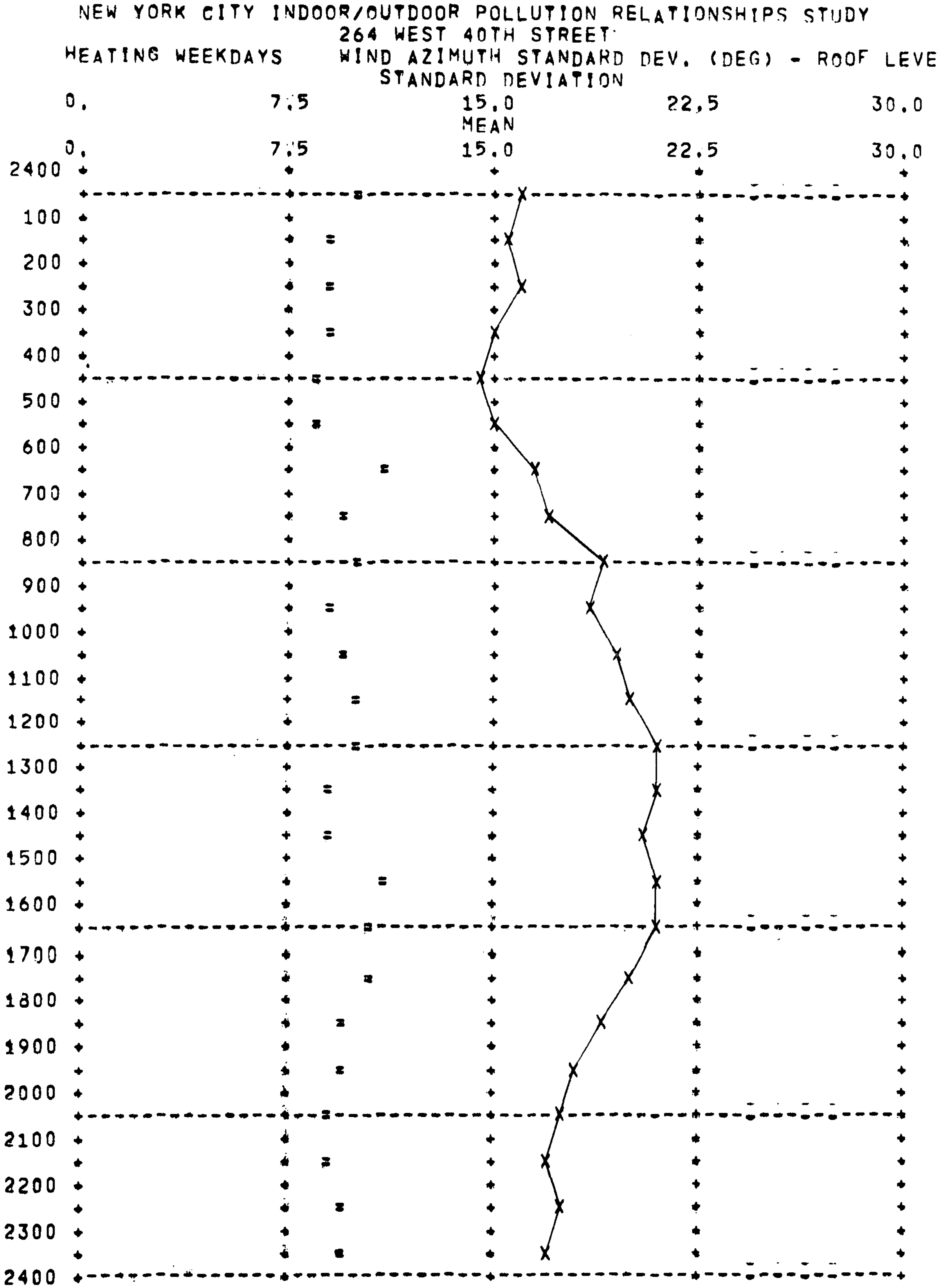
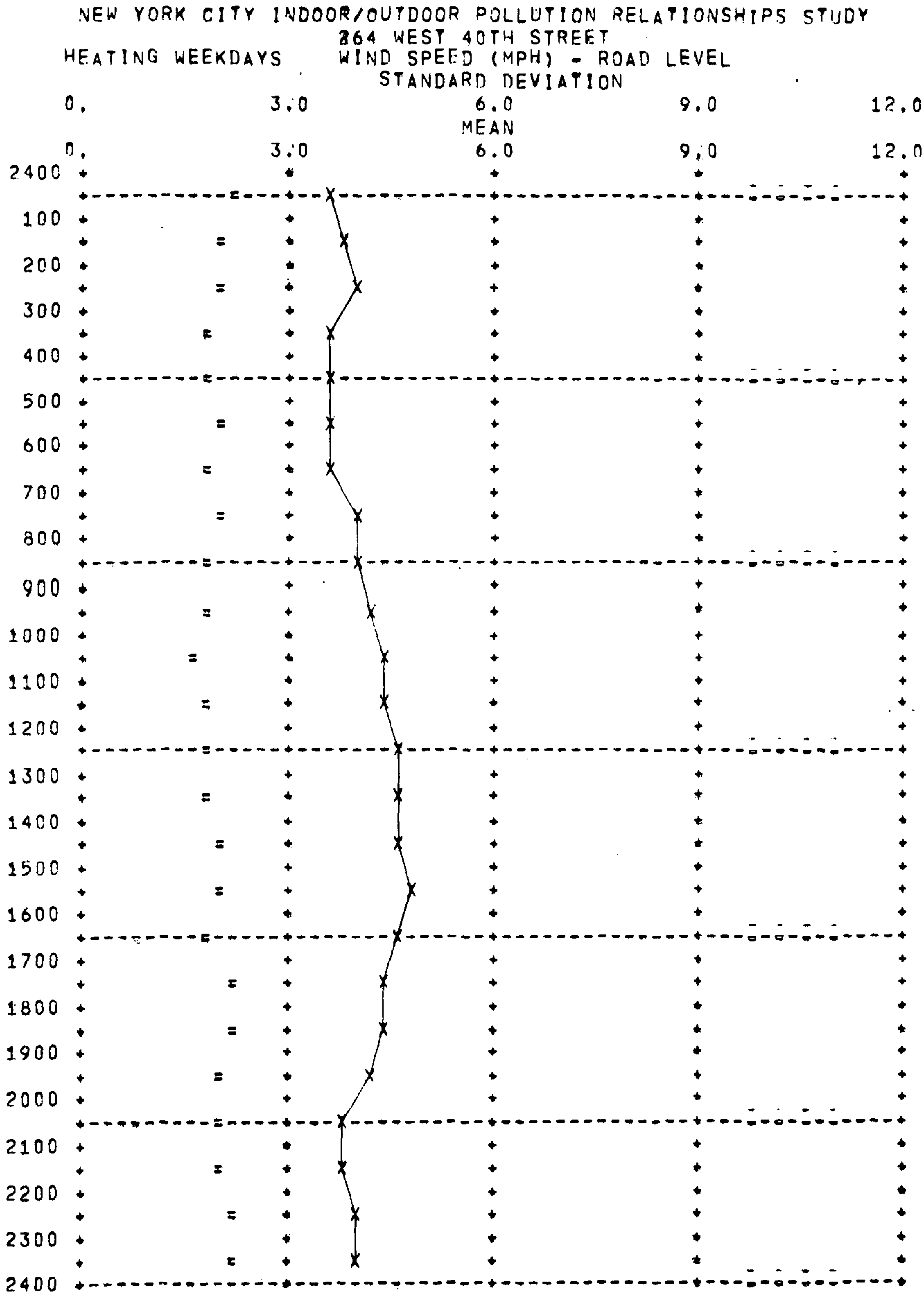

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS
WIND AZIMUTH STANDARD DEV. (DEG) - ROOF LEVEL
STANDARD DEVIATION
0. 7.5 15.0 22.5 30.0
MEAN
0. 7.5 15.0 22.5 30.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

Figure 4.2-13



NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS
WIND SPEED (MPH) - ROAD LEVEL
STANDARD DEVIATION
0. 3.0 6.0 9.0 12.0
MEAN
0. 3.0 6.0 9.0 12.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

Figure 4.2-14

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS   WIND AZIMUTH STANDARD DEV. (DEG) - ROAD LEVEL

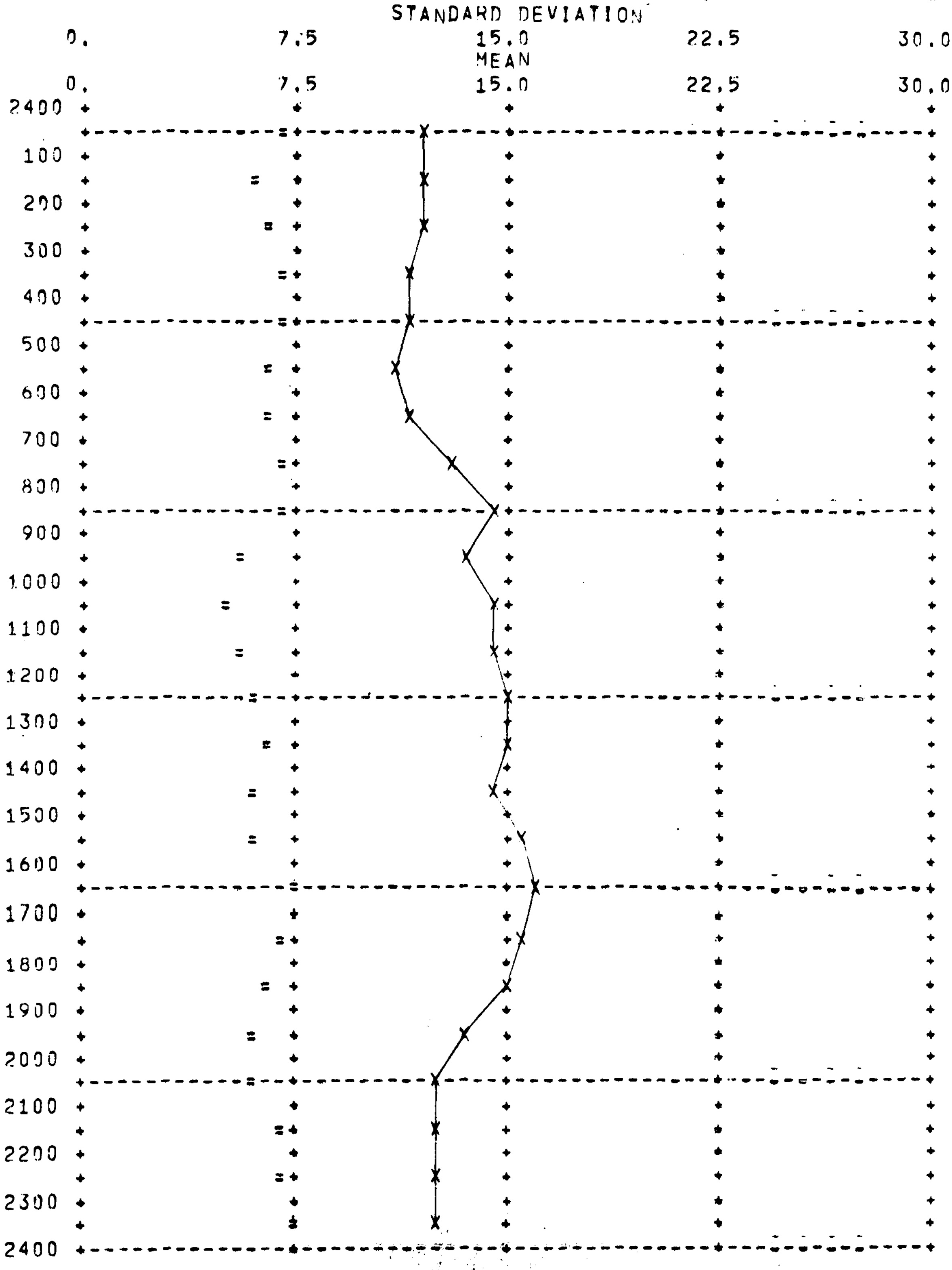


Figure 4.2-15

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS   TEMPERATURE (DEG. F) - 12 FT. ABOVE ROAD
STANDARD DEVIATION

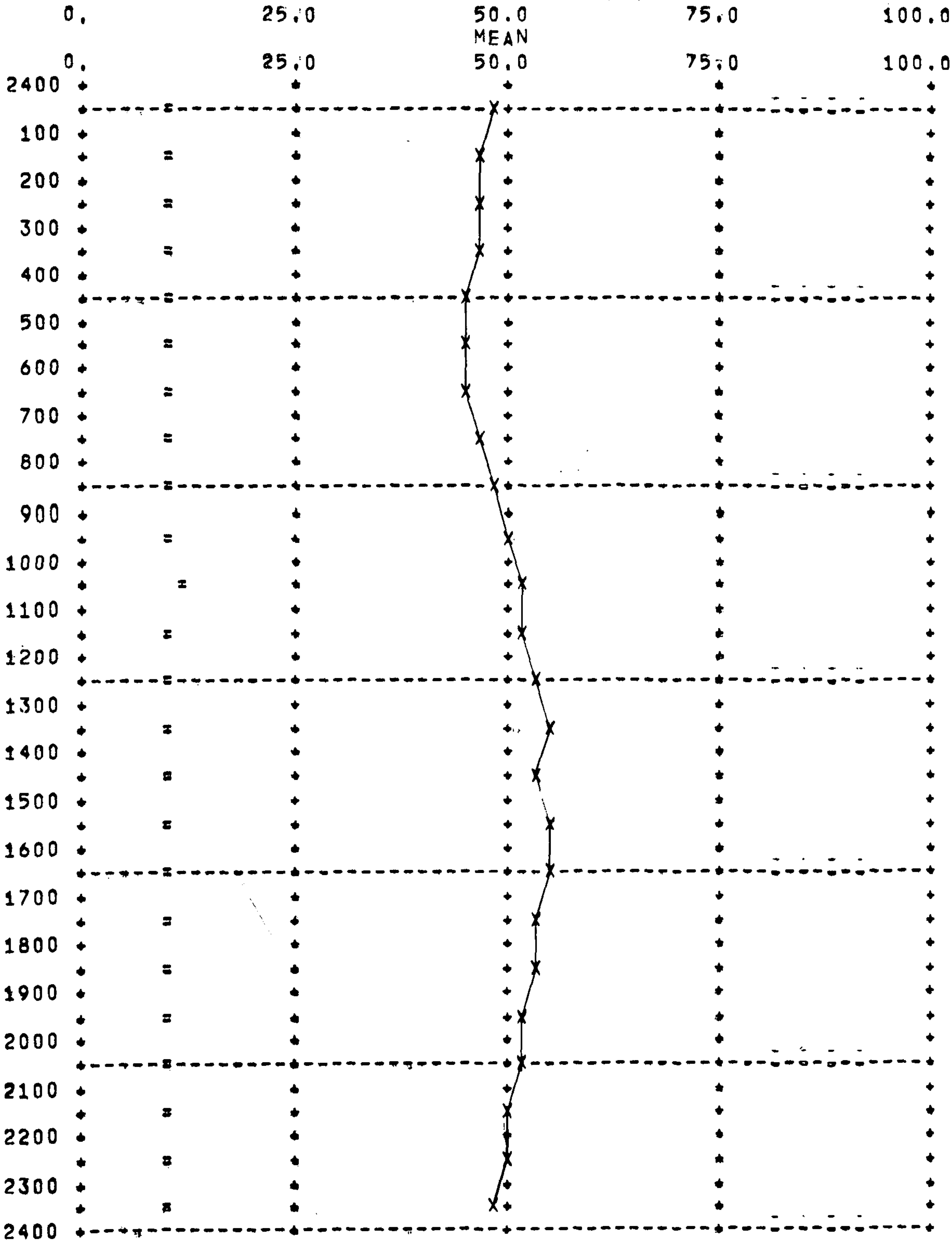


Figure 4.2-16

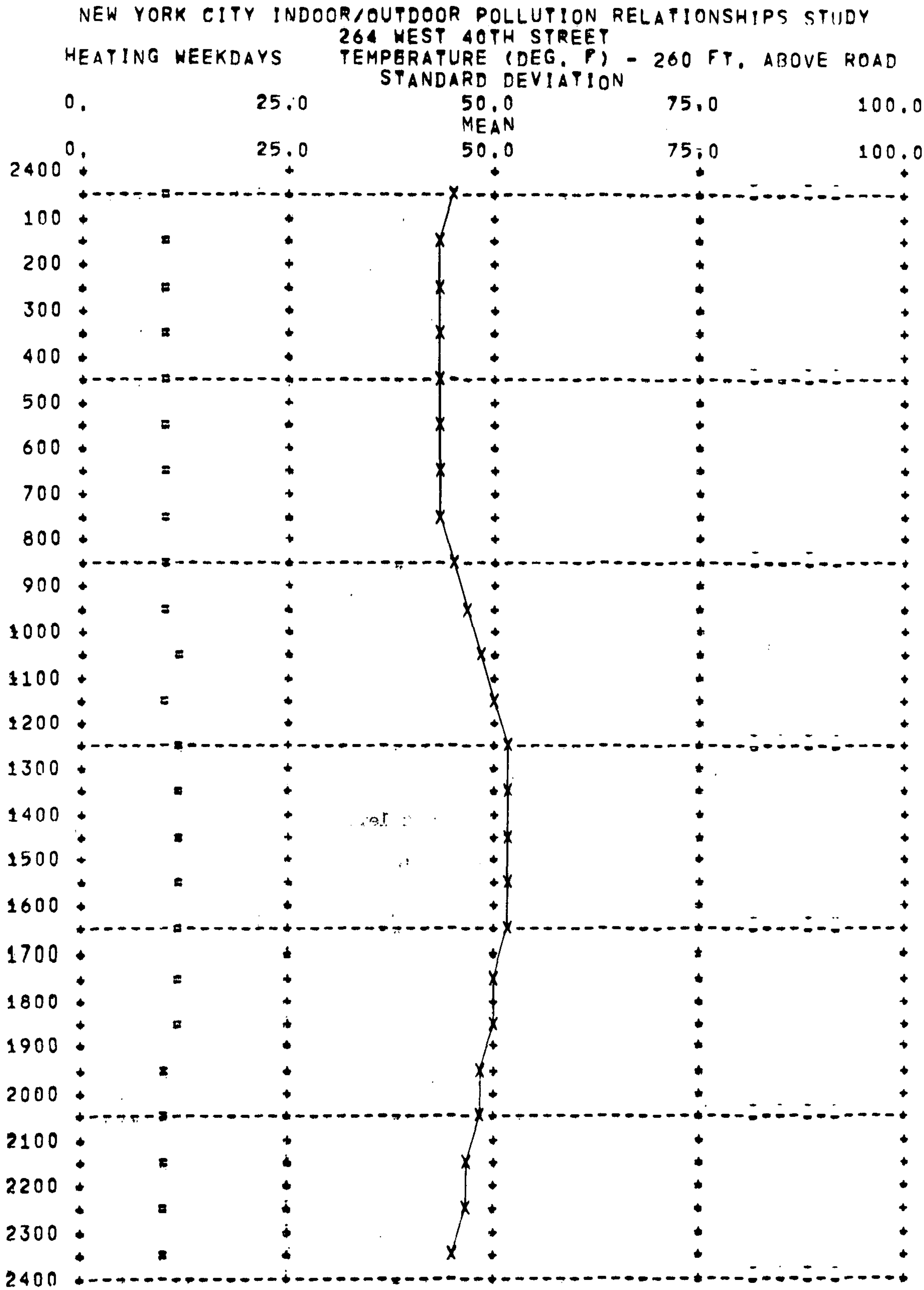

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS
TEMPERATURE (DEG. F) - 260 FT. ABOVE ROAD
STANDARD DEVIATION
0. 25.0 50.0 75.0 100.0
MEAN
0. 25.0 50.0 75.0 100.0
2400 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400

Figure 4.2- 17

SECTION 5.0
RESULTS OF STUDY

5.1 Site 1 - Air Rights Structure - Trans Manhattan Expressway

Measurements to define the indoor outdoor relationships of pollutants at the air rights structure were started on September 9, 1970 and terminated on January 14, 1971. The measurement locations are defined in detail in Section 4.1. The methodology for obtaining the measurements is discussed in Section 3.0. The exact amount of data obtained for each measurement is identified in the appropriate portion of this section.

The data obtained was divided into heating and non heating seasons on the basis of the daily average temperature at the site. All non-heating days occurred during Sept. and Oct. The heating season included some Sept. and Oct. days and all of the Nov., Dec. and Jan. measurement days. Approximately 4 times as much data was obtained for the heating season as was obtained for the non-heating season.

5.1.1 Carbon Monoxide

Carbon monoxide measurements at this site were made at five elevations. Two measurements were made at the three foot level of the highway, one at the median strip and the other at the north perimeter. Both indoor and outdoor measurements were made at the third, the 15th, the 23rd and the 32nd floors of the air rights structure.

The carbon monoxide measurements began on September 9, 1970 during the non-heating season and terminated January 14, 1971 in the heating season for the building locations. Accordingly, 25 days of data were taken during the non heating season, 19 of these were weekdays and 6 were weekend days. 103 days of data were obtained during the heating season, 73 of which were weekdays and 30 which were weekend days. There was a delay, at the 15th floor, in obtaining permission from the tenants in the apartments for placement of an indoor probe. As a result of this, the two probes at this level were positioned outdoors from September 9 to November 3. Indoor measurements were started on November 5 at the 15th floor. No indoor measurements were obtained during the non-heating season.

Measurements at the road level did not begin until September 25 and terminated on Jan. 11, 1971. As a result, only 7 days of non-heating weekdays and 2 days of non-heating weekend days CO data was obtained for the highway.

5.1.1.1 Heating Season

The highest carbon monoxide values recorded at this site was measured at the three foot level at the north edge of the road. This value was 112 ppm and was recorded on December 15, 1970 between 1700 and 1800 hrs. It is interesting to note that for this period, although the traffic count was not excessively high, 6700 vehicles/hr, the vehicle velocity was ususually low, 25 miles per hour, the winds were very light and the turbulence index parameter was a global minima at 4 degrees. All of which indicated a period of meteorological stability concurrent with lower vehicle velocities.

As shown in the tabulation below, the highest 24 hour average CO concentrations during the heating season were measured at the median strip probe. In general, both peak and average CO levels decreased as the measurement locations increased above the road. Similarly the percentage of the time that the Federal criterions of 9 ppm average over an 8 hour period and 35 ppm for a 1 hour period were exceeded also decreased with height above the road.

	Med.	Edge	3rdO	3rdI	15thO	15thI	23rdO	23rdI	32ndO	32ndI
	Location									
Weekday Data						*				
Ave CO - ppm	25.7	24.9	7.0	7.0	5.8	6.7	3.6	4.2	3.9	6.6
Peak CO- ppm	92	112	33	29	35	21	36	19	23	28
Exceed 9 ppm/ 8 hr - %	91.4	95.4	23.1	13.5	13.4	18.7	4.2	4.1	3.0	19.7
Exceed 35ppm/ 1 hr - %	26.6	23.1	0	0	0	0	.1	.1	0	0
Weekend Data										
Ave CO - ppm	24.4	22.8	5.9	6.0	5.1	5.3	2.7	3.1	3.4	6.0
Peak CO -ppm	74.5	92.1	23.7	17.7	25.4	19.4	18.5	11.7	18.4	18.3
Exceed 9ppm/ 8 hr - %	87.3	93.2	15.6	12.4	9.6	3.4	2.0	0	3.3	15.4
Exceed 35ppm/ 1 hr - %	22.5	15.6	0	0	0	0	0	0	0	0

*11/15/70 to 1/14/71

Examination of the above data will show that both peak and average CO levels were higher on weekdays than on weekends. Average indoor concentrations were always equal to or higher than average outdoor concentrations at the corresponding level. Both the indoor/outdoor and weekday/weekend data groupings show an inversion in CO concentrations at 23rd floor level.

5.1.1.1.1 CO Traffic Relationships

A good correlation occurs between the diurnal patterns of the carbon monoxide, particularly on the lower levels, and the traffic. The diurnal patterns for weekdays shown in Figures 5.1.1-1 to -5 exhibit similar double-peaked patterns with maxima typically between 0800 and 0900 in the morning and 1500-1600 in the evening. Note that the diurnal profiles of CO concentrations show a good correlation pattern with each other as well as with the profile of traffic. The phase relationship of the outdoor concentrations is closer to

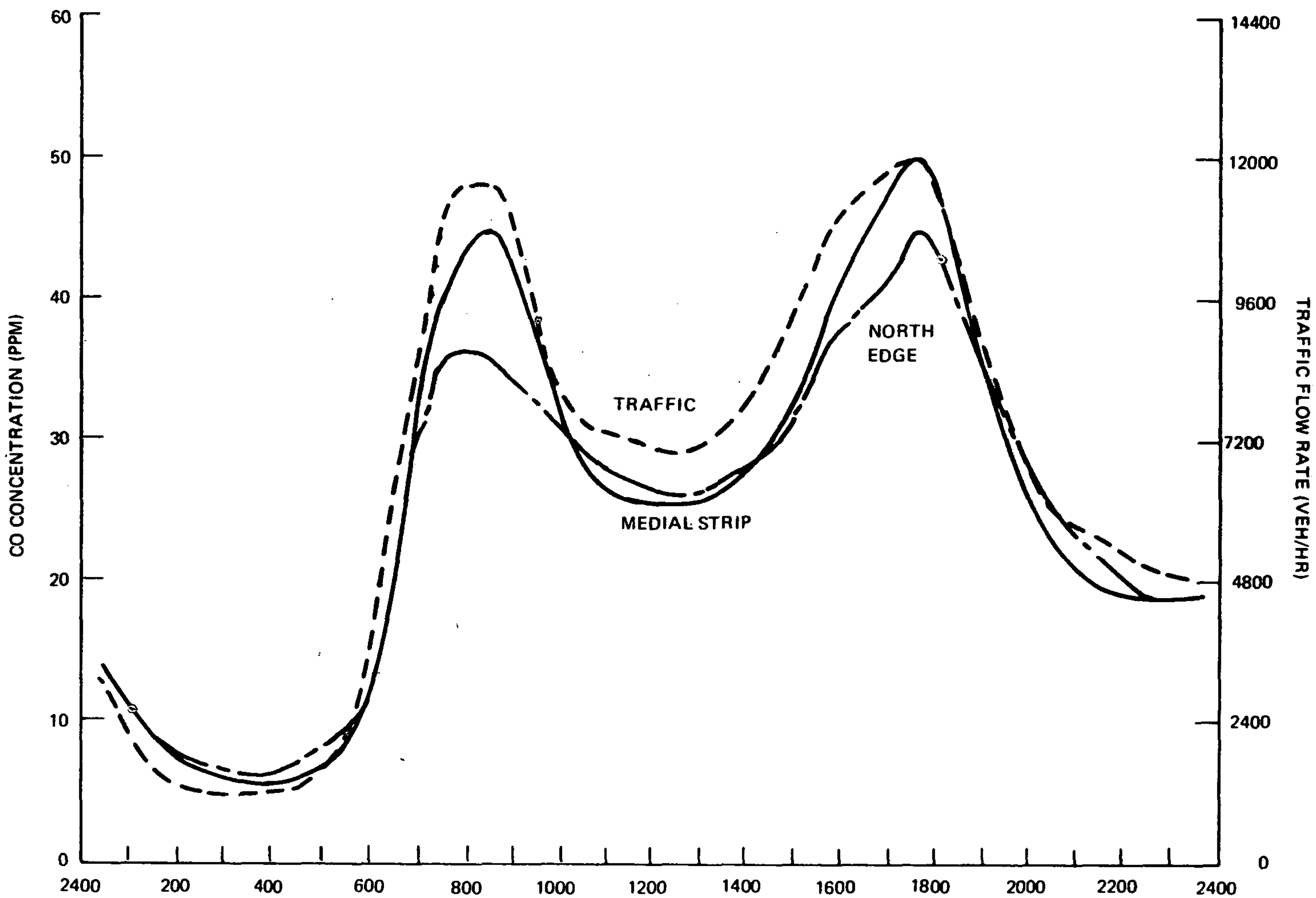


Figure 5.1.1-1. Diurnal CO & Traffic - Site 1 - Heating Season - Road Level - Weekdays

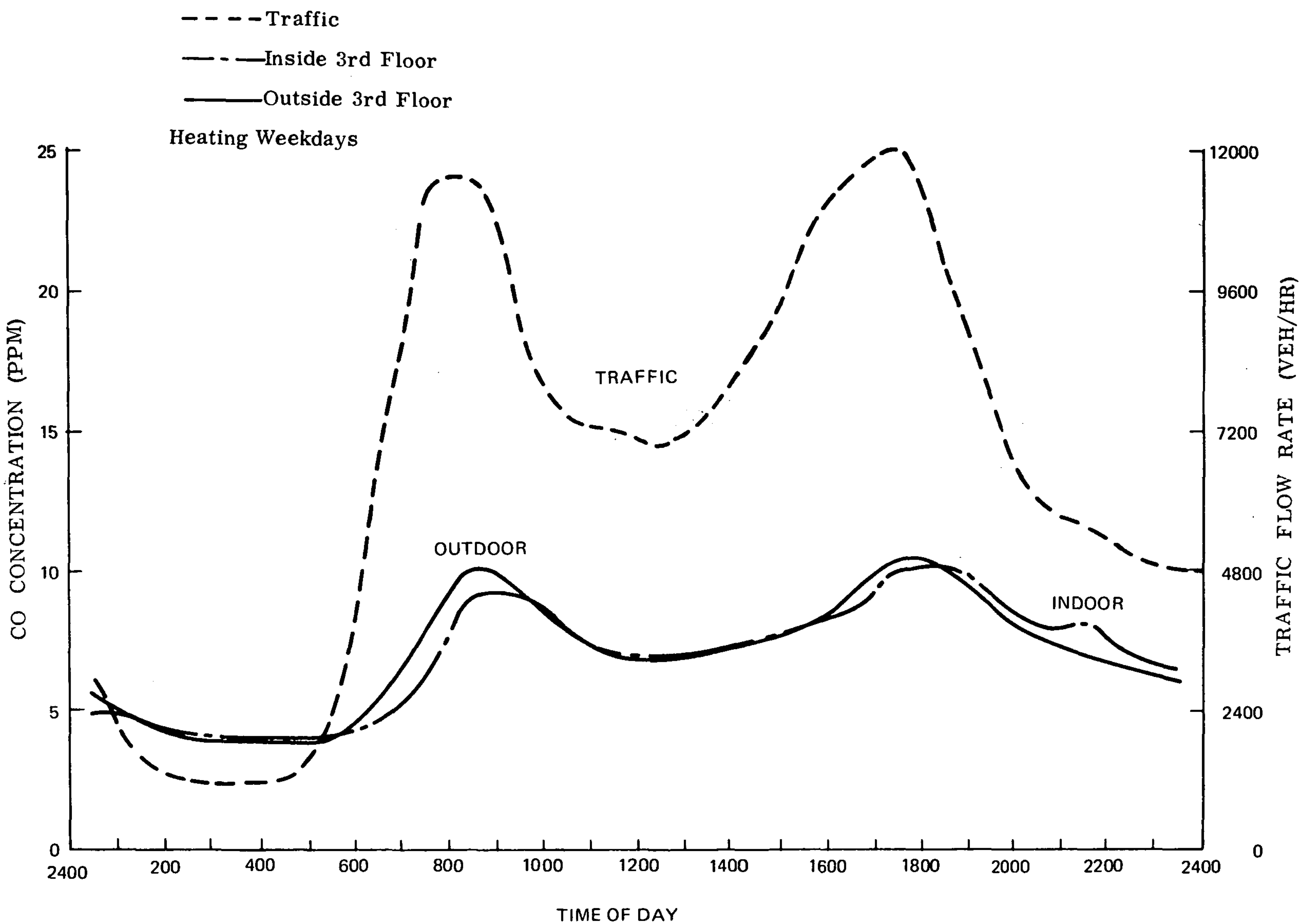


Figure 5.1.1-2. Diurnal CO & Traffic - Site 1 - Heating Season - 3rd Floor - Weekdays

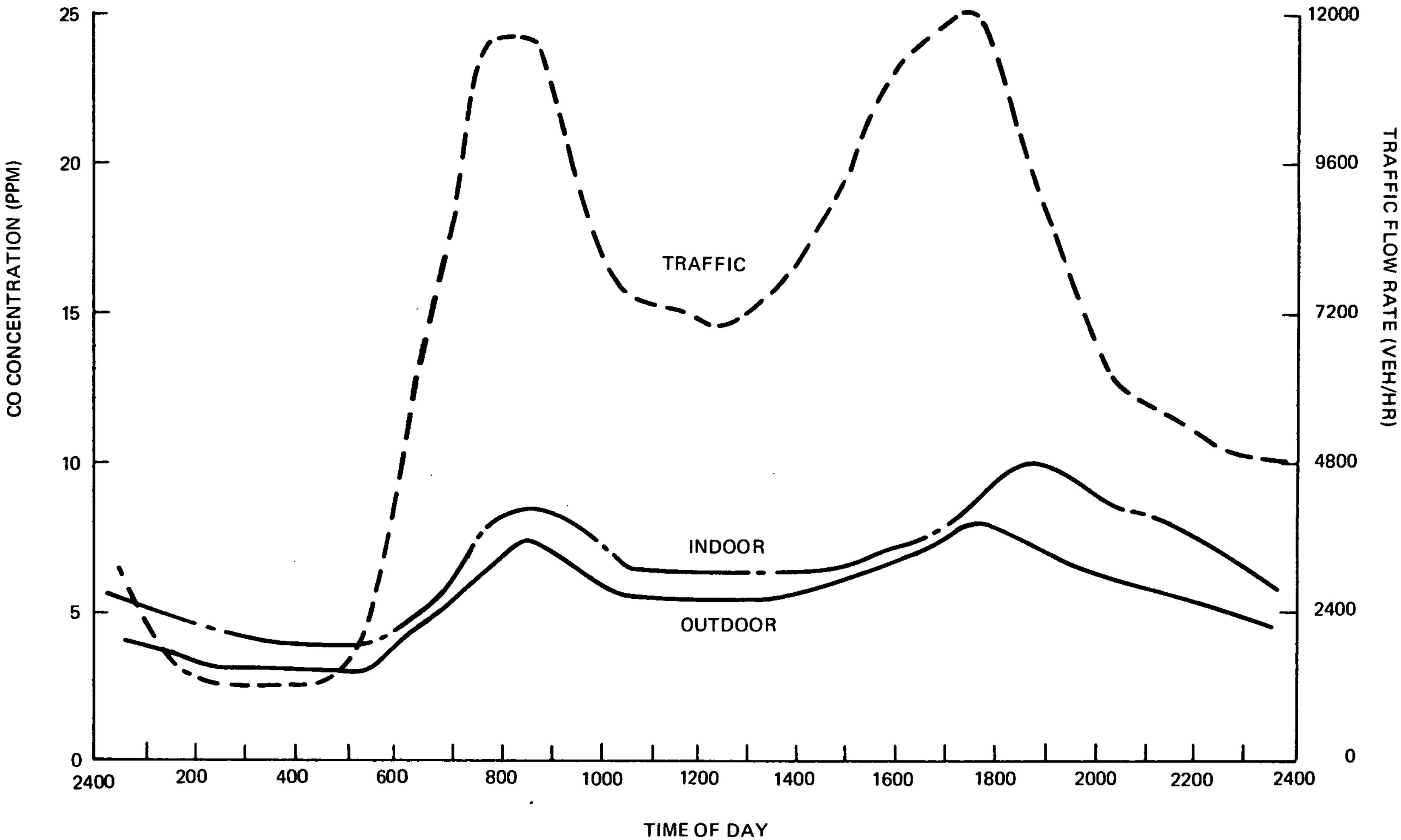


Figure 5.1.1-3. Diurnal CO & Traffic - Site 1 - Heating Season - 15th Floor - Weekdays

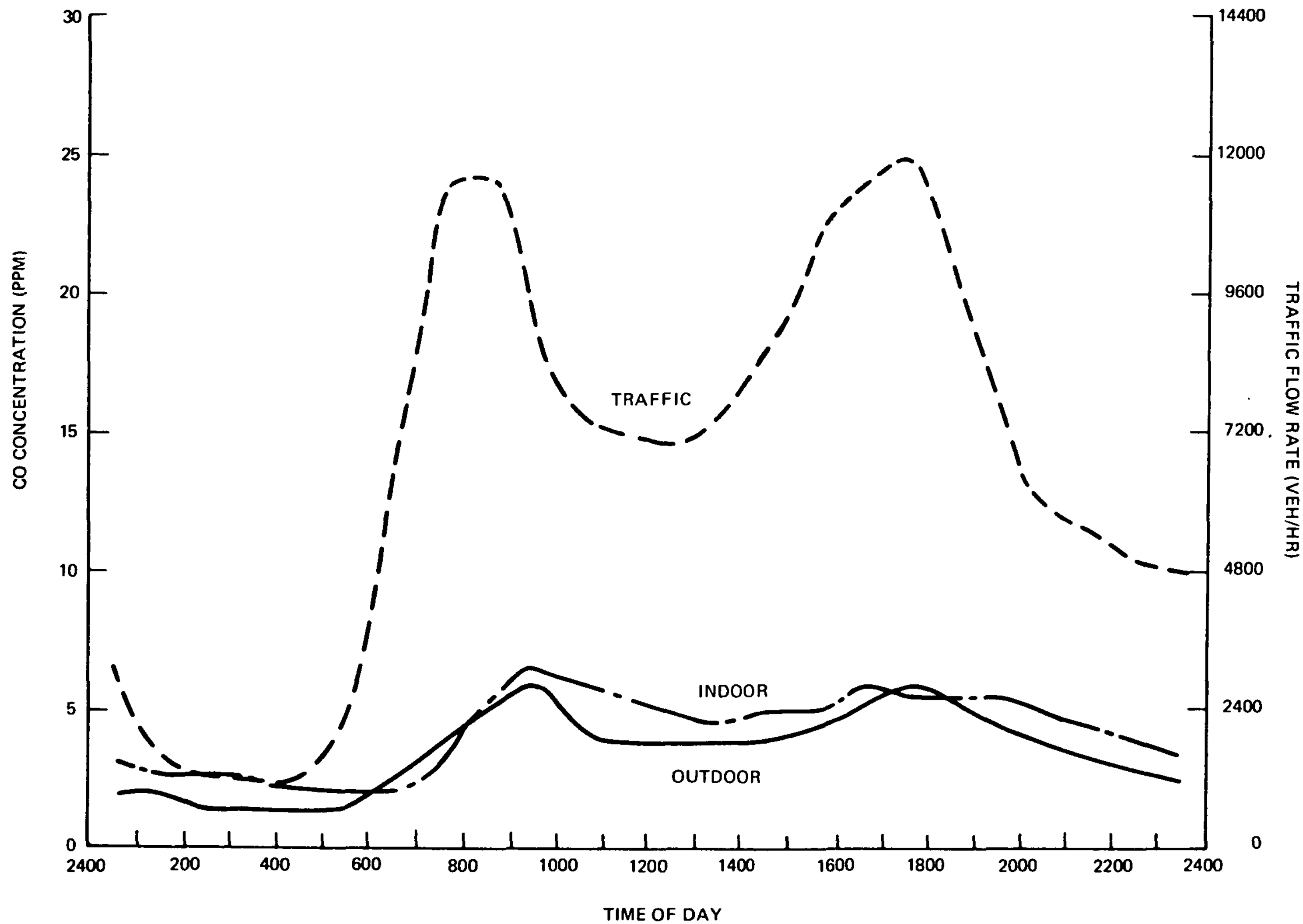


Figure 5.1.1-4. Diurnal CO & Traffic - Site 1 - Heating Season - 23rd Floor - Weekdays

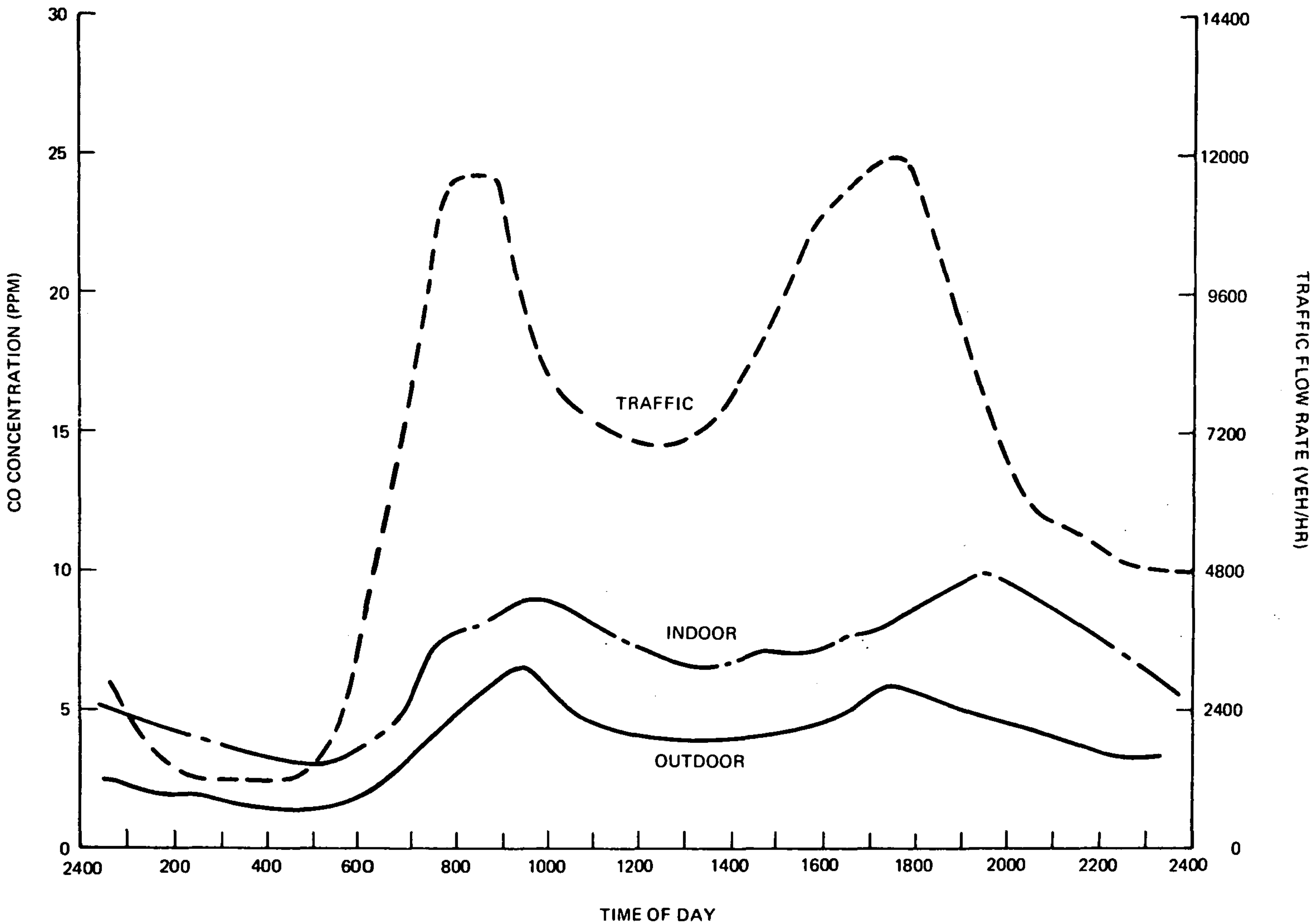


Figure 5.1.1-5. Diurnal CO & Traffic - Site 1 - Heating Season - 32nd Floor - Weekdays

that of the traffic, particular in the afternoon hours, than is the indoor concentration compared to the traffic. The diurnal pattern for the carbon monoxide and the traffic on the weekends show a trend of a single peaked maxima generally in the afternoon around 1600 to 1800 (Figures 5.1.1-6 & -7).

Figure 5.1.1-8 and -9 show the diurnal values of the CO concentration at the road plotted against the diurnal values of the traffic flow and of the vehicular velocities. The line that best fits the data in the least squares sense, as determined by a linear regression analysis, is drawn on each graph. The results of the linear regression analysis, are summarized in Tables 5.1.1-1 and 5.1.1-2.

The correlation coefficients between the CO concentrations at both the 3 foot level on the median strip and the north side of the road and the traffic flow rates are .99. Since the correlation coefficient is an indicator of the strength of a linear relationship between the variables under consideration, there appears to be an almost perfect linear relationship on the weekdays during the heating season between the CO concentration 3 feet above the Trans-Manhatten Expressway and the traffic flow rate. This confirms very well the assumption that the heavy traffic volume on the Trans-Manhattan Expressway is the major source of the CO concentrations.

As shown in Table 5.1.1-1 and -2 and figures 5.1.1-1 thru -5 the correlations with traffic flow rate and velocity decrease as a function height above the roadway.

5.1.1.1.2 Indoor Outdoor Relationships

As mentioned earlier, daily average indoor concentrations always were equal to or greater than comparable outdoor concentrations. Hourly average CO concentrations outdoors at both the 15th and 32nd Floors (see figures 5.1.1-3 + -5) always were lower than indoor concentrations. However at the 3rd floor level, (figure 5.1.1-2) outdoor hourly average contrations exceeded indoor concentrations during the hours of morning and evening rush hours and then dropped below the indoor CO levels. Indoor diurnal CO peaks occurred progressively later than traffic peaks as a function of distance above the ground level of the air rights structure except for the 23rd floor (Figure 5.1.1-4).

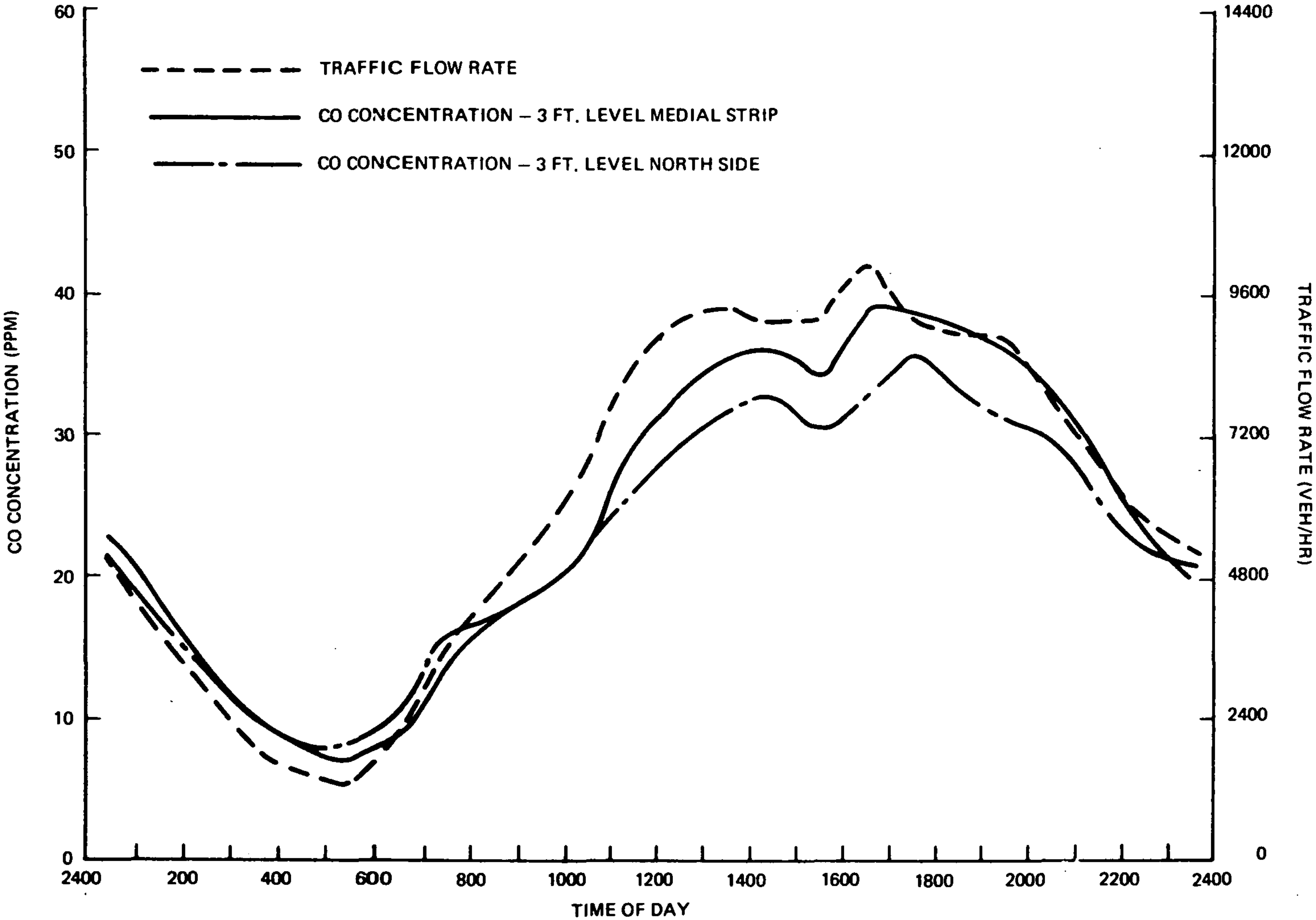


Figure 5.1.1-6. Diurnal CO & Traffic - Site 1 - Heating Season - Weekends - Road Level

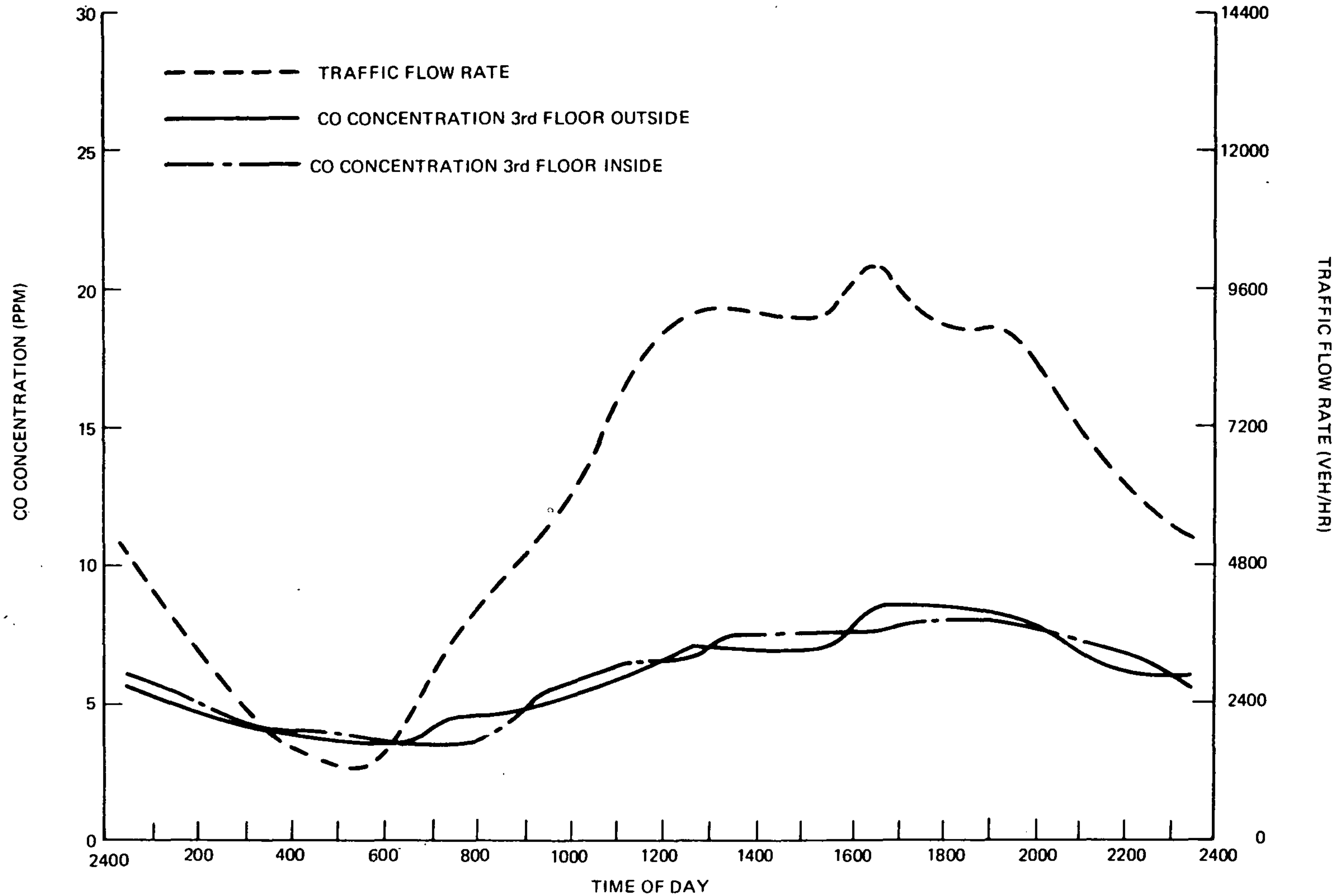
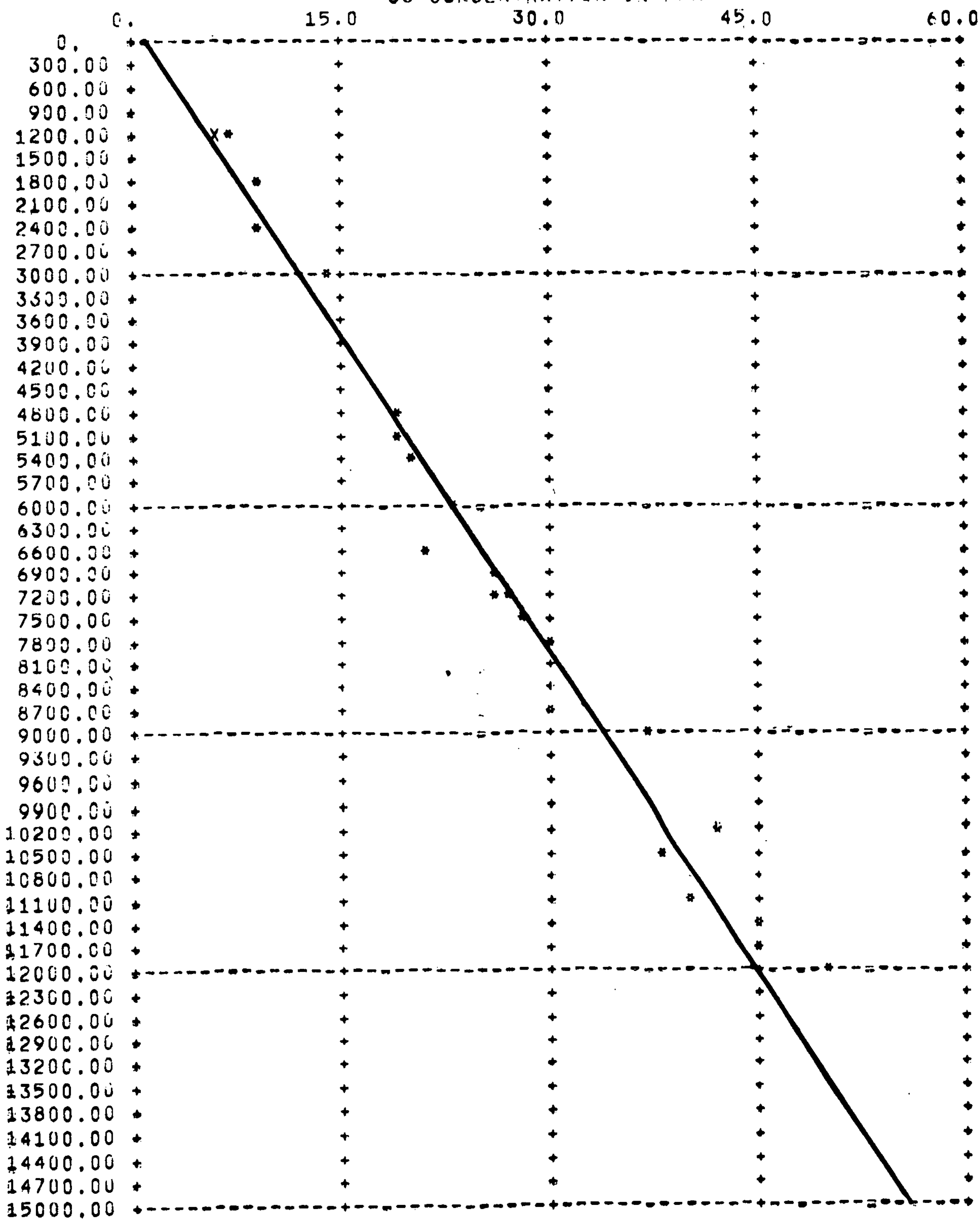
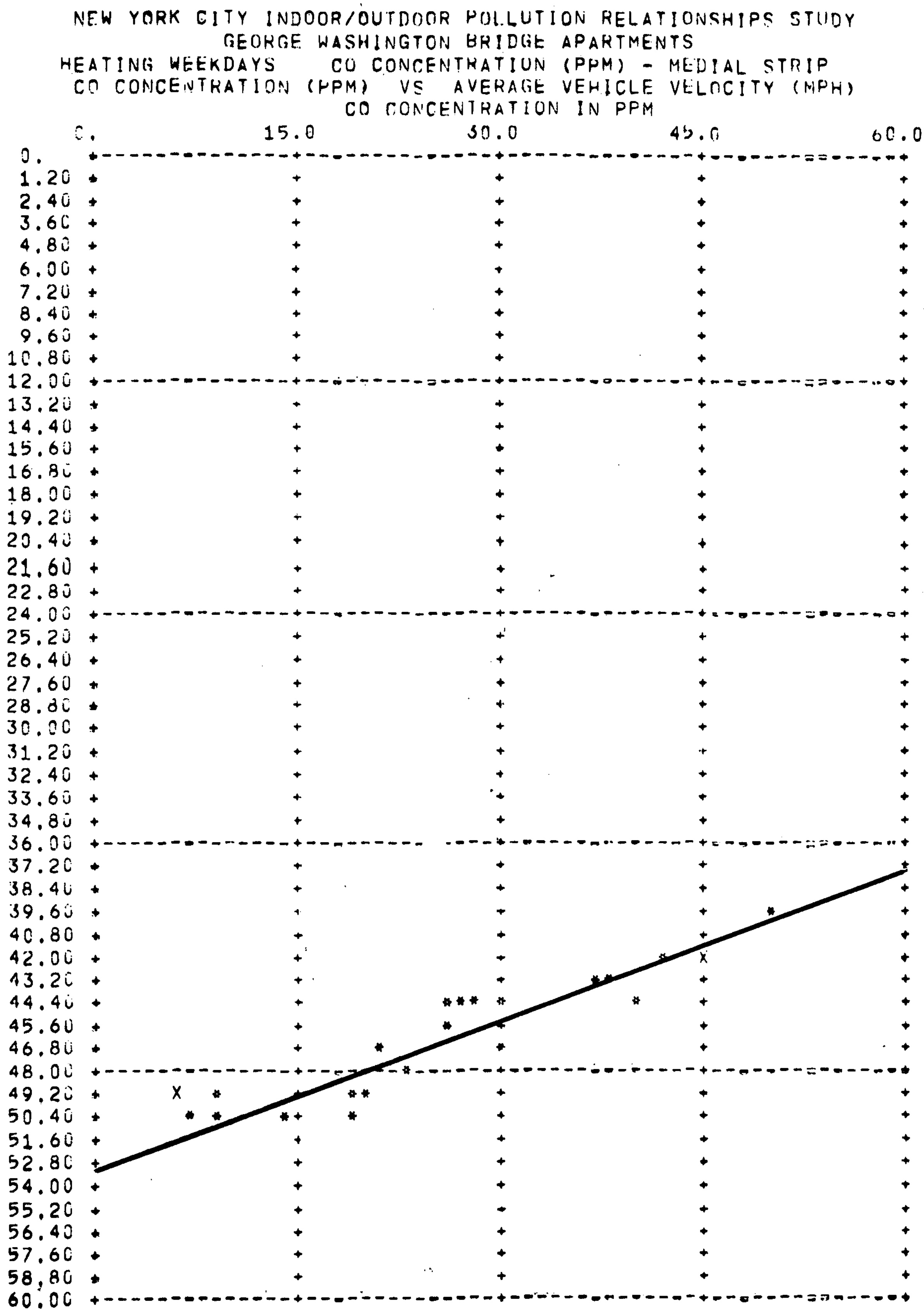


Figure 5.1.1-7. Diurnal CO & Traffic - Site 1 - Heating Season - Weekends - 3rd Floor

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS CO CONCENTRATION (PPM) - MEDIAL STRIP
CO CONCENTRATION (PPM) VS TRAFFIC FLOW RATE (VEH/HR)
CO CONCENTRATION IN PPM



CO = .0037 TFR + .95
Figure 5.1.1-8



$CO = -3.7927v + 4200.82$

Figure 5.1.1-9

TABLE 5.1.1-1

LINEAR REGRESSION ANALYSIS RESULTS

Air Rights Structure -- Heating Weekdays

Traffic Flow Rate (Ind. Var.)

VS

	CO Conc. Medial Strip	CO Conc. 3 Ft. North	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	.99	.99	.93	.81
Intercept	.95	3.69	3.25	3.92
Slope	.0037	.0032	.0008	.0007
Mean of Dependent Variable Observations	25.70	24.91	6.96	6.95
Mean of Independent Variable Observations	6668.63	6668.63	6668.63	6668.63

Air Rights Structure -- Heating Weekends

Traffic Flow Rate (Ind. Var.)

VS

	CO Conc. Medial Strip	CO Conc. 3 Ft. North	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	.98	.98	.93	.94
Intercept	2.07	4.62	2.51	2.90
Slope	.0037	.0030	.0007	.0007
Mean of Dependent Variable Observations	24.41	22.75	5.93	6.03
Mean of Independent Variable Observations	6105.17	6105.17	6105.17	6105.17

TABLE 5.1.1-2

LINEAR REGRESSION ANALYSIS RESULTS

Air Rights Structure -- Heating Weekdays

Average Vehicle Velocity (Ind.Var)

VS

	CO Conc. Medial Strip	CO Conc. 3 Ft. North	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	-.92	-.92	-.85	-.74
Intercept	200.82	175.09	31.37	27.85
Slope	-3.7927	-3.2526	-.5288	-.4525
Mean of Dependent Variable Observations	25.70	24.91	6.96	6.95
Mean of Independent Variable Observations	46.17	46.17	46.17	46.17

Air Rights Structurs -- Heating Weekends

Average Vehicle Velocity (Ind.Var.)

VS

	CO Conc. Medial Strip	CO Conc. 3 Ft. North	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	-.96	-.96	-.92	-.91
Intercept	195.19	162.30	31.18	29.82
Slope	-3.6205	-2.9585	-.5352	-.5043
Mean of Dependent Variable Observations	24.41	22.75	5.93	6.03
Mean of Independent Variable Observations	47.17	47.17	47.17	47.17

There can, of course, be a number of causes contributing to the higher values indoors than outdoors but, considering the long term averages on a diurnal basis, it is difficult to attribute the general pattern to a single source. It seems logical, therefore, to conclude that there are probably several mechanisms at work which would explain the pattern. The first of these considers permeation of the CO from the outside into the smaller internal volume and by this constant process thereby increasing the indoor concentration over that of outdoors. The second mechanism is the stack effect due to the indoor-outdoor temperature differential in the heating season. By this mechanism one can expect CO entering the building at the lower floors to be transported upward through open doors and elevator shafts and enter the upper level apartments via cracks in doorways and ventilators and the like, again increasing indoor concentration. The third mechanisms of course could be that of internal sources themselves. It is known that the tenants on the 32nd floor complained of not receiving sufficient heat and for that reason used their ovens for heating purposes an unusually large period of time.

The apartment at the 23rd floor was the GE command post for the program at this site. These quarters were used for the conduct of the program only, and were not used as living quarters. In other words there was negligible use of the cooking facilities and there was no occupancy of the apartment after approximately 1700 hours, on weekdays. Moreover, there was absolutely no occupancy of the apartment on weekends. Thus, while the activities of the tenants in the apartments at other elevations might have some impact on the levels of CO measured, measurements at the 23rd floor level should be the most unbiased in this respect of any measurements taken at this site.

The effect of these mechanisms can be seen from the following tabulation which compares daily average concentrations with the concentrations recorded during the evening rush hour at 5-6 PM.

CO CONCENTRATION - PPM

	DAILY AVE.			5-6 PM AVE.		
	O	I	DIFF.	O	I	DIFF.
3rd Floor	7.0	7.0	0	10.7	9.9	0.8
23rd Floor	3.6	4.2	-0.6	6.2	5.7	0.5
32nd Floor	3.9	6.6	-2.7	5.9	8.2	-2.3
3rd-23rd Diff.	3.4	2.8	0.6	4.5	4.2	0.3
23rd-32nd Diff.	-0.3	-2.4	-2.1	0.3	-2.5	-2.8

As would be expected, the daily average concentrations are always lower than the rush hour CO levels. Concentrations decrease both outdoors and indoors from the 3rd to 23rd floors for both the daily average and 5-6 PM periods. However, concentrations increase between the 23rd and 32nd floors for all locations except the outdoor rush hour period. Apparently the anticipated decrease in CO level with height above the roadway is noticeable only outdoors, when the Trans Manhattan Expressway traffic is high. Indoor concentrations at the 3rd and 32rd floors are lower than outdoor concentrations during the rush hour period, but are higher than outdoors on a daily average basis. Concentrations at the 32nd floor are always higher indoors than outdoors.

5.1.1.2 Non Heating Season

CO measurements during the non heating season represent approximately one quarter of the heating season measurements and therefore are not as significant. As can be seen from the tabulation below, daily average CO levels at the air rights structure during the non-heating season closely duplicate the heating season daily averages for both weekday and weekend periods. There is no consistent difference in concentration levels on weekdays between the two seasons. Non-heating CO levels on weekends, however, are slightly lower at all building locations.

	Location									
	Med	Edge	3rdO	3rdI	15thO	15thI	23rdO	23rdI	23ndO	32ndI
Weekday Data										
Ave Co-ppm	30.6	31.1	7.2	6.4	6.4	NA	4.0	4.5	4.3	5.0
Peak CO-ppm	75	72	28	23	29	NA	20	19	19	17
Exceed 9 ppm/ 8 hr-%	97.9	97.9	20.3	15.2	18.1	NA	3.9	5.1	3.6	2.9
Exceed 35ppm/ 1 hr-%	38.5	39.7	0	0	0	NA	0	0	0	0
Weekend Data										
Ave CO-ppm	28.1	26.2	5.1	5.6	4.2	NA	1.5	2.7	2.7	4.3
Peak CO-ppm	48.1	45.3	16.2	17.9	21.7	NA	7.7	23.0	9.8	12.6
Exceed 9 ppm/ 8 hr-%	100.0	100.0	9.8	13.8	13.8	NA	0	4.1	0	12.2
Exceed 35ppm/ 1 hr - %	29.2	29.2	0	0	0	NA	0	0	0	0

It can be seen that average CO levels at the Trans Manhattan Expressway were higher than for the heating season. Federal standards, at road level, were violated a larger percentage of the time. Concentrations again decrease with height above the roadway. In general, the percentage violations of Federal Standards at the air rights structure were lower during the non heating season.

Peak and average CO levels again were higher on weekdays than on weekends. With the exception of the weekday 3rd floor data, average indoor concentrations were higher than average outdoor concentrations. Twenty third floor CO levels, both indoors and outdoors, again are lower than CO levels measured at the 32nd floor.

5.1.1.2.1 CO Traffic Relationships

The diurnal carbon monoxide and traffic patterns for weekdays during the non-heating season are shown in Figures 5.1.1-10 thru -13. In general there is good correlation between CO and traffic parameters. Figures 5.1.1-14 and -15 show the diurnal values of the CO concentrations at the median strip plotted against the diurnal values of traffic flow rate and of vehicular velocities. It will be noted from Tables 5.1.1-3 and 5.1.1-4, which indicate the results of linear regression analyses, that the average traffic flow rate during the non-heating season was slightly higher than that for the heating season (6884 vs. 6668 veh/hr.). This higher traffic flow rate is the reason for higher CO concentrations during the non-heating season than the heating season at the outdoor locations on weekdays.

No non heating reason weekend traffic data was obtained. Therefore no discussion of CO traffic relationships is possible.

5.1.1.2.2 Indoor Outdoor Relationships

Daily average indoor concentrations at the 3rd, 23rd and 32nd floors in general are lower during the non-heating season than during the heating season for both weekdays and weekends. A comparision of Figures 5.1.1-11 thru -13 with Figures 5.1.1-2,-4 and -5 shows that the differential CO level at the 32nd floor is markedly different for the two seasons, however, this seasonal difference is not as apparent at the 3rd and 23rd floors.

The major cause of this seasonal difference is a significant reduction in the indoor concentrations at the 32nd floor during the non-heating seasons. It can be seen from the following table comparing weekday daily averages with concentrations recorded at 5-6 PM, that both outdoor and indoor concentrations decrease with height above the roadway during the rush hour period. It should be noted that

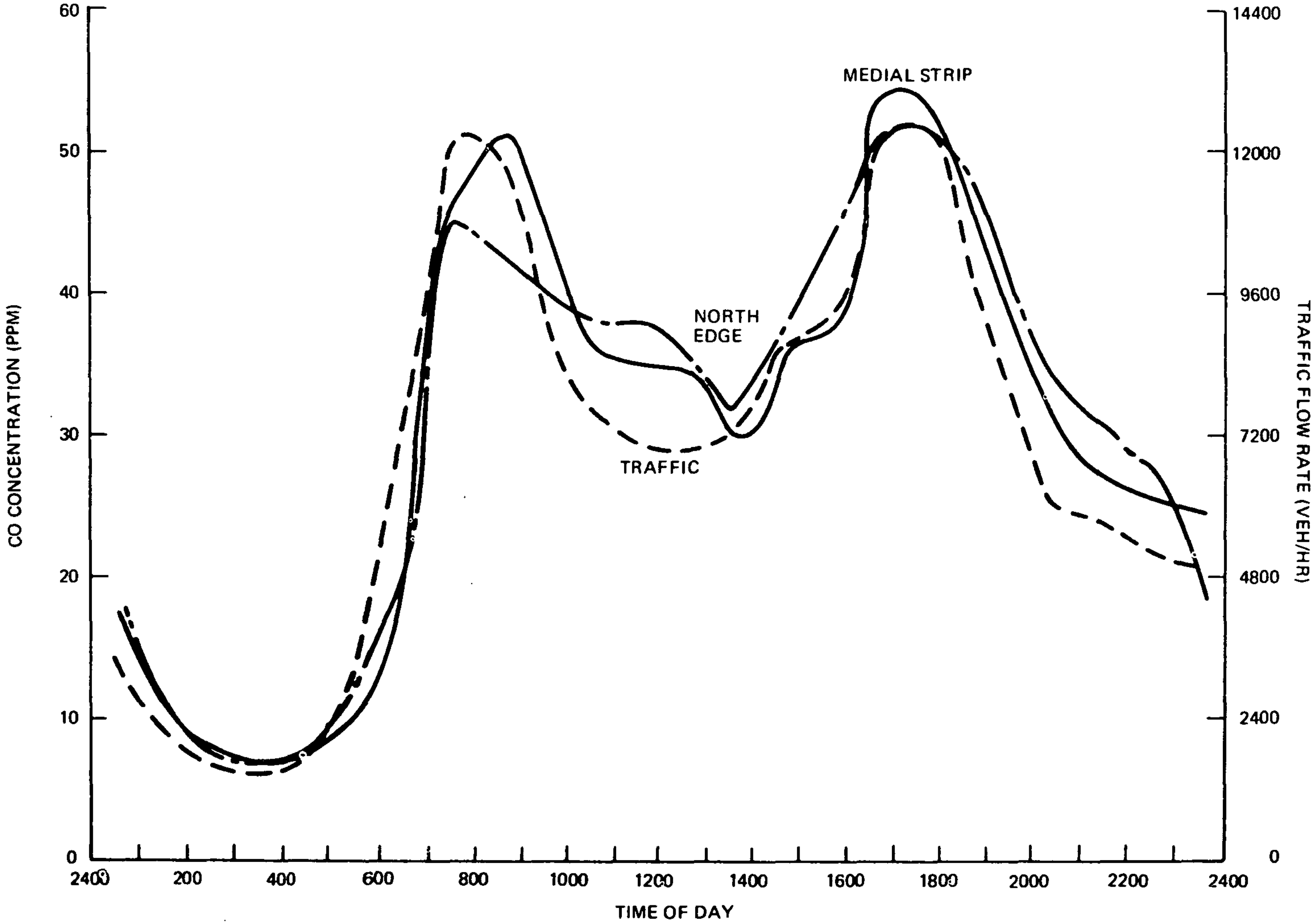


Figure 5.1.1-10. Diurnal CO and Traffic - Site 1 - Non-heating Weekdays - Road Level

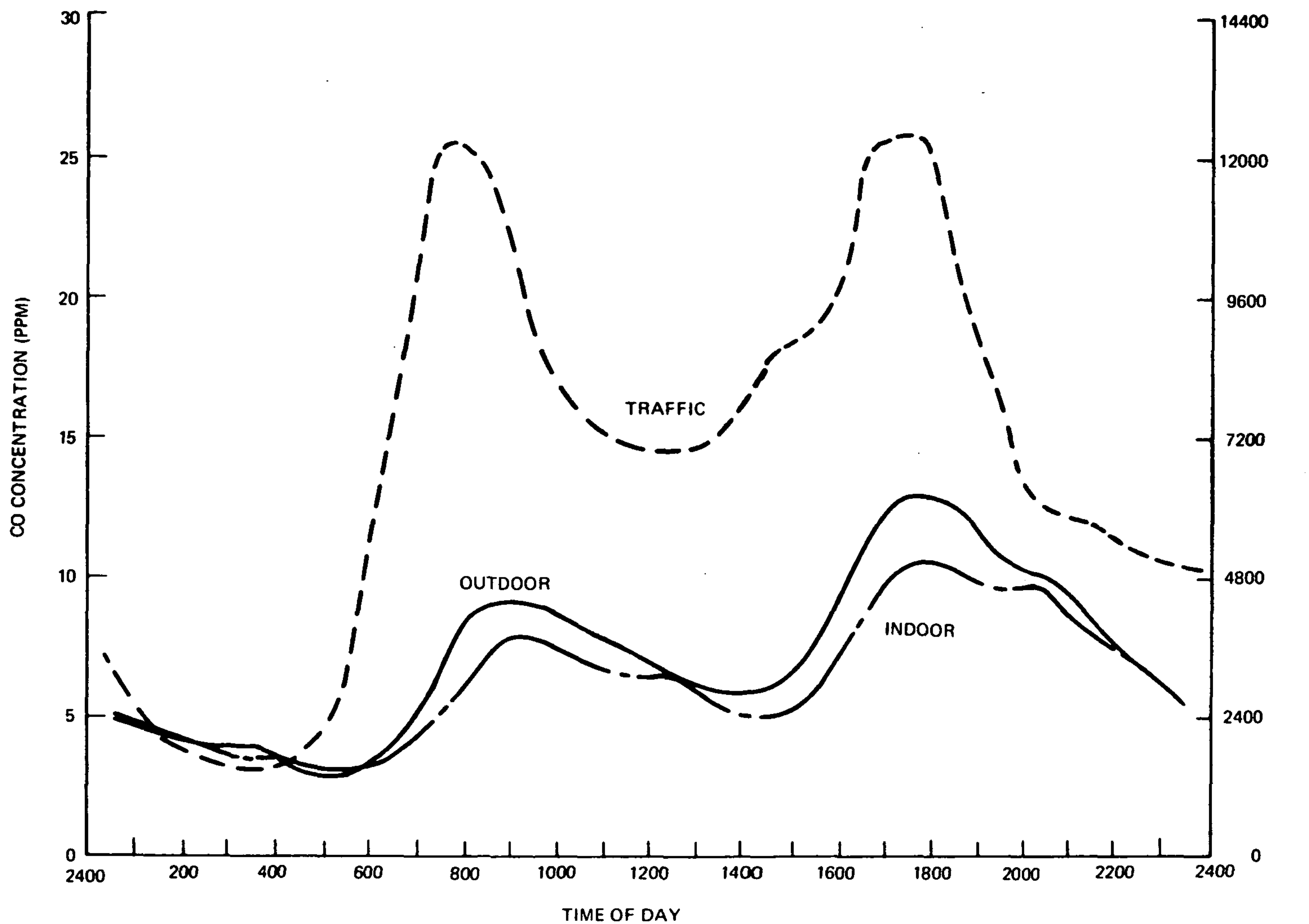


Figure 5.1.1-11. Diurnal CO and Traffic - Site 1 - Non-heating Weekdays - 3rd Floor

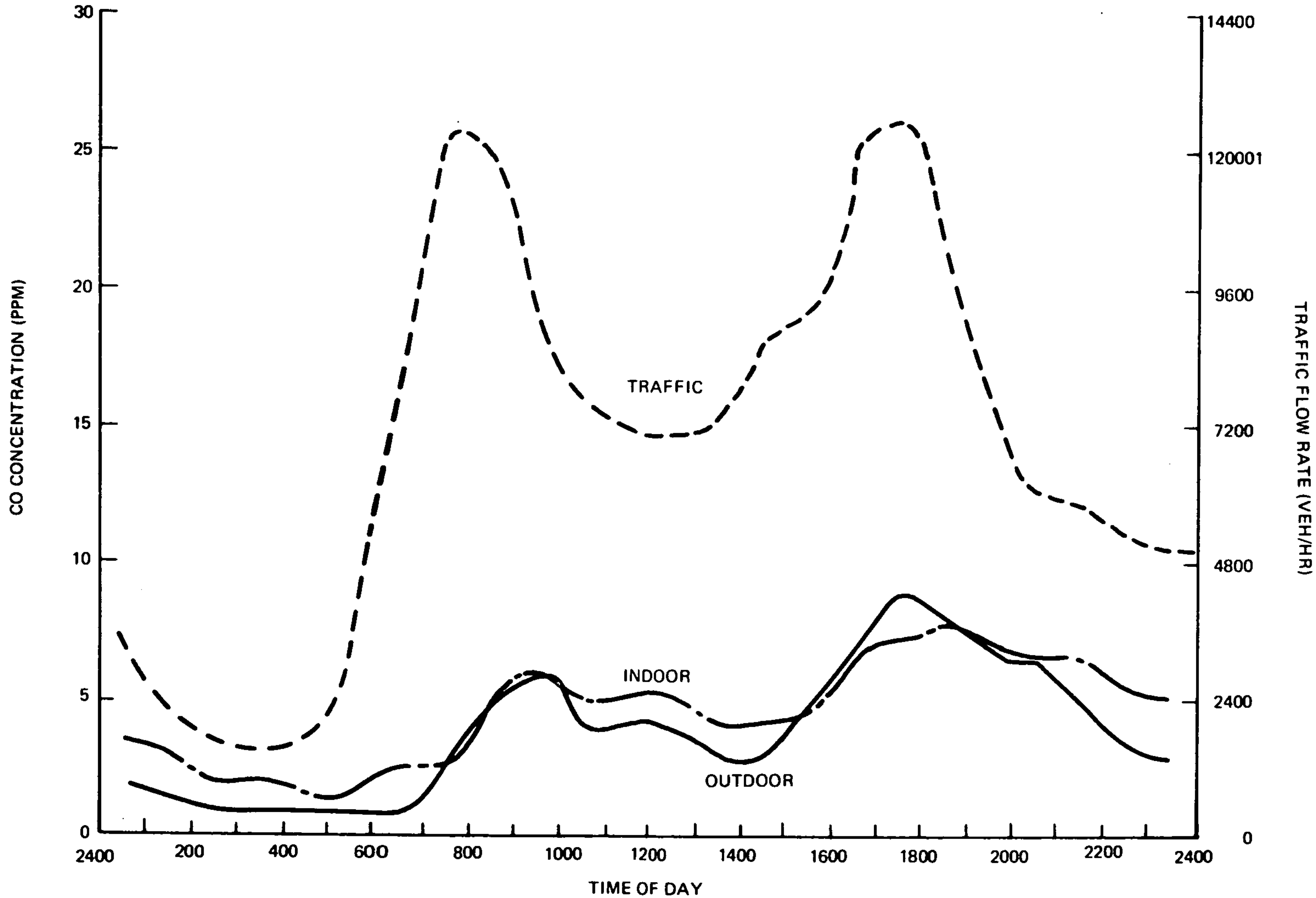


Figure 5.1.1-12. Diurnal CO and Traffic - Site 1 - Non-heating Weekdays - 23rd Floor

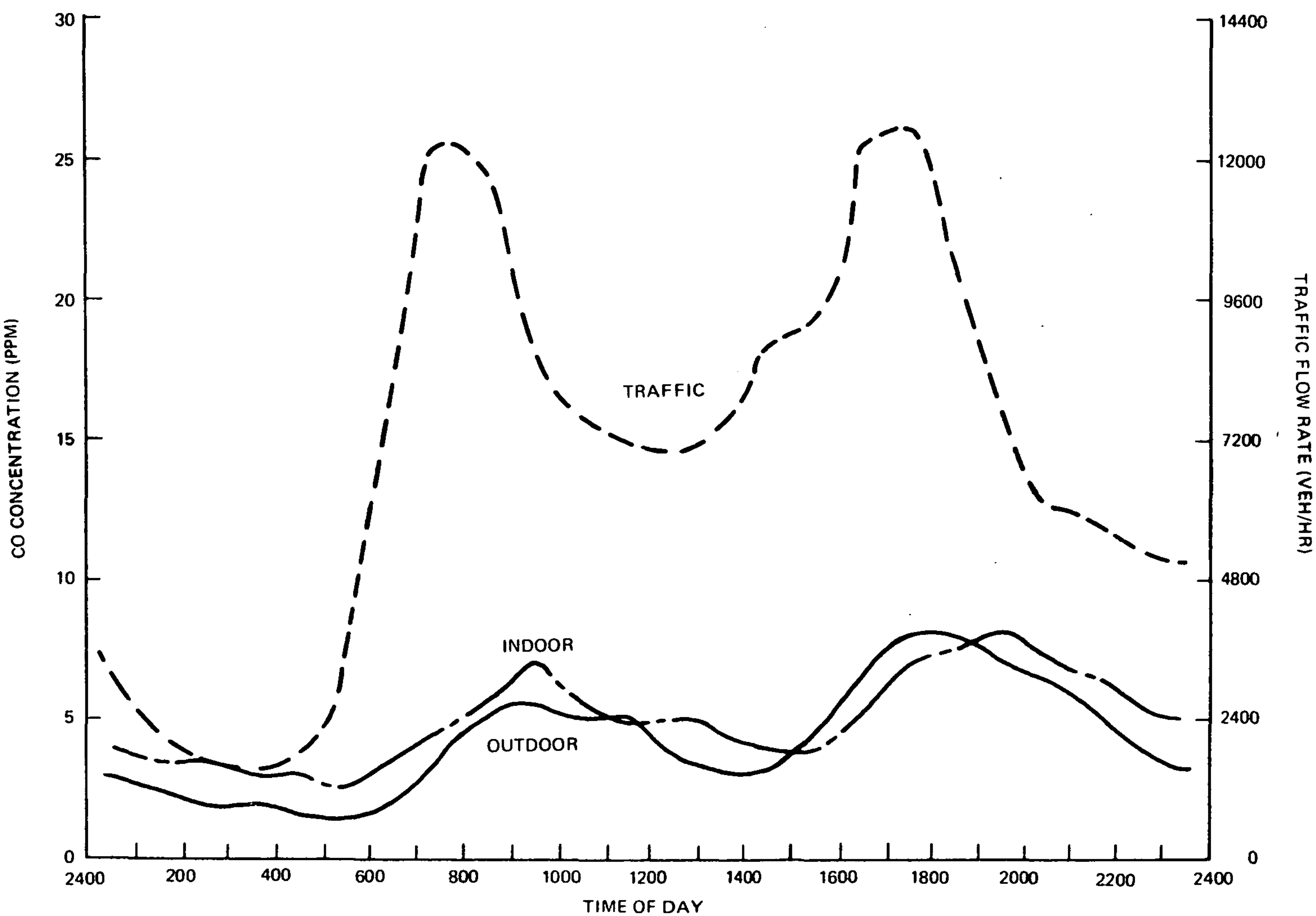
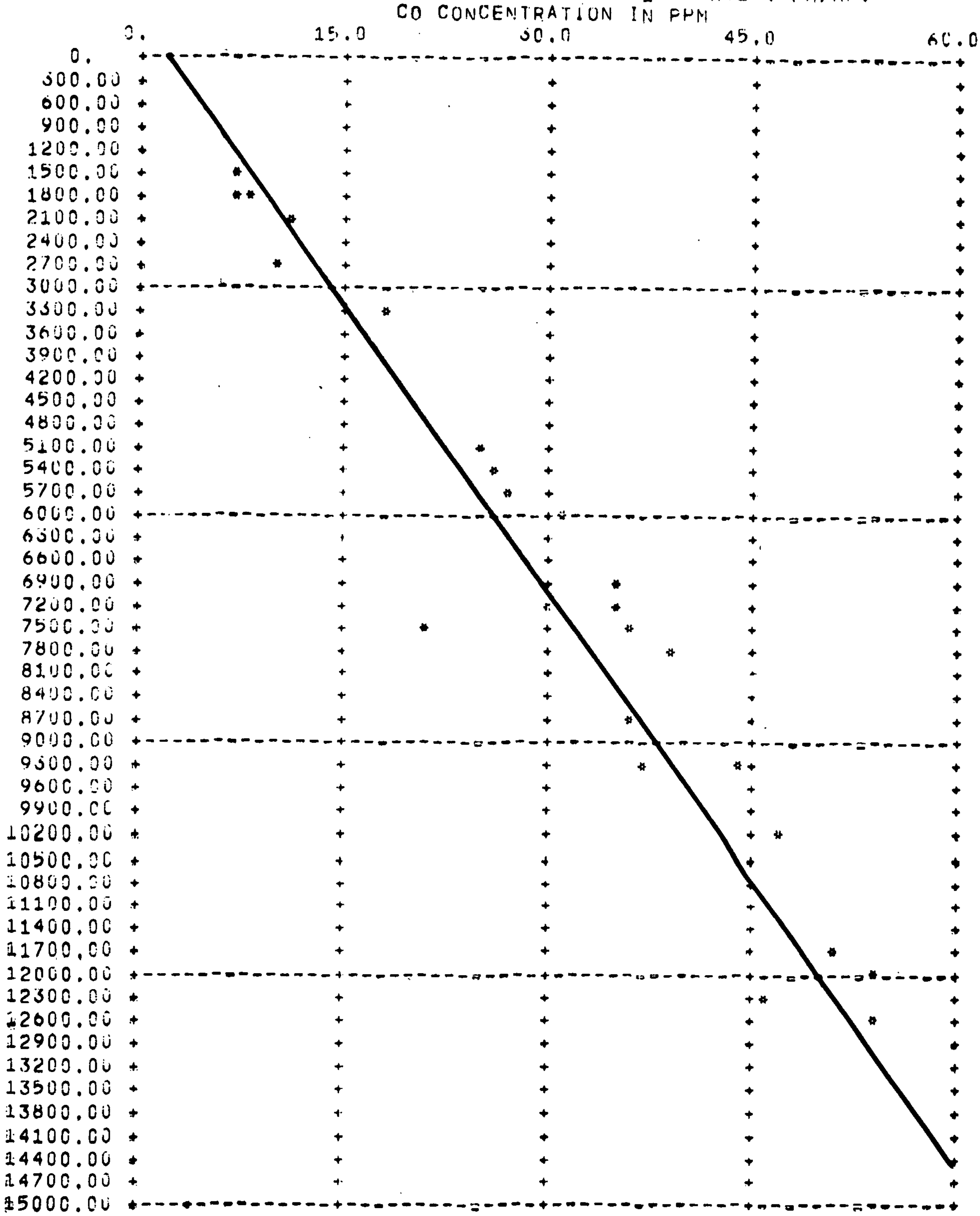


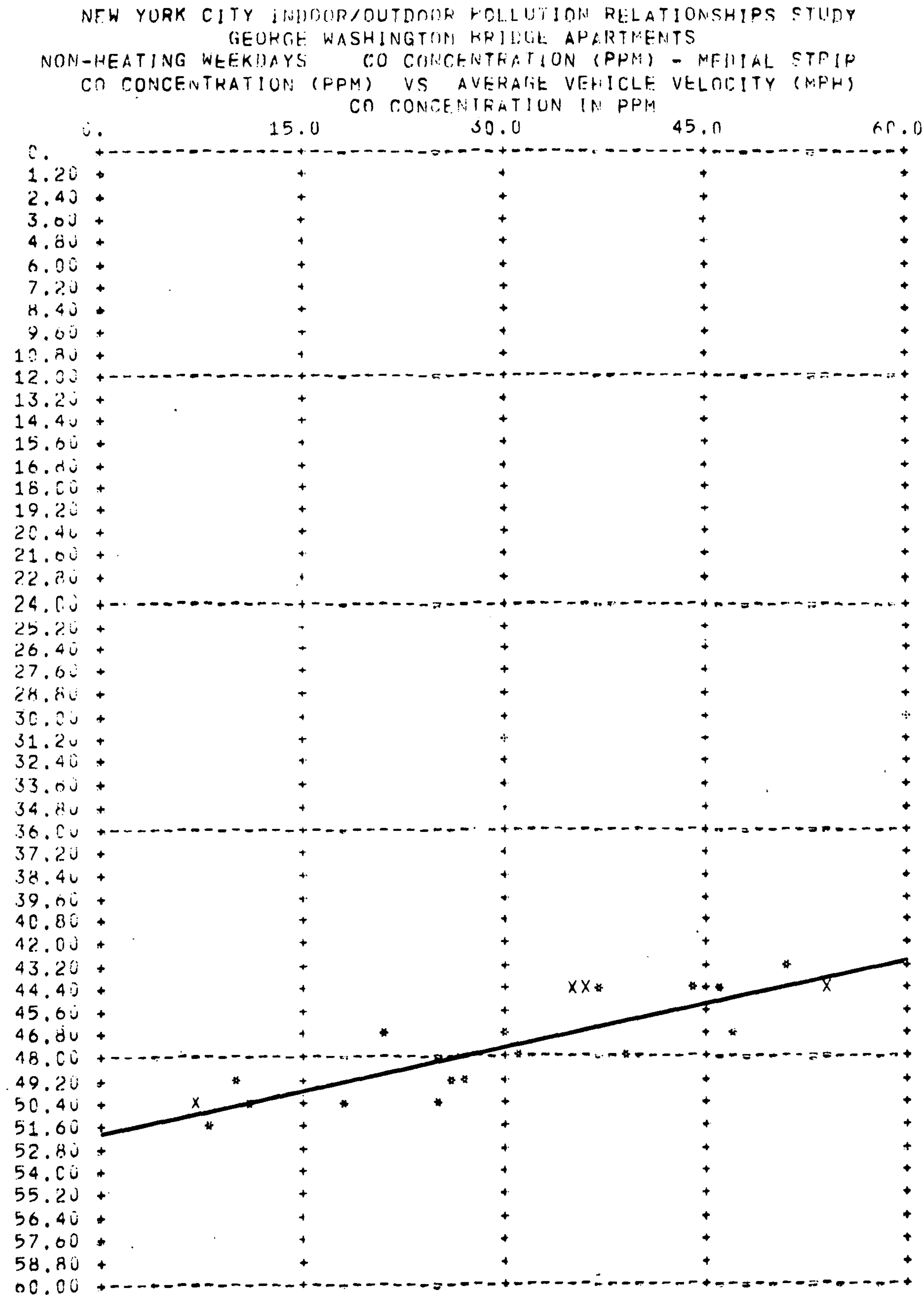
Figure 5.1.1-13. Diurnal CO and Traffic - Site 1 - Non-heating Weekdays - 32nd Floor

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
NON-HEATING WEEKDAYS CO CONCENTRATION (PPM) - MEDIAL STRIP
CO CONCENTRATION (PPM) VS TRAFFIC FLOW RATE (VEH/HR)



$$CO = .0042\ TFR + 2.05$$

Figure 5.1.1-14



$CO = -4.6608v + 250.34$

Figure 5.1.1-15

TABLE 5.1.1-3

LINEAR REGRESSION ANALYSIS RESULTS

Air Rights Structure -- Non-Heating Weekdays

Traffic Flow Rate (Ind. Var.)

VS

	CO Conc. Median Strip	CO Conc. 3 Ft. North	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	.97	.95	.76	.64
Intercept	2.05	4.27	2.96	3.48
Slope	.0042	.0041	.0009	.0006
Mean of Dependent Variable Observations	30.64	31.08	7.15	6.38
Mean of Independent Variable Observations	6884.25	6884.25	6884.25	6884.25

Air Rights Structure -- Non-Heating Weekends

Traffic Flow Rate (Ind. Var.)

VS

	CO Conc. Medial Strip	CO Conc. 3 Ft. North	CO Conc. 3 Ft. Out	CO Conc. 3rd Fl. In
Correlation Coefficient				
Intercept				
Slope	NO TRAFFIC FLOW RATE DATA			
Mean of Dependent Variable Observations				
Mean of Independent Variable Observations				

TABLE 5.1.1-4

LINEAR REGRESSION ANALYSIS RESULTS

Air Rights Structure -- Non-Heating Weekdays

Average Vehicle Velocity (Ind. Var.)

VS

	CO Conc. Medial Strip	CO Conc. 3 Ft. North	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	-.84	-.84	-.53	-.41
Intercept	250.34	242.82	33.27	23.01
Slope	-4.6608	-4.4921	-.5541	-.3529
Mean of Dependent Variable Observations	30.64	31.08	7.15	6.38
Mean of Independent Variable Observations	47.14	47.14	47.14	47.14

Air Rights Structure -- Non-Heating Weekends

Average Vehicle Velocity (Ind. Var.)

VS

	CO Conc. Medial Strip	CO Conc. 3 Ft. North	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient				
Intercept				
Slope	NO AVERAGE VEHICLE VELOCITY DATA			
Mean of Dependent Variable Observations				
Mean of Independent Variable Observations				

CO CONCENTRATION - PPM

	DAILY AVE.			5-6 PM AVE.		
	O	I	DIFF	O	I	DIFF
3rd Floor	7.2	6.4	0.8	12.8	10.4	2.4
23rd Floor	4.0	4.5	-0.5	8.8	7.0	1.8
32nd Floor	4.3	5.0	-0.7	8.0	6.8	1.2
3rd - 23rd Diff	3.2	1.9	1.3	4.0	3.4	0.6
23rd - 32nd Diff	-0.3	-0.5	-0.2	0.8	0.2	0.6

while the daily average concentrations increase from the 23rd to 32nd floors, the increase indoors is considerably less than noted during the heating season.

5.1.1.3 CO Meteorological Relationships

The effect of changes in meteorological conditions on the carbon monoxide levels at the air rights structure was explored for the 3rd, 23rd and 32nd floor locations. This analysis shows that the measured CO concentrations are influenced by the relative location of the probes and the highway and site geometry.

The relationship between CO pollution patterns and the meteorological variables was investigated through the use of the 5-6 PM hourly average data rather than daily average data. Both heating and non-heating season information was used. The non-heating season data points are shown as X's on the diagrams herein.

As previously shown on pages 5-17 and 5-28, the hourly average concentrations at 5-6 PM displayed the expected decrease in CO level with height above the roadway at both outdoor and indoor locations during the non-heating season and outdoors during the heating season. Only the indoor CO concentration at the 32nd floor during the heating season was higher than the comparable indoor concentration at the 23rd floor. Thus, during the 5-6 PM period, a heating/non-heating seasonal difference is noted between the 23rd and 32nd floors indoors.

Valid data on roof level wind azimuth was obtained at the 5-6 PM hour for 44 weekdays during the heating season and 5 weekdays during the non heating season. Southerly winds occured 13 times and northerly winds prevailed 36 times. However, between October 8 and November 5, southerly winds were recorded on 10 days and northerly winds five times. All of the non heating days were marked by southerly winds. Northerly winds were experienced primarily in November, December and January during the heating season. This suggests that wind azimuth, which varies as a function of the season of the year, significantly contributes to the "increase" of CO concentration at the 32nd floor.

The 5-6 PM hourly average data was selected because this time period represented the maximum traffic conditions on the Trans Manhattan Expressway. Peak hourly average CO concentrations occured at this time of the day at the two road levels locations and both the outdoor and indoor locations at the 3rd floor level. This peak conditions also existed at the 23rd floor outdoor location but did not hold true either at the 23rd floor indoor location or at both locations on the 32nd floor. Daily peaks at these three locations did not correspond to traffic peaks, indicating a time lag between road level CO concentrations and the concentrations at the higher locations.

As seen in Figures 4.1-1, -2 and -3, the Trans Manhattan Expressway lies along a line with a northwesterly heading of approximately 300°. The building face under study is perpendicular to the highway, along a line from 210° to 30°, and is on the northern side of the structure. The apartments involved overlook the westbound traffic lanes. Surrounding buildings protect the air rights structure at the 3rd floor level but do not at the 23rd and 32 floor levels.

5.1.1.3.1 Meteorological Factors

Meteorological conditions at the roof level and the site geometry combine to produce the wind conditions at ground level. Figure 5.1.1-16 shows the relationship of the wind azimuth angle at the road level to the roof level wind

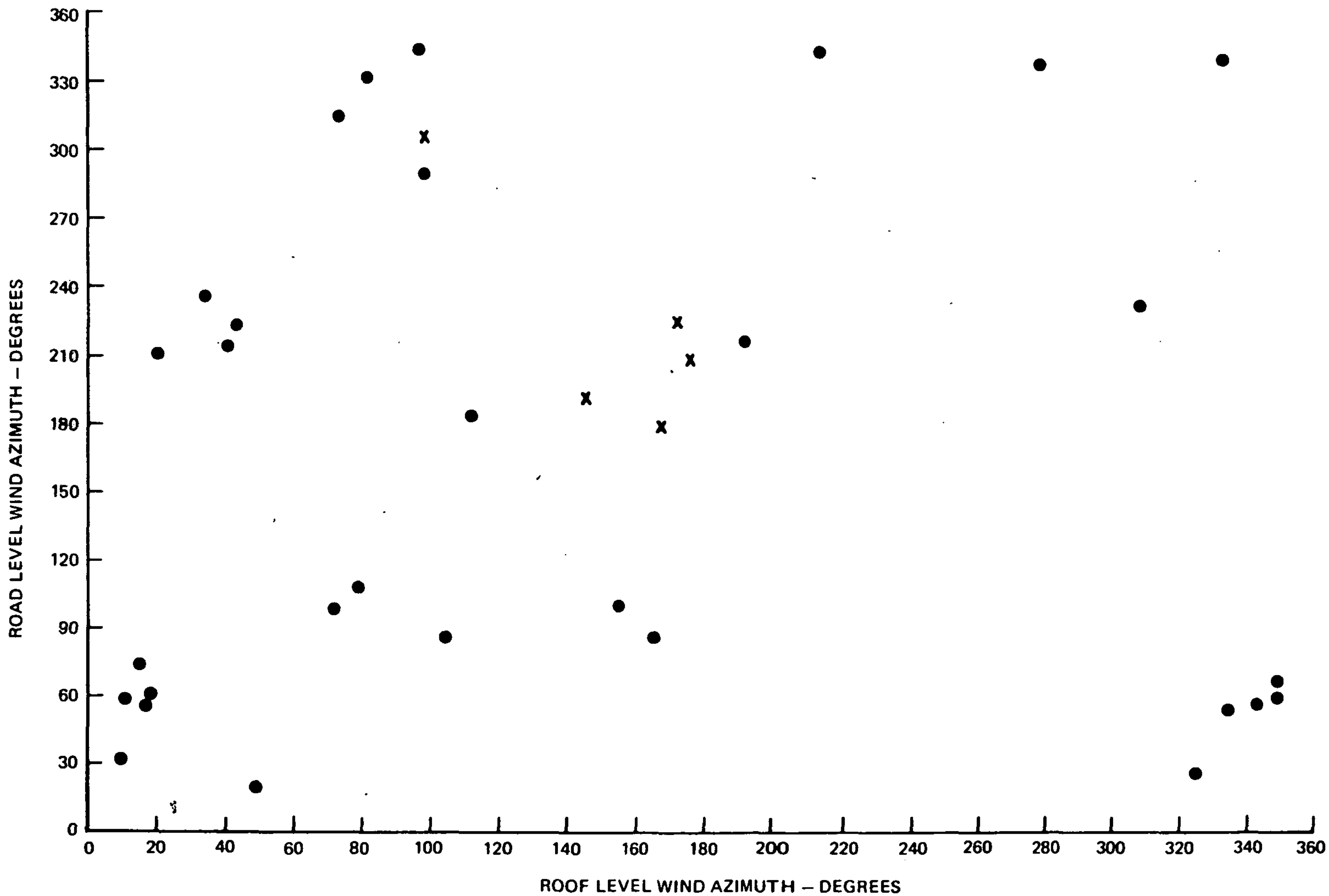


Figure 5.1.1-16. Road Level Vs. Roof Level Wind Azimuth - 6 PM - Weekdays - Site 1

azimuth. It can be seen that the road level wind generally blew from the same azimuth angle as the roof wind. Occasionally, however, road winds blew approximately 180° from the roof wind direction. Road wind speeds generally were lower than roof winds, as shown on Figure 5.1.1-17. Wind speeds, at both locations, varied with wind azimuth. However, higher velocities were more frequent when the winds blew essentially parallel to the face of the building, see Figures 5.1.1-18 and -19. The roof wind azimuth and wind speed combine with the site configuration to create the road level wind conditions.

Roof level temperatures vary for each roof azimuth angle. High temperatures are generally associated with southerly winds and low temperature with northerly winds, as shown on Figure 5.1.1-20. Temperature variations at roof level are reflected at road level as shown by the lines of constant temperature lapse drawn on the figure.

Temperature lapse is controlled by the azimuth angles of the roof and road winds. As can be seen from Figures 5.1.1-21 and -22, maximum temperature lapse, as measured on the northerly side of the air rights structure, occurs when the roof wind is from 112°, or from behind the building. Minimum lapse occurs when the roof and road winds blow parallel to the face of the building but in opposite directions (20° and 210°). Temperature lapse therefore is a function of the wind azimuth angles at the two levels and the location of the road level temperature measurement. (If the road measurement had been made on the southern side of the building, the temperature lapse for the 112° roof wind would have been low, while 300° roof winds would have produced higher lapse measurements.)

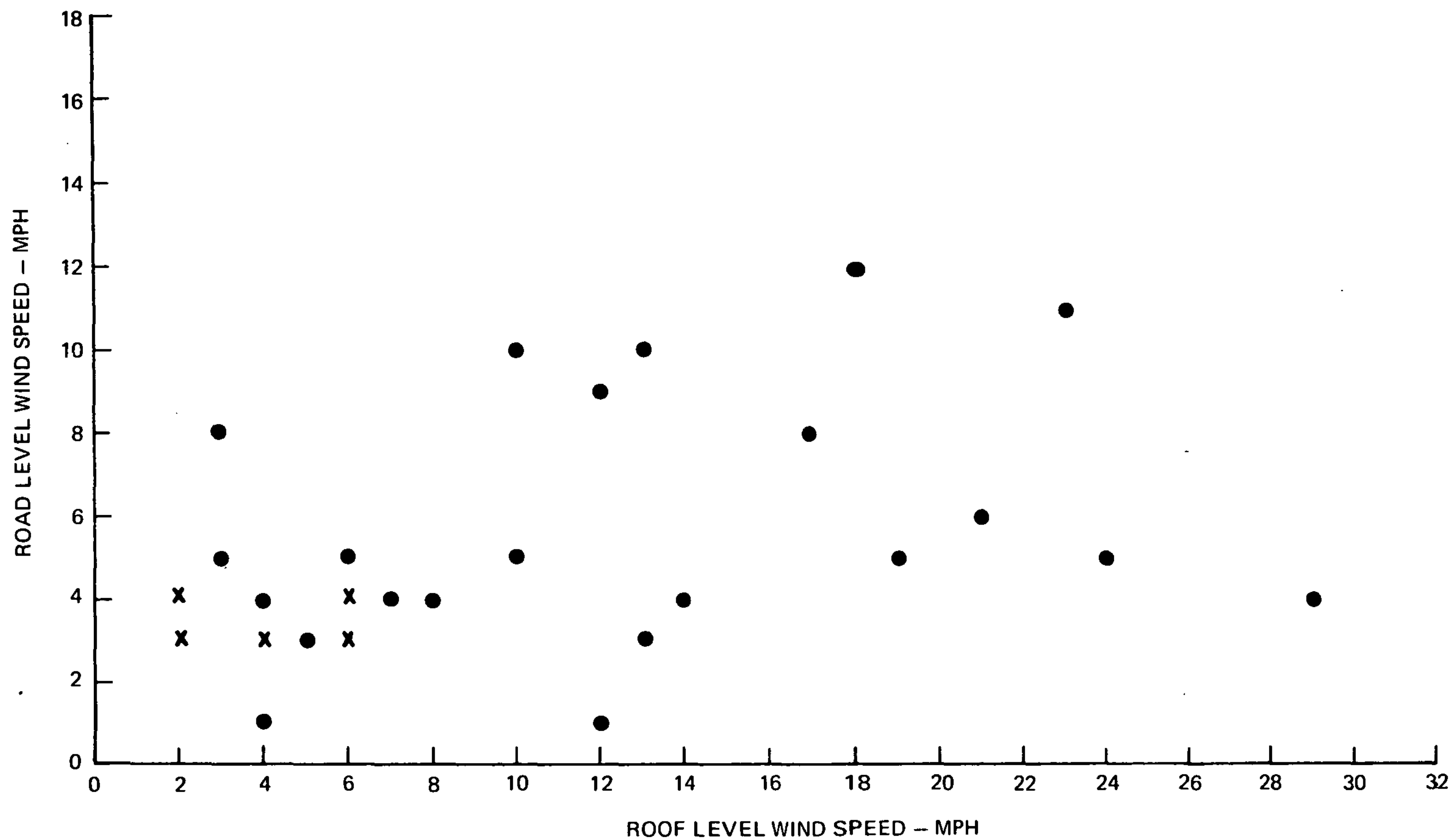


Figure 5.1.1-17. Road Level Vs. Roof Level Wind Speeds - 6 PM - Weekdays - Site 1

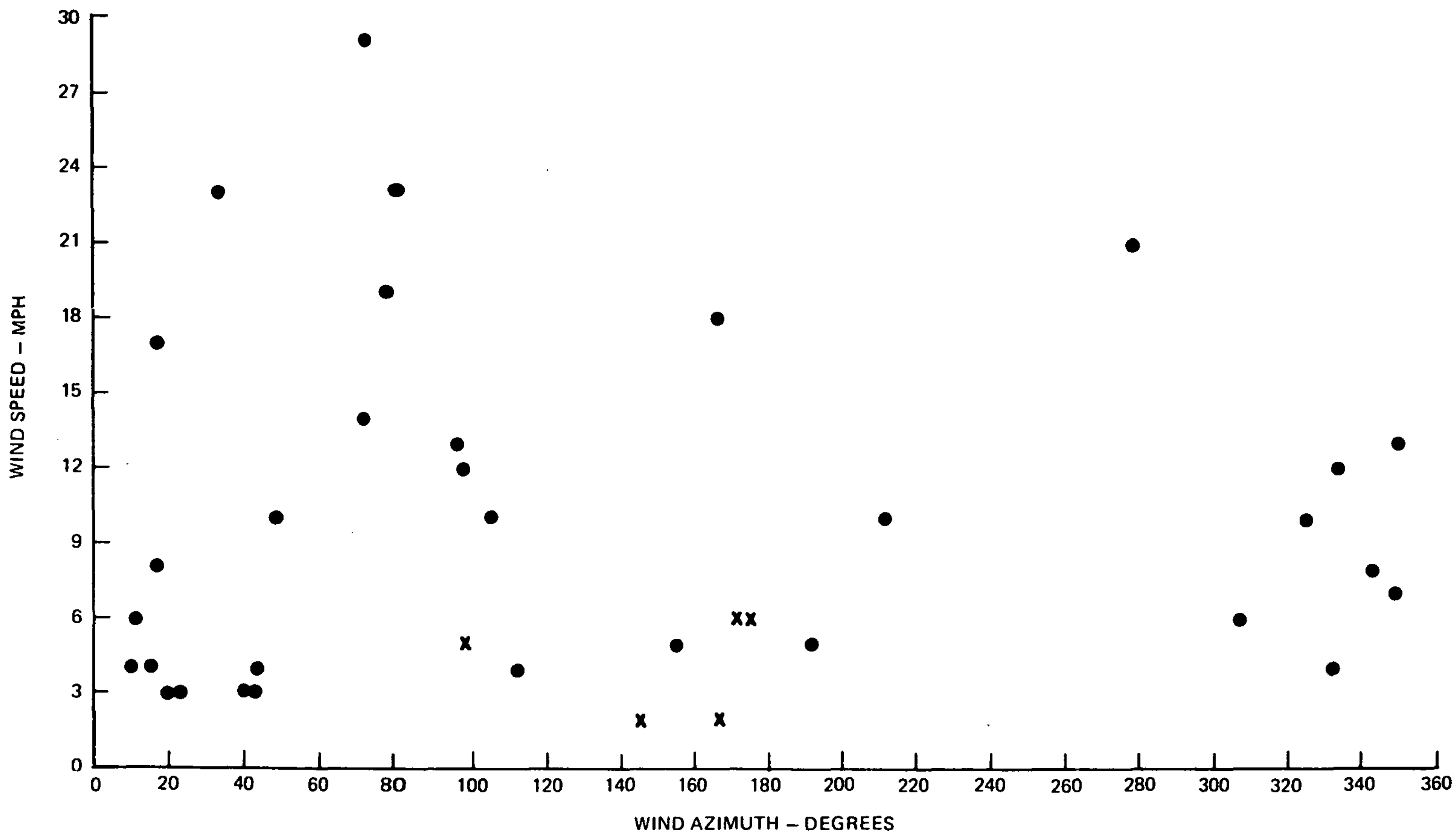


Figure 5.1.1-18. Roof Level Wind Speed Vs. Roof Level Wind Azimuth - 6 PM - Weekdays - Site 1

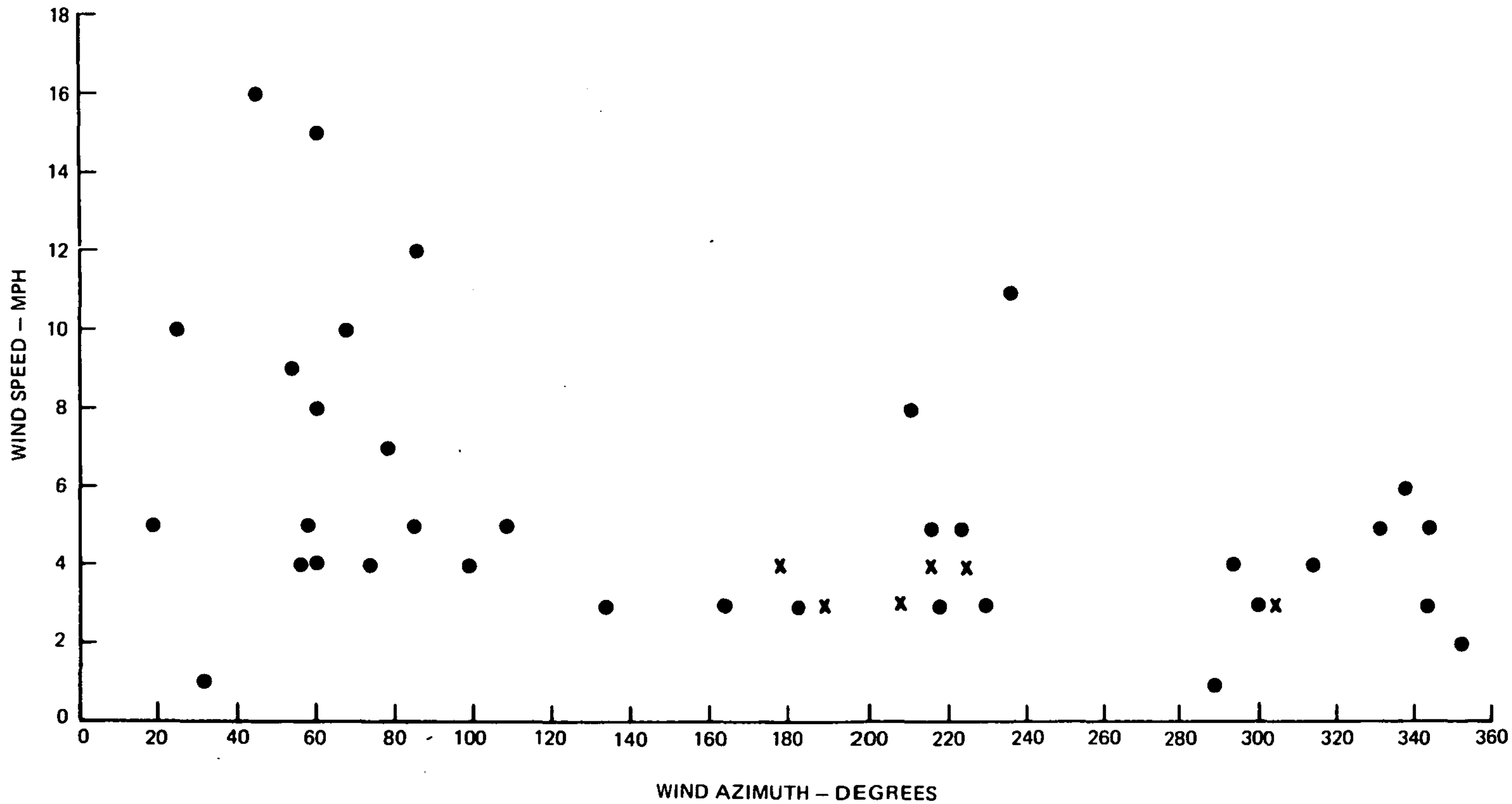


Figure 5.1.1-19. Road Level Wind Speed Vs. Road Level Wind Azimuth - 6 PM - Weekdays - Site 1

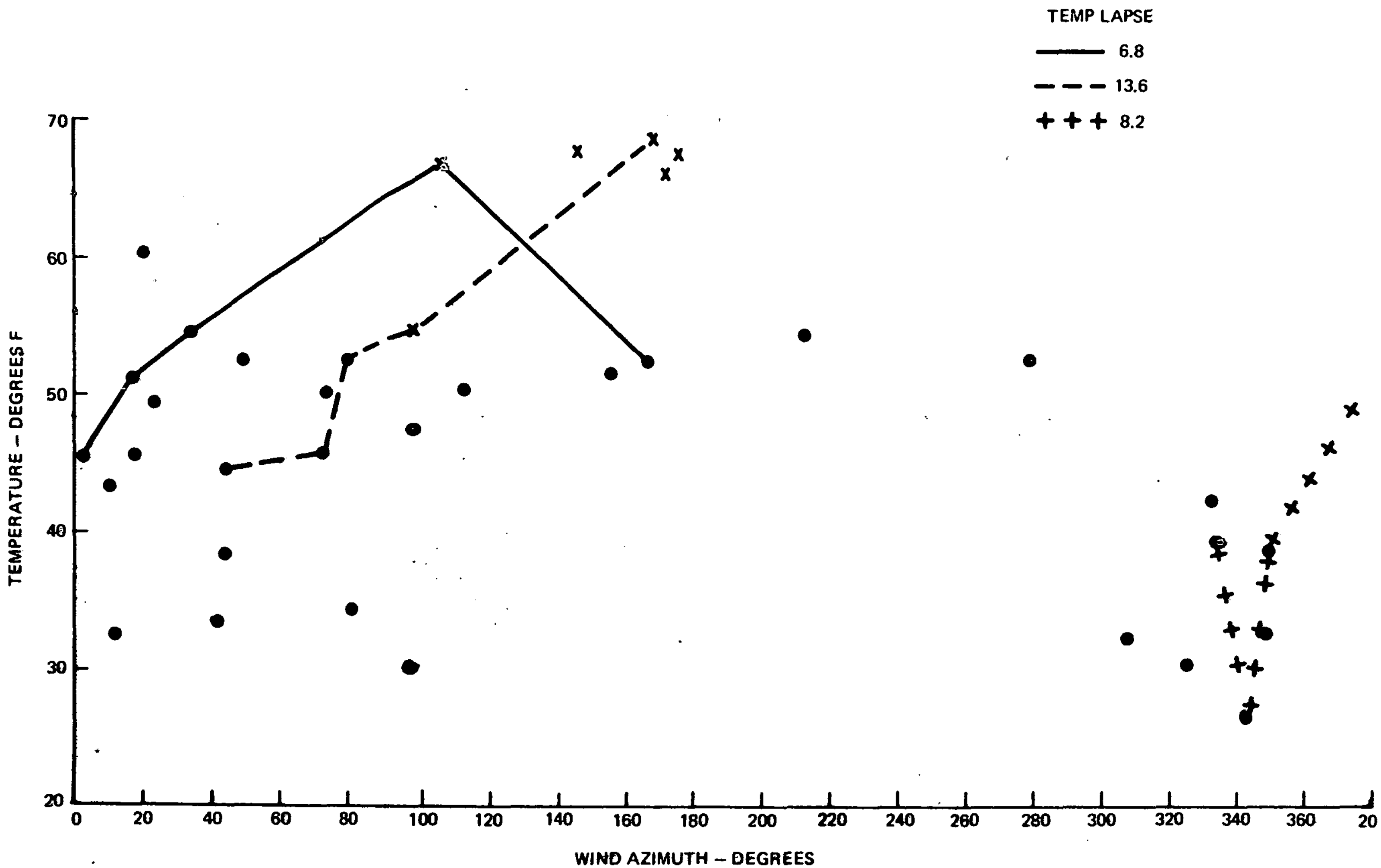


Figure 5.1.1-20. Roof Level Temperature Vs. Roof Level Wind Azimuth - 6 PM - Weekdays - Site 1

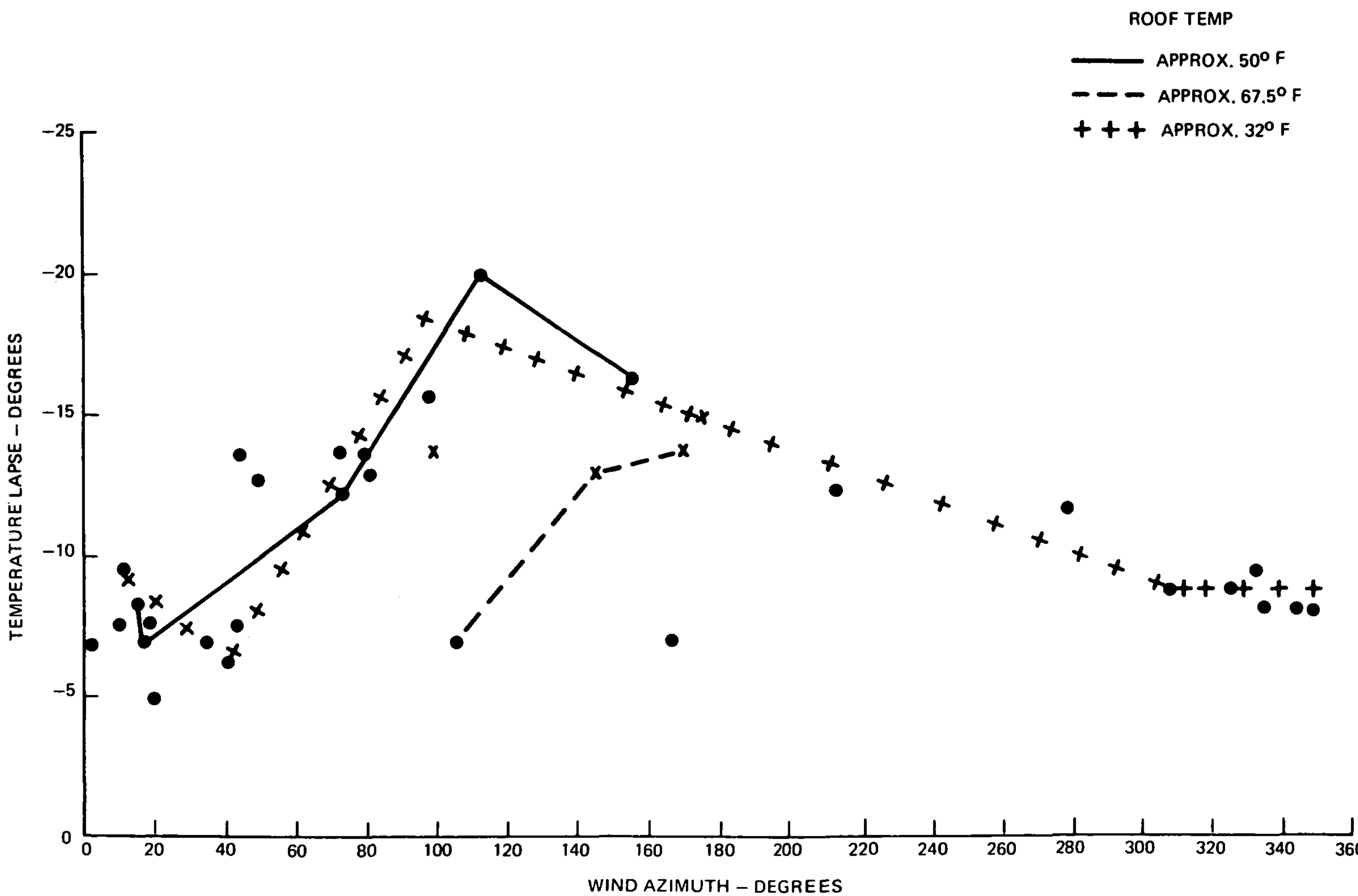


Figure 5.1.1-21. Temperature Lapse Vs. Roof Level Wind Azimuth - 6 PM - Weekdays - Site 1

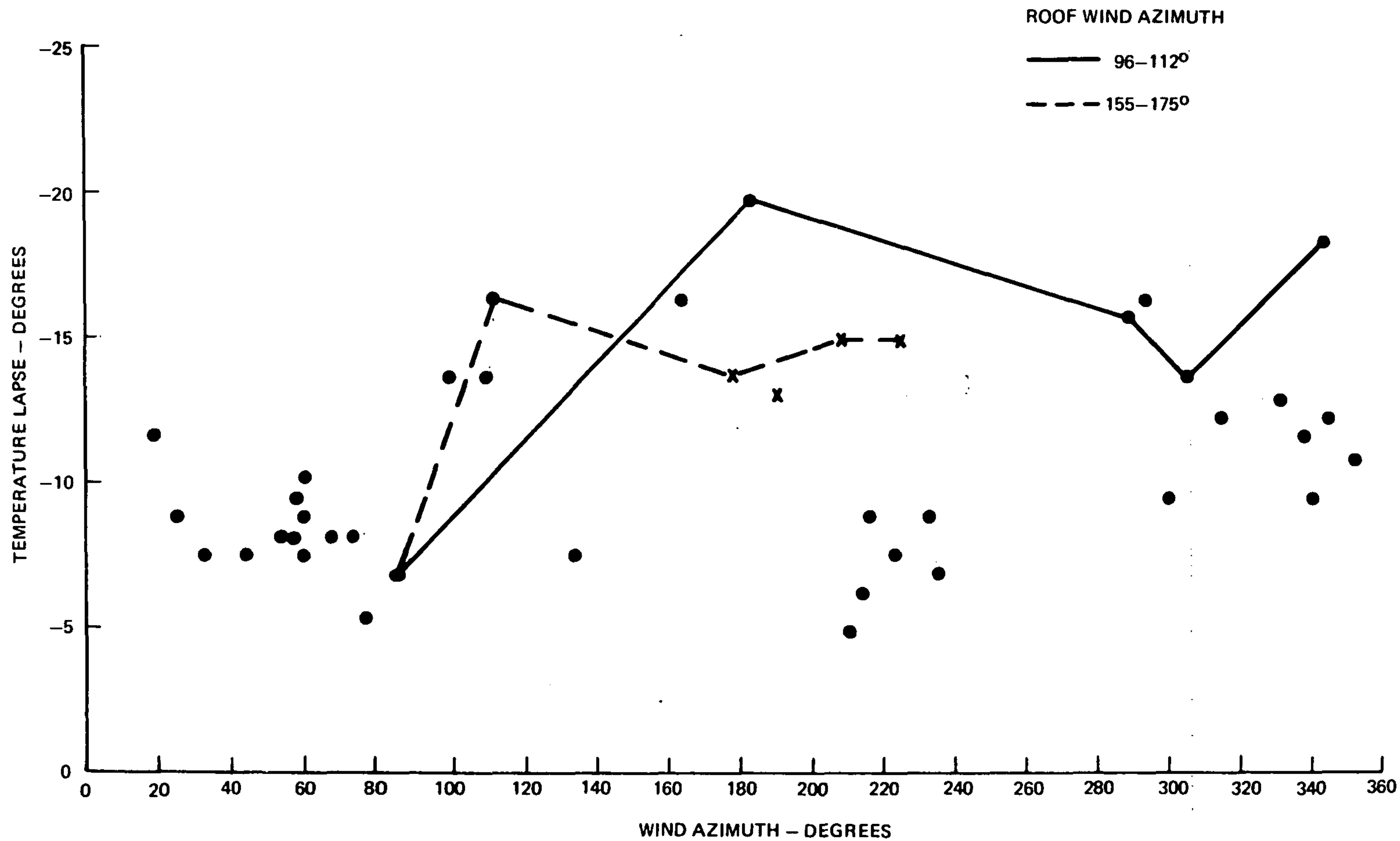


Figure 5.1.1-22. Temperature Lapse Vs. Road Level Wind Azimuth - 6 PM - Weekdays - Site 1

Road level wind sigma azimuth is greatly affected by road level wind azimuth. As shown in Figure 5.1.1-23, the highest turbulance conditions occured when the wind blew parallel to the road towards the face of the building under study. Low turbulence predominanted when the road level wind was parallel to the building face. Comparison of Figures 5.1.1-19 and -23 will show that wind azimuth determined the wind sigma azimuth more so than road level wind speed.

It appears, therefore, that wind azimuth is the dominant meteorological variable. As shown, roof wind azimuth influences roof wind speed and road level wind azimuth. Road level wind azimuth determines road level wind sigma and wind speed. Roof and road wind azimuths combine to establish temperature lapse.

5.1.1.3.2 Median Strip Concentration

Figure 5.1.1-24 is a plot of the CO concentration as measured at the median strip of the Trans Manhattan Expressway. This figure shows that a large variation occured in traffic flow rate during the evening rush hour period. It also shows that there is a significant variation in CO level at the median strip for each traffic volume. However the CO/traffic relationship conforms very well with that discussed in paragraphs 5.1.1.1.1 and 5.1.1.2.1, as indicated by the parallel lines.

As mentioned in section 5.1.1.1, the peak CO level measured at the median strip was 91.3 ppm. This peak occurred during the 5-6 PM period on a day when the traffic flow rate was 12,200 vehicles per hour. The meteorological conditions for the 4 instances at which the 5-6 PM traffic flow rate was 12,200 vehicles per hour are tabulated below. These data points are circled on figures which follow.

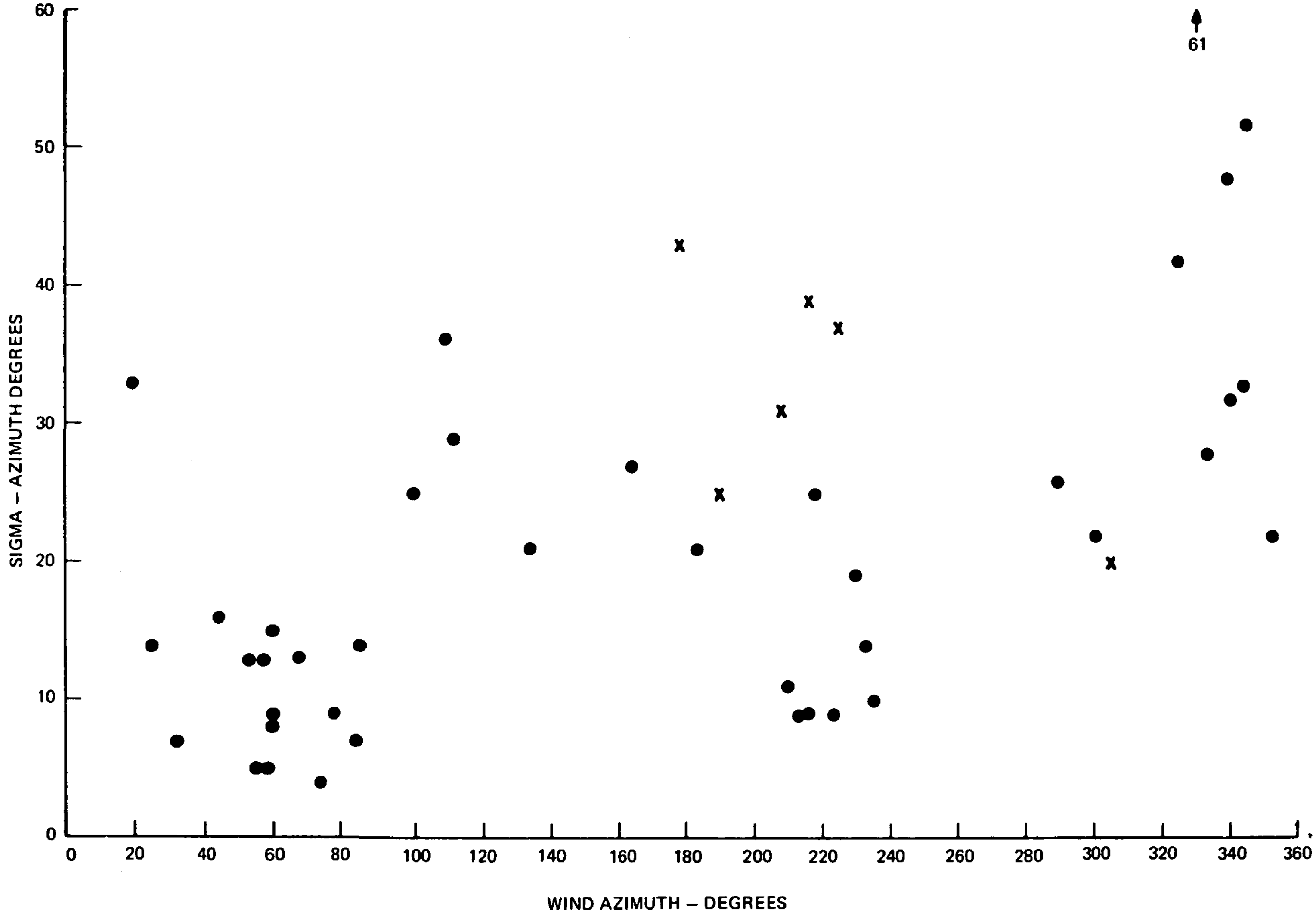


Figure 5.1.1-23. Road Level Sigma Azimuth Vs. Road Level Wind Azimuth - 6 PM - Weekdays - Site 1

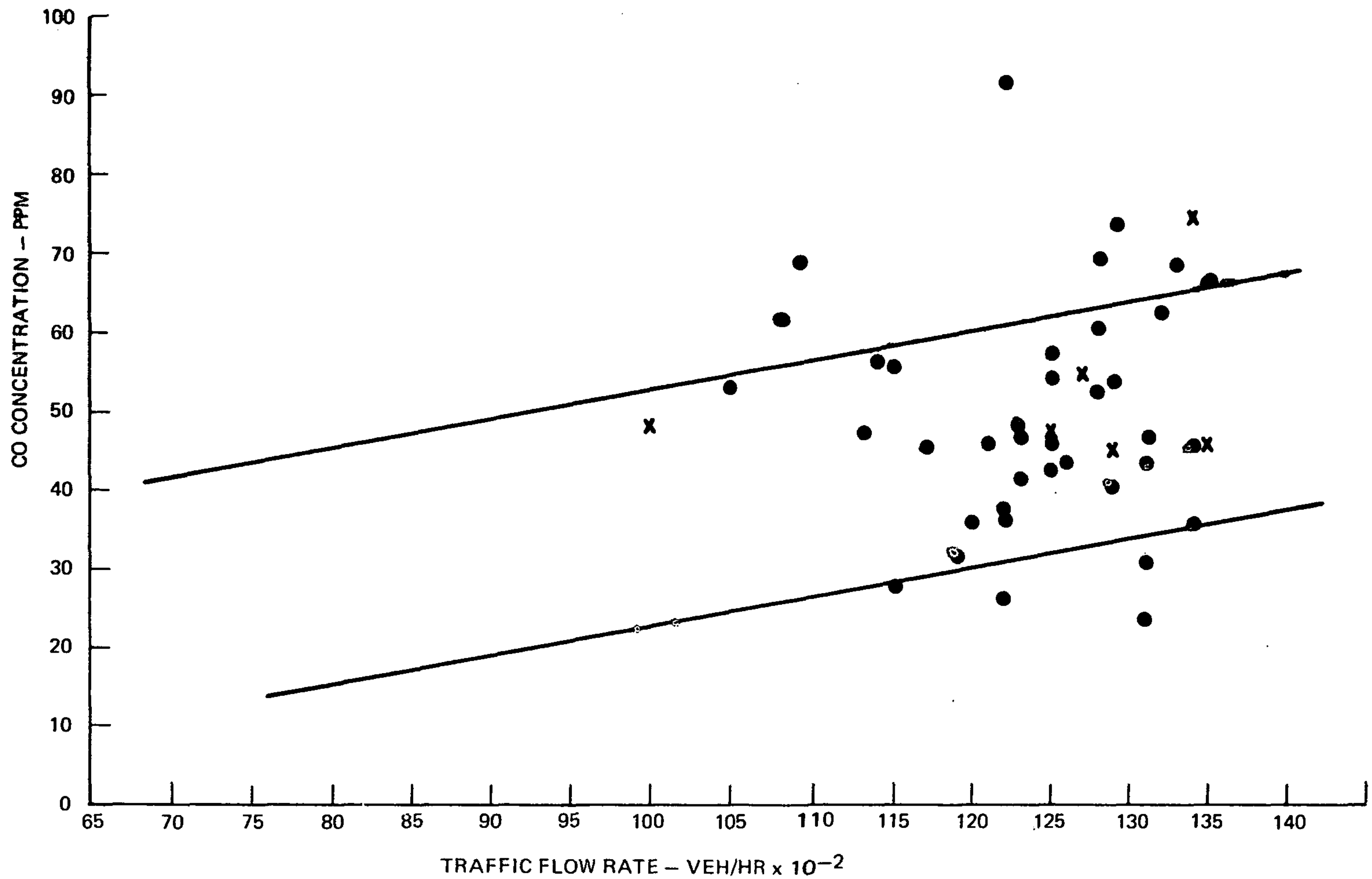


Figure 5.1.1-24. Median Strip Concentration Vs. Traffic Flow Rate - 6 PM - Weekdays - Site 1

CO PPM	Traffic Veh/Hr	Wind Azimuth Degrees	Wind Sigma Degrees	Wind Speed MPH	Temp. Lapse Degrees
26.1	122	60	15	15	10.2
36.0	122	-	-	-	13.6
37.2	122	338	48	6	11.6
91.3	122	58	5	5	9.5

Examination of Figures 5.1.1-25 thru -28 will show how the road level meteorological conditions affect the median strip CO level. The peak CO conditions occurred when the wind was blowing from 58°, wind speed was 5 mph and wind sigma was low at 5°. When the wind speed increased to 15 mph, blowing at essentially the same azimuth angle and with a sigma of 15°, the CO concentration dropped significantly to 26.1 ppm. When the wind shifted to 338° at 6 mph and sigma increased to 48°, the CO was 37.2 ppm. Thus, the median strip CO level for a constant traffic flow rate is greatly influenced by meteorological conditions.

It will be noticed from these constant traffic days, and the constant 5 mph wind speed days (see Table 5.1.1-5 for data) which are connected on Figures 5.1.1-25, 27 and -28, that wind azimuth, wind speed and wind sigma combine to determine median CO level. Median strip CO tends to be high when the wind speed and wind sigma perpendicular to the road are low, and low when winds speed and sigma are high. Winds parallel to the road produce average concentrations. Median strip CO is not noticeably influenced by temperature lapse. The suggestion of a CO/temperature lapse relationship given by the constant wind data points on Figure 5.1.1-28 is in reality the change in CO level due to the changes in other meteorological conditions.

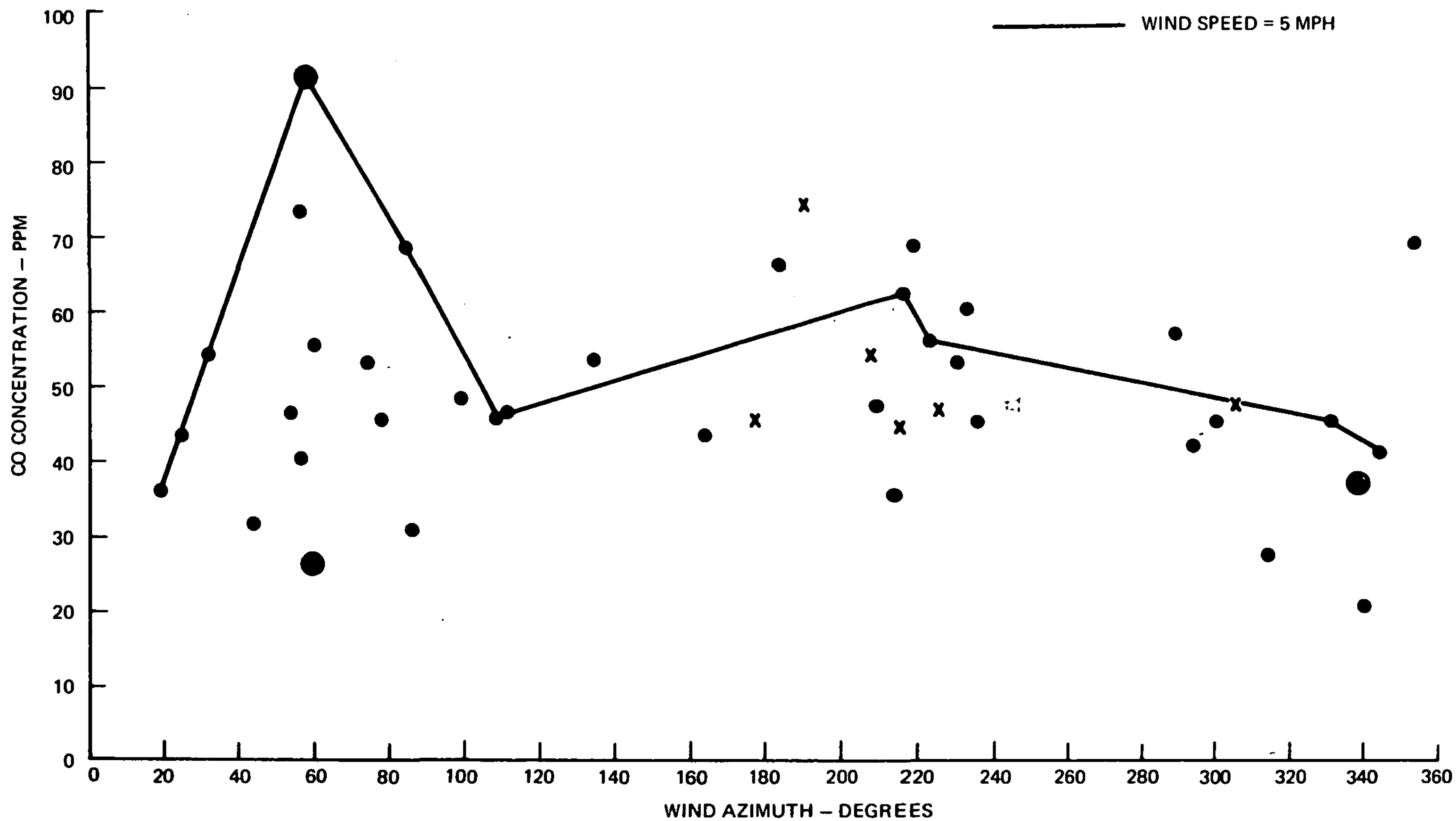


Figure 5.1.1-25. Median Strip CO Concentration Vs. Road Level Wind Azimuth - 6 PM - Weekdays - Site 1

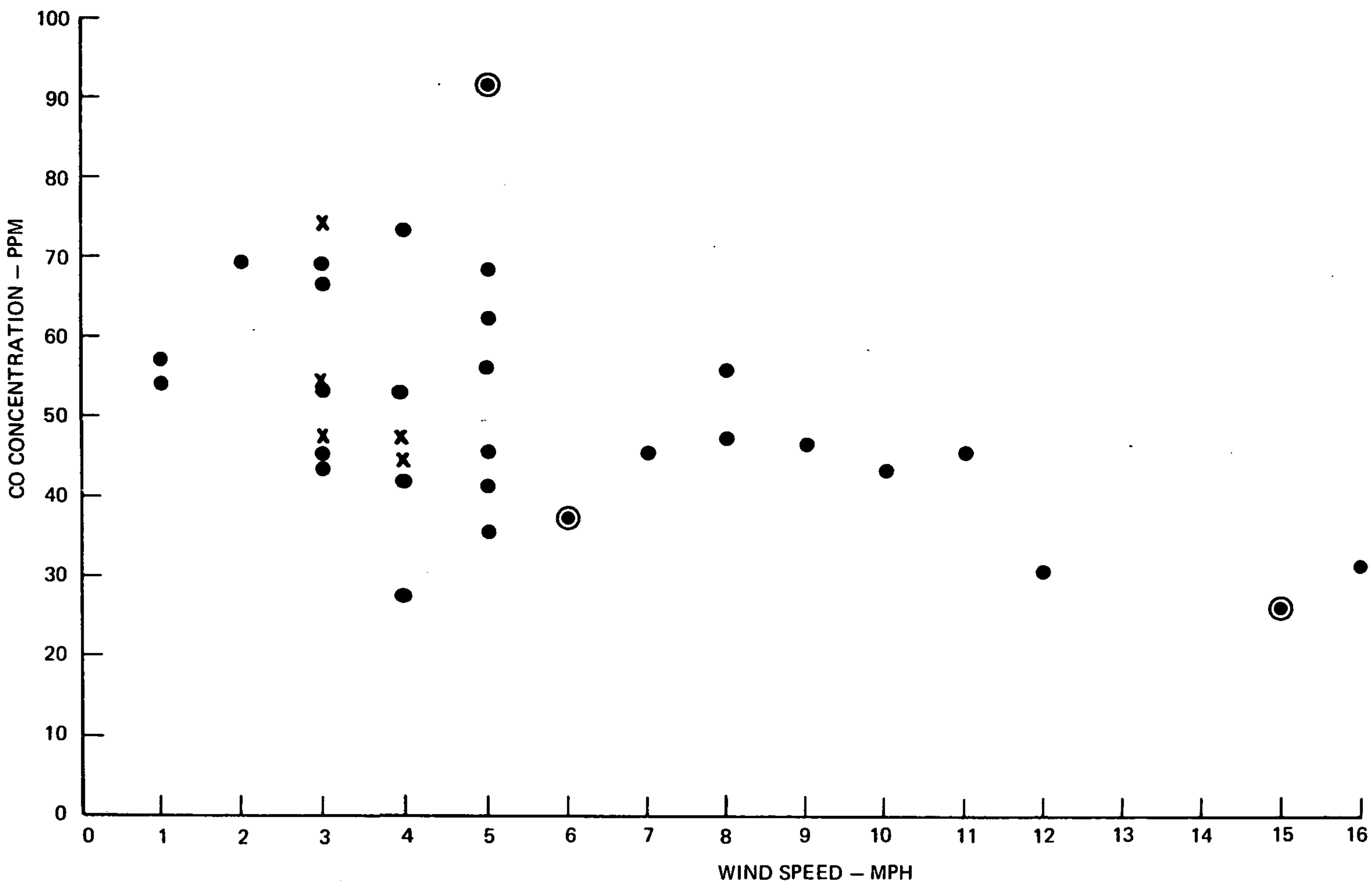


Figure 5.1.1-26. Median Strip CO Concentration Vs. Road Level Wind Speed - 6 PM - Weekdays - Site 1

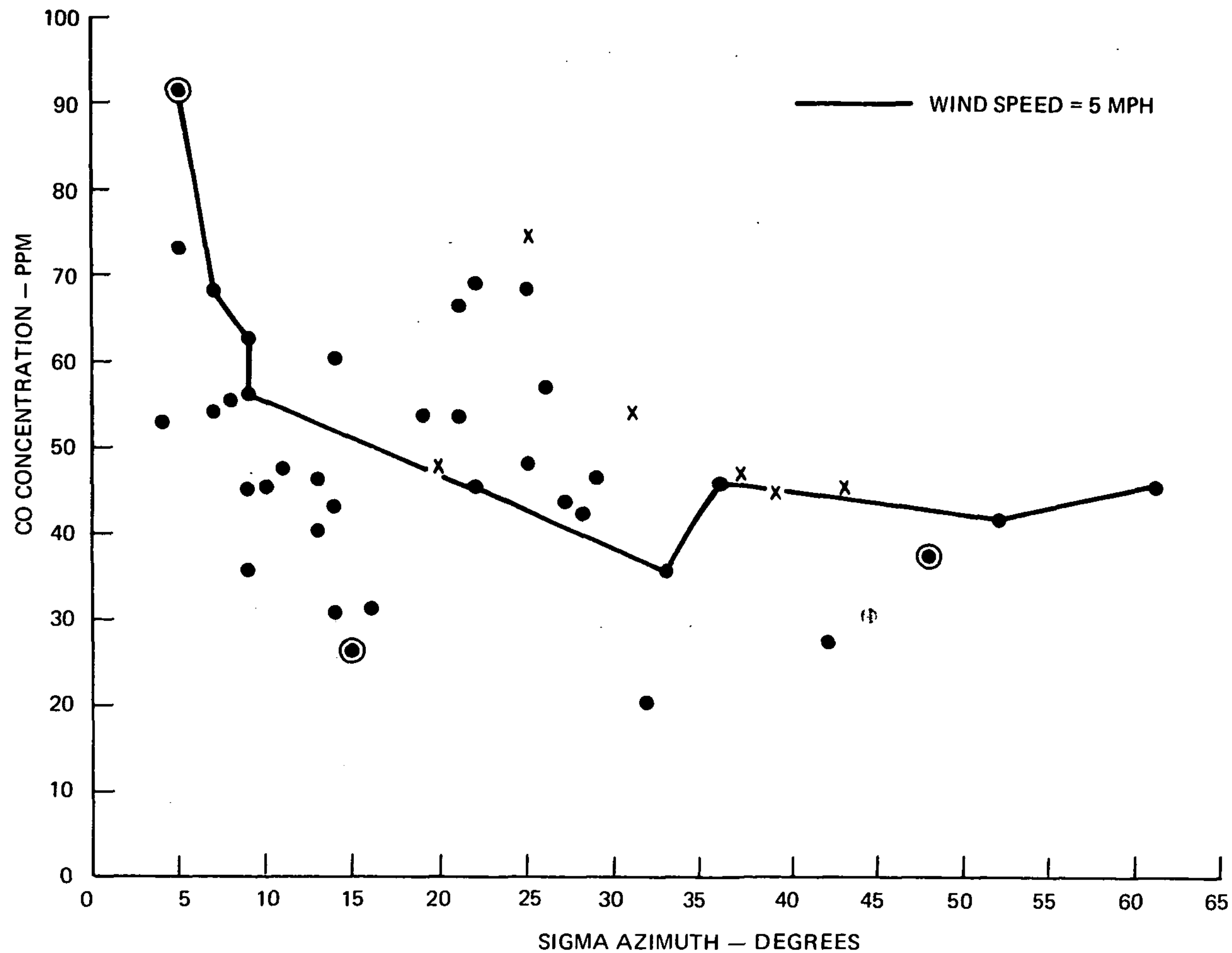


Figure 5.1.1-27. Median Strip CO Concentration Vs. Road Level Sigma Azimuth - 6 PM - Weekdays - Site 1

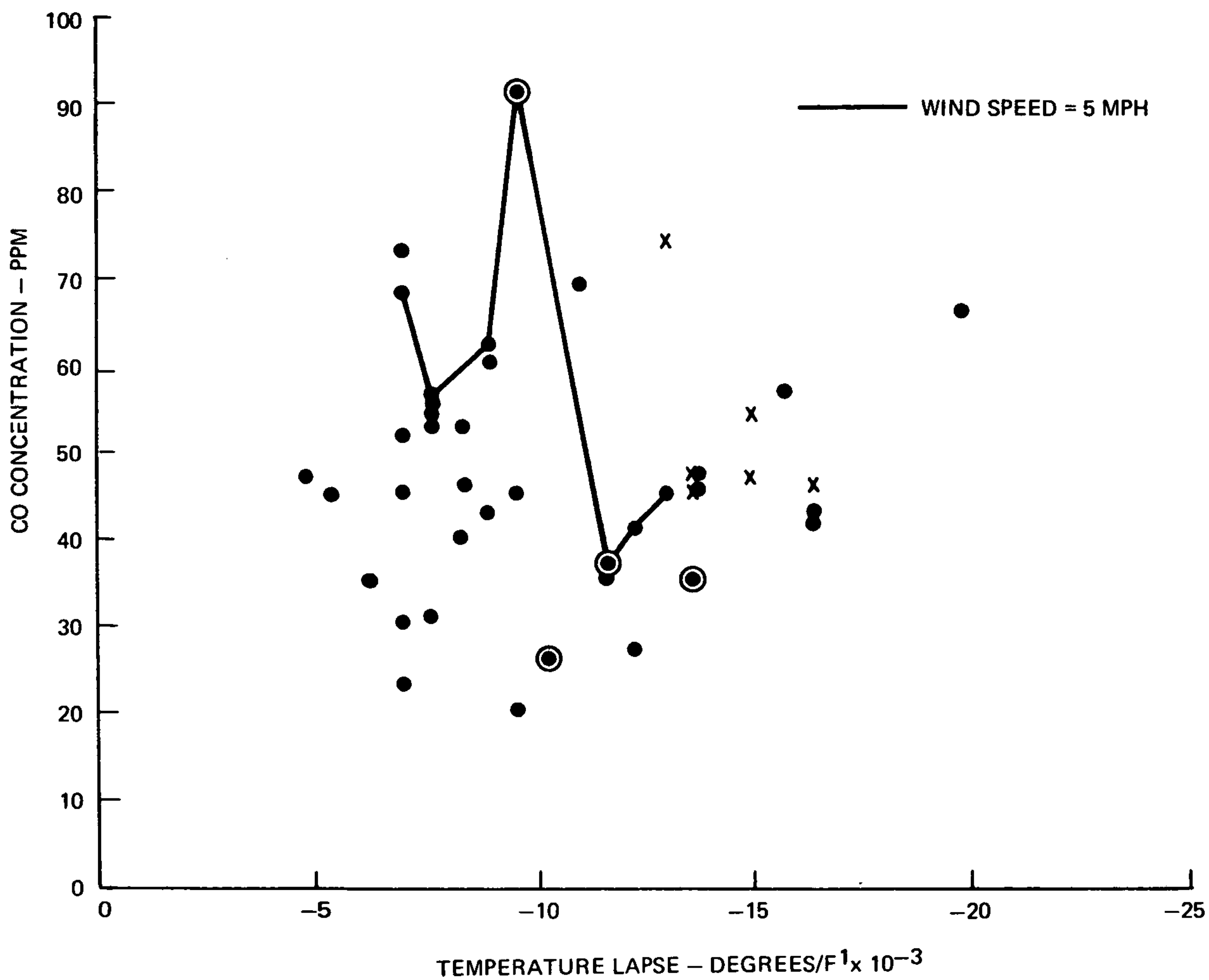


Figure 5.1.1-28. Median Strip CO Concentration Vs. Temperature Lapse - 6 PM - Weekdays - Site 1

TABLE 5.1.1-5

CONSTANT 5 MPH DATA - ROAD LEVEL - SITE 1

CO PPM	TRAFFIC VEH/HR	WIND AZIMUTH DEGREES	WIND SIGMA DEGREES	WIND SPEED MPH	TEMP LAPSE DEGREES
35.9	120	19	33	5	11.6
41.6	123	344	52	5	12.2
45.6	121	331	61	5	12.9
46.0	121	109	36	5	13.6
56.6	114	223	9	5	7.5
62.3	132	216	9	5	8.8
68.6	133	85	7	5	6.8
91.3	122	58	5	5	9.5

The minimum median strip CO of 20.7 ppm occurred, as shown on Figure 5.1.1-24, at the minimum traffic flow rate of 5600 vehicles per hour. The low level of CO is mainly the result of the low traffic conditions and not significantly perturbed by meteorological variations.

5.1.1.3.3 3rd Floor Concentrations

CO concentrations at the 3rd floor outdoor and indoor locations for the same meteorological variables are shown on Figures 5.1.1-29 thru -36. Examination of comparable curves will reveal that the relationship of CO concentration to the meteorological variables is essentially the same for both outdoor and indoor locations. However, the effect of the meteorological factors is appreciably different from that noticed at the median strip. A comparison of corresponding figures for the two locations will show that wind azimuth angles which decrease the median strip CO level increase the concentration at the 3rd floor. Sigma azimuth appears to decrease median strip CO while increasing the 3rd floor levels. Median strip concentrations do not noticeably respond to temperature lapse changes. However, temperature lapse increases produce higher CO levels at the 3rd floor locations. In other words, the meteorological conditions which reduce on roadway CO levels increase CO levels at off roadway locations.

At the 3rd floor, road winds from approximately 60° produce low outdoor and indoor concentrations. Winds from 220° and 320° produce a wide variation in CO level. It will be noticed the peak 3rd floor outdoor and indoor CO levels of 39.9 ppm and 28.7 ppm occurred when the wind blew from 218° at 3 mph. Wind Sigma was an average of 25°. Temperature lapse is missing. The next two high outdoors concentrations, 28.1 and 27.3 ppm, also occurred for southerly wind conditions at 3 mph and 20-25° sigma. The 27.3 ppm reading resulted

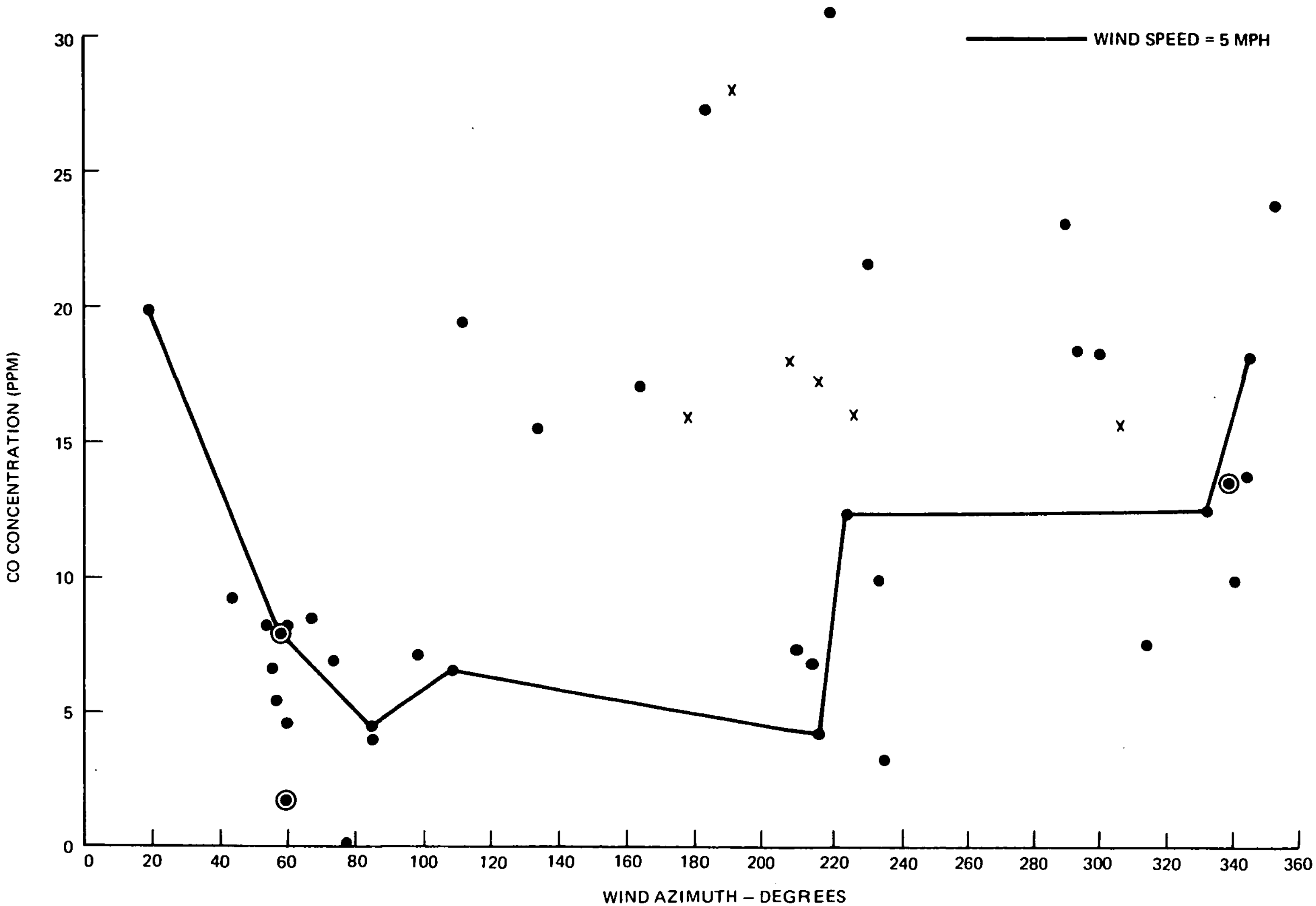


Figure 5.1.1-29. CO Concentration Outdoors 3rd Floor Vs. Road Level Wind Azimuth - 6 PM - Weekdays - Site 1

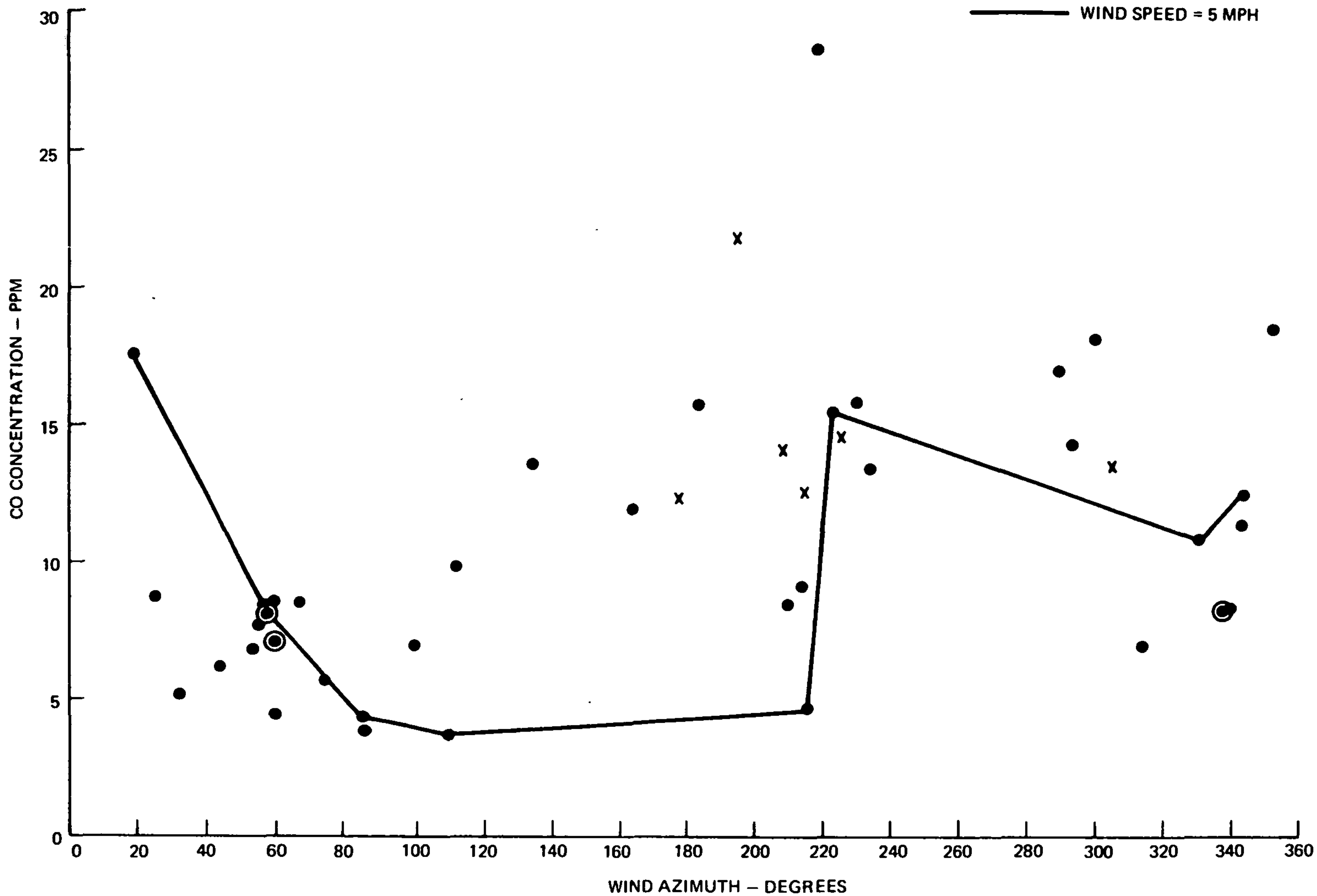


Figure 5.1.1-30. CO Concentration Indoor 3rd Floor Vs. Road Level Wind Azimuth 6 PM - Weekdays - Site 1

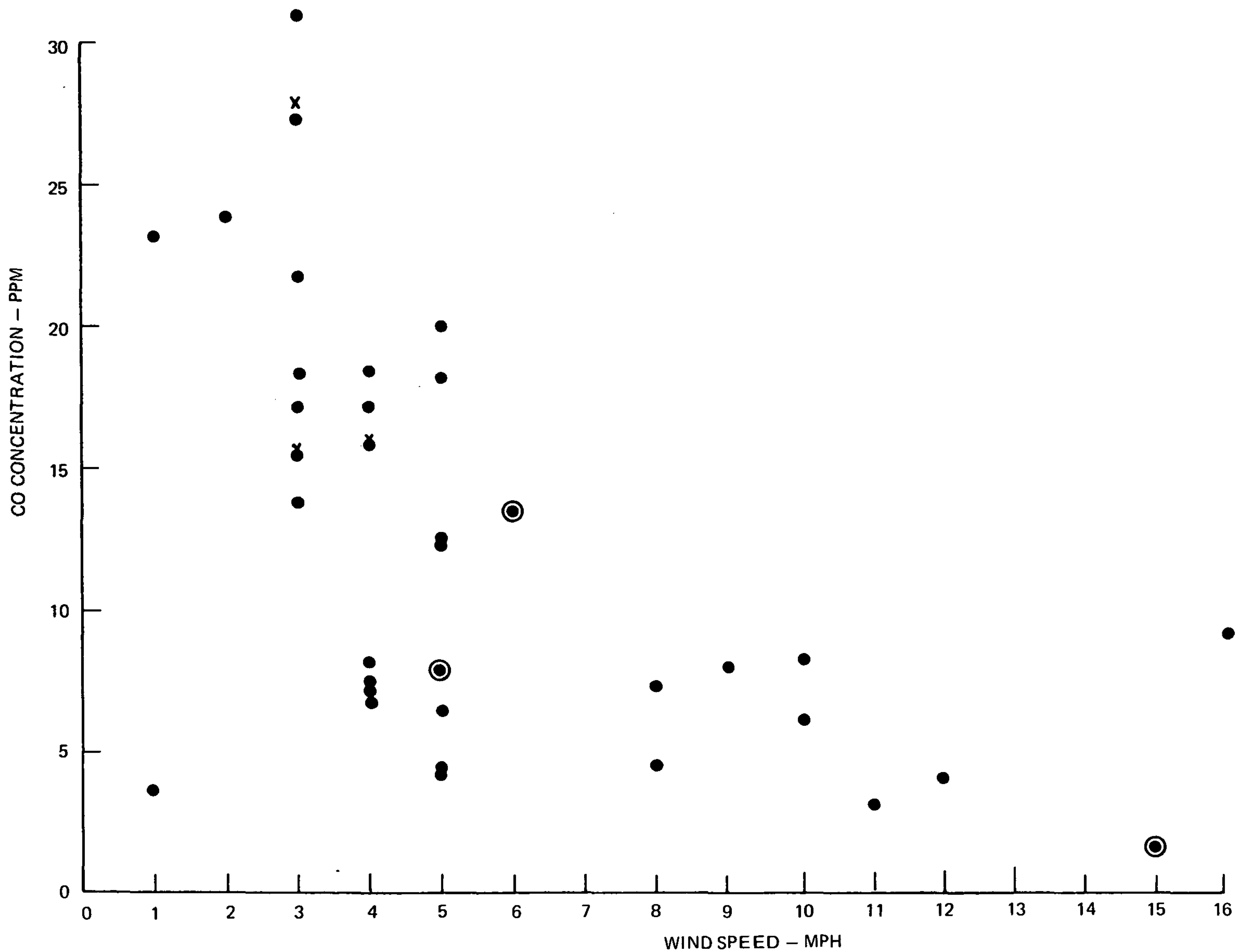


Figure 5.1.1-31. CO Concentration Outdoors 3rd Floor Vs. Road Level Wind Speed - 6 PM - Weekdays - Site 1

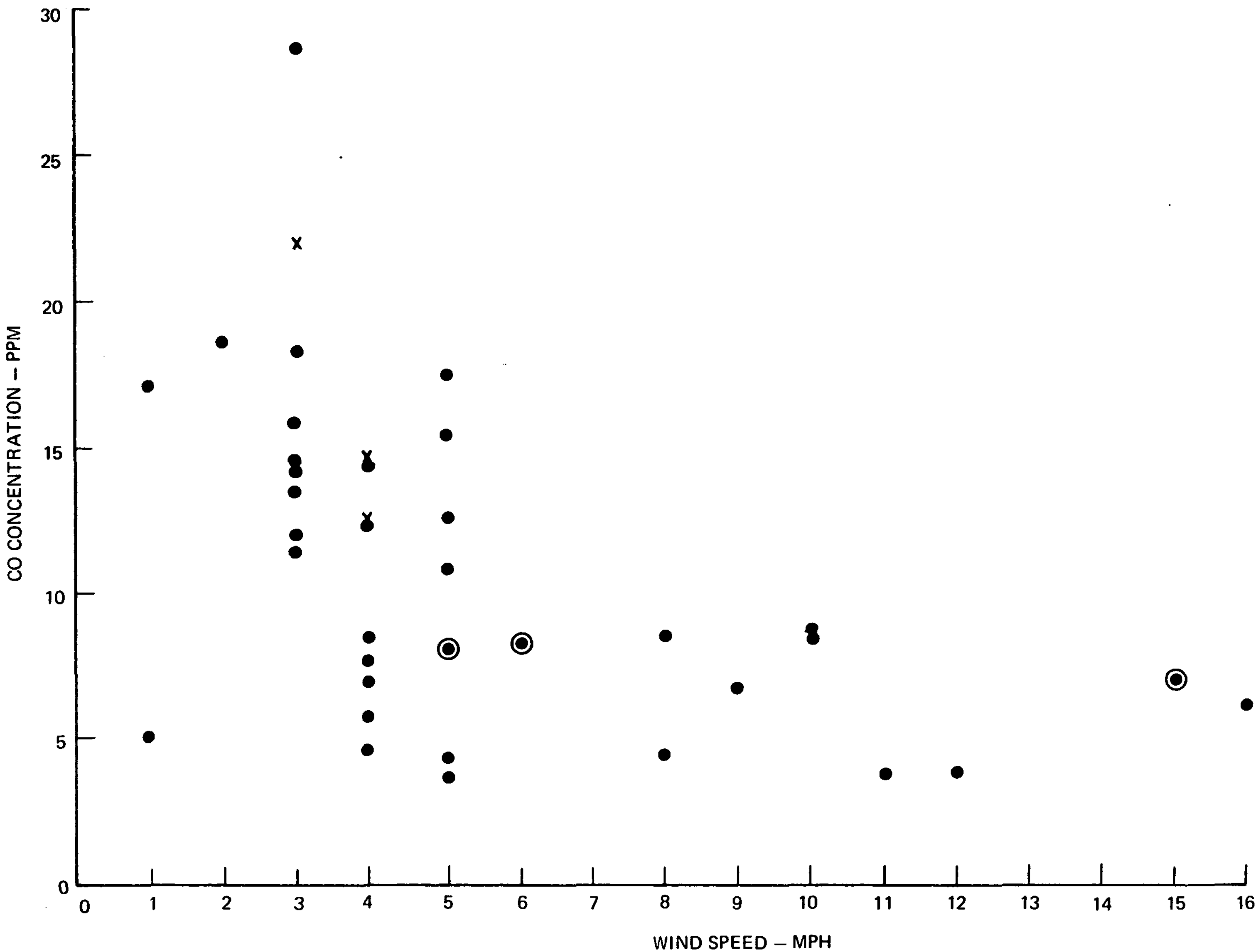


Figure 5.1.1-32. CO Concentrations Indoor 3rd Floor Vs. Road Level Wind Speed - 6 PM - Weekdays - Site 1

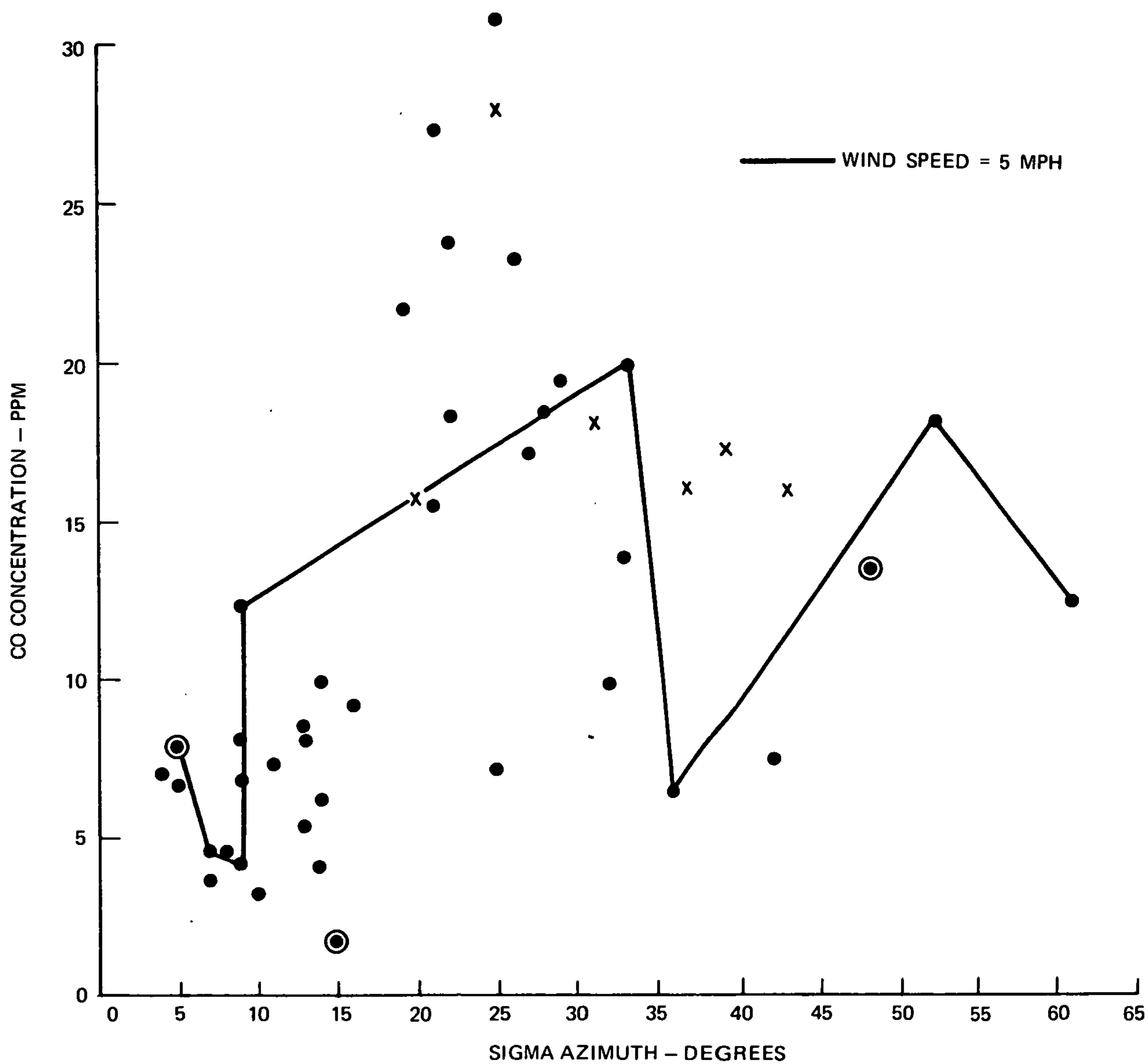


Figure 5.1.1-33. CO Concentration Outdoors 3rd Floor Vs. Road Level Sigma Azimuth - 6 PM - Weekdays - Site 1

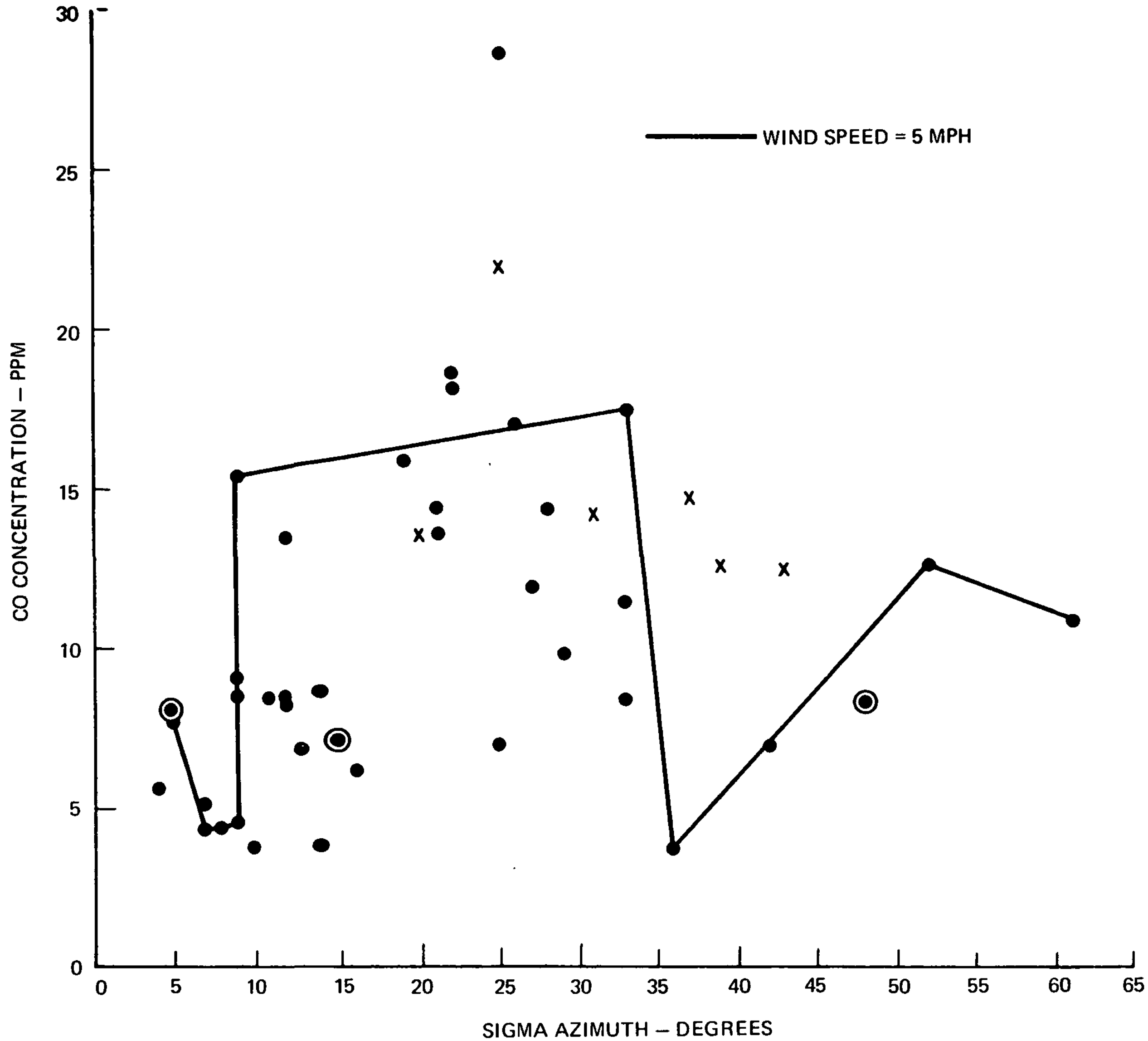


Figure 5.1.1-34. CO Concentration Indoors 3rd Floor Vs. Road Level Sigma Azimuth - 6 PM - Weekdays - Site 1

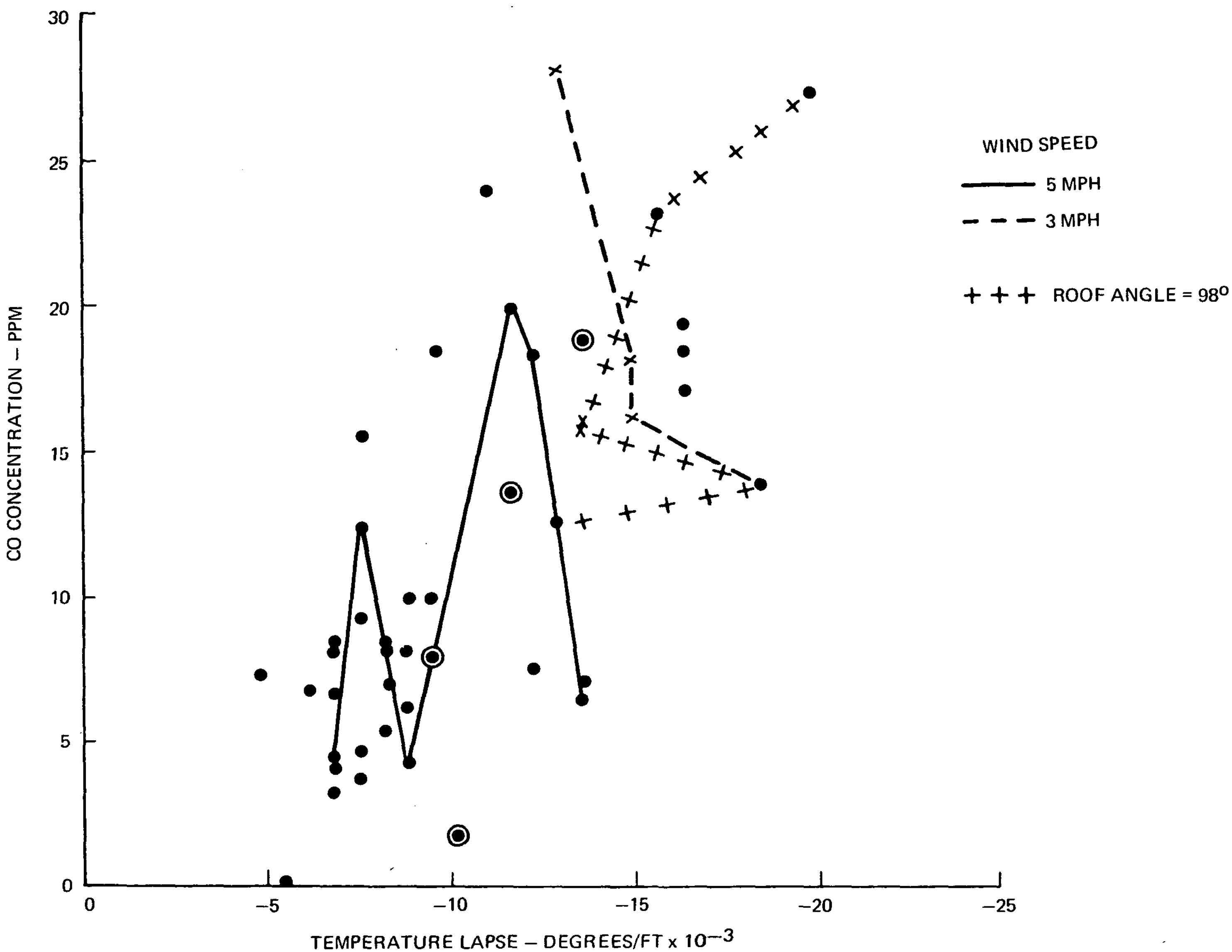


Figure 5.1.1-35. CO Concentration Outdoors 3rd Floor Vs. Temperature Lapse - 6 PM - Weekdays - Site 1

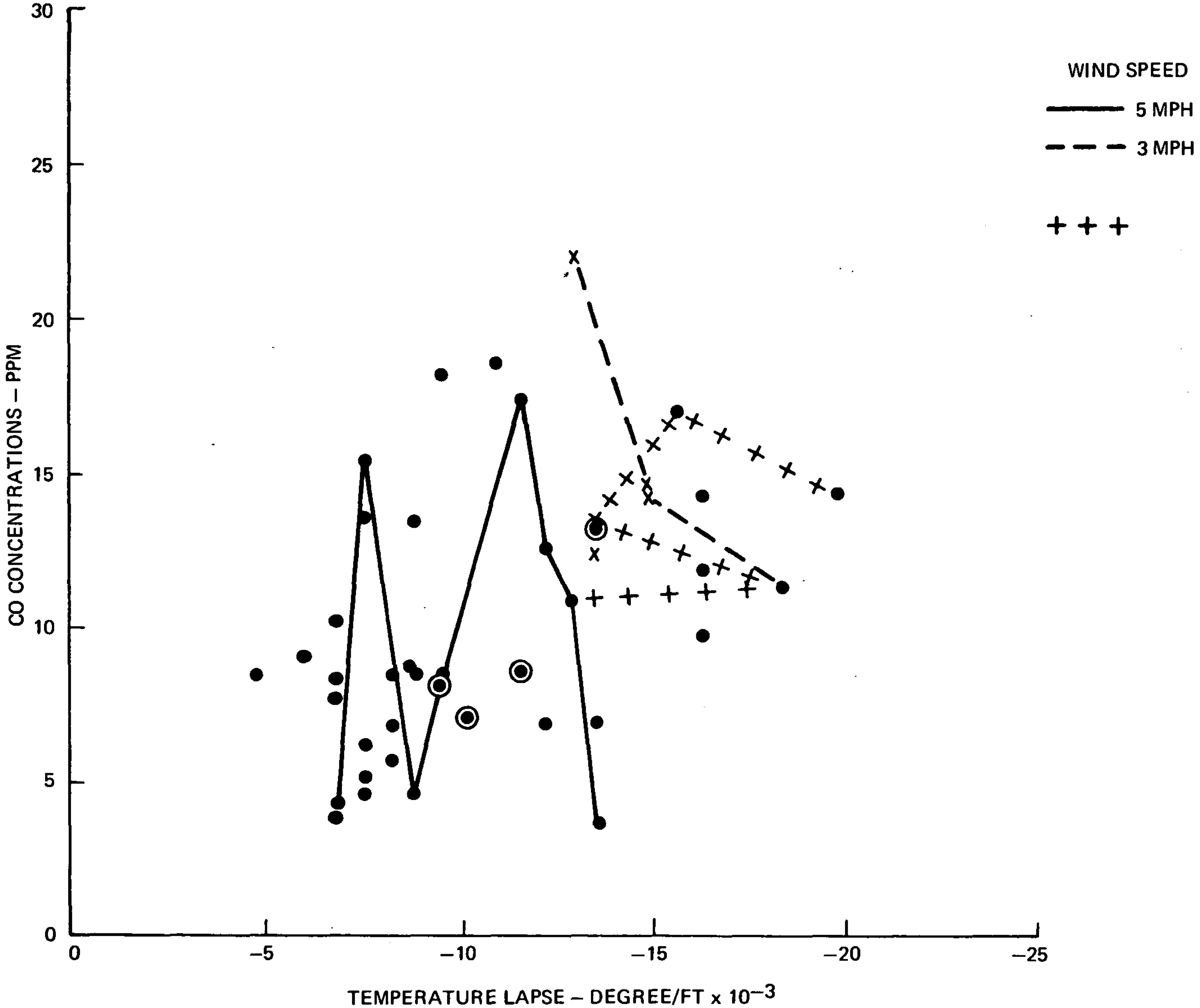


Figure 5.1.1-36. CO Concentration Indoors 3rd Floor Vs. Temperature Lapse – 6 PM – Weekdays – Site 1

when temperature lapse was a maximum of -19.7 degrees. However, the 28.1 ppm CO level was recorded when the temperature lapse was only -12.9 degrees. Minimum concentrations of 1.7 ppm outdoors and 3.7 ppm indoors occurred for easterly road wind conditions when the respective temperature lapses were -10.2 and -13.6 degrees.

Examination of the data tabulated below for 3rd floor CO concentrations for the five instances when temperature lapse readings of -7.5 and 13.6 degrees were measured will show that wind azimuth angle, not temperature lapse, is the dominant meteorological factor.

Temperature Lapse = 7.5				Temperature Lapse = 13.6			
CO		Azimuth		CO		Azimuth	
Out	In	Road	Roof	Out	In	Road	Roof
3.7	5.1	32	10	6.5	3.7	109	79
4.6	4.4	60	18	7.1	7.0	99	72
9.2	6.2	44	-	15.7	13.6	305	98
12.3	15.4	223	43	15.9	12.4	178	167
15.5	13.6	134	-	18.8	13.3	-	44

Both sets of data show a wide variation in CO level. Within each set, CO levels are low for easterly winds at both road and roof elevations. High CO levels occur for other road wind azimuth angles. This effect is graphically displayed on Figures 5.1.1-35 and -36 by the cross hatched lines which show CO/temperature lapse relationship for the wind azimuth angles listed below.

Wind Azimuth		Temp. Lapse	CO	
Road	Roof		Out	In
331	81	12.9	12.5	10.8
343	96	18.3	13.8	11.4
305	98	13.6	15.7	13.6
289	98	15.6	23.2	17.0
183	112	19.7	27.3	14.4

It will be noticed that when the roof wind angle is essentially constant (98°), CO outdoors at the 3rd floor increases as the road wind shifts from the northwest to the south. The change is independent of temperature lapse.

The largest variation in 3rd floor CO levels occur for road azimuth angles between 200 and 240° see Figures 5.1.1-29 and -30. As will be shown later, this wide CO range is caused by the roof wind azimuth angle. Roof winds from the same general southwesterly angle increase 3rd floor CO while opposing roof winds significantly decreased 3rd floor concentrations. Thus, CO at the 3rd floor outdoor location is established by the traffic flow rate on the Trans Manhattan Expressway and both road and roof wind azimuth angle.

CO at the 3rd floor indoor location is established by the 3rd floor outdoor concentration and road level wind azimuth. As shown on Figure 5.1.1-37, the concentration indoors at the 3rd floor is generally linear with 3rd floor outdoor CO. Deviations from the linear relationship are caused by variations in road azimuth, as indicated by the constant wind azimuth lines. See Table 5.1.1-6 for data. Road winds from 215° produce higher concentrations indoors than road winds from 340°. The range of CO levels both indoors and outdoors is small for road winds of 340° even though the roof wind swings from 212° to 96°. However, a large variation in CO is seen outdoors as roof winds vary from 41° to 192° when the road wind is from 215°. The large change in indoor concentrations for these road winds is caused by the large change outdoors.

The outdoor/indoor differential at the 3rd floor also is a function of outside CO level and road wind azimuth angle. Figure 5.1.1-38 presents the data. A comparison of this figure with Figure 5.1.1-37 will show that the variations in O/I differential are due to the changes in indoor CO level.

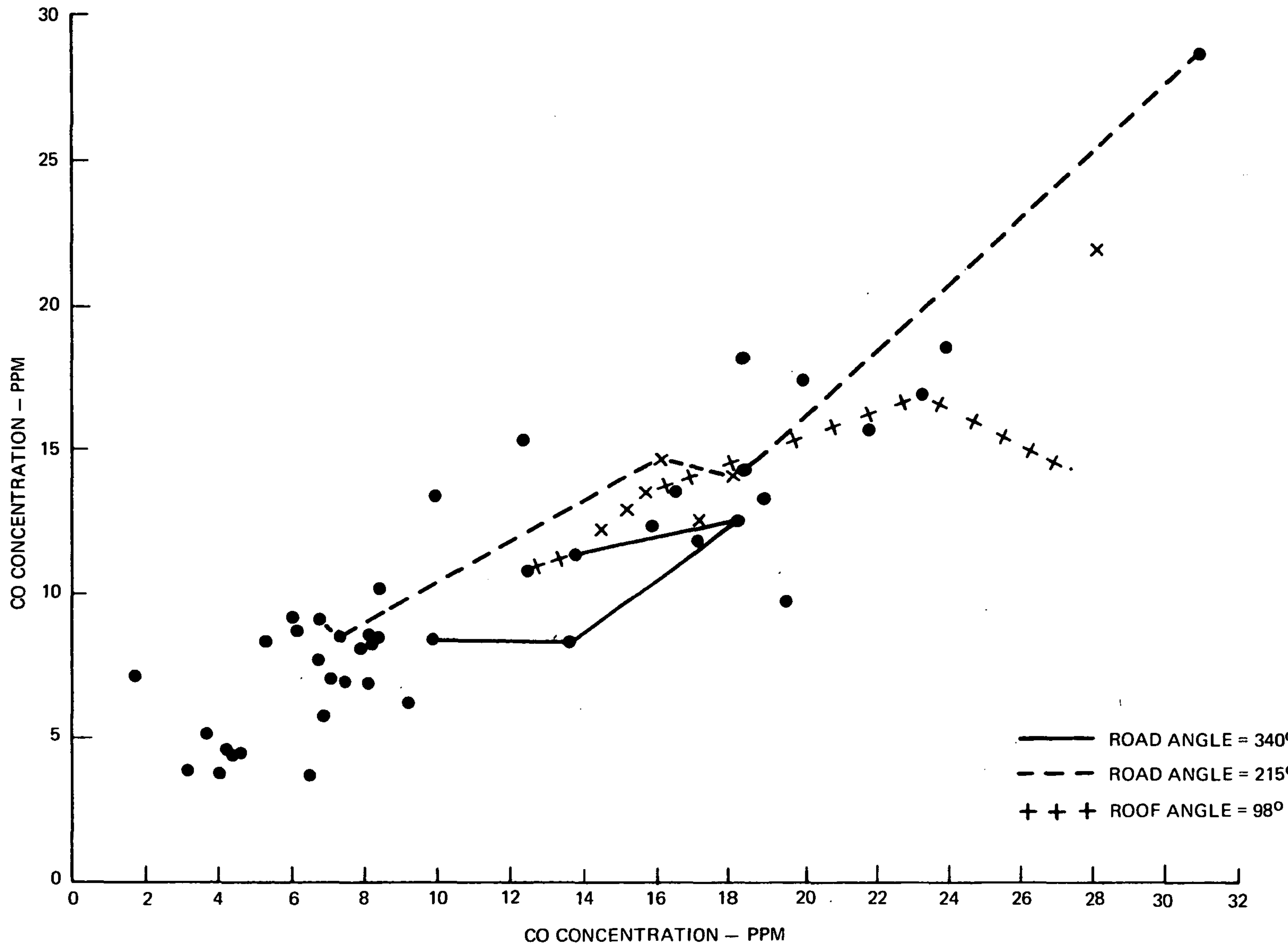


Figure 5.1.1-37. CO Concentration – 3rd Floor Indoor Vs. Outdoor – 6 PM – Weekdays – Site 1

TABLE 5.1.1-6

CONSTANT WIND AZIMUTH DATA - SITE 1

Road Angle	183	289	305	331	343	340	338	344	214	210	225	208	218
Roof Angle	112	98	98	81	96	332	278	212	41	20	171	175	192
CO-3rdO	27.3	23.2	15.7	12.5	13.8	9.9	13.6	18.2	6.8	7.3	16.1	18.1	30.9
" -3rdI	14.4	17.0	13.6	10.8	11.4	8.4	8.3	12.6	9.1	8.5	14.7	14.2	28.7
" -23dO	20.7	10.0	12.3	10.7	10.9	.1	6.3	16.4	4.0	2.1	11.8	12.8	19.6
" -23dI	9.7	8.1	8.3	8.5	8.9	.1	3.8	10.4	4.7	2.5	9.8	8.1	11.6
" -32ndO	13.9	9.4	11.4	11.8	10.6	5.7	7.6	10.9	2.9	2.9	10.7	11.7	18.2
" -32ndI	7.7	12.5	8.6	13.6	11.9	17.2	5.4	10.8	9.3	6.9	9.2	9.8	13.4
▽CO-3-23O	6.6	13.2	3.4	1.8	2.9	9.8	7.3	1.8	2.8	5.2	4.3	5.3	11.3
" -3-23I	4.7	8.9	5.3	2.3	2.5	8.3	4.5	2.2	4.4	6.0	4.9	6.1	17.1
" -3-32O	13.4	13.8	4.3	.7	3.2	4.2	6.0	7.3	3.9	4.4	5.4	6.4	12.7
" -3-32I	6.7	4.5	5.0	-2.8	-.5	-8.8	2.9	1.8	-.2	1.6	5.5	4.4	15.3
" -23-32O	6.8	.6	.9	-1.1	.3	-5.6	-1.3	5.5	1.1	-.8	1.1	1.1	1.4
" -23-32I	2.0	-4.4	-.3	-5.1	-3.0	-17.1	-1.6	-.4	-4.6	-4.4	.6	-1.7	-1.8
△O/I-3	12.9	6.2	2.1	1.7	2.4	1.5	5.3	5.6	-2.3	-.8	1.4	3.9	2.2
" -23	11.0	1.9	4.0	2.2	2.0	0	2.5	6.0	-.7	-.4	2.0	4.7	8.0
" -32	6.2	-3.1	2.8	-1.8	-1.3	-11.5	2.2	.1	-6.4	-4.0	1.5	1.9	4.8
△CO-30-23I	17.6	15.1	7.4	4.0	4.9	9.8	9.8	7.8	2.1	4.8	6.3	10.0	19.3
" -30-32I	19.6	10.7	7.1	-1.1	1.9	-7.3	8.2	7.4	-2.5	.4	6.9	8.3	17.5

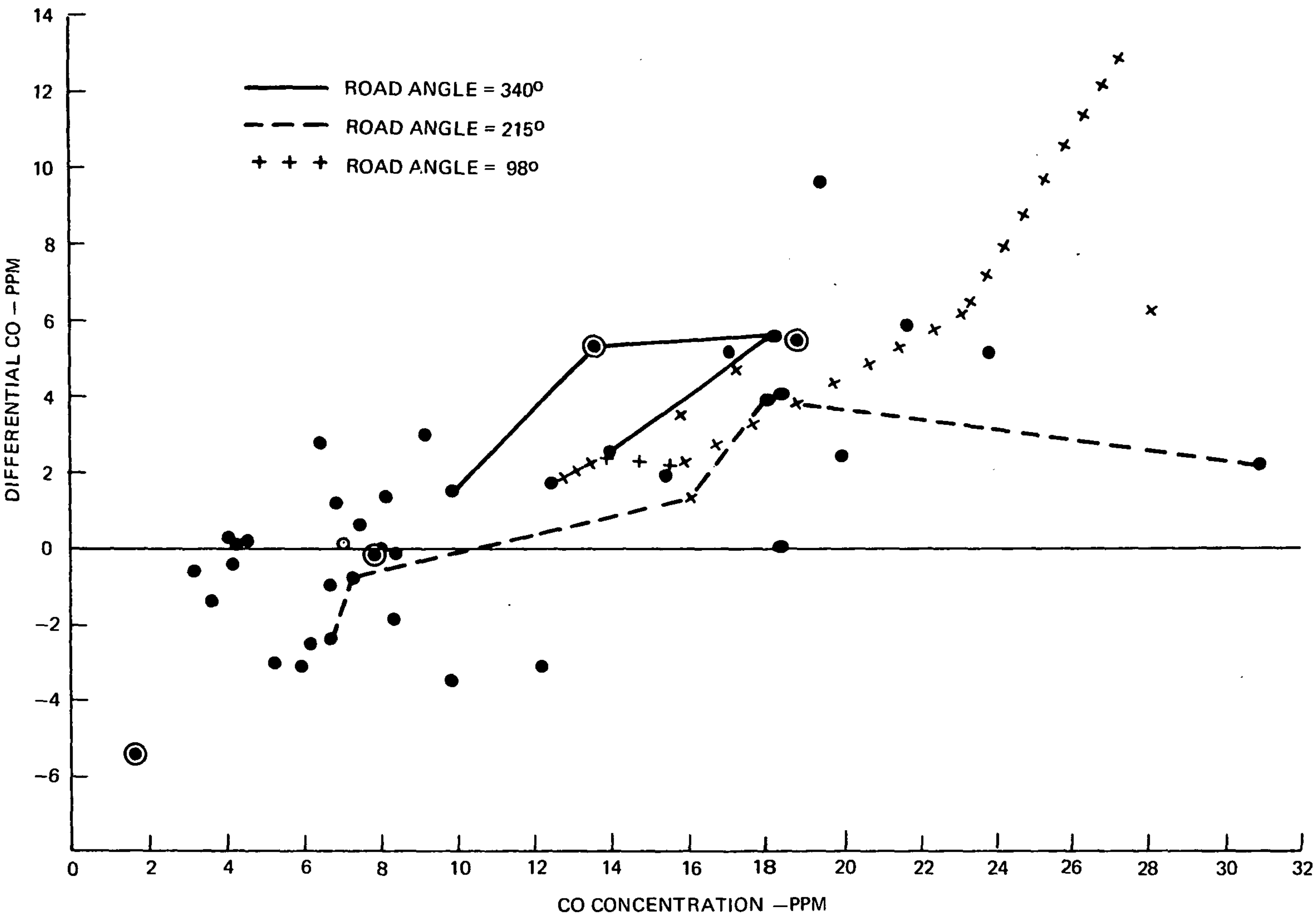


Figure 5.1.1-38. Differential CO Outdoor/Indoor – 3rd Floor Vs. 3rd Floor CO Concentration – 6 PM – Weekday – Site 1

Higher differentials occur for road winds from 340° than for winds from 215°. Outdoor CO levels always are higher than indoor levels when the outdoor concentration is 13 ppm or greater. When the outdoor level is less than 13 ppm, the O/I differential varies, positive or negative, according to the nearness of the roof wind to 60°, as can be seen from the constant 215° road wind data on Figure 5.1.1-39. As can be seen from Figures 5.1.1-40 thru -42, the other road level meteorological conditions do not significantly influence 3rd floor outdoor/indoor differential.

5.1.1.3.4 23rd Floor Concentrations

Twenty-third floor concentrations during the 5-6 PM period always were lower than 3rd floor concentrations at both indoor and outdoor locations for both the heating and non-heating seasons. At the 23rd floor, non-heating season indoor CO levels were consistently lower than outdoor concentrations. While heating season CO levels frequently were higher indoors than outdoors, the average level indoors during the 5-6 PM period was lower than outdoors. As a result, both indoor and outdoor locations showed a reduction in average CO level from the 3rd to 23rd floor locations during this period.

As pointed out on page 5-29, the 23rd floor outdoor concentration peaked during the 5-6 PM period in the same fashion as the concentrations at the roadway and 3rd floor locations. The outdoor CO level at the 23rd floor is basically determined by the 3rd floor outdoor concentration. Figure 5.1.1-43 shows that the 23rd and 3rd floor outdoor concentrations are linearly related. High 3rd floor concentrations produced high 23rd floor concentrations and vice versa.

The relationship of the CO level at the two outdoor locations again is modified by the wind azimuth angles at both the road and roof elevations. This can be seen by examination of constant wind azimuth conditions plotted on

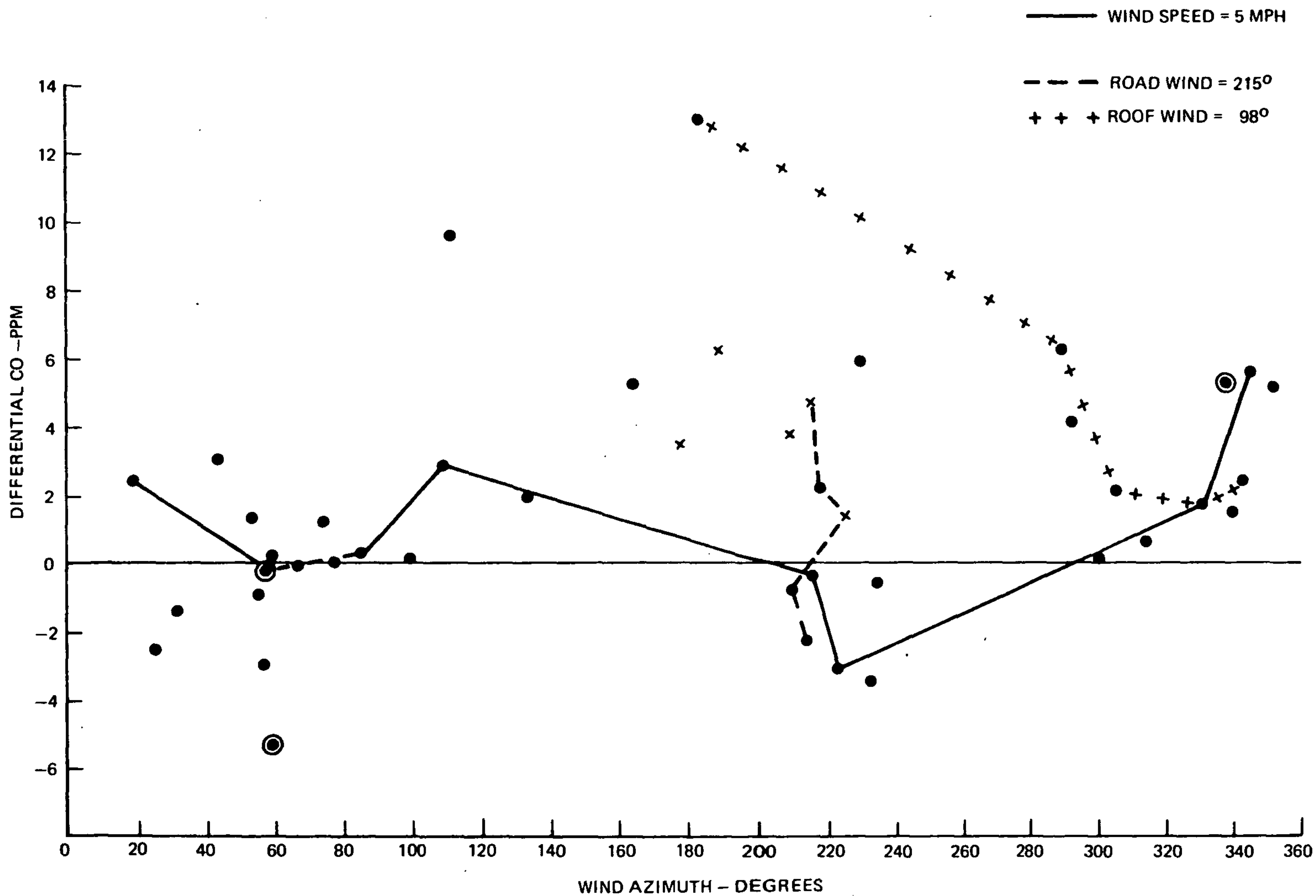


Figure 5.1.1-39. Differential CO Outdoor/Indoor – 3rd Floor Vs. Road Level Wind Azimuth – 6 PM – Weekdays – Site 1

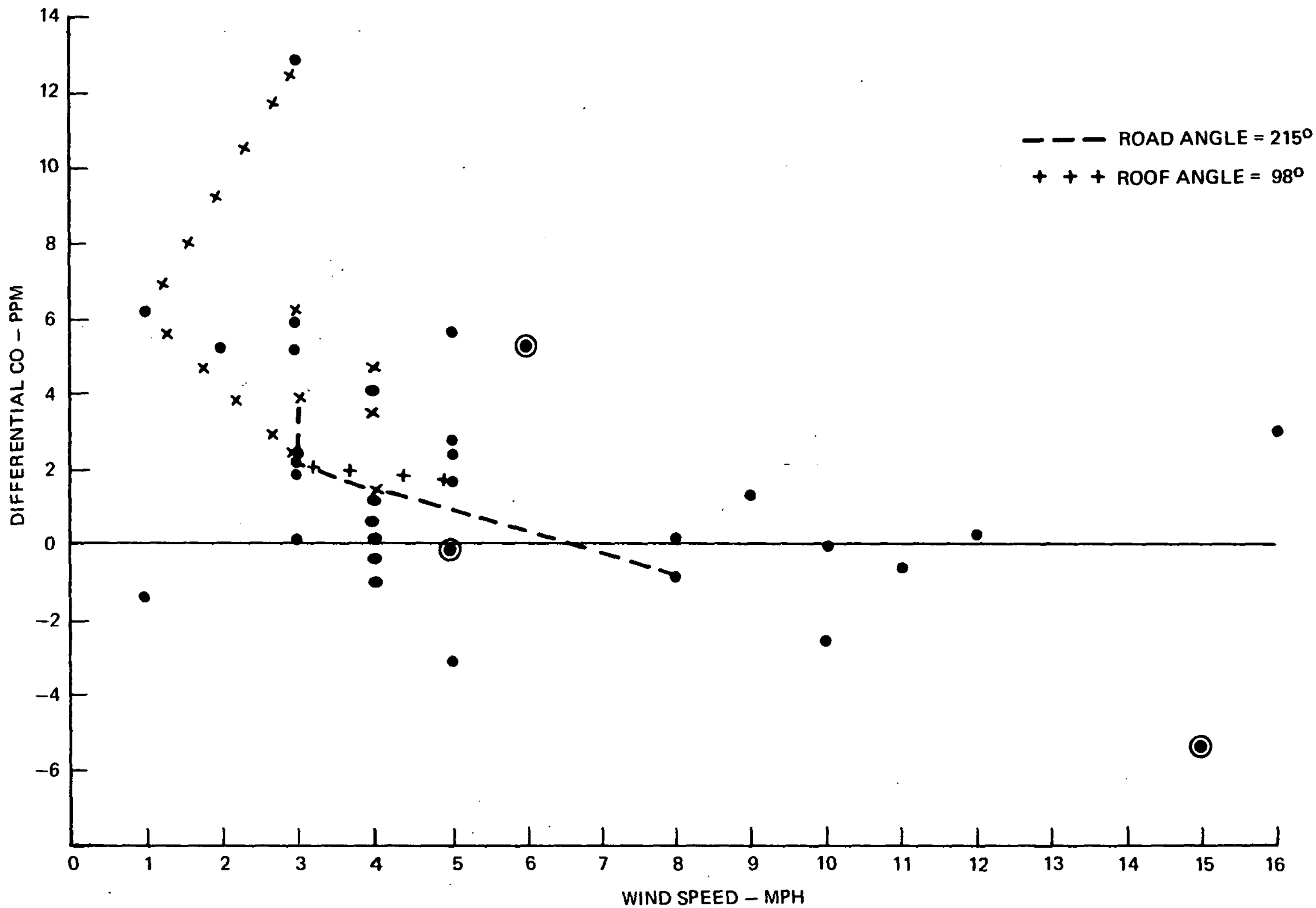


Figure 5.1.1-40. Differential CO – Outdoor/Indoor 3rd Floor Vs. Road Level Wind Speed – 6 PM – Weekdays – Site 1

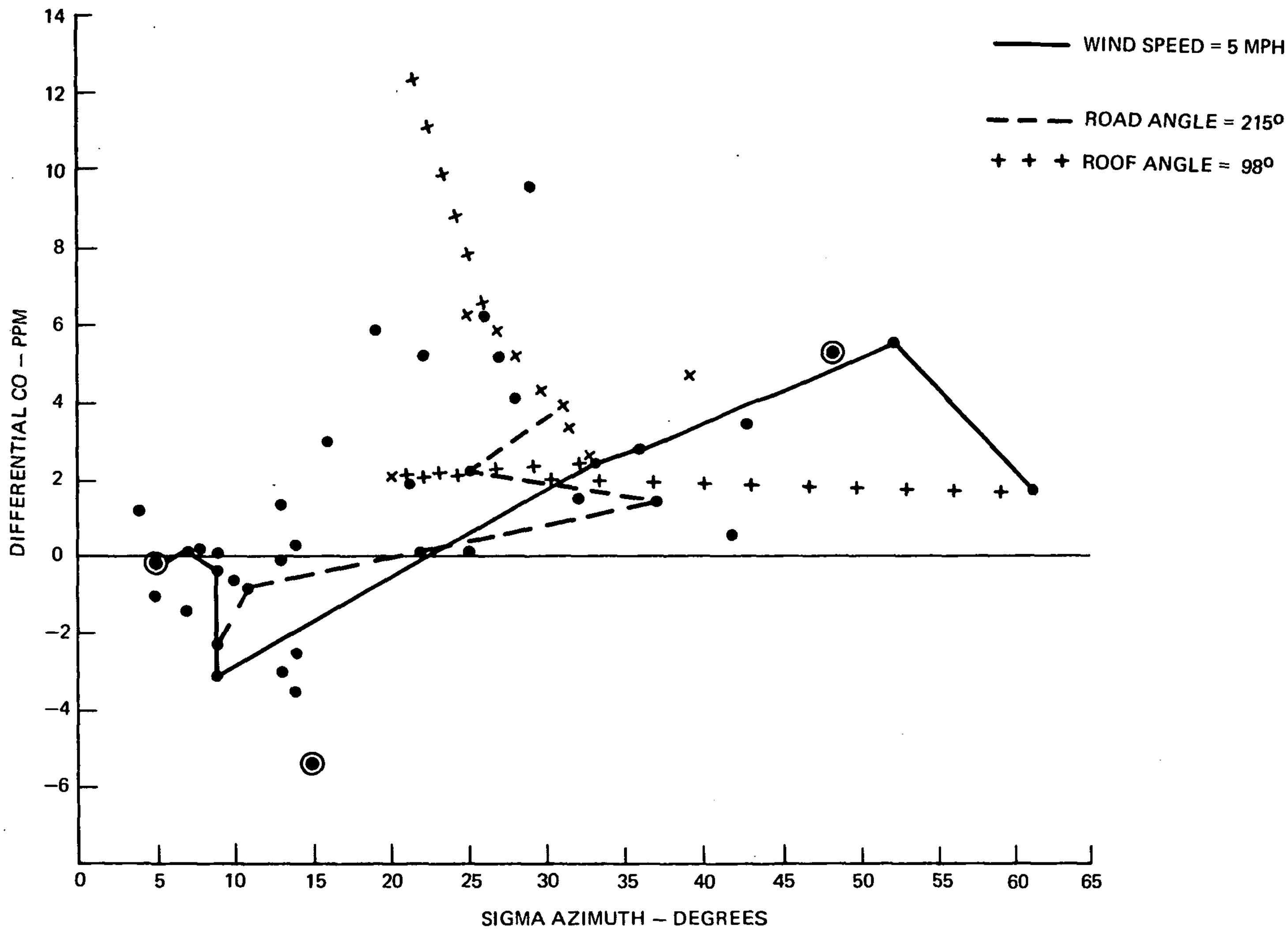


Figure 5.1.1-41. Differential CO – Outdoor/Indoor – 3rd Floor Vs. Road Level Sigma Azimuth – 6 PM – Weekdays – Site 1

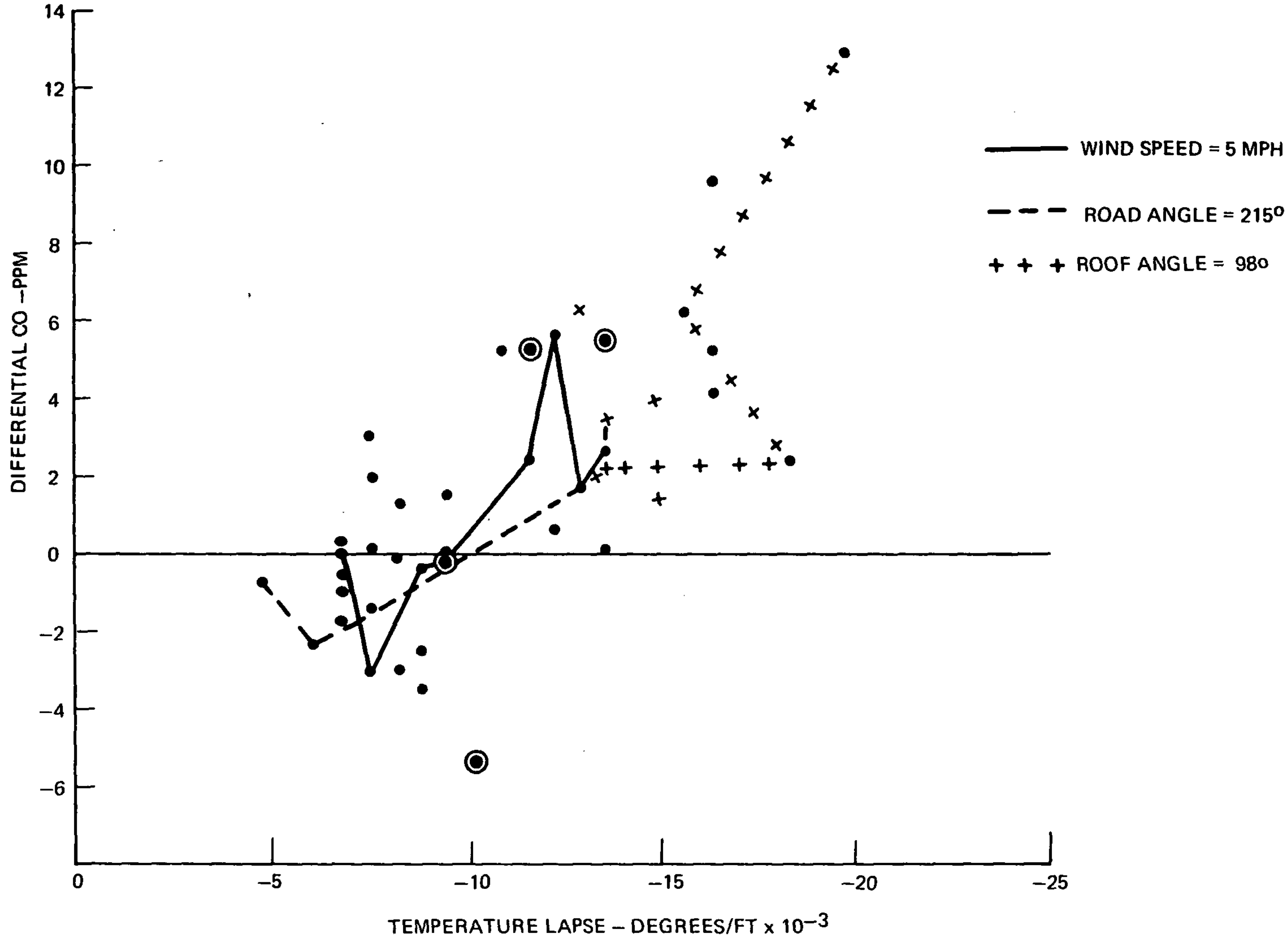


Figure 5.1.1-42. Differential CO Outdoor/Indoor – 3rd Floor Vs. Temperature Lapse – 6 PM – Weekdays – Site 1

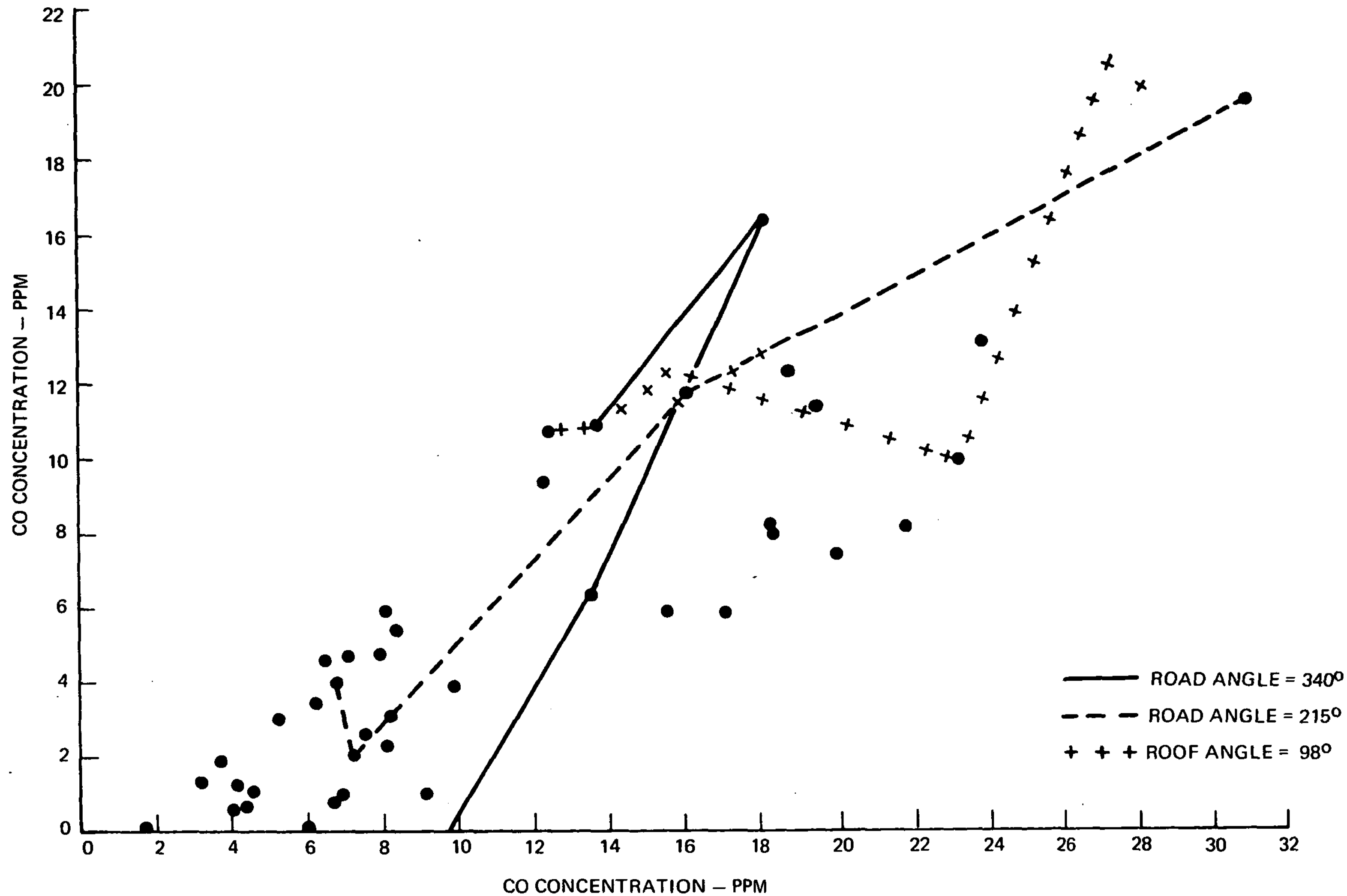


Figure 5.1.1-43. CO Concentration 23rd Floor Outdoors Vs. CO Concentration 3rd Floor Outdoors – 6 PM – Weekdays – Site 1

Figure 5.1.1-44 and previously presented on Table 5.1.1-6. It will be noticed that when the road wind blows parallel to the face of the building from 215°, the CO level outdoors at the 23rd floor varies in the same manner as CO at the 3rd floor location. As the opposing roof wind shifts from parallel to the building face at 20°, to "behind" the building, at 41°, 23rd floor concentration increases. When the roof wind moves from "behind" the building at 171° to 192° the 23rd floor concentration also sharply increases.

The roof wind angle also appears significant when the road wind is from 340°. The 23rd outdoor CO level rises sharply as the roof wind shifts from the same angle (332°) to 278 and 212°. Roof winds from 98°, behind the building, tend to oppose the road wind and reduce 23rd floor concentration. CO level is fairly high, however.

The effect of the relative wind positions is vividly seen by the constant 98° roof angle data. The 23rd floor outdoor CO is nearly a constant 11 ppm when the road wind is 315±30°. However, the maximum 23rd floor outdoor concentration of 20.7 ppm was recorded when the road wind flew from 183°.

The differential CO level, outdoors to indoors, at the 23rd floor again shows a basically linear relationship to the CO level outdoors at the 3rd floor, See Figure 5.1.1-45. The 23rd floor differential, however, is primarily related to the CO concentration at the 23rd floor outdoor location. As can be seen from Figure 5.1.1-46, road wind azimuth variations have far less effect on the O/I differential than noticed at the 3rd floor. Roof wind changes still influence the outdoor/indoor differential significantly as shown on Figure 5.1.1-47. It should be noted that 23rd floor concentrations indoors exceed outdoor CO level when roof winds are between 300° and 60°; i.e., blowing towards the 23rd floor room under study.

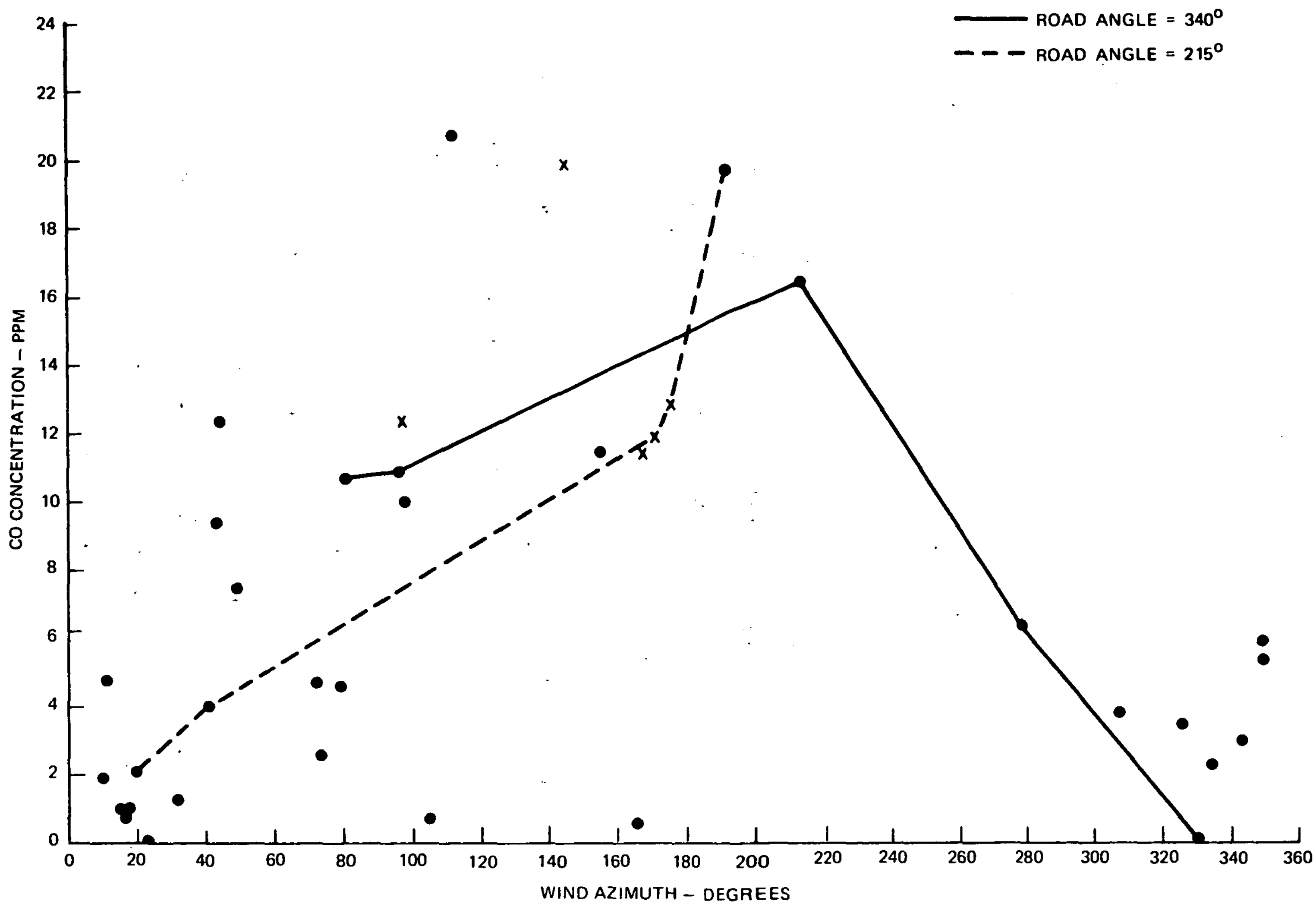


Figure 5.1.1-44. CO Concentration – Outdoors 23rd Floor Vs. Roof Level Wind Azimuth – 6 PM – Weekdays – Site 1

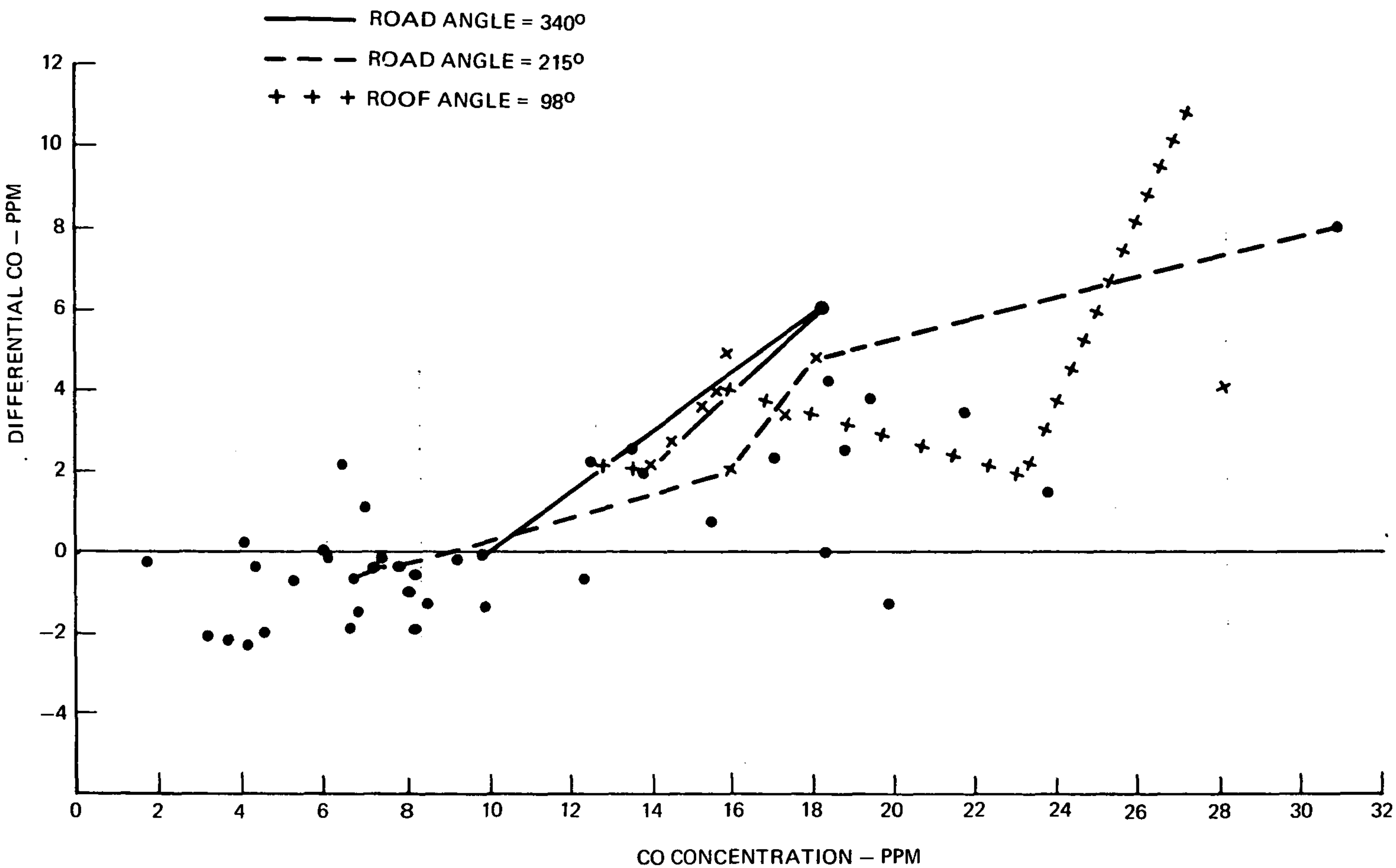


Figure 5.1.1-45. Differential CO Outdoor/Indoor – 23rd Floor Vs. 3rd Floor CO Concentration Outdoors – 6 PM – Weekdays – Site 1

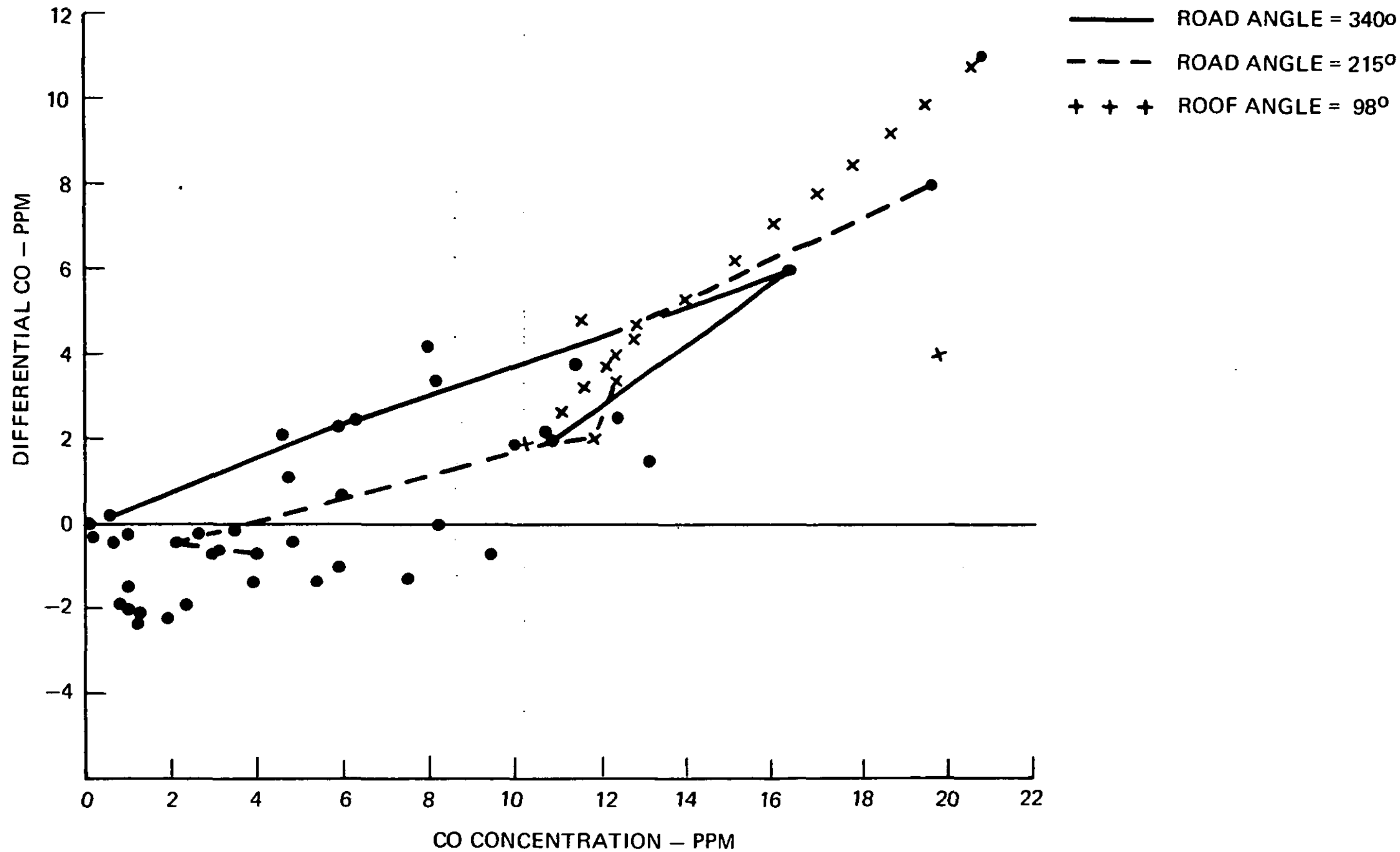


Figure 5.1.1-46. Differential CO – Outdoor/Indoor 23rd Floor Vs. 23rd Floor CO Concentration Outdoors – 6 PM – Weekdays – Site 1

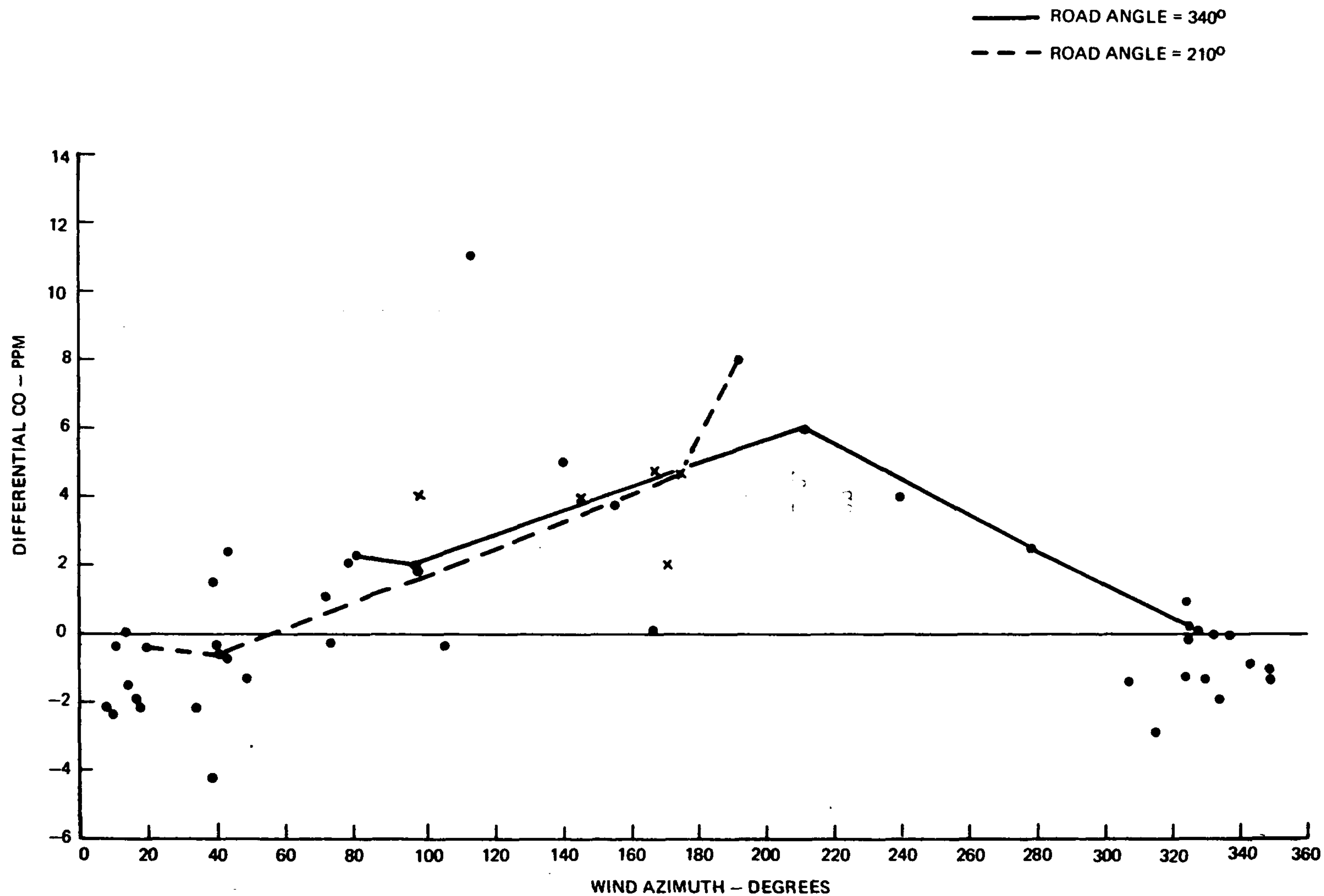


Figure 5.1.1-47. Differential CO – Outdoor/Indoor – 23rd Floor Vs. Roof Level Wind Azimuth – 6 PM – Weekdays – Site 1

Figures 5.1.1-48 and -49 show the change in CO levels between the 3rd and 23rd floor for both the outdoor and indoor locations as a function of the 3rd floor outdoor concentration. Both locations demonstrate the same behavior. The differentials are low (negative) when the 3rd floor CO level is low, and high when high concentrations exist at the 3rd floor. This suggests that both locations respond to the same variables. The 3rd to 23rd floor differential is always greater indoors than outdoors for road winds from 210°. The magnitude of the outdoor and indoor differentials is significantly different for the 210° road wind when the roof wind is from 192°. This shows that roof winds parallel to the building face strongly affect 23rd floor outdoor CO. Both indoor and outdoor locations show essentially a linear differential between the 3rd and 23rd floors for an increasing concentration outdoors at the 3rd floor when the roof wind is from 98° for road winds from the northwest. However, the differentials are significantly reduced for the road wind of 183°. Therefore 23rd floor concentrations, both indoors and outdoors, are proportionately higher for southerly road winds than for northerly road winds.

The change in CO level indoors from the 3rd to 23rd floors is, in reality, primarily influenced by the 3rd floor indoor concentration. As shown on Figure 5.1.1-50, the relationship between the two indoor locations is more clearly linear than that indicated on Figure 5.1.1-49. It should be noticed that the indoor differential for the 98° roof wind condition is practically a straight line. The variations in differential CO indoors 3rd to 23rd floors shown on Figures 5.1.1-51 and -52 for this wind condition are, therefore, due to variations in 3rd floor indoor concentrations and not road

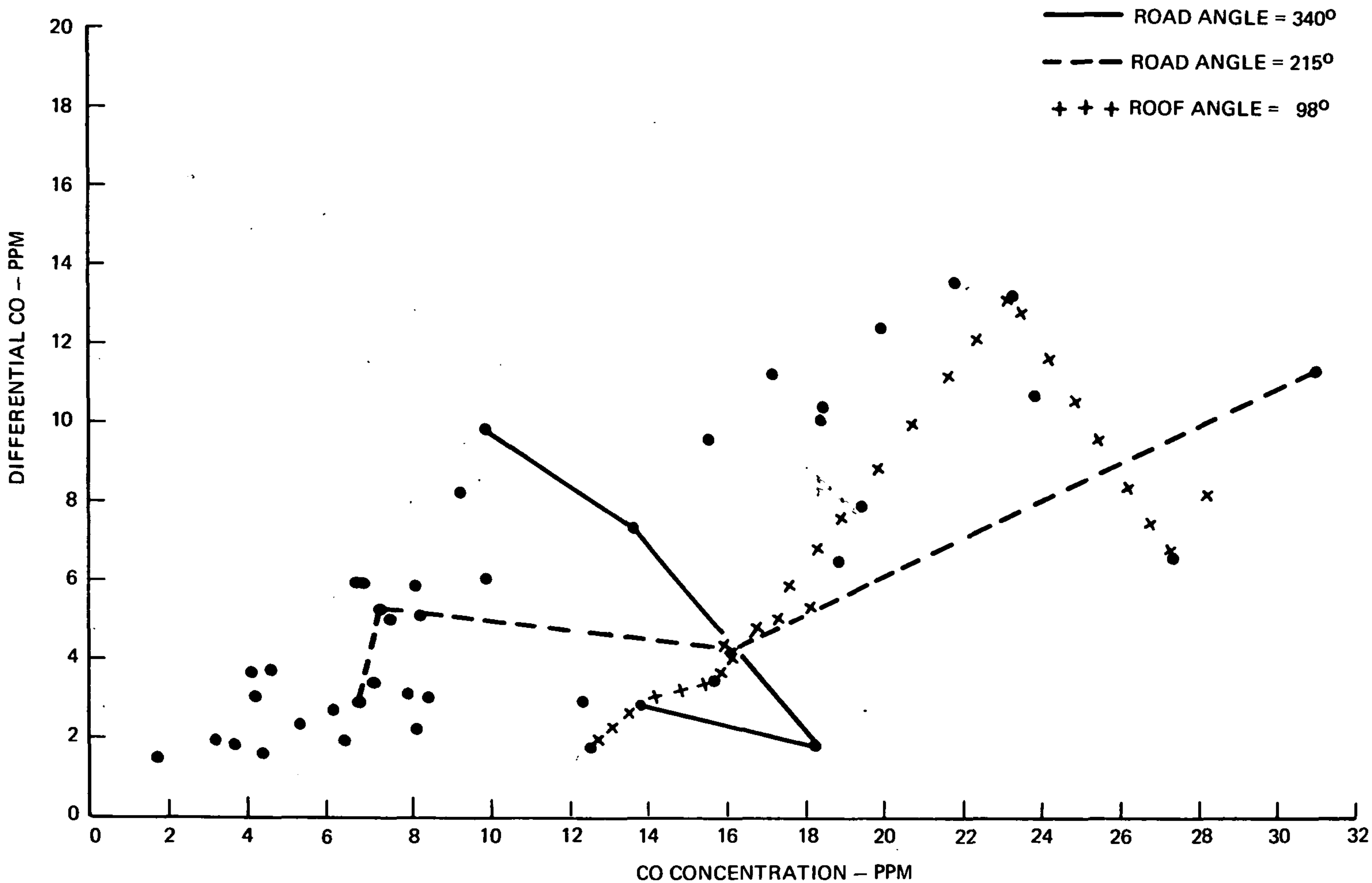


Figure 5.1.1-48. Differential CO Outdoor – 3rd To 23rd Floor Vs. 3rd Floor CO Concentration Outdoors – 6 PM – Weekdays – Site 1

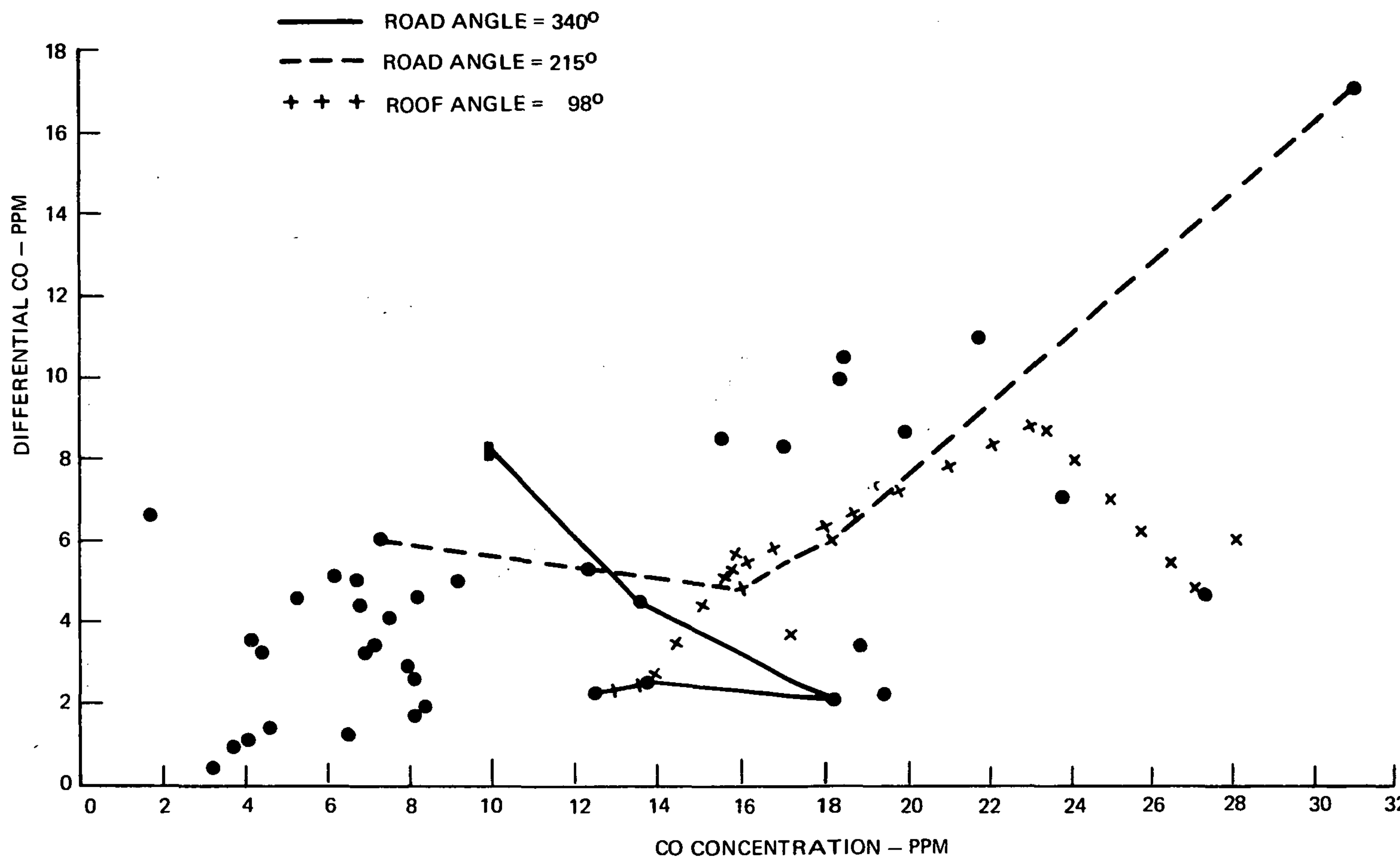


Figure 5.1.1-49. Differential CO – Indoors – 3rd To 23rd Floor Vs. 3rd Floor Concentration Outdoors – 6 PM – Weekdays – Site 1

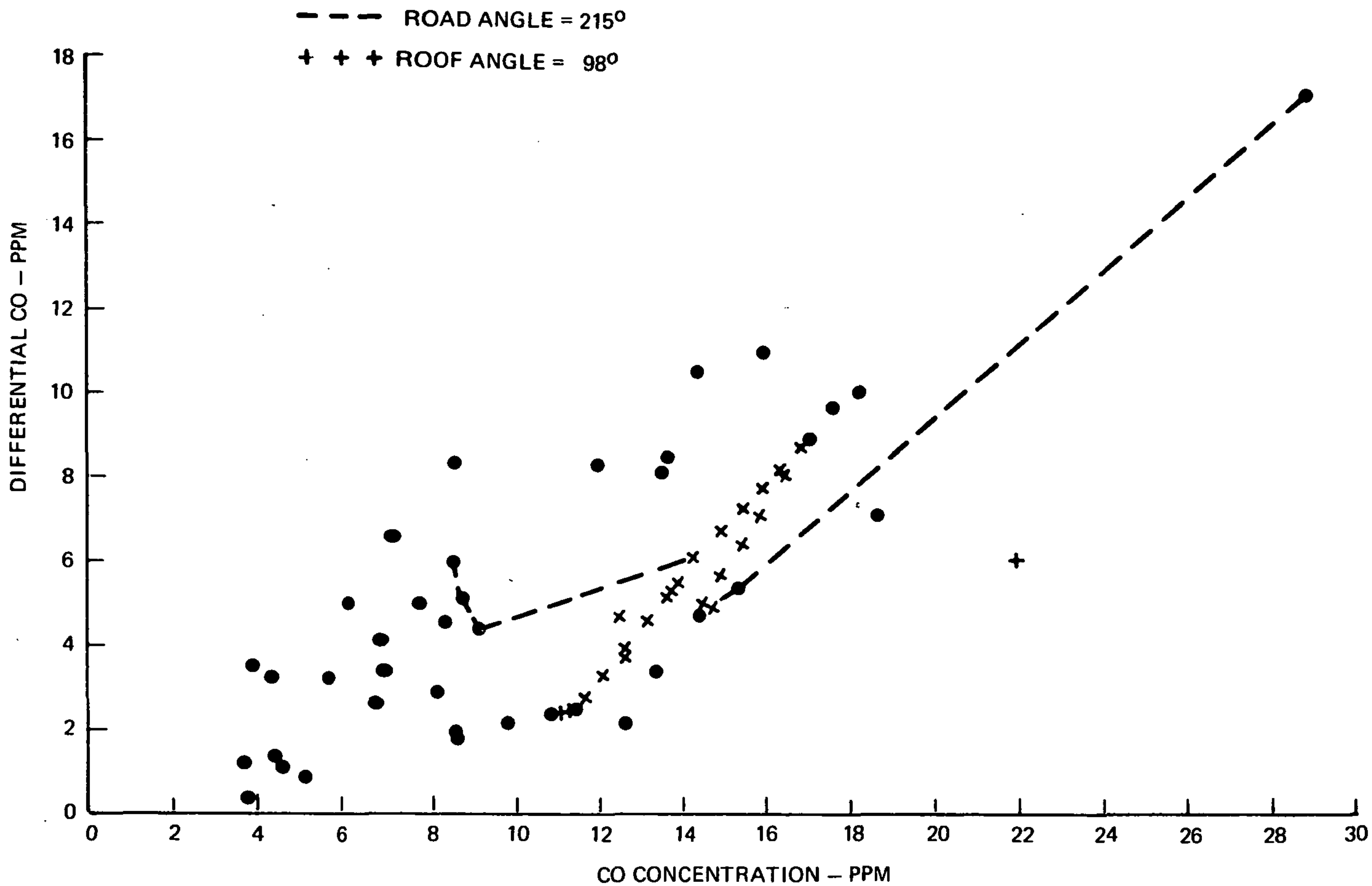


Figure 5.1.1-50. Differential CO Indoors – 3rd To 23rd Floor Vs. 3rd Floor Indoor CO Concentration – 6 PM – Weekdays – Site 1

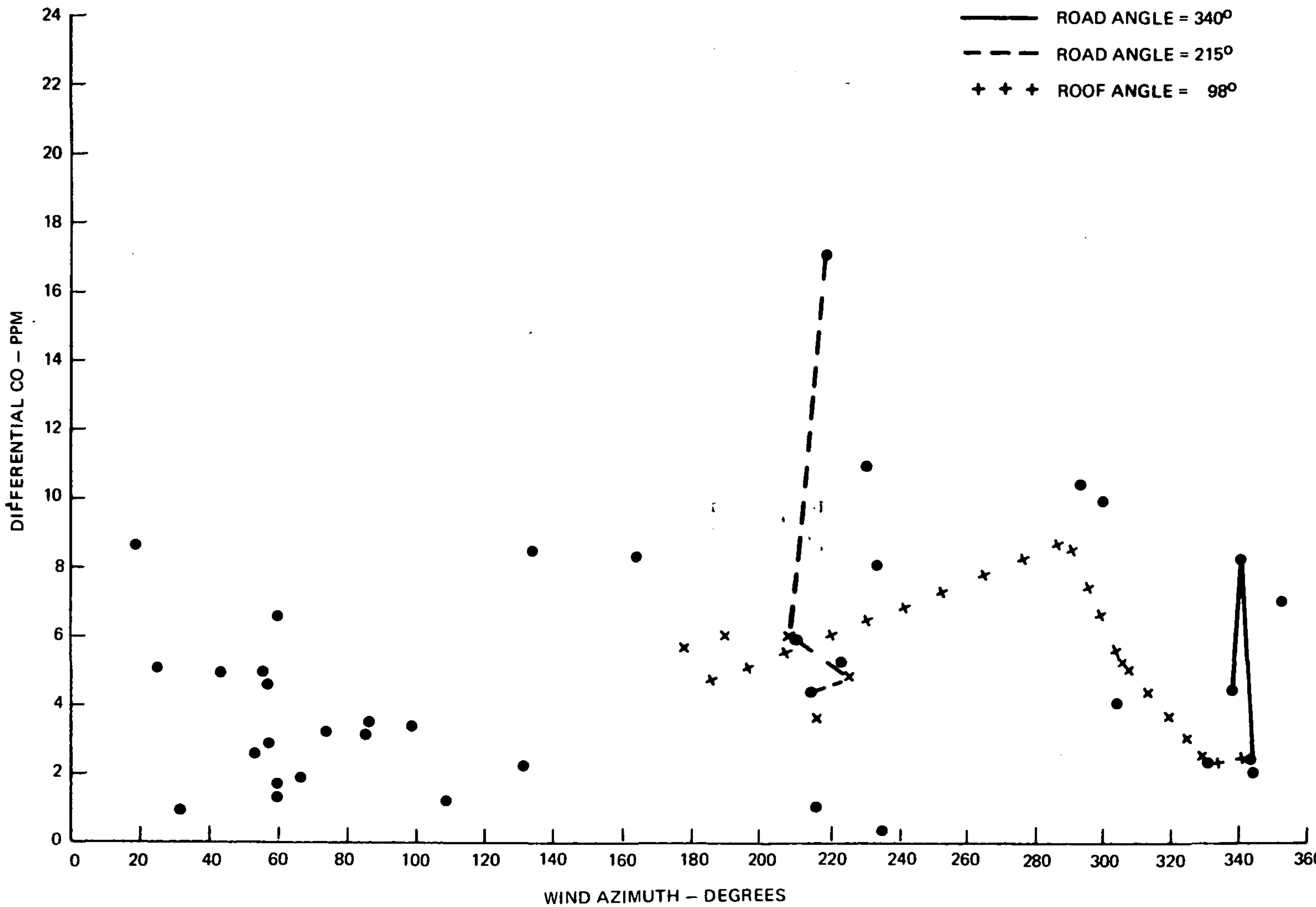


Figure 5.1.1-51. Differential CO Indoors – 3rd To 23rd Floor Vs. Road Level Wind Azimuth – 6 PM – Weekdays – Site 1

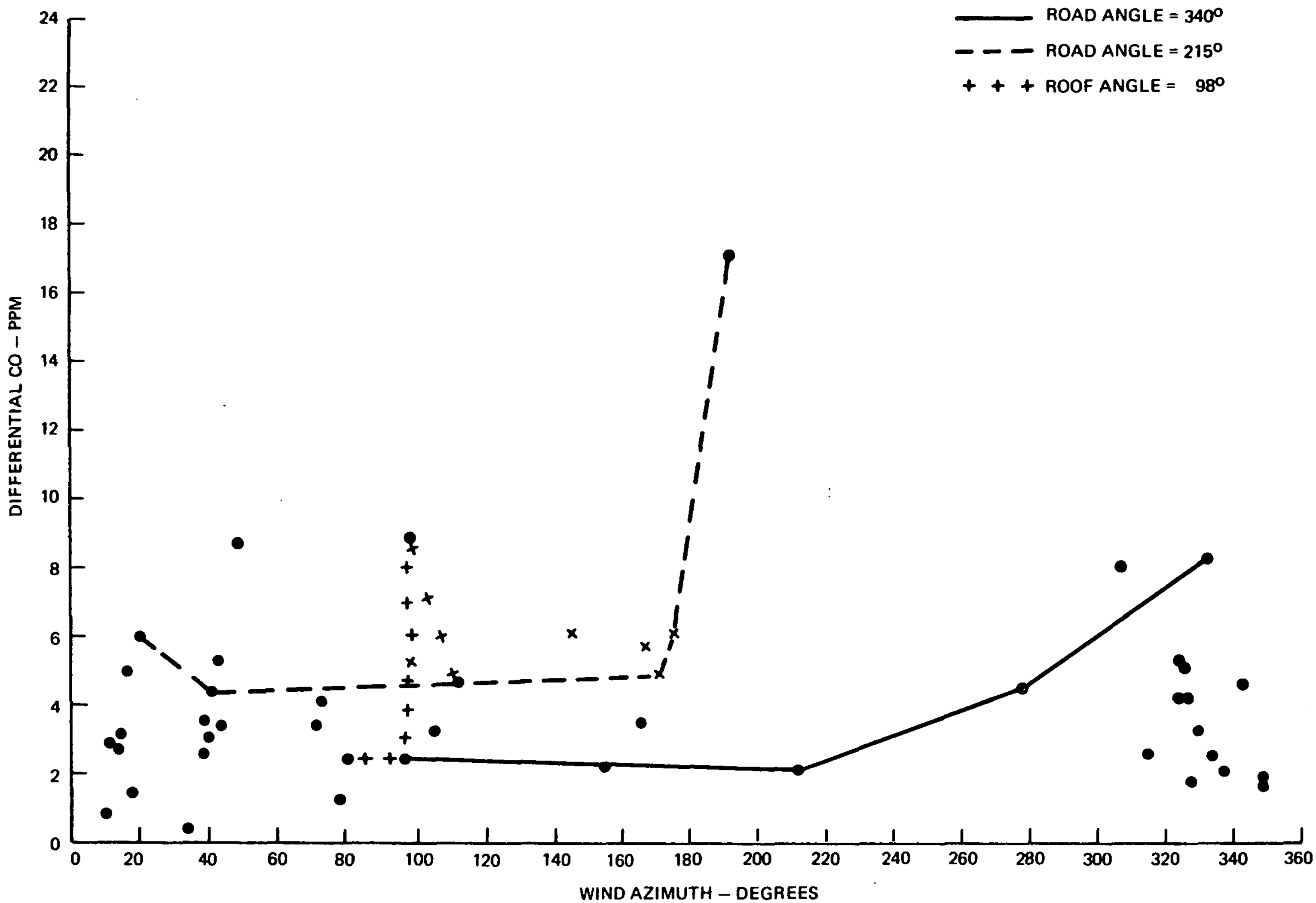


Figure 5.1.1-52. Differential CO – Indoor – 3rd to 23rd Floor Vs. Roof Level Wind Azimuth – 6 PM – Weekdays – Site 1

wind angle changes. The changes in indoor differential for constant road wind angle conditions are the result of both 3rd floor indoor CO levels and changes in roof wind conditions. This demonstrates that variations in road winds effect CO levels at the 3rd floor locations but do not directly influence concentrations at higher elevations.

5.1.1.3.5 32nd Floor Concentrations

Concentrations at the 32nd floor during the 5-6 PM period displayed a different pattern, with respect to lower floor concentrations, than were seen at the 23rd floor. Outdoor concentrations, with a single exception, were lower than 3rd floor outdoor levels. Similarly indoor concentrations generally were lower at the 32nd floor than seen at the 3rd floor. However, both outdoor and indoor CO levels were usually higher than comparable concentrations at the 23rd floor. It is significant to note that during the non-heating season, all 32nd floor outdoor concentrations and most indoor concentrations were lower than those measured at the same time at the 23rd floor. As a result, the non-heating season displayed a reduction in average CO level, both outdoors and indoors, with height for this 5-6 PM period. This decrease in average CO level also occurred outdoors during the heating season but did not at the indoor location.

The CO levels at the 32nd floor locations are related to the 3rd floor outdoor concentrations in a similar fashion as noted at the 3rd and 23rd floors. The 32nd floor outdoor/indoor differential relationship to 3rd floor outdoor CO, as seen in Figure 5.1.1-53, is somewhat lower however. This is caused primarily by the general reduction in CO at the upper floors.

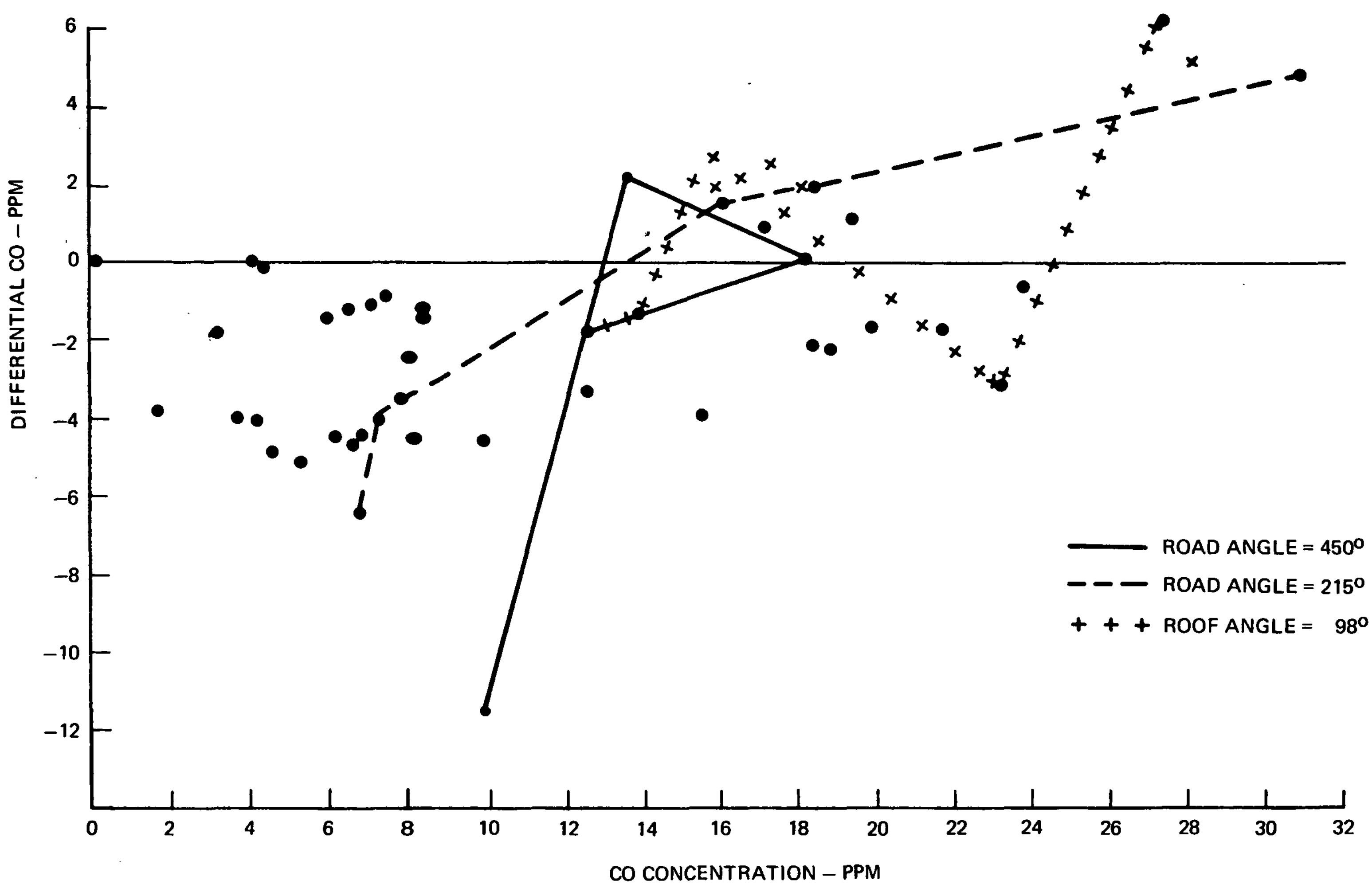


Figure 5.1.1-53. Differential CO – Outdoor/Indoor – 32nd Floor Vs. 3rd Floor CO Concentration Outdoors – 6 PM – Weekdays – Site 1

The 32nd floor O/I differential displays an even more linear relationship when compared to the 32nd floor outdoor concentration, see Figure 5.1.1-54.

A comparison of Figures 5.1.1-53 and -54 shows the marked reduction in 32nd floor outdoor concentration over that recorded at the 3rd floor. Thirty-second floor indoor concentrations typically are higher than 32nd floor outdoor concentrations, especially for low outdoor CO levels. It will be noticed from Figure 5.1.1-55, that the negative 32nd floor differentials always are associated with roof winds between 300° and 100°. Positive differentials occurred only when the roof wind blew from behind the building. The maximum differential was measured when the roof and road winds both blew from behind the building. The minimum occurred when the winds both blew towards the building from 340°. Thus it is seen that wind azimuth plus outdoor CO level control the differential concentration at the 32nd floor in the same manner as noted at the 23rd floor, previously shown on Figure 5.1.1-47.

Wind azimuth, however, produces a markedly different effect on the relative concentrations at various floors of the air-rights building. Figure 5.1.1-56 presents the 23rd - 32nd floor indoor CO differential plotted against roof wind azimuth. As shown by the constant road angle conditions, roof winds from behind the building reduce the CO level indoors at the 32nd floor, while roof winds blowing towards the building increase 32nd floor indoor concentration. This increase in CO level at the higher floor was not seen between the 3rd and 23rd floors, see Figure 5.1.1-52. The net result as shown on Figure 5.1.1-57 is for 32nd floor indoor CO to be higher than 23rd floor indoor CO the majority of the time. Thirty-second floor indoor CO is lower than 23rd floor CO only when one or both of the winds blow from behind the building.

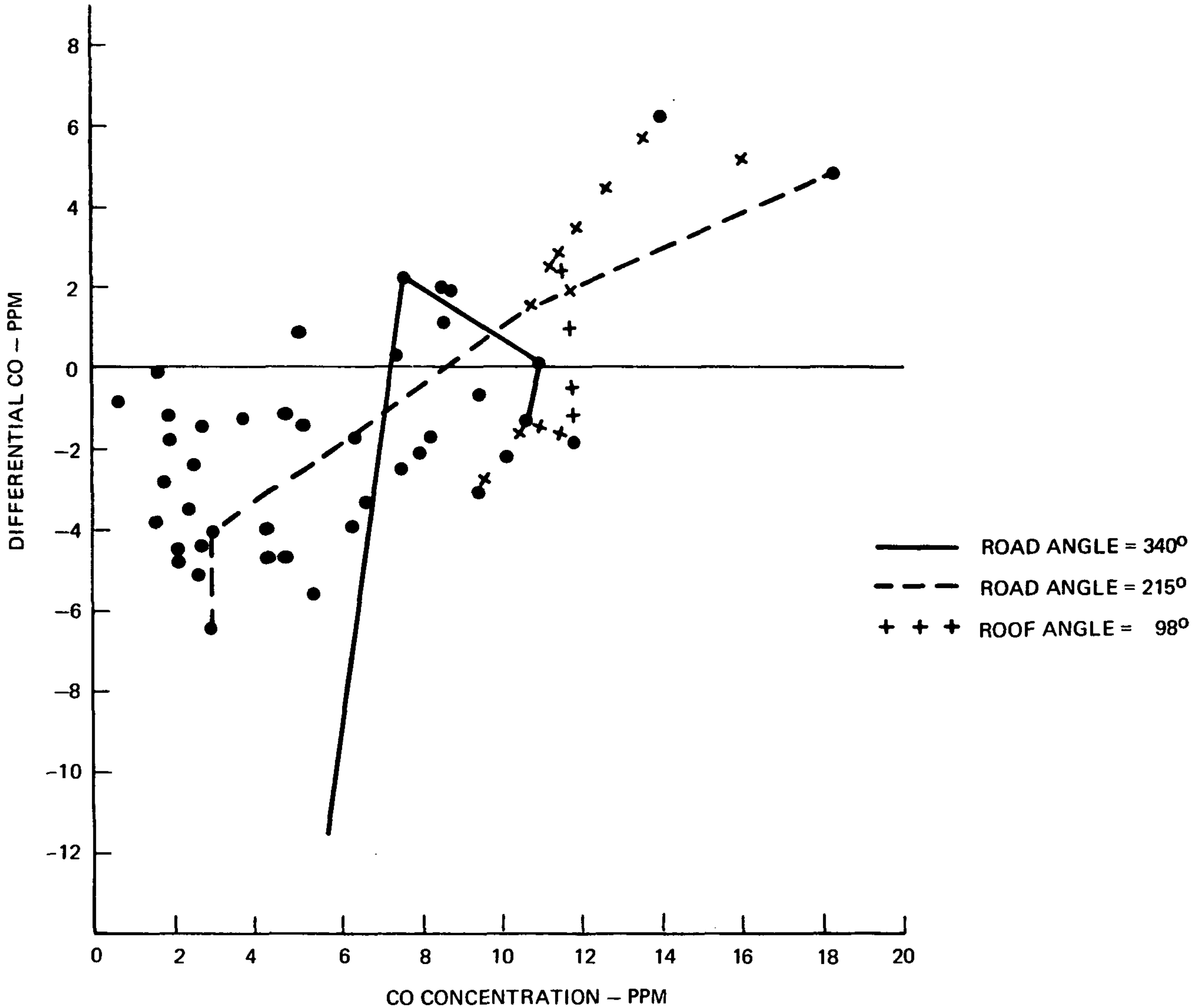


Figure 5.1.1-54. Differential CO – Outdoor/Indoor – 32 Floor Vs. 32 Floor Concentration Outdoors – 6 PM – Weekdays – Site 1

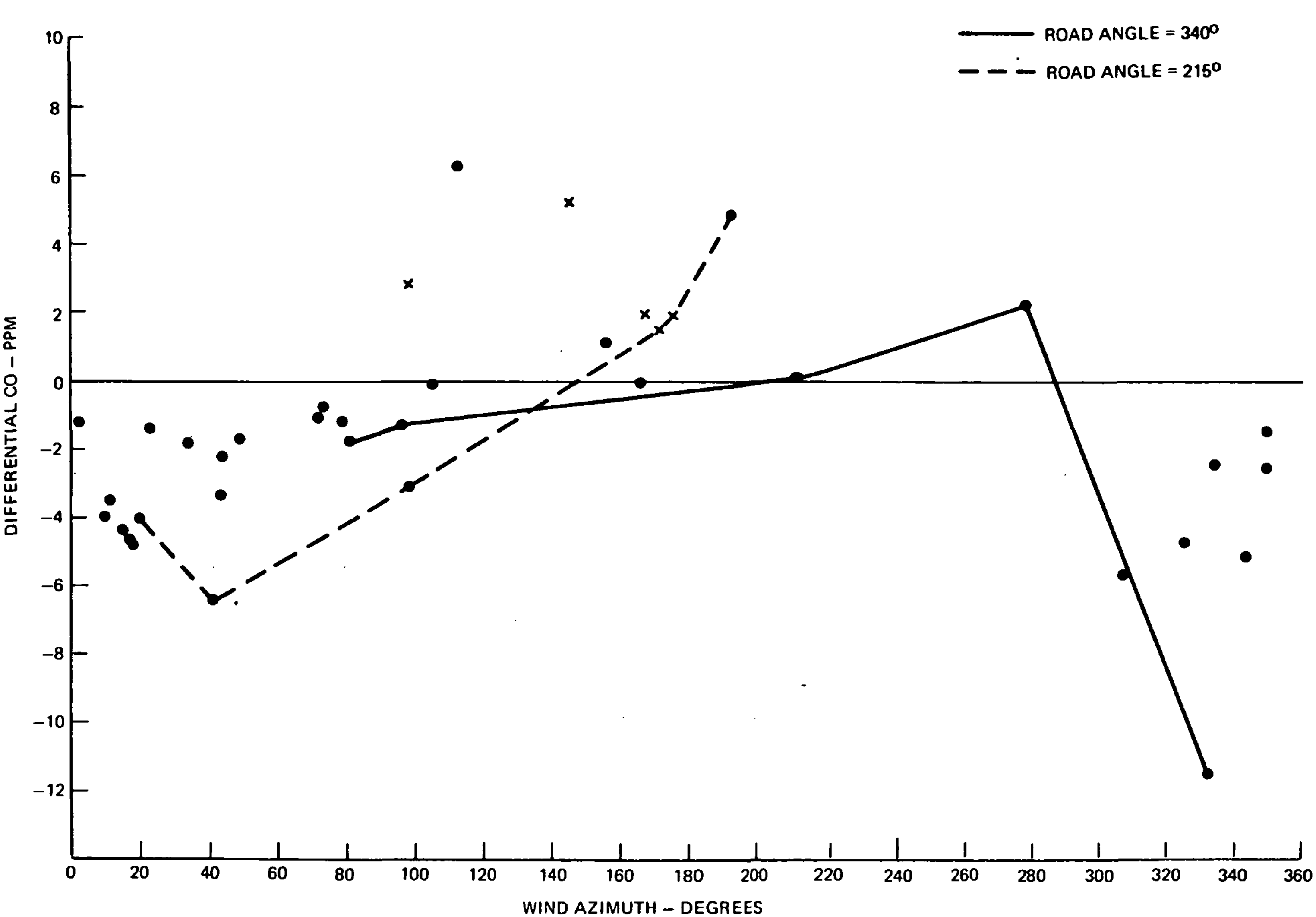


Figure 5.1.1-55. Differential CO – Outdoor/Indoor – 32nd Floor Vs. Roof Level Wind Azimuth – 6 PM – Weekdays – Site 1

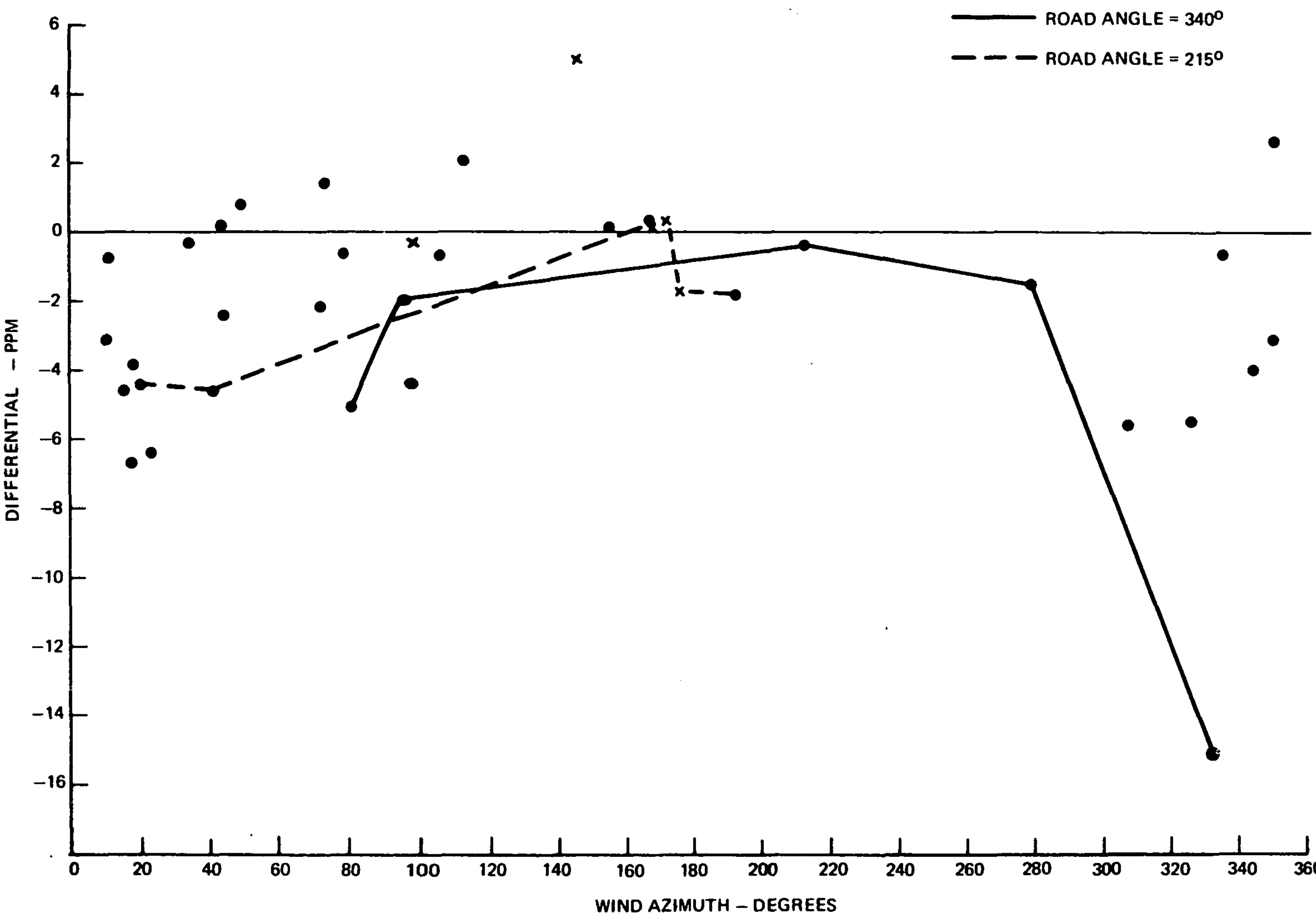


Figure 5.1.1-56. Differential CO – Indoors 23rd To 32nd Floors Vs. Roof Level Wind Azimuth – 6 PM – Weekdays – Site 1

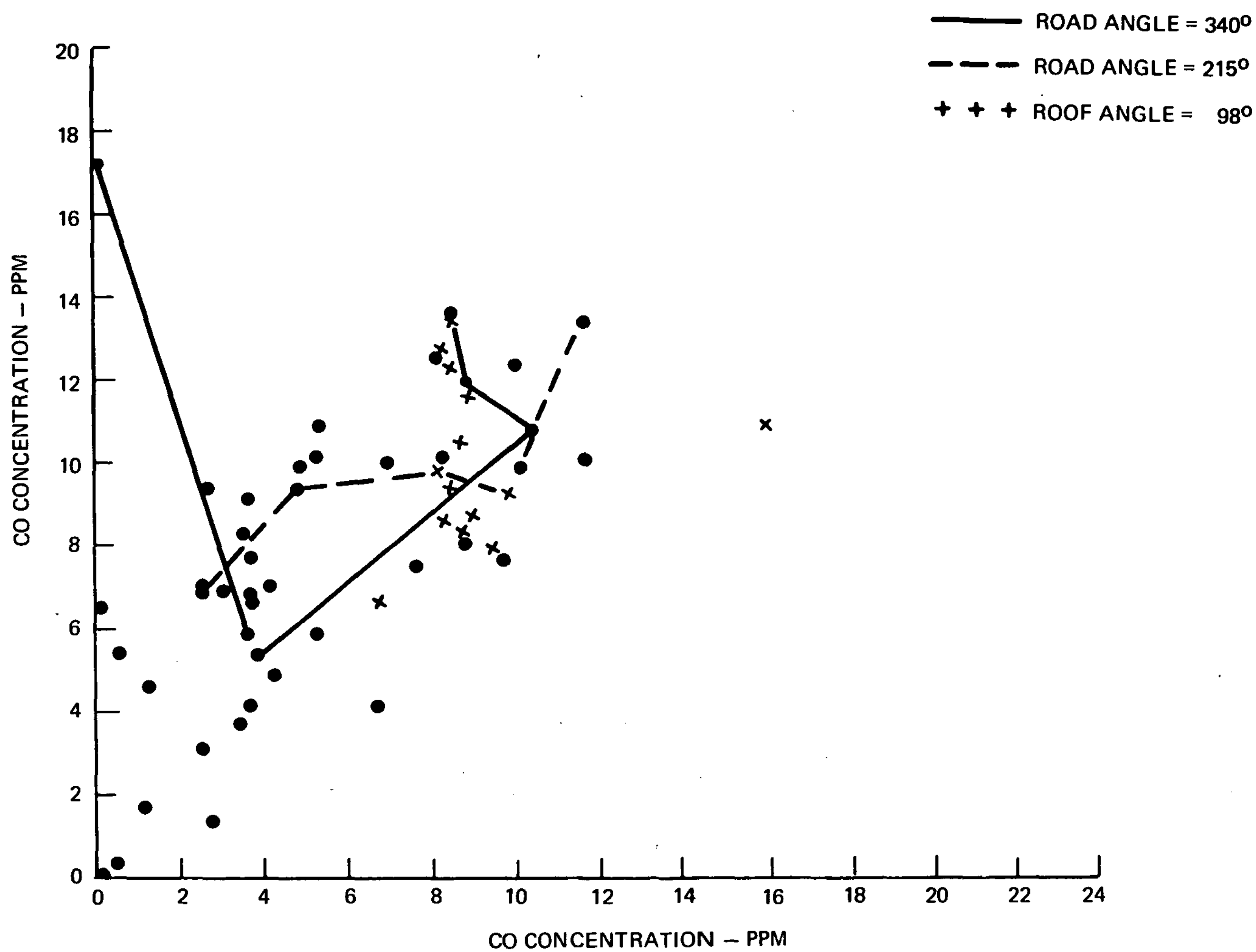


Figure 5.1.1-57. CO Concentration – 32nd Floor Indoors Vs. CO Concentration 23rd Floor Indoors – 6 PM – Weekdays – Site 1

The change in CO levels between the 23rd and 32nd floor outdoor levels again is basically linear with respect to the lower elevation position. In general, the concentrations decrease with height, except, as can be seen on Figure 5.1.1-58, for those instances when very low concentration levels were recorded at the 23rd floor. As previously shown on Figure 5.1.1-44, these low 23rd floor concentrations occurred for roof winds blowing towards the room under study, from 300° to 60°. Therefore, 23rd floor outdoor concentrations strongly influence 32nd floor outdoor CO levels.

5.1.1.3.6 Meteorological Summary

CO concentrations at the air-rights structure during the 5-6 PM period are directly traceable to the traffic flow rate on the Trans Manhattan Expressway and the azimuth angle of both road and roof level winds. Wind speed, wind sigma, temperature and temperature lapse variations effects are secondary to wind direction.

CO levels at the median strip and the 3rd floor outdoor location are inversely related. High concentrations occur at the 3rd floor location when the road wind blows from the highway toward the 3rd floor probe location. Under these conditions median strip CO is low. The 3rd floor CO is low, and median strip high, when winds blow away from the building towards the highway.

CO levels at the 23rd floor outdoor and 3rd floor indoor locations are controlled by 3rd floor outdoor CO and wind angle. Similarly 32nd floor outdoor CO is influenced by 23rd floor concentrations and wind direction. Indoors, the concentrations at successively higher floors is dependent upon the CO level at the floors below and the wind angles.

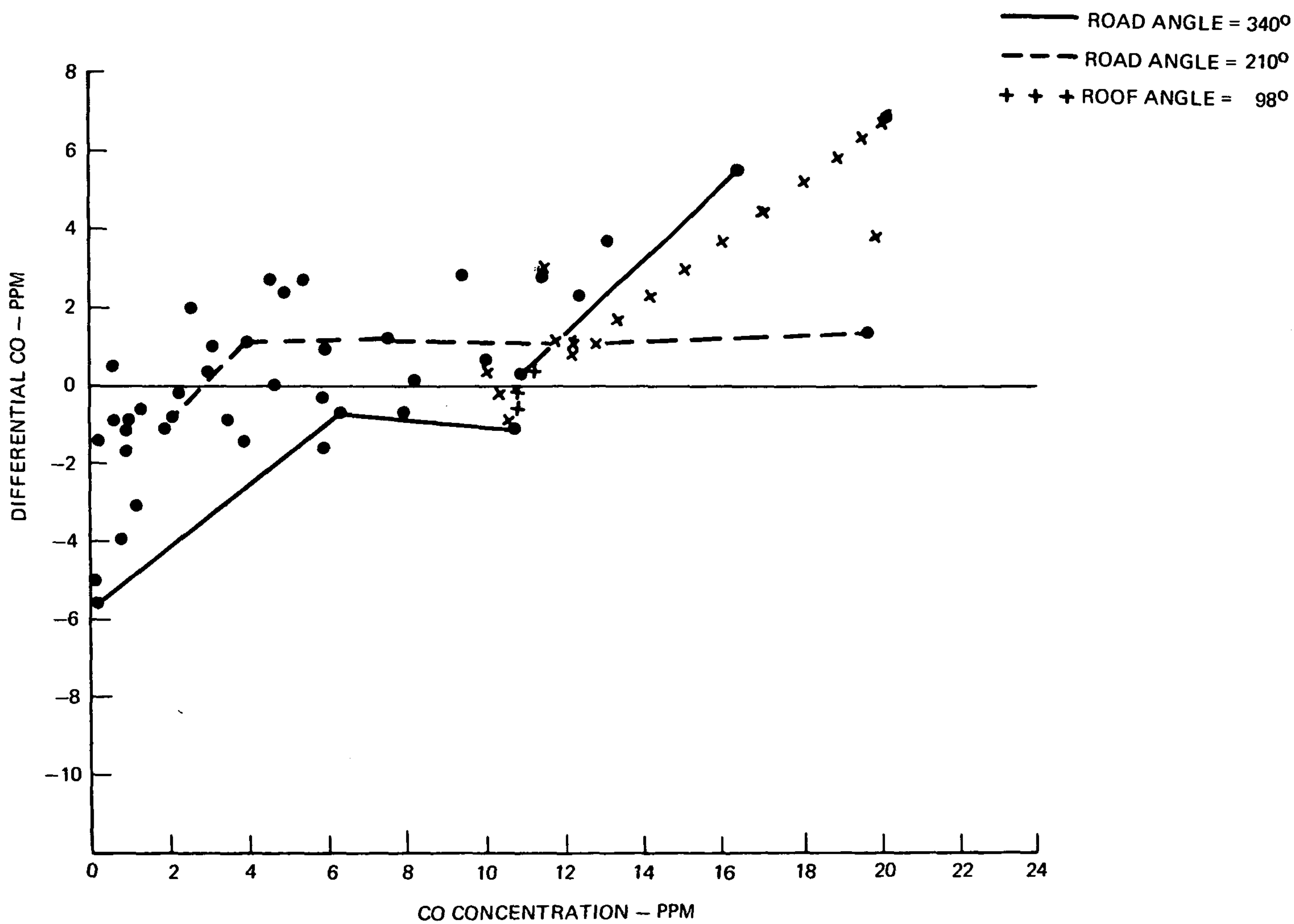


Figure 5.1.1-58. Differential CO – Outdoor – 23rd To 32nd Floor Vs. 23rd Floor CO Concentration – 6 PM – Weekdays – Site 1

The carbon monoxide changes from the base of the building to the 32nd floor are affected differently by the various wind azimuth angles. Figures 5.1.1-59 thru -62 present the change in CO concentration between the 3rd and 23rd and between the 23rd and 32nd floors, both outdoors and indoors for four different roof wind azimuth angle conditions. Each curve on the four figures is plotted against the CO concentration present at the lower floor for the data involved. For example, the abscissa represents the CO level indoors at the 3rd floor for the 3-23I curves and represents the CO level outdoors at the 23rd floor for the 23-32O curves. The data for Figure 5.1.1-59, which shows the constant 98° roof wind azimuth angle is provided in Table 5.1.1-6.

Examination of the four figures will show that during the 5-6 PM period, concentrations at the 23rd floor always were lower than comparable 3rd floor CO levels. However, in the majority of instances, concentrations at the 32nd floor were lower than comparable 23rd floor CO levels. All plots on each of the four figures show a positive slope with increase in CO concentration at the reference position. The differential in CO levels between different floors is low, or negative, when the CO level at the lower floor is small. Conversely high concentrations at the lower floors produce positive differentials.

It will be noted from Figure 5.1.1-59, that the differential between floors is higher indoors than outdoors for roof winds from 98°. This means that the CO levels indoors from the 3rd-23rd and 23rd-32nd floors will reduce more than comparable CO levels outdoors for easterly roof winds, for the same concentration at the lower floor. As indicated by the slope of the curves, large changes in CO levels occur for small changes in concentration at the lower floors.

When the roof wind shifts to 160° as shown on Figure 5.1.1-60, the differential curves flatten out, showing that southerly winds have little affect on CO levels on the north face of the air rights structure. The indoor and outdoor changes appear uniform for each pair of floors. The higher change indicated for the 3-23rd floor is probably due to the greater vertical distance between the 3rd and 23rd floors than exists between the 23rd and 32nd floors.

As the roof wind shifts so it is blowing towards the building face under study, see Figures 5.1.1-61 and -62, the differential between floors generally becomes lower indoors than outdoors. This means northerly winds will produce lower CO levels outdoors than indoors. In other words, roof winds blowing towards the building disperse the outdoor CO. This affect appears stronger at the 23rd floor than at the 32nd floor.

It is very evident that the CO levels recorded at the northeast corner of the air rights structure display a variation which is responsive to the seasons of the year. Southerly winds, which always occurred during the "non-heating" season and rarely prevailed during the "heating" season, do not disperse the Trans Manhattan generated CO on the north face of the building. The carbon monoxide concentration decayed exponentially with height above the roadway. Conversely, the predominate north and northeast winds recorded during the heating season decrease CO levels at the intermediate floors of the air-rights structure. These winds have a dual effect. They decrease outdoor concentrations at the upper floors of the building. In addition, indoor concentrations, which entered the building at lower floors, are trapped within the rooms on the top floors by the winds blowing towards them.

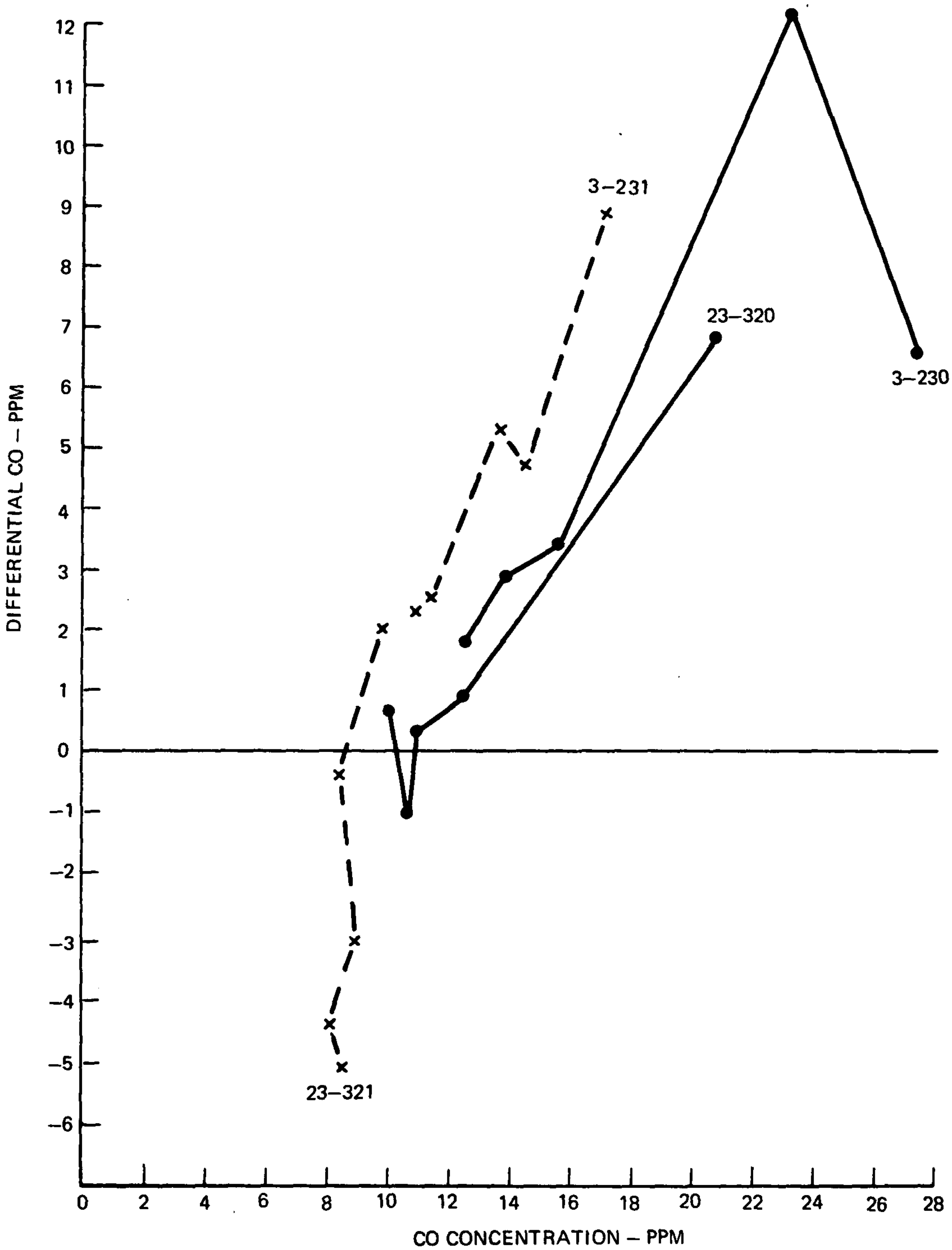


Figure 5.1.1-59. Differential CO For Constant 98° Roof Wind Angle

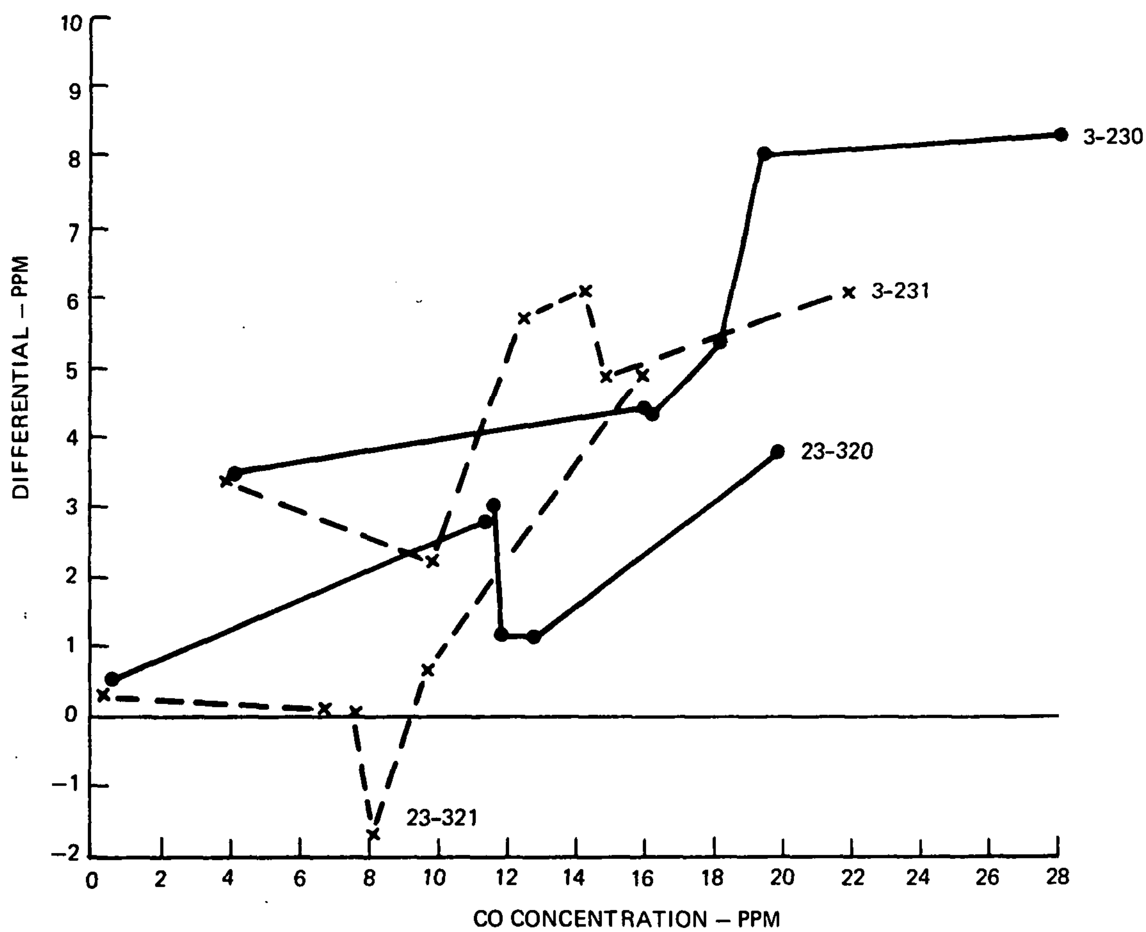


Figure 5.1.1-60. Differential CO For Constant 160° Roof Wind Angle

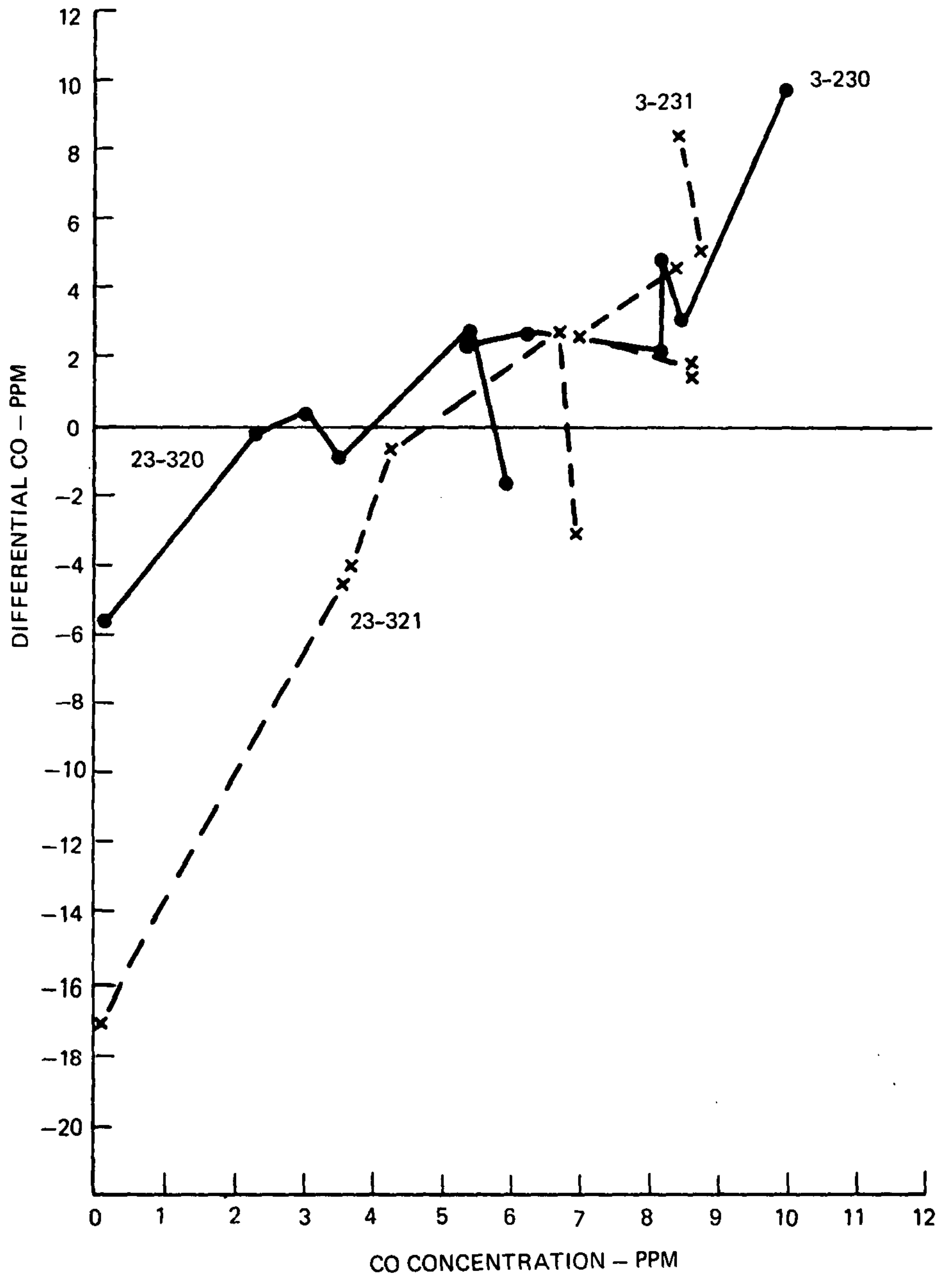


Figure 5.1.1-61. Differential CO For Constant 340° Roof Wind Angle

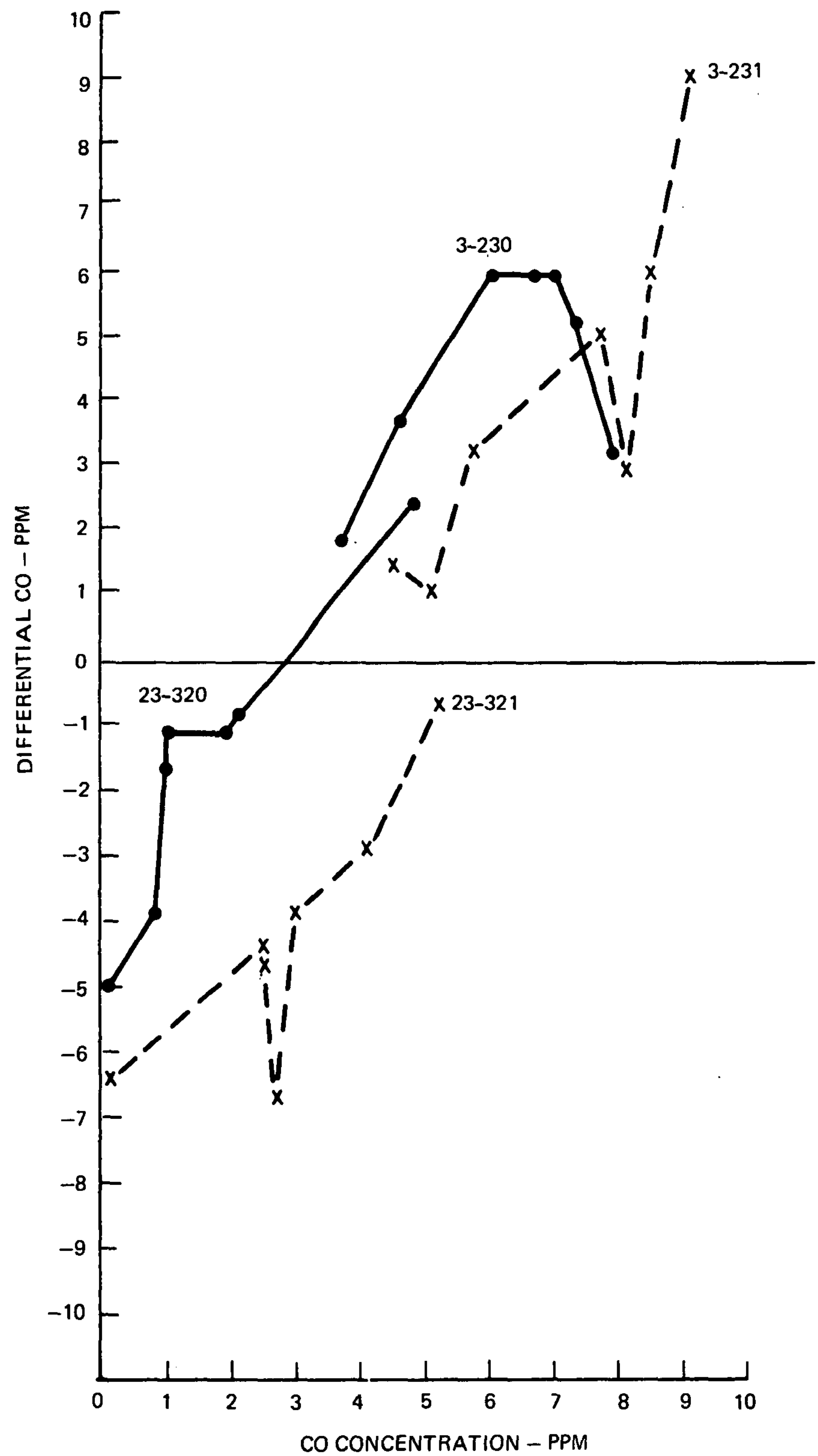


Figure 5.1.1-62. Differential CO For Constant 16° Roof Wind Angle

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5.1.2 Hydrocarbons

Hydrocarbon samples were acquired for indoor outdoor data at three levels of the air rights structure. Measurements started, using the 3rd and 32nd floor indoor and outdoor probes, on September 16, 1970. It was discovered that unusually high readings were obtained at the 32nd floor. These could be attributed to internal sources, particularly a gas stove and oven which was used almost constantly by the tenants who complained of not receiving enough heat at their upper floor apartment. Accordingly the measurement location was switched to the probes at the 23rd floor on November 21, 1970.

The transfer of the measurement location during the monitoring period created an unbalance in the size of the data samples at the three levels monitored. Fourteen days of data was obtained at the 3rd and 32nd floors during the non-heating season, 12 of these were weekdays and 2 were weekend days. No data on hydrocarbon levels during the non-heating season was obtained at the 23rd floor. One hundred and three days of data was obtained during the heating season at the 3rd floor with 73 of these being weekdays and 30 being weekend days. Approximately 50 days of heating season data was collected at the 32nd and 23rd floor levels.

5.1.2.1 Heating Season

The weekday diurnal curves for hydrocarbon concentrations at the 3 outdoor locations (Figures 5.1.2-1, -2 and -3) show some similarity to the diurnal traffic. However, the increased level of hydrocarbons at the 32nd floor, as compared to the 23rd and 3rd floors, and the lack of similarity of the diurnal curves for internal hydrocarbon concentrations (Figures 5.1.2-4, -5 and -6) suggest that traffic on the Trans Manhattan Expressway is not the prime source of hydrocarbons at this site. Plots of hydrocarbon concentration vs. traffic flow rate

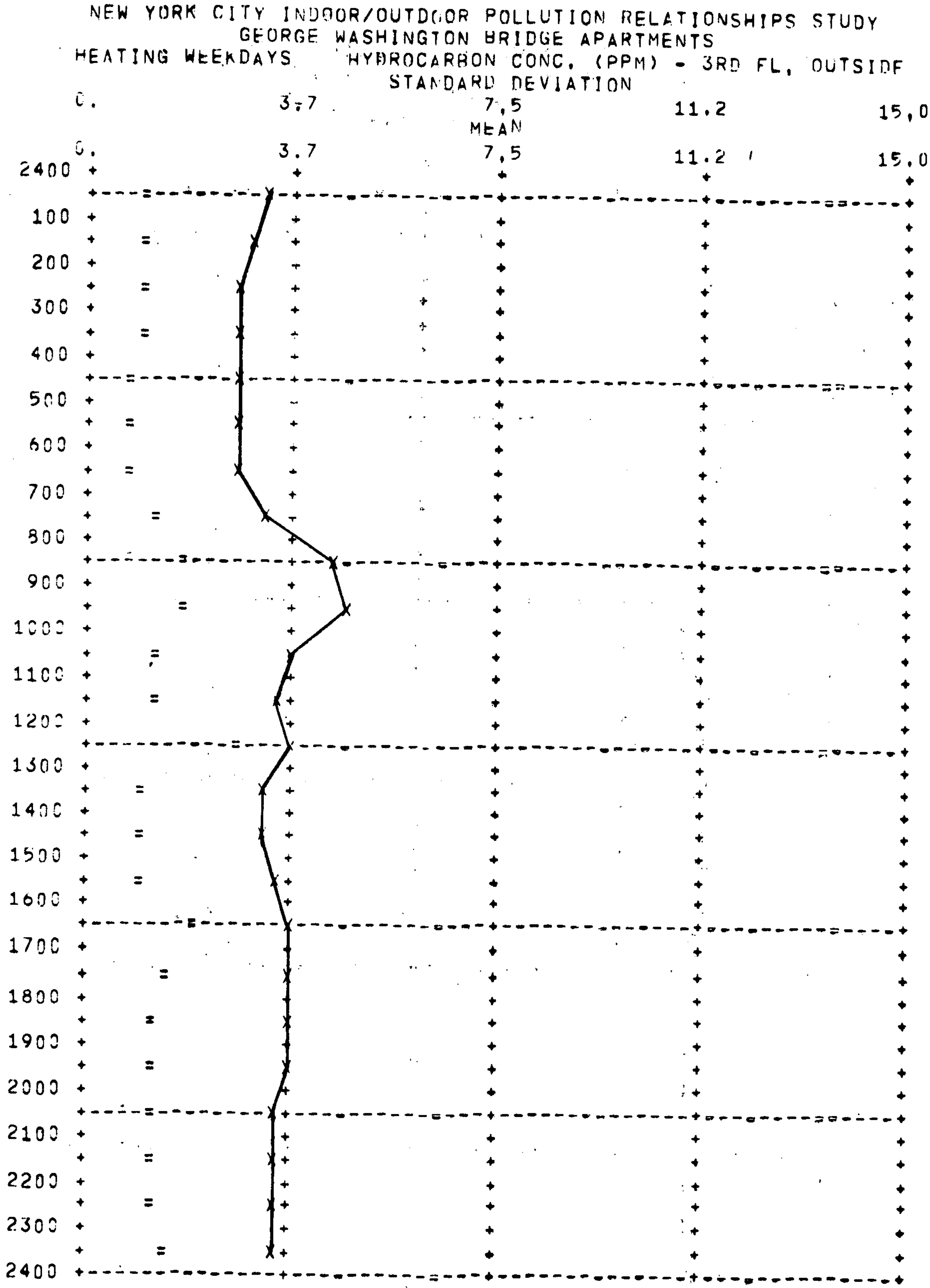

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 3RD FL, OUTSIDE
STANDARD DEVIATION
0. 3.7 7.5 11.2 15.0
MEAN
0. 3.7 7.5 11.2 15.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

FIGURE 5.1.2-1

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 23RD FL. OUTSIDE

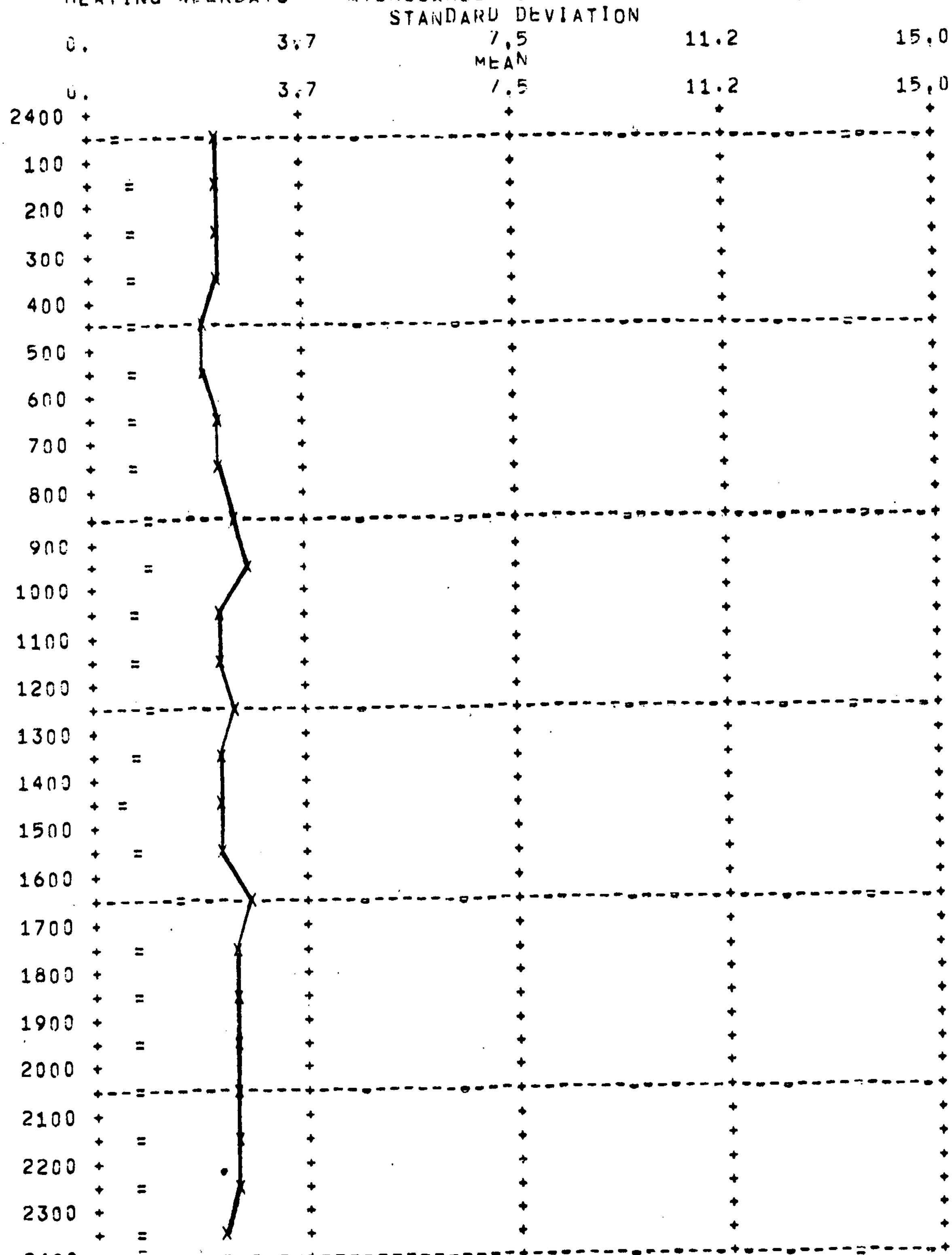


FIGURE 5.12-2

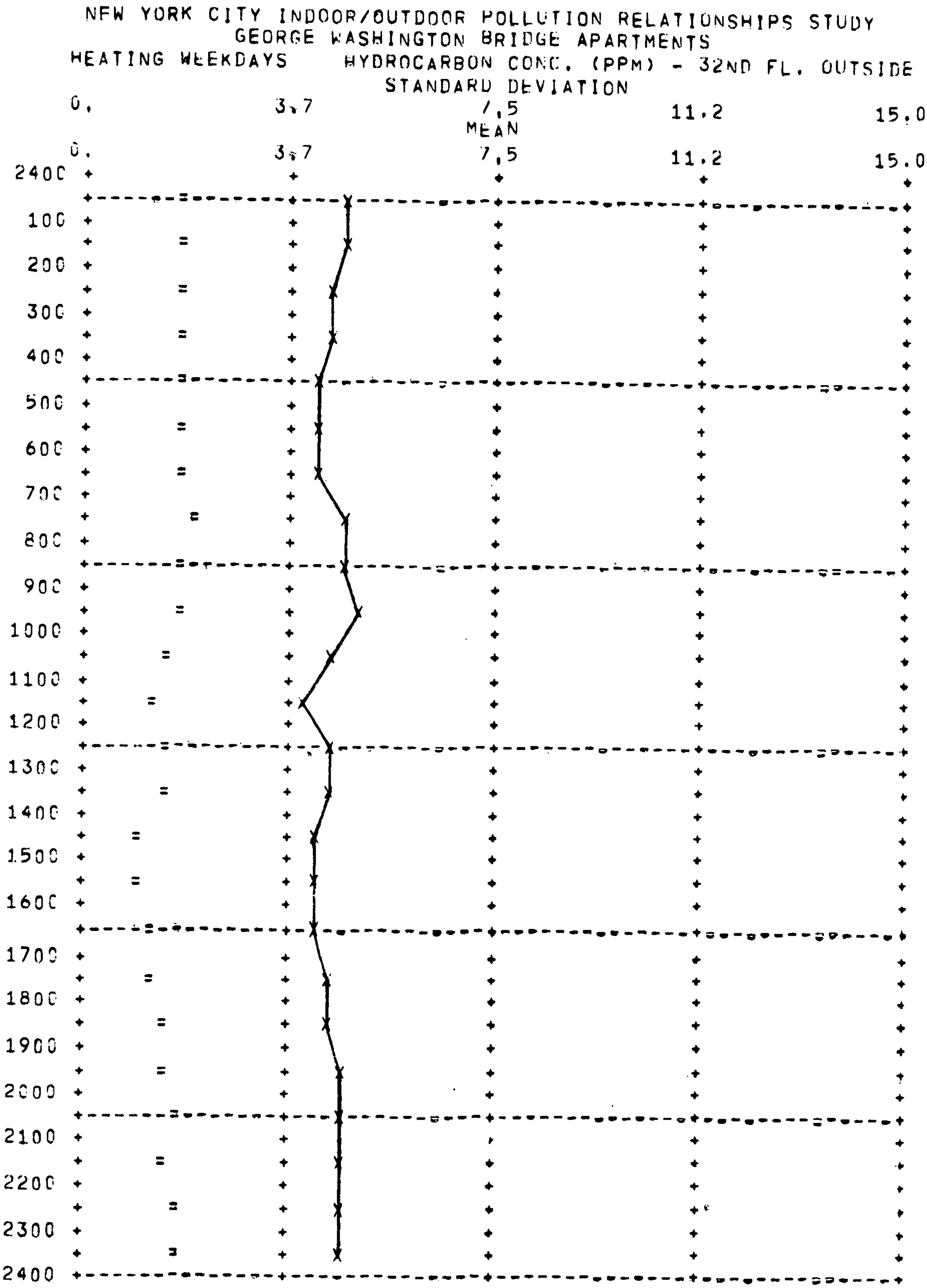

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 32ND FL. OUTSIDE
STANDARD DEVIATION
0. 3.7 7.5 11.2 15.0
MEAN
0. 3.7 7.5 11.2 15.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

FIGURE 5.1.2-3

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 3RD FL, INSIDE

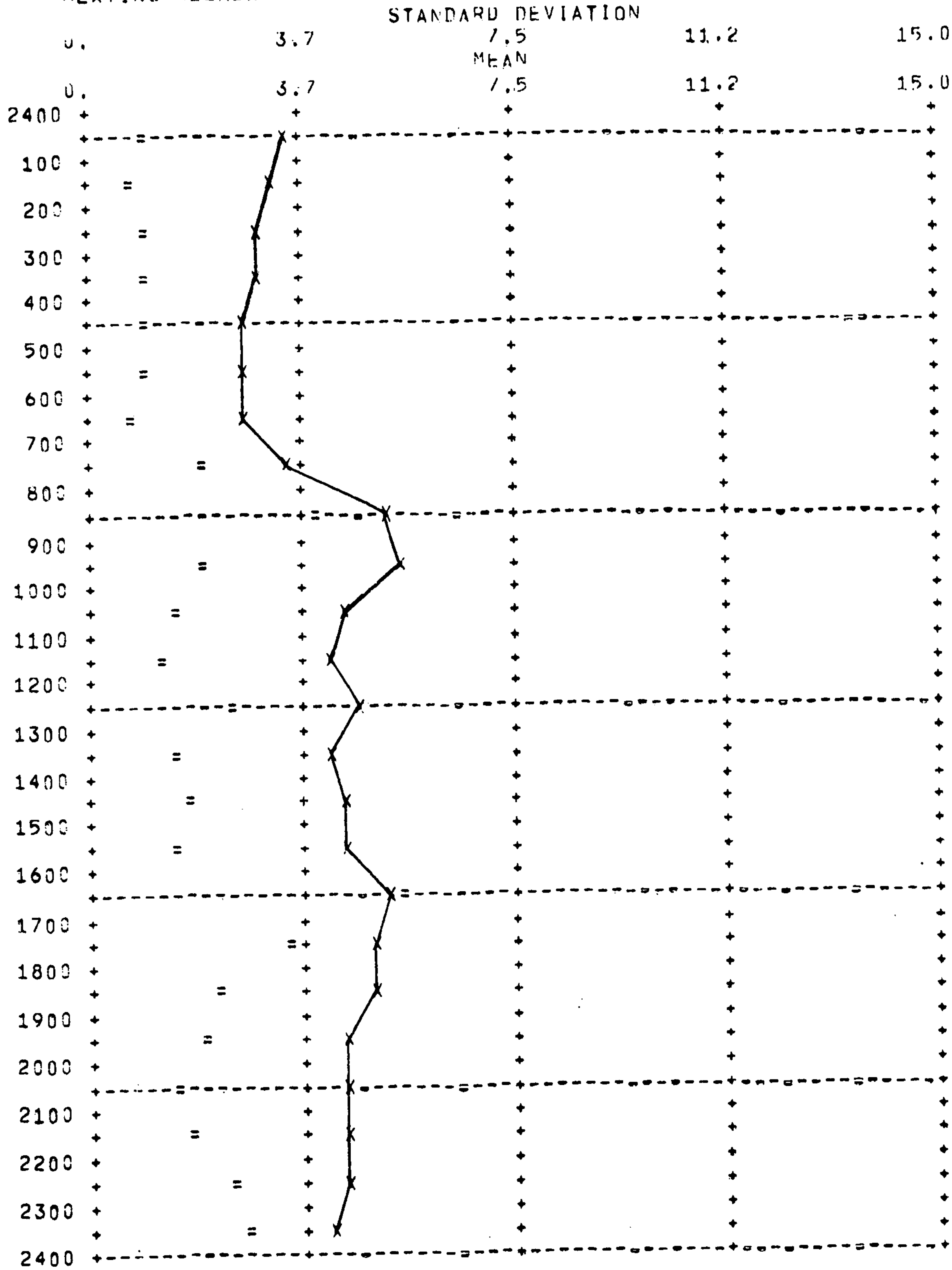
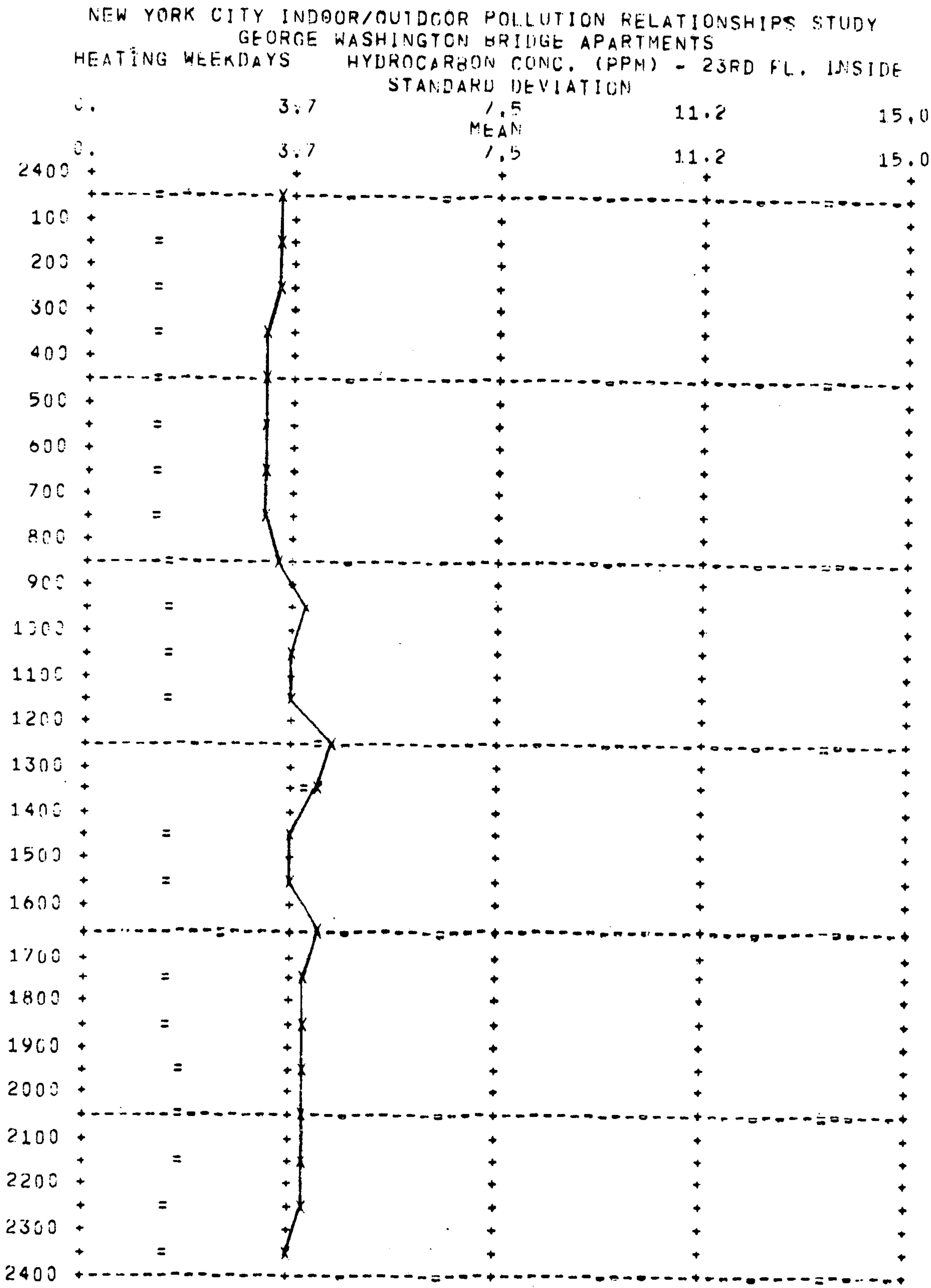


FIGURE 5.1.2-4


NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 23RD FL. INSIDE
STANDARD DEVIATION
0. 3.7 7.5 11.2 15.0
MEAN
0. 3.7 7.5 11.2 15.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
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1900
2000
2100
2200
2300
2400

FIGURE 5.1.2-5

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 32ND FL. INSIDE

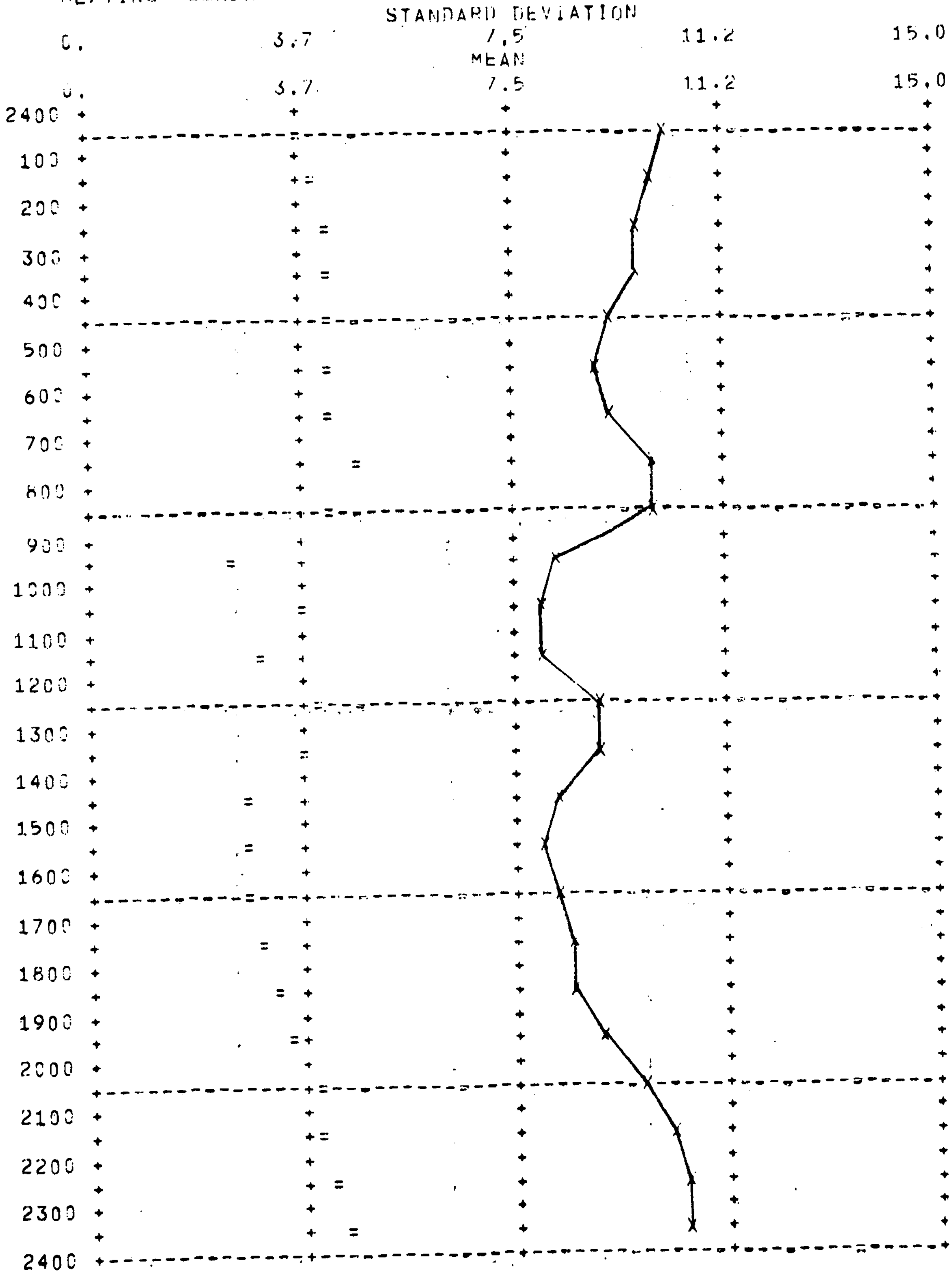


FIGURE 5.1.2-6

and velocity, as shown in Figures 5.1.2-7 thru -12, hint at a correlation with traffic at the 3rd floor outside level but not at the 23rd or 32nd floor.

The outdoor-indoor differential concentrations for all floors showed a consistent pattern of higher indoor concentrations both on weekdays and weekends. Weekday average hydrocarbon data at 3rd floor show higher readings indoor than outdoor (4.14 PPM vs. 3.43). At the 32nd floor average indoor values are higher than outdoor readings by a factor of 2 (9.22 PPM vs. 4.52). The 32nd floor weekend indoor average is 10.32 PPM. The maximum average value indicates the high degree of internal source activity on weekends with maximum occupancy of the apartment. The maximum outdoor concentration was 4.72 PPM. This concentration was also at the 32nd floor on weekends and was obviously related to the maximum indoor reading. Readings at the 23rd floor were more representative of anticipated conditions. The 23rd floor readings for weekdays were 2.37 PPM/3.74 PPM, outdoor and indoor respectively. In general, it must be assumed that, at all levels, the dominant source of hydrocarbons is internal.

At the 3rd floor, concentrations were less than 4 PPM 65% of all hours outdoors and 50% of all hours indoors. At the 23rd floor the readings were less than 4 PPM 95% of all hours outdoors and 62% of all hours indoors. The 32nd floor had readings less than 4 PPM only 36% of all hours outdoors and approximately 1% of the time indoors.

5.1.2.2 Non Heating Season

The diurnal curves for hydrocarbon concentrations at the 3rd floor differ to some extent from those for the heating season. The weekday curves (Figure 5.1.2-13 and -14) show a single early afternoon maximum peaking between 1400 and 1500 hours. However, these peaks are due to some data which is suspect.

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 3RD FL, OUTSIDE
HYDROCARBON CONC. (PPM) VS TRAFFIC FLOW RATE (VEH/HR)

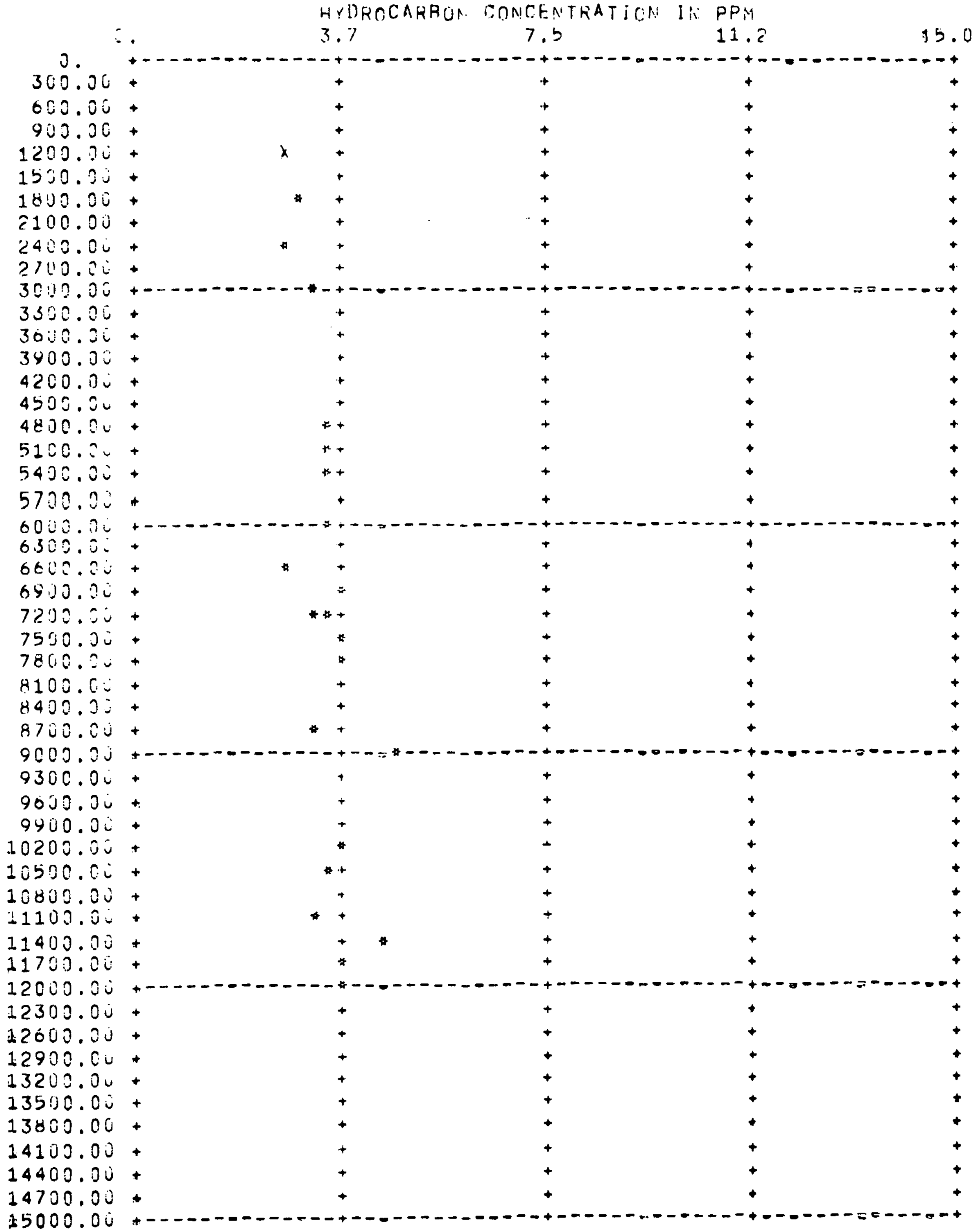


FIGURE 5.1.2-7

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 3RD FL, OUTSIDE
HYDROCARBON CONC. (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)
HYDROCARBON CONCENTRATION IN PPM

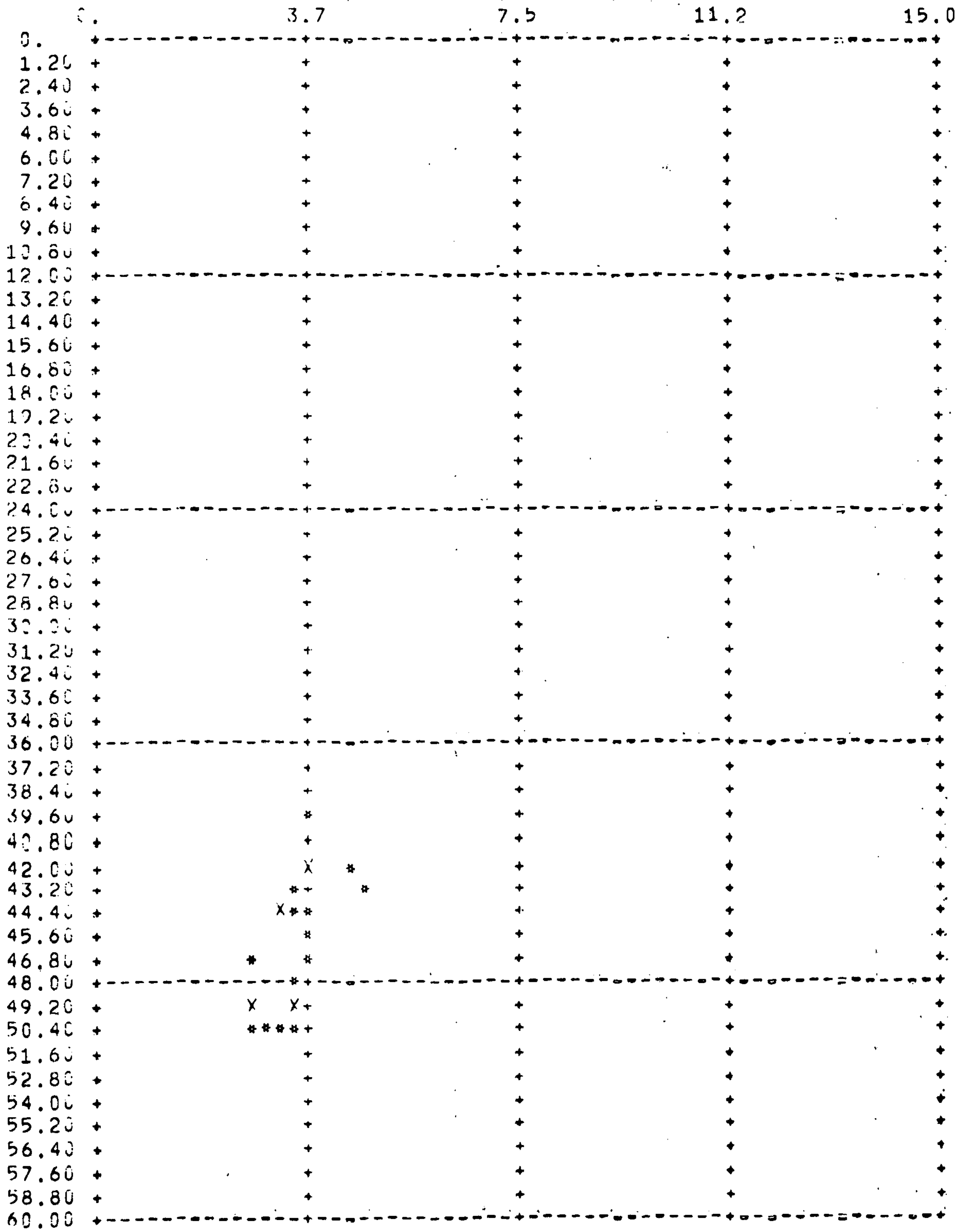


FIGURE 5.1.2-8

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 23RD FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS TRAFFIC FLOW RATE (VEH/HR)

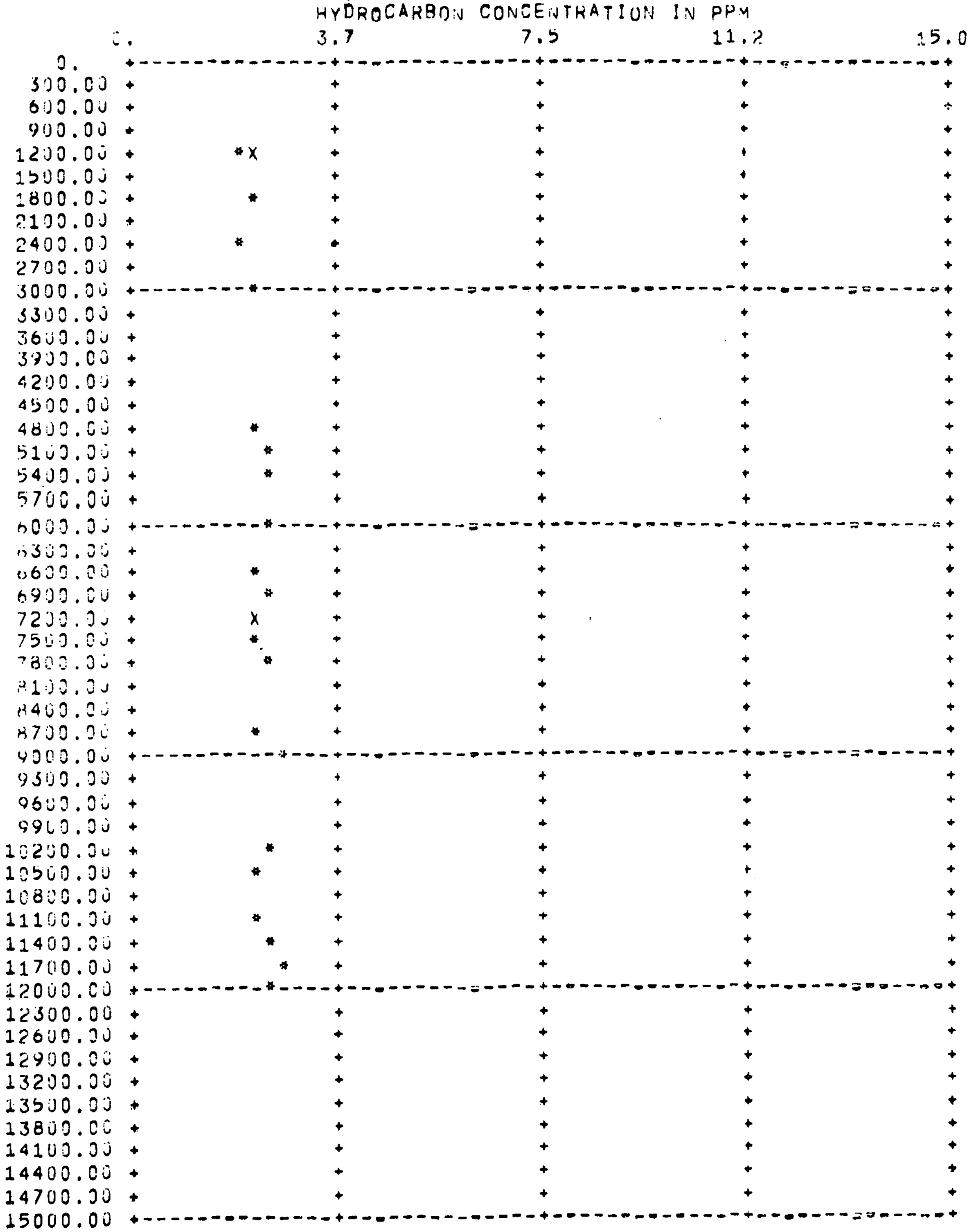


FIGURE 5.1.2-9

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 23RD FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)

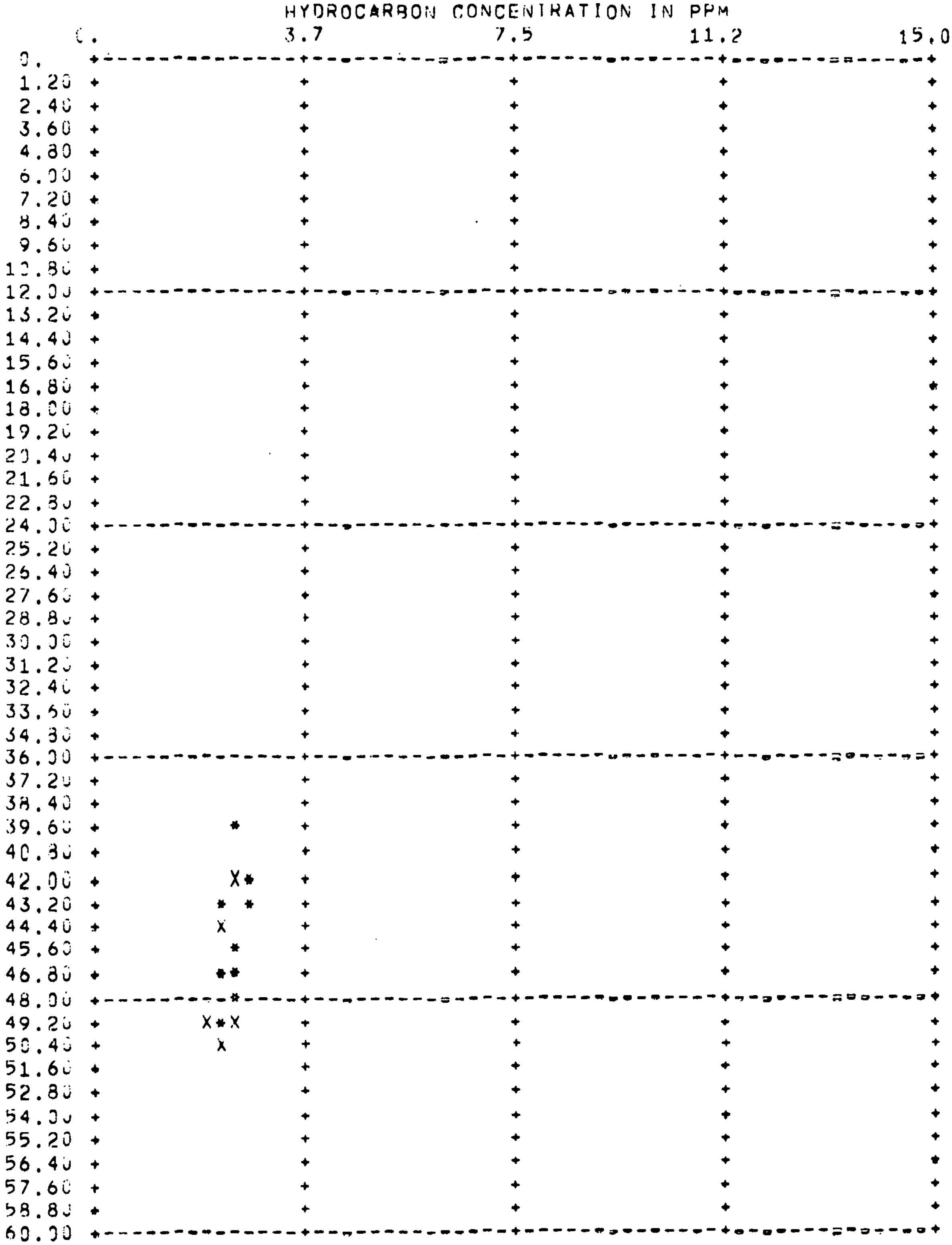


FIGURE 5.1.2-10

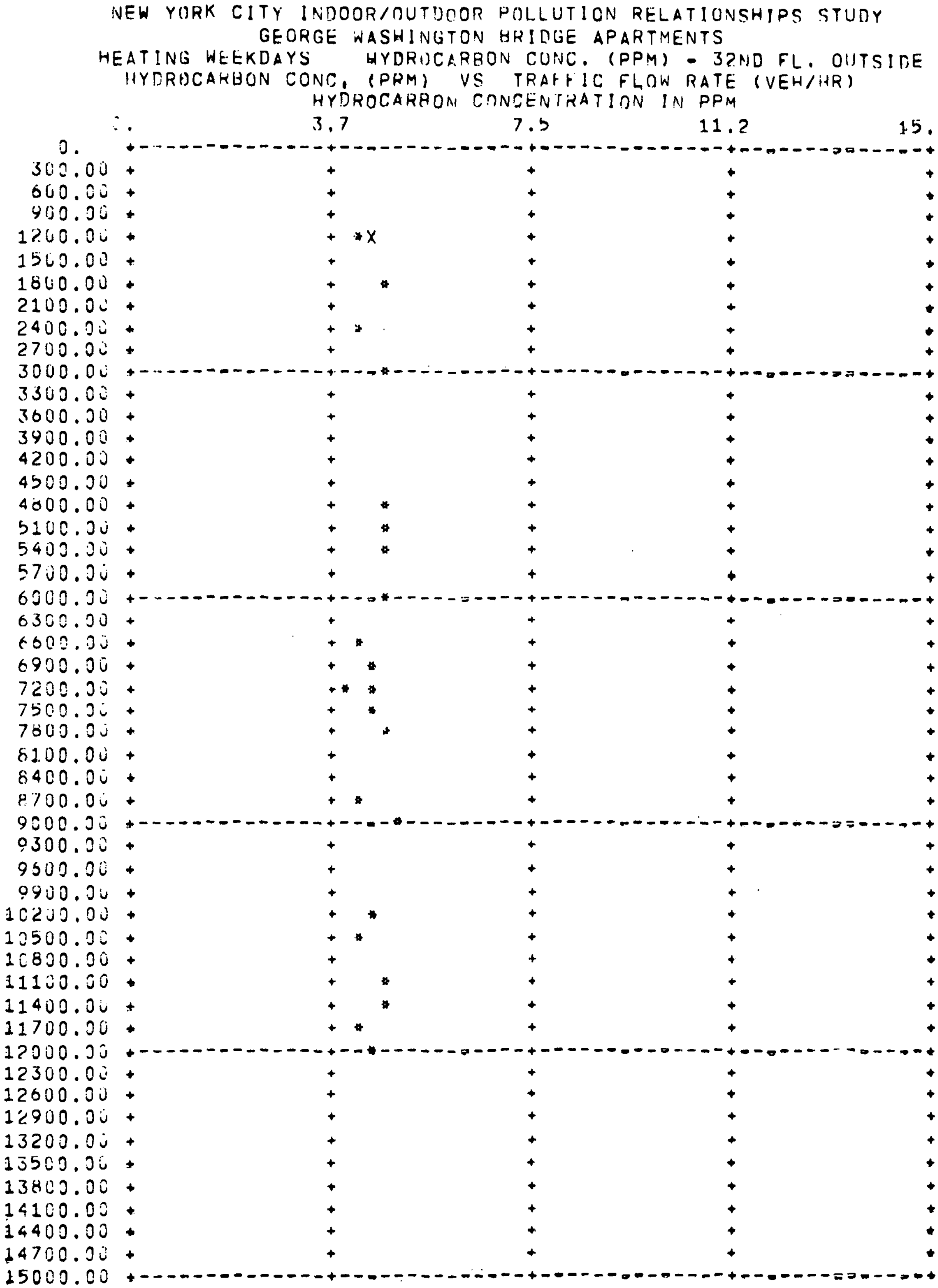


FIGURE 5.1.2-11

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 32ND FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)
HYDROCARBON CONCENTRATION IN PPM

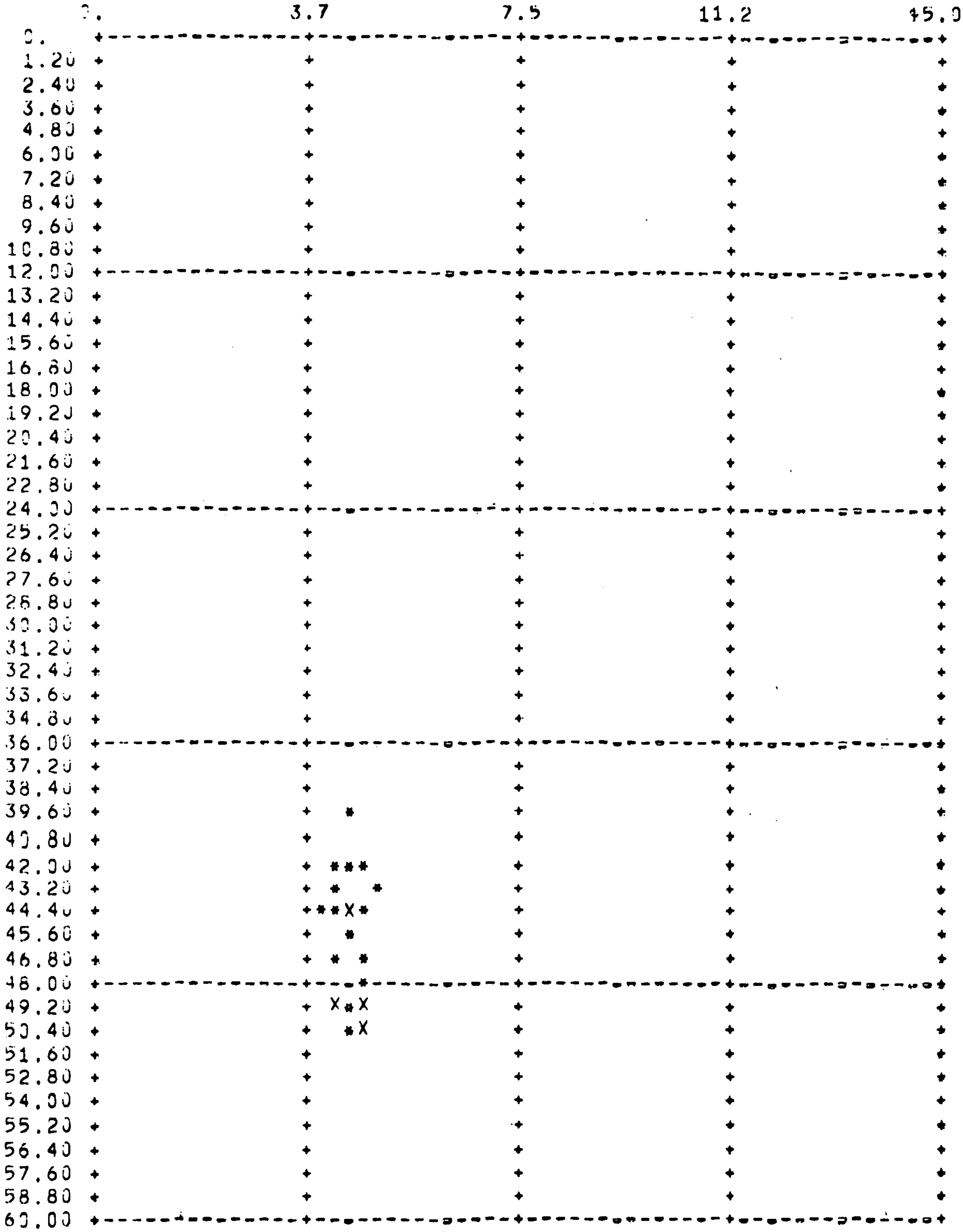


FIGURE 5.1.2-12

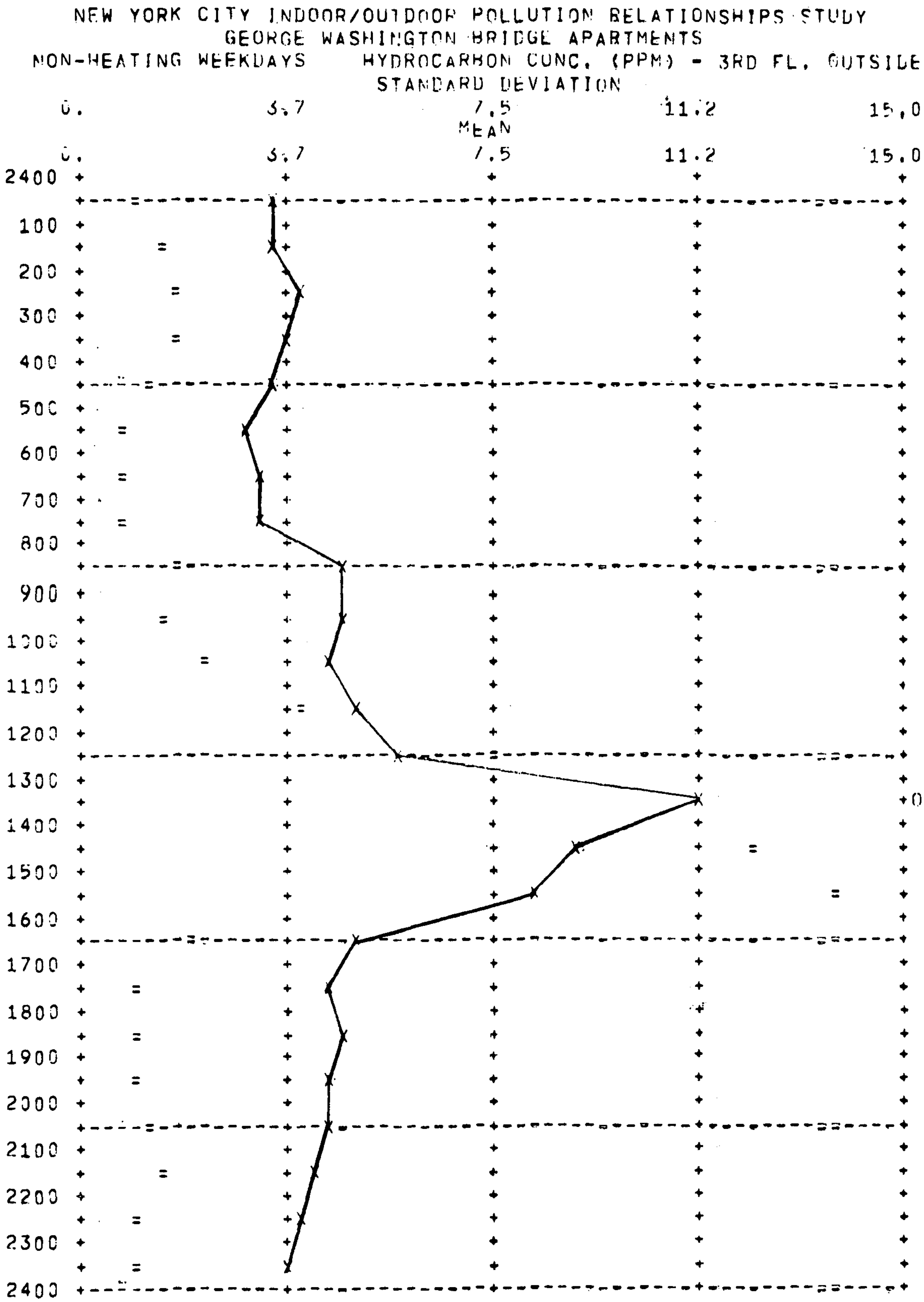


Figure 5.1.2-13

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
NON-HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 3RD FL. INSIDE

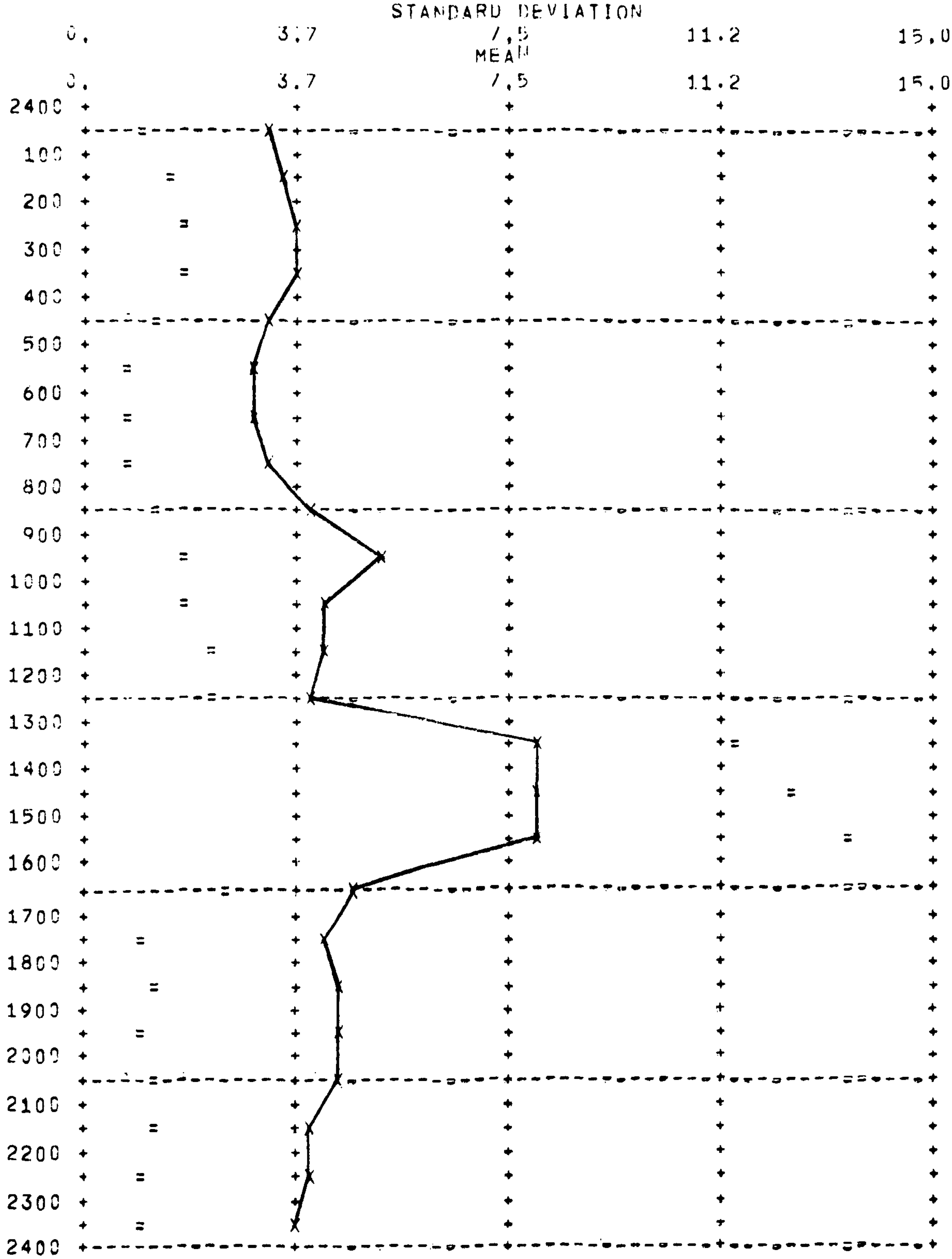


Figure 5.1.2-14

Unusually high readings occurred on 9/17/70 from 12 N to 3 PM and on 9/21/70 from 1 PM to 4 PM. Within the small sample, these high readings have a marked effect on the hourly means reflected by the large standard deviations. If, for example, we eliminate the high readings mentioned above from the outside location data, then the mean values for hourly averages outside, from the interval 12 N - 1 PM to 3-4 PM, would be as shown below.

Interval	Old Mean	New Mean
12 N - 1 PM	5.84 PPM	3.85 PPM
1 - 2 PM	11.34 PPM	3.66 PPM
2 - 3 PM	9.05 PPM	3.92 PPM
3 - 4 PM	8.29 PPM	3.81 PPM

These new means are comparable to the other hourly Means and the outside diurnal curve will therefore be relatively flat with no significant maxima. This modified diurnal curve is very similar to that for the heating season. A similar modification to the plots for 3rd floor outside hydrocarbon concentrations vs. traffic flow rate and velocity (Figure 5.1.2-15 and -16) would also create curves like those for traffic parameters during the heating season. These modified curves also suggest a hydrocarbon traffic relationship.

The outside-inside differential concentration at the 3rd floor for this period differed from that of the heating season in that it showed no concentration gradient for a majority of the period with a small period of higher outside values.

The gradients at the 32nd floor still showed the influence of internal sources, but were somewhat less than those during the heating season. Figures 5.1.2-17 thru -20 show the diurnal curves at this elevation. Note that the unusua high readings recorded at the third floor were not recorded at this floor.

The outside concentration differential between the 3rd/32nd floors shows predominantly negative pattern, indicating higher concentrations on the upper

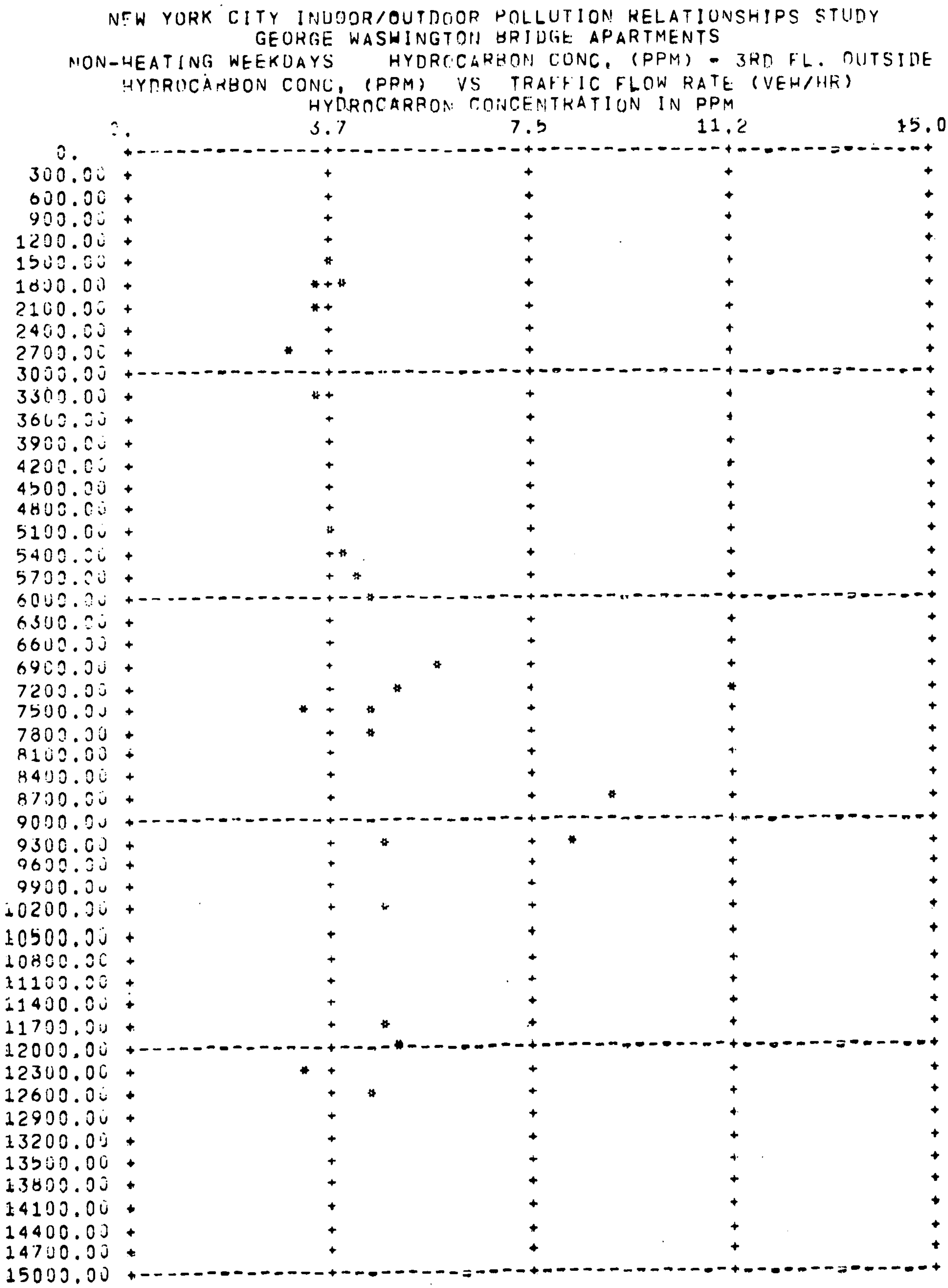


Figure 5.1.2-15

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
NON-HEATING WEEKDAYS HYDROCARBON CONC, (PPM) - 3RD FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)
HYDROCARBON CONCENTRATION IN PPM

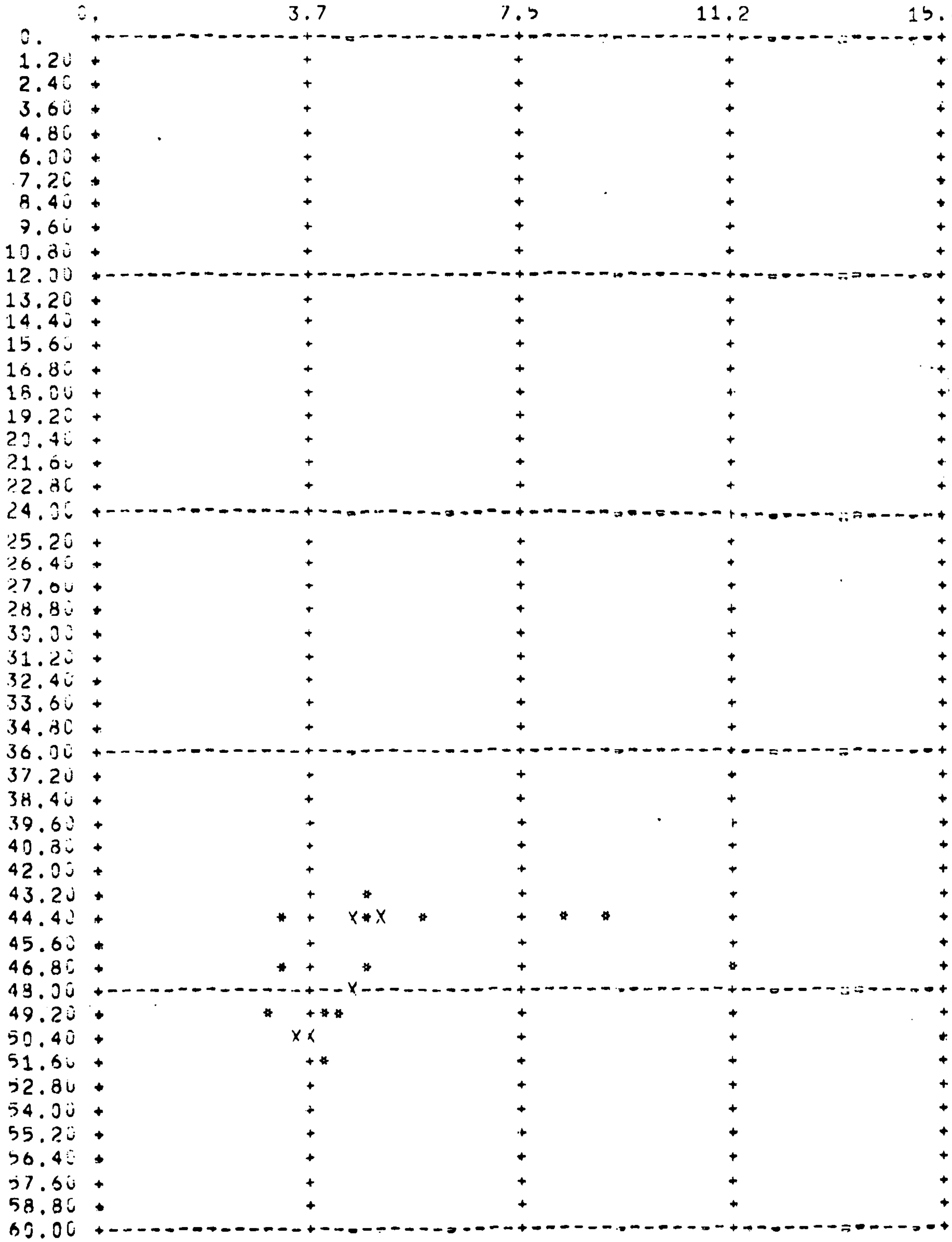


Figure 5.1.2-16

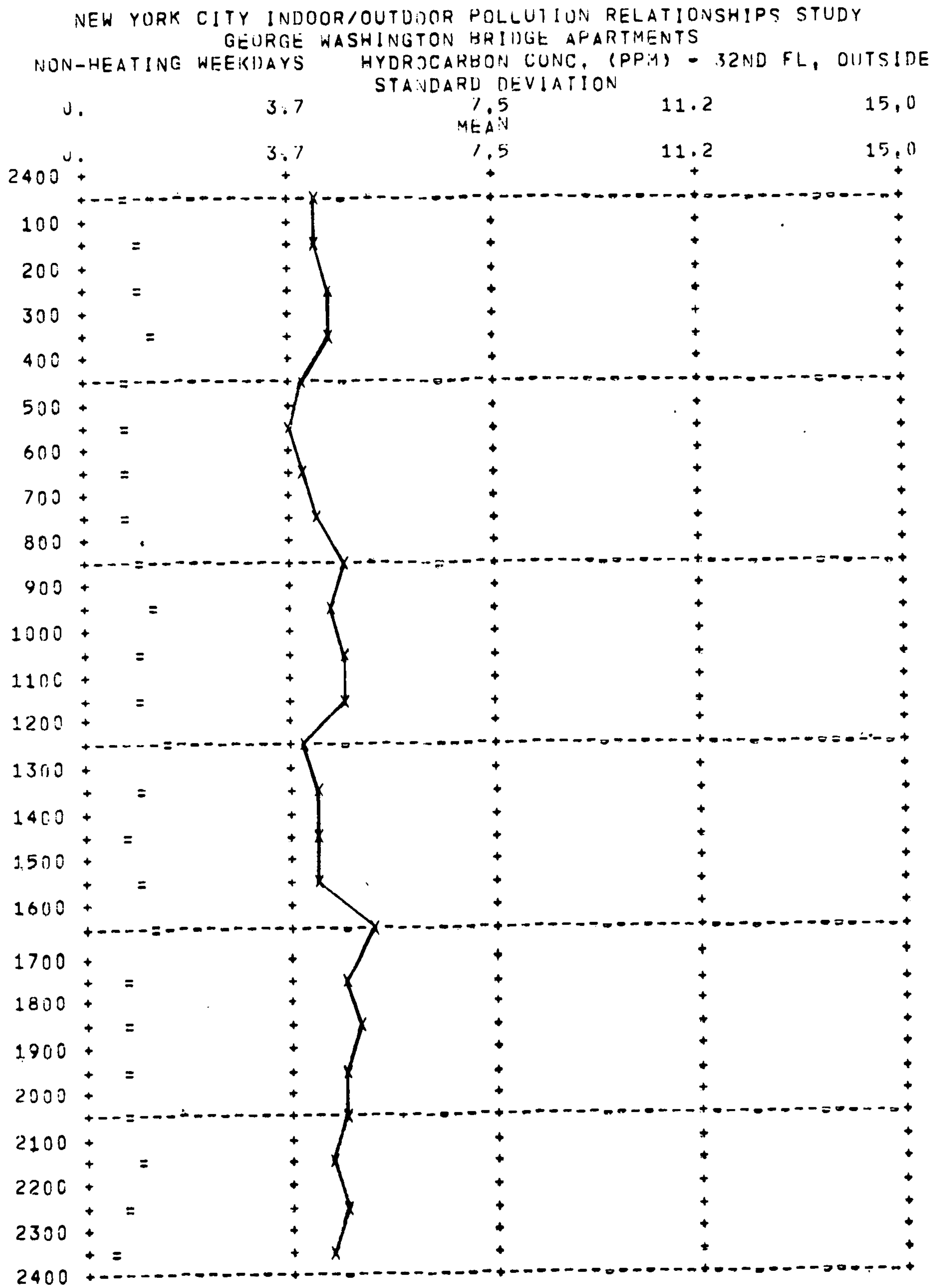


Figure 5.1.2-17

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
NON-HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 32ND FL, INSIDE

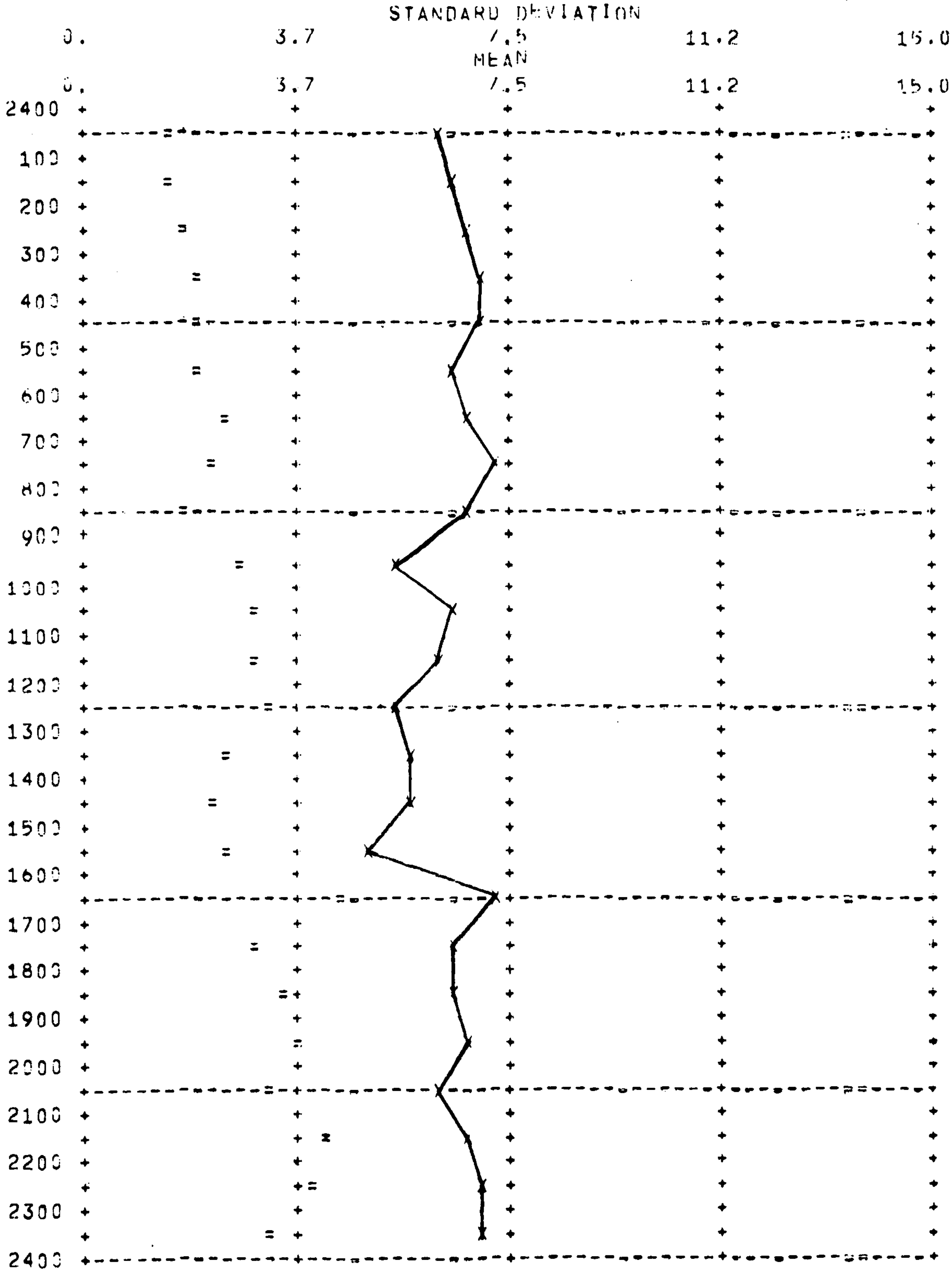


Figure 5.1.2-18

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
NON-HEATING WEEKDAYS HYDROCARBON CONC, (PPM) - 32ND FL, OUTSIDE
HYDROCARBON CONC, (PPM) VS TRAFFIC FLOW RATE (VEH/HR)

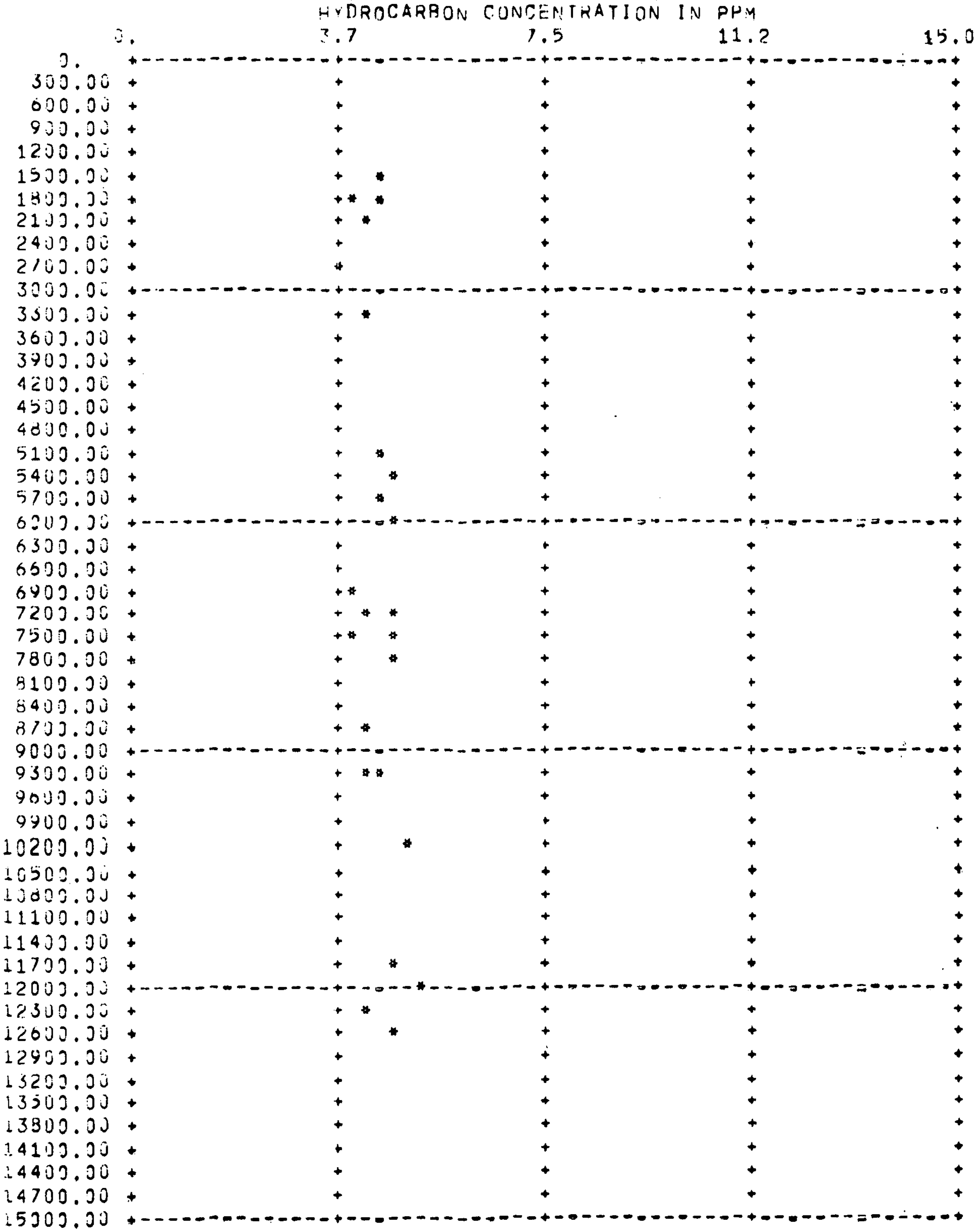


Figure 5.1.2-19

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
GEORGE WASHINGTON BRIDGE APARTMENTS
NON-HEATING WEEKDAYS   HYDROCARBON CONC, (PPM) - 32ND FL, OUTSIDE
HYDROCARBON CONC. (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)
HYDROCARBON CONCENTRATION IN PPM

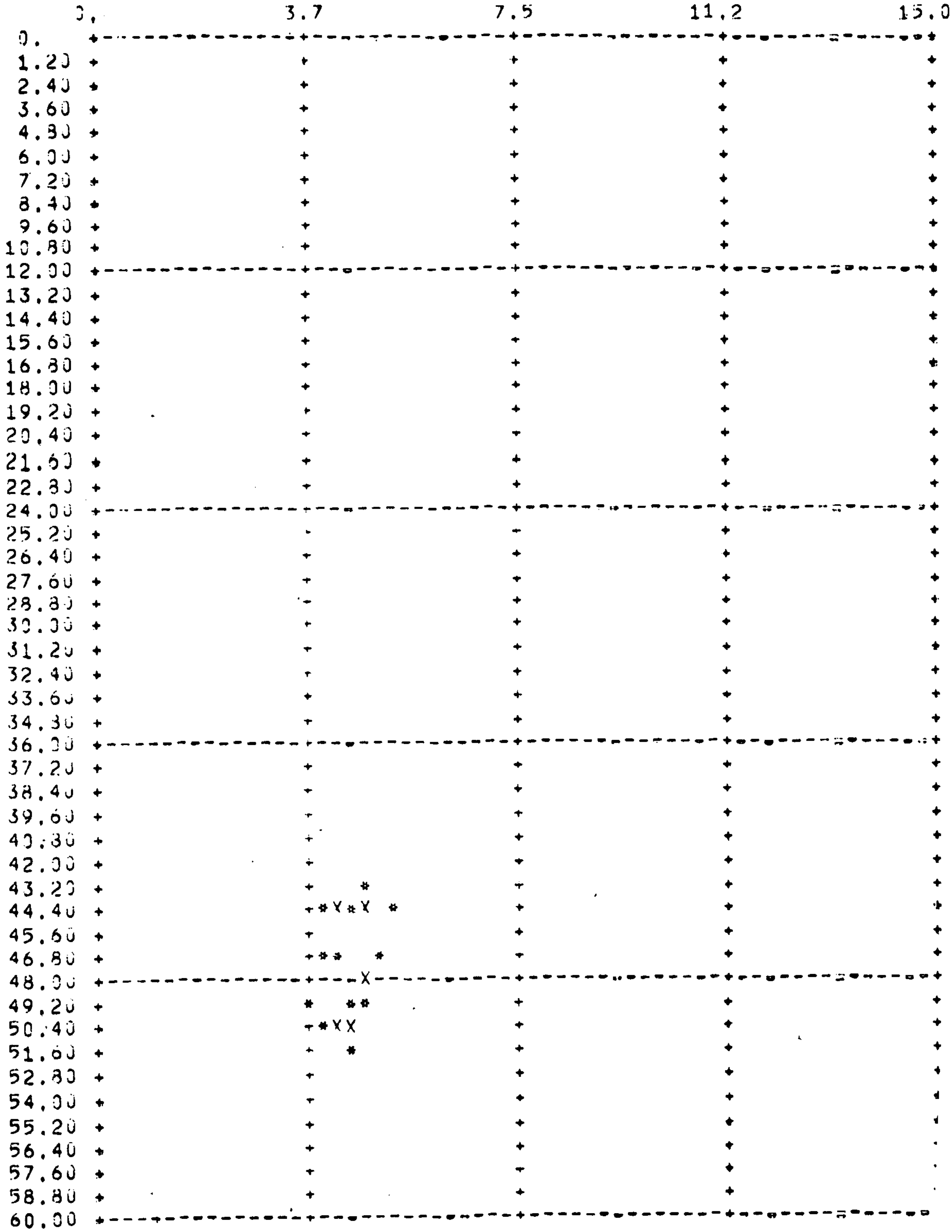


Figure 5.1.2-20

floor. Again, the internal source is the plausible explanation. Unfortunately, there is no 23rd floor data available for this season but there is good reason to believe that it would exhibit a decay with height as shown in the heating season.

Weekday average hydrocarbon data for this period show higher outside readings (4.82 PPM outside vs. 4.45 PPM inside) at the 3rd floor. The reverse is true of the 32nd floor with the values being 4.46 PPM outside vs. 6.48 PPM inside.

The 3rd floor outside weekday measurements were less than 6 PPM 90% of the time while the outside weekend values never exceeded 5 PPM. The lower floor inside values were less than 6 PPM more than 90% of the time.

5.1.3 Particulates

Particulate samples were obtained at six locations associated with the air-rights structure thru the use of five High Volume Air Samplers. Initially two samplers were located at the second floor level, one inside and the other outside. Similarly two samplers were located at indoor and outdoor locations at the roof level. The sampler at the inside roof level was relocated upwards to the tower room near the end of the testing period. The fifth sampler was installed indoors in the boiler room midway during the program.

Data was obtained at the roof and second floor locations for only two days during the non-heating season. No non-heating season measurements were made in either the tower or boiler room. Particulate data was obtained at all six locations during the heating season. The data sample size varied however from four days inside the tower to twenty-one days at the outdoor roof location.

All particulate data obtained at the air rights structure during both the heating and non-heating seasons are presented in Table 5.1.3-1. Analysis of this data revealed that particulate concentrations are not directly related to heating or non heating seasons. Therefore, the ensuing discussion considers all of the data regardless of season.

The highest total particulate concentrations at the air-rights structure were recorded at the outside locations. The National secondary standard for particulates (150 ug/M^3) was exceeded on 9 out of 20 days at the 2nd floor outdoor location. This secondary standard also was exceeded at the roof outdoor location three times and in the boiler room once. Only two of the nine high concentrations at the 2nd floor balcony

TABLE 5.1.3-1

PARTICULATES - $\mu g/M^3$
GEORGE WASHINGTON BRIDGE APARTMENTS

	Outside		Inside			
Date	2nd Fl	Roof	2nd Fl	Roof	BR	T
Heating						
9/30	-	135.4	-	100.1	-	-
10/26	128.8	71.2	48.5	79.4	-	-
10/27	-	71.2	-	98.0	-	-
11/2	87.6	50.3	-	92.2	-	-
11/16	96.7	72.9	54.6	100.8	-	-
11/17	176.5	136.1	95.5	142.4	-	-
11/23	-	93.4	-	-	-	-
11/24	108.1	75.4	60.9	57.4	-	-
12/1	174.0	177.1	-	69.9	143.2	-
12/2	130.7	121.2	-	69.4	126.2	-
12/7	122.7	79.6	105.6	70.6	88.5	-
12/8	204.9	243.6	-	106.9	184.8	-
12/9	177.9	140.7	78.0	93.5	124.6	-
12/14	141.7	95.1	45.8	91.1	82.6	-
12/15	287.6	96.4	49.5	93.8	129.2	-
12/16	105.6	36.4	29.4	-	75.9	-
12/21	213.6	107.6	52.9	-	115.5	-
12/22	121.7	65.6	38.8	-	104.5	81.8
12/28	264.4	144.4	35.1	-	89.9	56.0
12/29	194.8	87.7	35.5	-	90.2	75.9
1/12	158.8	59.9	-	-	-	62.7
Non-Heating						
9/17	129.1	192.5	79.5	-	-	-
10/14	115.2	104.7	90.7	82.5	-	-
Ave.	156.9	106.8	60.0	89.9	112.9	69.1

exceeded the primary standard of 260 $\mu g/M^3$. The other three locations never exceeded the primary or secondary standards during any of the 24 hour samplings. The lowest concentrations were recorded inside at the second floor level.

Both inside and outside concentrations varied greatly from day to day and there was great overlapping of the concentration ranges as shown on Figure 5.1.3-1. Outside, the particulate concentration fluctuated more than it did inside the building. Second floor concentrations exceeded roof concentrations outdoors 17 out of the 20 days for which comparable samples were obtained. The second floor indoor particulate level never exceeded the outdoor 2nd floor concentration for the same day. The roof inside concentrations exceeded the concentrations outdoors seven times for the same days.

Examination of Figure 5.1.3-1 shows that, in general, the particulate level at all six locations show similar characteristics. Minimum levels were recorded on 12/16 at three locations, i.e., roof outside, boiler room and 2nd floor inside. The particulate level at the 2nd floor outside for that date was the next to lowest concentration measured at that location. The low at the 2nd floor outdoor location occurred on 11/2; the same date for which the roof outside level was the next to lowest reading. Similarly, primary and secondary peaks occurred at most locations on 11/17, 12/8 and 12/28. The behavorial likeness of the particulates at all locations strongly suggests that they are affected by a common source.

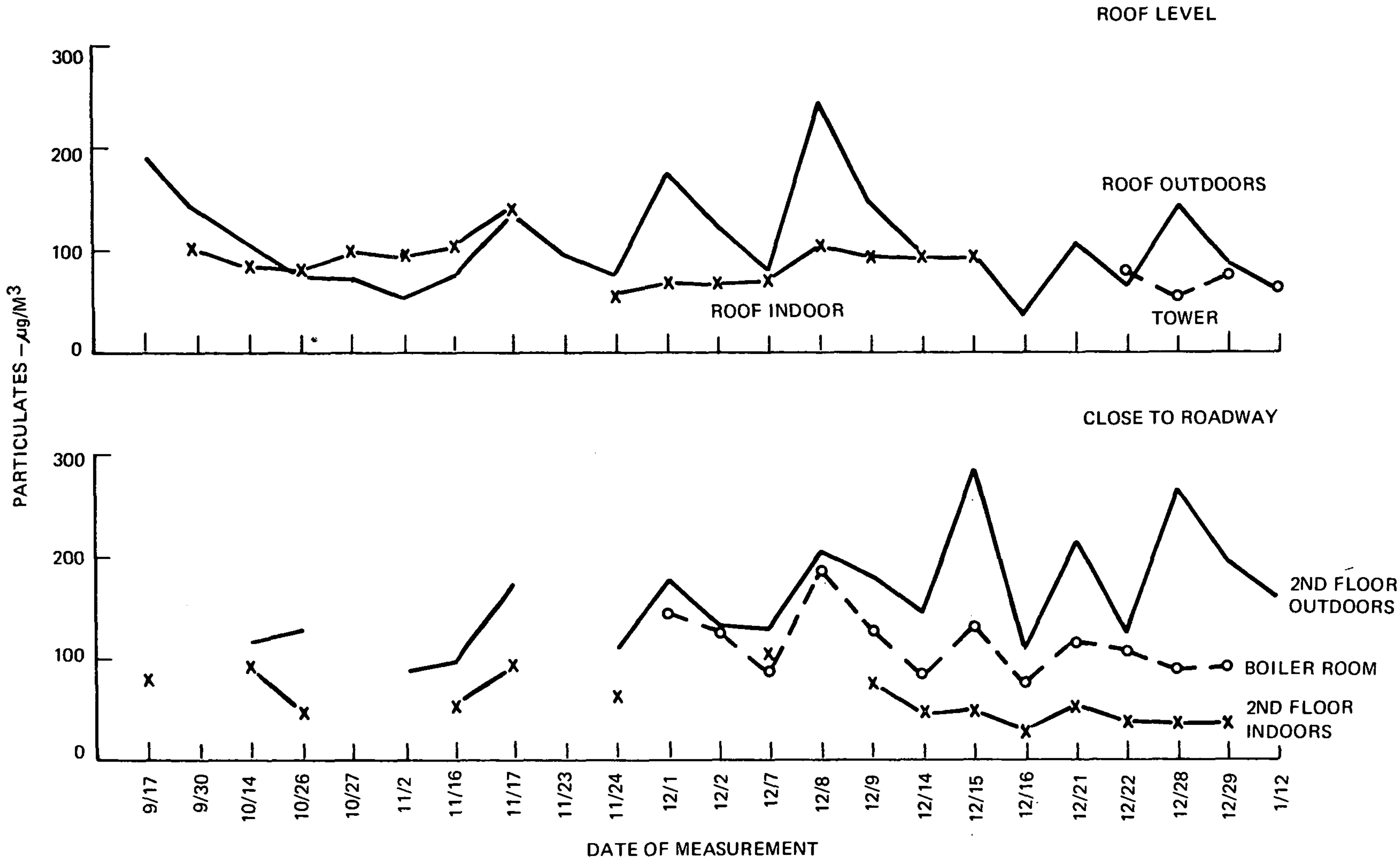


Figure 5.1.3-1. Particulates – George Washington Bridge Apartments

5.1.3.1 Analysis Technique

Each particulate sample obtained was gathered over a consecutive 24 hour period. However, the 24 hour periods varied from day to day. Since the start and end times for each sample were known, and the particulate sample represented a complete diurnal cycle, daily comparisons of particulate levels with traffic and meteorological conditions were made.

The analysis was conducted by determining the average hourly level of the parameter involved for the 24 hour span for which particulate data was obtained. Since complete 24 hour readings were not always available for each parameter, data is not presented when more than four readings were missing. Average hourly data was used, or assumed, to replace the missing readings when less than four readings were not recorded. The resultant data is shown on Table 5.1.3-2.

5.1.3.2 Particulate Relationships

Analysis of the daily total particulate levels with the average hourly traffic flow rate for the 24 hour sample period shows little or no direct relationship. Figure 5.1.3-2 presents the total particulate level at the roof and 2nd floor levels plotted against average traffic flow rate. Both outdoor locations show a random pattern. The indoor particulate levels are independent of traffic flow rate.

Wind azimuth angle significantly influences particulate level. At roof level the particulates are very responsive to roof wind as shown on Figure 5.1.3-3, peaking at 270^{o} and decreasing as the wind shifts clockwise to 45^{o} or counterclockwise to 180^{o}. Indoor roof level concentrations respond to roof winds in exactly the opposite fashion. Low particulate levels occur

TABLE 5.1.3-2

SITE ENVIRONMENT
GEORGE WASHINGTON BRIDGE APARTMENTS

Date	Road Traf	2nd Floor Temp	2nd Floor Az Angle	2nd Floor Wd Sp	Roof Temp	Roof Az Angle	Roof Wd Sp
9/17 *	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-
10/14 *	7201	70	147	3.9	67	189	-
26	6411	52	111	5.3	48	59	19.8
27	6528	45	113	2.9	42	65	11.0
11/2	6277	55	59	6.4	54	47	12.1
16	6475	40	300	6.8	38	358	6.1
17	6541	46	349	1.6	43	46	7.9
23	7027	30	-	-	28	-	-
24	7182	30	319	8.9	28	346	8.0
12/1	6411	50	-	-	48	300	7.0
2	6360	55	220	6.9	54	9	3.2
7	6775	23	348	-	22	-	3.7
8	6491	37	248	-	35	276	5.0
9	6297	43	269	8.8	42	357	6.4
14	6180	34	304	-	33	344	5.6
15	6531	31	17	-	28	57	-
16	-	37	336	-	34	-	-
21	6456	31	-	-	28	57	13.0
22	6036	30	-	-	27	2	-
28	6939	26	-	-	25	321	7.8
29	7120	24	-	-	23	331	8.4
1/12	-	25	-	-	22	-	-
Ave	6586	39	353	5.7	37	356	8.3

* NON-HEATING DAY

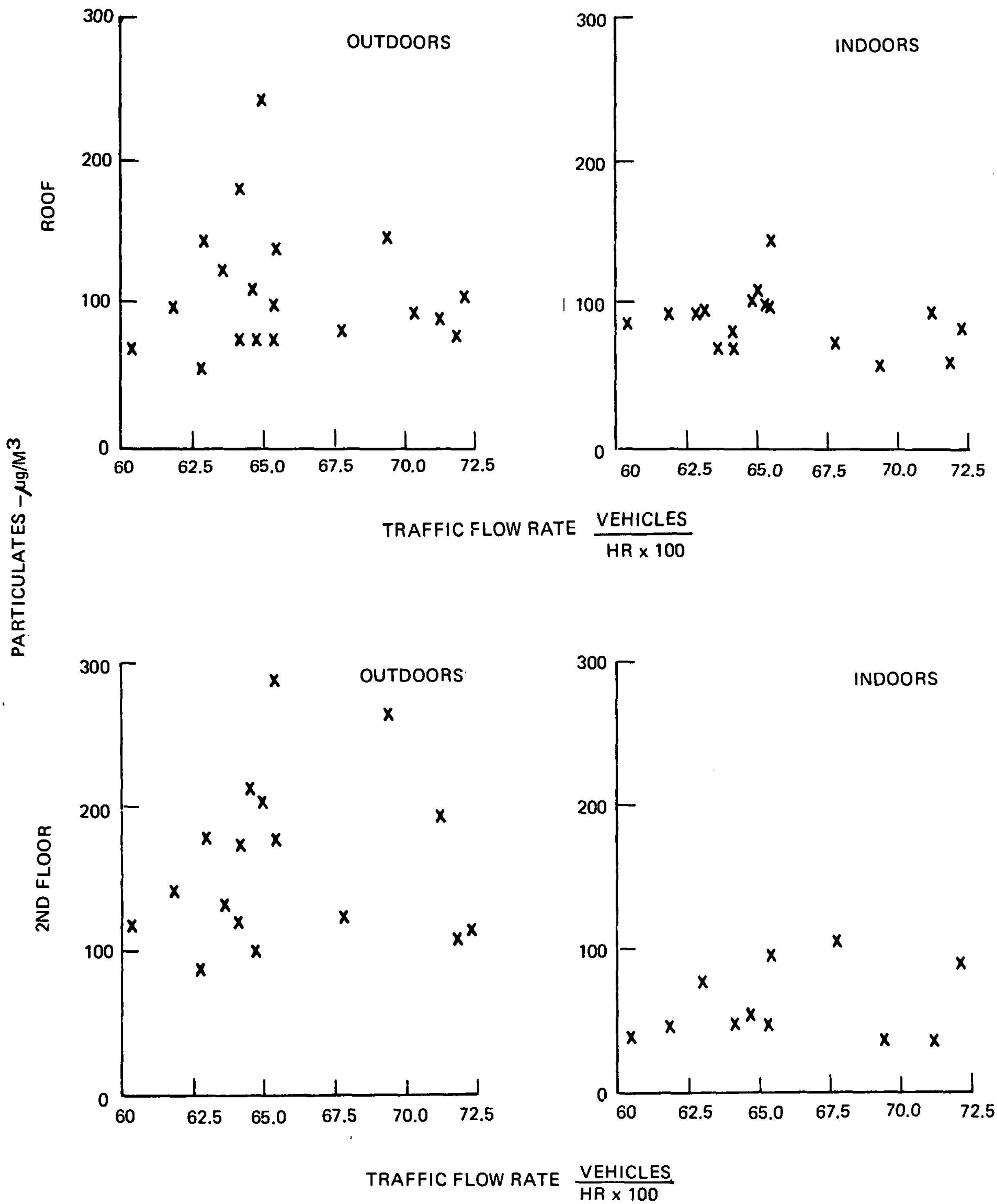


Figure 5.1.3-2. Particulates Vs. Traffic Flow Rate - Site 1

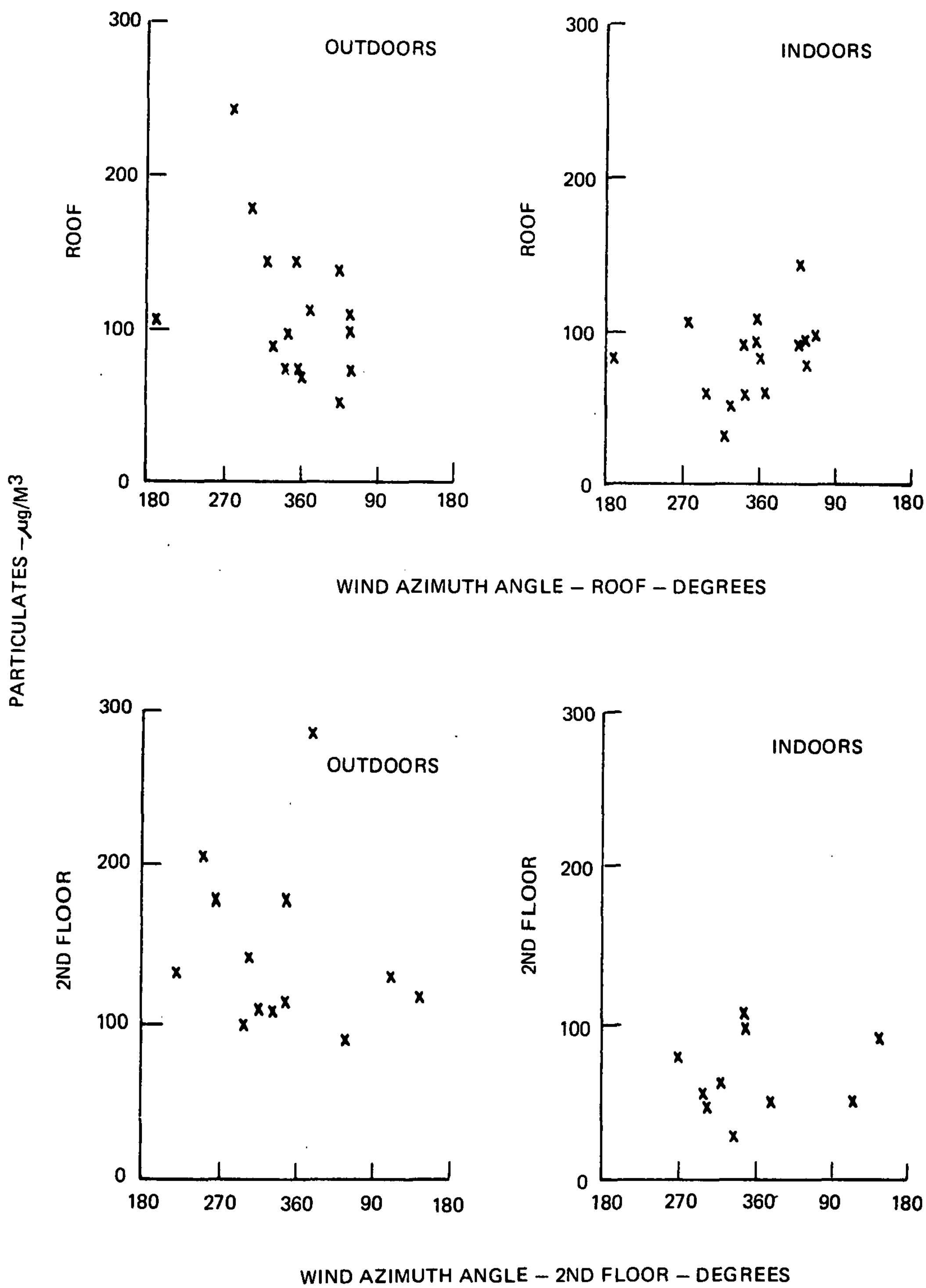


Figure 5.1.3-3. Particulates Vs. Wind Azimuth Angle – Site 1

at 300° and high levels occur at 45°. At the second floor level, neither the outdoor nor the indoor particulate levels demonstrate strong relationship to wind direction as measured at the 2nd floor level. However, the 2nd floor particulates show a relationship to roof wind azimuth angle as demonstrated on Figure 5.1.3-4. The outdoor particulates are low when the roof wind blows from about 45° and increase as the wind shifts counterclockwise towards 270°. The opposite effect is seen at the 2nd door indoor location. At roof level, the outdoor roof concentration levels suggest a particulate/road wind relationship but the indoor particulate concentrations are random with road wind.

As can be seen from Figure 5.1.3-5, the particulate/temperature relationship appears random at the two outdoor locations. The second floor concentrations however display a general reduction with temperature increase. Indoors, both roof and 2nd floor particulate concentrations are independent of temperature.

The 2nd floor outdoor particulates actually are influenced by both winds and the prevailing temperature. Figure 5.1.3-6 again presents 2nd floor outdoor particulates versus roof level wind and shows the days of constant temperature conditions. This plot clearly indicates that roof winds from the north reduce the particulate concentration. The actual particulate level increases for constant roof wind angles as temperature decreases. Particulates also increase for constant roof winds as the road wind shifts from the east thru north and to the west. This can be seen on Figure 5.1.3-7, which shows particulates versus 2nd floor wind and lines of constant roof wind. (The abscissa is folded about 270° road azimuth.)

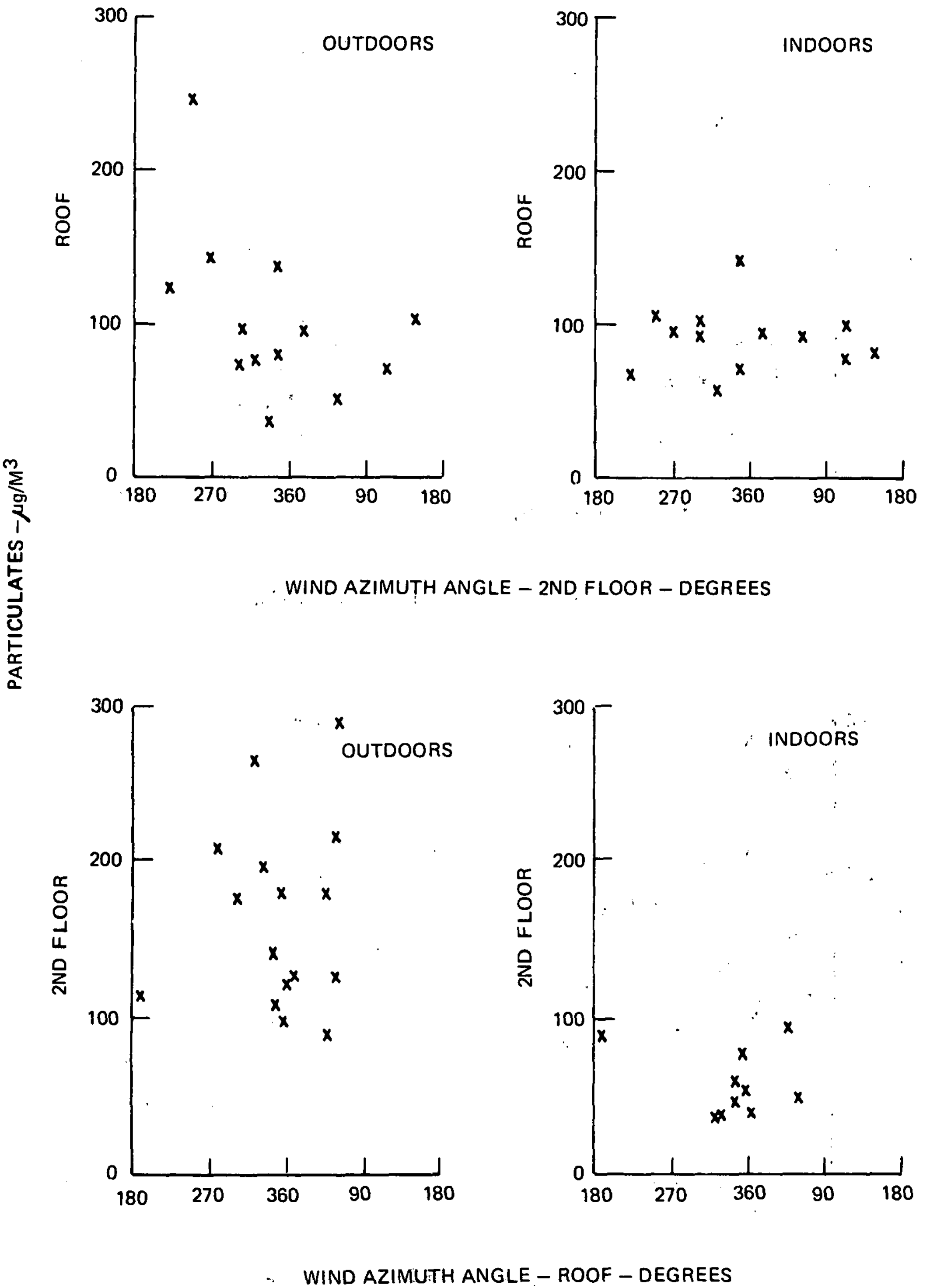


Figure 5.1.3-4. Particulates Vs. Wind Azimuth Angle – Site 1

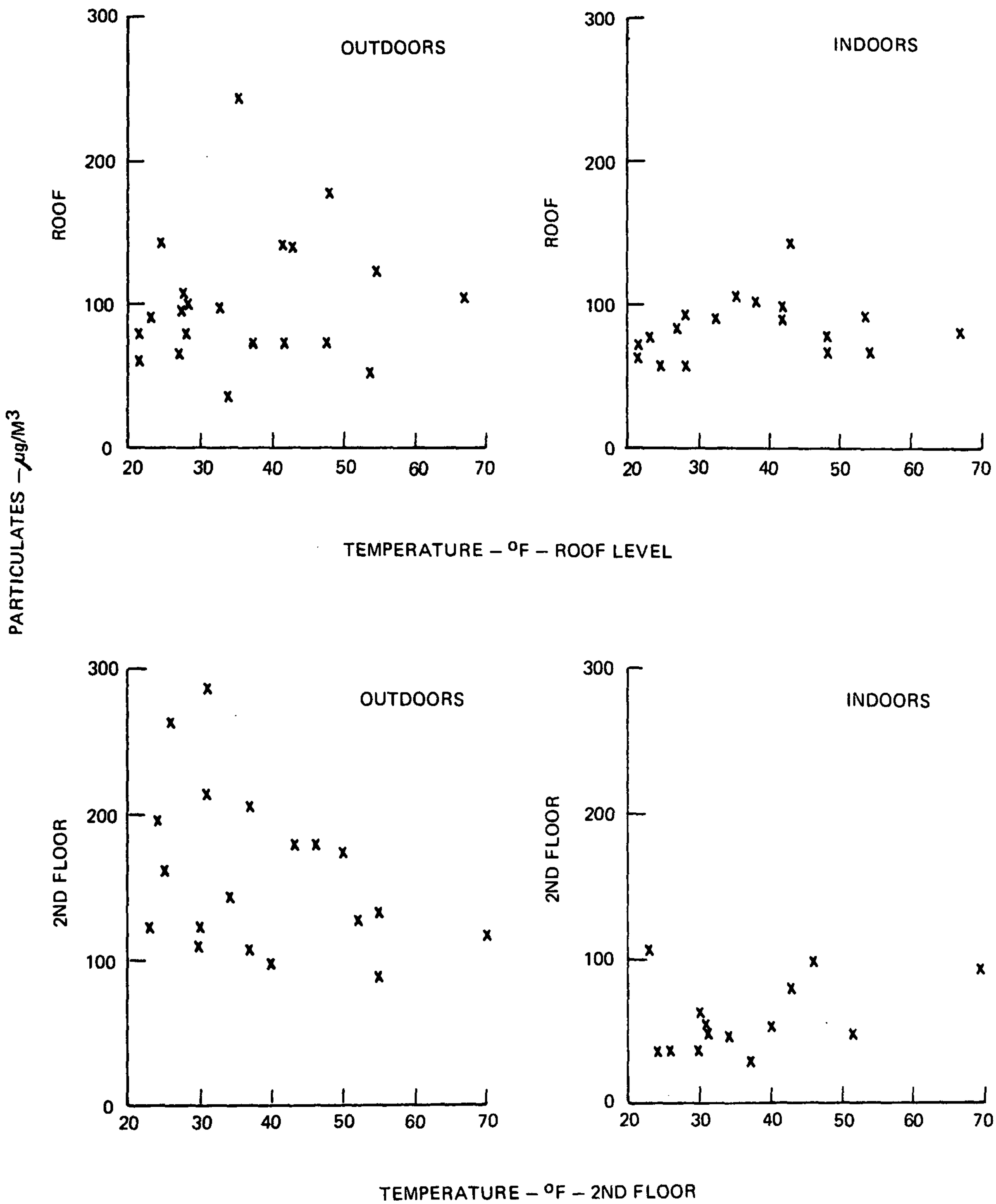


Figure 5.1.3-5. Particulates Vs. Temperature – Site 1

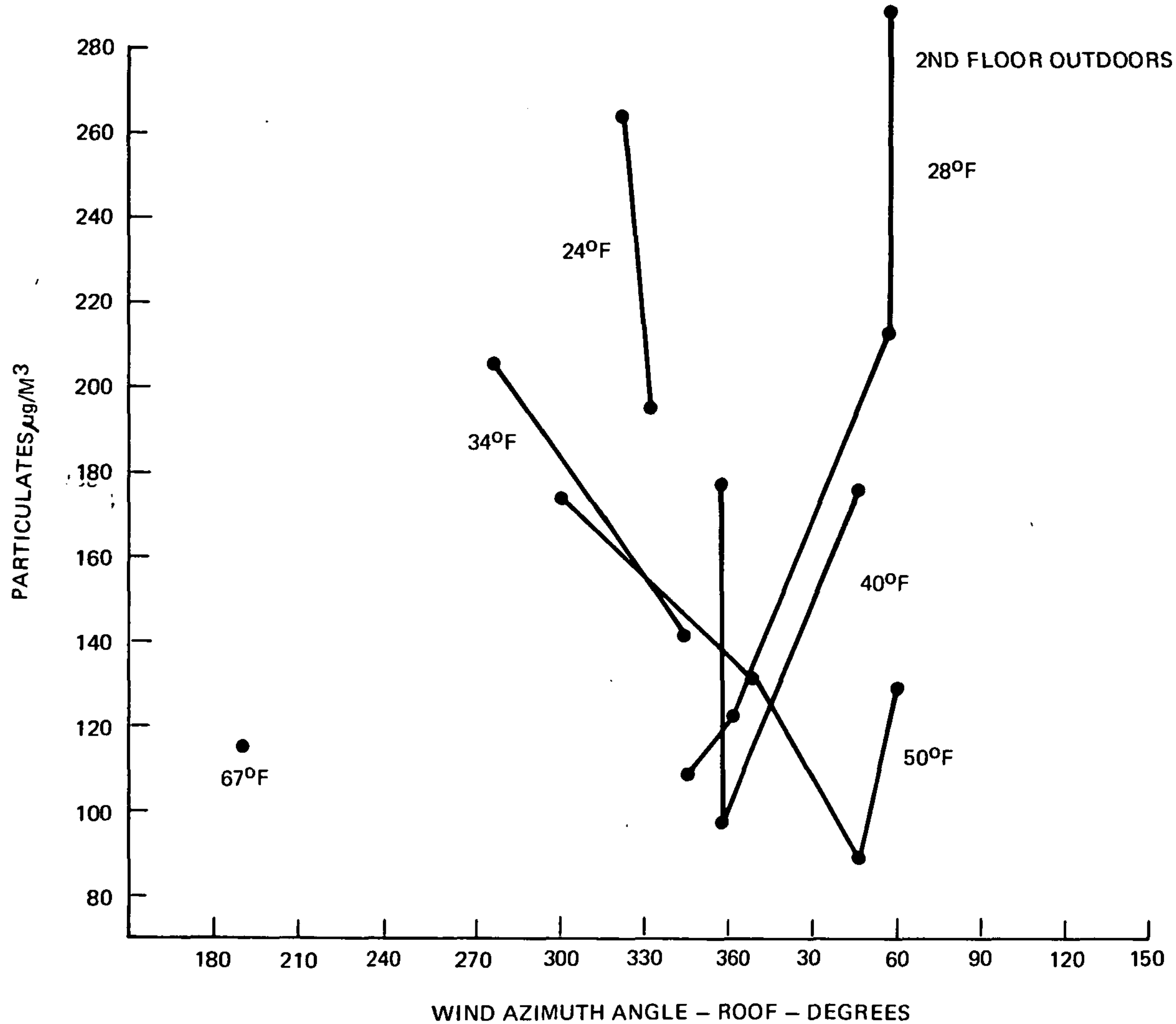


Figure 5.1.3-6. Particulates Vs. Roof Wind and Roof Temperature – Site 1

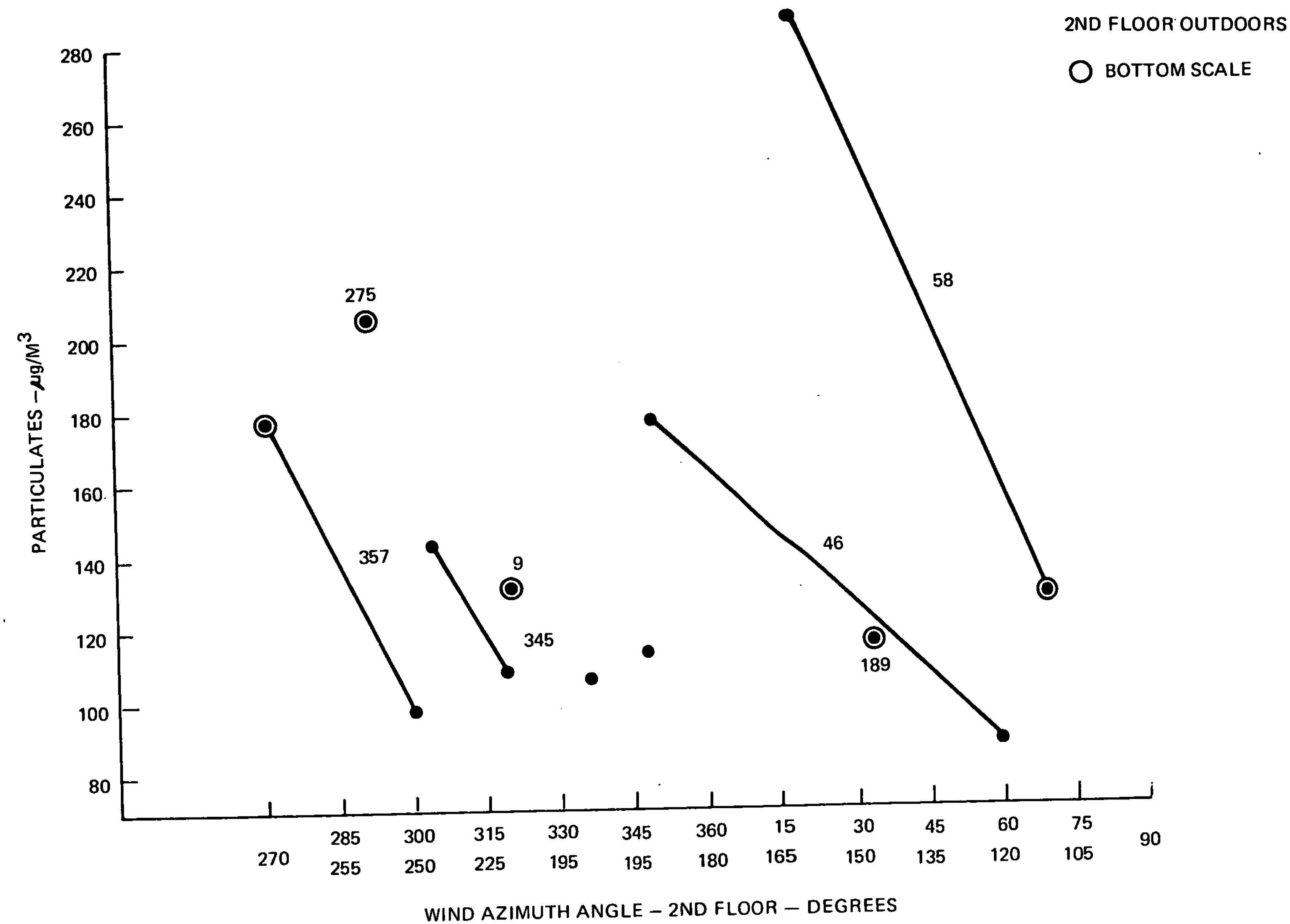


Figure 5.1.3-7. Particulates Vs. 2nd Floor and Roof Wind Azimuth Angles – Site 1

The indoor/outdoor particulate relationship at roof level is clearly determined by roof wind, as shown on Figure 5.1.3-8. The outside concentration is considerably greater than inside concentration for a 270^o roof wind. The differential reduces as the wind shifts from this angle, such that the inside concentration exceeds outside particulate level for roof winds from the northeast (45^o). It is evident therefore, that roof level particulates are derived from the same source. The concentrations measured outdoors and indoors are determined by the roof wind angle. Temperature does not appear to have a significant effect.

The indoor/outdoor particulate differential at the 2nd floor plotted on Figure 5.1.3-8 does not show a comparable relationship to 2nd floor wind. It will be noticed that this differential shows the same relationship to temperature as seen on Figure 5.1.3-5 for the outdoor particulates. This is because 2nd floor differential is a function of 2nd floor outdoor concentrations as shown on Figure 5.1.3-9. Indoor concentrations are independent of outdoor particulates at the 2nd floor.

The particulate relationship outdoors between roof and floor levels is also determined by roof level wind direction. As can be seen from Figure 5.1.3-10, roof particulates are higher than 2nd floor concentrations at 270^{o}roof winds and significantly lower for north and east winds. The plot of outdoor differential versus 2nd floor wind suggests that the road wind angle does not noticeabley influence the differential. The indoor differential shows the reverse effect with roof wind azimuth i.e., high for north and east winds and low as the roof wind shifts towards 270^o. This reflects the contribution of roof winds on the roof level

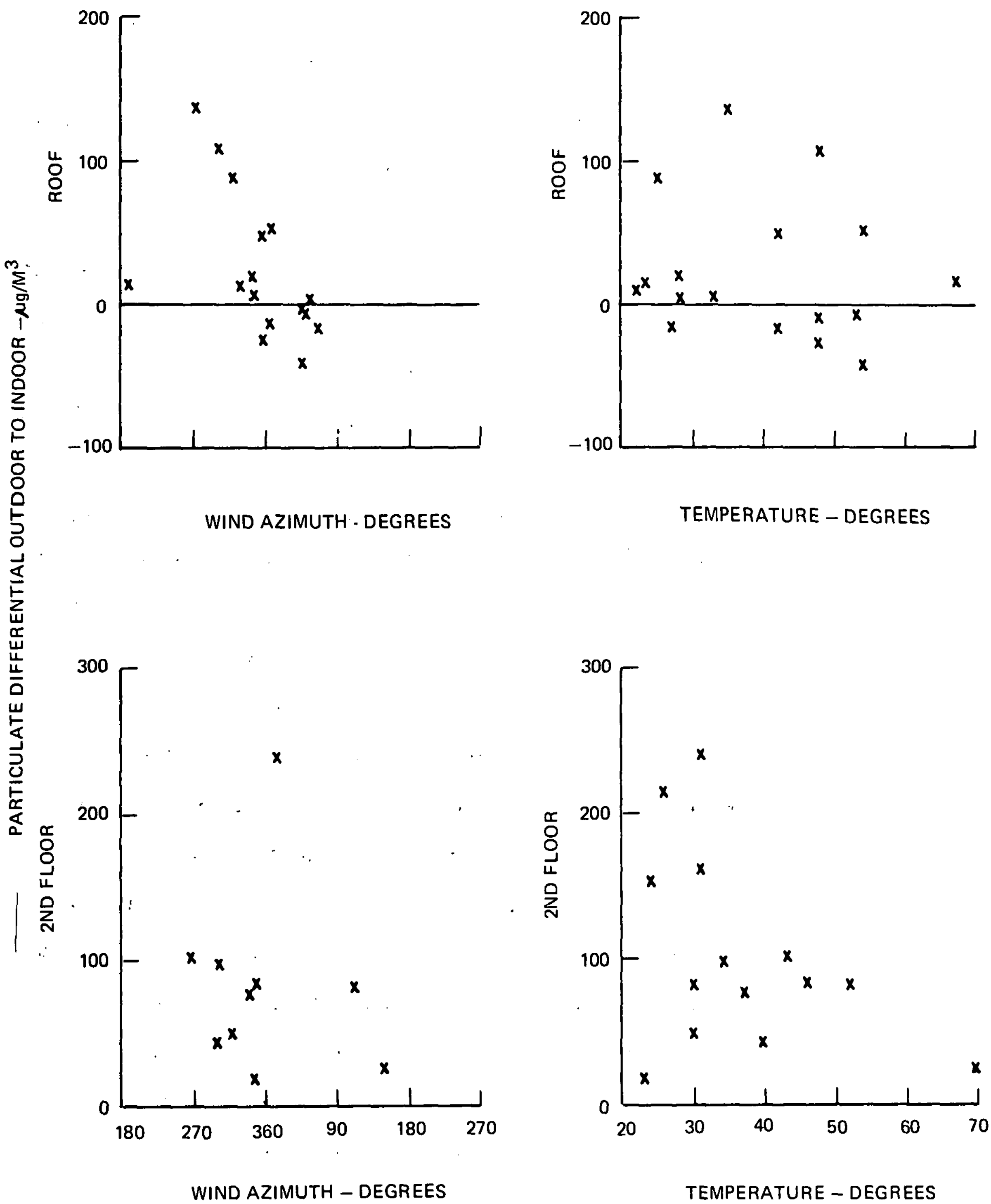


Figure 5.1.3-8. Particulate Differential – Site 1

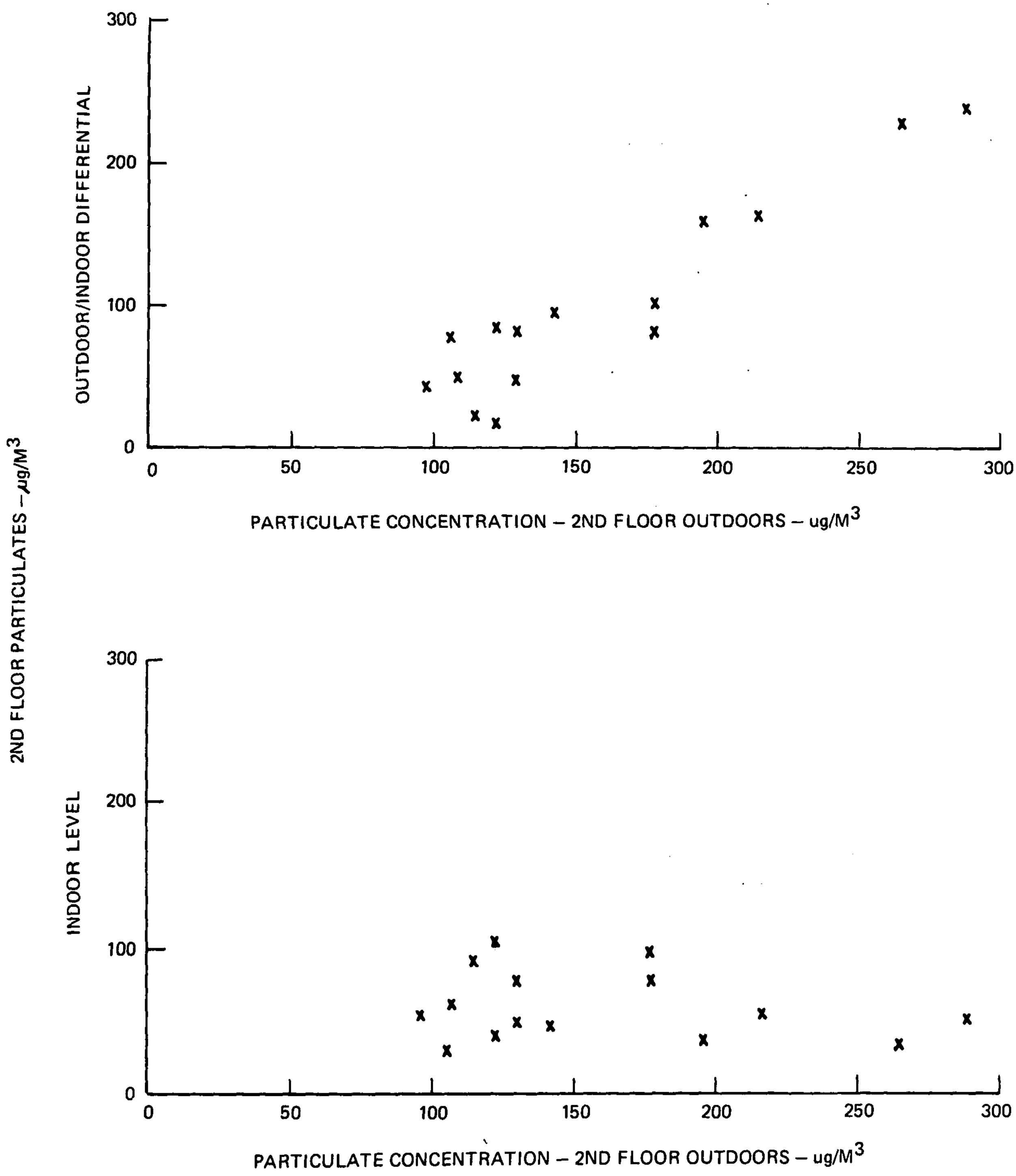


Figure 5.1.3-9. 2nd Floor Particulates – Site 1

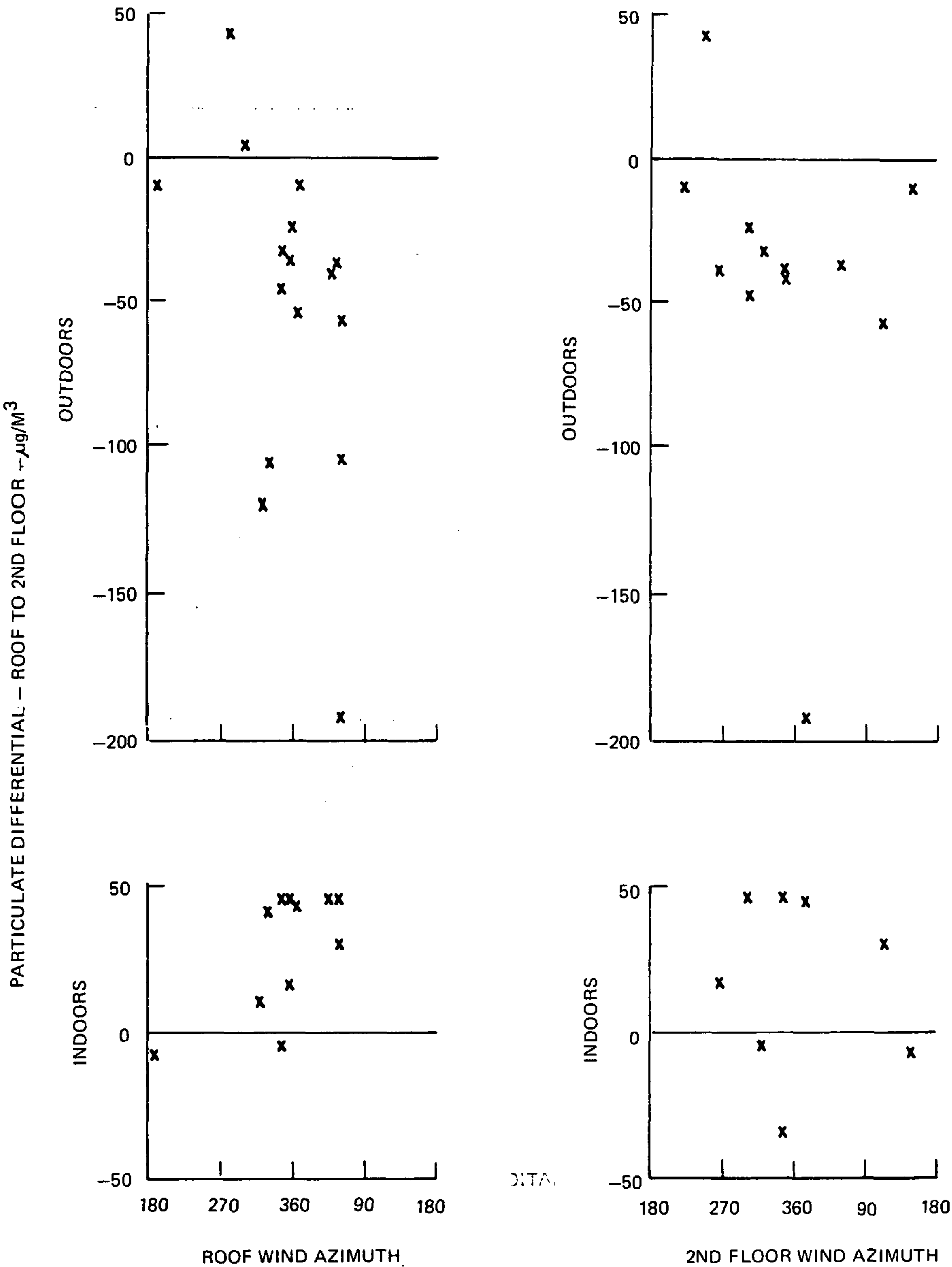


Figure 5.1.3-10. Particulate Differential – Site 1

indoor particulates. The indoor differential appears random with 2nd floor wind, reflecting the lack of impact of road wind on either roof or 2nd floor indoor particulate levels.

Boiler room particulates appear to be related to both roof and 2nd floor level winds and not to traffic or temperature. Similarly the differential between the boiler room and the roof and 2nd floor inside locations suggest a wind direction influence. The smallness of the data sample precludes a positive conclusion (See Figures 5.1.3-11 and -12). The inference is drawn, however, that particulates found in the boiler room come from the same source as roof level particulates.

5.1.3.3 Particulate Summation

Examination of Figures 4.1-3 on page 4-5 will show that the Hi Vol Sampler on the roof was located east of the building chminey. The roof indoor sampler was closer to the chimney than the outdoor sampler. Winds from 270° would blow from the chimney towards the outdoor sampler. Similarly winds from the north and east would blow towards the indoor sampler. The plot of particulate differential at roof level shown on Figure 5.1.3-8 clearly indicates that roof level particulates eminate from the chimney.

Figure 4.1-3 also shows that the 2nd floor outdoor Hi Vol is west of the chimney. Roof winds which blow chimney exhausts directly away from the outdoor roof sampler blow them towards the 2nd floor sampler. However, winds at the lower floors determine how these particulates are dispersed as they settle towards the 2nd floor sampler.

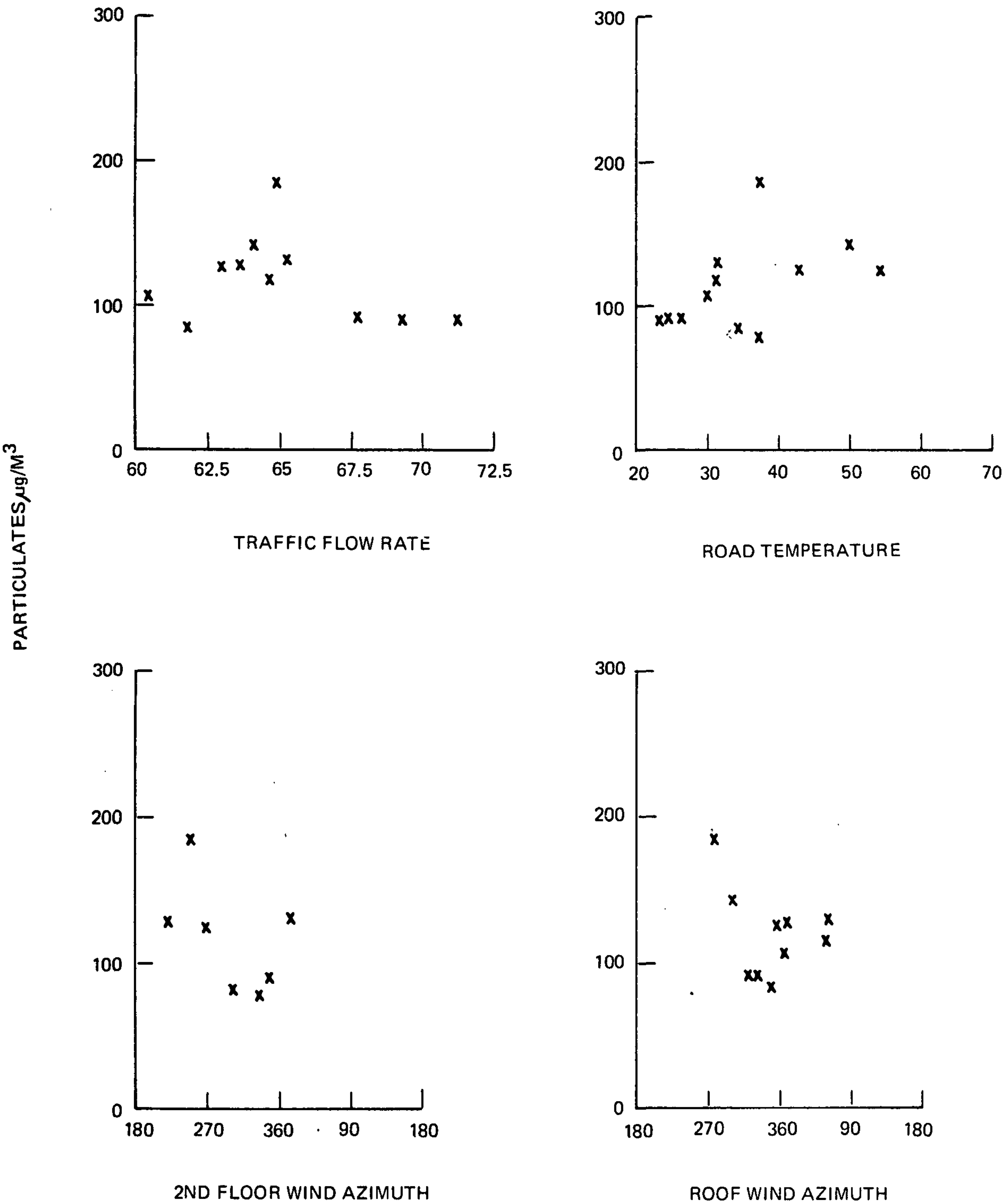


Figure 5.1.3-11. Boiler-Room Particulates – Site 1

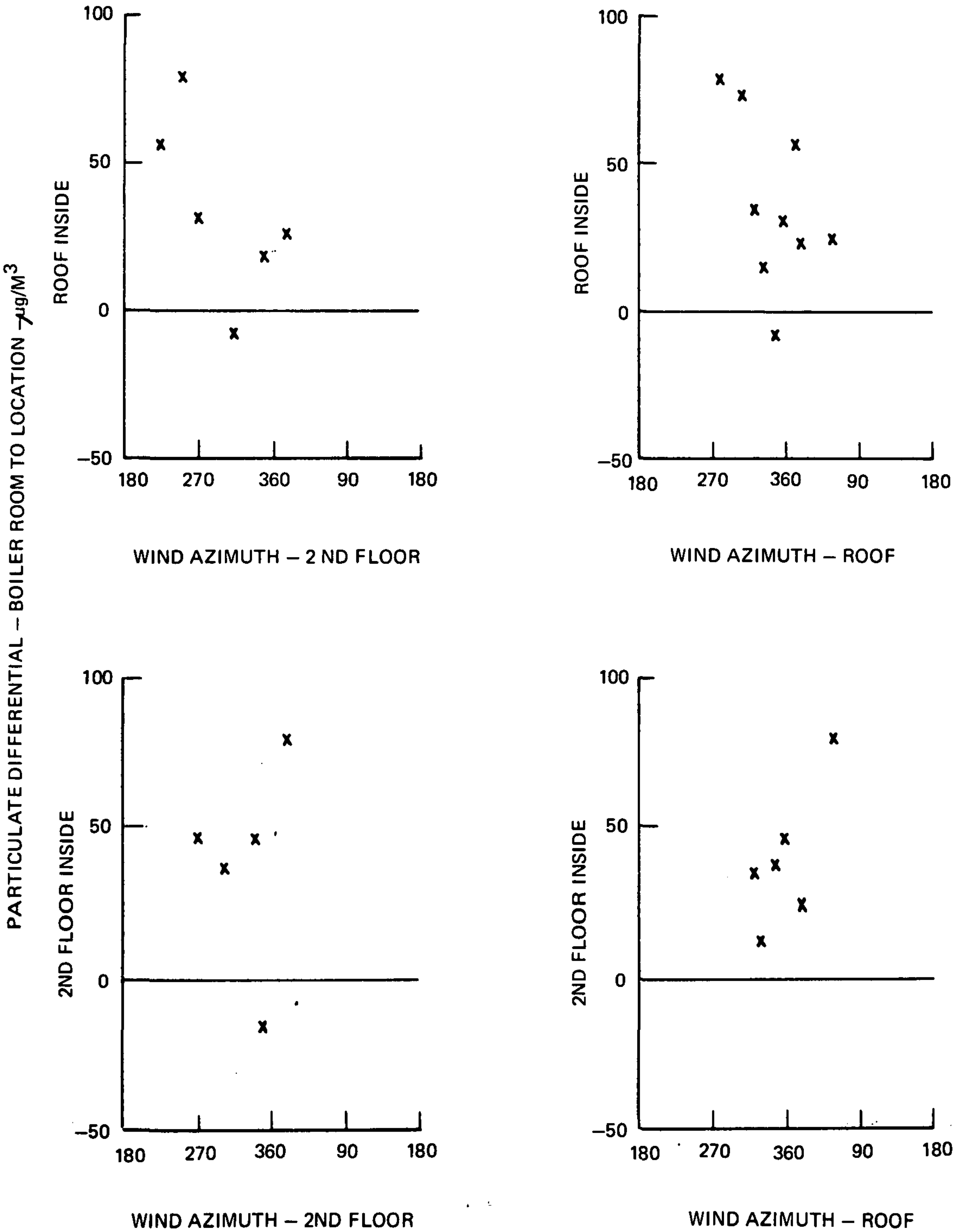


Figure 5.1.3-12. Boiler Room Particulate Differential – Site 1

5.1.4 Lead

All particulate samples collected at the George Washington Bridge Apartments were analyzed for lead content using an atomic absorption technique. The analysis determined both the quantity and percentage of lead included in the particulate samples. Figures and Tables 5.1.4-1 and -2 present the data obtained.

Comparison of the figures reveals a general similarity at the roof level locations between the quantity and percentage of lead. Close to the road, however, a marked difference was recorded during December in lead quantity between the outdoor and indoor locations. This difference did not happen in a similar manner for the lead percentage. Comparison of Figure 5.1.4-1 with Figure 5.1.3-1, for total particulates, will suggest that the lead quantity measured close to the road is directly related to total particulates. Lead percentage however appears to be unrelated to total particulates.

5.1.4.1 Lead Quantity

The highest lead concentration was recorded outside on the second floor balcony on December 1. The second highest concentration occurred in the basement boiler room on the same day. The lowest lead concentrations were measured on December 16 indoors at the 2nd floor level. At roof level outdoor and indoor concentrations varied in a common fashion. The wide variations at all locations from day to day suggest that wind direction influences lead concentrations in a similar fashion as it affected total particulates.

Figure 5.1.4-3 presents the lead concentrations at roof and 2nd floor locations plotted against the winds at the respective floors. Roof winds from 270° produce high concentrations and winds from 45° and 180° create

TABLE 5.1.4-1

LEAD - $\mu g/M^3$

GEORGE WASHINGTON BRIDGE APARTMENTS

Date	2nd Flr. (Outside)	Roof (Outside)	2nd Flr. (Inside)	Roof (Inside)	BR.	Tower
Heating						
9/30	-	1.27	-	1.30	-	-
10/26	2.53	.52	1.06	.97	-	-
10/27	-	.97	-	1.28	-	-
11/ 2	1.61	.61	-	.72	-	-
11/16	2.68	1.00	1.58	1.52	-	-
11/17	3.07	1.84	-	1.59	-	-
11/23	-	2.43	-	-	-	-
11/24	3.68	2.19	3.29	1.78	-	-
12/ 1	6.35	1.95	-	1.82	5.87	-
12/ 2	2.75	2.18	-	1.74	4.54	-
12/ 7	4.30	2.47	2.96	2.75	3.62	-
12/ 8	4.30	2.68	-	2.25	5.73	-
12/ 9	3.56	1.97	1.40	1.78	3.74	-
12/14	3.26	1.43	1.01	1.37	3.30	-
12/15	4.89	1.06	1.24	1.31	3.88	-
12/16	3.59	1.02	.38	-	3.19	-
12/21	3.63	.86	.74	-	3.35	-
12/22	4.02	.98	.78	-	5.02	1.72
12/28	3.17	1.44	1.30	-	2.61	1.79
12/29	2.53	1.14	1.28	-	3.16	2.13
1/12	2.22	.78	-	-	-	1.91
Non-Heating						
9/17	1.69	1.18	1.05	-	-	-
10/14	2.09	1.41	1.96	1.42	-	-
Ave.	3.29	1.44	1.43	1.56	4.00	1.71

TABLE 5.1.4-2

PERCENT LEAD

GEORGE WASHINGTON BRIDGE APARTMENTS

Date	2nd Flr.	Roof	2nd Flr.	Roof	BR	Tower
	Outside		Inside			
	Heating					
9/30	-	.94	-	1.29	-	-
10/26	1.96	.73	2.18	1.10	-	-
10/27	2.61	1.36	2.25	1.30	-	-
11/ 2	1.83	1.20	1.20	.77	-	-
11/16	2.77	1.38	2.89	1.51	-	-
11/17	1.74	1.35	1.21	1.12	-	-
11/23	3.20	2.6	-	1.60	-	-
11/24	3.40	2.9	5.4	3.1	-	-
12/ 1	2.50	1.1	-	2.6	4.1	-
12/ 2	2.10	1.8	-	2.5	3.6	-
12/ 7	3.50	3.1	2.8	3.9	4.1	-
12/ 8	2.10	1.1	2.1	2.1	3.1	-
12/ 9	2.00	1.4	1.8	1.9	3.0	-
12/14	2.30	1.5	2.2	1.5	4.0	-
12/15	1.70	1.1	2.5	1.4	3.0	-
12/16	3.40	2.8	1.3	.6	4.2	-
12/21	1.70	.8	1.4	-	2.9	-
12/22	3.30	1.5	2.0	-	4.8	2.1
12/28	1.20	1.0	3.7	-	2.9	3.2
12.29	1.30	1.3	3.6	-	3.5	2.8
1/12	1.40	1.3	3.0	-	-	1.9
	Non-Heating					
9/17	1.31	.61	1.32	.47	-	-
10/14	1.82	1.35	2.16	1.73	-	-
Ave.	2.2	1.5	2.4	1.7	3.6	2.5

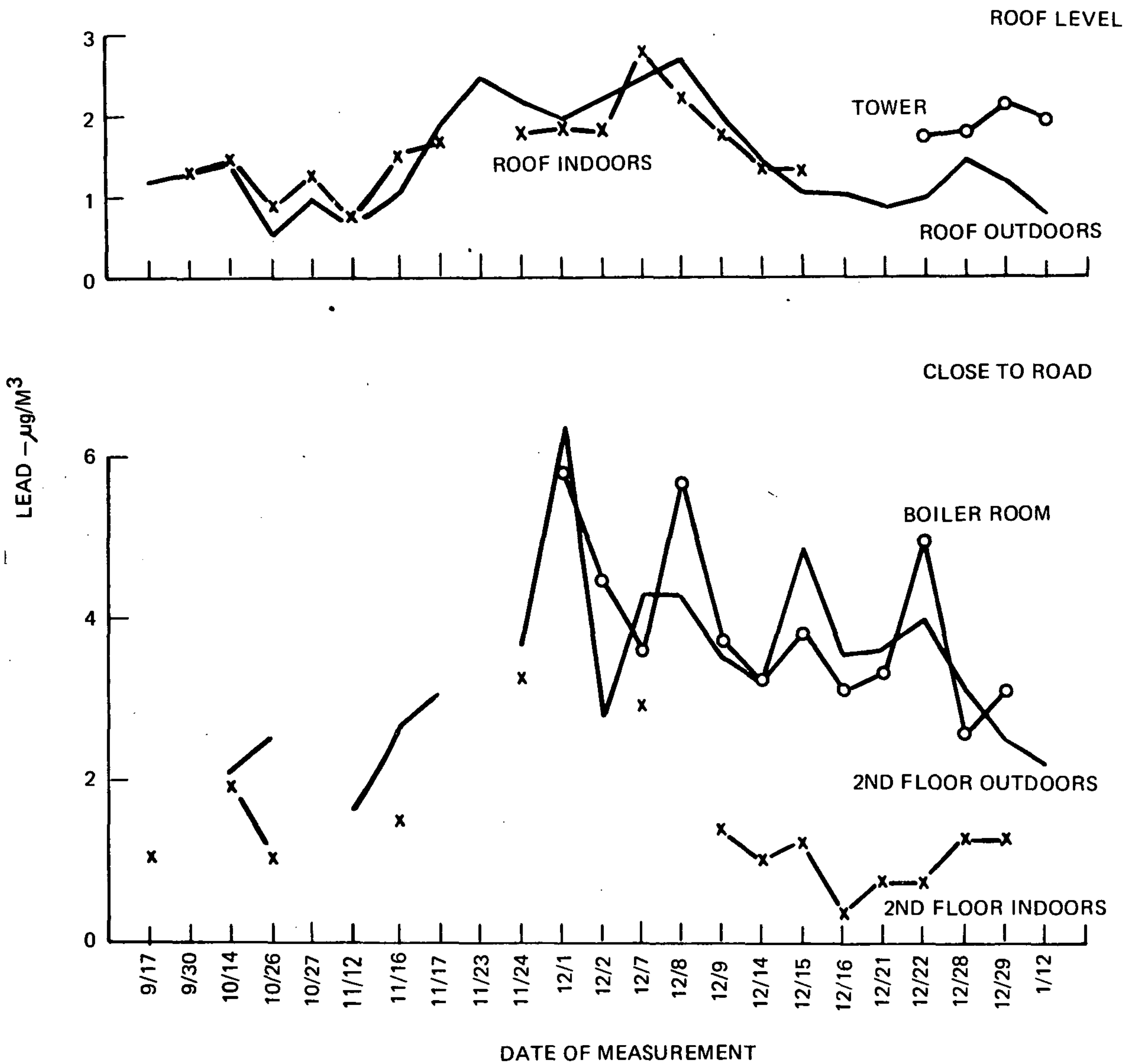


Figure 5.1.4-1. Lead – George Washington Bridge Apartments

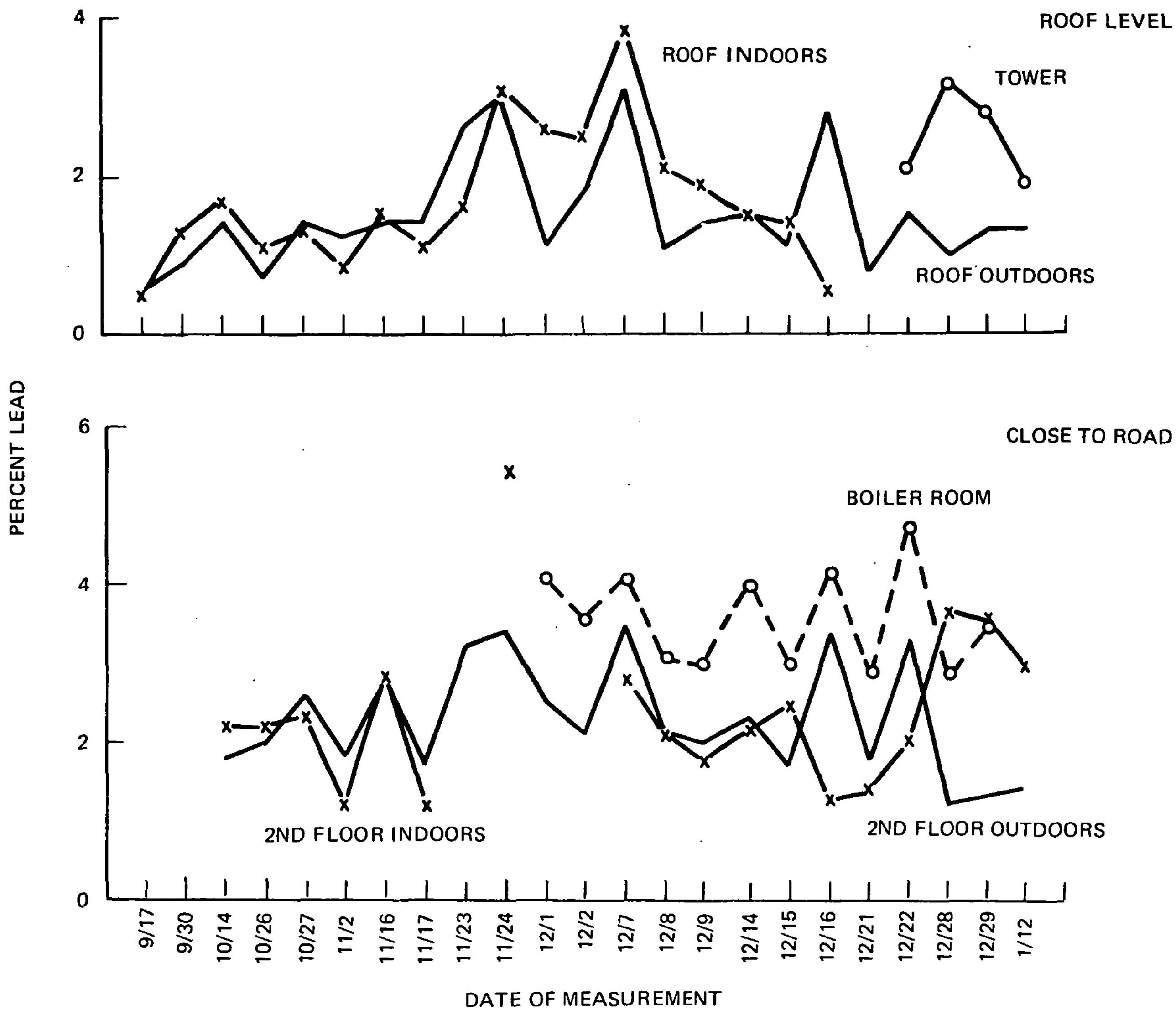


Figure 5.1.4-2. Percent Lead - George Washington Bridge Apartments

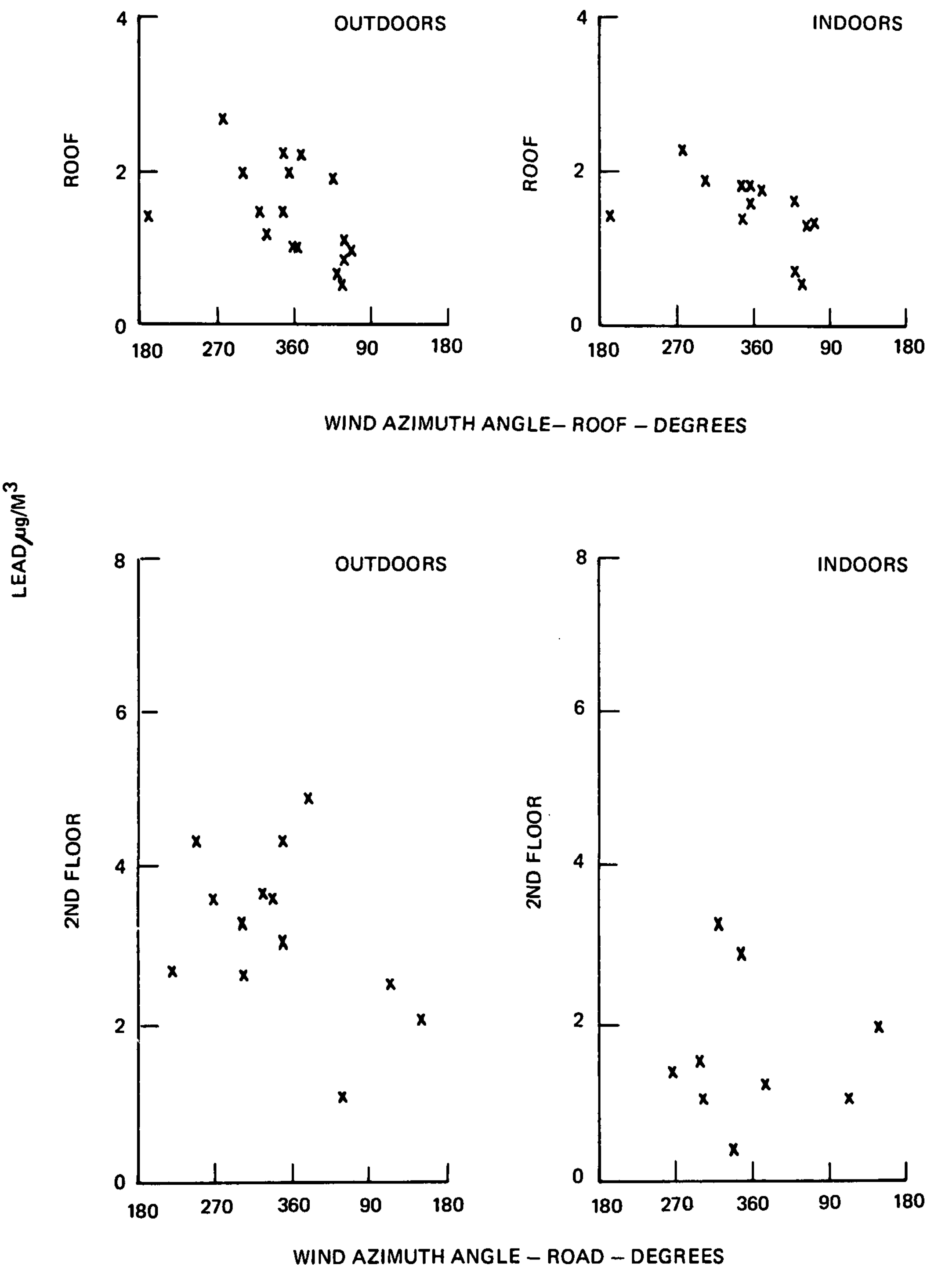


Figure 5.1.4-3. Lead Vs. Wind Azimuth Angle - Site 1

low lead concentrations at both the outdoor and indoor locations. This is the same effect as seen for outdoor total particulates. It, however, is opposite that seen for indoor total particulates. This suggests that the roof level lead concentrations eminate from a source other than the chimney; probably traffic on the Trans Manhattan Expressway.

Lead concentrations at the 2nd floor show high outdoor level for road winds from 300^{o}. As these winds shift counterclockwise thru the west and south, lead concentrations decrease. This is as expected since west and southerly winds blow Trans Manhattan generated pollutants away from the Hi Vol Sampler on the 2nd floor balcony. Second floor indoor concentrations appear random with wind.

Outdoor/indoor lead differentials are controlled at both the roof and 2nd floors by wind direction as shown on Figure 5.1.4-4. The roof level differential is not as distinct as previously noted for total particulates since the source of the lead is northwest of both roof level samplers. Second floor differential shows larger differentials; i.e., higher outdoor concentrations, for east winds and lower differentials for west and south winds.

Since the lead concentrations are highway generated, the vertical differentials are much larger outdoors. As can be seen from Figure 5.1.4-5, 2nd floor lead levels are always greater than roof levels outdoors. Outdoor differentials are influenced by both 2nd floor and roof level wind directions. Indoor differentials vary about zero, showing the small effect of wind on indoor concentrations. Both outdoor and indoor differentials show a closer relation to 2nd floor wind than to roof wind.

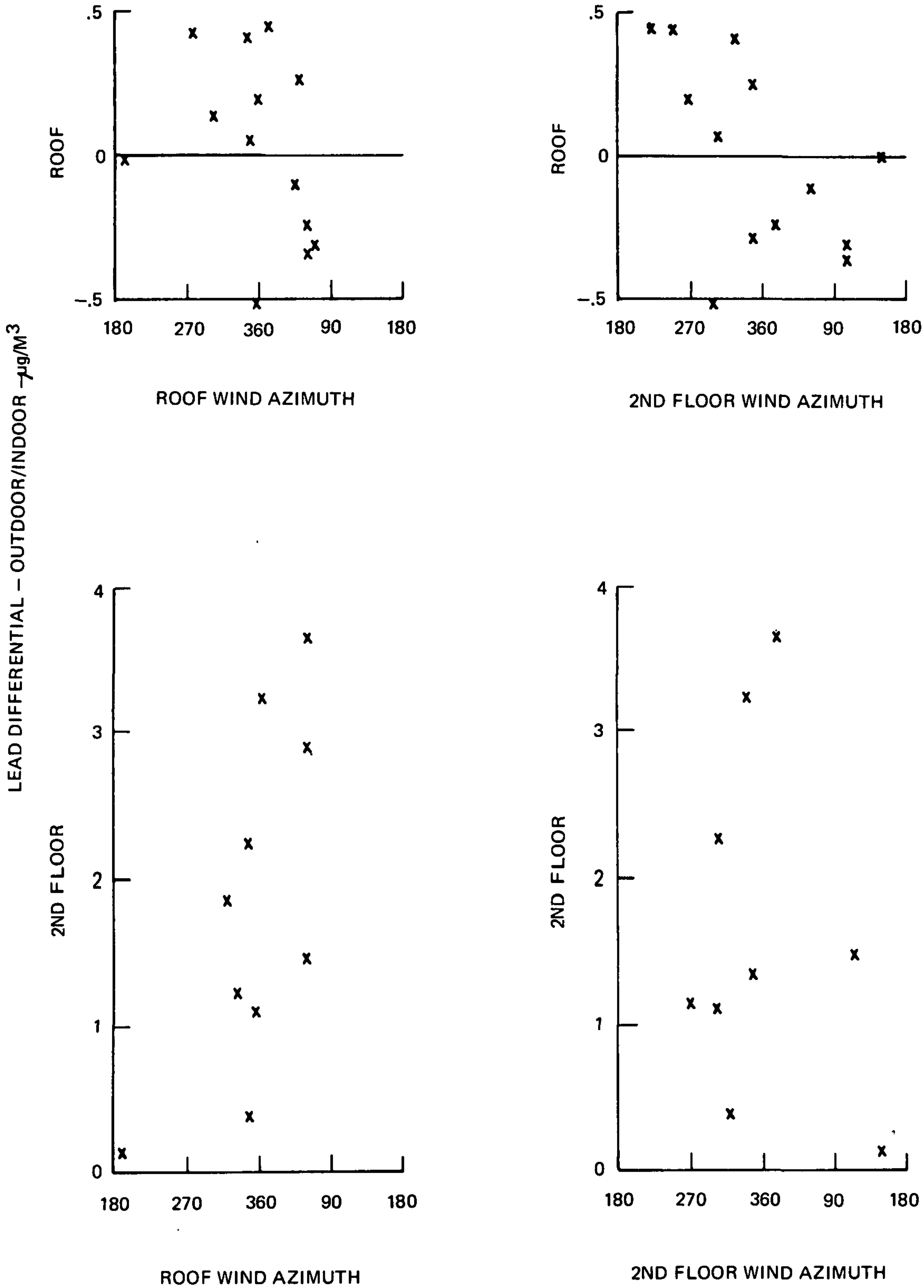


Figure 5.1.4-4. Outdoor/Indoor Lead Differential - Site 1

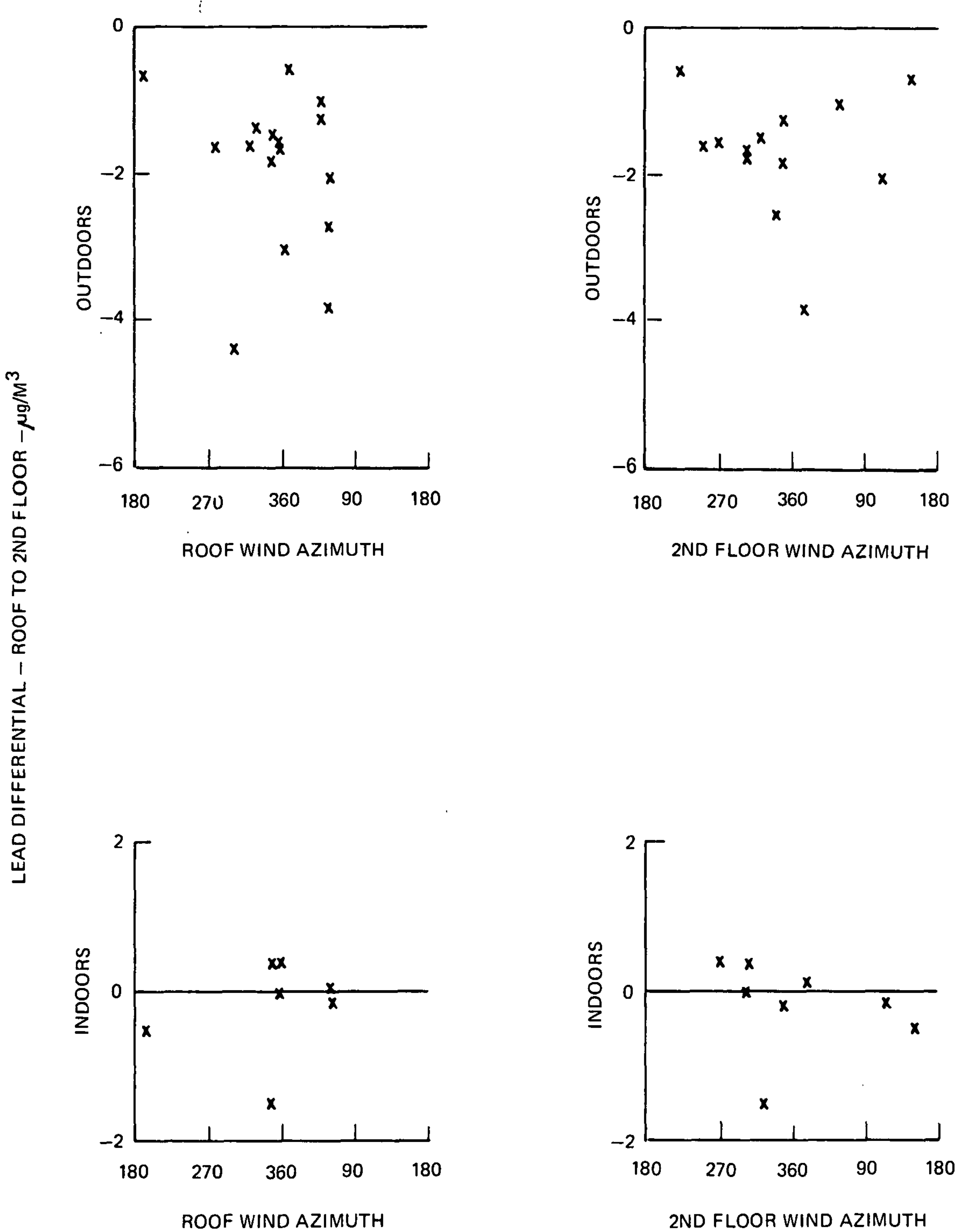


Figure 5.1.4-5. Roof to 2nd Floor Lead Differential - Site 1

The impact of 2nd floor wind can be seen dramatically from Figure 5.1.4-6 which presents data relative to lead concentrations for the boiler room. The lead level in the boiler room is highest for winds blown towards the 178th Street end of the building. The differential lead concentrations to both the roof and 2nd floor inside locations show identical patterns. The differential to the 2nd floor outdoor location is practically a straight line, with the highest differential for winds from 178th Street.

It must be concluded that indoor lead concentrations are blown into the end of the building and filter upwards. Road winds that increase boiler room concentrations therefore effect indoor roof concentrations.

5.1.4.2 Lead Percentage

The highest percentage of lead concentration in the total particulates was found inside at the 2nd floor level on November 24, corresponding to the peak of lead particulates. The lead percentages were high at the 2nd floor outdoor and both roof locations for the same day. Total particulates at the time were well below the average levels for all four locations. However this correspondence in relative percentage of lead did not hold true for all sampling days.

The percent of lead concentration measured is a function of the quantity of roof eminated particulates and traffic generated lead. Since these are independent sources, lead percentage is not directly relatable to environmental factors at the site. As can be seen from Figures 5.1.4-7 and -8, neither traffic nor wind direction significantly establish the percent lead. There is an indication that the 2nd floor and roof indoor locations

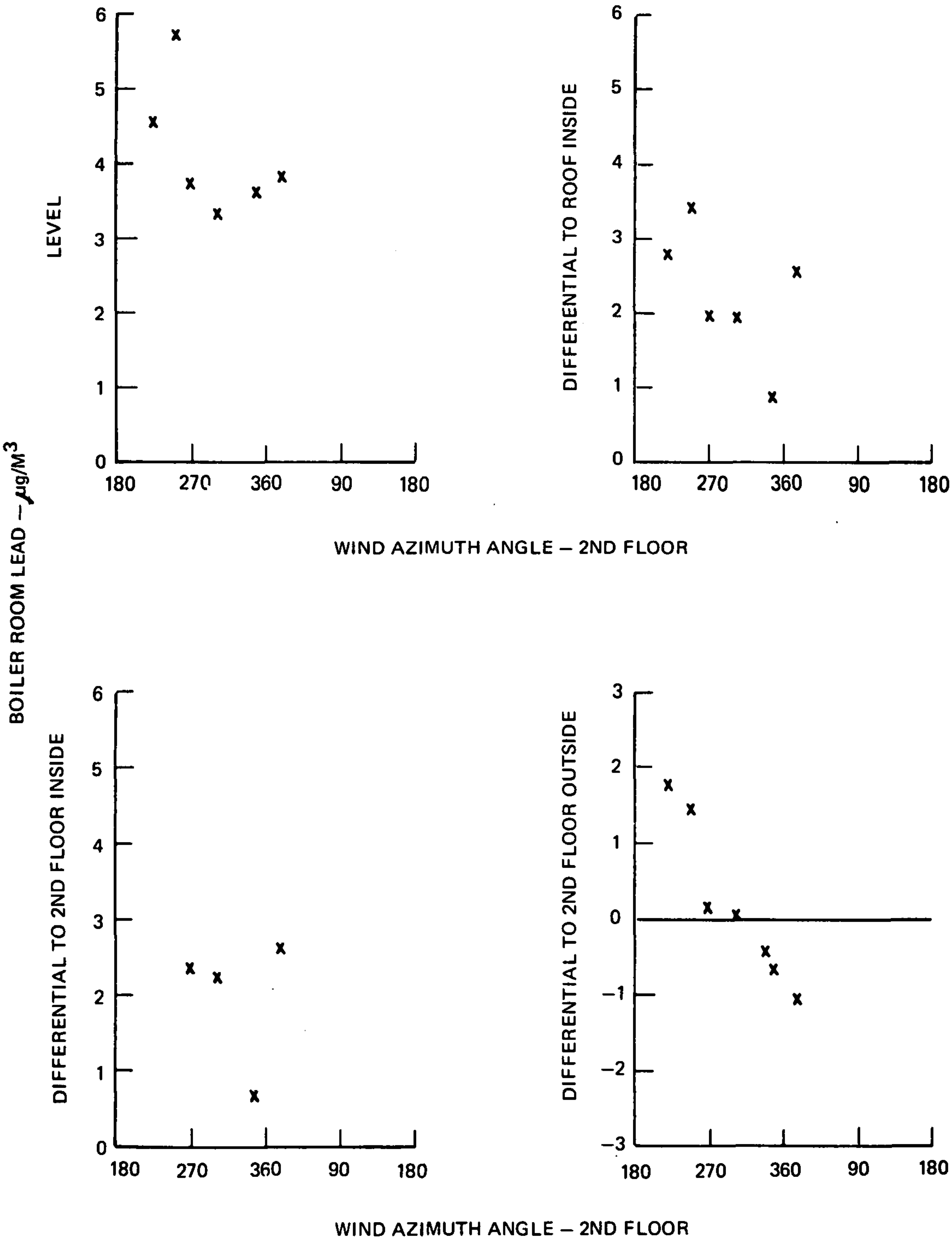


Figure 5.1.4-6. Boiler Room Lead Concentrations - Site 1

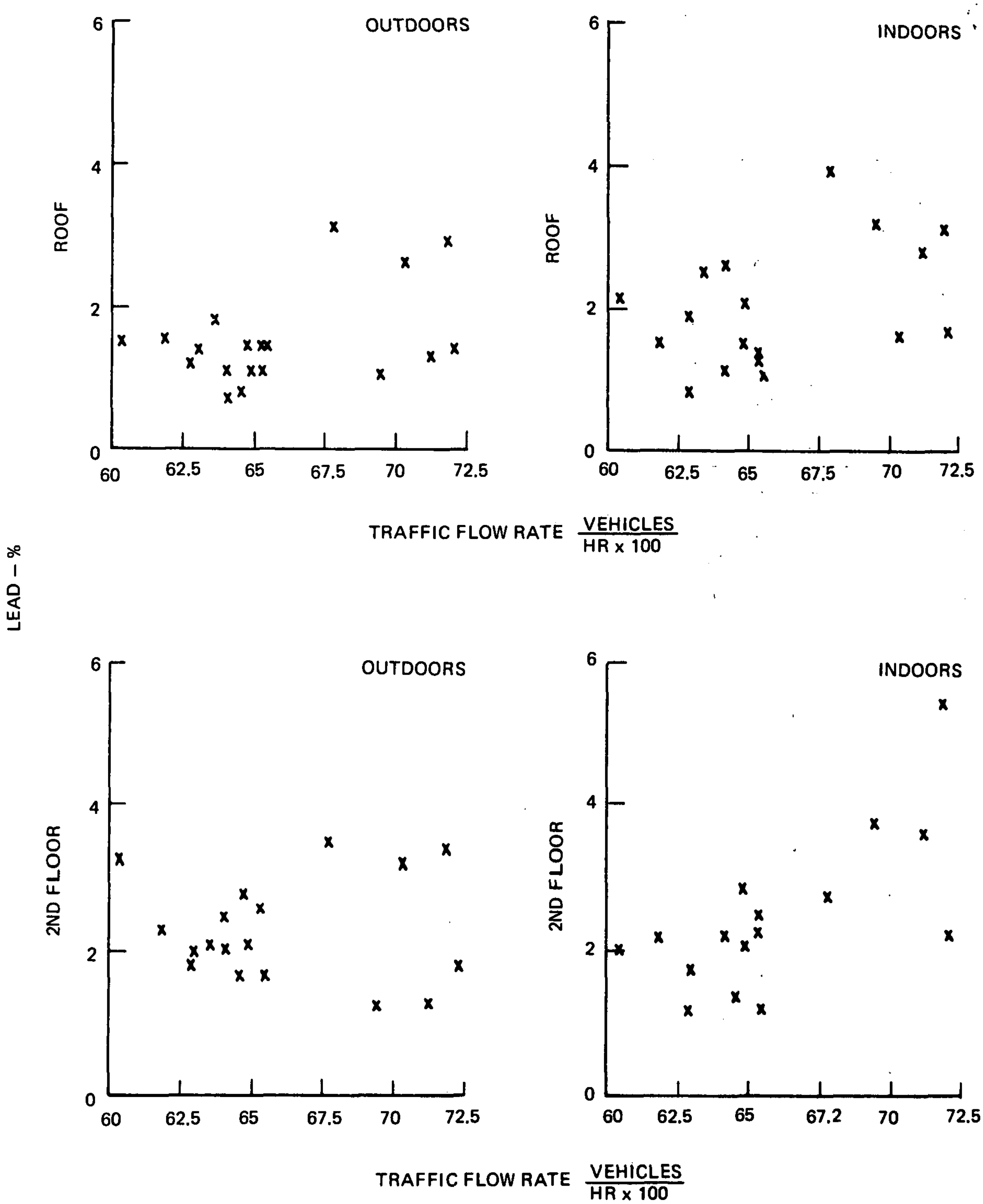


Figure 5.1.4-7. Percent Lead Vs. Traffic Flow Rate - Site 1

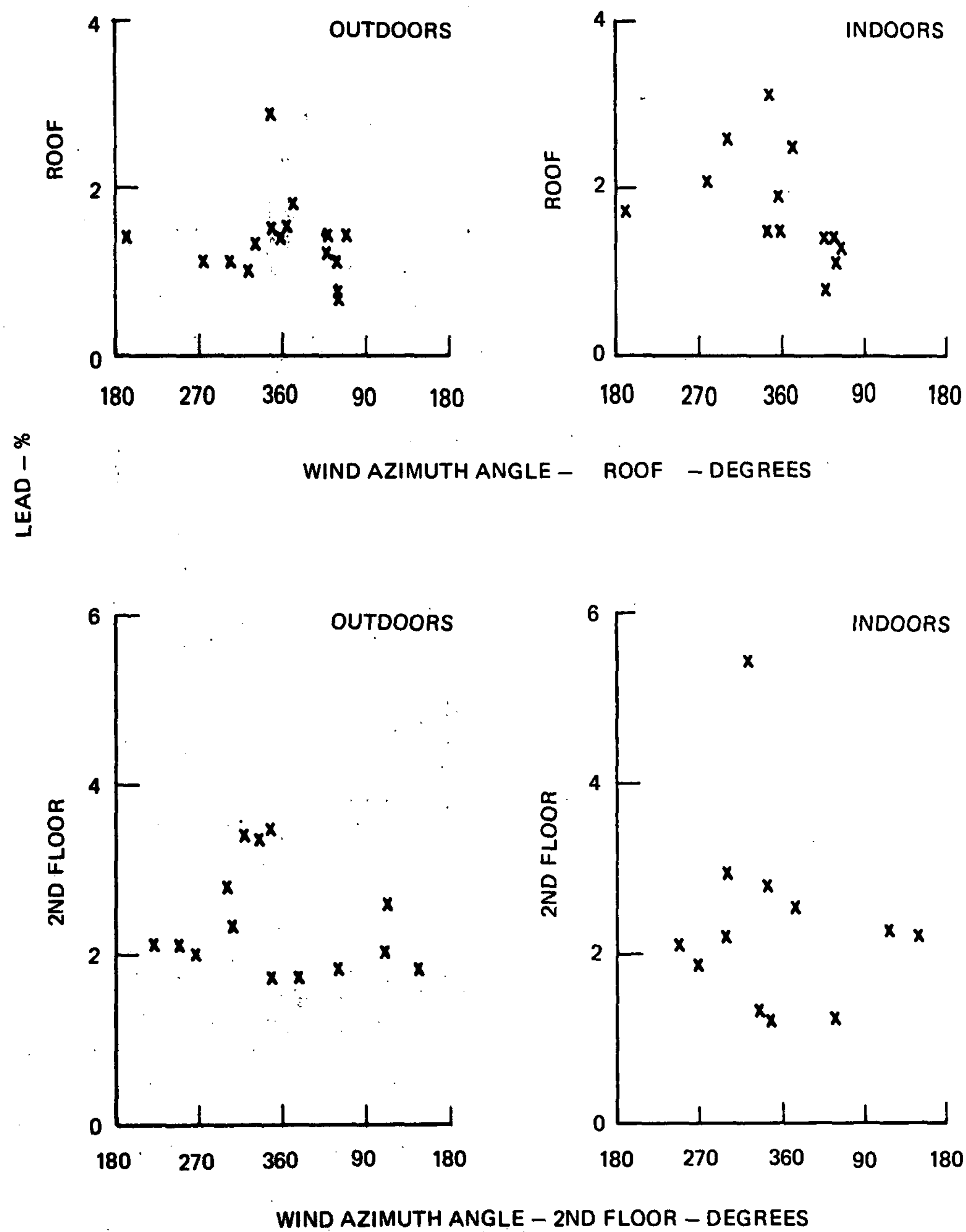


Figure 5.1.4-8. Percent Lead Vs. Wind Azimuth Angle - Site 1

respond to increasing traffic conditions. This phenomenon, i.e., indoors more responsive to traffic than outdoors, is basically caused by the easy access of lead particles from outside thru the ends of the building at the 178th and 179th Street levels.

Since the lead concentrations are street level generated and the total particulates are roof level eminated, the percent lead measured at the various sampling locations reflect the resultant quantity of lead and particulates disbursed to the locations by the winds. It was previously shown on Figure 5.1.3-7, that both roof and 2nd floor winds influenced total particulate concentration at the 2nd floor outdoor locations. Both winds again influence the percent lead, but as shown on Figure 5.1.4-9, the shift in road level wind direction, for a constant roof wind angle produces the opposite effect on percent lead. This is the result of street level origin of lead.

Outdoor/indoor differential at roof level, Figure 5.1.4-10, is low for roof winds from 300^{o}, corresponding to high O/I total particulate differentials, see Figure 5.1.3-8. Roof winds from the north and east which produced essentially a zero total particulate differential also produced essentially a zero percent lead differential. This demonstrates the greater influence of total particulates at roof level. The greater influence of lead, close to the road level, can be seen from the random 2nd floor percent lead differential shown on Figure 5.1.4-10. Figure 5.1.4-11 shows the same effect when the roof to 2nd floor percent lead differentials are examined.

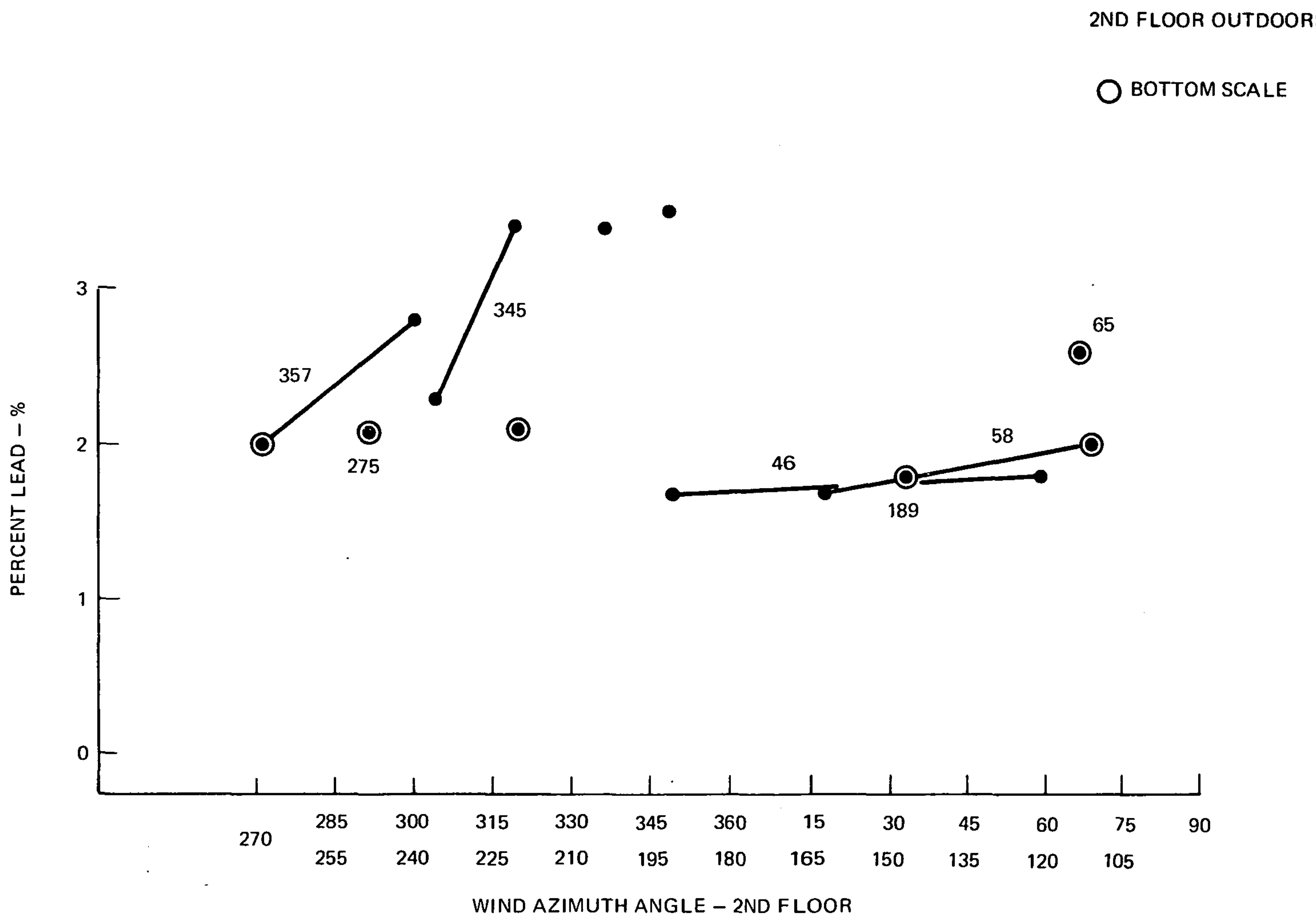


Figure 5.1.4-9. Percent Lead Vs. 2nd Floor & Roof Wind Azimuth Angle - Site 1

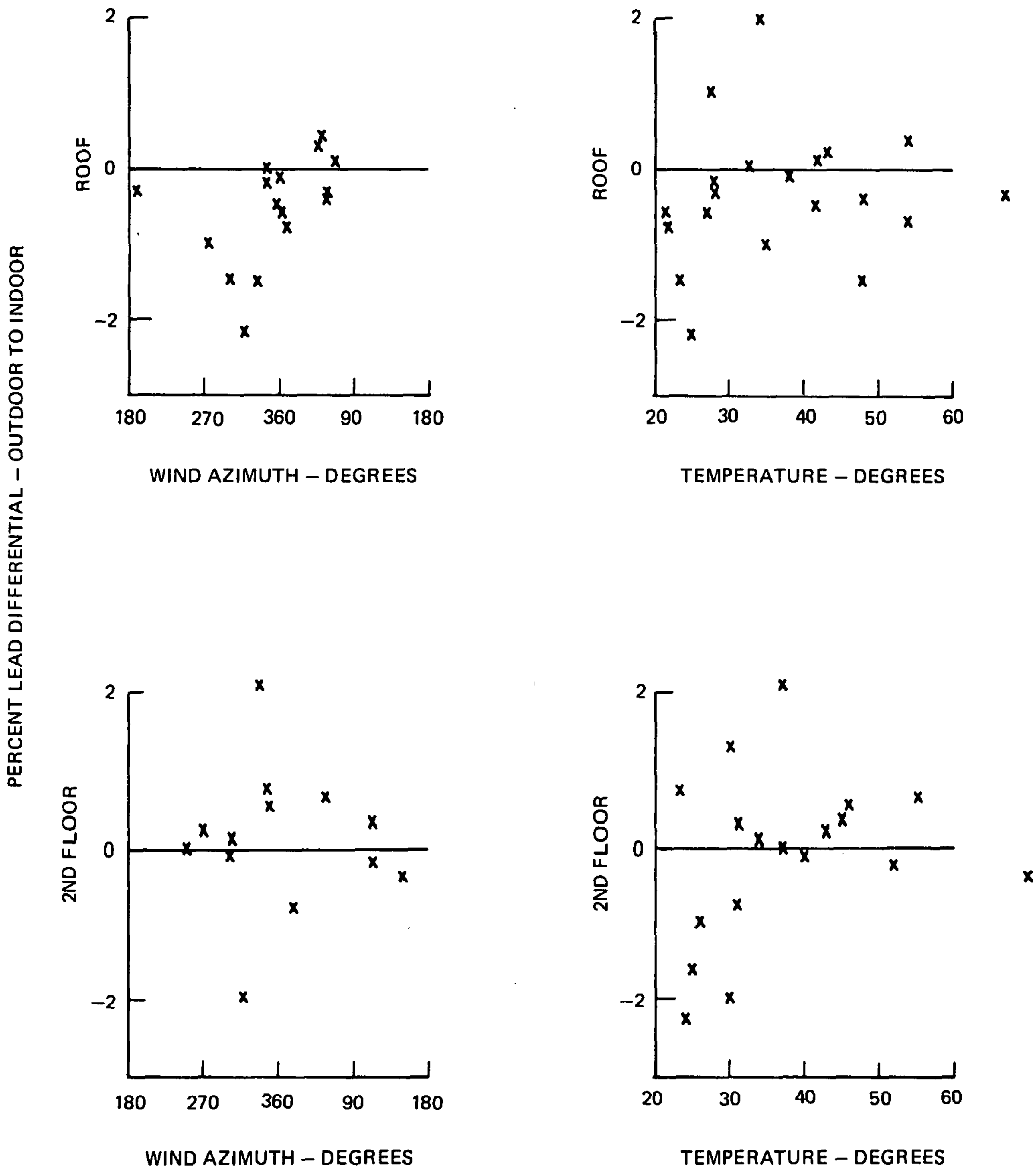


Figure 5.1.4-10. Percent Lead Differential - Site 1

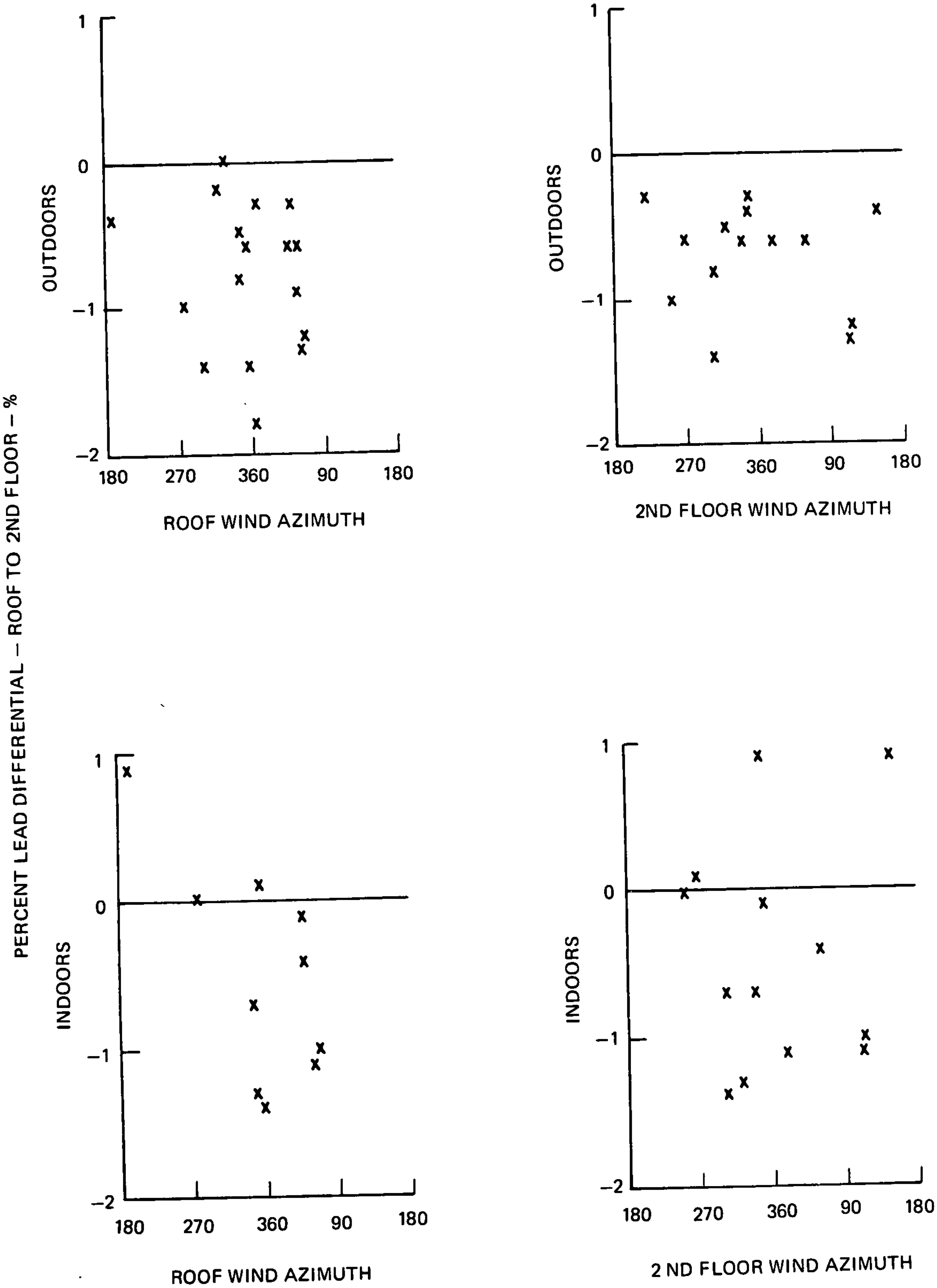


Figure 5.1.4-11. Percent Lead Differential - Site 1

Boiler room percent lead, see Figure 5.1.4-12, and the differentials from the boiler room to roof and 2nd floor indoor locations show a reverse relation to wind as seen on Figure 5.1.4-6 for lead quantity. The differential, boiler room to 2nd floor outdoors, however, is completely random, reflecting the randomness of total particulates at the 2nd floor location.

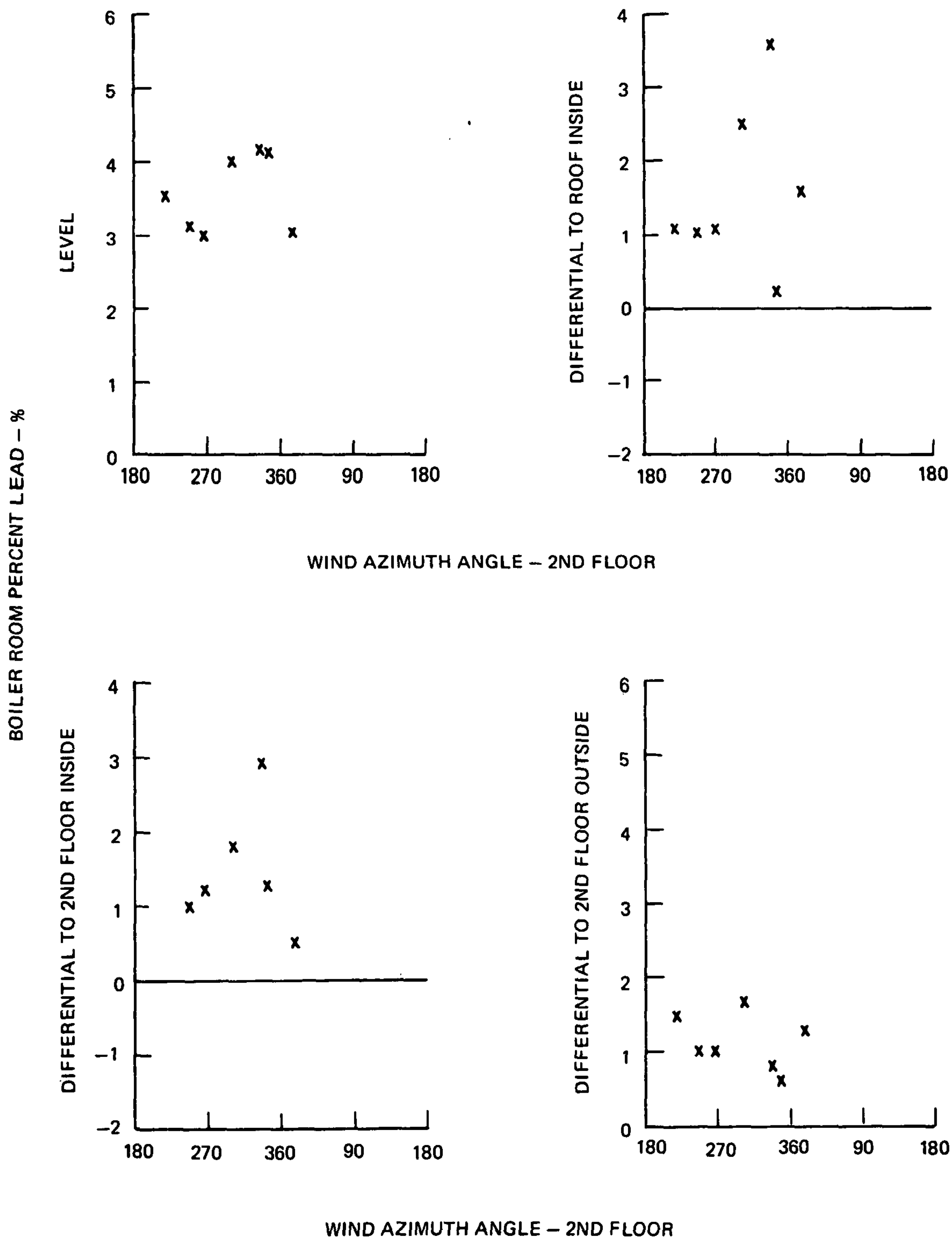


Figure 5.1.4-12. Boiler Room Percent Lead - Site 1

5.2 Site 2 - Canyon Structure - West 40th Street

Measurements to define the indoor outdoor relationships of pollutants at the canyon structure were started on Feb. 11, 1971 and ended June 30, 1971. The methodology for obtaining the measurements is discussed in Section 3.0. The measurement locations at this site are defined in detail in Section 4.2. The amount of data obtained for each measurement is identified in the appropriate portion of this section.

The data obtained for each pollutant was divided into heating and non-heating seasons on the basis of the daily average temperature at the site. All non-heating days occurred during May and June. The heating season included all of the February, March and April measurement days plus the remaining days in May and June. Approximately 3 times as much data was obtained for the heating season as was obtained for the non-heating season.

5.2.1 Carbon Monoxide

Carbon monoxide measurements were taken at five elevations at this site. Two measurements were made at the nine foot level of the street, one on the south side and the other on the north side. Both indoor and outdoor measurements were made on the 3rd, 5th 11th and 19th floors of the canyon structure, The CO measurements associated with the building began on February 11, 1971 during the heating season and ended on June 30, 1971 in the non-heating season. Accordingly 106 days of data was obtained during the heating season, 74 of which were weekdays and 32 were weekend days. 32 days of non-heating season data was taken, 26 of these were weekdays and 8 were weekend days.

Measurements of carbon monoxide at the street level were begun on Feb. 18 on the south side. North side measurements were not started until March 15. As a result, the heating season data sample for the south side of the street is for 98 days but is only 74 days for the north side.

5.2.1.1 Heating Season

The highest carbon monoxide value at this site during the heating season was recorded at the nine foot level on the north side of the road. This was 51.2 ppm. As shown in the tabulation below, the 24 hour average concentrations at street level were 11.2 ppm on both sides of 40th Street during the period of 3/15 to 6/15. The average concentration at the south side, from 2/18 to 3/12 was higher, 13.4 ppm, making the composite south side concentration equal to 12.3 ppm. (It is assumed that the north side average CO level for the period starting on 2/18, would be essentially the same.)

	Location									
	S.S	N.S	3rdO	3rdI	5thO	5thI	11thO	11thI	19thO	19thI
Weekday Data	*	*								
Ave CO-ppm	11.2	11.2	9.9	9.5	7.7	7.8	6.6	6.9	5.4	6.8
Peak CO-ppm	46.6	51.2	45.0	34.5	33.8	25.3	25.8	25.3	24.6	30.7
Exceed 9 ppm/ 8 hr-%	59.3	62.1	47.5	47.6	28.0	29.2	20.4	20.2	7.8	17.4
Exceed 35 ppm/ 1 hr-%	1.1	.4	.4	0	0	0	0	0	0	0
Weekend Data										
Ave CO-ppm	8.3	8.1	8.4	7.4	6.5	6.4	6.0	6.1	4.9	5.4
Peak CO-ppm	22.5	22.3	29.7	25.1	24.4	19.6	21.7	17.8	16.7	15.1
Exceed 9 ppm/ 8 hr-%	35.9	35.9	37.8	31.1	26.8	28.0	24.7	23.5	6.2	12.8
Exceed 35 ppm/ 1 hr-%	0	0	0	0	0	0	0	0	0	0

*3/15/71 to 6/15/71

In general, both the peak and average CO levels decreased for both indoor and outdoor locations as the measurement location increased above road level. Similarly the percentage of time that the Federal criterions of 9 ppm average over an 8 hour period and 35 ppm for a 1 hour period were exceeded also decreased with height above the road.

Weekday peak and average concentrations were always higher than weekend levels at comparable locations. Average indoor concentrations at the 11th and 19th floors were always higher than corresponding outdoor CO levels. In general, the reverse was recorded at the 3rd and 5th floor locations.

5.2.1.1.1 CO Traffic Relationships

The diurnal patterns of carbon monoxide concentrations at all 5 elevations for weekdays are distinctly different from the diurnal traffic pattern, as shown on Figures 5.2.1-1 to -5. The CO profiles show distinct double peaks characteristic of morning and evening rush hour periods. The traffic pattern, however, shows a morning peak almost two hours after the CO peak occurred and an evening peak which again is later than the CO peak.

The diurnal CO patterns on opposite sides of the street (Figure 5.2.1-1) are very much alike, as would be expected on a one way street. A visual comparison with the weekday diurnal vehicular velocity curve (Figure 4.2-5) suggests that the CO peaks are a function of velocity reductions during the same time periods. It is possible, however, that the CO peaks may be due to traffic on other streets in the vicinity or traffic associated with the nearby parking garages.

It is interesting to note that the diurnal CO patterns at the 3rd, 5th, and 11th floor outdoor locations (Figures 5.2.1-2 to -4) appear to follow the north side CO pattern. Indoor diurnal patterns appear to follow the south side CO profile at the 3rd floor and a combination of the north and south side patterns at higher building elevations.

The weekend diurnal CO and traffic patterns for the road and 3rd floor levels are shown on Figures 5.2.1-6 and -7. Both diurnal profiles are shaped significantly different from the weekday curves. Again the lack of correspondence between peaking traffic on 40th Street and CO concentrations at the road and 3rd floor levels, suggests other traffic contributes to the CO level at the canyon site.

Figures 5.2.1-8 and -9 show the diurnal values of the CO concentrations at the north side of the road plotted against the diurnal values of traffic flow rate and vehicular velocity. The results of a linear regression

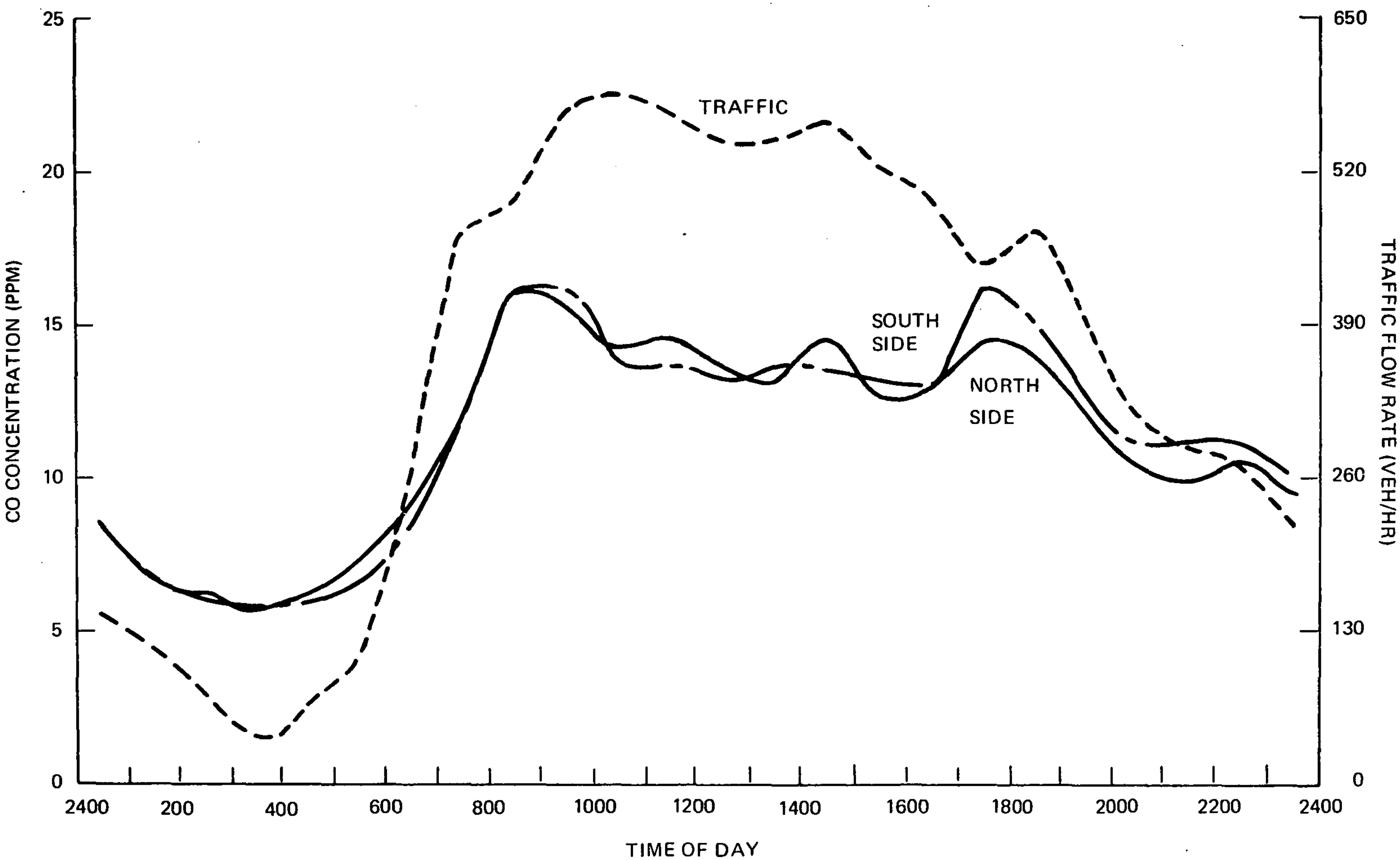


Figure 5.2.1-1. Diurnal CO & Traffic - Site 2 - Heating Season - Road Level - Weekdays

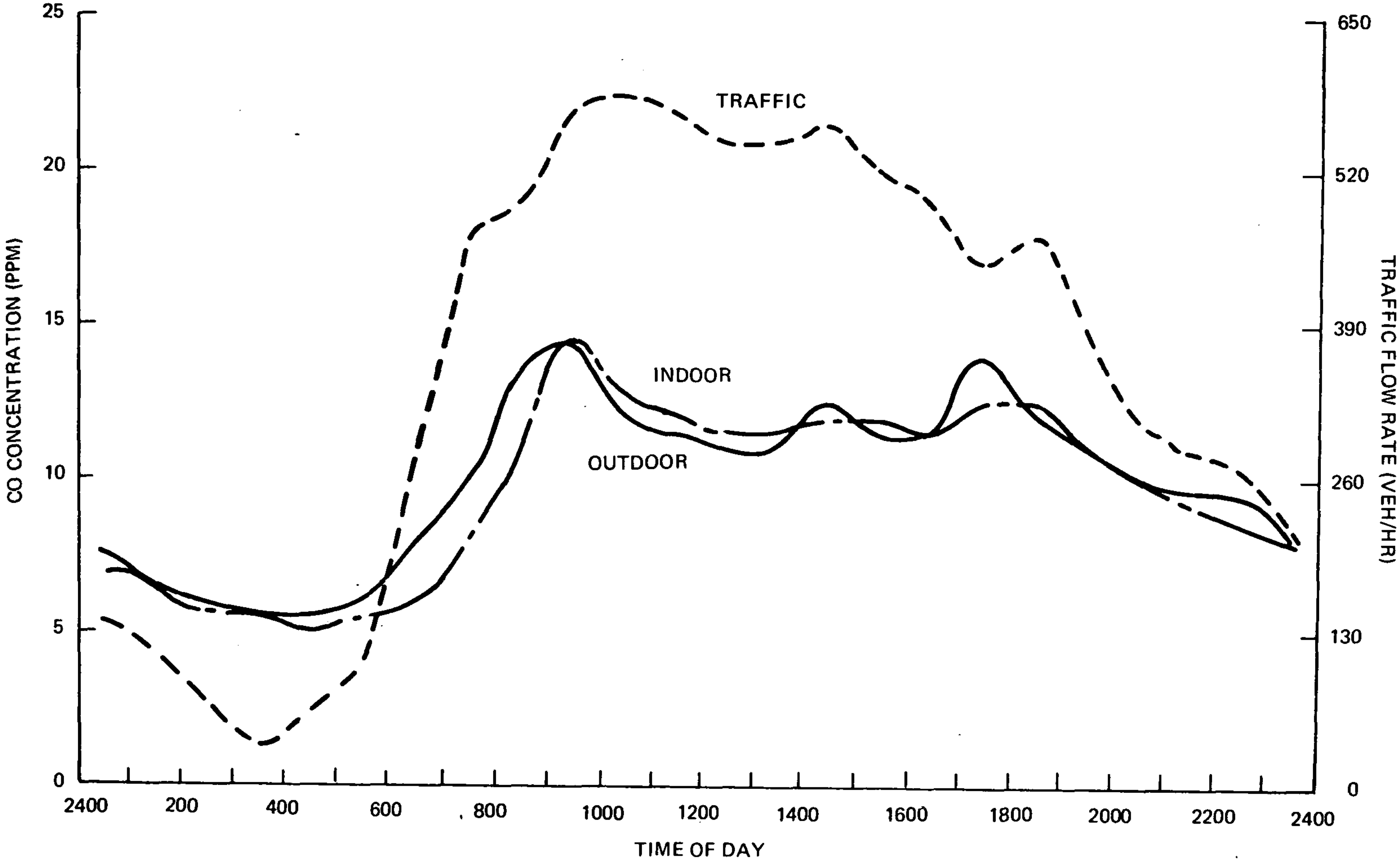


Figure 5.2.1-2. Diurnal CO & Traffic - Site 2 - Heating Season - 3rd Floor - Weekdays

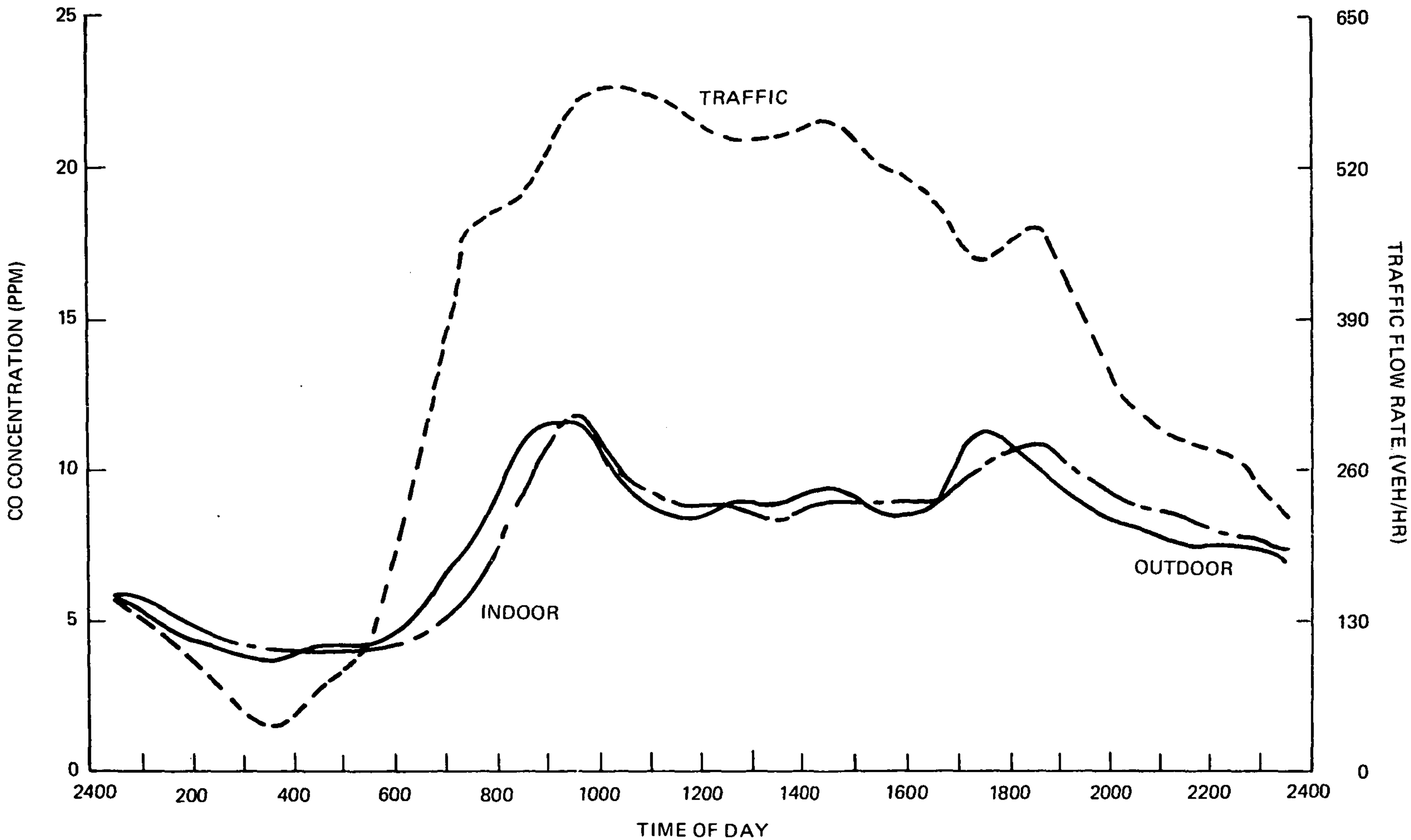


Figure 5.2.1-3. Diurnal CO & Traffic - Site 2 - Heating Season - 5th Floor - Weekdays

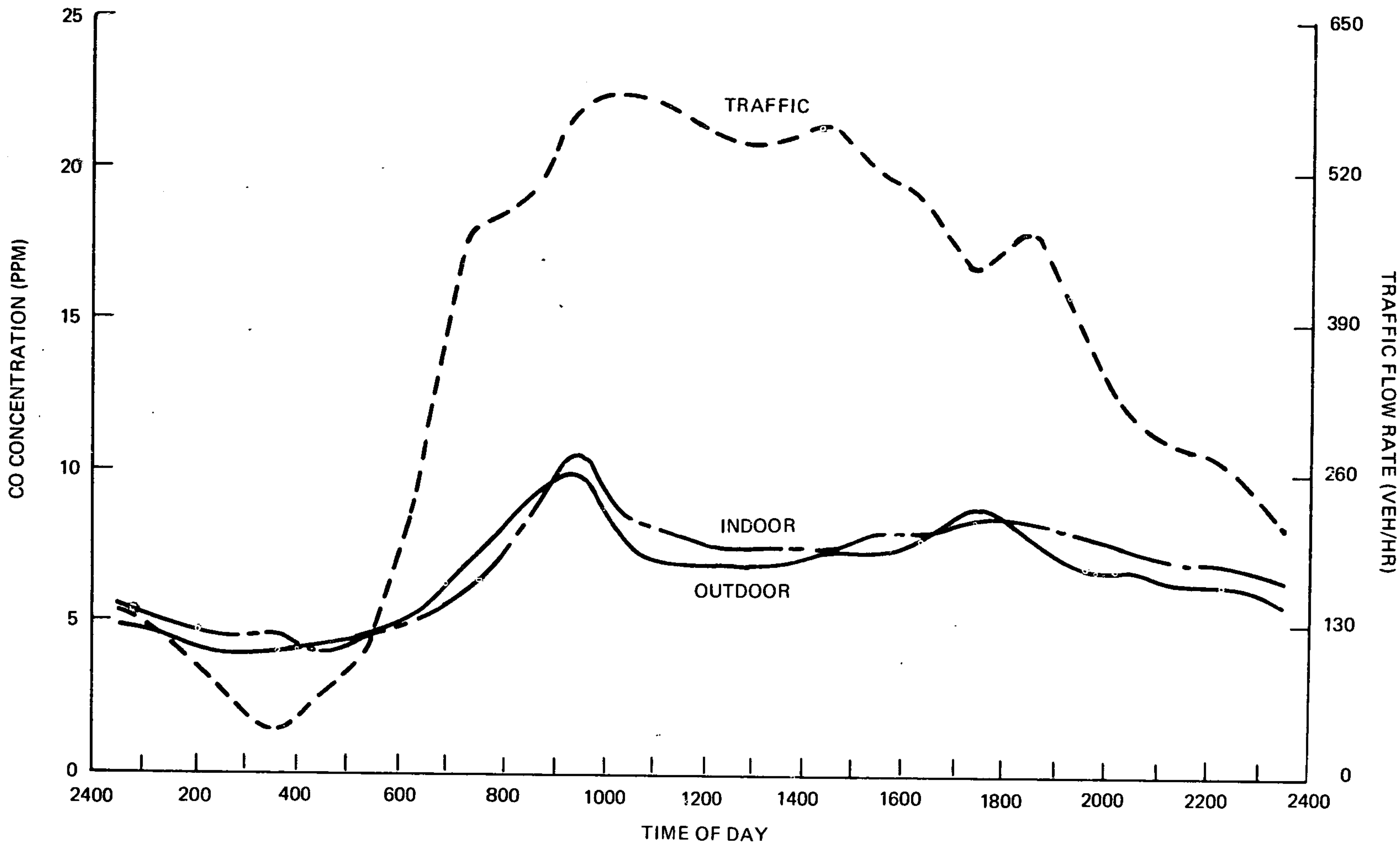


Figure 5.2.1-4. Diurnal CO & Traffic - Site 2 - Heating Season - 11th Floor -Weekdays

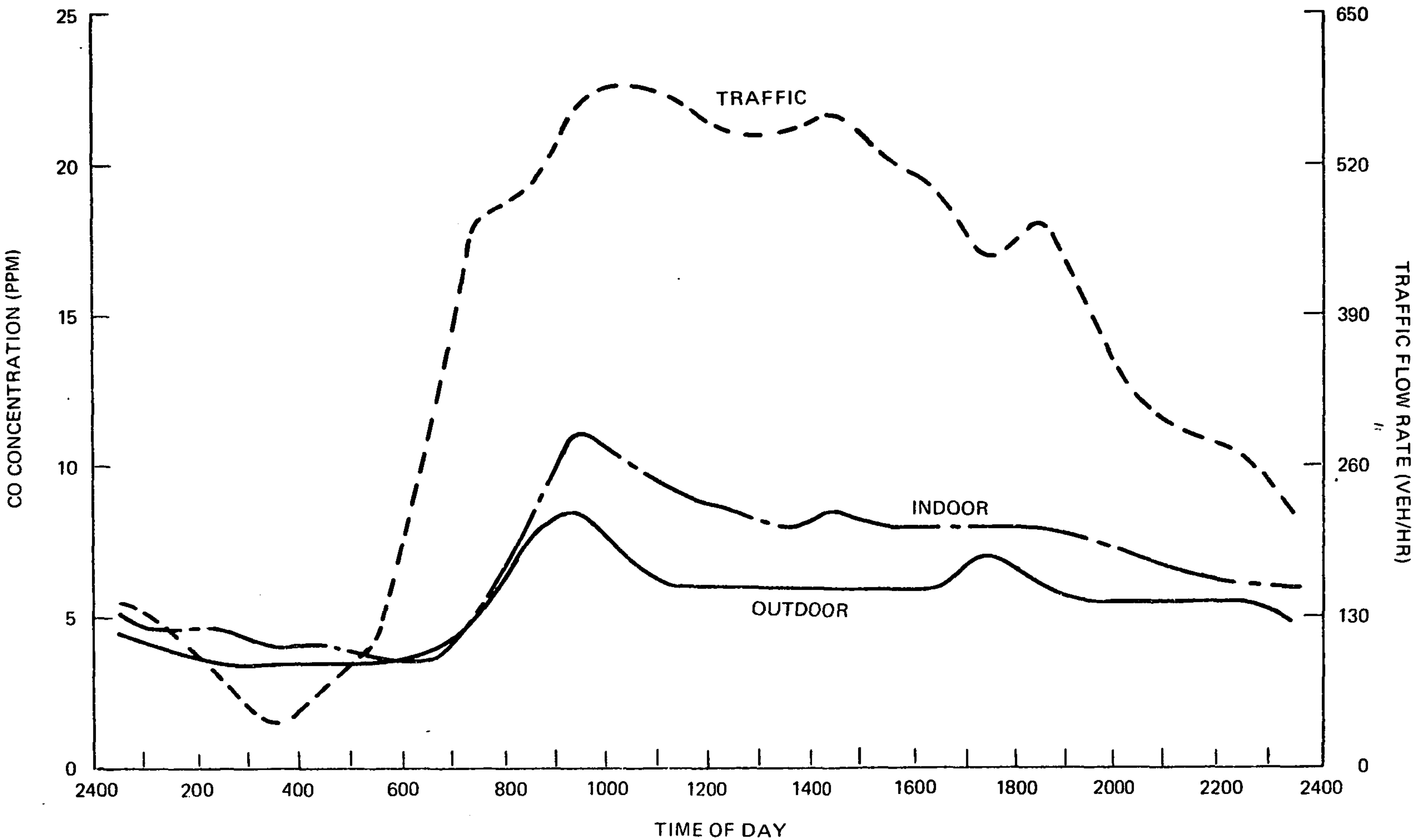


Figure 5.2.1-5. Diurnal CO & Traffic - Site 2 - Heating Season - 19th Floor - Weekday

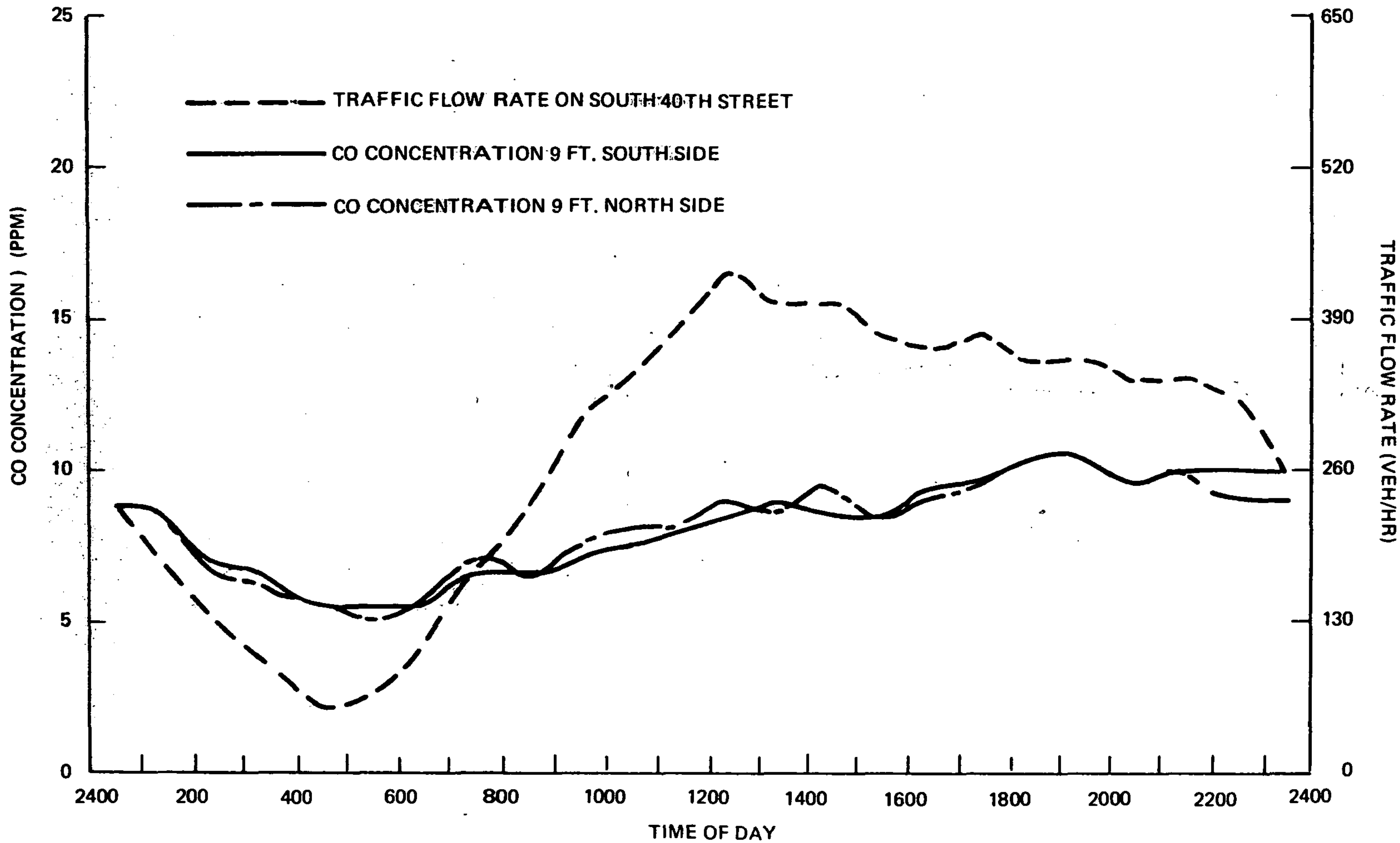


Figure 5.2.1-6. Diurnal CO & Traffic - Site 2 - Heating Season - Weekends - Road Level

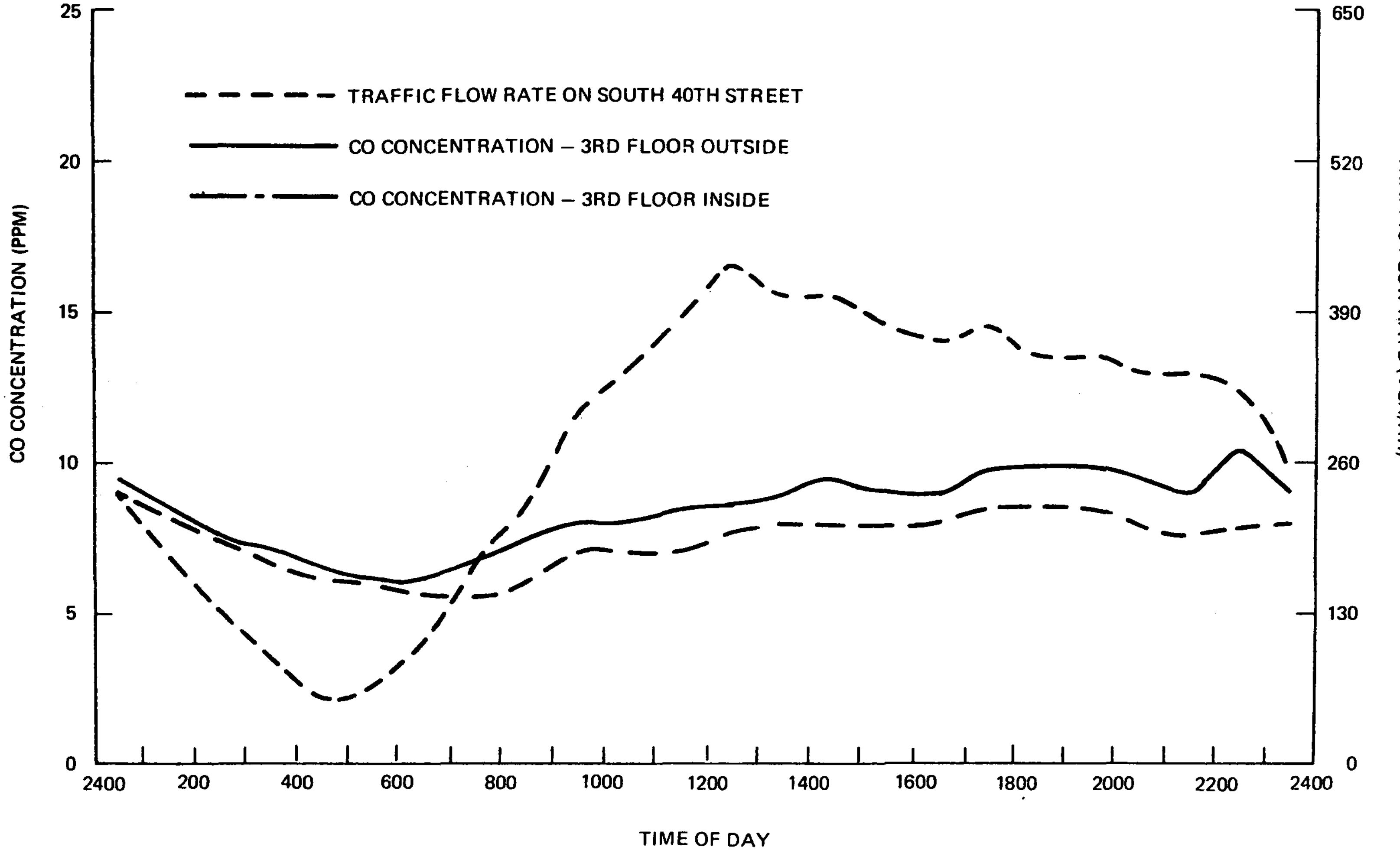
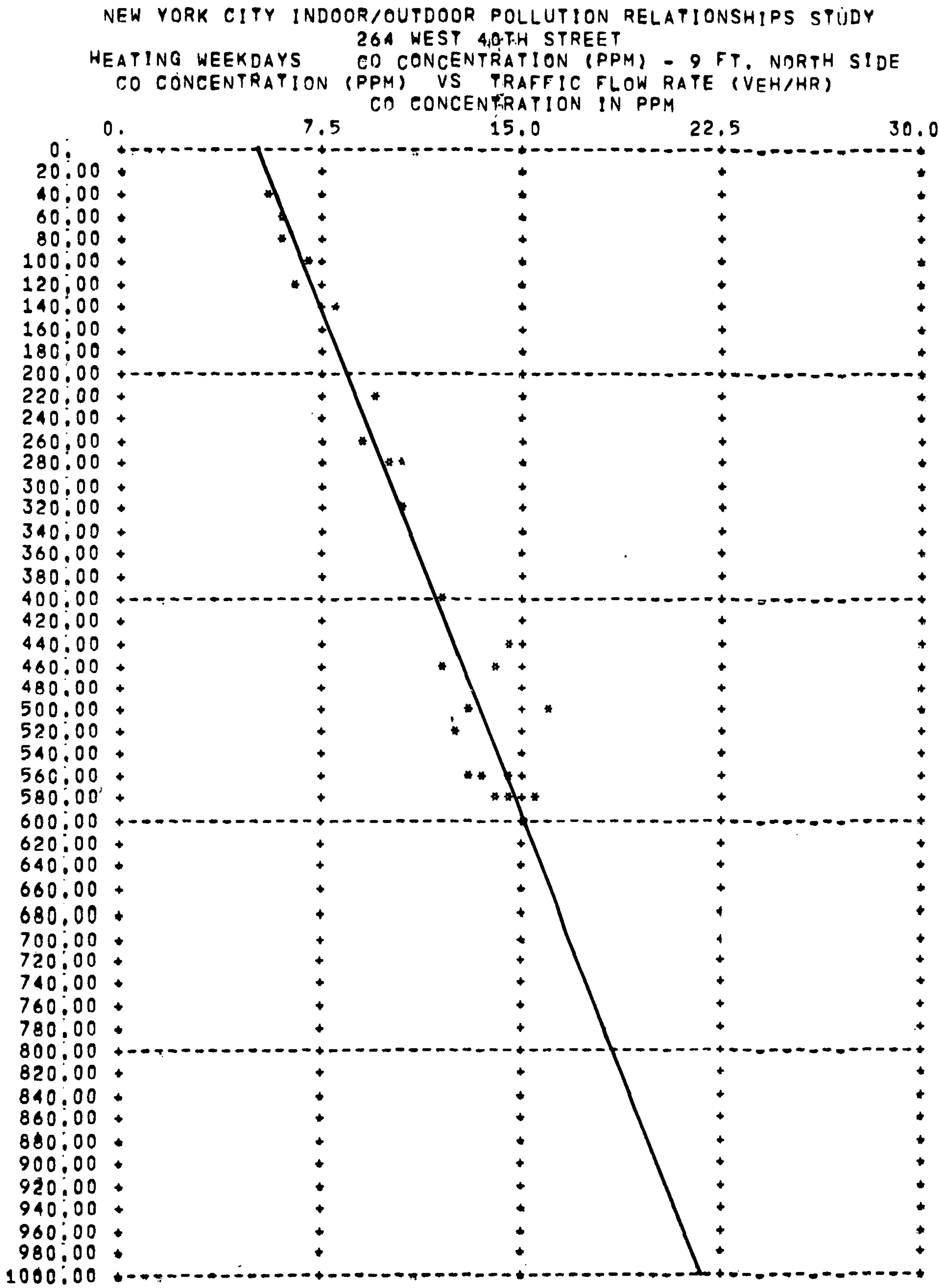
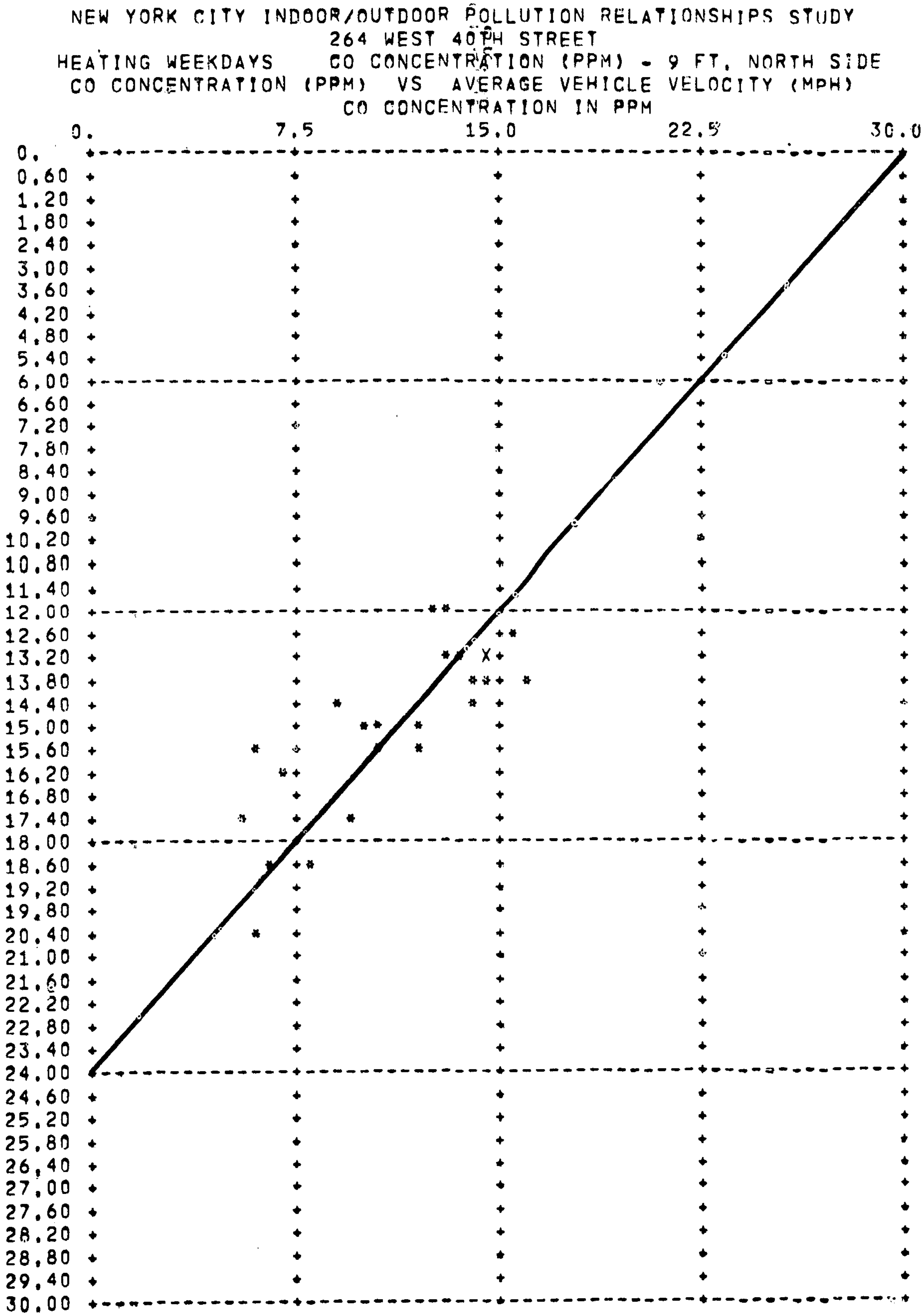


Figure 5.2.1-7. Diurnal CO & Traffic - Site 2 - Heating Season - Weekends - 3rd Floor



CO = .0166 TFR + 5.24

Figure 5.2.1-8



$CO = -1.254v + 30.04$

Figure 5.2.1-9

analysis for the road and 3rd floor locations are summarized in Tables 5.2.1-1 and 5.2.1-2. It will be noted that the correlations coefficients are, in general, considerably lower than found at Site 1. Correlation with traffic velocity is extremely poor.

5.2.1.1.2 Indoor/Outdoor Relationships

Daily average CO concentrations on weekdays were higher outdoors than indoors only at the 3rd floor level. Daily average indoor concentrations exceed outdoor CO levels at the 5th, 11th and 19th floors. This phenomenon, as shown on Figures 5.2.1-5 thru -5, is primarily due to the greater responsiveness of 3rd floor outdoor CO to traffic changes than seen at higher floors. A comparison of the outdoor plots for the four floors will show a lesser CO sensitivity outdoors, with height above the roadway, to the diurnal CO curve for the north side of 40th Street, see Figure 5.2.1-1.

As mentioned earlier, the indoor CO concentrations more nearly reflect the diurnal CO curve for the south side of the street. This suggests that CO enters the building close to ground level and diffuses upwards thru internal passageways. These passageways introduce a time delay between street level CO and indoor concentrations at the upper floors. As a result outdoor CO increases faster than indoor CO levels at most floors. Since outdoor CO is dissipated more rapidly than CO confined within the structure, outdoor CO levels also decrease sooner with changes in roadway CO level.

The long term effect of entrapment of CO within the building can be seen from the following table which compares daily average CO levels at each floor with the 5-6 pm average concentrations.

TABLE 5.2.1-1

LINEAR REGRESSION ANALYSES RESULTS

264 W. 40th Street - Heating Weekdays

Traffic Flow Rate (Ind. Var.)

VS

	CO Conc. 9 Ft. North	CO Conc. 9 Ft. South	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	.96	.92	.92	.92
Intercept	5.25	5.32	5.23	4.55
Slope	.0166	.0166	.0131	.0140
Mean of Dependent Variable Observations	11.19	11.25	9.92	9.55
Mean of Independent Variable Observations	357.46	357.46	357.46	357.46

264 W. 40th Street - Heating Weekends

Traffic Flow Rate (Ind. Var.)

VS

	CO Conc. 9 Ft. North	CO Conc. 9 Ft. South	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	.83	.75	.75	.66
Intercept	5.21	5.36	6.25	5.93
Slope	.0108	.0104	.0079	.0053
Mean of Dependent Variable Observations	8.15	8.20	8.40	7.39
Mean of Independent Variable Observations	273.41	273.41	273.41	273.41

TABLE 5.2.1-2

LINEAR REGRESSION ANALYSES RESULTS

264 W. 40th Street - Heating Weekdays

Average Vehicle Velocity (Ind. Var.)

VS

	CO Conc. 9 Ft. North	CO Conc. 9 Ft. South	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	-.82	-.80	-.80	-.80
Intercept	30.04	30.44	25.15	25.69
Slope	-1.254	-1.276	-1.013	-1.073
Mean of Dependent Variable Observations	11.19	11.25	9.92	9.55
Mean of Independent Variable Observations	15.04	15.04	15.04	15.04

264 W. 40th Street - Heating Weekends

Average Vehicle Velocity (Ind. Var.)

VS

	CO Conc. 9 Ft. North	CO Conc. 9 Ft. South	CO Conc. 3rd Fl. Out	CO Conc. 3rd Fl. In
Correlation Coefficient	-.31	-.22	-.30	-.28
Intercept	16.69	14.64	14.90	12.15
Slope	-.4678	-.3531	-.3560	-.2606
Mean of Dependent Variable Observations	8.15	8.20	8.40	7.39
Mean of Independent Variable Observations	18.25	18.25	18.25	18.25

CO CONCENTRATION - PPM

	DAILY AVE			5-6 PM AVE		
	O	I	Diff	O	I	Diff
3rd Floor	9.9	9.5	0.4	14.2	12.6	1.6
5th Floor	7.7	7.8	-0.1	11.5	10.3	1.2
11th Floor	6.6	6.9	-0.3	9.2	8.8	.4
19th Floor	5.4	6.8	-1.4	6.9	8.1	-1.2
3rd to 5th Diff	2.2	1.7	0.5	2.7	2.3	0.4
5th to 11th Diff	1.1	0.9	0.2	2.3	1.5	0.8
11th to 19th Diff	1.2	0.1	1.1	2.3	0.7	1.6

It will be noticed that while both sets of data show a decrease in CO levels at the respective outdoor and indoor locations with height, the daily average outdoor/indoor differential becomes negative at the 5th floor but only the 19th floor differential is negative for the 5-6 pm averages.

It is apparent that on a daily basis, the middle and upper floors of the building act as a CO trap on heating weekdays. CO, which enters the building at low levels thru open doors and elevator shafts, spreads thruout the building. Due to the density difference between the heated indoor air and the cold atmosphere outside, the lower level building air and its associated CO travel upwards to the higher floors. In its indoor vertical path, the CO receives relatively less dilution than corresponding outdoor concentrations which are exposed to turbulent mixing. The internal dissipation of this entrapped CO is too slow to reduce internal CO levels below prevailing outdoor CO concentrations at each floor.

Re-examination of the daily average CO concentrations on weekends, shown on page 5-159, will reveal that CO concentrations indoors were lower than outdoors for a considerably larger height above the roadway than seen on weekdays. This occurred because roadway CO levels were significantly lower and less CO was introduced into the building close to the ground. The smaller CO source allowed the entrapped CO to dissipate, producing lower daily average CO levels at the upper floors.

The outdoor differentials at each floor, as developed further in Section 5.2.1.3, are basically a reflection of the direction of change in CO levels at the particular floor. Differentials are positive; i.e., outdoor levels higher, when CO levels are increasing and negative when CO levels are decreasing.

5.2.1.2 Non Heating Season

CO concentrations measured at the canyon site during the non-heating season are tabulated below. In general, concentrations are lower at all building locations than recorded during the heating season. Only the 3rd and 5th floor outdoor locations showed higher non-heating season average CO levels.

	Location									
	S.S	N.S	3rdO	3rdI	5thO	5thI	11thO	11thI	19thO	19thI
Weekday Data										
Ave CO-ppm	11.2	10.8	10.3	8.2	8.1	7.1	4.8	4.7	4.2	3.8
Peak CO-ppm	39.4	37.8	37.3	30.0	35.2	22.1	21.1	15.6	18.3	13.4
Exceed 9ppm/ 8 hr-%	55.8	60.4	48.8	33.0	36.0	28.3	8.4	5.2	1.4	1.2
Exceed 35pm/ 1 hr-%	.5	.2	.2	0	.2	0	0	0	0	0
Weekend Data										
Ave CO-ppm	7.3	7.0	7.0	4.9	4.1	3.6	1.7	1.6	1.1	.8
Peak CO-ppm	19.1	21.2	18.7	10.9	15.6	10.6	6.6	7.2	4.7	4.3
Exceed 9ppm/ 8 hr-%	21.3	16.5	18.3	.6	7.3	1.8	0	0	0	0
Exceed 35 ppm/ 1 hr-%	0	0	0	0	0	0	0	0	0	0

Peak and average CO levels again were higher on weekdays than on weekends. The higher indoor concentrations at the 11th and 19th floors recorded during the heating season did not occur. All peak and average CO levels during the non heating season, with the sole exception of the 5th floor weekend data, were lower indoors than outdoors at comparable levels.

5.2.1.2.1 CO Traffic Relationships

The diurnal profiles of carbon monoxide and traffic volume for non-heating season weekdays are shown in Figures 5.2.1-10 thru -14. The diurnal profiles exhibit the same shapes as noted for the heating season. Similarly, the weekend diurnal profiles, Figures 5.2.1-15 and -16, for the non-heating season closely duplicate those found during the heating season. As shown on Figures 5.2.1-17 and -18, and table 5.2.1-3 and -4, the correlation of CO levels with traffic parameters is weaker during the non-heating season than during the heating

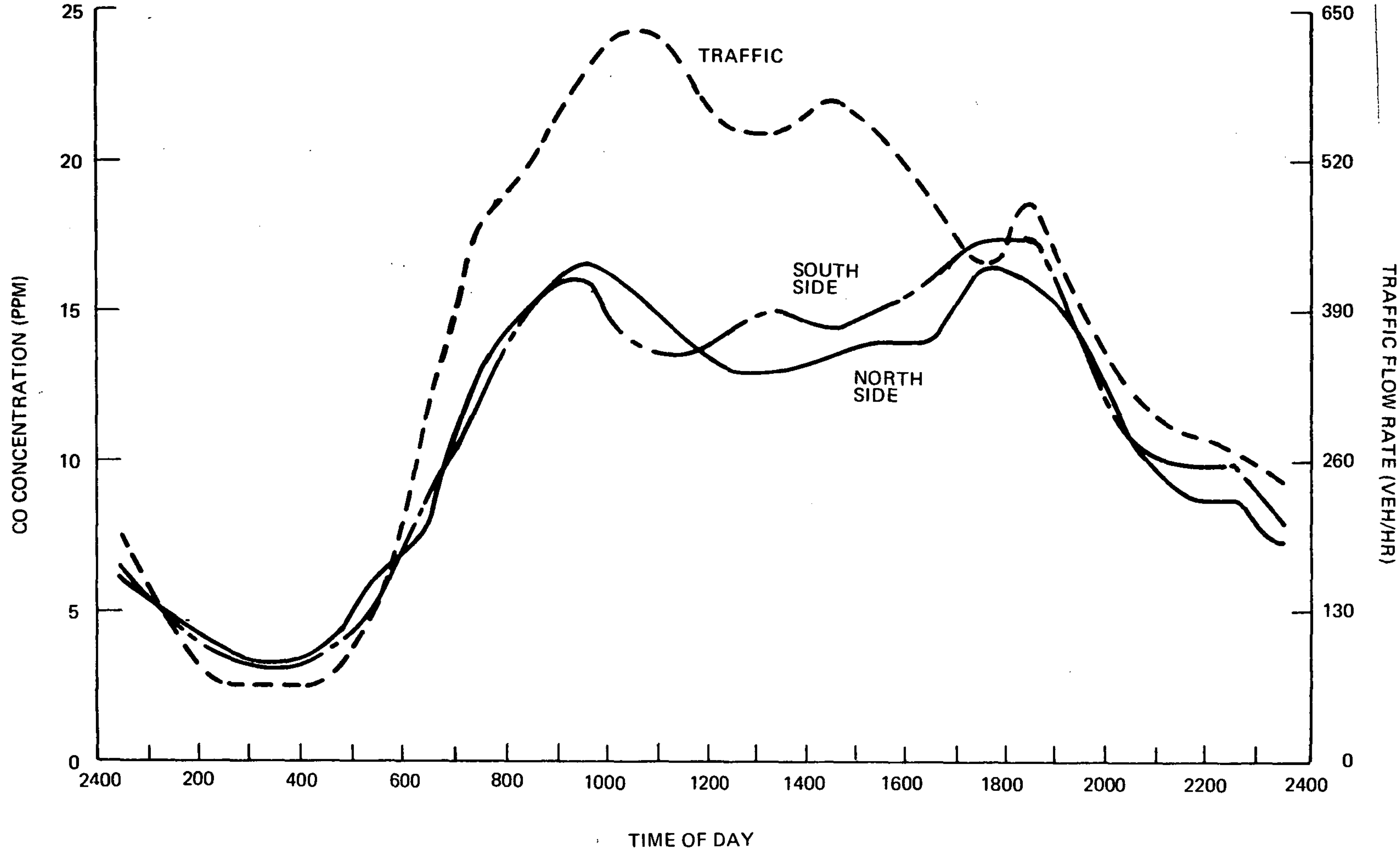


Figure 5.2.1-10. Diurnal CO & Traffic - Site 2 Non-Heating Season - Road Level - Weekdays

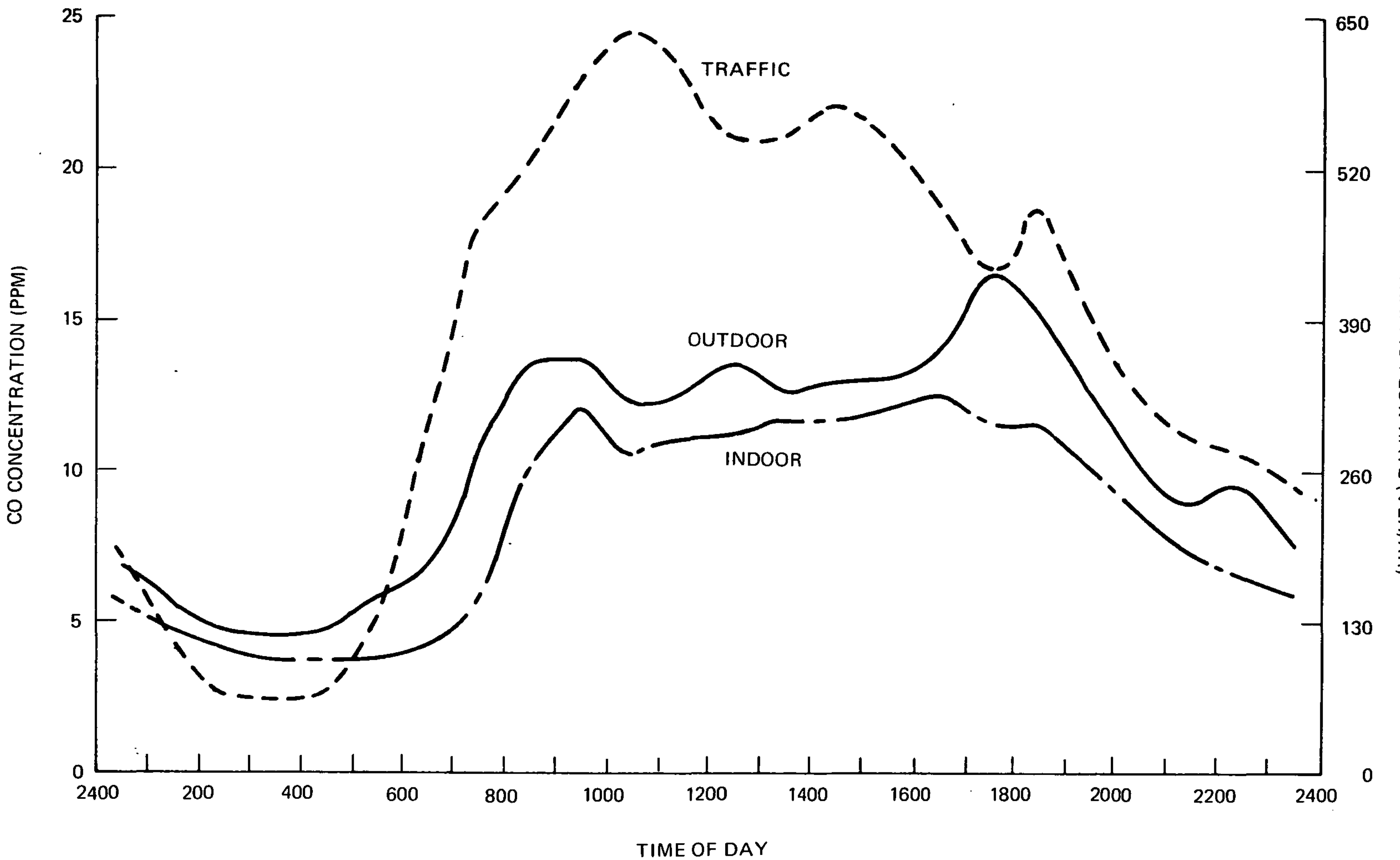


Figure 5.2.1-11. Diurnal CO & Traffic - Site 2 - Non Heating Season - 3rd Floor - Weekdays

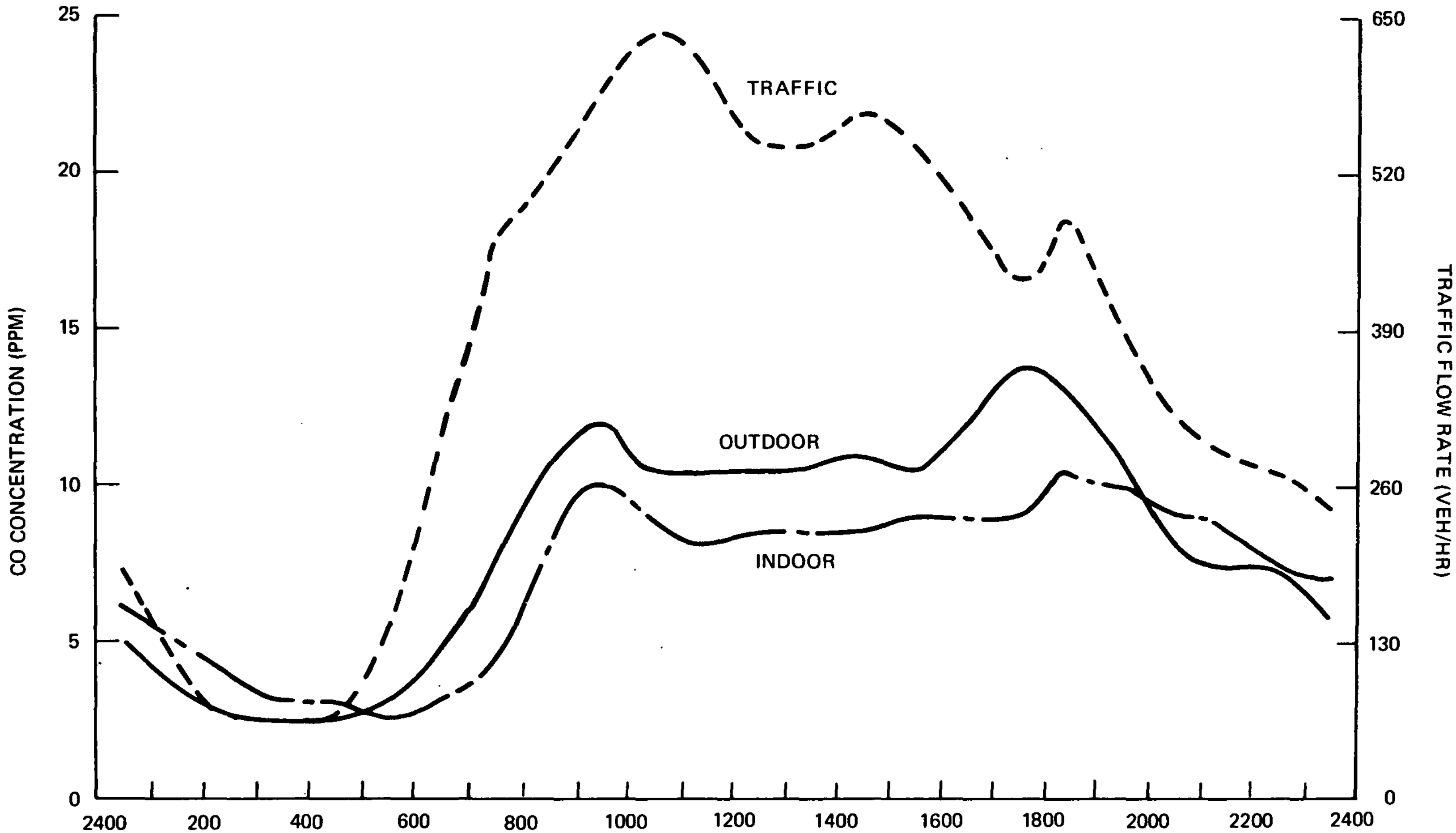


Figure 5.2.1-12. Diurnal CO & Traffic - Site 2 - Non Heating Season - 5th Floor - Weekdays

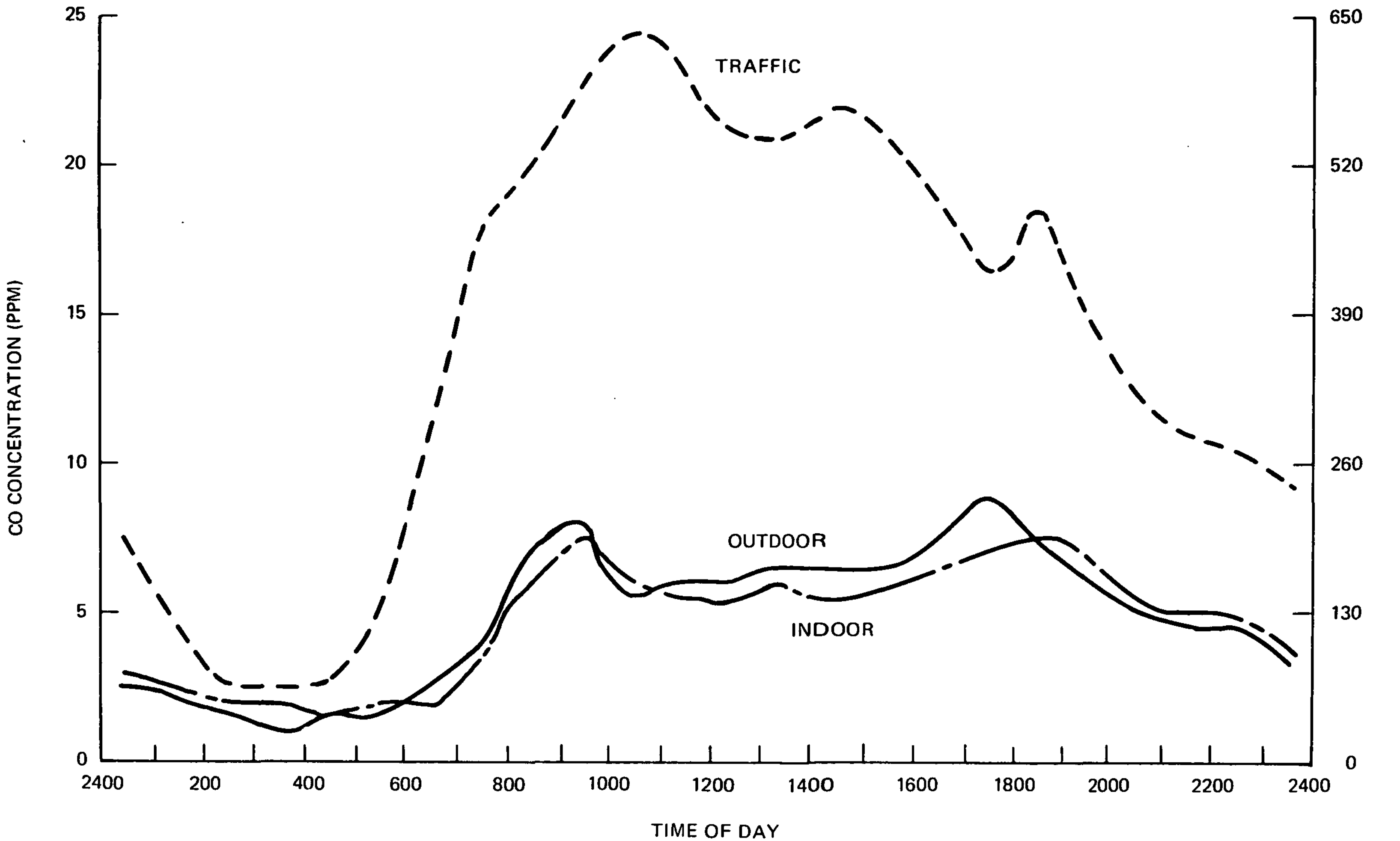


Figure 5.2.1-13. Diurnal CO & Traffic - Site 2 - Non Heating Season 11th Floor - Weekdays

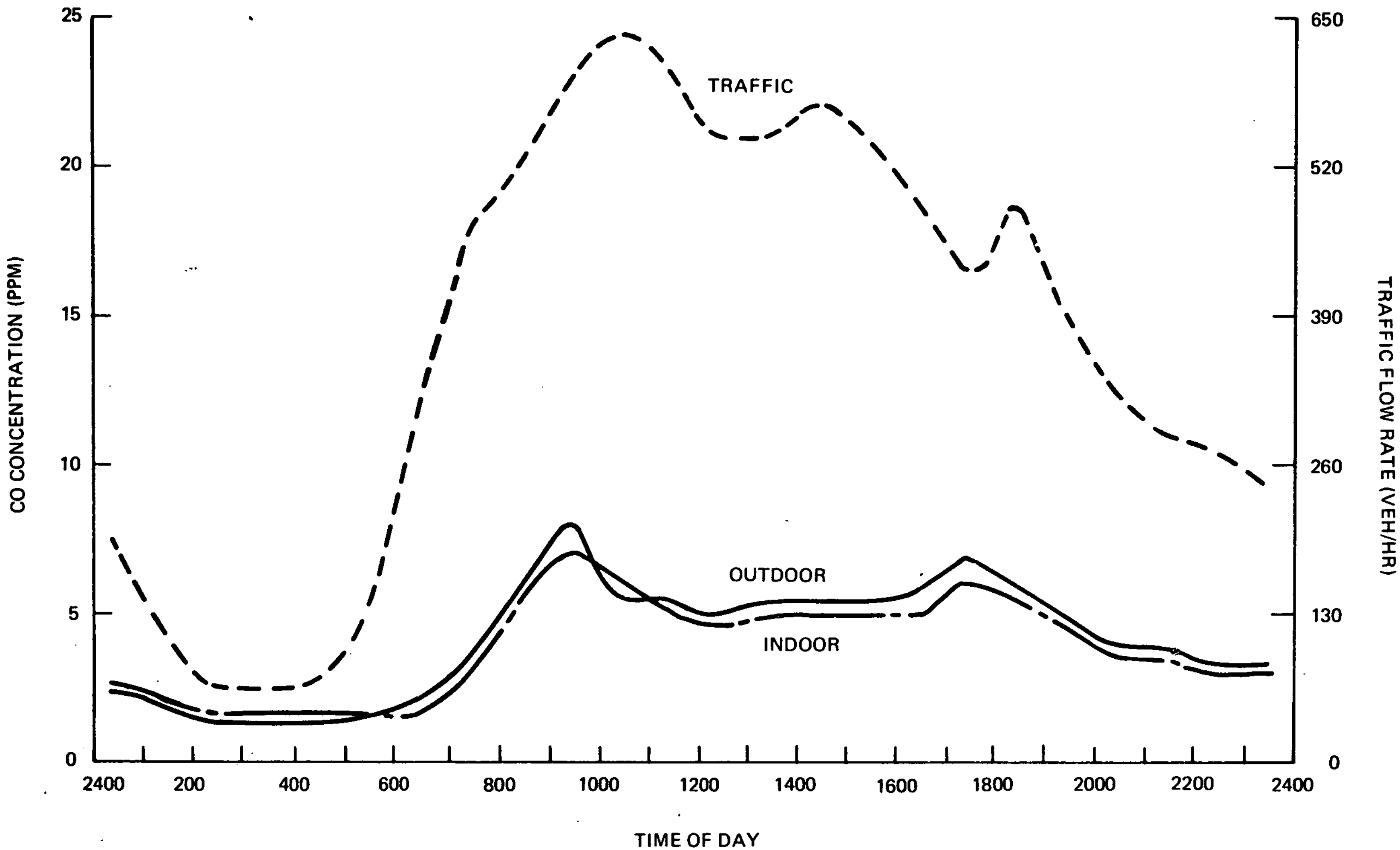


Figure 5.2.1-14. Diurnal CO & Traffic - Site 2 - Non Heating Season - 19th Floor - Weekdays

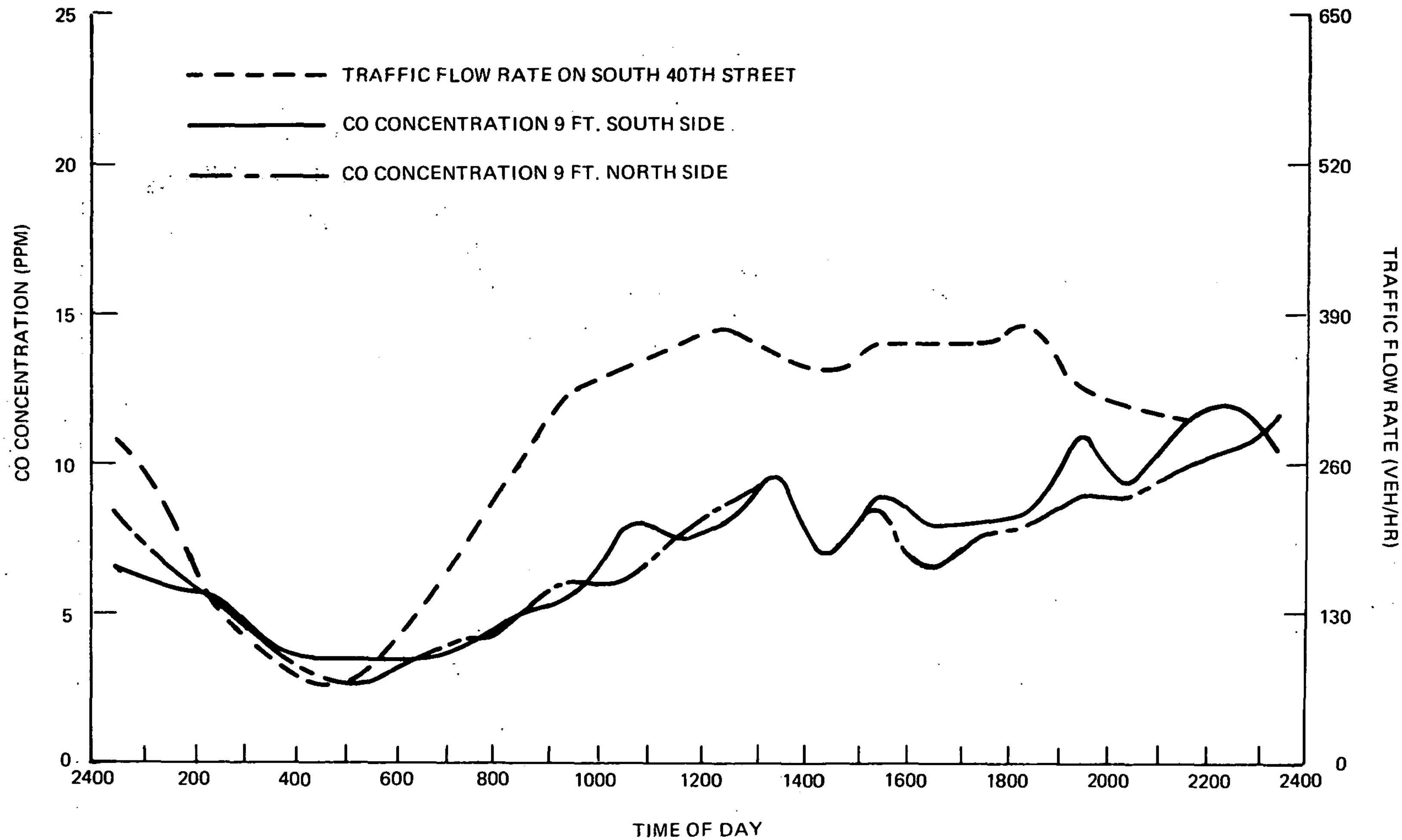


Figure 5.2.1-15. Diurnal CO & Traffic - Site 2 - Non Heating Season - Weekends - Road Level

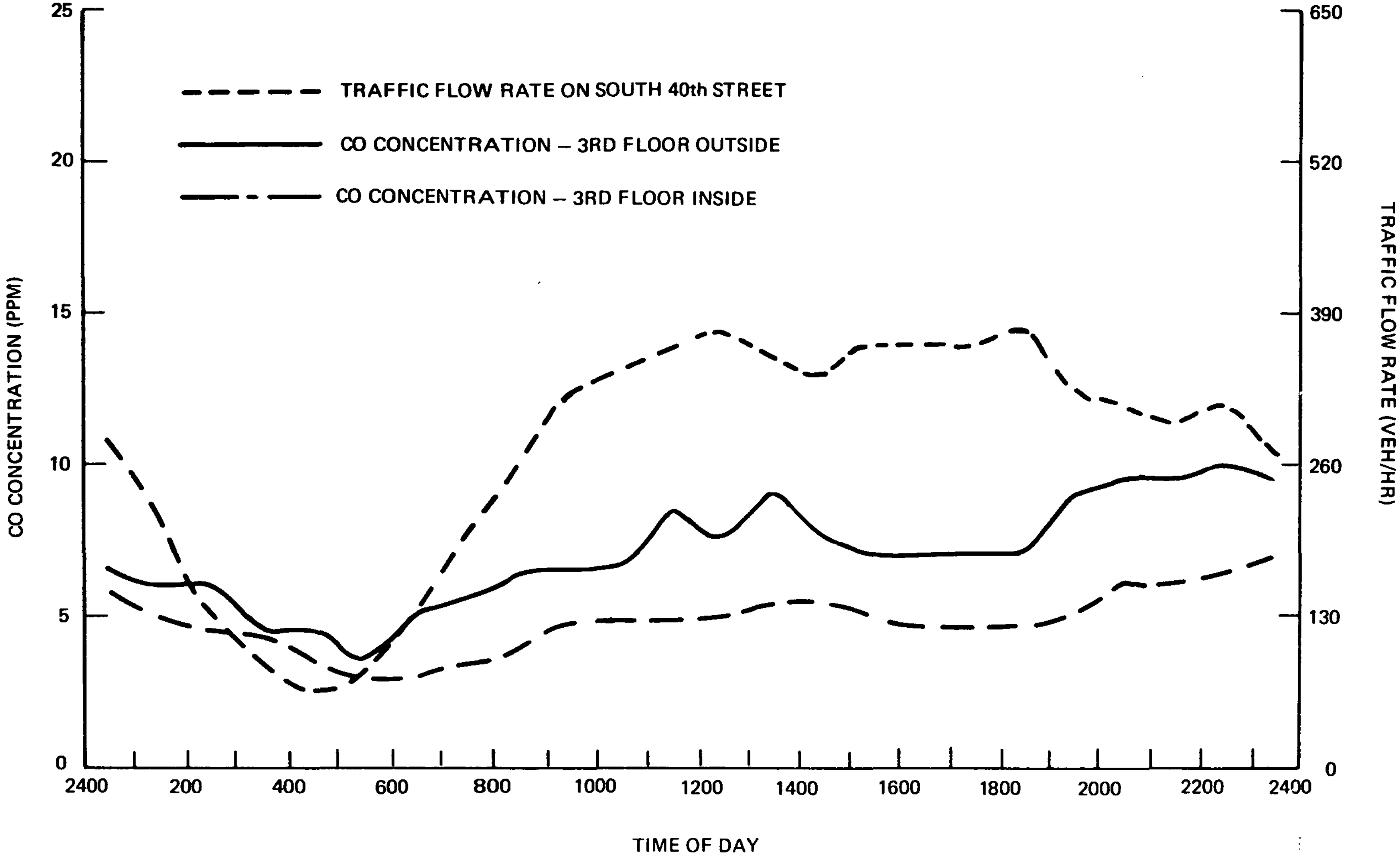
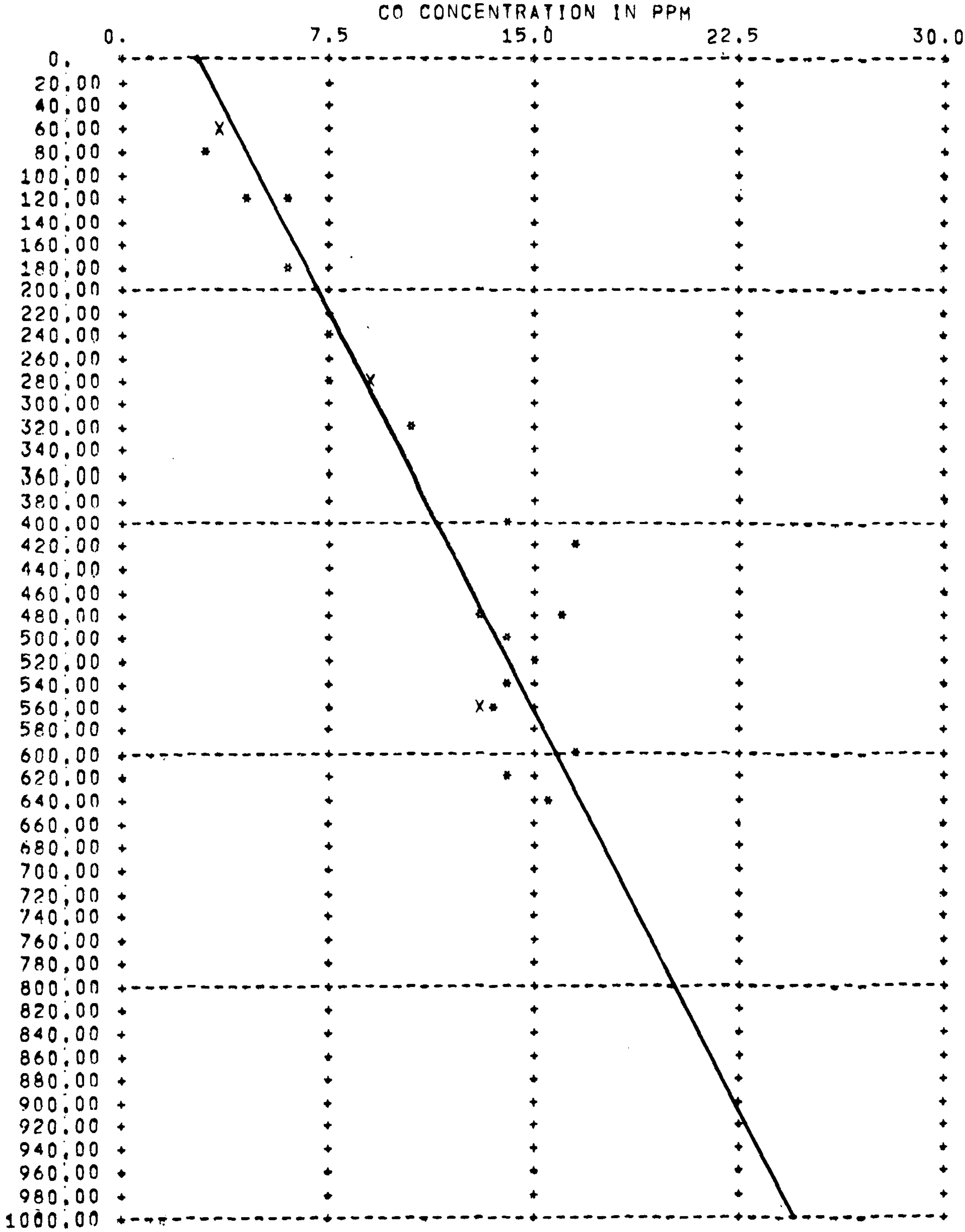


Figure 5.2.1-16. Diurnal CO & Traffic - Site 2 - Non Heating Season - Weekends - 3rd Floor

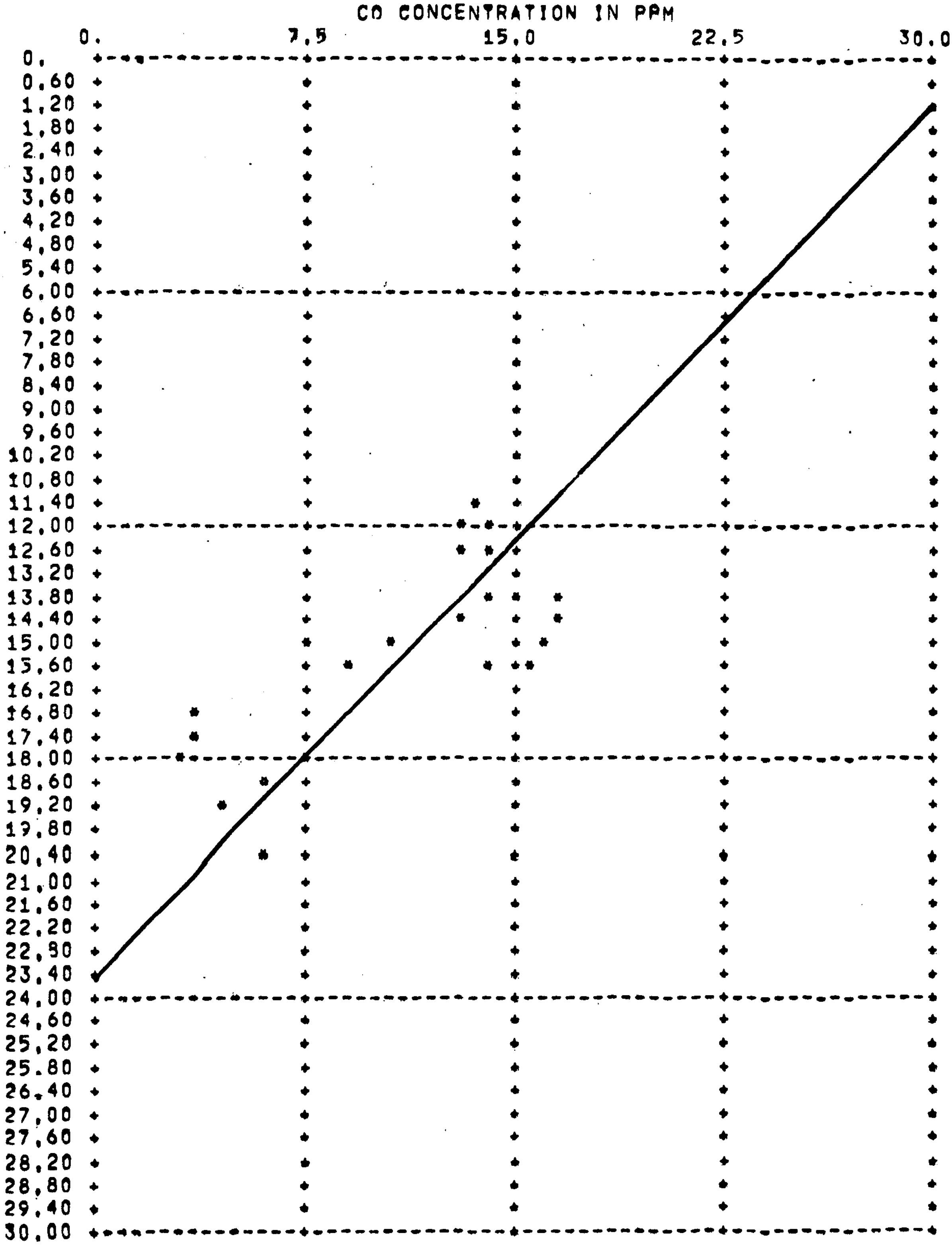
NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS CO CONCENTRATION (PPM) - 9 FT. NORTH SIDE
CO CONCENTRATION (PPM) VS TRAFFIC FLOW RATE (VEH/HR)



CO = .0219 TFR + 2.65

Figure 5.2.1-17

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS CO CONCENTRATION (PPM) - 9 FT, NORTH SIDE
CO CONCENTRATION (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)



CO = -1.343v + 31.52

Figure 5.2.1-18

TABLE 5.2.1-3

LINEAR REGRESSION ANALYSIS RESULTS

264 W. 40th Street - Non-Heating Weekdays

Traffic Flow Rate (Ind. Var.)

VS

	CO CONC. 9 FT NORTH	CO CONC. 9 FT SOUTH	CO CONC. 3rd FL. OUT	CO CONC. 3rd FL. IN
Correlation Coefficient	.93	.91	.89	.90
Intercept	2.65	2.70	3.87	2.46
Slope	.0219	.0229	.0173	.0156
Mean of Dependent Variable Observations	10.75	11.17	10.25	8.24
Mean of Independent Variable Observations	369.38	369.38	369.38	369.38

264 W. 40th Street - Non-Heating Weekends

Traffic Flow Rate (Ind. Var.)

VS

	CO CONC. 9 FT NORTH	CO CONC. 9 FT SOUTH	CO CONC. 3rd FL. OUT	CO CONC. 3rd FL. IN
Correlation Coefficient	.74	.70	.70	.55
Intercept	2.26	2.42	3.85	3.50
Slope	.0172	.0177	.0116	.0051
Mean of Dependent Variable Observations	6.98	7.28	7.04	4.90
Mean of Independent Variable Observations	274.54	274.54	274.54	274.54

TABLE 5.2.1-4

LINEAR REGRESSION ANALYSES RESULTS

264 W. 40th Street - Non-Heating Weekdays

Average Vehicle Velocity (Ind. Var.)

VS

	CO CONC. 9 FT NORTH	CO CONC. 9 FT SOUTH	CO CONC. 3rd FL. OUT	CO CONC. 3rd FL. IN
Correlation Coefficient	-.72	-.77	-.75	-.75
Intercept	31.52	34.86	28.29	24.32
Slope	-1.343	-1.533	-1.167	-1.040
Mean of Dependent Variable Observations	10.75	11.17	10.25	8.24
Mean of Independent Variable Observations	15.46	15.46	15.46	15.46

264 W. 40th Street - Non-Heating Weekends

Average Vehicle Velocity (Ind. Var.)

VS

	CO CONC. 9 FT NORTH	CO CONC. 9 FT SOUTH	CO CONC. 3rd FL. OUT	CO CONC. 3rd FL. IN
Correlation Coefficient	-.04	-.01	-.01	.02
Intercept	8.76	7.78	7.43	4.54
Slope	-.0974	-.0028	-.0216	.0201
Mean of Dependent Variable Observations	6.98	7.28	7.04	4.90
Mean of Independent Variable Observations	18.22	18.22	18.22	18.22

season. This lack of correlation is very evident on the weekends, suggesting that there is enough carbon monoxide from other sources in the vicinity of site 2 to destroy the apparent relationship between CO concentrations and 40th Street traffic flow rates suggested for weekdays.

5.2.1.2.2 Indoor Outdoor Relationships

During the non-heating season, the daily average CO concentrations were always higher outdoors than indoors at all floors for both weekdays and weekends. Several factors in combination serve to produce this reversal of the previously discussed heating season characteristics. First, the building is no longer much warmer than the ambient air surrounding it. Second, the windows of the building are open in the warm weather since the structure is not air conditioned. Third, the prevailing wind direction during the non-heating season is from the south.

It is significant to note that appreciably lower amounts of average CO were measured indoors at the 3rd floor during the non-heating season than during the heating season for essentially the same average street level CO, as previously shown on pages 5-159 & -175. As can be seen from Figure 5.2.1-11, the non-heating season indoor CO level at the 3rd floor never was higher than comparable outdoor concentrations. The average outdoor indoor differential at this floor was significantly larger, 2.1 ppm, during the non-heating season than the 0.4 ppm average O/I differential during the heating season.

During the daylight hours, indoor concentrations remained lower than outdoor concentrations at progressively higher floors. See Figures 5.2.1-12 thru -14. However, during the evening hours when building temperatures may be above outdoor temperatures or windows may be closed because workers have left for the day, indoor concentrations decrease more slowly than outdoor levels. The CO remains entrapped within the building, producing negative O/I differentials at the upper floors. Indoor concentrations do not drop below outdoor concentrations at these floors until early in the morning, when increasing traffic produces a significantly larger outdoor CO level.

The smaller proportion of street level CO entrapped at the 3rd floor indoor level results in lesser amounts of CO traveling upwards to high floors. This can be seen from the following comparison of daily average CO levels at each floor with the 5-6 pm average concentrations.

CO CONCENTRATION - PPM

	DAILY AVE			5-6PM AVE		
	O	I	Diff	O	I	Diff
3rd Floor	10.3	8.2	2.1	16.4	11.3	5.1
5th Floor	8.1	7.1	1.0	14.2	9.2	5.0
11th Floor	4.8	4.7	0.1	9.1	7.2	1.9
19th Floor	4.2	3.8	0.4	6.9	5.8	1.1
3rd to 5th Diff	2.2	1.1	1.1	2.2	2.1	0.1
5th to 11th Diff	3.3	2.4	0.9	5.1	2.0	3.1
11th to 19th Diff	0.6	0.9	-0.3	2.2	1.4	0.8

5.2.1.3 CO Meteorological Relationships

The carbon monoxide/meteorological relationships at the canyon site were investigated through the use of 5-6 pm hourly average data rather than daily average data. The analysis was limited to the 3rd and 19th floors since CO levels showed a consistent reduction with height above the roadway at both the outdoor and indoor locations during both heating and non-heating seasons.

It should be noted that, as shown on Figures 4.2-1 thru -3, that West 40th Street runs from west to east. The building under study is on the south side of the street. All CO and temperature measurements associated with the building were taken on its north face. Surrounding buildings protected the structure up to the 5th floor.

5.2.1.3.1 Meteorological Factors

Roof level meteorological conditions and site geometry again combine to produce the wind conditions at the West 40th Street level. The resultant road winds show a significantly different relationship to roof winds than recorded at the air rights structure, Site 1. As can be seen from Figure 5.2.1-19, road winds generally blew from 180° to 300° regardless of the direction of the roof wind. Westerly roof winds always produced westerly road winds and southeasterly roof winds generated southeasterly road winds. However, as the roof wind moved from 150° to 40°, road winds moved in the opposite direction; i.e., towards 300°. In essence, road winds generally blew from west to east; the same direction as the one-way traffic flow.

Roof winds from the west generally produced moderate wind speeds at both roof and road levels. Wind speed decreased as the roof wind shifted counterclockwise thru 180° to the east. Average wind speed decreased approximately 2 mph for comparable roof wind angles from the start of the

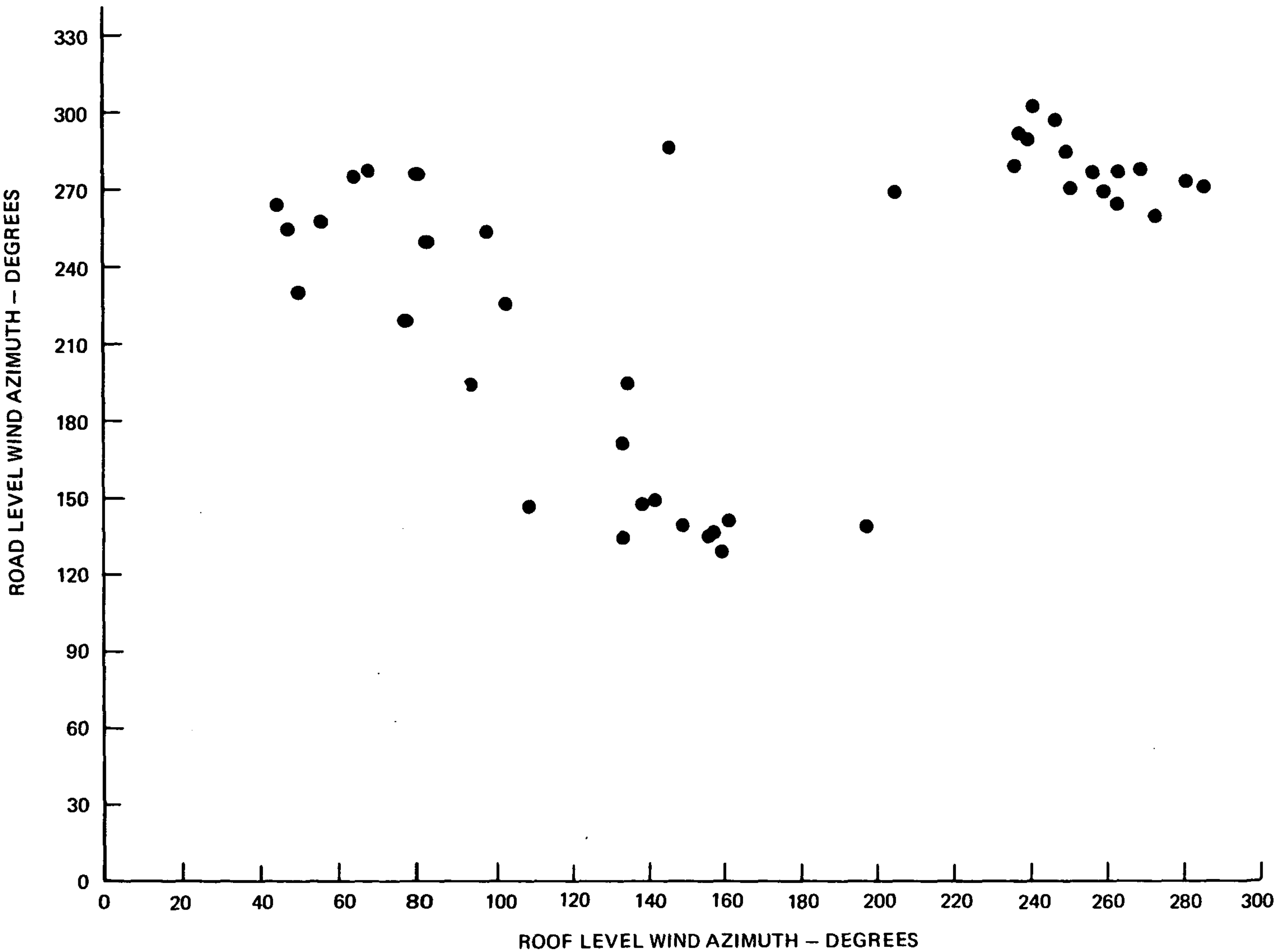


Figure 5.2.1-19. Road Level Vs. Roof Level Wind Azimuth - 6 PM - Heating Weekdays - Site 2

monitoring in February to the end in early summer.

During the heating season, average temperatures rose approximately 20°F for comparable roof wind directions. Site temperature, as measured at roof level, was very responsive to wind direction. Low temperatures occurred when the wind blew from the west. The temperature rose as the wind shifted to the south and then decreased as the wind moved to the east. The combination of change in temperature with calendar time and roof wind direction resulted in a very scattered temperature/wind direction relationship, as shown on Figure 5.2.1-20. The significance of wind angle on temperature level is demonstrated by the constant temperature lapse lines drawn on the figure. In general, temperature lapse is low for higher temperatures for a fixed roof wind angle. As can be seen from Figure 5.2.1-21, temperature lapse is not influenced by roof wind direction, as was previously noted for the air rights structure at Site 2.

At road level, wind speed and wind sigma appear to be related as shown on Figure 5.2.1-22. High sigmas occur for high wind speed from the west. Sigmas decrease as wind speed decreases. Southeasterly winds produce the reverse wind speed sigma relationship.

It can be seen from the preceding figures that roof wind direction is the major meteorological variable. While the other meteorological factors also vary, these variances are so closely associated with changes in roof wind that their effects are not discernable.

5.2.1.3.2 <u>3rd Floor Concentrations</u>

CO concentrations at the 3rd Floor outdoor location, as suggested above, are not responsive to any of the road level meteorological factors as shown on Figures 5.2.1-23 thru -26. In reality, 3rd floor concentrations

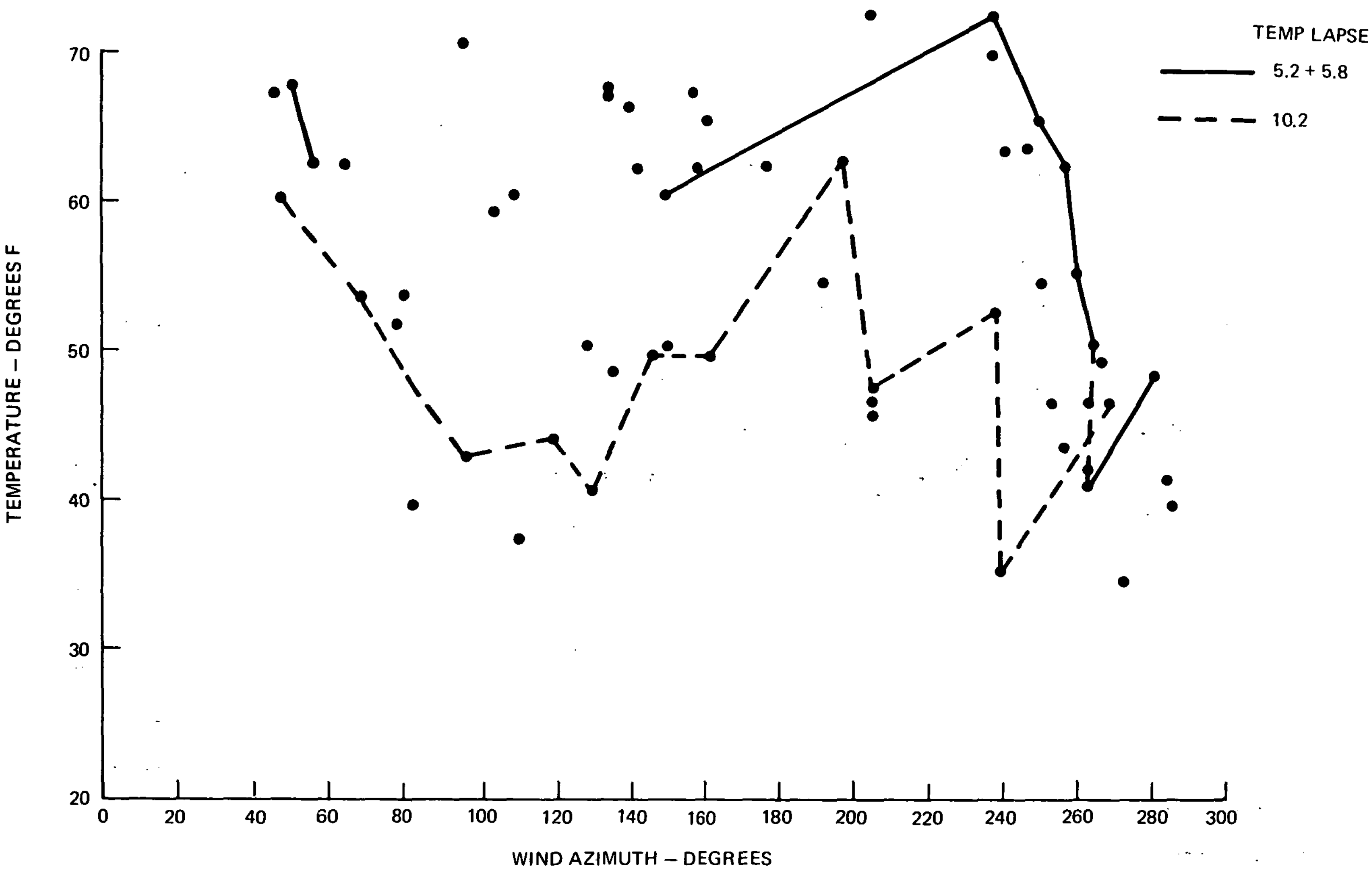


Figure 5.2.1-20. Roof Level Temperature Vs. Roof Level Wind Azimuth - 6 PM - Weekday - Site 2

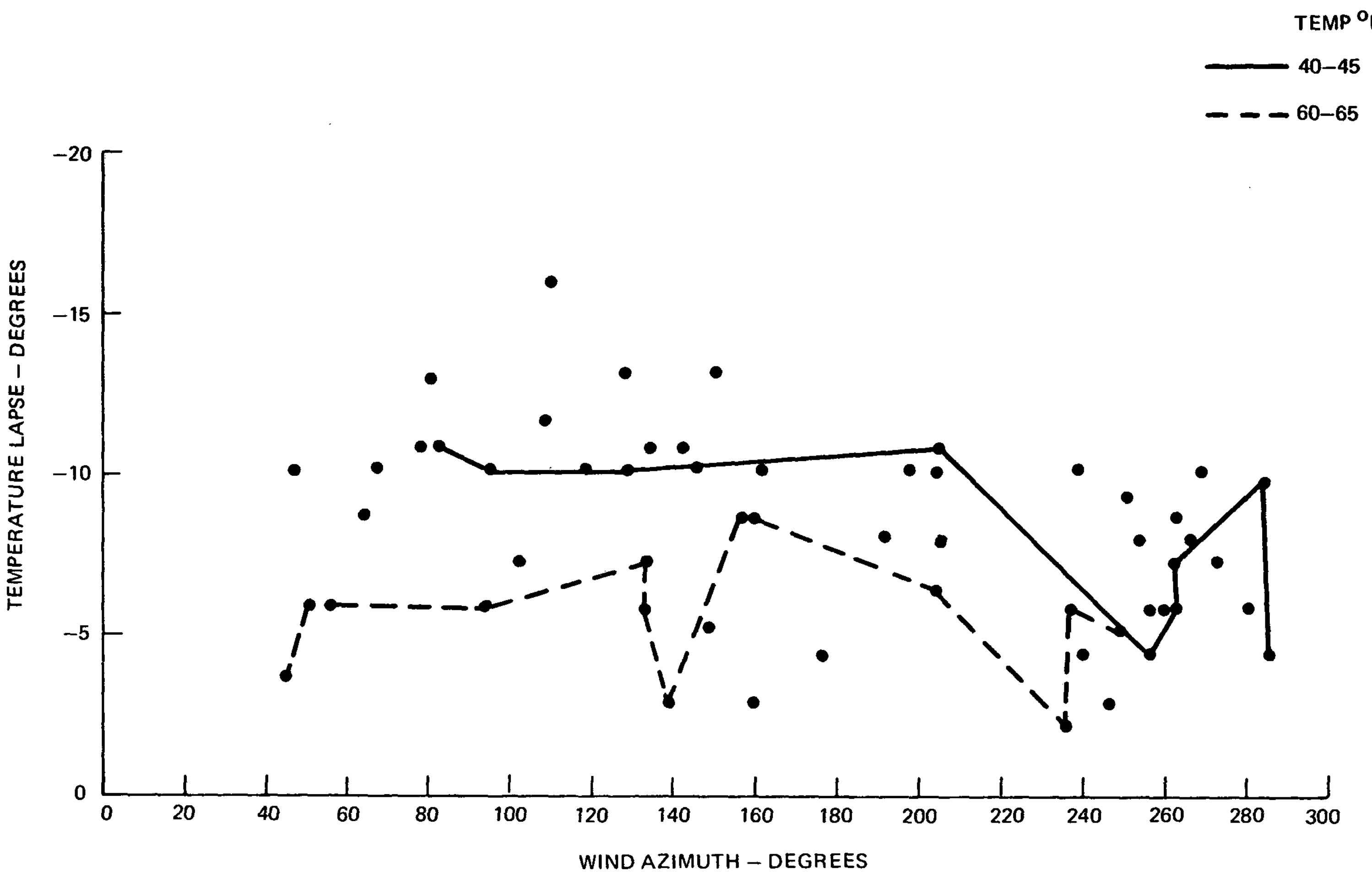


Figure 5.2.1-21. Temperature Lapse Vs. Roof Level Wind Azimuth - 6 PM - Heating Weekday - Site 2

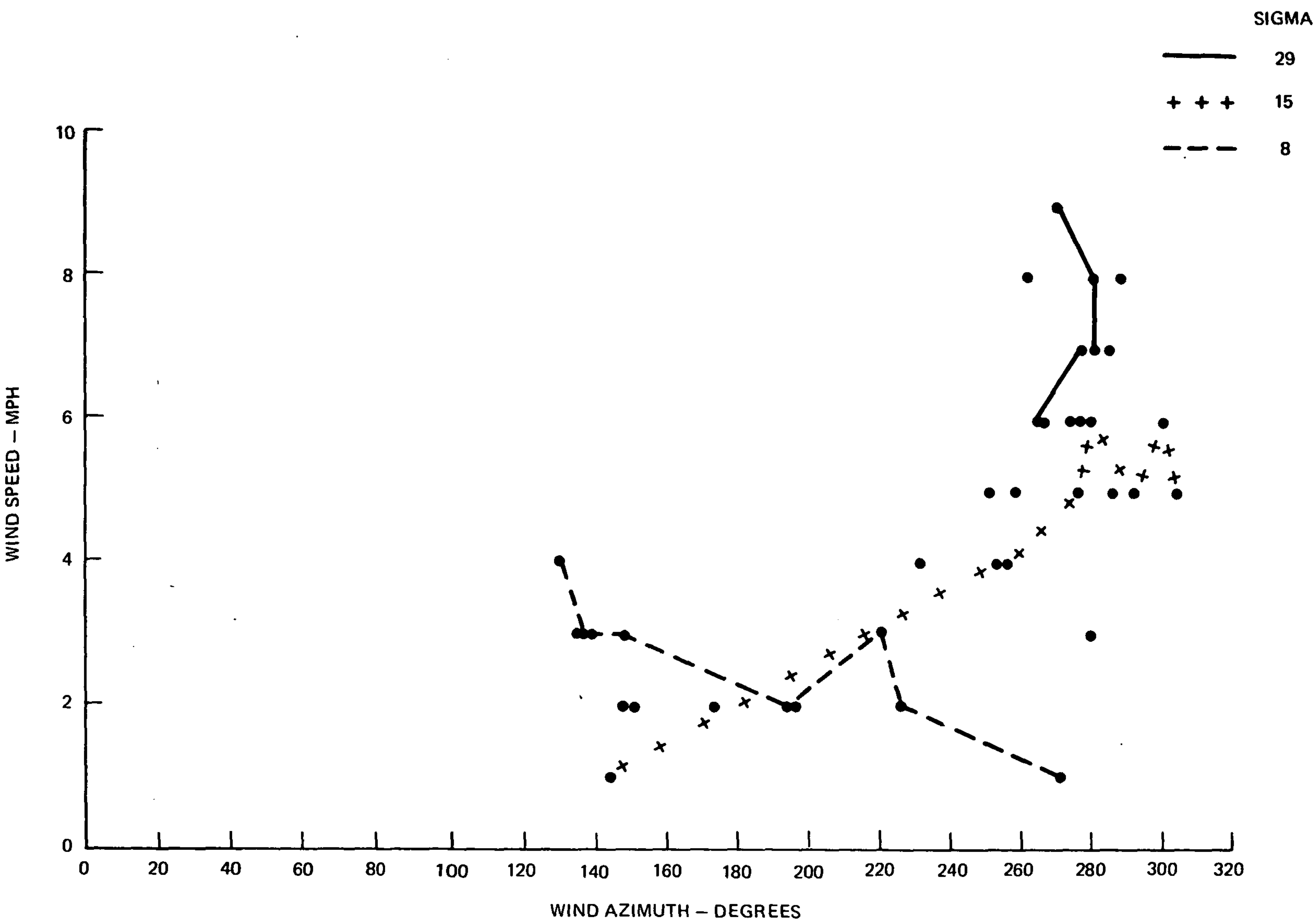


Figure 5.2.1-22. Wind Speed Vs. Wind Azimuth Road Level - 6 PM - Heating Weekdays - Site 2

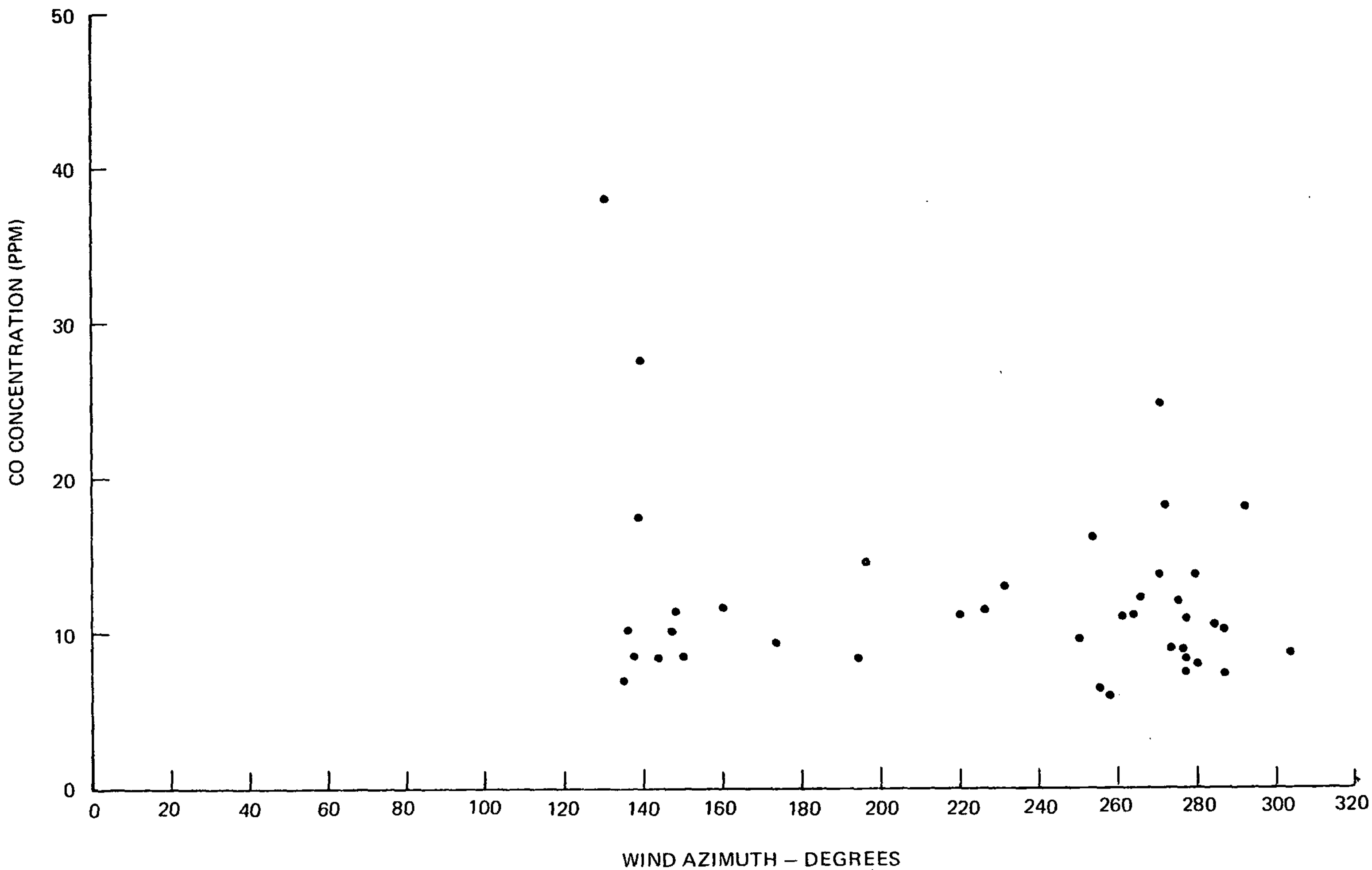


Figure 5.2.1-23. CO Concentration - 3rd Floor - Outdoors Vs. Road Level Wind Azimuth - 6 PM - Heating Weekdays Site 2

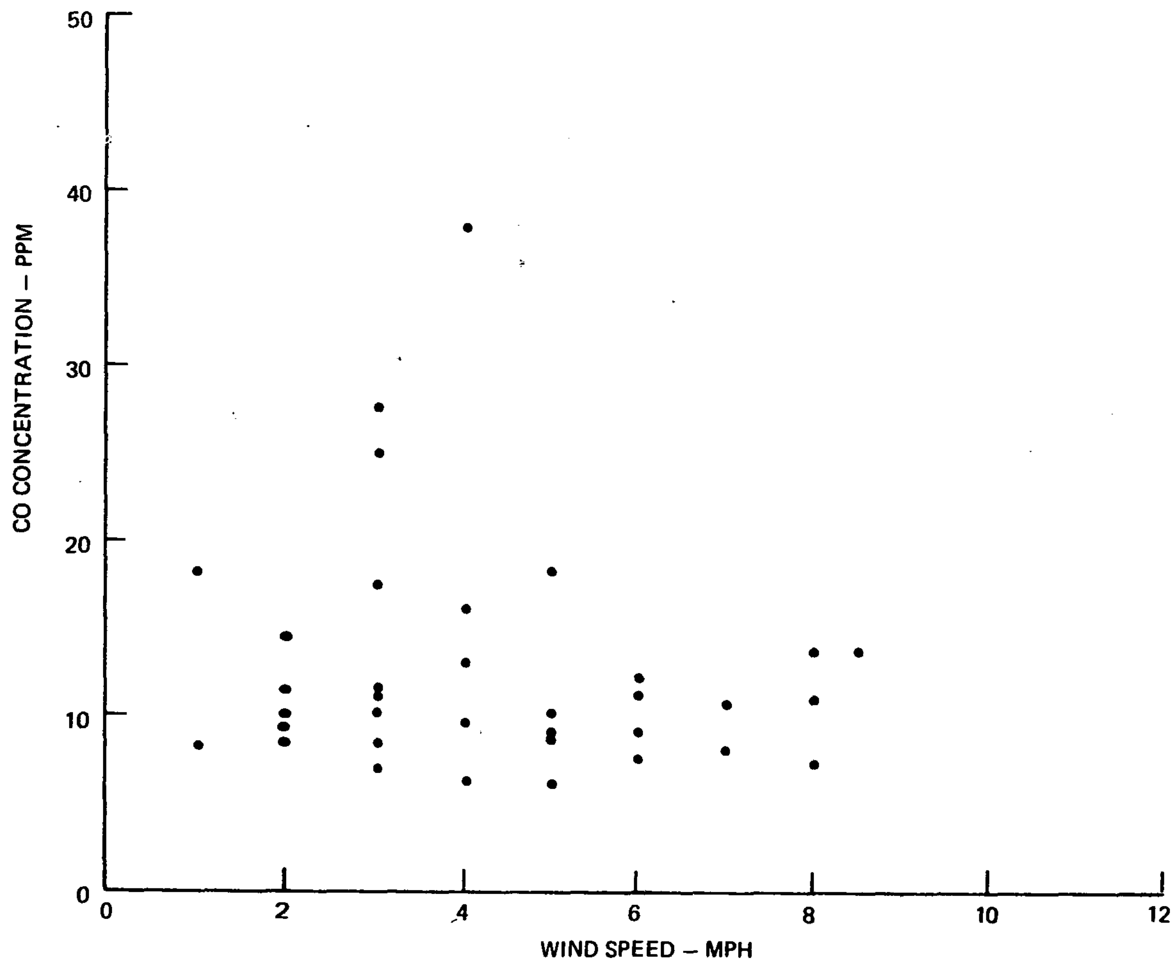


Figure 5.2.1-24. CO Concentration - 3rd Floor Outdoors Vs. Road Level Wind Speed - 6 PM - Heating Weekdays Site 2

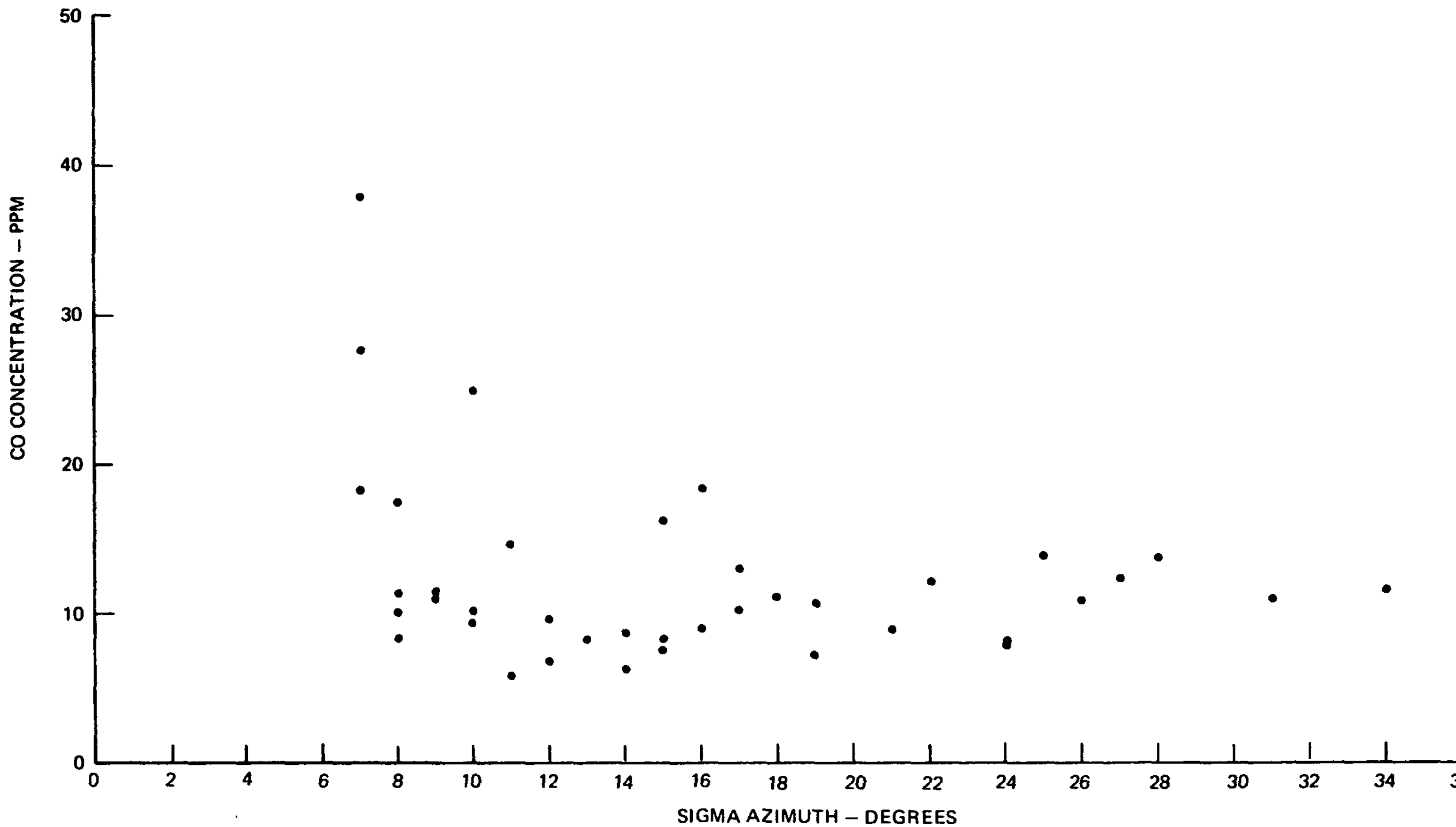


Figure 5.2.1-25. CO Concentration - 3rd Floor Outdoors Vs. Road Level Sigma Azimuth - 6 PM - Heating Weekdays - Site 2

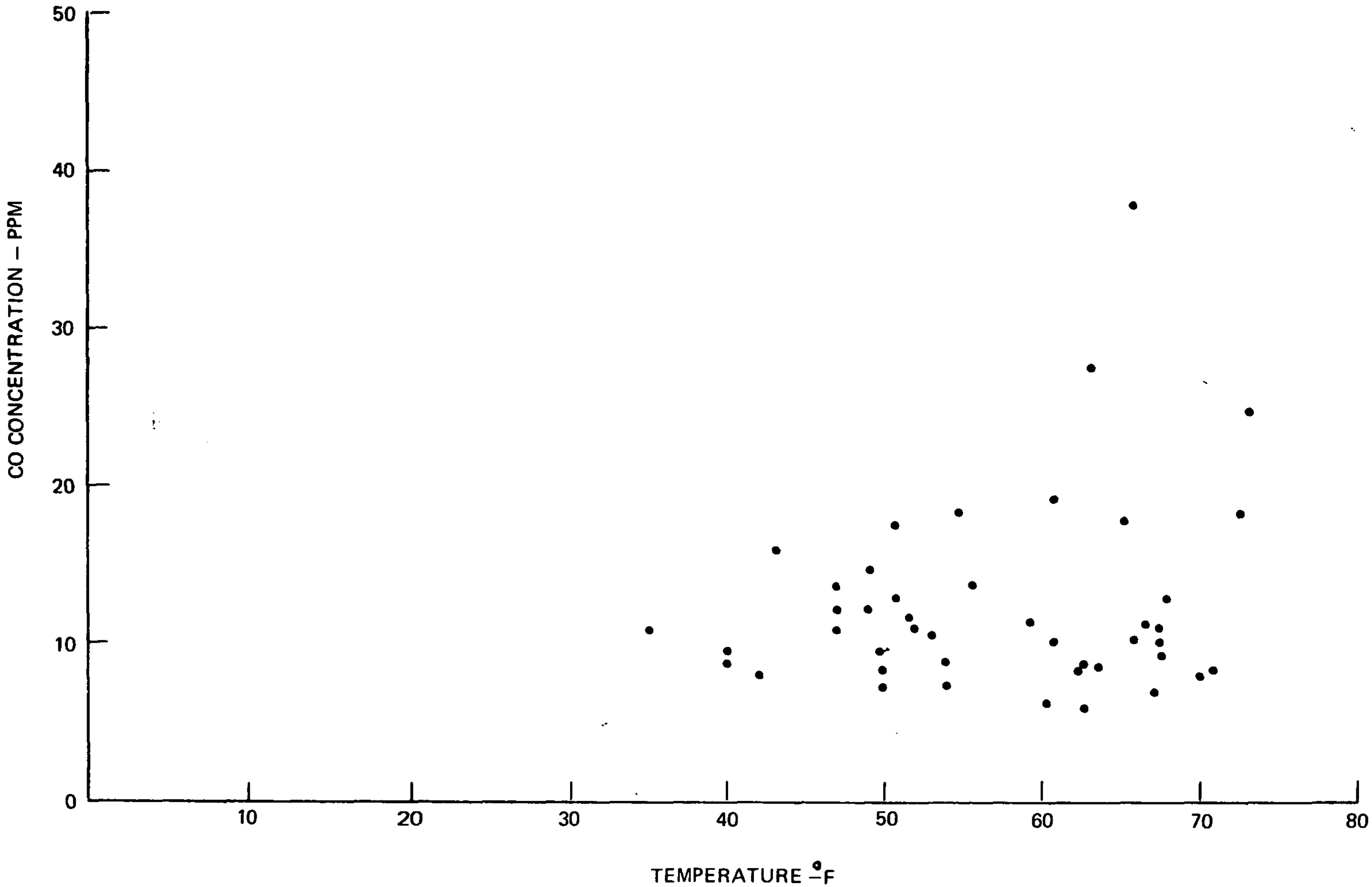


Figure 5.2.1-26. CO Concentration - 3rd Floor Outdoors Vs. Road Level Temperature - 6 PM - Heating Weekdays - Site 2

are primarily related to the carbon monoxide levels found at the road level. Since, as previously shown on Figure 5.2.1-1, the CO gradient across the road is very small - there is only a small difference between 3rd floor CO and CO on either side of the street. However, the outdoor CO appears to be more closely related to the north side CO and indoor CO to that measured on the south side. These relationships are shown on Figures 5.2.1-27 and -28. There is a suggestion that the roof wind has some bearing upon 3rd floor concentrations. It can be seen, from Figure 5.2.1-29, that higher CO levels were measured when the roof winds blew from the south behind the building.

The outdoor indoor differential at the 3rd floor is determined by both the CO concentration outdoors and site temperature. The differential increases as outdoor CO and site temperature increase as shown on Figures 5.2.1-30 and -31. As shown by the lines of constant 3rd floor CO overlayed on Figure 5.2.1-31, the differential is biased uniformly by 3rd floor outdoor CO for a constant road level temperature. However, the differential appears to be steeper at higher temperatures. This suggestion can be seen by comparing the slope of the heating season data points on Figure 5.2.1-30 with that for the non-heating season shown on Figure 5.21.1-32. The 3rd floor differential is affected slightly by the roof wind azimuth angle, as seen on Figure 5.2.1-33. This effect is primarily due to the greater influence of the roof wind on outdoor CO than on indoor concentrations.

5.2.1.3.3 Differential 3rd to 19th Floors

Outdoor and indoor concentrations are affected in identical fashions with height above the road. This can be seen by examining the change in CO levels between the 3rd and 19th floors for both the outdoor and indoor paths. Both vertical differentials display completely random patterns for changes in roof wind speed, roof temperature as site temperature lapses,

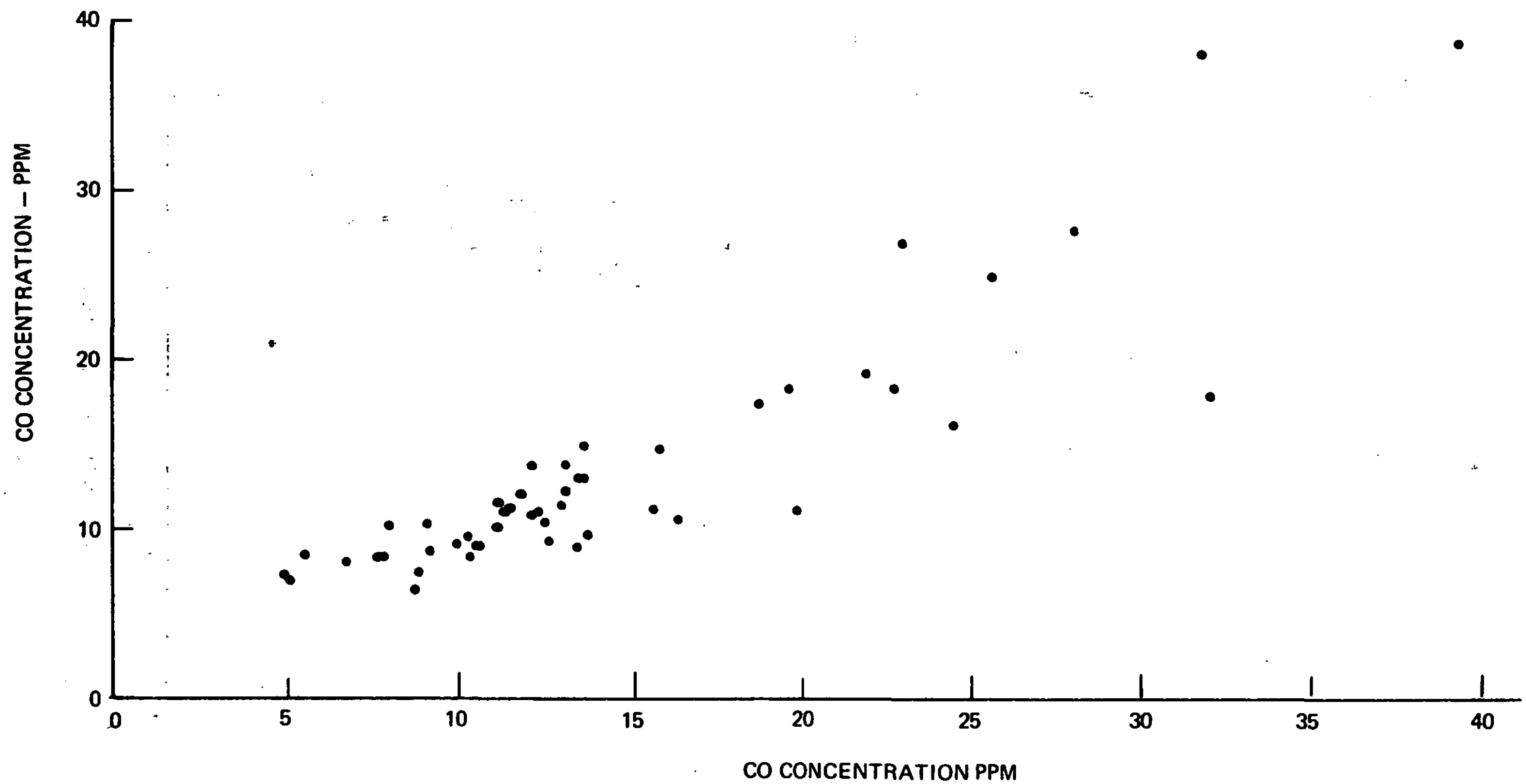


Figure 5.2.1-27. CO Concentration 3rd Floor Outdoors Vs. CO Concentration Road Level North Side – 6 PM Heating Weekdays Site 2

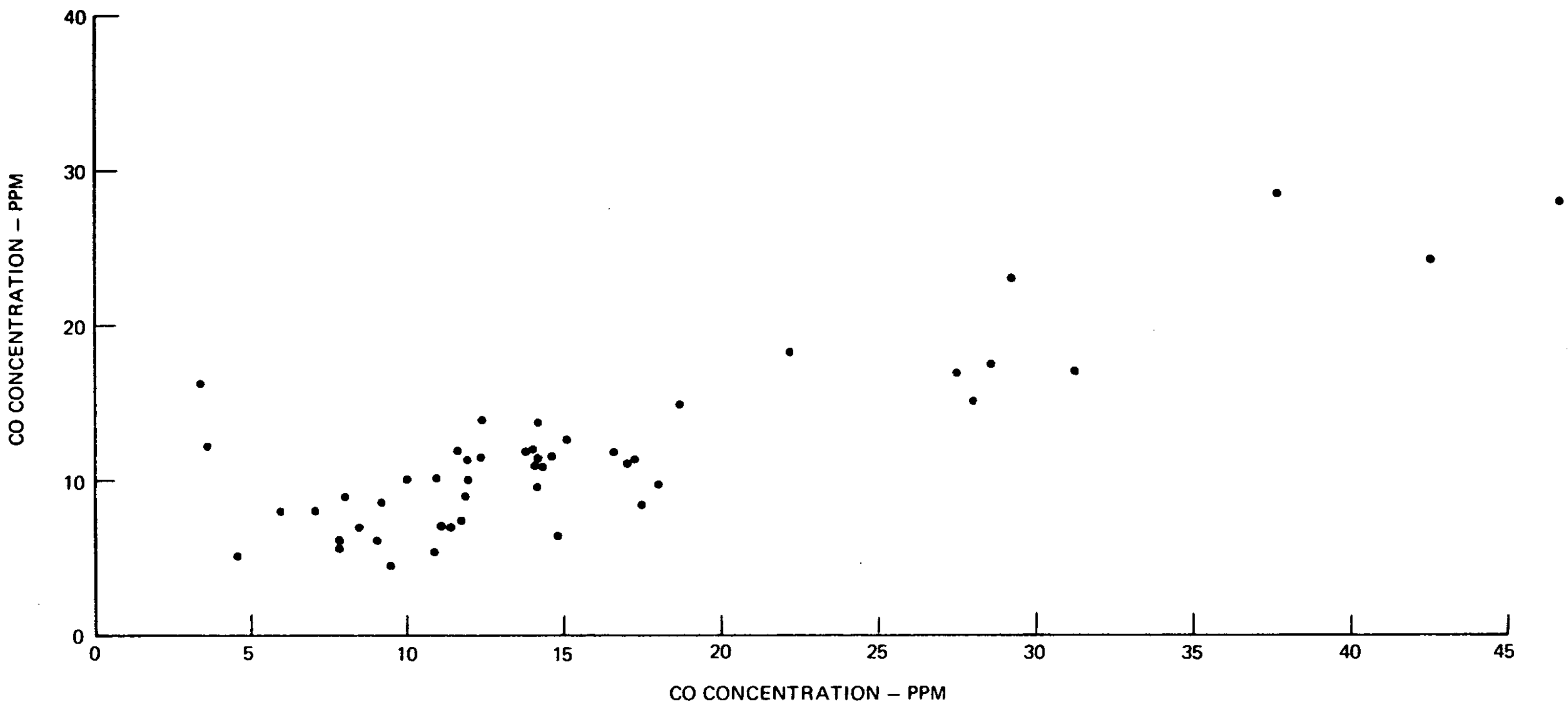


Figure 5.2.1-28. CO Concentration 3rd Floor Indoors Vs. CO Concentration Road Level South Side - 6 PM - Heating Weekday - Site 2

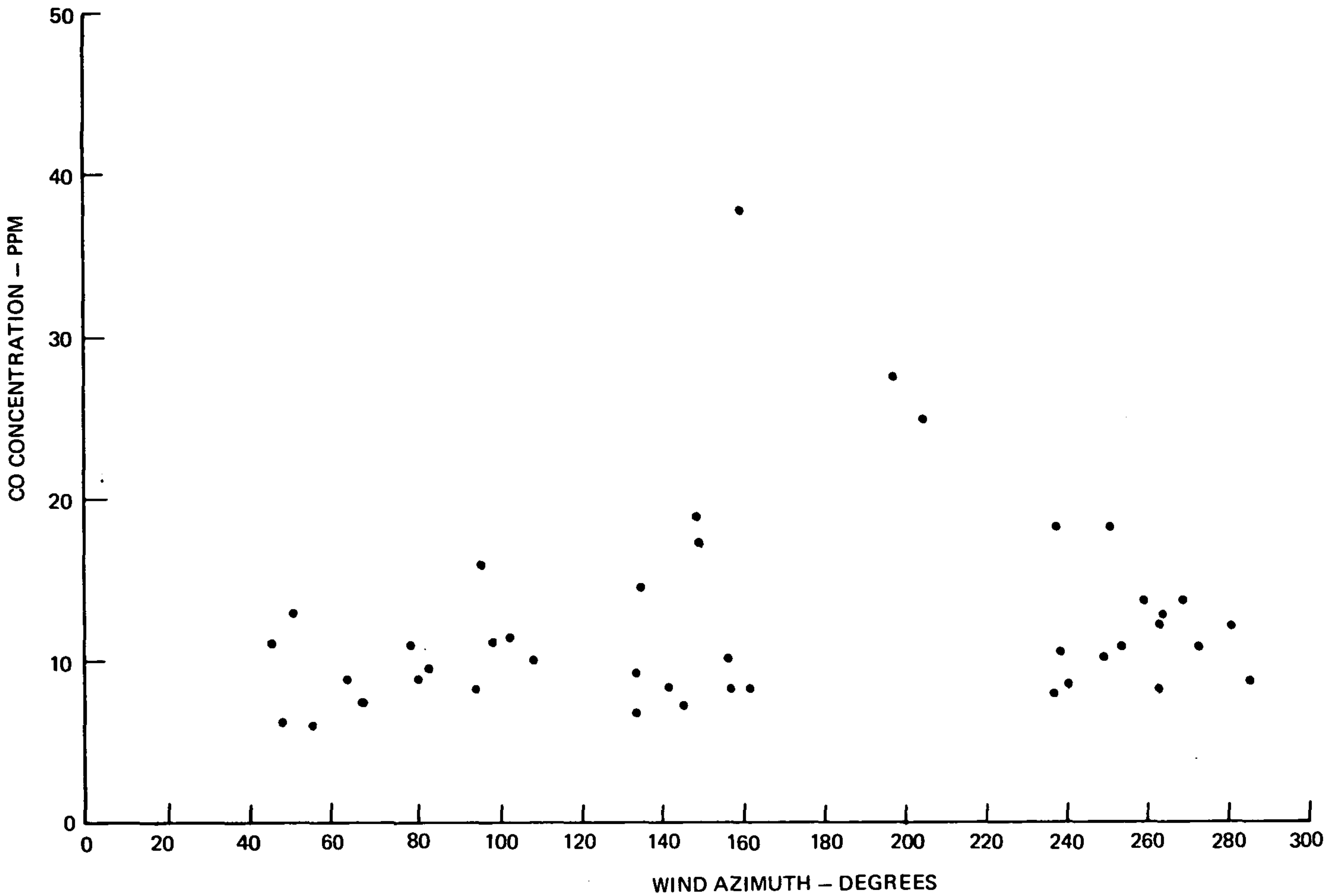


Figure 5.2.1-29. CO Concentration 3rd Floor Outdoor Vs. Roof Level Wind Azimuth - 6PM - Heating Weekdays - Site 2

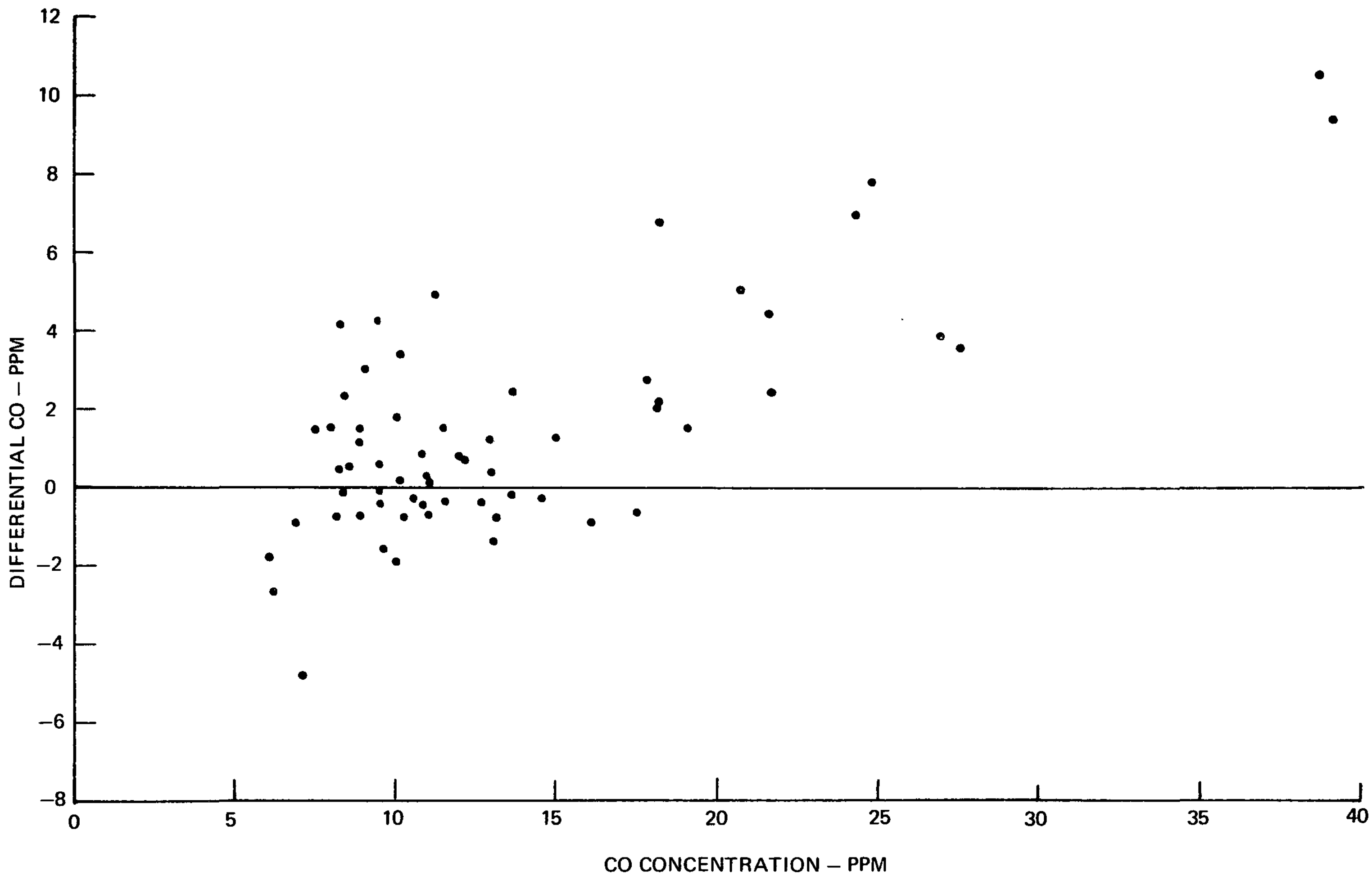


Figure 5.2.1-30. Differential CO - Outdoor/Indoor - 3rd Floor Vs. 3rd Floor Concentration Outdoors - 6 PM - Heating Weekdays Site 2

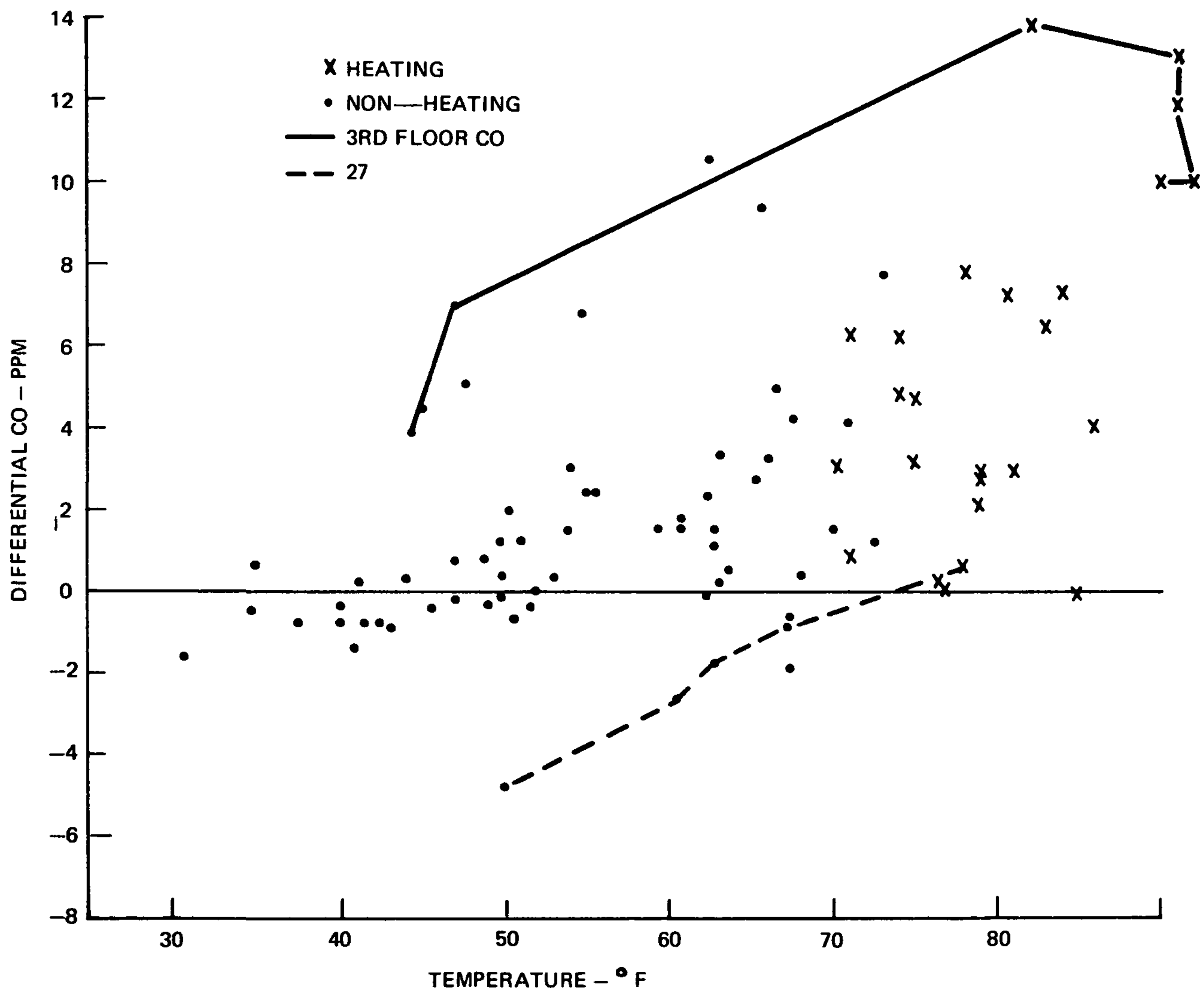


Figure 5.2.1-31. Differential CO - Outdoor/Indoor - 3rd Floor Vs. Road Level Temperature - 6PM - All Weekdays - Site 2

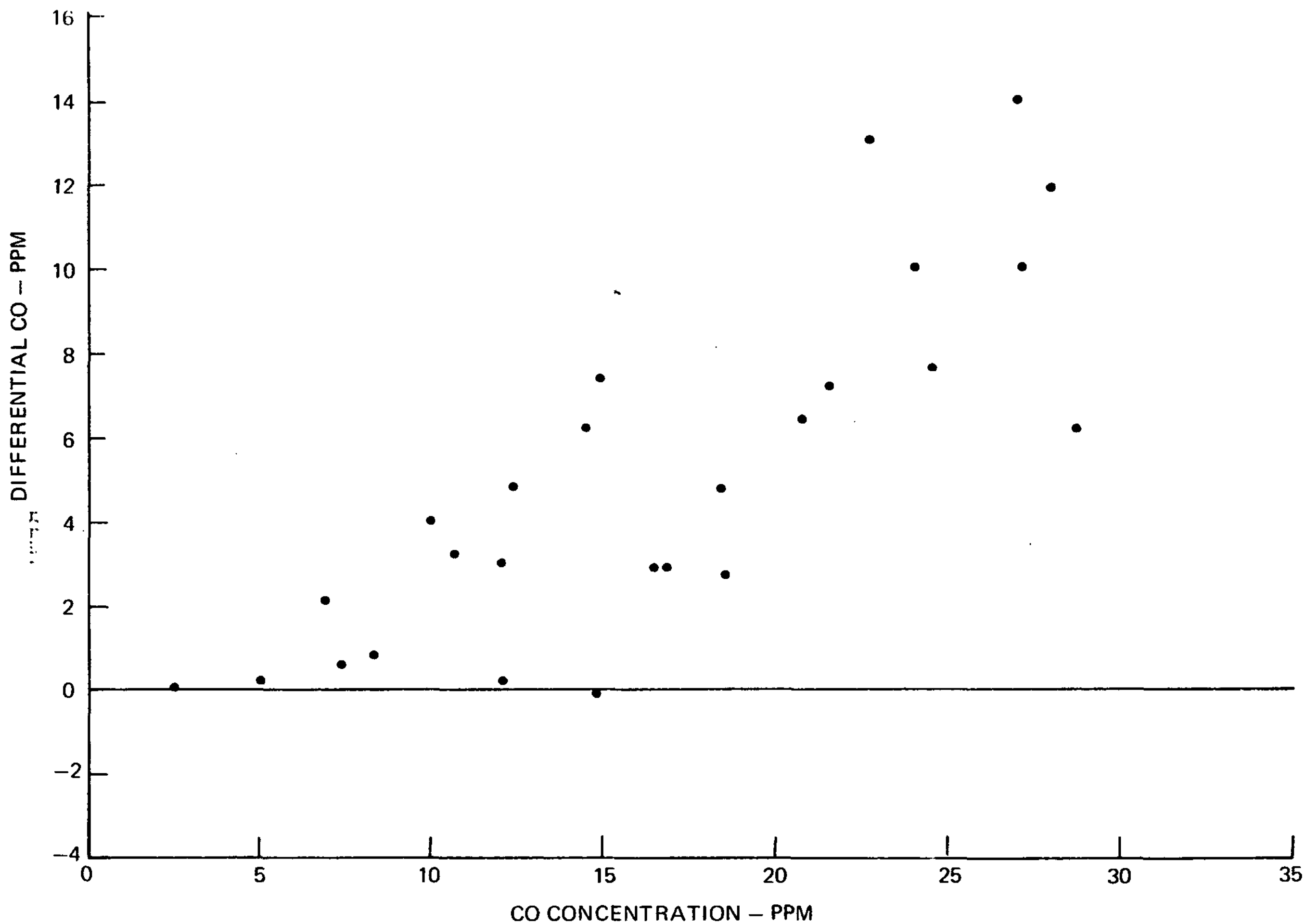


Figure 5.2.1-32. Differential CO - Outdoor/Indoor - 3rd Floor Vs. 3rd Floor Concentration Outdoors - 6 PM - Non-Heating Weekdays - Site 2

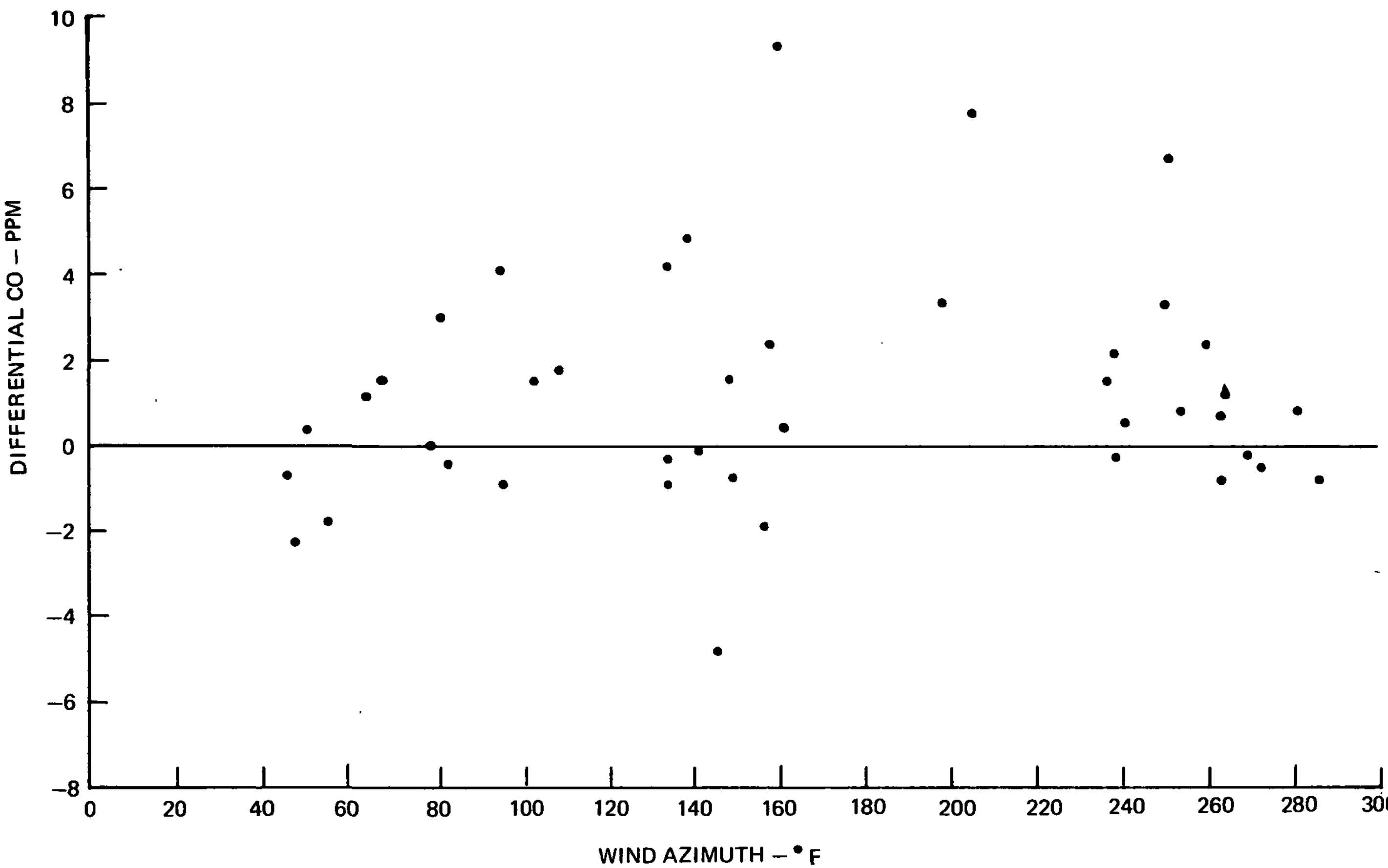


Figure 5.2.1-33. Differential CO - Outdoor/Indoor - 3rd Floor Vs. Roof Level Wind Azimuth - 6 PM - Heating Weekdays - Site 2

see Figures 5.2.1-34 thru -39. These differentials, as shown on Figures 5.2.1-40 and -41, show identical response to roof wind azimuth. Both outdoor and indoor vertical differentials are high for southerly winds and low for all other winds. This indicates that the sheltering affect from southerly winds seen at the 3rd floor is lost at the upper floors. It is felt that this is caused by the fact that adjacent buildings are only five stories high.

5.2.1.3.4 <u>19th Floor Concentrations</u>

CO concentrations at the 19th floor directly reflect the CO levels below as modified by the roof wind azimuth. Outdoor concentrations are significantly reduced in level from that seen at the 3rd floor. However, the 19th floor outdoor CO is still responsive to road level CO, as shown on Figure 5.2.1-42. The net effect of the vertical differentials noted in Section 5.2.1.3.3 is to produce outdoor CO levels, and 19th floor outdoor/indoor CO differentials which are random with roof wind. This can be seen from Figures 5.2.1-43 and -44.

The 19th floor outdoor/indoor differential retains essentially the same relationship to outdoor concentration and site temperature as seen at the 3rd floor. The 19th floor differential exhibits the same slope with respect to outdoor CO level, see Figure 5.2.1-45, as seen at the 3rd floor. The curves are displaced proportionately to the CO level at the respective floors. Site temperature has a lesser effect on outdoor/indoor differential at the 19th floor, however. While the differential again increases with temperature change, the rate of change is lower as shown on Figure 5.2.1-46.

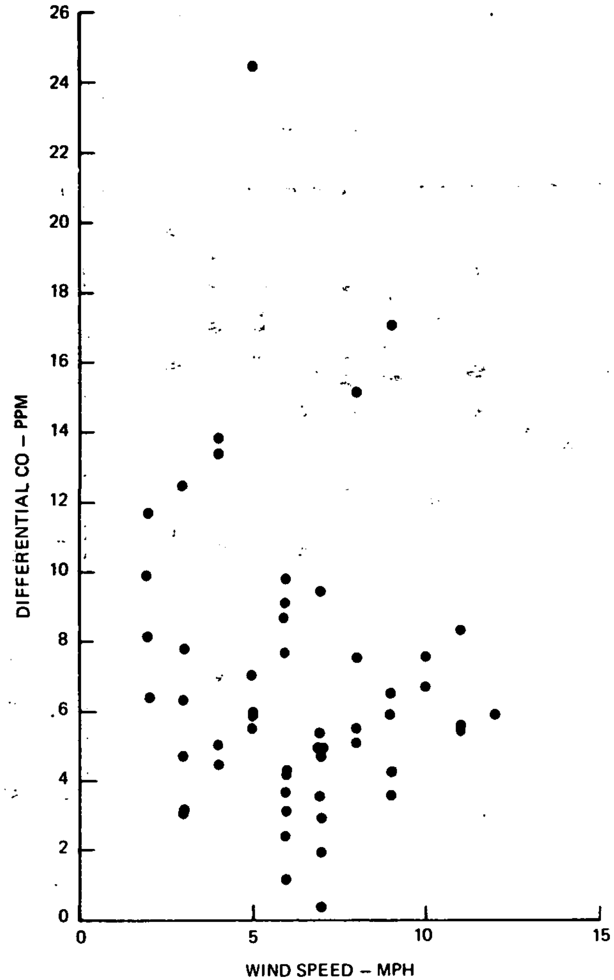


Figure 5.2.1-34. Differential CO - Outdoor - 3rd to 19th Floor Vs. Roof Level Wind Speed - 6 PM - Heating Weekdays - Site 2

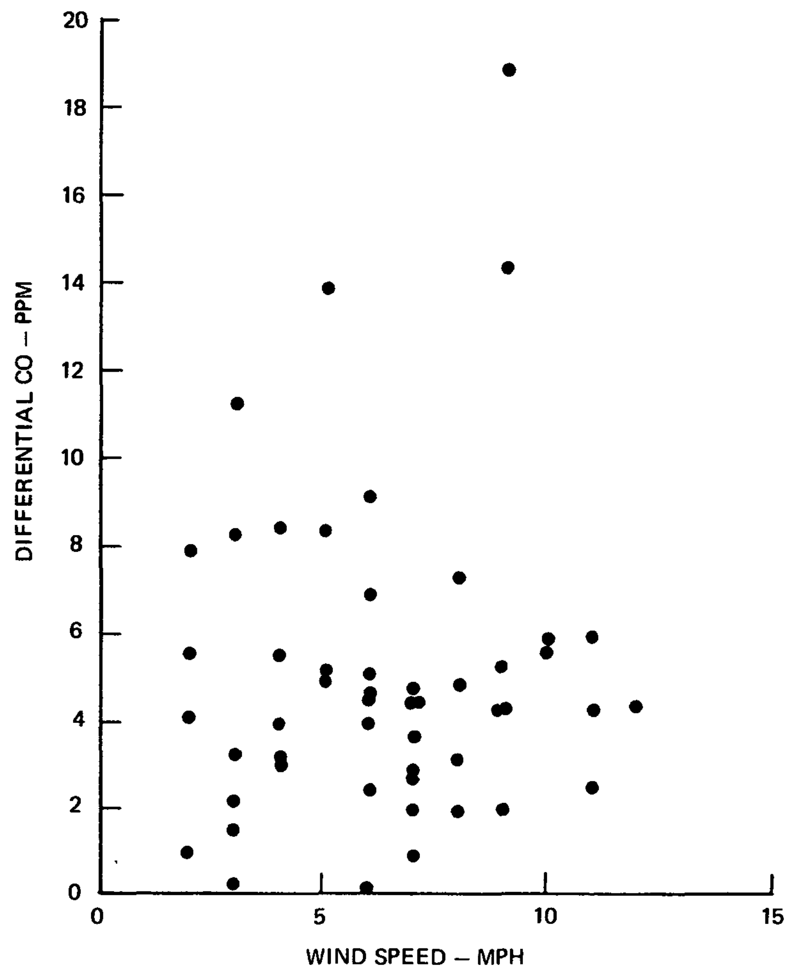


Figure 5.2.1-35. Differential CO - Indoor - 3rd to 19th Floor Vs. Roof Level Wind Speed - 6 PM - Heating Weekdays - Site 2

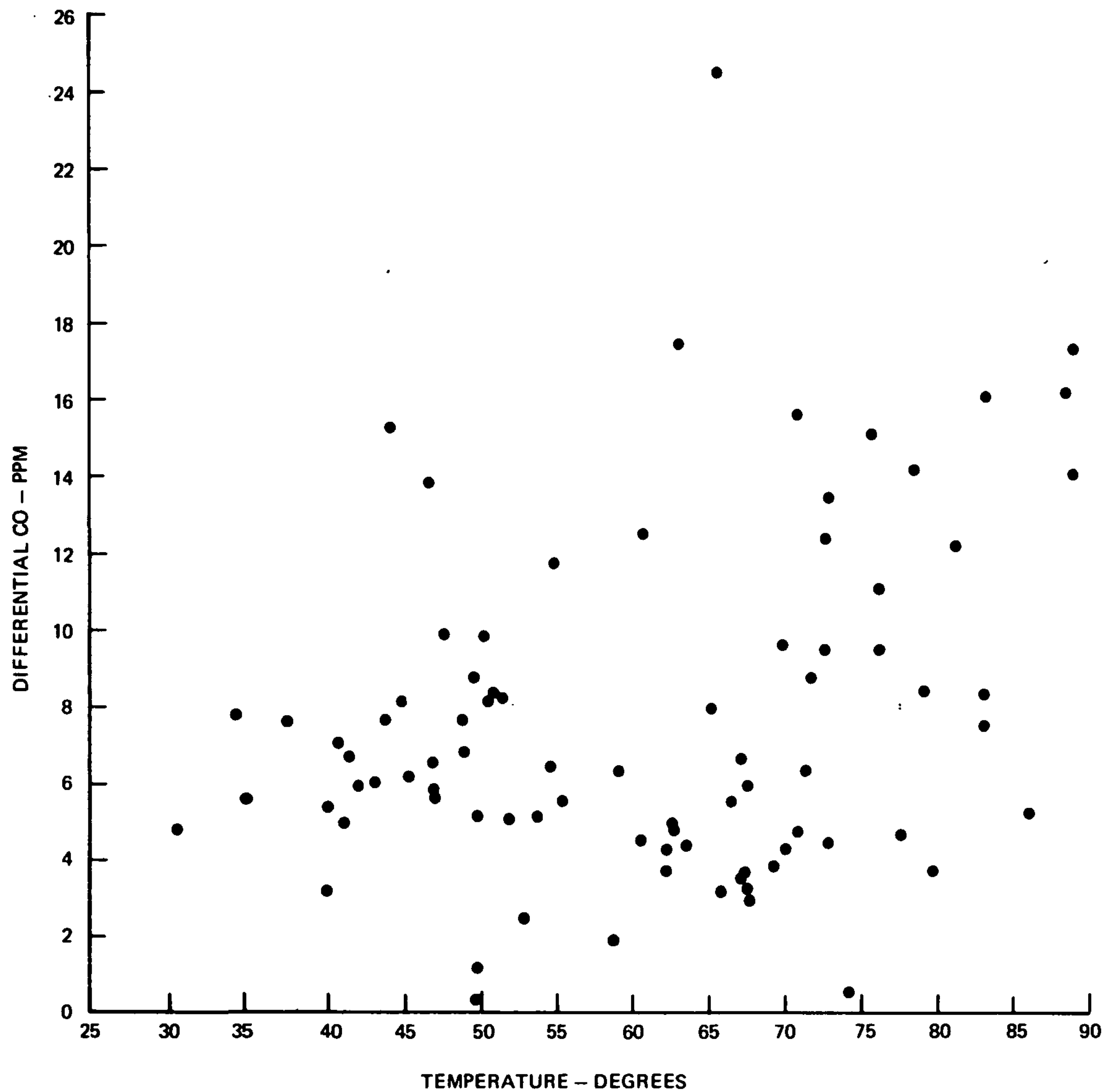


Figure 5.2.1-36. Differential CO - Outdoor - 3rd to 19th Floor Vs. Roof Level Temperature - 6 PM - All Weekdays - Site 2

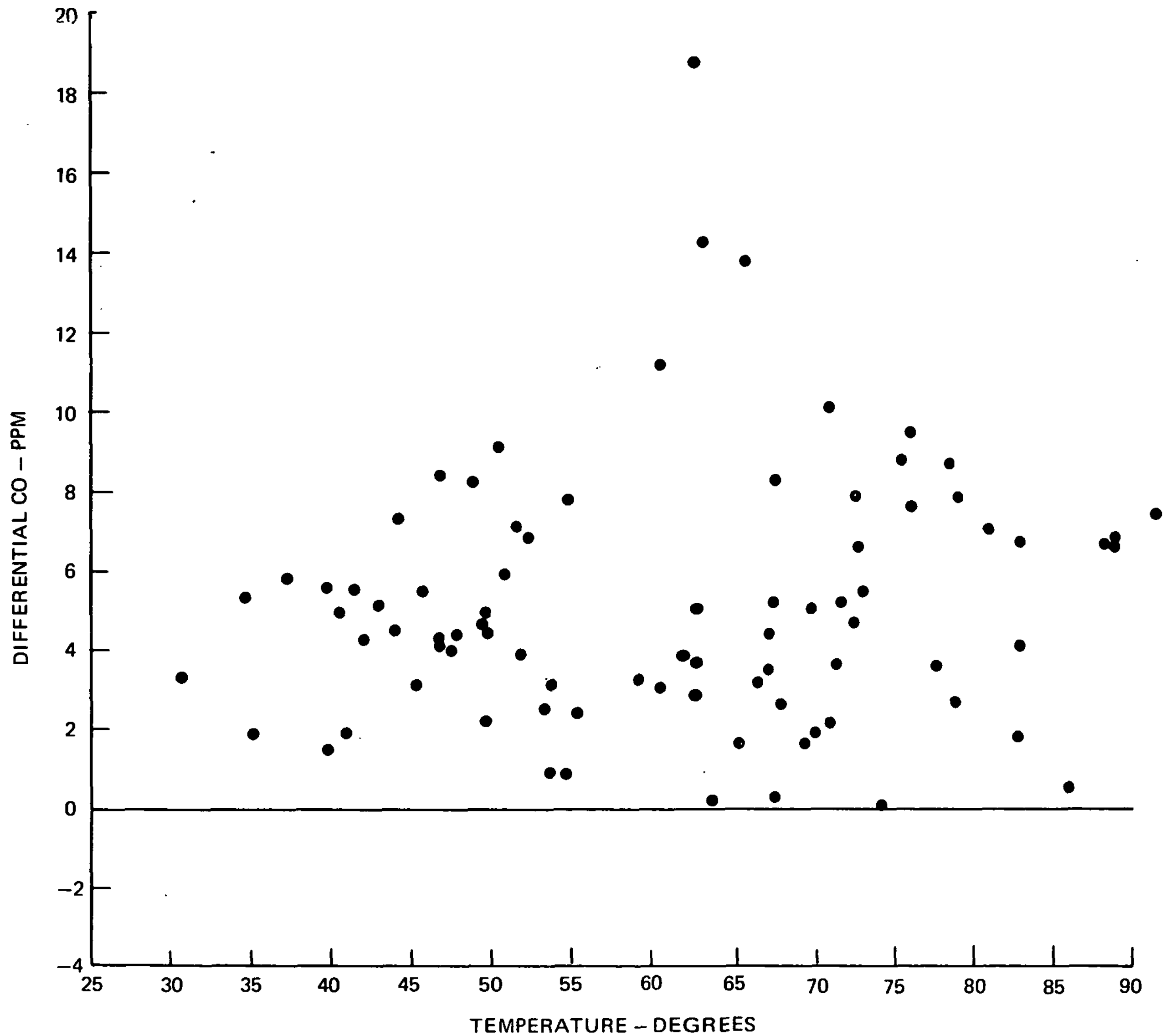


Figure 5.2.1-37. Differential CO – Indoor – 3rd To 19th Floor Vs. Roof Level Temperature – 6 PM – All Weekdays – Site 2

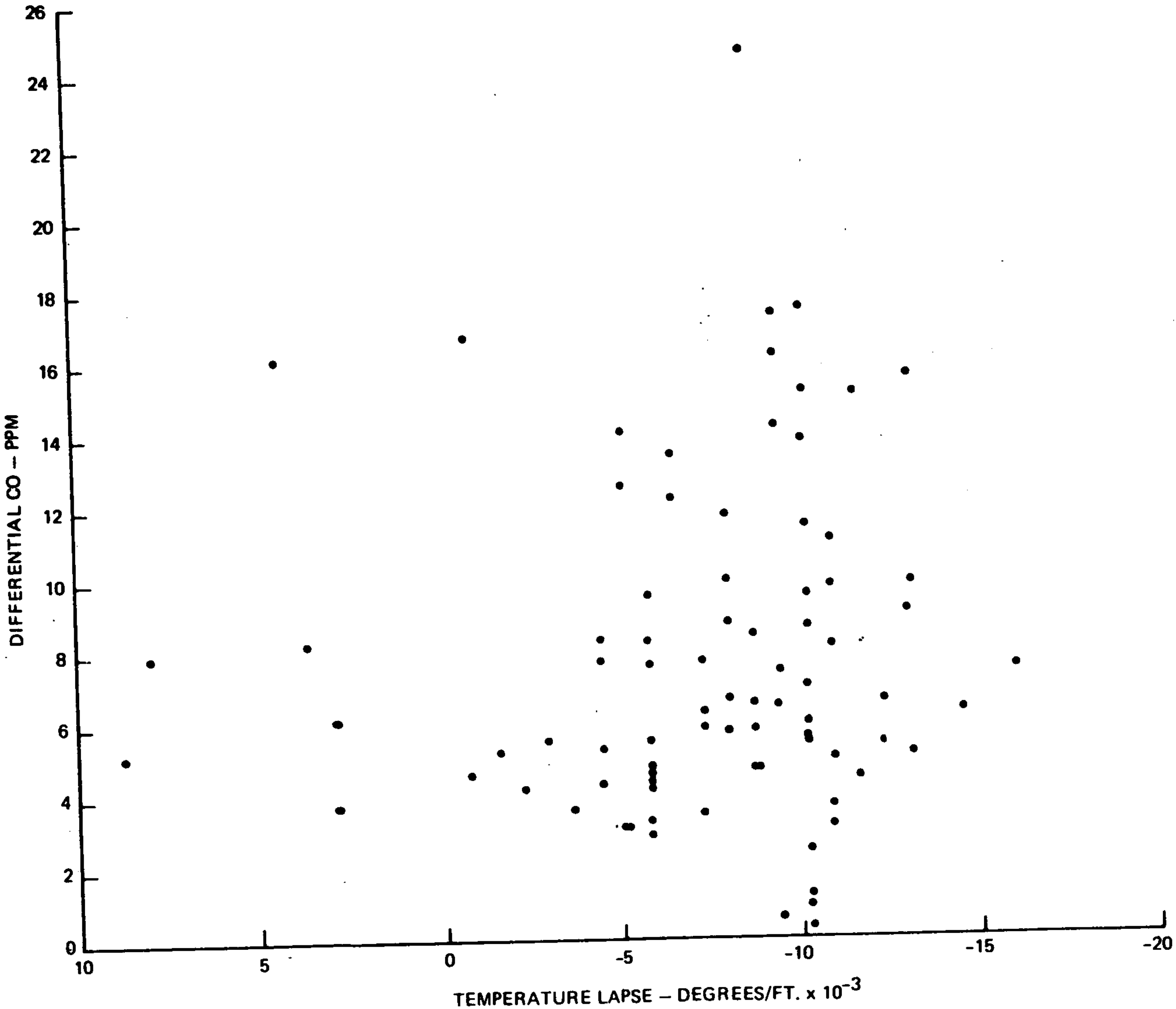


Figure 5.2.1-38. Differential CO – Outdoor – 3rd To 19th Floor Vs. Temperature Lapse – 6 PM – All Weekdays – Site 2

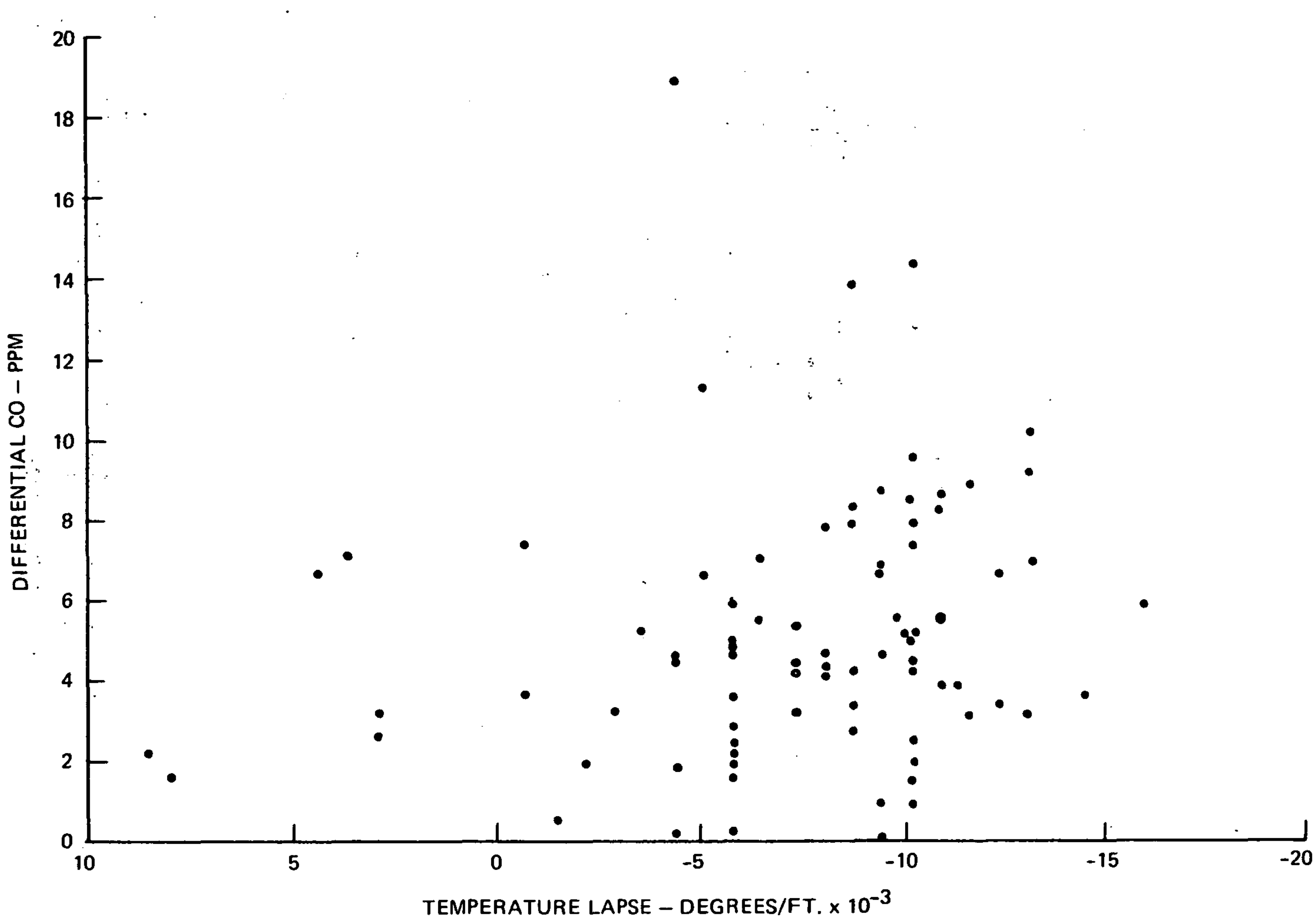


Figure 5.2.1-39. Differential CO – Indoor – 3rd To 19th Floor Vs. Temperature Lapse – 6 PM – All Weekdays – Site 2

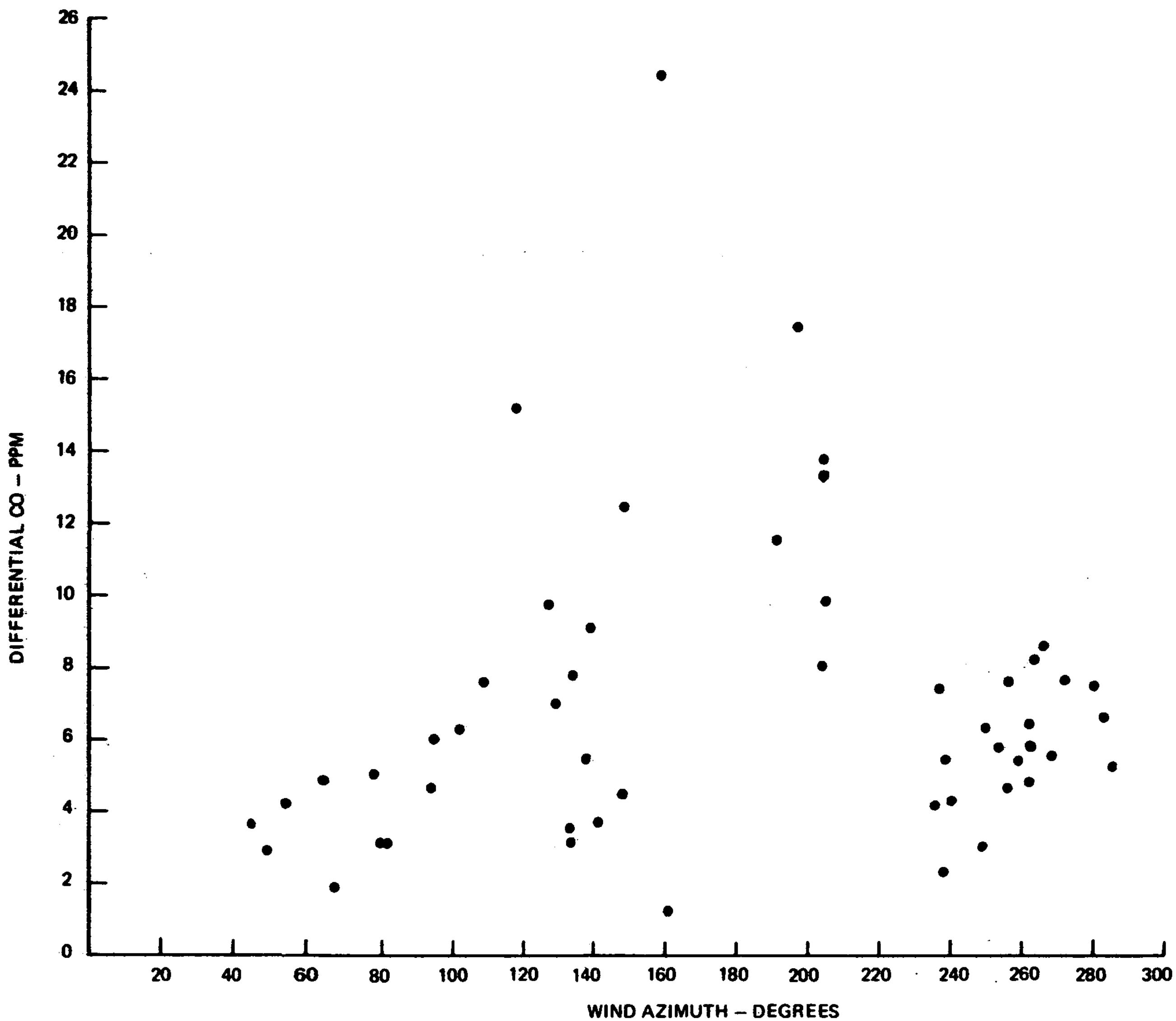


Figure 5.2.1-40. Differential CO – Outdoor – 3rd To 19th Floor Vs. Roof Level Wind Azimuth – 6 PM Heating Weekdays – Site 2

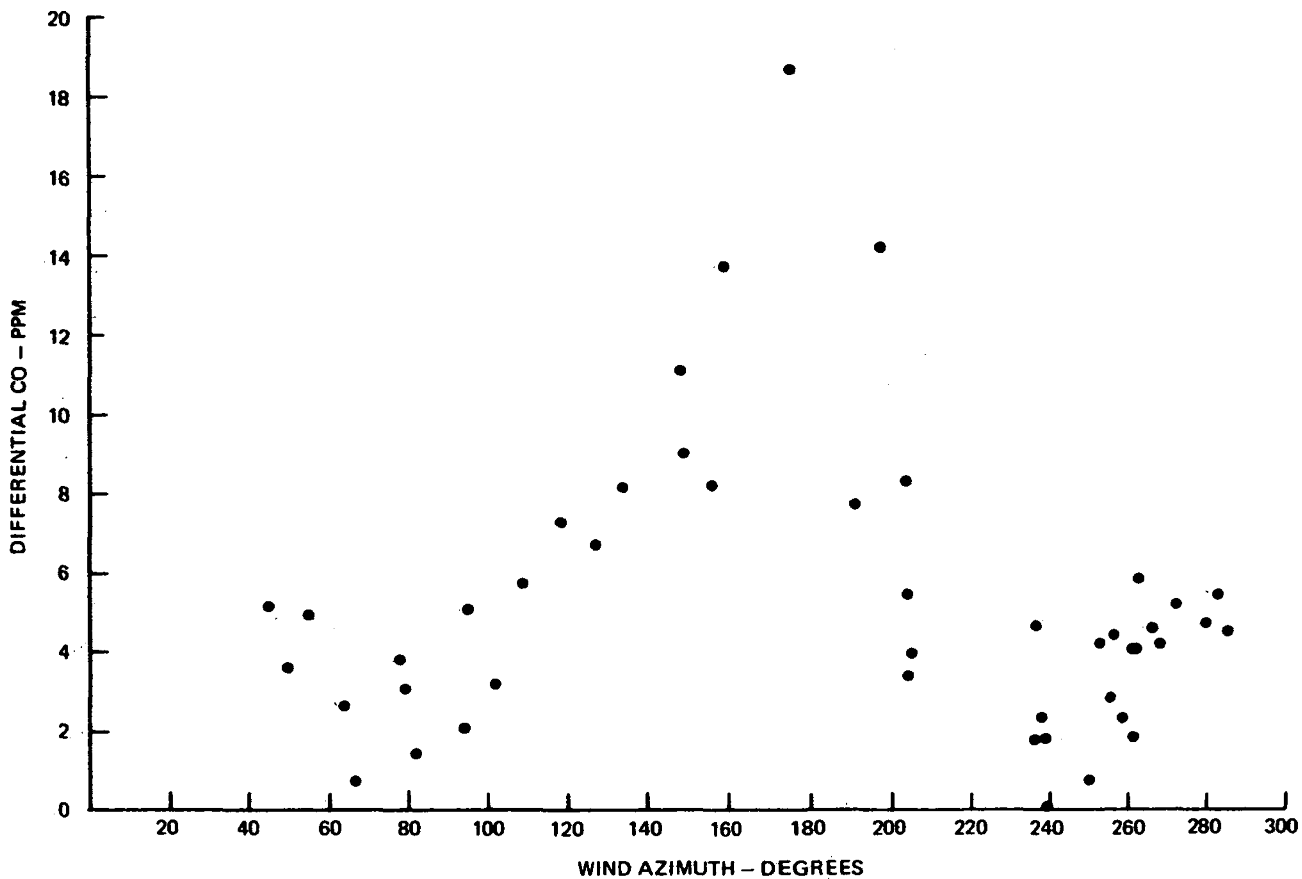


Figure 5.2.1-41. Differential CO – Indoor – 3rd To 19th Floor Vs. Roof Level Wind Azimuth – 6 PM – Heating Weekdays – Site 2

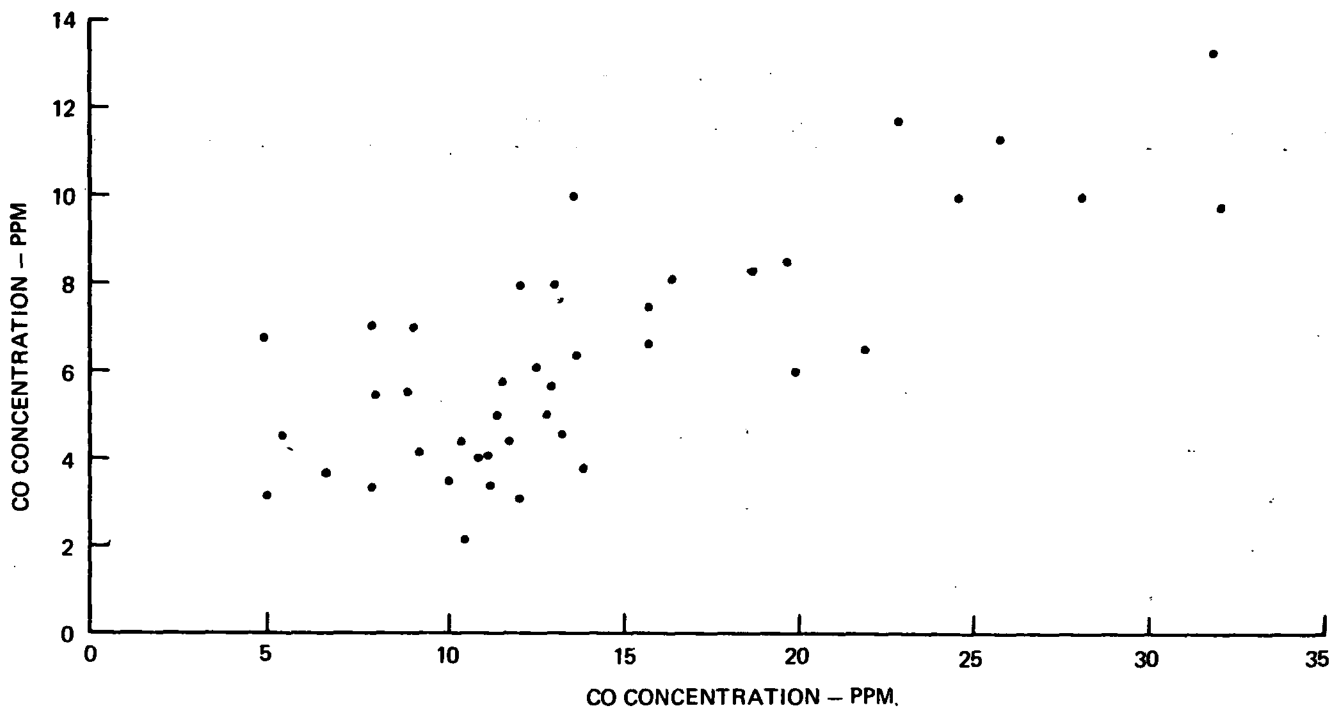


Figure 5.2.1-42. CO Concentration 19th Floor Outdoors Vs. CO Concentration Road Level North – 6 PM – Heating Weekdays – Site 2

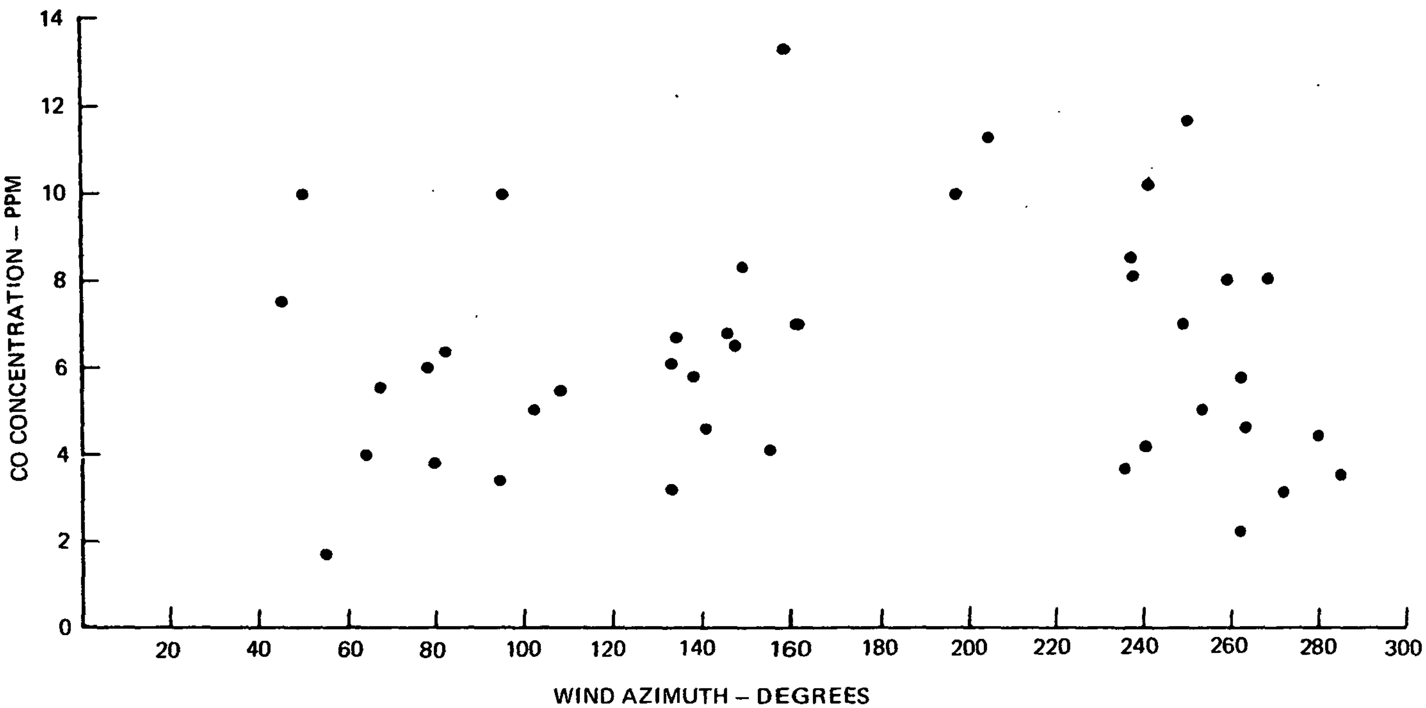


Figure 5.2.1-43. CO Concentration 19th Floor Outdoors Vs. Roof Level Wind Azimuth – 6 PM – Heating Weekdays – Site 2

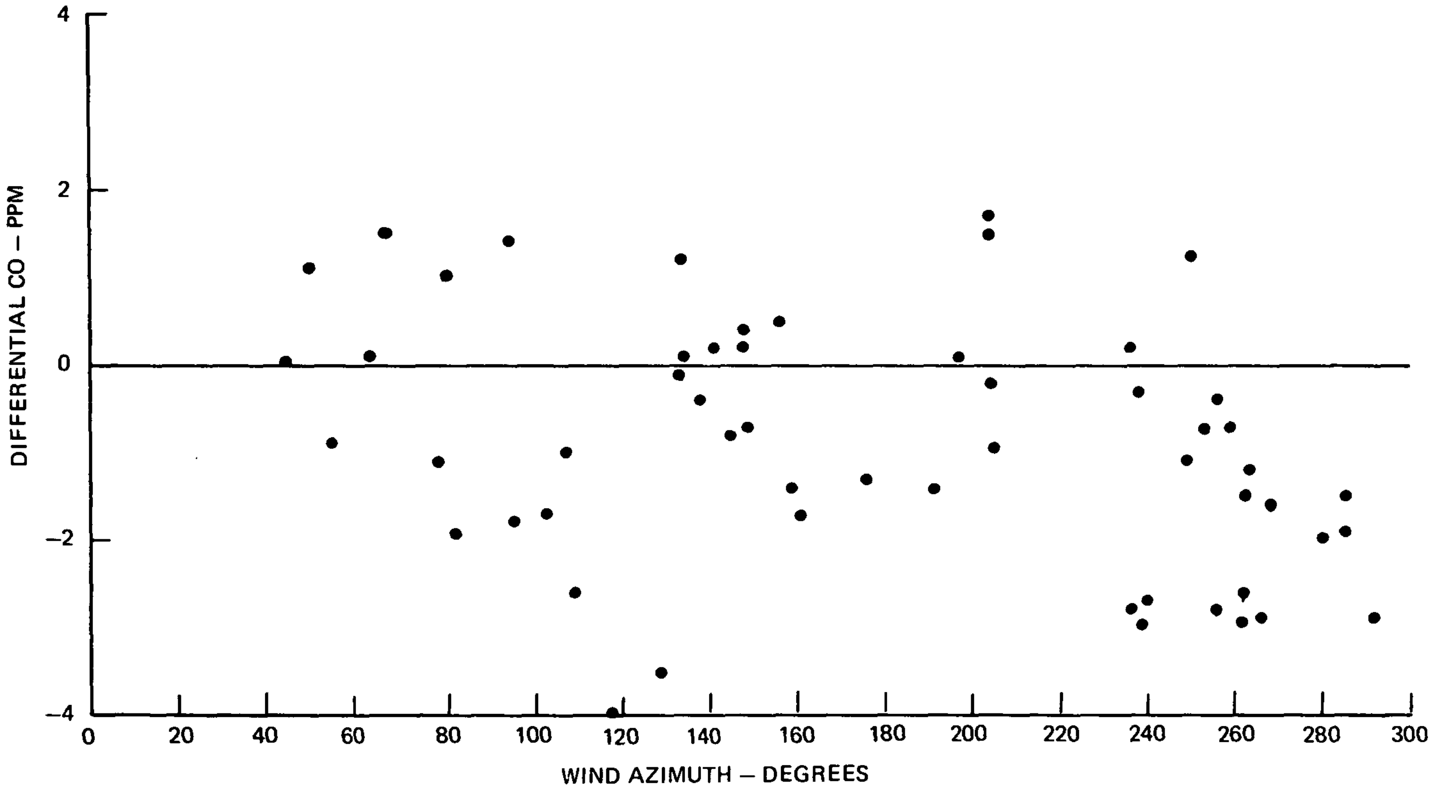


Figure 5.2.1-44. Differential CO – Outdoor/Indoor – 19th Floor Vs. Roof Level Wind Azimuth – 6 PM – Heating Weekdays – Site 2

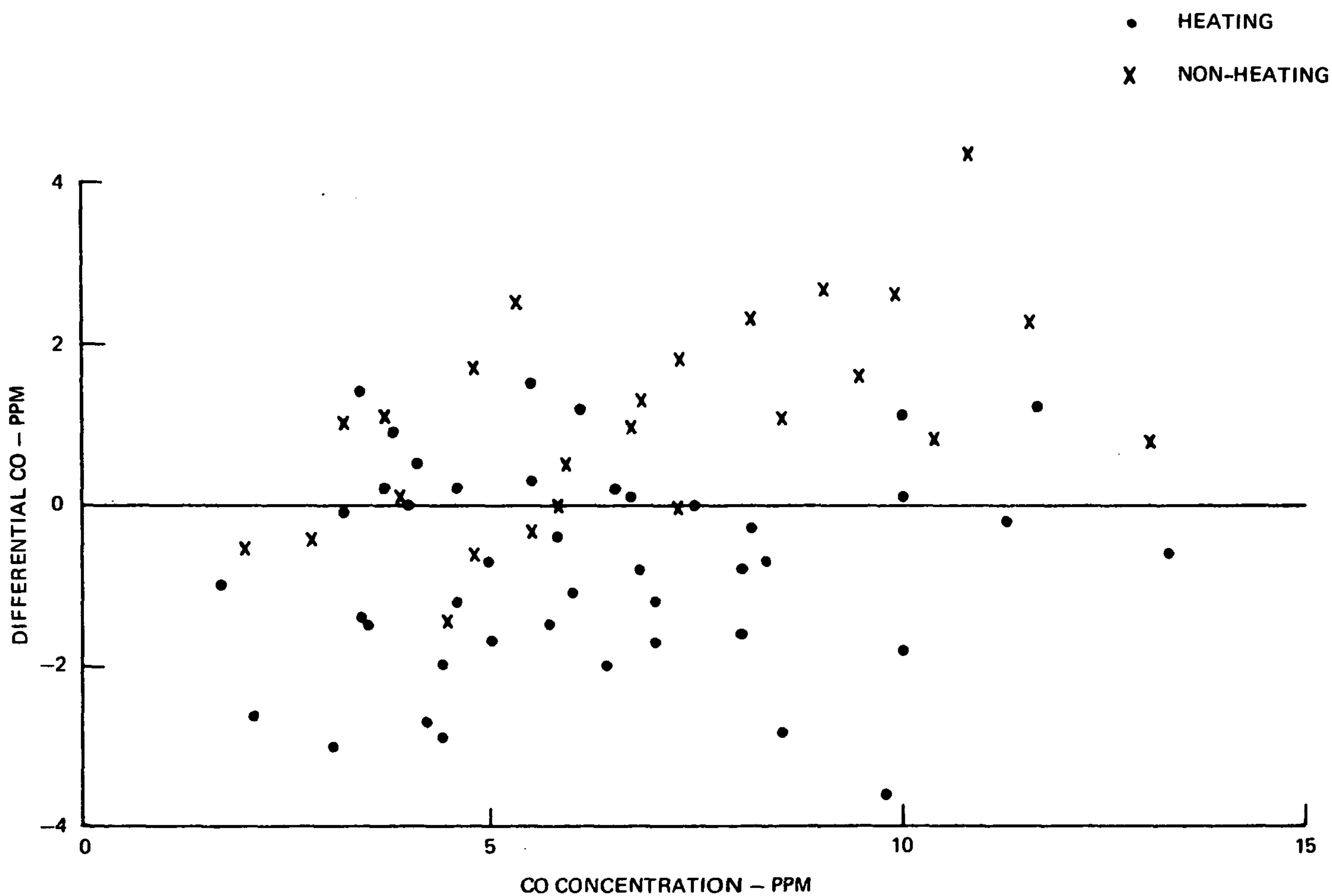


Figure 5.2.1-45. Differential CO Outdoor/Indoor – 19th Floor Vs. 19th Floor Concentration – 6 PM – All Weekdays – Site 2

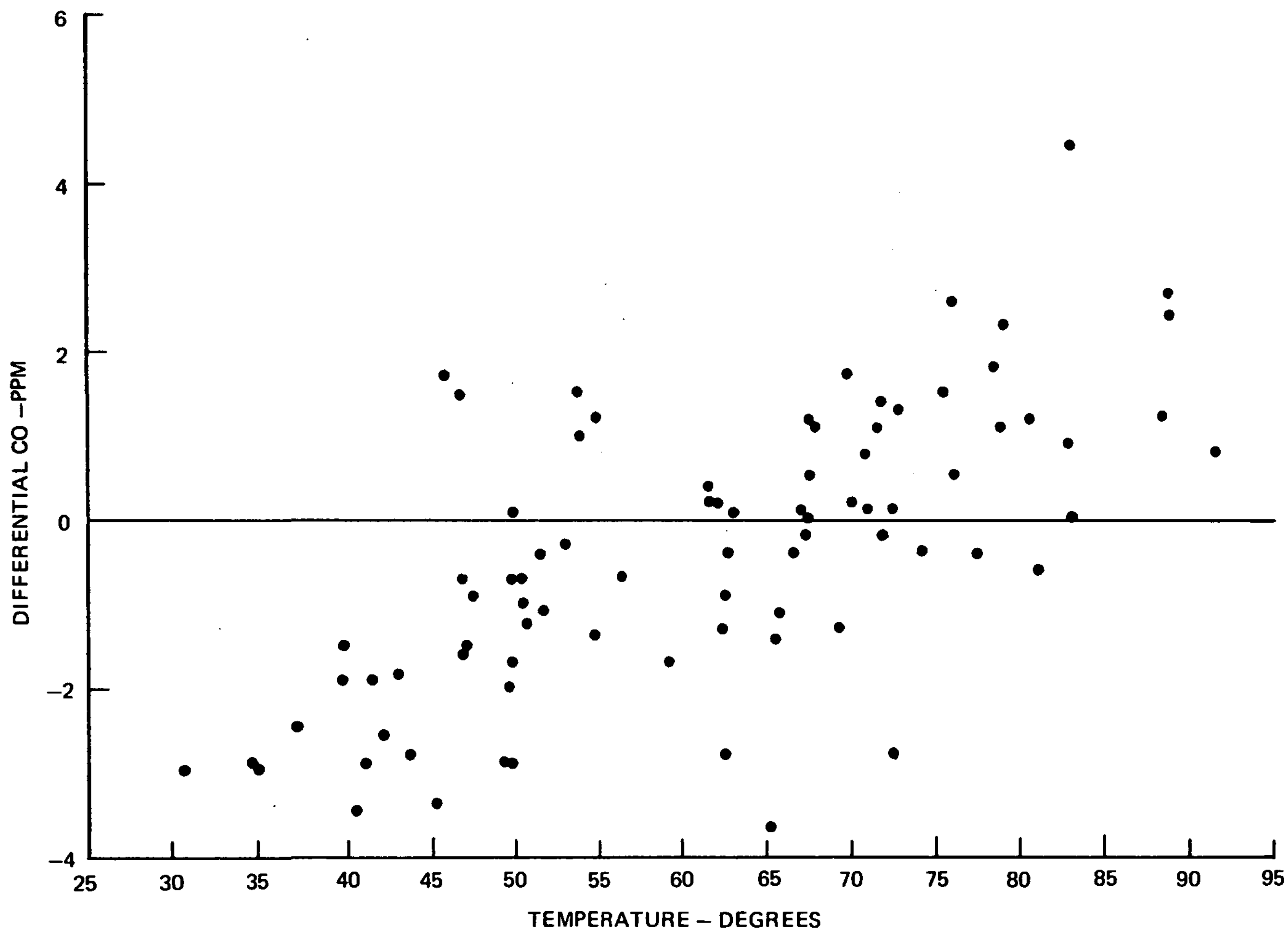


Figure 5.2.1-46. Differential CO – Outdoor/Indoor – 19th Floor Vs. Roof Level Temperature – 6 PM – All Weekdays – Site 2

5.2.2 Hydrocarbons

Hydrocarbon measurements at the West 40th Street site were taken at the 3rd and 11th floor indoor and outdoor locations simultaneously with the carbon monoxide data. One hundred and six days of heating season hydrocarbon data was obtained. Thirty two days of non heating season data was taken.

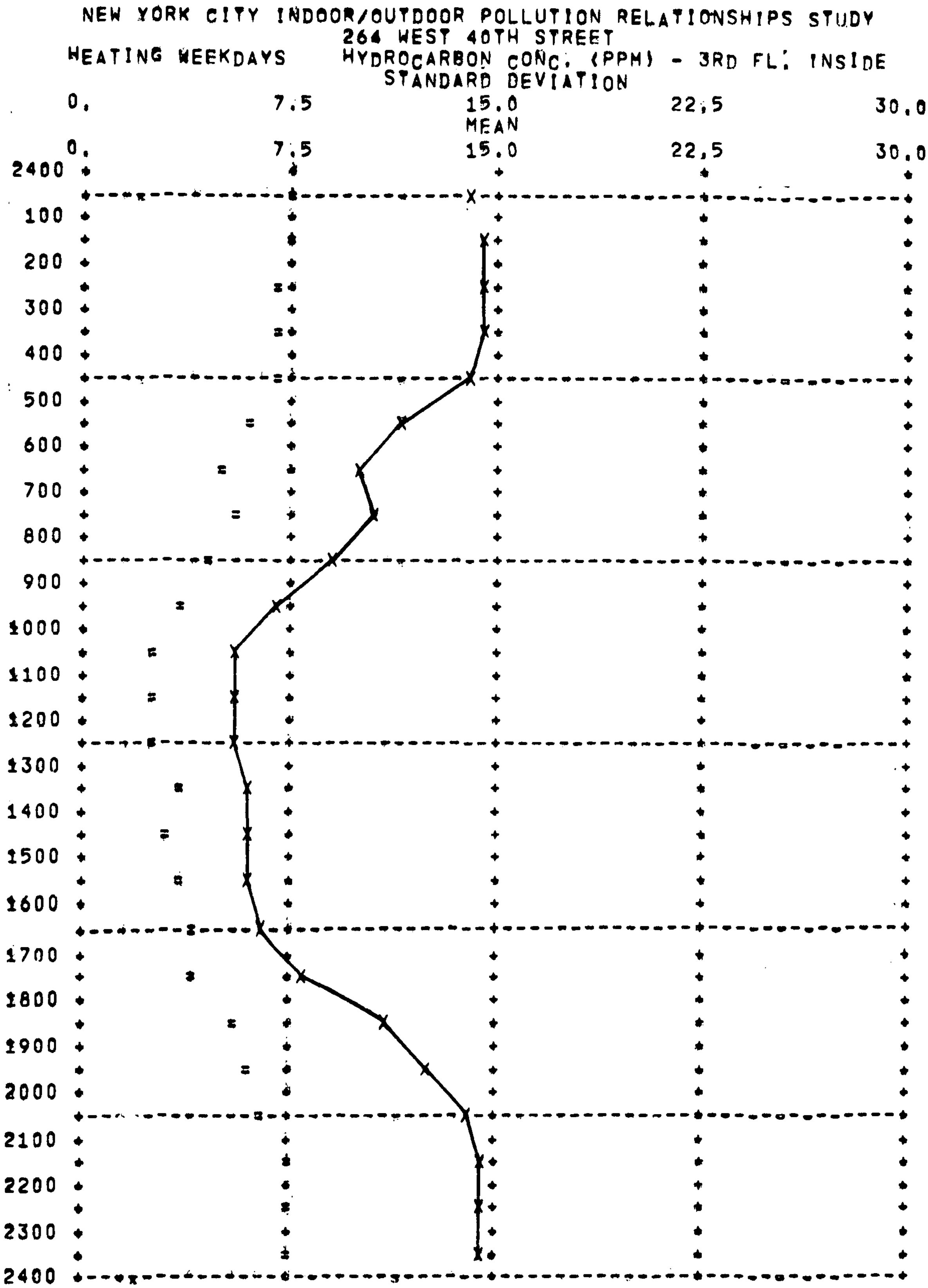
5.2.2.1 Heating Season

Indoor hydrocarbon concentrations were significantly higher than outdoor at the third floor level and slightly higher indoors at the 11th floor. The weekday average for the third floor indoor probe was 10.4 PPM as opposed to a 4.5 PPM average for the outdoor location. At the 11th floor the indoor average was 2.4 PPM while the outdoor average was 1.9 PPM.

3rd Floor

The highest hourly hydrocarbon average (34 PPM) that was measured at this site occurred at the third floor indoor location. The high indoor concentrations were the direct result of a paint spraying operation on the third floor. The diurnal curve (Figure 5.2.2-1) shows that the weekday hydrocarbon characteristics were almost entirely dictated by the spraying operation which began daily between 4 and 5 PM. This is the only location where a strong diurnal variation in hydrocarbon concentration occurs. Any variation in hydrocarbon concentration with traffic is effectively masked by strong contributions from the paint source.

The effect of paint spraying was even noticeable at the third floor outdoor location where its diurnal curve followed the indoor diurnal curve, although with much reduced amplitude (Figure 5.2.2-2). Levels outdoors tended to increase in the late afternoon when the spraying started and reached a maximum near 10 PM. Apparently the hydrocarbons escaping from the building overcame the feeble traffic influence to produce this maximum. The highest hourly average recorded at the outdoor location was 14.3 PPM. Pollutant vs. traffic plots (Figures 5.2.2-3 and -4) show no discernible relationship between hydrocarbon data and traffic volume or speed except that hydrocarbons may be considered a constant.



NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS
HYDROCARBON CONC. (PPM) - 3RD FL. INSIDE
STANDARD DEVIATION
0.
7.5
15.0
22.5
30.0
MEAN
0.
7.5
15.0
22.5
30.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

FIGURE 5.2.2-1

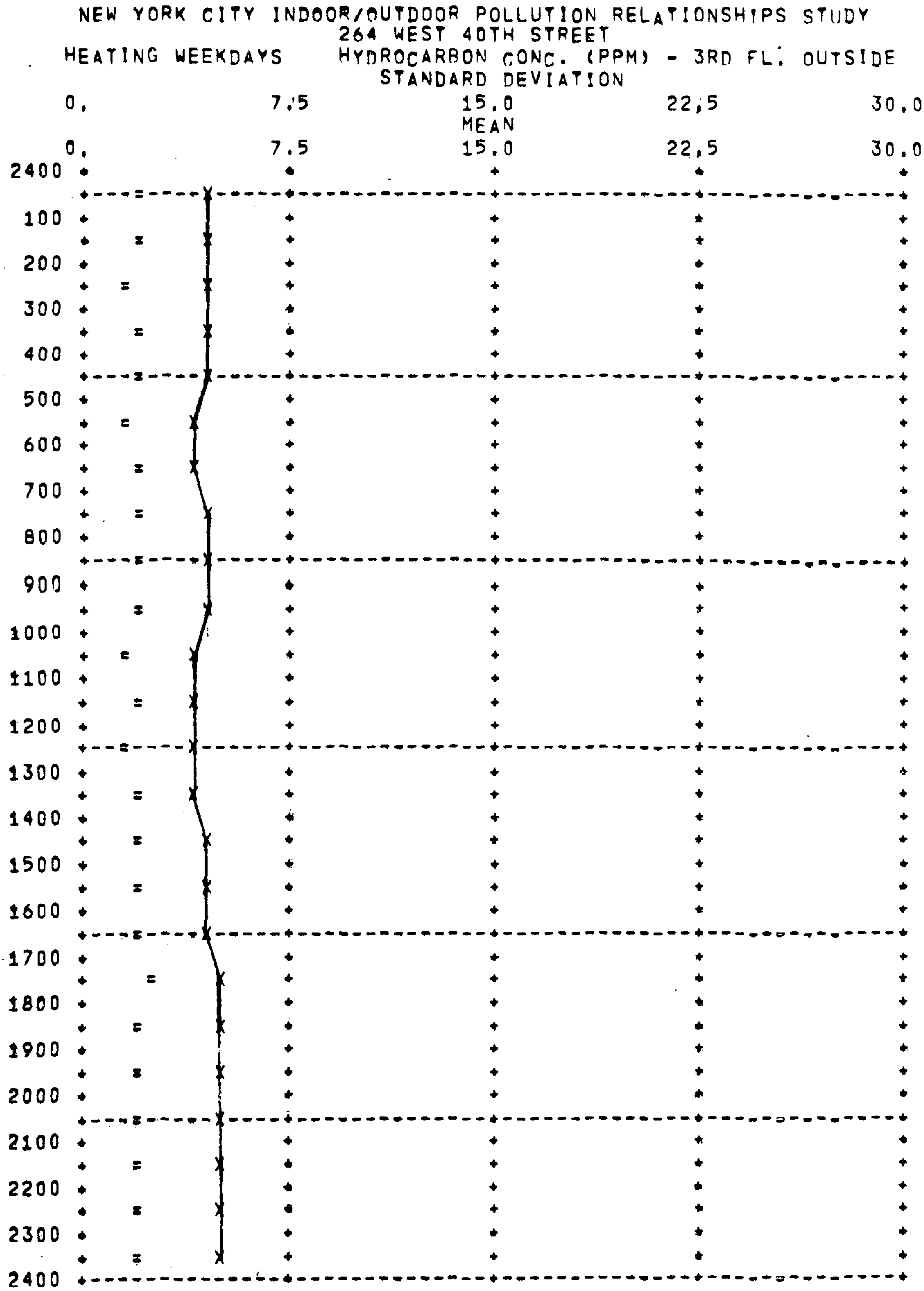

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS
HYDROCARBON CONC. (PPM) - 3RD FL. OUTSIDE
STANDARD DEVIATION
0. 7.5 15.0 22.5 30.0
MEAN
0. 7.5 15.0 22.5 30.0
2400
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400

FIGURE 5.2.2-2

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 3RD FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS TRAFFIC FLOW RATE (VEH/HR)

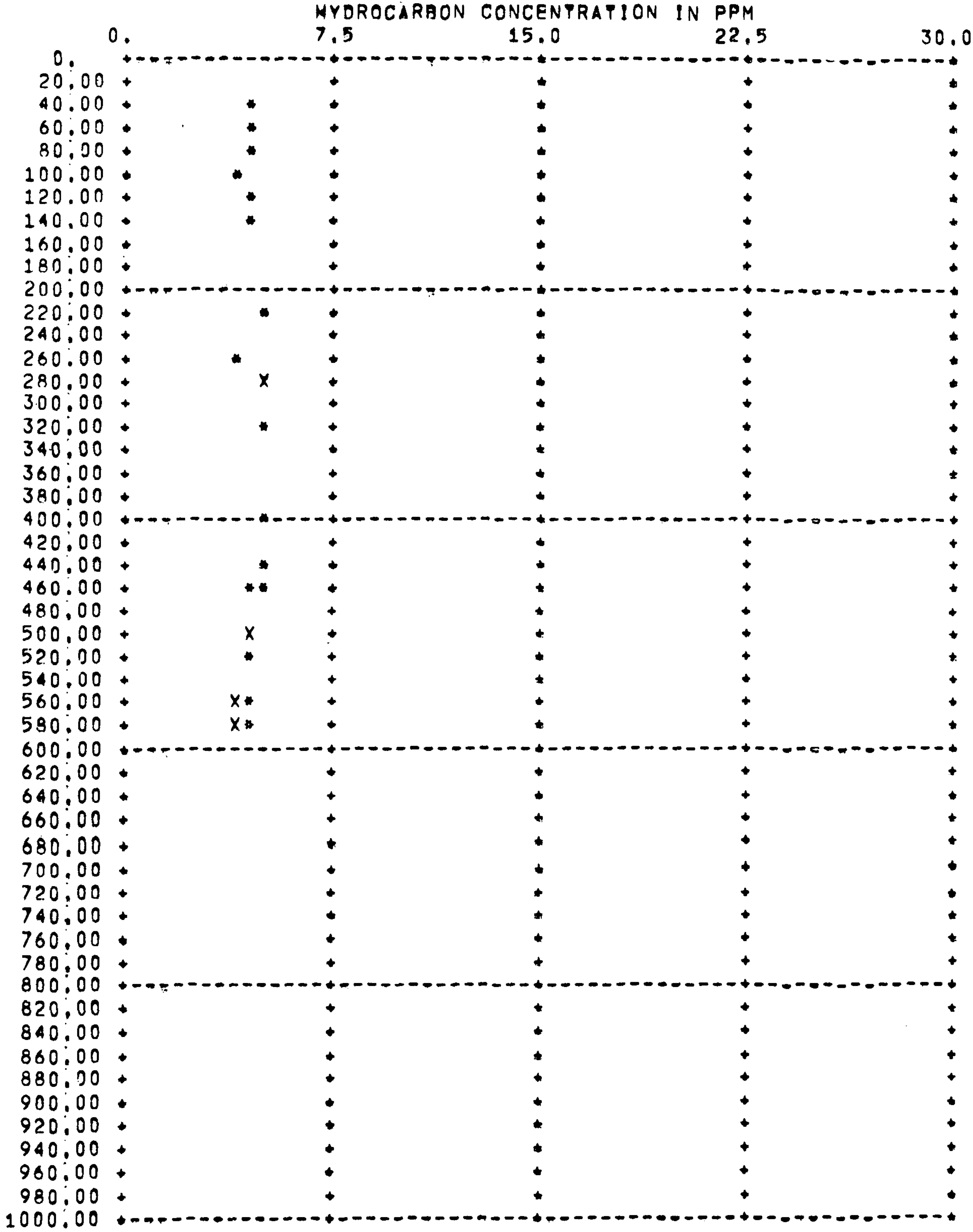


FIGURE 5.2.2-3

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 3RD FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)

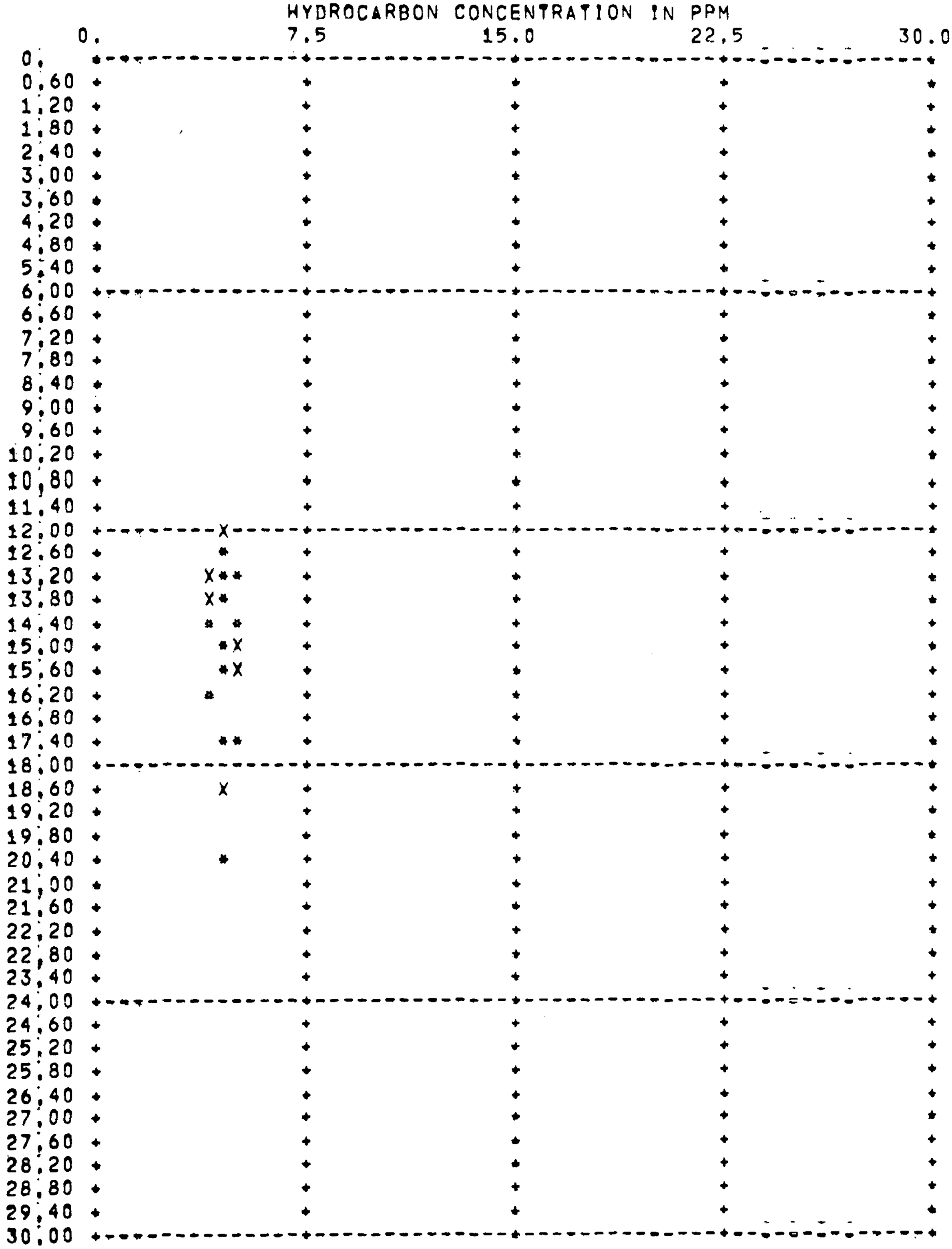


FIGURE 5.2.2-4

Weekend hydrocarbon data at the third floor level was also dominated by effects from the paint. Concentrations were lowest near noon and highest at night and during the early morning hours both inside and outside of the building. Average concentrations were again higher on the inside by a factor of 3 (12 PPM vs. 4 PPM outside). The highest hourly average recorded inside was 34.9 PPM while the highest outside was 15.2 PPM. Both of these extremes occurred between 2400 and 0100 on April 17, 1971. Traffic volume and velocity at that particular hour do not account for the high values and meteorological conditions were not conducive to stagnation. The high hydrocarbon levels, both indoors and outdoors, at that hour are clearly the sole result of the spray source.

11th Floor

Weekday hydrocarbon concentrations at the 11th Floor were apparently not affected to any great extent by the source on the third floor. Diurnal curves of both the indoor and outdoor concentrations (Figures 5.2.2-5 and -6) are very flat except for a slight maximum in the forenoon hours. Concentrations were higher inside than outside (2.4 PPM vs. 1.9 PPM) but much reduced from the third floor levels. The highest hourly average was 15.5 PPM inside and 7.9 PPM outside. Concentrations were less than 2 PPM 65% of all hours outside and 45% of all hours inside. Most concentrations fell between 1 and 2 PPM compared to nearly 4 PPM at the third floor. Plots of hydrocarbon against traffic volume and speed (Figures 5.2.2-7 and -8) do not show any direct relationship either indoor or outdoor.

The general weekday behavior was repeated on the weekends with the single major exception that the maxima occurred near midnight both indoors and outdoors. There is no firm explanation for this shift. It may not be real at all since the amplitude of the curve is so very small. When averaged over all hours, indoor values were higher than outdoor values by .6 PPM (2.1 PPM as opposed to 1.5 PPM) and both indoor and outdoor hydrocarbon concentrations, as far as could be determined, were constant with respect to traffic volume and speed on 40th Street.

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 11TH FL. INSIDE

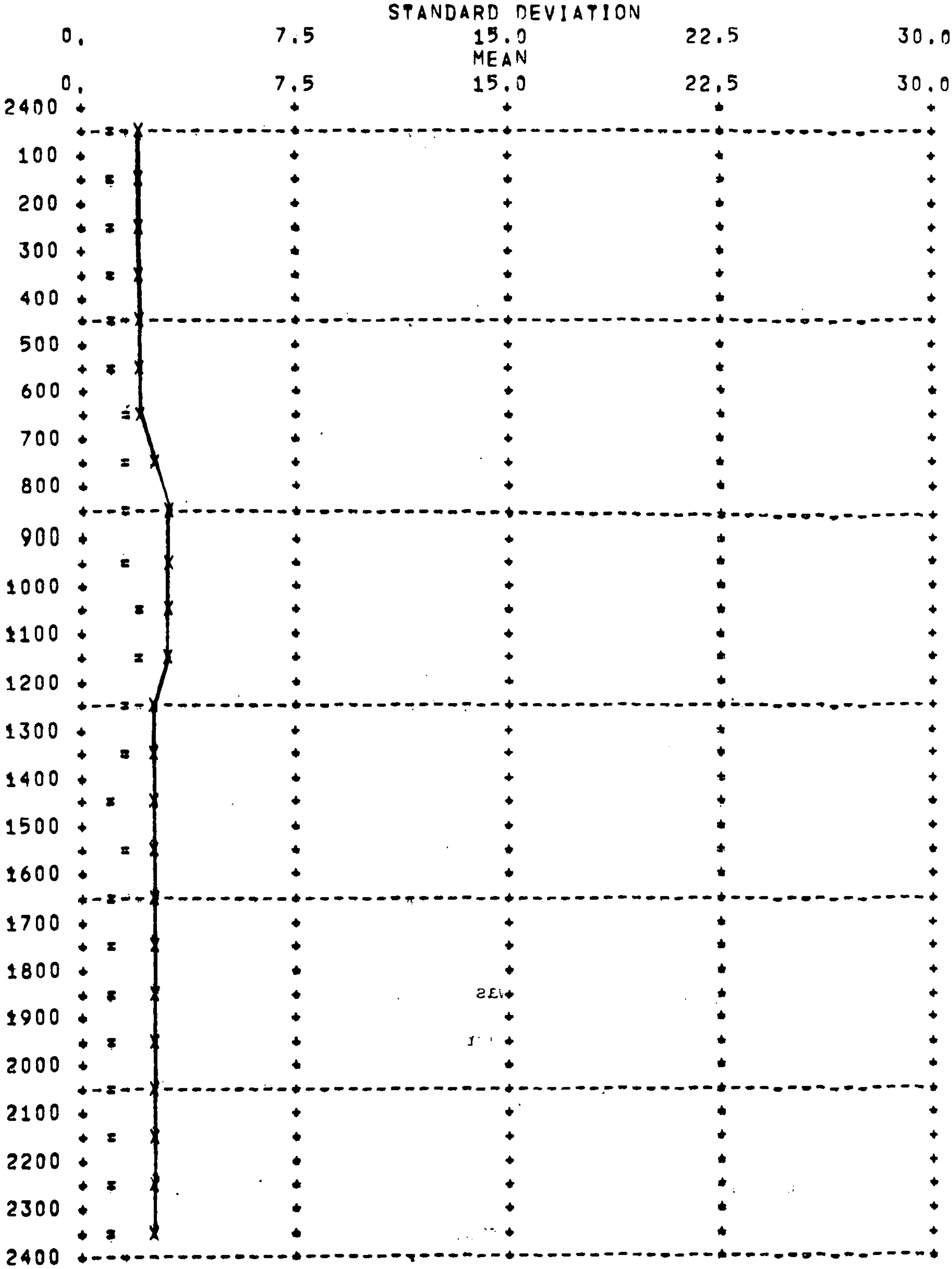


FIGURE 5.2.2-5

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 11TH FL. OUTSIDE
STANDARD DEVIATION

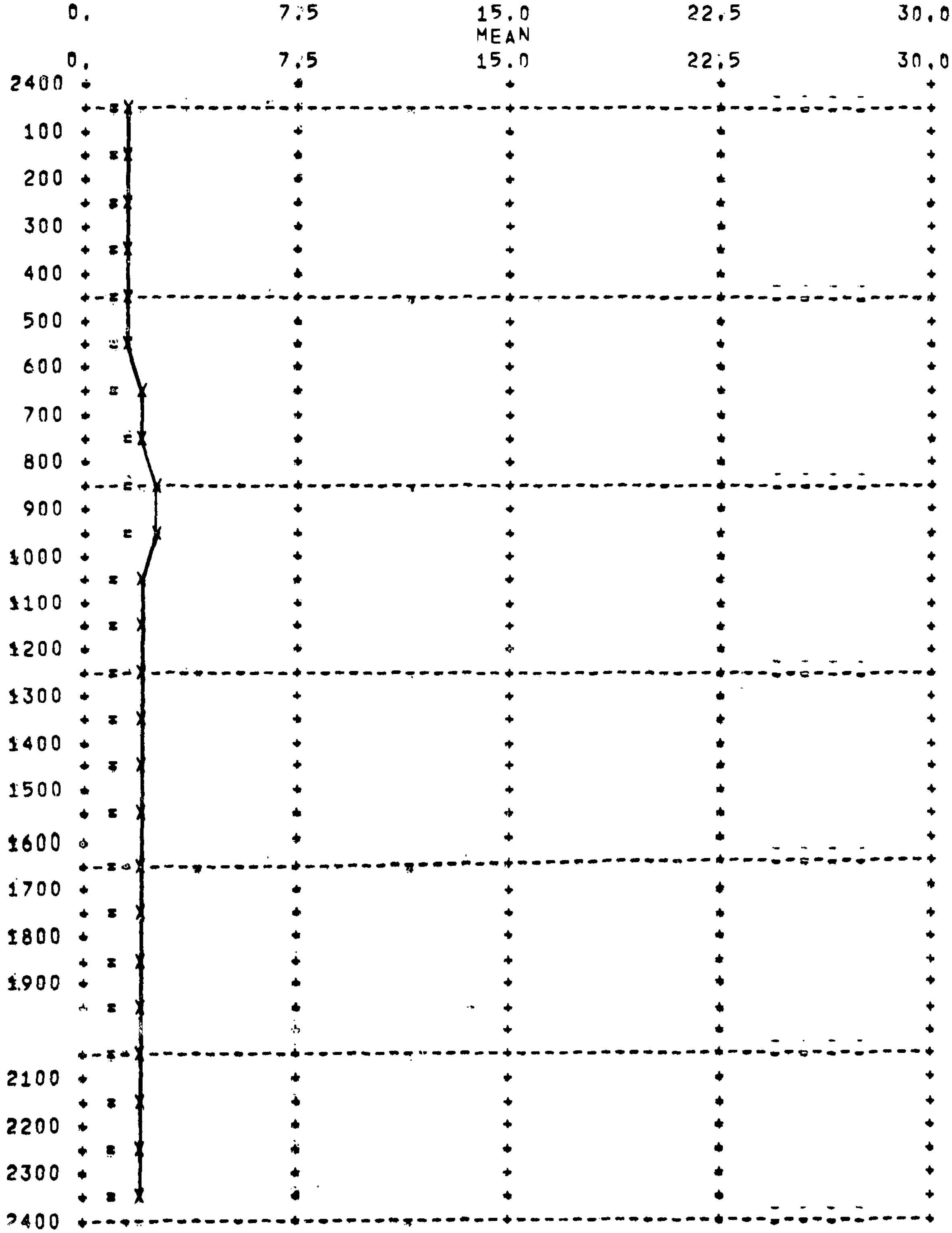


FIGURE 5.2.2-6

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 11TH FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS TRAFFIC FLOW RATE (VEH/HR)

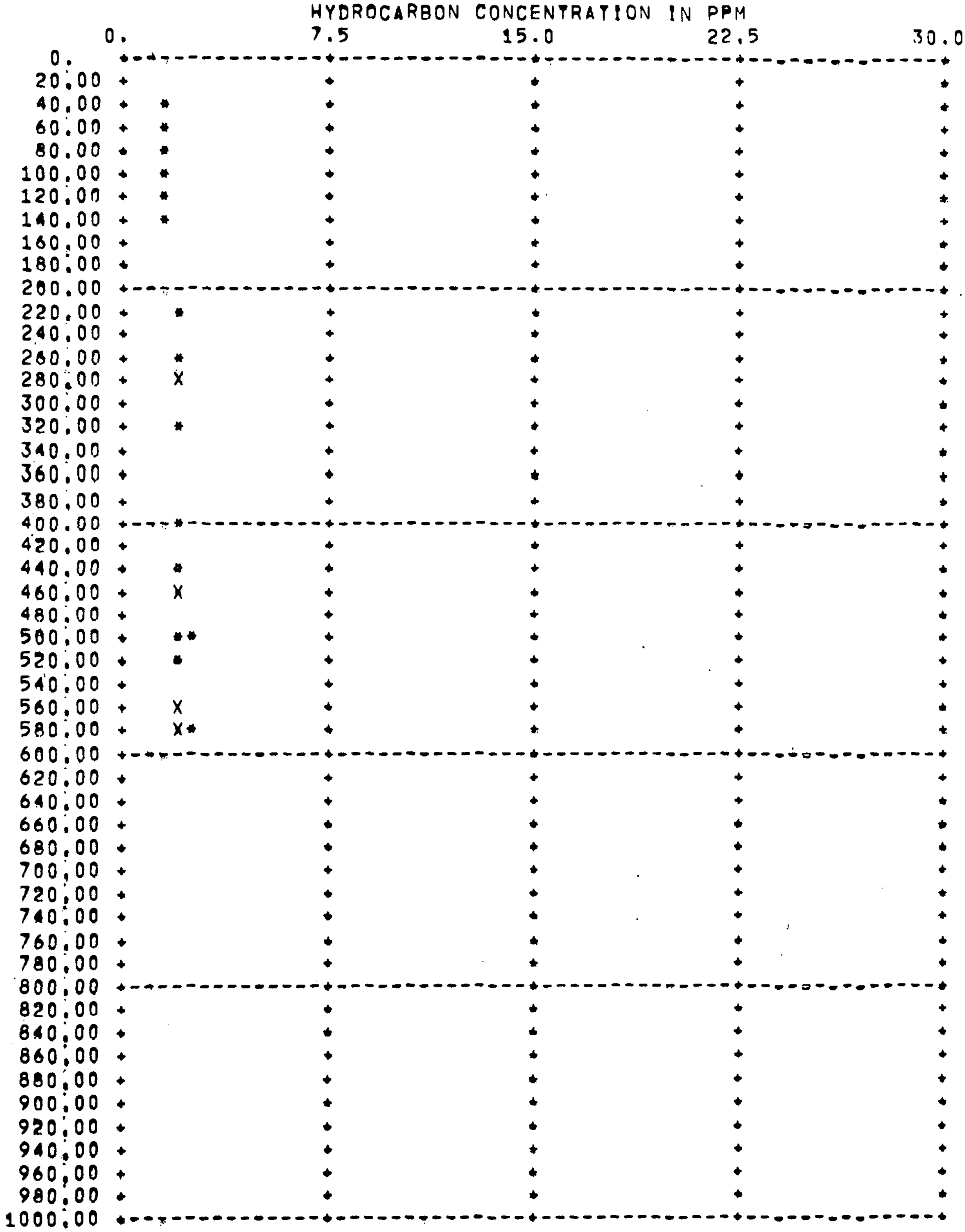


FIGURE 5.2.2-7

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 11TH FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)

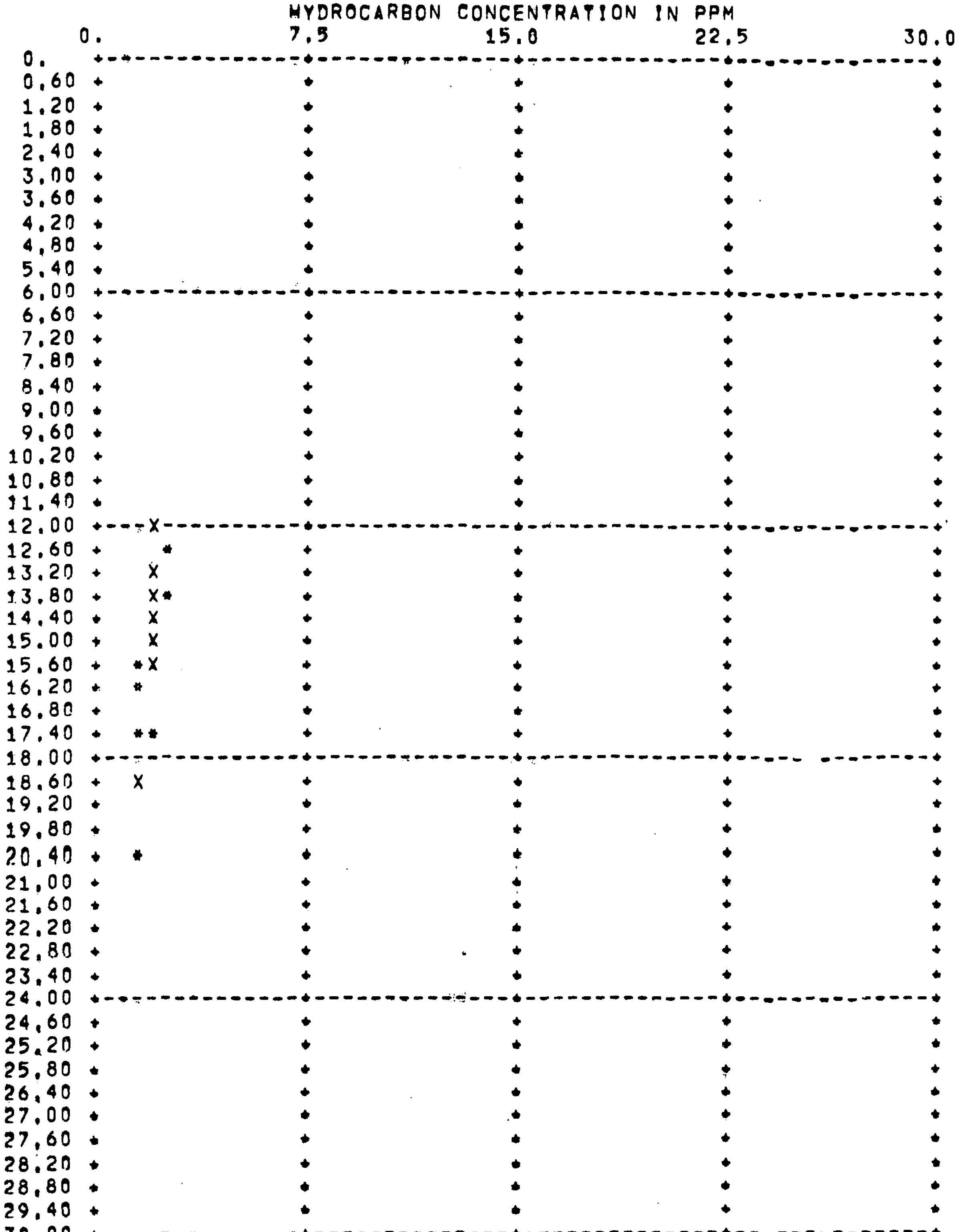


FIGURE 5.2.2-8

5.2.2.2 Non Heating Season

3rd Floor

Third floor hydrocarbon concentrations on non-heating weekdays were higher indoors than outdoors. The average all-hour level indoors was 8.1 PPM compared to 4.8 PPM outdoors. The elevated indoor readings stemmed from paint spraying on the third floor. There was a drop of 2 PPM in the indoor concentrations when compared to the heating season data; however, the outdoor average concentration rose slightly. This may be attributed to open windows allowing increased ventilation within that floor while subjecting the outdoor probe to increased contamination from within the structure. The increased air exchange would tend to lower concentrations near the indoor source while raising them slightly outdoors due to transport of the hydrocarbons through the open windows. The 24 hour maximum concentrations occur in the early morning on the indoor diurnal curve (Figure 5.2.2-9) while the outdoor curve is relatively flat (Figure 5.2.2-10). The outdoor concentrations were virtually constant with both traffic speed and volume as shown in Figures 5.2.2-11 and -12. The highest non-heating weekday hourly concentration recorded indoors was 30.9 PPM on May 11 while the highest outdoor concentration was 11.7 PPM on May 18.

Concentrations indoors on non-heating weekends were less than on heating weekends by 5 PPM for an all-hour average of 7.2 PPM. Outdoor weekend concentrations did not show this seasonal variation. Indoor levels were higher than corresponding outdoor concentrations. Plots of hydrocarbon vs. traffic speed and volume show virtually no discernible effect on the pollutant levels.

11th Floor

Eleventh floor concentrations were also higher indoors, although the difference was much less than on the third floor. Non-heating weekday concentrations showed an increase over heating season levels. This increase was small

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 3RD FL. INSIDE

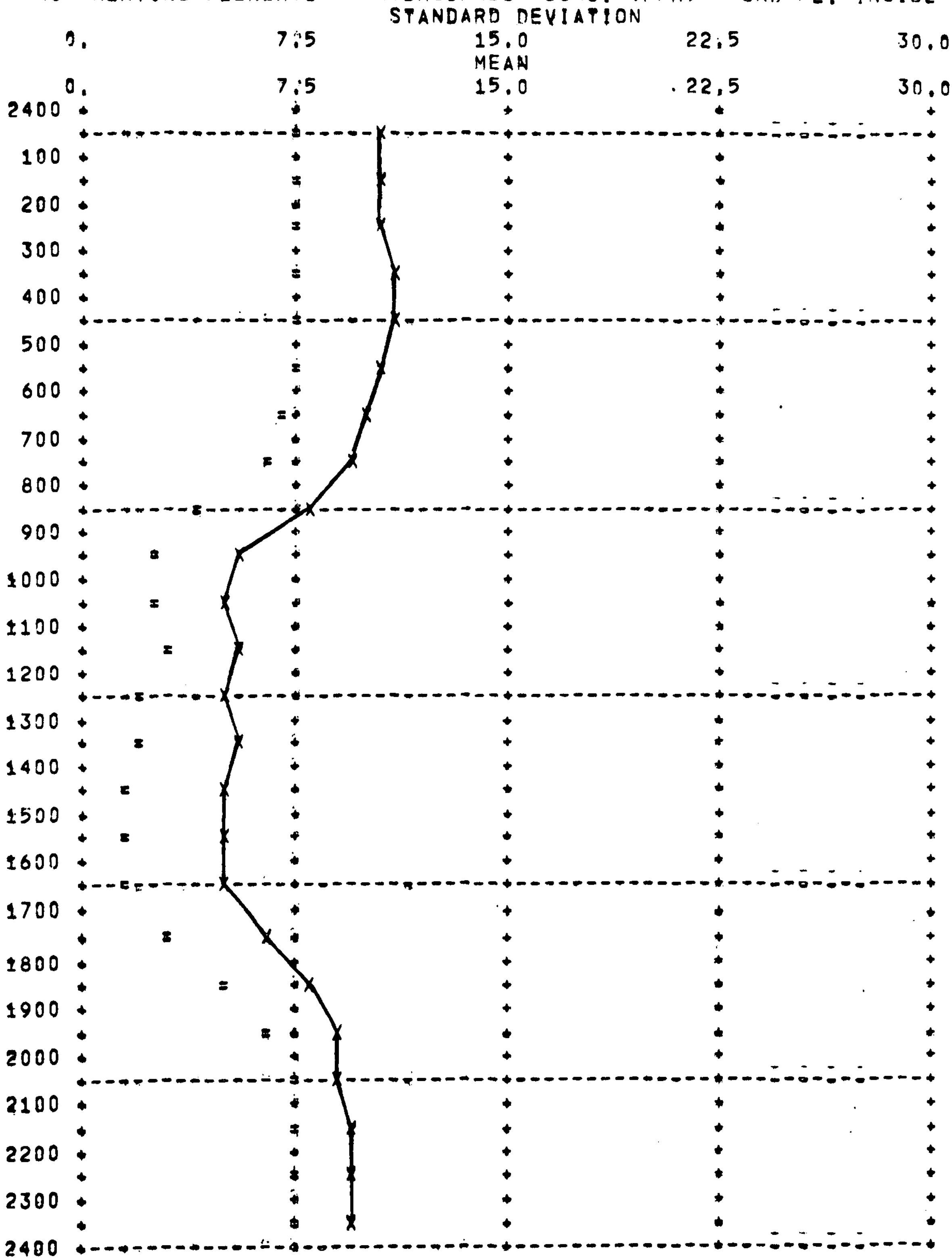


FIGURE 5.2.2-9

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 3RD FL. OUTSIDE

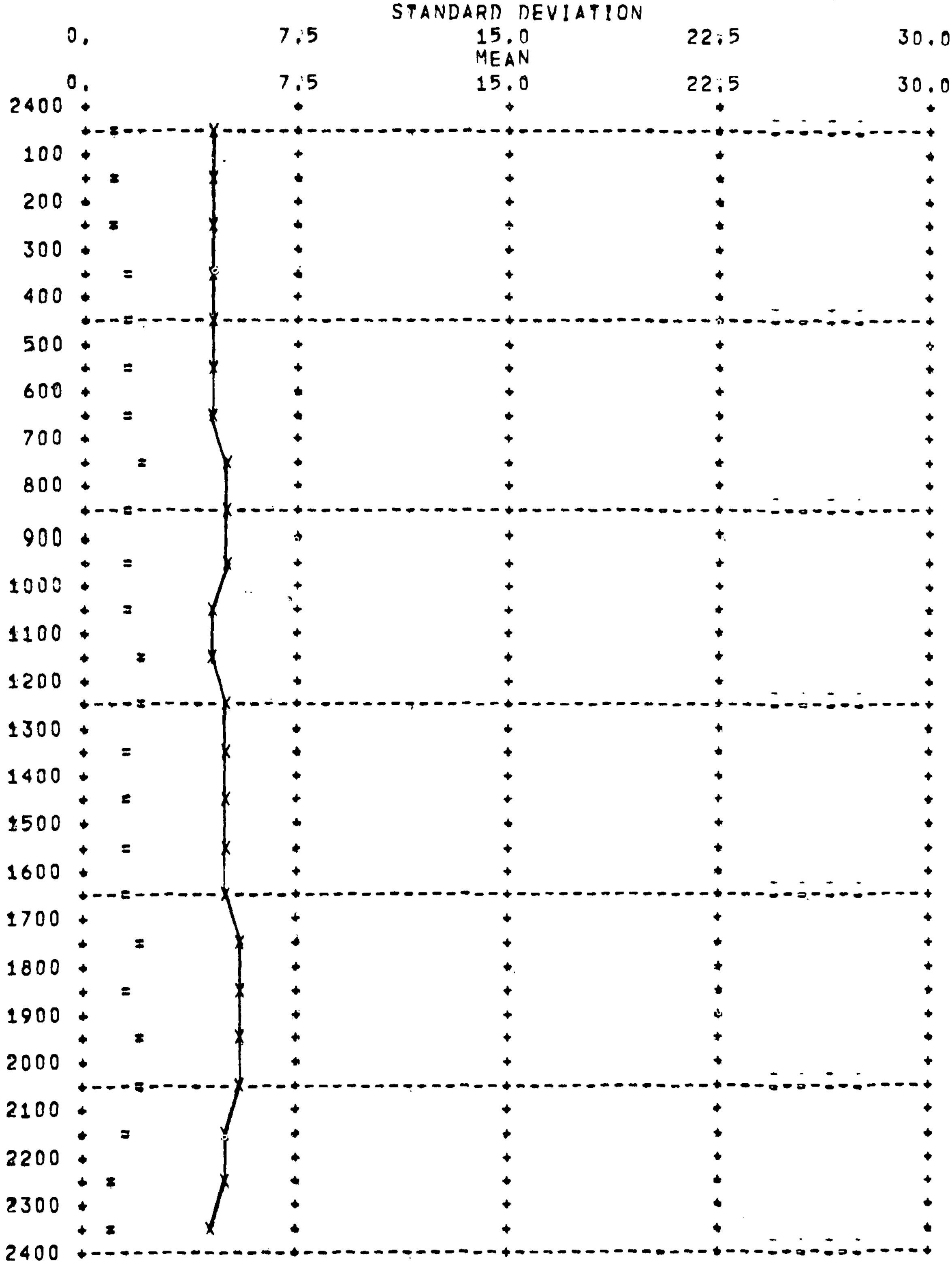


FIGURE 5.2.2-10

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 3RD FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS TRAFFIC FLOW RATE (VEH/HR)

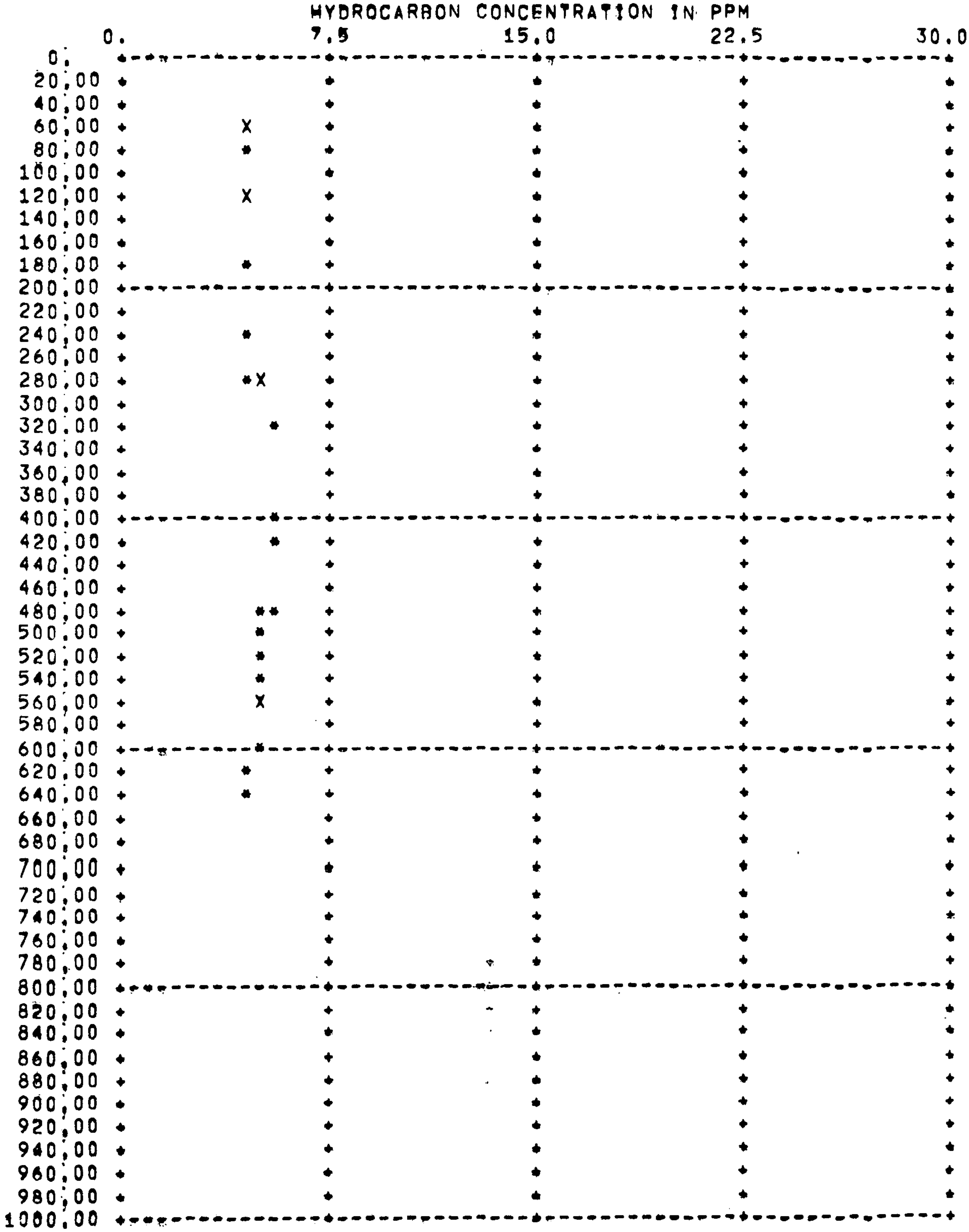


FIGURE 5.2.2-11

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 3RD FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)
HYDROCARBON CONCENTRATION IN PPM

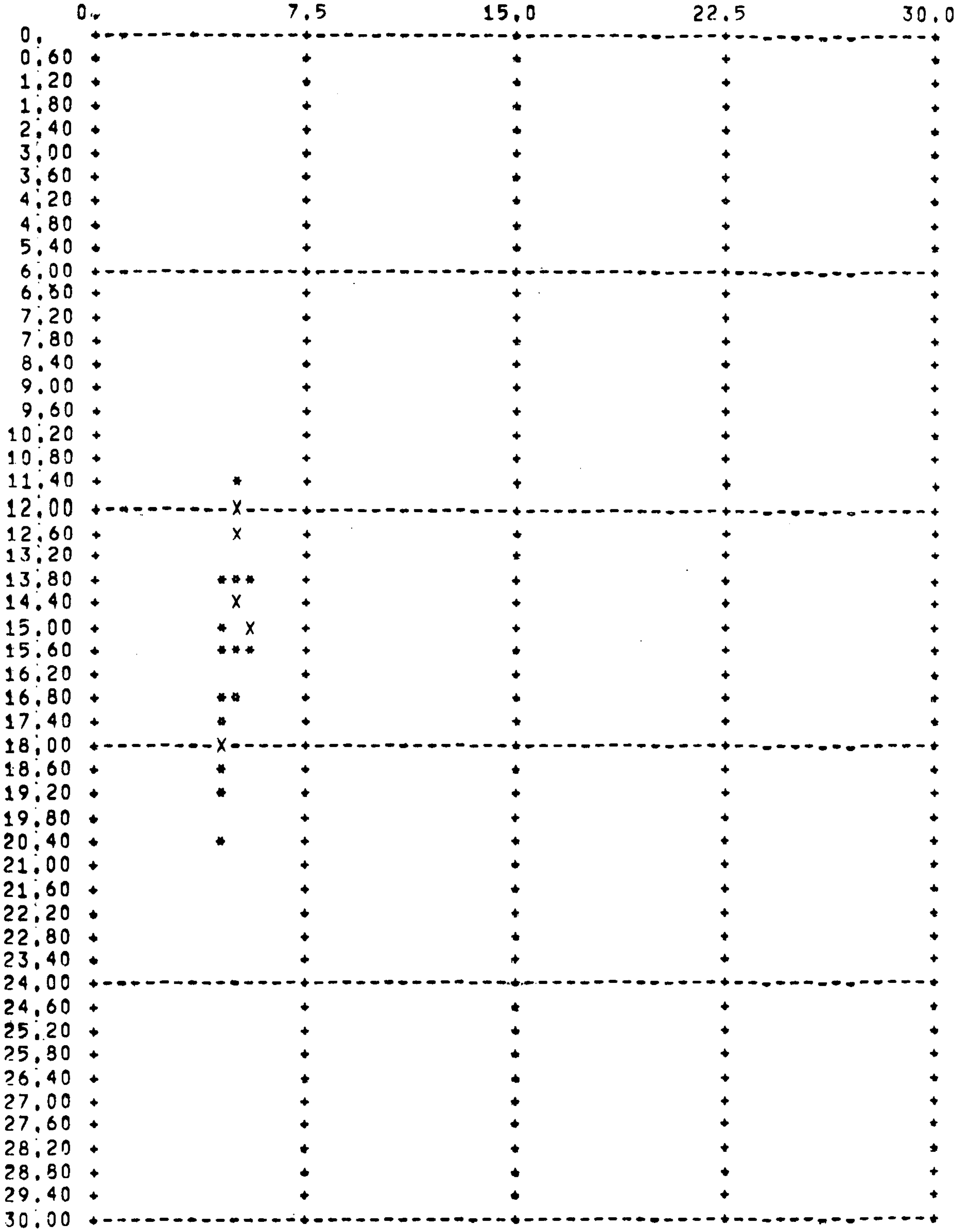


FIGURE 5.2.2-12

but significant, occurring both indoors and outdoors, and averaging approximately .5 PPM. Average indoor concentrations were 2.8 PPM while those outside were 2.4 PPM. The weekday diurnal curves of both eleventh floor locations were quite flat with small maxima near 8 AM (Figures 5.2.2.-13 and -14). Although the time of maximum concentration does not coincide with the hour of maximum traffic volume on 40th Street, the 8 AM peak is probably traffic generated. This is due to a relatively larger amount of hydrocarbon contribution to the eleventh floor area from other sources within the city. Traffic peaks occur on most major nearby city arteries near 8 AM, resulting in a hydrocarbon maximum near that hour. Again, as during the heating season, hydrocarbon vs. traffic plots show no direct relationship with volume or speed (Figures 5.2.2.-15 and -16). The slopes of the concentration vs. traffic plots are extremely small, usually less than .003 PPM/vehicle and less than -.05 PPM/MPH determined by least squares fit.

Weekend hydrocarbon concentrations were higher indoors than outdoors during the non-heating season. This completes a consistent pattern for this site - in all cases, indoor hydrocarbon concentrations were greater than corresponding outdoor concentrations. The indoor diurnal curve was not quite as flat as most other weekend curves, but this may be a result of the very restricted sample size of 6. The highest hourly average recorded indoors was 4.8 PPM on June 6; outdoors, it was 3.7 PPM on June 12.

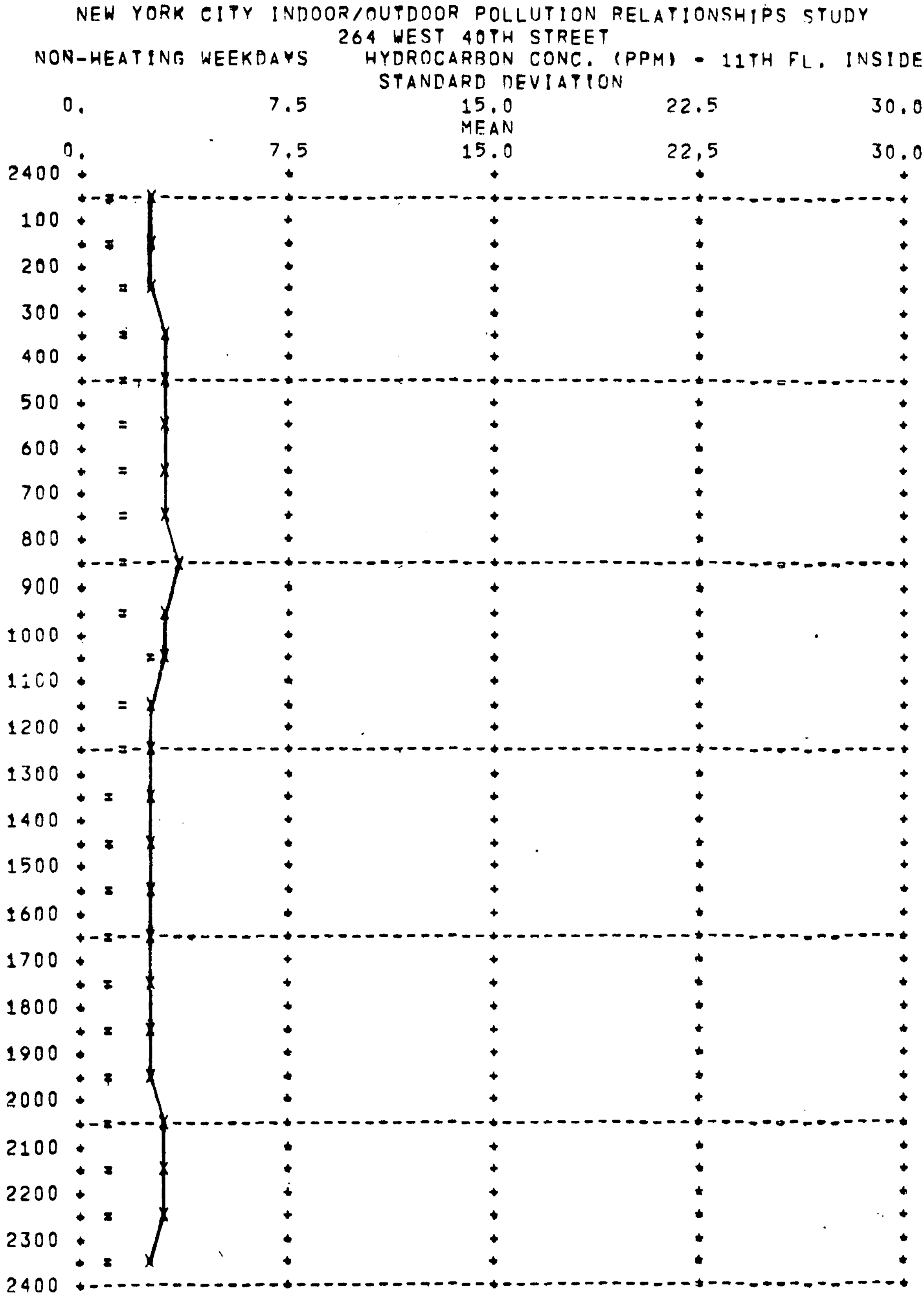


FIGURE 5.2.2-13

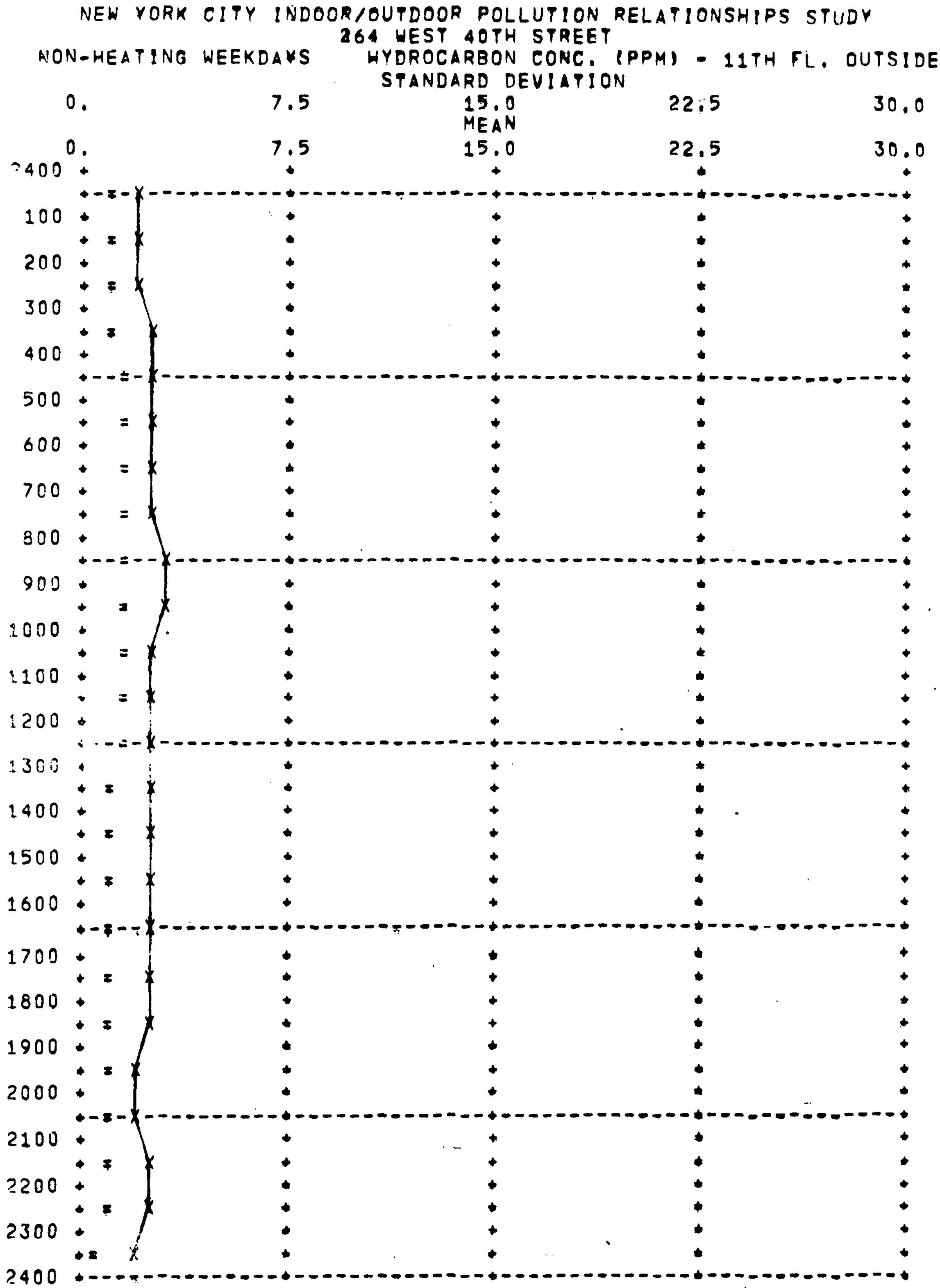


FIGURE 5.2.2-14

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS HYDROCARBON CONC. (PPM) - 11TH FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS TRAFFIC FLOW RATE (VEH/HR)
HYDROCARBON CONCENTRATION IN PPM

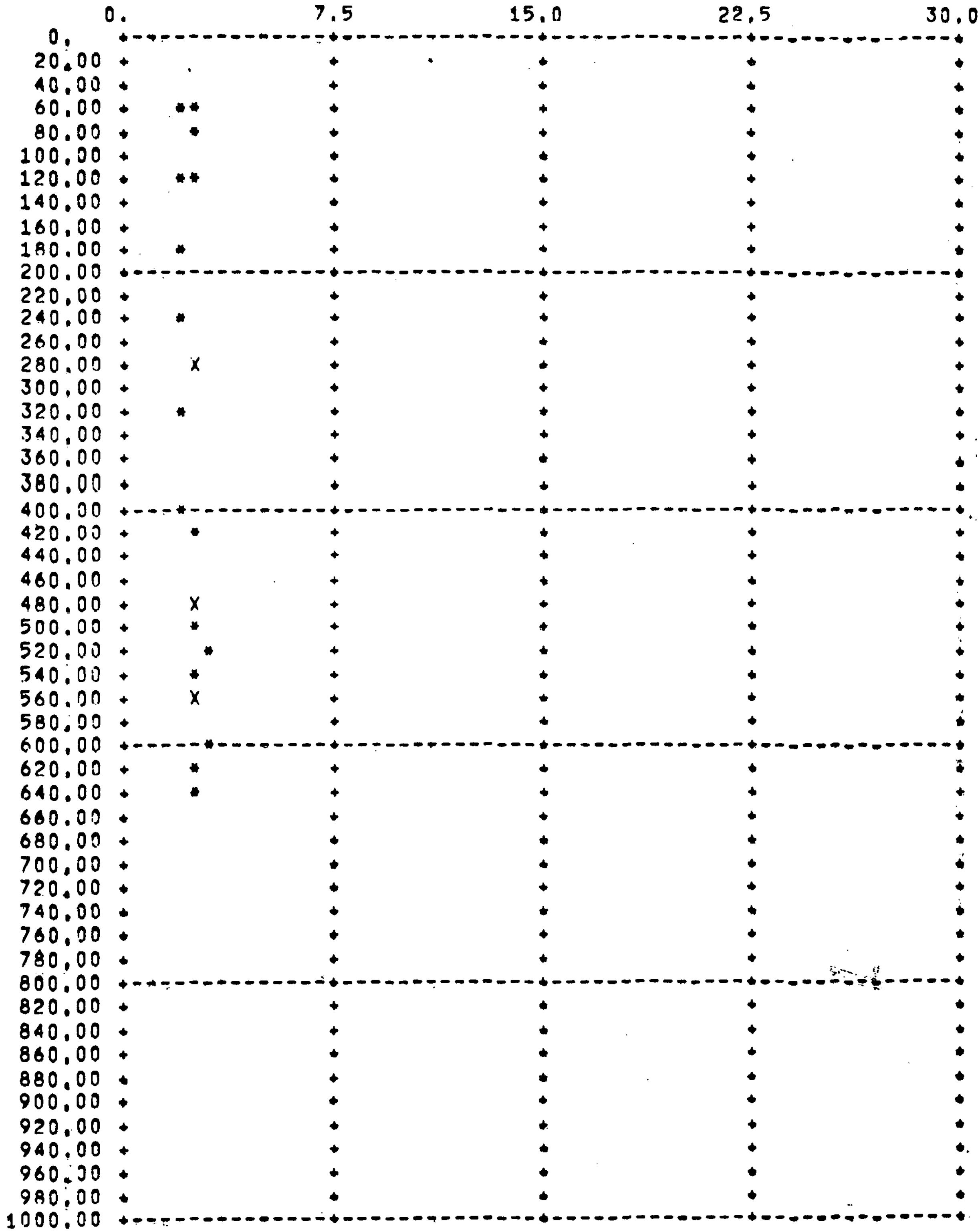


FIGURE 5.2.2-15

NEW YORK CITY INDOOR/OUTDOOR POLLUTION RELATIONSHIPS STUDY
264 WEST 40TH STREET
NON-HEATING WEEKDAYS   HYDROCARBON CONC. (PPM) - 11TH FL. OUTSIDE
HYDROCARBON CONC. (PPM) VS AVERAGE VEHICLE VELOCITY (MPH)
HYDROCARBON CONCENTRATION IN PPM

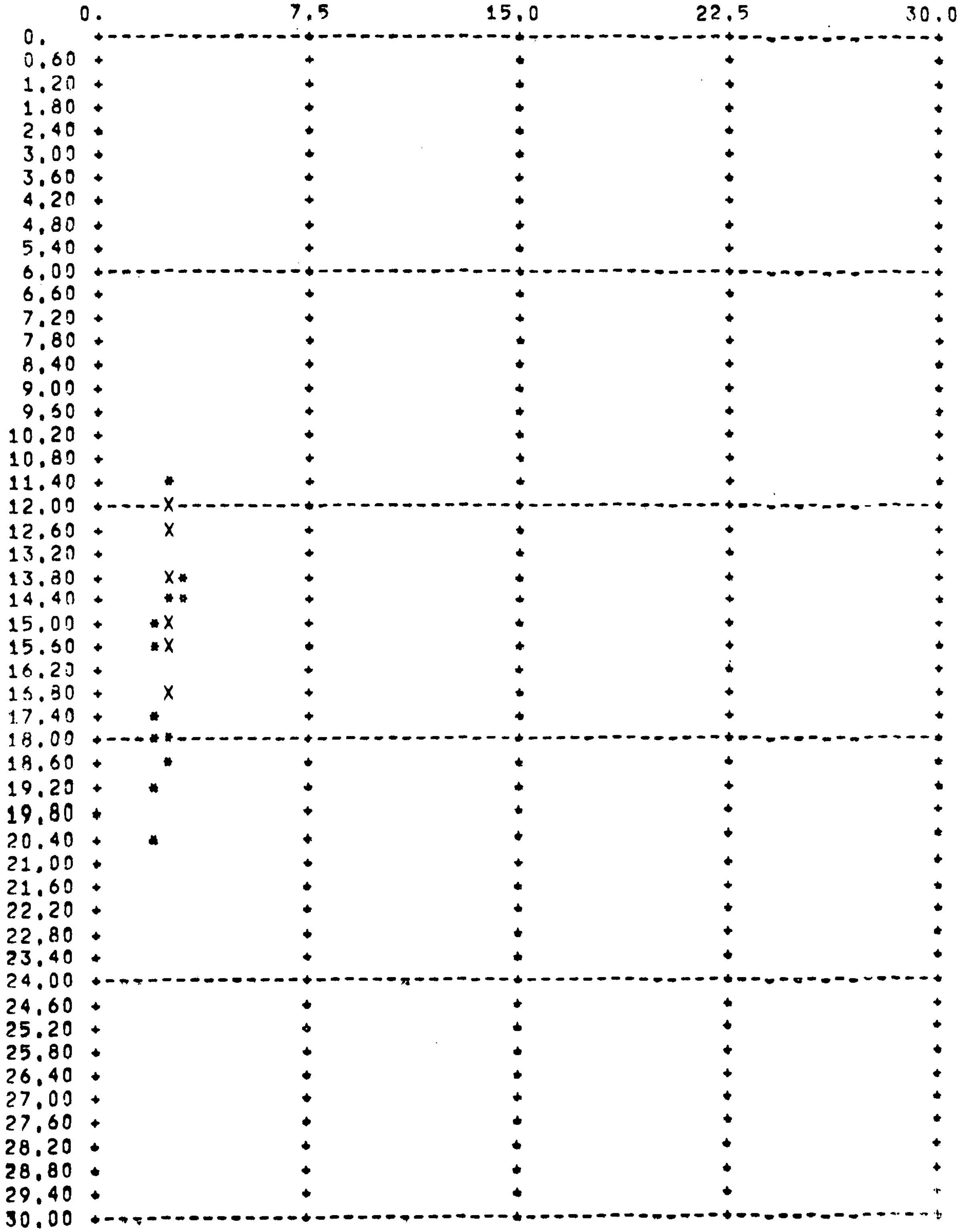


FIGURE 5.2.2-16

5.2.3 Particulates

Four sets of particulate samples were obtained at the West 40th Street site. Two High Volume Air Samplers were located inside the building on the 11th and 18th floors. The 11th floor location was inside the General Electric laboratory. The 18th floor sampler was positioned inside a closed storage area. Outside the building, one sampler was positioned on the 3rd floor fire balcony, facing west. The other outside sampler was located on the roof and faced West 40th Street

Particulate samples were obtained at the four locations for 18 days during the heating season and for 6 days during the non-heating season. Table 5.2.3-1 lists the data. Both inside and outside concentrations varied greatly from day to day and there was a great overlapping of concentration ranges. Figure 5.2.3-1 presents this information graphically. Examination of this figure will show that particulate concentrations at this site are not directly related to heating or non-heating seasons. Therefore, this discussion of particulates considers all of the data regardless of season.

The highest total particulate concentrations at the canyon structure were recorded outside the building. Both the 3rd floor and roof locations peaked at 229.8 ug/M^3 on April 13. The secondary peak for these two locations also occurred on the same day; i.e. May 11. Average concentrations at the two outdoor locations were essentially identical. The National secondary standard for particulates (150 ug/M^3) was exceeded on 6 days at each of these outdoor locations. The primary standard was not exceeded on any days.

The particulate concentrations outdoors were significantly higher than those recorded inside. The 11th floor inside concentrations exceeded the outside 3rd floor value only four times. The 18th floor inside concentrations

TABLE 5.2.3-1

PARTICULATES -ug/M^3

WEST 40TH STREET

Date	Outside 3	Roof	Inside 11	Inside 18
		Heating		
2/16	188.5	145.8	84.0	95.6
2/24	98.6	113.4	68.0	53.4
3/ 8	122.3	157.5	71.7	55.4
3/11	93.1	112.2	109.3	-
3/16	81.4	105.0	66.4	50.1
3/17	93.5	90.9	39.8	37.0
3/22	128.0	82.5	48.3	40.9
3/23	73.6	76.0	58.4	23.1
3/24	75.3	75.6	86.2	49.6
3/29	93.0	99.9	59.2	56.8
3/30	125.8	142.7	43.9	-
4/13	229.8	229.8	-	111.3
4/14	141.2	120.2	79.5	-
4/15	135.2	159.0	63.2	-
4/22	159.0	130.2	27.9	54.1
5/ 3	134.2	115.1	57.2	-
5/ 4	134.0	150.8	106.7	98.4
5/12	-	-	-	-
5/27	112.0	-	47.4	143.0
		Non-Heating		
5/10	191.8	189.0	-	105.7
5/11	212.0	213.5	93.4	83.4
5/26	-	-	-	54.0
6/ 2	125.0	116.0	59.5	51.5
6/10	156.0	-	83.7	52.0
6/30	-	-	108.0	87.2
7/13	124.0	130.0	128.0	44.4
7/14	74.0	71.9	85.0	34.2
Ave.	129.2	128.5	72.8	65.8

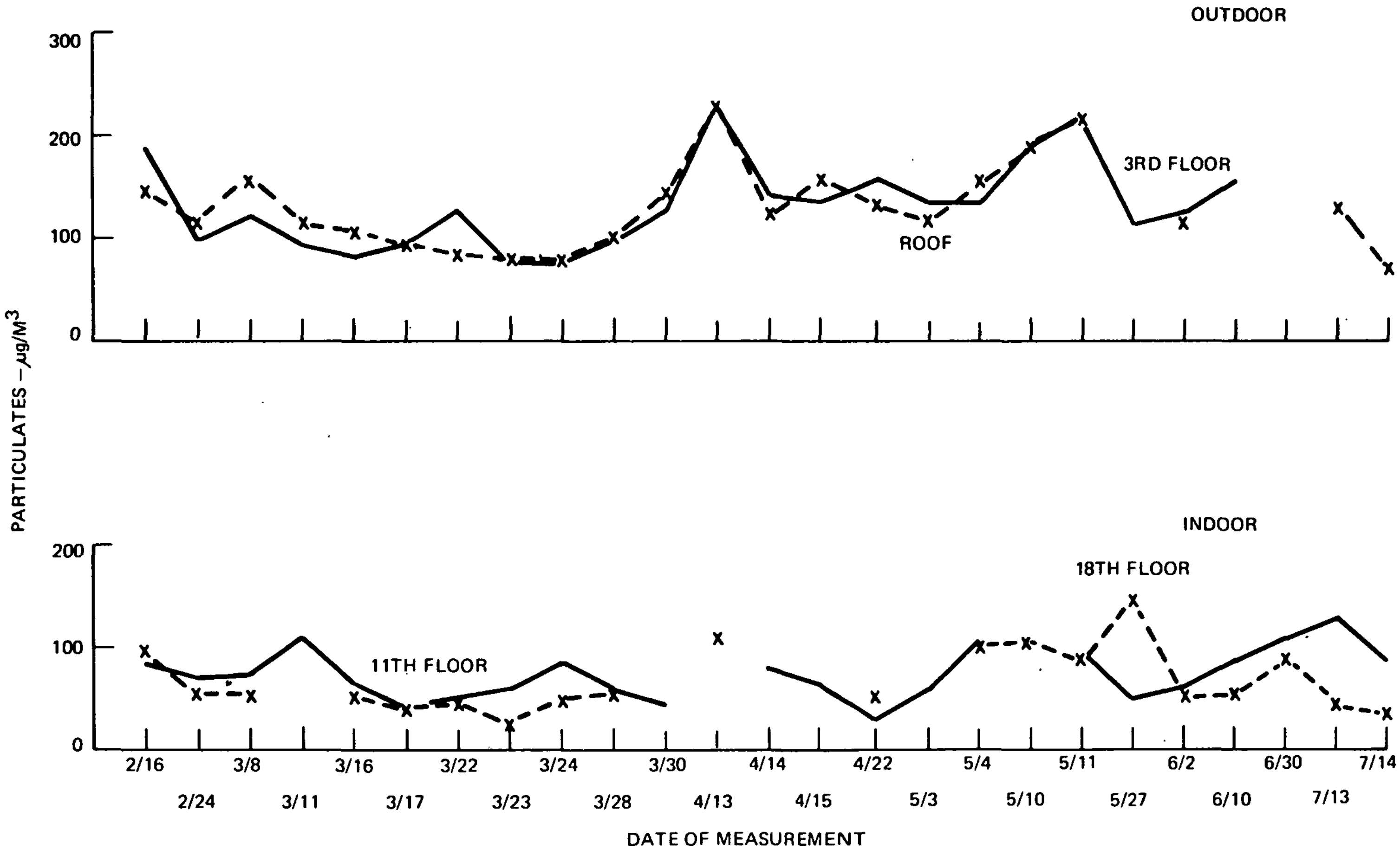


Figure 5.2.3-1. Particulates – West 40th Street

never exceeded the concentrations at either of the outside locations for the same time period. Average inside concentrations of 72.8 and 65.8 ug/M^3 for the 11th and 18th floors respectively were approximately 1/2 of outdoor average concentrations.

The total particulates recorded at the two outdoor locations throughout the sampling period closely duplicated each other. It is apparent that they have a common source. Indoor total particulates also showed a close relation to each other. However, indoor concentrations fluctuate differently than seen for outdoor concentrations.

5.2.3.1 Analysis Technique

The relationship of the four sets of particulate samples were explored using the same technique as used at the George Washington Bridge site. The resultant traffic and meteorological data for the West 40th Street site is presented in Table 5.2.3.2. It should be noted that significantly different meteorological conditions prevailed at this site than were recorded at Site 1. At this 40th Street site average roof winds were fairly constant and always blew from the south or west. In general, the resultant road level winds always shifted further to the northwest. No north or east winds were recorded at either roof or road levels.

5.2.3.2 Particulate Relationships

Analysis of the daily total particulates measured at the 3rd floor outdoor location showed no discernable relation to traffic on West 40th Street. This is shown on the upper plot on Figure 5.2.3-2. There were two possible explanations for this. First, the Hi Vol sampler, because of its location on the fire balcony was not directly exposed to 40th Street concentrations. Secondly, the prevailing winds probably masked 40th Street generated particulates to a large degree by additional particulates from 39th Street and 8th Avenue.

TABLE 5.2.3-2

SITE ENVIRONMENT

WEST 40TH STREET

Date	Ave. Hourly Traffic	Road Level Temp	Road Level Az Angle	Road Level Wd Sp	Roof Level Temp	Roof Level Az Angle	Roof Level Wd Sp
			Heating				
2/16		-	-	-	-	177	4.0
2/24		-	-	-	-	-	-
3/ 8		33	-	-	-	-	8.5
3/11		41	-	-	-	233	5.3
3/16	336	48	-	-	46	226	5.8
3/17	343	37	-	-	35	253	8.4
3/22	325	42	-	-	39	196	5.3
3/23	346	36	296	-	34	267	-
3/24	344	32	276	-	31	268	-
3/29	-	-	-	-	-	-	-
3/30	352	42	279	6.8	40	199	7.7
4/13	382	60	203	-	57	199	6.1
4/14	376	43	278	-	42	264	9.0
4/15	378	48	-	-	47	258	7.0
4/22	355	52	288	6.8	51	-	-
5/ 3	330	52	293	5.4	50	218	6.0
5/ 4	336	59	299	4.0	59	252	4.7
5/12	362	66	205	2.8	63	157	4.4
5/27	365	61	280	4.0	59	222	4.7
			Non-Heating				
5/10	323	65	247	2.3	65	167	2.4
5/11	337	70	183	1.8	68	191	3.8
5/26	358	68	300	4.4	63	252	4.7
6/ 2	393	66	165	2.0	65	171	5.0
6/10	371	72	203	2.5	70	124	3.9
6/30	-	-	-	-	-	-	-
7/13	-	-	-	-	-	-	-
7/14	-	-	-	-	-	-	-

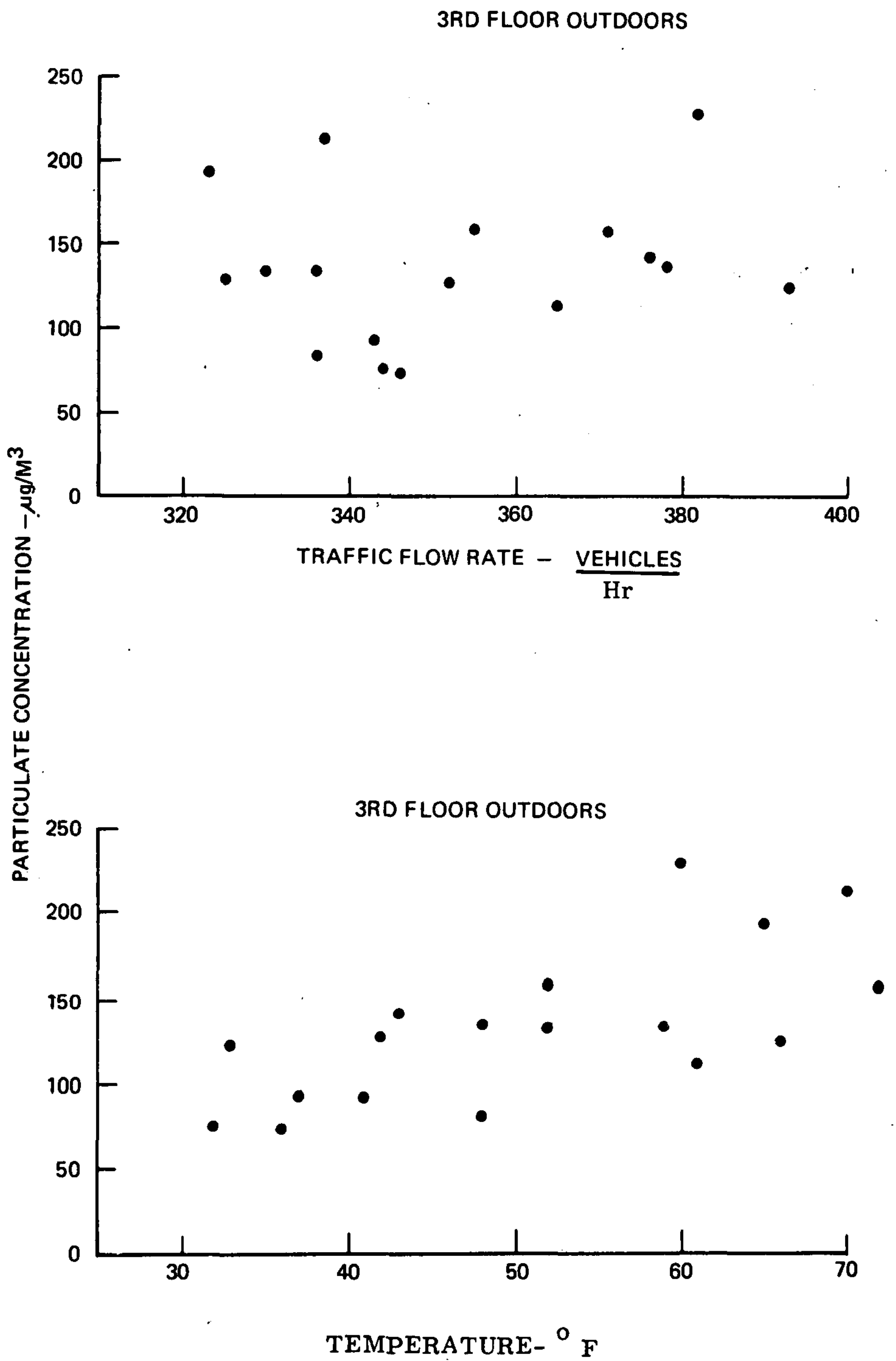


Figure 5.2.3-2. 3rd Floor Particulates Vs. Traffic and Temperature - Site 2

The 3rd floor outdoor particulate level, as shown on the lower plot of Figure 5.2.3-2, is responsive to site temperature as measured at road level. However, examination of the data on Table 5.2.3-2 will show that site temperature is directly relatable to roof wind azimuth. The lower temperatures occurred for westerly winds. South winds prevailed for days of high temperature. Therefore, it is felt that the apparent particulate/temperature relation is in reality a reflection of wind azimuth angle.

Figure 5.2.3-3 shows the particulate proof wind relationship for the four locations. The upper plots clearly indicate that the outdoor particulate levels are responsive to wind direction. South winds produce high total particulate concentrations. West winds produce low concentrations outdoors. Indoor concentrations, as shown on the lower plots, exhibit random relationship to roof wind direction.

Roof level winds are not as influential on particulate concentrations as can be seen on Figure 5.2.3-4. There is a suggestion, however, that peak particulate concentrations occurred for road winds close to 215° and reduced as the wind shifted in either direction. This would be logical in view of the site geometry previously shown on Figures 4.2-1 thru -3.

The particulate levels at the two outdoor locations vary differently as a function of roof wind direction. Reexamination of Figure 5.2.3-1 will show that 3rd floor concentrations exceed roof concentrations significantly on February 17 and March 22. Both days were marked with southerly winds. The difference in particulate levels outdoors, as shown in the upper left plot of Figure 5.2.3-5, is determined by roof level wind direction. The outdoor differential, roof to 3rd floor, is negative for southerly winds and positive for westerly winds. Road winds do not significantly influence this outdoor differential as can be seen in the upper right plot.

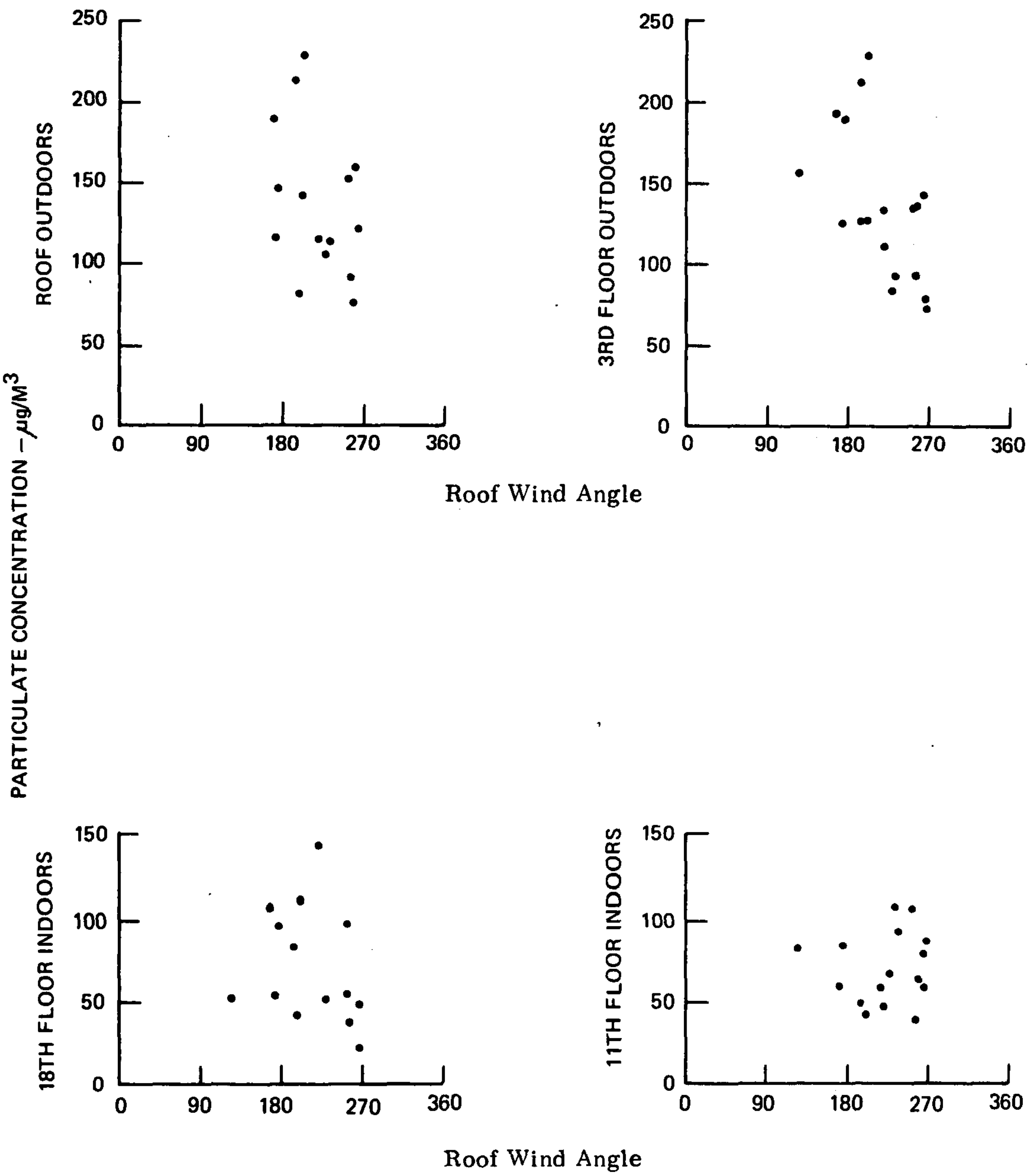


Figure 5.2.3-3. Particulates Vs. Roof Wind Angle – Site 2

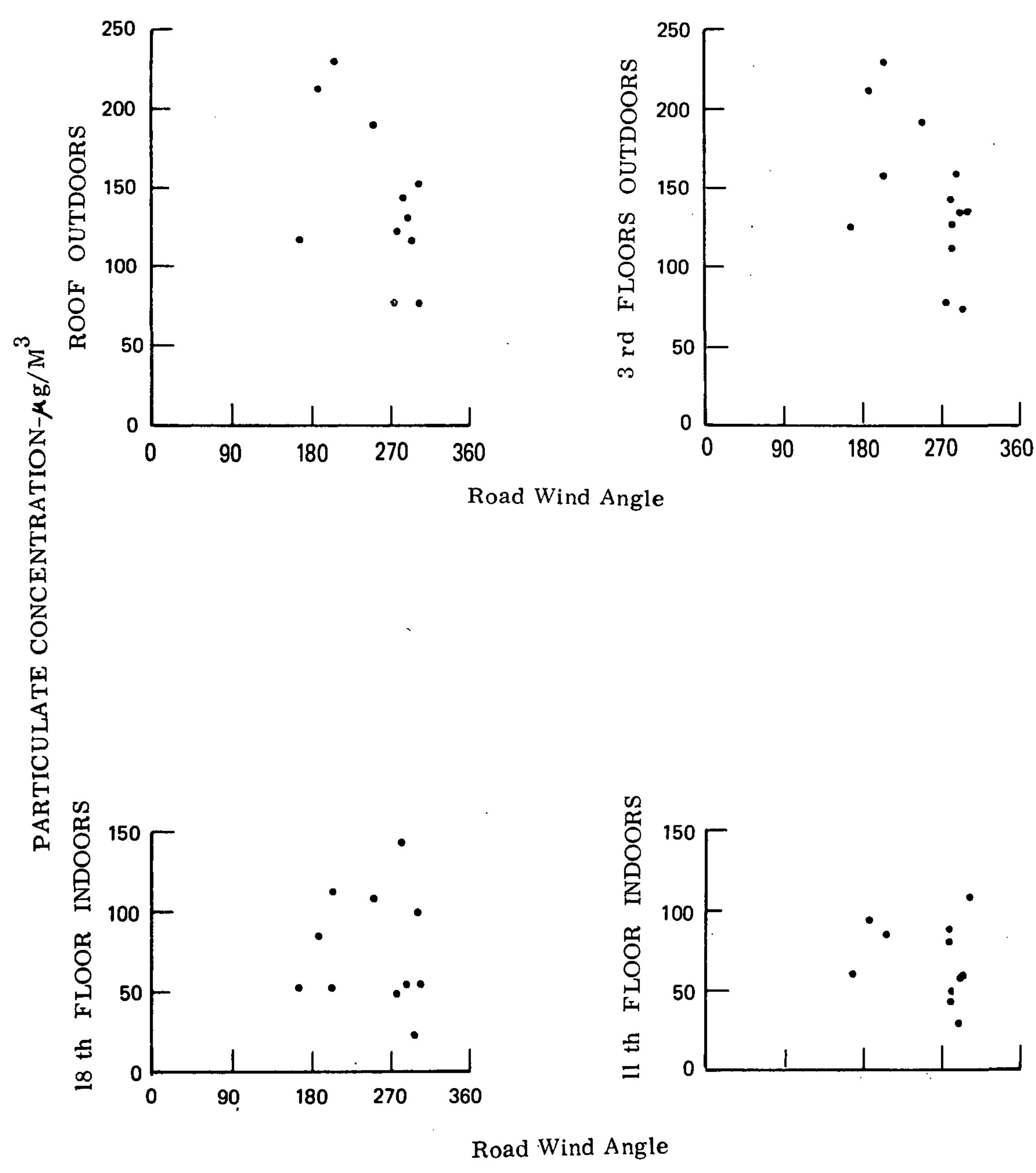


Figure 5.2.3-4. Particulates Vs. Road Wind Angle – Site 2

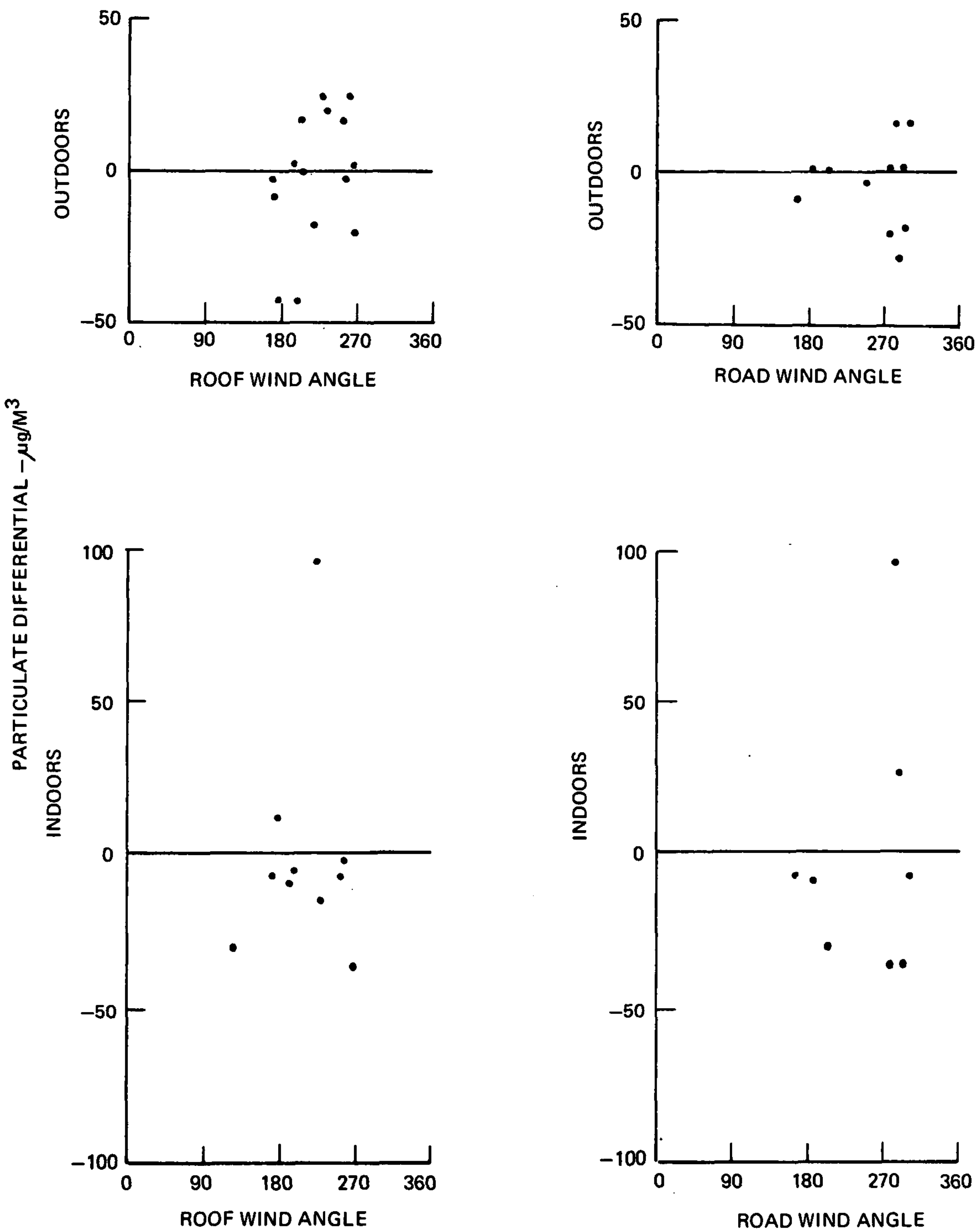


Figure 5.2.3-5. Particulate Differential Vs. Wind Angle – Site 2

The particulate differential indoors, from the 18th to 11th floors, does not show as clear a relationship to either roof or road level winds. Since the 18th floor Hi Vol Sampler was located within a closed storage area, 11th floor concentrations usually exceeded 18th floor particulate levels. The only two exceptions occurred for days when the roof wind blew from the south.

Indoor particulates are influenced somewhat by the roof level wind, however. This can be seen from Figure 5.2.3-6 which shows the differentials from roof to 18th floor and 3rd to 11th floors as a function of both roof and road level winds. As shown by the two left plots, the outdoor/indoor differential shows the same relation to roof wind as seen for outdoor particulate levels. That is, high differentials for south winds and low differentials for west winds.

5.2.3.3 Particulate Summation

Total particulates at the four sampling locations at Site 2 are derived from the same source. This source, however is not West 40th Street traffic. The source is south of the building. Roof level winds disperse particulates to the two outdoor locations as a function of azimuth angle. Concentrations are higher outdoors because the source is outdoors. Indoor locations receive varying amounts of particulates, reflecting wind direction. A lesser amount is measured within the storage area than at other indoor locations.

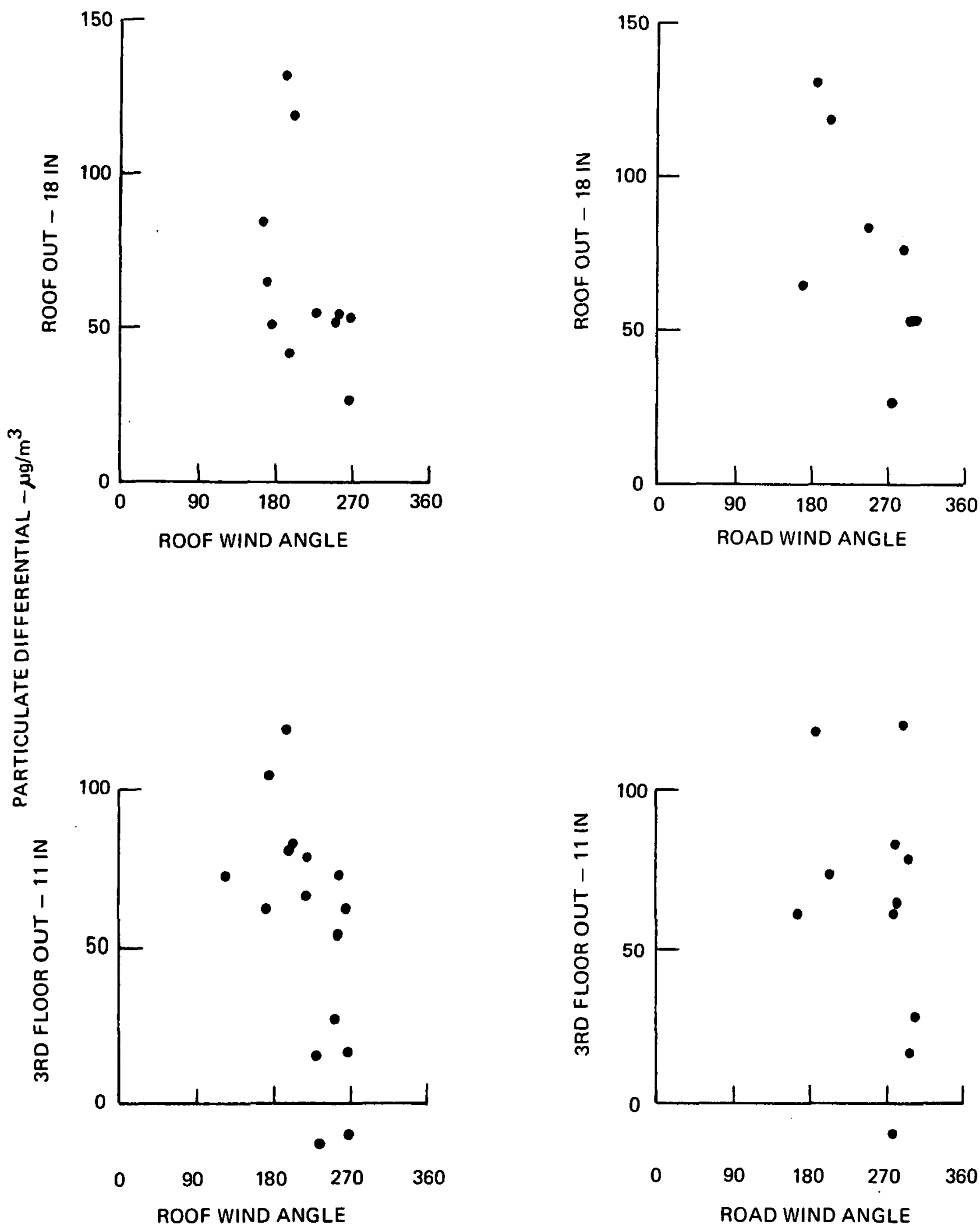


Figure 5.2.3-6. Outdoor/Indoor Particulate Differential Vs. Wind Angle – Site 2

5.2.4 Lead

The total particulate samples collected at the West 40th Street site were analyzed for lead content and percent using an atomic absorption technique. Figures and Tables 5.2.4-1 and -2 present the data obtained.

A comparison of the two figures shows considerable difference between the quantity and percentage of lead measured on comparable days. It should be noted that there is a general similarity between lead concentration and total particulates, see Figure 5.2.3-1, at all locations. This suggests that the lead quantity is directly related to total particulates. This relationship does not hold, however, for percent lead at any location.

5.2.4.1 Lead Quantity

The highest lead concentration was measured indoors on the 11th floor on May 11. All other locations record high concentrations on that date. Outdoor average concentrations were somewhat higher than the average indoor lead levels. The lowest concentration was recorded at the 11th floor indoor location on March 8. Other locations also were low in lead content on this date. While there is not a uniform relationship in lead concentration at all locations on all dates, the general consistency of data suggests that wind direction also strongly influences the lead concentrations.

Figure 5.2.4-3 presents the lead concentration at the 3rd floor balcony location as a function of both 40th Street traffic and site temperature. The upper plot shows that traffic on 40th Street does not directly influence the 3rd floor lead level. Lead level appears to increase as a function of site temperature. It should be noted, however, that the change in site temperature is directly related to roof wind azimuth.

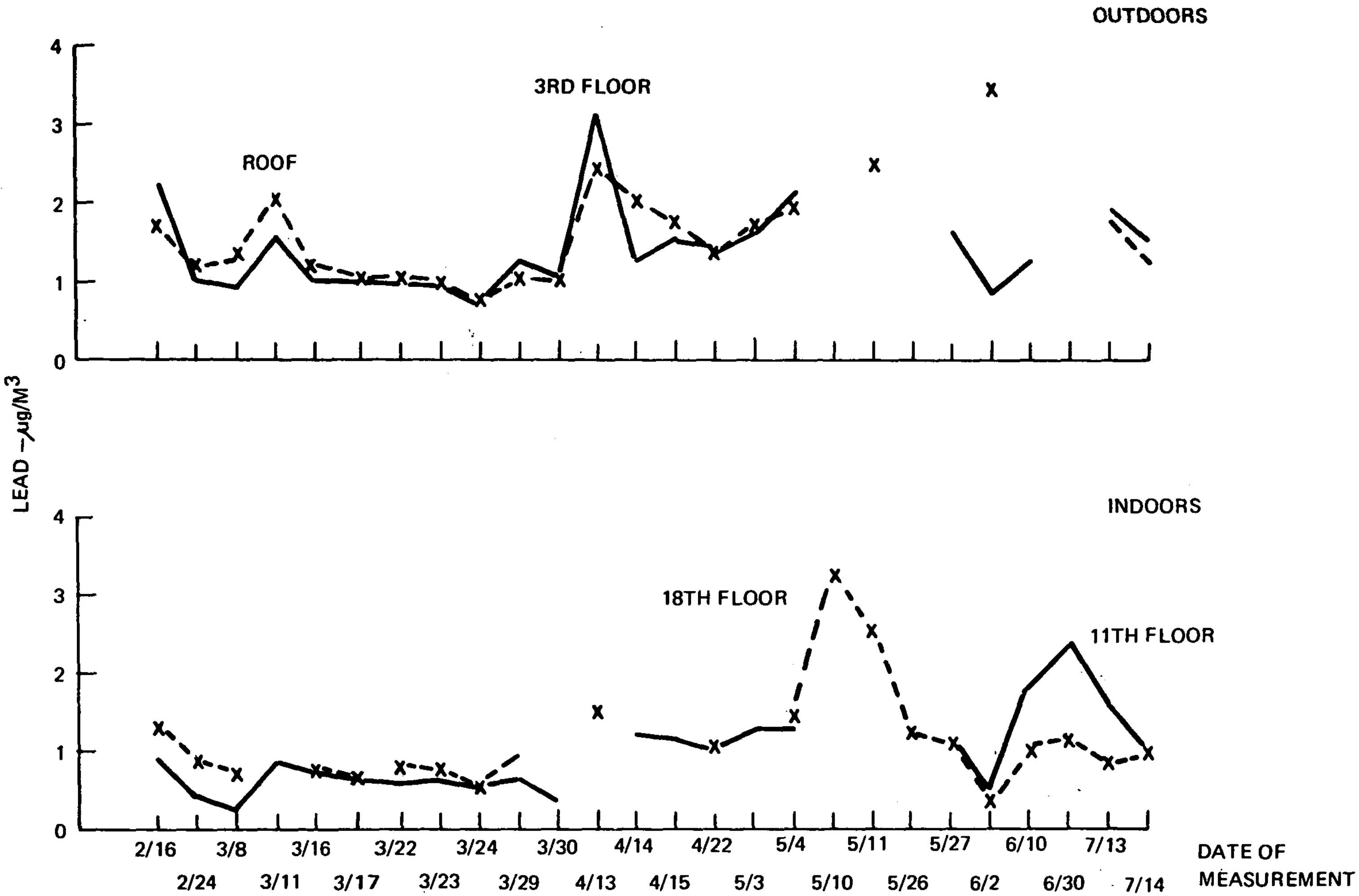


Figure 5.1.4-1. Lead – West 40th Street

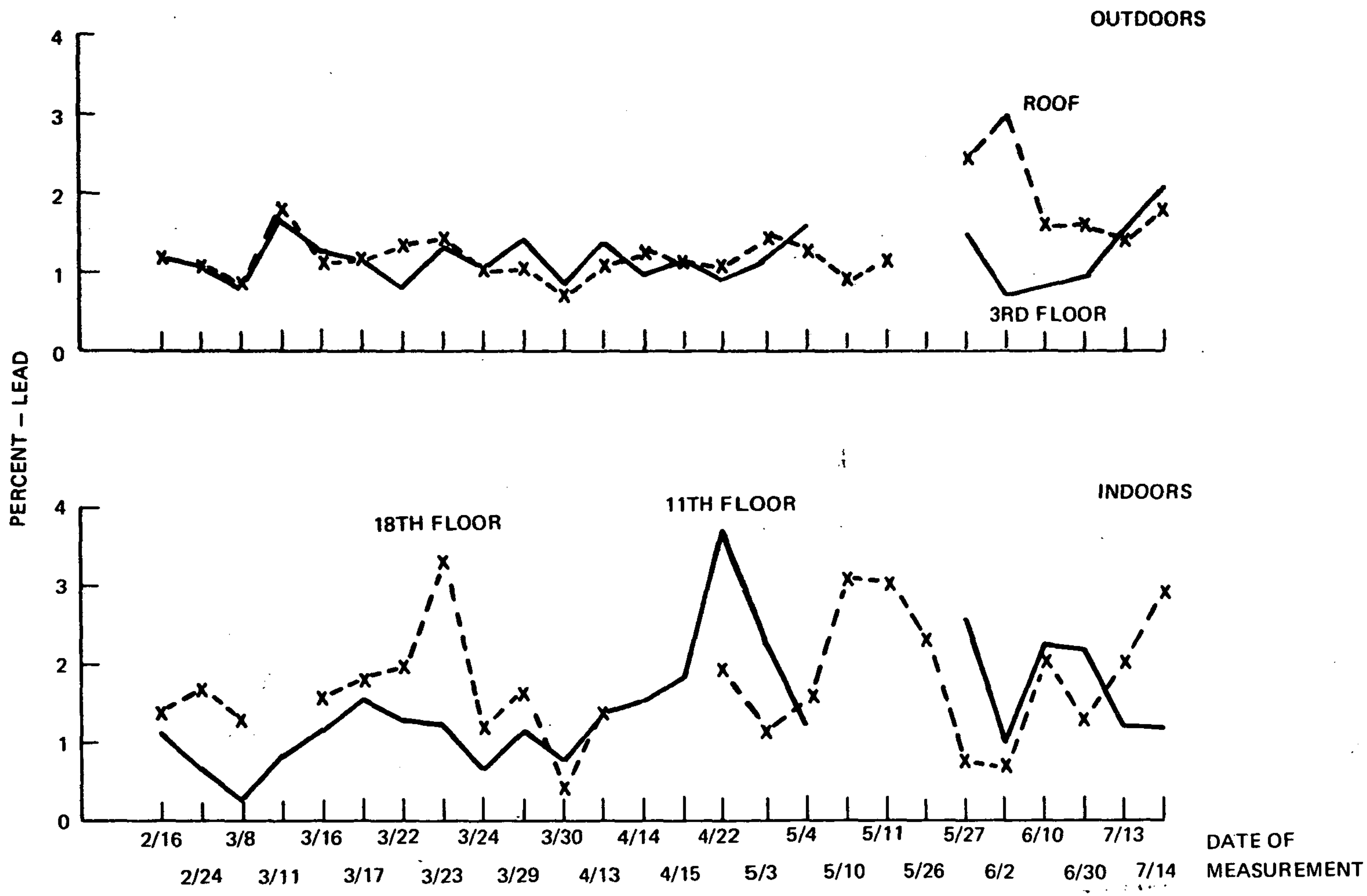


Figure 5.1.4-2. Lead Percentage – West 40th Street

TABLE 5.2.4-1

LEAD-ug/M^3

WEST 40TH STREET

Date	Outside 3	Roof	Inside 11	Inside 18
		Heating		
2/16	2.24	1.71	.92	1.31
2/24	1.00	1.19	.42	.87
3/ 8	.95	1.35	.25	.72
3/11	1.53	2.02	.87	-
3/16	1.00	1.19	.72	.78
3/17	1.04	1.01	.62	.67
3/22	1.00	1.08	.60	.80
3/23	.96	1.04	.69	.76
3/24	.75	.76	.53	.59
3/29	1.27	1.03	.68	.94
3/30	1.04	1.02	.35	-
4/13	3.13	2.46	-	1.57
4/14	1.29	1.99	1.22	-
4/15	1.51	1.74	1.18	-
4/22	1.40	1.34	1.04	1.07
5/ 3	1.59	1.72	1.28	-
5/ 4	2.12	1.94	1.27	1.49
5/12	-	-	-	-
5/27	1.65	-	1.20	1.11
		Non Heating		
5/10	-	-	-	3.28
5/11	3.25	2.52	3.47	2.56
5/26	-	-	-	1.25
6/ 2	.87	3.44	.56	.37
6/10	1.28	-	1.86	1.07
6/30	-	-	2.38	1.13
7/13	1.94	1.80	1.57	.89
7/14	1.55	1.29	1.00	1.00
Ave.	1.49	1.69	1.07	1.15

TABLE 5.2.4-2

PERCENT LEAD

WEST 40TH STREET

Date	Outside 3	Outside Roof	Inside 11	Inside 18
		Heating		
2/16	1.19	1.17	1.10	1.37
2/24	1.02	1.05	.62	1.64
3/ 8	.78	.86	.35	1.30
3/11	1.64	1.80	.80	-
3/16	1.23	1.14	1.13	1.54
3/17	1.11	1.11	1.55	1.82
3/22	.78	1.31	1.24	1.95
3/23	1.30	1.37	1.18	3.31
3/24	1.00	1.00	.61	1.18
3/29	1.37	1.03	1.15	1.65
3/30	.83	.71	.81	.43
4/13	1.36	1.07	1.37	1.41
4/14	.92	1.24	1.54	-
4/15	1.11	1.09	1.86	-
4/22	.88	1.06	3.72	1.95
5/ 3	1.18	1.49	2.22	1.15
5/ 4	1.58	1.28	1.19	1.52
5/12	-	2.43	2.53	.78
		Non-Heating		
5/10	-	.91	-	3.10
5/11	1.53	1.18	3.70	3.06
5/26	-	-	-	2.32
6/ 2	.70	2.97	.95	.71
6/10	.82	1.57	2.22	2.06
6/30	.91	1.57	2.20	1.30
7/13	1.56	1.39	1.22	2.01
7/14	2.09	1.79	1.18	2.94
Ave.	1.18	1.34	1.56	1.76

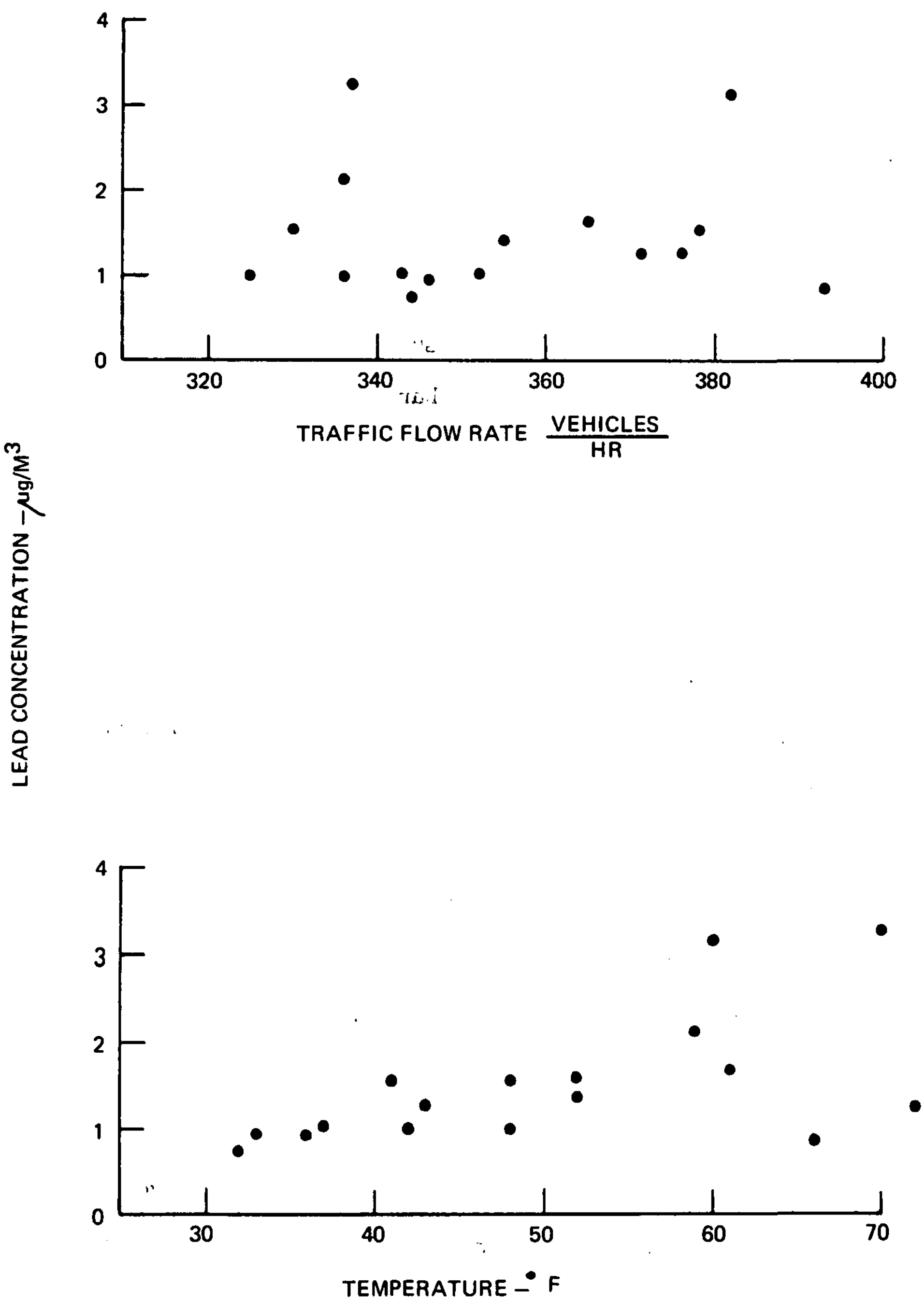


Figure 5.2.4-3. 3rd Floor Lead Vs. Traffic and Temperature – Site 2

The effect of roof and road wind direction on the lead concentrations at the four locations is shown on Figures 5.2.4-4 and -5. Again there is a clear relationship between roof outdoor lead concentration and roof wind direction. This relationship is not as strong however, for the 3rd floor outdoor location. Indoor lead concentrations appear to be random with roof wind. The effect of road winds is not obvious at any location.

Road winds, however, do influence the differential lead concentrations as shown on the right hand plots of Figure 5.2.4-6. Indoors, the 18th floor levels are significantly lower than 11th floor lead concentration for road winds from 200^{o}. This differential changes as this wind shifts in either direction. This road wind effect for the differential outdoors from the roof to 3rd floor location is similar. The same relationship is seen between road wind and the differential from the 3rd floor outdoor to 11th floor indoor location, see Figure 5.2.4-7.

It is apparent, therefore, that while the roof level lead concentration and the differential outdoors are basically controlled by roof wind, lead concentrations indoors, especially at the 11th floor, are influenced by road winds more than roof winds. This suggests that the lead concentrations at the site are determined by lead sources prevalent, in the general area of the canyon structure. Fortieth Street traffic contribution is masked by other lead sources.

5.2.4.2 <u>Lead Percentage</u>

While there are isolated instances when the percentage of lead reflected the quantity of lead at a particular location, there is a very random relationship between lead percentage and environmental conditions at all locations. A more extensive analysis might develop some relationships.

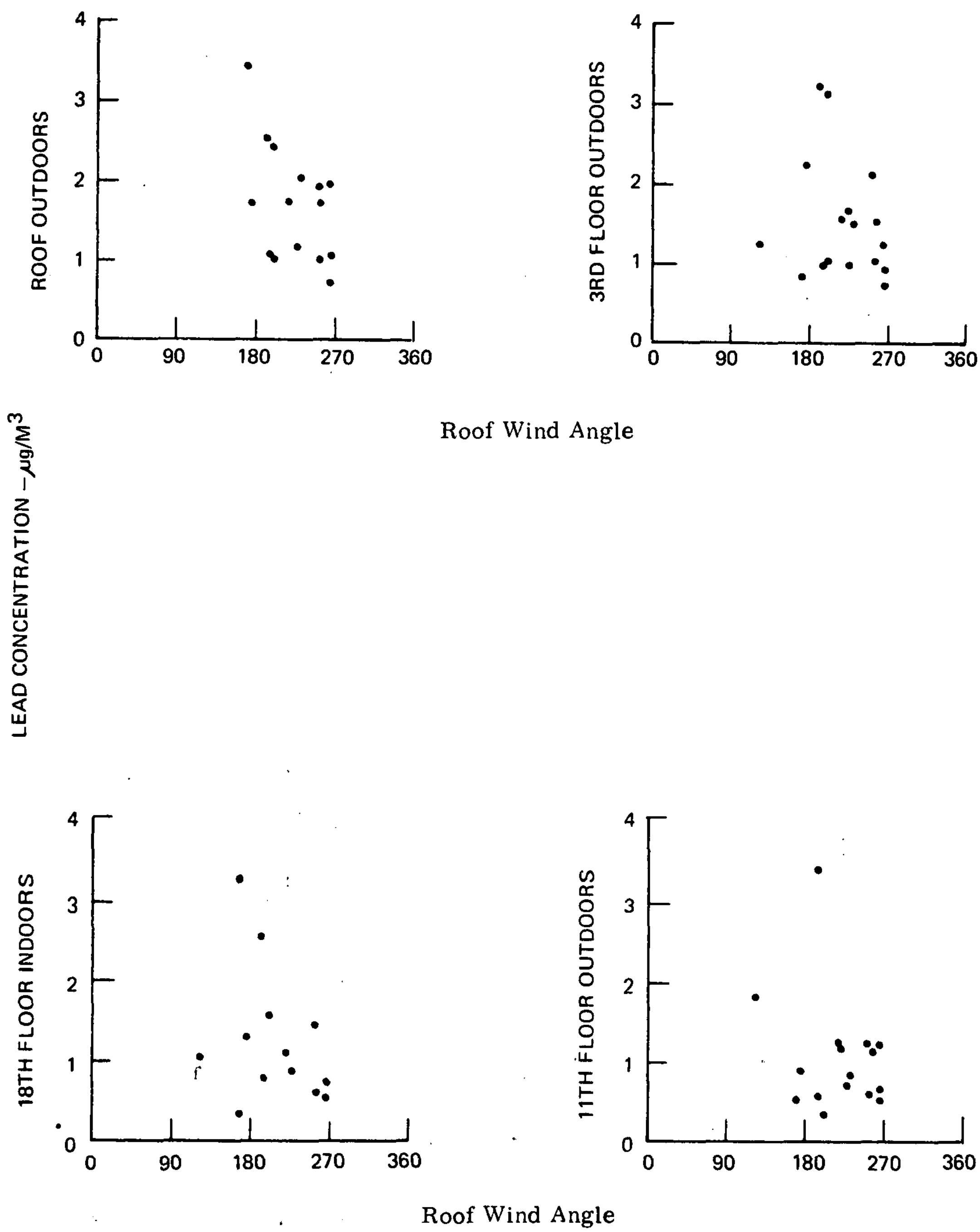


Figure 5.2.4-4. Lead Concentration Vs. Roof Wind Angle – Site 2

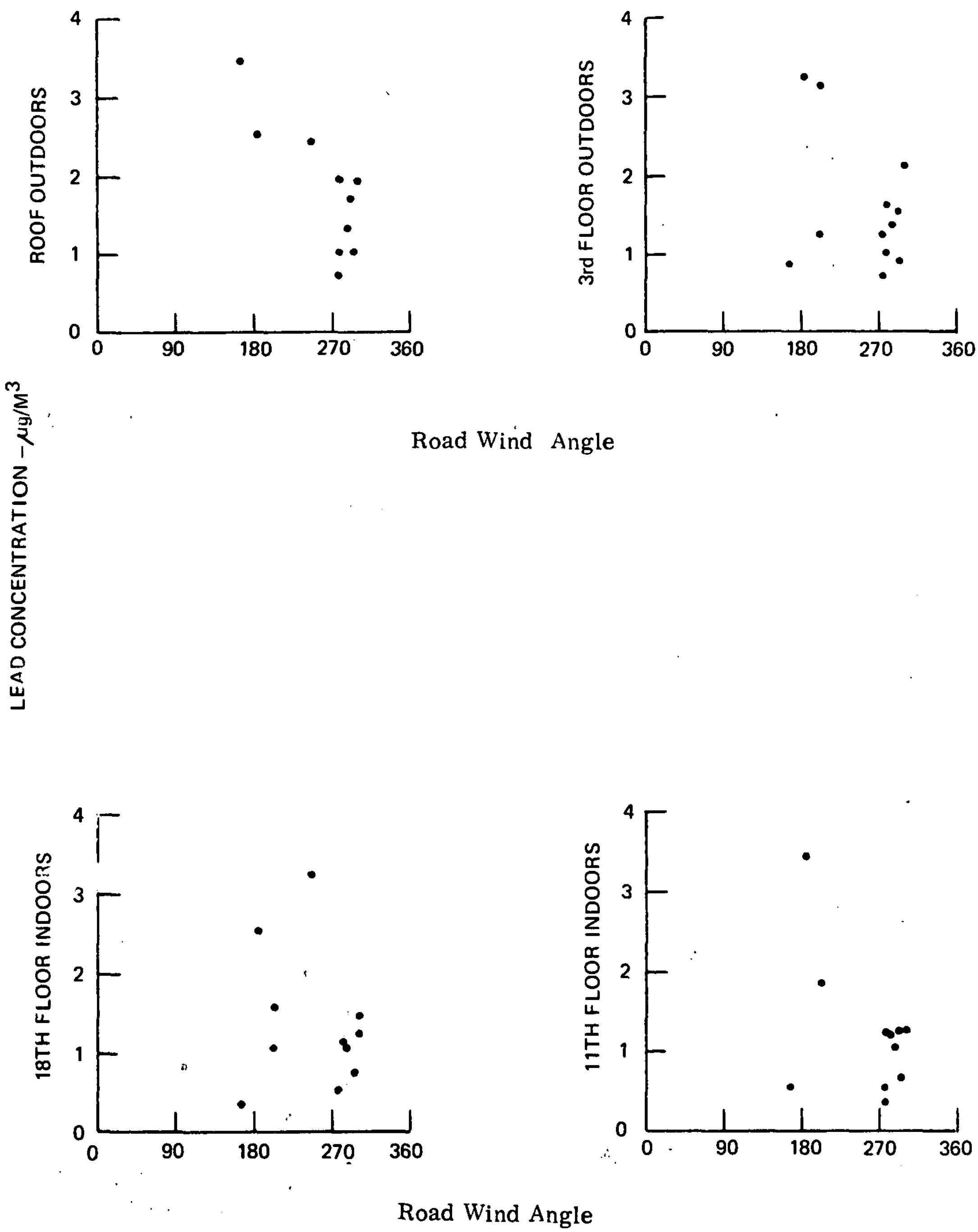


Figure 5.2.4-5. Lead Concentration Vs. Road Wind Angle – Site 2

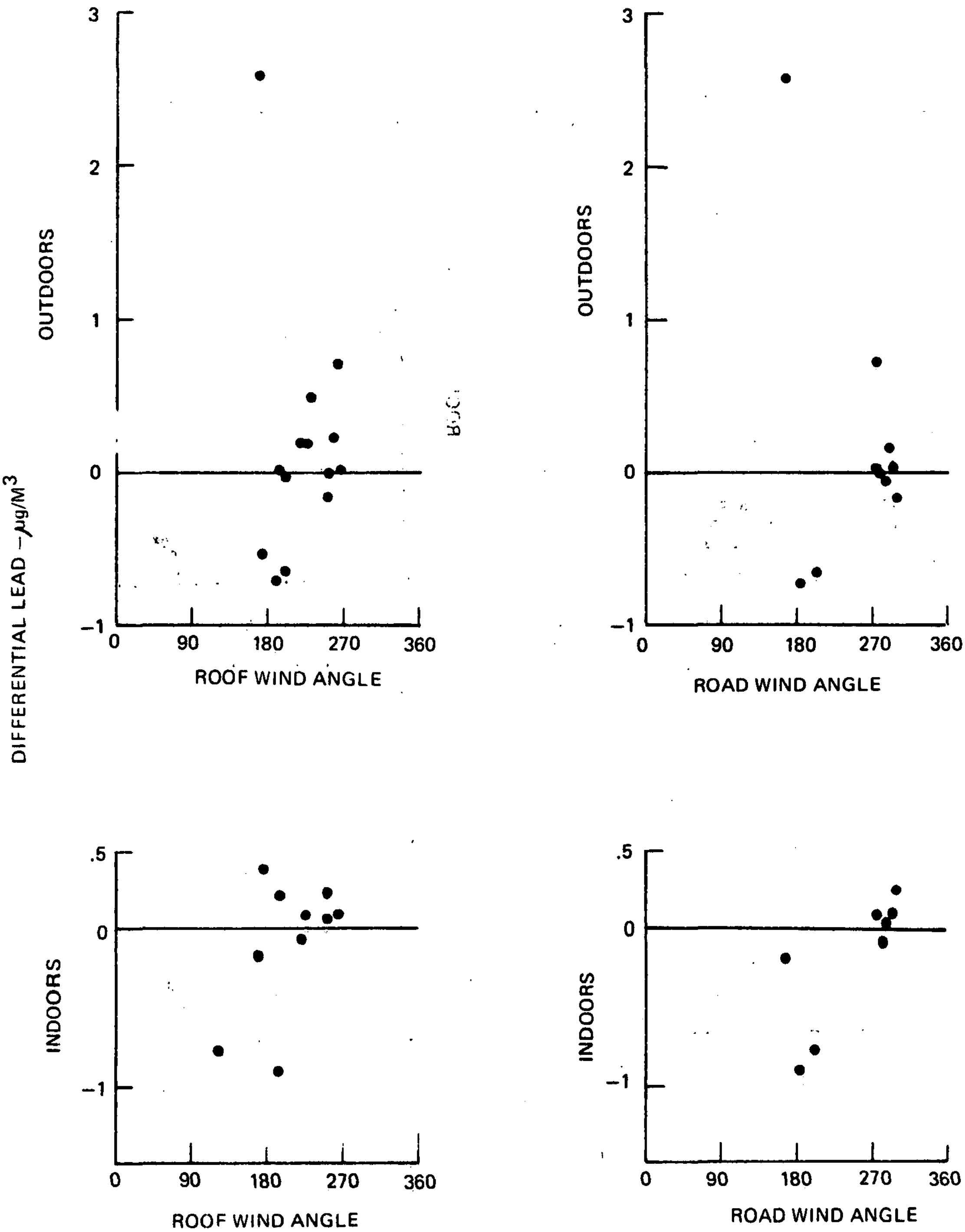


Figure 5.2.4-6. Lead Differential Vs. Wind Angle – Site 2

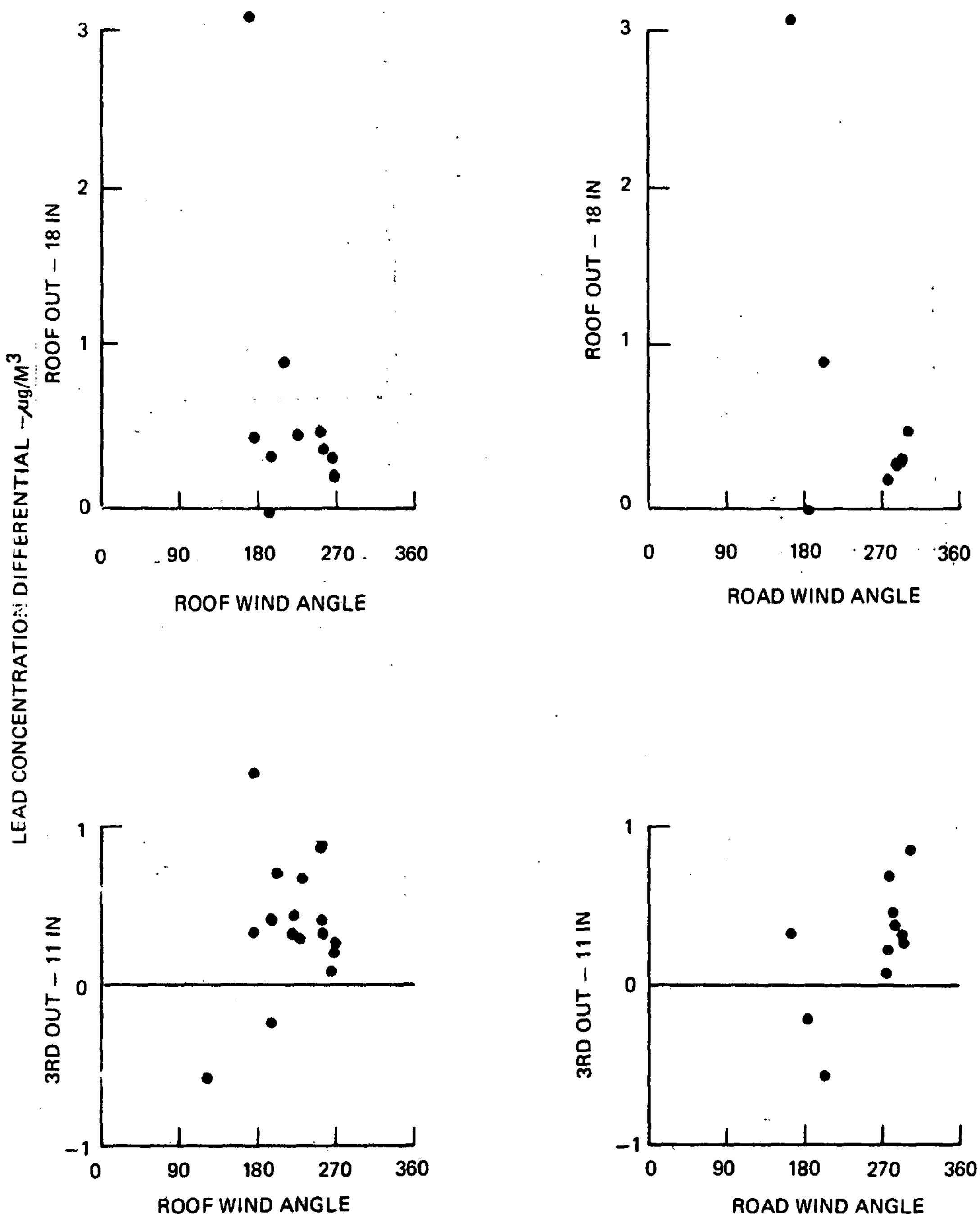


Figure 5.2.4-7. Outdoor/Indoor Lead Concentration Differential Vs. Wind Angle - Site 2

It is apparent, though, that the 3rd floor lead percentage is relatively constant for changes in traffic, site temperature and roof and road winds. This can be seen from Figure 5.2.4-8 and the upper right hand plots of 5.2.4-9 and -10. Since this is the closest location to ground level, this suggests that both particulates and lead are ground originated at the 40th Street site. The larger variation at both indoor locations then measured at the outdoor locations tend to substantiate this.

The differential lead percentages are presented in Figures 5.2.4-11 and -12. These plots further demonstrate the randomness of percent lead at all locations.

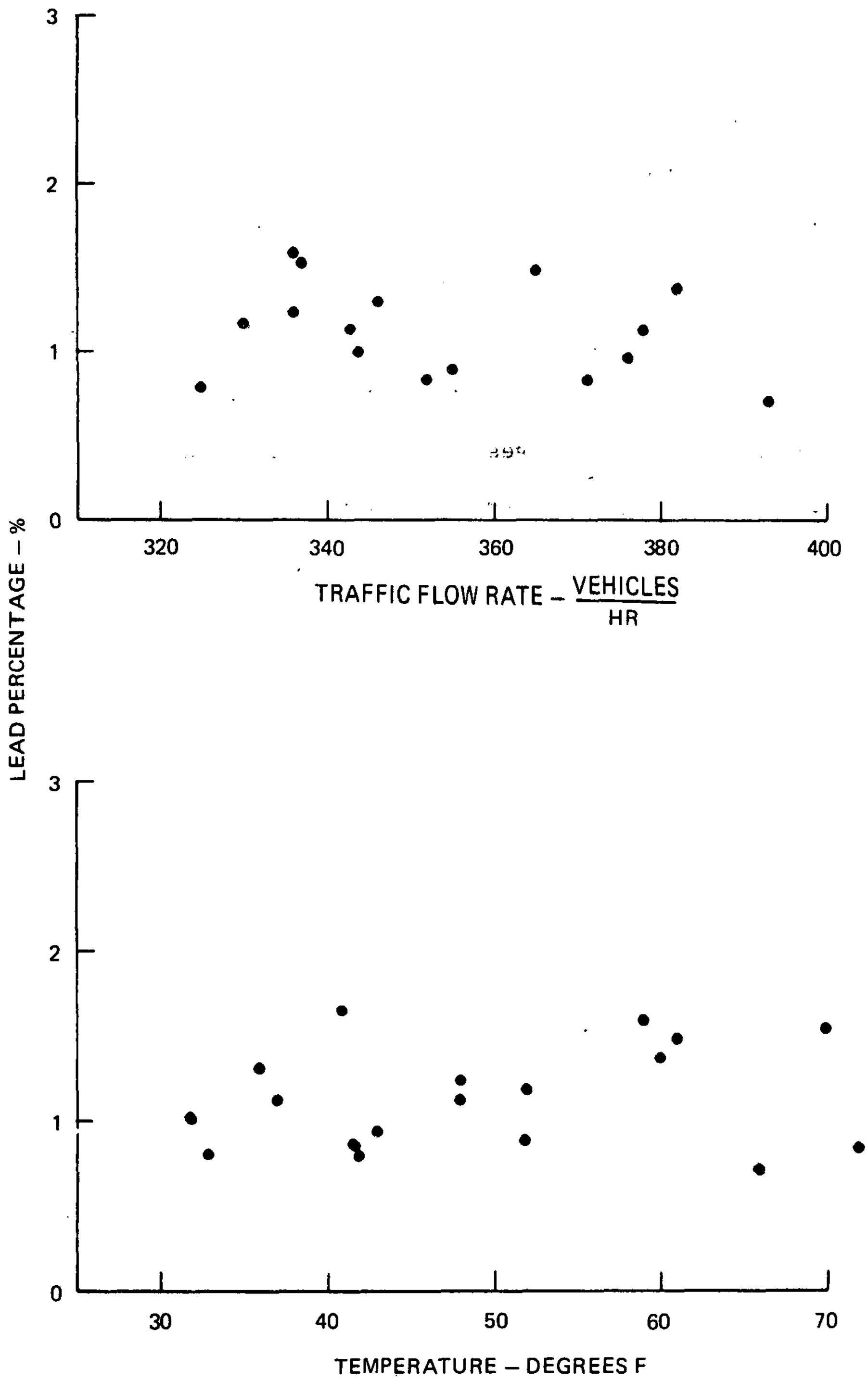


Figure 5.2.4-8. 3rd Floor Percent Lead Vs. Traffic and Temperature – Site 2

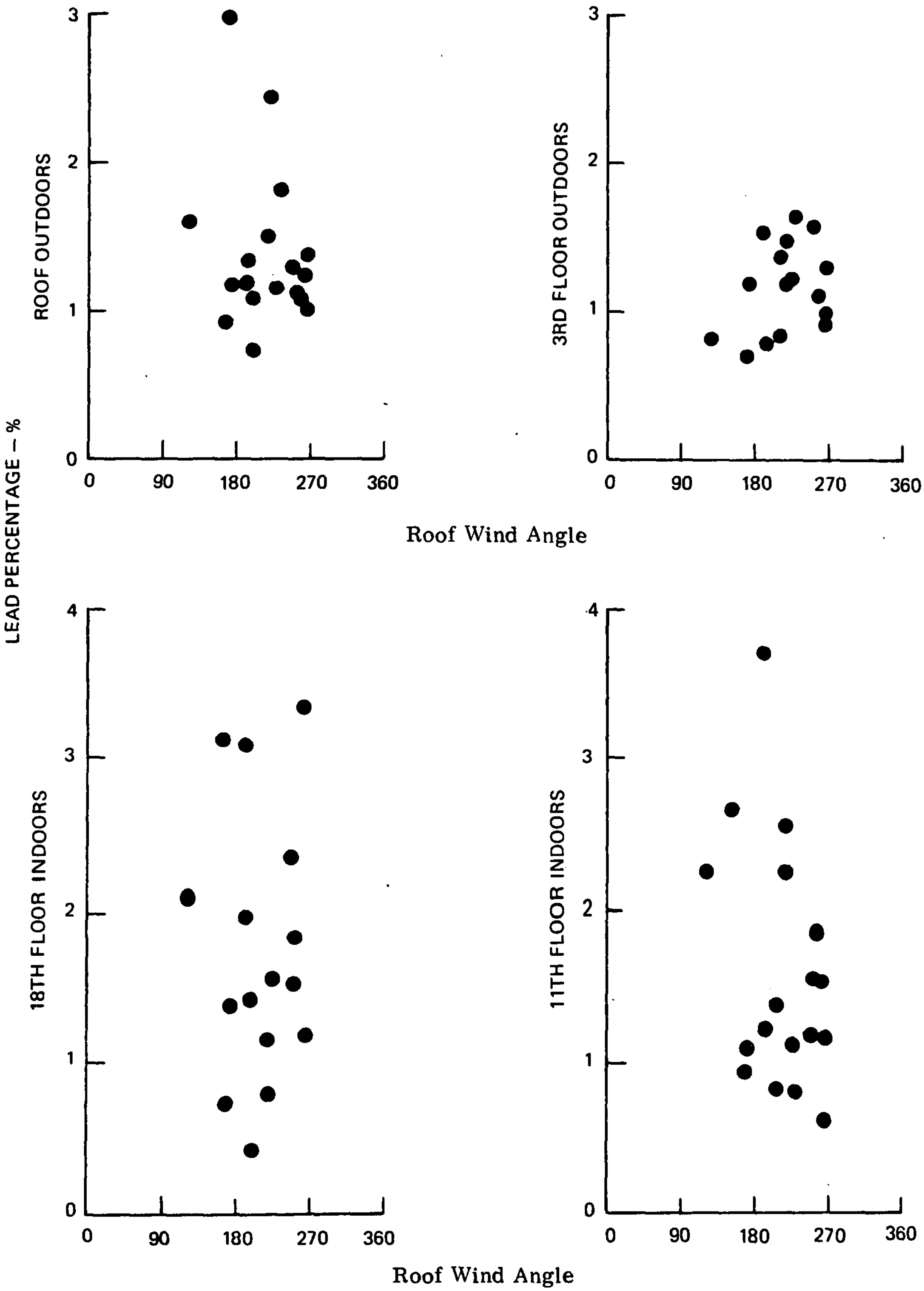


Figure 5.2.4-9. Lead Percentage Vs. Roof Wind Angle – Site 2

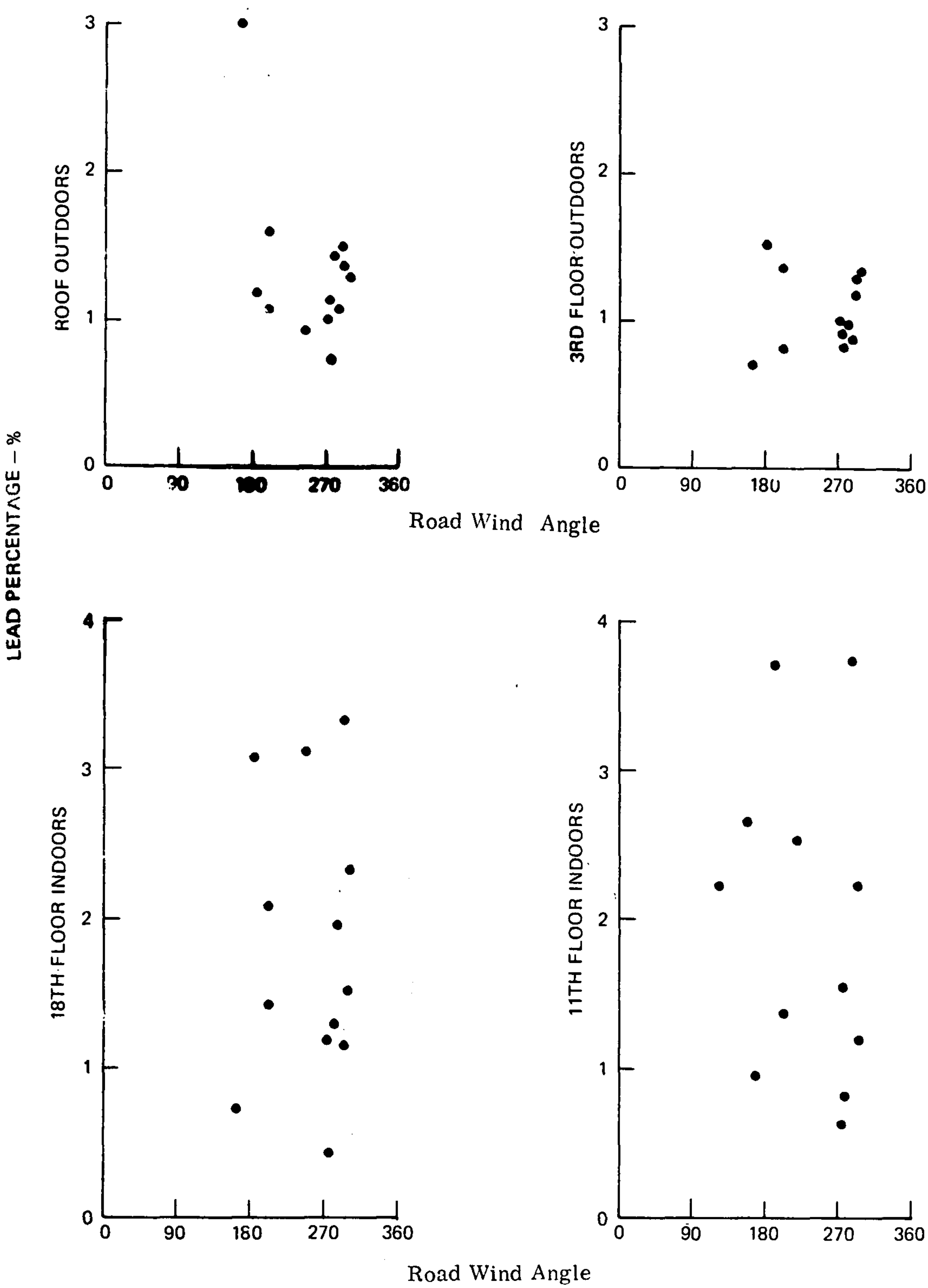


Figure 5.2.4-10. Lead Percentage Vs. Road Wind Angle – Site 2

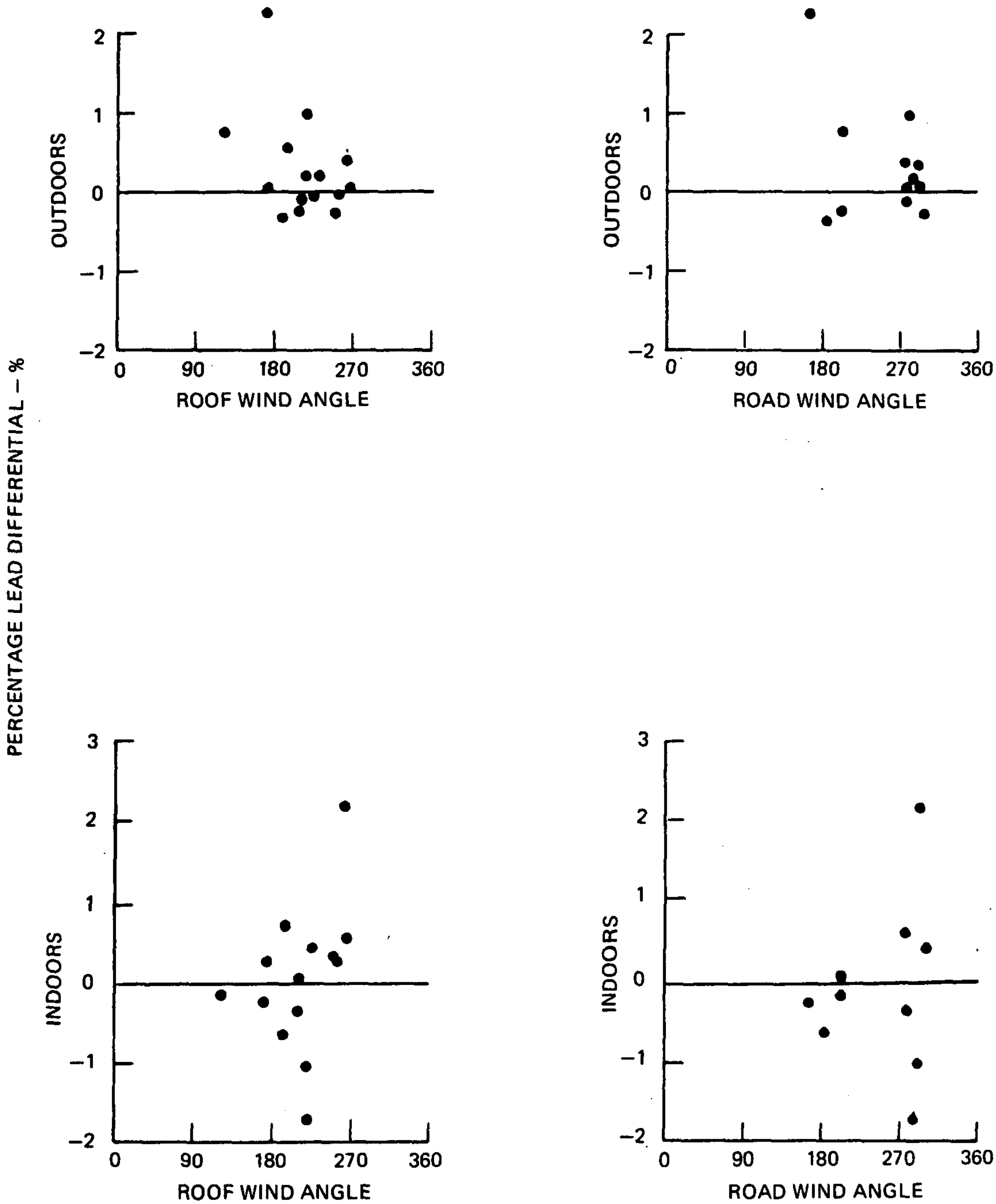


Figure 5.2.4-11. Percent Lead Differential Vs. Wind Angle – Site 2

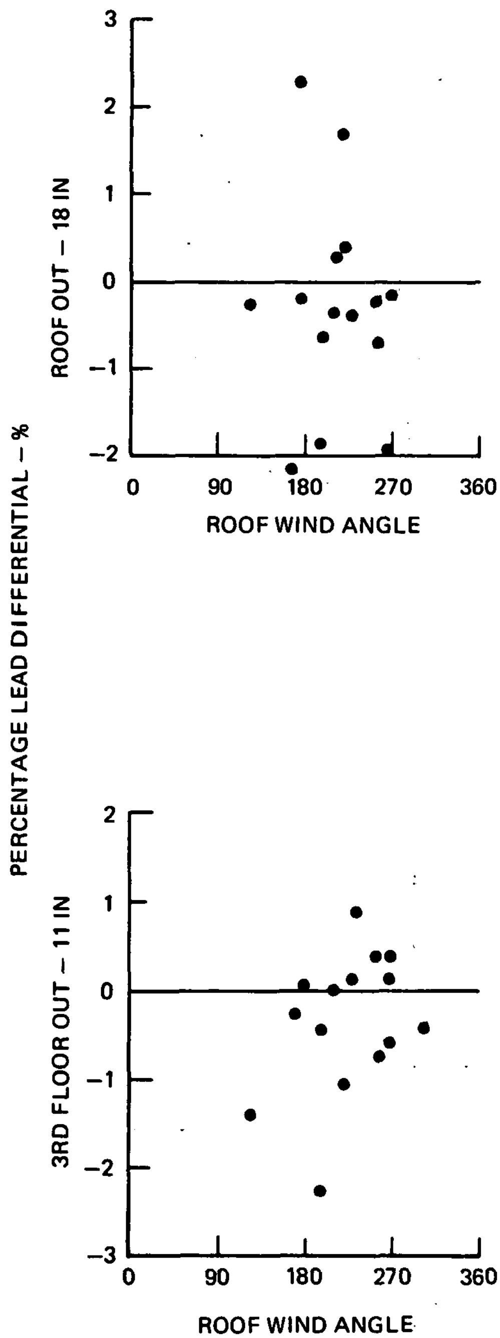


Figure 5.2.4-12. Outdoor/Indoor Percent Lead Differential Vs. Wind Angle – Site 2

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