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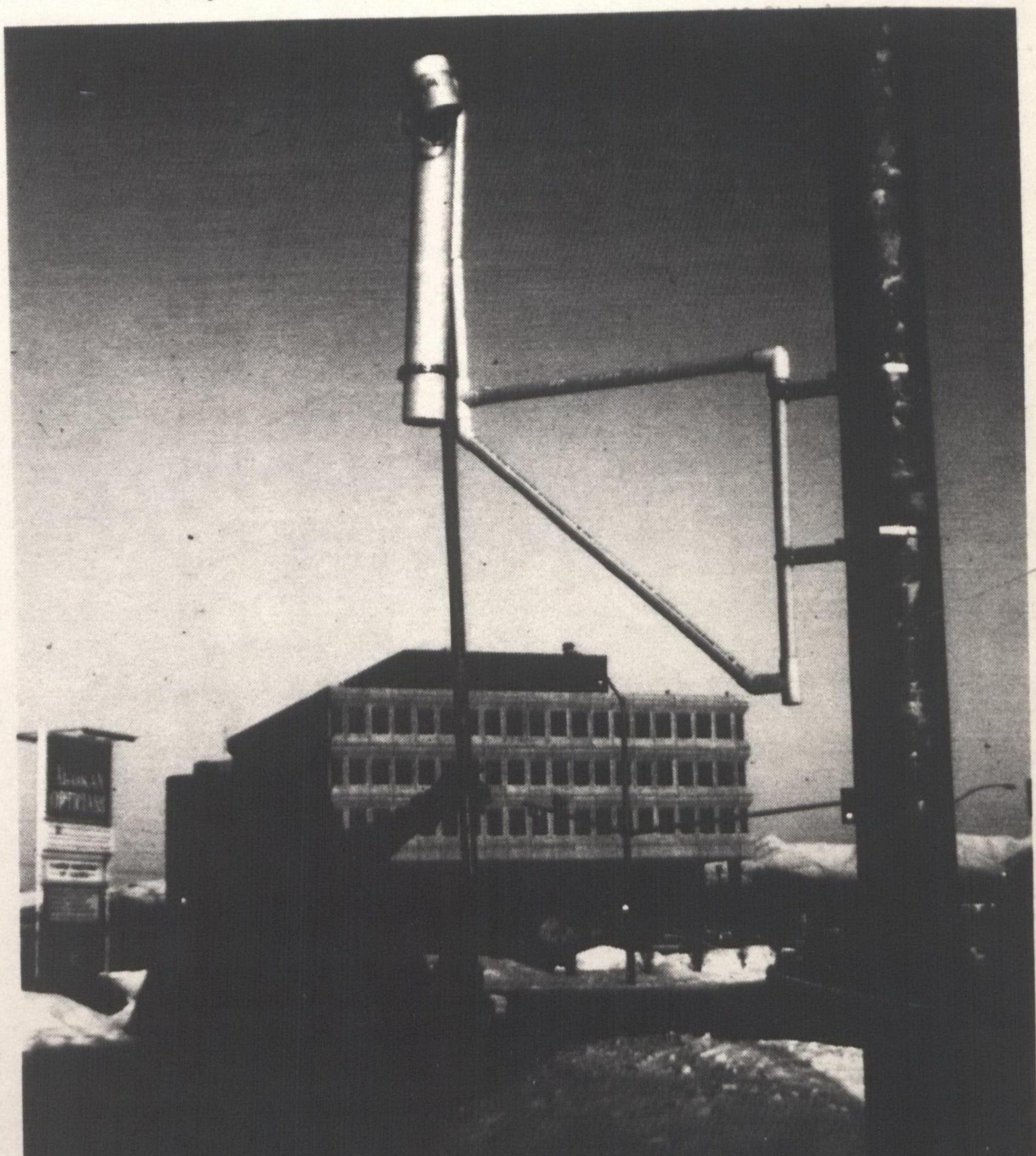
Carbon Monoxide Study Anchorage, Alaska

November 22, 1982 to February 11, 1983



ANCHORAGE

CARBON MONOXIDE STUDY

November 22, 1982 - February 11, 1983

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With The Cooperation and Concurrence

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DISCLAIMER

This report has undergone the U. S. Environmental Protection Agency's (EPA) peer review process and has been reviewed by both the Anchorage Air Pollution Control Authority/Municipality of Anchorage (AAPCA/MOA) and the Alaska Department of Environmental Conservation (ADEC) and is approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the EPA, AAPCA/MOA, or ADEC, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

PREFACE

As prescribed in the Clean Air Act (CAA) of 1970, the U.S. EPA established National Ambient Air Quality Standards (NAAQS) for protection of the public's health from carbon monoxide in air external to buildings to which the public has access. In a number of cities nationwide, including Anchorage, these standards have not yet been attained. Plans to achieve the standards are required under the CAA Amendments of 1977. It is hoped that the material presented herein will assist in achieving progress towards the protection of the public's health through the attainment of these standards.

ACKNOWLEDGEMENTS

I gratefully acknowledge the invaluable assistance of members of the Anchorage Air Pollution Control Authority/Municipality of Anchorage (AAPCA/MOA), Alaska Department of Environmental Conservation (ADEC) and Alaska Department of Transportation (ADOT). Without their continuing cooperation and unfailing efforts the successful completion of this study would not have been realized.

The study was accomplished with the following division of labor. The EPA was primarily responsible for study design and funding, quality assurance development, some field training, data processing and analyses, and report preparation. The AAPCA was primarily responsible for budget and contractor management, sampling initiation and maintenance, data collection and reduction, and quality assurance functions. These efforts were coordinated by George LaMore, Director of AAPCA/MOA and supported by a staff of Stephen Morris, Wes Tindall, Brenda Horn, and Ron King of MOA's Planning Department. Tom Chapple and Leonard Verrelli of ADEC were primarily responsible for providing State input to most study functions and coordinating the implementation of the traffic count program with ADOT and the MOA's Traffic Engineering Department.

The contributions of the National Weather Service/Anchorage International Airport, the control tower crew at the Merrill Field airport, and the meteorological staff at Elmendorf Air Force Base were also greatly appreciated.

Finally, a great debt is owed to the many members of the EPA Regional staff who provided guidance, encouragement, and assistance to the task at hand. Special gratitude is due to both Kenneth Carson and Laurie Fiske for their endeavors at the computer keyboard and Cathy Chavez for her enduring patience in many hours with the word processor.

ABSTRACT

Typically, levels of ambient carbon monoxide (CO) vary widely among the four existing permanent monitoring sites distributed throughout the city of Anchorage. An ambient air sampling program was designed and implemented to clarify and define, if possible, the relationship of carbon monoxide (CO) levels reported from these permanent sites and levels occurring elsewhere in the city. Integrated bag sampling was conducted on weekdays at approximately 50 sites during the interval spanning November 22, 1982 and February 11, 1983. Samples collected from each site were analyzed by the non-dispersive infrared (NDIR) method. Comparisons were then made between data arising from the study sites and the four permanent monitoring sites. A comprehensive quality assurance program was developed and ordered to the study to ensure the collection of data that were of known and appropriate accuracy, precision, representativeness, comparability and completeness.

In largely fulfilling the purpose of the study, the primary conclusions arising from analysis of the study data were twofold: 1) The permanent monitoring network does not adequately characterize either the absolute magnitude of CO levels or the frequency of standards exceedances encountered at an array of locations elsewhere in the study area, and 2) The basic or immediate representativeness of each permanent monitoring site has largely been established.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Since the onset of ambient air monitoring in 1974, a carbon monoxide (CO) problem has been identified with the city of Anchorage, Alaska. Violations of the standard* established by EPA for the protection of the public's health from ambient CO levels have been routinely recorded at each of the four permanent monitoring sites currently operated in Anchorage. It is estimated that some 90 percent of all the emissions of this colorless, odorless, and tasteless pollutant in Anchorage are directly attributable to motor vehicle exhaust. The persistence and severity of this problem have aroused and garnered the active concern of the general public, automobile industry and virtually all levels of government, local to federal.

Additional information relative to the magnitude and spatial distribution of this problem was sought to define the relationships between CO levels measured at the permanent sites and concentrations elsewhere throughout Anchorage. Accurate knowledge of this kind is critical in preparing an effective and comprehensive abatement strategy insofar as the interpretation of the ambient record bears heavily on the nature, scope and degree of control required.

The three entities with jurisdictional interest in the issue, the Municipality of Anchorage(MOA), the Alaska Department of Environmental Conservation (ADEC) and the U. S. Environmental Protection Agency (EPA) conceived and conducted a sampling study towards resolving the representativeness of the permanent monitoring network. This report presents the major results and conclusions from that study.

STUDY PURPOSE AND OBJECTIVES

The express purpose of the study was to examine and establish, if possible, the representativeness of each site in Anchorage's permanent CO monitoring network in characterizing the magnitude, spatial, and temporal aspects of the city's CO problem. The immediate utility of the information arising from the study would be twofold. It would assist in establishing a credible technical basis for the derivation of a design value for the city. This is the value to which the ultimate control strategy would be targeted for reduction of ambient CO to levels in compliance with EPA's standard. And it would serve in the selection of the permanent monitoring site(s) against which the effectiveness of the ultimate control strategy would be subsequently indexed.

Explicit objectives were developed to ensure that this purpose was fulfilled within the context of intervening time and resource constraints. Particular emphasis was given to the representativeness of the "7th and C", "Spenard", and "Garden" permanent CO sites in recognition of their relative importance in completing study aims. Another primary study objective was to provide for the retrieval of data possessing both high and demonstrable quality and statistically adequate quantity through application of a comprehensive and rigorous quality assurance program.

* The National Ambient Air Quality Standard (NAAQS) for CO is "...10 milligrams per cubic meter (9 p.p.m.) - maximum 8-hour concentration not to be exceeded more than once per year." (40 CFR Part 50)

STUDY DESIGN

Prior to the onset of actual sampling, a monitoring plan was developed to integrate and implement the various study objectives. The plan was designed to encompass three largely distinct functional components: siting, sampling and data analyses. These respective functions represented the three basic phases through which the study progressed. What follows is a brief description of each of these phases characterizing the study. It should be noted that a more exhaustive treatment of the siting and sampling functions may be found in two support documents: "Anchorage Carbon Monoxide Monitoring Plan 1982-1983" and the "Quality Assurance Plan for 1982-1983 Anchorage CO Study".

SITING METHODOLOGY

This particular study was unique in that it incorporated intensive and simultaneous sampling from the three spatial scales of representativeness most often emphasized in comprehensive CO monitoring programs: micro- (up to 100 meters), middle- (100 to 500 meters) and neighborhood- (.5 to 4 kilometers) spatial scales. Concurrent monitoring in each of these spatial scales provided a profile of CO impacts experienced in the urban core, along major traffic facilities, and residential neighborhoods.

Two terms are used here to discuss the concept of representativeness:

1) "Homogenous representativeness" is used in reference to the airmass over which the concentration of a pollutant is considered uniform.

2) "Analagous representativeness " is used in reference to two or more non-adjoining areas of homogenous representativeness sharing essentially identical pollutant concentration characteristics

There were two principal methods employed in designing the bulk of the study network located in Figure 1. The hot-spot approach, applied primarily to the design of the central business district (CBD) portion of the network and depicted in Figure 2 and Table 1, focused on the issue of analogous representativeness, while the grid technique used to configure the "Garden" (Figure 4 and Table 3) and "Sand Lake" (Figure 5 and Table 4) portions of the network emphasized homogenous representativeness. The "Corridor" network portrayed in Figure 3 and Table 2 was designed using both techniques.

Corollary, but largely subordinate study interests also intervened in the design exercise, and will be identified and discussed throughout the narrative that follows.

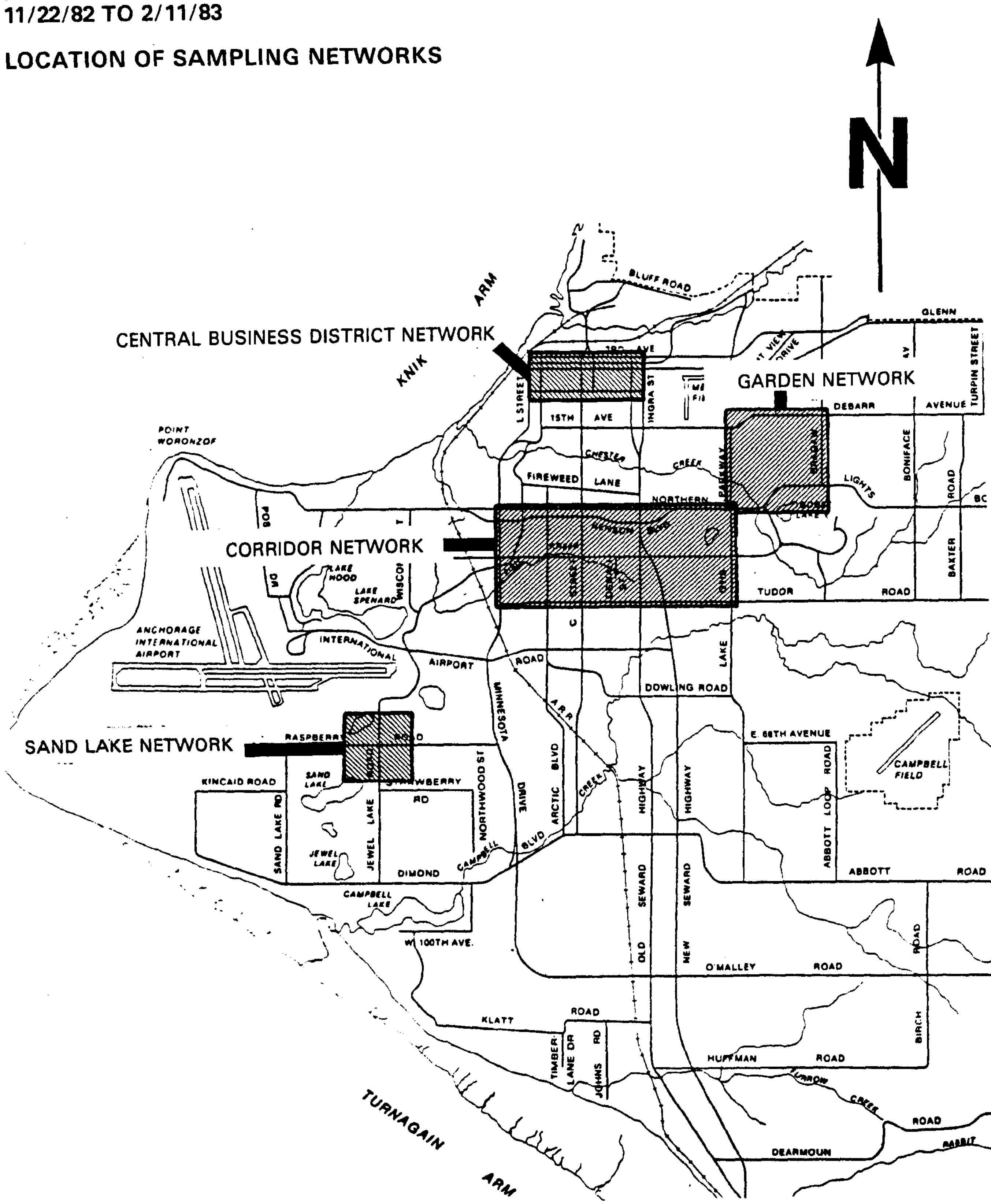
Hot-Spot Screening Technique

Generally, attempts to model absolute concentrations of CO over areas of small dimensions (up to 100 meters) and high emission density have met with little consistent success. Therefore, as in previous Region 10 CO studies, the screening model found in EPA's Carbon Monoxide Hot-Spot Guidelines (EPA 450/3-78-035) was used to identify sites of potentially high, NAAQS threatening CO concentrations and to subsequently configure an effective microscale sampling network for measuring maximum CO concentrations.

FIGURE 1

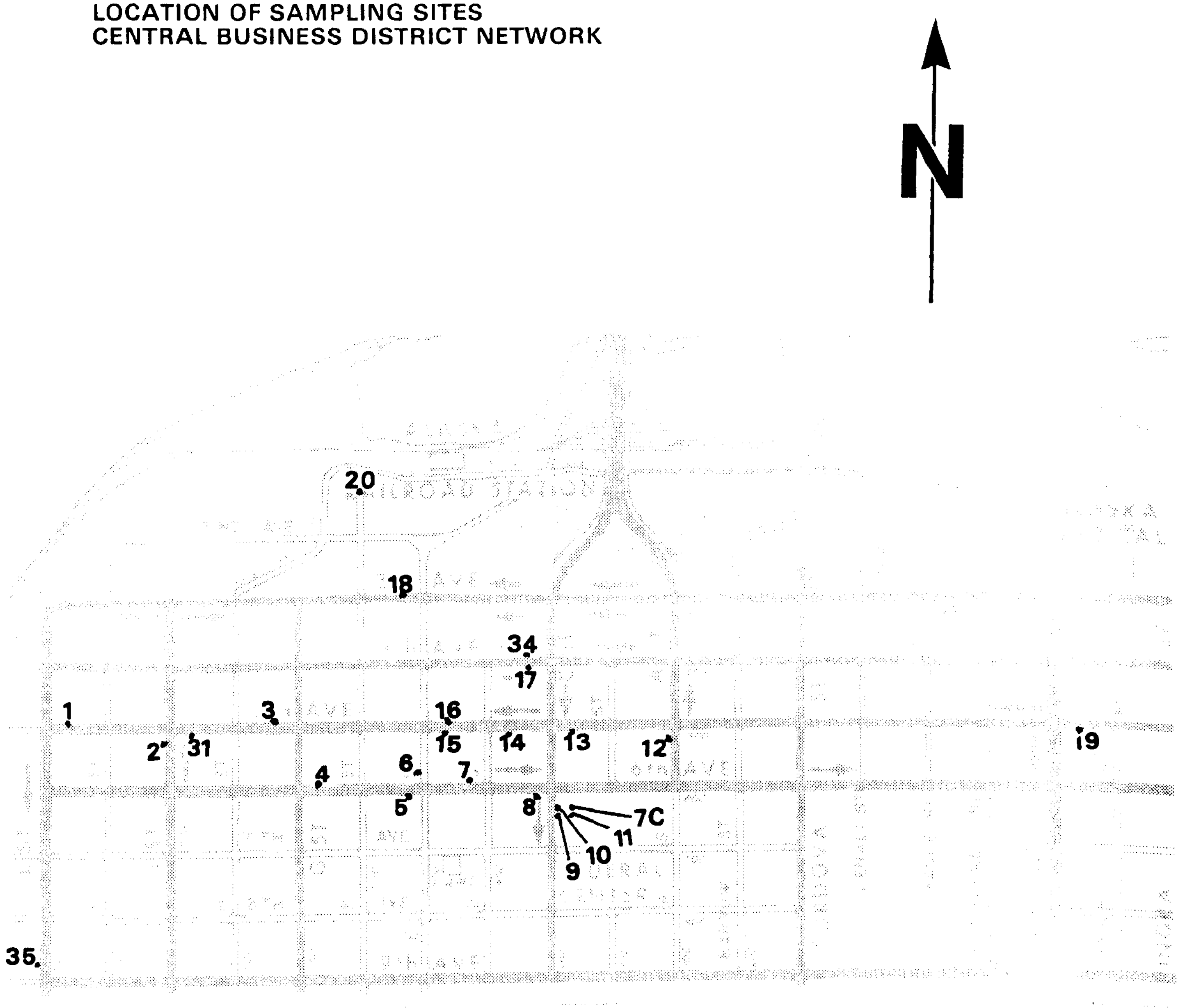
ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

LOCATION OF SAMPLING NETWORKS



ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

LOCATION OF SAMPLING SITES
CENTRAL BUSINESS DISTRICT NETWORK



PERMANENT SITE

7TH & C–7C

Table 1

Anchorage CO Study
November 22, 1982 - February 11, 1983

Site Identification
Central Business District Network

Site	Group*	Adjacent Street	Cross Street	Side of St	Type of Sampler	Spatial Scale
1	1	5th Ave	E/O L	N	Integrated	Micro
2	2	I St	S/O 5th Ave	W	"	"
3	2	5th Ave	W/O G St	S	"	"
4	2	6th Ave	E/O G St	N	"	"
5	1	6th Ave	W/O E St	S	"	"
6	1	E St	N/O 6th Ave	W	"	"
7	1	6th Ave	W/O D St	N	"	"
8	1	6th Ave	W/O C St	S	"	"
9**	1	C St	S/O 6th Ave	E	"	"
10**	N/A	C St	S/O 6th Ave	E	"	"
11***	1	C St	S/O 6th Ave	E	"	Middle
12	1	A St	S/O 5th Ave	W	"	Micro
13	1	5th Ave	E/O C St	S	"	"
14	2	5th Ave	E/O D St	S	"	"
15	1	5th Ave	E/O E St	S	"	"
16	2	5th Ave	E/O E St	N	"	"
17	2	4th Ave	W/O C St	S	"	"
18	1	3rd Ave	W/O E St	S	"	"
19	1	5th Ave	E/O Gambell St	S	"	"
20	1	F St	N/O 2nd Ave	E	"	Neighborhood
31	2	5th Ave	E/O I St	S	"	Micro
34	2	4th Ave	W/O C St	N	"	"
35	2	L St	N/O 9th St	W	"	"
Permanent Site						
7th & C	N/A	C St	S/O 6th Ave	E	Continuous	Middle

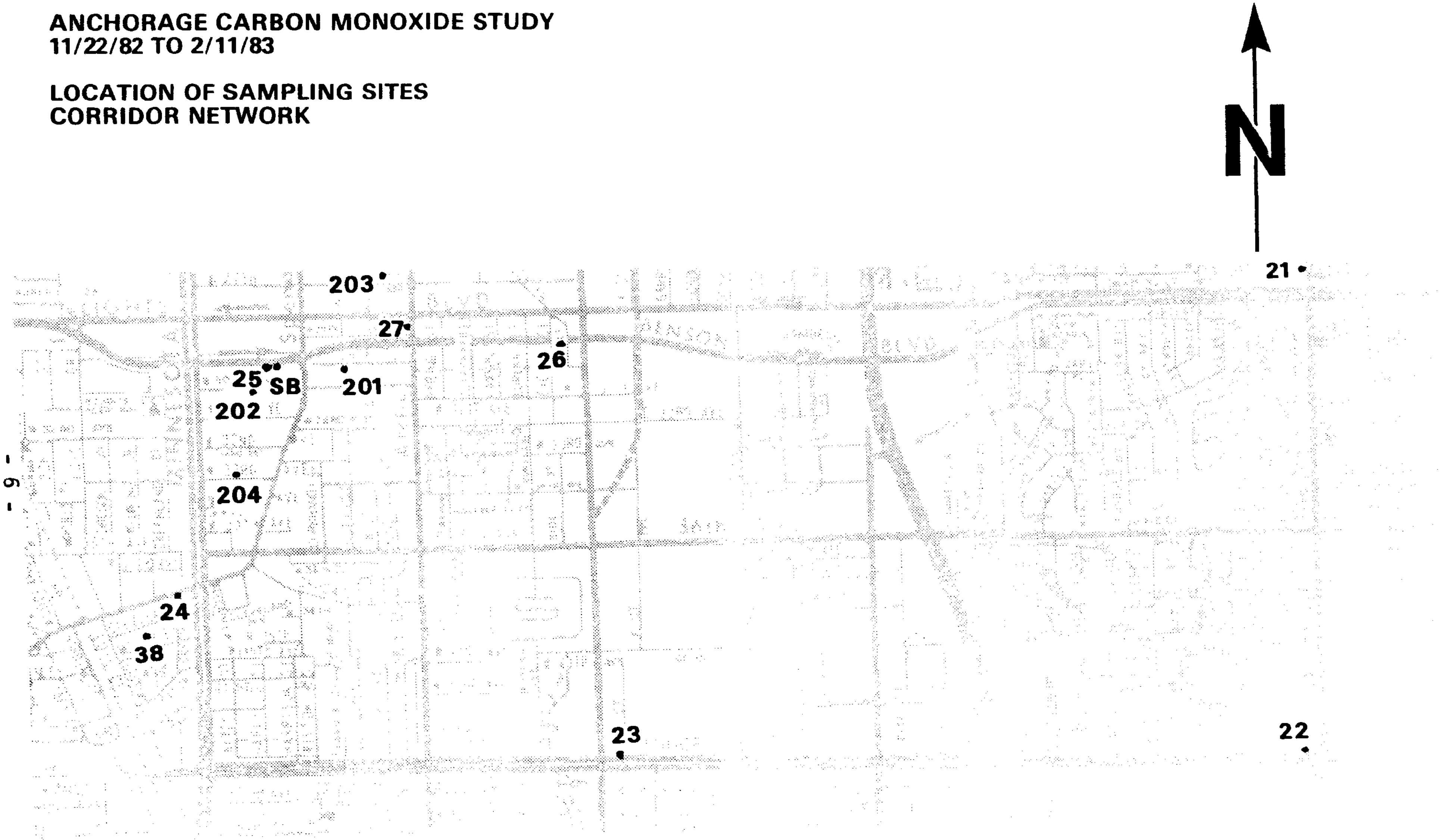
* - Group 1 sites were sampled a nominal 54 days.
Group 2 sites were sampled a nominal 30 days.

** - Collocated

*** - Collocated with permanent site

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

LOCATION OF SAMPLING SITES
CORRIDOR NETWORK



PERMANENT SITE

SPENARD & BENSON – SB

FIGURE 3

Table 2

Anchorage CO Study
November 22, 1982 - February 11, 1983

Site Identification
Corridor Network

Site	Group*	Adjacent Street	Cross Street	Side of Street	Type of Sampler	Spatial Scale
21	1	Seward	N/O Northern Lights	W	Integrated	Micro
22	2	Tudor	W/O Lake Otis	N	"	"
23	2	Tudor	E/O C St	N	"	"
24	1	Spenard	W/O Minnesota	S	"	"
25**	1	Benson	W/O Spenard	S	"	"
26	1	Benson	W/O C St	S	"	"
27	1	Arctic	S/O Northern Lights	W	"	"
201	N/A	Address:	1101 30th Ave	N/A	Sequential	Mid/Neigh
202	N/A	Address:	3002 Spenard Road	N/A	"	"
203	N/A	Address:	900 W 25th	N/A	"	"
204	N/A	Address:	1411 W 33rd	N/A	"	"
38	N/A	Address:	1807 Mckinley	N/A	"	"
Permanent Site						
Spenard/Benson		Benson	W/O Spenard	S	Continuous	Micro

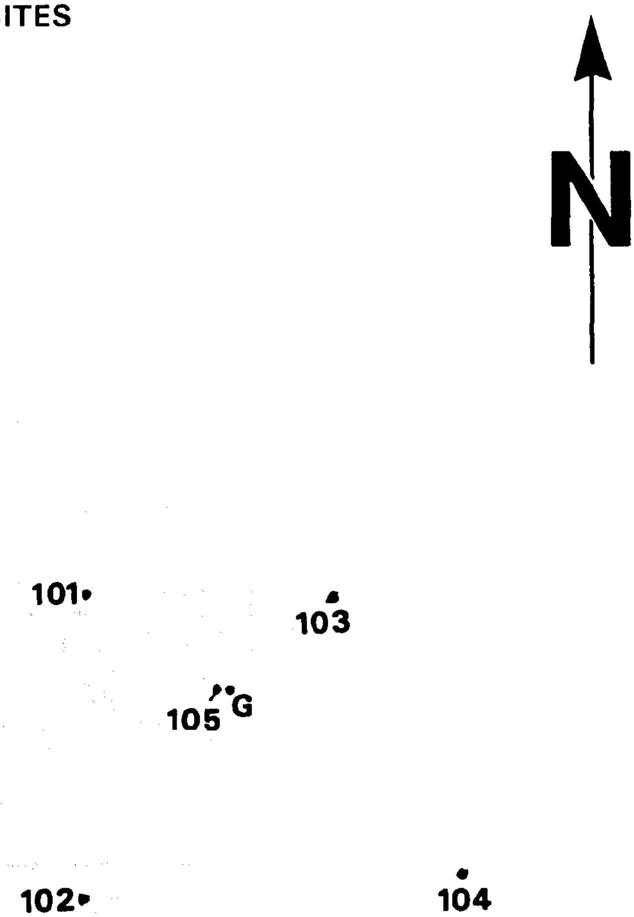
* - Group 1 sites were sampled a nominal 54 days.
Group 2 sites were sampled a nominal 30 days.

** - Collocated with permanent site

FIGURE 4

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

LOCATION OF SAMPLING SITES
GARDEN NETWORK



PERMANENT SITE

GARDEN—G

Table 3

Anchorage CO Study
November 22, 1982 - February 11, 1983

Site Identification
Garden Network

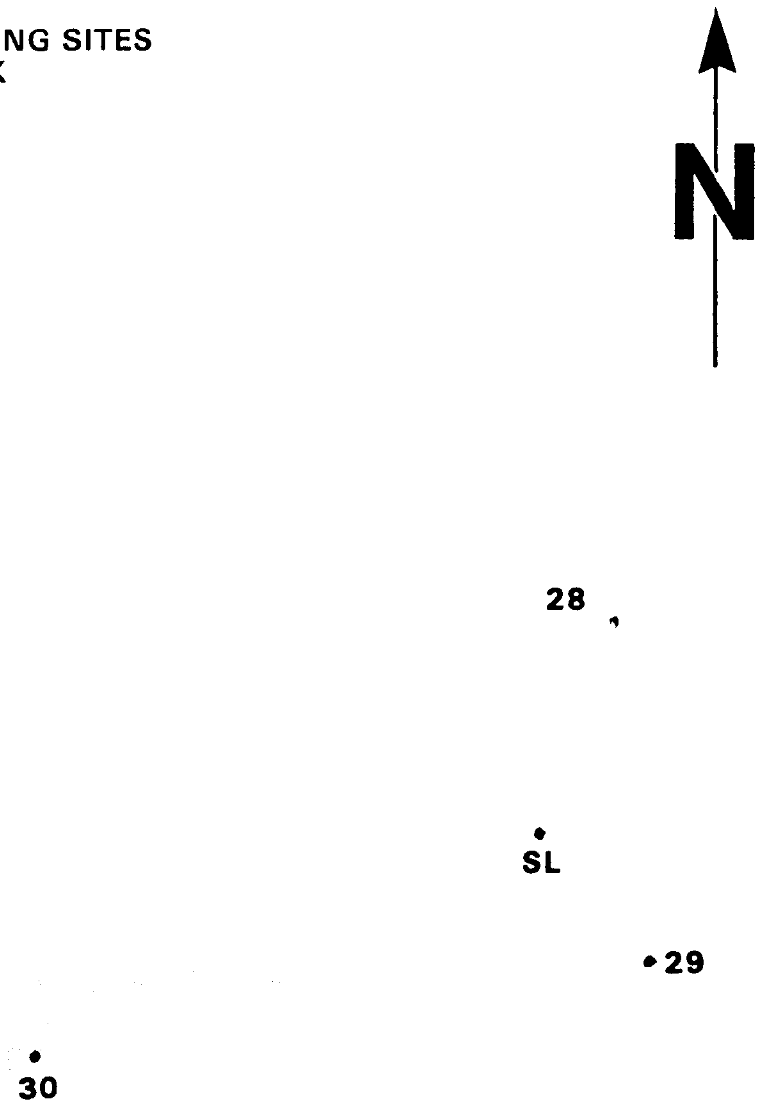
Site	Adjacent Street	Cross Street	Side of Street	Type of Sampler	Spatial Scale
101	E 15th St	W/O Alder	N/A	Sequential	Neighborhood
102	Alder	S/O E 20th St	W	"	"
103	Rosemary	S/O E 15th St	W	"	"
104	E 20th St	W/O Nichols	S	"	"
105*	E 16th	E/O Garden	S	"	"
Permanent Site					
Garden	16th St	E/O Garden	S	Continuous	"

* - Collocated with permanent site

FIGURE 5

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

LOCATION OF SAMPLING SITES
SAND LAKE NETWORK



PERMANENT SITE

SAND LAKE-SL

Table 4

Anchorage CO Study
November 22, 1982 - February 11, 1983

Site Identification
Sand Lake Network

Site	Adjacent Street	Cross Street	Side of Street	Type of Sampler	Spatial Scale
28	W. 64th St	W/O Cranberry St	N	Integrated	Neighborhood
29	Cranberry St	N/O W. 71st St	E	"	"
30	Caravelle Dr	W/O Crawford St	S	"	"
Permanent Site					
SL*	Raspberry Rd	W/O Cranberry St	S	Continuous	Neighborhood

* - Sand Lake

This screening model is predicated on an extensive array of relatively severe underlying assumptions (low ambient temperature and wind speed, "ideal" receptor location, vehicle composition, etc.). When considered collectively, these assumptions compose a conservative or worst-case scenario for the inducement of CO exceedance potential at subject intersections. Model output is simply in terms of whether an intersection exhibits hot-spot potential. The model does not characterize the nature of this potential with respect to either absolute magnitude or projected frequency of standard exceedance.

The number of intersections identified by the model as potential CO hot-spots far exceeded the number of samplers available to the study. Therefore, each intersection identified to possess potential subsequently underwent a second-tier evaluation towards ranking the entire candidate pool with respect to the adjusted strength of potential. Heavily reliant on previous sampling experience, several factors were subjectively weighted relative to their aggregate contribution to CO concentrations at each intersection. Finally, intersections from this ranked listing were considered against the logistical limitations posed by both the sampling methodology and the spatial distribution of candidate sites.

Each of these samplers was sited in conformance with EPA's siting criteria for monitoring maximum concentrations of CO in a micro spatial scale (40 CFR Part 58, Appendix E).

Grid Design Technique

The grid design technique is a relatively straightforward method of establishing both the homogenous and analogous aspects of pollutant concentrations throughout an airmass. This technique is particularly applicable to the design of a sampling network emphasizing the middle- and neighborhood- spatial scales of representativeness of existing permanent monitoring sites.

The technique used here involved designing a grid of samplers at sites both equidistant from the permanent monitor and each other and in basically comparable physical environments. The dimension of the circumscribing radius was arbitrary. The dimension(s) selected for this study coincided as nearly as possible with the increments EPA uses in defining middle- and neighborhood-scales of representativeness: 100 meters to .5 kilometers and .5 kilometers to 4 kilometers respectively (40 CFR 58, Appendix D). Once the general sampling location had been determined, other pertinent factors were considered in the selection of individual prospective sites towards enhancing inter-site comparability.

Each of these samplers was sited to conform to EPA's siting criteria for sampling in a neighborhood spatial scale (40 CFR Part 58, Appendix E). Due to design peculiarities, probe inlet height for the sequential samplers was approximately two (2) meters lower than the lower limit prescribed by the siting criteria. However, since these sites were sufficiently removed from roadways, this slight probe inconsistency is not thought to have affected the data to any discernible extent.

SAMPLING METHODOLOGY

This function was itself composed of several individual elements including: selection of study and sampling intervals, selection of sampling methods, and quality assurance.

Selection of Study and Sampling Intervals

Ambient CO levels are typically cyclic in nature, revolving through several temporal scales simultaneously, from diurnal to seasonal in duration. In order to optimize the probability of sampling the phenomenon of interest, i.e. high CO concentrations and thereby realize the most effective utilization of resources, a pre-study analysis was performed to determine the seasonal and daily intervals most frequently characterized by maximum CO potential. This was accomplished through a historical review of the data reported from each of the four permanent CO sites in Anchorage during the four previous winter seasons. The results of the review are summarized in Table 5.

TABLE 5 Results of Pre-Study Data Analyses

Permanent CO Site	Months of Greatest Exceedance Frequency (Decreasing Order)	5 Consecutive Days of Greatest Exceedance Frequency	Daily 8-hour or 16-Hour Interval* of Greatest Exceedance Frequency
7th and C	Dec, Jan, Nov, Feb	Monday-Friday	11:00 a.m. - 7:00 p.m.
Spenard and Benson	Dec, Jan, Nov, Feb	Monday-Friday	11:00 a.m. - 7:00 p.m.
Garden	Dec, Jan, Nov, Feb	Monday-Friday	9:00 a.m. - 1:00 a.m.
Sand Lake	Dec, Jan, Nov, Feb	Monday-Friday	N/A

* - Duration of subject interval corresponds to type of sampler used in conjunction with permanent site.

In retrospect, all sampling intervals selected for these sub-networks were largely validated by subsequent sampling data.

Selection of Sampling Methods

Sampling methods were selected which retrieved the types of information that most effectively responded to the study objectives. This, while satisfying a mix of other selection criteria including: direct and indirect resource consumption per data unit, physical and performance specifications, etc.

Two basic types of samplers were employed to collect ambient CO samples: single bag samplers and multiple, consecutive sequencing bag samplers, hereinafter referred to as integrated and sequential samplers respectively. Both samplers operate on the integrated principal where an ambient sample is pumped at a constant rate over the time interval of interest. All bag samples were analyzed via the NDIR (non-dispersive infra-red) method* to yield the "average" ambient CO concentration over the subject interval.

* - EPA-designated reference method: Beckman Model 866 CO Analyzer

The integrated samplers, deployed extensively in the CBD and Corridor portions of the study network, were used to collect two consecutive four-hour "average" samples each study day. The resultant concentrations were then averaged to construct an eight-hour average concentration of CO for comparison against the eight-hour NAAQS. Three of these samplers were modified to collect a single eight-hour bag sample and deployed in the grid about the Sand Lake permanent monitor.

The sequential samplers were located throughout the study network, but primarily in the Spenard and Garden grid networks where a discrete hourly profile was desired for comparison with the focal permanent site and other sites in the grid. These samplers collected 16 consecutive samples allowing for the construction of up to as many as eight overlapping 8-hour intervals each study day for comparison against each other and the standard.

Traffic and meteorological data were also collected over the term of the study. While these data are of particularly critical significance to future analyses of the data, they will not be included in this report.

Quality Assurance

A comprehensive and rigorous quality assurance (QA) program was developed, documented, and implemented to ensure that study data were of known and appropriate quality, completeness, comparability, and representativeness. This program provided for routine measures of accuracy and precision for sampling, analytical, and data reduction functions.

The quality of all meteorological and traffic count data are largely unknown due to the lack of direct control of the data generation operation. The quality is believed to be sufficient for the ultimate intended purpose of the data.

DATA ANALYSES

Several methods exist by which to analyze and compare data from the study sites and the permanent monitors. Two basic approaches are presented in this report to examine the representativeness of the permanent sites. The first approach compares data on a day-to-day basis. Because the study sites were sampled for a single eight- or sixteen-hour period each day, data from the permanent monitors for the identical interval were chosen for purposes of temporal congruity.

The second approach compares data from the entire study interval, regardless of whether the compared data occurred on the same day. This method of analysis lends itself to examining larger patterns and frequencies of CO levels throughout the term of the study while smoothing the daily inter-site variability which can occur especially as a result of meteorological impacts.

The results of the analyses presented here reflect the most significant results and conclusions stemming from a more extensive treatment. Because of time constraints, this expanded treatment of study data will not be compiled into a single report document until some later date.

LIMITATIONS

Even well-designed studies of this nature are subject to uncertainties of which both researcher and reader alike should be cognizant. These qualifications do not necessarily impair the validity of the study results, but rather frames their present and future application and interpretation within the context of appropriate caution. The following uncertainties have been identified with this study:

1) The study spanned only a single CO "season". There is a possibility, albeit remote, that the variety of conditions influencing CO levels (traffic, economic, construction, meteorological, etc.) combined to create a situation grossly anomalous with respect to both previous and succeeding seasons.

Comment: In a general sense, this situation is not thought to have occurred here. Cursory inspection of the two factors to which CO levels are particularly sensitive, traffic volumes and certain meteorological parameters, indicate basic conformity to conditions characterizing previous seasons. However, future construction activities and traffic revisions may impair the long-term utility of site-specific study data by the degree of their cumulative effect on CO levels.

2) Study sampling data was collected daily for discrete eight- or sixteen-hour periods. Just as inter-site relationships may exhibit some degree of daily variability when data are compared for concurrent periods, these relationships may also vary during periods within a day for which comparable study data are largely lacking.

Comment: The pre-study analyses conducted to determine optimum sampling intervals were validated by data actually collected during the study. While these intervals, particularly the eight-hour, may not have wholly accounted for any or all of this potential temporal variability, the study data strongly reflect the intervals most frequently exhibiting the daily maximum concentrations as measured by the focal permanent sites. The glaring exception to this is found at the Sand Lake network which enjoyed a more limited study treatment and where the pre-study analysis was largely ignored for logistical reasons.

3) As referenced previously, the number of intersections identified as possessing CO potential in the pre-study siting exercise far outstripped the number of available samplers. Because of resource and logistical considerations, many of the intersections rated at higher potential were passed over for lower rated ones.

Comment: When reviewing the study results, the reader should note that data for that portion of the network sited to retrieve maximum concentrations in no way reflects all areas in Anchorage thought to possess CO potential. Additionally, the reader should be cautioned not to interpret the proportion of relatively higher impact sites to lower impact sites in the data displays as necessarily characteristic of the severity of CO levels occurring throughout the study area.

4) There were some uncertainties associated with the siting of individual microscale samplers for measuring maximum concentrations. Because CO can be a highly localized phenomemon, especially when considered over micro spatial scales, there is a relatively low theoretical probability of selecting the particular leg and then the particular side of the leg of an intersection at which the maximum concentration most frequently occurs.

Comment: It is possible there are other locations at or near subject intersections that experience consistently higher CO levels than those measured at the study site. Previous experience in evaluating site specific features enhances the probability of proper selection. However, this too is often counterbalanced by difficulties in siting opportunity and/or logistics. On balance then, the data presented herein should not be interpreted to necessarily represent the maximum CO concentrations occurring at any particular intersection. Therefore, caution should be exercised when drawing inter-site and NAAQS comparisons.

5) The study data were generated by ambient air quality sampling methods which are not approved by EPA for use as the primary basis for either NAAQS attainment/nonattainment determinations or the definitive demonstration of control strategy effectiveness.

Comment: There are uncertainties associated with virtually all methods employed to monitor ambient pollutants, EPA-approved or not. While the methods chosen for this study are subject to relatively greater variability in precision and accuracy than the EPA-approved methods located at the permanent sites in Anchorage, special measures were taken towards defining and minimizing it. As discussed later, these measures were really quite successful in yielding a data base of roughly comparable quality to that generated by the permanent network.

6) Gaps in the data record for each study site can impair inter-site comparisons in that data from certain sites may not reflect phenomena of interest which were measured successfully at other sites.

Comment: This is a real problem which we hoped to minimize by sampling over a long interval. What is particularly troublesome in relatively short-term studies of this kind is that the inter-site relationships that are generally well-described by regression analysis for instance may not be so well defined for some relatively isolated but nevertheless important features of interest, such as maximum concentrations. Because of this, gaps in the data record can be critical. Unfortunately, the occurrence of at least some gaps are unavoidable (refer to Table 13 for data capture rates for each site). Every effort was made to minimize the number of these gaps while preserving the fundamental integrity of the data base. Additionally, analysis involving direct comparisons between sites were performed, where possible, using data bases reflecting only concurrently sampled data.

CONCLUSIONS

The major conclusions relative to the primary study purpose are as follows:

1) Carbon monoxide levels at a number of sites throughout the study area exceeded the standard with greater frequency and were of consistently higher magnitude than the sites in the permanent monitoring network for the period of study. The general consensus among the study principals (MOA, ADEC,and EPA) is that this situation is duplicated within a range at an array of other locations throughout the Municipality.

2) When considered in aggregate, the permanent monitoring network frequently exhibited sub-exceedance values when one or more study sites elsewhere in the study area reported standards exceedances.

3) The most severe CO impacts in terms of both magnitude and frequency, were exhibited by microscale sites on larger traffic facilities or corridors.

4) There was typically wide variability in the CO levels between some locations throughout the study area for corresponding intervals. On a number of occasions when one or more microscale study sites measured concentrations exceeding the standard, sub-exceedance values were being measured at other microscale and neighborhood sites.

5) While only certain combinations of study sites from the microscale network were well-correlated when considered on a date-paired (simultaneous) basis, all of these sites, including those collocated with the permanent sites were extremely well-correlated with each other on a rank-paired (season-long) basis.

6) The 7th & C permanent site was relatively representative of the lower level microscale sites and may be at or below levels measured at the neighborhood sites.

7) While the Spenard & Benson permanent site was often representative of study sites reporting CO levels in the mid to upper range (but not the highest range) on a study-long basis, it was not very successful in characterizing levels at other individual study sites on a daily basis. This site is also properly designated as a microscale site, although it may have definite utility in characterizing levels in adjoining (homogenous representativeness) and nearby but non-adjoining (analogous representativeness) neighborhoods with an appropriate correction factor.

8) The Garden permanent site was not unduly influenced by a single and/or immediate CO source, and generally characterized CO levels throughout the adjoining Garden neighborhood grid (homogenous representativeness). It may experience CO levels somewhat elevated over other areas in the Garden grid by virtue of its central location in the emission grid.

9) The Sand Lake permanent site generally characterized CO levels in both the adjoining (homogenous representativeness) and nearby but non-adjoining (analogous representativeness) neighborhoods.

RESULTS AND DISCUSSION

Samples collected during virtually identical periods over a large array of sites affords a characterization of CO distribution over a relatively wide area. Data were analyzed for (1) the relative magnitude of CO concentrations reported at various sites throughout Anchorage and (2) any suggested patterns of ambient levels. Direct comparisons were made with data arising from the permanent monitors. Comparisons were also made in the form of ratios and regression/correlation analyses. Since at most study sites either two 4-hour or 16 hourly samples were collected daily, some measure of temporal variability was also subject to comparative evaluation.

Summary statistics are primarily depicted in the form of tables and box-plots or box-plot/base map combinations which enable a visualization of the spatial and temporal distribution of values for the statistics of interest. The box-plots portray the distribution of subject data as follows: maximum value, 9th decile, 3rd quartile, mean, median (2nd quartile), 1st quartile, 1st decile, minimum value. The treatment of eight-hour average data also includes the number of instances when the standard was exceeded and, when individual sites are considered, the second highest value to which the standard is indexed.

The tables and box-plots do not depict data from all sites at which sampling was conducted. Sites which were sampled either over a very short term or to fulfill relatively minor study objectives were not included.

Finally, the various major analysis sections may not contain identical slates of parameters that underwent analytical consideration. Parameters were chosen that best reflected the critical emphasis of the study.

MICROSCALE STUDY NETWORK: CBD AND CORRIDOR SITES

This first section discusses the results from that portion of the study network sited primarily to retrieve maximum CO concentrations in a micro spatial scale. The microscale network was composed of two rather distinct sub-networks, one located within the general boundaries of the Anchorage's CBD and the other adjacent to outlying (the CBD) traffic corridors. While virtually all of these microscale sites were identical with respect to physical probe siting characteristics (i.e. distance to: nearest traffic lane, nearest intersection, obstructions, ground, etc.), there are several basic features that distinguish the CBD network from the Corridor network: 1) The CBD generally has a higher density of streets with 'significant' traffic volumes, 2) Several CBD sites were located on streets bordered on one or both sides by one-story or higher buildings whereas all of the Corridor sites were located in relatively open, well-ventilated areas, and 3) Streets adjacent to and nearby the Corridor sites typically carried higher traffic volumes than those in the CBD.

As a quality assurance measure of inter-method comparability, study sites 11 and 25 were collocated with the 7th & C and Spenard permanent sites respectively. In an effort to bolster the comparability of data actually undergoing analyses (with respect to variability, completeness, etc.), comparisons of data from study sites to the 7th & C and Spenard & Benson permanent sites were actually referenced to the data record for these integrated sites, hereinafter referred to as site 11/7th&C and site 25/Spenard respectively.

It was recognized from the study's outset that in order to ensure that sampling objectives were effectively and efficiently realized, the study network as originally configured would be subject to periodic revision as a function of ongoing data analysis and resource considerations. Study design prescribed the magnitude and schedule of these network revisions by striking a balance between the statistical integrity (number of cases) and ultimate utility of the study data.

As a result, of the 29 individual study sites evaluated in this exercise, 18 (hereinafter referred to as Group 1 sites) were sampled a nominal 50 days. Group 1 consists of sites 1, 5, 6, 7, 8, 9, 11, 12, 13, 15, 18, 19, 20, 21, 24, 25, 26, and 27. Site 10 was collocated with site 9 and was therefore excused from the exercise. Site 20 was the "background" CBD site and is included here for purposes of contrast and comparison.

The remaining 10 sites (hereinafter referred to as Group 2 sites) were sampled a nominal 30 days. Group 2 consists of sites 2, 3, 4, 14, 16, 17, 22, 23, 34, 31, and 35. Eight sites, 2, 3, 4, 14, 16, 17, 22, and 23 were sampled during roughly the first half of the study. With the exception of site 17, these sites were discontinued because they were redundant with other sites in the study network and were re-sited one or more times in order to fulfill other short-term study objectives. Site 17 was the target of chronic vandalism and was subsequently moved directly across the street at mid-study and re-numbered to 34. Sites 31 and 35 were the only other sites sampled during the second half of the study for which data are considered in this exercise.

Because of the disparate size and contribution of the these two groups, Group 2 data receives minimal treatment in this narrative.

<u>Study-Long Network Statistics</u>

The statistics that follow primarily reflect the characteristics of CO measured at each study site.

Maximum Eight-Hour Averages -

Elevated concentrations of CO were measured not only in the immediate vicinity of the 7th & C and Spenard permanent monitors, but at other sites throughout Anchorage (see Limitations 3 and 4). Figures 6, 7, and 8 and Tables 6 and 7 exhibit the maximum eight-hour averages reported from each site during the study.

Group 1 Sites

(General Discussion)

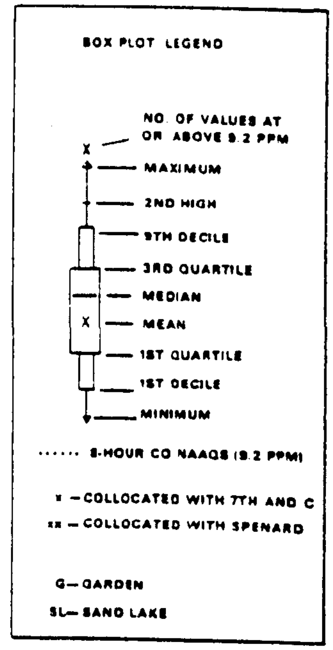
A. Eight-hour maximums for Group 1 sites ranged from 6.2 ppm (site 20) to 27.4 ppm (site 24).

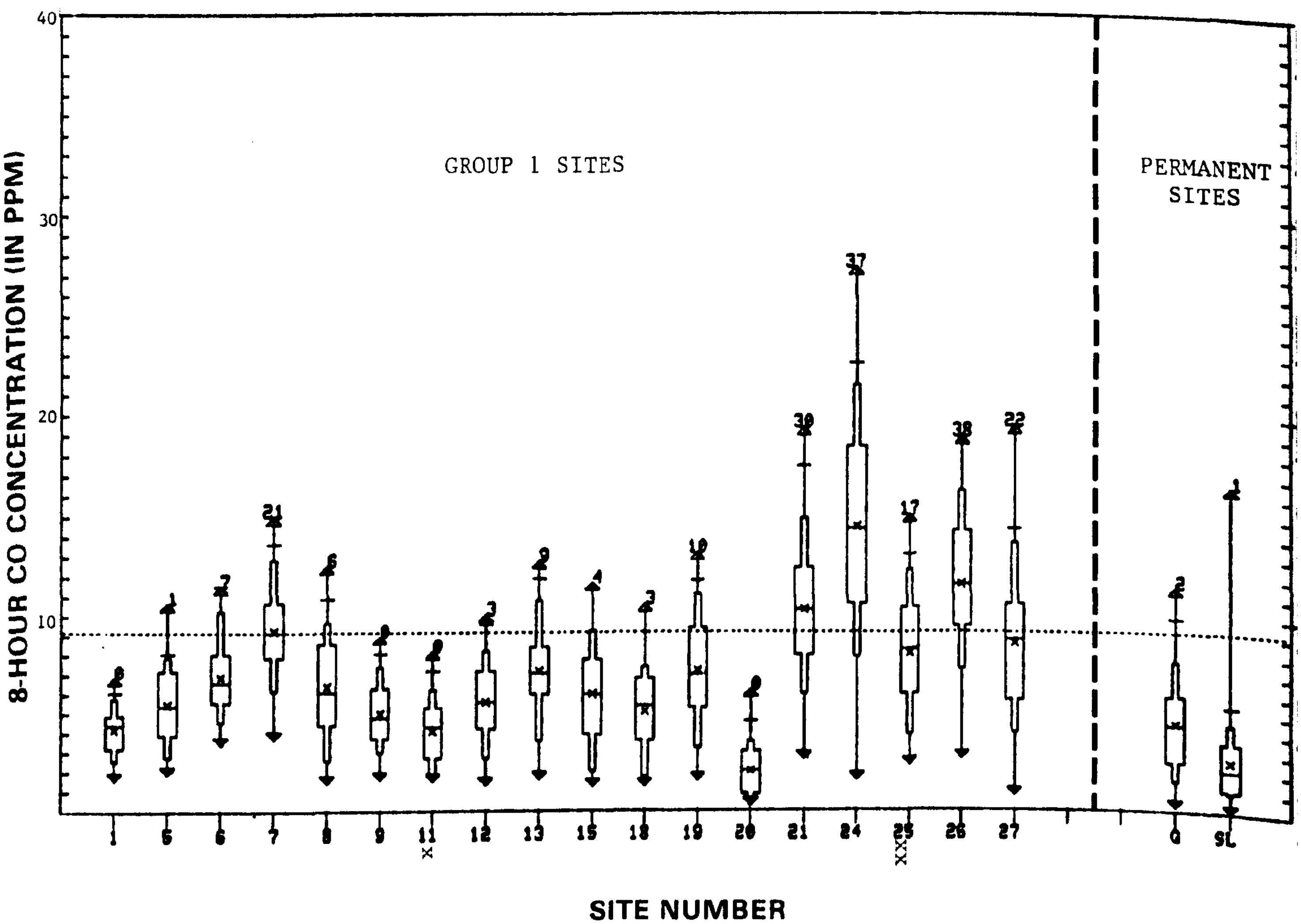
B. Eight-hour maximums for site 11/7th&C and site 25/Spenard were 8.1 ppm and 15.1 ppm respectively.

FIGURE 6

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE AVERAGE CONCENTRATIONS FOR AN 8-HOUR PERIOD (11:00 A.M. to 7:00 P.M.) AT EACH SITE



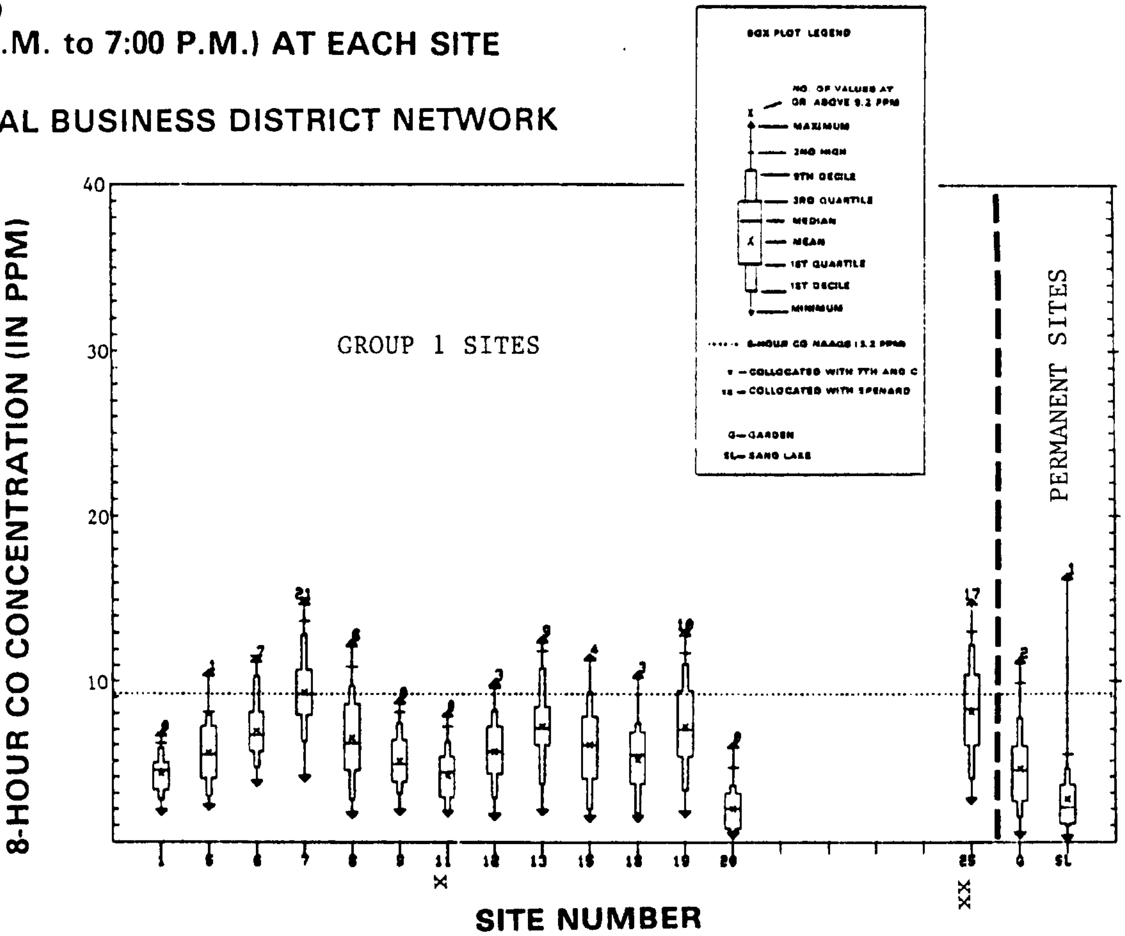


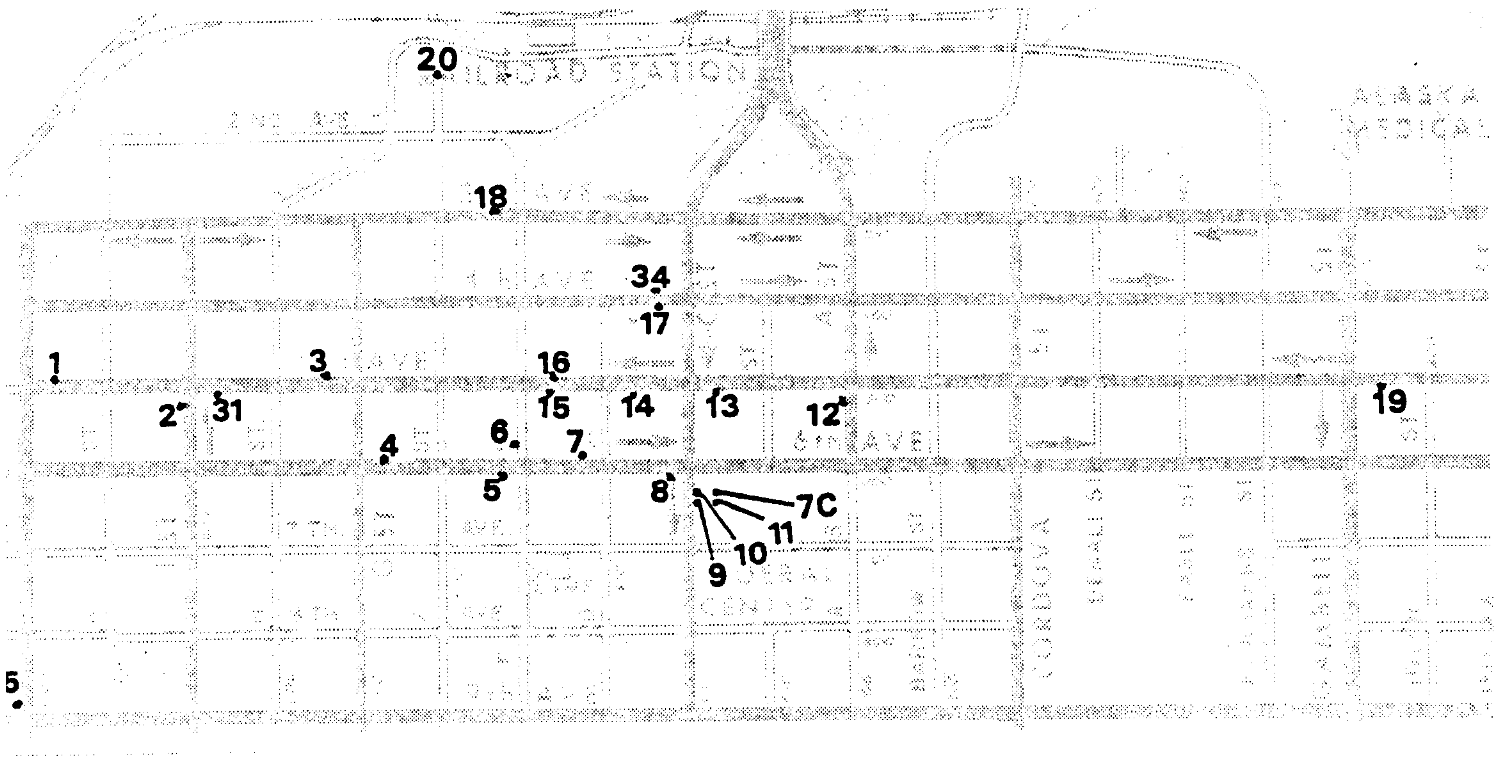
ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

FIGURE 7

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE AVERAGE CONCENTRATIONS FOR AN 8-HOUR PERIOD (11:00 A.M. to 7:00 P.M.) AT EACH SITE

CENTRAL BUSINESS DISTRICT NETWORK





ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE AVERAGE CONCENTRATIONS FOR AN 8-HOUR PERIOD (11:00 A.M. to 7:00 P.M.) AT EACH SITE

CORRIDOR NETWORK

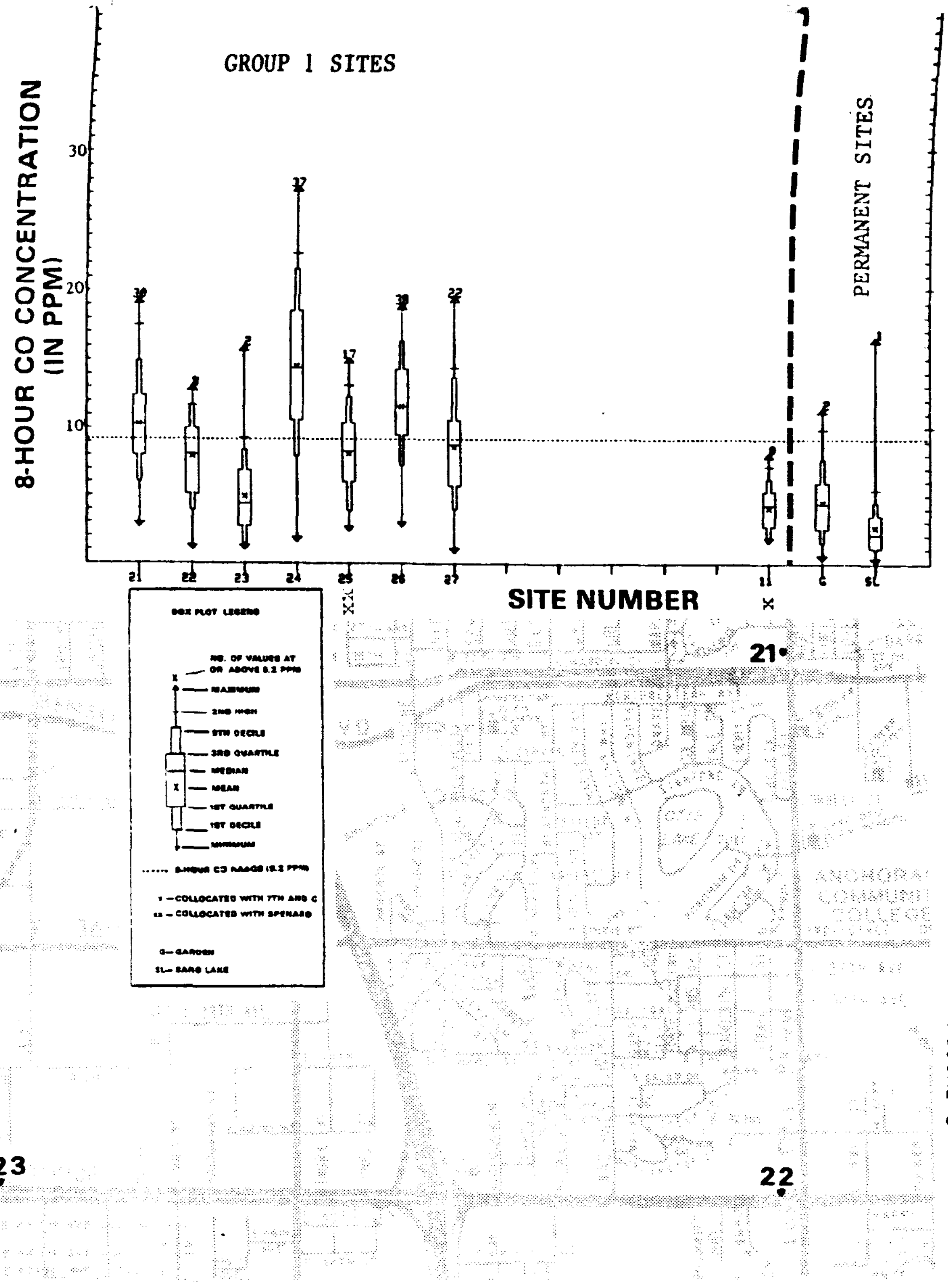


FIGURE 8

(Study/Permanent Site Comparisons)

C. Eight-hour maximums at 15 of the 17 Group 1 sites were 10% to 238% higher than that for site 11/7th&C (9 of which were over 50% higher).

D. Eight-hour maximums at five Group 1 sites were greater than or equal to that for site 25/Spenard (four of which were between 26% and 81% higher).

E. Eight-hour maximums at 11 Group 1 sites were within ± 30% of that at site 25/Spenard.

Table 6 Distribution of Maximum 8-Hour CO Concentration From the Study Sites

Range of Maximum 8-HR CO (In ppm)	Percentage of Group 1 Within Range	Percentage of Group 2 Within Range	Percentage of Group 1 and Group 2 Within Range
0 - 2.9	0%	0%	0%
3.0 - 5.9	0%	0%	0%
6.0 - 8.9	16.7%	45.5%	27.6%
9.0 - 11.9	33.3%	27.3%	31.0%
12.0 - 14.9	16.7%	18.2%	17.2%
15.0 - 17.9	11.1%	9.1%	10.3%
18.0 - 20.9	16.7%	0%	10.3%
20.9 -	5.6%	0%	3.4%

Table 7 Comparison of Maximum 8-Hour CO Concentrations*
From Study Sites and Permanent Sites

Site No. Group 1 Sites	Date of Max 8-HR CO Conc.	Maximum 8-HR CO Conc. (ppm)	Ratio of Study Site to Site 11** (8.1 ppm)	Ratio of Study Site to Site 25*** (15.1 ppm)
1	01/05/82	6.9	0.9	0.5
5	01/05/83	10.7	1.3	0.7
6	02/09/83	11.6	1.4	0.8
7	12/20/82	15.1	1.9	1.0
8	01/05/83	12.6	1.6	0.8
9	01/05/83	9.0	1.1	0.6
11**	12/3/82	8.1	1.0	0.5
12	01/05/83	10.1	1.3	0.7
13	12/20/82	12.8	1.6	0.9
15	12/03/82	11.7	1.4	0.8
18	12/03/82	10.6	1.3	0.7
19	12/20/82	13.2	1.6	0.9
20	01/05/83	6.2	0.8	0.4
21	12/03/82	19.4	2.4	1.3
24	12/03/82	27.4	3.3	1.8
25***	12/20/82	15.1	1.9	1.0
26	12/03/82	19.0	2.4	1.3
27	12/03/82	19.5	2.4	1.3
Group 2 Sites				
2	01/04/83	6.0	0.7	0.4
3	01/05/83	6.4	0.8	0.4
4	12/03/82	7.3	0.9	0.5
14	01/05/83	11.5	1.4	0.8
16	12/03/82	10.1	1.3	0.7
17	12/03/82	12.5	1.5	0.8
22	12/30/82	13.1	1.6	0.9
23	12/03/82	16.0	2.0	1.1
31	01/21/83	7.5	0.9	0.5
34	02/03/83	10.5	1.3	0.7
35	01/14/83	8.2	1.0	0.5

* - Measured during the period 11:00 a.m. to 7:00 p.m. on study sampling days only.

** - Collocated with the 7th & C permanent site

*** - Collocated with the Spenard & Benson permanent site.

Second Highest Eight-Hour Averages -

The eight-hour NAAQS for CO is indexed to the second highest eight-hour average concentration of CO measured at a given site in a calendar year. Similar to maximum averages, the levels of second high CO averages were also elevated throughout the study network. Figures 6, 7, and 8 exhibit the second highest eight-hour average measured at each site during the study.

Group 1 Sites

(General Discussion)

A. Eight-hour second highs for Group 1 sites range from 4.6 ppm (site 20) to 22.5 ppm (site 24).

B. Eight-hour second highs for site 11/7th&C and site 25/Spenard were 7.2 ppm and 14.6 ppm respectively.

(Study/Permanent Site Comparison)

C. Eight-hour second highs for 15 of 17 Group 1 sites were between 13% and 213% higher than that for site 11/7th&C (11 of which were over 50% higher).

D. Eight-hour second highs at 5 Group 1 sites equaled or exceeded that for site 25/Spenard (3 of which were 34% to 70% higher).

E. Eight-hour second highs at 8 Group 1 sites were within ± 30% of that for site 25/Spenard.

Table 8 - Comparison of 2nd Highest 8-Hour CO Concentrations*
From Study Sites and Permanent Sites

Site No. Group 1 Sites	Date of 2nd Hi 8-HR CO Conc.	2nd Hi 8-HR CO Conc. (ppm)	Ratio of Study Site to Site 11** (7.2 ppm)	Ratio of Study Site to Site 25*** (13.1 ppm)
1	12/22/82	6.1	0.85	0.47
5	02/09/83	8.1	1.13	0.62
6	01/18/83	11.6	1.61	0.89
7	12/03/82	13.7	1.90	1.05
8	01/18/83	10.9	1.51	0.83
9	11/29/82	8.1	1.13	0.62
11**	02/01/83	7.2	1.00	0.49
12	12/03/82	9.6	1.33	0.73
13	12/21/82	11.9	1.65	0.91
15	12/13/82	11.4	1.58	0.87
18	01/05/83	10.2	1.42	0.78
19	01/05/83	11.8	1.64	0.90
20	12/03/82	4.6	0.64	0.35
21	12/20/82	17.5	2.43	1.34
24	12/17/82	22.5	3.13	1.72
25***	02/01/83	13.1	1.82	1.00
26	02/01/83	18.6	2.58	1.27
27	12/23/82	14.4	2.00	1.10
Group 2				
2	12/13/82	5.9	0.82	0.45
3	01/04/83	6.0	0.83	0.46
4	12/16/82	6.4	0.89	0.49
14	12/03/82	11.1	1.54	0.85
16	01/04/83	9.7	1.35	0.74
17	12/13/82	9.3	1.29	0.71
22	12/09/82	11.7	1.63	0.89
23	01/05/83	9.3	1.29	0.71
31	01/31/83	6.8	0.94	0.52
34	02/01/83	10.4	1.44	0.79
35	01/18/83	5.7	0.79	0.44

* - Measured during the period 11:00 a.m. to 7:00 p.m. on study sampling days only.

** - Collocated with the 7th & C permanent site

*** - Collocated with the Spenard & Benson permanent site.

Eight-Hour Means and Medians -

Measures of central tendency such as means (arithmetic averages) and medians (the mid-point value of data ranked by magnitude) were examined to evaluate aspects of the chronic nature of concentrations reported at each site. As there is little significant difference between the mean and median for each site, only the mean will be referenced here. For each site, all eight-hour averages reported during the study were averaged to produce the mean eight-hour concentration. Figures 6, 7, and 8 exhibit eight-hour means and medians for each sampling site.

Group 1 Sites

(General Discussion)

A. Means for the Group 1 sites ranged from 2.0 ppm (site 20) to 14.5 ppm (site 24).

B. Means for sites 11/7th&C and 25/Spenard were 4.1 and 8.1 respectively.

(Study/Permanent Site Comparison)

C. Means for 16 Group 1 sites were 2% to 254% greater than that for site 11/7th&C (10 of which were more than 50% higher).

D. Means for 5 Group 1 sites were 6% to 79% greater than that for site 25/Spenard (3 of which were 27% to 79% higher).

E. Means for 4 Group 1 sites were greater than the standard while none of the permanent sites exhibited one.

F. Means for 8 Group 1 sites were within ± 30% of that for site 25/Spenard.

Frequency of Eight-Hour NAAQS Exceedances -

There was wide variability in the number of eight-hour NAAQS exceedances reported from sites in the study network. The statistic chosen for evaluation here is the simple frequency of exceedance values to all values for each site. Figures 6, 7, and 8 exhibit exceedance characteristics.

Group 1 Sites

(General Discussion)

A. The frequency of exceedances for the 14 Group 1 sites exhibiting exceedances ranged from 2% (site 5) to 84% (site 24).

B. The frequency of exceedances for site 11/7th&C and site 25/Spenard were 0% and 37% respectively.

(Study/Permanent Site Comparison)

C. The frequency of exceedances for 5 Group 1 sites were 30% to 111% higher than that for site 25/Spenard (3 of which were 80% to 228% higher).

D. The frequency of exceedances at 12 Group 1 sites were 70% or lower than that for site 25/Spenard (5 of which measured one or no exceedances).

Minimum Eight-Hour Averages -

Minimum values are of interest insofar as they assist in characterizing "background" types of concentrations. Figures 6, 7, and 8 exhibit the minimum eight-hour averages for each site.

Group 1 Sites

(General Discussion)

A. Minimum eight-hour averages for Group 1 sites ranged from 0.2 ppm (site 20) to 3.7 ppm (site 7).

B. Minimum eight-hour averages for site 11/7th&C and site 25/Spenard were 1.5 ppm and 2.3 ppm respectively.

C. Minimum eight-hour averages for 2 Group 1 sites in the CBD (sites 6 & 7) were at least 1.0 to 2.0 ppm higher than than any other Group 1 sites.

Ratios of Study to Permanent Sites

An intuitively appealing way of expressing the relationship between a pair of sites is computing a simple ratio of the sites' values for the same day. The relationship between each of the microscale sites and site 11/7th&C and site 25/Spenard are exhibited in Figures 9 and 10 respectively.

Group 1 Sites

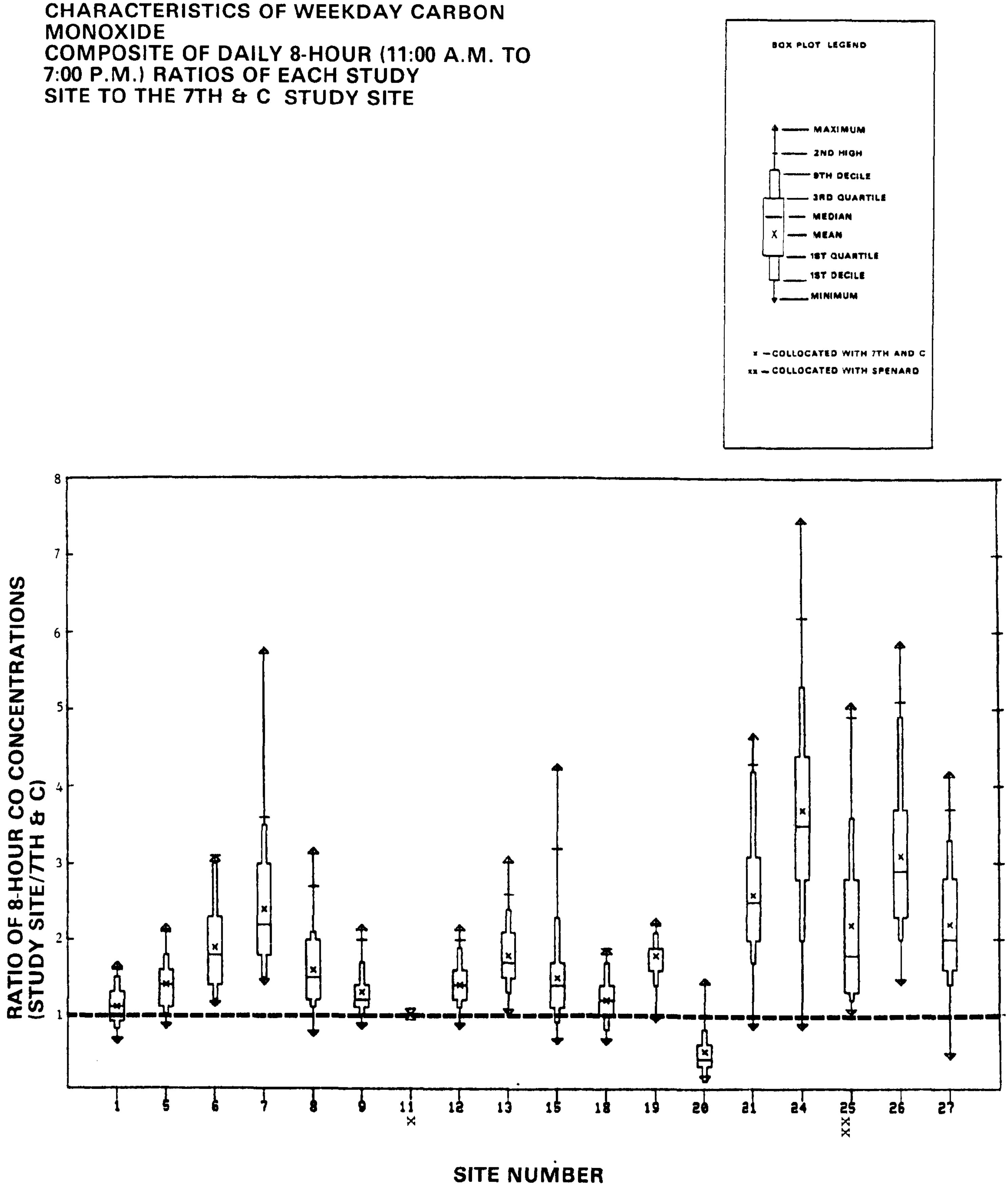
A. All but one Group 1 sites (site 20, the CBD "background" site) had a mean ratio with site 11/7th&C greater than 1.0.

B. Seven of the 18 Group 1 sites had mean ratios with site 25/Spenard greater than or equal to 1.0.

FIGURE 9

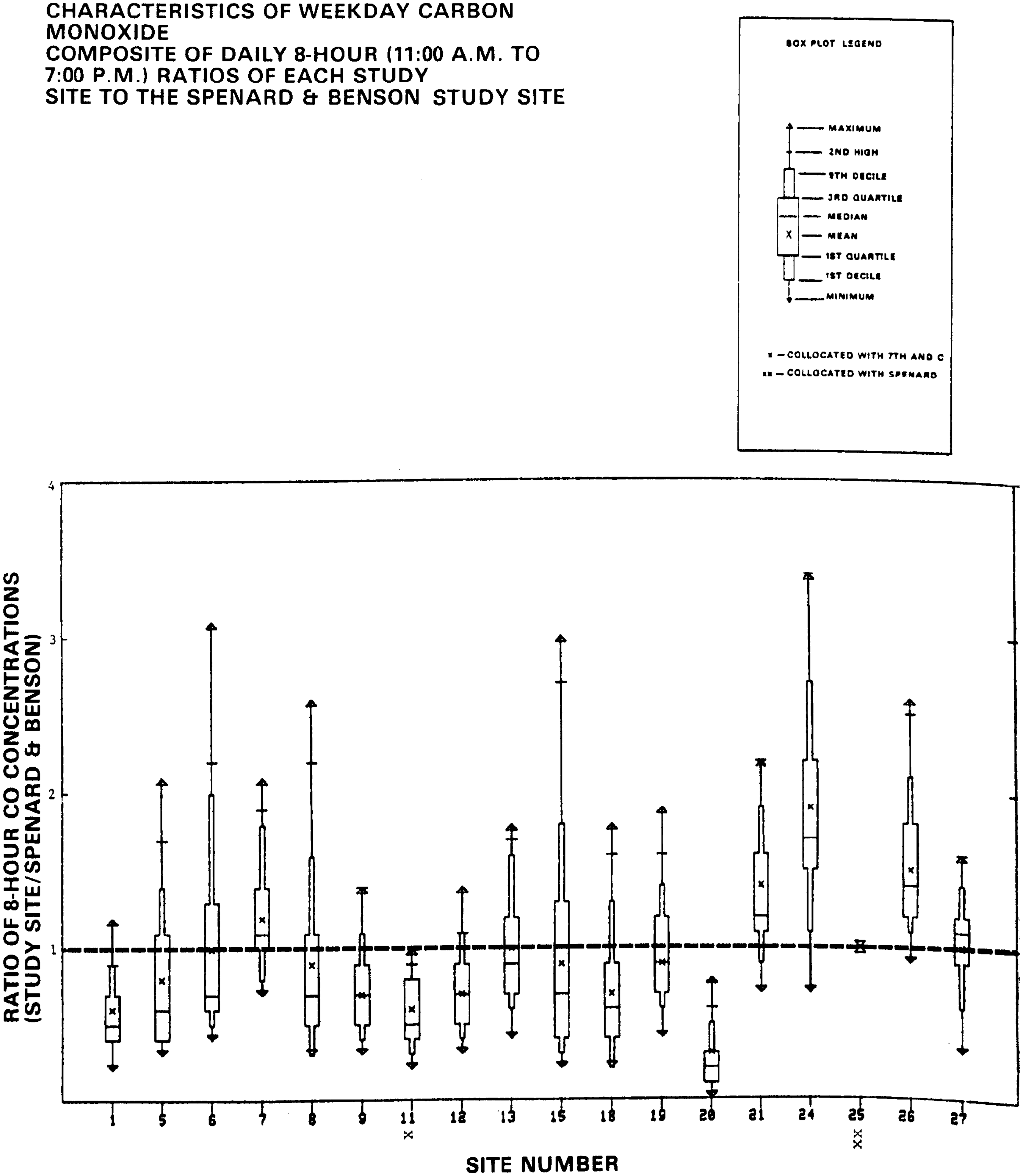
ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
COMPOSITE OF DAILY 8-HOUR (11:00 A.M. TO 7:00 P.M.) RATIOS OF EACH STUDY SITE TO THE 7TH & C STUDY SITE



ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
COMPOSITE OF DAILY 8-HOUR (11:00 A.M. TO 7:00 P.M.) RATIOS OF EACH STUDY SITE TO THE SPENARD & BENSON STUDY SITE



Daily Network Characteristics

Another facet of the data analysis examined the day-to-day characteristics of the study data. This kind of analysis not only provides a profile of "simultaneous" impacts throughout the study area, but facilitates examining patterns of CO concentrations measured at the permanent sites and elsewhere in the study area. Figures 11 and 12 exhibit the daily composite of 8-hour concentrations reported from Group 1 study sites.

Daily Maximum Eight-Hour Averages -

The daily maximum value reported from among all sites in the study network illustrate the variable and chronic aspects of inter-site relationships on a day-specific basis. Table 9 exhibits the relationship of the daily study network maximum to corresponding site 11/7th&C and site 25/Spenard daily values.

Group 1 Sites

(General Discussion)

A. Daily maximum eight-hour averages for Group 1 sites ranged from 6.1 ppm (12/27) to 27.4 ppm (12/3), both measured at site 24.

B. The daily maximum eight-hour average was most frequently recorded at sites 24 and 26. Site 24 was the site of the daily maximum on 69% of the sample days (with 5 "ties"*), while site 26 recorded the daily maximum on 24% of the sample days (with 9 "ties").

C. The daily maximum eight-hour average was recorded at only four other Group 1 sites at an individual frequency of less than 7% of all sample days.

D. Site 11/7th&C and site 25/Spenard reported the daily maximum on 0% and 2% ("tied" with 3 other sites) respectively over all sample days.

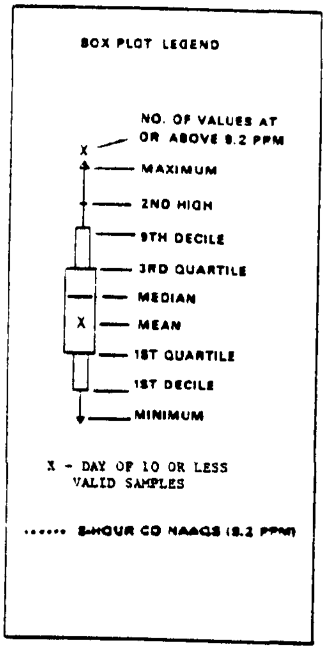
* - Tied values are those within approximately ± 0.5 ppm of each other.

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
COMPOSITE RANGE OF CO CONCENTRATIONS FOR ALL SITES DURING THE 8-HOUR PERIOD (11:00 A.M. TO 7:00 P.M.)

NOVEMBER & DECEMBER 1982

(GROUP 1 SITES ONLY)



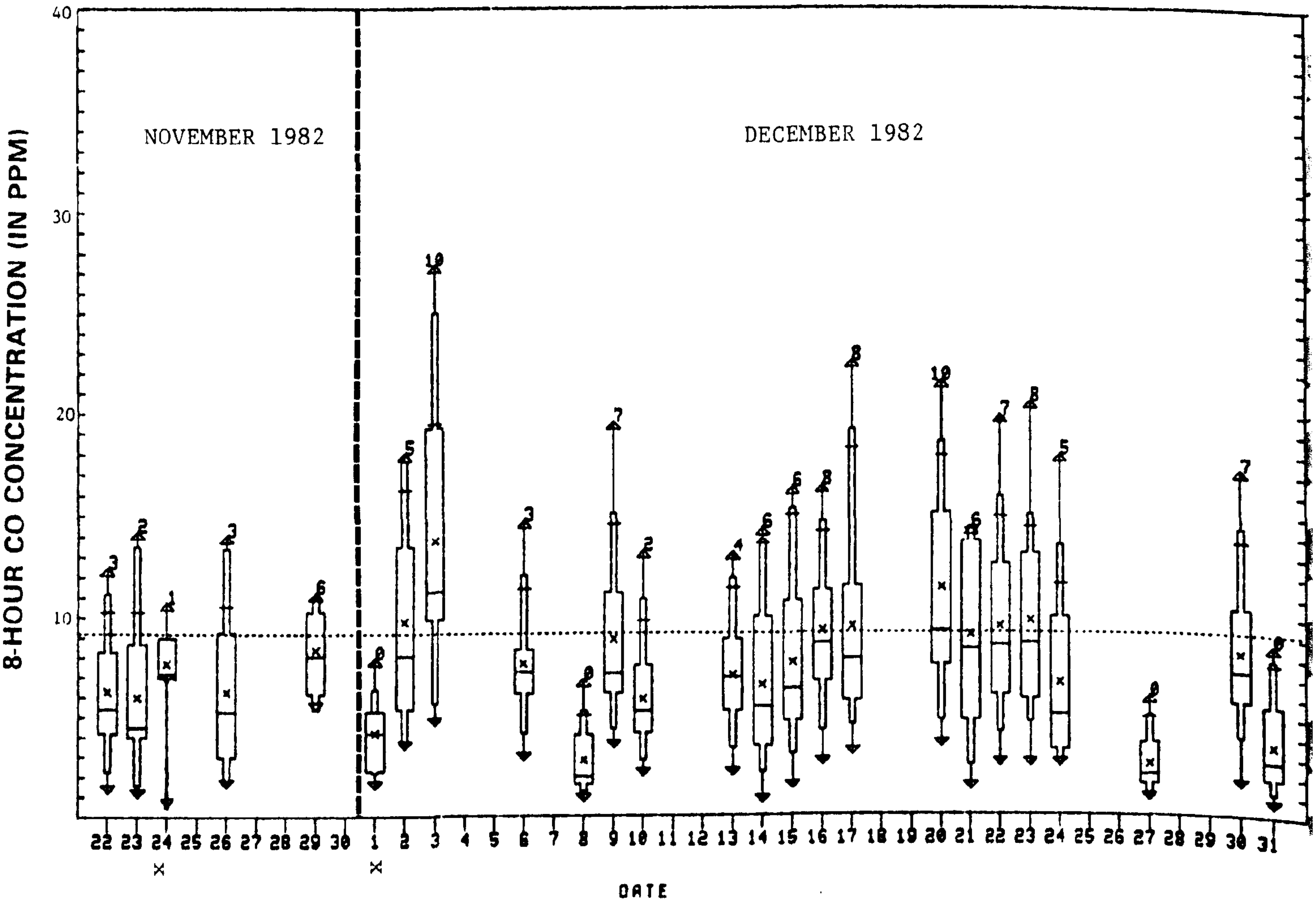


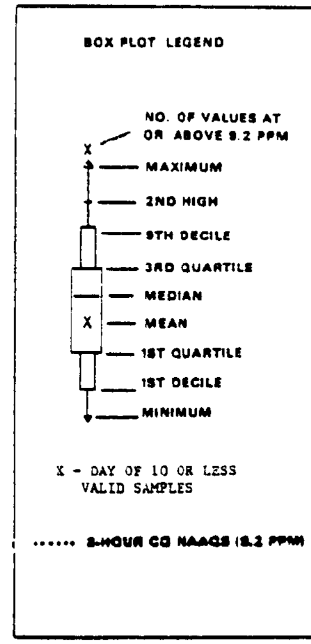
FIGURE 12

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
COMPOSITE RANGE OF CO CONCENTRATIONS FOR ALL SITES DURING THE 8-HOUR PERIOD (11:00 A.M. TO 7:00 P.M.)

JANUARY & FEBRUARY 1983

(GROUP 1 SITES ONLY)



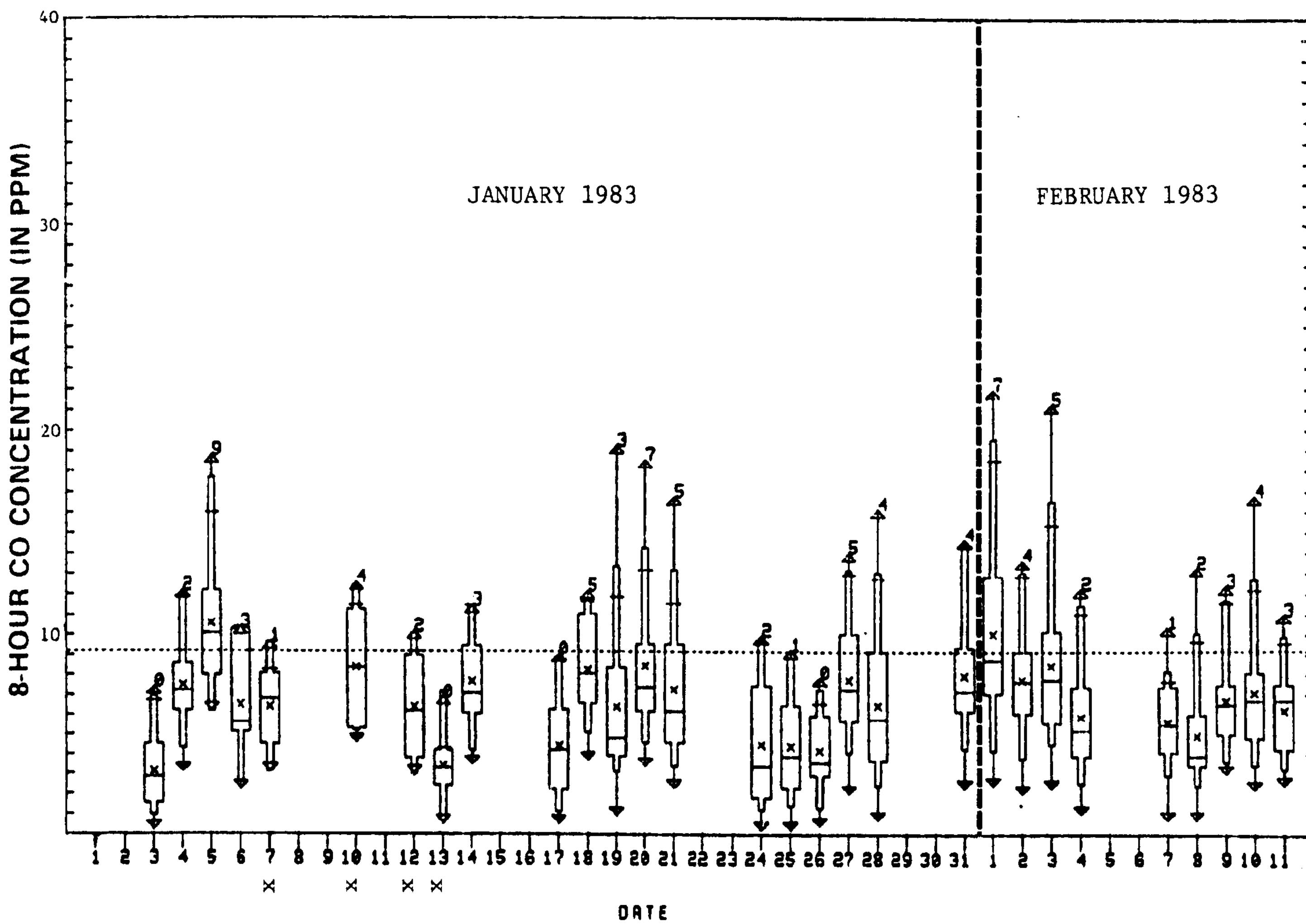


Table 9
Daily Comparison of Study Network Maximum 8-Hour CO Concentration to Permanent Site Values

Site w/ Daily Max(*)	Date	Daily Maximum 8-HR CO Conc. (PPM)	Site 11/7th&C Corresponding 8-HR CO Conc. (PPM)	Ratio of Daily Maximum Site To Site 11/7th & C	Site 25/Spenard Corresponding 8-HR CO Conc. (PPM)	Ratio of Daily Max. Site To Site 25th/Spenard
24	11/22/82	12.5	3.1	4.0	6.6	1.9
24	11/23/82	14.5	-	-	7.8	1.8
7	11/24/82	10.8	-	-	-	-
24	11/26/82	14.1	2.7	5.2	7.5	1.9
24(26)	11/29/82	11.3	5.4	2.1	6.0	1.9
24	12/01/82	8.0	2.3	3.5	3.3	2.4
24	12/02/82	18.1	5.1	3.6	10.5	1.7
24	12/03/82	27.4	8.1	3.4	14.6	1.9
24	12/06/82	14.8	5.3	2.8	6.6	2.2
15	12/08/82	6.8	1.5	4.5	2.3	3.0
24	12/09/82	19.6	5.9	3.3	10.7	1.8
24	12/10/82	13.3	3.2	4.2	8.3	1.6
24	12/13/82	13.2	4.7	2.8	6.0	2.2
24	12/14/82	14.4	-	-	9.7	1.5
24	12/15/82	16.4	3.5	4.7	10.4	1.6
24	12/16/82	16.5	6.2	2.7	8.2	2.0
24	12/17/82	22.5	5.0	4.5	9.9	2.3
24	12/20/82	21.6	6.2	3.5	15.1	1.4
26(27)	12/21/82	14.4	3.9	3.7	12.4	1.2
24	12/22/82	19.9	4.6	4.3	11.8	1.7
24	12/23/82	20.5	5.0	4.1	12.3	1.7
24	12/24/82	18.0	2.4	7.5	10.4	1.7
15	12/27/82	6.1	1.9	3.2	2.3	2.7
24	12/30/82	17.3	6.1	2.8	7.3	2.4
7	12/31/82	8.7	1.5	5.8	7.7	1.1
26	1/03/83	7.4	1.7	4.4	4.9	1.5
26(21)	1/04/83	12.2	5.1	2.4	6.2	2.0
24	1/05/83	18.8	6.2	3.0	-	-
26(7)	1/06/83	10.4	-	-	9.0	1.2
24	1/07/83	9.7	3.3	2.9	5.7	1.7
24	1/10/83	12.6	-	-	11.5	1.1
26	1/12/83	10.2	-	-	8.4	1.2
25(34)	1/13/83	6.9	2.3	3.0	6.9	1.0
21(26)	1/14/83	11.5	-	-	8.3	1.4
21(24)	1/17/83	9.1	2.1	4.3	5.6	1.6
26(21)	1/18/83	12.2	5.4	2.3	6.8	1.8
24	1/19/83	19.3	3.7	5.2	9.9	2.0
24	1/20/83	18.6	5.8	3.2	9.5	2.0
24	1/21/83	16.8	3.9	4.3	10.9	1.5
24(26)	1/24/83	10.0	1.7	5.9	8.3	1.2
26(26)	1/25/83	9.8	1.9	5.2	6.4	1.5
39	1/26/83	9.3	-	-	3.0	3.1
26	1/27/83	14.1	4.8	2.9	13.0	1.1
24	1/28/83	16.2	2.6	6.2	9.6	1.7
24(26,39)	1/31/83	14.7	5.5	2.7	8.9	1.7
24	2/01/83	22.0	7.2	3.1	13.1	1.7
24	2/02/83	13.7	5.2	2.6	6.3	2.2
26	2/03/83	15.4	5.0	3.1	8.9	1.7
24	2/04/83	12.3	4.8	2.6	5.8	2.1
39	2/07/83	14.6	5.0	2.9	6.2	2.4
24	2/08/83	13.3	3.1	4.3	3.9	3.4
24	2/09/83	12.4	3.7	3.4	3.8	3.3
24	2/10/83	16.8	3.5	4.8	4.9	3.4
26(39)	2/11/83	11.0	3.4	3.2	4.3	2.5

* Tied ± 0.5 ppm

(Study/Permanent Site Comparison)

E. The daily maximum from one (or more) of the Group 1 sites exceeded the corresponding value from site 11/7th&C and site 25/Spenard on all but one sample day (1/13 when site 25/Spenard "tied" three other study sites at a value of 6.9 ppm).

F. The daily maximums, from one (or more) of the study sites was on average, 285% higher than the corresponding values at site 11/7th&C, ranging from 110% to 650% higher.

G. The daily maximum from one (or more) of the study sites was on average 195% higher than corresponding values at site 25/Spenard, ranging from 0% to 240% higher.

Frequency of Daily Eight-Hour Exceedances From the Network -

The number of eight-hour exceedances reported by the study network on a daily basis provides a measure of the spatial severity of the CO situation during identical periods.

Group 1 Sites

(General Discussion)

A. An exceedance of the standard was recorded at one or more Group 1 sites on 85% of all sample days.

B. An exceedance of the standard was reported at four or more Group 1 sites on 57% of all days sampled.

(Study/Permanent Site Comparison)

C. Site 11/7th&C did not report an exceedance on any day when one or more Group 1 sites did.

D. Site 25/Spenard did not report an exceedance on 56% of the days when one or more Group 1 sites did and on 36% of the days when four or more Group 1 sites did.

Distribution of Daily Eight-Hour Averages

Quartiles and deciles were derived to describe the distribution of values reported from the study network during a sample day.

Group 1 Sites

(Study/Permanent Site Comparison)

A. On a daily basis, site 25/Spenard was at or below the median (2nd quartile) of Group 1 sites on 28% of the days and at or below the 3rd quartile on 74% of the days for which corresponding data are available.

B. On a daily basis, site 11/7th&C was at or below the 1st quartile of all Group 1 sites on 87% of the days for which corresponding data are available.

Range of Daily Eight-Hour Averages

The range of values reported from the study network during a particular day can provide a valuable index of intra-network variability. In addition, it can grossly imply that portion of the daily maximum which may be attributable to "background" levels of CO. This information can be important insofar as the calculation of the design value incorporates a "background" component. For instance, a high "background" level might establish that less site-specific control is required to bring levels at an 'offending' site into compliance. The reverse is also the case for low "background" levels.

Group 1 Sites

A. The daily range of eight-hour averages ranged from 4.0 ppm(11/24) to 22.8 ppm (12/3).

B. The daily range of eight-hour averages averaged 11.9 ppm.

C. The daily range of eight-hour averages exceeded 18.0 ppm on seven or 13% of the sample days, and 20.0 ppm on one day.

D. On the 22 days when the daily range of eight-hour averages was less than 10.0 ppm, the daily maximum did not exceed 12.6 ppm.

Correlation and Regression Analysis

One way of mathematically expressing the relationship between data from two sites is by fitting a line that best minimizes the distance of all data points to that line. One such line is the linear regression line. Straight by definition, a simple equation describes the origin and rate of change or slope of this line. So, by knowing the value of what is called the "independent" variable, one can predict what could be described as the "average" value of the "dependant" variable.

This "average" value is typically subject to some error due to the fact that not all actual data points are situated precisely on the regression line. Therefore, statistics are needed to describe the variability associated with this prediction. One such statistic is the coefficient of correlation. When squared, it becomes the coefficient of determination which is the proportion of variation in the dependant variable explained by variation in the independent variable. The higher the value of this coefficient, the more variation is explained and the stronger the relationship is between two data sets.

A particularly nettlesome problem with the traditional regression line is that it assigns all the variability due to sampling error to the dependant variable ignoring similar errors introduced by the independent variable. Since this would not accurately reflect the realities of errors in study sampling, a variation of this approach called two-way regression has been devised by statisticians to distribute this error term symmetrically to both variables. The regression parameters for Group 1 sites, including both one-way and two-way regression lines are presented in Table 10 (it should be noted that one cannot actually "solve" for 'x' in the one-way line). It should be noted that all references to regression parameters such as slope and intercept reflect the two-way line.

Typically, the greater the number of cases one can inspect relative to a particular phenomenon, the greater the confidence one has in 'understanding' it. This is exhibited in regression/correlation statistics where the confidence interval about some statistic (correlation coefficient for instance) shrinks, or confidence increases as more cases are considered. For reference in conjunction with the regression/coefficient tables, Table 11 has been prepared to illustrate the effect the number of cases has on confidence limits about various 'r' values.

Two basic kinds of correlation/regression analyses were performed on the data. The first type of analysis compared data for a particular interval that were paired by date to examine relative levels of CO experienced concurrently at a pair of sites. The second analytical approach used data sets ranked by magnitude and paired by rank. This second approach recognizes the effects of especially meteorology on the temporal variability of CO levels between sites, in particular microscale sites, by not 'requiring' any pair of sites to 'perform' in some characteristic fashion simultaneously (as the first approach does). This typically lends itself to examining larger (seasonal) patterns and frequencies of CO levels throughout some study area.

Date-Paired Correlation/Regression

Group 1 Sites

A. All eighteen sites had coefficients of correlation greater than or equal to 0.80 with at least one other site, ranging from one site (site 25) to twelve sites (site 12).

B. Sixteen sites had coefficients of correlation greater than or equal to 0.85 with at least one other site, ranging from one site (sites 15 and 25) to six sites (sites 12 and 27).

C. Nine sites had coefficients of correlation greater than or equal to 0.90 with at least one other site, ranging from one site (sites 1,8,9, and 18) to three sites (sites 12 and 19).

Rank-Paired Correlation/Regression

Each Group 1 site correlated with all other Group 1 sites at 0.93 or better.

TABLE 10 CORRELATION/REGRESSION RESULTS FOR GROUP 1 SITES

IND. SITE	DEP. SITE	CORRELATION	COEF. DETER.	NO. OF PAIRS	2-WAY REGRESSION EQ.	1-WAY REGRESSION EQ.
1	5	0.859	0.738	38.0	Y = 1.871X + -2.227	Y = 1.184X + -0.619
1	6	0.677	0.458	38.0	Y = 2.009X + -1.359	Y = 1.106X + 2.401
1	7	0.755	0.570	33.0	Y = 2.689X + -1.928	Y = 1.664X + 2.293
1	8	0.788	0.620	38.0	Y = 2.607X + -4.555	Y = 1.736X + -0.863
1	9	0.815	0.664	40.0	Y = 1.545X + -1.347	Y = 1.166X + 0.234
1	11	0.782	0.612	40.0	Y = 1.293X + -1.349	Y = 0.957X + 0.071
1	12	0.899	0.809	40.0	Y = 1.775X + -1.901	Y = 1.514X + -0.818
1	13	0.826	0.683	42.0	Y = 2.266X + -2.425	Y = 1.658X + 0.160
1	15	0.605	0.366	34.0	Y = 3.430X + -8.033	Y = 1.409X + 0.176
1	18	0.803	0.644	41.0	Y = 2.083X + -3.570	Y = 1.470X + -1.008
1	19	0.835	0.697	35.0	Y = 2.486X + -3.317	Y = 1.832X + -0.561
1	20	0.793	0.629	43.0	Y = 1.039X + -2.425	Y = 0.918X + -1.500
1	21	0.817	0.667	41.0	Y = 3.103X + -3.082	Y = 2.164X + 0.912
1	24	0.795	0.632	35.0	Y = 5.315X + -7.977	Y = 3.426X + 0.029
1	25	0.610	0.372	41.0	Y = 3.839X + -7.993	Y = 1.570X + 1.383
1	26	0.750	0.562	40.0	Y = 3.837X + -4.336	Y = 2.259X + 2.217
1	27	0.817	0.668	39.0	Y = 3.460X + -5.909	Y = 2.396X + -1.553
5	6	0.794	0.630	39.0	Y = 0.931X + 1.851	Y = 0.750X + 2.831
5	7	0.686	0.471	36.0	Y = 1.421X + 1.418	Y = 0.875X + 4.367
5	8	0.932	0.868	39.0	Y = 1.361X + -1.257	Y = 1.242X + -0.593
5	9	0.802	0.643	39.0	Y = 0.818X + 0.582	Y = 0.682X + 1.328
5	11	0.792	0.628	38.0	Y = 0.687X + 0.300	Y = 0.567X + 0.853
5	12	0.838	0.702	40.0	Y = 0.972X + 0.148	Y = 0.818X + 0.981
5	13	0.783	0.613	43.0	Y = 1.165X + 0.551	Y = 0.883X + 2.111
5	15	0.802	0.644	36.0	Y = 1.372X + -1.622	Y = 1.036X + 0.012
5	18	0.936	0.875	42.0	Y = 1.113X + -1.060	Y = 1.035X + -0.627
5	19	0.765	0.586	34.0	Y = 1.495X + -1.083	Y = 1.045X + 1.395
5	20	0.832	0.693	42.0	Y = 0.571X + -1.134	Y = 0.519X + -0.850
5	21	0.725	0.525	41.0	Y = 1.720X + 0.376	Y = 1.083X + 3.868
5	24	0.614	0.378	37.0	Y = 3.769X + -6.162	Y = 1.564X + 5.689
5	25	0.340	0.115	39.0	Y = 3.044X + -8.498	Y = 0.530X + 4.992
5	26	0.576	0.332	41.0	Y = 2.463X + -1.758	Y = 1.012X + 5.890
5	27	0.680	0.463	36.0	Y = 2.111X + -3.074	Y = 1.158X + 1.893
6	7	0.378	0.143	36.0	Y = 1.835X + -3.421	Y = 0.481X + 5.914
6	8	0.838	0.702	37.0	Y = 1.367X + -3.103	Y = 1.091X + -1.173
6	9	0.796	0.634	39.0	Y = 0.817X + -0.697	Y = 0.674X + 0.279
6	11	0.744	0.554	40.0	Y = 0.718X + -0.953	Y = 0.580X + 0.012
6	12	0.634	0.401	41.0	Y = 1.148X + -2.383	Y = 0.691X + 0.785
6	13	0.593	0.351	41.0	Y = 1.502X + -3.508	Y = 0.758X + 1.824
6	15	0.782	0.611	35.0	Y = 1.343X + -3.628	Y = 0.986X + -1.110
6	18	0.777	0.604	40.0	Y = 1.253X + -3.620	Y = 0.926X + -1.329
6	19	0.584	0.341	34.0	Y = 1.611X + -5.364	Y = 0.638X + 1.346
6	20	0.635	0.403	43.0	Y = 0.515X + -1.506	Y = 0.409X + -0.780
6	21	0.508	0.258	41.0	Y = 2.701X + -9.010	Y = 0.890X + 3.926
6	24	0.365	0.133	36.0	Y = 7.072X + -34.467	Y = 1.038X + 7.311
6	25	0.002	0.000	41.0	Y = 375.730X + ********	Y = 0.003X + 7.876
6	26	0.358	0.128	42.0	Y = 3.586X + -13.386	Y = 0.628X + 7.221
6	27	0.386	0.149	39.0	Y = 3.900X + -18.580	Y = 0.733X + 3.255
7	8	0.497	0.247	35.0	Y = 0.824X + -1.314	Y = 0.451X + 2.147
7	9	0.519	0.269	34.0	Y = 0.481X + 0.547	Y = 0.347X + 1.783
7	11	0.658	0.433	36.0	Y = 0.527X + -0.682	Y = 0.425X + 0.261
7	12	0.870	0.756	35.0	Y = 0.763X + -1.380	Y = 0.687X + -0.676
7	13	0.845	0.715	38.0	Y = 1.016X + -2.207	Y = 0.857X + -0.715
7	15	0.390	0.152	34.0	Y = 1.075X + -3.919	Y = 0.401X + 2.357
7	18	0.650	0.423	37.0	Y = 0.939X + -3.344	Y = 0.624X + -0.489
7	19	0.797	0.635	28.0	Y = 1.225X + -3.767	Y = 0.937X + -1.144
7	20	0.499	0.249	39.0	Y = 0.253X + -0.367	Y = 0.218X + -0.047
7	21	0.833	0.694	36.0	Y = 1.464X + -3.195	Y = 1.147X + -0.242
7	24	0.814	0.662	35.0	Y = 2.579X + -8.781	Y = 1.816X + -1.811
7	25	0.787	0.620	35.0	Y = 1.322X + -3.763	Y = 0.982X + -0.667
7	26	0.753	0.567	39.0	Y = 1.689X + -3.771	Y = 1.126X + 1.453
7	27	0.881	0.776	37.0	Y = 1.556X + -5.615	Y = 1.304X + -3.279
8	9	0.745	0.554	38.0	Y = 0.580X + 1.336	Y = 0.492X + 1.910
8	11	0.725	0.526	38.0	Y = 0.506X + 0.938	Y = 0.435X + 1.394
8	12	0.707	0.500	40.0	Y = 0.697X + 1.249	Y = 0.546X + 2.198
8	13	0.681	0.463	41.0	Y = 0.917X + 1.417	Y = 0.641X + 3.191
8	15	0.881	0.776	36.0	Y = 1.020X + -0.403	Y = 0.896X + 0.351
8	18	0.865	0.749	40.0	Y = 0.799X + 0.123	Y = 0.713X + 0.669
8	19	0.652	0.426	34.0	Y = 1.113X + 0.083	Y = 0.700X + 2.794
8	20	0.828	0.685	42.0	Y = 0.421X + -0.885	Y = 0.395X + -0.519
8	21	0.620	0.385	40.0	Y = 1.417X + 1.082	Y = 0.772X + 5.259
8	24	0.453	0.205	34.0	Y = 4.053X + -10.348	Y = 0.988X + 8.845
8	25	0.254	0.065	38.0	Y = 2.180X + -5.648	Y = 0.316X + 6.187
8	26	0.429	0.184	39.0	Y = 2.216X + -1.866	Y = 0.621X + 8.006
8	27	0.473	0.223	38.0	Y = 1.840X + -3.011	Y = 0.639X + 4.492
9	11	0.917	0.841	40.0	Y = 0.862X + -0.330	Y = 0.801X + -0.016
9	12	0.827	0.683	41.0	Y = 1.276X + -0.850	Y = 1.011X + 0.467
9	13	0.716	0.513	42.0	Y = 1.664X + -1.341	Y = 1.039X + 1.884
9	15	0.577	0.333	35.0	Y = 1.924X + -3.732	Y = 0.857X + 1.653
9	18	0.841	0.708	42.0	Y = 1.385X + -1.979	Y = 1.108X + -0.589
9	19	0.871	0.759	35.0	Y = 1.750X + -1.692	Y = 1.427X + -0.069
9	20	0.680	0.462	43.0	Y = 0.641X + -1.272	Y = 0.500X + -0.570
9	21	0.700	0.490	40.0	Y = 2.374X + -2.079	Y = 1.327X + 3.319
9	24	0.589	0.347	37.0	Y = 4.870X + -10.176	Y = 1.410X + 5.176
9	25	0.409	0.167	42.0	Y = 3.577X + -9.991	Y = 0.769X + 4.049
9	26	0.661	0.437	42.0	Y = 3.053X + -3.811	Y = 1.486X + 1.994
9	27	0.548	0.300	40.0	Y = 3.352X + -8.102	Y = 1.171X + 2.544

(TABLE 10 CONT.)

IND. SITE	DEP. SITE	CORRELATION	COEF.DETER.	NO.OF PAIRS	2-WAY REGRESSION EQ.	1-WAY REGRESSION EQ.
11	12	0.885	0.783	40.0	Y = 1.422X + -0.181	Y = 1.211X + 0.686
11	13	0.806	0.649	43.0	Y = 1.720X + 0.029	Y = 1.256X + 2.007
11	15	0.669	0.418	37.0	Y = 1.953X + -2.111	Y = 1.065X + 1.612
11	18	0.848	0.719	42.0	Y = 1.557X + -1.272	Y = 1.239X + 0.055
11	19	0.920	0.847	35.0	Y = 1.949X + -0.794	Y = 1.712X + 0.186
11	20	0.702	0.493	43.0	Y = 0.705X + -0.910	Y = 0.548X + -0.253
11	21	0.738	0.545	43.0	Y = 2.669X + -0.973	Y = 1.592X + 3.618
11	24	0.701	0.492	38.0	Y = 4.587X + -4.648	Y = 2.159X + 4.889
11	25	0.447	0.200	41.0	Y = 3.545X + -6.446	Y = 0.881X + 4.444
11	26	0.749	0.561	42.0	Y = 2.901X + -0.278	Y = 1.753X + 4.485
11	27	0.723	0.523	42.0	Y = 2.910X + -3.266	Y = 1.658X + 1.854
12	13	0.911	0.829	44.0	Y = 1.227X + 0.203	Y = 1.097X + 0.939
12	15	0.597	0.356	37.0	Y = 1.654X + -3.207	Y = 0.812X + 1.412
12	18	0.835	0.697	43.0	Y = 1.228X + -1.623	Y = 0.991X + -0.322
12	19	0.935	0.875	35.0	Y = 1.324X + -0.131	Y = 1.216X + 0.448
12	20	0.708	0.501	44.0	Y = 0.527X + -0.950	Y = 0.440X + -0.496
12	21	0.860	0.740	42.0	Y = 1.763X + 0.233	Y = 1.410X + 2.226
12	24	0.802	0.644	37.0	Y = 3.101X + -2.915	Y = 2.095X + 2.766
12	25	0.627	0.393	41.0	Y = 1.950X + -2.590	Y = 0.970X + 2.673
12	26	0.823	0.677	42.0	Y = 1.961X + 0.626	Y = 1.449X + 3.475
12	27	0.835	0.697	40.0	Y = 2.049X + -2.816	Y = 1.541X + -0.026
13	15	0.630	0.396	39.0	Y = 1.142X + -2.231	Y = 0.685X + 1.065
13	18	0.777	0.604	47.0	Y = 1.080X + -2.339	Y = 0.825X + -0.556
13	19	0.909	0.826	36.0	Y = 1.165X + -1.103	Y = 1.044X + -0.232
13	20	0.615	0.378	45.0	Y = 0.376X + -0.747	Y = 0.320X + -0.335
13	21	0.807	0.652	45.0	Y = 1.534X + -0.911	Y = 1.144X + 1.944
13	24	0.834	0.695	41.0	Y = 2.595X + -4.119	Y = 1.902X + 0.874
13	25	0.648	0.420	42.0	Y = 1.436X + -2.358	Y = 0.822X + 2.093
13	26	0.803	0.645	46.0	Y = 1.686X + -0.433	Y = 1.230X + 2.828
13	27	0.850	0.723	44.0	Y = 1.609X + -2.993	Y = 1.280X + -0.637
15	18	0.765	0.585	38.0	Y = 0.846X + 0.200	Y = 0.673X + 1.214
15	19	0.511	0.261	30.0	Y = 1.307X + -0.651	Y = 0.587X + 3.558
15	20	0.743	0.552	38.0	Y = 0.346X + -0.141	Y = 0.320X + 0.011
15	21	0.551	0.304	38.0	Y = 1.565X + 0.813	Y = 0.710X + 5.948
15	24	0.380	0.145	32.0	Y = 4.869X + -14.074	Y = 0.845X + 9.627
15	25	0.088	0.008	36.0	Y = 4.187X + -16.794	Y = 0.104X + 7.249
15	26	0.401	0.161	37.0	Y = 2.279X + -1.502	Y = 0.575X + 8.444
15	27	0.491	0.243	36.0	Y = 1.980X + -2.992	Y = 0.703X + 4.478
18	19	0.777	0.603	36.0	Y = 1.271X + 0.706	Y = 0.936X + 2.394
18	20	0.825	0.681	45.0	Y = 0.509X + -0.589	Y = 0.467X + -0.376
18	21	0.674	0.454	43.0	Y = 1.612X + 1.680	Y = 0.936X + 5.235
18	24	0.633	0.401	41.0	Y = 3.262X + -1.909	Y = 1.458X + 7.206
18	25	0.262	0.068	42.0	Y = 2.607X + -5.108	Y = 0.349X + 6.080
18	26	0.612	0.374	45.0	Y = 2.052X + 1.236	Y = 0.972X + 6.631
18	27	0.647	0.419	43.0	Y = 2.023X + -1.483	Y = 1.042X + 3.292
19	20	0.660	0.436	38.0	Y = 0.339X + -0.394	Y = 0.302X + -0.133
19	21	0.829	0.687	37.0	Y = 1.232X + 1.304	Y = 0.986X + 3.093
19	24	0.821	0.674	30.0	Y = 2.087X + -0.292	Y = 1.526X + 3.928
19	25	0.671	0.451	37.0	Y = 1.224X + -0.687	Y = 0.769X + 2.530
19	26	0.842	0.709	34.0	Y = 1.397X + 1.963	Y = 1.118X + 3.968
19	27	0.809	0.655	35.0	Y = 1.303X + -1.038	Y = 1.003X + 1.105
20	21	0.676	0.458	44.0	Y = 3.667X + 2.888	Y = 1.807X + 6.698
20	24	0.600	0.360	40.0	Y = 6.814X + 1.080	Y = 2.539X + 9.759
20	25	0.363	0.132	44.0	Y = 6.663X + -4.557	Y = 0.991X + 6.152
20	26	0.524	0.274	45.0	Y = 5.588X + 0.964	Y = 1.651X + 8.629
20	27	0.606	0.367	43.0	Y = 5.093X + -1.086	Y = 1.982X + 4.868
21	24	0.822	0.675	38.0	Y = 1.649X + -1.991	Y = 1.246X + 2.162
21	25	0.766	0.587	42.0	Y = 0.974X + -1.830	Y = 0.751X + 0.425
21	26	0.865	0.748	43.0	Y = 1.100X + 0.583	Y = 0.939X + 2.234
21	27	0.881	0.776	43.0	Y = 1.104X + -2.623	Y = 0.961X + -1.173
24	25	0.773	0.597	37.0	Y = 0.513X + 0.672	Y = 0.455X + 1.514
24	26	0.891	0.795	41.0	Y = 0.678X + 1.822	Y = 0.629X + 2.525
24	27	0.890	0.793	39.0	Y = 0.648X + -0.800	Y = 0.604X + -0.146
25	26	0.785	0.616	43.0	Y = 1.177X + 2.209	Y = 0.893X + 4.523
25	27	0.853	0.728	42.0	Y = 1.109X + -0.662	Y = 0.932X + 0.786
26	27	0.852	0.726	44.0	Y = 0.971X + -2.761	Y = 0.831X + -1.127

Table 11 95% Confidence Limits About 'r' as a Function of 'n'

R \ N	10	20	30	40	50	60	70	80	90	100
0.10	0.10 .69/-.57	0.10 .52/-.36	0.10 .44/-.27	0.10 .40/-.22	0.10 .37/-.18	0.10 .35/-.16	0.10 .33/-.14	0.10 .31/-.12	0.10 .30/-.11	0.10 .29/-.10
0.20	0.20 .74/-.49	0.20 .59/-.27	0.20 .52/-.17	0.20 .48/-.12	0.20 .45/-.08	0.20 .43/-.06	0.20 .42/-.04	0.20 .40/-.02	0.20 .39/-.01	0.20 .38/0.00
0.30	0.30 .78/-.41	0.30 .66/-.16	0.30 .60/-.07	0.30 .56/-.01	0.30 .53/0.02	0.30 .51/0.05	0.30 .50/0.07	0.30 .49/0.09	0.30 .48/0.10	0.30 .47/0.11
0.40	0.40 .82/-.31	0.40 .72/-.05	0.40 .66/0.05	0.40 .63/0.10	0.40 .61/0.14	0.40 .59/0.16	0.40 .58/0.18	0.40 .57/0.20	0.40 .56/0.21	0.40 .55/0.22
0.50	0.50 .86/-.19	0.50 .77/0.07	0.50 .73/0.17	0.50 .70/0.22	0.50 .68/0.26	0.50 .67/0.28	0.50 .66/0.30	0.50 .65/0.31	0.50 .64/0.33	0.50 .63/0.34
0.60	0.60 .89/-.05	0.60 .82/0.21	0.60 .79/0.31	0.60 .77/0.35	0.60 .75/0.39	0.60 .74/0.41	0.60 .73/0.42	0.60 .72/0.44	0.60 .72/0.45	0.60 .71/0.46
0.70	0.70 .92/0.13	0.70 .87/0.37	0.70 .85/0.45	0.70 .83/0.50	0.70 .82/0.52	0.70 .81/0.54	0.70 .80/0.56	0.70 .80/0.57	0.70 .79/0.58	0.70 .79/0.58
0.80	0.80 .95/0.34	0.80 .92/0.55	0.80 .90/0.62	0.80 .89/0.65	0.80 .88/0.67	0.80 .88/0.69	0.80 .87/0.70	0.80 .87/0.70	0.80 .86/0.71	0.80 .86/0.72
0.90	0.90 .98/0.62	0.90 .96/0.76	0.90 .95/0.80	0.90 .95/0.82	0.90 .94/0.83	0.90 .94/0.84	0.90 .94/0.84	0.90 .93/0.85	0.90 .93/0.85	0.90 .93/0.85

Comparison of CBD and Corridor Sites

Both the magnitude of CO levels and the frequency of NAAQS exceedances recorded at most Corridor sites were consistently and markedly higher than those recorded at most of the CBD sites.

Group 1 Sites

A. Maximum eight-hour averages for CBD sites ranged from 6.2 ppm (sites 1 and 20) to 15.1 ppm (site 7), while those for the Corridor sites ranged from 15.1 ppm (site 25/Spenard) to 27.4 (site 24).

B. The second highest eight-hour averages for CBD sites ranged from 4.6 ppm (site 20) to 13.7 ppm (site 7), while those for the Corridor sites ranged from 13.1 ppm (site 25/Spenard) to 22.6 ppm (site 24).

C. The frequency of NAAQS exceedances for CBD sites ranged from 0% (sites 1, 9, 11, and 20) to 51% (site 7), while those for Corridor sites ranged from 37% (site 25) to 84% (site 24).

D. The means and ranges (minimum to maximum) of values at all Corridor sites were markedly greater than those for all CBD sites, except that CBD site 7's mean was greater than two of the five Corridor sites (sites 25 and 27).

E. Site 1 had a coefficient of correlation greater than or equal to 0.75 with fourteen of the seventeen other Group 1 sites (and 0.80 for nine) in both CBD and Corridor locations.

F. While ten sites in the CBD (sites 1,5,6,8,9,11,12,13,18, and 19) had coefficients of correlation greater than approximately 0.75 with between five (site 6) to eleven (site 5) other CBD sites, they did not correlate with any Corridor sites at 0.75 or better.

G. Three CBD sites (sites 7,15, and 20) had coefficients of correlation greater than approximately 0.75 with between four (site 7) and ten (site 1) other CBD sites and with between two (site 11) and four (sites 1,7,12,13, and 19) of the five Corridor sites.

H. All five corridor sites had coefficients of correlation greater than 0.77 with each other.

I. Site 25/Spenard did <u>not</u> correlate with any CBD sites at 0.80 or better. However, when the continuous record is used in lieu of the integrated data, the Spenard & Benson permanent site correlated at 0.74, 0.77, and 0.81 with sites 7,12, and 13 respectively.

Relationship of "AM" to "PM" Four-Hour Averages

The analysis of both intra-site and inter-site relationships of "AM" (11:00 A.M. to 3:00 P.M.) and "PM" (3:00 P.M. to 7:00 P.M.) four-hour values can provide a characterization of the temporal variability of CO levels at individual sites and over the entire study area. Figures 13 and 14 present the composite statistics from each site for the "AM" and "PM" periods respectively. Due to time constraints, this analysis received a relatively limited treatment in this report.

Group 1 Sites Only

A. For parameters such as range, maximums, 2nd highs, minimums, means, and medians, each site's "PM" values were consistently greater than or equal to the "AM" values when all sample days are considered. The notable exceptions to this were sites 13 and 20 where the maximum and 2nd highest "AM" values exceeded those "PM" measures, with site 13's "AM" mean also exceeding its' "PM" mean.

B. The maximum "AM" averages ranged from 6.4 ppm (site 1) to 25.1 (site 24). The maximum "PM" averages ranged from 5.8 ppm (site 20) to 30.1 ppm (site 24).

C. The minimum values for both "AM" and "PM" periods were essentially equal (within ± 1.0 ppm) at 15 of the 18 Group 1 sites.

D. The median of each site's daily "AM"/"PM" ratio ranged from 0.8 (sites 1,5,7,9,11,18, and 20) to 1.2 (site 13).

E. Some 16 of the Group 1 sites exhibited median "AM"/"PM" ratios less than or equal to 1.0, demonstrating general dominance of "PM" over "AM" values when considered on a daily basis.

F. The minimum "AM"/"PM" ratios ranged from 0.0* (sites 20) to 0.5 (sites 13,15, and 24), with an average minimum ratio over all sites of 0.3.

G. The maximum "AM"/"PM" ratios ranged from 1.5 (sites 1 and 18) to 17.8 (site 26) with an average maximum ratio over all Group 1 sites of 3.0.

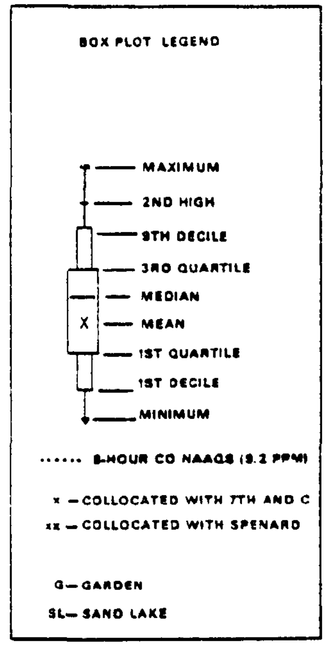
Groups 1 and 2 Combined

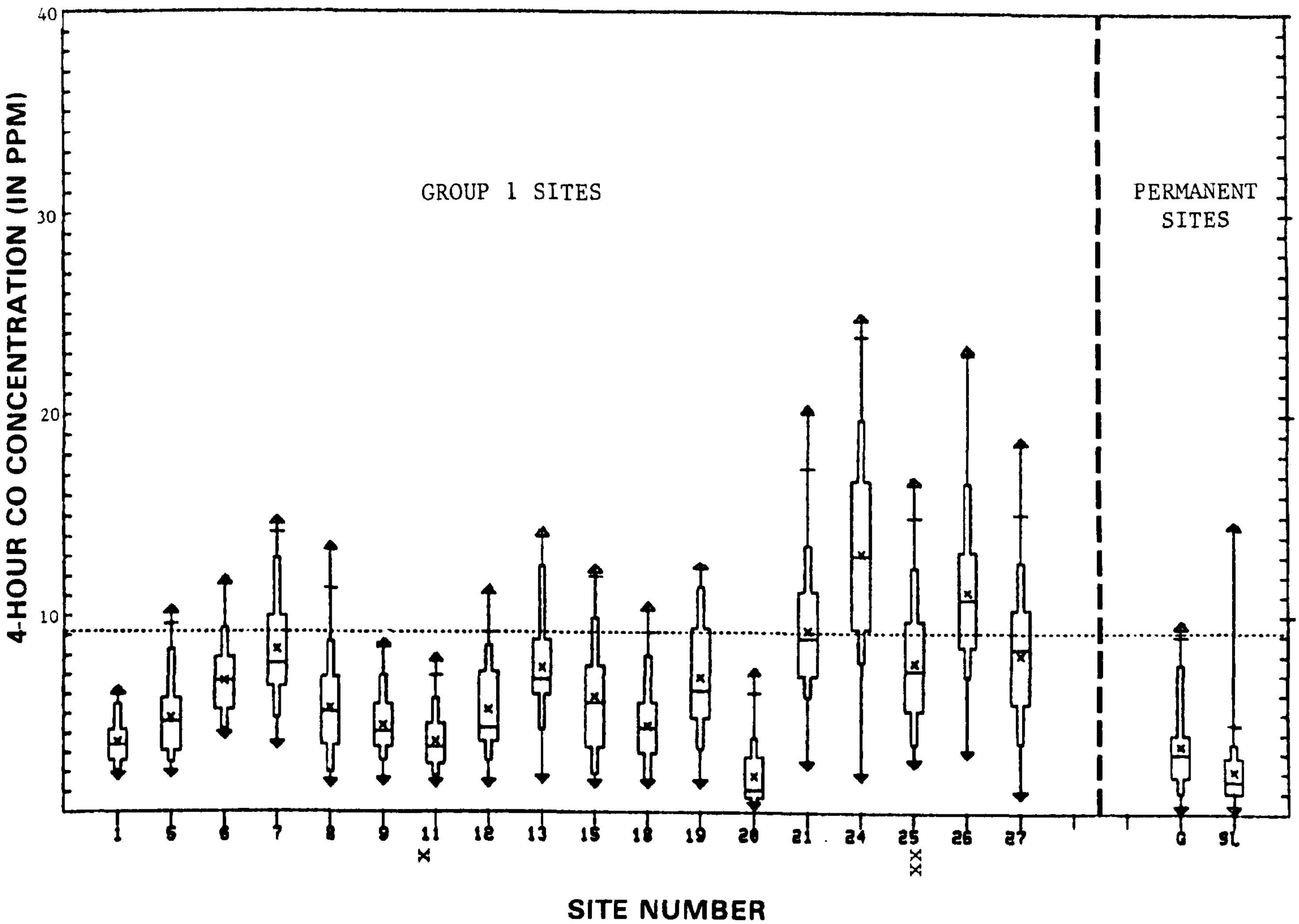
H. Considering all sites (Groups 1 and 2), the daily "PM" maximum was greater than the "AM" maximum on 59% of all sample days (not including 10 days that were within + 0.5 ppm) by an average of 4.6 ppm, and ranging from 0.6 ppm (T2/1) to 16.3 ppm (2/1) greater. Conversely, the daily "AM" maximum was greater than the "PM" maximum on 22% of all sample days, not including those days within 0.5 ppm, by an average of 3.2 ppm, and ranging from 0.7 ppm (1/3) to 10.7 ppm (12/10) greater.

* - Reflects rounding of a ratio value less than 0.05.

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

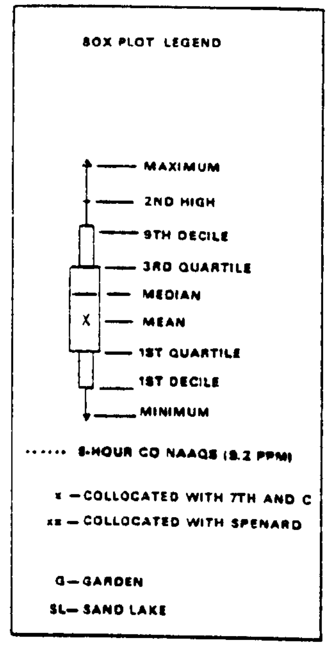
CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
AVERAGE CONCENTRATIONS FOR THE "AM" 4-HOUR PERIOD
(11:00 A.M. TO 3:00 P.M.) AT EACH SITE

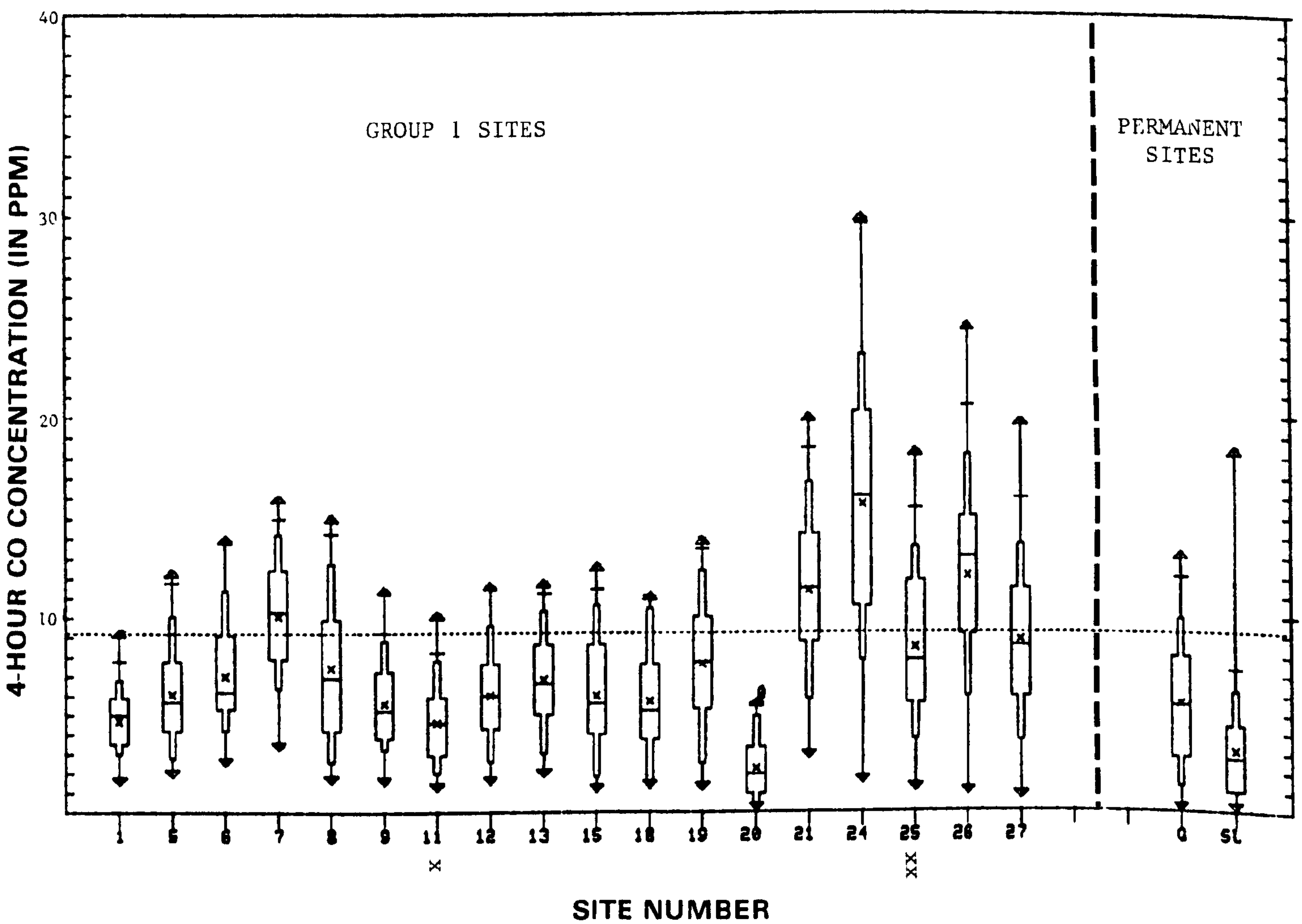




ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE AVERAGE CONCENTRATIONS FOR THE "PM" 4-HOUR PERIOD (3:00 A.M. TO 7:00 P.M.) AT EACH SITE





I. On 67% of all sample days, the daily composite median of all sites'(again Groups 1 and 2) "AM"/"PM" ratios was less than 1.0.

J. The average number of daily exceedances reported from the study network (Groups 1 and 2) was essentially identical regardless of whether the "AM"/"PM" ratio was greater or less than 1.0. However, on the day when the highest proportion of sites exceeded the standard (78% on 12/3), "AM" averages were clearly greater than "PM" at over 55% of the study sites. Conversely, on the day when the second highest proportion of exceedances were recorded (68% on 1/5), "PM" averages were clearly greater than "AM" averages at about 63% of the study sites.

GRID NETWORKS

The primary emphasis of the grid monitoring networks was to establish the representativeness of the Spenard & Benson, Garden, and Sand Lake permanent sites over middle and neighborhood spatial scales. The results and discussion that follow are given on a network-specific basis.

Garden Network

The objective for the Garden study network was to examine and establish, if possible, the homogenous representativeness of the permanent Garden site. A total of five sequential samplers were dedicated to this study network. The locations of these samplers are plotted in Figure 4. Note that site 105 was collocated with the permanent probe for purposes of method comparison and quality assurance. Inspection of the data reveals that a systematic difference between the sequential and continuous sampling methods may be indicated (refer to Quality Assurance section). Therefore, site 105 was considered the surrogate of the permanent site for the purpose of maintaining congruity among the data bases considered during the regression portion of the analysis.

Even though the samplers employed in this network collected hourly data, four-hour block data were used in these inter-site comparisons to overcome potential biases due to autocorrelation and to dampen potential temporal shifts or offsets associated with impacts at one sampler (or samplers) not simultaneously, but eventually experienced at the other grid sites. If these temporal variations were profound (on the order of two or more hours) and/or intermittent, then the determination of homogeneity would be made immensely more difficult. This is not thought to have occurred here to any appreciable extent.

Data arising from the Garden network are displayed in Table 12 and Figure 15.

A. The Garden permanent site had a coefficient of correlation between 0.94 (site 101) and 0.96 (sites 102 and 103) with each of the five sites in the Garden study network (0.95 with collocated site 105).

B. The regression lines for each of the Garden site/study site pairings had slopes of between 0.83 and 0.87 with intercepts at or below 0.6 ppm.

Table 12 Correlation/Regression Results* for Permanent and Study Sites

IND. SITE	DEP. SITE	CORRELATION	COEF.DETER.	NO.OF PAIRS	2-WAY REGRESSION EQ.	1-WAY REGRESSION EQ.
7AC	SPBE	0.702	0.492	211.0	Y = 2.118X + -0.971	Y = 1.215X + 2.150
7AC	GARD	0.734	0.538	218.0	Y = 1.752X + -1.548	Y = 1.118X + 0.605
7AC	SDLK	0.652	0.425	207.0	Y = 1.224X + -1.748	Y = 0.744X + -0.093
7AC	1019	0.640	0.410	107.0	Y = 1.565X + -1.563	Y = 0.858X + 0.997
7AC	1029	0.589	0.347	51.0	Y = 1.872X + -2.552	Y = 0.866X + 1.017
7AC	1039	0.563	0.317	44.0	Y = 1.568X + -1.558	Y = 0.730X + 1.550
7AC	1049	0.596	0.355	98.0	Y = 1.602X + -1.539	Y = 0.794X + 1.414
7AC	1059	0.627	0.393	86.0	Y = 1.509X + -1.462	Y = 0.815X + 1.243
7AC	2019	0.785	0.616	97.0	Y = 0.956X + 0.292	Y = 0.758X + 0.978
7AC	2029	0.751	0.564	90.0	Y = 1.034X + -0.197	Y = 0.770X + 0.746
7AC	2039	0.788	0.621	58.0	Y = 1.101X + -0.901	Y = 0.850X + 0.058
7AC	3019	0.690	0.477	75.0	Y = 2.056X + 0.417	Y = 1.160X + 3.523
SPBE	GARD	0.694	0.482	213.0	Y = 0.831X + -0.761	Y = 0.610X + 0.642
SPBE	SDLK	0.783	0.613	202.0	Y = 0.595X + -1.252	Y = 0.518X + -0.760
SPBE	1019	0.586	0.344	107.0	Y = 0.640X + 0.086	Y = 0.449X + 1.301
SPBE	1029	0.632	0.400	54.0	Y = 0.680X + -0.635	Y = 0.494X + 0.678
SPBE	1039	0.647	0.419	46.0	Y = 0.575X + 0.199	Y = 0.448X + 1.127
SPBE	1049	0.546	0.298	99.0	Y = 0.636X + 0.246	Y = 0.424X + 1.608
SPBE	1059	0.590	0.348	86.0	Y = 0.588X + 0.500	Y = 0.428X + 1.584
SPBE	2019	0.687	0.471	98.0	Y = 0.498X + 0.746	Y = 0.417X + 1.216
SPBE	2029	0.860	0.740	91.0	Y = 0.592X + 0.075	Y = 0.546X + 0.354
SPBE	2039	0.804	0.646	57.0	Y = 0.716X + -0.766	Y = 0.613X + -0.185
SPBE	3019	0.749	0.561	76.0	Y = 0.797X + 2.384	Y = 0.631X + 3.467
GARD	SDLK	0.685	0.469	209.0	Y = 0.685X + -0.540	Y = 0.527X + 0.160
GARD	1019	0.943	0.890	108.0	Y = 0.831X + 0.234	Y = 0.792X + 0.416
GARD	1029	0.958	0.918	54.0	Y = 0.875X + 0.133	Y = 0.843X + 0.279
GARD	1039	0.958	0.917	47.0	Y = 0.835X + 0.580	Y = 0.805X + 0.712
GARD	1049	0.945	0.893	100.0	Y = 0.844X + 0.317	Y = 0.805X + 0.503
GARD	1059	0.953	0.909	88.0	Y = 0.847X + 0.356	Y = 0.814X + 0.516
GARD	2019	0.723	0.523	100.0	Y = 0.544X + 1.308	Y = 0.460X + 1.669
GARD	2029	0.754	0.569	93.0	Y = 0.591X + 0.815	Y = 0.503X + 1.225
GARD	2039	0.606	0.367	58.0	Y = 0.653X + 0.174	Y = 0.466X + 1.073
GARD	3019	0.470	0.221	76.0	Y = 1.078X + 3.089	Y = 0.487X + 5.548
SDLK	1019	0.586	0.343	103.0	Y = 1.514X + 0.418	Y = 0.751X + 2.254
SDLK	1029	0.725	0.526	48.0	Y = 1.623X + -0.135	Y = 1.037X + 1.336
SDLK	1039	0.670	0.449	47.0	Y = 1.648X + 0.171	Y = 0.944X + 1.963
SDLK	1049	0.565	0.320	94.0	Y = 2.190X + -0.581	Y = 0.907X + 2.250
SDLK	1059	0.557	0.310	88.0	Y = 1.465X + 0.536	Y = 0.691X + 2.604
SDLK	2019	0.588	0.345	94.0	Y = 1.018X + 1.378	Y = 0.594X + 2.308
SDLK	2029	0.701	0.492	93.0	Y = 1.035X + 1.192	Y = 0.719X + 1.923
SDLK	2039	0.667	0.445	58.0	Y = 1.089X + 0.761	Y = 0.706X + 1.657
SDLK	3019	0.569	0.324	71.0	Y = 2.526X + 1.827	Y = 1.011X + 5.338
1019	1029	0.875	0.766	44.0	Y = 1.179X + -0.456	Y = 1.012X + 0.271
1019	1039	0.918	0.843	37.0	Y = 1.081X + 0.063	Y = 0.986X + 0.419
1019	1049	0.920	0.846	90.0	Y = 1.023X + 0.089	Y = 0.940X + 0.452
1019	1059	0.907	0.823	86.0	Y = 1.036X + 0.058	Y = 0.937X + 0.487
1019	2019	0.712	0.507	94.0	Y = 0.617X + 1.198	Y = 0.501X + 1.662
1019	2029	0.710	0.505	89.0	Y = 0.670X + 0.724	Y = 0.533X + 1.291
1019	2039	0.630	0.396	58.0	Y = 0.819X + -0.195	Y = 0.555X + 0.934
1019	3019	0.459	0.210	63.0	Y = 1.832X + 0.647	Y = 0.613X + 5.303
1029	1039	0.895	0.801	45.0	Y = 1.028X + 0.163	Y = 0.917X + 0.622
1029	1049	0.924	0.853	46.0	Y = 0.937X + 0.437	Y = 0.870X + 0.726
1029	1059	0.940	0.883	28.0	Y = 1.080X + -0.174	Y = 1.010X + 0.183
1029	2019	0.650	0.423	40.0	Y = 0.433X + 1.791	Y = 0.365X + 2.053
1029	2029	0.749	0.561	35.0	Y = 0.677X + 0.669	Y = 0.558X + 1.228
1029	3019	0.410	0.168	52.0	Y = 1.254X + 2.864	Y = 0.450X + 6.257
1039	1049	0.890	0.792	37.0	Y = 0.955X + 0.068	Y = 0.854X + 0.539
1039	1059	0.963	0.927	27.0	Y = 1.040X + -0.105	Y = 1.000X + 0.083
1039	2019	0.779	0.607	30.0	Y = 0.784X + 0.600	Y = 0.644X + 1.107
1039	2029	0.838	0.702	34.0	Y = 0.767X + 0.364	Y = 0.670X + 0.792
1039	3019	0.503	0.253	43.0	Y = 1.629X + 1.873	Y = 0.648X + 5.989
1049	1059	0.887	0.787	67.0	Y = 1.047X + -0.076	Y = 0.924X + 0.480
1049	2019	0.712	0.507	83.0	Y = 0.648X + 1.064	Y = 0.521X + 1.595
1049	2029	0.729	0.531	71.0	Y = 0.735X + 0.376	Y = 0.581X + 1.063
1049	2039	0.600	0.360	52.0	Y = 0.801X + -0.169	Y = 0.525X + 0.991
1049	3019	0.419	0.176	58.0	Y = 1.669X + 0.987	Y = 0.524X + 5.790
1059	2019	0.686	0.471	75.0	Y = 0.663X + 0.931	Y = 0.515X + 1.559
1059	2029	0.704	0.496	77.0	Y = 0.651X + 0.688	Y = 0.518X + 1.301
1059	2039	0.619	0.383	54.0	Y = 0.787X + 0.022	Y = 0.533X + 1.142
1059	3019	0.459	0.211	42.0	Y = 1.565X + 0.726	Y = 0.571X + 5.141
2019	2029	0.891	0.793	83.0	Y = 1.001X + -0.245	Y = 0.891X + 0.157
2019	2039	0.832	0.692	53.0	Y = 1.101X + -0.907	Y = 0.901X + -0.122
2019	3019	0.602	0.362	57.0	Y = 2.392X + -1.177	Y = 1.058X + 3.365
2029	2039	0.862	0.743	51.0	Y = 1.123X + -0.698	Y = 0.953X + -0.092
2029	3019	0.651	0.424	47.0	Y = 2.031X + 0.562	Y = 1.055X + 3.818
2039	3019	0.828	0.685	13.0	Y = 1.966X + -1.036	Y = 1.466X + 0.720

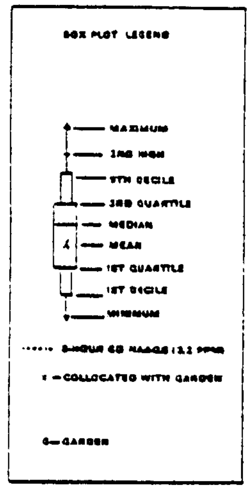
* - Reflects Data for Three 4-Hour Blocks per Day: 11:00 a.m. - 3:00 p.m.
3:00 p.m. - 7:00 p.m.
7:00 p.m. -11:00 p.m.

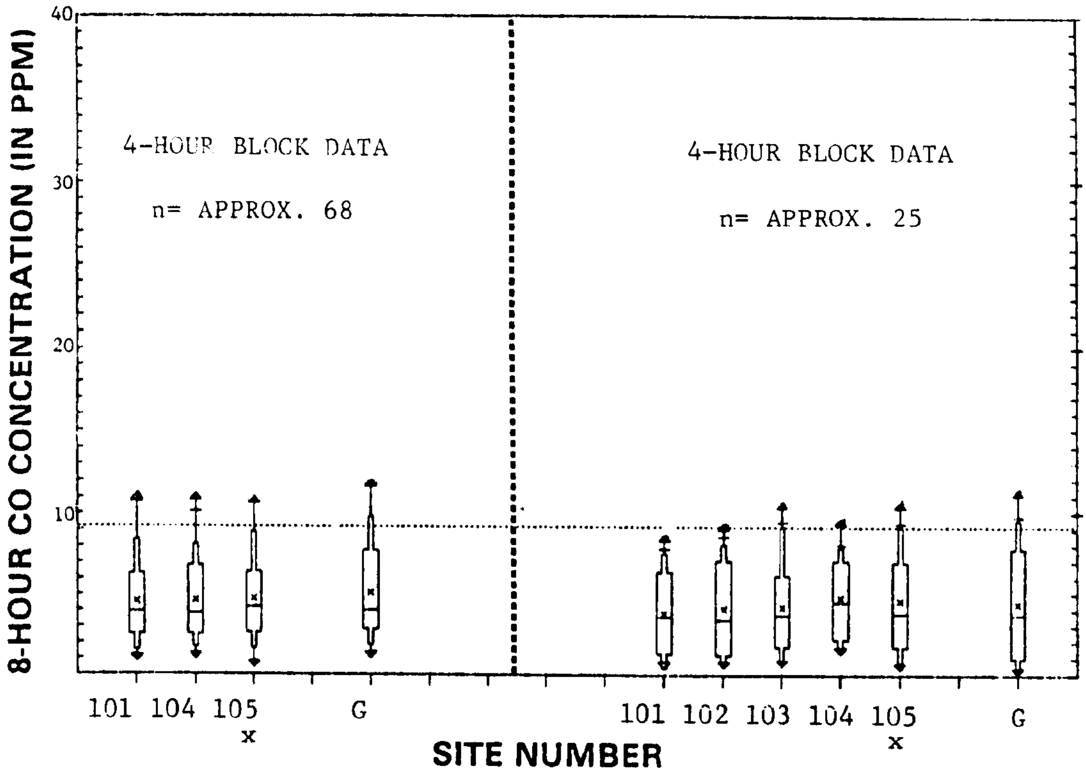
FIGURE 15

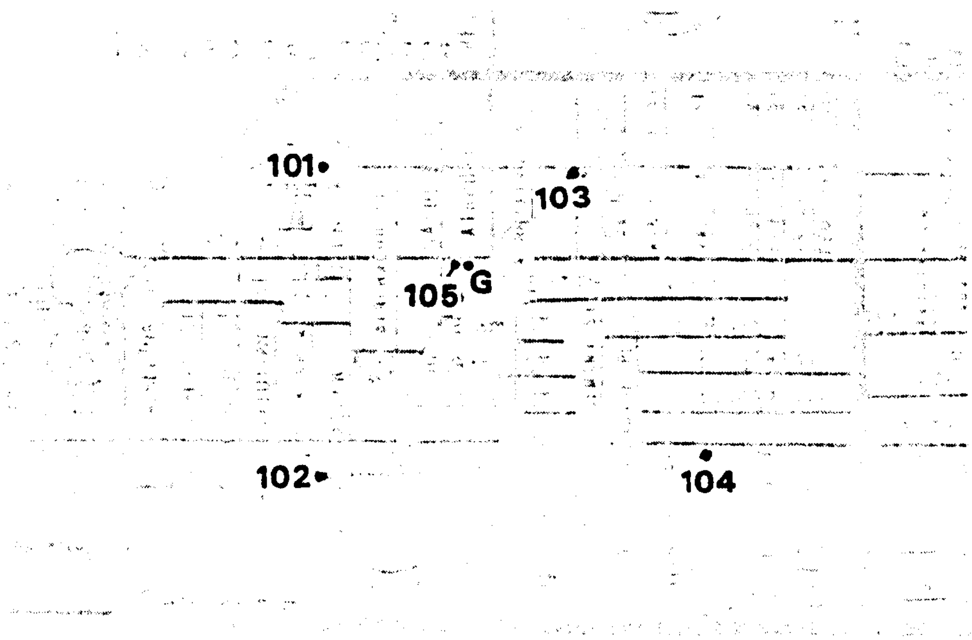
ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE

GARDEN NETWORK







C. While the correlation coefficients for the pairings of site 105 and the other Garden network study sites were somewhat lower than those for the Garden permanent site pairings, ranging from 0.89 (site 104) to .96 (site 103), the slopes were closer to unity (1.0) ranging from 0.93 (site 102) to 0.97 (site 101), with intercepts less than 0.6ppm.

Sand Lake Network

The objective for the Sand Lake study network was to examine and establish, if possible, the homogenous and analogous representativeness of the Sand Lake permanent site. Three study sites were deployed about the permanent site. Their locations are plotted on Figure 5. Study site 29 was sited to examine the homogenous representativeness of the Sand Lake site. Because sites 28 and 30 were located across one or more well-traveled arterials from the Sand Lake site, they yielded data relative to analogous representativeness.

As a result of the use of 8-hour integrated samplers in this network, daily eight-hour block data were used in these inter-site comparisons. In addition, sampling was not conducted during the period of most frequent maximum daily concentrations for logistical reasons. Therefore, the relationships described by Figure 16 and the correlation/regression results appearing in Table 12 may not adequately characterize the circumstances of other periods within a day.

A. The Sand Lake permanent site had a coefficient of correlation of 0.88 with site 28, 0.97 with site 29, and 0.92 with site 30, with slopes indicating that study sites 29 and 30 were 2% and 19% higher on average than the Sand Lake site, while site 28 was 6% lower on average.

B. Site 30, across Jewell Lake Road from the other sites, correlated at 0.79 and 0.73 with sites 28 and 29 respectively, with slopes indicating that it is 26% lower than site 28 and 4% higher than site 29 on average.

Spenard & Benson Network

The objective for the Spenard & Benson network was to examine and establish the homogenous and analogous representativeness of the Spenard permanent site. A total of four sites were eventually deployed in the Spenard network, consisting of three sequential and one integrated samplers. The location of these sites are plotted on Figure 3. Sites 201 and 203 were located across one or more major traffic facilities and therefore retrieved data relative to analogous representativeness. Sites 202 and 204 were located in the neighborhood contiguous with the Spenard permanent site and examined homogenous representativeness.

Again, though hourly data were available from three of these study sites, four- hour block data were utilized in the correlation/regression analysis. As site 204 retrieved 8-hour block data, comparisons with that site were made on that basis.

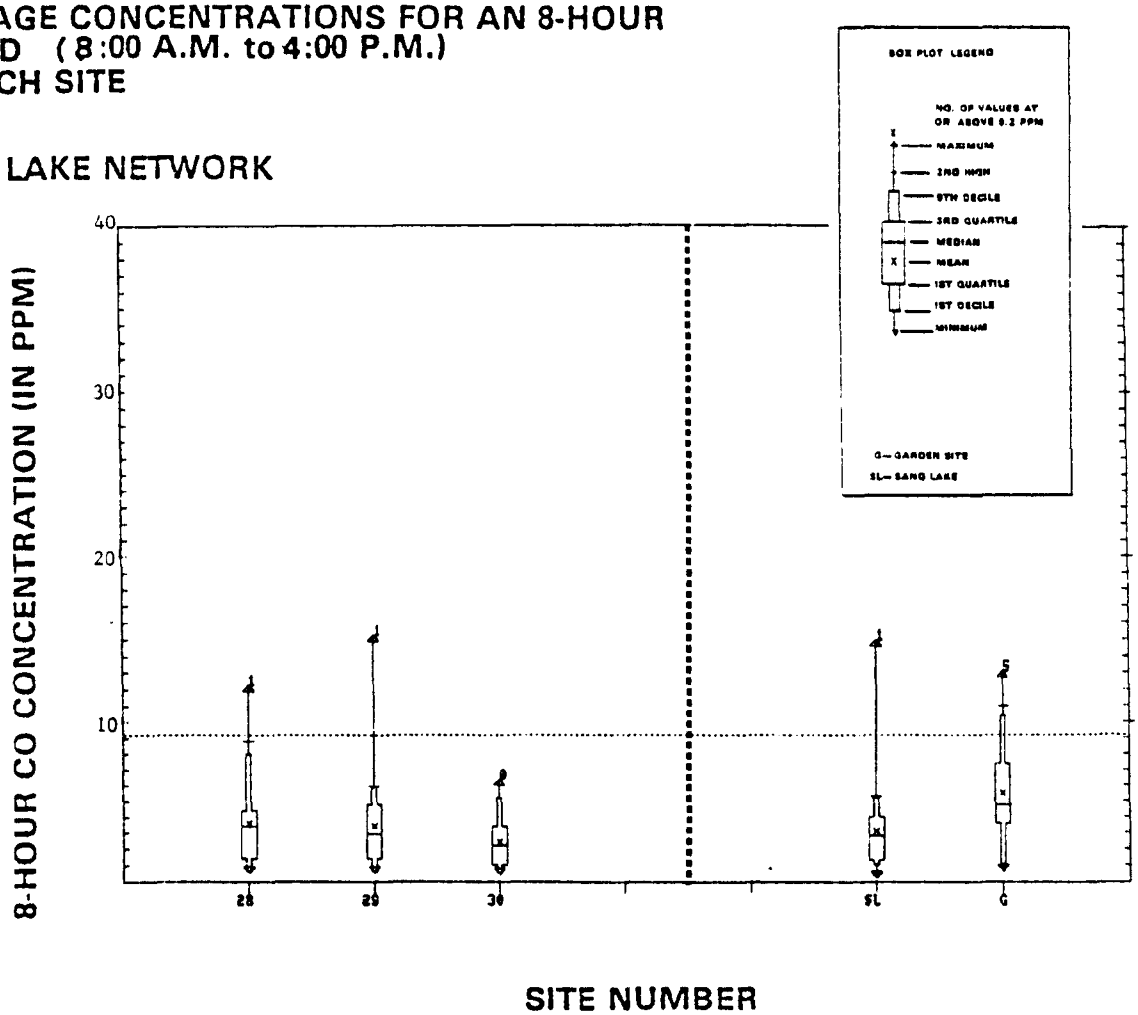
In addition to the Spenard grid sites, site 38, located in the neighborhood SW of the intersection of Spenard and Minnesota was included for comparison with the Spenard grid network.

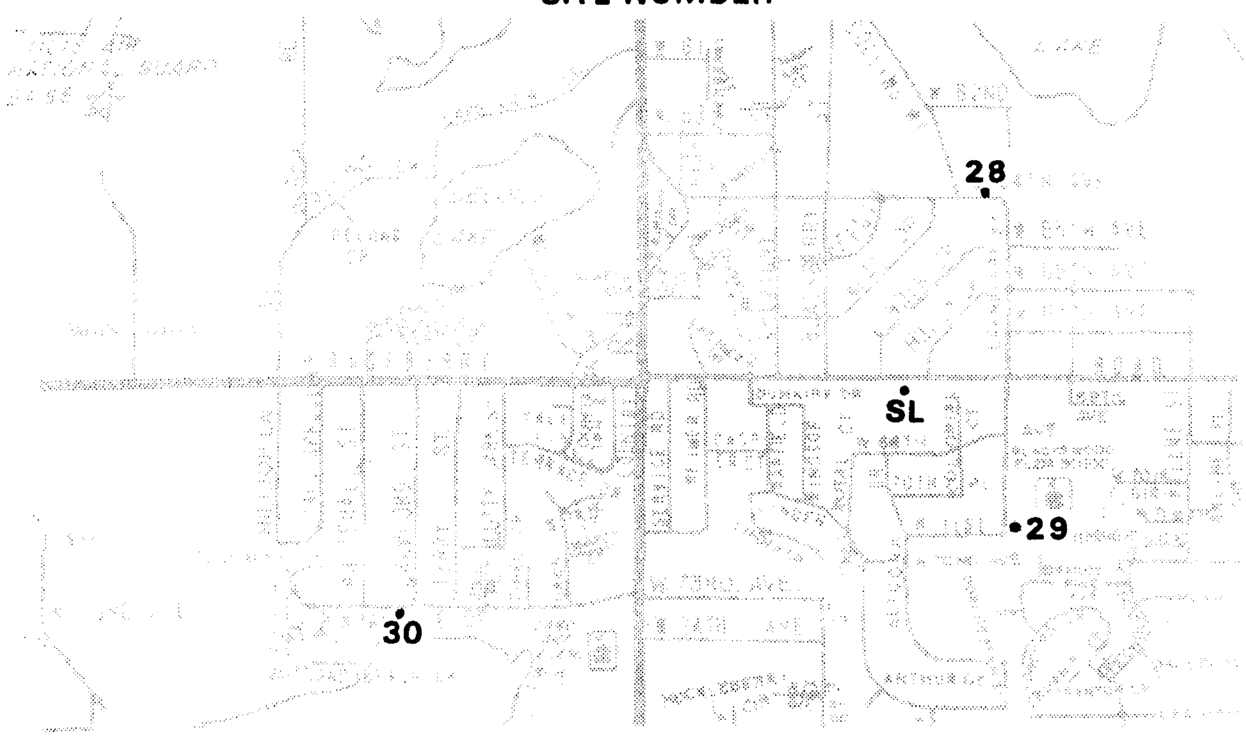
ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

FIGURE 16

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
AVERAGE CONCENTRATIONS FOR AN 8-HOUR PERIOD (8:00 A.M. to 4:00 P.M.)
AT EACH SITE

SAND LAKE NETWORK





Data arising from this network are displayed in Figure 17 and Table 12.

A. The Spenard permanent site had coefficients of correlation of 0.69, 0.86, and 0.80 with sites 201, 202, and 203 respectively, at slopes of 0.50, 0.59, and 0.72.

B. On an 8-hour block basis, the Spenard permanent site correlated at 0.72 with study site 204.

C. Site 202 correlated at 0.89 and 0.86 with sites 201 and 203 respectively, and with slopes of 1.00 and 1.12.

D. Site 201 correlated with site 203 at 0.83 with a slope of 1.10.

E. On an 8-hour block basis, site 204 correlated with sites 201, 202, and 203 at 0.80 or better with slopes indicating that it is on average between 15% to 28% higher.

F. On an 8-hour block basis, site 204 correlated at 0.85 with site 38, running 4% higher on average.

INTER-NETWORK COMPARISONS

Relationships of CO levels measured in areas spatially removed from each other were examined in order to characterize their distribution throughout the city. This kind of analysis can be difficult in that impacts may not be simultaneous over the entire breadth of the study area (city). A more exhaustive analysis towards accounting for any of these potential temporal shifts will be attempted when time allows.

Four-hour block data was used throughout the bulk of this analysis. Correlation/regression results are displayed in Table 12. Instances where it was necessary to use 8-hour block data (as with the Sand Lake samplers) are identified.

Because there was no integrated sampler collocated with the Garden permanent site, Garden data were used for comparisons with the integrated sites. However, it should be noted when reviewing these comparisons that there may be a small systematic difference in the sampling methodologies between the integrated and continuous sites with the latter perhaps 3% to 5% higher than the former on average (refer to Quality Assurance section).

Finally, all available data (including weekends) from the permanent sites were used in comparisons with each other.

Inter-Permanent Site Comparisons

A. Between the permanent sites, correlations ranged from 0.69 to 0.80.

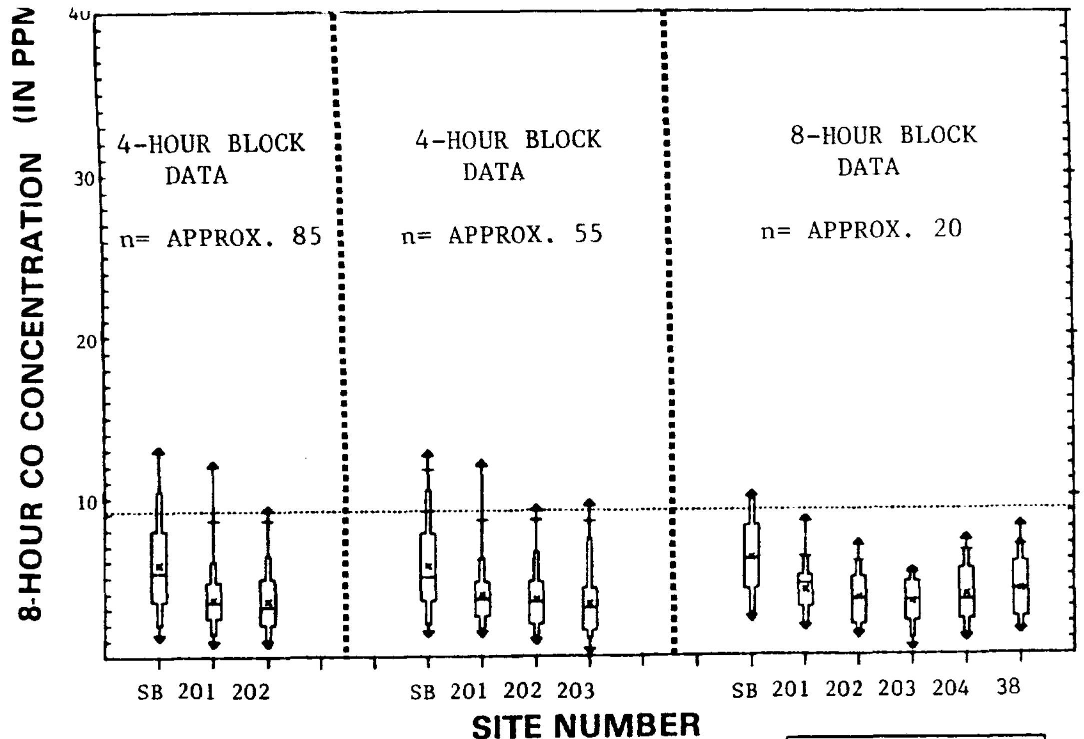
B. As indicated by the slope of the regression line, Spenard & Benson was 98% and 31% higher on average than the 7th & C and Sand Lake sites respectively, with intercepts of -0.62 and 1.10.

C. Spenard & Benson was 11% higher on average than the Garden site.

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE

SPENARD & BENSON NETWORK



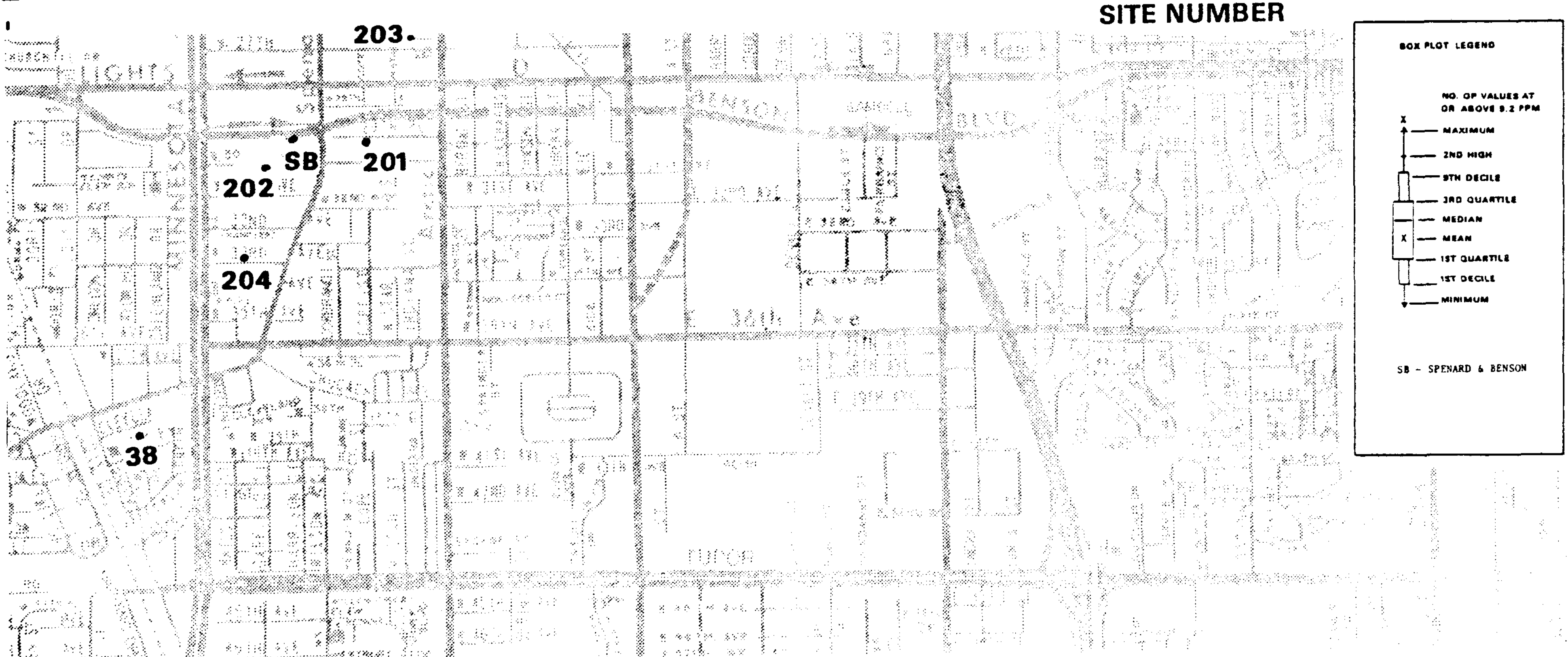


FIGURE 17

D. Garden was 87% and 73% higher on average than the 7th & C and Sand Lake sites respectively, with intercepts of -1.45 and 0.11.

E. Sand Lake was 9% higher on average than the 7th & C site, with an intercept of -1.00.

Permanent/Group 1 Site Comparisons (8-Hour Block Data)

F. The 7th & C and Spenard & Benson sites have been compared to Group 1 sites in a previous section.

G. The Garden site correlated at 0.80 or better with four other Group 1 sites (sites 19,21,24, and 26).

H. The Sand Lake site did not correlate at 0.80 or better with any Group 1 sites.

Permanent/Garden Network Comparison

I. The 7th & C, Spenard & Benson and Sand Lake permanent sites did not correlate at 0.75 or better with any Garden study site

Permanent/Sand Lake Network Comparison (8-Hour Block Data)

J. The 7th & C, Spenard & Benson, and Garden sites correlated at 0.74 to 0.80 with site 29 in the Sand Lake network. In addition, Spenard & Benson correlated at 0.87 with site 28 in the Sand Lake Network.

Permanent/Spenard & Benson Network Comparison

K. The 7th & C and Garden permanent sites correlated at 0.75 or better with five (sites 201,202, and 203 on a 4-hour block basis, and sites 204 and 38 on an 8-hour block basis), and one (site 202) sites respectively in the Spenard & Benson network. The Sand Lake site did not correlate with any Spenard network site at 0.75 or better.

Other Network to Network Comparisons

L. Sites 201 and 202 of the Spenard grid network correlated at 0.75 or better with one (site 103) and two (sites 102 and 103) sites respectively in the Garden network.

M. Twelve of eighteen Group 1 sites and no Group 2 sites correlated at 0.75 or better with site 38 (in the neighborhood adjoining Spenard and Minnesota).

Table 13 Correlation/Regression Results* for Permanent Sites

IND. SITE	DEP. SITE	CORRELATION	COEF.DETER.	NO.OF PAIRS	2-WAY REGRESSION EQ.			1-WAY REGRESSION EQ.		
7AC	SPBE	0.780	0.609	417.0	Y =	1.983X +	-0.616	Y =	1.351X +	1.227
7AC	GARD	0.751	0.565	434.0	Y =	1.866X +	-1.449	Y =	1.216X +	0.404
7AC	SDLK	0.692	0.479	410.0	Y =	1.095X +	-1.002	Y =	0.737X +	0.039
SPBE	GARD	0.737	0.543	422.0	Y =	0.904X +	-0.677	Y =	0.684X +	0.460
SPBE	SDLK	0.796	0.633	398.0	Y =	0.551X +	-0.609	Y =	0.491X +	-0.292
GARD	SDLK	0.703	0.494	416.0	Y =	0.578X +	-0.063	Y =	0.474X +	0.346

* - Reflects Data for Six 4-Hour Blocks per Day

QUALITY ASSURANCE

The number and diversity of study sampling regimes necessitated a comprehensive and highly coordinated approach to yield data of appropriate precision, accuracy, and completeness. As referenced previously, a rigorous quality assurance (QA) program was developed and applied to the study. An enormous body of quality assurance documentation was amassed during the study in support of data quality. This QA program was composed of three basic elements: sampling QA, analytical QA, and data handling QA to preserve both the integrity and completeness of the data.

Sampling QA

Explicit and routine field QA protocols were designed and implemented to ensure that samples being collected were both representative of ambient CO concentrations at the individual sampling sites and comparable in terms of quality to samples collected elsewhere in the study network. Measures of sampling performance are described below.

Sampling Precision

A pair of integrated samplers was collocated (within 2 meters) to quantify the extent of variability associated with the sampling method. The results in terms of 8-hour averages are described below:

A. Collocated samplers 9 and 10 correlated at 0.97 with a slope of nearly 1.0.

B. The mean difference between sites 9 and 10 was 0.0, with individual differences ranging from -0.9 to 1.6 ppm.

C. Eighty percent of the differences between sites 9 and 10 were within ± 0.6 ppm (leaving only two differences greater than ± 0.6 ppm: -0.9 ppm and 1.6 ppm).

Sampling Accuracy

Pairs of integrated samplers/permanent monitors and sequential sampler/permanent monitor were deployed in the study network. While in the traditional sense this was not a true audit of sampler accuracy since an absolute standard was not directly employed, it was assumed that data retrieved from the permanent monitors were of sufficiently higher or at least less variable quality that they were considered a "quasi" audit source. This also provided a measure of method comparability. The results are described below:

A. Collocated sites 11 and 7th & C correlated at 0.95 with the permanent site running about 3% higher on average than site 11.

B. Absolute differences between site 11 and 7th & C ranged from -1.1 ppm to 1.1 ppm.

C. Collocated sites 25 and Spenard correlated at 0.90 with the Spenard & Benson permanent site running about 5% higher on average (at an intercept of -1.52) than site 25.

D. Of the 43 total pairs of data resulting from the comparison of site 25 and the Spenard & Benson permanent site, differences ranged from -1.8 ppm to 4.8 ppm. Of these, 22 were within ± 1.3 ppm and 38 were within ± 2.6 ppm. Seventeen of the 21 differences greater than ± 1.3 ppm occurred when one or both members of the pair were less than 9.0 ppm.

(Because the variability exhibited by this particular pair of sites was greater than that of other collocated pairs, it became the object of further investigation towards accounting for the source of the variability. It is now thought that both sampling devices were operating within their normal respective limits and that the source of most of the few but large differences is attributable to site-specific peculiarities.)

E. Using 4-hour block data, collocated sites 105 and Garden correlated at 0.95 with the permanent site running 18% higher on average than 105 (a systematic dilution problem associated with the sequential method is suspected as the source of this offset).

Study Sampling Method Comparison

An integrated sampler and a sequential sampler were collocated to provide an index of the comparability of these two methods. Collocated sites 7 and 301 correlated at 0.90 with the integrated sampler (site 7) running about 12% higher on average than the sequential sampler (the same sequential dilution problem referenced in "C" above is suspected as the source of this difference).

Analytical QA

Analytical performance was continually monitored to ensure the integrity of the study data. Two measures of this analytical performance are described below.

Analytical Precision

The Beckman Model 866 CO analyzer used for analysis of bag samples was challenged 5 to 10 times daily with a precision atmosphere traceable to the National Bureau of Standards (NBS). Due to the limited availability of precision materials, the level of these precision checks varied from 12% to 36% of analyzer range. It should be noted that the precision confidence limits were computed using the percent difference of analyzer response to the known concentration of the precision atmosphere. As the proportional difference of a fixed absolute difference is greater for lower than higher concentrations, results from each precision level were considered individually. The results of these checks are described below.

A. For the 24 precision checks performed at the nominal 6 ppm level, the absolute differences ranged from -0.7 ppm to 0.3 ppm, with percent differences yielding an upper 95% confidence limit (CI) of 5.62 and a lower 95% CI of -5.48.

B. For the 84 precision checks performed at the nominal 9 ppm level, the absolute differences ranged from -0.7 ppm to 0.3 ppm, with percent differences yielding an upper 95% CI of 6.42 and a lower 95% CI of -2.20.

C. For the 102 precision checks performed at the 17 ppm level, the absolute differences ranged from -0.7 ppm to 0.3 ppm, with percent differences yielding an upper 95% CI of 2.31 and a lower 95% CI of -2.01.

Another routine measure of analytical precision was the re-analysis of a number of samples to ascertain the cumulative variability associated with the analytical protocol. The results of these checks are not presented here.

Analytical Accuracy

The CO analyzer was audited two times with test atmospheres traceable to NBS to evaluate its response to known and absolute concentrations of CO. The number of audits do not merit a statistical treatment of the resulting data. The results of these audits are summarized below:

A. The first audit (performed on January 5, 1983) indicated that the analyzer was reading between 2.0% and 4.4% high.

B. The second audit (performed on February 18, 1983) indicated that the analyzer was reading between 0.4% and 2.6% high.

Data Handling QA

The abundant amount of data arising from the study and the numerous manipulations it underwent created the potential for errors in transcription, processing, and computation. A rigorous program of routine checks was instituted towards identifying and correcting these errors. The results of this program will not be presented here. However, this program was extremely effective in minimizing and eliminating these errors.

Data Completeness

Data completeness is a function of two somewhat competing objectives: 1) maximizing the proportion of successfully collected samples relative to all sampling attempts while 2) preserving the fundamental and desired integrity of the data base. The stated objective of this study was to successfully capture valid data for 85% of the total attempts (validity criteria was defined in the study QA plan). Data recovery rates for each of the subject study sites are shown in Table 13.

Table 14 Valid Data Recovery Rates By Site

Group 1 Sites	"AM"* Data Recovery Rate (in percent)	"PM"** Data Recovery Rate (in percent)	8-Hour Data Recovery Rate (in percent)
1	85.2	96.3	81.5
5	96.3	85.2	83.3
6	92.6	88.9	83.3
7	81.5	94.4	75.9
8	90.7	79.6	77.8
9	98.1	87.0	85.2
11	92.6	92.6	85.2
12	96.3	88.9	85.2
13	96.3	94.4	92.6
15	81.5	88.9	74.1
18	90.7	96.3	90.7
19	92.6	75.9	70.4
20	96.3	90.7	90.7
21	94.4	88.9	85.2
24	90.7	90.7	81.5
25	96.3	87.0	85.2
26	96.3	92.6	90.7
27	90.7	94.4	85.2
Sand Lake Sites***			
28			85.7
29			85.7
30			82.1

* - 11:00 a.m. to 3:00 p.m.

** - 3:00 p.m. to 7:00 p.m.

*** - Reflects eight-hour interval of 8:00 a.m. to 4:00 p.m.