

# Spokane Carbon Monoxide Study

December 5, 1988  
to  
February 24, 1989

*June, 1990  
Air Monitoring and Analysis Section  
Environmental Protection Agency  
Region 10*

**SPOKANE CARBON MONOXIDE STUDY**

**DECEMBER 5, 1988**

**TO**

**FEBRUARY 24, 1989**

**PREPARED BY**

**JOHN C. PALMER  
U.S. ENVIRONMENTAL PROTECTION AGENCY**

**AND**

**JON W. SCHWEISS  
U.S. ENVIRONMENTAL PROTECTION AGENCY**

**June, 1990**

## ABSTRACT

An EPA/Ecology carbon monoxide (CO) study was conducted last winter in Spokane, Washington. The purpose of the study was to determine if the permanent monitoring stations appropriately characterize CO in Spokane. To do this, samples were collected and analyzed at approximately forty locations near heavily traveled streets on fifty-four weekdays. The CO values measured at these locations were compared to the data collected at the permanent monitors.

The results show that the permanent monitoring sites appropriately characterize CO in Spokane. The study data indicate the permanent Hamilton site adequately represents other areas of high ambient CO impact in Spokane. Although the Hamilton site may exceed the National Ambient Air Quality Standard (NAAQS) more frequently than other areas, it is not an isolated "hot-spot" CO problem area. The study revealed that other areas exhibit maximum CO levels near the same magnitude as those measured at the Hamilton Street site.

The areas with the highest measured CO levels were along Division, Hamilton, Broadway, and 3rd streets. All very heavy traffic corridors. The study also showed that the permanent monitors in the central business district (Post office and Liquor store sites) adequately characterizes CO levels downtown.

## ACKNOWLEDGEMENTS

The study was realized through a cooperative effort by the Washington Department of Ecology (Ecology) and the Environmental Protection Agency (EPA).

Ecology was primarily responsible for equipment installation, field sampling and sample analysis, and data validation. The EPA was primarily responsible for study design and report preparation.

## INTRODUCTION

Since the onset of continuous monitoring in 1976, a carbon monoxide (CO) problem has been identified with the city of Spokane. The city was declared in non-attainment of the State and Federal air quality standards for CO<sup>1</sup>. Maximum ambient concentrations at the permanent sites continue to exceed the level of the standard. Some uncertainty persists over the ability of these sites to characterize maximum CO impacts throughout Spokane. A special study was conceived by Ecology and the EPA to provide information relative to the magnitude and spatial distribution of CO in Spokane. This report presents the major results and conclusions from that study.

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<sup>1</sup> - The National Ambient Air Quality Standard (NAAQS) for CO is "... 9 parts per million (ppm) - maximum 8-hour concentration not to be exceeded more than once per year." (40 CFR Part 50)

## STUDY PURPOSE AND OBJECTIVES

The purpose of the special sampling study was to examine and establish, if possible, the magnitude and spatial and temporal aspects of ambient CO in Spokane. The immediate utility of the study information would be to assess whether the permanent sites provide an adequate profile of maximum CO levels in Spokane such that decisions to develop control strategies could proceed from a technically sound basis. If indicated, the study would also assist in relocating the permanent sites or adding additional monitors.

Explicit objectives were developed to ensure the fulfillment of the study purpose within the context of intervening time and resource constraints. The principal study objective was to assess maximum ambient CO impacts associated with mobile source emissions. Another important study objective was to provide for the retrieval of data possessing both high and demonstrable quality and statistically adequate quantity through the application of a rigorous quality assurance program.

## STUDY DESIGN

The study progressed through three functional phases: network design and siting, the sampling program, and data analyses. What follows are brief descriptions of each of these components.

### Network Design and Siting

Ambient concentrations of CO are a function of many contributing factors. For ambient CO dominated by mobile sources, the most important of these parameters seem to be traffic burden (expressed in both vehicle counts and traffic dynamics) and ventilation potential. The ultimate design of the CO study network was largely a product of considering these two features.

Ecology and EPA staff screened traffic data obtained from the City of Spokane to create a list of candidate intersections for subsequent assessment. The guiding criteria for developing this list were high cumulative traffic counts encountered at intersections. It was assumed that this cumulative count would grossly indicate traffic congestion, and presumably high ambient CO potential.

Upon completing this preliminary list of candidate sampling locations, EPA and Ecology staff physically inspected each intersection to examine peculiar traffic dynamics and the potential for meteorological confinement. All these factors were subjectively weighted with respect to their potential for inducing maximum CO concentrations. Problems posed by network logistics were also considered prior to selecting sites from the prioritized candidate list for inclusion in the actual study network. The Corridor study network is displayed in Figure 1 and described in Table 1, and the Central Business District (CBD) study network is displayed in Figure 2 and described in Table 2.

All samplers were sited in conformance with EPA's criteria for monitoring ambient CO.

### Sampling Program

This aspect of the study was composed of several individual elements: selection of study and sampling intervals, selection of sampling methods, field operations, and quality assurance. Each are briefly described below.

Ambient CO levels are typically cyclic in nature. CO levels vary on a seasonal and diurnal basis. In order to optimize the probability of sampling the phenomenon of interest (i.e. high CO concentrations), historical CO data from Spokane's permanent sites were reviewed. Historical data indicated that the season of greatest pollutant potential occurs between October and March. The months of December, January, and February were ultimately chosen for sampling.

FIGURE 1

SPOKANE CARBON MONOXIDE STUDY  
DECEMBER 5, 1988 TO FEBRUARY 24, 1989

LOCATION OF SAMPLING SITES  
CORRIDOR NETWORK

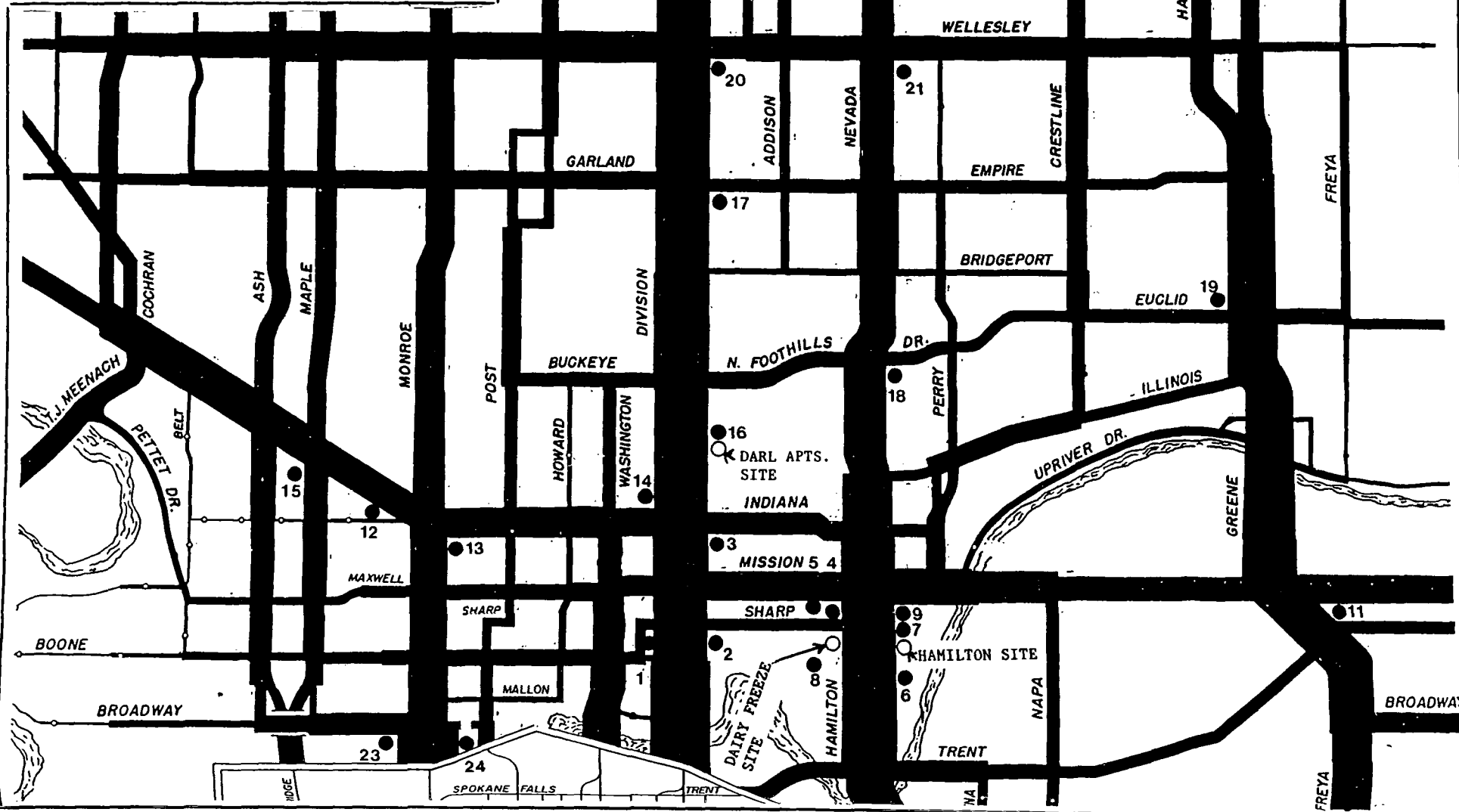




TABLE 1

SPOKANE CARBON MONOXIDE STUDY  
DECEMBER 5, 1988 TO FEBRUARY 24, 1989

## CORRIDOR NETWORK

SITE NUMBER	ADJACENT STREET	CROSS STREET	SIDE OF STREET	SPATIAL SCALE
1	Division	Sharp	SW	Micro
2*	Division	Sharp	SE	"
3	Division	Mission	SE	"
4	Hamilton	Sharp	NW	"
5	Mission	Hamilton	SW	"
6	Hamilton	Sharp	SE	"
7	Hamilton	Sinto	NE	Middle
8	Hamilton	Sharp	SW	"
9	Hamilton	Mission	SE	Micro
10**	Hamilton	Sharp	SW	"
11	Greene	Mission	SE	"
12	NW Blvd.	Monroe	SW	"
13	Monroe	Indiana	SE	"
14	Division	Indiana	NW	"
15	Maple	NW Blvd.	SW	"
16***	Division	Jackson	SE	Middle
17	Division	S Bridgeport	SE	Micro
18	Hamilton	N Foothill Dr	SE	"
19	Market (Greene)	Euclid	NW	"
20	Division	Wellesley	SE	"
21	Nevada (Hamilton)	Wellesley	SE	"
22	Francis	Division	SW	"
23	Broadway	Monroe	SW	"
24	Monroe	Broadway	SE	"
HAM	Hamilton	Sharp	SE	Micro
DFE	Hamilton	Sharp	SW	"
DAR	Division	Jackson	SE	Middle

\* - Precision Sampling Location

\*\* - Collocated with Dairy Freeze (DFE) continuous analyzer

\*\*\* - Collocated with Darl Apts. (DAR) continuous analyzer

HAM - Hamilton Site (official Ecology site)

DFE - Dairy Freeze Site (Ecology special study site)

DAR - Darl Apts. Site (official Ecology site)

FIGURE 2

SPOKANE CARBON MONOXIDE STUDY  
DECEMBER 5, 1988 TO FEBRUARY 24, 1989

LOCATION OF SAMPLING SITES  
CENTRAL BUSINESS DISTRICT NETWORK

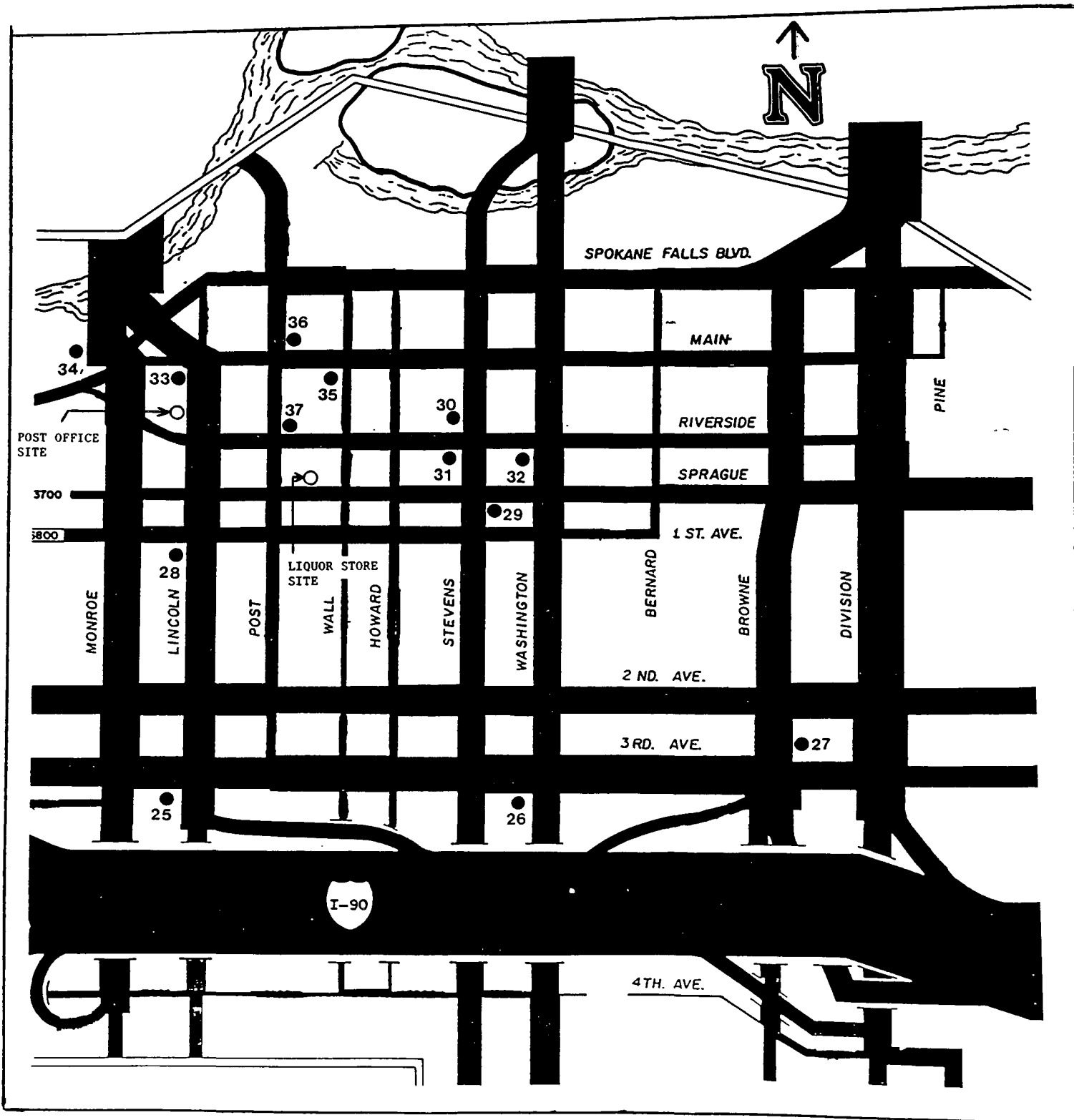


TABLE 2

SPOKANE CARBON MONOXIDE STUDY  
DECEMBER 5, 1988 TO FEBRUARY 24, 1989

## CENTRAL BUSINESS DISTRICT NETWORK

SITE NUMBER	ADJACENT STREET	CROSS STREET	SIDE OF STREET	SPATIAL SCALE
25	3rd	Lincoln	NW	Micro
26	3rd	Washington	SW	"
27	Browne	3rd	NE	"
28	Lincoln	1st Ave	SW	"
29	Sprague	Stevens	SE	"
30	Stevens	Riverside	NW	"
31	Riverside	Stevens	SW	"
32	Riverside	Washington	SW	"
33*	Lincoln	Main	SW	"
34	Monroe	Main	NW	"
35	Main	Wall	SW	"
36	Post	Main	NE	"
37	Riverside	Post	NE	"
LIQ	Sprague	Post	NE	Middle
POS	Lincoln	Riverside	NW	"

\* - Precision Sampling Location

LIQ - Liquor Store Site (official Ecology site)

POS - Post Office Site (official Ecology site)

Analysis of the historical CO data also indicated that CO levels were generally higher on weekdays than on weekends and that the eight-hour daily maximum CO value was most frequently recorded during the 11:00 A.M. to 7:00 P.M. interval. Consequently, samples were collected weekdays over this eight-hour period.

Integrated bag samplers were employed in the study. Simple and rugged in design, this sampler collected an ambient air sample pumped at a constant rate over 8 hours into a single polyethylene bag. Bag samples were analyzed by a Dasibi Model 3003 analyzer (an EPA-designated reference method) to yield an 'average' CO concentration over the 8-hour sampling period.

In addition to the bag samplers, a temporary continuous analyzer was established adjacent to the Dairy Freeze restaurant at the intersection of Hamilton and Sharp (located directly across the street from the permanent Hamilton monitor). The data from this continuous analyzer (hereinafter denoted as 'DFE') and the Darl Apts. site (denoted as 'DAR') were utilized for method comparison (see Quality Assurance). Study sites 10 and 16 were collocated with the Dairy Freeze site and the Darl Apts. site, respectively.

Study sampling was performed by Ecology. The scope and nature of activities are detailed in the project quality assurance plan.

A comprehensive and rigorous quality assurance program was developed and ordered to the study to ensure that resultant data were of known and appropriate quality, representativeness, completeness, and comparability. This program provided for routine measures of both sampling and analytical performance.

### Data Analyses

Discussions of the types of data analyses undertaken appear in the Results and Discussion section.

## LIMITATIONS

Studies of this sort 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 limitations have been identified with this study:

1) Conditions inducing high levels of ambient CO are typically so infrequent that studies of limited duration run the risk of missing the rather rare phenomena of interest. Further, the statistical population of sample data in the range of interest is really marginal to examine inter-site relationships of this type in an absolutely definitive fashion. Finally, even minor data gaps in a short duration study like this can severely impair inter-site and 'seasonal' characterizations, again because the phenomena of interest are relatively rare.

Data collected from the permanent sites over the 1989-90 winter season indicate the study period did encompass the major air stagnation episodes of the season. However, historical data from the permanent sites indicate that CO levels during the 1989-90 winter season were low relative to past years.

2) The number of intersections identified in the network design exercise as possessing CO potential far outstripped the number of samplers available to the study. The reader should note that the study sites portrayed herein do not represent the entire array of intersections thought to possess potential. Also, because of the limited number of study sites, the proportion of relatively higher impact sites to lower impact sites is not necessarily characteristic of the severity of CO levels occurring throughout the area.

3) In a similar vein, there are often substantial uncertainties associated with siting microscale samplers to measure maximum concentrations. Because high CO levels can be a highly localized phenomenon, particularly when considered over micro-spatial scales, there is a relatively low theoretical probability of effectively weighing contributing factors towards selecting the particular leg, and then the particular side of the leg where maximum concentrations are most likely to occur.

4) The study data were generated using sampling methods (integrated bag samplers) not approved by EPA for use as the primary basis for NAAQS attainment determinations or the definitive demonstration of control strategy effectiveness. However, these methods have been proven to be excellent indicators of absolute ambient CO concentrations.

## RESULTS AND DISCUSSION

Data were analyzed for the relative magnitude of CO concentrations reported at various sites throughout Spokane. Intersite comparisons between the study sites and the permanent sites were made.

Data were summarized for each site in the corridor and central business district networks, and for each day over all sites in each of the respective networks. Summary statistics are primarily depicted in the form of tables and box-plots. The box plots portray the distribution of subject data as follows: maximum value, 2nd maximum, 9th decile, 3rd quartile, mean, median, 1st quartile, 1st decile, minimum value. Also included in the summary plots are the number of instances the eight-hour NAAQS was exceeded.

### Study Long Network Statistics

As discussed earlier, CO levels vary considerably across monitoring sites on a day-to-day basis. Examining data over the entire study interval recognizes and dampens this possible volatility in daily inter-site relationships. Study-long data are displayed for each of the study sites from the corridor network (including the continuous Hamilton ('HAM'), Darl Apts. ('DAR'), and Dairy Freeze ('DFE') sites) in Figure 3 and Tables 3 and 5. Study-long data for the study sites from the central business district network (including data from the continuous Post Office ('POS'), Liquor Store ('LIQ'), and Hamilton ('HAM') sites) are displayed in Figure 4 and Tables 4 and 6. EPA reference data (not bag sampling data) are reported for the continuous sites. What follows are brief descriptions of data features of particular interest.

#### Maximum-Eight-Hour-Averages

Even though the NAAQS is directed to second-high 8-hour averages (on an annual basis), maximum averages are an appropriate focus for a short-duration study such as this.

##### Corridor Network-

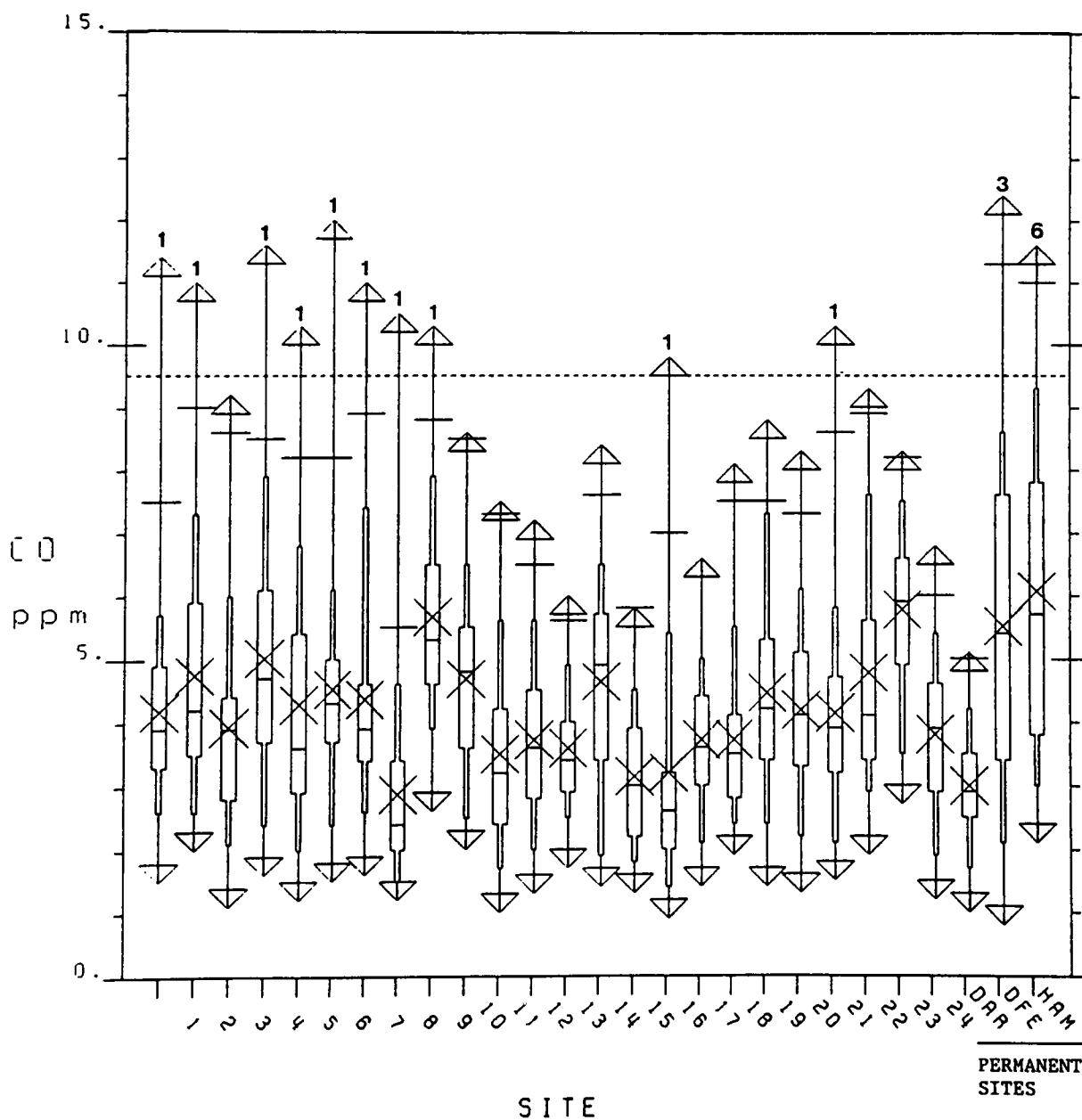
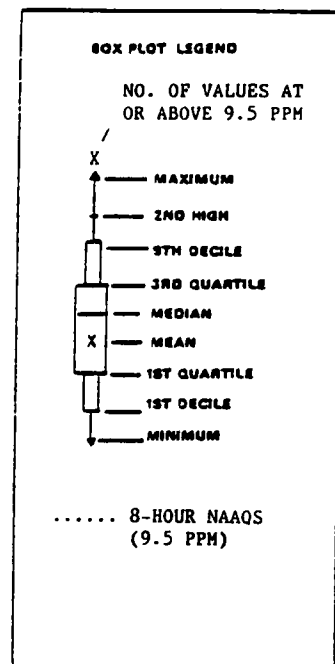
A. Eight-hour maximums from the corridor study sites ranged from 5.8 ppm (site 15) to 12.0 ppm (site 6).

B. Eight-hour maximums recorded at the permanent Hamilton, Darl Apts., and Dairy Freeze sites were 11.6 ppm, 5.1 ppm, and 12.4 ppm, respectively.

##### Central Business District Network-

A. Eight-hour maximums from the CBD study sites ranged from 5.0 ppm (site 37) to 13.6 ppm (site 26).

8-HR PERIOD (11:00 A.M. TO 7:00 P.M.)



### SUMMARY OF 8-HOUR SPOKANE STUDY DATA

DATE	SITE													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12-05-88	5.7	2.9	6.2	4.7	6.5	5.2	4.3	3.4	3.7	-999	5.1	3.9	4.9	5.0
12-06-88	3.7	3.6	9.2	3.8	3.6	12.0	4.6	1.8	6.8	-999	3.7	2.6	3.8	3.5
12-07-88	2.7	4.1	2.6	2.4	3.3	3.3	3.1	2.2	8.0	-999	2.7	3.4	4.3	2.9
12-08-88	6.5	4.3	1.1	8.5	6.5	5.3	4.7	4.0	7.9	-999	2.7	4.5	2.9	5.2
12-09-88	3.8	4.2	2.5	4.1	3.8	4.7	4.8	4.7	4.8	-999	3.2	3.6	4.9	4.9
12-12-88	4.0	5.0	2.2	3.5	6.8	4.2	3.8	2.5	8.2	-999	3.5	6.5	-999	2.6
12-13-88	3.4	3.8	2.7	2.2	2.3	3.5	3.9	1.9	4.0	-999	2.2	2.7	2.1	1.7
12-14-88	5.4	6.3	4.5	5.8	8.0	6.1	8.2	5.5	5.8	-999	4.1	7.2	4.8	4.6
12-15-88	11.4	11.0	5.6	8.0	10.3	7.3	6.0	10.5	10.3	-999	7.3	5.3	6.0	6.0
12-16-88	7.5	7.3	5.0	8.5	7.1	-999	11.0	-999	7.4	-999	6.5	6.0	5.6	6.5
12-19-88	3.0	4.8	3.5	2.8	3.0	2.0	4.0	1.8	6.8	-999	4.5	2.9	3.4	3.3
12-20-88	5.4	8.3	5.5	7.0	7.4	4.6	3.4	3.5	5.1	-999	4.2	5.6	3.0	5.5
12-21-88	5.3	5.8	3.9	4.4	-999	4.8	4.5	2.3	8.8	3.5	3.3	4.3	4.0	5.8
12-22-88	4.3	9.0	4.3	2.1	6.0	4.3	2.8	2.8	5.0	6.0	6.3	3.6	3.3	1.4
12-23-88	4.5	5.0	4.0	4.0	3.4	4.3	4.1	2.3	6.3	4.8	2.9	3.0	3.6	6.5
12-27-88	5.1	8.1	3.0	4.8	5.0	3.8	3.5	3.3	5.0	5.5	3.0	4.1	4.5	4.3
12-28-88	3.4	4.1	2.8	3.9	4.5	2.1	4.1	1.9	3.9	2.1	3.6	2.0	2.9	4.5
12-29-88	2.8	3.0	4.1	6.1	3.5	4.0	3.4	3.0	5.8	5.3	2.5	4.4	3.5	6.8
12-30-88	3.9	4.0	3.8	5.7	2.4	1.9	2.6	2.1	4.7	2.1	1.9	2.8	2.8	7.6
01-03-89	1.9	2.0	2.1	5.8	2.8	3.5	3.9	3.0	3.8	3.8	2.6	3.1	2.5	6.3
01-04-89	5.1	2.9	4.0	5.4	4.3	5.0	4.5	2.0	6.7	5.4	2.1	3.5	3.8	-999
01-05-89	3.5	3.8	3.1	2.1	3.6	4.1	3.6	2.1	5.5	4.0	3.2	3.1	3.4	1.9
01-06-89	3.4	3.5	-999	4.1	2.1	3.9	4.0	1.6	6.4	4.2	3.9	2.9	2.8	-999
01-09-89	3.5	4.6	3.0	4.6	3.6	4.6	3.5	3.2	4.8	3.8	3.8	4.0	4.0	3.6
01-10-89	4.0	2.9	4.4	4.8	3.5	4.1	3.7	2.6	5.2	2.5	2.6	2.4	3.0	3.1
01-11-89	3.6	4.0	4.4	3.5	3.0	4.7	4.5	2.6	5.8	3.9	2.4	2.9	4.0	6.7
01-12-89	4.4	3.7	2.6	6.6	3.0	3.7	3.6	2.4	4.9	3.7	2.9	3.4	4.0	6.1
01-13-89	2.6	3.2	4.0	3.0	1.2	3.0	2.8	1.2	4.2	2.0	3.2	1.9	2.5	3.4
01-17-89	3.2	2.5	2.9	4.1	2.0	3.9	3.5	1.5	5.5	2.5	2.7	1.6	2.9	2.9
01-18-89	3.3	2.6	4.0	2.9	2.8	2.6	2.4	1.9	3.1	3.2	1.7	1.4	2.9	2.6
01-19-89	4.9	4.8	4.7	4.6	6.5	4.9	3.3	3.6	5.4	4.9	2.4</			



TABLE 3 (con't)

(DAR:Darl Apts., DFE:Dairy Freeze, HAM:Hamilton Street)

DATE	SITE												
	15	16	17	18	19	20	21	22	23	24	DAR	DFE	HAM
12-05-88	3.9	-999	4.4	4.7	-999	5.4	4.8	3.8	-999	4.9	2.6	7.6	9.8
12-06-88	2.8	-999	3.8	4.5	3.4	4.2	3.9	3.6	4.7	4.0	3.0	3.7	7.9
12-07-88	2.7	-999	2.8	3.9	4.6	4.6	4.7	2.9	3.3	3.9	3.2	3.5	9.3
12-08-88	5.2	-999	4.4	4.3	3.1	3.8	3.2	3.2	7.2	4.5	4.9	12.4	6.3
12-09-88	3.9	-999	3.6	3.3	3.9	4.1	4.3	3.4	5.0	4.1	2.0	9.1	9.6
12-12-88	3.0	-999	3.5	2.4	2.0	1.6	1.7	3.0	3.5	1.2	4.1	8.6	11.0
12-13-88	1.9	-999	3.1	2.7	3.4	2.9	3.6	2.0	5.3	1.8	1.7	0.8	2.7
12-14-88	4.1	-999	4.0	7.5	5.0	4.5	4.1	5.9	5.0	5.0	2.9	7.6	8.4
12-15-88	5.8	-999	6.3	5.5	7.0	8.3	10.3	9.3	6.0	6.8	5.1	8.2	11.6
12-16-88	5.2	-999	4.7	5.0	7.3	7.3	5.5	7.3	8.3	6.0	3.7	11.3	9.6
12-19-88	2.5	-999	4.9	2.8	3.0	3.3	4.1	2.5	4.9	3.2	4.0	3.1	5.3
12-20-88	3.0	-999	3.8	3.4	4.6	4.4	4.5	8.0	7.7	4.4	3.0	8.9	7.7
12-21-88	3.0	-999	5.6	3.9	6.0	3.6	-3.5	3.4	4.9	5.0	-999	7.6	6.6
12-22-88	5.0	-999	3.0	3.5	2.3	3.5	4.3	5.0	7.3	4.0	2.9	9.2	5.8
12-23-88	3.6	-999	4.3	3.6	7.5	4.4	3.6	4.6	6.3	3.4	5.0	5.4	3.8
12-27-88	4.1	-999	2.4	3.5	3.8	2.5	3.5	8.8	5.8	3.4	2.7	7.9	8.3
12-28-88	2.1	-999	3.7	3.8	2.9	4.0	8.6	3.9	5.5	2.9	3.3	3.2	3.1
12-29-88	2.1	-999	3.5	3.3	3.5	5.1	3.8	6.6	7.1	4.3	3.7	7.3	4.6
12-30-88	2.2	-999	5.0	3.2	4.2	3.3	3.8	6.4	7.9	3.1	4.2	4.5	3.1
01-03-89	2.5	-999	2.4	3.5	5.0	1.6	2.0	6.0	5.9	2.5	2.7	4.5	2.6
01-04-89	4.4	-999	4.1	4.1	7.4	4.6	3.9	2.9	6.3	3.9	3.5	7.0	5.5
01-05-89	3.1	-999	3.6	3.4	4.1	5.0	3.5	4.1	2.7	3.5	2.5	1.0	5.0
01-06-89	2.1	-999	4.4	3.0	5.6	6.5	5.2	2.5	3.7	3.4	4.1	3.8	5.7
01-09-89	3.0	-999	3.9	3.4	3.0	2.6	3.6	3.6	6.6	5.0	2.8	7.8	9.0
01-10-89	2.6	3.1	3.6	2.8	5.8	4.3	2.9	4.1	5.5	4.1	3.7	5.4	5.2
01-11-89	2.2	3.1	4.6	4.0	4.4	6.6	4.5	3.2	6.0	4.9	3.4	3.5	4.5
01-12-89	2.5	1.0	3.3	2.6	7.5	3.1	3.0	3.7	6.4	3.5	3.0	4.9	3.0
01-13-89	1.6	2.6	2.8	2.2	-999	1.9	2.8	3.4	6.9	1.9	2.5	1.6	3.3
01-17-89	2.2	3.1	2.9	2.4	3.2	2.2	2.7	4.1	7.5	3.3	2.7	3.4	3.6
01-18-89	1.9	1.9	2.1	2.7	2.4	3.4	2.1	1.9	4.9	1.9	2.0	0.9	3.5
01-19-89	2.7	2.6	3.5	3.8	3.4	3.9	4.5	4.7	6.1	4.9	2.9	7.3	8.2
01-20-89	3.6	7.0	4.3	4.6	4.9	5.3	4.9	6.5	6.2	5.5	4.2	6.1	7.8
01-23-89	1.8	3.0	3.5	3.5	3.8	4.5	4.3	3.9	5.7	3.2	3.2	3.4	3.6
01-24-89	2.4	2.5	3.4	2.9	5.5	3.8	3.6	4.0	6.0	4.1	3.0	4.2	3.2
01-25-89	2.5	2.7	2.5	2.1	7.3	4.0	2.0	5.4	6.1	3.6	1.9	6.0	3.0
01-26-89	3.7	2.0	3.6	2.6	8.8	3.6	3.1	5.6	7.2	2.6	2.4	7.2	5.1
01-27-89	3.0	2.3	3.3	2.0	5.3	4.6	4.2	7.6	5.2	3.4	2.6	4.7	5.6
01-30-89	1.3	1.5	1.8	1.9	3.1	2.3	4.3	3.8	6.7	2.6	1.5	1.6	2.1
01-31-89	1.4	1.7	1.5	-999	1.5	3.6	2.3	3.1	3.9	2.2	2.1	2.3	5.3
02-01-89	1.4	0.9	-999	2.4	1.4	1.3	1.5	-999	2.8	1.4	1.1	2.1	4.5
02-02-89	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	1.2	2.3	4.5
02-03-89	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	1.0	2.3	4.7
02-06-89	2.6	2.2	3.9	3.4	4.1	5.0	3.8	-999	3.0	4.4	3.5	6.7	7.6
02-07-89	3.6	4.6	4.4	4.1	5.2	5.2	6.7	6.8	5.6	2.7	4.2	5.7	8.2
02-08-89	4.5	5.4	4.3	6.0	4.0	6.1	5.8	7.6	6.0	5.0	3.6	8.5	7.8
02-09-89	5.8	9.8	3.4	8.1	4.2	6.2	7.2	8.9	5.7	4.6	3.5	7.8	7.2
02-10-89	3.9	3.6	5.1	5.5	4.1	5.9	4.9	5.1	6.6	6.0	3.5	7.2	9.9
02-13-89	2.9	2.3	4.9	3.7	3.4	5.8	4.1	4.0	5.7	3.8	2.9	4.4	6.4
02-14-89	3.4	4.7	5.0	5.5	4.5	5.2	5.8	5.0	5.7	5.6	4.1	5.3	8.5
02-15-89	3.3	2.9	3.6	3.6	5.6	3.9	4.7	5.6	8.2	4.5	2.7	6.0	2.8
02-16-89	3.0	2.5	1.7	4.7	5.3	4.8	3.7	5.6	4.9	2.1	1.7	3.7	7.7
02-17-89	3.7	1.4	1.4	2.8	3.2	2.2	3.4	4.1	4.0	2.2	1.6	5.2	5.9
02-21-89	4.3	-999	6.6	4.2	4.3	3.6	5.3	5.0	8.0	5.4	2.4	9.5	7.6
02-22-89	3.7	6.1	3.0	3.7	4.0	3.3	2.9	4.0	6.5	4.3	2.5	6.3	6.3
02-23-89	3.9	3.2	4.0	3.6	4.3	5.1	3.8	4.1	6.1	3.3	2.9	6.7	4.8
02-24-89	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	3.3	2.5	6.0

FIGURE 4

SPOKANE CARBON MONOXIDE STUDY

CENTRAL BUSINESS DISTRICT SITES  
 SAMPLED WEEKDAYS FROM 12/5/88 - 2/24/89  
 (Nominally Reflects 56 Sample days)

COMPOSITE OF CO CONCENTRATIONS  
 MEASURED AT EACH SITE DURING AN  
 8-HR PERIOD (11:00 A.M. TO 7:00 P.M.)

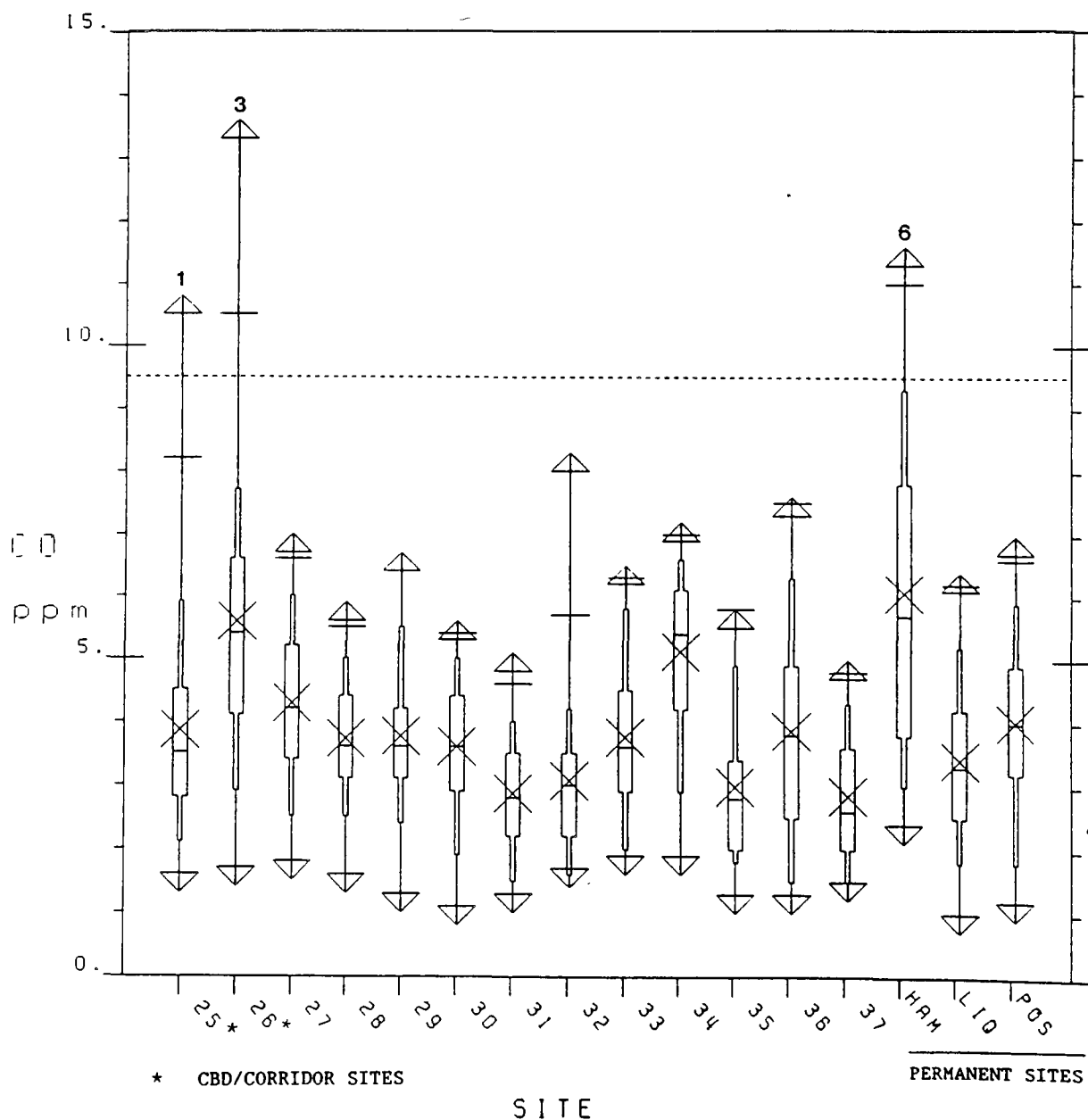
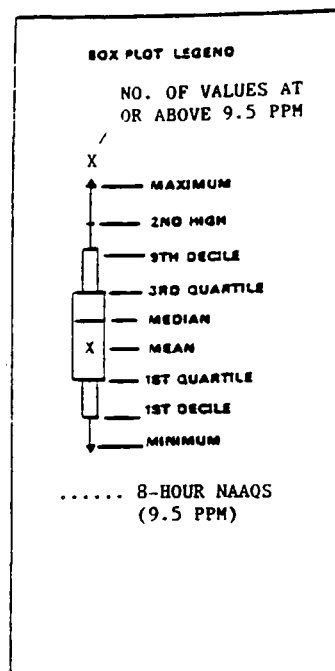


TABLE 4

## SUMMARY OF 8-HOUR SPOKANE STUDY DATA

CENTRAL BUSINESS DISTRICT SITES  
(INCLUDING DATA FROM THE PERMANENT SITES)

(LIQ:Liquor Store, POS:Post Office)

DATE	SITE														
	25	26	27	28	29	30	31	32	33	34	35	36	37	LIQ	POS
12-05-88	3.5	4.7	4.6	4.5	4.2	3.9	3.3	3.2	4.2	5.5	2.6	5.3	3.6	4.4	4.3
12-06-88	3.7	3.5	3.0	3.0	3.0	3.0	2.8	3.0	3.8	3.8	3.2	3.4	2.8	2.9	4.8
12-07-88	3.2	-999	3.4	3.8	4.4	4.4	2.2	3.0	4.6	4.6	1.5	2.2	2.6	2.9	5.1
12-08-88	4.5	5.0	4.8	4.0	4.3	5.0	3.9	4.0	4.6	5.0	2.2	4.7	2.2	5.9	7.0
12-09-88	5.2	5.5	3.4	5.4	5.4	5.0	5.1	5.2	2.6	5.8	5.8	7.5	4.4	4.0	3.6
12-12-88	4.6	3.2	2.8	4.9	5.5	1.9	2.6	4.0	3.8	6.0	3.7	5.5	4.2	6.0	6.6
12-13-88	2.1	3.4	2.2	3.3	2.6	1.6	2.4	2.4	2.1	2.0	2.0	1.4	1.5	0.8	2.0
12-14-88	3.2	4.6	3.5	4.1	4.1	4.1	3.2	2.5	4.6	4.2	3.2	5.8	3.5	3.7	4.0
12-15-88	5.4	10.5	6.3	5.0	5.8	5.6	4.2	4.5	6.5	7.0	5.8	5.5	5.0	5.2	6.3
12-16-88	4.6	5.3	4.8	4.5	5.6	4.5	4.0	3.3	6.3	5.8	5.5	7.3	4.5	5.8	6.0
12-19-88	3.0	5.1	2.5	4.0	3.3	3.9	2.9	3.4	4.3	3.0	3.1	1.6	2.6	2.3	4.9
12-20-88	3.6	4.4	4.2	3.0	3.4	3.4	2.6	2.2	3.0	5.1	2.0	7.6	4.6	4.2	3.8
12-21-88	3.9	4.8	4.2	3.4	3.3	5.4	3.6	3.4	2.0	6.8	4.4	3.4	2.2	3.7	5.8
12-22-88	4.9	4.2	3.4	3.1	3.4	3.6	3.4	2.2	3.0	5.3	4.5	6.4	4.1	4.3	4.3
12-23-88	3.5	5.2	4.0	3.6	3.4	5.0	3.6	3.4	3.5	6.1	4.9	3.6	2.1	2.7	4.6
12-27-88	4.4	4.0	3.6	3.1	3.4	-999	3.8	1.6	3.2	4.0	2.0	6.0	2.0	4.1	3.2
12-28-88	3.0	5.6	5.2	3.0	3.5	3.5	1.5	2.6	4.2	6.2	3.5	3.2	2.0	2.4	3.2
12-29-88	4.0	-999	6.6	-999	4.0	5.0	4.0	4.0	-999	5.5	5.8	4.0	2.0	5.3	5.7
12-30-88	2.6	7.1	5.0	3.0	2.0	3.8	2.4	2.2	2.9	4.4	2.4	3.0	1.2	2.9	3.0
01-03-89	2.6	7.1	4.7	2.8	2.4	3.0	2.2	1.6	3.2	4.6	2.9	2.6	1.4	2.5	2.7
01-04-89	4.3	10.0	5.9	3.2	3.5	5.0	3.3	3.0	3.4	5.7	2.5	3.4	1.9	3.9	4.5
01-05-89	2.8	5.0	2.6	4.6	3.1	2.4	2.6	2.8	2.8	7.0	3.0	1.5	2.4	3.0	4.0
01-06-89	3.1	7.4	3.5	3.2	4.0	3.8	3.2	3.0	4.7	5.0	2.5	2.5	-999	3.5	5.5
01-09-89	2.9	5.4	3.0	3.6	3.7	2.0	2.1	2.9	4.1	5.4	2.0	4.2	2.5	4.3	4.4
01-10-89	2.6	5.8	3.3	2.5	3.0	2.8	2.5	3.6	3.2	4.0	2.5	2.0	1.6	2.8	4.8
01-11-89	3.4	6.6	4.1	3.8	3.8	5.0	3.6	3.5	4.0	6.5	3.5	3.0	3.0	1.8	4.5
01-12-89	3.2	7.2	5.8	4.2	3.4	4.7	3.4	3.2	4.6	6.2	3.6	4.0	3.0	2.9	5.2
01-13-89	2.1	3.8	2.9	2.5	2.4	1.8	1.5	1.6	2.3	4.6	1.8	1.6	1.6	1.1	2.3
01-17-89	2.8	5.0	3.5	3.2	3.3	3.1	2.1	1.8	3.6	5.6	2.6	2.2	1.5	1.9	3.0
01-18-89	1.8	2.9	2.2	3.0	2.4	1.8	1.1	1.4	1.9	4.4	1.8	1.6	1.2	0.7	1.9
01-19-89	3.5	3.9	3.4	3.9	3.2	3.2	2.4	1.8	3.2	4.2	2.0	4.8	3.1	3.3	3.2
01-20-89	5.0	6.9	5.7	5.0	5.6	4.7	3.7	3.3	5.3	6.6	3.1	5.1	3.9	4.2	5.8
01-23-89	2.5	6.6	5.6	4.2	3.6	3.3	2.7	3.5	4.0	6.6	2.0	2.5	4.0	2.2	3.7
01-24-89	2.1	6.0	5.0	3.3	3.8	4.2	2.6	2.7	3.4	5.6	3.3	3.3	3.1	3.7	3.3
01-25-89	6.6	7.7	5.0	3.4	3.7	4.3	3.2	2.1	3.2	6.0	3.4	4.2	-999	3.3	3.3
01-26-89	3.4	4.1	6.0	3.4	3.6	3.8	3.2	8.3	2.5	2.5	2.2	3.9	-999	3.8	3.7
01-27-89	3.5	5.9	5.6	3.9	5.5	4.1	2.8	4.7	3.5	6.9	3.2	3.8	2.4	3.5	3.8
01-30-89	1.8	5.9	3.8	2.5	2.0	2.0	1.6	1.6	2.2	3.6	2.0	1.2	-999	1.2	1.5
01-31-89	1.7	1.5	2.0	3.4	3.1	2.1	1.3	-999	2.0	4.1	1.2	1.4	2.1	2.6	3.4
02-01-89	1.3	1.4	1.5	1.3	1.0	0.8	1.0	-999	-999	1.6	1.0	-999	1.5	1.9	1.0
02-02-89	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	2.0	0.9
02-03-89	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	2.2	1.0
02-06-89	3.5	6.0	4.2	4.2	4.4	3.6	3.5	3.5	6.0	5.2	2.5	3.6	3.6	4.4	6.3
02-07-89	8.2	6.6	7.0	4.6	4.2	4.2	4.6	3.4	5.8	6.0	3.0	5.0	3.4	4.5	5.9
02-08-89	5.9	13.6	4.2	5.5	6.7	4.4	3.5	5.7	5.4	5.8	5.4	6.3	4.3	6.2	4.9
02-09-89	10.8	6.0	5.2	5.2	4.6	3.2	3.4	2.8	4.0	6.4	2.8	6.6	3.8	6.4	4.5
02-10-89	5.2	7.9	5.9	5.5	6.4	4.4	4.0	3.8	6.1	7.2	2.9	4.5	4.8	5.1	5.9
02-13-89	-999	7.2	4.2	4.4	3.9	3.4	2.6	3.5	4.5	5.8	3.0	3.6	2.5	3.2	4.4
02-14-89	3.4	5.4	3.0	5.9	4.6	5.4	2.9	3.6	5.9	5.5	3.0	3.8	3.6	5.2	6.1
02-15-89	-999	8.6	6.2	4.0	3.7	4.5	4.0	4.2	3.8	6.4	4.4	4.9	3.2	2.8	3.0
02-16-89	3.9	2.4	5.9	1.9	-999	2.9	2.9	2.5	1.6	2.9	2.4	3.4	2.4	1.7	1.4
02-17-89	-999	2.9	-999	1.7	2.0	2.2	1.6	1.6	2.0	2.5	1.4	3.8	2.1	2.9	1.8
02-21-89	4.4	3.8	4.0	3.5	4.2	3.2	2.0	2.0	3.8	3.0	-999	4.9	3.7	4.0	3.6
02-22-89	6.2	4.5	4.3	3.4	2.5	3.0	2.5	1.9	2.9	5.2	2.7	4.8	3.0	2.9	3.2
02-23-89	2.6	6.2	6.2	3.3	3.4	3.5	2.2	2.5	3.5	5.4	2.1	2.8	2.6	3.5	4.2
02-24-89	6.6	6.8	3.8	4.4	3.8	2.5	1.8	2.4	3.7	6.6	2.6	1.0	2.0	3.1	4.3

TABLE 5

## SUMMARY STATISTICS OF 8-HOUR SPOKANE CO STUDY DATA

## CORRIDOR SITES

(INCLUDING DATA FROM THE PERMANENT SITES)

(DAR:Darl Apts., DFE:Dairy Freeze, HAM:Hamilton Street)

Location	Max	2nd	Perc					enti		les	Min	Rnge	Arit	Geom	Stan	Vali	Tota
	Obs	High	99	95	90	75	50	25	10	Obs		Mean	Mean	Dev	Obs	Obs	
1	11.4	7.5	7.5	6.0	5.7	4.9	3.9	3.3	2.6	1.5	9.9	4.2	3.9	1.5	53.	56.	
2	11.0	9.0	9.0	8.3	7.3	5.9	4.2	3.5	2.6	2.0	9.0	4.8	4.4	1.9	53.	56.	
3	9.2	8.6	8.6	6.2	6.0	4.4	3.9	2.8	2.1	1.1	8.1	3.9	3.6	1.7	51.	56.	
4	11.6	8.5	8.5	8.3	7.9	6.1	4.7	3.7	2.4	1.6	10.0	5.0	4.6	2.0	53.	56.	
5	10.3	8.0	8.0	7.1	6.6	5.4	3.6	2.9	2.0	1.2	9.1	4.2	3.8	2.0	51.	56.	
6	12.0	8.2	8.2	6.9	6.1	5.0	4.3	3.7	2.4	1.5	10.5	4.5	4.2	1.7	52.	56.	
7	11.0	8.9	8.9	8.2	7.4	4.6	3.9	3.4	2.6	1.6	9.4	4.4	4.0	1.9	51.	56.	
8	10.5	5.5	5.5	4.7	4.6	3.4	2.4	2.0	1.5	1.2	9.3	2.9	2.6	1.5	52.	56.	
9	10.3	8.8	8.8	8.2	7.9	6.5	5.3	4.6	3.9	2.6	7.7	5.7	5.4	1.6	51.	56.	
10	8.6	8.5	8.6	7.8	6.5	5.5	4.8	3.6	2.5	2.0	6.6	4.7	4.3	1.6	39.	56.	
11	7.5	7.3	7.3	6.3	5.6	4.2	3.2	2.4	1.7	1.0	6.5	3.5	3.1	1.6	53.	56.	
12	7.2	6.5	6.5	6.0	5.6	4.5	3.6	2.8	2.0	1.3	5.9	3.7	3.4	1.3	53.	56.	
13	6.0	5.6	6.0	5.5	4.9	4.0	3.4	2.9	2.5	1.7	4.3	3.6	3.4	1.0	38.	56.	
14	8.4	7.6	7.6	6.7	6.5	5.7	4.9	3.4	1.9	1.4	7.0	4.6	4.2	1.6	51.	56.	
15	5.8	5.8	5.8	5.2	4.5	3.9	3.0	2.2	1.8	1.3	4.5	3.1	2.9	1.1	53.	56.	
16	9.8	7.0	9.8	7.0	5.4	3.2	2.6	2.0	1.4	0.9	8.9	3.2	2.7	1.9	28.	56.	
17	6.6	6.3	6.3	5.1	5.0	4.4	3.6	3.0	2.1	1.4	5.2	3.7	3.5	1.1	52.	56.	
18	8.1	7.5	7.5	5.5	5.5	4.1	3.5	2.8	2.4	1.9	6.2	3.7	3.5	1.2	52.	56.	
19	8.8	7.5	7.5	7.4	7.3	5.3	4.2	3.4	2.4	1.4	7.4	4.5	4.1	1.6	51.	56.	
20	8.3	7.3	7.3	6.5	6.1	5.1	4.1	3.3	2.2	1.3	7.0	4.2	3.9	1.5	53.	56.	
21	10.3	8.6	8.6	6.7	5.8	4.7	3.9	3.2	2.1	1.5	8.8	4.1	3.8	1.6	53.	56.	
22	9.3	8.9	8.9	8.0	7.6	5.6	4.1	3.4	2.9	1.9	7.4	4.8	4.4	1.8	51.	56.	
23	8.3	8.2	8.2	7.9	7.5	6.6	5.9	4.9	3.5	2.7	5.6	5.8	5.5	1.4	52.	56.	
24	6.8	6.0	6.0	5.6	5.4	4.6	3.9	2.9	1.9	1.2	5.6	3.8	3.5	1.2	53.	56.	
DAR	5.1	5.0	5.0	4.2	4.2	3.5	2.9	2.5	1.7	1.0	4.1	3.0	2.8	0.9	55.	56.	
DFE	12.4	11.3	11.3	9.2	8.6	7.6	5.4	3.4	2.1	0.8	11.6	5.5	4.7	2.7	56.	56.	
HAM	11.6	11.0	11.0	9.8	9.3	7.8	5.7	3.8	3.0	2.1	9.5	6.1	5.5	2.4	56.	56.	

TABLE 6

## SUMMARY STATISTICS OF 8-HOUR SPOKANE CO STUDY DATA

## CENTRAL BUSINESS DISTRICT SITES

(INCLUDING DATA FROM THE PERMANENT SITES)

(HAM:Hamilton Street, LIQ:Liquor Store, POS:Post Office)

Location	Max	2nd	Perc							enti	les	Min	Rnge	Arit	Geom	Stan	Vali	Tota
	Obs	High	99	95	90	75	50	25	10	Obs		Mean	Mean	Dev	Obs	Obs		
25	10.8	8.2	8.2	6.6	5.9	4.5	3.5	2.8	2.1	1.3	9.5	3.8	3.5	1.7	51.	56.		
26	13.6	10.5	10.5	8.6	7.7	6.6	5.4	4.1	2.9	1.4	12.2	5.5	5.1	2.2	52.	56.		
27	7.0	6.6	6.6	6.2	6.0	5.2	4.2	3.4	2.5	1.5	5.5	4.2	4.0	1.3	53.	56.		
28	5.9	5.5	5.5	5.4	5.0	4.4	3.6	3.1	2.5	1.3	4.6	3.7	3.5	1.0	53.	56.		
29	6.7	6.4	6.4	5.6	5.5	4.2	3.6	3.1	2.4	1.0	5.7	3.7	3.5	1.1	53.	56.		
30	5.6	5.4	5.4	5.0	5.0	4.4	3.6	2.9	1.9	0.8	4.8	3.6	3.3	1.1	53.	56.		
31	5.1	4.6	4.6	4.0	4.0	3.5	2.8	2.2	1.5	1.0	4.1	2.8	2.7	0.9	54.	56.		
32	8.3	5.7	5.7	4.7	4.2	3.5	3.0	2.2	1.6	1.4	6.9	3.0	2.8	1.2	52.	56.		
33	6.5	6.3	6.3	6.0	5.8	4.5	3.6	2.9	2.0	1.6	4.9	3.7	3.5	1.2	52.	56.		
34	7.2	7.0	7.0	6.9	6.6	6.1	5.4	4.2	2.9	1.6	5.6	5.1	4.9	1.4	54.	56.		
35	5.8	5.8	5.8	5.5	4.9	3.4	2.8	2.0	1.8	1.0	4.8	2.9	2.7	1.2	53.	56.		
36	7.6	7.5	7.5	6.6	6.3	4.9	3.8	2.5	1.5	1.0	6.6	3.8	3.4	1.7	53.	56.		
37	5.0	4.8	5.0	4.6	4.3	3.6	2.6	2.0	1.5	1.2	3.8	2.8	2.6	1.0	50.	56.		
HAM	11.6	11.0	11.0	9.8	9.3	7.8	5.7	3.8	3.0	2.1	9.5	6.0	5.5	2.4	56.	56.		
LIQ	6.4	6.2	6.2	5.9	5.2	4.2	3.3	2.5	1.8	0.7	5.7	3.4	3.1	1.4	56.	56.		
POS	7.0	6.6	6.6	6.3	5.9	4.9	4.0	3.2	1.8	0.9	6.1	4.0	3.6	1.5	56.	56.		

B. Eight-hour maximums recorded at the permanent Liquor Store and Post Office sites were 6.4 ppm and 7.0 ppm, respectively.

#### 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.

##### Corridor Network-

A. Eight-hour second highs from the corridor sites ranged from 5.5 ppm (site 8) to 9.0 (site 2).

B. Eight-hour second highs recorded at the permanent Hamilton, Darl Apts., and Dairy Freeze sites were 11.0 ppm, 5.0 ppm, and 11.3 ppm, respectively.

##### Central Business District-

A. Eight-hour second highs from the CBD sites ranged from 4.6 ppm (site 31) to 10.5 ppm (site 26).

B. Eight-hour second highs recorded at the permanent Liquor Store and Post Office sites were 6.2 ppm and 6.6 ppm, respectively.

#### Frequency-of-Eight-Hour-NAAQS-Exceedances

This statistic indicates the number of times the 9 ppm eight-hour CO NAAQS was exceeded at particular sites.

##### Corridor Network-

A. Ten of the twenty-four corridor sites (sites 1,2,4,5,6,7,8,9,16,21) exceeded the level of the standard once over the study period.

B. The permanent Hamilton, Darl Apts., and Dairy Freeze sites exceeded the standard six, three, and zero times respectively over the study period.

##### Central Business District-

A. Two of the thirteen CBD sites exceeded the level of the standard. Site 26 exceeded the level three times and site 25 exceeded the level once.

B. Neither the permanent Liquor Store or Post Office site exceeded the standard over the study period.

## Means-of-the-Eight-Hour-Averages

This statistic provides an indication of the chronic nature of CO concentrations measured at a site over time.

### Corridor Network-

- A. The arithmetic means of daily eight-hour averages from the corridor sites ranged from 2.9 ppm (site 8) to 5.3 ppm (site 23).
- B. The arithmetic mean of daily eight-hour averages recorded at the permanent Hamilton, Darl Apts., and Dairy Freeze sites were 6.1 ppm, 5.5 ppm, and 3.0 ppm, respectively.

### Central Business District-

- A. The arithmetic means of daily eight-hour averages from the CBD sites ranged from 2.8 ppm (sites 31 and 37) to 5.5 ppm (site 26).
- B. The arithmetic mean of daily eight-hour averages recorded at the permanent Liquor Store and Post Offices sites were 3.4 ppm, 4.0 ppm, respectively.

## Daily Network Statistics

Another facet of the data analysis examined the day-to-day characteristics of the study data. This kind of analysis provides a profile of 'simultaneous' impacts throughout the study area. Figures 5 and 6 portray composites of eight-hour concentrations reported from each site in the corridor network. The corresponding daily eight-hour average recorded at the Hamilton site is plotted individually on figures 5 and 6. Figures 7 and 8 portray composites of eight-hour concentrations reported from each site in the CBD network. The corresponding daily eight-hour average recorded at the Post Office site is plotted individually on figures 7 and 8. Summary statistics for the corridor and CBD networks are presented in Tables 7 and 8, respectively.

## Daily-Maximum-Eight-Hour-Average

The daily maximum value reported from among all sites in the study network illustrates relative CO magnitudes throughout the network on a daily basis. This measure also demonstrates the day-to-day volatility of ambient CO levels.

### Corridor Network-

- A. The daily maximum eight-hour average reported from the corridor network ranged from 2.8 ppm (2/1/89) to 12.0 ppm (12/6/88).

B. Twenty of the twenty-four corridor sites recorded the daily corridor network maximum eight-hour average<sup>2</sup> on at least one day of the study.

C. Site 22, site 9, and site 19 recorded the daily corridor network maximum on 19, 10, and 7 days, respectively. Sites 2, 7, and 14 each recorded the daily corridor network maximum on 6 days.

D. The permanent Hamilton and Dairy Freeze sites recorded the daily corridor network maximum on 21 and 17 days, respectively.

E. The daily maximum reported from the sites in the corridor network was greater than the corresponding concentration at the permanent Hamilton site on 32 of the 53 study days.

#### Central Business District-

A. The daily maximum eight-hour average reported from the CBD network ranged from 1.6 ppm (2/1/89) to 13.6 ppm (2/8/89).

B. Ten of the twelve CBD sites recorded the daily CBD network maximum eight-hour average<sup>3</sup> on at least one day of the study.

C. Site 26 and site 34 recorded the daily CBD network maximum on 26 and 22 days, respectively. Sites 36 recorded the daily CBD network maximum on 12 days.

D. The permanent Liquor Store and Post Office sites recorded the daily corridor network maximum on 3 and 7 days, respectively.

E. The daily maximum reported from the sites in the corridor network was greater than the corresponding concentration at the permanent Post Office site on 46 of the 53 study days.

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<sup>2</sup> - Site data were considered 'tied' for a particular measure if they were within +/- 0.5 ppm of each other.

<sup>3</sup> - Site data were considered 'tied' for a particular measure if they were within +/- 0.5 ppm of each other.

FIGURE 5

SPOKANE CARBON MONOXIDE STUDY

CORRIDOR SITES

FIRST HALF OF STUDY

SAMPLED WEEKDAYS FROM 12/5/88 - 1/13/89

(Nominally Reflects 23 sites)

DAILY COMPOSITE OF CO CONCENTRATIONS

MEASURED AT ALL CORRIDOR SITES DURING

AN 8-HR PERIOD (11:00 A.M. TO 7:00 P.M.)

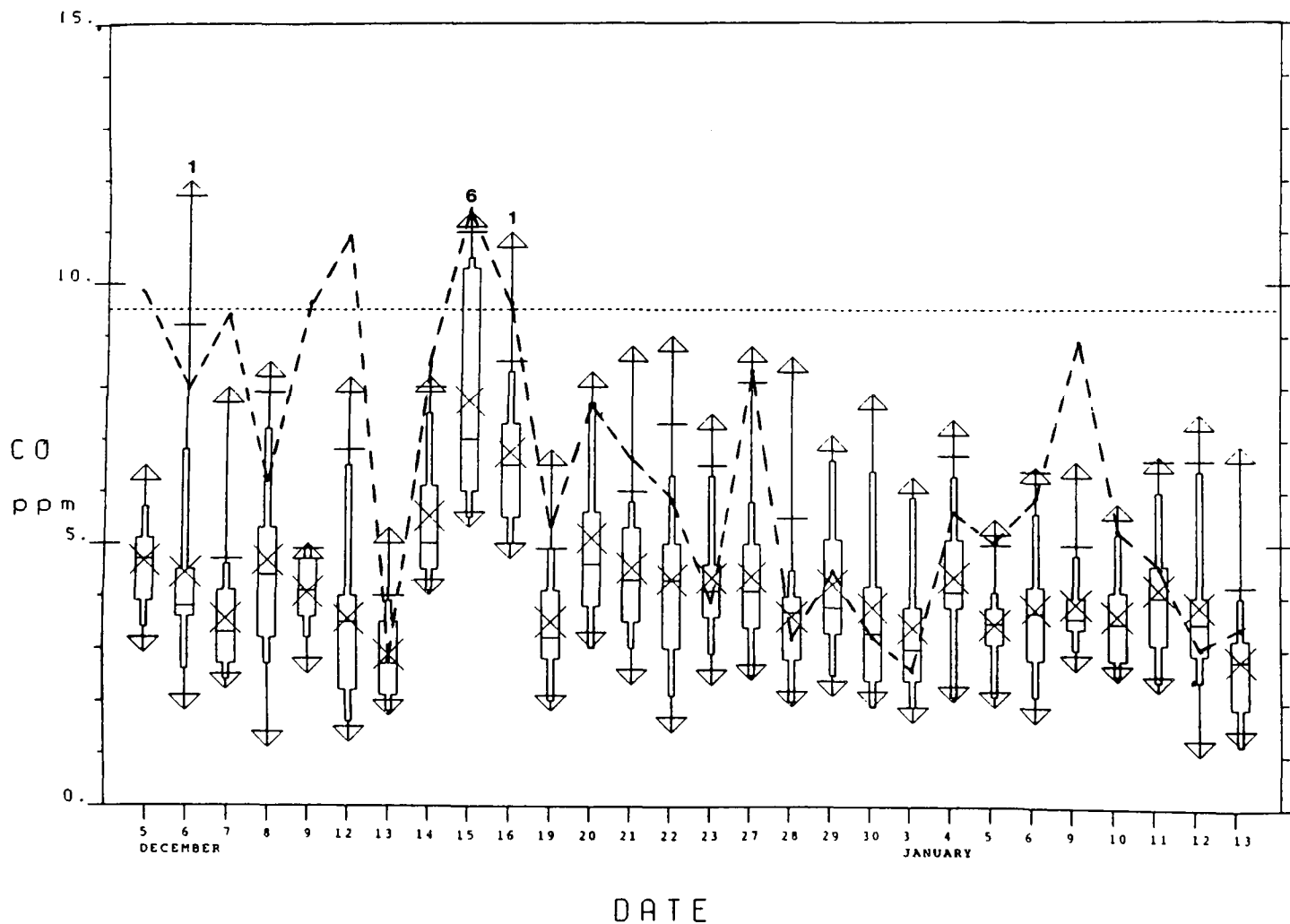
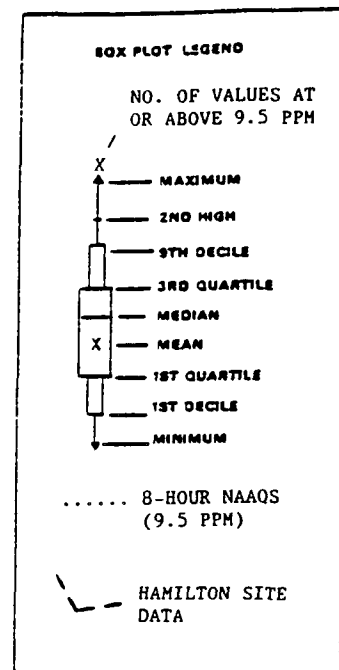




FIGURE 6

SPOKANE CARBON MONOXIDE STUDY

CORRIDOR SITES

SECOND HALF OF STUDY

SAMPLED WEEKDAYS FROM 1/13/89 - 2/24/89

(Nominally Reflects 23 sites)

DAILY COMPOSITE OF CO CONCENTRATIONS

MEASURED AT ALL CORRIDOR SITES DURING

AN 8-HR PERIOD (11:00 A.M. TO 7:00 P.M.)

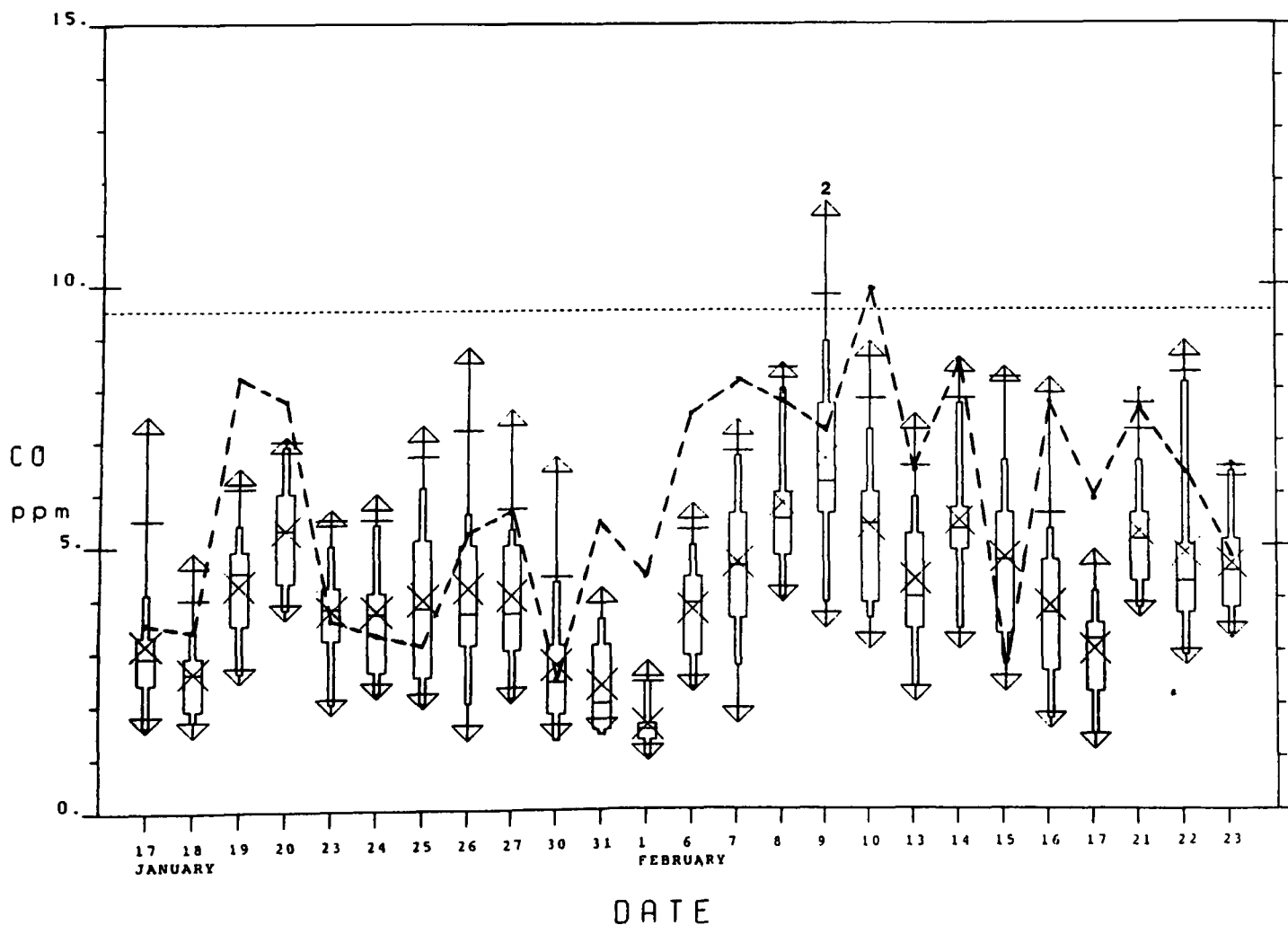
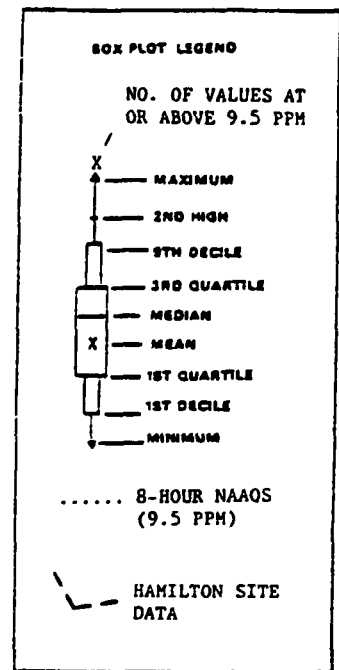


FIGURE 7

SPOKANE CARBON MONOXIDE STUDY

CENTRAL BUSINESS DISTRICT SITES

FIRST HALF OF STUDY

SAMPLED WEEKDAYS FROM 12/5/88 - 1/13/89

(Nominally Reflects 13 sites)

DAILY COMPOSITE OF CO CONCENTRATIONS

MEASURED AT ALL CBD SITES DURING

AN 8-HR PERIOD (11:00 A.M. TO 7:00 P.M.)

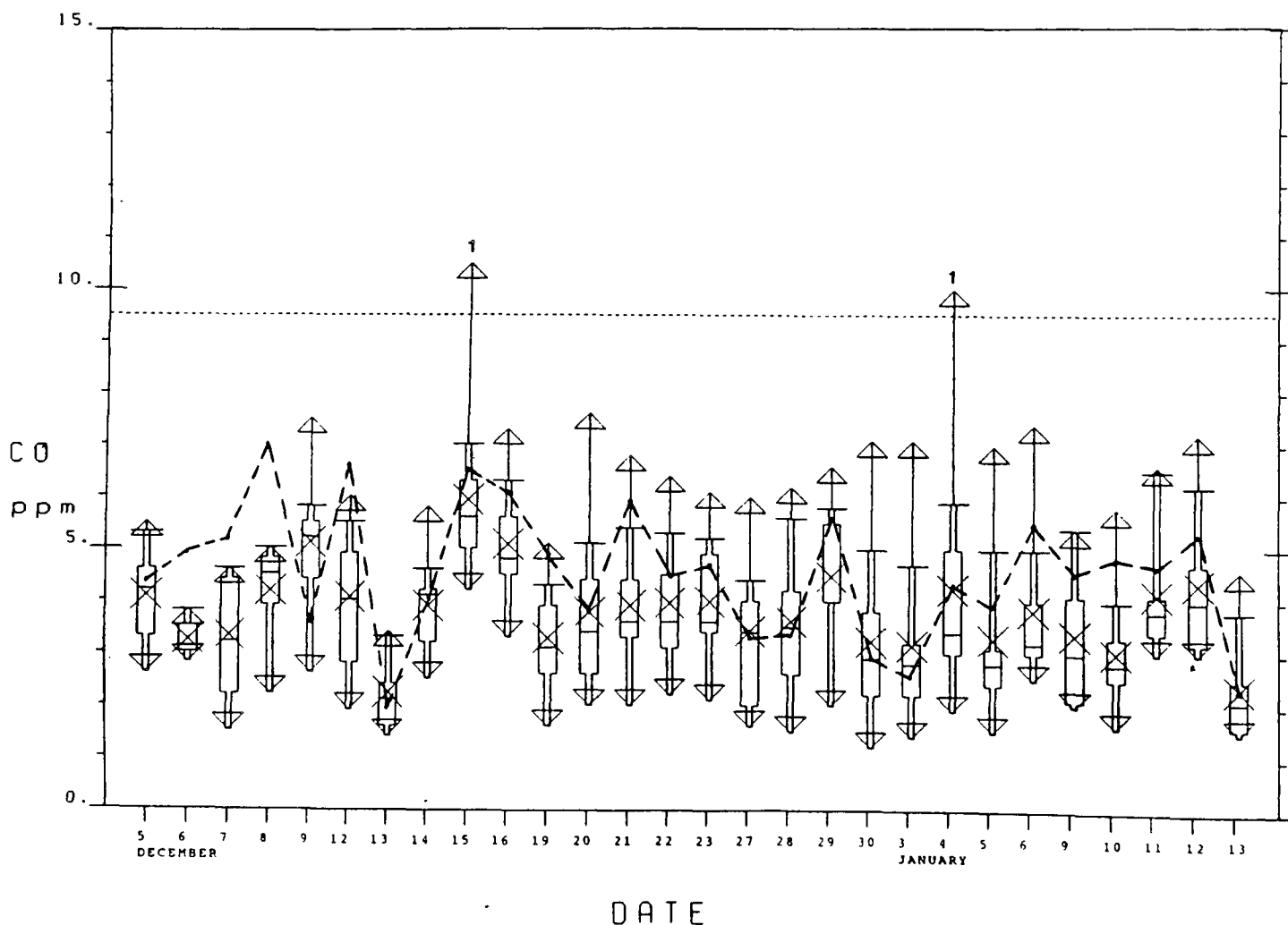
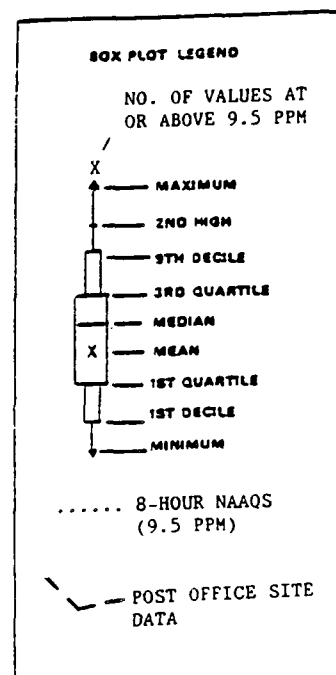


FIGURE 8

SPOKANE CARBON MONOXIDE STUDY

CENTRAL BUSINESS DISTRICT SITES

SECOND HALF OF STUDY

SAMPLED WEEKDAYS FROM 1/13/89 - 2/24/89

(Nominally Reflects 13 sites)

DAILY COMPOSITE OF CO CONCENTRATIONS

MEASURED AT ALL CBD SITES DURING

AN 8-HR PERIOD (11:00 A.M. TO 7:00 P.M.)

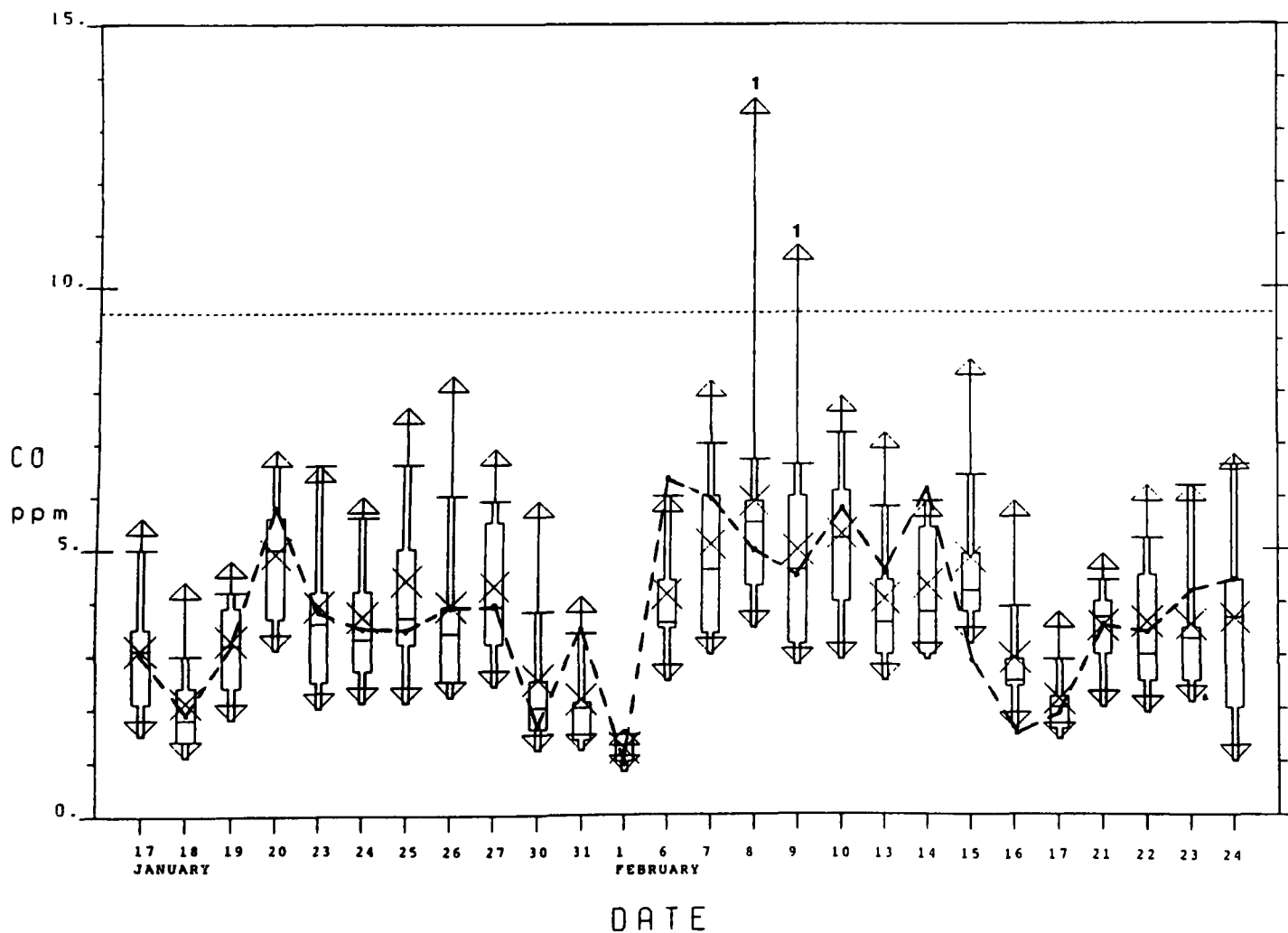
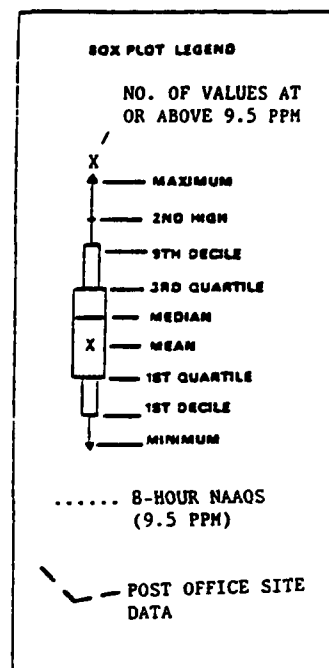


TABLE 7

## DAILY CO SUMMARY STATISTICS FOR THE CORRIDOR NETWORK

(DOES NOT INCLUDE DATA FROM THE PERMANENT SITES)

Day	Max Obs	2nd High	99	95	Perc 90	enti 75	les 50	25	10	Min Obs	Rnge	Arit Mean	Geom Mean	Stan Dev	Vali Obs	Tota Obs
12/5	6.5	6.2	6.5	6.2	5.7	5.1	4.7	3.9	3.4	2.9	3.6	4.6	4.5	0.9	20.	24.
6	12.0	9.2	12.0	9.2	6.8	4.5	3.8	3.6	2.6	1.8	10.2	4.4	4.0	2.2	22.	24.
7	8.0	4.7	8.0	4.7	4.6	4.1	3.3	2.7	2.4	2.2	5.8	3.5	3.4	1.2	22.	24.
8	8.5	7.9	8.5	7.9	7.2	5.3	4.4	3.2	2.7	1.1	7.4	4.6	4.3	1.7	22.	24.
9	5.0	4.9	5.0	4.9	4.9	4.7	4.1	3.6	3.2	2.5	2.5	4.0	4.0	0.6	22.	24.
12	8.2	6.8	8.2	6.8	6.5	4.0	3.5	2.2	1.6	1.2	7.0	3.5	3.1	1.8	21.	24.
13	5.3	4.0	5.3	4.0	3.9	3.5	2.7	2.1	1.8	1.7	3.6	2.8	2.7	0.9	22.	24.
14	8.2	8.0	8.2	8.0	7.5	6.1	5.0	4.5	4.1	4.0	4.2	5.5	5.3	1.2	22.	24.
15	11.4	11.0	11.4	11.0	10.5	10.3	7.0	6.0	5.5	5.3	6.1	7.7	7.4	2.0	22.	24.
16	11.0	8.5	11.0	8.5	8.3	7.3	6.5	5.5	5.0	4.7	6.3	6.7	6.6	1.5	22.	24.
19	6.8	4.9	6.8	4.9	4.9	4.1	3.2	2.8	2.0	1.8	5.0	3.5	3.3	1.1	22.	24.
20	8.3	8.0	8.3	8.0	7.7	5.6	4.6	3.8	3.0	3.0	5.3	5.1	4.8	1.6	22.	24.
21	8.8	6.0	8.8	6.0	5.8	5.3	4.3	3.5	3.0	2.3	6.5	4.5	4.3	1.3	22.	24.
22	9.0	7.3	9.0	7.3	6.3	5.0	4.3	3.0	2.1	1.4	7.6	4.3	3.9	1.7	23.	24.
23	7.5	6.5	7.5	6.5	6.3	4.6	4.1	3.6	2.9	2.3	5.2	4.3	4.1	1.2	23.	24.
27	8.8	8.1	8.8	8.1	5.8	5.0	4.1	3.4	2.5	2.4	6.4	4.3	4.1	1.5	23.	24.
28	8.6	5.5	8.6	5.5	4.5	4.0	3.7	2.8	2.0	1.9	6.7	3.6	3.3	1.4	23.	24.
29	7.1	6.8	7.1	6.8	6.6	5.1	3.8	3.3	2.5	2.1	5.0	4.2	4.0	1.4	23.	24.
30	7.9	7.6	7.9	7.6	6.4	4.2	3.3	2.4	1.9	1.9	6.0	3.8	3.4	1.7	23.	24.
1/3	6.3	6.0	6.3	6.0	5.9	3.8	3.0	2.4	1.9	1.6	4.7	3.4	3.1	1.4	23.	24.
4	7.4	6.7	7.4	6.7	6.3	5.1	4.1	3.8	2.1	2.0	5.4	4.3	4.1	1.3	22.	24.
5	5.5	5.0	5.5	5.0	4.1	3.8	3.5	3.1	2.1	1.9	3.6	3.4	3.3	0.8	23.	24.
6	6.5	6.4	6.5	6.4	5.6	4.2	3.7	2.8	2.1	1.6	4.9	3.7	3.5	1.3	21.	24.
9	6.6	5.0	6.6	5.0	4.8	4.0	3.6	3.4	3.0	2.6	4.0	3.8	3.8	0.8	23.	24.
10	5.8	5.5	5.8	5.5	5.2	4.1	3.5	2.8	2.5	2.4	3.4	3.6	3.5	1.0	24.	24.
11	6.7	6.6	6.7	6.6	6.0	4.6	4.0	3.1	2.4	2.2	4.5	4.1	3.9	1.2	24.	24.
12	7.5	6.6	7.5	6.6	6.4	4.0	3.5	2.9	2.4	1.0	6.5	3.8	3.5	1.5	24.	24.
13	6.9	4.2	6.9	4.2	4.0	3.2	2.8	1.9	1.2	1.2	5.7	2.8	2.5	1.2	23.	24.
17	7.5	5.5	7.5	5.5	4.1	3.3	2.9	2.4	1.6	1.5	6.0	3.1	2.9	1.2	24.	24.
18	4.9	4.0	4.9	4.0	3.4	2.9	2.6	1.9	1.7	1.4	3.5	2.6	2.5	0.8	24.	24.
19	6.5	6.1	6.5	6.1	5.4	4.9	4.5	3.5	2.6	2.4	4.1	4.2	4.1	1.0	24.	24.
20	7.1	7.0	7.1	7.0	6.9	6.0	5.3	4.3	3.8	3.6	3.5	5.3	5.2	1.0	24.	24.
23	5.7	5.5	5.7	5.5	5.0	4.2	3.8	3.2	2.0	1.8	3.9	3.7	3.6	1.0	24.	24.
24	6.0	5.5	6.0	5.5	5.4	4.1	3.7	2.6	2.2	2.1	3.9	3.7	3.5	1.1	24.	24.
25	7.3	6.7	7.3	6.7	6.1	5.1	3.8	2.5	2.0	1.9	5.4	3.9	3.6	1.6	24.	24.
26	8.8	7.2	8.8	7.2	5.6	5.0	3.7	3.1	2.0	1.3	7.5	4.1	3.8	1.6	24.	24.
27	7.6	5.7	7.6	5.7	5.3	5.0	3.7	3.0	2.1	2.0	5.6	4.0	3.8	1.3	24.	24.
30	6.7	4.4	6.7	4.4	4.3	3.1	2.4	1.8	1.3	1.3	5.4	2.7	2.4	1.3	23.	24.
31	4.2	3.9	4.2	3.9	3.6	3.1	2.0	1.5	1.4	1.4	2.8	2.3	2.1	0.9	22.	24.
2/1	2.8	2.4	2.8	2.4	2.4	1.6	1.5	1.3	1.0	0.9	1.9	1.5	1.5	0.5	19.	24.
6	5.8	5.3	5.8	5.3	5.0	4.4	3.9	2.9	2.3	2.2	3.6	3.7	3.6	1.0	21.	24.
7	7.4	6.8	7.4	6.8	6.7	5.6	4.6	3.6	2.7	1.6	5.8	4.6	4.4	1.4	23.	24.
8	8.5	8.4	8.5	8.4	8.0	6.0	5.5	4.8	4.0	3.9	4.6	5.8	5.6	1.4	23.	24.
9	11.6	9.8	11.6	9.8	8.9	7.7	6.2	5.6	3.9	3.4	8.2	6.6	6.3	1.9	23.	24.
10	8.9	7.8	8.9	7.8	7.2	6.0	5.4	3.9	3.6	3.0	5.9	5.3	5.1	1.4	23.	24.
13	7.5	6.5	7.5	6.5	5.9	5.2	4.0	3.4	2.3	2.0	5.5	4.3	4.1	1.4	22.	24.
14	8.6	7.8	8.6	7.8	7.7	5.7	5.3	4.9	3.4	3.0	5.6	5.4	5.3	1.3	23.	24.
15	8.4	8.2	8.4	8.2	6.6	5.6	4.7	3.3	2.8	2.2	6.2	4.7	4.4	1.6	21.	24.
16	8.2	5.6	8.2	5.6	5.3	4.7	3.7	2.6	1.7	1.5	6.7	3.8	3.5	1.5	23.	24.
17	4.9	4.6	4.9	4.6	4.1	3.5	3.2	2.2	1.4	1.1	3.8	3.0	2.8	1.0	23.	24.
21	8.0	7.2	8.0	7.2	6.6	5.6	5.1	4.3	3.8	3.6	4.4	5.2	5.1	1.0	22.	24.
22	8.9	8.3	8.9	8.3	8.1	5.0	4.3	3.7	2.9	2.7	6.2	4.8	4.5	1.7	23.	24.
23	6.6	6.5	6.6	6.5	6.4	5.1	4.5	3.8	3.3	3.2	3.4	4.6	4.5	1.0	23.	24.

TABLE 8

DAILY CO SUMMARY STATISTICS FOR THE CENTRAL BUSINESS DISTRICT NETWORK  
(DOES NOT INCLUDE DATA FROM THE PERMANENT SITES)

Day	Max Obs	2nd High	99	95	Perc entiles					Min Obs	Rnge	Arit Mean	Geom Mean	Stan Dev	Vali Obs	Tota Obs
12/5	5.5	5.3	5.5	5.3	5.3	4.6	4.2	3.3	2.6	2.6	2.9	4.0	4.0	0.8	13.	13.
6	3.8	3.8	3.8	3.8	3.8	3.5	3.0	3.0	2.8	2.8	1.0	3.2	3.2	0.4	13.	13.
7	4.6	4.6	4.6	4.6	4.6	4.4	3.2	2.2	1.5	1.5	3.1	3.3	3.1	1.0	12.	13.
8	5.0	5.0	5.0	5.0	5.0	4.8	4.5	3.9	2.2	2.2	2.8	4.1	4.0	0.9	13.	13.
9	7.5	5.8	7.5	5.8	5.8	5.5	5.2	4.4	2.6	2.6	4.9	5.1	4.9	1.1	13.	13.
12	6.0	5.5	6.0	5.5	5.5	4.9	4.0	2.8	1.9	1.9	4.1	4.0	3.8	1.2	13.	13.
13	3.4	3.3	3.4	3.3	3.3	2.4	2.1	1.6	1.4	1.4	2.0	2.2	2.1	0.6	13.	13.
14	5.8	4.6	5.8	4.6	4.6	4.2	4.1	3.2	2.5	2.5	3.3	3.8	3.8	0.8	13.	13.
15	10.5	7.0	10.5	7.0	7.0	6.3	5.6	5.0	4.2	4.2	6.3	5.9	5.7	1.5	13.	13.
16	7.3	6.3	7.3	6.3	6.3	5.6	4.8	4.5	3.3	3.3	4.0	5.0	4.9	1.0	13.	13.
19	5.1	4.3	5.1	4.3	4.3	3.9	3.1	2.6	1.6	1.6	3.5	3.2	3.1	0.9	13.	13.
20	7.6	5.1	7.6	5.1	5.1	4.4	3.4	2.6	2.0	2.0	5.6	3.7	3.5	1.4	13.	13.
21	6.8	5.4	6.8	5.4	5.4	4.4	3.6	3.3	2.0	2.0	4.8	3.9	3.7	1.2	13.	13.
22	6.4	5.3	6.4	5.3	5.3	4.5	3.6	3.1	2.2	2.2	4.2	3.9	3.8	1.1	13.	13.
23	6.1	5.2	6.1	5.2	5.2	4.9	3.6	3.4	2.1	2.1	4.0	3.9	3.8	1.0	13.	13.
27	6.0	4.4	6.0	4.4	4.4	4.0	3.4	2.0	1.6	1.6	4.4	3.4	3.2	1.2	12.	13.
28	6.2	5.6	6.2	5.6	5.6	4.2	3.5	2.6	1.5	1.5	4.7	3.6	3.3	1.3	13.	13.
29	6.6	5.8	6.6	5.8	5.8	5.5	4.0	4.0	2.0	2.0	4.6	4.4	4.3	1.2	10.	13.
30	7.1	5.0	7.1	5.0	5.0	3.8	2.9	2.2	1.2	1.2	5.9	3.2	2.9	1.5	13.	13.
1/3	7.1	4.7	7.1	4.7	4.7	3.2	2.8	2.2	1.4	1.4	5.7	3.1	2.8	1.5	13.	13.
4	10.0	5.9	10.0	5.9	5.9	5.0	3.4	3.0	1.9	1.9	8.1	4.2	3.8	2.0	13.	13.
5	7.0	5.0	7.0	5.0	5.0	3.1	2.8	2.4	1.5	1.5	5.5	3.2	3.0	1.4	13.	13.
6	7.4	5.0	7.4	5.0	5.0	4.0	3.2	3.0	2.5	2.5	4.9	3.8	3.6	1.3	12.	13.
9	5.4	5.4	5.4	5.4	5.4	4.1	3.0	2.1	2.0	2.0	3.4	3.3	3.1	1.1	13.	13.
10	5.8	4.0	5.8	4.0	4.0	3.3	2.8	2.5	1.6	1.6	4.2	3.0	2.8	1.0	13.	13.
11	6.6	6.5	6.6	6.5	6.5	4.1	3.8	3.4	3.0	3.0	3.6	4.1	4.0	1.1	13.	13.
12	7.2	6.2	7.2	6.2	6.2	4.7	4.0	3.2	3.0	3.0	4.2	4.3	4.1	1.3	13.	13.
13	4.6	3.8	4.6	3.8	3.8	2.5	2.1	1.6	1.5	1.5	3.1	2.3	2.2	0.9	13.	13.
17	5.6	5.0	5.6	5.0	5.0	3.5	3.1	2.1	1.5	1.5	4.1	3.1	2.9	1.1	13.	13.
18	4.4	3.0	4.4	3.0	3.0	2.4	1.8	1.4	1.1	1.1	3.3	2.1	1.9	0.9	13.	13.
19	4.8	4.2	4.8	4.2	4.2	3.9	3.2	2.4	1.8	1.8	3.0	3.2	3.1	0.8	13.	13.
20	6.9	6.6	6.9	6.6	6.6	5.6	5.0	3.7	3.1	3.1	3.8	4.9	4.7	1.1	13.	13.
23	6.6	6.6	6.6	6.6	6.6	4.2	3.6	2.5	2.0	2.0	4.6	3.9	3.6	1.4	13.	13.
24	6.0	5.6	6.0	5.6	5.6	4.2	3.3	2.7	2.1	2.1	3.9	3.7	3.5	1.1	13.	13.
25	7.7	6.6	7.7	6.6	6.6	5.0	3.7	3.2	2.1	2.1	5.6	4.4	4.1	1.6	12.	13.
26	8.3	6.0	8.3	6.0	6.0	3.9	3.4	2.5	2.2	2.2	6.1	3.9	3.6	1.6	12.	13.
27	6.9	5.9	6.9	5.9	5.9	5.5	3.9	3.2	2.4	2.4	4.5	4.2	4.1	1.3	13.	13.
30	5.9	3.8	5.9	3.8	3.8	2.5	2.0	1.6	1.2	1.2	4.7	2.5	2.2	1.3	12.	13.
31	4.1	3.4	4.1	3.4	3.4	2.1	2.0	1.4	1.2	1.2	2.9	2.1	2.0	0.9	12.	13.
2/1	1.6	1.5	1.6	1.6	1.5	1.5	1.3	1.0	0.8	0.8	0.8	1.2	1.2	0.3	10.	13.
6	6.0	6.0	6.0	6.0	6.0	4.4	3.6	3.5	2.5	2.5	3.5	4.1	4.0	1.0	13.	13.
7	8.2	7.0	8.2	7.0	7.0	6.0	4.6	3.4	3.0	3.0	5.2	5.0	4.8	1.5	13.	13.
8	13.6	6.7	13.6	6.7	6.7	5.9	5.5	4.3	3.5	3.5	10.1	5.9	5.5	2.4	13.	13.
9	10.8	6.6	10.8	6.6	6.6	6.0	4.6	3.2	2.8	2.8	8.0	4.9	4.6	2.1	13.	13.
10	7.9	7.2	7.9	7.2	7.2	6.1	5.2	4.0	2.9	2.9	5.0	5.2	5.1	1.4	13.	13.
13	7.2	5.8	7.2	5.8	5.8	4.4	3.6	3.0	2.5	2.5	4.7	4.0	3.8	1.3	12.	13.
14	5.9	5.9	5.9	5.9	5.9	5.4	3.8	3.0	2.9	2.9	3.0	4.3	4.1	1.1	13.	13.
15	8.6	6.4	8.6	6.4	6.4	4.9	4.2	3.8	3.2	3.2	5.4	4.8	4.6	1.5	12.	13.
16	5.9	3.9	5.9	3.9	3.9	2.9	2.5	2.4	1.6	1.6	4.3	2.9	2.7	1.1	12.	13.
17	3.8	2.9	3.8	2.9	2.9	2.2	2.0	1.6	1.4	1.4	2.4	2.1	2.0	0.7	11.	13.
21	4.9	4.4	4.9	4.4	4.4	4.0	3.7	3.0	2.0	2.0	2.9	3.5	3.4	0.8	12.	13.
22	6.2	5.2	6.2	5.2	5.2	4.5	3.0	2.5	1.9	1.9	4.3	3.6	3.4	1.2	13.	13.
23	6.2	6.2	6.2	6.2	6.2	3.5	3.3	2.5	2.1	2.1	4.1	3.5	3.3	1.4	13.	13.
24	6.8	6.6	6.8	6.6	6.6	4.4	3.7	2.0	1.0	1.0	5.8	3.6	3.2	1.9	13.	13.

### Range-of-Daily-Eight-Hour-Averages

The range of values reported from a study network during a particular day can provide a valuable index of intersite variability. In addition, it can grossly imply that portion of the daily maximum which could most conservatively (over-predicting) be attributable to 'background' levels of CO. For both networks, the largest daily range occurred on the day with the highest recorded eight-hour value.

#### Corridor Network-

A. The daily range of eight-hour averages ranged from 1.9 ppm (2/1/89) to 10.2 ppm (12/6/88) for the corridor network.

#### Central Business District-

A. The daily range of eight-hour averages ranged from 1.0 ppm (12/6/88) to 10.1 ppm (2/8/89) for the CBD network.

### Average-Daily-Network-Eight-Hour-Averages

This statistic illustrates the average CO levels occurring at the maximum impact areas in Spokane on a daily basis.

#### Corridor Network-

A. The daily arithmetic mean ranged from 7.7 ppm (12/15/88) to 1.5 (2/1/89) for the corridor sites.

#### Central Business District-

A. The daily arithmetic mean ranged from 5.9 ppm (12/15/89 and 2/8/89) to 1.2 ppm (2/1/89) for the CBD sites.

### Sample Interval Comparison

The selected eight-hour sampling interval (11:00 a.m. to 7:00 p.m.) generally represented the eight-hour period with the highest CO level on a daily basis. However, on several days, the Hamilton monitor recorded the daily maximum eight-hour values during later intervals (i.e. ending hour 8:00 P.M. to 12:00 midnight). In fact, the highest values recorded at the Hamilton site during study period occurred over later eight-hour periods. For example, the highest eight-hour value recorded at the Hamilton site during the study period was 14.3 ppm, which occurred during the interval from 2:00 p.m. to 10:00 p.m.

### Hamilton Sub-Network

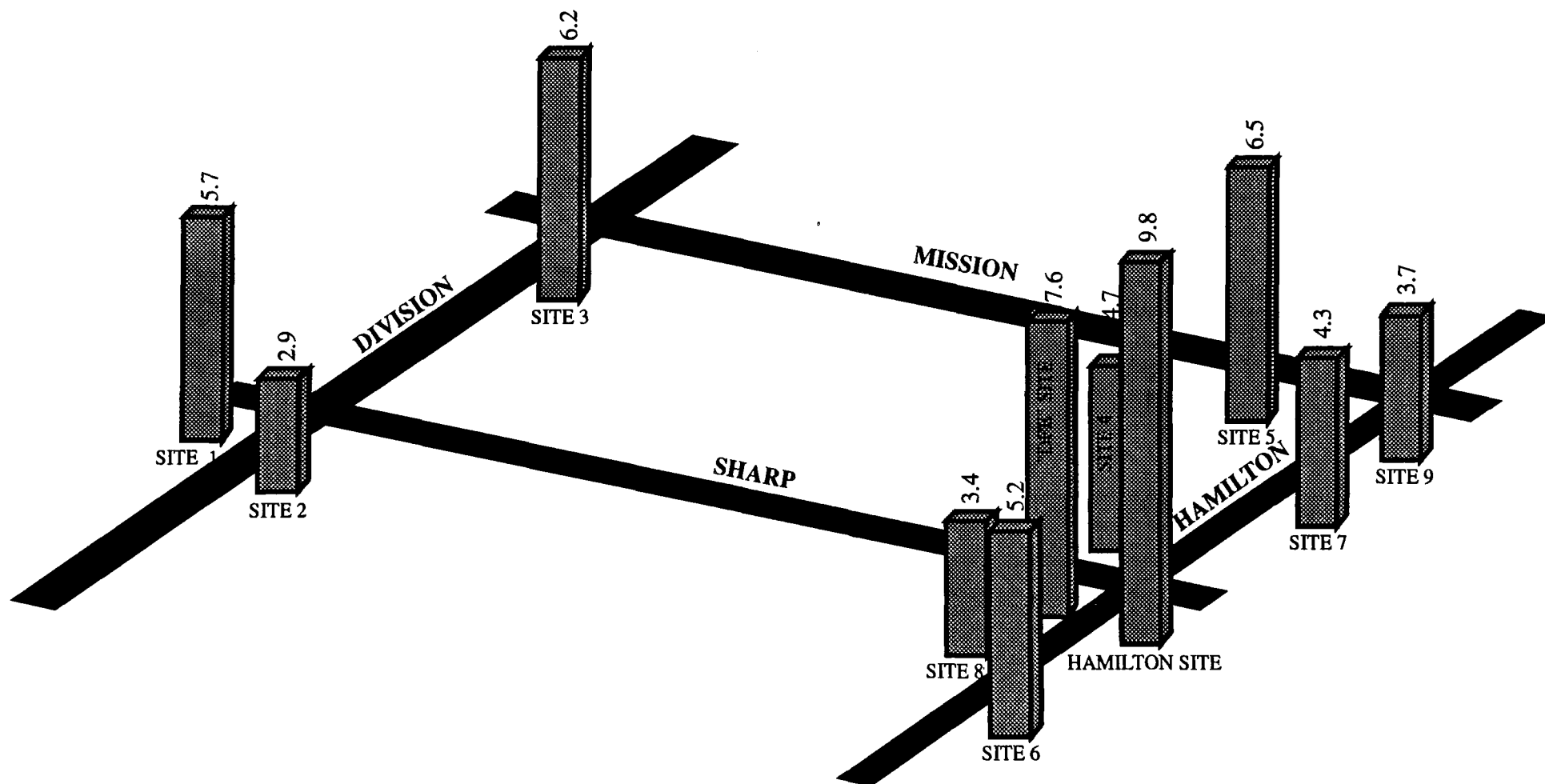
CO levels recorded at the study sites in the vicinity of the permanent Hamilton site are displayed on the following bar-graphs. The nine days displayed reflect days which at least one site in the sub-network exceeded the level of the standard.

As depicted in the bar-graphs, on four days (12/6, 12/8, 12/16, 2/9) a number of the study sites were higher than the Hamilton site. Conversely, on four other days (12/5, 12/9, 12/10, 12/12) the Hamilton site was higher than any of the study sites. The bar-graph for December 15, the day with the most number of exceedances, shows that CO levels were above the standard at a number of locations in the area.

# CO STUDY SITES NEAR HAMILTON SITE

12/5/88

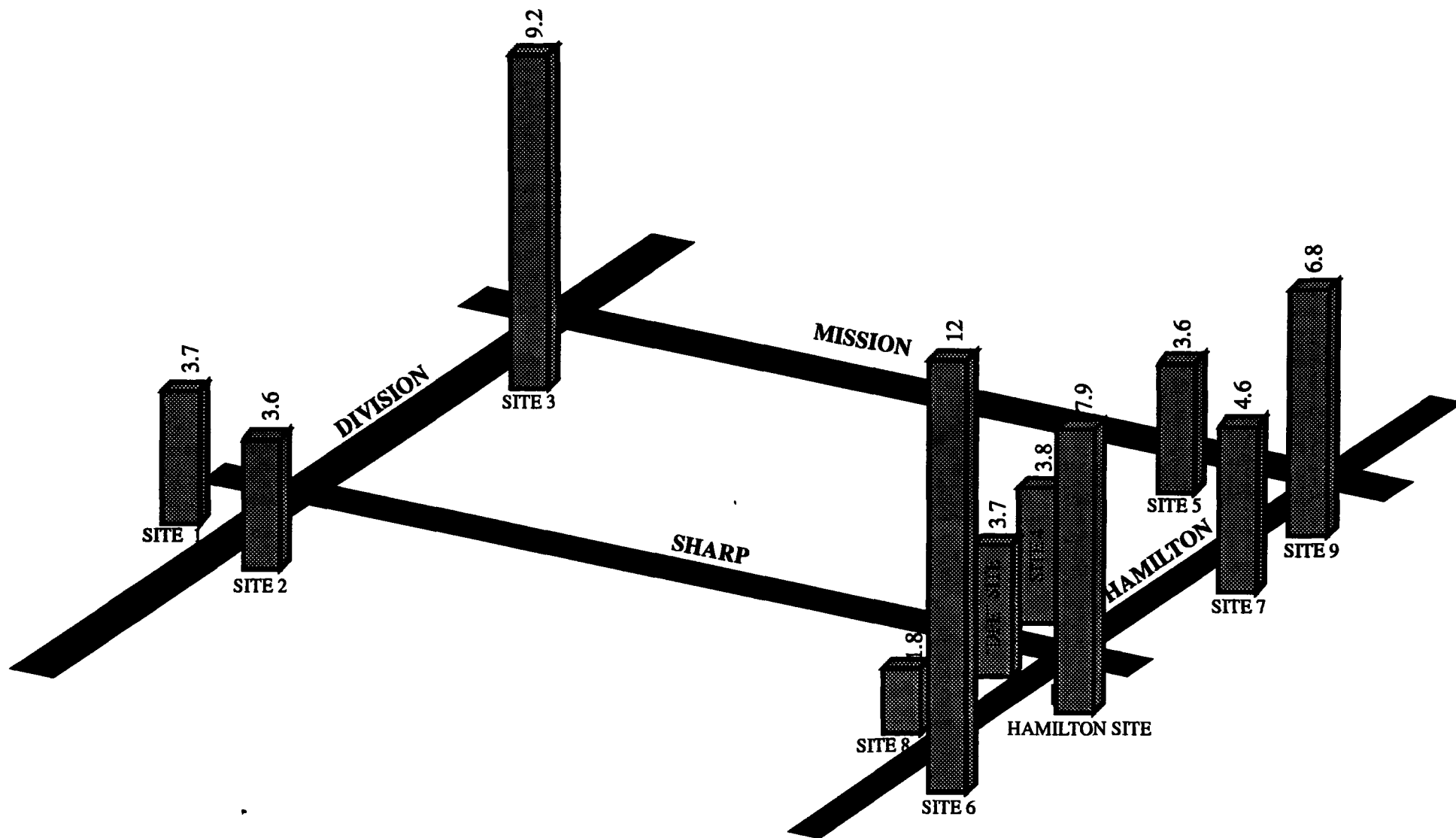
(PPM)





# CO STUDY SITES NEAR HAMILTON SITE

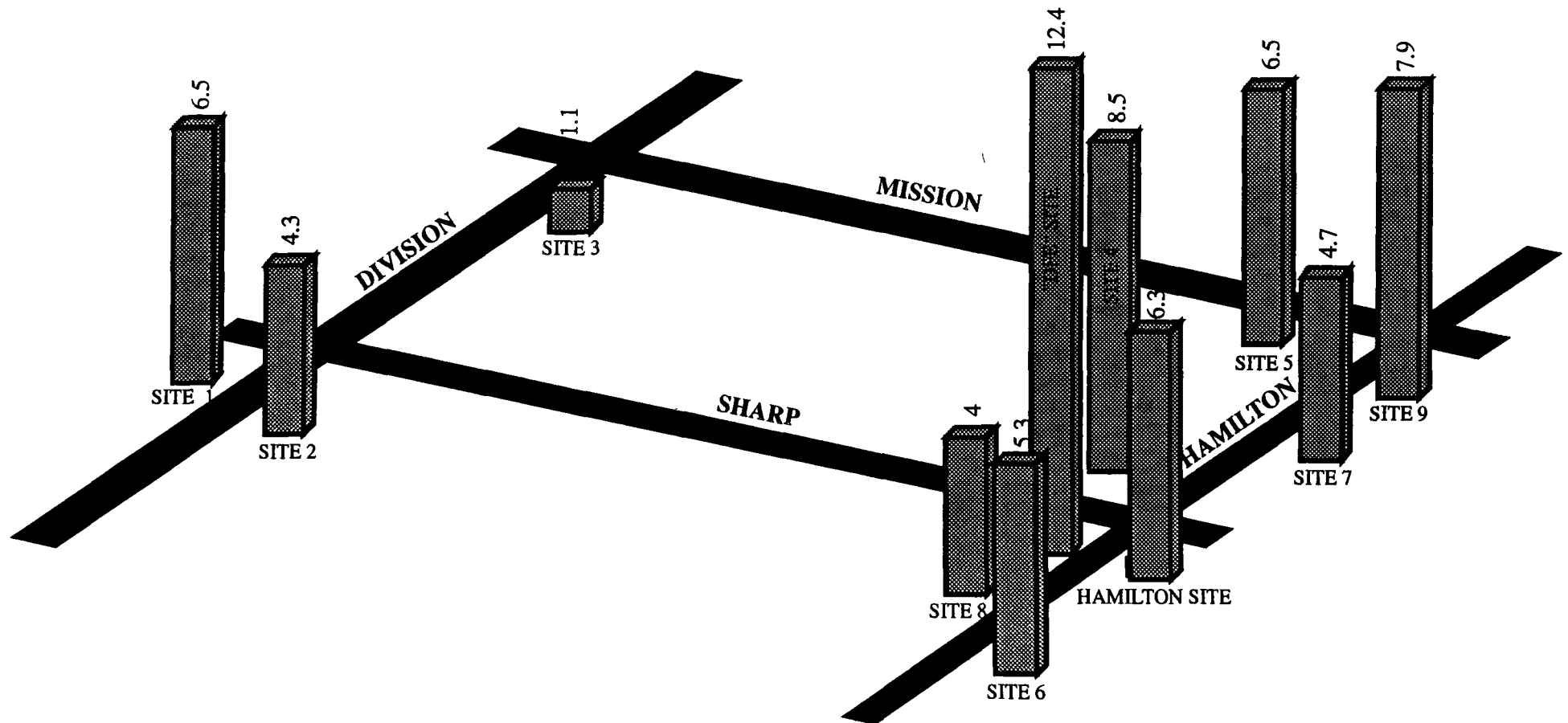
12/6/88  
(PPM)



# CO STUDY SITES NEAR HAMILTON SITE

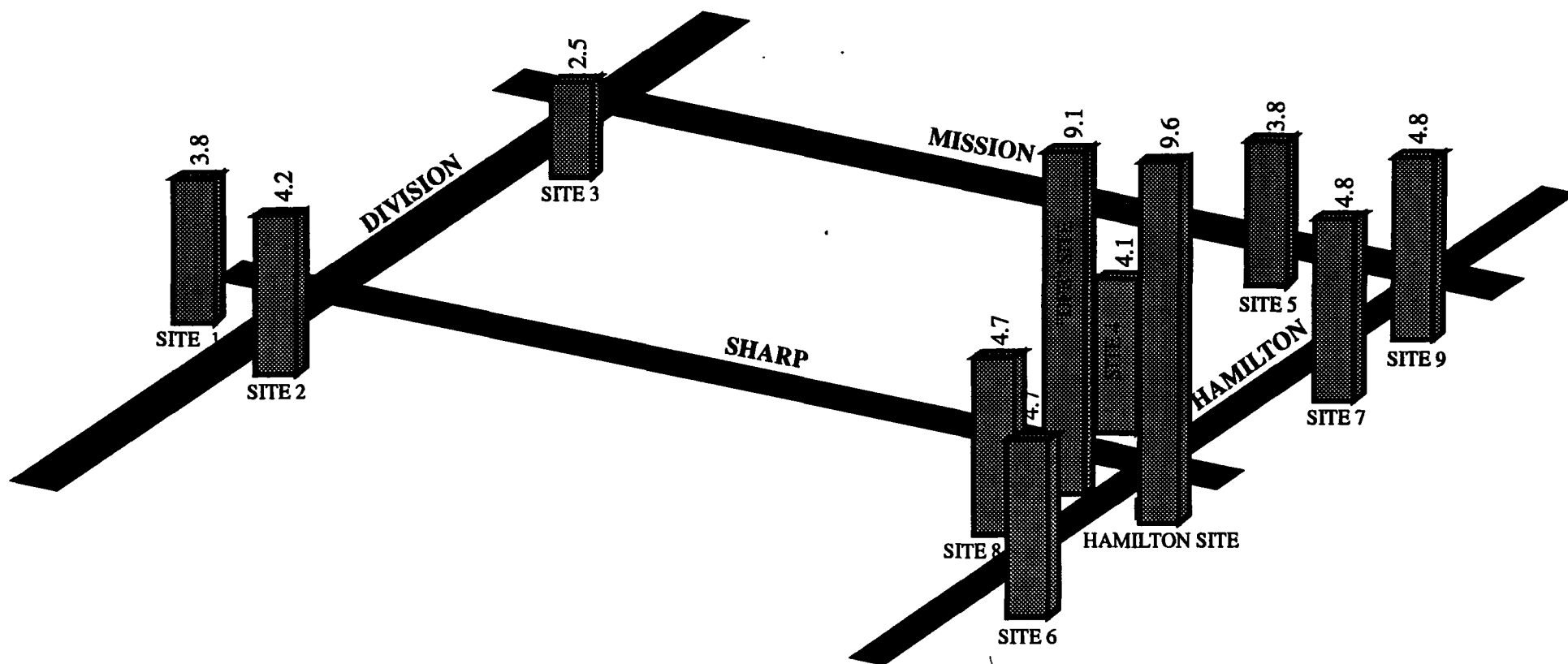
12/8/88

(PPM)



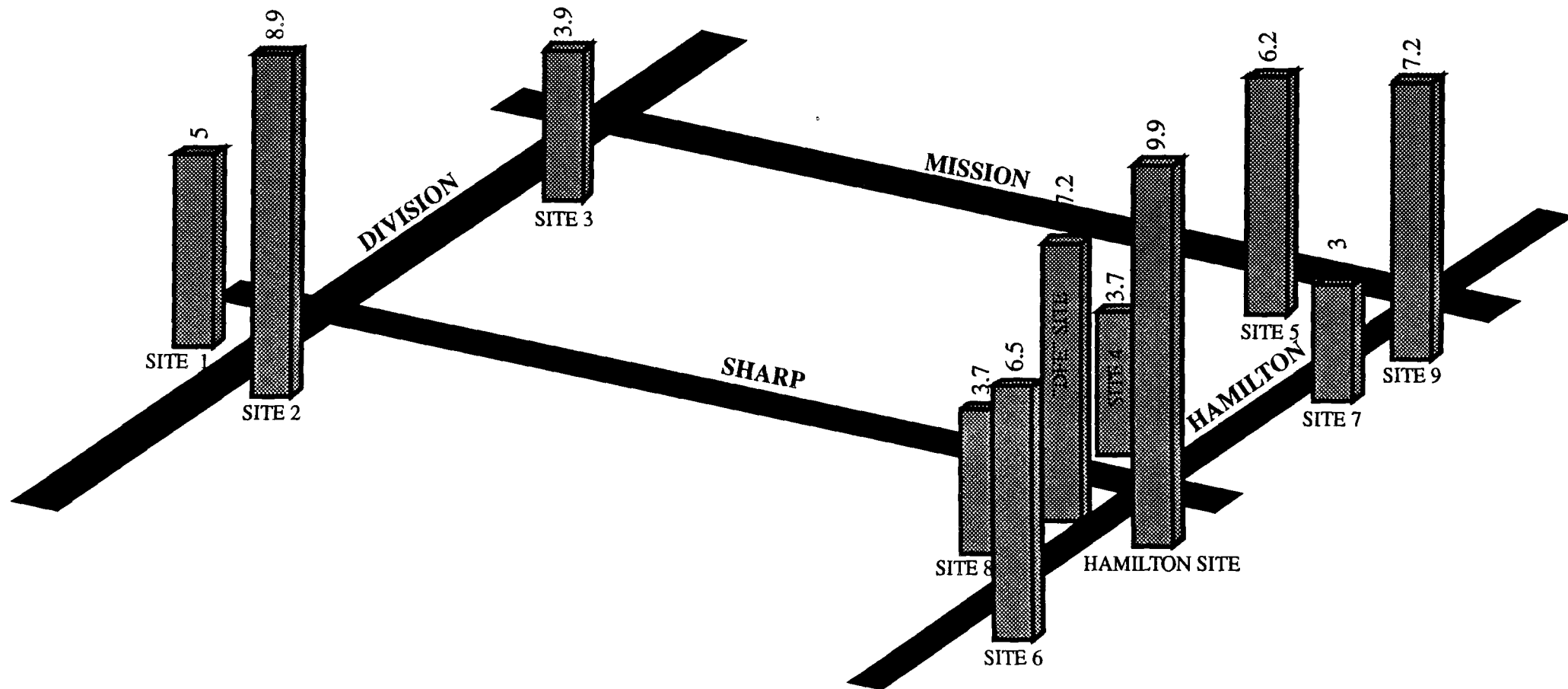
# CO STUDY SITES NEAR HAMILTON SITE

12/9/88  
(PPM)



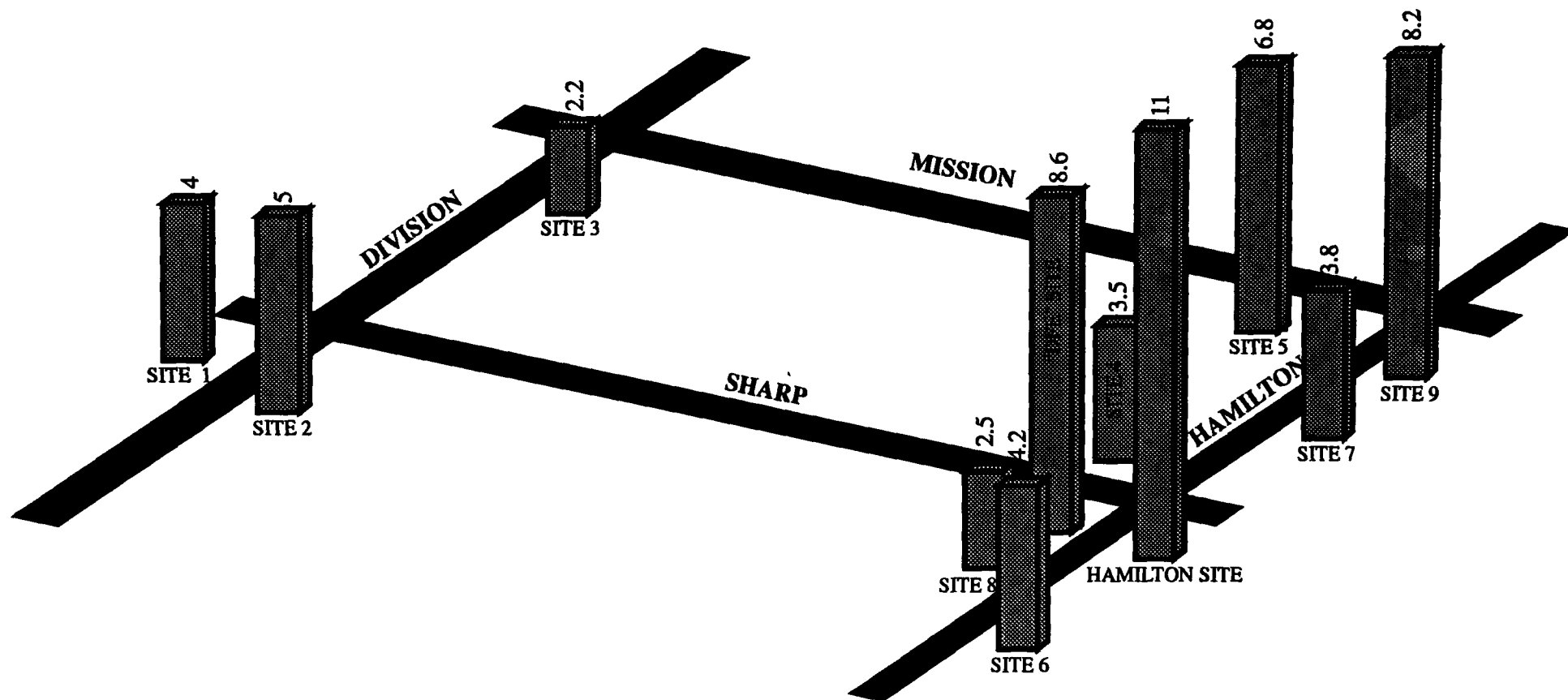
# CO STUDY SITES NEAR HAMILTON SITE

12/10/89  
(PPM)



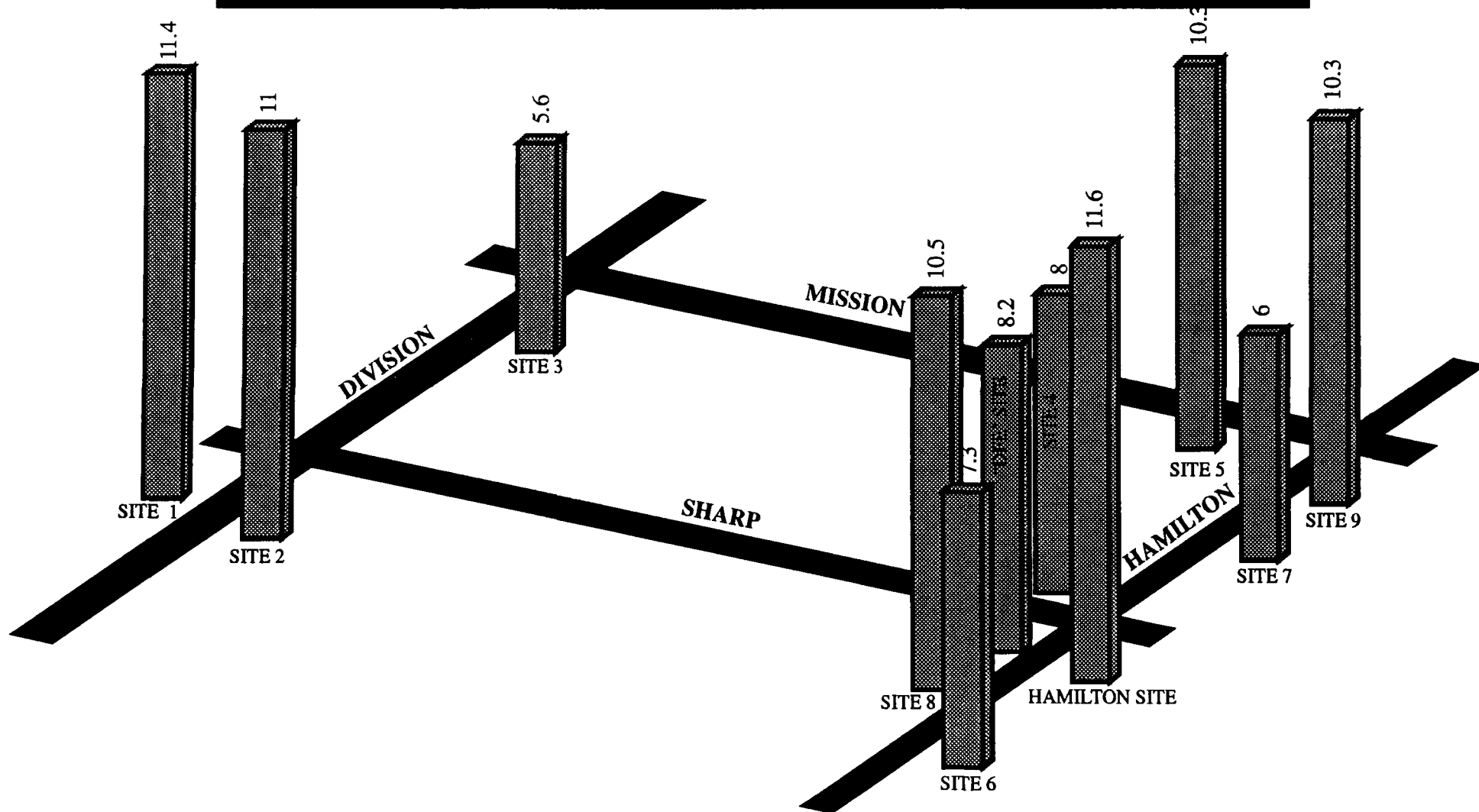
# CO STUDY SITES NEAR HAMILTON SITE

12/12/88  
(PPM)



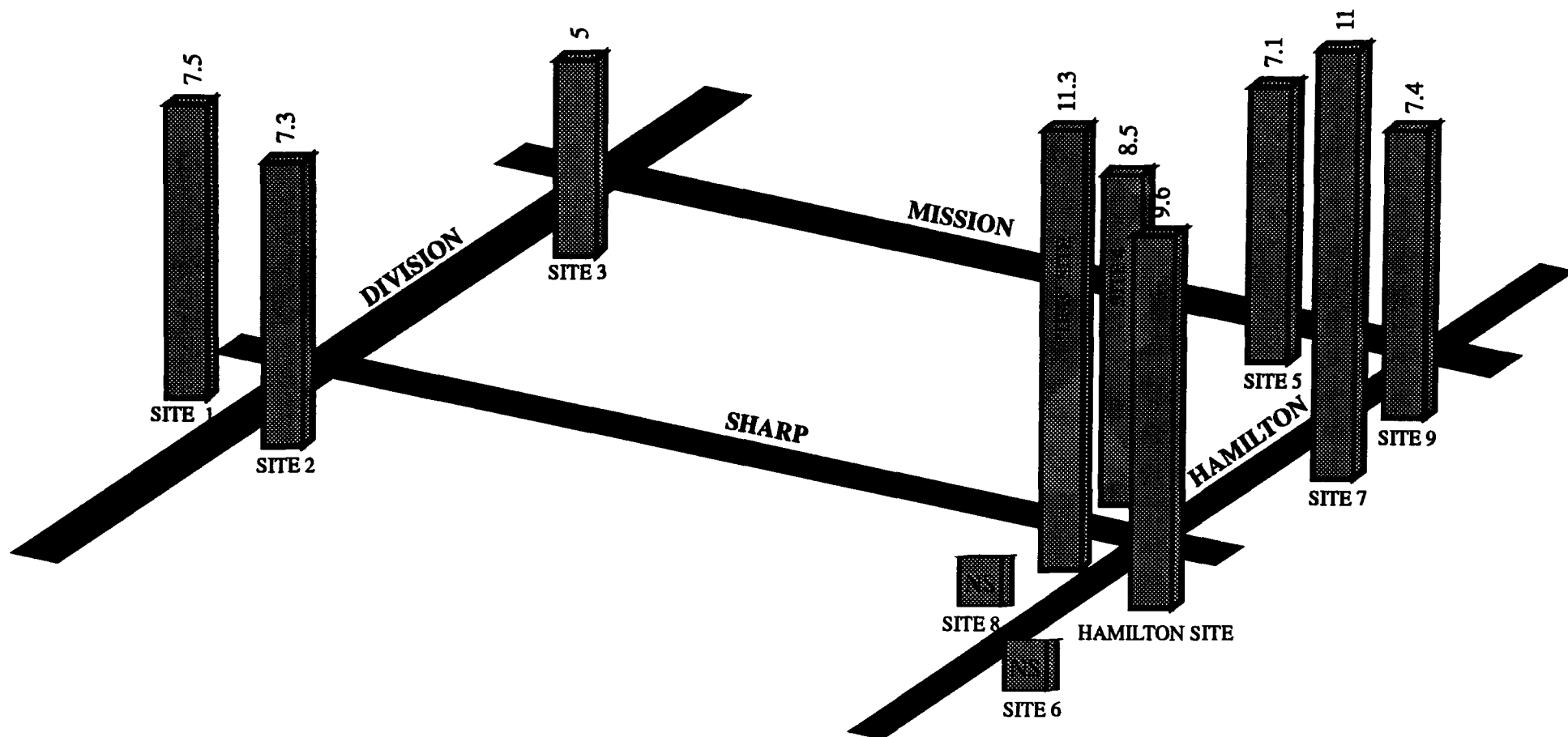
# CO STUDY SITES NEAR HAMILTON SITE

12/15/88  
(PPM)



# CO STUDY SITES NEAR HAMILTON SITE

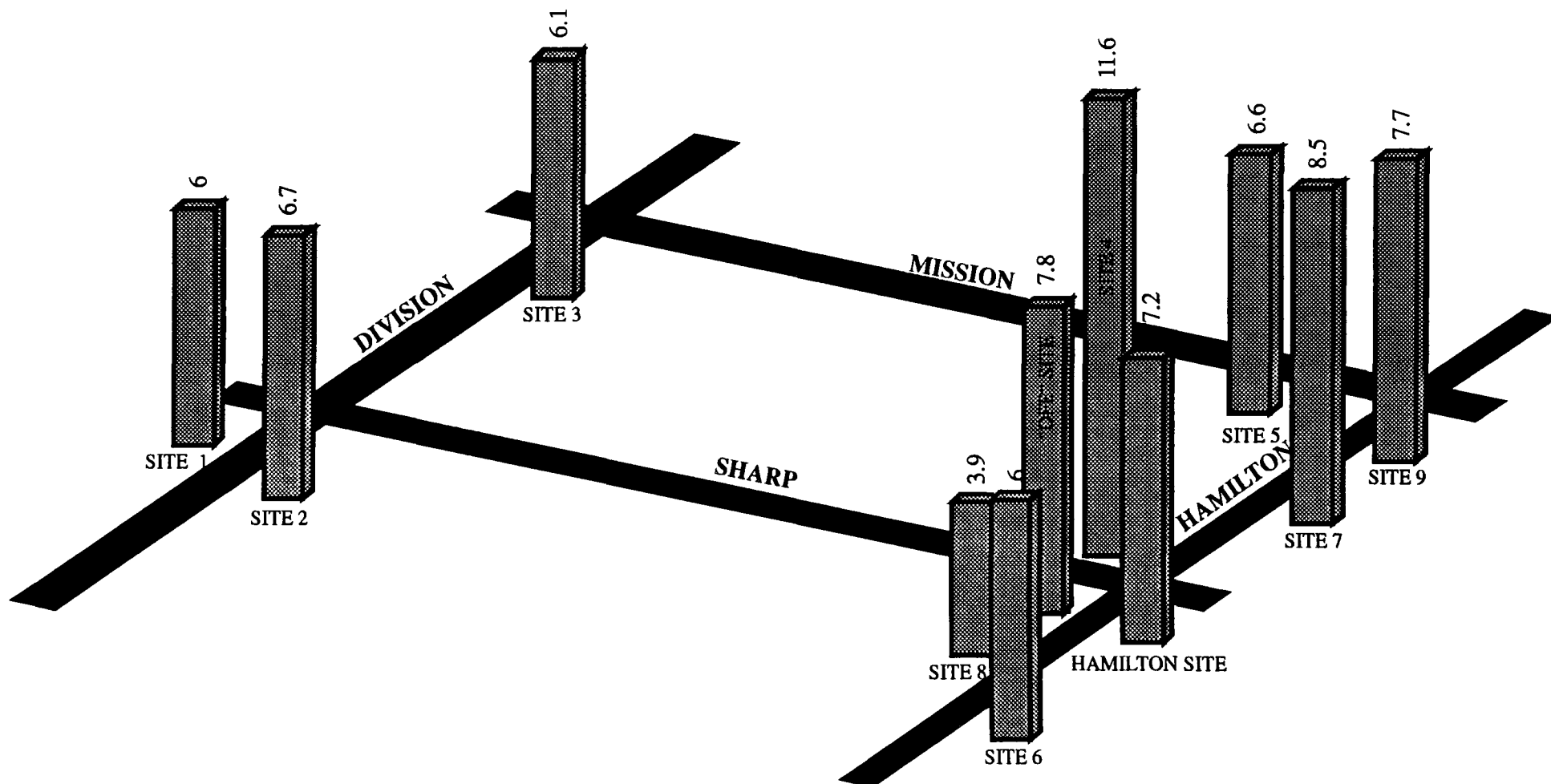
12/16/88  
(PPM)



# CO STUDY SITES NEAR HAMILTON SITE

2/9/88

(PPM)





## QUALITY ASSURANCE

As referenced previously, a quality assurance (QA) project plan was developed and ordered to the study. Although the study data resulted in sufficient precision and accuracy to have achieved the study objectives, the degree of uncertainty ( $\pm 2.0$  ppm) associated with the data is greater than what is normally attained with this type of study. The following is a brief synopsis of the precision and accuracy of the study data.

### Sampling Precision

Two pairs of integrated samplers were collocated (within 2 meters) to quantify the extent of variability (precision) associated with the sampling method. The precision results for this study had a large degree of variability. The average absolute difference between the collocated samplers at site 33 was 0.5 ppm. The absolute difference was greater than 2.0 ppm on 2 of the 52 sample pairs (absolute dif. of 2.6 and 3.6 ppm). The average absolute difference between the samplers at site 2 was 0.7 ppm. The absolute difference was greater than 2.0 ppm on 2 of the 53 sample pairs (absolute dif. of 3.2 and 5.5 ppm).

Thorough review of the sampling documentation (% of bag filled, bag leaks, pump rates, ect.) did not reveal an explanation for any of the significant differences.

### Sampling Accuracy

Two integrated bag samplers were collocated with the continuous analyzers (site 10 and 'DFE'; site 16 and 'DAR'). While in a strict technical sense this was not a true audit of sampler accuracy (since an absolute standard was not directly employed) it was assumed that the data from the continuous analyzer were of sufficiently higher quality that they were considered a "quasi" audit source. This also provided a measure of method comparability. Because of logistical problems, a bag sampler could not be collocated with the permanent Hamilton site.

The average absolute difference between the data from the bag sampler and the continuous analyzer at the Dairy Freeze site ('DFE') was 0.7 ppm. On average the analyzer data was 19.8% higher than the bag sampler data. The absolute difference between the methods was larger than 2.0 ppm for 10 of the 38 sample pairs (up to 4.1 ppm difference). On 8 of the 10 days with a discrepancy greater than 2.0 ppm, the analyzer was higher than the bag sampler.

The average absolute difference between the data from the bag sampler and the analyzer at the Darl Apts. site ('DAR') was 0.6 ppm. On average the analyzer was 19.4% higher than the bag sampler. The absolute difference between the methods was larger than 2.0 ppm for 2 of the 28 sample pairs (up to 6.3 ppm difference). On both of the days with a discrepancy greater than 2.0 ppm, the sampler was higher than the analyzer.

### Analytical Precision

The Dasibi 3003 CO analyzer used for analysis of bag samples was challenged before and after each analysis session with precision and or span atmospheres traceable to the National Bureau of Standards (NBS). Control limits of  $\pm 0.5$  ppm, as indicated in the project QA plan, were upheld to control instrument drift and ensure a high degree of analytical precision.

### Analytical Accuracy

The Dasibi CO analyzer was audited once with test atmospheres traceable to NBS to evaluate its response to known absolute concentrations of CO. The analyzers performance during the audit was in conformance with the criteria outlined in the project QA plan.

## CONCLUSIONS AND RECOMMENDATIONS

The major conclusions and recommendations arising from this study are as follows:

- 1) Twelve of the thirty six study sites exceeded the level of the CO NAAQS over the study period. Of the four permanent CO monitors in Spokane, only the Hamilton site exceeded the CO NAAQS during the study. Exceedance level CO concentrations were primarily recorded near heavily travelled roadways, including Hamilton street, Division street, and 3rd Avenue.
- 2) The permanent Hamilton monitor recorded more CO exceedances than any of the study sites. On a daily basis, the permanent Hamilton site was most frequently the highest site relative to all the study sites. However, on over half of the study days, at least one of the study sites recorded higher CO levels than those reported at the Hamilton site.
- 3) The Dairy Freeze temporary continuous analyzer (located directly across the street from the Hamilton monitor) and the Hamilton monitor, recorded CO levels that were of similar magnitude. While there was substantial variability between the two sites on a daily basis, the highest CO levels recorded at each of the sites over the study period were essentially equivalent. The maximum and 2nd maximum 8-hour CO values recorded at the Dairy Freeze site were slightly higher than those recorded at the Hamilton site, but the Hamilton site recorded a larger number of values above the CO NAAQS.
- 4) The study data indicate the permanent Hamilton site adequately represents areas of maximum impact in Spokane. While the Hamilton site appears to represent the area that exceeds the CO NAAQS with the greatest frequency, it also represents a large array of CO problem areas located throughout the Spokane Corridor grid. Thus, the Hamilton site is not an isolated 'hot-spot' CO problem area. For example, the Hamilton site recorded the highest value on only five of the ten days an exceedance was recorded from among all the study sites. Finally, the Hamilton-Dairy Freeze comparison shows that the permanent Hamilton monitor adequately characterizes CO impacts throughout the air parcel near the Hamilton-Sharp intersection on a season-long basis.
- 5) The permanent Liquor store and Post Office sites adequately represent the magnitude and frequency of maximum impacts occurring in the core central business district area. However, the study data indicate the maximum CO levels along 3rd Avenue, which is on the periphery of downtown, are significantly higher than those in downtown proper.
- 6) It is recommended that new permanent sites be established near 3rd Avenue and along Division street. The purpose of these sites will be to measure maximum CO levels and establish definitive comparisons to the Hamilton site. No additional changes to the permanent network are recommended at this time.

7) Because a number of technical problems were encountered, the study data have a significant degree of associated uncertainty. The study data are generally considered to be accurate within  $\pm 2.0$  ppm. While this level of uncertainty exceeds that typically associated with studies of this kind, the foregoing conclusions and recommendations are advanced with a high degree of technical confidence.

8) The vast proportion (85-90%) of the CO measured at street-side locations is believed to be attributable to automotive emissions. However, measurement of the highest CO levels during later eight-hour intervals suggests the possibility of a higher quotient of contribution from residential wood combustion emissions. It is plausible, however, that more stagnant conditions exist later in the evening reducing the dispersion of automotive emissions. These potential scenarios should be further investigated.