APPENDIX B

CARBON SATURATION STUDY AND APPENDICES

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CARBON MONOXIDE (CO) SATURATION STUDY

Final Report (P.O #172634)

Prepared for:

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April 1, 2002

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Final Report (P.O #172634)

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It is typical that, in addition to field personnel, a scientific field study requires the knowledge and cooperation of many scientists for its success. In this regard, Dennis Ransel of the Clark County Department of Air Quality Management (DAQM) provided overall study management and coordination within DAQM. L. Femi Durosinmi of DAQM made many helpful technical suggestions as well as coordinated our use of DAQM monitoring facilities.

The field operations phase was conducted in a nearly flawless manner resulting in a near-perfect data capture rate, due to the experience and diligence of the field crew (in alphabetic order): Robert Baxter, Paul Fransioli, William Knuth, Derek Lehrman, and David Yoho. The auditor, Mr. David Bush, provided many helpful suggestions and corrected some initial siting problems. Recognition is also owed to Derek Lehrman and Elizabeth Niccum who spent many tedious hours on data organization and validation required to develop this data base. Many thanks to Susan Hynek who, in addition to contributing considerable organizational skills to the overall project, was central in compiling information and figures for this report.

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EXECUTIVE SUMMARY

CARBON MONOXIDE (CO) SATURATION STUDY

Study Purpose

The Clark County, Nevada, Department of Air Quality Management (DAQM) contracted a "saturation" study to measure carbon monoxide (CO) throughout the Las Vegas Valley. The Study was performed during the seasonal period historically experiencing CO levels that exceeded the 8-hour National Ambient Air Quality Standard (NAAQS). The purposes of the Las Vegas CO Saturation Study were to:

- Identify geographic patterns of CO concentrations, including potential areas with higher concentrations not previously known
- See if the DAQM routine CO monitoring station locations are representative of areas with higher CO occurrences in the Valley, and
- Improve the conceptual understanding of the relationship between land use, meteorology, and ambient CO concentrations.

Summary of Carbon Monoxide Saturation Study Sampling

The Study began with a network of 32 continuous CO samplers operating throughout the Las Vegas Valley. Stations were added during the program to refine the spatial distribution of higher concentrations, ending with 63 stations. A mobile van equipped with an EPA equivalent CO analyzer and a sophisticated position recording system operated during two Intensive Operating Periods when higher CO concentrations were likely to occur. An extensive quality assurance program adds credibility to the results. This extensive sampling and quality assurance program provided an effective "saturation" of the Valley producing the data needed to fulfill the purposes of the Study.

Summary of Results

The primary result of the Study is that the DAQM CO monitoring station locations are representative of the higher CO concentrations in the Valley. In summary:

- The highest 8-hour average CO concentration observed in the Saturation Study network of sites occurred in a residential area near Eastern Avenue and Charleston Boulevard, a few blocks south of the DAQM Sunrise Acres monitoring station. The CO concentrations were comparable at both sites and well below the corresponding NAAQS of 9 ppm. Except for one downtown Study site purposely located with a definite micro-scale exposure, the higher 8-hour average concentrations all occurred in the area east of downtown Las Vegas near the DAQM Sunrise Acres monitoring station. **Figure 1** is a smoothed contour map plot of peak 8-hour average CO concentrations measured at the sites in the Saturation Study area. The DAQM CO monitoring station locations are also shown in Figure 1 depicting how the distribution of higher CO concentrations identified by the Saturation Study sampling was well-defined by six surrounding DAQM stations.

- Many of the Study sites with relatively high 8-hour CO averages were near the Eastern-Charleston-Fremont area in residential neighborhoods, away from the busier streets in the area. These occurrences were on cold nights with low wind speeds, which indicates low rates of atmospheric dispersion and probable accumulation of CO in the first 100 feet above ground level. Other parts of the Valley with apparently similar emission sources do not experience as high CO concentrations, suggesting the possibility of local meteorological features that tend to trap CO in this area. Traffic flow and a different mix of CO sources in this area, such as automobiles and home appliances, are other possible factors that can contribute to this observation.

- A micro-scale Saturation Study site along Casino Center Drive near Fremont at a taxi stand and a parking garage showed the highest one-hour CO average, 18.3 ppm. This is about half the 1-hour NAAQS (35 ppm). The highest associated 8-hour average CO concentration was 7.0 ppm. None of the other micro-scale stations located in the immediate downtown area, nor anywhere else in the tourist-oriented areas approached these values that were probably influenced by a few vehicles with relatively high CO emissions.

Recommendations

The closely spaced group of DAQM CO stations near the Sunrise Acres station was correctly located to identify the higher 8-hour average CO concentrations occurring in the Las Vegas valley. Diminishing or greatly changing site locations in this area is not advised. Further definition of the spatial extent of lesser, but still relatively high for the Valley, CO concentrations could be achieved with more monitoring toward the southeast along Boulder Highway, south of Sahara, and northwest of downtown Las Vegas near Rancho Drive and the U.S. 95 interchange with I-15.

Further investigation may be warranted of the relative influence of CO emissions from small, non-mobile sources such as home heating appliances.

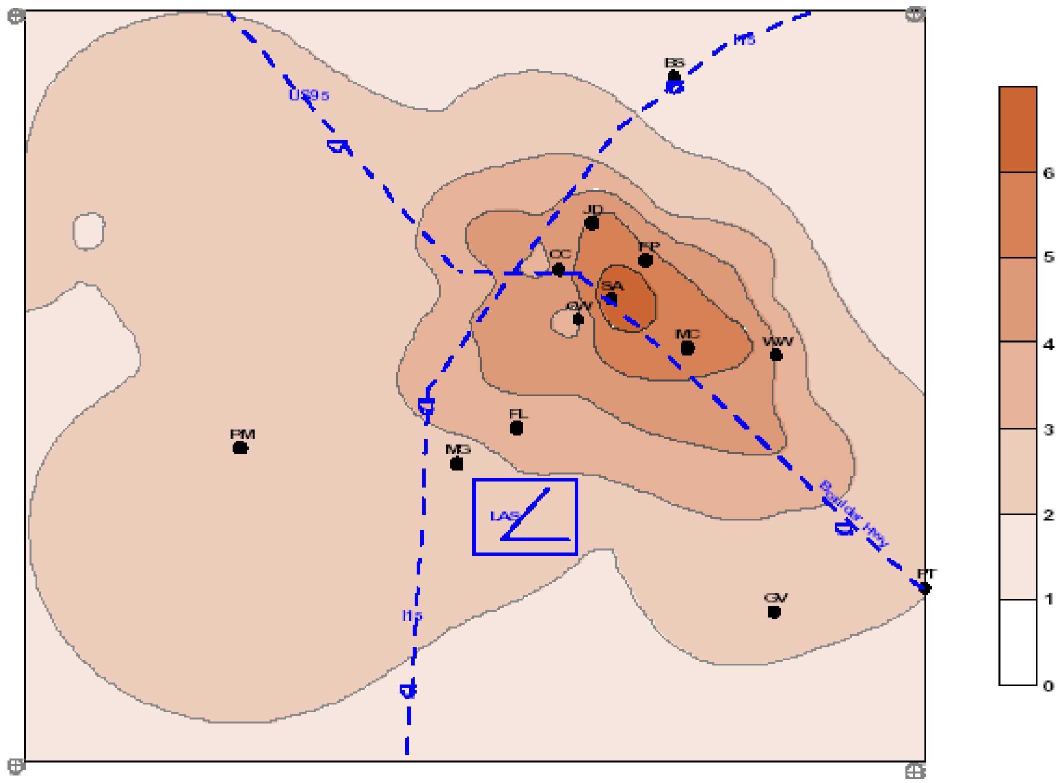


Figure 1. Peak 8-Hour Average CO (ppm) for Period November 20, 2001 to January 5, 2002. Showing DAQM Network Sites.

1. INTRODUCTION

The Clark County, Nevada, Department of Air Quality Management (DAQM) contracted a "saturation" study of carbon monoxide (CO) concentrations occurring during the seasonal period from before Thanksgiving to after New Year's Day, specifically, November 20, 2001 through January 5, 2002. Historically, this is the most likely period to have the highest CO concentrations measured by the County's air monitoring network. The study objectives are:

- Obtain additional CO concentration information in areas where the National Ambient Air Quality Standard (NAAQS) for CO has been exceeded (exceedances)
- Improve the conceptual understanding of the relationship between land use, meteorology, and ambient CO concentrations
- Identify geographic areas with high CO concentrations to support risk assessment and potential population exposure to CO exceedances, and
- Evaluate the current Clark County DAQM monitoring network CO sampling locations in accordance with U.S. Environmental Protection Agency (EPA) siting criteria.

In short, the study was planned to answer two primary questions: are the DAQM monitoring sites adequately identifying the highest 8-hour average concentrations occurring in the metropolitan Las Vegas Valley area, and what geographic areas are affected by high CO concentrations? Prior to 1999, at least one 8-hour average per year exceeded the primary National Ambient Air Quality Standard (NAAQS) for CO, 9 parts-per-million (ppm). Aggressive efforts to reduce CO emissions have contributed to the significant decline in exceedance occurrences; none have been recorded since 1998. The saturation study was planned to provide the information to assess the adequacy of the spatial distribution of County DAQM monitoring sites.

1.1 Overview of the Field Program

The technical approach to meeting the study objectives was to operate a network of CO monitoring sites throughout the Valley, with emphasis on the locales historically most likely to experience the highest CO concentrations and where rapid recent development has occurred. Increasing the number of sampling locations well above the number of sites in the DAQM monitoring network effectively "saturates" the community with sampling locations to provide the data needed to achieve the study objectives. The Saturation Network was to be achieved by a combination of fixed (called "Static") sites and moveable (called "Dynamic") sites operated during the anticipated worst-case meteorological conditions. The samplers ran nearly continuously at the monitoring sites, producing a very complete record of CO concentrations at the selected locations. Another element in saturating the Valley with measurements was conducting mobile sampling using an instrument van during intensive operating periods (IOP). The van was driven around the Valley to observe CO loading in a real-time mode during nighttime and early-morning hours when meteorological conditions conducive to peak CO concentrations occur.

The network monitoring sites were located throughout the Las Vegas Valley, with a higher density east of the downtown area. Previous monitoring and modeling results indicated this to be the most likely area to encounter higher CO concentrations during periods of typical worst-case meteorological conditions and higher CO emission rates. The dynamic sites were located both to increase the density of sampling locations in the static network and to test other areas that might produce higher CO concentrations due to expected airflow pathways. As dynamic sites were installed and the preliminary data appeared useful in delineating spatial CO patterns, many were left operating continuously to maximize the amount of information collected.

The samplers used at the Saturation Network sites were small self-contained units manufactured by the Onset Computer Corporation. The sampler consists of an electrochemical sensor and on-board datalogger housed in a rectangular plastic container about four inches long by three inches wide and 1.5 inches high. The sampler was housed in a polyvinyl chloride (PVC) circular pipe section closed on the top with a grate on the bottom and holes in the side for air circulation. EPA recognizes the virtual impossibility of operating a network of reference analyzers in the density needed for a saturation study. Hence, various saturation studies have utilized non-reference sampling methods with appropriate comparisons to ensure adequacy of the information for the intended purposes. Preliminary tests in sampling chambers and the ambient environment coupled with comparative results from samplers collocated with DAQM designated equivalent analyzers at monitoring sites and in the mobile sampling van all showed excellent justification for recognizing results from the samplers as adequate for the purposes of this study.

1.2 Overview of the Data Processing and Analysis

All the individual Onset samplers were calibrated in a chamber using "zero" (pure) and NIST traceable concentrations of CO gas. The sampler responses were checked throughout the program to ensure continued performance within the quality control guidelines. Sampler responses to ambient conditions were recorded on a one-minute interval as the raw data. The raw data were transferred to a standard computer data base at frequent intervals and immediately reviewed by the field personnel to ensure proper operation. In this manner, problems were identified and corrected in a timely manner.

The Saturation Network data base consists of approximately three-million validated one-minute instantaneous CO measurements from the continuous monitoring network and mobile sampling. The one-minute continuous data have been transformed to hourly and eight-hourly averages and included in the electronic data base.

Comparisons between the Onset samples and collocated CO measurements made by DAQM reference analyzers at two select sites indicated a small diurnal cycle bias of the Onset readings, generally less than 0.5 ppm. This bias apparently depends on ambient air temperature. Thus, in addition to factoring the individual sampler multipoint calibration responses a correction was also made for the apparent temperature bias. The corrected data files were then used in the statistical analysis to determine the comparability of the Saturation Network results and the DAQM routine network results.

The analysis task consisted of two major elements: the Saturation Network of fixed sites and the mobile sampling with the monitoring van. The geographic distribution of CO concentrations throughout the Valley as defined by the Saturation Network of fixed sites was determined for those periods of observed high levels and for the overall maximum levels experienced during the field study. The maximum impacted areas were then compared with the locations of the DAQM sites. The mobile sampling measurements mapped the CO distribution to verify that the Saturation network was correctly configured to identify peak CO concentrations, and provided justification for Dynamic sites that were installed during the course of the field study.

2. INSTRUMENTATION

Two types of CO sampling instrumentation were used to collect the carbon monoxide (CO) data. The CO samplers used in the network study sites were manufactured by Onset Computer Corporation (Onset). The samplers are small, self-contained units that include the CO sampler and a datalogger. The primary CO sampling in the mobile van used during the Intensive Operating Periods (IOP) was a Dasibi 3003 CO analyzer, which is an EPA Equivalent Method per 40 CFR 53.

2.1 Network Sampling Instrumentation

Extensive testing of the samplers was performed prior to proposing them in this study because the CO samplers had not yet been used for an ambient measurement application. During testing, individual sampler calibration responses were measured using a Dasibi 3003 CO analyzer. These responses were used in data processing. During operations, aggressive quality control checks and operating samplers at two sites collocated with DAQM sites typically receiving higher CO concentrations helped to provide good comparability of results from the Study samplers and the DAQM CO monitors. **Figure 2-1** shows the CO analyzer, as received from Onset. The preliminary manufacturers specifications are shown in Appendix G.

Figure 2-1. Onset CO Analyzer

Tests were performed to ensure that natural ventilation through the polyvinyl chloride cylindrical tube housings would provide an adequate time response to changing CO concentrations. The initial response to increasing CO concentrations was at least as quick as that of the Dasibi analyzer, but a small lag time in the Onset sampler response was noted during decreasing concentrations. This lag was shown to be inherent in the detector technology and not in the natural ventilation of the sampler housing.

Other tests also indicated a small temperature dependence in the Onset sampler response. This temperature relationship was further defined by both laboratory controlled conditions and by comparing the collocated measurements made in the field (between the DAQM Dasibi analyzer and the Onset sampler) during field conditions occurring in the Study. The relationship was applied during data processing. A summary of each of the evaluations is described in Appendix G.

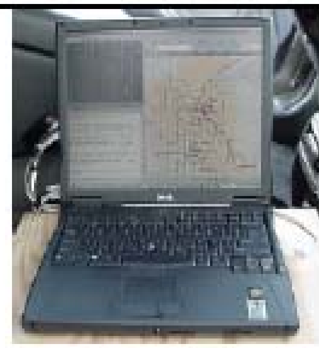
2.2 Mobile Sampling Instrumentation

To aid in the spatial mapping of CO concentrations and assess the adequacy of the placement of the fixed site sampling network, a van was outfitted for mobile CO monitoring. The real time observations mapped the horizontal extent of the CO plume and aided in understanding the areas of highest concentration for placement of fixed site samplers during the IOPs. The mobile van was a late model sport-utility vehicle known to have low CO emissions, minimizing the potential impact of the van on the measurements.

Figure 2-2 shows several views of the vehicle with the sampling probe mounted on the roof. This inlet height allowed sampling above the level of the tailpipe emissions and in the region of generally well-mixed air. The sample was drawn through the inlet by a pump system supplying air both to a Dasibi 3003 CO analyzer and to two Onset CO analyzers configured in a series flow arrangement. The first Onset CO sampler was programmed to collect data at 5-second intervals to help identify possible “spikes” (rapid rise and fall in concentration) possibly due to nearby vehicles. A laptop computer polled the second Onset CO sampler at one-second intervals to compute one-minute averages. CO readings from the Dasibi 3003 were also collected at one-second intervals and stored as one-minute averages on a Campbell CR10 datalogger and subsequently by the laptop computer. The CR10 datalogger also recorded the outside air temperature from a platinum RTD probe mounted on the support rod for the sample inlet. The temperature data were recorded at the end of each minute.

The mobile van position was monitored by a Garmin Etrex Global Positioning System (GPS) and recorded by a laptop computer. One-second position readings were calculated to one-minute averages of latitude, longitude and altitude. Once each minute the Dasibi, Onset analyzer and GPS data files were merged and a graphical “strip chart” type display of the data was updated on two laptop computers. This real-time display allowed “scrolling” capabilities to look back in time at past data. A second GPS receiver provided the real time position to a street map display on the same two laptop computers as the strip chart display. One of the computers was in the front seat where a scientist evaluated the data in real time and kept a log of events. The three computers were networked through a LAN hub and the computer times synchronized prior to the start to assure proper updating of the real-time files. Finally, on selected routes, 30-second pictures from a digital camera mounted and with a forward view were recorded on the laptop computer located in the front seat. **Figure 2-3** shows a block diagram of the van analyzer and computer layout.

Sampling Van (sample inlet & temperature probe were on roof-mounted antenna)



Display on front seat computer for CO concentration, vehicle position and observation log entry.

Rear view of rack with deep cycle battery & pump system feeding the analyzers.

View looking from front seat to the back instrument rack, inverter & computers.

Figure 2-2. Views of Sampling Van and Instrumentation

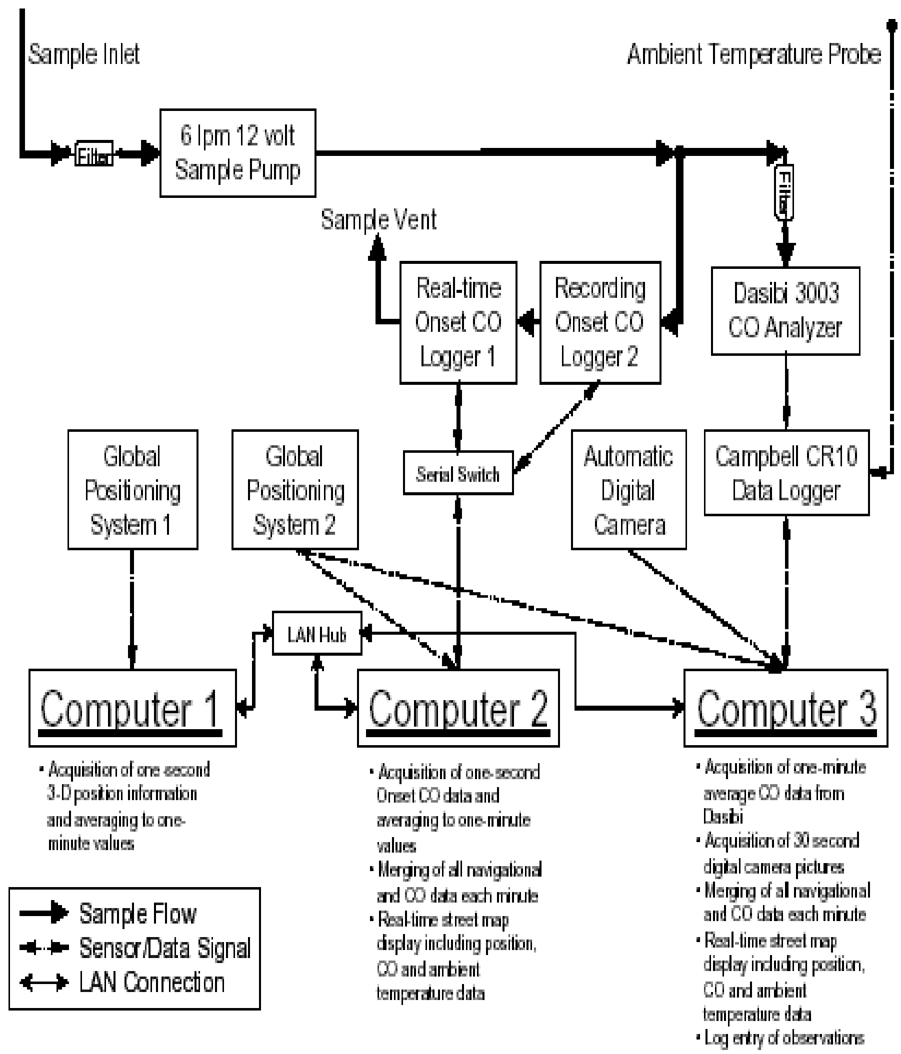


Figure 2-3. Block Diagram of Mobile Sampling Van Instrumentation

3. NETWORK OF SITES

The siting rationale and descriptions of the Static and Dynamic sites which comprise the Saturation Network operated in this study are presented in this section. Siting the network stations was accomplished complying with Title 40 of the Code of Federal Regulations, Part 58, including 58.14, "Special Purpose Monitors". A few of the sites fit a micro-scale site criterion of proximity to roads, but most of the sites have either middle- or neighborhood-scale exposures. These exposures were chosen to match the neighborhood scale exposure of most of the DAQM sites.

3.1 Rationale for Station Siting

Historically, the meteorological conditions producing the highest CO concentrations were a near-stagnation condition, consisting of low wind speeds in a shallow stable layer caused by a nighttime temperature inversion. These conditions, combined with high CO emission rates related to higher vehicle traffic occurring during nighttime and early morning hours, have produced the periods with concentrations exceeding the NAAQS (exceedance).

Past monitoring experience by Clark County (DAQM and its predecessor organization performing regulatory compliance monitoring, the Clark County Health District) has shown that the inner urban area east-southeast of downtown Las Vegas is the most likely area to experience higher 8-hour average CO concentrations. The single site in the DAQM Network continually responsible for recent exceedance cases is the Sunrise Acres site. This site is in an elementary school on the east side of Eastern Avenue, about 150 m north of Charleston Boulevard. The site location is about 400 m northwest of a previous monitoring site on East Charleston that also measured exceedance levels of CO. In addition to the routine monitoring results, DAQM air quality modeling and special CO and meteorological studies reported in Appendix E of the CO State Implementation Plan also predict the same geographic area as the location of the highest estimated CO concentrations.

The previous monitoring results, the modeling studies, and an understanding of the local meteorological conditions conducive to producing higher CO concentrations were used in designing a two-tier continuous monitoring Saturation Network of Static (fixed) and Dynamic (movable) sites. A higher density of both Static and Dynamic sites were located in the inner city area to optimize finding possible areas experiencing higher CO concentrations than those occurring at existing DAQM sites. Another purpose intended in the higher density of sites was to identify the extent of the geographical area affected by the higher CO concentrations. This area of historically higher incidence of CO is referred to as the inner core zone in this project.

Portions of the Saturation Network were also established in other areas of the Las Vegas Valley where routine DAQM CO monitoring was not taking place. Some of these sites were located in the outer perimeter of the valley air basin, in areas where very low levels of CO are predicted, but recent new development indicates that an increase in ambient CO levels may be possible. Other network sites were placed in areas that are more established, but where high CO levels were not encountered previously. Such areas were considered to be possible transition zones where CO levels may be increasing as higher concentrations from the inner core may occasionally impinge, or where increased emissions from the cleaner areas may transport. The objective of these transition zone sites was to document the gradient of CO concentrations from the inner core area to the cleaner outer fringe areas. Another objective for site placement was to measure fluctuating CO exposure in areas where local topography may affect transport of emissions due to the occurrence of “drainage” flow from surrounding elevated terrain. Those areas are referred to as transport zones.

Although the vast majority of the Saturation Network sites were intended to be sited at locations that are considered neighborhood scale by EPA guidelines, three Network sites were designed to be micro-scale sites. These sites were established to measure CO levels very close to emission sources in the downtown area, and in the resort corridor along Las Vegas Blvd., where pedestrians may be exposed to locally high levels of CO. A third micro-scale site was placed at the DAQM “Micro Site” (MS) on East Charleston where particulate measurements are taking place, but no CO monitoring is ongoing. Also, a number of middle scale monitoring sites were designed into the Network with the objective of measuring the CO exposure resident in possible higher risk locations. Middle sites were established in the near downtown area, at the Fashion Show Mall just off Las Vegas Blvd., originally near the M.A.S.H. homeless area, and in a high density housing project near East Las Vegas.

Two Saturation Network CO monitors were placed at existing DAQM sites with the specific objective of comparing results with the DAQM’s CO monitoring effort in order to determine data comparability. The Onset monitors were mounted within 2 meters of the DAQM air-sampling inlet in order that both methods would sample “the same air”. The sites designated as co-located were Crestwood School (DAQM CW) and Freedom Park (DAQM FP). The Sunrise Acres site was not used because of its accessibility issues.

Figures 3-1 and 3-2 provide maps depicting the names and geographical locations of the sites that comprise the Saturation network. The first map encompasses the entire project area. The naming convention used to identify the sites was developed at the outset of the study using a grid superimposed over a map of the entire area (not shown) and the alphanumeric site identifications derived from the letter/number coordinates in the grid. Figure 3-1 also includes the locations of the DAQM sites where CO is monitored. Figure 3-2 provides a closer view of the denser inner core monitoring area.

Detailed descriptions, including site coordinates, elevations, locations, characteristics and pictures are presented in Appendix A of this report. Each continuous monitoring Saturation Network site is depicted with a full description in the appendix.

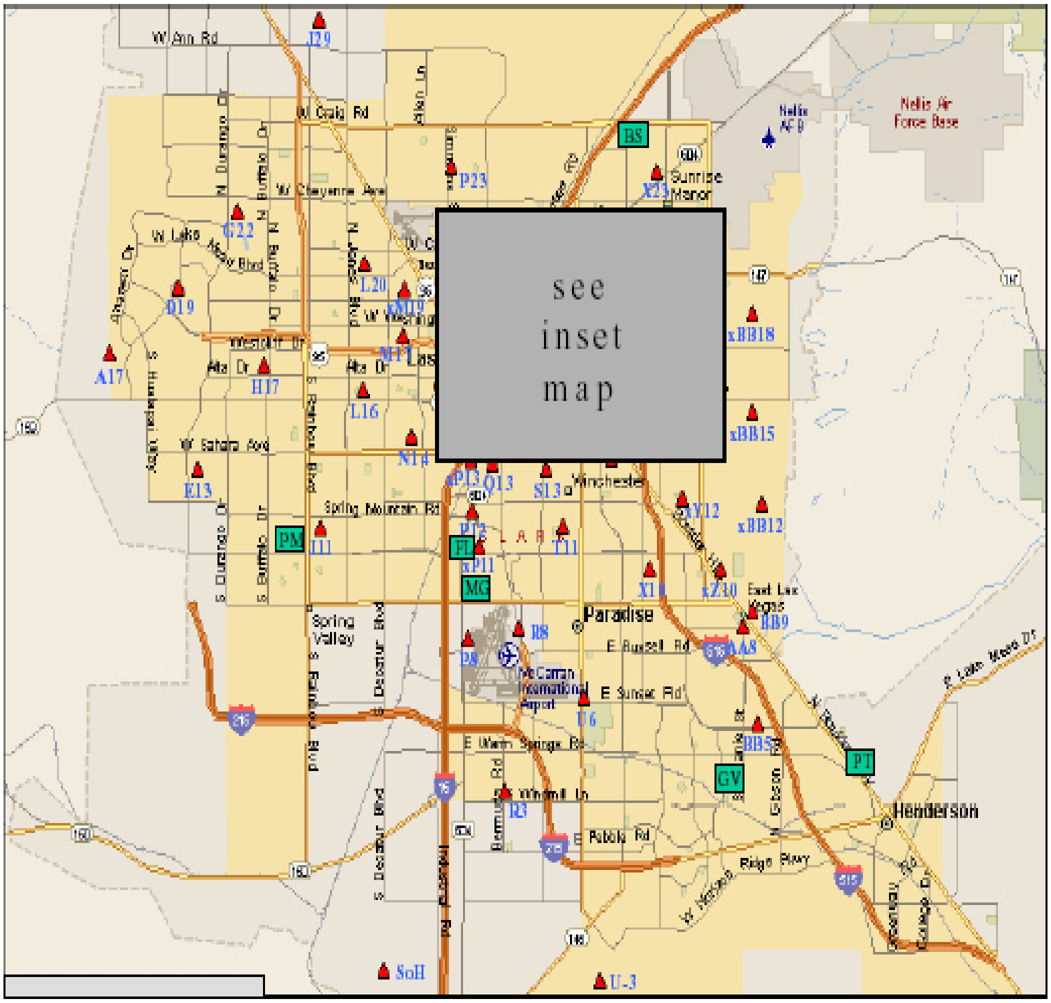


Figure 3-1. Map Showing Site Locations Used in the Study (DAQM sites indicated with a green square/Saturation sites with a red triangle)

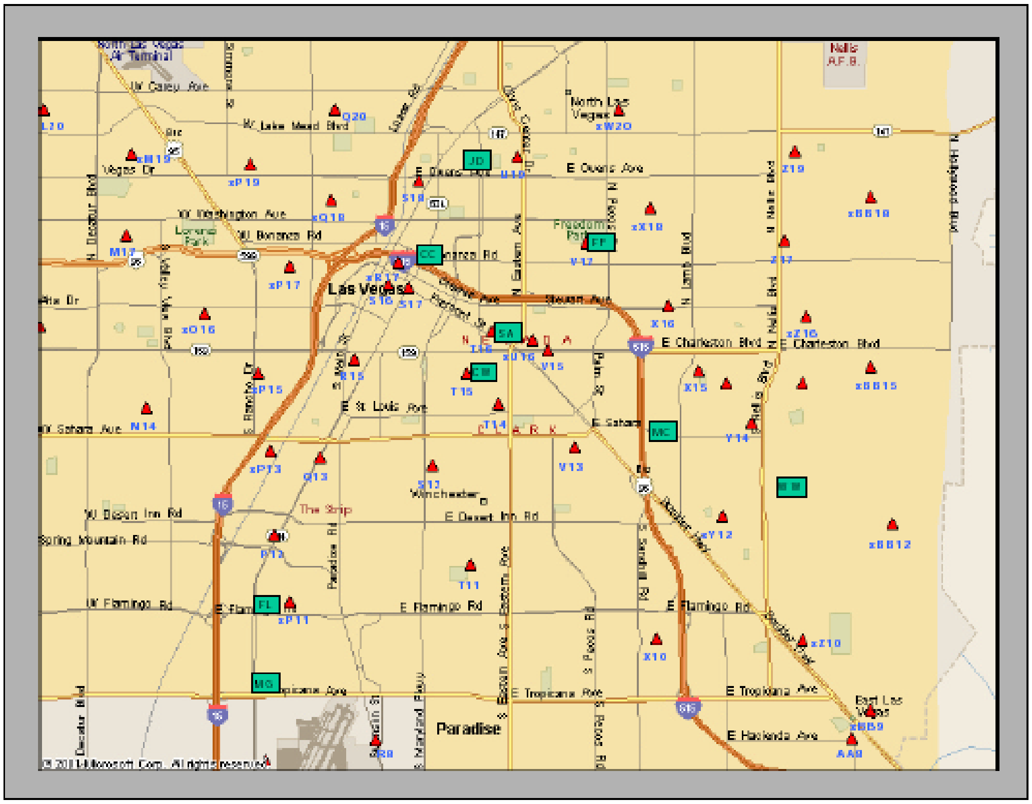


Figure 3-2. Inset Map Showing Site Locations Used in the Study (DAQM sites indicated with a green square/Saturation sites with a red triangle)

Table 3-1 presents a summary listing of the Saturation sites that were designated as Static sites at the beginning of the project. All of these sites ran continuously at the location indicated, except where vandalism or maintenance considerations temporarily interrupted monitoring. Also included in the summary are the initial siting objectives according to EPA scale guidelines, and the project zone criteria discussed above.

Table 3-2 presents a summary listing of the Dynamic sites. The Dynamic sites were established later in the monitoring program after initial monitoring results enabled the identification of areas where additional monitoring could prove useful. The results produced by these sites showed the locations to be worthwhile to measuring CO for the purposes intended. Hence, the analyzers were left in place for the remainder of the project.

3.2 Intensive Operating Period Measurement Areas

The sampling van traversed the valley in two general modes. One pattern was cross-section passes to identify possible new areas of higher concentrations not covered by the Saturation network. The other pattern was a close inspection of the immediate area in the vicinity of DAQM and Saturation Network sites to identify possible higher CO concentrations.

Table 3-1. Saturation Monitoring Network – Static Sites

Site ID	Start Date	Latitude (dd.ddddd)	Longitude (ddd.ddddd)	Elevation (m) (msl)	Site Objective (Scale)	Site Objective (Zone)
A17	20-Nov	36.17333	-115.33267	925	Neighborhood	Outer
AA8	07-Dec	36.09360	-115.04668	514	Middle	Transport
BB5	20-Nov	36.06533	-115.04017	531	Neighborhood	Outer
BB9	20-Nov	36.09832	-115.04283	507	Neighborhood	Transport
D19	21-Nov	36.19250	-115.30117	823	Neighborhood	Outer
E13	20-Nov	36.13950	-115.29233	832	Neighborhood	Outer
H17	20-Nov	36.16967	-115.26283	770	Neighborhood	Gradient
G22	27-Nov	36.21467	-115.27432	740	Neighborhood	Outer
J11	20-Nov	36.12233	-115.23700	709	Neighborhood	Gradient
J29	30-Nov	36.27050	-115.23800	703	Neighborhood	Outer
L16	20-Nov	36.16300	-115.21800	688	Neighborhood	Gradient
L20	20-Nov	36.19967	-115.21723	681	Neighborhood	Gradient
N14	20-Nov	36.14933	-115.19567	659	Neighborhood	Gradient
M17	20-Nov	36.17833	-115.19983	671	Neighborhood	Gradient
P12	27-Nov	36.12767	-115.16850	-	Middle	Gradient
P23	20-Nov	36.22753	-115.17767	658	Neighborhood	Outer
P8	20-Nov	36.09000	-115.17050	653	Neighborhood	Gradient
Q13	20-Nov	36.14090	-115.15897	621	Micro	Inner core
R3	22-Nov	36.04610	-115.15329	662	Neighborhood	Outer
R15	08-Dec	36.15748	-115.15184	614	Neighborhood	Inner core
Q20	20-Nov	36.19980	-115.15583	607	Neighborhood	Gradient
R8	20-Nov	36.09350	-115.14717	629	Neighborhood	Gradient
T11	20-Nov	36.12283	-115.12733	579	Neighborhood	Inner core
S13	20-Nov	36.13955	-115.13508	608	Neighborhood	Inner core
S16	20-Nov	36.17034	-115.14462	628	Micro	Inner core
S17	07-Dec	36.16963	-115.14023	617	Middle	Inner core
S18	30-Nov	36.18783	-115.13823	-	Middle	Inner core
SoH	30-Nov	35.99350	-115.20830	736	Neighborhood	Outer
T14	20-Nov	36.15004	-115.12131	566	Neighborhood	Inner core
T15	20-Nov	36.15522	-115.12792	589	Co-located	DAQM CW
T16	20-Nov	36.16238	-115.12269	572	Neighborhood	Inner core
U19	20-Nov	36.19175	-115.11730	554	Neighborhood	Inner core
U6	20-Nov	36.07300	-115.11783	618	Neighborhood	Gradient
U-3	22-Nov	35.99039	-115.11028	-	Neighborhood	Outer
V13	20-Nov	36.14262	-115.10532	560	Neighborhood	Inner core
V15	20-Nov	36.15902	-115.11089	562	Micro	Inner core
V17	20-Nov	36.17717	-115.10301	552	Co-located	DAQM FP
X16	20-Nov	36.16650	-115.08555	533	Neighborhood	Gradient
X15 (1st)	20-Nov	36.15350	-115.07333	530	Neighborhood	Gradient
X15 (2nd)	15-Dec	36.15561	-115.07902	530	Neighborhood	Gradient
X10	20-Nov	36.11050	-115.08800	562	Neighborhood	Gradient
X23	30-Nov	36.22600	-115.08467	568	Neighborhood	Outer
Y14	20-Nov	36.14671	-115.06779	531	Neighborhood	Transport
Z17	20-Nov	36.17765	-115.06097	541	Neighborhood	Gradient
Z19 (1st)	20-Nov	36.15350	-115.05733	541	Neighborhood	Gradient
Z19 (2nd)	23-Nov	36.19273	-115.05871	541	Neighborhood	Gradient

Table 3-2. Saturation Monitoring Network – Dynamic Sites

Site ID	Start Date	Latitude (dd.ddddd)	Longitude (ddd.ddddd)	Elevation (m) (msl)	Site Objective (Scale)	Site Objective (Zone)
xBB12	07-Dec	36.12972	-115.03817	TBA	Neighborhood	Transport
xBB15	07-Dec	36.15624	-115.04272	520	Neighborhood	Transport
xBB18	07-Dec	36.18500	-115.04267	546	Neighborhood	Outer
xM19	17-Dec	36.19217	-115.19878	660	Neighborhood	Gradient
xO16	08-Dec	36.16537	-115.18342	-	Neighborhood	Gradient
xP15	19-Dec	36.15517	-115.17195	-	Neighborhood	Inner core
xP17	19-Dec	36.17325	-115.16545	-	Neighborhood	Inner core
xP19	19-Dec	36.19047	-115.17383	635	Neighborhood	Gradient
xQ18	17-Dec	36.18443	-115.15647	621	Neighborhood	Inner core
xV21	07-Dec	36.21400	-115.10967	567	Neighborhood	Gradient
xW20	07-Dec	36.19983	-115.09600	550	Neighborhood	Gradient
xX18	07-Dec	36.18317	-115.08933	551	Neighborhood	Transport
xY12	17-Dec	36.13107	-115.07407	525	Neighborhood	Gradient
xZ16	07-Dec	36.16490	-115.05643	-	Neighborhood	Transport
xZ10	27-Dec	36.11031	-115.05715	507	Neighborhood	Gradient
xU16	26-Dec	36.16070	-115.11400	566	Neighborhood	Inner core
xP11	27-Dec	36.11680	-115.16538	631	Neighborhood	Inner core
xP13	27-Dec	36.14193	-115.16940	640	Neighborhood	Inner core
xR17	27-Dec	36.17397	-115.14247	617	Neighborhood	Inner core

4. QUALITY ASSURANCE

Quality assurance activities were a fundamental portion of all phases of the Study. The activities included equipment tests and data validation following U.S. EPA monitoring guidance, network siting following a standard operating procedure written for the study, and independent audits of network siting, CO sampler calibrations, and data validation.

4.1 Acceptance Tests

The equipment and gas standards used in the Study underwent acceptance tests prior to use in data collection.

Calibration Gases

Zero air certified as containing less than 0.1 ppm CO, and two cylinders of CO in nitrogen at concentrations of 43.3 and 43.5 ppm for span gas were purchased from Scott-Marin, a reputable supplier of gases used in air quality studies. The concentrations in the span cylinders were verified using an EPA multiblend protocol gas within the supplier's analysis tolerance of ±5% using the Dasibi 3003 analyzer.

Dasibi 3003 CO Analyzer

The Dasibi 3003 analyzer used in testing and in the mobile van was calibrated using multiple concentrations diluted from an EPA protocol multiblend cylinder. The analyzer was calibrated to a slope of 1.00 and intercept of ±0.2 ppm at the laboratory temperature of 25°C. Subsequent zero and span checks were performed in the field to verify the instrument responded with a zero within 1 ppm and a span tolerance of ±10%, using the project cylinders described above. The operational environment for the analyzer was maintained at 25 ±4°C. In most instances the tolerance was maintained within ±2°C of 25°C. All calibrations during the acceptance test were performed while operating on the 12-volt powered sine wave inverter system to duplicate the power environment in the mobile van during the field program.

Onset CO Analyzers

The Onset CO analyzers selected for the field sampling were still in a prototype status at the time of the field program. In order to purchase the units we signed a release recognizing this status and accepted the role of evaluating and establishing our own calibration for each of the individual units. Prior to delivery, Onset performed their own manufacturing acceptance testing, which assured the units functioned properly and met their own internal acceptance criteria for performance. Upon delivery at the Parsons field office in Valencia, each of the units underwent a detailed performance evaluation to establish the logger response to known concentrations of CO.

The specific goals of the acceptance testing were as follows:

- Establish that the units could be programmed, operated and data offloaded in accordance with the manufacturers operating instructions
- Verify the appropriate time keeping of the internal clocks in each of the units
- Verify the physical serial number on the outside of the logger matched the serial number embedded in the data stream
- Establish the performance characteristics of each unit in terms of a calibration slope, zero intercept and correlation coefficient

Each of these goals was evaluated simultaneously through chamber testing of the CO instruments. The chamber consisted of a modified "lung" type sampler with three access ports for calibration gas input, sampling of the concentrations within the chamber, and an excess calibration gas exhaust. The concentration of the calibration gas within the chamber was kept uniform by using four mixing fans located at each corner of the chamber. **Figure 4-1** shows the chamber with the cover opened and approximately 30 units being prepared for testing. The line to the middle of the chamber provided the calibration gas input. The terminal block on the lower right connected power to the fans as well as a data line for one of the Onset analyzers to monitor the real-time CO concentration, as seen by their data loggers. The real-time unit is seen in the lower right. With the top closed the entire chamber was sealed and the only vent was from the exhaust port on the right side of the chamber.

Figure 4-1. Chamber for Calibrating the Onset CO Analyzers

Each of the instruments within the chamber was exposed to zero and three upscale concentrations of CO. The upscale CO concentrations were 11.2, 20.0 and 40.1 ppm. These concentrations were selected to represent anticipated concentrations within the normal operating range of a CO analyzer that is operated in accordance with EPA guidelines. Each unit then had a calibration sticker applied that provided the slope and intercept as well as a calculated tolerance for any subsequent zero or span test performed to determine if the calibration had changed. The criteria for acceptable response in these subsequent tests was ±1.5 ppm on the zero and ±10% on the span. This sticker can be seen on the sampler shown in Figure 4-1. A calibration database was maintained for all of the Onset samplers with the link to the sampler based on the unit specific serial number. The database of calibration factors for all samplers showed slopes ranging from 0.86 to 1.06, and zero intercepts ranging from –3.2 to +0.3 ppm. The average slope of all CO loggers was 0.94. The response of the samplers to the varying CO concentrations was very linear with the worst of the correlation coefficients being 0.9996.

4.2 Audit Results

Independent audits were conducted of all major components of the study. Internal reports including audit methods and results are included as **Appendix D** of this report. Findings are summarized below.

4.2.1 Clark County CO Network Performance Audits

On November 14 and 16, performance audits were conducted at four County air monitoring sites (City Center, Sunrise Acres, JD Smith, and Freedom Park). Complete audit results, including a summary of the audit standards, are included on forms found in Appendix D. A summary of the results is presented in **Table 4-1**. No problems were noted, with all analyzers reading within approximately 4 percent of true

Table 4-1. Clark County Audit Results

Site	Slope	Intercept	Correlation
City Center	0.987	-0.1	1.0000
Sunrise Acres	0.959	-0.1	1.0000
JD Smith	1.011	-0.7	1.0000
Freedom Park	0.977	0.1	1.0000

4.2.2 Static Network Siting Audits

On November 16 and 17, 25 of the Static sites were visited and reviewed against EPA criteria for siting micro-, middle-, and neighborhood-scale CO monitoring scales. Possible deviations from these criteria were noted and forwarded to the field personnel for consideration. Based on the audit observations, one of the static locations (Z19) was moved to better meet neighborhood-scale siting criteria.

4.2.3 Onset CO Analyzer Performance Audits

On November 14, performance audits were conducted at the Las Vegas field office of all 60 of the Onset CO analyzers available at the time. The audits consisted of exposing the monitors to three CO concentrations (0, 10.35 and 25.2 ppm). The audits were conducted using the same standards used during the audit the County's CO monitoring effort (above). Audit responses were compared against the calibration equations previously obtained for each Onset analyzer.

In general, the results of the audit were very good. Some variability was noted between the audit response and the original calibration response; however, this variability was centered around a slope of one, showing essentially no bias. Only two Onset analyzers had response differences that statistically fell outside of the audit results as a whole (based on two standard deviations from the mean). One of the units was removed from the study after further review of calibration data confirmed its poor performance.

As part of the performance audit, two additional calibration-related issues were investigated. First, several variations on the chamber calibration methodology were explored to see if they had a bearing on the calibrated response of the analyzers. While some differences in response were noted, they were minor and not considered significant. The second issue concerned the possibility of the Onset analyzer's response being affected by ambient temperature. Several units were put in a small calibration chamber and placed in a freezer. A span concentration was pumped into the chamber and the response noted. The chamber was then removed from the freezer and allowed to slowly warm up. Results of this test pointed to a significant change in the Hobo's response as a function of temperature, which resulted in further investigations that are discussed elsewhere in this report.

4.2.4 Sampling Van Performance Audit

The Dasibi model 3003 CO analyzer and the two Onset analyzers used in the sampling van were audited using procedures and standards identical to those of the performance audits described above. No problems were noted.

4.2.5 Data Processing Audit

On February 1, 2002, a systems audit was conducted of the study's data processing effort at the T&B Systems facility in Santa Rosa, CA. The audit consisted of interviews with key data processing personnel, and included tracking raw data points through the data processing effort to verify that procedures were being followed. The only data processing issue of note concerned the application of the zero factors to the Hobo data. A review of the data using the originally established slope and intercept calibration equations revealed a large number of CO concentrations that were negative, indicating that there might be problems with the zero (intercept) calibration factors, which were typically in the –0.5 to –2.0 ppm range. Further investigation showed that the zeros for the Hobos depend significantly on temperature, and that zero offsets essentially disappeared during cold nighttime hours. This issue is discussed elsewhere in this report.

4.3 Field Zero/span Checks

During the course of the field program there were routine zero and span quality control checks performed on the CO measurement equipment. These checks are described below for the mobile monitoring van and the Onset CO analyzers.

Mobile Van

For the mobile monitoring van, quality control checks that included zero and span gas checks were performed several times during each of the two intensive operational periods. The zero and span checks were performed by introducing the cylinder air through a "tee" arrangement placed on the inlet line on top of the van. All zero and span checks were therefore performed through the entire sample system, including filters and the relatively long inlet line. The zero check was performed prior to the span check, and both traces were allowed to stabilize at least 3 minutes before the readings were taken.

The results of the zero and span checks were noted in the field log book and compared to a criteria of ±1 ppm for zero and ±10% for the span concentration. All checks with the Dasibi were within criteria, while the calibration did shift on the real-time Onset analyzer after a sensor replacement on 12/18. The results of that zero/span immediately after replacement prompted a change in the calibration equation used for that unit.

Onset CO Analyzer

The same calibration chamber used to perform the acceptance testing and development of the initial response factors was used in the field to conduct routine zero and span checks on the Onset analyzers. Standardized project zero and span cylinders provided the calibration gas to conduct the checks. Any specific analyzer was checked at the field office at time intervals ranging from 2 to 3 weeks, depending on the schedule for deployment and retrieval of the units from the network. During each of the zero/span check runs, anywhere from 10 to 35 units were placed in the chamber and 30 minutes allowed for concentration stabilization. The calibration database was keyed to the Onset CO analyzer serial number and contained the results of the initial multipoint calibration as well as each zero and span. Any Onset analyzer failing to maintain either the zero or span tolerance was pulled from service and evaluated further to determine the reasons for the failure and the potential for re-calibration and return to service. With the exception of only two units, all Onset CO analyzers maintained their respective responses within the acceptance criteria of ±1.5

ppm on zero, and ±10% on span. Data from these two samplers were flagged for further investigation during data validation.

4.4 Data Processing and Data Base Structure

Processing the three million one-minute average data records taken during the Saturation Study was accomplished applying individual sampler calibration factors, a correction factor for apparent temperature bias, and deployment records tracking the samplers as they were used at various locations. The individual sampler calibration factors were computed from sampler tests in a controlled chamber environment applying EPA Protocol calibration CO gas flowing through the chamber. The relatively small (small fraction of a ppm) temperature bias was computed from comparisons of the collocated samplers at two DAQM CO stations. Preliminary data processing performed in the field maintained good continuity of the information on any Study site which characteristically included several different analyzers during the field study. The one-minute instantaneous measurements were compiled into a relational-structured data base. Both one-hour and running 8-hour averages were computed to conform with the time periods needed to show compliance with NAAQS. The subsequent data summaries were utilized in identifying the time periods when the highest CO concentrations were experienced.

4.4.1 Static and Dynamic Network Measurements

Raw (Data Validation Level 00) CO measurements underwent processing both in the field (Data Validation Level 0.5) and in Santa Rosa after the completion of the field study (to Data Validation Level 1.5). Standard Operating Procedures for both in-field and post-field data handling and processing are given in Appendix B. Those procedures are summarized below.

<u>In-Field Processing</u>
Data records in Onset's native format were exported to ASCII format after checking to ensure date and times were consistent with technician notes. The ASCII file was read into an Excel format, and each record transformed to include the Site ID, unit serial number, and a data validation flagging field. The first hour of data after installation was automatically flagged as "suspect" based on our experience with regard to the time required for the instrument to stabilize.

<u>Post-Field Processing</u>
A computer-based processing and objective screening program was developed. All of the Level 0.5 files that were created in the field were processed through the program.
The one-minute CO readings were first screened to flag as invalid single-record spikes greater than 10 ppm. The one-minute CO readings were next span-adjusted using factors developed from multi-point calibrations (refer to Appendix E). The calibration corrections were applied on the basis of serial number rather than site as instruments moved between sites.

A data base of hourly-averaged one-minute records was compiled. At least 30 records (30 minutes) were required for a valid hourly-average. An hourly-average not meeting this requirement was flagged as invalid or missing. The hourly-averaged data were next adjusted for ambient temperature based on an algorithm developed from cold-chamber test results (refer to Appendix G). Time-series plots of the one-hour averaged data were produced and examined by experienced personnel for outliers.

A data base of eight-hour averaged CO levels was compiled from the validated hourly-averaged data set. A minimum of six valid hourly-averages were required to produce a valid eight-hour average.

Further validation (Level 1.5) of the data base was based on analyses of the data. As outliers were identified, records were flagged either as "suspect" or "invalid". Data was declared "invalid" only if there was compelling supporting evidence. Otherwise the data are flagged as "suspect".

<u>Database Structure</u>

The CO measurements acquired during the field study were compiled into an electronic data base for transfer to the Clark County DAQM. Both hourly-averaged and eight-hour running averages are available in Microsoft Excel compatible file formats. The file and record structure is shown in **Table 4-2**.

4.4.2 Sampling Van Measurements

The sampling van acquired measurements consisted of a number of components that were merged to form the final database of one-minute averages. The van and data recording system was described in Section 2.

The navigation, Dasibi and Onset data streams were merged in real-time at the end of each minute. The merging was performed based on the time of the Dasibi data stream as it was recorded on the CR10 data logger. All clocks in the data logger and computers were synchronized to the nearest second at the start of each sampling run based on the GPS reported time as the project standard. The merged data file then provided one-minute records containing date, time, latitude, longitude, altitude, ambient temperature, Dasibi CO and Onset CO. As the CO values had any needed correction factors applied in the initial data stream, the data in the merged file only needed validation to flag, as appropriate, any invalid or suspect data points based on observations noted in the observation log from each of the data collection periods.

Table 4-2. File and Record Format

File Format:
MicroSoft Windows Excel (XLS) -Version 2000 Naming convention: NNNNmmddyy, where NNNN refers to

T&B Systems site names (See Appendix A) and mmddyy refers to version release data.

Record Format	
Column	Field Description
A	Site Name (Appendix A)
B	Onset Instrument Serial Number
C	Site Latitude
D	Site Longitude
E	Date
F	Start Time (PST) of averaging interval
G	CO average (hourly or running 8-hour average)
H	Data Validation Flag
	V= Valid
	S= Suspect
	I = Invalid

The observation logs were manually reviewed and validation flags applied to the merged data file to flag any values not considered valid. The validation codes used were as follows:

- -90 Interference from local sources such as high emitting vehicles
- -95 Data suspect due to calibration or temperature drift
- -99 Data invalid due to instrument malfunction

For all practical purposes no data were used in the analysis that had any of the above codes. In the analysis and data displays, the Dasibi data took precedence when that data were available; otherwise the data from the real-time Onset analyzer were used.

4.5 Comparison Tests

At two DAQM sites, Freedom Park and Crestwood, Onset CO analyzers were collocated with standard (Dasibi) CO monitors at the inlet to the DAQM system. The two sites were recommended by DAQM personnel based on potential CO exposure and site access considerations. Measurements were made continuously for the extent of the field study. Data was lost for approximately one-week (December 23-28) due to a data logger failure. Both 1-hour and 8-hour averaged Onset data were compared with the DAQM monitor data set. The initial comparison was using Onset measurements corrected only for calibration span (slope). Results of the comparisons are summarized in **Table 4-3**. As can be seen, given the fact that hourly averages <0.50 ppm occurred with more than a 40 percent frequency during the field study and that the DAQM Standard Procedure is to report CO levels less than 0.50 ppm as zero (0.00 ppm), the data compare reasonably well. Eightyfive percent of the differences between the two instruments at Freedom Park, and 74 percent of the differences observed at Crestwood were less than 1 ppm.

It was noted that differences between the collocated instruments showed a distinct diurnal pattern, i.e. the Onset analyzers read lower than the Dasibi units during the nighttime and greater during the daytime. This was consistent with results of our cold-chamber tests of the Onset CO analyzer in which the calibrations appeared to be sensitive to ambient temperature. The relationship between monitor differences at the two sites and ambient temperature can be observed in **Figure 4-2,** which shows the differences observed at Freedom Park as a function of ambient temperature. The best fit linear regression to the data yielded a slope of 0.163 and intercept of -1.78 (shown on figure).

The results of applying this adjustment to the Onset measurements are shown in Table 4-3 as well and can be compared to the non-adjusted data. It should be noted that the adjustment factor was derived from the Freedom Park collocated instruments, and applied to Crestwood as validation that this adjustment can be likewise applied to the other sites in the network. All the comparative parameters were improved. The Crestwood data set correlation improved from 0.69 to 0.76 and the standard deviation of the differences decreased from 0.86 to 0.82. Perhaps even more significant is that after adjustment for ambient temperature 92 percent of the differences were less than 1 ppm and all (100 percent) were less than 2 ppm at Crestwood. The calculations included DAQM readings <0.5 ppm that had been truncated to 0.0 ppm.

The two data sets were subjected to Wilcoxon Matched Pairs tests. Results showed that the actual probability of the differences occurring by chance is less than .01 percent.

Table 4-3. Intercomparison Descriptive Statistics

Standard Deviation	0.81	0.62	0.86	0.64
Correlation Coefficient	0.79	0.86	0.69	0.85
< 1 ppm*	85%	97%	74%	92%
<2 ppm*	97%	99%	94%	100%

*percent of CO measurement differences less than indicated amount.

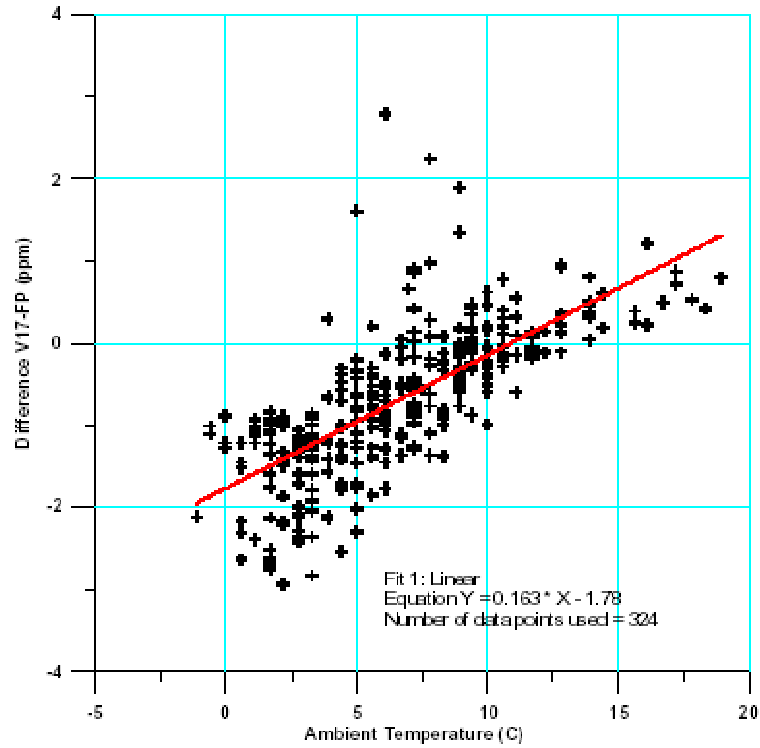


Figure 4-2. Differences Between Onset and Dasibi CO Analyzers vs Ambient Temperature - Freedom Park

Peak daily 8-hour averages using the fully adjusted and validated data sets were next compared with the County's collocated measurements. The average difference between the instruments was 0.26 and 0.29 ppm for Freedom Park and Crestwood, respectively, well within the accuracy of the equipment. The standard deviation of the differences was 0.55 and 0.53 ppm, respectively. Time series plots of the measurements are shown on **Figures 4-3 and 4-4**. It can be concluded that the Onset analyzers are comparable to the County's CO monitors over the range of ambient levels experienced during the study.

4.6 Data Capture

The overall data capture rate for the Saturation Network Static and Dynamic sites was 94.7 percent. Data capture in this study is defined as the number of valid hour average records in the data base as opposed to the maximum possible, based on the date and time of site startup. The capture rate for each individual site is given in **Table 4-4** along with the start date and time.

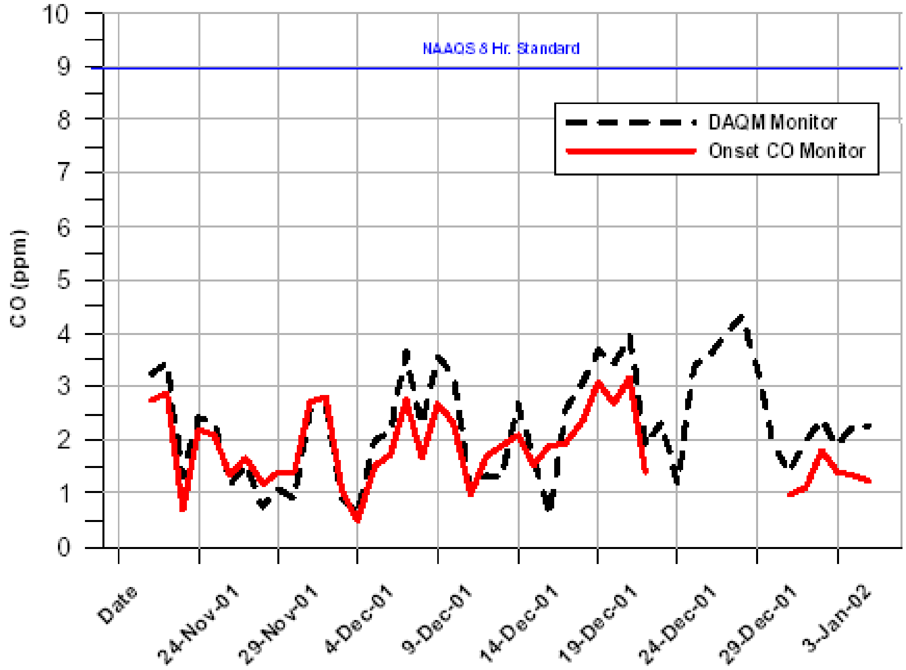


Figure 4-3. Freedom Park Collocated Measurements 8-Hour Average Daily Maximum

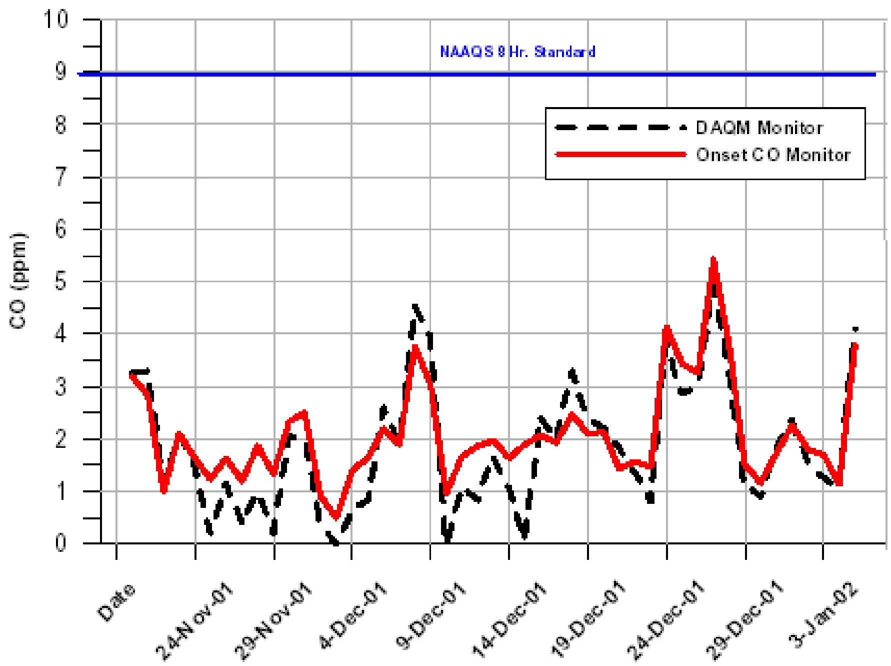


Figure 4-4. Crestwood Collocated Measurements 8-Hour Average Daily Maximum

Table 4-4. Hourly Data Capture Rates for the Saturation Network

Site	Start_Date	Valid Data Rec	Max Possible	Data Capture(%)
A17	27-Nov-01	870	943	92.3
AA8	7-Dec-01	502	707	71.0
BB5	20-Nov-01	1122	1125	99.7
BB9	20-Nov-01	1122	1125	99.7
D19	21-Nov-01	1015	1088	93.3
E13	20-Nov-01	1051	1125	93.4
G22	27-Nov-01	871	944	92.3
H17	27-Nov-01	940	943	99.7
J11	20-Nov-01	1052	1125	93.5
J29	30-Nov-01	821	873	94.0
L16	20-Nov-01	1122	1125	99.7
L20	20-Nov-01	1121	1125	99.6
M17	20-Nov-01	1121	1125	99.6
N14	20-Nov-01	1073	1125	95.4
P12	27-Nov-01	943	946	99.7
P23	20-Nov-01	1122	1125	99.7
P8	20-Nov-01	1124	1126	99.8
Q13	20-Nov-01	1122	1125	99.7
Q20	20-Nov-01	1121	1125	99.6
R15	8-Dec-01	682	684	99.7
R3	25-Nov-01	993	995	99.8
R8	20-Nov-01	1123	1125	99.8
S13	20-Nov-01	1121	1125	99.6
S16	20-Nov-01	1121	1125	99.6
S17	7-Dec-01	700	703	99.6
S18	30-Nov-01	867	871	99.5
SoH	30-Nov-01	815	869	93.8
T11	20-Nov-01	1122	1125	99.7
T14	20-Nov-01	1121	1125	99.6
T15	20-Nov-01	949	1125	84.4
T16	20-Nov-01	1120	1125	99.6
U-3	17-Dec-01	416	468	88.9
U19	20-Nov-01	1120	1125	99.6
U6	20-Nov-01	1122	1125	99.7
V13	20-Nov-01	1121	1125	99.6
V15	20-Nov-01	935	1125	83.1
V17	20-Nov-01	1121	1125	99.6
X10	20-Nov-01	1120	1125	99.6
X15	20-Nov-01	834	1125	74.1
X16	20-Nov-01	1001	1125	89.0
X23	30-Nov-01	819	871	94.0
Y14	20-Nov-01	934	1125	83.0
Z17	20-Nov-01	802	1125	71.3
Z19	20-Nov-01	1122	1125	99.7

Table 4-4. Hourly Data Capture Rates for the Saturation Network

Site	Start_Date	Valid Data Rec	Max Possible	Data Capture(%)
xBB12	7-Dec-01	610	707	86.3
xBB15	7-Dec-01	609	707	86.1
xBB18	7-Dec-01	608	706	86.1
xM19	17-Dec-01	461	463	99.6
xO16	8-Dec-01	640	684	93.6
xP11	27-Dec-01	225	225	100.0
xP13	27-Dec-01	224	225	99.6
xP15	19-Dec-01	414	416	99.5
xP17	19-Dec-01	413	415	99.5
xP19	19-Dec-01	414	415	99.8
xQ18	17-Dec-01	462	463	99.8
xR17	27-Dec-01	224	224	100.0
xU16	26-Dec-01	246	246	100.0
xV21	7-Dec-01	606	704	86.1
xW20	7-Dec-01	606	705	86.0
xX18	7-Dec-01	656	705	93.0
xY12	17-Dec-01	411	462	89.0
xZ10	27-Dec-01	222	222	100.0
xZ16	7-Dec-01	657	707	92.9
SUMMARY:		52144	55057	94.7

5. FIELD PROGRAM

Operational aspects of the field measurement program are provided in this section to further document the CO measurements taken during the Study.

5.1 Project Weather Conditions

Synoptic and local weather conditions were monitored and analyzed each day for the duration of the project beginning on November 18, 2001, and ending on January 5, 2002. The meteorological information routinely gathered during this period was used to determine the daily atmospheric dispersion conditions occurring in the Las Vegas Valley, and to generate dispersion forecast information that was used for planning Intensive Operating Period (IOP) deployment. Weather data that was routinely gathered included surface and upper air synoptic maps, satellite images, local (Desert Rock) upper air soundings, surface wind data from key valley sites and National Weather Surface (NWS) published discussions of forecast model output.

A ridge of high pressure dominated the weather over the Western U.S. for several days prior to November 20, and continued to influence dispersion conditions in the Las Vegas Valley into November 21. The result was relatively stagnant conditions with clear skies and light winds with significant low-level inversion development during the nocturnal hours, and only weak mixing during the daylight hours. Synoptic scale wind flow was minimal, thus enabling local valley transport patterns to predominate. Pollutant concentrations did elevate during this period particularly during the nocturnal periods, but the mixed layer deepened enough from diurnal surface heating during the daylight hours to allow moderate daytime dispersion, and not allow significant carryover of concentrations from one day to the next.

By the morning of November 21, the ridge had weakened and slid eastward as westerly flow aloft brought more moisture and less stability to the project area. The resultant deeper mixing conditions produced increased dispersion by afternoon and a corresponding significant drop in pollution concentrations by evening. This marked the beginning of a cooler and more unsettled period of weather that prevailed through the remainder of November. A series of alternating short-wave troughs and ridges migrated out of the Eastern Pacific and across the Western U.S. during that time. No precipitation occurred in the project area, but deep mixing layers and strong gradient winds resulted. Even during the short-lived short ridge events, synoptic-scale wind flow enhanced strong Colorado River regional flow to keep both thermodynamic and mechanical mixing optimal.

The unsettled pattern of late November continued into early December as fast moving short troughs and ridges migrated off the Pacific and across the Great Basin. However, by December 5 a somewhat broader and longer-lived ridge followed a short wave trough into southeastern California, Nevada, and Arizona. The ridge brought weaker gradient flow, warmer temperatures aloft, and generally stagnant dispersion conditions to the project area during the 5th and 6th. The IOP crew was alerted to this situation two days previously, but deployment was cancelled on the 5th because of forecast strong winds expected on 12/07/01. A strong surface high-pressure area developed in the northern Great Basin on the 7th and slipped southward into the southern area by December 8. The initial development of this ridge on the 7th increased the surface gradient considerably during that day resulting in strong enough winds in the project area to clean out any accumulated pollutants remaining from the quasi-stagnant conditions of the previous two-day. By the evening of December 8, surface and upper ridging had settled over the area again leading to poor dispersion conditions. However, those conditions only persisted through the morning of December 9, as greater mixing and less nocturnal stability associated with an approaching trough produced good dispersion by afternoon.

By the afternoon of December 9, a cold front associated with a long-wave eastern Pacific trough was moving across northern and central California. The effects of a lifting air mass ahead of this approaching system were felt in the project area by the afternoon of that day. The frontal system marked the beginning of a period of a broad-scale trough along the Pacific coast and associated good air quality in the project area that lasted through December 15.

A fast-moving storm system impacted southern Nevada late on December 14 and had moved eastward into the Inter-Mountain area by early on the 15th. This system signaled the end of the unsettled weather pattern that had dominated the project area during the previous week. A broad high-pressure area began to build over the region on December 15 initially bringing decreasing clouds but breezy and somewhat unstable conditions on that day. In anticipation of the development of stagnant conditions associated with this high-pressure ridge, the IOP crew was alerted on December 14, and deployed on December 16. By the evening of the 16th, pressure gradients had decreased and wind flow had diminished sufficiently to allow the air mass in the project area to stabilize. During the period from December 17 through 19, the broad ridge of high pressure was prominent enough to block the influx of several short wave troughs into the southern Great Basin, allowing the air mass over the project area to remain stable. Shallow nocturnal inversion layers and light surface flow characterized the dispersion conditions during the nighttime periods on the 17th, 18th, and 19th. Vertical mixing during the daytime periods were somewhat restricted, but surface heating from insolation deepened the boundary layer enough to inhibit the accumulation of CO from day-to-day carryover.

By late on December 19, the Great Basin ridge was flattening and a new Pacific trough was forming offshore. However, the limited dispersion conditions in the project area persisted through the 19th, and well into the 20th before the advancing weather system affected the area. In addition, overrunning high cloudiness during the daylight hours on the 20th inhibited daytime mixing and allowed the persistence of elevated CO readings well into the late morning. Limited dispersion conditions continued in the project area until the onset of stronger gradient wind flow that evening. The area then experienced the influx of colder, less stable air accompanied by windier conditions that persisted to December 24.

A very strong but narrow ridge of high pressure developed off the Pacific coast on December 23 behind the troughing pattern that was affecting the Great Basin at that time. The ridge moved onshore early on the 24th producing stable atmospheric conditions in the project area by late that evening. The new air mass was initially quite cold, and the daytime mixing layer was fairly deep with some leftover Colorado River regional drainage persisting on the 25th. Local radiation inversions formed during the evening of the 25th accompanied by diminished winds. The IOP crew was alerted on December 24 for possible deployment on the December 26. Intensive sampling began the evening of the 26th. Although the West Coast ridge produced relatively stable conditions in the project area through December 28, the center of the ridge never moved eastward out of California, and the area remained in northerly flow with relatively cool air advection aloft. As a result, dispersion conditions were poor at night, but the atmosphere destabilized enough during the daylight hours to prevent carryover during the IOP. By 12/28/01, the strength of the ridge had been significantly eroded, and sub-tropical moisture from a disturbance in the Pacific off Southern California was advecting aloft into the area. Dispersion conditions were still relatively poor during the morning of the 28th, but stagnant conditions were gone by that evening.

An upper level disturbance that caused the influx of sub-tropical moisture aloft moved through the project area during December 29, and was followed by a weak short wave ridge on December 31, 2001 and January 1, 2002. The ridge was rather diffuse and transitory, but it did allow some stabilization during the evening of the 31st and morning of January 1, 2002. A short wave frontal system moved through central California on January 2, and enhanced dispersion in the project area during the 2nd and 3rd. A somewhat stronger ridge of high pressure built in over the Great Basin on January 4th. The atmosphere did not immediately stabilize in the project area, however, because the incoming ridge induced a rather strong north-to-south pressure gradient, and the resultant breezy conditions kept the boundary layer relatively deep and well-mixed. By January 5, the gradient had relaxed, and the ridge stabilized the air mass in the Las Vegas Valley. Relatively stagnant dispersion conditions prevailed through January 9, but no carryover occurred due to sufficient daytime mixing. Dispersion conditions during that period were similar to those measured during the two IOP periods in December.

5.2 Continuous Monitoring

The operation of the Saturation Network took place in two phases. They were: 1) the siting and installation of the Static sites; and 2) the expansion, maintenance, and data recovery operations phase. The initial phase took place during the period from November 10 to November 22, and the second phase was accomplished from November 22 through January 20, including the five-day decommissioning period after the termination of monitoring on January 5.

5.2.1 Static Network Establishment (November 10 to 22, 2001)

Field site selection activities began shortly after November 10. The original 35 Static sites were installed by November 22. Site locations were determined using the criteria and philosophy discussed in Section 3 of this report. A typical installation consisted of attaching a mounting hook to an existing pole or structure at the locations determined during the siting process. An installation was considered complete when the instrument enclosure and operating Onset CO analyzer was installed at a site. **Table 5-1** presents a list of the original Static sites and the dates that valid data collecting started. During the installation, site GPS coordinates and elevation were determined. A map of the site locations is included in Section 3 of this report. Site Descriptions, which include coordinates, elevations, site objectives, physical descriptions and pictures, are given in Appendix A. Standard Operating Procedures (SOP) for the launching and deployment of the Onset CO analyzers are included in Appendix B. A complete summary table documenting all the site deployment activities is presented in Appendix C.

Table 5-1. Data Start Dates for Original Static Network

Site I.D.	Data Start Date	Site I.D.	Data Start Date
A17	20-Nov	S18 (1st)	20-Nov
BB5	20-Nov	T14	20-Nov
BB9	20-Nov	T15	20-Nov
E13	20-Nov	T16	20-Nov
H17	20-Nov	U19	20-Nov
J11	20-Nov	U6	20-Nov
L16	20-Nov	V13	20-Nov
L20	20-Nov	V15	20-Nov
N14	20-Nov	V17	20-Nov
M17	20-Nov	X16	20-Nov
P23	20-Nov	X15 (1st)	20-Nov
P8	20-Nov	X10	20-Nov
Q13	20-Nov	Y14	20-Nov
Q20	20-Nov	Z17	20-Nov
R8	20-Nov	Z19 (1st)	20-Nov
S13	20-Nov	D19	21-Nov
S16	20-Nov	R3	22-Nov
T11	20-Nov	U-3	22-Nov

Note: All sites operated through Jan. 5, '02.

The initial network of sites was discussed with the DAQM staff at the DAQM offices on November 21. As a result of that meeting, Static sites D19, R3, and U-3 were established and became operational on November 21 and 22. The addition of those sites to the Network of 32 that was operating by November 20, made the total number of original operational Static sites 35.

An internal performance and siting audit was conducted during the initial start up period. Multipoint calibration checks of the Onset CO analyzers were conducted, and 25 of the

Static sites were checked during the audit. Audit activities are discussed in Section 4.2 of this report.

5.2.2 Network, Expansion, Maintenance and Data Recovery (November 22, 2001 to January 20, 2002)

The base of knowledge of the dispersion characteristics of the project area was broadened as information was gathered from the initial Static Network, the DAQM Network measurements, and observations by field personnel. This additional insight enabled the expansion of the Saturation Network to more effectively measure the CO exposure. As a result, the original 35-site Static Network was expanded to 44 sites during the period from November 27 to December 8. The deployment crew made siting decisions for the addition of sites G22, P12, R15, S17 and S18. The new S18 site was relocated within the secure area at the M.A.S.H. facility after the original unit was stolen from its location on Foremaster Lane. In addition, a meeting between DAQM and study personnel on November 30 resulted in the establishment of the AA8, J29, SoH and X23 sites. **Table 5-2** lists the added sites and the operations start date. In addition, descriptions of the sites can be found in Appendix A.

In anticipation of a possible initial IOP event, the first eight Dynamic sites were established and installed during December 7 and 8. Siting decisions were once again made by the deployment crew, and were based on additional information obtained during the first two weeks of the monitoring program. Anticipated IOP conditions did not materialize, but it was decided to leave the eight Dynamic sites in operation in order to gain more information. The sites remained operational for the remainder of the program. In like manner, another six Dynamic monitoring sites were established during the first IOP operation on December 17 to 19, and five more were installed during the second IOP on December 26 and 27. All those sites also remained operational through the end of the study. Table 5-2 also lists all the Dynamic sites and the dates when data logging started. Note that Dynamic site names all contain a prefix lower case (x). Site descriptions for all the Dynamic sites can be found in Appendix A of this report.

Table 5-2. Data Start Dates for Expanded Static and Dynamic Network

Site I.D.	Data Start Date
Z19 (2nd)	23-Nov
G22	27-Nov
P12	27-Nov
J29	30-Nov
S18 (2nd)	30-Nov
SoH	30-Nov
X23	30-Nov
AA8	07-Dec
S17	07-Dec
xBB12	07-Dec
xBB15	07-Dec
xBB18	07-Dec
xV21	07-Dec
xW20	07-Dec
xX18	07-Dec
xZ16	07-Dec
R15	08-Dec
xO16	08-Dec
X15 (2nd)	15-Dec
xM19	17-Dec
xQ18	17-Dec
xY12	17-Dec
xP15	19-Dec
xP17	19-Dec
xP19	19-Dec
xU16	26-Dec
xZ10	27-Dec
xP11	27-Dec
xP13	27-Dec
xR17	27-Dec

Site I.D. Data Start Date

Notes: All sites operated through Jan. 5, 02
Prefix x denotes Dynamic sit

Maintenance of the Saturation Network consisted of periodic site visits by the field technicians to download data and repair or replace damaged equipment. A complete summary of the site visit and data recovery activity is available from the Deployment and Recovery Summary in Appendix C. During the initial period of monitoring, one sampler was stolen from the original S18 location on Foremaster Lane before any data could be recovered. In addition, four samplers failed to operate properly during the initial 10 days of monitoring resulting in data lose. Site vandalism also occurred at the original X15 site, resulting in data lose there despite eventual recovery of the Onset analyzer. The site was subsequently relocated. Three more analyzers failed to operate late in the project. Sites T15 and Z17 failed during the first IOP, and site AA8 collected no data after December 30.

In order to check and document the operational consistency of the Onset CO analyzers, three rounds of zero/span calibrations were run on each sampler during the field study. The first round of zero/span checks was performed at the T&B Systems field office during December 3 to 6; the second round took place after the first IOP during December 21 to 24; and the third run took place after the end of the monitoring program, on January 8 to 9. The checks, which are described in more detail in Section 4, were run using the same sealed controlled airflow chamber used during acceptance testing and the internal audit. Certified standard zero air and 43.3 ppm CO span gas were used in the chamber for durations of 30 minutes each. Appendix B contains the SOP's describing the zero/span procedure. The results are provided in tabular form in Appendix E.

Recorded CO data were downloaded from the Onset analyzers on an as-required basis during the period of field operations. No more than a 12-day interval between downloads occurred for any given sampler, and more often the interval was much shorter. A particular effort was made to download data just prior and after IOP operations, and also during the initial week of the project in order to assure that problems were identified early. See Appendix C for a complete summary of the sampler deployment and data downloading history.

Data was typically downloaded at the T&B Systems field office, where it then underwent initial processing and QC. The processing included the conversion of the raw data files to ASCII text format, and then to MS Excel format. An initial visual check of raw data plots was also performed immediately after the download. The Excel formatted data was then labeled and trimmed of extraneous data recorded outside of the valid monitoring period. The data set was then examined again, and invalid or suspect data were flagged. At that point, the data was considered to be at Validation Level 0.5, and it was sent to the T&B Systems main office for further processing. Appendix B in this report contains the SOP's for the field data recovery and initial data processing sequence.

5.3 Intensive Operations Period (IOP) Activities

The synoptic weather conditions during the field effort provided two periods when a full IOP effort including the operation of the sampling van (for instantaneous mobile measurements) and Saturation Network (continuous monitoring) was possible. These periods were December 16 through December 20, 2001, and December 26 through December 29, 2001.

Figure 5-1 shows time-series histogram plots of the daily peak CO 8-hour averages for two Saturation Network monitoring sites; one representative of the inner core area and the other representative of the outer fringe, away from direct urban influence. There were three distinct time periods when high CO loading in the inner core area was evident. The CO peaks were centered on December 8, December 19, and
December 27. As discussed above, the latter two periods were IOPs and full operations were conducted. The period from December 4 through December 9 provided the first opportunity for an IOP operation, and in fact the IOP field crew was ready to travel to the field on the morning of the 5^{th} when the IOP was aborted due to forecast increasing winds for December 7. Stronger winds did materialize on the $7^{th,}$ as a short wave system slipped through the Great Basin. Another short ridge of high pressure built into the area on December 8 and 9, but that feature was cut short by more troughing activity by the 10^{th}. As can be seen from Figure 5-1, CO levels were building up on December 4-6, dropped significantly on December 7, then increased again on the 8th and 9th before CO levels dropped to background values again on the 10th. It is clear that IOPs were conducted during the most favorable conditions for producing high CO concentrations that occurred during the field study.

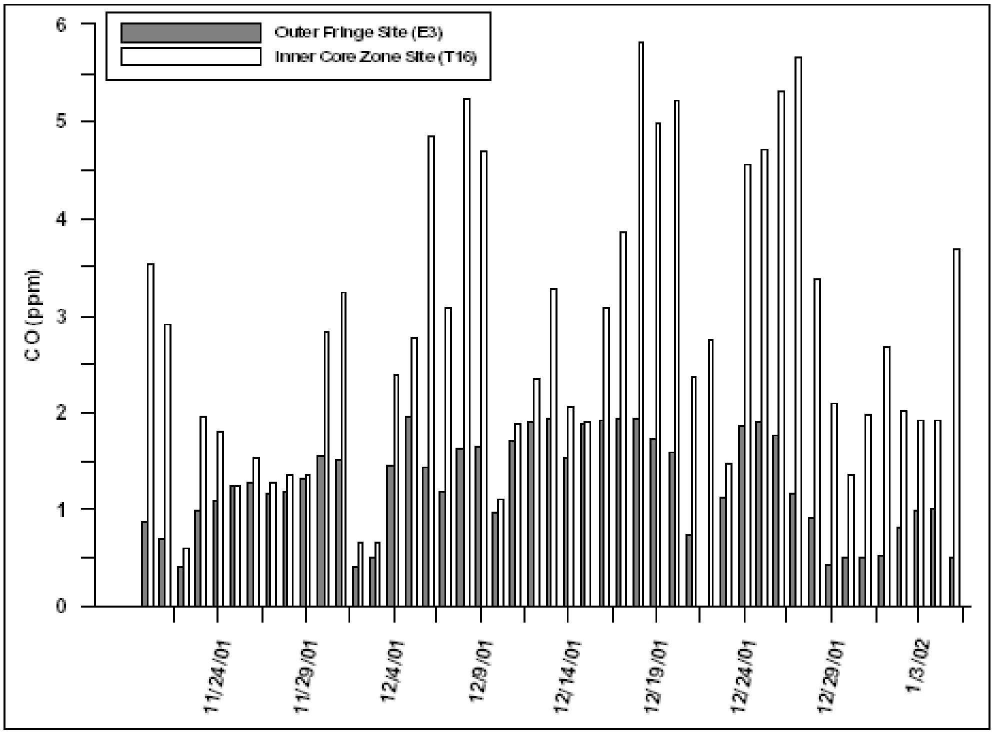


Figure 5-1. Time-Series of 8-hr Averaged CO Peaks from Saturation Network

5.3.1 IOP Coordinated Operations

The Saturation Network was expanded three times during the IOP periods to include Dynamic monitoring sites. Placement of the Dynamic sites was determined based on intelligence gained from stationary (Static sites) and mobile sampling. During the first IOP, 54 sites comprised the Saturation Network. Six Dynamic sites were added during the first IOP. At the start of the second IOP, the Saturation Network consisted of 63 sites.

The sampling van was maintained in a ready mode by the operators throughout the study and was mobilized once the decision for IOP sampling was made.

IOP field sampling operations were run out of the T&B Systems field office in Las Vegas. Sampling van instrumentation warm-up and shutdown, as well as zero/span calibration checks, was done at that location. The sampling strategy, including the routes and times, was determined based on the conditions existing during the operational days. Current weather and CO concentrations, available in near real-time from the DAQM Network, and real-time feed back of monitored data from the van were used to adjust operations sequence in a real-time while thus optimizing measurements.

5.3.2 Mobile Van Sampling

Data from the van served two purposes, to map the spatial distribution of CO throughout the Las Vegas Valley, and to aid in the selection of the regions to place the dynamic samplers. **Table 5-3** summarizes the mobile van sampling runs within the IOP periods and provides a brief overview of the goals of the sampling and an indication of the maximum observed CO concentrations during the mapping exercises. **Figure 5-2** is an example of a map showing the route of the sampling van and times when sampling was performed. Maps depicting the van routes for each sampling run are given in Appendix H.-

Table 5-3. Summary of Sampling Van Operations

Run #	Period of Operation	Description of Sampling Performed	Maximum CO (ppm)
1	12/16 1837-2200	• Evaluation of the system to sample on busy streets • Test and identify appropriate streets for traversing • Perform initial surveys of key identified areas	5.6
2	12/17 0731-0956	• Map extent of CO plume down Boulder Highway • Investigate CO levels in haze plume toward Henderson • Investigate the N/S extent of the CO values in 5-points area • Investigate the E/W extent of the CO plume along Charleston	9.6
3	12/17 1712-2218	• Map the E/W and N/S extent of CO plume in downtown and 5-points area • Implement a "confirmation loop" to verify higher CO levels along the major roadways by performing short trips through neighborhoods adjoining the primary traverse roads • Investigate the relationship of observed wood smoke smell to CO levels	8.0
4	12/18 0717-1029	• Focus on target areas and map neighborhoods around maximum concentrations near existing monitoring stations • Investigate the southern extent of the CO plume • Investigate the western extent of the CO plume	9.0
5	12/18 1807-2215	• Investigate the northwest extent of the CO plume during the evening rush hour traffic • Perform a detailed investigation of the higher CO levels in the target area and spatial extent of the highest concentrations	9.5
6	12/19 0708-1017	• Investigate the northwest extent of the CO plume during the morning rush hour traffic • Evaluate the N/S and E/W extent of the CO plume • Investigate the regions around select AQM stations to verify appropriate siting for high CO levels • Investigate the southeast extent of the CO plume to try and observe CO entrained in the drainage flow	8.3
7	12/19-12/20 1830-0009	• Evaluate the N/S extent of the CO carryover from the daytime • Characterize the evening profile along Rancho Road in the northwest • Identify the potential drainage flow pattern and track the path of the CO plume when drainage is established	8.5
8	12/26 2216-2330	• Evaluate the post-rush hour traffic to look at the spatial extent of the CO plume • Observe the somewhat reduced traffic city-wide during the holiday period • Evaluate the first day plume of a multi-day event	7.7
9	12/27 0703-1001	• Attempt to observe carry-over from previous evening • Evaluate the CO distribution during non-school and reduced work travel schedule • Identify other potential areas where CO may be present • Evaluate the entire valley CO from northwest to southeast • Explore areas south of Owens and west of Eastern for areas of elevated CO	7.9
10	12/27-12/28 1711-0206	• Perform extensive spatial mapping to find additional potential CO maximums • Identify if the drainage flow is draining CO toward Lake Mead • Investigate the CO levels in the northwest and around those Casinos	9.7
11	12/28-12/29	• Perform north to south traverse down strip to observe CO	8.3

	1814-0042	exposure to pedestrians • Evaluate NW area for CO during period of improved mixing • Perform additional neighborhood evaluations	

Figure 5-2. Sample Map of Mobile Sampling Times and Locations for the Evening of December 16, 2001

6. RESULTS

6.1 Saturation Network Sampling - Static and Dynamic Sites

The 1-hour and 8-hour averaged databases from the 63-site Saturation Network were examined to determine the geographic distribution of CO during peak periods. The Saturation Network included three sites that had been classified during the siting process as representative of the micro-scale, and were intended to measure impacts from very localized sources. Three other sites, although not originally classified as micro-scale, exhibited characteristics that suggest significant impacts from local sources on an intermittent basis. This subset of sites is addressed separately in the following discussion.

6.1.2 Maximum CO Levels

6.1.2.1 Maximum Over Period of Field Measurements

The major objective of this study is to determine if the DAQM CO Network captures peak CO ambient concentrations, and is representative of the CO exposure levels in the Las Vegas Valley. As can be seen from **Figure 6-1**, this appears to be the case. In the figure, isopleths of the peak running 8-hour averaged CO levels generated from the Saturation Network data for the period of the field study (November 20, 2001 to January 5, 2002) are shown. The locations of the existing DAQM sites that measure CO are shown as well. Of particular note is that there is a concentration of DAQM sites in the most severely impacted area. The Sunrise Acres (SA) site was ideally located to measure maximum levels as defined by the Saturation Network. Generally low CO concentrations (peaks <2.5 ppm) were experienced in the fringe areas outside the inner core. A sense of the CO gradient between the core and the outer areas in the Las Vegas Valley is provided on the time-series plots shown in Figure 5-1 of this report. A representative sample of peak concentrations at select locations throughout the Valley is given in **Table 6-1**.

Table 6-1. Peak 8-hour CO Concentrations (ppm) from Select Sites in the Saturation Network

Location	Site ID	Highest	2nd Highest	3rd Highest
Inner Core - Las Vegas	xU16	7.18	7.07	7.01
Airport Access Road	R8	2.92	2.88	2.88
New Development - So. Highlands	SoH	1.95	1.94	1.93
Westside Community - The Lakes	E13	1.96	1.95	1.94
Southside Community - Galleria Mall	BB5	2.29	2.28	2.26

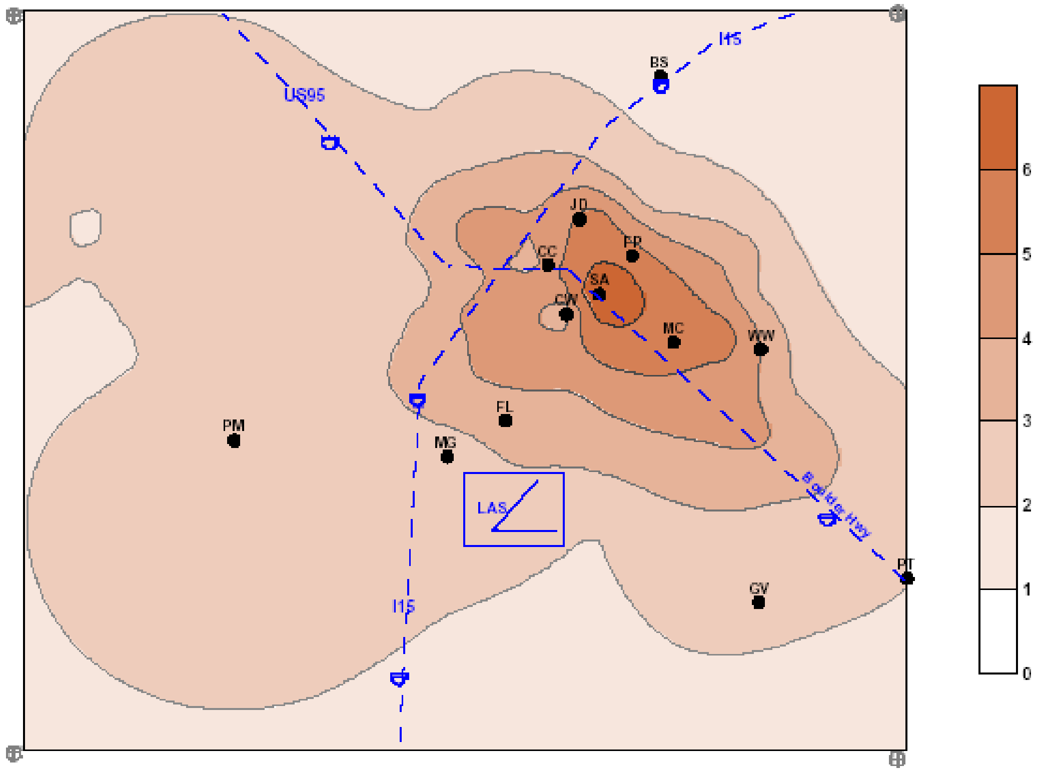


Figure 6-1. Peak 8-hour Average CO (ppm) for Period November 20 to January 5 Showing DAQM CO Sites

Figure 6-2 shows the Saturation Network sites that were used to develop the CO map on Figure 6-1. The philosophy associated with the selection of Saturation sites is discussed in Section 3 of this report. As can be seen from Figure 6-2, the Saturation Network included representative sites from throughout the developed areas of the Las Vegas Valley.

6.1.2.2 Maximum During IOPs

It should be noted that Figures 6-1 and 6-2 were constructed using the peak 8-hour concentrations experienced during the field study without regard to date. In fact, 50 percent of the peaks shown occurred on either December 26 or 27, and 80 percent during one of the two IOP's (December 17-20 and December 26-28). However, the number of sites in the Saturation Network increased from 36 on November 20 to 63 by the end of the second IOP. Ten additional sites were installed after reviewing the Static and mobile measurements acquired during the first IOP thus providing additional coverage in potential locations of elevated CO levels. The reader is referred to Tables 5-1 and 5-2 in this report for a complete list of the dates data acquisition started at sites in the Saturation Network.

The maximum or peak 8-hour CO concentrations occurring during the two IOP's are shown in **Figures 6-3 and 6-4**. All sites in the Saturation Network are included in the dataset from which the figures were developed, including micro-scale sites. Although all days that comprised the IOPs were included, the peak concentrations experienced during the first IOP were evenly distributed between the 17th and 18th, and mostly on the 27th during the latter IOP.

In general, the geographic distribution of CO was similar during both episodes in that the inner core area was impacted the greatest, and high concentrations tended to follow the terrain sloping southeastward parallel to the Las Vegas wash. The latter feature is due to transport by terrain-induced drainage flows during the nighttime. CO levels within the drainage flow were measured in more detail during mobile sampling that is discussed in Section 6.2.

Notable differences in the geographic distribution of CO between the two episodes are that high concentrations were more widespread and background levels throughout the Valley were somewhat lower during the late December IOP.

Although the DAQM Network covers the maximum impacted area, secondary areas to the southeast and northwest of the Las Vegas City Center where impacts owing to drainage-flow transport are not well defined.

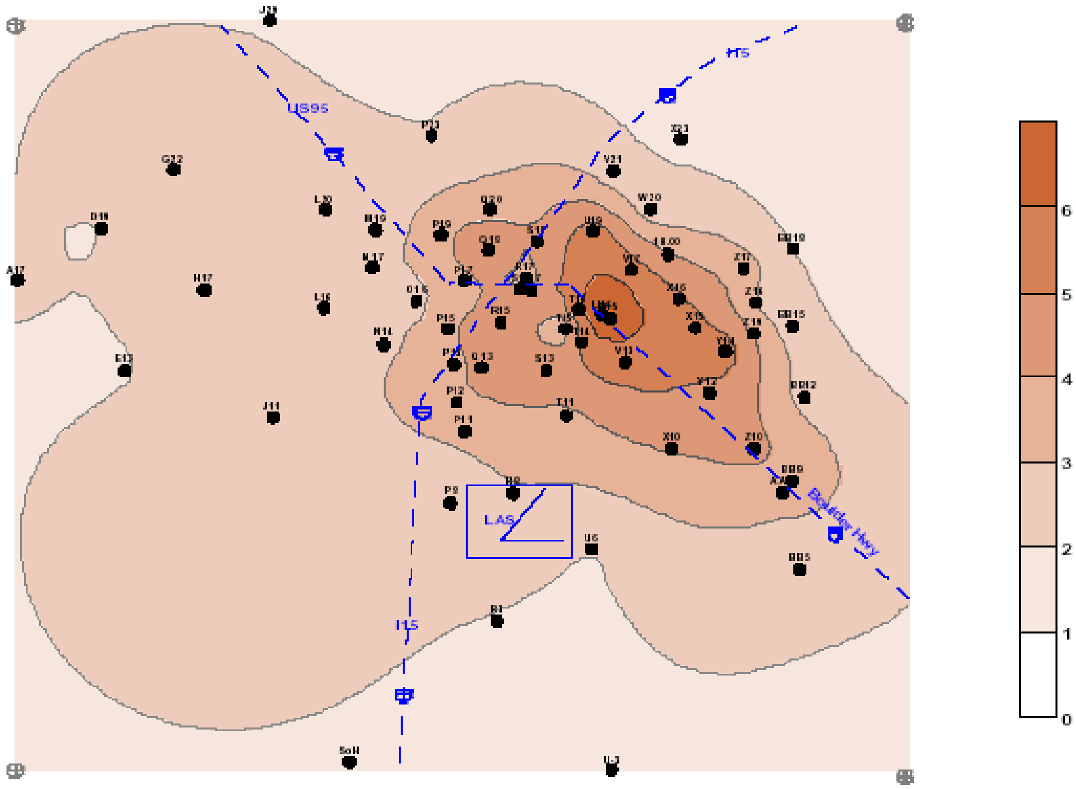


Figure 6-2. Peak 8-hour Average CO (ppm) for Period November 20 to January 5 Showing Saturation Network Sites

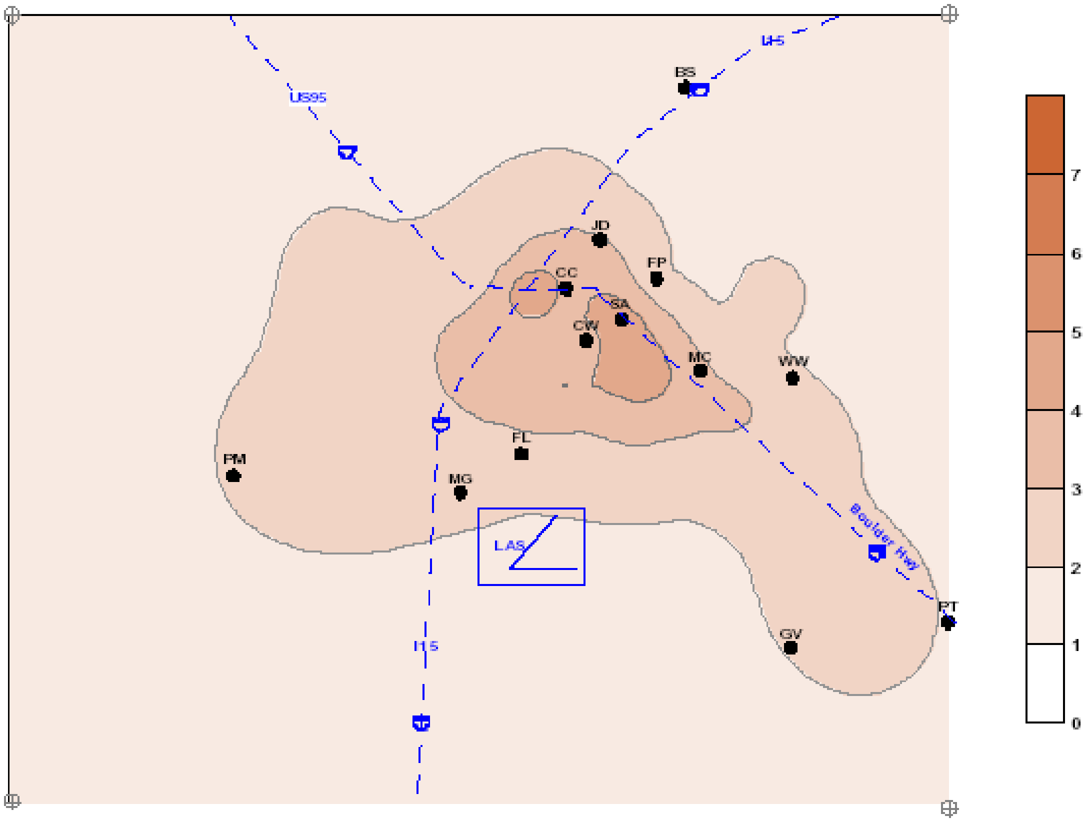


Figure 6-3. Peak 8-hour Average CO (ppm) for Period December 16 to 20, 2001 Showing DAQM Network Sites

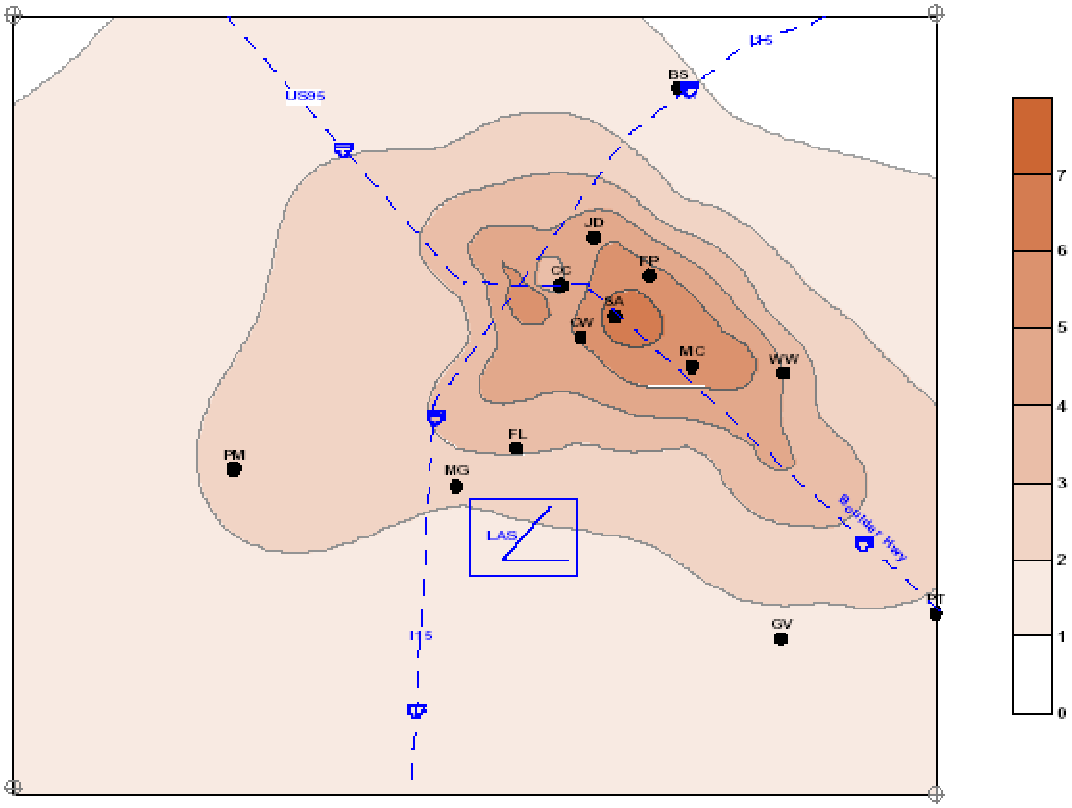


Figure 6-4. Peak 8-hour Average CO (ppm) for Period December 27 to 29, 2001 Showing DAQM Network Sites

6.1.3 Micro-scale Measurements and Aberrations

6.1.3.1 Micro-scale Sites

Three of the Saturation Network sites were classified as micro-scale and were included to aid in understanding the behavior of local sources. The S16 site was located at a taxi loading area adjacent to the Fremont Street Experience. A second site, Q13, was curbside to Las Vegas Blvd, in front of a theme park (Wet and Wild), and exposed to heavy vehicular traffic. The third site, V15, was located at the DAQM's designated Microscale site (MS) (CO monitoring has been discontinued at this site).

The highest CO levels experienced in the Saturation Network were at the S16 or "Taxi stand" site. Peak instantaneous levels in excess of 40 ppm were measured. Hourly averages ranged as high as 18.3 ppm. Both levels were the maximum measured in the Saturation Network. Owing to the more intermittent nature of the source activity (waiting taxis), S16 did not experience the highest 8-hour averages in the Saturation Network. The typical diurnal variation in hourly concentrations is shown in **Figure 6-5**.

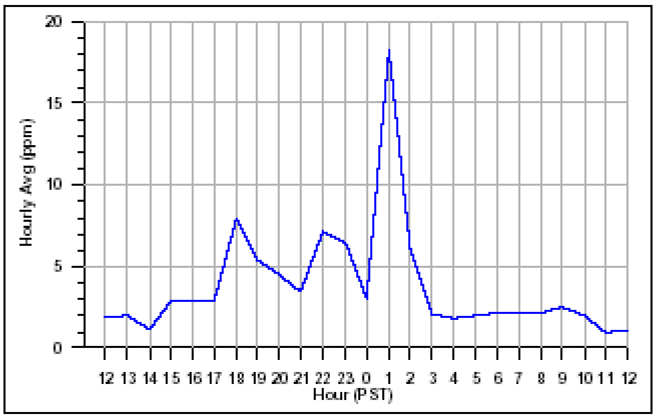


Figure 6-5. Diurnal Variation in Hourly CO at S16 (Taxi Stand)
December 11 to 12, 2001

6.1.3.2 Aberrations

Three other sites that were initially classified as either middle- or neighborhood-scale stood out as outliers when the measurements at those sites were compared to the other sites in the network. The sites, N14, L16, and P12 experienced isolated high CO levels that, from our examination of the high-resolution minute readings, were considered valid measurements. The former two are located in residential neighborhoods with only local traffic thus it can only be assumed that the high levels were caused by vehicles parking with engines running for extended periods (5-10 minutes). This resulted in unexpectedly high hourly averages on an occasional basis but did not appear to significantly affect the 8-hour averaged levels. The third site (P12) was located in front of the Fashion Show mall on Las Vegas Blvd. The analyzer was located approximately 35 meters from the intersection of Las Vegas Blvd. and Fashion Show Rd., near the front entrance to the Saks Fifth Avenue Department store. The site should be adequately distanced far enough away from Las Vegas Blvd. so as not be overwhelmed by vehicular traffic. Nevertheless, high CO levels were persistent to the extent that the hourly averages were elevated above those of the surrounding saturation sites. These three sites were excluded from hourly analyses but included in the results for 8-hour average CO readings.

An examination of the maximum concentrations experienced during the field program provides additional useful information. **Table 6-2** provides the peak 8-hour averaged CO levels measured by the Saturation Network ranked by concentrations. The data set used to produce the table itself was a subset of the total data consisting of the top five levels measured at each site in the Network hence the maximum entries possible in Table 6-2 is five. Also included is the site name, date and time of occurrence. Note that the peak levels in the table were experienced at four of the 63 sites in the Saturation Network. The S16 site at the taxi stand is a micro-scale site not necessarily representative of a significant health risk exposure to more than a small group of people. The three other sites, xU16, V15, and T16 are of primary interest. They are all located in the so-called inner core area. The V15 monitor was located at the DAQM Microscale site at which the routine measurement of CO was discontinued, as it was not considered representative of the general population exposure in that area. However, the Saturation Network xU16 site was located nearby in a neighborhood at a reasonable distance from heavy vehicle traffic or industrial sources. As can be seen from the data in the table, the highest levels were measured at that site. The Saturation T16 site was also located in a neighborhood several blocks west of the Sunrise Acres site. Measurements at the T16 site were among the highest levels experienced during the study.

The maximum 8-hour CO concentrations at all Saturation sites are shown in **Table 6-3**. The date and time of occurrence is also given. Note that most of the peak levels were measured during the two IOPs. Nearly all of the 10 sites that were exceptions are located outside the urban area. U19, situated near the county's J.D. Smith site, experienced maximum CO levels on December 8, which had been a candidate IOP day.

Table 6-2. Twenty 8-hour CO Concentrations Measured in the Saturation Network

Site ID	Date	Start_hr	Co(ppm)
xU16	27-Dec-01	18	7.18
xU16	27-Dec-01	17	7.07
S16	27-Dec-01	17	7.05
xU16	26-Dec-01	15	7.01
S16	11-Dec-01	18	7.01
S16	27-Dec-01	18	6.97
xU16	27-Dec-01	19	6.97
S16	27-Dec-01	16	6.95
xU16	26-Dec-01	18	6.94
S16	27-Dec-01	15	6.92
V15	27-Dec-01	18	6.56
V15	27-Dec-01	19	6.45
V15	27-Dec-01	17	6.41
V15	27-Dec-01	16	6.11
V15	26-Dec-01	18	6.08
T16	19-Dec-01	8	5.81
T16	18-Dec-01	19	5.68
T16	19-Dec-01	7	5.64
T16	27-Dec-01	19	5.61

Table 6-3. Maximum 8-hour CO Concentrations at All Saturation Network Sites

Site	Date	Start_hr	CO(ppm)
Z19	20-Dec-01	13	2.37
Z17	20-Dec-01	13	3.59
Y14	27-Dec-01	19	5.58
xZ16	22-Dec-01	19	2.91
xZ10	27-Dec-01	19	4.23
xY12	27-Dec-01	19	4.65
xX18	27-Dec-01	18	4.05
xW20	27-Dec-01	17	2.32
xV21	27-Dec-01	17	2.42
xU16	27-Dec-01	18	7.18
xR17	27-Dec-01	18	3.23
xQ18	27-Dec-01	18	5.25
xP19	27-Dec-01	18	3.78
xP17	01-Jan-02	18	3.66
xP15	19-Dec-01	18	3.94
xP13	27-Dec-01	20	3.57
xP11	27-Dec-01	19	3.19
xO16	27-Dec-01	19	2.62
xM19	27-Dec-01	18	2.47
xBB18	17-Dec-01	23	1.97
xBB15	27-Dec-01	19	2.49
xBB12	27-Dec-01	22	2.58
X23	17-Dec-01	23	1.96
X16	27-Dec-01	19	5.14
X15	27-Dec-01	19	5.21
V17	27-Dec-01	18	5.45
V15	27-Dec-01	18	6.56
V13	27-Dec-01	18	5.53
U6	17-Dec-01	23	1.98
U-3	17-Dec-01	23	1.95
U19	08-Dec-01	18	5.55

Site	Date	Start_hr	CO(ppm)
T16	19-Dec-01	8	5.81
T15	20-Dec-01	2	3.16
T14	26-Dec-01	19	5.33
T11	26-Dec-01	2	3.75
SoH	17-Dec-01	23	1.95
S18	27-Dec-01	18	4.05
S17	26-Dec-01	19	4.73
S13	20-Dec-01	2	4.63
R8	13-Dec-01	19	2.92
R3	26-Nov-01	1	1.99
R15	27-Dec-01	19	4.39
Q20	27-Dec-01	18	3.55
Q13	19-Dec-01	8	4.44
P8	18-Dec-01	1	2.29
P23	08-Dec-01	18	2.05
P12	29-Nov-01	4	3.78
N14	30-Nov-01	5	2.85
M17	19-Dec-01	3	2.95
L20	27-Dec-01	18	2.48
L16	05-Dec-01	3	2.90
J29	17-Dec-01	23	1.96
J11	28-Dec-01	18	2.94
H17	20-Dec-01	7	2.30
G22	20-Dec-01	6	2.36
E13	05-Dec-01	6	1.96
D19	16-Dec-01	3	1.99
BB9	27-Dec-01	19	3.92
BB5	19-Dec-01	3	2.29
AA8	27-Dec-01	18	3.29
A17	04-Dec-01	10	2.05

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6.2 MOBILE SAMPLING

The results of the sampling performed using the sampling van are presented in two sections. The first section describes the measurements during the first IOP from December 16 to 20. The second section describes measurements during the second IOP from December 26 to 29. Within each section are discussions for each of the periods when sampling was performed. Included with each discussion are color-coded maps depicting the observed spatial distribution of CO over the respective sampling period. As appropriate, more detailed discussions and finer resolution maps are provided to present the sampling results. One of the key areas of focus was in the inner core region around the intersection of Charleston Blvd., Eastern Avenue, and Fremont Street. For simplicity this area is referred to in the discussions below as the CEF area.

6.2.1 December 16 – 20

Seven sampling events were conducted during the first IOP. The results from each of the events are described below.

<u>December 16 Evening</u>

Figure 6-7 presents the overall CO observations during the sampling period. Key findings from the run include:

- While not high in relative concentration, there were several instances when rises in CO concentration were accompanied by the smell of wood smoke. These observations were made on Owens Avenue between North Pecos Road and North Lamb Drive.
- It appeared that heavy traffic, such as traffic along Decatur or Charleston in peak commute times, added about 1 to 2 ppm to the general background of CO in the area. Medium to light traffic, with no high emitting vehicles nearby, had little or no influence on the observed CO concentrations.
- Little CO was seen in the region west of I-15 and south of 95. Additionally, the region in the northwest from Charleston to W. Lake Mead and from Rainbow over to Buffalo saw no significant levels of CO.
- Of the east/west traverses made, the highest concentrations were observed in the areas around Eastern Avenue.

<u>December 17 Morning</u>

Figure 6-8 presents the overall CO observations during the sampling period. Key findings from the run include:

- Morning concentrations in the CEF area were greater than 6 ppm with some observations to over 9 ppm along Desert Inn Road, between Eastern and Boulder Hwy, south of this region.
- A traverse down Boulder Hwy showed the drainage flow had been established with concentrations above 4 ppm in the region northwest of Missouri Ave. Concentrations remained above 3 ppm down to Warm Springs Road.
- Traveling down toward Henderson to the region where the haze was observed showed relatively low concentrations of CO.
- The primary CO plume during the north/south traverse along Eastern showed the higher levels of CO to be between Lake Mead Blvd and Desert Inn Road.

December 17 Evening

Figure 6-9 presents the overall CO observations during the sampling period. Key findings from the run include:

- The region of highest concentrations was bounded on the east by Lamb Blvd and the north by Carey Ave.
- A traverse along Charleston Blvd. showed the highest concentrations centered in the CEF area. A north/south traverse along Eastern Ave. showed the highest concentrations in the vicinity of Stewart Ave.
- Multiple traverses along Vegas Drive/Owens Ave showed a peak in the vicinity of Rancho Drive (Business 95) and at about the crossing with Eastern Ave.
- Implementation of the “confirmation loop”, where a short drive through neighborhoods adjoining the busy streets was performed, confirming the addition of about 1-2 ppm to the observations along heavily traveled streets.
- Traveling through some neighborhoods there was a wood smoke smell, but concentrations appeared to have no more than 1 ppm added as a result.

December 18 Morning

Figure 6-10 presents the overall CO observations during the sampling period. Key findings from the run include:

- General CO levels throughout the mapping area from the west through the CEF region and to about Lamb Blvd were in the 5 to 7 ppm range. Little CO was observed in the northeast area around Freedom Park. It appeared the primary CO plume was broad and may have been draining in the direction of Boulder Hwy.

- The highest concentrations were observed prior to 9:00 with levels throughout the neighborhoods surrounding the CEF region showing values upwards of 9 ppm.
- By 9:00 much of the overall CO was diminishing rapidly in concentration with the traverse south on Pecos Road from Cheyenne Ave. showing only a minor increase to about 5.5 ppm as Boulder Hwy. was crossed.
- The southern areas down to and around McCarren airport were mapped after 9:00 and little CO was seen. This was potentially due to the later hour and associated greater vertical mixing of the CO significantly reducing the surface level concentrations.

December 18 Evening

Figure 6-11 presents the overall CO observations during the sampling period. Key findings from the run include:

- Concentrations along Rancho Rd. in excess of 7 ppm were observed heading northwest. The elevated concentrations continued to about the North Las Vegas Air Terminal after which they dropped to under 5 ppm. By Craig Road the concentrations were under 4 ppm. The concentrations then dropped to under 3 ppm by the intersection of Rainbow Blvd and Rancho Road. Observations made by the sampling van in this southern part of Rancho Road prompted the addition of Saturation Network sites to characterize this area.
- Several traverses south on Eastern and in the neighborhoods within 2 km of the CEF area showed that to be the region of maximum CO concentration. **Figure 6-12** shows a map with this area and observed CO concentrations displayed. It is clear that while some of the highest CO concentrations were observed along Eastern Ave, the surrounding neighborhoods also showed significant concentrations.
- Observations made this evening with the sampling van prompted the addition of another Saturation Network site (Dynamic site) during the second IOP within the neighborhood adjacent to the Sunrise Acres DAQM station. It appeared the higher levels of observed CO were due to a source other than vehicle emissions.

December 19 Morning

Figure 6-13 presents the overall CO observations during the sampling period. Key findings from the run include:

- The initial morning traverse up Rancho Road to the northwest showed elevated concentrations of CO up until just before Craig Road. Confirming the neighborhood scale of the CO, rather than just representative of road type emissions, a trip through the housing development just south of Vegas Drive showed values over 7 ppm. Additionally, levels above 5 ppm were seen as far south as Flamingo Road while traversing Decatur on the west side. This showed a more general plume throughout the valley during the morning hours.
- The traverse from north to south along Martin Luther King Blvd showed relatively low concentrations (<4 ppm). This implied a region of lower concentrations of CO between the northwest and west regions, and the inner core area in the eastern portion of the valley. The subsequent traverses through the regions around Freedom Park and Sunrise Acres showed concentrations over 8 ppm.
- Traverses along Stewart Ave in the region of Eastern showed that area to have some of the highest concentrations, with the peak observed value over 8 ppm. Surveys around the DAQM sites showed them to be in the appropriate general region.
- A traverse down Boulder Hwy showed the CO plume to start tapering off between Tropicana Ave. and Russell Road, where concentrations fell below 4 ppm. This implied some of the CO had been entrained in the nighttime drainage flow.
- By the 9:00 to 10:00 hour the overall CO concentrations were dropping rapidly. This was a result of the mixed layer growing and diluting the morning CO.

December 19 – 20 Evening/Night

Figure 6-14 presents the overall CO observations during the sampling period. Key findings from the run include:

- Low concentrations (<3 ppm) were seen along the very western traverse up Durango Drive and then down Rancho Road to the south. The northwest area north of Vegas Drive and west of Decatur had concentrations less than 4 ppm.
- The north/south and east/west extent of the plume was more extensive during this period suggesting the Valley did not clean out during the daytime, and a general elevated CO background was carried over into the nighttime hours.

Concentrations in excess of 5 ppm were seen from Flamingo Road on the south to above Lake Mead Blvd in the north and from Decatur Blvd. on the west to Nellis Blvd. on the east.

- The higher concentrations of CO crossing Nellis Blvd to the southeast of the main CO area suggests that drainage flow was setting up to the southeast. This is further illustrated in **Figure 6-15** which shows the numeric values of the concentrations observed in the vicinity of Vegas Valley Drive and Nellis Blvd. Further downwind, concentrations east of Boulder Hwy and south of Stallion Mountain Golf Club suggested the plume was following the Las Vegas Wash toward Lake Mead. While relatively low, the values along the drainage path of 4 ppm, falling to around 3 within the wash, does support the drainage pattern. The reduction in concentration was most likely due to dilution from low CO concentration air draining from the hills to the east.
- On the basis of the mobile observations, an additional Saturation Network site was added in the vicinity of the Boulder Hwy intersection with Flamingo and Nellis, behind Sams Town. This site would help identify drainage flow concentrations heading toward the Las Vegas Wash. The site was added prior to the first sampling event of the second IOP.

6.2.2 December 26-29

<u>December 26 Evening</u>

Figure 6-16 presents the overall CO observations during the sampling period. Key findings from the run include:

- Only low concentrations of CO were observed west of I-15.
- The mapping of the CO plume showed the highest concentrations to be in the region of the CEF intersection and down Fremont Street toward Boulder Hwy. Concentrations over 7 ppm were observed.

<u>December 27 Morning</u>

Figure 6-17 presents the overall CO observations during the sampling period. Key findings from the run include:

- The highest observed concentrations were within an approximate 3 km radius of the CEF area. The highest values were seen along the Eastern Ave traverse and along Fremont from the intersection to the northwest. While the focus was on areas other than around the Sunrise Acres School, that area most likely was also seeing higher values. Prior mapping identified the additional Saturation Network site that was installed at the start of this second IOP, so additional mapping was not performed.

- Given the reduced amount of traffic due to schools being closed, and overall lighter traffic due to the holiday period, much of the CO seen may have been due to carryover through the night period, or possibly locally produced from home or water heating.

December 27 – 28 Evening/Night

Figure 6-18 presents the overall CO observations during the sampling period. Key findings from the run include:

- Mapping performed on the west side around the new developments and casinos showed no significant concentrations of CO.
- The most significant concentrations of CO were not on either the extreme east or west side of the valley, they were found back in the region of the CEF intersection and in the region around Owens Drive between Main St. and Eastern Ave. **Figure 6-19** shows the numeric concentration values in the Owens region with some of the highest values seen off of the major streets. Given the lack of automobile sources, the CO may be more related to home or water heating related sources. Similarly, **Figure 6-20** shows the CO measurements around the neighborhood near the Sunrise Acres site. Again, the high values were observed away from the major streets and was not related to adjacent vehicle sources.
- Along Boulder Hwy is a secondary peak in CO that was observed in the vicinity of Boulder Hwy and Nellis Blvd. This was in the vicinity of Sam's Town. **Figure 6-21** shows the measured CO concentrations.
- Traverses made down Boulder Hwy showed the plume extending almost to Henderson. Tracing the plume out along East Lake Mead Drive and down into the low areas where drainage would occur showed slightly elevated concentrations in the low areas thatwould be draining toward Lake Mead. **Figure 6-22** shows the observed CO concentrations along the southeast portion of the sampling van track.

December 28 – 29 Evening/Night

Figure 6-23 presents the overall CO observations during the sampling period. Key findings from the run include:

- The traverse down the Strip did show some elevated concentrations when traffic was heavy. However, concentrations were no higher than in the CEF region. The higher concentrations were seen down to approximately Tropicana Ave.

- The general concentrations throughout the study region were still relatively high, but values diminished significantly south of Tropicana Ave., as they did down the Strip. Higher levels were also seen up to the northwest, potentially due to a change in the wind direction.
- Some of the highest levels were seen along an east/west traverse on Stewart Ave. from Nellis to Las Vegas Blvd. up to Bonanza and across Rancho to Vegas Drive and finally ending at Decatur Blvd.
- Surveying the area around Sunrise Acres showed that this site was not in the maximum CO region this night. The maximum region was more to the northwest. It is suspected that a wind direction from the southeast may have moved the overall plume in that direction.

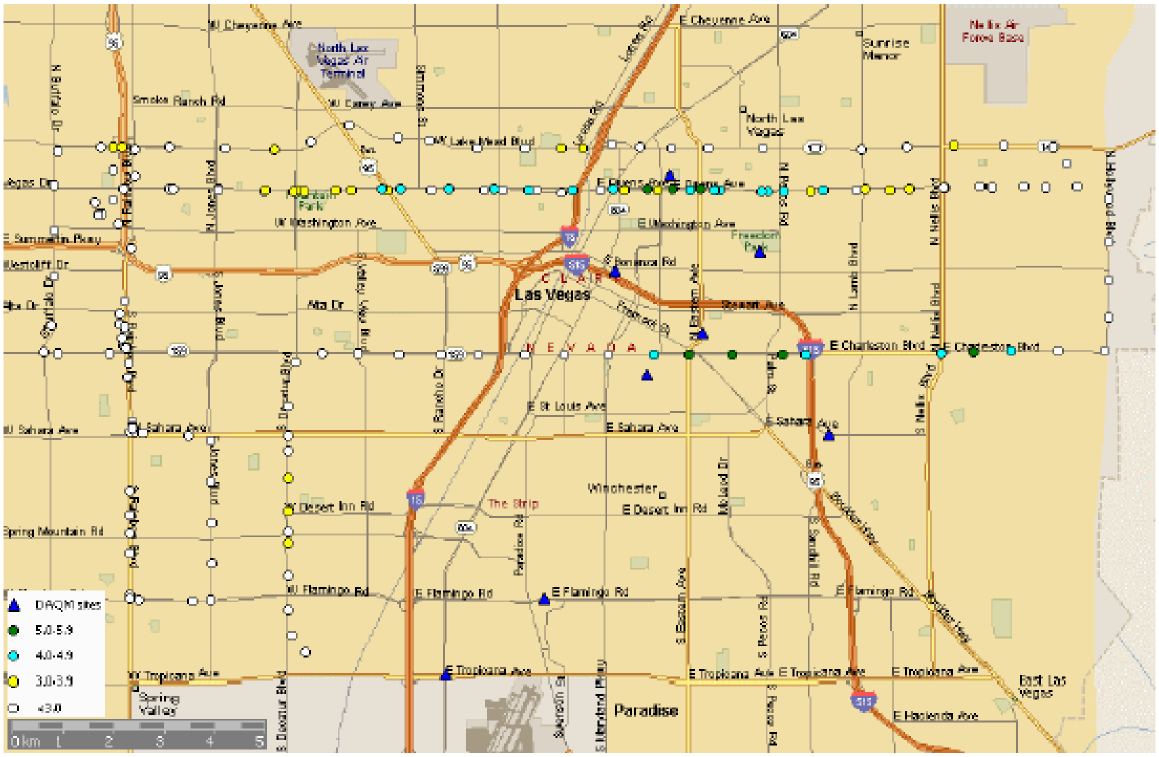


Figure 6-7. Observed CO Concentrations (ppm) During December 16 Evening Period

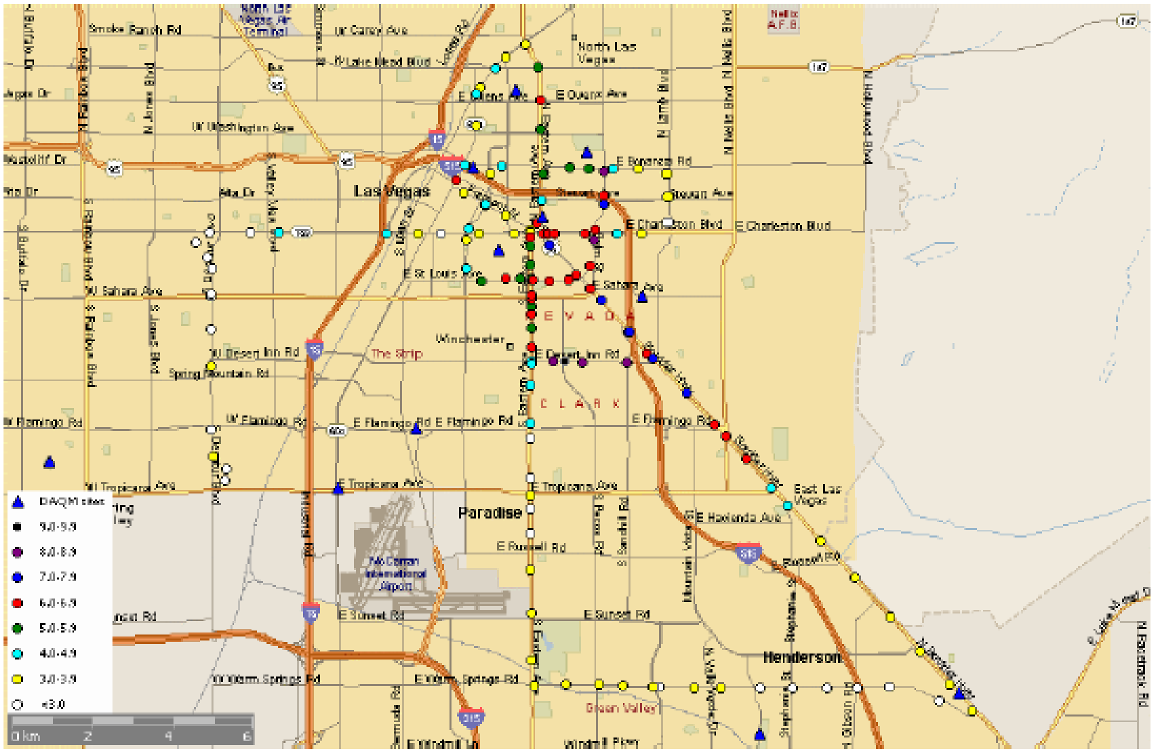


Figure 6-8. Observed CO Concentrations (ppm) During December 17 Morning Period

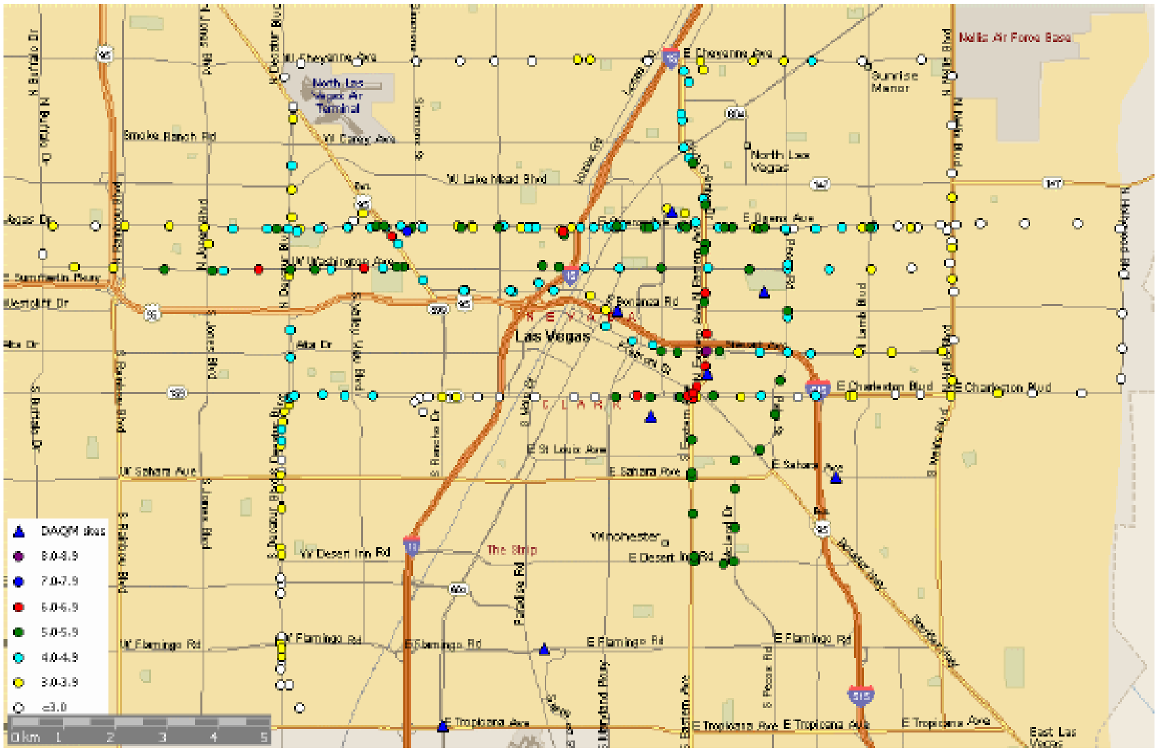


Figure 6-9. Observed CO Concentrations (ppm) During December 17 Evening Period

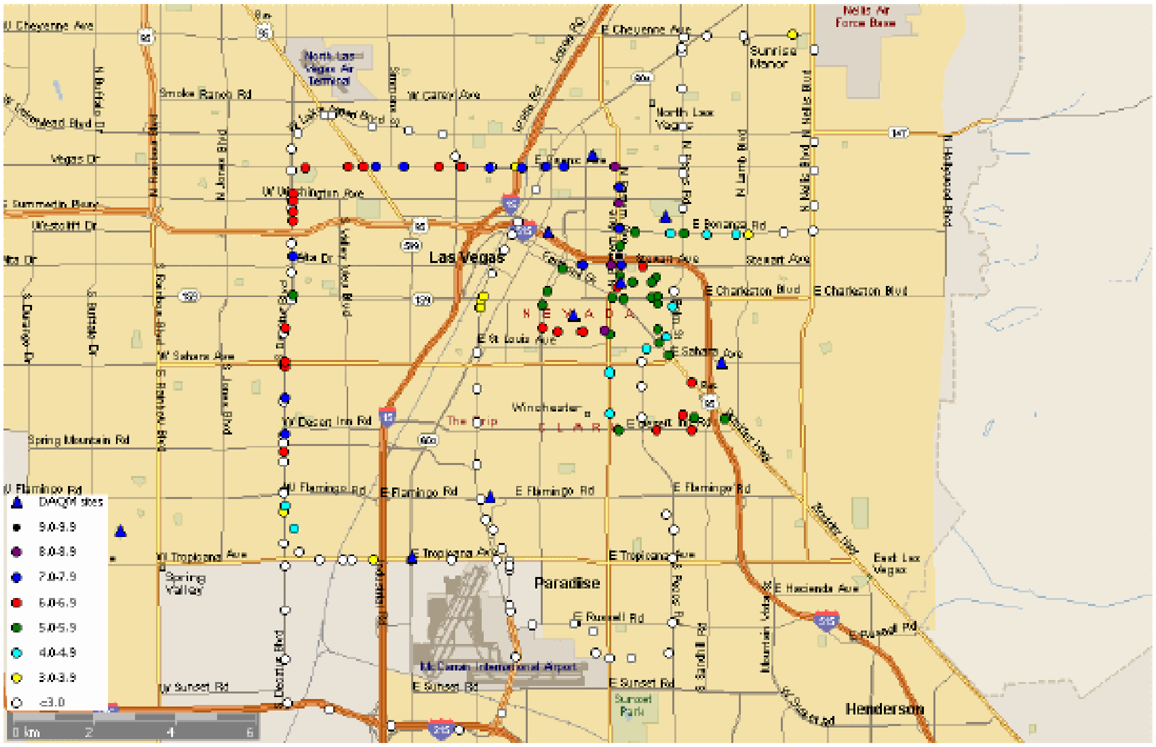


Figure 6-10 Observed CO Concentrations (ppm) During December 18 Morning Period

Figure 6-11. Observed CO Concentrations (ppm) During December 18 Evening Period

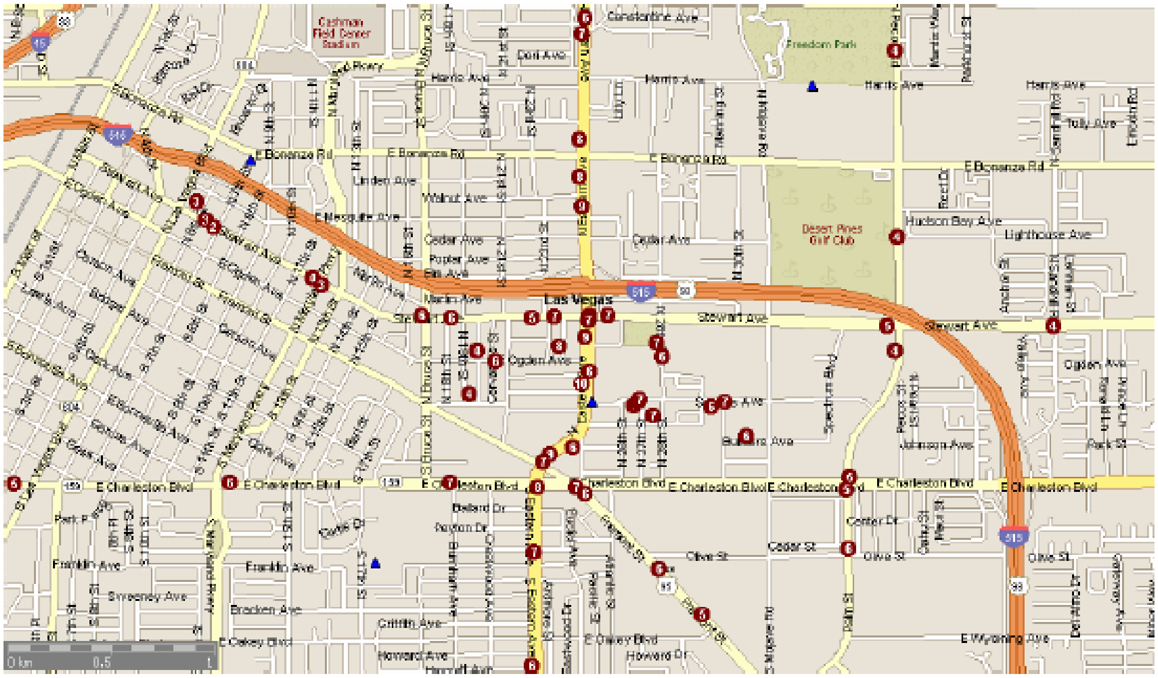


Figure 6-12. Observed Numeric CO Concentrations (ppm) During December 18 Evening Period in the CEF Region. (The DAQM sites are shown in blue triangles.)

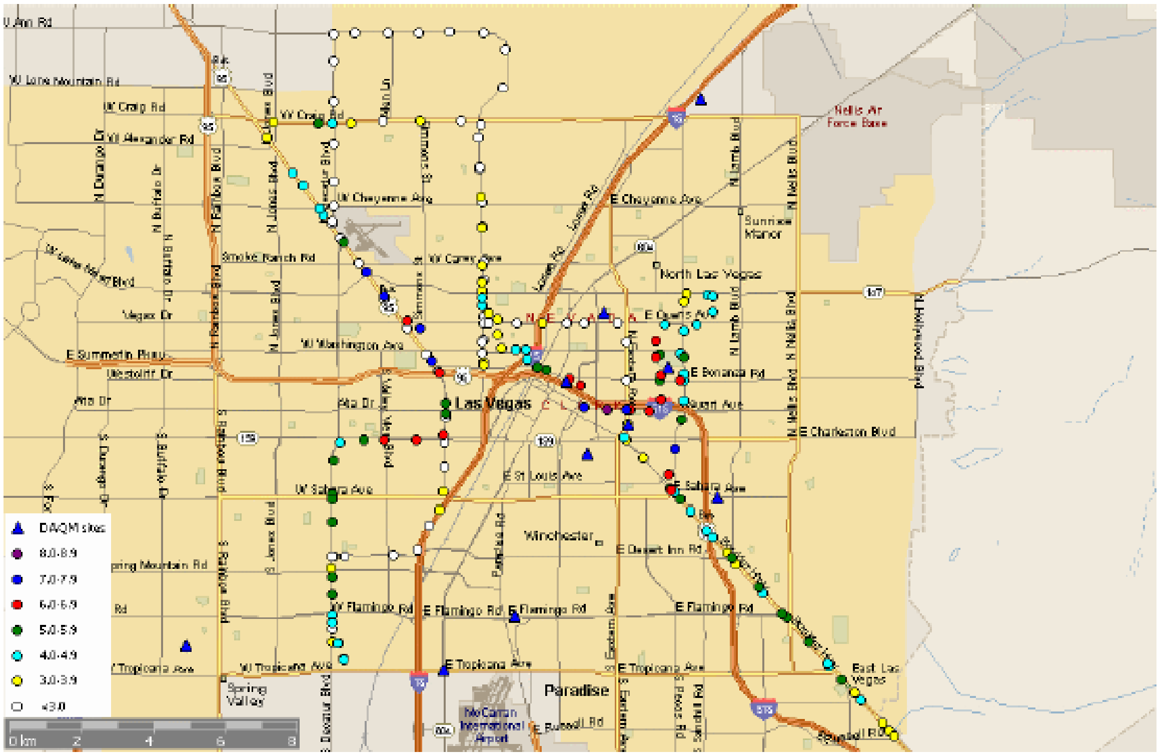


Figure 6-13. Observed CO Concentrations (ppm) During December 19 Morning Period

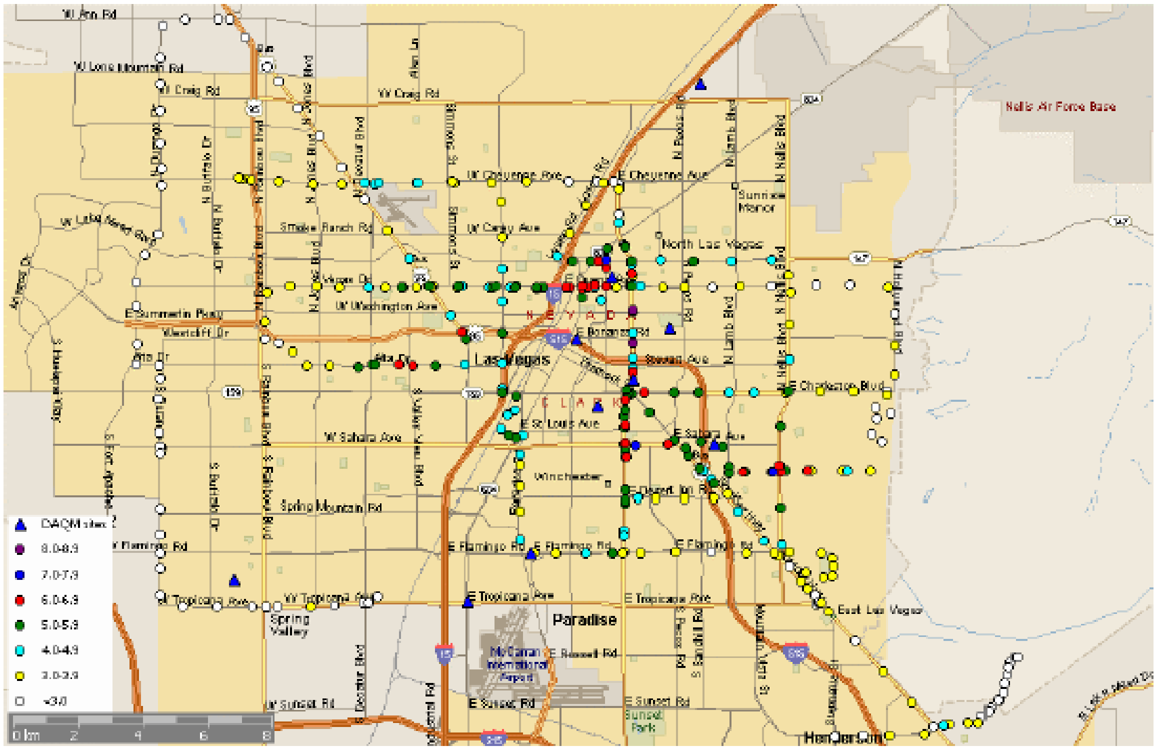


Figure 6-14. Observed CO Concentrations (ppm) During December 19 to 20 Evening/Night Period

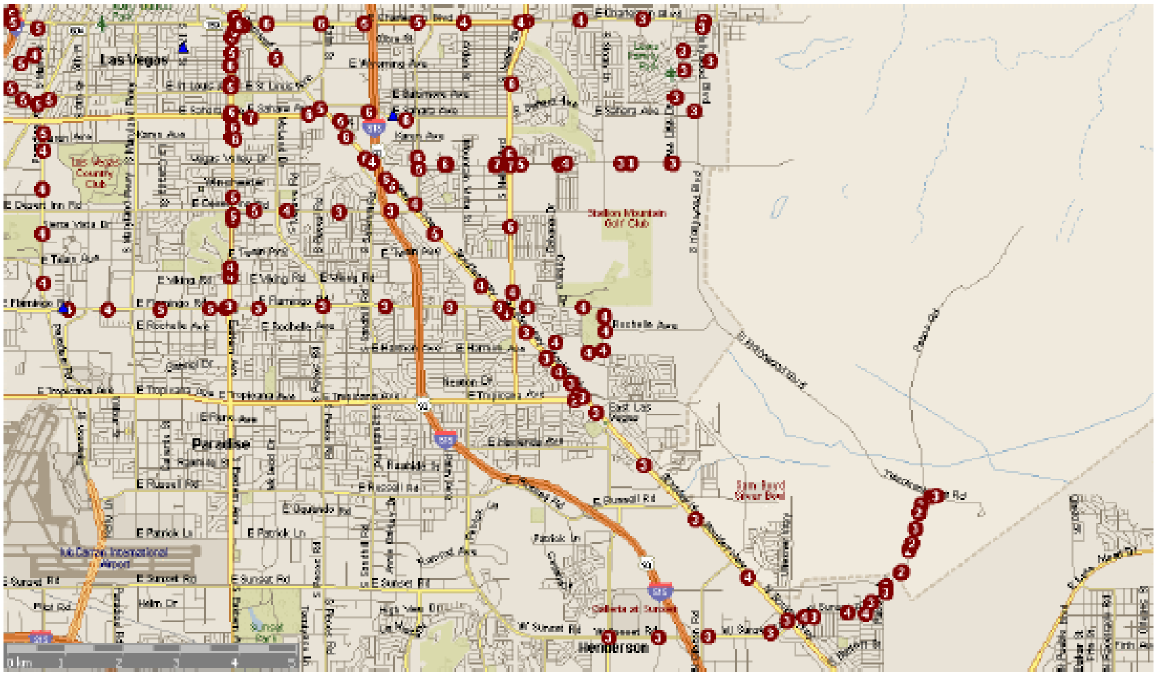


Figure 6-15. Observed Numeric CO Concentrations (ppm) During December 19 to 20 Evening/Night Period Concentrations illustrate the drainage flow. DAQM sites are shown in blue triangles.

Figure 6-16. Observed CO Concentrations (ppm) During December 26 Evening Period

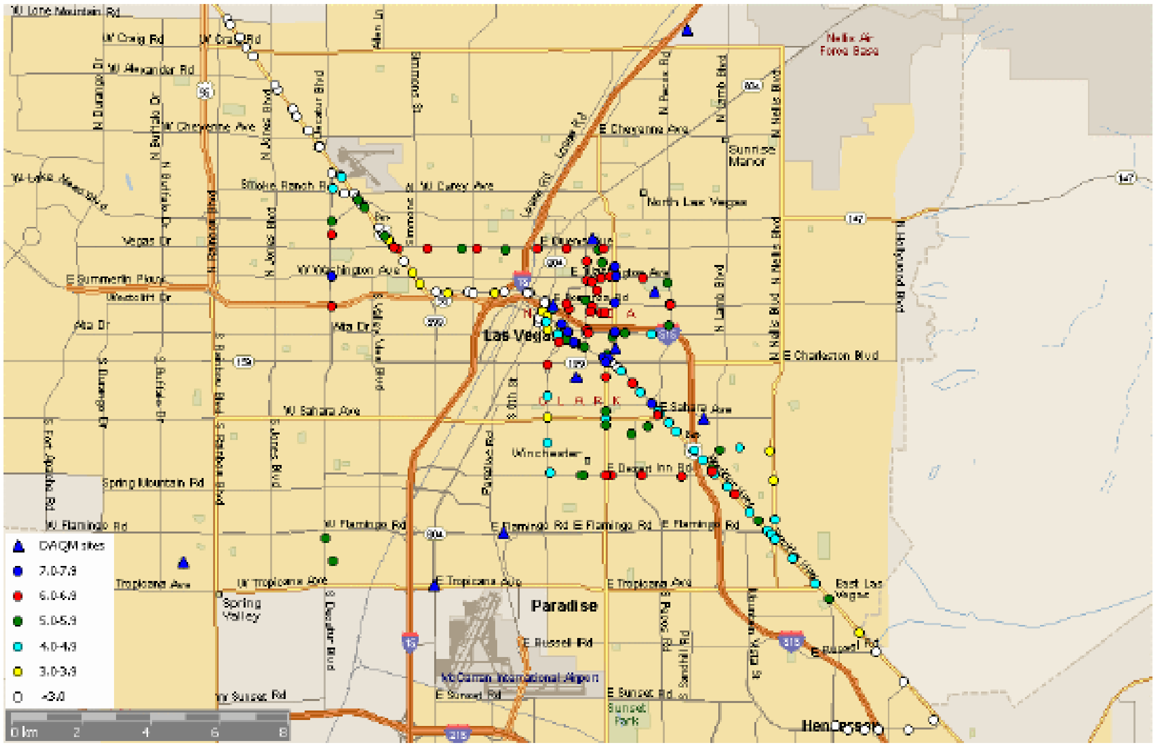


Figure 6-17. Observed CO Concentrations (ppm) During December 27 Morning Period

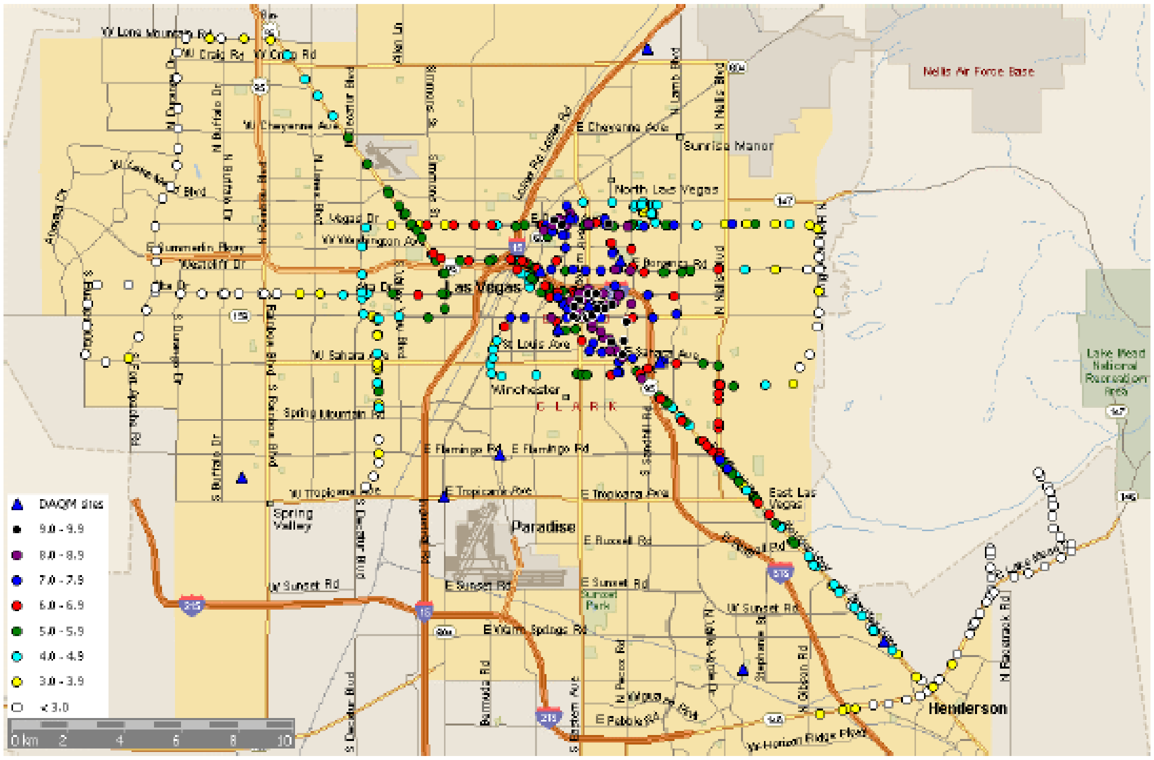


Figure 6-18. Observed CO Concentrations (ppm) During December 27 to 28 Evening/Night Period

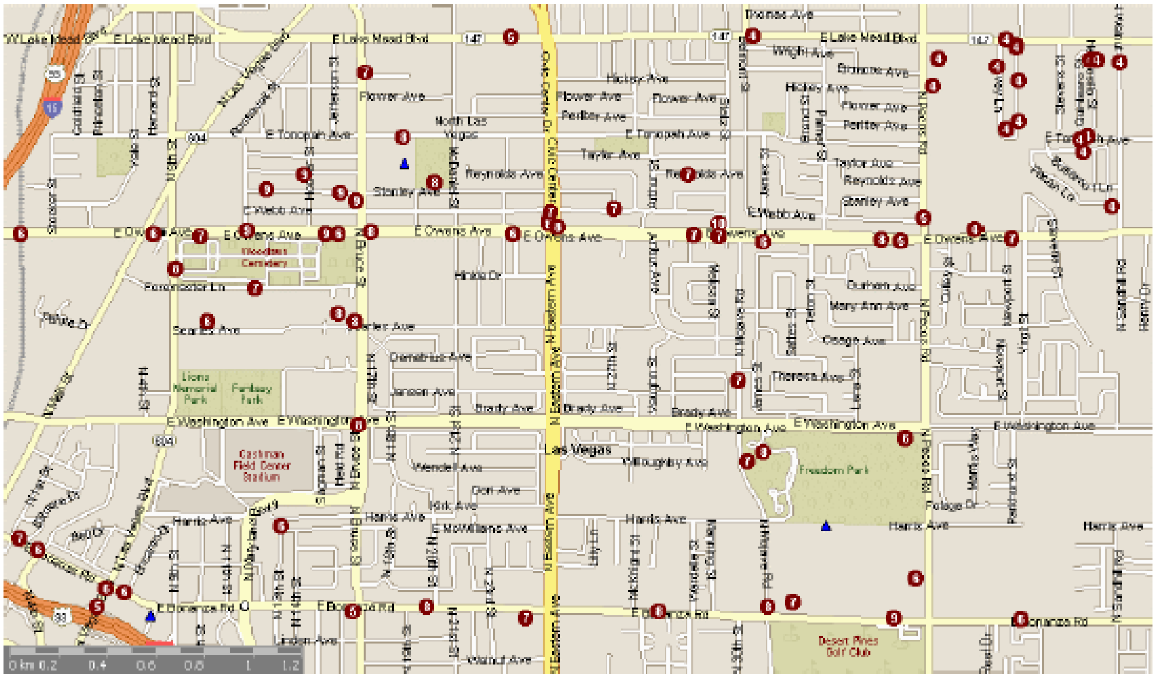


Figure 6-19. Observed Numeric CO Concentrations (ppm) During December 27 to 28 Evening/Night Period in the Region of Owens Ave. DAQM sites are shown in blue triangles.

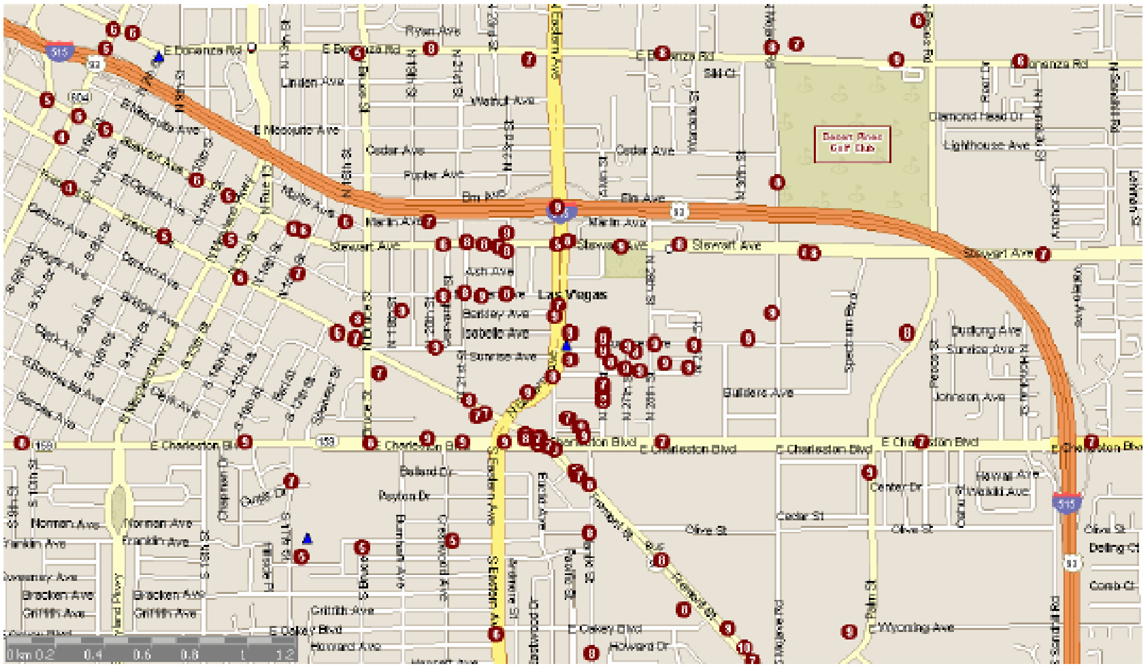


Figure 6-20. Observed Numeric CO Concentrations (ppm) During December 27 to 28 Evening/Night Period in the Region of the Sunrise Acres Site. The DAQM sites are shown in blue triangles.

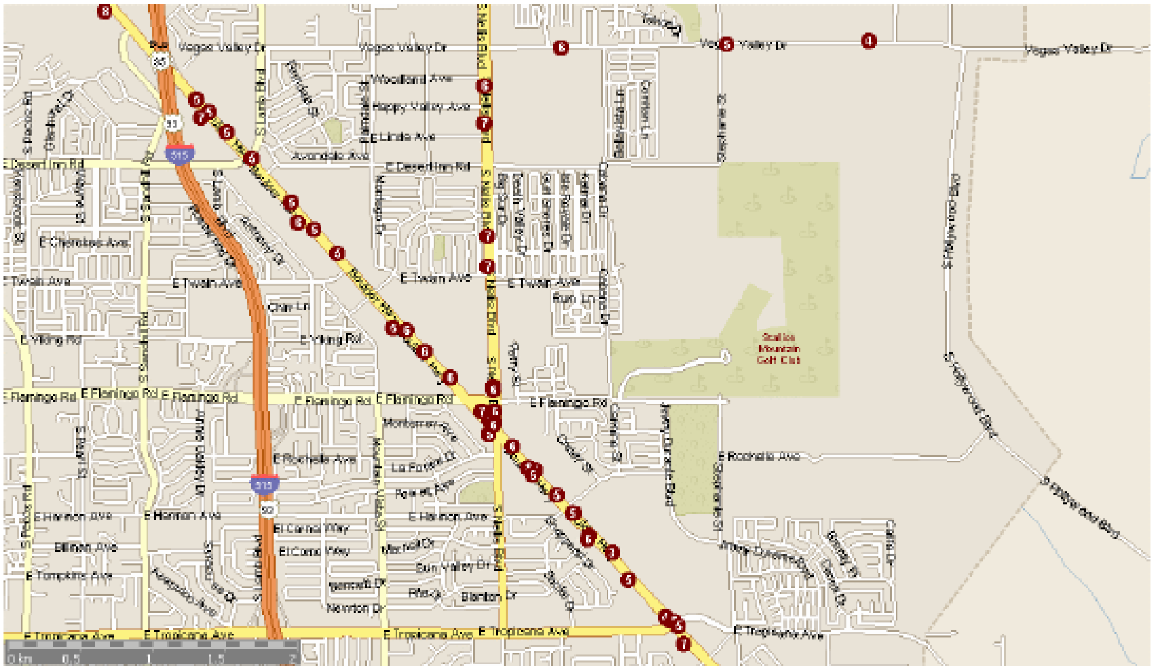


Figure 6-21. Observed Numeric CO Concentrations (ppm) During December 27 to 28 Evening/Night Period Showing the Concentrations in the Vicinity of Boulder Hwy and Nellis Blvd. There are noDAQM sites in this region.

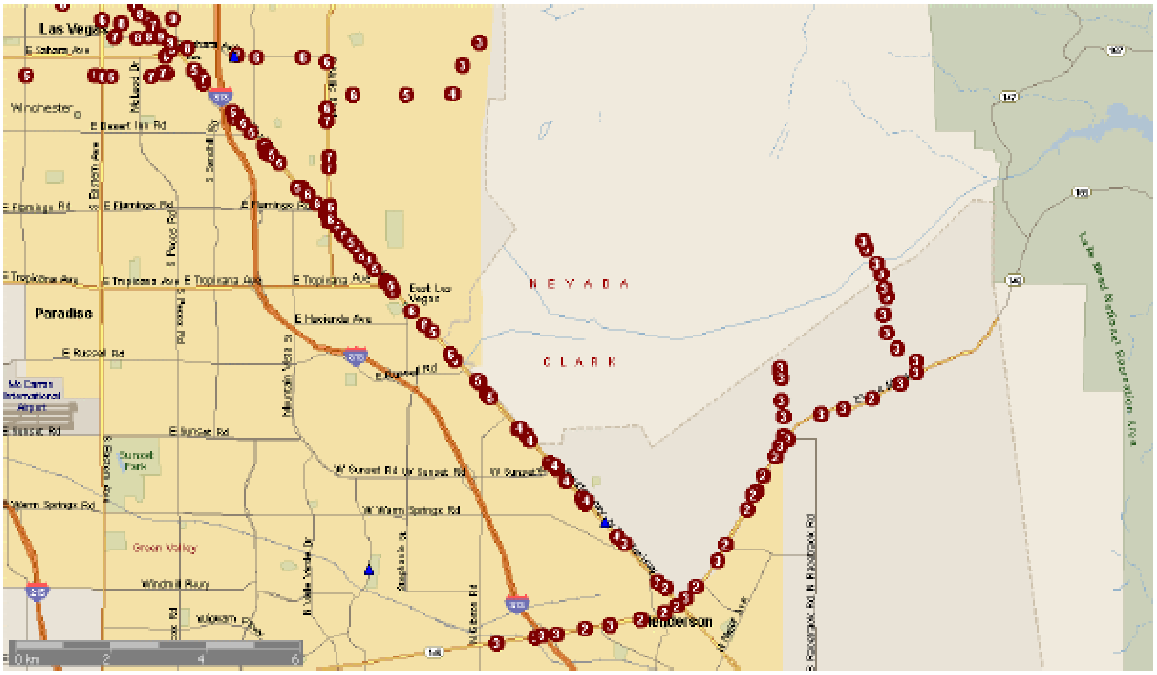


Figure 6-22. Observed Numeric CO Concentrations (ppm) During December 28 to 29 Evening/Night Period The concentrations illustrate the drainage flow. The DAQM sites are shown in blue triangles.

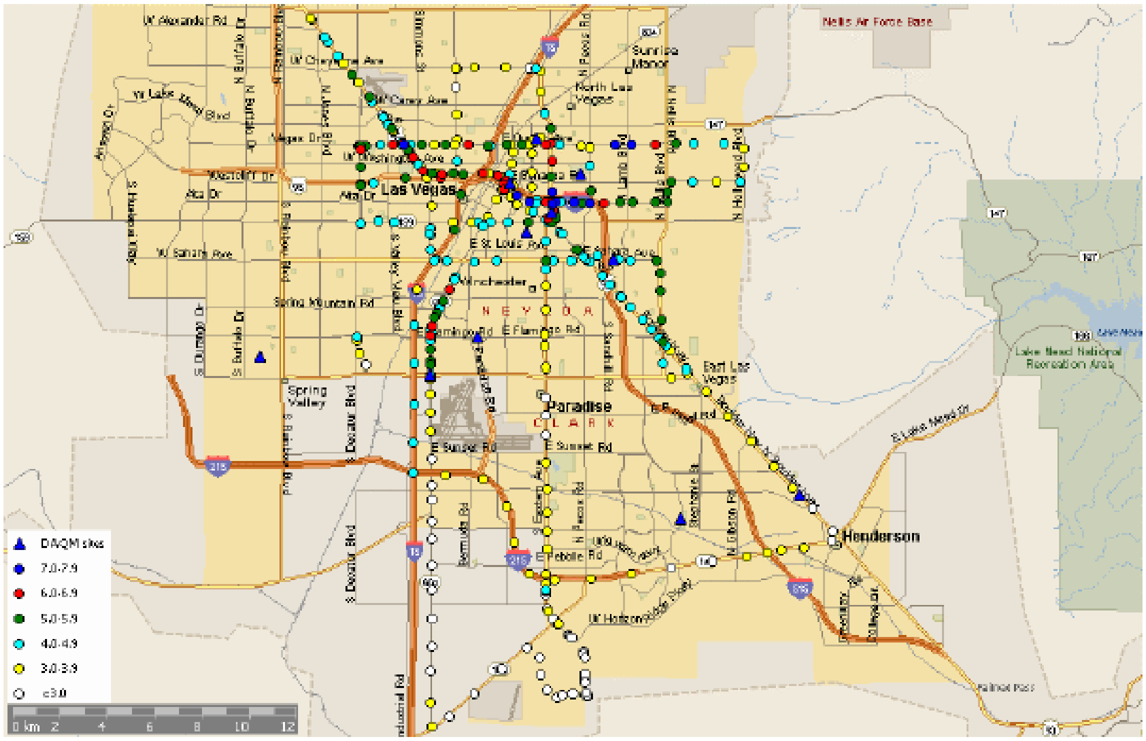


Figure 6-23. Observed CO Concentrations (ppm) During December 28 to 29 Evening/Night Period

7. KEY FINDINGS AND RECOMMENDATIONS

<u>Key Findings</u>

Six of the Clark County DAQM CO monitoring sites are located in the parts of the Las Vegas Valley that experience the higher CO levels, and the Sunrise Acres site is centered in the area of maximum impact. This observation leads to the conclusion that the DAQM CO monitoring sites are suitably located to identify the peak CO concentrations and the corresponding general area in which the higher levels occur.

Aside from the S16 micro-scale site in downtown Las Vegas, the highest CO concentrations measured during the Saturation Study occurred in the vicinity of the Sunrise Acres DAQM site. This site has experienced the highest concentrations in the DAQM network during recent years. The Saturation Network revealed that relatively high CO levels extend beyond the major streets in the area into the residential neighborhoods. Figures showing the peak 8-hour average CO concentrations indicate that the higher concentrations (above 5 ppm) extend about one mile to the north, south, and east of the peak area. This area includes six of the DAQM CO monitoring sites: CC, CW, JD, FP, SA and MC. Most of the area covered by the higher CO concentrations is east of Interstate 15.

The peak 1-~~one-~~hour average CO concentration measured at the Saturation Study sites was 18.3 parts-per-million (ppm); this occurred at the S16 micro-scale exposure site near Casino Center and Fremont Street. The peak 1-hour averages at the remaining sites were all less than 10 ppm. These levels are all well below the 1-hour National Ambient Air Quality Standard (NAAQS) of 35 ppm.

The peak 8-hour average CO concentration measured during the program was 7.2 ppm. This occurred at the U16 site, which is two blocks south of the DAQM monitoring site at the Sunrise Acres School near the intersection of Eastern Avenue, Charleston Boulevard and Fremont Street. This CO level is below the 8-hour NAAQS of 9 ppm. The peak 8-hour average occurring at the Sunrise Acres DAQM site (from November 20 through December 2001) was 6.0 ppm, which was during the same 8-hour time period as the maximum at U16.

At least two secondary CO peak areas were observed in the Saturation Network that are not as well covered by the existing DAQM. One area is just northwest of the I15/95 interchange. The other is along the Boulder Highway where elevated concentrations of CO entrained in the nocturnal drainage were observed.

In the outlying areas of the Las Vegas Valley where DAQM monitoring is sparse, measured levels within the Saturation Network were confirmed to be very low.

Higher than expected CO levels were observed in residential neighborhoods that are not immediately adjacent to major thoroughfares. These elevated concentrations may not be related to traffic patterns but instead, may be the result of other sources of CO, such as space or water heating. The areas where this was observed are high population density residential neighborhoods where CO exhaust from older heaters and water-heating appliances may be significantly higher than in newer neighborhoods.

Key Recommendations

While the Sunrise Acres site CO levels were close to the peak 8-hour averages observed in the Saturation Study network, the area east and south of that site experienced slightly higher concentrations during the peak nighttime episode of this Study period. The differences may be due in part to uncertainties in each of the sampling instruments, and partly due to differences in CO concentrations occurring under the specific emission and dispersion conditions occurring that particular night. Thus, CO monitoring near the Sunrise Acres site seems highly recommended to continue documenting maximum concentrations occurring in the Valley.

Two areas might be considered for possible future CO monitoring sites if the rapidly increasing population growth continues in the Las Vegas Valley. These are the area northwest of the downtown freeway interchange, and near Boulder Highway south of the intersection with Nellis Blvd. and north of the intersection with Tropicana.

To gain a better understanding of the CO transport and dispersion in the Las Vegas Valley, it is recommended that a database of the meteorology in the boundary layer be acquired and examined.

As the data suggest, the emissions inventory should be examined for contribution from non-vehicular CO sources, especially in high-density residential areas where older appliances may be in use.

APPENDIX A

SITE DESCRIPTIONS AND PHOTOGRAPHS

Static Site A17

Objective: Neighborhood scale / Outer zone

Location: an existent District site, at the intersection of Greenmoor and Pavilion Center, on the edge of the parking lot for the Palo Verde High School. Mounted on the Met Tower. Very quiet residential neighborhood, at our western-most location rising up out of the valley. No obstructions.

Closest Main Intersection: Alta & Town Center Drive
(Approximately 400 m north of Alta and 820 m west of Town Center Drive).

Elevation: 3036 ft / 925 m

Lat./Long.: N36.17333°; W 115.33267°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site AA8

Objective: Middle scale / Transport zone

Location: in a low-income housing project, in a cul-de-sac that is the first right (N) on Hacienda after turning left (W) off of Stephanie; just NW of the intersection of Hacienda and Stephanie; NE of nearby power substation (800-900 m). Residential neighborhood to the west and to the immediate south, low-density industrial elsewhere. Metal pole. Mostly unobstructed except for a one-story residence approximately 7-8 m to the east.

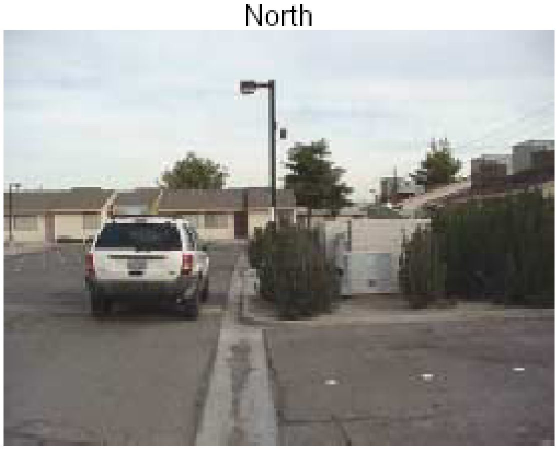
Closest Main Intersection: E. Russell & Boulder Highway
(Approximately 1100 m north of Russell and 360 m west of Boulder Hwy).

Elevation: 1685 ft / 514 m

Lat./Long.: N 36.09360°; W 115.04668°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Static Site BB5

(Initially AA4 & CC4)

Objective: Neighborhood scale / Outer zone

Location: the edge of the parking lot for the Galleria Mall, at the SE "corner". Enter at the easternmost Mall entrance off of Sunset, down incline til facing parking lot, turn north (right) and the site is on the second light post on the left. Metal pole. No obstructions.

Closest Main Intersection: Sunset & Stephanie, just west of the US93/Interstate 515. (Approximately 220 m north of Sunset, 560 m east of Stephanie and 625 m west of the 93/515).

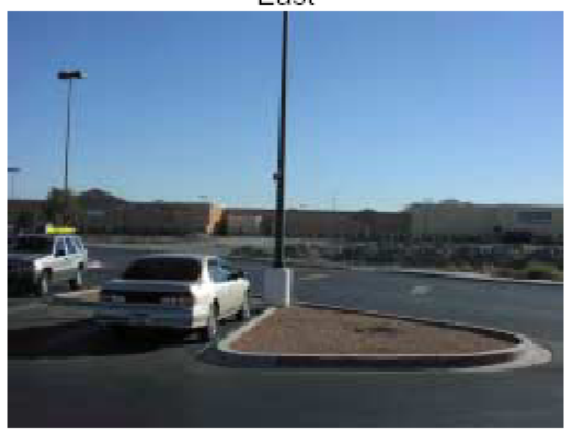
Elevation: 1743 ft / 531 m

Lat./Long.: N36.06533°; W 115.04017°

Site pictures with views looking toward the indicated directions.

North

East



South

West

Static Site BB9

(Initially CC7)

Objective: Neighborhood scale / Transport zone

Location: Bunch, mid-way between Whitney and Keenan, on west side of the street between 5851 & 5859 Bunch. Quiet residential street, residential/commercially mixed area. Wood pole. No obstructions.

Closest Main Intersection: E. Tropicana & Boulder Highway
(Approximately 275 m south of Tropicana, 380 m northeast of Boulder Highway).

Elevation: 1663 ft / 507 m

Lat./Long.: N36.09832°; W 115.04283°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site D19
(Initially D18)

Objective: Neighborhood scale / Outer zone

Location: just off of a roundabout called Village Center Drive, between Town Center Drive and Hills Center Drive, in an empty lot in the NE “quadrant”, hung on a large sign advertising a future business park. Residential/commercially mixed area, low-density. No obstructions.

Closest Main Intersection: Town Center Drive & Summerlin Parkway
(Approximately 700 m norheast of intersection, 80 m east of the roundabout).

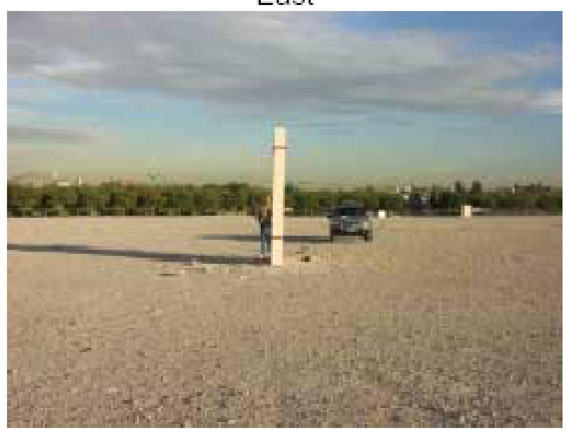
Elevation: 2700 ft / 823 m

Lat./Long.: N36.1925°; W 115.30117°

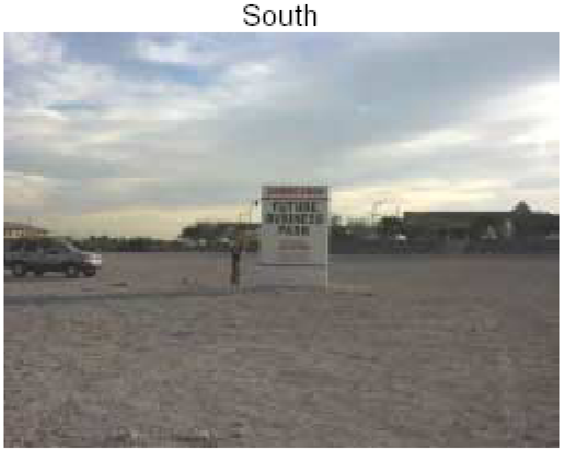
Site pictures with views looking toward the indicated directions.

North

East



South



West

Static Site E13

(Initially G13))

Objective: Neighborhood scale / Outer zone

Location: the intersection of Waterview and Gentle Rain. Very quiet residential intersection (Gentle Rain ends @ Waterview). Concrete pole. No obstructions.

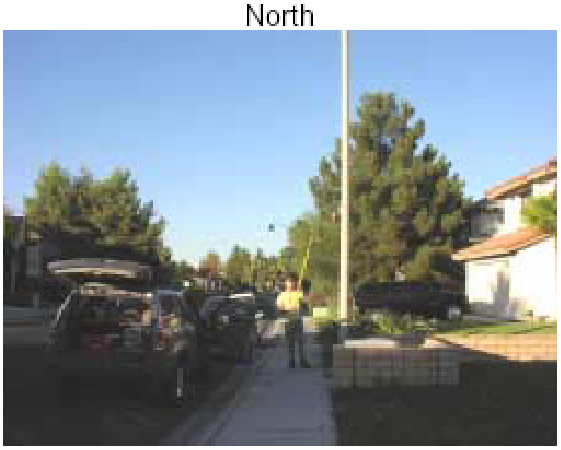
Closest Main Intersection: W. Sahara & Fort Apache
(Approximately 530 m south of Sahara and 450 m east of Fort Apache).

Elevation: 2730 ft / 832 m

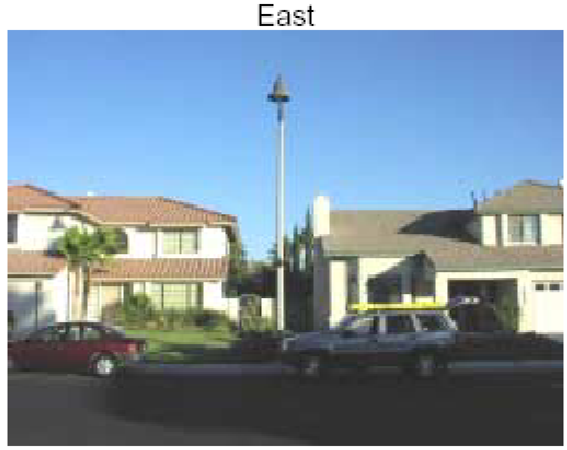
Lat./Long.: N36.1395°; W 115.29233°

Site pictures with views looking toward the indicated directions.

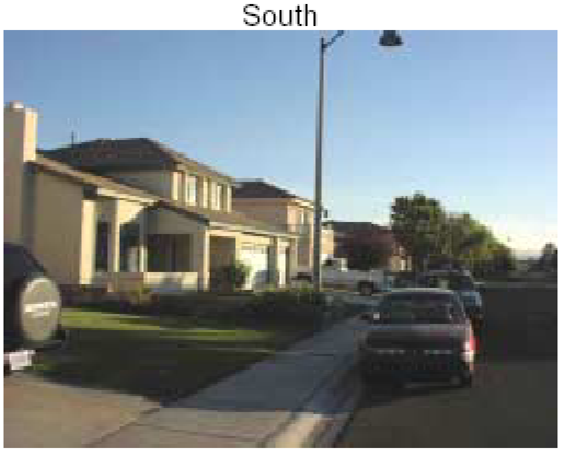
North



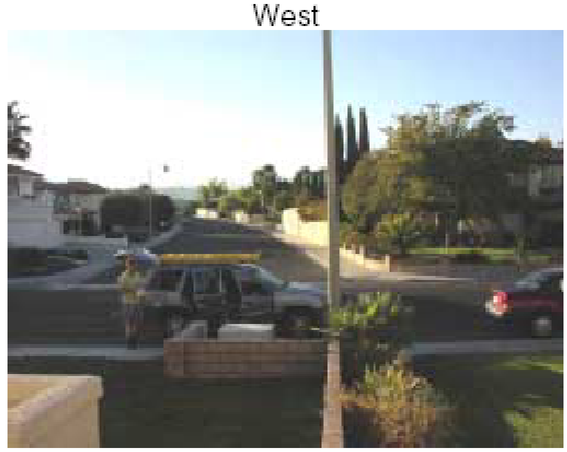
East



South



West



Static Site G22
(Initially R20)

Objective: Neighborhood scale / Outer zone

Location: just west of Coral Shores, at intersection of Coral Shores and Soaring Gull, at base of man-made “canal”. Very quiet neighborhood. Very light local traffic. Metal pole. No obstructions.

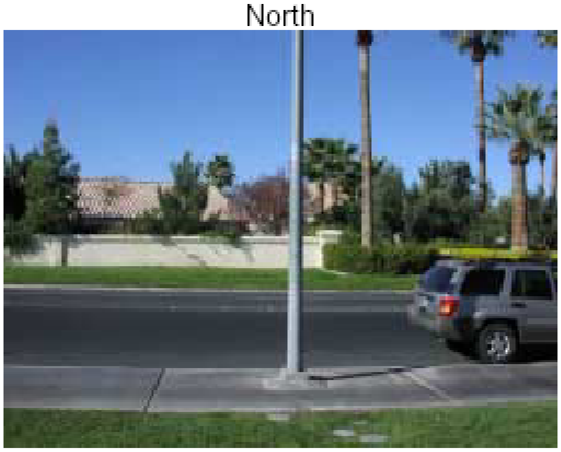
Closest Main Intersection: Rampart & W. Cheyenne
(Approximately 400 m south of Cheyenne and 430 m east of Rampart).

Elevation: 2429 ft / 740 m

Lat./Long.: N36.21467°; W 115.2743°

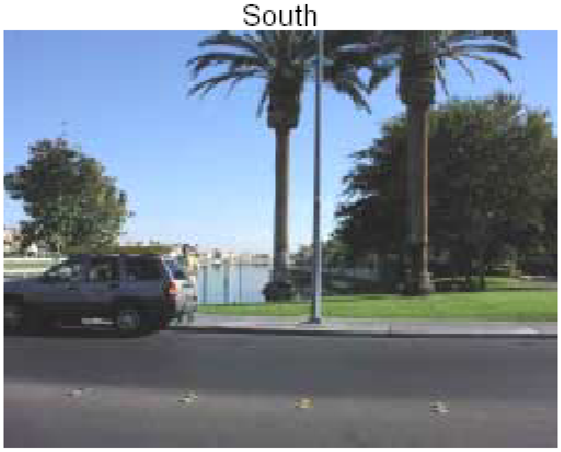
Site pictures with views looking toward the indicated directions.

North

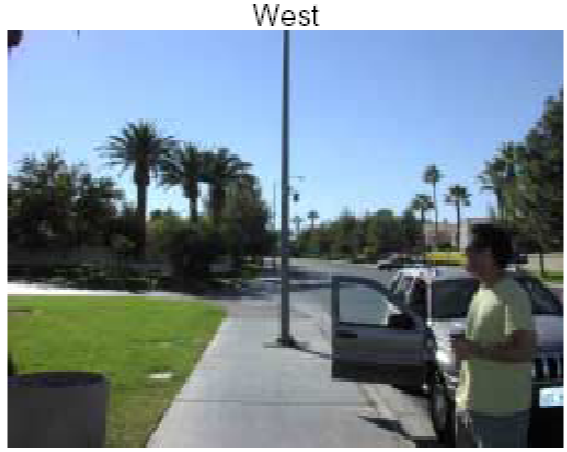


East

South



West



Static Site H17

(Initially G17)

Objective: Neighborhood scale / Gradient zone

Location: an existent District site, at the intersection of Villa Monterey and Ducharme. On an elevated pole attached to west side of the District's enclosing fence. On elementary school grounds, across the street from a park, otherwise a residential area. No obstructions.

Closest Main Intersection: Alta & S. Buffalo
(Approximately 350 m north of Alta and 300 m west of Buffalo).

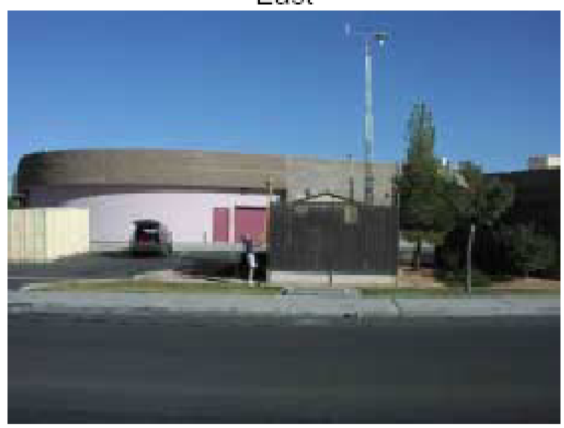
Elevation: 2526 ft / 770 m

Lat./Long.: N36.16967°; W 115.26283°

Site pictures with views looking toward the indicated directions.

North

East



South

West

Static Site J11

Objective: Neighborhood scale / Gradient zone

Location: the intersection of Baywood and Boxwood, directly in front of house with foreclosure notices (northeast corner). Quiet residential neighborhood. Metal pole. No obstructions.

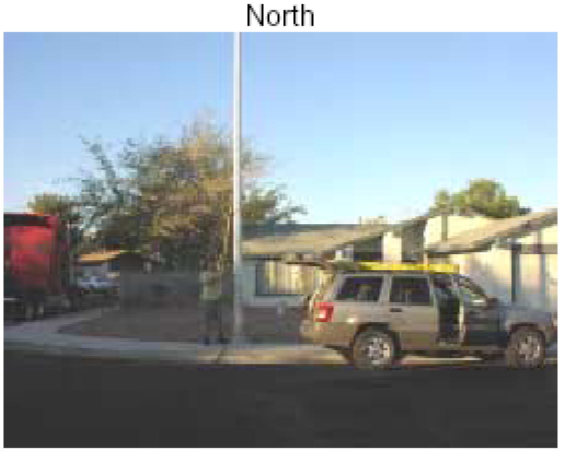
Closest Main Intersection: Torrey Pines & Spring Mountain
(Approximately 350 m south of Spring Mountain and 250 m west of Torrey).

Elevation: 2325 ft / 709 m

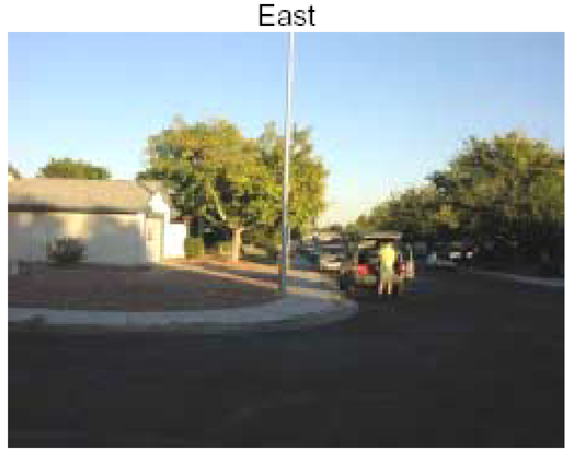
Lat./Long.: N36.12233°; W 115.237°

Site pictures with views looking toward the indicated directions.

North



East



South

West

Static Site J29

Objective: Neighborhood scale / Outer zone

Location: an existent District site, in a park just south of the Joe Neal elementary school, on Rebecca between Azure and Tropical Pkwy. Mounted on the Met tower. Low-density residential neighborhood, combined with undeveloped open space, our Northern-most site. No obstructions.

Closest Main Intersection: W. Ann & N. Rainbow Blvd.
(Approximately 880 m north of Ann and 360 m east of Rainbow).

Elevation: 2308 ft / 703 m

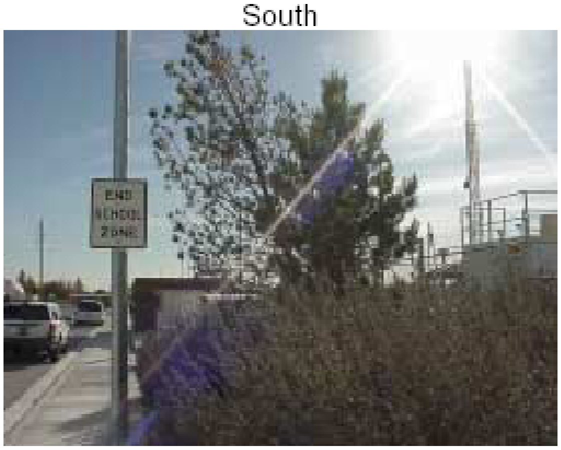
Lat./Long.: N36.2705° W 115.238°

Site pictures with views looking toward the indicated directions.

North

East

South



West

Static Site L16

(Initially K16)

Objective: Neighborhood scale / Gradient zone.

Location: Evergreen Ave. between Idle and Evergreen Circle, directly in front of 5609 Evergreen Ave. Residential neighborhood. Wood pole. No obstructions.

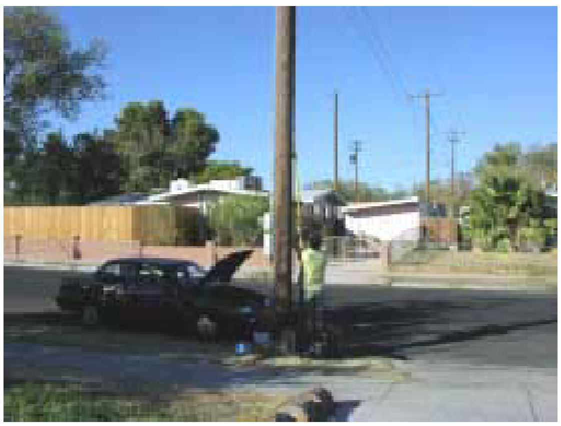
Closest Main Intersection: S. Jones Blvd. & W. Charleston Blvd. (Approximately 450 m north of Charleston and 550 m east of Jones).

Elevation: 2258 ft / 688 m

Lat./Long.: N36.163°; W 115.218°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Static Site L20

(Initially K20)

Objective: Neighborhood scale / Gradient zone.

Location: Balzar between Foster and Jeanne, directly in front of 5525 Balzar. Quiet residential neighborhood. Metal pole, south side of street. No obstructions.

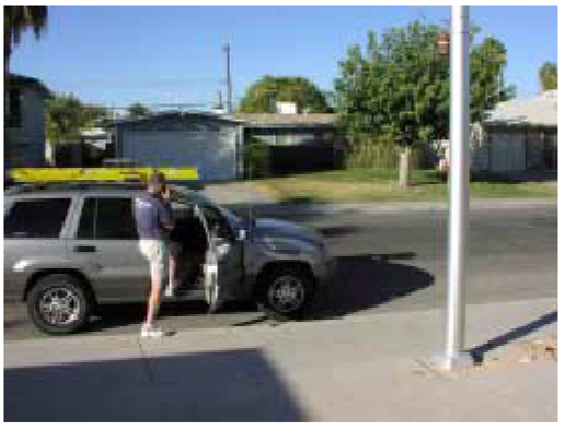
Closest Main Intersection: W. Lake Mead Blvd. & N. Jones
(Approximately 430 m north of Lake Mead and 500 m east of Jones).

Elevation: 2235 ft / 681 m

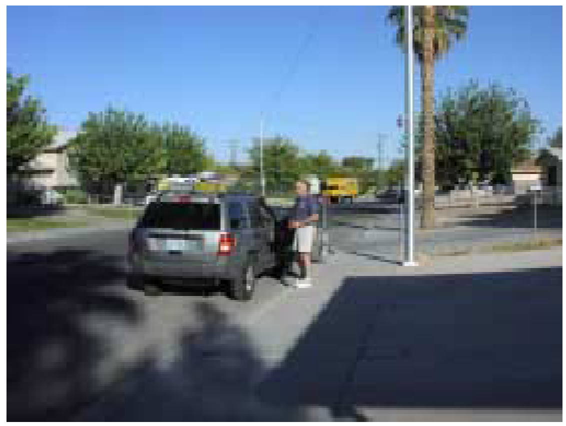
Lat./Long.: N36.19967°; W 115.21723°

Site pictures with views looking toward the indicated directions.

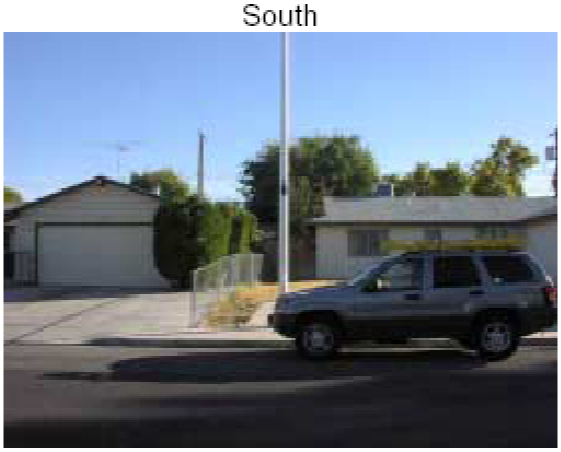
North



East



South



West

Static Site M17

(Initially N18)

Objective: Neighborhood scale / Gradient zone.

Location: bend of the intersection of Hogan and Fortune, across from 4336 Hogan. Quiet residential neighborhood, 500 m north of the 95 Freeway. Metal pole. No obstructions.

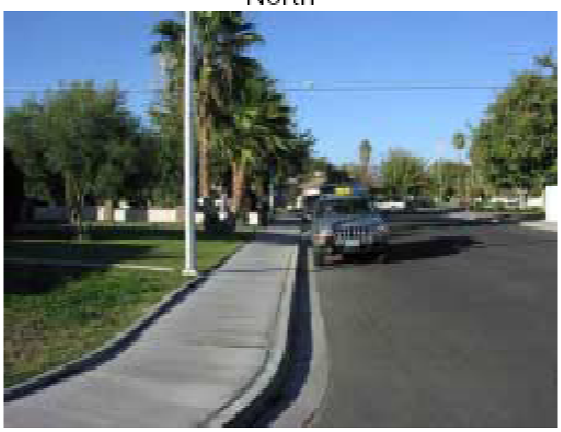
Closest Main Intersection: W. Washington & N. Decatur Blvd.
(Approximately 300 m south of Washington and 680 m east of Decatur).

Elevation: 2201 ft / 671 m

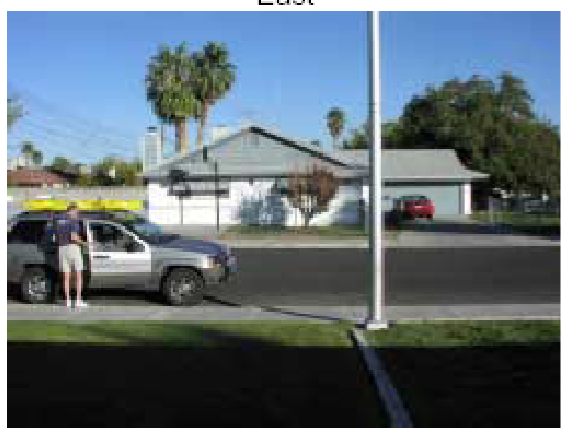
Lat./Long.: N36.17833°; W 115.19983

Site pictures with views looking toward the indicated directions.

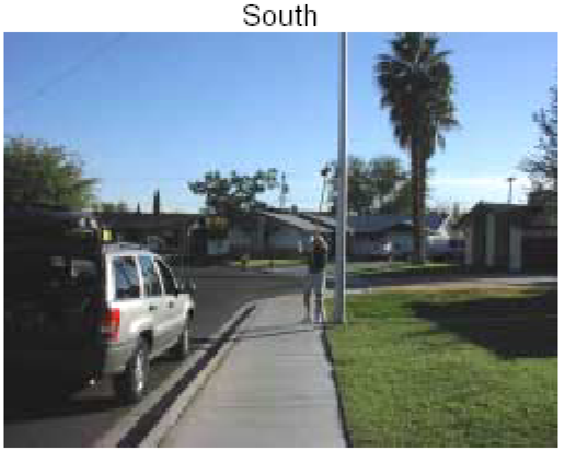
North



East



South



West

Static Site N14

Objective: Neighborhood scale / Gradient zone.

Location: El Parque Ave. between Los Altos and Las Verdes, on the first wooden pole east of Los Altos, directly across from an elementary school. Residential neighborhood, some additional through traffic. No obstructions.

Closest Main Intersection: W. Sahara & S. Valley View Blvd.
(Approximately 575 m north of Sahara and 430 m west of Valley View).

Elevation: 2163 ft / 659 m

Lat./Long.: N36.14933°; W 115.1956

Site pictures with views looking toward the indicated directions.

North

Not available

East

South

West

Static Site P8

(Initially P7)

Objective: Neighborhood scale / Gradient zone

Location: the west side of the Airport, at the intersection of Four Seasons Drive and Giles (the street sign at intersection still reads “Diablo” and Giles, but turn onto “Four Seasons” off of Las Vegas Blvd.; the street must have recently been re-named). All low-density industrial area, steady traffic on Las Vegas Blvd. Wood pole on NW corner of intersection. No obstructions.

Closest Main Intersection: Las Vegas Blvd. & Four Seasons Drive (Approximately 200 m east of Las Vegas Blvd.).

Elevation: 2144 ft / 653 m

Lat./Long.: N36.09°; W 115.1705°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site P12
(Initially P11)

Objective: Middle scale / Gradient zone

Location: approximately 35 m from the intersection of Las Vegas Blvd. and Fashion Show Rd., directly in front of the Saks Fifth Ave., in front of the Fashion Show Mall. Metal pole. No obstructions.

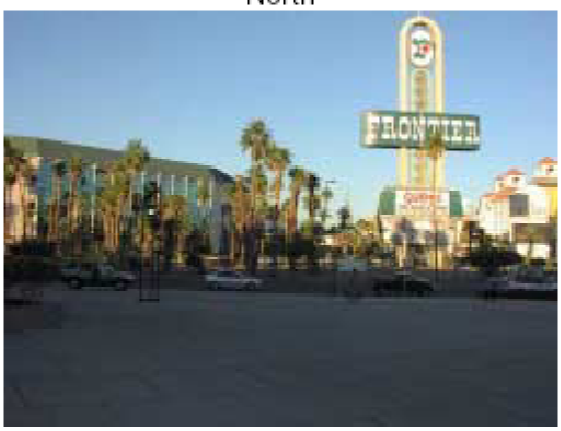
Closest Main Intersection: N. Las Vegas Blvd. & Spring Mountain
(Approximately 275 m north of Spring Mountain).

Elevation: TBA ±.

Lat./Long.: N36.12767°; W 115.1685°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Static Site P23

Objective: Neighborhood scale / Outer zone

Location: Fuselier, between Gowan and Gilmore, on the 2nd telephone pole south of Gilmore. Very little traffic, located in a large area of raw land between residential neighborhoods. Wood pole. No obstructions.

Closest Main Intersection: W. Cheyenne & Martin Luther King Blvd.
(Approximately 1100 m north of Cheyenne and 1400 m west of Martin Luther King).

Elevation: 2159 ft / 658 m

Lat./Long.: N36.2275°; W 115.17767°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site Q13

Objective: Micro scale / Inner core

Location: the east side of Las Vegas Blvd. at the southwest entrance to Wet & Wild. Site is 1 m from the curb. Metal pole. No obstructions.

Closest Main Intersection: S. Las Vegas Blvd. & W. Sahara Ave.
(Approximately 500 m south of Sahara).

Elevation: 2038 ft / 621 m

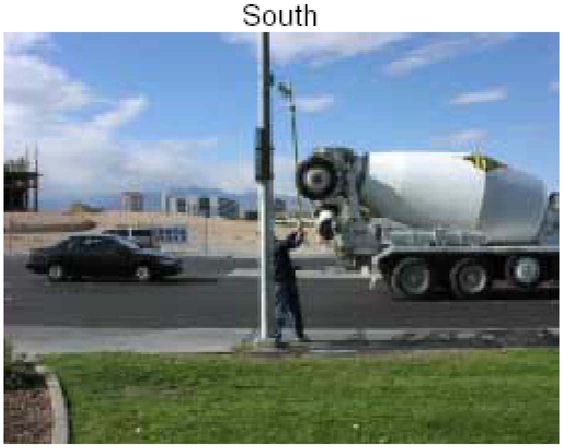
Lat./Long.: N36.14090°; W 115.15897

Site pictures with views looking toward the indicated directions.

North

East

South



West

Static Site Q20
(Initially R20)

Objective: Neighborhood scale / Gradient zone.

Location: the northeast outer-edge quadrant of a roundabout, across from Johnson Park (which forms the circle in the center), east of Balzar and Concord, very near Bartlett and Concord. Low-density residential neighborhood. Wood pole. No obstructions. Morning daylight only visits recommended.

Closest Main Intersection: Lake Mead Blvd. & Martin Luther King Blvd.
(Approximately 480 m north of Lake Mead Blvd and 490 m east of Martin Luther King).

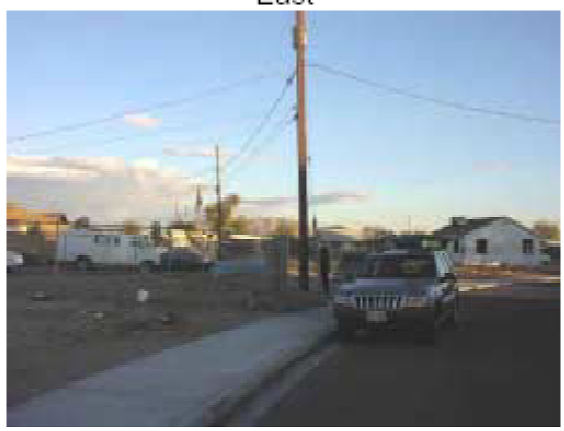
Elevation: 1992 ft / 607 m

Lat./Long.: N36.19980°; W 115.15583°

Site pictures with views looking toward the indicated directions.

North

East



South

West

Static Site R3

(Initially R2)

Objective: Neighborhood scale / Outer zone

Location: an unpaved extension of Mesa Verde Lane, approximately 80 m east of Bermuda (Mesa Verde pavement ends at Bermuda). Wood pole # P1430. No obstructions.

Closest Main Intersection: W. Windmill Lane & Bermuda
(Approximately 425 north of Windmill).
Metro Map Coordinates: 75 A4

Elevation: 2173 ft / 662 m

Lat./Long.: N36.04610°, W 115.15329°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site R8

(Initially R7)

Objective: Neighborhood scale / Gradient zone

Location: Paradise approaching the Airport, at the split to Kitty Hawk & Swenson (heading south, in empty lot on the left just before the split). Approx 850 m north of Airport Terminal. Steady airport traffic on both sides. Wood pole. No obstructions.

Closest Main Intersection: Paradise at Swenson
(Approximately 30 m east of Paradise, 70 m west of Swenson).

Elevation: 2065 ft / 629 m

Lat./Long.: N36.0935°; W 115.14717°

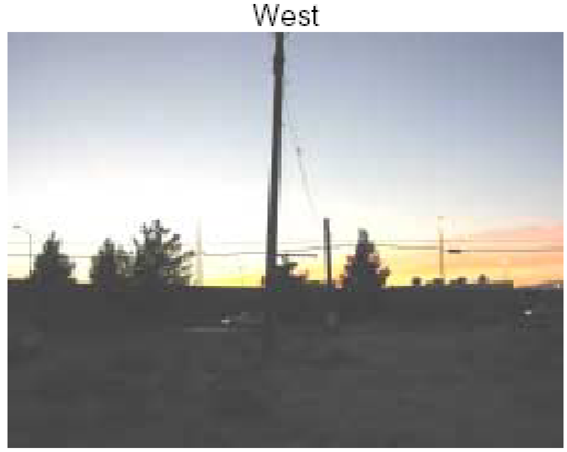
Site pictures with views looking toward the indicated directions.

North

East

South

West



Static Site R15

Objective: Neighborhood scale / Inner core

Location: approximately 30 m off of California mid-way between 3rd and Casino Center on a wood pole (#P81623) in a parking area behind an unoccupied building (one-story 10 m to the west), otherwise unobstructed.

Closest Main Intersection: S. Main & E. Charleston Blvd.
(Approximately 200 m south of Charleston and 150 m east of Main).

Elevation: 2016 ft / 614 m

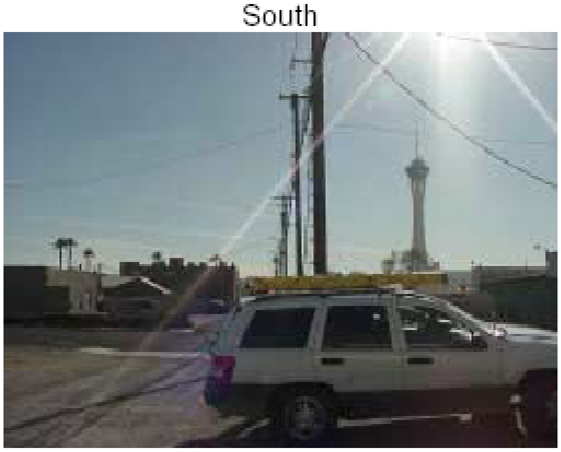
Lat./Long.: N36.15748°; W 115.15184°

Site pictures with views looking toward the indicated directions.

North

East

South



West

Static Site S13

Objective: Neighborhood scale / Inner core

Location: behind the BPL office building at 2770 S. Maryland Pkwy, about 40 m north from the rear parking lot across a dirt field, on a pole in the backyard of a cream colored house bordering the lot (facing Karen Ave.). 9 to 5 staff all arriving and departing near the same time from the parking lot may then affect CO levels. Steady heavy traffic on Maryland Pkwy, a major thoroughfare.

Closest Main Intersection: S. Maryland Pkwy & E. Sahara Ave.

(Approximately 80 m south of Karen Ave. and 100 m east of Maryland).

Elevation: 1994 ft / 608 m

Lat./Long.: N36.13955°; W 115.13508°

Site pictures with views looking toward the indicated directions.

North

East

South

Not available

West

Static Site S16

Objective: Micro scale / Inner core

Location: the east side of Casino Center Drive, directly across the street from the main entrance to the Golden Nugget, 30 m north of the intersection of Casino Center and Carson. 80 m south of the Fremont Experience. Metal pole, 1 m from the curb. A busy taxi-stand in the evening, with taxis idling below the sampler. Possible CO spikes and/or RF electronic noise from taxis.

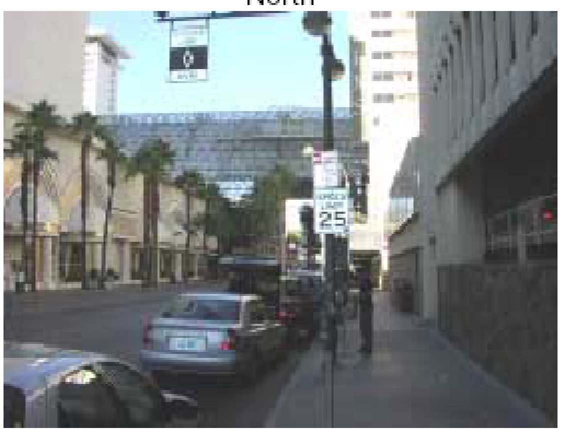
Closest Main Intersection: S. Las Vegas Blvd. & Fremont
(Approximately 330 m west of Las Vegas Blvd).

Elevation: 2059 ft / 628 m

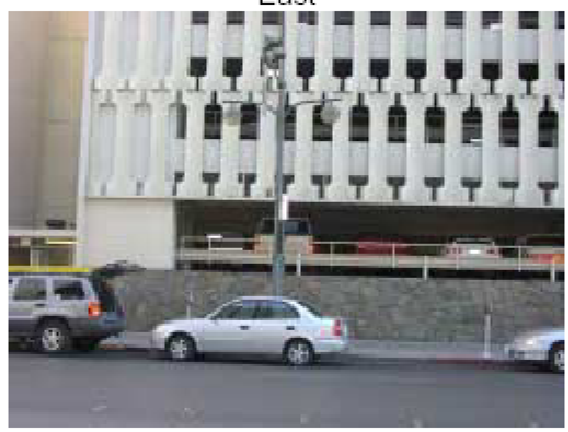
Lat./Long.: N36.17034°; W 115.14462°

Site pictures with views looking toward the indicated directions.

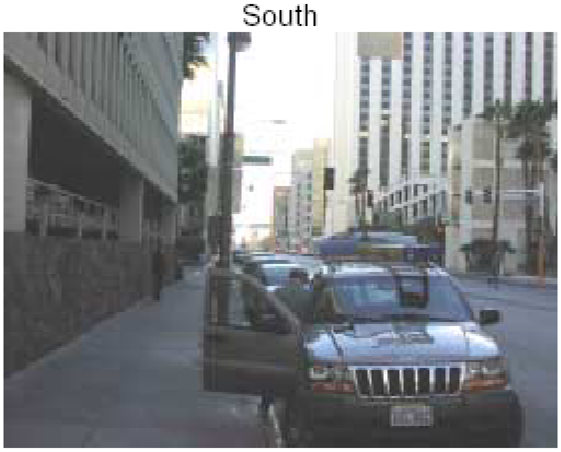
North



East



South



West

Not available

Static Site S17

Objective: Middle scale / Inner core

Location: downtown near the NE corner of Fremont and Las Vegas Blvd. Wood pole # P53473, at the edge of a parking lot (at alleyway). Lots of traffic, no obstructions.

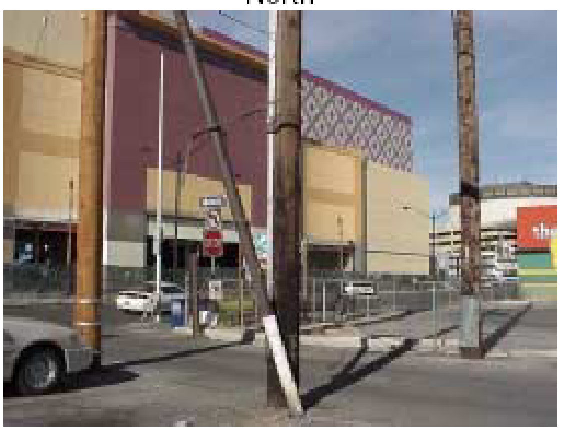
Closest Main Intersection: S. Las Vegas Blvd. & Fremont
(Approximately 30 m north of Fremont and 10 m east of Las Vegas Blvd).

Elevation: 2024 ft / 617 m

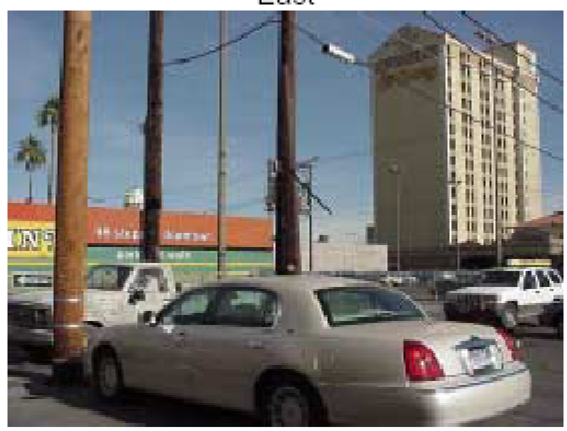
Lat./Long.: N36.16963°; W 115.14023°

Site pictures with views looking toward the indicated directions.

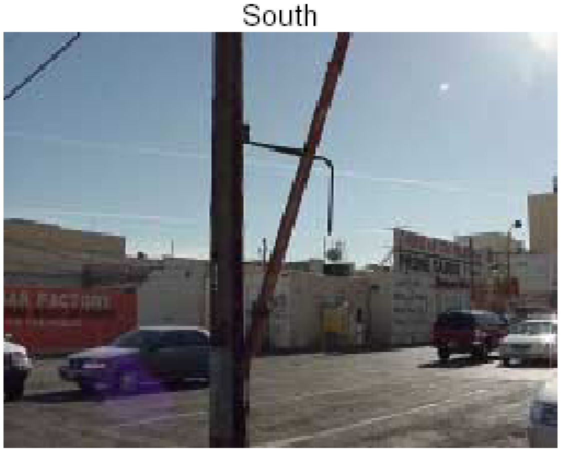
North



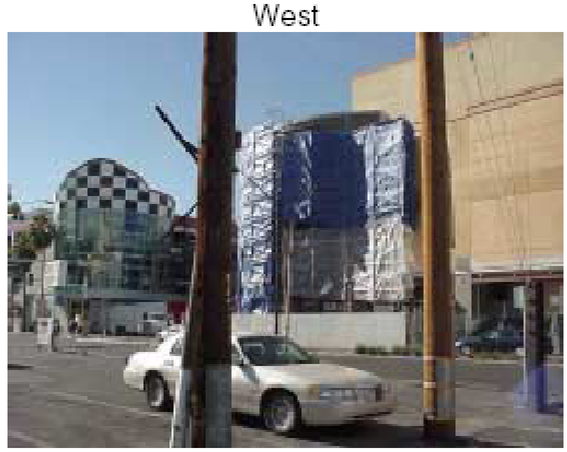
East



South



West



Static Site S18

Objective: Neighborhood scale / Inner core

Re-Location: M.A.S.H site, on the northwest corner of the MASH property, on one of the white painted poles holding up a canopy over playground equipment, about 180 m west of the intersection of W. Owens Ave. and N. Main. Need to enter the property from N. Main and identify yourself to security before being allowed an entrance. Mostly unobstructed, except for the canopy rising to the immediate south of sampler.

Closest Main Intersection: W. Owens Ave. & N. Main

Elevation: TBA ±.

Lat./Long.: N36.18783°; W 115.13823°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site SoH

(aka Southern Highlands site)

Objective: Neighborhood scale / Outer zone

Location: the intersection of Biagi and Vernoa Drive (northeast corner), approximately 30 m south of the intersection of Biagi and Somerset Hills Ave., on a metal light pole. Residential area, steady construction traffic in the area during daylight hours, mostly south of the area on Southern Highlands. During the last few weeks of monitoring, grading occurred and a foundation was poured almost right beneath the sampler for a new house, and this will reflect in the data as heavy equipment was used. Our southern-most site. No obstructions.

Closest Main Intersection: Southern Highlands Pkwy & Somerset Hills
(Approximately 150 m West of Southern Highlands Pkwy (the area's main thoroughfare).

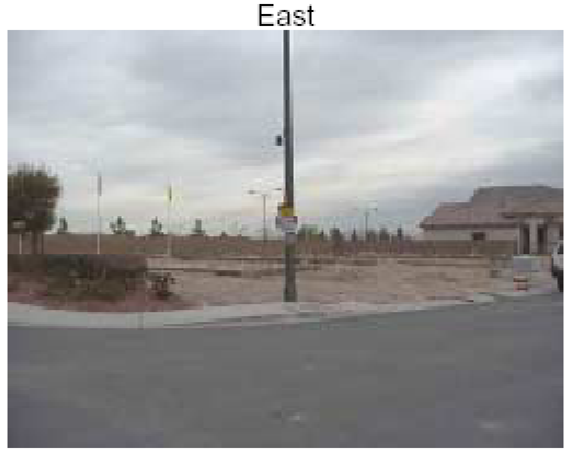
Elevation: 2415 ft / 736 m

Lat./Long.: N 35.99350°; W 115.20830°

Site pictures with views looking toward the indicated directions.

North

East



South

West

Static Site T11

(Initially S11)

Objective: Neighborhood scale / Inner core

Location: on Ottawa Drive between Ottawa Circle and Spencer, just east of Spencer, on the first wooden pole on the south side of Ottawa Dr. Quiet residential neighborhood, no through traffic (sign posted as well). No obstructions.

Closest Main Intersection: S. Maryland Pkwy. and E. Desert Inn
(Approximately 800 m south of Desert Inn, and 900 m east of Maryland).

Elevation: 1898 ft / 579 m

Lat./Long.: N36.12283°; W 115.12733°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site T14

Objective: Neighborhood scale / Inner core

Location: Crestwood mid-way between Canosa and Hassett, in a very quiet residential neighborhood. 200 m north of St. Louis Ave., on pole # P17075.

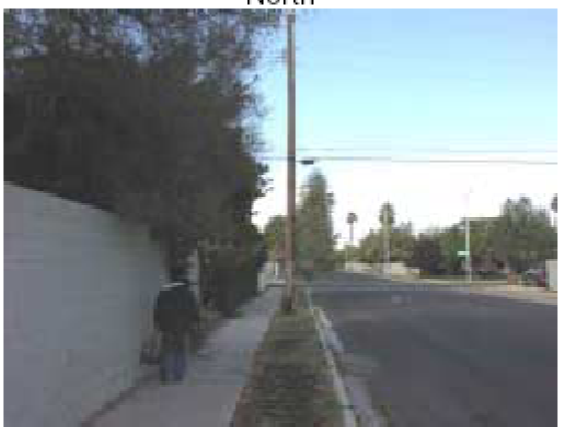
Closest Main Intersection: E. Sahara Ave. & S. Eastern Ave.. (Approximately 650 m north of Sahara and 300 m west of Eastern Ave..).

Elevation: 1858 ft / 566 m

Lat./Long.: N36.15004°; W 115.12131°

Site pictures with views looking toward the indicated directions.

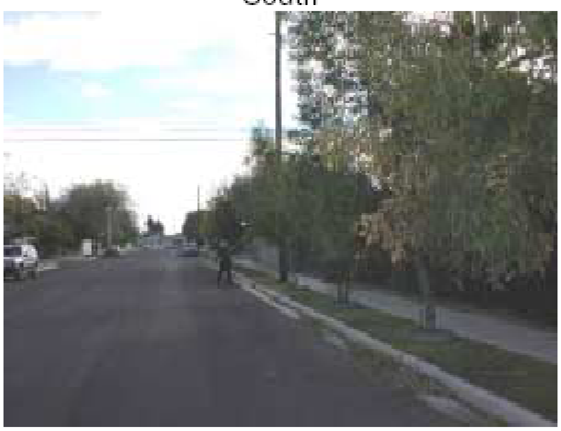
North



East

Not available

South



West

Static Site T15

(Co-location: @district site CW, both collecting CO data)

Objective: Neighborhood scale / Inner core

Location: Crestwood School, 1300 Paulin Way (at the intersection with Franklin Ave.); site is located a the far west side of the school; access from Wengert Ave., through the back of the parking lot.

Closest Main Intersection: E. Charleston Blvd. & S. Maryland Pkwy.
(Approximately 420 m south of Charleston and 820 m east of Maryland).

Elevation: 1932 ft / 589 m

Lat./Long.: N36.15522°; W 115.12792°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Not available

Static Site T16

Objective: Neighborhood scale / Inner core

Location: the entrance to an alley off of Sunrise Ave. directly across from N. 19th (which ends at a "T"). Site is approximately100 m north of Fremont and 150 m east of the intersection of Sunrise and Fremont. Heavy traffic on Fremont, but not here. Pole # 88860.

Closest Main Intersection: Fremont & E. Charleston Blvd & N. Eastern Ave.

Elevation: 1877 ft / 572 m

Lat./Long.: N36.16238°; W 115.12269°

Site pictures with views looking toward the indicated directions.

North

East

South

Not available

West

Static Site U6
(Initially U5)

Objective: Neighborhood scale / Gradient zone

Location: the east side of the Airport, in the parking lot of "Park 2000" Business Park, on metal pole directly across from Suite 18 ("Vegas and More"). Industrial area. Steady traffic (both streets are major thoroughfares). No obstructions. Immediately under an Easterly runway approach to the Airport.

Closest Main Intersection: S. Eastern & Sunset
(Approximately 100 m north of Sunset and 50 m east of Eastern).

Elevation: 2028 ft / 618 m

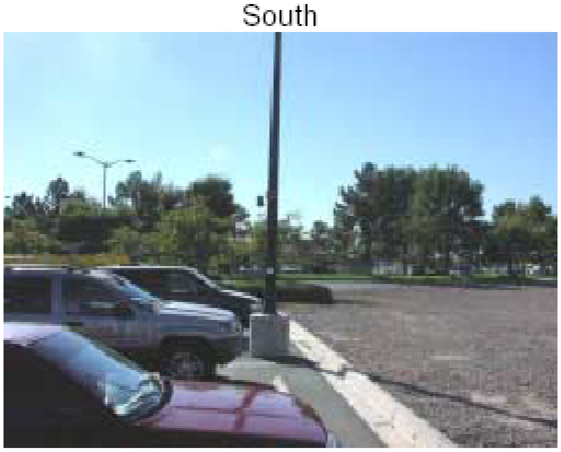
Lat./Long.: N36.0730°; W 115.11783°

Site pictures with views looking toward the indicated directions.

North

East

South



West

Static Site U19

Objective: Neighborhood scale / Inner core

Location: the western edge of a Mormon Church parking lot at the intersection of Tonopah and N. Eastern Aves; parking lot entrance on Tonopah, directly across from 2504 Tonopah.

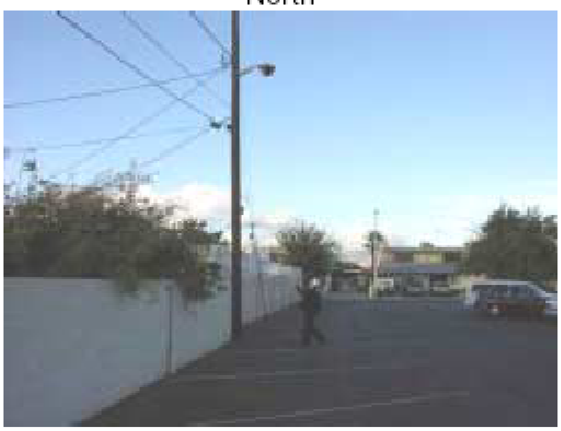
Closest Main Intersection: E. Eastern Ave. & E. Owens Ave.
(Approximately 380 m north of Owens and 80 m west of Eastern).

Elevation: 1818 ft / 554 m

Lat./Long.: N36.19175° W 115.11730°

Site pictures with views looking toward the indicated directions.

North



East

Not available

South

West

Static Site U-3

(Erroneously referenced as U3)

Objective: Neighborhood scale / Outer zone

Location: South of the intersection of Green Valley Pkwy and Coronado Center Drive on a new unused dead-end road that will become Coronado Valley Rd once future housing development that it leads to is built, on the third metal light pole on the right; site is approximately 80 m south of the intersection, south of Coronado High School and approximately 200 m south of the High School's parking lot. May see some increased CO levels at around the beginning and end of the school day. No obstructions.

Closest Main Intersection: Green Valley Pkwy & S. Eastern Ave.
(Approximately 840 m west of Eastern).

Elevation: TBA ±.

Lat./Long.: **N**35.99039° W 115.11028°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site V13

Objective: Neighborhood scale / Inner core
Location: Mojave just north of Heritage Lane, approximately 200 m south from E. Sahara Ave. Mojave is not a major thoroughfare, but is well trafficked during daylight hours.

Closest Main Intersection: E. Sahara Ave. & Fremont/Boulder Highway

(Approximately 475 m southwest from main intersection)

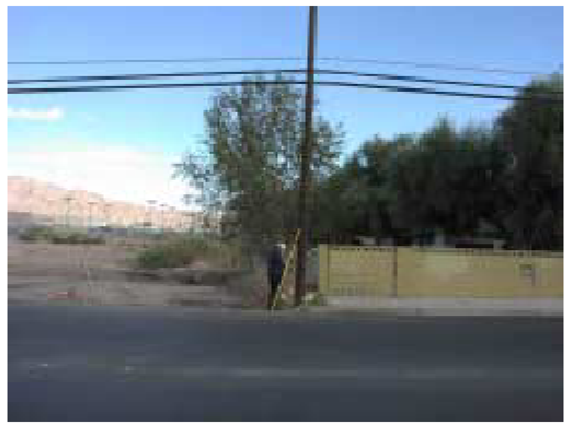
Elevation: 1836 ft / 560 m

Lat./Long.: N36.14262°; W 115.10532°

Site pictures with views looking toward the indicated directions.

North

East



South

West

Static Site V15

Objective: Micro scale / Inner core

Location: an existent District site (MS) but not collocated (MS doe not monitor CO) at the intersection of 28^{th} and E. Charleston Blvd., about 15 m north from Charleston.

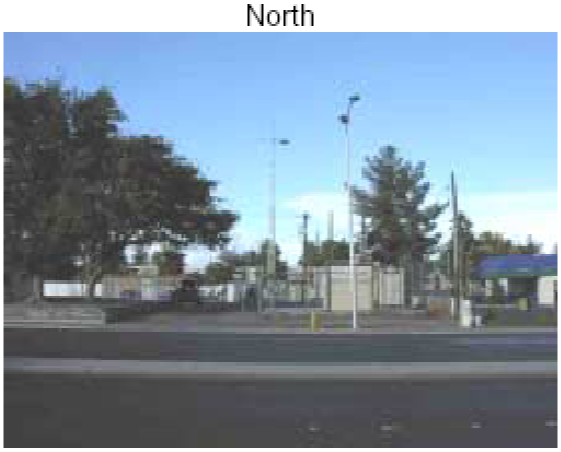
Closest Main Intersection: Fremont & E. Charleston Blvd & N. Eastern Ave. (Approximately 440 m east of this intersection).

Elevation: 1843 ft / 562 m

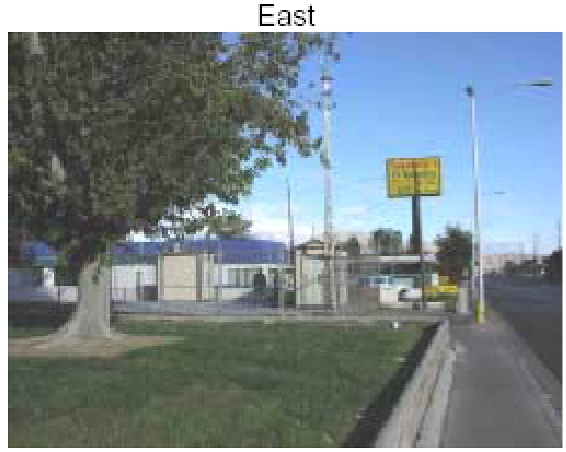
Lat./Long.: N36.159°; W 115.11089°

Site pictures with views looking toward the indicated directions.

North



East



South

West

Static Site V17

Objective: Neighborhood scale / Inner core

Location: an existent District site (FP), co-located (collecting CO data as well) in Freedom Park, approximately¼ mile north of E. Bonanza (400 m), and ¼ mile west of Pecos (425 m). Entrance off of Bonanza is the most reliable access (though that off of Mojave is closer to the actual site). Sampler is mounted on top of the building but not on the Met tower.

Closest Main Intersection: E Bonanza & N. Pecos

Elevation: 1810 ft / 552 m

Lat./Long.: N36.17717°, W 115.10301°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site X10

(Initially Y10)

Objective: Neighborhood scale / Gradient zone

Location: Brighthill Ave. west of Annie Oakley Drive, directly in front of 3959 Brighthill. Quiet residential neighborhood, 520 m west of the 93/515. Metal pole. No obstructions.

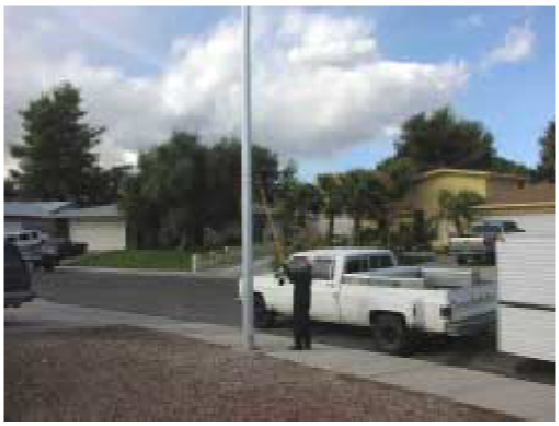
Closest Main Intersection: E. Flamingo and S. Sandhill, just west of U.S. Highway 93 / Interstate 515. (Approximately 520 m south of Flamingo, 280 m east of Sandhill).

Elevation: 1844 ft / 562 m

Lat./Long.: N36.1105°; W 115.088°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Static Site X15
(First location)

Objective: Neighborhood scale / Gradient zone

Location: in the center of Shoong Park, approximately 30 m west of Wesley, and 300 m east of Snyder Elementary School. Very little traffic. Dark lamppost/Metal pole. No obstructions.

Closest Main Intersection E. Charleston Blvd. & S. Lamb Blvd.
(Approximately .5 kilometer south of Charleston and 350 m east of Lamb).

Elevation: 1740 ft / 530 m

Lat./Long.: N36.1535°; W 115.07333°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site X15
(Second location)

(Start date 12/15/01, at 1149 PST; site re-located due to repeated vandalism to the site in the park)

Objective: Neighborhood scale / Gradient zone

Location: Colorado Ave, 40 m west of the intersection of Colorado and Charmaine. On a metal (silver) pole, 2 m off of Colorado, along the northern edge of the Snyder Elementary School and at the northwest corner of Shoong Park. Very quiet street with little traffic, but there will be peaks before and after school. No obstructions.

Closest Main Intersection: E. Charleston Blvd. & S. Lamb Blvd.
(Approximately 350 m south of Charleston and 200 m east of Lamb).

Elevation: 1740 ft / 530 m

Lat./Long.: N36.15561°; W 115.07902°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site X16

(Initially W16)

Objective: Neighborhood scale / Gradient zone

Location: in the far northeast corner of a Mormon Church near the intersection of Prince and Stewart, approximately 100 m north of Stewart. Lot almost always empty, will be lots of micro-scale sources for a few hours on Sunday mornings. Prince terminates at Stewart. Pole # 115131

Closest Main Intersection: Stewart Ave.. & N. Lamb Blvd.
(Approximately 480 m west of Lamb).

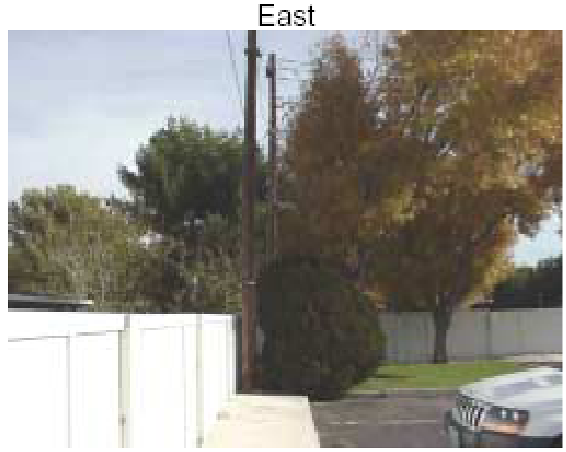
Elevation: 1750 ft / 533 m

Lat./Long.: N36.16650°, W 115.08555°

Site pictures with views looking toward the indicated directions.

North

East



South

Not available

West

Static Site X23

Objective: Neighborhood scale / Outer zone

Location: in the Alexander Villas Park near the NW corner, near the intersection of Lincoln and E. Gowan, (13 m east of Lincoln and 80 m north of E. Gowan). Residential area to the north and northwest, undeveloped to the south and east). Metal lightpole next to walkway. No obstructions.

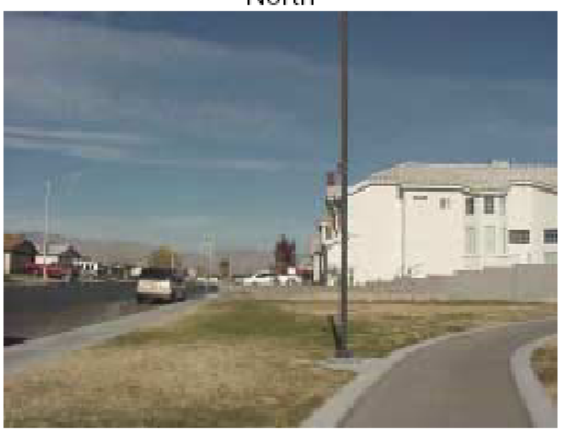
Closest Main Intersection: N. Las Vegas Blvd. & N. Lamb Blvd.
(Approximately 350 m north of Las Vegas Blvd. and 400 m east of Lamb).

Elevation: 1862 ft / 568 m

Lat./Long.: N36.226°; W 115.08467°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Static Site Y14

(Initially Z13)

Objective: Neighborhood scale / Transport zone

Location: Frank mid-way between Cleveland and Baltimore Aves., in a residential neighborhood.

Closest Main Intersection: E. Sahara Ave. & S. Nellis Blvd.

(Approximately 260 m north of Sahara and 200 m west of Nellis).

Elevation: 1741 ft / 531 m

Lat./Long.: N36.14671°; W 115.06779°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Static Site Z17

Objective: Neighborhood scale / Gradient zone

Location: Ute approximately 50 m south of the intersection with Harris, on the west side of the street; pole # 28414. Ute is a very quiet residential street, Harris will have some local rush hour traffic.

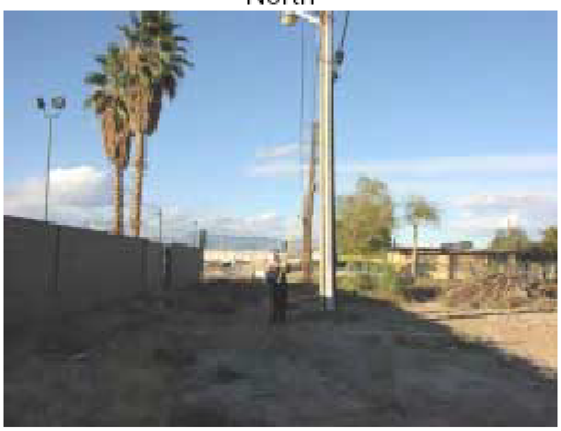
Closest Main Intersection: E. Bonanza and N. Nellis Blvd.
(Approximately 425 m north of Bonanza and 100 m east of Nellis).

Elevation: 1775 ft / 541 m

Lat./Long.: N 36.17765°; W 115.06097°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Dynamic Site Z19

(First location)
(End date 11/23/01, at 1433 PST)

Objective: Neighborhood scale / Gradient zone

Location: Kell between Ringe Lane and Betty Lane. Pole # 75997.

Closest Main Intersection: N. Nellis Blvd. & E. Lake Mead Blvd.
(Approximately 400 m south of Lake Mead Blvd and 120 m east of Nellis).

Elevation: 1775 ft / 541 m

Lat./Long.: N36.1535°; W 115.05733°

Site pictures with views looking toward the indicated directions.

North East

NO PHOTOS AVAILABLE

South West

Static Site Z19

(Second location - start date 11/23/01 at 1436 PST)

Objective: Neighborhood scale / Gradient zone

Location: about 1½ blocks east of the original location on Kell, in the southeast corner of the parking lot of a very small church (the size of a house), so church vehicle traffic should be light even when the church is in use.

Closest Main Intersection: N. Nellis Blvd. and E. Lake Mead Blvd.
(Approximately 400 m south of Lake Mead Blvd and 300 m east of Nellis).

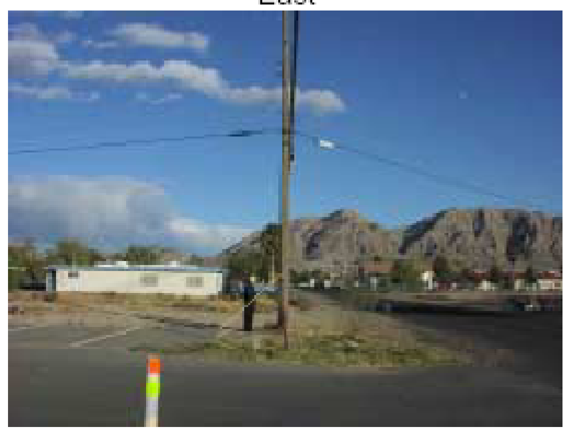
Elevation: 1774 ft / 541 m

Lat./Long.: N36.19273°; W 115.05871°

Site pictures with views looking toward the indicated directions.

North

East



South

West

Dynamic Site xBB12:

Objective: Neighborhood scale / Transport zone

Location: just outside of the NE corner of the golf course at the Stallion Mountain Country Club, immediately south of the Nevada Power Sunrise Generating Plant (1/2 mile, 825 m) and a water treatment plant (400 m). On an unpaved road ¾ mile east of the pavement's end of Desert Inn Rd. Very near the Las Vegas Wash. Wood pole. No obstructions. Some construction traffic.

Closest Main Intersection: E. Desert Inn & Cabana Drive.
(Approximately 1 mile east of Cabana Drive)

Elevation: TBA ±.

Lat./Long.: N36.12972°; W 115.03817°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Dynamic Site xBB15

Objective: Neighborhood scale / Transport zone

Location: immediately next to a tributary of the Las Vegas wash, in an undeveloped tract of land immediately adjacent to a housing development to the east and to another tract of land being graded in preparation for development about 50 m to the north. On weekends the site is accessible directly from Charleston through the construction area, but during the week the site must be accessed from the end of Flowering Plum Ave. by crawling through a drainage hole in the wall that demarcates the edge of the development. Wood pole. No obstructions.

Closest Main Intersection: E. Charleston Blvd. & S. Sloan Lane
(Approximately 380 m south of Charleston, 425 m east of Sloan and 30 m west of the end of Flowering Plum).

Elevation: 1706 ft / 520 m

Lat./Long.: N36.15624°; W 115.04272°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Dynamic Site xBB18

Objective Neighborhood scale / Outer zone

Location: Honeygrove Ave. a ½ block (50 m) east of N. Sloan Lane, in a vacant lot in the midst of a neighborhood between 5930 & 5950 Honeygrove, on the north side of the street. Very quiet residential area, local traffic only. Wood pole. No obstructions.

Closest Main Intersection: N. Sloan Lane & E. Washington Ave.
(Approximately 480 m north of Washington)

Elevation: 1791 ft / 546 m

Lat./Long.: N36.185°; W 115.04267°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Dynamic Site xM19

(Initially xMN19)

Objective: Neighborhood scale / Gradient zone

Location: Gaye just East of Parkchester Drive on the South side of the street, just before the bend in the road, 60 m east of the intersection. Quiet residential neighborhood. Wood pole. Mostly unobstructed, but there is a leafless tree (leafless during the duration of this project) approximately 4-6 m to the East.

Closest Main Intersection: Vegas Drive & N. Decatur Blvd.
(Approximately 400 m north of Vegas and 700 m east of Decatur)

Elevation: 2166 ft / 660 m

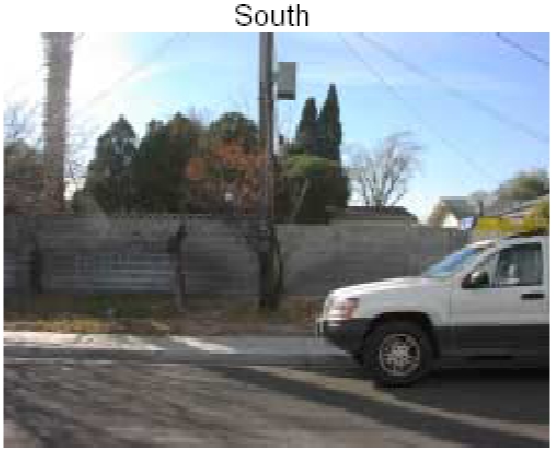
Lat./Long.: N36.19217°; W 115.19878°

Site pictures with views looking toward the indicated directions.

North

East

South



West

Dynamic Site xO16

Objective: Neighborhood scale / Gradient zone

Location: Campbell Drive, approximately 60 m south of the intersection of Campbell and Alta Drive, on the east side of the street. Unobstructed except for bushy trees 15 –20 m to the east and south. Light traffic. Wood pole.

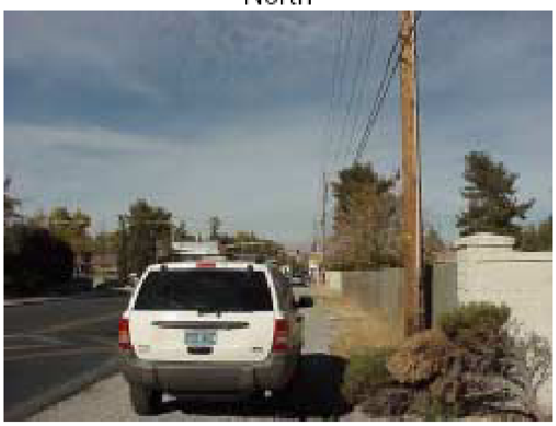
Closest Main Intersection: Alta Drive and S. Rancho Drive
(Approximately 1060 m south of the US95, 850 m west of Rancho).

Elevation: TBA ±.

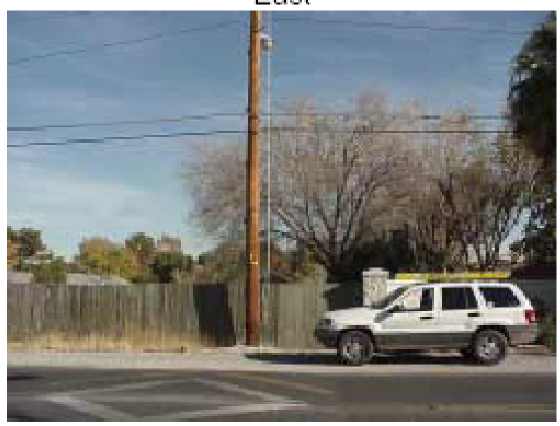
Lat./Long.: N36.16537°; W 115.18342°

Site pictures with views looking toward the indicated directions.

North



East



South

West

Not Available

Dynamic Site xP11

Objective: Neighborhood scale / Inner core

Location: in a large paved area between two apartment buildings on Koval Lane; between Winnick Ave. and Albert Ave., on the 3rd wooden pole west of Koval (about 80 m). Not directly above parking spaces, but there are parking spaces on either side (15 - 25 m away). No obstructions.

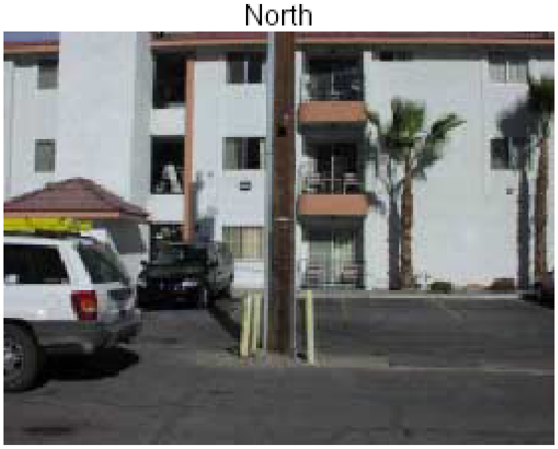
Closest Main Intersection: E. Flamingo & Koval Lane
(Approximately 210 m north of Flamingo and 750 m east of Las Vegas Blvd).

Elevation: 2071 ft / 631 m

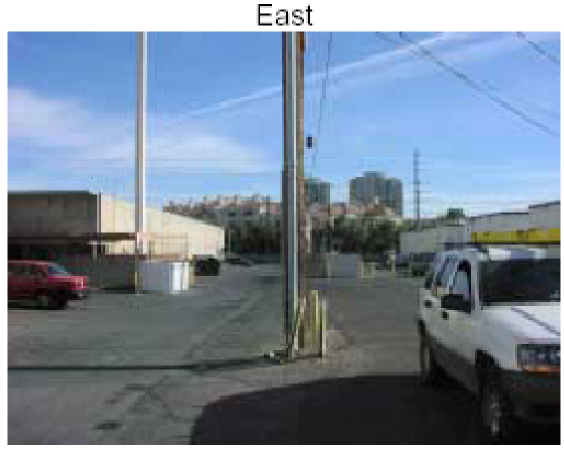
Lat./Long.: N36.11680°; W 115.16538°

Site pictures with views looking toward the indicated directions.

North



East



South

West

Dynamic Site xP13

Objective: Neighborhood scale / Inner core

Location: in an alleyway mid-way between Western Ave. and S. Highland Drive (to the southeast & northwest), and mid-way between Presidio and Sutter Ave. (to the southwest & northeast). Very industrial area, wedged between the I-15 and the Union Pacific RR tracks. Wood pole. No obstructions. Daylight hours recommended; difficult to access this area, only from either Wyoming Ave. (at Western Ave.) to the north, or from Fashion Show Lane (at Highland Drive) to the south. No major cross-streets.

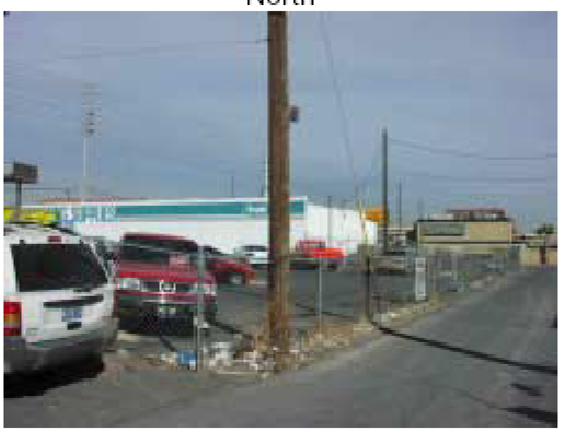
Closest Main Intersection: Spring Mountain & Industrial
(Approximately 280 m east of the I-15, 150 m west of the RR tracks, and 880 m west of the Strip).

Elevation: 2099 ft / 640 m

Lat./Long.: N36.14193°; W 115.1694°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Dynamic Site xP15

Objective: Neighborhood scale / Inner core

Location: Waldman Ave. approximately 40 m west of Pine and 80 m east of Rancho Drive, on the south side of the street. Wood pole #28831. No obstructions.

Closest Main Intersection: Rancho Drive & W. Charleston Blvd.
(Approximately 410 m south of Charleston).

Elevation: TBA ±.

Lat./Long.: N36.15517° W 115.17195°

Site pictures with views looking toward the indicated directions.

North

Not available

East

South

West

Dynamic Site xP17

Objective: Neighborhood scale / Inner core

Location: Shadow Lane and W. Mesquite Ave. 5 m from the SW corner. Metal pole. No obstructions, but there is a small bushy tree approximately10 m to the West. Residential neighborhood, very little traffic. 250 m south of the US95 freeway.

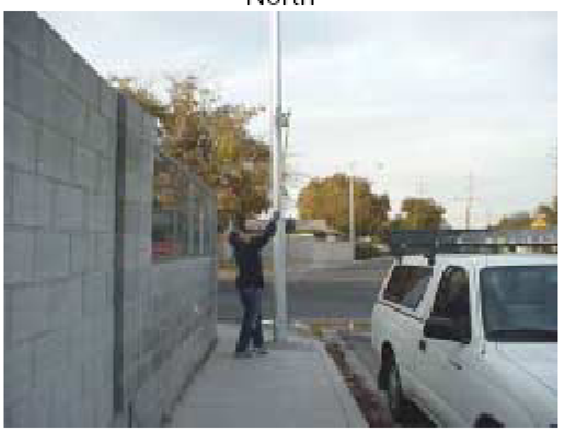
Closest Main Intersection: Alta & Martin Luther King Blvd.
(Approximately 800 m north of Alta and 450 m west of Martin Luther King).

Elevation: TBA ±.

Lat./Long.: N36.17325° W 115.16545°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Dynamic Site xP19

Objective: Neighborhood scale / Gradient zone

Location: Beatty Lane mid-way between Manhattan and Luning (40 m from either), on the South side of the street. Residential neighborhood. Wood pole. No obstructions.

Closest Main Intersection: Vegas Drive & Martin Luther King Blvd.
(Approximately 180 m north of Vegas and 1180 m, ¾ mile, west of Martin Luther King).

Elevation: 2083 ft / 635 m

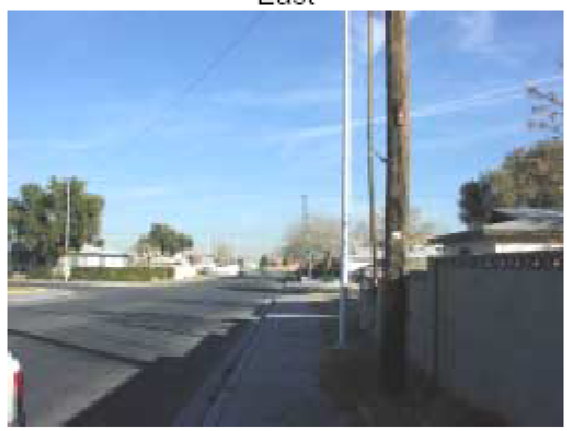
Lat./Long.: N36.19047°; W 115.17383°

Site pictures with views looking toward the indicated directions.

North

Not available

East



South

West

Dynamic Site xQ18:

Objective: Neighborhood scale / Inner core

Location: a ½ block (60 m) north of the intersection of Madison Ave. and J Street, on the west side of the street just north of the church. Quiet residential neighborhood. Mostly unobstructed, but there is a tree approximately 5 m to the west.

Closest Main Intersection Martin Luther King Blvd. & W. Washington Ave.. (Approximately 390 m north of Washington and 400 m east of Martin Luther King).

Elevation: 2036 ft / 621 m

Lat./Long.: N36.18443°; W 115.15647°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Dynamic Site xR17

Objective: Neighborhood scale / Inner core

Location: in the far northeast corner of the Main Street Station (open-air) parking lot (not the parking structure), 40 m from Casino Center Drive. Immediately south of (100 m from) the US 93/Interstate 515. Metal pole. No obstructions.

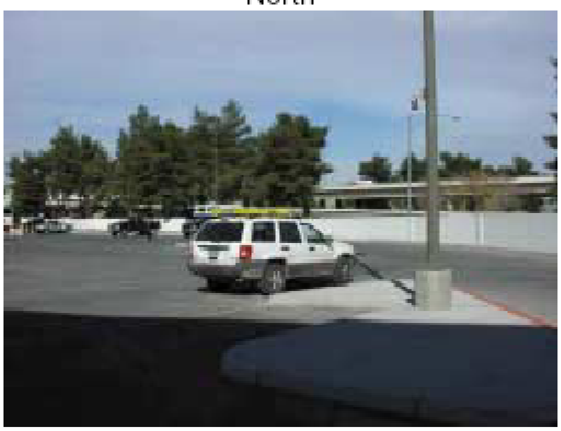
Closest Main Intersection: Main Street & Stewart Ave.
(Approximately 180 m southeast of Main and 100 m northeast of Stewart).

Elevation: 2025 ft / 617 m

Lat./Long.: N36.17397°; W 115.14247°

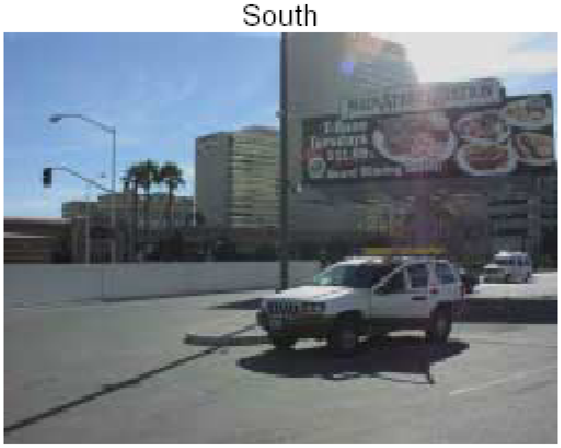
Site pictures with views looking toward the indicated directions.

North



East

South



West

Dynamic Site xU16:

Objective: Neighborhood scale / Inner core

Location: N. 26th between Valley and Sunrise Street (not Avenue), about 10 m north of Sunrise, on the west side of the street. Wood pole (#P90190). Mostly unobstructed, but there is a one-story (empty) building 3-4 m to the west. AM only visits recommended. This site is located very near static site V15.

Closest Main Intersection: Fremont & N. Eastern Ave. & E. Charleston (Approximately 200 m north of Charleston and 200 m east of Eastern).

Elevation: 1857 ft / 566 m

Lat./Long.: N36.1607°; W 115.11400°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Dynamic Site xV21
(Initially xUV21)

Objective: Neighborhood scale / Gradient zone

Location: the intersection of E. Brooks and Harewood, on the NW corner, very close to the Las Vegas Wash (50-60 m west of the Wash). Quiet residential neighborhood, local traffic only. Metal pole. No obstructions.

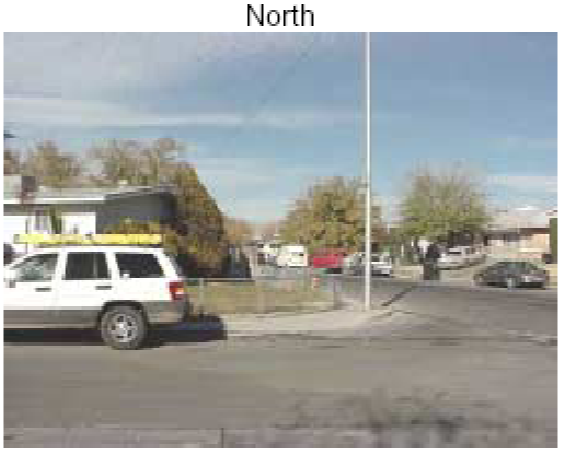
Closest Main Intersection: N. Las Vegas Blvd. & E. Evans Ave.
(Approximately 425 m north of Evans and 550 m northwest of Las Vegas Blvd).

Elevation: 1859 ft / 567 m

Lat./Long.: N36.214°; W 115.10967°″

Site pictures with views looking toward the indicated directions.

North



East

South

West

Dynamic Site xW20

Objective: Neighborhood scale / Gradient zone

Location: an unpaved road approximately20 m north of the paved intersection of N. Judson and Clifford, on the first wooden pole on the east side of the road. Low-density residential area, very little traffic. No obstructions.

Location: a ¼ mile east of the Las Vegas Wash (Approx 500 m).

Closest Main Intersection: N. Pecos & E. Lake Mead Blvd.
(Approximately 500 m north of Lake Mead Blvd and 225 m east of Pecos).

Elevation: 1805 ft / 550 m

Lat./Long.: N36.19983°; W 115.096°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Dynamic Site xX18

Objective: Neighborhood scale / Transport zone

Location: immediately next to the Las Vegas Wash, on the northwest corner of Proclamation & N. Sandhill (where both streets terminate). Residential neighborhood. Metal pole. No obstructions.

Closest Main Intersection: N. Pecos & E. Washington
(Approximately 250 m north of Washington, 830 m east of Pecos).
Metro Map Coordinates: 46 A/B 3

Elevation: 1807 ft / 551 m

Lat./Long.: N36.18317°; W 115.08933°

Site pictures with views looking toward the indicated directions.

North

East

South

West

Dynamic Site xY12

Objective: Neighborhood scale / Gradient zone

Location: Mountain Vista, 50 m south of the intersection with Linda Ave., and 150 m north of the intersection with E. Desert Inn (Approx). On wooden pole # P74602, on the east side of the street. Unobstructed, but here is a high wall about 20 m to the west.

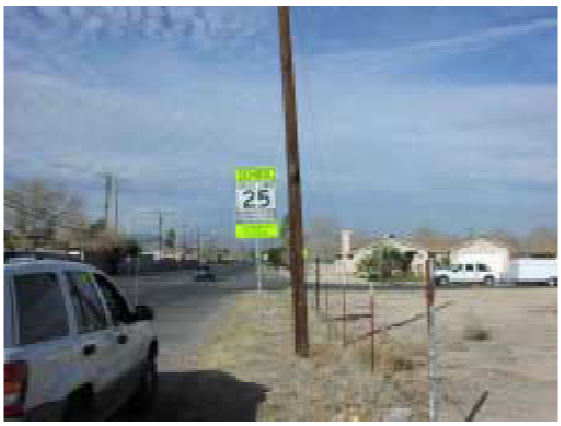
Closest Main Intersection: E. Desert Inn & S. Nellis Blvd.
(Approximately 800 m east of Nellis).

Elevation: 1721 ft / 525 m

Lat./Long.: N36.13107°; W 115.07407°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Dynamic Site xZ10

Objective: Neighborhood scale / Gradient zone

Location: west side of Crater directly in front of 4355 Crater, approximately 40 m north of E. Harmon Ave., 600 m southeast of Sam's Town Casino. Metal pole, no obstructions. Residential neighborhood, but Boulder Highway is 300 m to the southwest, a busy commercial thoroughfare.

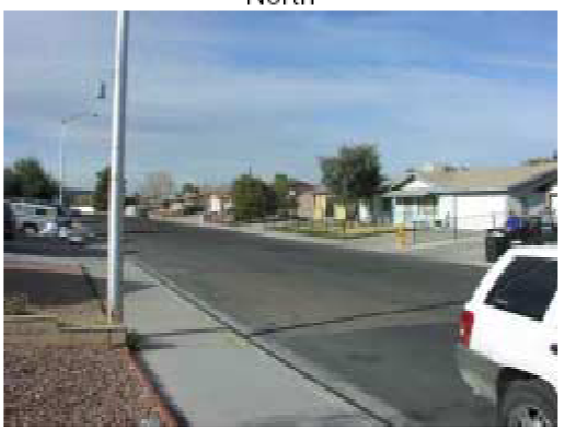
Closest Main Intersection: E. Harmon Ave. & Boulder Highway

Elevation: 1662 ft / 507 m

Lat./Long.: N36.11031°, W 115.05715°

Site pictures with views looking toward the indicated directions.

North



East

South

West

Dynamic Site xZ16:

Objective: Neighborhood scale / Transport zone

Location: a wood powerline pole on the median of Sir George Drive at the intersection of Sir Philip Drive. Very quiet low-density residential neighborhood, little traffic. No obstructions.

Closest Main Intersection: E. Charleston Blvd. & N. Nellis Blvd.
(Approximately 625 m north of Charleston, 560 m east of Nellis).

Elevation: TBA ±.

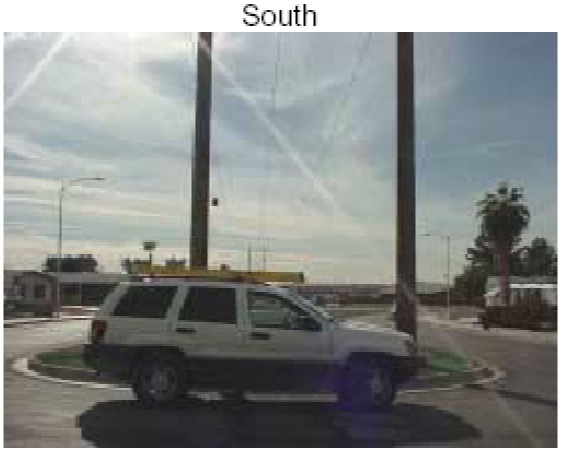
Lat./Long.: N36.1649°; W 115.05643°

Site pictures with views looking toward the indicated directions.

North

East

South



West

APPENDIX B

STANDARD OPERATING PROCEDURES (SOP)

APPENDIX B

STANDARD OPERATING PROCEDURES

1. Siting CO Saturation Monitoring Network

To clarify the nature of the link between general monitoring objectives and the physical location of a particular monitoring station, the concept of spatial scale of representativeness of a monitoring station has been defined by EPA and others. The goal in siting stations is to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring objective of the station. The primary monitoring objective of this study is to determine the adequacy of the current Clark County CO monitoring network to identify the highest CO concentrations occurring in the valley, and the extent of geographic area experiencing concentrations that approach or exceed the National Ambient Air Quality Standards. EPA requires (40CFR58.14) that analyzers used in this way meet the siting criteria of SLAMS stations (State and Local Air Monitoring Stations).

Spatial scale of representativeness is described in terms of the physical dimensions of the air parcel nearest to a monitoring station throughout which actual pollutant concentrations are reasonably similar. The scales of representativeness that we need to be concerned about in this project are:

> **Micro-**Scale-defines the concentrations in air volumes associated with area dimensions ranging from several meters to about l00 meters. A few stations along Las Vegas Blvd and in other areas with large amounts of pedestrian traffic are planned in this spatial scale.
>
> **Neighborhood** Scale-defines concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4 kilometers range. Most of the stations will be in this scale to complement most of the Clark County network stations that were sited to these scale criteria.

One study objective is to determine maximum CO concentrations, including areas where pedestrians may reasonably be exposed, such as the Las Vegas Strip. Such areas would most likely be located within major street canyons of large urban areas and near traffic corridors. Stations located in these areas are micro-scale, since CO concentrations typically peak nearest roadways and decrease rapidly as the monitor is moved from the roadway. For this scale, physical location is determined by consideration of CO emission patterns, pedestrian activity, and physical characteristics affecting pollutant dispersion.

To determine typical CO concentrations over a reasonably broad geographic area having relatively high CO concentrations, a neighborhood scale station is more appropriate. Such a station would likely be located in a residential or commercial area having a high overall CO emission density but not in the immediate vicinity of any single roadway.

Given the goal of siting micro-scale and neighborhood stations, the EPA siting guidance for CO stations includes the following limitations on site and inlet locations.

Horizontal and Vertical Placement of the Probe - EPA recommended required height of the inlet probe for CO monitoring is about 3 meters above ground level, which is a compromise between the breathing height and protecting the inlet from interference and vandalism. In practice, probes are placed between breathing height and on top of buildings, and the EPA allows vertical placement heights between 3 and 15 meters for middle and neighborhood scale sites. (the Fresno (EPA) supersite, Santa Rosa and San Francisco Arkansas BAAQMD sites are two-story buildings with probes on roof.) Adhering to probe heights close to the breathing zone is more critical for micro-scale sites, where the EPA recommends inlet heights of 2.5 to 3.5 meters.

Spacing from Roadways - Roadways tend to contribute to the levels of CO in the ambient air. Thus average daily traffic is an important criterion in determining distance from the nearby roadways. For neighborhood scale analyzers, EPA recommends minimum separation distances from 10 meters to 250 meters for most roadways in the Las Vegas area. Furthermore, mid-block locations are preferable to intersections, where CO concentrations become locally elevated with start and stop driving conditions. In selection of the micro-scale site along a roadway, it is preferable that the site be on the side of the road that will have traffic back up to a red light. It is the idle mode in vehicles that produce the most CO that could impact pedestrian traffic.

Spacing from Trees and Buildings - EPA generally recommends distances greater than 10-meters from the trees. Buildings and other obstacles can obstruct normal wind flow around a probe or monitoring path. To avoid this interference, the probe or at least 90 percent of the monitoring path must have unrestricted airflow and be located away from obstacles so that the distance from the probe or monitoring path is at least twice the height that the obstacle protrudes above the probe or monitoring path. This requirement could be too restrictive but do the best you can documenting any sight shortcomings. Furthermore, the probe should be at least one-meter from any supporting structures or obstacles. This may not be possible if the supporting structure is a phone pole, but in those instances the exposure will likely still meet the 90% criterion.

In summary, the samplers will be located about 3-meters above ground level and at least one-meter from walls or structures, in locations providing reasonably unrestricted airflow. Micro-scale samplers could be within 10-meters of roadways, near the intersection, and on the side where traffic will back up to red lights, while the remainder of the network will be located in mid-block locations at distances greater than 10-meters from roadways or other specific CO sources.

APPENDIX B

STANDARD OPERATING PROCEDURES

2. Launching, Deployment and Retrieving Onset Analyzers

The following steps are to be followed in the process of operating the Onset CO analyzers:

Prior to leaving for the field:

1. Check computer clock using GPS time (local PST)
2. Run Boxcar
3. For each monitor to be deployed, connect to computer using Onset interface cable and press "Connect" icon
4. Set "Description" to monitor serial number followed by deployment number SSSSSS DD
5. Set "Sampling interval" to one-minute
6. "Measurement" to Channel 1 (only)
7. Make sure "wrap around" and "delayed launch" boxes NOT checked.
8. Check battery condition; if less than 10 percent set aside
9. Log serial number, deployment number, current date, average logger reading
10. Enter "Start" to launch
11. Unplug monitor and check to ensure operations light (blue) is blinking
12. Connect next monitor following instructions above for all subsequent units that will be deployed

At each site:

1. Visual check of site condition. Document site anomalies.
2. Remove existing monitor, noting serial number, date and time
3. Check to ensure that new monitor is operational (blue light flashing). If not set aside.
4. Log serial number of newly installed unit and time installed
5. Note: keep removed analyzers separate from those being installed

Back from field:

1. Enter the deployed and retrieved monitor information into master database
   Check serial number vs site id for consistency
2. Check computer clock using GPS time (local PST)
3. Run Boxcar
4. For each monitor retrieved, connect to computer using Onset interface cable and press "Connect" icon
   a) Check "file name" to ensure the file header is correct and in format SSSSSS DD
   b) Check that the downloaded file destination is D:\Las Vegas CO Study\Data\Level0-5
5. Check the resulting data plot to ensure unit operated properly, and period of measurement is consistent with master data base launch and retrieval dates/times

Place retrived monitor into proper bin (not trash)

APPENDIX B

STANDARD OPERATING PROCEDURES

3. Level 0.5 Data Validating of Onset CO Analyzers

From BOXCAR menu double click on desired .dtf file

"Export" file to Microsoft Excel
1. Channel 1 series only
2. Include serial number
3. Check sample data listing for
   i. Date/time OK
   ii. CO values are reported to tenths of ppm (xx.x)
1. Then press "Export" button
2. Save naming file with siteID Serial No and Deployment No. with .txt extension   Example= V15 447729 4.TXT

Repeat for the complete set of new raw Level 0 data files before continuing

Read txt files into Excel
  Delimited file type
  Check boxes for tab, comma, and space
  Then "Next" and "Finish"
  Format time field as "13:30" example shown

Insert two columns before first column

Paste in headers for columns
  "Site SN Date Time CO DataFlag"

Copy/Paste SN from original header information to all records

Paste Site ID to all records

Delete first two rows which are the original header

Delete all data records from start to time sampler actually hung

Flag first hour of data after hanging to suspect (S)

Save file as type "Excel Workbook" in Folder "Level0.5" using naming convention as follows;

SSSS MMDD serialnumber where SSSS=site name, MMDD=start date of data in this file

APPENDIX B

STANDARD OPERATING PROCEDURES

4. Level 1 Data Validation

1. One-minute CO readings are subjected to an objective screening routine that flags as invalid one-record spikes that are greater than 10 ppm.
2. One-minute CO readings are adjusted for slope and zero offsets developed from multi-point calibrations (See attached table). Calibration corrections are applied on the basis of serial number rather than site as units moved between sites.
3. As required, the one-minute CO readings will be adjusted for ambient temperature based on the algorithm developed from cold-test results.
4. Time-series plots of the one-hour averaged data will be examined by experience personnel for outliers.
5. Daily peak levels will be examined outliers relative to the network of sites will be examined and validated.

APPENDIX B

STANDARD OPERATING PROCEDURES

5. Onset Multipoint Calibration Database Instructions

1. Each calibration point in database will have a separate record, even if multiple points are collected during the same calibration run.

2. **The entries made must be the raw data logger output and not have any calibration factors applied. The only reason the factors are listed on the loggers is to give a field sense of the observed concentrations.**

3. Notes are to be included of any observation of significance. This includes temperatures or other CO sources in the vicinity or calibration system problems.

4. The calibration source information should be entered for each point. This will include a distinction between the dilution calibrator or a zero/span cylinder.

5. Any cylinder calibrations should include the cylinder number or ID.

6. Dilution calibrations should include the calibrator ID and cylinder ID. The flow settings are maintained in the calibration log.

7. The Cal factors are manually calculated for each data logger using a linear regression of input/response calculations.

8. No modifications are to be made to the format of this database (adding or deleting fields) as we will be merging multiple records from various entry sources.

9. The column for both the main database and cal factors under initials provides the information on who collected the data and who entered the data. Don't skip this step as it provides a means of tracking the information.

10. The cal factor records will be used to calibrate the collected data over a given interval. The decision of what interval to apply the calibration will be made after multiple entries are made.

APPENDIX B

STANDARD OPERATING PROCEDURES

6. Zero and Span Measurements of Onset CO Analyzers

1. Check then note cylinder pressures (zero air and span gas)
2. Launch all the analyzers being tested noting in file description that this is a chamber test. Example: SSSSSS 11-25 Chamber test
3. Place monitors into chamber being careful to leave space between each units inlet ports. Maximum capacity of chamber is 35 units
4. Plug one of the analyzers to data cable.
5. Connect zero air cylinder to flowmeter and adjust flowmeter to full-scale using regulator valve not flowmeter valve.
6. Disconnect flowmeter and connect inlet line to chamber
7. Allow 25-30 minutes for reading to stabilize.
8. After reading has stabilized, close zero air regulator stage one valve first then stage two.
9. Remove inlet line from zero air regulator and connect to span gas and repeat flowmeter setting as described in step 5. Connect inlet line to chamber.
10. Allow 25-30 minutes for reading to stabilize.
11. At completion, close both regulator stage one and two valves.
12. Remove monitors from chamber and, using Boxcar software pick off zero and span readings for each unit. Record:
    - Serial Number
    - Time (end of test)
    - Zero reading
    - Span reading
    - Pass or fail
13. Pass or fail is determined by comparing zero and span tolerances marked on each unit. Readings must fall within stated levels.
14. Any units failing set aside.
15. Enter data into master spreadsheet.
16. Each point separate record in spreadsheet

APPENDIX C

DEPLOYMENT AND RECOVERY SUMMARY

APPENDIX C
Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
P23	11/18	12:30	11/27	13:55	447698	11/20	0:01	X	Delayed start to 11/20 @ 00:01
G22	11/18	12:51	11/27	14:13	447703	11/20	0:01	X	Delayed start to 11/20 @ 00:01/failed in field, no data
A17	11/18	13:21	11/27	15:16	447672	11/20	0:01	X	Delayed start to 11/20 @ 00:01/DATA SUSPECT
H17	11/18	13:44	11/27	15:30	447712	11/20	0:01	X	Delayed start to 11/20 @ 00:01
L16	11/18	13:57	11/28	9:30	447728	11/20	0:01	X	Delayed start to 11/20 @ 00:01
L20	11/18	14:21	11/28	9:05	447702	11/20	0:01	X	Delayed start to 11/20 @ 00:01
M17	11/18	14:43	11/28	9:18	447710	11/20	0:01	X	Delayed start to 11/20 @ 00:01
N14	11/18	14:57	11/28	9:54	447676	11/20	0:01	X	Delayed start to 11/20 @ 00:01
E13	11/18	15:25	11/27	15:47	447688	11/20	0:01	X	Delayed start to 11/20 @ 00:01
J11	11/18	15:45	11/27	16:20	447674	11/20	0:01	X	Delayed start to 11/20 @ 00:01
H9	11/18	15:57	11/21	13:35	447722	11/20	0:01	X	Delayed start to 11/20 @ 00:01. Site removed
R8	11/18	16:45	11/25	10:35	447678	11/20	0:01	X	Delayed start to 11/20 @ 00:01
U6	11/18	16:59	11/25	10:56	447673	11/20	0:01	X	Delayed start to 11/20 @ 00:01
P8	11/18	17:20	11/25	10:24	447691	11/20	0:01	X	Delayed start to 11/20 @ 00:01
BB5	11/19	8:50	11/27	11:24	447732	11/20	0:01	X	Delayed start to 11/20 @ 00:01
BB9	11/19	9:23	11/27	11:54	447680	11/20	0:01	X	Delayed start to 11/20 @ 00:01
T11	11/18	12:31	11/25	13:15	447739	11/20	0:01	X	Delayed start to 11/20 @ 00:01
X10	11/18	13:01	11/25	12:54	447725	11/20	0:01	X	Delayed start to 11/20 @ 00:01
Y14	11/18	13:17	11/25	14:59	447733	11/20	0:01	X	Delayed start to 11/20 @ 00:01
V13	11/18	13:36	11/25	13:45	447740	11/20	0:01	X	Delayed start to 11/20 @ 00:01
X15	11/18	13:49	11/25	14:47	447724	11/20	0:01	X	Delayed start to 11/20 @ 00:01
X16	11/18	14:24	11/28	10:20	447720	11/20	0:01	X	Delayed start to 11/20 @ 00:01
V17	11/18	14:41	11/26	12:10	447715	11/20	0:01	X	Delayed start to 11/20 @ 00:01
Z17	11/18	14:58	11/25	15:17	447737	11/20	0:01	X	Delayed start to 11/20 @ 00:01
Z19	11/18	15:07	11/25	15:26	447716	11/20	0:01	X	Delayed start to 11/20 @ 00:01
U19	11/18	15:56	11/25	15:39	447738	11/20	0:01	X	Delayed start to 11/20 @ 00:01
Q20	11/18	16:14	11/25	16:01	447704	11/20	0:01	X	Delayed start to 11/20 @ 00:01
S18	11/18	16:27	no	no	?	11/20	0:01	no	STOLEN FROM SITE
T16	11/18	16:44	11/25	14:18	447692	11/20	0:01	X	Delayed start to 11/20 @ 00:01
V15	11/18	16:59	11/25	14:31	447729	11/20	0:01	X	Delayed start to 11/20 @ 00:01

APPENDIX C – Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
T15	11/19	10:05	11/25	14:05	447689	11/20	0:01	X	Delayed start to 11/20 @ 00:01
T14	11/19	10:21	11/25	13:56	447721	11/20	0:01	X	Delayed start to 11/20 @ 00:01
S13	11/19	10:40	11/25	13:29	447731	11/20	0:01	X	Delayed start to 11/20 @ 00:01
Q13	11/19	11:48	11/26	12:53	447708	11/20	0:01	X	Delayed start to 11/20 @ 00:01
S16	11/19	14:44	11/27	13:00	447687	11/20	0:01	X	Delayed start to 11/20 @ 00:01
P12	11/19	15:48	11/27	12:38	447681	11/20	0:01	X	Delayed start to 11/20 @ 00:01failed in field, no data
R3	11/22	9:27	11/25	11:09	447682	21-Nov	21:48	X	unit fails in field, data suspect, pulled out of rotation
U-3	11/22	10:06	11/25	11:31	447685	21-Nov	21:45	X	
D19	11/21	15:08	11/27	14:48	447722			X	Site installation - Summerlin Library
V15	11/25	14:32	12/3	10:00	447735	25-Nov	8:59	X	sampler failed in the field; no data; will test
X15	11/25	14:48	12/3	11:34	447686	25-Nov	8:58	X	
Y14	11/25	15:00	12/3	11:42	447675	25-Nov	8:56	X	sampler failed in the field; no data; will test
Z17	11/25	15:19	12/3	9:23	447701	25-Nov	8:55	X	
Z19	11/25	15:27	12/3	9:17	447709	25-Nov	8:53	X	
U19	11/25	15:40	12/3	9:43	447700	25-Nov	8:54	X	
Q20	11/25	16:02	12/5	9:24	447723	25-Nov	8:52	X	
P8	11/25	10:26	12/4	15:15	447694	25-Nov	9:16	X	
R8	11/25	10:38	12/4	15:26	447677	25-Nov	9:14	X	
U6	11/25	10:59	12/4	15:02	447706	25-Nov	9:07	X	
T16	11/25	14:19	12/3	9:52	447727	25-Nov	9:01	X	
T11	11/25	13:18	12/3	10:58	447684	25-Nov	9:03	X	
S13	11/25	13:31	12/3	10:31	447705	25-Nov	9:16	X	
V13	11/25	13:46	12/3	11:09	447734	25-Nov	9:11	X	
T14	11/25	13:57	12/3	10:19	447707	25-Nov	9:00	X	
T15	11/25	14:06	12/3	10:12	447697	25-Nov	9:02	X	
R3	11/25	11:10	12/6	11:31	447736	25-Nov	9:06	X	
U3	11/25	11:32	12/6	11:10	447690	25-Nov	9:05	X	
X10	11/25	12:57	12/3	12:21	447693	25-Nov	9:02	X	
Q13	11/26	12:56	12/3	13:00	447695	25-Nov	9:09	X	
V17	11/26	12:15	12/3	9:33	447696	?	?	X	
A17	11/27	15:19	12/4	9:50	447708	27-Nov	10:07	X	
N14	11/28	9:57	12/4	11:30	447670	27-Nov	10:06	X	

APPENDIX C – Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
J11	11/27	16:23	12/4	13:03	447715	27-Nov	10:05	X	
H17	11/27	15:33		10:06	447683	27-Nov	10:09	X	
L16	11/28	9:32	12/4	12:44	447711	27-Nov	10:15	X	
M17	11/28	9:20	12/4	10:34	447726	27-Nov	10:16	X	
P12	11/27	12:42	12/3	12:52	447699	27-Nov	10:17	X	
X16	11/28	10:22	12/3	11:22	447714	27-Nov	10:19	X	sampler failed in the field; no data;
D19	11/27	14:50	12/4	9:38	447679	27-Nov	10:20	X	
G22	11/27	14:15	12/4	9:25	447685	27-Nov	10:23	X	
E13	11/27	15:48	12/4	12:22	447691	27-Nov	10:26	X	
BB9	11/27	11:56	12/4	13:45	447733	27-Nov	10:27	X	
BB5	11/27	11:28	12/4	14:12	447725	27-Nov	10:30	X	
L20	11/28	9:07	12/4	10:24	447737	27-Nov	10:31	X	
S16	11/27	13:03	12/3	13:11	447729	27-Nov	10:32	X	
P23	11/27	13:57	12/4	9:09	447678	27-Nov	10:34	X	
S18	11/30	15:27	12/3	13:24	447698	30-Nov	12:05	X	
SoH	11/30	17:06	12/6	10:47	447722	30-Nov	12:06	X	
X23	11/30	15:03	12/3	13:45	447687	30-Nov	12:09	X	
J29	11/30	13:15	12/3	14:24	447680	30-Nov	12:11	X	
P12	12/3	12:54	12/14	12:48	447728	03-Dec	7:22	X	
Y14	12/3	11:45	12/14	13:53	447740	03-Dec	7:23	X	
X15	12/3	11:37	12/14	onground	447702	03-Dec	7:24	X	twice vandalized; all data suspect
X16	12/3	11:24	12/14	12:55	447719	03-Dec	7:25	X	
Z19	12/3	9:19	12/14	12:09	447704	03-Dec	7:27	X	
V15	12/3	10:02	12/15	13:43	447673	03-Dec	7:28	X	
T16	12/3	9:54	12/15	13:10	447712	03-Dec	7:29	X	
V17	12/3	9:35	12/15	12:35	447692	03-Dec	7:30	X	
Z17	12/3	9:25	12/14	12:16	447739	03-Dec	7:31	X	
J29	12/3	14:25	12/15	9:00	447731	03-Dec	7:32	X	
X23	12/3	13:47	12/14	11:23	447732	03-Dec	7:33	X	
S16	12/3	13:13	12/14	14:27	447689	03-Dec	7:35	X	
Q13	12/3	13:02	12/14	13:33	447676	03-Dec	7:36	X	
X10	12/3	12:22	12/14	14:22	447681	03-Dec	7:40	X	

APPENDIX C – Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
T11	12/3	10:59	12/15	16:35	447718	03-Dec	7:41	X	
V13	12/3	11:11	12/15	16:01	447738	03-Dec	7:43	X	
T14	12/3	10:20	12/15	14:55	447710	03-Dec	7:45	X	
S13	12/3	10:33	12/15	15:37	447688	03-Dec	7:46	X	
U19	12/3	9:45	12/14	15:16	447716	03-Dec	7:47	X	
S18	12/3	13:27	12/16	10:28	447720	03-Dec	7:48	X	
T15	12/3	10:14	12/15	14:14	447721	03-Dec	7:49	X	
R3	12/6	11:33	12/16	13:53	447695	04-Dec	7:39	X	
SoH	12/6	10:49	12/17	10:02	447698	04-Dec	7:40	X	
J11	12/4	13:06	12/14	15:42	447693	04-Dec	7:42	X	
Q20	12/5	9:28	12/14	15:54	447709	04-Dec	7:43	X	
U6	12/4	15:06	12/15	12:02	447724	04-Dec	7:44	X	
R8	12/4	15:29	12/15	11:47	447705	04-Dec	7:45	X	
U3	12/6	11:12	12/17	10:20	447680	04-Dec	7:46	X	
BB9	12/4	13:48	12/14	14:40	447686	04-Dec	7:47	X	
BB5	12/4	14:16	12/14	14:54	447734	04-Dec	7:48	X	
P8	12/4	15:18	12/15	12:14	447687	04-Dec	7:49	X	
H17	12/4	10:08	12/15	10:21	447700	04-Dec	7:50	X	
E13	12/4	12:25	12/15	10:37	447701	04-Dec	7:51	X	
M17	12/4	10:38	12/15	11:27	447727	04-Dec	7:52	X	
N14	12/4	11:35	12/15	11:12	447697	04-Dec	7:53	X	
L20	12/4	10:28	12/15	9:15	447707	04-Dec	7:54	X	
G22	12/4	9:28	12/15	9:38	447684	04-Dec	7:55	X	
L16	12/4	12:47	12/15	10:58	447696	04-Dec	7:56	X	
D19	12/4	9:40	12/15	9:52	447729	04-Dec	7:57	X	
A17	12/4	9:52	12/15	10:10	447674	04-Dec	7:58	X	
P23	12/4	9:11	12/15	8:36	447699	04-Dec	7:59	X	
xBB12	12/7	11:25	12/14	14:09	447722	07-Dec	9:47	X	
xZ16	12/7	11:55	12/14	13:10	447679	07-Dec	9:49	X	dynamicsite
xBB18	12/7	12:20	12/14	13:20	447725	07-Dec	9:50	X	dynamicsite
xBB15	12/7	11:45	12/14	13:33	447691	07-Dec	9:51	X	dynamicsite
xX18	12/7	13:18	12/14	11:56	447677	07-Dec	9:52	X	dynamicsite

APPENDIX C – Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
xW20	12/7	13:50	12/14	11:47	447737	07-Dec	9:53	X	dynamic site
AA8	12/7	11:08	12/14	14:34	447708	07-Dec	9:55	X	
xV21	12/7	14:43	12/14	11:35	447726	07-Dec	9:56	X	
S17	12/7	15:35	12/14	14:48	447736	07-Dec	9:57	X	new static site
R15	12/8	10:48	12/14	14:00	447733	08-Dec	9:21	X	new static site
xO16	12/8	10:58	12/14	16:35	447678	08-Dec	9:20	X	dynamic site
X10	12/14	14:26	12/24	11:17	447711	14-Dec	9:04	X	
AA8	12/14	14:38	12/21	12:51	447723	14-Dec	9:05	X	
Z17	12/14	12:19	12/23	15:27	447670	14-Dec	9:06	X	
Z19	12/14	12:14	12/23	15:18	447706	14-Dec	9:07	X	
X23	12/14	11:28	12/21	12:17	447683	14-Dec	9:08	X	
J11	12/14	15:45	12/21	9:47	447685	14-Dec	9:10	X	
Y14	12/14	14:00	12/23	16:10	447690	14-Dec	9:11	X	
BB5	12/14	14:57	12/24	11:36	447694	14-Dec	9:12	X	
BB9	12/14	14:44	12/24	11:06	447715	14-Dec	9:13	X	
X16	12/14	12:58	12/23	15:51	447401	14-Dec	9:14	X	
P12	12/14	13:27	12/22	10:16	447728	14-Dec	13:23	X	
Q13	12/14	13:50	12/22	10:23	447676	14-Dec	13:46	X	
R15	12/14	14:11	12/22	10:33	447733	14-Dec	14:09	X	
S16	12/14	14:42	12/22	10:47	447689	14-Dec	14:39	X	
S17	12/14	15:00	12/22	10:55	447736	14-Dec	14:58	X	
U19	12/14	15:29	12/22	11:16	447716	14-Dec	15:26	X	
Q20	12/14	16:08	12/22	10:31	447709	14-Dec	16:04	X	
M17	15-Dec	11:30	12/22	9:47	447719	15-Dec	7:24	X	
L16	15-Dec	11:03	12/22	9:33	447732	15-Dec	7:25	X	
P8	15-Dec	12:18	12/22	12:01	447737	15-Dec	7:26	X	
N14	15-Dec	11:16	12/21	9:27	447691	15-Dec	7:27	X	
L20	15-Dec	9:18	12/22	10:02	447722	15-Dec	7:29	X	
G22	15-Dec	9:40	12/21	11:07	447726	15-Dec	7:30	X	
A17	15-Dec	10:15	12/21	10:22	447704	15-Dec	7:31	X	
R8	15-Dec	11:51	12/22	11:38	447725	15-Dec	7:34	X	
U6	15-Dec	12:05	12/22	11:50	447702	15-Dec	7:38	X	

APPENDIX C – Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
J29	15-Dec	9:01	12/21	11:43	447681	15-Dec	7:39	X	
D19	15-Dec	9:55	12/21	10:55	447734	15-Dec	7:40	X	
H17	15-Dec	10:25	12/22	9:20	447686	15-Dec	7:41	X	
E13	15-Dec	10:40	12/21	10:05	447693	15-Dec	7:43	X	
P23	15-Dec	8:39	12/22	10:45	447740	15-Dec	7:44	X	
X15	15-Dec	11:52	12/23	15:59	447678	15-Dec	11:49	X	
V17	15-Dec	12:57	12/22	11:26	447692	15-Dec	12:50	X	
T16	15-Dec	13:35	12/22	11:39	447712	15-Dec	13:22	X	
V15	15-Dec	14:04	12/22	11:49	447673	15-Dec	13:59	X	
T15	15-Dec	14:32	12/22	12:04	447721	15-Dec	14:25	X	
T14	15-Dec	15:08	12/23	16:32	447710	15-Dec	15:04	X	
S13	15-Dec	15:51	12/23	16:46	447688	15-Dec	15:47	X	
V13	15-Dec	16:15	12/23	16:23	447738	15-Dec	16:11	X	
T11	15-Dec	16:51	12/23	17:05	447718	15-Dec	16:46	X	
xX18	16-Dec	11:25	12/22	12:33	447677	16-Dec	8:35	X	
xBB15	16-Dec	11:55	12/21	13:15	447700	16-Dec	8:39	X	
xV21	16-Dec	10:45	12/21	12:29	447679	16-Dec	8:40	X	
S18	16-Dec	10:32	12/22	11:05	447708	16-Dec	8:41	X	
xW20	16-Dec	10:56	12/21	12:37	447684	16-Dec	8:42	X	
xZ16	16-Dec	11:36	12/23	15:44	447674	16-Dec	8:43	X	
R3	16-Dec	13:58	12/24	10:40	447707	16-Dec	8:44	X	
xBB12	16-Dec	12:10	12/21	13:04	447697	16-Dec	8:46	X	
xBB18	16-Dec	11:45	12/21	13:04	447701	16-Dec	8:47	X	
xO16	16-Dec	10:18	12/22	11:23	447729	16-Dec	8:48	X	
SoH	17-Dec	10:07	12/21	11:34	447720	17-Dec	8:33	X	
U-3	17-Dec	10:25	12/21	12:23	447695	17-Dec	8:34	X	
xY12	17-Dec	16:14	12/21	13:23	447696	17-Dec	13:53	X	new dynamic site installed during IOP
xM19	17-Dec	15:40	12/22	9:55	447698	17-Dec	13:54	X	new dynamic site installed during IOP
xQ18	17-Dec	15:00	12/22	10:24	447680	17-Dec	13:55	X	new dynamic site installed during IOP
xP17	19-Dec	15:55	12/22	11:06	447727	18-Dec	12:55	X	new dynamic site installed during IOP
xP15	19-Dec	14:38	12/22	11:14	447705	18-Dec	12:56	X	new dynamic site installed during IOP
xP19	19-Dec	15:15	12/22	10:15	447724	19-Dec	7:43	X	new dynamic site installed during IOP

APPENDIX C – Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
P8	22-Dec	12:05	1/7	9:35	447685	22-Dec	8:34	X	
xP15	22-Dec	11:18	12/30	10:04	447693	22-Dec	8:35	X	
U6	22-Dec	11:54	1/7	10:05	447734	22-Dec	8:36	X	
R8	22-Dec	11:43	1/7	9:49	447361	22-Dec	8:37	X	
xO16	22-Dec	11:26	12/30	9:44	447388	22-Dec	8:38	X	
L20	22-Dec	10:06	12/30	9:24	447739	22-Dec	8:39	X	
xP17	22-Dec	11:09	12/30	9:55	447731	22-Dec	8:40	X	
xQ18	22-Dec	10:28	12/30	8:48	447695	22-Dec	8:41	X	
P23	22-Dec	10:48	1/6	11:23	447681	22-Dec	8:42	X	
Q20	22-Dec	10:35	12/30	8:55	447391	22-Dec	8:43	X	
xP19	22-Dec	10:19	12/30	9:03	447684	22-Dec	8:44	X	
M17	22-Dec	9:50	12/30	9:35	447691	22-Dec	8:45	X	
L16	22-Dec	9:37	1/6	13:05	447726	22-Dec	8:46	X	
xM19	22-Dec	9:58	12/30	9:12	447687	22-Dec	8:47	X	
H17	22-Dec	9:25	1/6	9:53	447704	22-Dec	8:48	X	
T15	22-Dec	12:07	12/29	15:33	447701	22-Dec	8:45	no	sampler had shut off at installation; static charge? ..
U19	22-Dec	11:18	12/30	11:19	447394	22-Dec	8:47	X	
V17	22-Dec	11:29	12/29	16:00	447359	22-Dec	8:50	X	
S17	22-Dec	10:59	12/30	10:37	447696	22-Dec	8:52	X	
xX18	22-Dec	12:36	12/30	11:52	447699	22-Dec	8:53	X	
R15	22-Dec	10:36	1/7	11:46	447700	22-Dec	8:54	X	
T16	22-Dec	11:42	12/29	14:12	447720	22-Dec	8:55	X	
S16	22-Dec	10:50	1/7	10:33	447363	22-Dec	8:56	X	
V15	22-Dec	11:52	12/29	14:47	447683	22-Dec	8:57	X	
S18	22-Dec	11:08	12/30	11:00	447679	22-Dec	8:59	X	
Q13	22-Dec	10:26	1/7	11:59	447697	22-Dec	9:00	X	
P12	22-Dec	10:18	1/7	12:27	447723	22-Dec	9:02	X	
A17	23-Dec	9:18	12/29	13:55	447702	23-Dec	7:56	X	
J11	23-Dec	8:44	12/29	13:30	447705	23-Dec	7:57	X	
N14	23-Dec	8:50	12/30	10:18	447721	23-Dec	7:58	X	
E13	23-Dec	9:04	12/29	13:42	447677	23-Dec	7:59	X	
G22	23-Dec	9:33	12/29	14:13	447729	23-Dec	8:00	X	

APPENDIX C – Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
xW20	23-Dec	14:37	1/8	12:23	447733	23-Dec	8:01	X	
X23	23-Dec	14:21	1/6	11:39	447716	23-Dec	8:02	X	
D19	23-Dec	9:25	12/29	14:04	447736	23-Dec	8:03	X	
xV21	23-Dec	14:28	1/6	11:54	447740	23-Dec	8:04	X	
xBB18	23-Dec	14:48	1/8	12:49	447728	23-Dec	8:05	X	
xBB15	23-Dec	14:56	1/8	16:38	447680	23-Dec	8:06	X	
J29	23-Dec	13:54	1/6	10:54	447708	23-Dec	12:48	X	
SoH	23-Dec	16:06	1/7	11:09	447698	23-Dec	12:52	X	
xY12	23-Dec	15:09	12/30	13:41	447676	23-Dec	12:53	X	
xBB12	23-Dec	15:15	1/8	13:37	447692	23-Dec	12:54	X	
U-3	23-Dec	16:25	1/7	10:48	447673	23-Dec	12:56	X	
AA8	23-Dec	15:35	12/30	15:13	447689	23-Dec	12:58	X	
T11	23-Dec	17:09	1/8	14:17	447737	23-Dec	11:26	X	
X16	23-Dec	15:54	12/30	12:12	447686	23-Dec	14:13	X	
S13	23-Dec	16:50	12/30	10:11	447727	23-Dec	14:14	X	
xZ16	23-Dec	15:46	12/30	12:34	447722	23-Dec	14:17	X	
V13	23-Dec	16:26	12/29	16:52	447732	23-Dec	14:19	X	
Z17	23-Dec	15:29	1/8	15:10	447725	23-Dec	14:21	X	Sampler failed in field, no data collected
X15	23-Dec	16:01	12/30	12:53	447719	23-Dec	14:22	X	
Z19	23-Dec	15:20	1/8	15:22	447709	23-Dec	14:23	X	
T14	23-Dec	16:34	12/29	15:17	447724	23-Dec	14:25	X	
Y14	23-Dec	16:13	12/30	13:15	447712	23-Dec	14:26	X	
R3	24-Dec	10:45	1/7	10:27	447690	24-Dec	9:49	X	
BB9	24-Dec	11:09	1/7	12:00	447688	24-Dec	9:46	X	
X10	24-Dec	11:21	12/30	14:26	447710	24-Dec	9:59	X	
BB5	24-Dec	11:40	1/7	12:42	447738	24-Dec	10:04	X	
xU16	26-Dec	16:28	12/29	14:33	447674	26-Dec	14:51	X	new dynamic site;
xR17	27-Dec	14:45	1/8	11:15	447718	27-Dec	11:55	X	new dynamic site
xP13	27-Dec	13:50	12/30	13:35	447715	27-Dec	11:57	X	new dynamic site
xP11	27-Dec	13:08	12/30	13:47	447401	27-Dec	11:58	X	new dynamic site
xZ10	27-Dec	16:04	12/30	14:05	447706	27-Dec	13:46	X	new dynamic site
T16	29-Dec	14:28	1/8	14:25	447720	29-Dec	14:24	X	

APPENDIX C – Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
xU16	29-Dec	14:46	1/8	12:08	447674	29-Dec	14:43	X	
V15	29-Dec	15:06	1/6	9:55	447683	29-Dec	15:04	X	
T14	29-Dec	15:29	1/6	15:38	447724	29-Dec	15:26	X	
T15	29-Dec	15:48	1/6	10:13	447701	29-Dec	15:42	X	
V17	29-Dec	16:14	1/6	11:04	447359	29-Dec	16:12	X	
V13	29-Dec	17:07	1/8	14:12	447732	29-Dec	17:03	X	
M17	30-Dec	9:39	1/6	12:37	447678	30-Dec	7:51	X	
xP17	30-Dec	10:00	1/8	10:00	447705	30-Dec	7:52	X	
xQ18	30-Dec	8:52	1/7	14:32	447711	30-Dec	7:55	X	
xP19	30-Dec	9:07	1/8	9:02	447707	30-Dec	7:58	X	
xP15	30-Dec	10:08	1/8	10:12	447670	30-Dec	7:59	X	
Q20	30-Dec	8:58	1/8	11:44	447694	30-Dec	8:01	X	
N14	30-Dec	10:23	1/6	13:21	447677	30-Dec	8:03	X	
xM19	30-Dec	9:15	1/8	9:34	447736	30-Dec	8:04	X	
xO16	30-Dec	9:47	1/6	12:24	447702	30-Dec	8:05	X	
L20	30-Dec	9:28	1/6	12:50	447729	30-Dec	8:06	X	
J11	30-Dec	12:20	1/6	9:17	447391	30-Dec	11:34	X	
A17	30-Dec	12:44	1/6	10:13	447695	30-Dec	11:36	X	
D19	30-Dec	13:00	1/6	10:25	447684	30-Dec	11:38	X	
E13	30-Dec	12:32	1/6	9:35	447739	30-Dec	11:39	X	
G22	30-Dec	13:08	1/6	10:35	447693	30-Dec	11:45	X	
xP13	30-Dec	13:38	1/8	10:31	447691	30-Dec	11:46	X	
xP11	30-Dec	13:51	1/8	10:46	447687	30-Dec	11:47	X	
S13	30-Dec	10:27	1/8	13:41	447727	30-Dec	10:23	X	
S17	30-Dec	10:54	1/7	10:15	447696	30-Dec	10:52	X	
S18	30-Dec	11:12	1/8	11:30	447679	30-Dec	11:10	X	
U19	30-Dec	11:31	1/6	11:34	447394	30-Dec	11:30	X	
xX18	30-Dec	12:05	1/8	12:36	447699	30-Dec	12:03	X	
X16	30-Dec	12:24	1/8	15:47	447686	30-Dec	12:21	X	
xZ16	30-Dec	12:46	1/9	11:21	447722	30-Dec	12:43	X	
X15	30-Dec	13:04	1/8	15:59	447719	30-Dec	13:02	X	
Y14	30-Dec	13:27	1/8	16:18	447712	30-Dec	13:24	X	

APPENDIX C – Deployment & Recovery Summary

To Site	Deploy Date	Time (PST)	Recovery Date	Time (PST)	Onset Serial No	Launch Date	Launch Time (PST)	Dumped √	Comments
xY12	30-Dec	13:55	1/6	16:00	447676	30-Dec	13:52	X	
xZ10	30-Dec	14:17	1/8	13:53	447706	30-Dec	14:14	X	
X10	30-Dec	14:50	1/9	11:39	447710	30-Dec	14:35	X	
AA8	30-Dec	15:26	1/7	11:46	447689	30-Dec	15:22	no	Sampler failed in field, no data collected

NOTE: Data files labeled with "x" signify that these files are from dynamic sites (e.g., xBB12)

APPENDIX D

AUDIT RESULTS

Memorandum

To: Don Lehrman, Bob Baxter

CC: Bill Knuth, Derek Lehrman

From: David Bush

Date: 11/18/01

Re: Las Vegas Siting Audit

This is a quick summary of the siting audits that I conducted on November 15 and 16, 2001. I was able to visit 25 of the static sites. The sites visited were: G13, G22, J11, K16, K20, N14, N18, P23, R20, S11, S13, T14, V13, W16, X15, Y10, Z13, Z17, Z19, CW, FP, MS, PM, PV, and WJ. The following issues were noted:

- The WI6 site is located within approximately one meter of a large group of trees that effectively cuts off about 90° of the monitoring path. Thus, the site does not meet EPA CO siting criteria, which state that the inlet should be 10 meters from the dripline of trees, and barely meets criteria for exposure and distance from obstacles. As an obstacle, the trees also change the scale of the site from "neighborhood" to "middle", which may not be desired. The location of this site should be evaluated.

- The K16 site is, in general, properly sited as a "neighborhood" scale site. However, during the audit visit, an unusually large number of vehicles (some of them of older models) were parked at the residences surrounding the site. Up to four or five vehicles per house were noted in some cases. It may be that the current location will have an unrepresentative number of "local sources".

- A saturation monitor is being sited at the County's microscale PM site (MS) for microscale CO measurements. The monitor is currently located at a height of four meters. To best simulated microscale CO measurements, it is recommended that the monitor be lowered to a height between 2.5 and 3.5 meters, the EPA criteria for siting CO microscale inlets.

- The V13, Z17 and Z19 sites are all located within a couple hundred meters of major, busy streets. This would make their scale more "middle" than "neighborhood". In addition, the Z17 site is located about six meters west of a large wall, which may act as an obstruction, again making it more "middle" than "neighborhood" scales. If "neighborhood" scale siting is desired (for comparison with virtually all of the other saturation sites, which are "neighborhood" scale), it is recommended that the sites be located further from these streets.

- In general, the County "neighborhood" sites are located on the grounds of public facilities. In most cases, the sites are located not too far away from public parking lots. This is inherently different from the siting of the saturation study "neighborhood" sites, which are located primarily near single family homes. Since goals of the study included measurement of CO at County sites not currently measuring CO and collocating measurements at County sites currently measuring CO, no changes in siting are recommended. However, this inherent difference in the siting of "neighborhood" scales sites should be taken into account when reviewing the data.

- The T14 site is located very near the County CW site, and both of these “neighborhood” sites are likely sampling essentially the same air mass. In addition, the T14 siting is not ideal, since a wall, trees and shrubs are located starting at about two meters west of the monitor. It may be that the saturation monitor may be more useful in a different location. However, there may be some differences between the two sites due to the parking lot adjacent to the CW site. This may provide information addressing the previous comment, though the site might have to be changed to get away from the trees/obstacles. The purpose for this site should be further evaluated.

- The S13 site could not be located given the instructions available.

My recommendation is the Bob visit the sites that I was not able to visit to provide a quasi-independent review of the siting of those locations.

Feel free to call me if you have any questions.

Memorandum Response

To: David Bush

CC: Bill Knuth, Derek Lehrman, Don Lehrman, Bob Baxter

From: Bob Baxter

Date: 11/21/01

Re: Response to Las Vegas Siting Audit

This memorandum responds to the Las Vegas Siting Audit performed by David Bush. The audit identified some very pertinent subjects and our response to the comments is provided below. Sites were selected to as closely as possible represent the micro and neighborhood scale EPA recommended siting criteria. Because of some limitations in site availability some of the selected sites should be reclassified as middle, as opposed to neighborhood. This should not be a problem since the overall goal is to see if there are regions, either micro, middle or neighborhood, that are in exceedance of the standard. The original comments by Mr. Bush are in italics, our response is in standard text.

This is a quick summary of the siting audits that I conducted on November 15 and 16, 2001. I was able to visit 25 of the static sites. The sites visited were: G13, G22, J11, K16, K20, N14, N18, P23, R20, S11, S13, T14, V13, W16, X15, Y10, Z13, Z17, Z19, CW, FP, MS, PM, PV, and WJ. The following issues were noted:

- *The W16 site is located within approximately one meter from a large group of trees that effectively cuts off about 90° of the monitoring path. Thus, the site does not meet EPA CO siting criteria, which state that the inlet should be 10 meters from the dripline of trees, and barely meets criteria for exposure and distance from obstacles. As an obstacle, the trees also change the scale of the site from "neighborhood" to "middle", which may not be desired. The location of this site should be evaluated.*

Response: Agreed, there is some blockage to the flow and it may be more representative of middle scale. The site was revisited on 11/21 and the neighborhood behind the church was explored but no appropriate site was identified as security and wooden poles were not available. An alternative site is on the pole within the parking lot of the church, which is away from the obstructions, but in the middle of the Sunday morning parking (a source). We favor leaving the site where it is currently located and label the site as middle scale. CO is inert and we don't feel the adjacent foliage will influence the ambient CO concentrations.

- *The K16 site is in general properly sited as a "neighborhood" scale site. However, during the audit visit, an unusually large number of vehicles (some of them of older models) were parked at the residences surrounding the site. Up to four or five vehicles per house were noted in some cases. It may be that the current location will have an unrepresentative number of "local sources".*

Response: The site was revisited and no unusual vehicle loads were observed at 1700 PST on 11/21/2001. While there were vehicles parked, the number of them did not look out of the ordinary. We favor keeping the site as is.

- *A saturation monitor is being sited at the County's microscale PM site (MS) for microscale CO measurements. The monitor is currently located at a height of four meters. To best simulated microscale CO measurements, it is recommended that the monitor be lowered to a height between 2.5 and 3.5 meters, the EPA criteria for siting CO microscale inlets.*

Response: While we agree that the criteria recommends up to the 3.5 meter height, we placed the sampler at 4 meters to be above the influence of the adjacent monitoring shelter. We favor a little higher sampler height versus the potential for interference from the adjoining structure. We will maintain the sampler height at the existing height.

- *The V13, Z17 and Z19 sites are all located within a couple hundred meters of major, busy streets. This would make their scale more "middle" than "neighborhood". In addition, the Z17 site is located about six meters west of a large wall, which may act as an obstruction, again making it more "middle" than "neighborhood" scales. If "neighborhood" scale siting is desired (for comparison with virtually all of the other saturation sites, which are "neighborhood" scale), it is recommended that the sites be located further from these streets.*

Response: For site V13, we agree it should be relabeled as middle scale. At site Z17 the large wall was recognized in the placement and the sampler is located above the top of the wall. The obstruction created by the wall is no worse than what would be created by an adjacent shelter. We agree that it should be relabeled as middle scale but the exposure is good and we will retain it as a site. At site Z19 we agree it is in a region that would be considered middle scale. We will be moving the site approximately one block to the east in front of a church and it can then be classified as Neighborhood.

- *In general, the County "neighborhood" sites are located on the grounds of public facilities. In most cases, the sites are located not too far away from public parking lots. This is inherently different from the siting of the saturation study "neighborhood" sites, which are located primarily near single family homes. Since goals of the study included measurement of CO at County sites not currently measuring CO and collocating measurements at County sites currently measuring CO, no changes in siting are recommended. However, this inherent difference in the siting of "neighborhood" scales sites should be taken into account when reviewing the data.*

Response: Agreed, this will be considered in the analysis.

- *The T14 site is located very near the County CW site, and both of these "neighborhood" sites are likely sampling essentially the same air mass. In addition, the T14 siting is not ideal, since a wall, trees and shrubs are located starting at about two meters west of the monitor. It may be that the saturation monitor may be more useful in a different location. However, there may be some differences between the two sites due to the parking lot adjacent to the CW site. This may provide information addressing the previous comment, though the site might have to be changed to get away from the trees/obstacles. The purpose for this site should be further evaluated.*

Response: While the two sites (T15-CW and T14) are in the same general air mass, the T15 site is almost a microscale site because of the heavy traffic during school hours. The purpose of the T14 site is to see if the school site is representative of the general neighborhood. While the T14 site does not meet all of the exposure criteria, the general neighborhood is older and has established large trees and shrubs everywhere making the siting difficult. On 11/21 the site was revisited and a better site that met security and exposure criteria was not be identified. We favor leaving the site as-is.

- *The S13 site could not be located given the instructions available.*

Response: We would like Dave to audit this site, as well as other potential sites on a second trip he will be making in the near future on his next visit.

Memorandum

To: Don Lehrman, Bob Baxter

CC: Bill Knuth, Derek Lehrman

From: David Bush

Date: 11/21/01

Re: Las Vegas Hobo Audits

This is a quick summary of the audits that I conducted on November 14, 2001 of the Hobo CO monitors.

The audits consisted of exposing the monitors to three CO concentrations (0, 10.35 and 25.2 ppm) by pumping gases generated using a Dasibi 5009 dilution calibrator through a chamber containing a number of Hobos. The concentrations were introduced in the following order: zero, 10 ppm, 25 ppm, followed by a final zero. A period of 0.5 hours was allowed for each point to stabilize. An audit Hobo was used to monitor the conditions within the chamber. A total of four runs were made in order to audit all of the available Hobos, as follows:

- The first run (beginning at 08:50) was conducted using the small case that had been originally designated for the audits. A total of five Hobos (plus the audit Hobo) fit in this chamber. Concentrations were introduced into the chamber at 5 lpm. Since this equates to a windspeed of only about 0.01 m/s, it had been determined that this method was not the most representative of actual monitoring conditions, where wind would most likely assist in the monitors' sampling. The method was also not very practical, since, given the relatively long response times and the large number of monitors, it would have taken several days to audit all of the Hobos. However, since this had been the original plan for the audit, this method was used for this first batch.

- The remainder of the audits was conducted in the large chamber that Bob used for the original calibrations. The five Hobos from the first run were also reaudited using this chamber. About 20 Hobos were audited at a time. The chamber was equipped with four fans that kept the air within the chamber circulating, simulating wind assisted sampling. For the first set in this chamber (beginning at 12:30), audit concentrations were introduced at a flow rate of 5 lpm. Noting the long response time for the final zero after the span concentrations, the flow rate was increased to 8 lpm for the final two runs (beginning at 14:40 and 16:40) in order to see if a higher purge rate for the chamber affected the audit results in any way.

- Several Hobos were involved in multiple runs in order to identify any variations between runs.

Results of the audits are included in the attached table. This table was generated using Bob's original workbook containing his initial calibration data, with three extra sheets. The table presents the results by serial number, with only the first test of each Hobo (for reasons presented below) presented. The following was noted:

- In general, the results of the audit were very good. Some variability was noted between the audit response relative to the original calibration response; however, this variability is centered around a slope of one, showing essentially no bias. The audit zero responses were typically higher than the calibration response, though the reason for this is not known for sure. One possibility is that CO is not being completely flushed out of the chamber, though this doesn't seem likely. A more probable explanation is that a response period greater than 0.5 hours is required. However, a 0.5-hour response period seems like a reasonable test for the system.

- Only two Hobos had responses that statistically fell outside of the audit results (based on two standard deviations from the mean). These were serial numbers 477730 and 477708, which both had issues with the zeros.
- Span responses obtained using the small case were about 4.5% lower than those obtained using the large, fan-equipped chamber. This is consistent with expectations that wind will improve the response characteristics of the samplers. The results are more interesting for studies where the samplers will be used indoors, with the implication that they will read about 5% lower.
- Hobos subjected to multiple runs consistently showed an increase in response with each additional run. The increase occurred both for the zero and for the span points. Of the 14 repeat audits, only two monitors did not show this increase. It is presumed that this increase is a byproduct of the long response times encountered when the monitors recover from high spans, though it is not apparent why the span values would also show an increase.
- No significant differences were noted between the three runs using the large chamber, even taking into account the increase in the calibration gas flow rate described above.

In conclusion, based on the audit results, I would say that the Hobos have an accuracy of about ±1 ppm, and that all of the Hobos appear to be operational. The zeros for the two outliers mentioned above should be rechecked. All of the other Hobos produced audit results that appear to fall under the category of random error.

Feel free to call me if you have any questions.

				Raw			Corrected			% difference		Audit results		
S/N	Slope	Int	Time	Zero	10.35 ppm	25.2 ppm	Zero	10.35 ppm	25.2 ppm	10.35 ppm	25.2 ppm	Slope	Int	Corr
447670	1.062	-2.0	14:40	2.4	12.1	26.6	0.6	10.9	26.3	5.3%	4.3%	1.021	0.5	0.9999
447673	0.883	-0.9	14:40	2.2	13	31.5	1.1	10.6	26.9	2.3%	6.8%	1.031	0.6	0.9989
447674	0.877	-1.5	14:40	2.7	14.4	32.4	0.9	11.1	26.9	7.4%	6.7%	1.035	0.7	0.9998
447675	0.939	-0.3	16:40	0.7	12	28.3	0.4	11.0	26.3	6.2%	4.4%	1.029	0.4	1.0000
447676	0.856	-0.3	14:40	1.7	13.2	31.5	1.2	11.0	26.7	6.5%	5.9%	1.015	0.9	0.9996
447677	0.878	-1.1	16:40	2.7	13.9	31.5	1.2	11.1	26.5	7.1%	5.3%	1.006	1.0	0.9997
447678	0.916	-0.9	14:40	1.7	12.9	30	0.6	10.9	26.6	5.2%	5.4%	1.031	0.5	0.9999
447679	0.956	-0.3	16:40	0.8	11	26.6	0.4	10.2	25.1	-1.7%	-0.4%	0.981	0.3	0.9998
447680	0.945	-1.5	12:30	2.7	13.5	30.5	1.1	11.3	27.4	9.2%	8.6%	1.045	0.9	0.9997
447681	0.959	-0.5	14:40	1.6	12.1	28.6	1.0	11.1	26.9	7.3%	6.9%	1.031	0.8	0.9997
447683	0.954	-1.0	16:40	1.4	12	28.3	0.4	10.5	26.1	1.4%	3.4%	1.021	0.2	0.9998
447684	0.908	-1.4	14:40	1.9	12.7	29.5	0.4	10.2	25.4	-1.7%	0.9%	0.997	0.2	0.9998
447685	0.890	-2.2	14:40	2.7	13.8	31.5	0.2	10.1	25.9	-2.4%	2.6%	1.021	0.0	0.9996
447686	1.022	-1.9	16:40	1.7	11.7	26.6	-0.1	10.1	25.3	-2.5%	0.4%	1.010	-0.2	0.9999
447688	0.855	-2.0	14:40	2.2	13.7	31.5	-0.1	9.7	25.0	-5.9%	-0.9%	0.996	-0.3	0.9998
447689	0.938	-1.0	14:40	1	11.5	28	0.0	9.8	25.3	-5.1%	0.4%	1.008	-0.2	0.9997
447690	0.906	-1.3	16:40	1.6	12.3	29.1	0.1	9.8	25.0	-5.2%	-0.7%	0.991	-0.1	0.9997
447691	0.904	-0.9	14:40	1.2	12	28.6	0.2	9.9	24.9	-4.2%	-1.1%	0.985	0.0	0.9998
447692	0.968	-0.9	8:50	0.7	10.5	25.2	-0.2	9.3	23.5	-10.1%	-6.6%	0.943	-0.3	0.9999
447693	0.881	-1.0	16:40	1.4	12.3	29.9	0.2	9.8	25.3	-5.3%	0.5%	1.000	-0.1	0.9995
447695	0.922	-2.0	14:40	2.4	12.9	29.5	0.2	9.9	25.2	-4.6%	-0.1%	0.994	0.0	0.9996
447697	0.957	-1.7	16:40	1.7	12.9	30	-0.1	10.6	27.0	2.7%	7.1%	1.076	-0.2	0.9999
447698	0.918	-0.6	12:30	1.2	11.5	27.7	0.5	10.0	24.9	-3.4%	-1.3%	0.968	0.3	0.9997
447699	0.966	-2.0	16:40	1.7	12.5	28.6	-0.4	10.0	25.6	-2.9%	1.6%	1.033	-0.5	0.9999
447700	0.938	-1.4	16:40	1.6	12.5	29.1	0.1	10.3	25.9	-0.5%	2.7%	1.026	-0.1	0.9999
447701	0.992	-0.7	16:40	0.7	10.5	25.6	0.0	9.7	24.7	-6.1%	-2.0%	0.982	-0.2	0.9998
447702	1.051	-1.3	12:30	0.7	10	24.7	-0.5	9.2	24.7	-10.8%	-2.0%	1.004	-0.8	0.9997
447703	0.870	-1.0	14:40	1.2	12.1	28.6	0.0	9.5	23.9	-8.3%	-5.4%	0.947	-0.1	0.9999
447704	0.952	-0.7	8:50	0.2	10.5	26.5	-0.5	9.3	24.5	-10.3%	-2.7%	0.996	-0.7	0.9998
447705	0.862	-2.6	16:40	2.7	14.4	32.2	-0.3	9.8	25.2	-5.3%	-0.2%	1.011	-0.4	0.9999
447706	0.980	-0.8	16:40	0.7	11	26.4	-0.1	10.0	25.1	-3.3%	-0.4%	1.000	-0.2	0.9999
447707	0.885	-1.1	16:40	1.7	12.7	29.8	0.4	10.1	25.3	-2.2%	0.2%	0.989	0.2	0.9998
447708	0.917	-3.2	14:40	2.7	13.9	31.55	-0.7	9.5	25.7	-8.0%	2.0%	1.053	-1.0	0.9997
447709	0.913	-1.2	16:40	1.7	12.7	29.8	0.3	10.4	26.0	0.1%	3.1%	1.020	0.1	0.9998
447710	0.926	-1.1	14:40	1.2	12.1	29.4	0.0	10.1	26.1	-2.7%	3.5%	1.040	-0.3	0.9996
447711	0.943	-1.8	16:40	2	12.9	29.5	0.1	10.4	26.1	0.5%	3.4%	1.031	0.0	0.9999
447712	0.961	-1.3	12:30	1.5	11.9	26.6	0.1	10.1	24.3	-2.1%	-3.7%	0.957	0.2	1.0000
447714	0.894	-0.3	12:30	0.5	10.9	27.6	0.1	9.4	24.4	-8.7%	-3.3%	0.964	-0.1	0.9995
447715	0.915	-0.5	12:30	1.1	11.8	28.3	0.5	10.3	25.4	-0.5%	0.8%	0.990	0.3	0.9998
447716	0.930	-0.2	12:30	0.2	10.5	26.6	0.0	9.6	24.5	-7.6%	-2.6%	0.977	-0.2	0.9997
447717	0.910	-0.3	12:30	0.2	10	27.1	-0.1	8.8	24.4	-15.0%	-3.3%	0.977	-0.6	0.9986
447718	0.920	0.0	12:30	0.2	10	26.6	0.2	9.2	24.5	-11.1%	-2.9%	0.968	-0.2	0.9990
447719	0.913	-1.0	12:30	1.2	12	28	0.1	10.0	24.6	-3.4%	-2.4%	0.972	0.1	1.0000
447720	0.905	-0.5	12:30	1.7	12.5	28.6	1.1	10.8	25.4	4.7%	0.8%	0.967	1.0	0.9999
447721	0.968	0.0	12:30	0.5	10.5	26.1	0.5	10.1	25.2	-2.1%	0.1%	0.985	0.3	0.9997
447722	0.910	-0.1	12:30	1.2	12.5	28	1.0	11.3	25.4	8.7%	0.6%	0.967	1.1	0.9999
447723	0.965	-0.5	16:40	1.2	11.4	26.9	0.7	10.5	25.4	1.4%	1.0%	0.986	0.5	0.9999
447724	0.987	-0.7	8:50	1.7	10.9	25.6	1.0	10.0	24.5	-3.1%	-2.6%	0.939	0.7	0.9996
447725	0.905	-0.4	12:30	1	11.7	28.2	0.5	10.2	25.2	-1.2%	-0.2%	0.978	0.4	0.9998
447726	0.903	-0.9	14:40	1.9	12.9	30	0.9	10.8	26.2	4.2%	4.0%	1.009	0.7	0.9998
447727	1.006	-0.5	8:50	1.2	10.5	24.7	0.7	10.1	24.4	-2.6%	-3.3%	0.940	0.6	0.9999
447728	0.942	-0.5	14:40	1.5	12	28.1	0.9	10.8	26.0	4.7%	3.1%	0.996	0.8	0.9998
447729	0.916	-0.1	12:30	0.8	11.1	27.6	0.7	10.1	25.2	-2.5%	0.0%	0.977	0.4	0.9995
447730	0.960	-0.3	16:40	2.2	12.2	27.6	1.8	11.4	26.2	10.6%	4.1%	0.969	1.7	0.9998
447731	0.952	-0.2	12:30	1.1	11.4	27.6	0.9	10.7	26.1	3.2%	3.6%	1.004	0.7	0.9997
447732	1.000	-0.8	8:50	1.2	10.5	25.1	0.4	9.7	24.3	-6.3%	-3.6%	0.951	0.2	0.9997
447733	0.991	-0.6	12:30	1.5	12	27.6	0.9	11.3	26.7	8.8%	6.0%	1.027	0.8	1.0000
447734	0.942	-0.9	16:40	2.2	12.9	29.5	1.1	11.2	26.8	8.3%	6.5%	1.022	0.9	0.9998
447736	0.925	0.3	16:40	0.2	10.5	27	0.4	10.0	25.2	-3.7%	0.1%	0.987	0.2	0.9995
447737	1.006	-0.5	12:30	1.2	11.8	26.8	0.7	11.4	26.5	10.0%	5.1%	1.022	0.8	1.0000
447738	0.965	-0.5	12:30	0.7	11	26.3	0.2	10.1	24.9	-2.4%	-1.3%	0.981	0.1	1.0000
447739	0.919	-0.4	12:30	1.5	12.5	29.2	1.0	11.1	26.4	7.2%	4.9%	1.011	0.9	0.9999
447740	0.917	-0.3	12:30	1.2	12	28.5	0.8	10.7	25.8	3.3%	2.5%	0.995	0.6	0.9999
477672	0.917	-0.3	14:40	1.5	11.3	26.6	1.1	10.1	24.1	-2.9%	-4.4%	0.916	0.9	0.9997
477687	0.917	-0.3	14:40	1.2	12.5	29.3	0.8	11.2	26.6	7.8%	5.4%	1.024	0.7	1.0000
									Average	-0.7%	1.2%	0.997	0.25	
									Std Dev	6.0%	3.5%	0.031	0.52	

Memorandum

To: Don Lehrman, Bob Baxter

CC: Bill Knuth, Derek Lehrman

From: David Bush

Date: 11/30/01

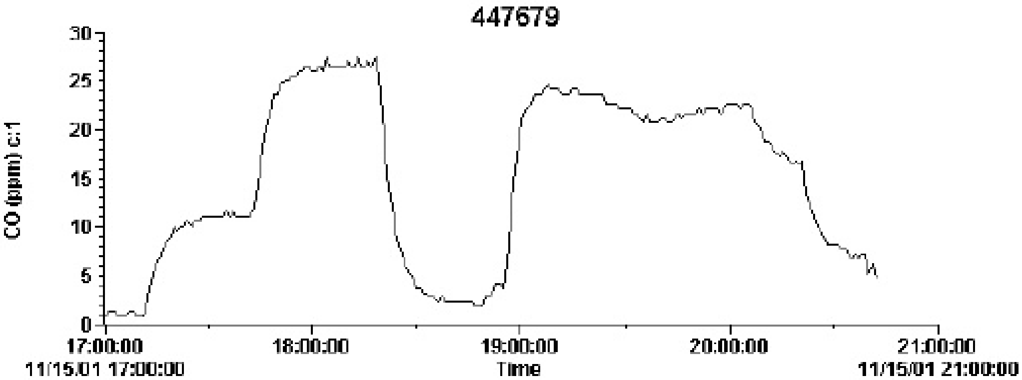
Re: Additional Hobo Test

This is a quick summary of the tests I conducted on the Hobo's response to cold.

Below is a graph that is representative of each of the five Hobos that I put in the freezer. It shows the original zero and two span points audit of the sampler conducted at room temperature (29° C) using the large calibration chamber. The sampler was then placed along with four other Hobos in the small audit case which I had placed in the freezer in Bill's apartment, and I immediately began introducing the high span (25 ppm) audit gas into the case at 18:55. A gas flow rate of 5 lpm was maintained throughout the test. The case had been placed in the freezer approximately one hour before to allow it to equilibrate to the colder temperatures. After letting things stabilize for half an hour, I recorder the air temperature within the case using the Radio Shack probe that I had sealed within the case, and removed the case from the freezer to allow it to gradually warm up. I recorded the following temperatures and times:

19:25	-7° C
19:32	-4° C
19:41	1° C
19:54	7° C
20:06	10° C

At this point, in an effort to devise a method of making things warm up quicker, I accidentally severed the line leading to the temperature probe, and therefore ended the test.



As you can see, the CO response appears to be significantly affected by temperature. The span response appears to have dropped from 26.6 ppm at 29° C to 20.8 ppm at sub-freezing temperatures, approximately a 20% drop. However, there is not a good correlation between the instantaneous temperature and the corresponding CO readings, with a notable lag between the CO trend relative to the temperature trend. One possible explanation would be that the temperature of the air within the sampler itself lagged the "ambient" air temperature. This is consistent with observations made in a previous memo that highlight the limitations of using a chamber that does not have fans to force circulation. Another is that the "temperature correction" feature within the Hobo has some sort of inherent lag. Or it could be that going from 29° C to -7° C in half and hour somehow confuses the sensor and/or the "temperature compensating" feature.

Since we don't have a stable trace associated with a stable temperature, and since the test was aborted prior to returning to the higher temperature, the test is far from conclusive. However the audit test does, I believe, demonstrate a need for more thorough tests of this nature. In terms of establishing CO gradients within the Las Vegas network, any temperature dependency on the part of the Hobos is not that critical, since the entire network will be operating under essentially the same temperature conditions at any given time. All five to the tested Hobos behaved in the same manner and magnitude, so I am reasonably convinced that any temperature dependency is systematic, and consistent for all of the samplers. However, if the Hobo data is to be used to evaluate data relative to ambient air standards, a 20% underestimating of concentrations is probably significant, and should be accurately quantified.

Some quick thoughts on additional tests. My initial idea is to place an ice bag(s) in the big chamber, using the fans to circulate the air. The temperature in the chamber could hopefully be regulated by the amount of ice and the flow rate of the gas being introduced into the chamber. I would place the Hobos on some sort of insolated platform to eliminate any possible influence caused by the Hobo box cooling off at a significantly different rate than the air within it (just trying to simulate ambient operation). No doubt there may be better ways to do the test. I think the key is trying to create relatively stable, maintained cold temperatures to assure that any change in response is not due to rapid/differential heating/cooling of the sampler's components.

Memorandum

To: Bob Baxter

CC: Don Lehrman

From: David Bush

Date: 02/08/02

Re: Van Performance Audit Results

Attached are the performance audit results for the CO monitoring equipment that you used in the van. Per our discussions at the time of the audit, no problems were noted, with both the conventional Dasibi CO analyzer and the Onset Hobo CO monitor reading within 3% of true.

PARSONS ENGINEERING SCIENCE
CARBON MONOXIDE

Date:	11/12/01	Site name:	Van
Start:	17:55 LST	Operator:	Parsons
Finish:	19:30 LST	Project:	Saturation Study
Audited by:	David Bush		
Witness:	Bob Baxter		

Analyzer make:	Dasibi	Model:	3003
Serial No.:	NA	Filter:	NA
Sample flow:	NA	Span setting:	NA
Zero setting:	NA	Vacuum:	NA
Range:	50 PPM	Last cal.:	

Operator provided correction factors:
Corrected data = (IND. * A) + B

	Chart	DAS
Factors= A:	1.000	1.000
B:	0.000	0.000

Audit Point	PPM Input (X)	PPM Chart (Y)	PPM DAS (Y)
1	0.3	#N/A	0.5
2	6.5	#N/A	6.6
3	15.9	#N/A	15.9
4	37.6	#N/A	38.1

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	Chart	DAS
Slope:	#N/A	1.009
Intercept:	#N/A	0.1
Correlation:	#N/A	1.0000

Comments: None.

Audit Equipment	Make	Model	ID	Last Calibration
Dilution System:	Dasibi	5009 CP	281	10/17/01
Zero Air System:	UP Air	SMI	NA	NA
Calibration Gas:	SMI	Multi	JJ12496	07/07/00

PARSONS ENGINEERING SCIENCE
CARBON MONOXIDE

Date:	11/12/01	Site name:	Van
Start:	17:55 LST	Operator:	Parsons
Finish:	19:30 LST	Project:	Saturation Study
Audited by:	David Bush		
Witness:	Bob Baxter		

Analyzer make:	Onset	Model:	Hobo CO
Serial No.:	447671	Filter:	NA
Sample flow:	NA	Span setting:	NA
Zero setting:	NA	Vacuum:	NA
Range:	50 PPM	Last cal.:	10/16/01

Operator provided correction factors:
Corrected data = (IND. * A) + B

	Chart	DAS
Factors= A:	1.000	1.000
B:	0.000	0.000

Audit Point	PPM Input (X)	PPM Chart (Y)	PPM DAS (Y)
1	0.3	#N/A	0.2
2	6.5	#N/A	6.2
3	15.9	#N/A	15.2
4	37.6	#N/A	36.6

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	Chart	DAS
Slope:	#N/A	0.976
Intercept:	#N/A	-0.2
Correlation:	#N/A	1.0000

Comments: None.

Audit Equipment	Make	Model	ID	Last Calibration
Dilution System:	Dasibi	5009 CP	281	10/17/01
Zero Air System:	UP Air	SMI	NA	NA
Calibration Gas:	SMI	Multi	JJ12496	07/07/00

Memorandum

To: Don Lehrman

CC: Bill Knuth

From: David Bush

Date: 02/08/02

Re: Clark County CO Monitoring Network Audits

Attached are the results of the performance audits conducted at the Clark County as part of the Las Vegas Saturation Study. No problems were noted, with all analyzers reading within about 4% of true. In addition to conducting the performance audits, a brief systems audit was conducted at each site. Again, no problems were noted.

PARSONS ENGINEERING SCIENCE
CARBON MONOXIDE

Date: 11/14/01
Start: 08:50 LST
Finish: 10:15 LST
Audited by: David Bush
Witness: Mickey Palmer

Site name: City Center
Operator: Clark County
Project: Clark County

Analyzer make: Dasibi
Serial No.: 878
Sample flow: 1.1 lpm
Zero setting: 48 mV
Range: 50 PPM

Model: 3008
Filter: Yes
Span setting: 100
Vacuum: NA
Last cal.: 10/09/01

Operator provided correction factors:
Corrected data = (IND. * A) + B

	Chart	DAS
Factors= A:	1.000	1.000
B:	0.000	0.000

Audit Point	PPM Input (X)	PPM Chart (Y)	PPM DAS (Y)
1	0.0	0.0	0.1
2	6.5	6.5	6.3
3	17.3	25.0	16.8
4	39.9	39.2	39.4

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	Chart	DAS
Slope:	0.993	0.987
Intercept:	1.9	-0.1
Correlation:	0.9748	1.0000

Comments: None.

Audit Equipment	Make	Model	ID	Last Calibration
Dilution System:	Dasibi	5009 CP	281	10/17/01
Zero Air System:	UP Air	SMI	NA	NA
Calibration Gas:	SMI	Multi	JJ12496	07/07/00

PARSONS ENGINEERING SCIENCE

CARBON MONOXIDE

Date:	11/14/01	Site name:	Sunrise Acres
Start:	10:50 LST	Operator:	Clark County
Finish:	12:00 LST	Project:	Clark County
Audited by:	David Bush		
Witness:	Mickey Palmer		

Analyzer make:	Dasibi	Model:	3008
Serial No.:	1036	Filter:	Yes
Sample flow:	1.1 lpm	Span setting:	117
Zero setting:	64 mV	Vacuum:	NA
Range:	50 PPM	Last cal.:	10/05/01

Operator provided correction factors:
Corrected data = (IND. * A) + B

	Chart	DAS
Factors= A:	1.000	1.000
B:	-5.000	0.000

Audit Point	PPM Input (X)	PPM Chart (Y)	PPM DAS (Y)
1	0.0	0.0	0.0
2	6.5	6.1	6.1
3	17.3	16.3	16.5
4	39.9	38.0	38.2

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	Chart	DAS
Slope:	0.953	0.959
Intercept:	-0.1	-0.1
Correlation:	1.0000	1.0000

Comments: None.

Audit Equipment	Make	Model	ID	Last Calibration
Dilution System:	Dasibi	5009 CP	281	10/17/01
Zero Air System:	UP Air	SMI	NA	NA
Calibration Gas:	SMI	Multi	JJ12496	07/07/00

PARSONS ENGINEERING SCIENCE
CARBON MONOXIDE

Date:	11/14/01	Site name:	JD Smith
Start:	14:20 LST	Operator:	Clark County
Finish:	15:20 LST	Project:	Clark County
Audited by:	David Bush		
Witness:	Monte Symmonds		

Analyzer make:	Dasibi	Model:	3008
Serial No.:	1121	Filter:	Yes
Sample flow:	1.3 lpm	Span setting:	190
Zero setting:	96 mV	Vacuum:	NA
Range:	50 PPM	Last cal.:	10/11/01

Operator provided correction factors:
Corrected data = (IND. * A) + B

	Chart	DAS
Factors= A:	1.000	1.000
B:	0.000	0.000

Audit Point	PPM Input (X)	PPM Chart (Y)	PPM DAS (Y)
1	0.0	0.0	-0.7
2	6.5	6.5	5.8
3	17.3	17.6	16.9
4	39.9	40.2	39.6

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	Chart	DAS
Slope:	1.008	1.011
Intercept:	0.0	-0.7
Correlation:	1.0000	1.0000

Comments: None.

Audit Equipment	Make	Model	ID	Last Calibration
Dilution System:	Dasibi	5009 CP	281	10/17/01
Zero Air System:	UP Air	SMI	NA	NA
Calibration Gas:	SMI	Multi	JJ12496	07/07/00

PARSONS ENGINEERING SCIENCE
CARBON MONOXIDE

Date:	11/16/01	Site name:	Freedom Park

Start:	10:40 LST	Operator:	Clark County
Finish:	12:00 LST	Project:	Clark County
Audited by:	David Bush		
Witness:	Monte Symmonds		

Analyzer make:	Dasibi	Model:	3008
Serial No.:	1170	Filter:	Yes
Sample flow:	1.3 lpm	Span setting:	232
Zero setting:	66 mV	Vacuum:	NA
Range:	50 PPM	Last cal.:	10/11/01

Operator provided correction factors:
Corrected data = (IND. * A) + B

	Chart	DAS
Factors= A:	1.000	1.000
B:	0.000	0.000

Audit Point	PPM Input (X)	PPM Chart (Y)	PPM DAS (Y)
1	0.0	0.7	0.0
2	6.5	7.0	6.4
3	17.3	17.8	17.2
4	39.9	39.3	39.0

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	Chart	DAS
Slope:	0.968	0.977
Intercept:	0.8	0.1
Correlation:	0.9999	1.0000

Comments: None.

Audit Equipment	Make	Model	ID	Last Calibration
Dilution System:	Dasibi	5009 CP	281	10/17/01
Zero Air System:	UP Air	SMI	NA	NA
Calibration Gas:	SMI	Multi	JJ12496	07/07/00

Memorandum

To: Don Lehrman

CC: Bill Knuth, Derek Lehrman, Bob Baxter

From: David Bush

Date: 02/11/02

Re: Van Performance Audit Results

The following is a brief summary of my observations obtained during the data processing audit that I conducted at T&B Systems on February 1, 2002. In addition to discussions with Bill and Derek regarding the processing of the Hobo CO data, I also spoke Bob about the van data.

As we discussed at the time of the audit, the only data processing issue of note was the application of the zero factors to the Hobo data originally anticipated based on the calibrations before and during the study. A review of the processed data revealed a large number of CO concentrations that were negative, indicating that there might be problems with the zero calibration factors, which were typically in the –0.5 to –2.0 ppm range. Further investigation showed that the zeros for the Hobos depend significantly on temperature, and that zero offsets essentially disappeared during cold nighttime hours. This relationship has since been investigated, resulting in the current zero adjustment strategy, which estimates zero offsets as a function of temperature. This current strategy has successfully remove the bulk of the negative concentrations and made the data in general more comparable with the County's monitoring network.

Other than this issue, no problems were noted. Raw data points followed through the data processing effort were all handled correctly.

APPENDIX E

FIELD CALLIBRATION (ZERO/SPAN)

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447676	12/02/01	1713	1747	Field HQ	Zero	0	2.7	wrk
447676	12/02/01	1754	1826	Field HQ	Span	43.3	52	wrk
447716	12/02/01	1713	1747	Field HQ	Zero	0	1.7	wrk
447716	12/02/01	1754	1826	Field HQ	Span	43.3	47.6	wrk
447688	12/02/01	1713	1747	Field HQ	Zero	0	3.7	wrk
447688	12/02/01	1754	1826	Field HQ	Span	43.3	51	wrk
447681	12/02/01	1713	1747	Field HQ	Zero	0	3.2	wrk
447681	12/02/01	1754	1826	Field HQ	Span	43.3	48.1	wrk
447738	12/02/01	1713	1747	Field HQ	Zero	0	1.7	wrk
447738	12/02/01	1754	1826	Field HQ	Span	43.3	48.1	wrk
447710	12/02/01	1713	1747	Field HQ	Zero	0	1.7	wrk
447710	12/02/01	1754	1826	Field HQ	Span	43.3	49.1	wrk
447673	12/02/01	1713	1747	Field HQ	Zero	0	2.7	wrk
447673	12/02/01	1754	1826	Field HQ	Span	43.3	51	wrk
447692	12/02/01	1713	1747	Field HQ	Zero	0	2.2	wrk
447692	12/02/01	1754	1826	Field HQ	Span	43.3	47.1	wrk
447689	12/02/01	1713	1747	Field HQ	Zero	0	1.7	wrk
447689	12/02/01	1754	1826	Field HQ	Span	43.3	47.1	wrk
447718	12/02/01	1713	1747	Field HQ	Zero	0	0.7	wrk
447718	12/02/01	1754	1826	Field HQ	Span	43.3	48.1	wrk
447793	12/02/01	1713	1747	Field HQ	Zero	0	3.2	wrk
447793	12/02/01	1754	1826	Field HQ	Span	43.3	48.1	wrk
447702	12/02/01	1713	1747	Field HQ	Zero	0	1.2	wrk
447702	12/02/01	1754	1826	Field HQ	Span	43.3	42.2	wrk
447712	12/02/01	1713	1747	Field HQ	Zero	0	2.2	wrk
447712	12/02/01	1754	1826	Field HQ	Span	43.3	47.1	wrk
447719	12/02/01	1713	1747	Field HQ	Zero	0	3.7	wrk
447719	12/02/01	1754	1826	Field HQ	Span	43.3	49.1	wrk
447704	12/02/01	1713	1747	Field HQ	Zero	0	1.7	wrk
447704	12/02/01	1754	1826	Field HQ	Span	43.3	49.6	wrk
447728	12/02/01	1713	1747	Field HQ	Zero	0	2.2	wrk
447728	12/02/01	1754	1826	Field HQ	Span	43.3	47.9	wrk
447732	12/02/01	1713	1747	Field HQ	Zero	0	2.2	wrk
447732	12/02/01	1754	1826	Field HQ	Span	43.3	45.7	wrk
447721	12/02/01	1713	1747	Field HQ	Zero	0	1.2	wrk
447721	12/02/01	1754	1826	Field HQ	Span	43.3	44.2	wrk
447731	12/02/01	1713	1747	Field HQ	Zero	0	1.7	wrk
447731	12/02/01	1754	1826	Field HQ	Span	43.3	48.1	wrk
447740	12/02/01	1713	1747	Field HQ	Zero	0	2.2	wrk
447740	12/02/01	1754	1826	Field HQ	Span	43.3	48.1	wrk
447720	12/02/01	1713	1747	Field HQ	Zero	0	2.7	wrk
447720	12/02/01	1754	1826	Field HQ	Span	43.3	49.6	wrk

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447724	12/02/01	1713	1747	Field HQ	Zero	0	2.7	wrk
447724	12/02/01	1754	1826	Field HQ	Span	43.3	44.2	wrk
447699	12/03/01	1955	2031	Field HQ	Zero	0	2.2	wrk
447699	12/03/01	2039	2110	Field HQ	Span	43.3	47.1	wrk
447701	12/03/01	1955	2031	Field HQ	Zero	0	1.7	wrk
447701	12/03/01	2039	2110	Field HQ	Span	43.3	44.2	wrk
447734	12/03/01	1955	2031	Field HQ	Zero	0	2.2	wrk
447734	12/03/01	2039	2110	Field HQ	Span	43.3	48.1	wrk
447674	12/03/01	1955	2031	Field HQ	Zero	0	3.7	wrk
447674	12/03/01	2039	2110	Field HQ	Span	43.3	51.5	wrk
447727	12/03/01	1955	2031	Field HQ	Zero	0	1.7	wrk
447727	12/03/01	2039	2110	Field HQ	Span	43.3	43.7	wrk
447686	12/03/01	1955	2031	Field HQ	Zero	0	2.2	wrk
447686	12/03/01	2039	2110	Field HQ	Span	43.3	45.7	wrk
447697	12/03/01	1955	2031	Field HQ	Zero	0	2.7	wrk
447697	12/03/01	2039	2110	Field HQ	Span	43.3	49.1	wrk
447709	12/03/01	1955	2031	Field HQ	Zero	0	1.7	wrk
447709	12/03/01	2039	2110	Field HQ	Span	43.3	48.1	wrk
447729	12/03/01	1955	2031	Field HQ	Zero	0	1.2	wrk
447729	12/03/01	2039	2110	Field HQ	Span	43.3	47.6	wrk
447687	12/03/01	1955	2031	Field HQ	Zero	0	1.7	wrk
447687	12/03/01	2039	2110	Field HQ	Span	43.3	47.1	wrk
447680	12/03/01	1955	2031	Field HQ	Zero	0	2.7	wrk
447680	12/03/01	2039	2110	Field HQ	Span	43.3	51	wrk
447684	12/03/01	1955	2031	Field HQ	Zero	0	2.7	wrk
447684	12/03/01	2039	2110	Field HQ	Span	43.3	49.1	wrk
447700	12/03/01	1955	2031	Field HQ	Zero	0	2.2	wrk
447700	12/03/01	2039	2110	Field HQ	Span	43.3	48.6	wrk
447705	12/03/01	1955	2031	Field HQ	Zero	0	3.2	wrk
447705	12/03/01	2039	2110	Field HQ	Span	43.3	52.5	wrk
447707	12/03/01	1955	2031	Field HQ	Zero	0	2.2	wrk
447707	12/03/01	2039	2110	Field HQ	Span	43.3	49.1	wrk
447693	12/03/01	1955	2031	Field HQ	Zero	0	1.7	wrk
447693	12/03/01	2039	2110	Field HQ	Span	43.3	49.1	wrk
447696	12/03/01	1955	2031	Field HQ	Zero	0	2.7	wrk
447696	12/03/01	2039	2110	Field HQ	Span	43.3	49.6	wrk
447724	12/03/01	1955	2031	Field HQ	Zero	0	1.7	wrk
447724	12/03/01	2039	2110	Field HQ	Span	43.3	44.7	wrk
447695	12/03/01	1955	2031	Field HQ	Zero	0	3.2	wrk
447695	12/03/01	2039	2110	Field HQ	Span	43.3	49.1	wrk
447698	12/03/01	1955	2031	Field HQ	Zero	0	1.7	wrk
447698	12/03/01	2039	2110	Field HQ	Span	43.3	49.1	wrk

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447400	12/06/01	1850	1920	Field HQ	Zero	0	1.7	wrk
447400	12/06/01	1925	1958	Field HQ	Span	43.3	44.6	wrk
447401	12/06/01	1850	1920	Field HQ	Zero	0	1.2	wrk
447401	12/06/01	1925	1958	Field HQ	Span	43.3	44.4	wrk
447402	12/06/01	1850	1920	Field HQ	Zero	0	1.7	wrk
447402	12/06/01	1925	1958	Field HQ	Span	43.3	44.7	wrk
447683	12/06/01	1850	1920	Field HQ	Zero	0	1.7	wrk
447683	12/06/01	1925	1958	Field HQ	Span	43.3	45.5	wrk
447733	12/06/01	1850	1920	Field HQ	Zero	0	1.7	wrk
447773	12/06/01	1925	1958	Field HQ	Span	43.3	45.2	wrk
447711	12/06/01	1850	1920	Field HQ	Zero	0	2.2	wrk
447711	12/06/01	1925	1958	Field HQ	Span	43.3	47.6	wrk
447678	12/06/01	1850	1920	Field HQ	Zero	0	1.7	wrk
447678	12/06/01	1925	1958	Field HQ	Span	43.3	49.1	wrk
447715	12/06/01	1850	1920	Field HQ	Zero	0	1.2	wrk
447715	12/06/01	1925	1958	Field HQ	Span	43.3	46.1	wrk
447723	12/06/01	1850	1920	Field HQ	Zero	0	1.7	wrk
447723	12/06/01	1925	1958	Field HQ	Span	43.3	44.7	wrk
447691	12/06/01	1850	1920	Field HQ	Zero	0	1.7	wrk
447691	12/06/01	1925	1958	Field HQ	Span	43.3	47.5	wrk
447694	12/06/01	1850	1920	Field HQ	Zero	0	1.7	wrk
447694	12/06/01	1925	1958	Field HQ	Span	43.3	46.4	wrk
447677	12/06/01	1850	1920	Field HQ	Zero	0	2.7	wrk
447677	12/06/01	1925	1958	Field HQ	Span	43.3	49.6	wrk
447670	12/06/01	1850	1920	Field HQ	Zero	0	2.7	wrk
447670	12/06/01	1925	1958	Field HQ	Span	43.3	44.2	wrk
447706	12/06/01	1850	1920	Field HQ	Zero	0	1.2	wrk
447706	12/06/01	1925	1958	Field HQ	Span	43.3	45.2	wrk
447722	12/06/01	1850	1920	Field HQ	Zero	0	1.2	wrk
447722	12/06/01	1925	1958	Field HQ	Span	43.3	48.1	wrk
447690	12/06/01	1850	1920	Field HQ	Zero	0	2.2	wrk
447690	12/06/01	1925	1958	Field HQ	Span	43.3	49.1	wrk
447725	12/06/01	1850	1920	Field HQ	Zero	0	1.2	wrk
447725	12/06/01	1925	1958	Field HQ	Span	43.3	46.1	wrk
447685	12/06/01	1850	1920	Field HQ	Zero	0	2.2	wrk
447685	12/06/01	1925	1958	Field HQ	Span	43.3	49.6	wrk
447679	12/06/01	1850	1920	Field HQ	Zero	0	1.2	wrk
447679	12/06/01	1925	1958	Field HQ	Span	43.3	47.1	wrk
447736	12/06/01	1850	1920	Field HQ	Zero	0	1.2	wrk
447736	12/06/01	1925	1958	Field HQ	Span	43.3	48.1	wrk
447726	12/06/01	1850	1920	Field HQ	Zero	0	2.2	wrk
447726	12/06/01	1925	1958	Field HQ	Span	43.3	49.6	wrk

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447708	12/06/01	1850	1920	Field HQ	Zero	0	3.2	wrk
447708	12/06/01	1925	1958	Field HQ	Span	43.3	49.1	wrk
447737	12/06/01	1850	1920	Field HQ	Zero	0	1.2	wrk
447737	12/06/01	1925	1958	Field HQ	Span	43.3	44.2	wrk
447679	12/21/01	2130	2200	Field HQ	Zero	0	1.2	wrk
447679	12/21/01	2203	2238	Field HQ	Span	43.3	47.1	wrk
447704	12/21/01	2130	2200	Field HQ	Zero	0	1.2	wrk
447704	12/21/01	2203	2238	Field HQ	Span	43.3	51	wrk
447726	12/21/01	2130	2200	Field HQ	Zero	0	2.2	wrk
447726	12/21/01	2203	2238	Field HQ	Span	43.3	49.6	wrk
447685	12/21/01	2130	2200	Field HQ	Zero	0	3.2	wrk
447685	12/21/01	2203	2238	Field HQ	Span	43.3	52	wrk
447687	12/21/01	2130	2200	Field HQ	Zero	0	2.2	wrk
447687	12/21/01	2203	2238	Field HQ	Span	43.3	48.1	wrk
447691	12/21/01	2130	2200	Field HQ	Zero	0	2.2	wrk
447691	12/21/01	2203	2238	Field HQ	Span	43.3	48.1	wrk
447693	12/21/01	2130	2200	Field HQ	Zero	0	1.7	wrk
447693	12/21/01	2203	2238	Field HQ	Span	43.3	51	wrk
447684	12/21/01	2130	2200	Field HQ	Zero	0	2.2	wrk
447684	12/21/01	2203	2238	Field HQ	Span	43.3	51	wrk
447681	12/21/01	2130	2200	Field HQ	Zero	0	1.7	wrk
447681	12/21/01	2203	2238	Field HQ	Span	43.3	47.1	wrk
447734	12/21/01	2130	2200	Field HQ	Zero	0	1.7	wrk
447734	12/21/01	2203	2238	Field HQ	Span	43.3	47.1	wrk
447391	12/21/01	2130	2200	Field HQ	Zero	0	0.2	wrk
447391	12/21/01	2203	2238	Field HQ	Span	43.3	43.2	wrk
447695	12/21/01	2130	2200	Field HQ	Zero	0	2.1	wrk
447695	12/21/01	2203	2238	Field HQ	Span	43.3	47.6	wrk
447731	12/21/01	2130	2200	Field HQ	Zero	0	1.2	wrk
447731	12/21/01	2203	2238	Field HQ	Span	43.3	47.1	wrk
447739	12/21/01	2130	2200	Field HQ	Zero	0	1.7	wrk
447739	12/21/01	2203	2238	Field HQ	Span	43.3	50	wrk
447361	12/21/01	2130	2200	Field HQ	Zero	0	0.7	wrk
447361	12/21/01	2203	2238	Field HQ	Span	43.3	49.6	wrk
447720	12/21/01	2130	2200	Field HQ	Zero	0	1.2	wrk
447720	12/21/01	2203	2238	Field HQ	Span	43.3	49.1	wrk
447697	12/21/01	2130	2200	Field HQ	Zero	0	1.7	wrk
447697	12/21/01	2203	2238	Field HQ	Span	43.3	47.1	wrk
447388	12/21/01	2130	2200	Field HQ	Zero	0	0.2	wrk
447388	12/21/01	2203	2238	Field HQ	Span	43.3	43.7	wrk
447723	12/21/01	2130	2200	Field HQ	Zero	0	1.7	wrk
447723	12/21/01	2203	2238	Field HQ	Span	43.3	46.1	wrk

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447701	12/21/01	2130	2200	Field HQ	Zero	0	1.2	wrk
447701	12/21/01	2203	2238	Field HQ	Span	43.3	44.2	wrk
447696	12/21/01	2130	2200	Field HQ	Zero	0	2.2	wrk
447696	12/21/01	2203	2238	Field HQ	Span	43.3	49.6	wrk
447700	12/21/01	2130	2200	Field HQ	Zero	0	1.2	wrk
447700	12/21/01	2203	2238	Field HQ	Span	43.3	47.6	wrk
447394	12/21/01	2130	2200	Field HQ	Zero	0	0.7	wrk
447394	12/21/01	2203	2238	Field HQ	Span	43.3	43.2	wrk
447699	12/21/01	2130	2200	Field HQ	Zero	0	2.2	wrk
447699	12/21/01	2203	2238	Field HQ	Span	43.3	45.7	wrk
447363	12/21/01	2130	2200	Field HQ	Zero	0	0.2	wrk
447363	12/21/01	2203	2238	Field HQ	Span	43.3	43.7	wrk
447359	12/21/01	2130	2200	Field HQ	Zero	0	0.2	wrk
447395	12/21/01	2203	2238	Field HQ	Span	43.3	44.2	wrk
447683	12/21/01	2130	2200	Field HQ	Zero	0	1.7	wrk
447683	12/21/01	2203	2238	Field HQ	Span	43.3	48.1	wrk
447689	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447689	12/22/01	1947	2017	Field HQ	Span	43.3	47.1	wrk
447698	12/22/01	1915	1945	Field HQ	Zero	0	0.7	wrk
447698	12/22/01	1947	2017	Field HQ	Span	43.3	49.1	wrk
447673	12/22/01	1915	1945	Field HQ	Zero	0	1.7	wrk
447673	12/22/01	1947	2017	Field HQ	Span	43.3	51	wrk
447708	12/22/01	1915	1945	Field HQ	Zero	0	2.7	wrk
447708	12/22/01	1947	2017	Field HQ	Span	43.3	51	wrk
447692	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447692	12/22/01	1947	2017	Field HQ	Span	43.3	45.7	wrk
447680	12/22/01	1915	1945	Field HQ	Zero	0	2.2	wrk
447680	12/22/01	1947	2017	Field HQ	Span	43.3	49.1	wrk
447676	12/22/01	1915	1945	Field HQ	Zero	0	1.7	wrk
447676	12/22/01	1947	2017	Field HQ	Span	43.3	51	wrk
447728	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447728	12/22/01	1947	2017	Field HQ	Span	43.3	47.1	wrk
447716	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447716	12/22/01	1947	2017	Field HQ	Span	43.3	47.1	wrk
447740	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447740	12/22/01	1947	2017	Field HQ	Span	43.3	49.1	wrk
447736	12/22/01	1915	1945	Field HQ	Zero	0	0.7	wrk
447736	12/22/01	1947	2017	Field HQ	Span	43.3	47.6	wrk
447733	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447733	12/22/01	1947	2017	Field HQ	Span	43.3	47.1	wrk
447729	12/22/01	1915	1945	Field HQ	Zero	0	0.7	wrk
477729	12/22/01	1947	2017	Field HQ	Span	43.3	47.1	wrk

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447677	12/22/01	1915	1945	Field HQ	Zero	0	2.2	wrk
447677	12/22/01	1947	2017	Field HQ	Span	43.3	50	wrk
447721	12/22/01	1915	1945	Field HQ	Zero	0	0.7	wrk
447721	12/22/01	1947	2017	Field HQ	Span	43.3	43.2	wrk
447712	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447712	12/22/01	1947	2017	Field HQ	Span	43.3	45.2	wrk
447725	12/22/01	1915	1945	Field HQ	Zero	0	0.7	wrk
447725	12/22/01	1947	2017	Field HQ	Span	43.3	47.1	wrk
447724	12/22/01	1915	1945	Field HQ	Zero	0	1.7	wrk
447724	12/22/01	1947	2017	Field HQ	Span	43.3	43.7	wrk
447732	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447732	12/22/01	1947	2017	Field HQ	Span	43.3	44.2	wrk
447709	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447709	12/22/01	1947	2017	Field HQ	Span	43.3	48.1	wrk
447722	12/22/01	1915	1945	Field HQ	Zero	0	0.7	wrk
447722	12/22/01	1947	2017	Field HQ	Span	43.3	45.7	wrk
447719	12/22/01	1915	1945	Field HQ	Zero	0	1.7	wrk
447719	12/22/01	1947	2017	Field HQ	Span	43.3	47.1	wrk
447705	12/22/01	1915	1945	Field HQ	Zero	0	3.2	wrk
447705	12/22/01	1947	2017	Field HQ	Span	43.3	53.5	wrk
447702	12/22/01	1915	1945	Field HQ	Zero	0	0.7	wrk
447702	12/22/01	1947	2017	Field HQ	Span	43.3	41.3	wrk
447686	12/22/01	1915	1945	Field HQ	Zero	0	1.7	wrk
447686	12/22/01	1947	2017	Field HQ	Span	43.3	45.2	wrk
447737	12/22/01	1915	1945	Field HQ	Zero	0	1.2	wrk
447737	12/22/01	1947	2017	Field HQ	Span	43.3	44.7	wrk
447727	12/22/01	1915	1945	Field HQ	Zero	0	1.7	wrk
447727	12/22/01	1947	2017	Field HQ	Span	43.3	43.7	wrk
447401	12/24/01	750	820	Field HQ	Zero	0	0.7	wrk
447401	12/24/01	825	855	Field HQ	Span	43.3	43.2	wrk
447688	12/24/01	750	820	Field HQ	Zero	0	1.7	wrk
447688	12/24/01	825	855	Field HQ	Span	43.3	50	wrk
447690	12/24/01	750	820	Field HQ	Zero	0	1.2	wrk
447690	12/24/01	825	855	Field HQ	Span	43.3	48.1	wrk
447706	12/24/01	750	820	Field HQ	Zero	0	1.2	wrk
447706	12/24/01	825	855	Field HQ	Span	43.3	45.2	wrk
447718	12/24/01	750	820	Field HQ	Zero	0	0.7	wrk
447718	12/24/01	825	855	Field HQ	Span	43.3	49.1	wrk
447710	12/24/01	750	820	Field HQ	Zero	0	1.2	wrk
447710	12/24/01	825	855	Field HQ	Span	43.3	49.1	wrk
447738	12/24/01	750	820	Field HQ	Zero	0	0.7	wrk
447738	12/24/01	825	855	Field HQ	Span	43.3	47.1	wrk

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447674	12/24/01	750	820	Field HQ	Zero	0	1.7	wrk
447674	12/24/01	825	855	Field HQ	Span	43.3	51	wrk
447670	12/24/01	750	820	Field HQ	Zero	0	1.7	wrk
447670	12/24/01	825	855	Field HQ	Span	43.3	43.2	wrk
447678	12/24/01	750	820	Field HQ	Zero	0	1.2	wrk
447678	12/24/01	825	855	Field HQ	Span	43.3	49.1	wrk
447740	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447740	01/08/02	725	805	Field HQ	Span	43.3	49.1	wrk
447688	01/08/02	650	720	Field HQ	Zero	0	1.7	wrk
447688	01/08/02	725	805	Field HQ	Span	43.3	51	wrk
447391	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447391	01/08/02	725	805	Field HQ	Span	43.3	47.1	wrk
447734	01/08/02	650	720	Field HQ	Zero	0	1.7	wrk
447734	01/08/02	725	805	Field HQ	Span	43.3	48.1	wrk
447677	01/08/02	650	720	Field HQ	Zero	0	2.2	wrk
447677	01/08/02	725	805	Field HQ	Span	43.3	51	wrk
447715	01/08/02	650	720	Field HQ	Zero	0	1.7	wrk
447715	01/08/02	725	805	Field HQ	Span	43.3	48.1	wrk
447695	01/08/02	650	720	Field HQ	Zero	0	2.2	wrk
447695	01/08/02	725	805	Field HQ	Span	43.3	49.1	wrk
447729	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447729	01/08/02	725	805	Field HQ	Span	43.3	49.1	wrk
447678	01/08/02	650	720	Field HQ	Zero	0	1.7	wrk
447678	01/08/02	725	805	Field HQ	Span	43.3	50	wrk
447673	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447673	01/08/02	725	805	Field HQ	Span	43.3	49.1	wrk
447716	01/08/02	650	720	Field HQ	Zero	0	0.7	wrk
447716	01/08/02	725	805	Field HQ	Span	43.3	47.1	wrk
447363	01/08/02	650	720	Field HQ	Zero	0	0.2	wrk
447363	01/08/02	725	805	Field HQ	Span	43.3	47.1	wrk
447685	01/08/02	650	720	Field HQ	Zero	0	1.7	wrk
447685	01/08/02	725	805	Field HQ	Span	43.3	51	wrk
447690	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447690	01/08/02	725	805	Field HQ	Span	43.3	47.1	wrk
447711	01/08/02	650	720	Field HQ	Zero	0	1.7	wrk
447711	01/08/02	725	805	Field HQ	Span	43.3	48.1	wrk
447698	01/08/02	650	720	Field HQ	Zero	0	0.7	wrk
447698	01/08/02	725	805	Field HQ	Span	43.3	48.1	wrk
447684	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447684	01/08/02	725	805	Field HQ	Span	43.3	49.1	wrk
447361	01/08/02	650	720	Field HQ	Zero	0	0.7	wrk
447361	01/08/02	725	805	Field HQ	Span	43.3	50	wrk

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447689	01/08/02	650	720	Field HQ	Zero	0	0.7	wrk
447689	01/08/02	725	805	Field HQ	Span	43.3	48.1	wrk
447704	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447704	01/08/02	725	805	Field HQ	Span	43.3	49.1	wrk
447697	01/08/02	650	720	Field HQ	Zero	0	1.7	wrk
447697	01/08/02	725	805	Field HQ	Span	43.3	48.1	wrk
447681	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447681	01/08/02	725	805	Field HQ	Span	43.3	47.1	wrk
447708	01/08/02	650	720	Field HQ	Zero	0	2.2	wrk
447708	01/08/02	725	805	Field HQ	Span	43.3	48.1	wrk
447731	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447731	01/08/02	725	805	Field HQ	Span	43.3	47.1	wrk
447739	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447739	01/08/02	725	805	Field HQ	Span	43.3	48.1	wrk
447700	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447700	01/08/02	725	805	Field HQ	Span	43.3	46.6	wrk
447726	01/08/02	650	720	Field HQ	Zero	0	1.7	wrk
447726	01/08/02	725	805	Field HQ	Span	43.3	49.1	wrk
447388	01/08/02	650	720	Field HQ	Zero	0	0.7	wrk
447388	01/08/02	725	805	Field HQ	Span	43.3	47.1	wrk
447702	01/08/02	650	720	Field HQ	Zero	0	0.2	wrk
447702	01/08/02	725	805	Field HQ	Span	43.3	41.3	wrk
447693	01/08/02	650	720	Field HQ	Zero	0	0.7	wrk
447693	01/08/02	725	805	Field HQ	Span	43.3	49.1	wrk
447723	01/08/02	650	720	Field HQ	Zero	0	0.7	wrk
447723	01/08/02	725	805	Field HQ	Span	43.3	45.7	wrk
447721	01/08/02	650	720	Field HQ	Zero	0	0.7	wrk
447721	01/08/02	725	805	Field HQ	Span	43.3	45.2	wrk
447696	01/08/02	650	720	Field HQ	Zero	0	2.2	wrk
447696	01/08/02	725	805	Field HQ	Span	43.3	49.6	wrk
447401	01/08/02	650	720	Field HQ	Zero	0	1.2	wrk
447401	01/08/02	725	805	Field HQ	Span	43.3	43.2	wrk
447736	01/09/02			Field HQ	Zero	0	0.7	wrk
447736	01/09/02	725	805	Field HQ	Span	43.3	49.6	wrk
447699	01/09/02	650	720	Field HQ	Zero	0	1.7	wrk
447699	01/09/02	725	805	Field HQ	Span	43.3	45.7	wrk
447692	01/09/02	650	720	Field HQ	Zero	0	1.2	wrk
447692	01/09/02	725	805	Field HQ	Span	43.3	47.1	wrk
447725	01/09/02	650	720	Field HQ	Zero	0	1.2	wrk
447725	01/09/02	725	805	Field HQ	Span	43.3	47.1	wrk
447686	01/09/02	650	720	Field HQ	Zero	0	1.7	wrk
447686	01/09/02	725	805	Field HQ	Span	43.3	45.2	wrk

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447683	01/09/02	650	720	Field HQ	Zero	0	1.2	wrk
447683	01/09/02	725	805	Field HQ	Span	43.3	47.1	wrk
447706	01/09/02	1720	1750	Field HQ	Zero	0	0.7	wrk
447706	01/09/02	1755	1830	Field HQ	Span	43.3	44.7	wrk
447709	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447709	01/09/02	1755	1830	Field HQ	Span	43.3	48.1	wrk
447722	01/09/02	1720	1750	Field HQ	Zero	0	0.7	wrk
447722	01/09/02	1755	1830	Field HQ	Span	43.3	47.1	wrk
447680	01/09/02	1720	1750	Field HQ	Zero	0	2.2	wrk
447680	01/09/02	1755	1830	Field HQ	Span	43.3	49.1	wrk
447727	01/09/02	1720	1750	Field HQ	Zero	0	1.7	wrk
447727	01/09/02	1755	1830	Field HQ	Span	43.3	43.7	wrk
447694	01/09/02	1720	1750	Field HQ	Zero	0	1.7	wrk
447694	01/09/02	1755	1830	Field HQ	Span	43.3	47.1	wrk
447691	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447691	01/09/02	1755	1830	Field HQ	Span	43.3	47.1	wrk
447733	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447733	01/09/02	1755	1830	Field HQ	Span	43.3	44.2	wrk
447701	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447701	01/09/02	1755	1830	Field HQ	Span	43.3	43.2	wrk
447732	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447732	01/09/02	1755	1830	Field HQ	Span	43.3	44.7	wrk
447737	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447737	01/09/02	1755	1830	Field HQ	Span	43.3	45.7	wrk
447718	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447718	01/09/02	1755	1830	Field HQ	Span	43.3	49.1	wrk
447719	01/09/02	1720	1750	Field HQ	Zero	0	1.7	wrk
447719	01/09/02	1755	1830	Field HQ	Span	43.3	48.1	wrk
447710	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447710	01/09/02	1755	1830	Field HQ	Span	43.3	49.1	wrk
447676	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447676	01/09/02	1755	1830	Field HQ	Span	43.3	51.5	wrk
447394	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447394	01/09/02	1755	1830	Field HQ	Span	43.3	47.1	wrk
447705	01/09/02	1720	1750	Field HQ	Zero	0	3.2	wrk
447705	01/09/02	1755	1830	Field HQ	Span	43.3	52.5	wrk
447724	01/09/02	1720	1750	Field HQ	Zero	0	1.7	wrk
447724	01/09/02	1755	1830	Field HQ	Span	43.3	44.2	wrk
447679	01/09/02	1720	1750	Field HQ	Zero	0	0.7	wrk
447679	01/09/02	1755	1830	Field HQ	Span	43.3	47.1	wrk
447728	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447728	01/09/02	1755	1830	Field HQ	Span	43.3	45.7	wrk

Appendix E. Field Callibration (Zero/Span)

		Time	Time			CO (ppm)		
S/N	Date	Start	Finish	Location	Cal Source	Input	Response	Initials
447687	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447687	01/09/02	1755	1830	Field HQ	Span	43.3	47.1	wrk
447738	01/09/02	1720	1750	Field HQ	Zero	0	0.7	wrk
447738	01/09/02	1755	1830	Field HQ	Span	43.3	45.7	wrk
447720	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447720	01/09/02	1755	1830	Field HQ	Span	43.3	49.1	wrk
447707	01/09/02	1720	1750	Field HQ	Zero	0	1.7	wrk
447707	01/09/02	1755	1830	Field HQ	Span	43.3	49.1	wrk
447670	01/09/02	1720	1750	Field HQ	Zero	0	2.7	wrk
447670	01/09/02	1755	1830	Field HQ	Span	43.3	43.7	wrk
447674	01/09/02	1720	1750	Field HQ	Zero	0	3.2	wrk
447674	01/09/02	1755	1830	Field HQ	Span	43.3	52.5	wrk
447359	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447359	01/09/02	1755	1830	Field HQ	Span	43.3	47.1	wrk
447712	01/09/02	1720	1750	Field HQ	Zero	0	1.2	wrk
447712	01/09/02	1755	1830	Field HQ	Span	43.3	47.1	wrk

APPENDIX F

ACCEPTANCE TEST MULTIPOINT CALIBRATIONS

Appendix F. Acceptance Test Multipoint Calibrations

Span cylinder value (ppm): 43.4, Span tolerance (%): 10%, Zero tolerance (ppm): 1.5

		Slope	Int.	Corr.	Calculated Raw Tolerance Values			
S/N	Date	(#.###)	(#.#)	(#.####)	zero min	zero max	span min	span max
447346	10/12/2001	0.900	-0.5	1.0000	-1.2	2.2	43.9	53.5
447670	10/16/2001	1.062	-2.0	1.0000	0.5	3.4	38.7	46.9
447671	10/16/2001	1.020	0.0	0.9998	-1.5	1.4	38.3	46.8
447672	10/16/2001	1.014	-0.9	0.9999	-0.6	2.4	39.4	48.0
447673	10/16/2001	0.883	-0.9	0.9999	-0.8	2.6	45.1	55.0
447674	10/16/2001	0.877	-1.5	0.9999	-0.2	3.2	46.1	56.0
447675	10/16/2001	0.939	-0.3	1.0000	-1.3	1.9	41.9	51.1
447676	10/16/2001	0.856	-0.3	0.9999	-1.5	2.0	45.9	56.0
447677	10/16/2001	0.878	-1.1	1.0000	-0.6	2.8	45.6	55.5
447678	10/16/2001	0.916	-0.9	0.9999	-0.7	2.6	43.6	53.0
447679	10/16/2001	0.956	-0.3	1.0000	-1.2	1.9	41.2	50.3
447680	10/16/2001	0.945	-1.5	1.0000	-0.1	3.0	42.8	52.0
447681	10/16/2001	0.959	-0.5	0.9999	-1.1	2.1	41.2	50.3
447682	10/15/2001	0.959	-0.3	0.9999	-1.2	1.9	41.1	50.1
447683	10/15/2001	0.954	-1.0	1.0000	-0.6	2.5	41.9	51.0
447684	10/15/2001	0.908	-1.4	0.9998	-0.3	3.0	44.4	53.9
447685	10/15/2001	0.890	-2.2	0.9998	0.5	3.9	46.1	55.8
447686	10/15/2001	1.022	-1.9	1.0000	0.4	3.3	40.1	48.6
447687	10/15/2001	0.928	-1.0	1.0000	-0.6	2.6	43.1	52.4
447688	10/15/2001	0.855	-2.0	0.9998	0.2	3.7	47.6	57.8
447689	10/15/2001	0.938	-1.0	1.0000	-0.6	2.6	42.6	51.8
447690	10/15/2001	0.906	-1.3	0.9998	-0.3	3.0	44.5	54.0
447691	10/15/2001	0.904	-0.9	0.9998	-0.7	2.6	44.1	53.7
447692	10/15/2001	0.968	-0.9	0.9997	-0.7	2.4	41.2	50.2
447693	10/15/2001	0.881	-1.0	0.9999	-0.7	2.7	45.4	55.2
447694	10/15/2001	0.942	-1.5	0.9999	-0.1	3.1	43.0	52.2
447695	10/15/2001	0.922	-2.0	0.9999	0.4	3.7	44.4	53.8
447696	10/15/2001	0.911	-1.8	1.0000	0.2	3.4	44.7	54.2
447697	10/15/2001	0.957	-1.7	0.9999	0.1	3.3	42.5	51.6
447698	10/15/2001	0.918	-0.6	1.0000	-1.1	2.2	43.1	52.5
447699	10/15/2001	0.966	-2.0	1.0000	0.5	3.6	42.5	51.4
447700	10/15/2001	0.938	-1.4	1.0000	-0.2	3.0	43.1	52.3
447701	10/15/2001	0.992	-0.7	0.9999	-0.8	2.2	40.1	48.8
447702	10/15/2001	1.051	-1.3	1.0000	-0.1	2.7	38.4	46.7
447703	10/15/2001	0.870	-1.0	0.9999	-0.7	2.8	45.9	55.9
447704	10/15/2001	0.952	-0.7	0.9999	-0.9	2.3	41.7	50.9
447705	10/15/2001	0.862	-2.6	1.0000	0.9	4.3	47.9	58.0
447706	10/15/2001	0.980	-0.8	0.9999	-0.8	2.3	40.6	49.5
447707	10/15/2001	0.885	-1.1	1.0000	-0.6	2.8	45.2	55.1
447708	10/15/2001	0.917	-3.2	0.9999	1.6	4.9	45.8	55.3
447709	10/15/2001	0.913	-1.2	0.9998	-0.4	2.9	44.0	53.5

Appendix F. Acceptance Test Multipoint Calibrations

Span cylinder value (ppm): 43.4, Span tolerance (%): 10%, Zero tolerance (ppm): 1.5

		Slope	Int.	Corr.	Calculated Raw Tolerance Values			
S/N	Date	(#.###)	(#.#)	(#.####)	zero min	zero max	span min	span max
447710	10/15/2001	0.926	-1.1	0.9997	-0.5	2.8	43.3	52.7
447711	10/15/2001	0.943	-1.8	0.9999	0.2	3.4	43.2	52.4
447712	10/15/2001	0.961	-1.3	1.0000	-0.3	2.9	41.9	51.0
447714	10/15/2001	0.894	-0.3	0.9999	-1.4	2.0	44.0	53.7
447715	10/15/2001	0.915	-0.5	0.9999	-1.1	2.1	43.2	52.7
447716	10/15/2001	0.930	-0.2	0.9998	-1.4	1.8	42.2	51.5
447717	10/15/2001	0.910	-0.3	0.9999	-1.3	1.9	43.2	52.8
447718	10/15/2001	0.920	0.0	1.0000	-1.6	1.6	42.5	51.9
447719	10/15/2001	0.913	-1.0	0.9996	-0.7	2.6	43.7	53.2
447720	10/15/2001	0.905	-0.5	0.9999	-1.2	2.1	43.6	53.2
447721	10/15/2001	0.968	0.0	0.9999	-1.5	1.6	40.4	49.4
447722	10/15/2001	0.910	-0.1	1.0000	-1.5	1.8	43.0	52.6
447723	10/15/2001	0.965	-0.5	1.0000	-1.0	2.1	41.0	50.0
447724	10/15/2001	0.987	-0.7	1.0000	-0.8	2.2	40.3	49.1
447725	10/15/2001	0.905	-0.4	0.9999	-1.3	2.0	43.5	53.1
447726	10/15/2001	0.903	-0.9	0.9997	-0.8	2.5	44.1	53.8
447727	10/15/2001	1.006	-0.5	1.0000	-1.0	2.0	39.3	47.9
447728	10/15/2001	0.942	-0.5	0.9999	-1.1	2.1	41.9	51.2
447729	10/15/2001	0.916	-0.1	1.0000	-1.6	1.7	42.7	52.2
447730	10/16/2001	0.960	-0.3	1.0000	-1.3	1.8	41.0	50.0
447731	10/15/2001	0.952	-0.2	0.9999	-1.4	1.7	41.2	50.3
447732	10/15/2001	1.000	-0.8	1.0000	-0.7	2.3	39.9	48.5
447733	10/15/2001	0.991	-0.6	1.0000	-0.9	2.1	40.1	48.8
447734	10/15/2001	0.942	-0.9	0.9999	-0.7	2.5	42.4	51.6
447735	10/15/2001	0.920	-0.5	0.9999	-1.2	2.1	42.9	52.3
447736	10/15/2001	0.925	0.3	0.9996	-1.9	1.4	42.0	51.4
447737	10/15/2001	1.006	-0.5	1.0000	-1.0	2.0	39.3	47.9
447738	10/15/2001	0.965	-0.5	1.0000	-1.0	2.1	41.0	50.0
447739	10/15/2001	0.919	-0.4	0.9999	-1.2	2.0	42.9	52.4
447740	10/15/2001	0.917	-0.3	1.0000	-1.3	1.9	42.9	52.4

APPENDIX G

ONSET CO ANALYZER SPECIFICATIONS AND TESTS

APPENDIX G: ONSET CO ANALYZER SPECIFICATIONS

HOBO® Carbon Monoxide Logger
Monitor carbon monoxide (CO) levels in areas such as garages, terminals, loading docks, construction sites, furnace rooms, office buildings and living areas. Convenient battery operation eliminates the need to run wires for AC power, making it easy to deploy the HOBO CO logger at various potential hotspots. Use the resulting data to help identify problems with furnaces, vehicles, water heaters, stoves, fireplaces, ventilation, air supplies, and flues (non-condensing environments only). Optimize resolution and accuracy with three software-selectable ranges: 0 to 125 ppm, 0 to 500 ppm, 0 to 2000 ppm (parts per million).

Features and specifications
Capacity: 32,520 measurements total
User-selectable sampling intervals: 0.5 seconds to 9 hours, recording times up to 1 year
Readout and relaunch with optional HOBO Shuttle or HandCar software running on a Palm® handheld
Wall or ceiling mounting kit (hook/loop and screws included)
Programmable start time/date
Memory modes: stop when full, wrap-around when full
Nonvolatile EEPROM memory retains data even if battery fails
Blinking LED (blue) confirms operation
User-replaceable battery lasts 1 year in normal applications*
Battery level indication at launch
Expected sensor life: 5 years
Operating range: -20°C to +50°C (-4°F to +122°F), 10 to 95% relative humidity, non-condensing, non-fogging
Operating pressure range: 1 Atmosphere ± 10%
Time accuracy: ±1 minute per week at +20°C (+68°F)
Size/Weight: 5.7 x 2.6 x 1.6" (144 x 60 x 40 mm)/ approx. 0.29 lbs. (0.13 kilograms)

Measurement Specifications

Nominal Range (ppm)	Actual Range (ppm)	Resolution (ppm)	Accuracy
0 – 125	0.2 - 124.3	0.5 ±1 ppm	±10%
0 - 500	1 - 497.1	2 ±3 ppm	±10%
0 - 2000	4 - 1988	8 ±5 ppm	±10%

The CO sensor is temperature compensated over the entire operating range; however, very rapid temperature changes can contribute as much as an additional 10% error to the above accuracy specifications.

Physical shocks or rapid changes in ambient pressure may show up as spikes in the data.

Response time: 11 minutes typical, depending on installation location and orientation.

Exposure level reference

0-1 ppm Normal background
9 ppm ASHRAE Standard 62-1989 for living areas
50 ppm OSHA enclosed space 8-hour average levels**
100 ppm OSHA exposure limit**
200 ppm Mild headache, nausea, fatigue, and dizziness
800 ppm Convulsions and death within 2-3 hours

*Battery life is shorter when CO levels average 10 ppm or more. For example, battery life is 6 months at average concentrations of 100 ppm.
** U.S. Department of Labor Occupational Safety & Health Administration (OSHA) regulation 1917.24: The CO content in any enclosed space shall be maintained at not more than 50 ppm (0.005%). Remove all personnel from enclosed space if the CO concentration exceeds 100 ppm (0.01%).

Appendix G
Onset CO Analyzer Tests

Overall Response to CO

The initial evaluation of the CO analyzer was performed in a glass vessel to determine the overall response characteristics of two prototype units to determine the feasibility of the samplers to collect ambient level concentrations of CO. **Figure 1** shows the vessel with the two CO analyzers being exposed to the various CO concentrations. The CO was generated by mass flow dilution of protocol gas through an Environics model 100 calibrator and verified with a Dasibi 3003 CO analyzer.
Figure 2 shows the initial response data.

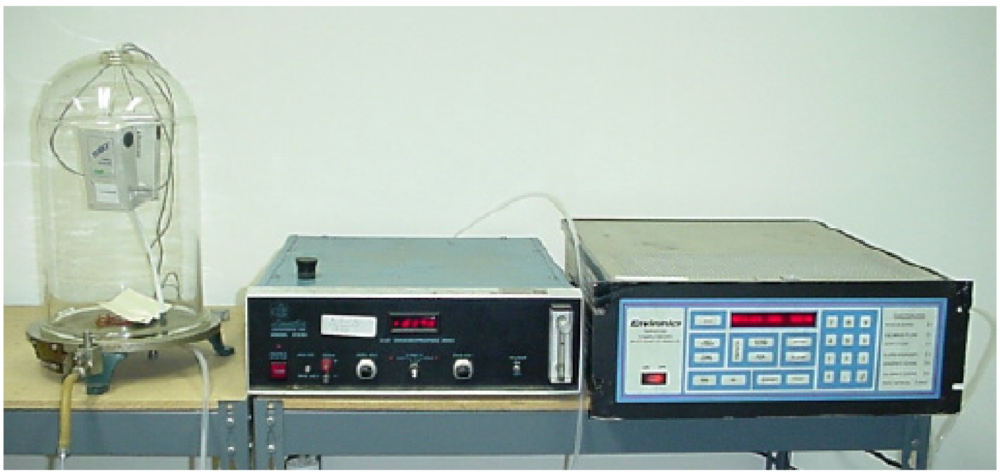


Figure 1. Initial CO Response Tests of the Prototype Onset CO Analyzer

On the basis of the test results the Onset CO analyzer was determined to be suitable for measurement of the anticipated levels of ambient CO, but would require further information on the individual calibration curves for each unit. This test led to the next set of evaluations for response characteristics and environmental enclosure development.

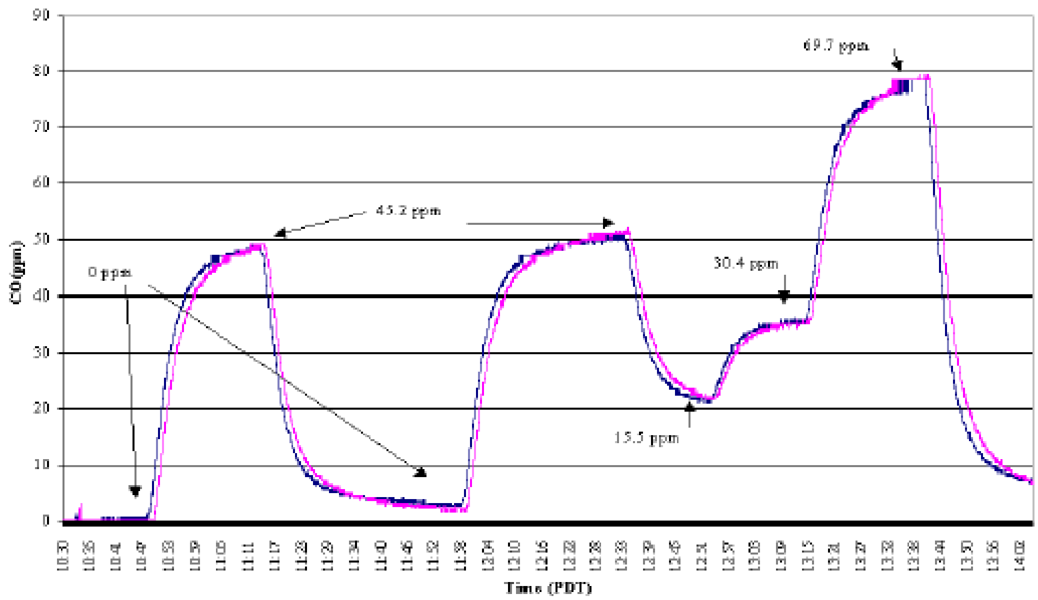


Figure 2. Initial Response Data from Two Prototype Onset CO Analyzers

Multiple Analyzer Comparison with No Air Flow Around Onset Analyzer

The response of two CO analyzers to changing concentrations of CO were evaluated in what may be called a "large chamber". The chamber was the workshop area at the Parsons Valencia office with the CO source being an older, pre emissions controlled vehicle. The goal of the test was two fold; first, to compare the response of two CO analyzers to each other, and second, to compare the response of the CO analyzer to an EPA designated equivalent method CO analyzer, the Dasibi 3003. The CO analyzer were programmed to collect one-minute samples while the data from the Dasibi were recorded as one minute averages of one-second scans. The sample inlet for the Dasibi was placed adjacent to the two Onset analyzers. The test was conducted by injecting CO into the shop area in the evening, closing the doors to the shop area, and allowing the CO concentrations to decrease through the night and into the next morning. The ambient temperature in the shop area was monitored throughout the test. Air flow during the test was negligible.

Figure 3 shows the comparison of the two Onset CO analyzers. It is clear from the figure that the two Onset analyzers produced nearly identical responses.

Figure 4 shows the comparison of the response of one Onset analyzer used in the test to the Dasibi measured concentrations at the same time. The observed trends were closely matched, but there was an observed lag in the rate of decrease of the CO concentration from the Onset analyzer. Whether this lag was due to lack of airflow around the Onset analyzer (they are a passive sampler) was not known, so a subsequent test was designed to evaluate the effect of airflow around the samplers.

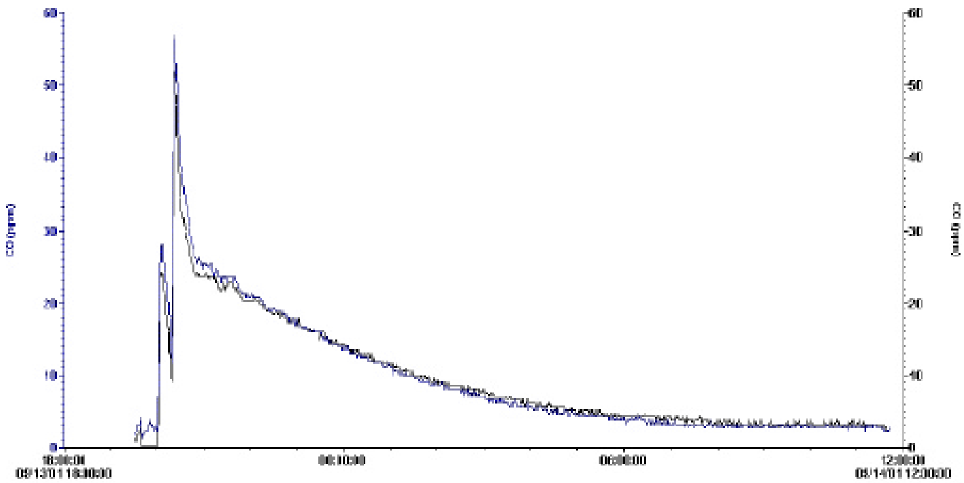


Figure 3. Comparison of Responses from Two Onset CO Analyzers to CO from Large CO Source

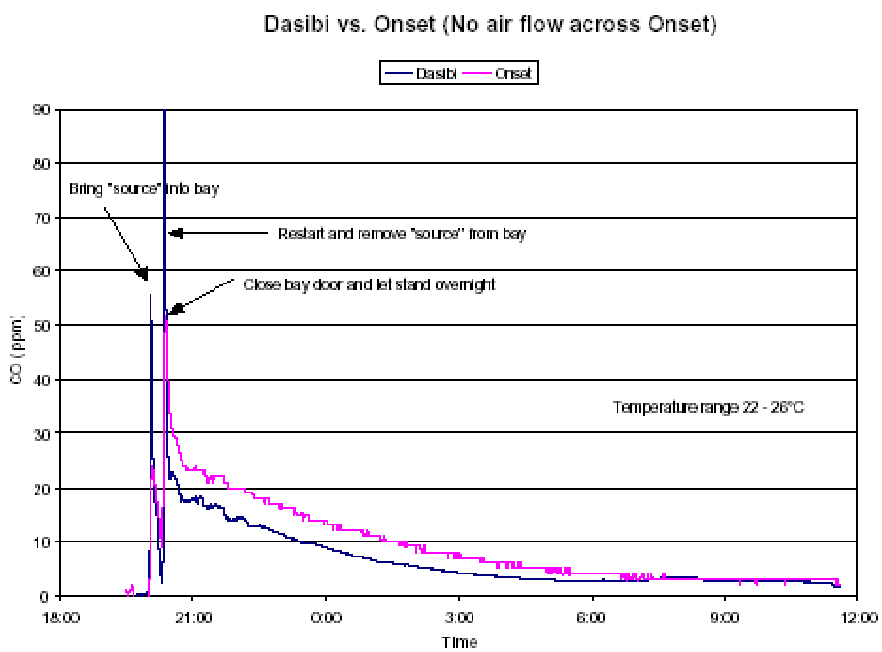


Figure 4. Comparison of Onset Analyzer vs. Dasibi Measured Concentrations to Fixed Concentrations of 43.5 ppm

Multiple Analyzer Comparison with Air Flow Around Onset Analyzer

Essentially a repeat of the above test, this test evaluated the decay response of the Onset analyzer, but added airflow around the samplers using a fan to mix the sampled environment around the Onset analyzer. Additionally, the particulate vents were removed from the analyzer to allow air to free-flow into the analyzer and around the detector cell. Results showed little change from the unventilated response above.

CO Comparison with Air Flow Around Onset Analyzer and Forced Air Circulation Through Detector Cell

Similar to the above tests with air flow around the Onset analyzers, this test added a vacuum pump to the Onset enclosure to force air circulation through the detector cell and determine if the passive nature of the detector caused the observed lag time or "tail" in the response of the analyzer after receiving a CO spike. For this test the ambient temperature was added to the data stream to document the environment around the Dasibi. It is well recognized that the model 3003 does have a temperature sensitivity that affects the zero response. The results of the test showed the response time of the Onset analyzer to be faster than the Dasibi, but the lag time, or tail, was still present implying the tail was due to the detector technology, not the passive nature of the sampling method

Response Time Evaluation of Onset Analyzers

The testing evaluated the response time of the Onset analyzers relative to the designated equivalent Dasibi CO analyzer. This was evaluated through two tests. The first test provided step changes of 0, 25 and 0 ppm CO in a chamber to compare the standard sampling configuration of the Onset analyzer to the Dasibi. The second test provided a direct injection of sample into the Onset analyzer and the Dasibi through a tee configuration to look only at the short lag time to the sensor cell and then the sensor cell response to the step change. This second test also added one intermediate concentration of 15 ppm after the 25 ppm maximum, before returning to zero. The concentrations were generated through mass flow dilution of protocol gas diluted with zero air produced by a zero air generator system. While the zero air system did not completely remove the CO, the intent of the tests were to evaluate the response time and any residual CO in the zero air would not interfere with the tests. All data were sampled and stored as one-second instantaneous values using an Onset 4-channel data logger. To compare equivalent data sets, the zero and span Onset concentrations were normalized to the Dasibi concentrations to provide equivalent zero and span responses. This provided a data set where any differences would be only due to differences in response time.

Figure 5 shows the chamber response time tests showing the slower response of the Onset analyzer. **Figure 6** shows the response time results using the direct injection of the concentrations and the very rapid initial response obtained from the direct injection. Related response time calculations are shown in **Table 1**. The response time is shown to one time constant, or 63% of the stepped change. The overall results from the chamber test shows that in relatively still conditions (low flow in chamber), the response time of the Onset analyzer will be no more than three times as long as the standard Dasibi instrument. With any air movement, this difference will become smaller.

When testing just the sensor cell response (through direct injection), the Onset instrument was almost twice as fast as the Dasibi, with the exception of the concentration returning to zero. At this return to zero point, the apparent tail, or ending lag, plays a more significant role by increasing the response time, but still keeping it faster than the Dasibi.

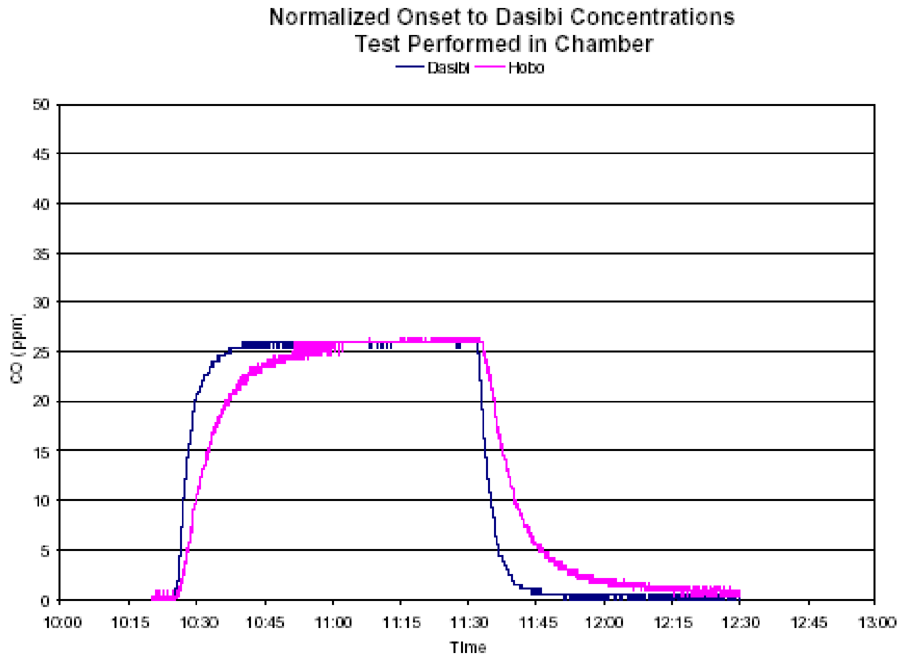


Figure 5. Chamber Response Time Test-Data Showing Slower Response of Onset Analyzer in Relatively Still Air

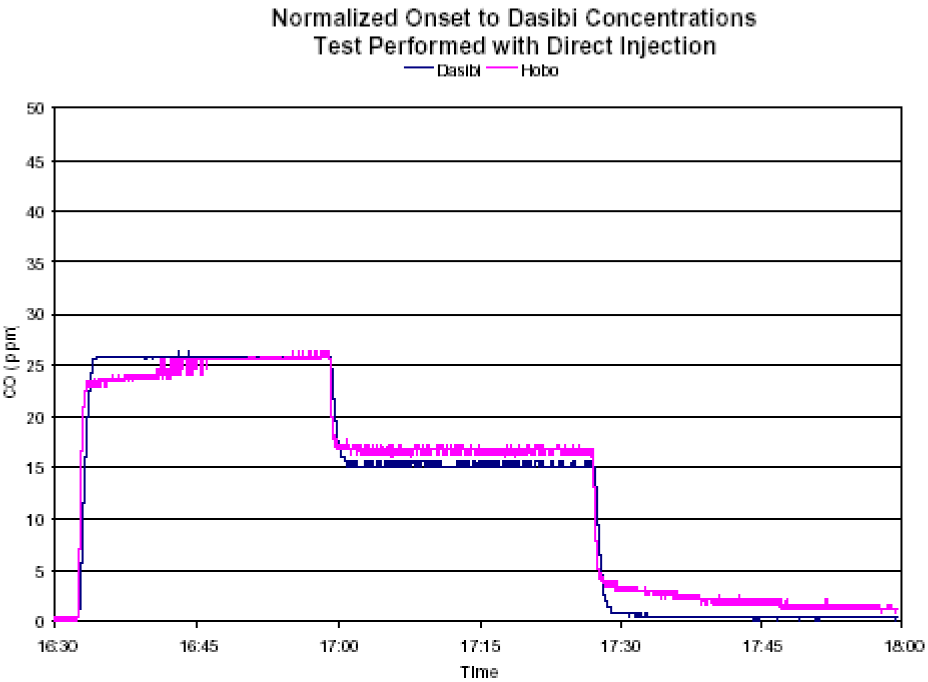


Figure 6. Direct Injection Response Time Test-Data Showing Response Comparison of Dasibi and Onset Analyzer

Table 1. Summary of Measured Time Constants (In Seconds)

	Dasibi in Chamber	Onset in Chamber	Dasibi Direct Injection	Onset Direct Injection
Rise 0 to 25 ppm	176	453	38	22
Fall 25 to 0 ppm	158	405	--	--
Fall 25 to 15 ppm	–	–	31	17
Fall 15 to 0 ppm	–	–	33	25

Evaluation Of Environmental Chamber Design

The Onset analyzers were not intended to be deployed in an outdoor environment, as exposure to moisture may cause unit failure. Several concepts were evaluated for an outdoor enclosure and a prototype design built for testing. Initial tests were performed by placing a analyzer without an enclosure adjacent to one with an enclosure and exposing both to the same changing atmosphere of CO. This test was performed in a garage that served as a "chamber" and providing a source of CO by twice starting the pre-emissions controlled vehicle to produce a momentary CO spike. **Figure 7** shows the results of the tests and the analyzer test setup. The chamber versus no-chamber Onset analyzers showed no significant difference in the measured CO concentrations or response time to rapidly changing conditions.

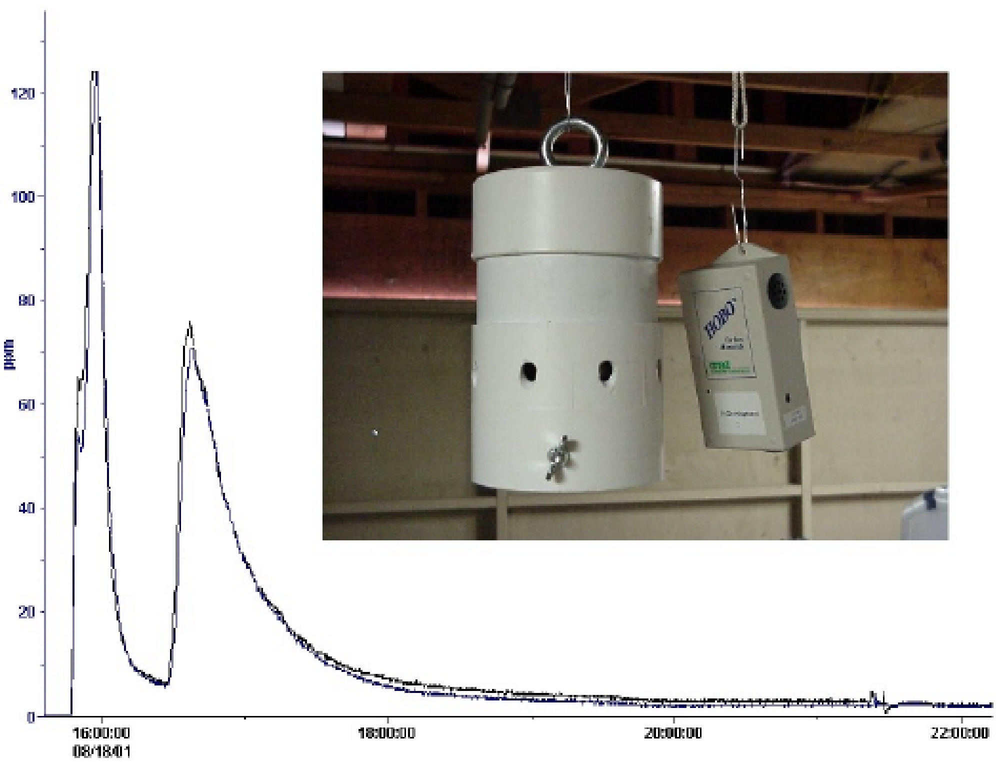


Figure 2-7. Test Results Comparing In Chamber Versus Outside Chamber (Sample Results and Side-by-Side Instruments Shown)

Evaluation of Temperature Sensitivity of the Onset CO Analyzers

Most of the chamber testing and calibrations performed were conducted under warmer temperatures in the late summer and fall. The field study was performed in the winter when temperatures were much colder. Prior to the field deployment, in November, the audits that were performed identified a potential temperature dependency of the CO analyzer response. Additionally, review of field data under the colder conditions experienced during the study showed the zero response observed during the warmer chamber tests may not be representative in the colder outdoor environment.

To further evaluate the potential dependency, four of the analyzers, selected at random from the pool of instruments, were subjected to further chamber testing in temperatures down to –10°C, bracketing the temperatures experienced in the field. The tests exposed the CO analyzers to zero air and the span concentration used for verifying the analyzer operation, 43.5 ppm. The chamber was placed in the temperature environments and allowed to equilibrate for at least one hour before the test concentrations were put into the chamber. To assure the appropriate air temperature, the inlet calibration gas was passed through 50 feet of ¼ inch copper tubing coiled inside the chamber to reduce the gas temperature to the chamber temperature.
The results of the span tests did show a fairly significant temperature dependency of the Onset analyzer with the response dropping with colder temperatures. **Figure 8** shows the response, with the calculated relationship displayed for the average response of the four data analyzers.

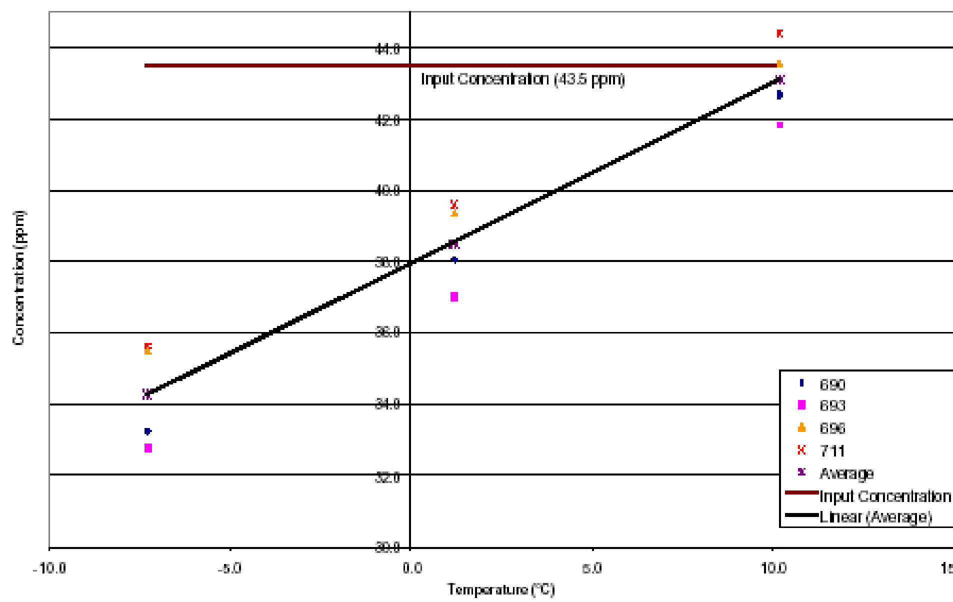


Figure 8. Average Temperature Dependency Response of Four Onset Analyzers to Fixed Concentration of 43.5 ppm

Additionally, under the colder temperatures, zero offsets, which initially ranged from around 0.5 to 2.0ppm during the initial calibrations, were found to now be about 0.2 ppm. These results were further confirmed in multiple tests with randomly selected Onset analyzers placed in an outdoor, cold environment, where it was noted that all of the analyzers reported the lowest reportable value of 0.2 ppm when the temperature dropped below about 6°C.

The results of the tests demonstrated a dependency of the analyzers on temperature for both the response slope and zero intercept. To correct for this dependency, the zero offset was removed from all calibration equations, the individual slopes applied, and the response corrected for temperature dependency using the results from the Freedom Park and Crestwood co-located comparison evaluations. These evaluations are described further in section 4.

Co-location of Onset Monitor with the Sunrise Acres DAQM Site

As a final evaluation to determine the suitability of the Onset monitors and test the design of the environmental chamber, one unit was co-located with the DAQM operated site at Sunrise Acres. The specific goal was to determine if the Onset system measured concentrations of CO comparable to those measured by the DAQM and could observe the concentration trends. The comparison data set was collected over a period of one week in September 2001. The data collected by the Onset unit was averaged into 10-minute values and compared to the 10-minute average data collected by the CO analyzer at site. As the Onset unit had not been chamber calibrated, the Onset data were normalized to the site data by performing a linear regression between the two to establish a slope and intercept. This effectively "calibrated" the Onset monitor to the site instrument so that the trends could be compared. **Figure 9** shows the resulting data. On the basis of the comparison it was clear that the Onset monitors would work quite well for the needed data collection in the concentration range of interest.

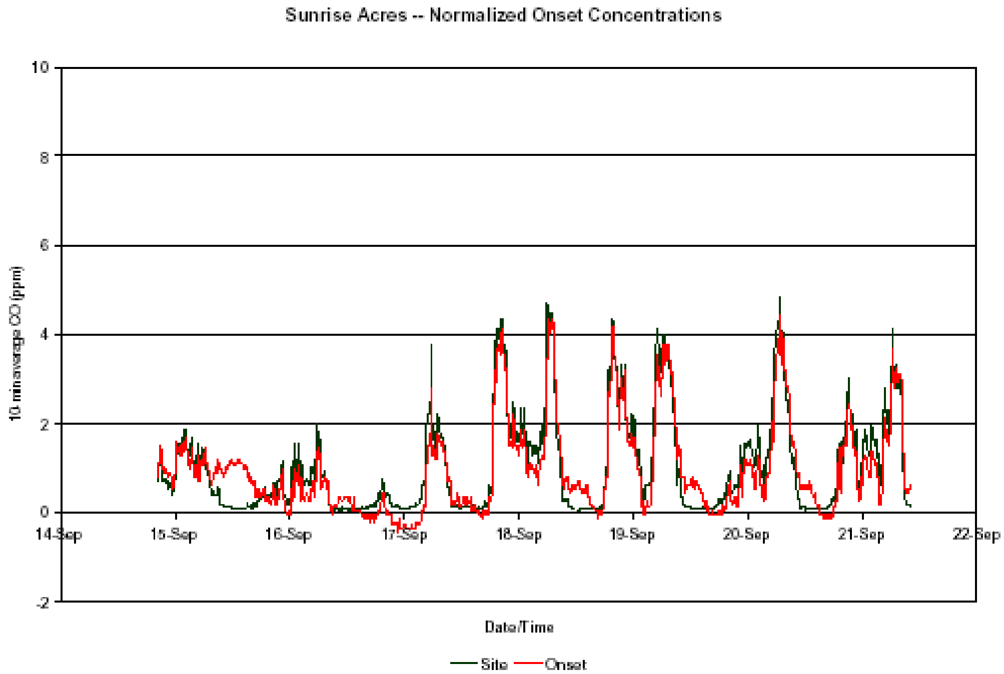


Figure 9. Comparison of Onset to Sunrise Acres CO Concentrations and Trends

APPENDIX H

MAPS SHOWING MOBILE SAMPLING TIMES & LOCATIONS

Figure 1. Mobile Sampling Times and Locations for the Evening of December 16, 2001

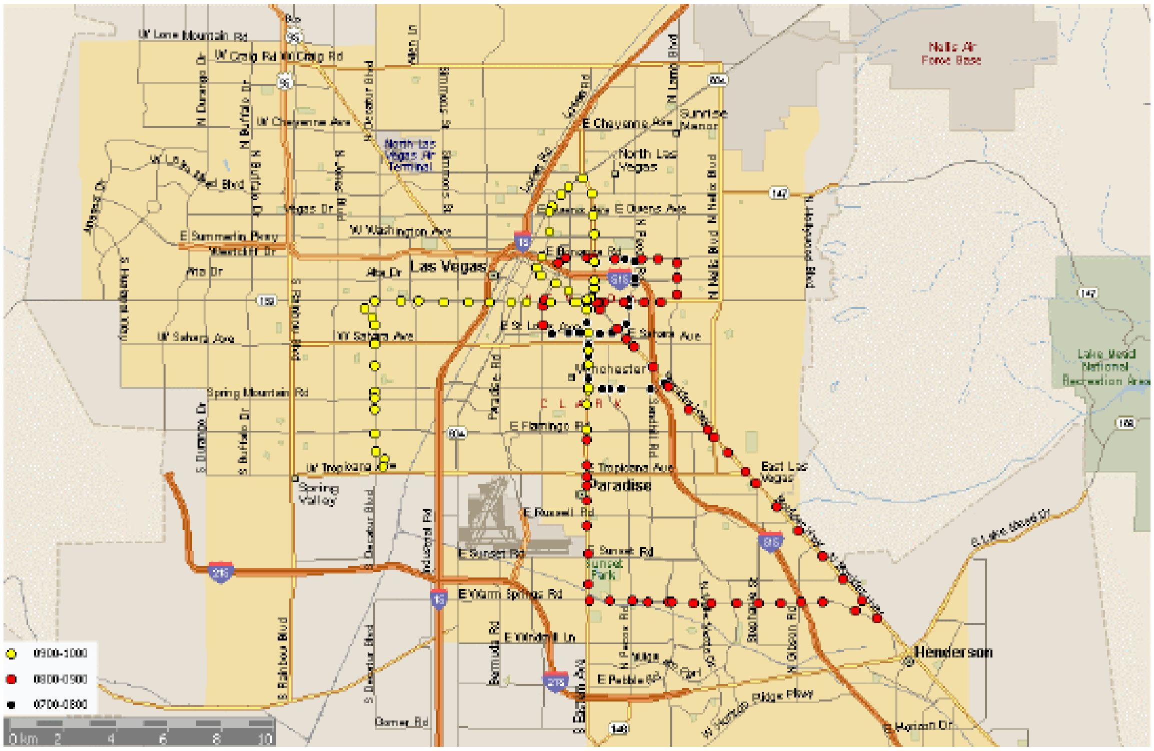


Figure 2. Mobile Sampling Times and Locations for the Morning of December 17, 2001

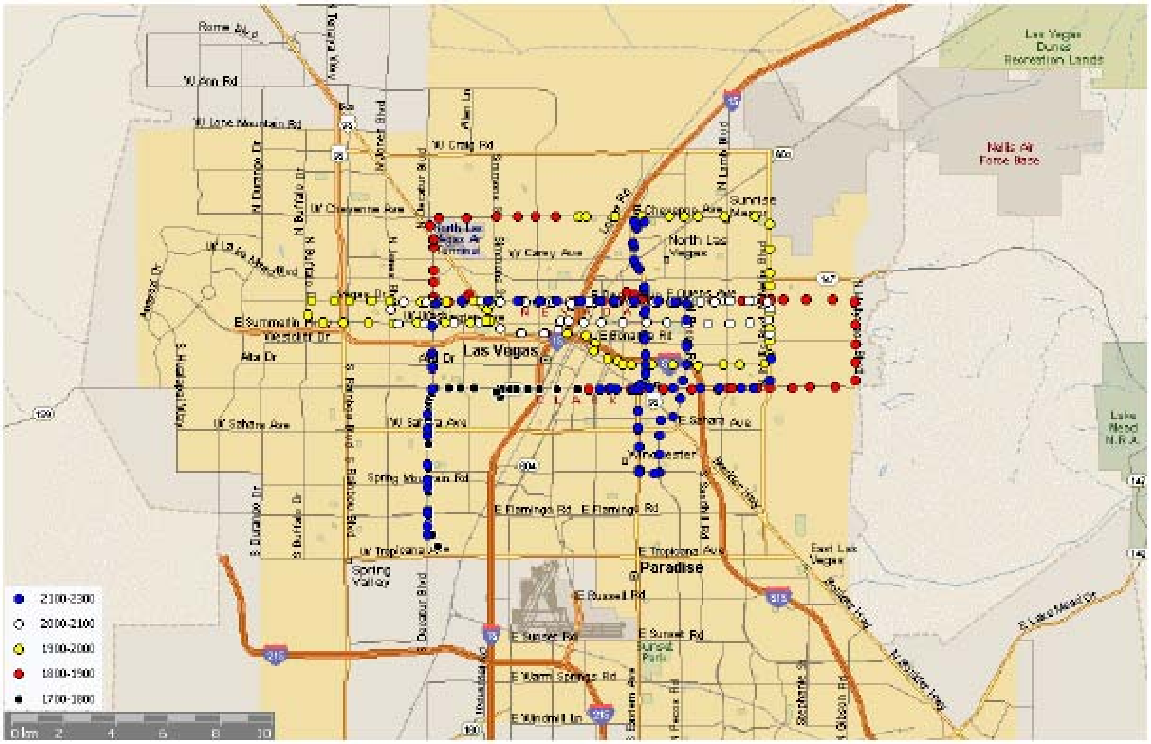


Figure 3. Mobile Sampling Times and Locations for the Evening of December 17, 2001

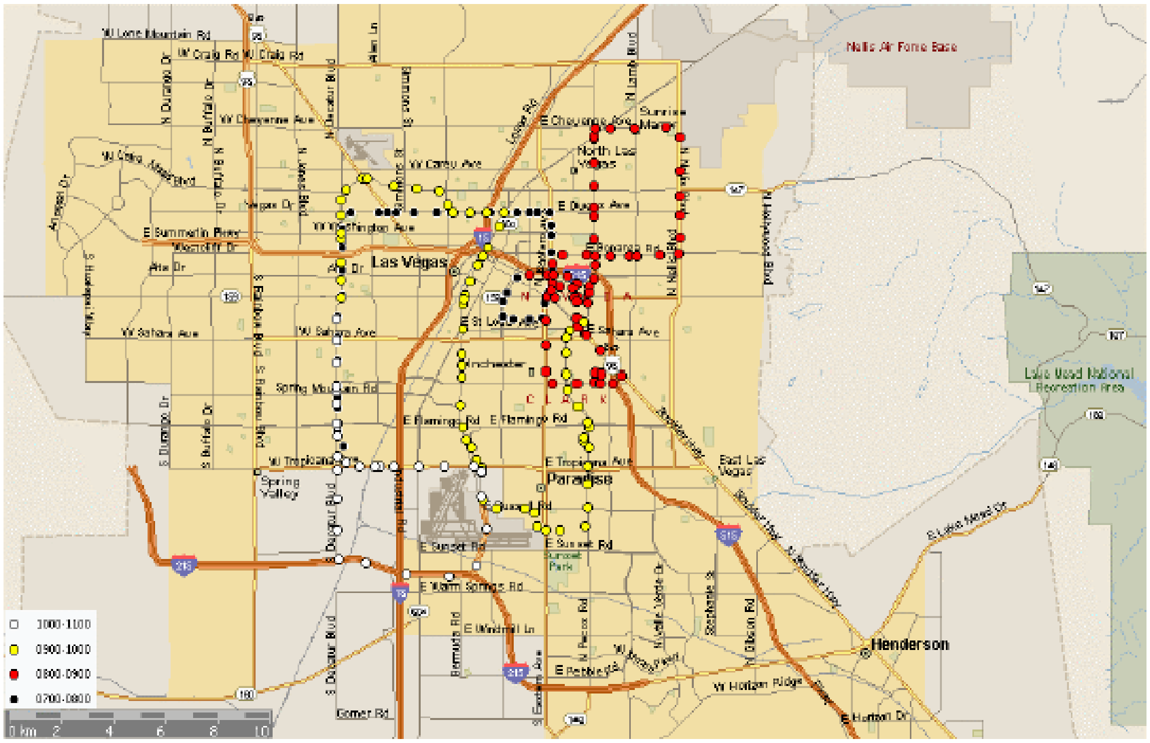


Figure 4. Mobile Sampling Times and Locations for the Morning of December 18, 2001

Figure 5. Mobile Sampling Times and Locations for the evening of December 18, 2001

Figure 6. Mobile Sampling Times and Locations for the Morning of December 19, 2001

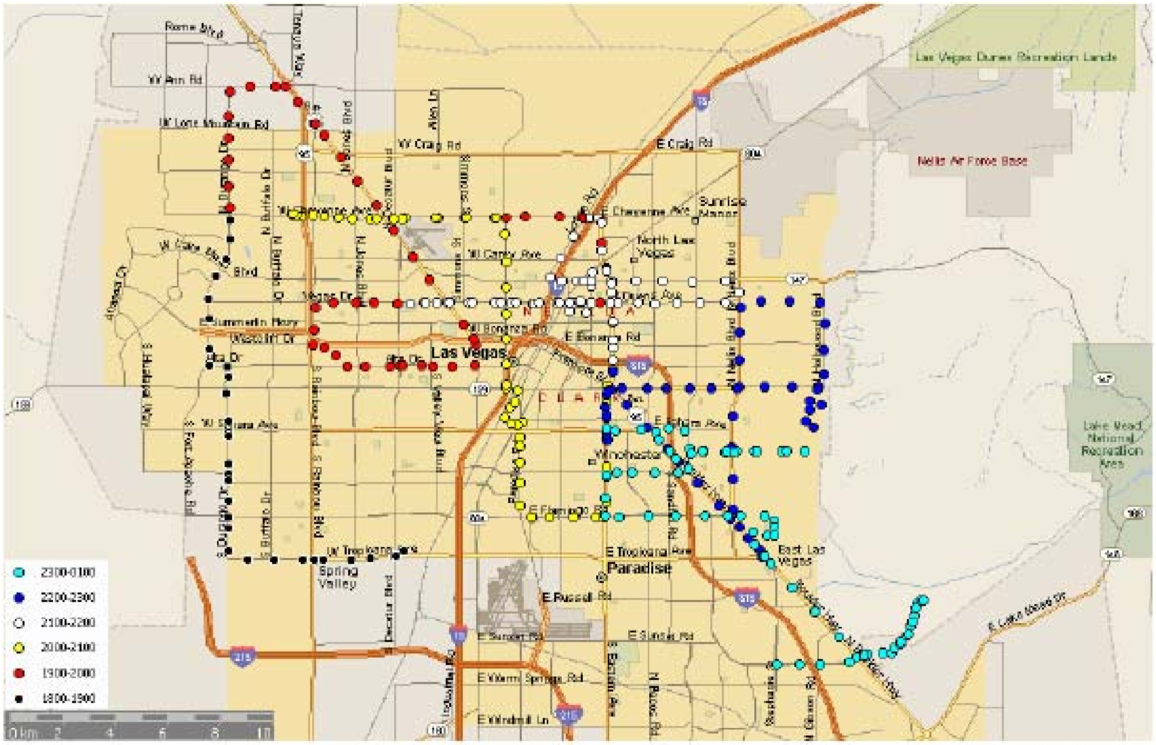


Figure 7. Mobile Sampling Times and Locations for the Evening and Into the Night of December 19 & 20, 2001

Figure 8. Mobile Sampling Times and Locations for the Evening of December 26, 2001

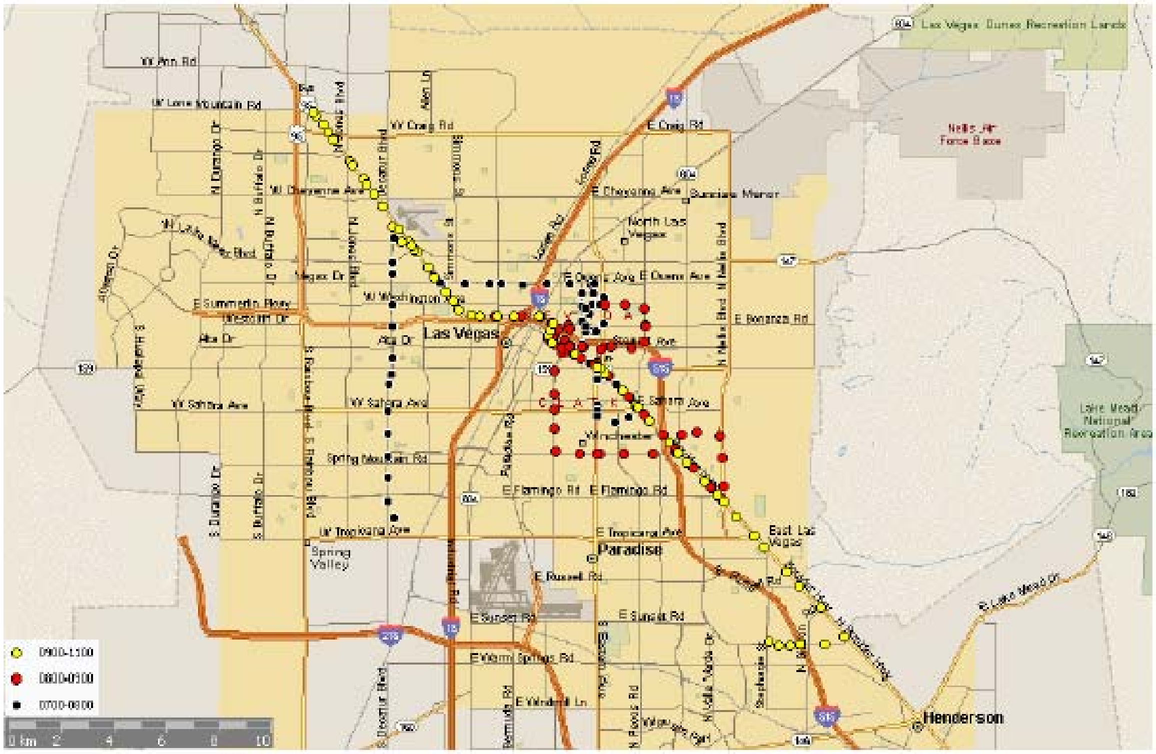


Figure 9. Mobile Sampling Times and Locations for the Morning of December 27, 2001

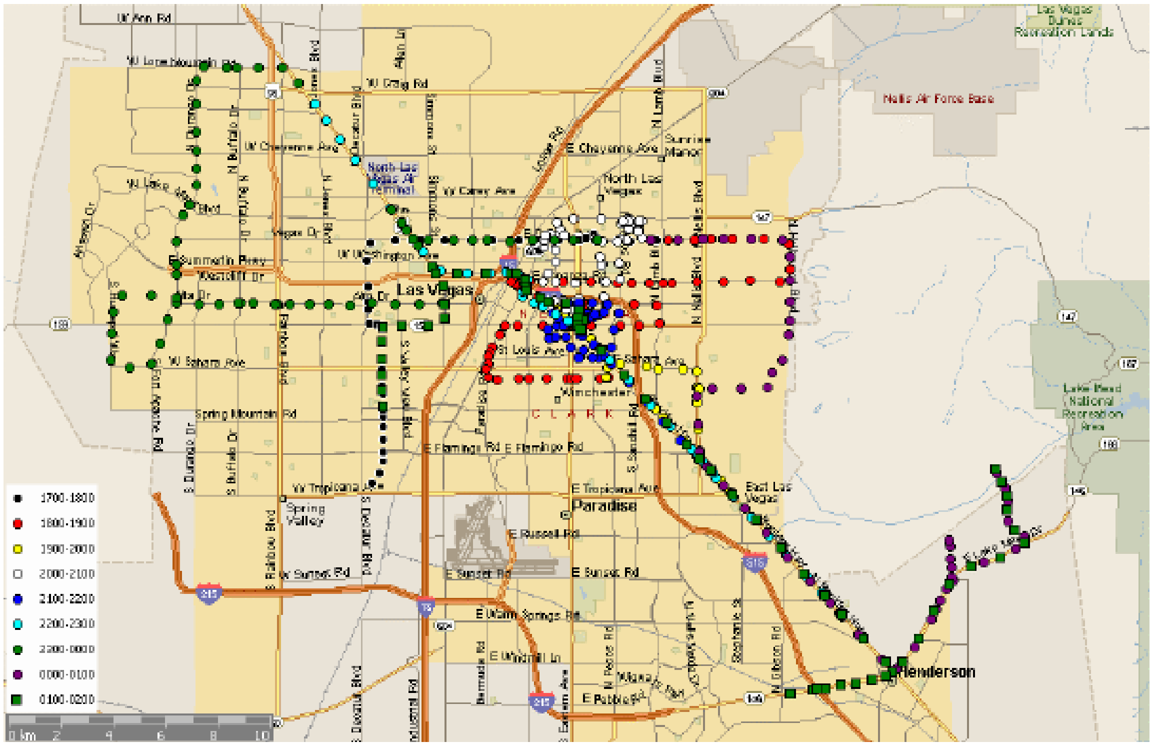


Figure 10. Mobile Sampling Times and Locations for the Evening, Nighttime and Early Morning of December 27 & 28, 2001

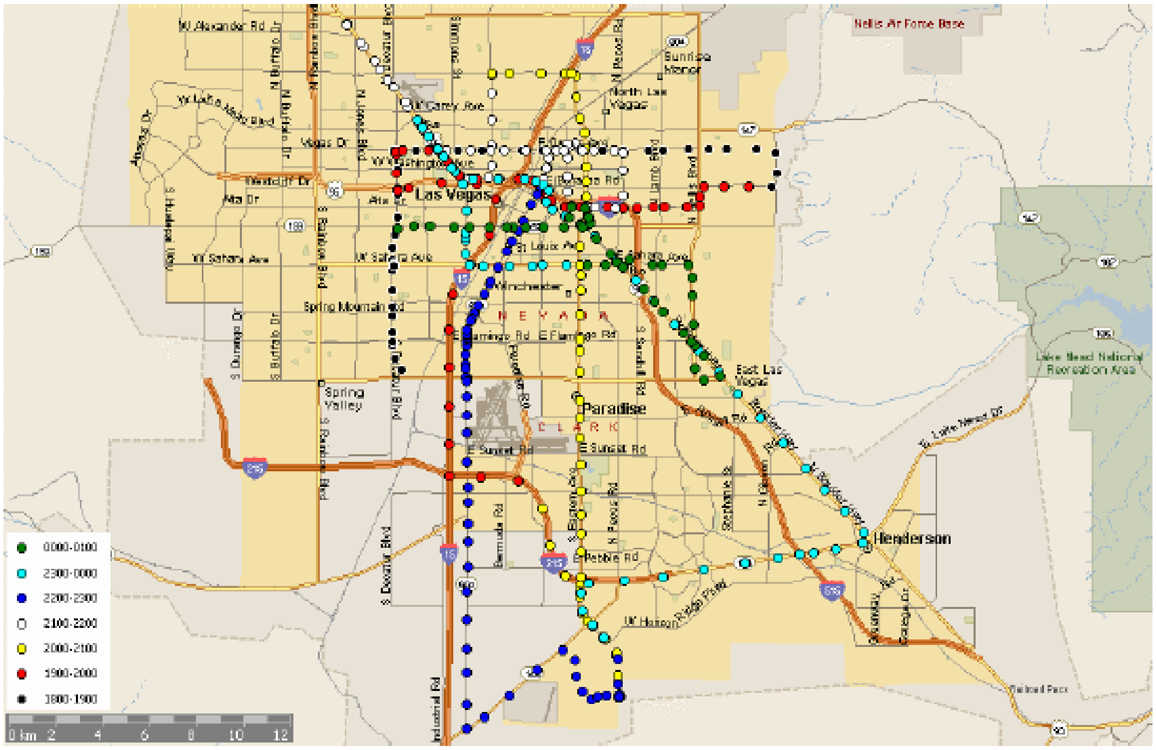


Figure 11. Mobile Sampling Times and Locations for the Evening, Nighttime and Early Morning of December 28 & 29, 2001