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FINAL REPORT
JULY 1997

Monitoring in Ozone Transport Corridors

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD
Research Division

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ABSTRACT

A monitoring program was established during the 1995 ozone season to examine the transport of ozone along two corridors out of the South Coast Air Basin (SoCAB) into the Mojave Desert, and in an offshore corridor coupling the SoCAB to the San Diego Air Basin. Eight sites, continuously monitoring ozone, ambient temperature, wind speed and direction, were established and operated for a period of five months (June-October 1995). Seven sites were located in the Mojave Desert: two at the outflow of Cajon Pass and Soledad Canyon, three at sites located on top of prominent peaks, and two at other strategic locations that supplemented the existing long-term network of measurements. The eighth site was at Santa Catalina Island. This site and the three sites on prominent peaks in the desert were intended to serve as surrogates for continuous measurements of conditions aloft. The data monitoring phase of the project is summarized in this report.

The results of a limited analysis of those measurements together with data from the long-term monitoring network and other supplementary sources are reported herein as well. The analysis primarily addressed several concerns expressed by the ARB staff. These included the frequency of transport from the SoCAB into the Mojave Desert, the relative contribution of local sources to ozone exceedances in the Desert, and specific characteristics noted in the data set that were deemed worthy of closer examination. Another concern was the number of ozone exceedances experienced at the Santa Catalina Island site and, to the limited extent that the data allowed, these occurrences were closely examined. Within the 1995 monitoring network, the representativeness of measurements made at sites that were located on top of prominent mountain tops as surrogates for measurements aloft was evaluated by comparisons with remote sensing instruments and aircraft soundings.

EXECUTIVE SUMMARY

A program was conducted during the 1995 ozone season in which a network of sites was established to monitor conditions in known transport corridors out of the South Coast Air Basin (SoCAB). The network was designed to 1) provide additional measurements in transport corridors from the SoCAB to the Mojave Desert through Soledad Canyon and Cajon Pass, and offshore from the SoCAB to San Diego County; and 2) evaluate the use of *platforms of opportunity* such as prominent peaks for making continuous measurements of conditions aloft. Ozone, wind speed, wind direction and temperature were measured at all sites in the network. A limited analysis of those measurements together with data from the routine monitoring network and other supplementary sources was conducted as well. The analysis primarily addressed several concerns expressed by the ARB staff. These included the frequency of transport from the SoCAB into the Mojave Desert, the relative contribution of local sources to ozone exceedances in the Desert, and specific characteristics noted in the data set that were deemed worthy of closer examination. Another concern was the number of ozone exceedances experienced at the Santa Catalina Island site and, to the limited extent that the data allowed, these occurrences were closely examined. Within the 1995 monitoring network, the representativeness of measurements made at sites that were located on top of prominent mountain tops as surrogates for measurements aloft was evaluated by comparisons with remote sensing instruments and aircraft soundings.

The first phase of the program was to conduct air and ground surveys for candidate sites. The results of the surveys are documented in a report entitled Task 1 - Feasibility and Design of the Monitoring Network. Using the survey results, the ARB and Mojave Desert Air Pollution Transport Committee selected a network of eight sites. Seven of the sites were located in the Mojave Desert and one was on Santa Catalina Island. Four sites were located on prominent mountain tops and two in the outflow region from the two passes. The remaining two were intended to help define regional flow patterns.

During the operational phase of the program, eight sites measuring ozone, temperature, and winds were established and operated for a five-month period (June-October) during the 1995 ozone season. The data were reported in five (monthly) data volumes and on electronic media. In spite of the remoteness of the sites, the data capture rate was exceptionally high and there were no major problems that resulted in significant data loss. Recovery rates were greater than 99% for the meteorological measurements, and, with one exception, 95% or greater for ozone. The data recovery rate for the one exception was 90%, which is still within acceptable limits.

Air flow into the Desert occurs primarily through three passes (Soledad Canyon, Cajon Pass and Tehachapi Pass). Flows from the southwest, south and northwest, respectively, merge into a westerly current in the northern and eastern sections of the Desert. Influx frequencies exceed 80% at all locations in the late afternoon, decreasing to 25-50% near sunrise. Flows from Soledad Canyon and Cajon Pass interact between Shadow Mt. and Quartzite Mt. to form the El Mirage convergence zone.

Exceedances of the State standard for ozone were most frequent during the monitoring period at Baldy Mesa and SE Palmdale. The lowest number of exceedance days was recorded at Ludlow (0), Barstow (6) and Boron (15). The median time for peak ozone on exceedance days was 16 PST near the entrance points such as SE Palmdale and Baldy Mesa. Downwind locations (Barstow, Shadow Mt., Quartzite Mt.) had median peak times of 18 PST. The median peak time at Mojave was 18 PST, notably later than at the other entrance locations.

The flow through Cajon Pass has a complex structure which results in unusual characteristics for ozone concentration peaks. Baldy Mesa and Phelan show higher exceedance frequencies from 13-15 PST than Hesperia or Quartzite Mt. Quartzite Mt. and Victorville follow the Hesperia pattern.

Fumigation events (the process in which pollutants residing in layers aloft are brought rapidly to the surface as the atmosphere destabilizes due to insolation) were identified by abrupt increases in ozone concentration at about 09 PST at various locations in the desert. From 9-24 days during the monitoring period showed increases to at least 70 ppb (09 PST) at these locations and are considered to be fumigation cases. A widespread fumigation event (August 19) resulted in early morning exceedances at Barstow, Boron, Lancaster and SE Palmdale as well as indications elsewhere as far east as Ludlow. The fumigated layer was attributed to carry-over from SoCAB transport on the previous day.

Barstow had exceedances on six days during the monitoring period. Concentrations on five of the days could be attributed to same-day transport from the SoCAB. The sixth day was the fumigation event of August 19.

Boron had 15 exceedance days during the June-October period. Thirteen of the days could be related to same-day transport into the Desert. One of the days (August 19) was the fumigation case. One of the days (June 14) had a marginal exceedance (95 ppb) as an isolated event in the western part of the Desert. Although the wind speed at the exceedance hour was well above average, there were no other indications of a transport effect from outside of the Desert.

An analysis of the possible effects of local sources on Barstow ozone concentrations indicated that most of the diurnal variations, not attributable to direct transport from outside the air basin, could be ascribed to variations in the regional background ozone levels.

Quartzite Mt. wind and ozone data were compared to Apple Valley profiler and aircraft sounding data. The Quartzite Mt. data were judged to be representative of conditions in the free atmosphere at that elevation but with an apparent reduction in wind speed of about 30%.

Exceedances of the State ozone standard occurred at the Santa Catalina Island site on 24 days (101 hours) during the monitoring period. In more than 50% of the hours, wind directions were from the northwest quadrant. The remaining cases were distributed rather evenly throughout the other three quadrants. The offshore wind patterns producing these concentrations are not clear from the data available with this program. A more extensive analysis utilizing coastal and profiler data is needed to understand the potential impacts of the offshore ozone.

1.0 INTRODUCTION

In 1995 a field program was undertaken by Technical & Business Systems, Inc. (T&B Systems) under the sponsorship of the California Air Resources Board (ARB) to monitor ozone and meteorological conditions in three major pollutant transport corridors out of the South Coast Air Basin (SoCAB). The transport corridors selected for study were:

a. Soledad Canyon, connecting the SoCAB to the western Mojave Desert,
b. Cajon Pass, coupling the eastern SoCAB to the central Mojave Desert, and
c. Offshore between Los Angeles and San Diego Counties.

The capability of monitoring conditions aloft from either existing tall towers or prominent terrain features was a major consideration in the design of the network. The first program task was to conduct air and ground surveys for candidate sites. The results of the surveys are documented in a report entitled Task 1 - Feasibility and Design of the Monitoring Network.

Using the survey results the ARB and Mojave Desert Air Pollution Transport Committee selected a network of eight sites. Seven of these were located in the Mojave Desert (Baldy Mesa, Boron, Flash II Mt., Ludlow, Quartzite Mt., SE Palmdale, Shadow Mt.) and one on Santa Catalina Island. Four sites were located on prominent mountain tops and two in the outflow region from the two passes. The remaining two were intended to help define regional flow patterns. ARB staff and the Mojave Desert Air Pollution Transport Committee were concerned about potential transport into the Mojave Desert from the San Joaquin Valley during the field study. To provide additional information on this potential source of ozone in the Mojave Desert, ARB staff also monitored in Tehachapi Pass.

From June through October 1995 continuous monitoring took place at the eight sites. Hourly records of ozone, ambient temperature and wind speed and direction were obtained. The results of the monitoring program are contained in five Monthly Data Reports issued to the ARB and in electronic format on magnetic media. In Section 2 of this report the data acquisition program is summarized. Pertinent monitoring site information, instrumentation utilized and QA/QC procedures employed are documented.

In addition to the sites established specifically for this program, a number of routine monitoring sites are maintained by the ARB and the local Districts in the Mojave Desert and surrounding region. The locations of all of the sites referred to in the discussions of the Mojave Desert region which follow, both project specific and those which are in the long-term monitoring network, are shown in Fig. 1-1. Table 1-1 identifies the locations on the map, and distinguishes the long-term sites from those which were only operational during the 1995 program.

The remainder of the report beginning with Section 3.0 contains the results of an analysis of the data. The analysis presented herein is not intended to be a complete exposition of the data but rather speaks primarily to several concerns expressed by the ARB staff. These included the frequency of transport from the SoCAB into the Mojave Desert and the potential contribution of

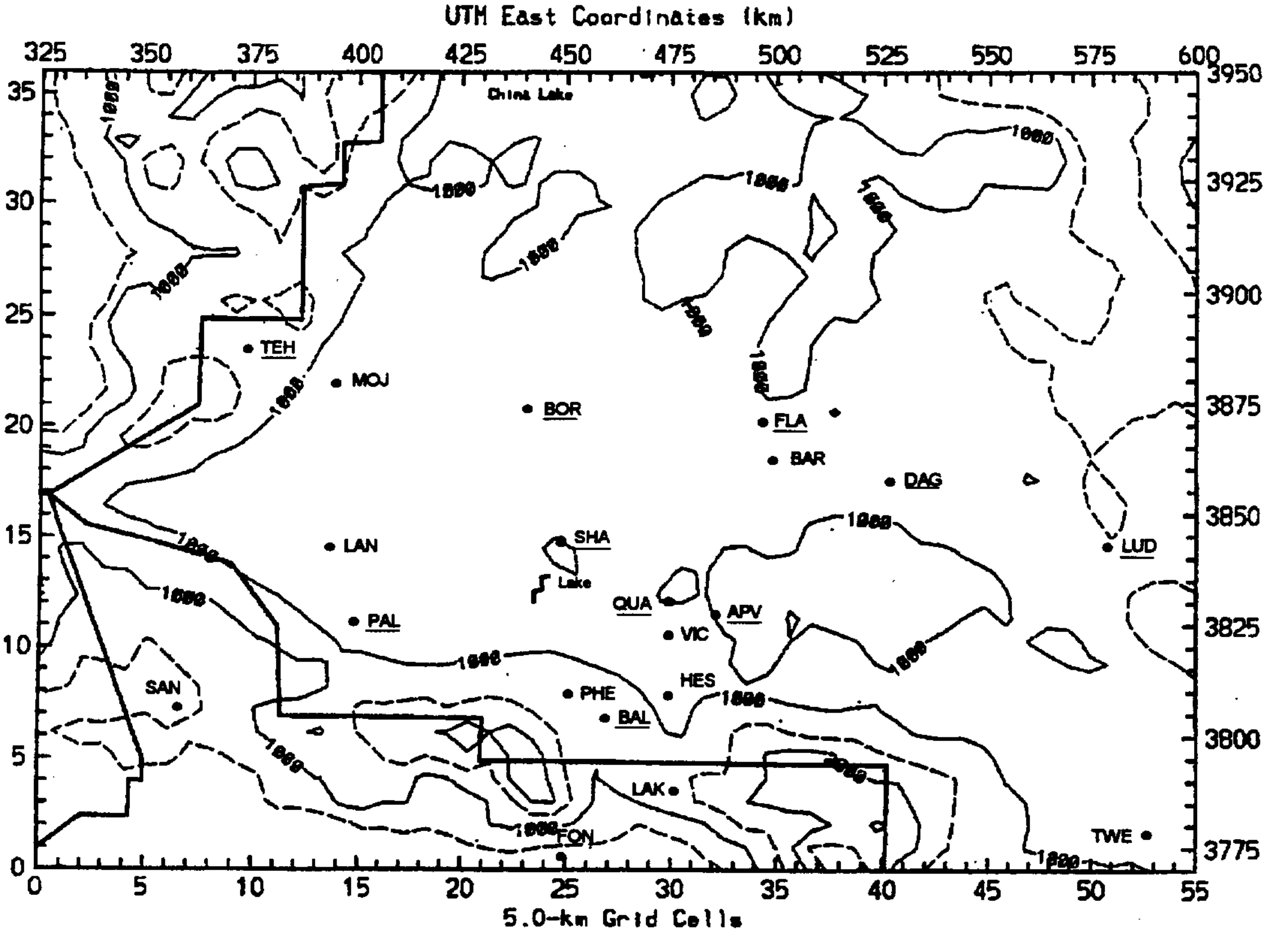


Fig. 1-1 Site Locations in Mojave Desert
(Sites operating only in 1995 are underlined)

arb-f1-1.drw

Table 1-1 Site Descriptions

Identifier	Status	Name	Elevation in feet, meters (msl)
APV	95	Apple Valley	2929, 893
BAL	95	Baldy Mesa	4250, 1295
BAR	LT	Barstow	2270, 692
BOR	95	Boron	2460, 750
DAG	95	Daggett	1927, 587
FON	LT	Fontana	1250, 381
FLA	95	Flash II Mt.	3325, 1013
HES	LT	Hesperia	3280, 1000
LAK	LT	Lake Gregory	4540, 1384
LAN	LT	Lancaster	2325, 709
LUD	95	Ludlow	1782, 543
MOJ	LT	Mojave	2785, 849
PAL	95	SE Palmdale	2760, 841
PHE	LT	Phelan	4100, 125
QUA	95	Quartzite Mt.	4482, 1366
SAN	LT	Santa Clarita	1270, 387 (estimated)
SHA	95	Shadow Mt.	4120, 1256
THE	95	Tehachapi Pass	3979, 1213 (estimated)
TWE	LT	29 Palms	2053, 626
VIC	LT	Victorville	2873, 876

Notes: LT - Long Term
95 - Operational during summer 1995 only.

local sources to ozone exceedances in the Desert. In addition, the site at Santa Catalina Island experienced a number of ozone exceedances and, to the limited extent that the data allowed, these occurrences were also examined. Some unexpectedly low concentrations at Boron and Ludlow raised questions as to their validity and these data were examined more closely. The representativeness of measurements made at sites within the 1995 monitoring network that were located on top of prominent mountain tops as surrogates for measurements aloft was evaluated by comparisons with remote sensing instruments and aircraft soundings.

2.0 DATA ACQUISITION

2.1 Materials and Methods

2.1.1 Monitoring Sites

The ozone monitoring network was designed to provide information to aid the understanding of the origin of high ozone concentrations in the Mojave Desert region and along the San Diego County coastline focusing on the major transport corridors from the Los Angeles Basin. The project network comprised eight sites, seven of which were located in the Mojave Desert area. The eighth site was located on Santa Catalina Island. Fig. 2-1 is a map showing the locations of the eight sites. Four sites were placed at *elevated* locations which were intended to provide surrogate measurements of conditions aloft. The desert elevated sites were located on Quartzite Mt., which is approximately 1500 ft. above the surrounding terrain, on Shadow Mt., approximately 1100 ft. above its surroundings, and on Flash II Mt., approximately 1300 ft above the Barstow area to the south. The site on Santa Catalina Island was at the airport terminal complex, which is elevated 1600 ft above the ocean. Two of the sites, Baldy Mesa and SE Palmdale, were located at the exit of passes leading into the desert from the South Coast Air Basin (Soledad Canyon and Cajon Pass). The remaining two sites at Boron and Ludlow were situated so as to monitor ozone transport from the San Joaquin Valley and from the eastern desert region, respectively.

In selecting the network's monitoring locations and siting the individual sensors and probes, every effort was made to assure good exposure of the monitoring instruments and minimize any influences by local terrain features that could affect the measurements. United States Environmental Protection Agency (EPA) instrument siting guidelines for Prevention of Significant Deterioration (USEPA 1987a) were followed. Summarized below for each monitoring site are the nearby physical features and sources of local emission which could influence the measurements. Detailed descriptions and schematic diagrams of each site appear in Appendix A of this report.

Quartzite Mt.: Additional communication facilities (buildings and towers) are located on a slightly higher peak to the south. A large microwave tower is on the west end of the station. No trees are present. Nearby features will have only minimal effect on data reported by the station instruments. A cement manufacturing company and quarry area are located at the base of Quartzite Mt., approximately three miles away from the monitoring station. The city of Victorville, traffic on Interstate 15, and the town of Oro Grande would be the primary local pollution sources. Another potential pollution source is George Air Force Base, located approximately seven miles to the south.

Shadow Mt.: Other than the microwave station and microwave dish-type antennas on two sides, no other features are nearby that would affect data reported by the station. A few homes exist to the south approximately one mile. There are no other nearby pollution sources.

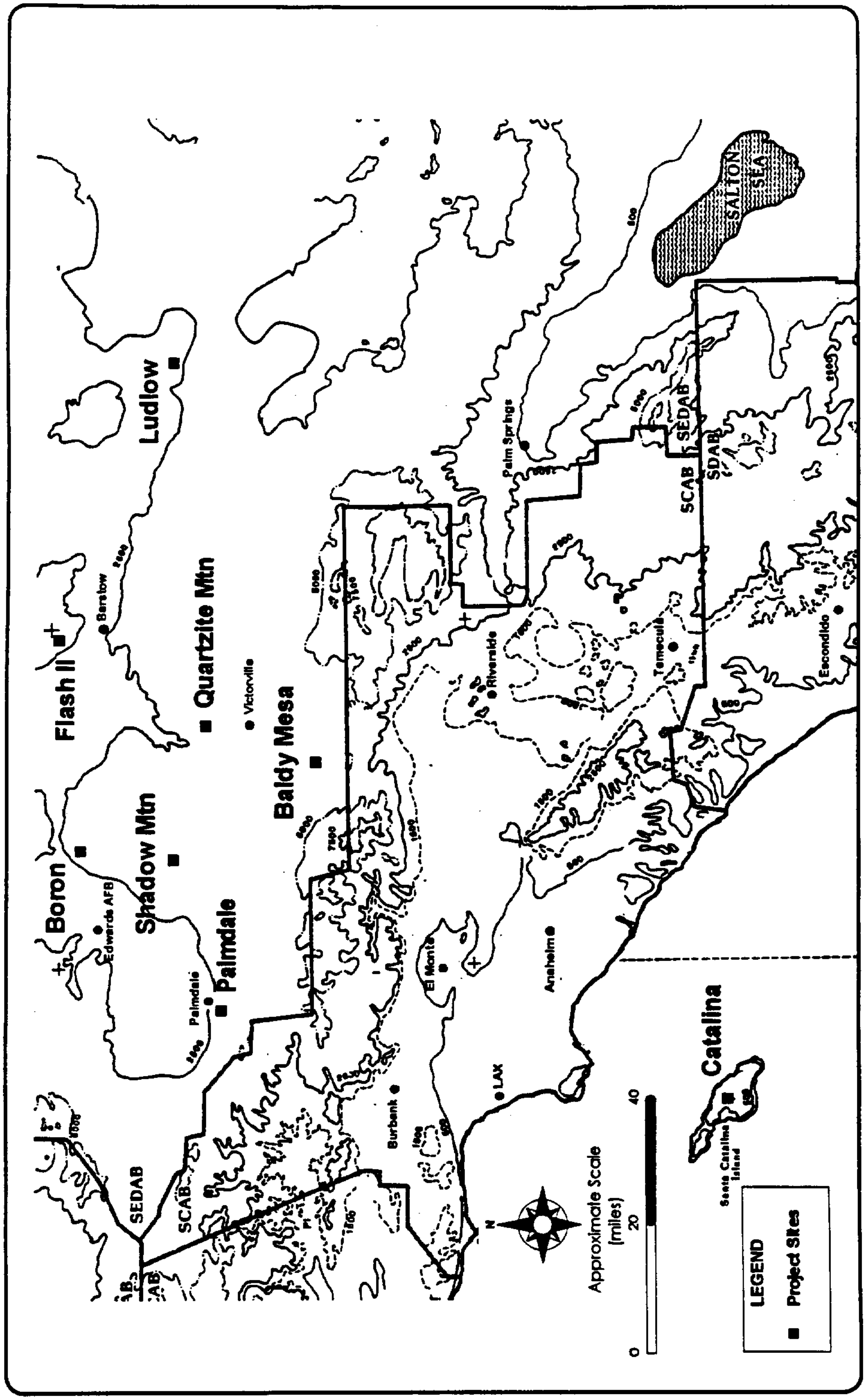


Fig. 2-1 Project Site Locations

Flash II Mt.: Other communication facilities with low buildings and towers are on another peak 200 yards to the southwest, but their effects on monitored parameters should be only minor. There are no trees nearby. The nearest significant source of pollution is the city of Barstow some five miles south-southeast of the site. An emergency power generator is located nearby but is downwind of the site during the dominant flow pattern.

Santa Catalina Island: The most prominent feature for this site is the airport itself with its runway, terminal/restaurant building, hangar, and other smaller structures. Buffalo Springs Reservoir is located 0.5 miles to the northwest. The ocean (Catalina Channel) is approximately two miles northeast of the airport. A hangar and aircraft refueling facility is located 300 feet southwest of the monitoring equipment and are sources of emission which could potentially influence measurements there. The restaurant kitchen located in the terminal building and taxing airplanes are also emission sources that can potentially influence ozone levels.

Baldy Mesa: The area surrounding the site is rural-residential. The closest home is located 200 feet west of the station. There are no other nearby prominent features and/or local emission sources that have potential to affect measurements there. Interstate 15, located approximately three miles to the southeast, is the nearest significant source of emissions.

SE Palmdale: An asphalt parking area is northeast of the shelter. Private residential areas are immediately south and east. To the west is a large open space covered with low vegetation. During prevailing wind conditions, there are no significant upwind local emission sources. Under other flow regimes, the city of SE Palmdale, local traffic and surrounding residential areas will likely have some influence on ambient ozone concentrations.

Boron: South of the monitoring shelter is located a one-story fire station approximately 60 feet away and a 40-foot tall fire hose drying tower 26 feet away. North of the shelter is a large vacant lot. To the west are located a concrete service area and asphalt driveway. A small grassy area then Boron Avenue are located to the east. Highway 58, which is about 0.4 miles north of the site, and light vehicular traffic in the small town of Boron are sources of local emissions. The fire trucks, together with common cleaning solutions and solvents used at the fire station, are the closest pollution sources

Ludlow: There are no significant nearby features that could significantly affect the wind reported at this site. The only structures are an abandoned service station and dilapidated outbuildings located approximately 150 feet to the south. No trees are nearby. Two nitric oxide sources which can potentially affect ozone readings there are a major highway, U.S. Highway 40, about 100 meters north of the monitor, and a truck stop located approximately 0.3 miles to the west. A two-lane frontage road is 200 feet to the south and a railroad track is approximately 0.2 miles south of the station. Open desert exists to the east.

2.1.2 Monitoring Equipment

Each monitoring station in the network was instrumented to continuously measure wind speed, wind direction, air temperature and ozone and store the resulting data as hourly and six-minute averages on the station data logger. Table 2-1 summarizes the instruments found at each site. Detailed tabular presentations of equipment specifications are available in Appendix B of this report.

Table 2-1 Summary of Monitoring Equipment

Parameter or Function	Report Units	Instrument Make, Model	Description
Wind Speed and Wind Direction	ms^{-1} degrees	R.M.Young, Model 05305	Propeller anemometer combined with molded polystyrene foam wind direction vane assembly.
Air Temperature	°C	Campbell Scientific, Model 107	Thermistor temperature probe.
Shelter Temperature	°C	Campbell Scientific Model 10TCRT	Thermistor temperature probe.
Ozone	ppb	Dasibi Environmental, Model 1003 AH	Continuous ozone analyzer utilizing UV photometry.
Data Acquisition	NA	Campbell Scientific, Model CR10	Multiple-input, programmable data logger.
Data Transmission	NA	Campbell Scientific DC112	Telephone modem

<u>Ozone Sampling System</u>

The ozone sampling system inlet consisted of an eight-inch long, 1.25 inch I.D. borosilicate glass cylinder onto which an ACE Glass threaded nipple was glass-welded. One end of a 0.25 inch O.D. Teflon® tubing sample line was inserted through the opening in the ACE Glass fitting's Teflon® nut and threaded onto the borosilicate glass cylinder. The other end of the Teflon® tubing sample line was connected to the Dasibi ozone analyzer sample inlet. Typically, the glass cylinder inlet was mounted on a mast or boom greater than one meter above the shelter's roof line and away from any obstacles or features that could influence ozone concentration levels. The glass cylinder opening faced downward to prevent rain and excess dust from entering the sample line. The Teflon® tubing sample line was conditioned by passing a high concentration of ozone through its length for 1-2 hours prior to its use in the sampling system. The tubing length was kept as short as possible and depended on shelter limitations and location of the ozone analyzer at each site. Fig. B-1 (Appendix B) presents a schematic of the ozone sampling inlet system used on the project.

Ozone Analyzer

The Model 1003AH operates on the principle of the absorption of ultraviolet (UV) light by the ozone molecule. UV light at a wavelength of 254 nm is passed through an air sample and is attenuated as a function of the path length and the ozone concentration. As the 1003AH alternates between sample and reference cycles, the internal electronics of the instrument compares the attenuation difference in samples of ambient air containing ozone and ozone-free air. This difference is converted to an electrical signal proportional to the concentration of ozone in the ambient air sample. The EPA equivalency designation is EQOA-0577-019.

Wind Speed and Wind Direction Sensor

The R.M.Young, Model 05305 Wind Monitor-AQ is a high-performance wind speed and direction sensor designed specifically for use with air quality measurements. It is a single-body instrument that combines a helicoid-shaped, four-blade propeller combined with a polystyrene foam vane body which together resemble a wingless airplane. The spinning propeller rotates a six-pole magnet in close proximity to a stationary coil and produces an AC sine wave (pulsed frequency) proportional to the wind speed. Wind direction is measured by a precision potentiometer connected to the vane assembly. The potentiometer's analog signal (voltage) changes relative to the vane's position over 360 degrees of arc.

Temperature Sensor

A Campbell Scientific, Model 107 thermistor-type temperature probe was used to measure ambient air temperature for the network. The full scale operating range of the probe was -30 to +50 degrees centigrade. To protect the temperature probe from direct solar heating, it was housed in a naturally aspirated radiation shield (R.M.Young, 41002).

Shelter Temperature Sensor

A Campbell Scientific, Model 10TCRT thermister-type temperature probe mounted on the control board within the Campbell Scientific CR10 Data Acquisition System was used to monitor the internal temperature of the site instrumentation shelters. The probes were non-aspirated. The full scale probe operating range was -35 to +50 degrees centigrade.

Data Acquisition System

A Campbell Scientific, Model CR10 was used to receive and store ozone and meteorological instrument input values. The CR10 Measurement and Control Module together with its detachable wiring panel is capable of providing the sensor measurement, timekeeping, communication, data reduction, and data storing functions needed for this project. Analog (voltage or amps), pulse counter, resistance and conductivity signals may be input to the CR10. Digital I/O ports allow direct or remote communication with the unit. The standard memory configuration allows storage of 29,900 data points in two final storage areas. The CR10 has user-selectable scan rates beginning with a maximum of 64 times per second. A one-second scan rate was used for this project. Data backup and long term data storage were provided by Campbell's Model SM192 which, when coupled to the CR10 was capable of storing an additional 192,896 bytes of data.

2.1.3 Quality Control/Quality Assurance Procedures

Quality control of the data begins with the standard operating procedures (SOP) and documentation that have been implemented for this project, and the requirement that the field technicians be familiar with these procedures. Copies of the SOP and required documentation were kept at each site.

As part of the SOP, routine weekly visits were made to each site. During each visit the equipment and site facility were visually inspected, and zero precision span (ZPS) checks were performed on the ozone analyzers. The ZPS check reports can be found in the monthly data reports.

Each monitoring site was interrogated daily via telephone, and the data reviewed by experienced personnel. When problems were suspected or data appeared questionable, the Monitoring Field Manager was immediately notified. The Monitoring Field Manager, after reviewing the suspect problem(s), deployed a technician to the site if required. In this manner, problems were discovered and resolved with minimum data loss.

Data were stored on-site in non-volatile memory modules as well as in the data logging systems. This redundancy allowed the data to be recovered in the event of a data system failure, or when communications to the site were disrupted.

Data quality assurance (QA) was provided by a number of functions. Multipoint calibrations of the meteorological and ozone monitoring equipment were performed at the initiation of monitoring. Thereafter, monthly multipoint calibrations of the ozone analyzers, and trimester multipoint calibrations of the meteorological sensors were performed. The multipoint calibrations ensured that the equipment was operating within project requirements. The results of the multipoint calibrations appear in the applicable monthly data reports.

Detailed Internal Quality Assurance Performance Audits were carried out on all the instrumentation at each of the eight monitoring sites during the final week of the program. The results of the audits served to confirm that the instrumentation was still operating properly at the end of the project. Section 2.2.4.1 and Appendix D of this report present the results of the audit. In addition, personnel from the ARB/MLD lab conducted Quality Assurance Performance Audits at the seven desert monitoring sites during the initial weeks of the monitoring project (logistical problems precluded their auditing the Catalina Is. site). The results of those audits are presented in Section 2.2.4.2.

The hourly-averaged data were reviewed by personnel experienced with the parameters being measured. The data were checked for internal consistency, and consistency with other sites -- both project sites and those operated by other agencies. Ozone consistency checks also included reasonableness with local and regional meteorological conditions.

Results of the data Quality Assurance (QA) review were documented on standard forms. QA codes identified the validity of each data field. If a measurement was missing or was determined to be invalid, the QA codes provide an explanation.

2.1.4 Data Validation

The purpose of data validation is to identify and document monitored data that do not represent actual air quality or meteorological conditions at the monitoring sites. The data validation procedures that were followed in this project exceed the guidelines recommended by EPA (USEPA 1987b). The data validation procedures outlined here were implemented solely by T&B Systems personnel, independent of the data collection task, which was the responsibility of Ogden Environmental and Energy Services (Ogden). This distinction between the two functions was an important feature of the quality assurance plan.

All data validation was carried out by experienced air quality scientists who are familiar with expected diurnal and daily trends of ozone, wind, and ambient temperature. In the initial Level 1 procedure, computer generated strip charts of high-resolution (six-minute) data were manually examined to identify obvious outliers that might indicate a gross error in a monitoring system. Fig. 2-2 presents an example of the QA strip chart. The manual review also allowed the detection of uncorrected drift in the zero-baseline of the ozone monitors.

Daily maximum and minimum hourly-averaged measurements from the sites within the network were compared with each other and with other regional measurements from routine monitoring stations. Time-series of hourly-averaged data for each measured parameter from each monitoring site were plotted side by side. In this manner, a single parameter was plotted for a number of sites. Fig. 2-3 gives an example of the side-by-side data plots used during data validation. Data validation was achieved by examining the diurnal variation of each parameter and comparing the records among the sites. This enabled the detection of unexpected trends in the data and other possible problems such as incorrect data system times.

Data values considered questionable were referred to the Field Manager for review and corrective action. Corrective action was to either invalidate the data based on the probable cause (calibration, span check, audit, equipment malfunction), or leave the data as is, but document the challenge. The data validation procedures result in a Level 1 data set that is thoroughly documented using standardized numeric codes, as depicted in Table 2-2. In those cases when there were invalidated or missing six-minute data, the hourly average was recomputed using a minimum of six five-minute averages (30 minutes) in accordance with EPA procedures (USEPA 1987b).

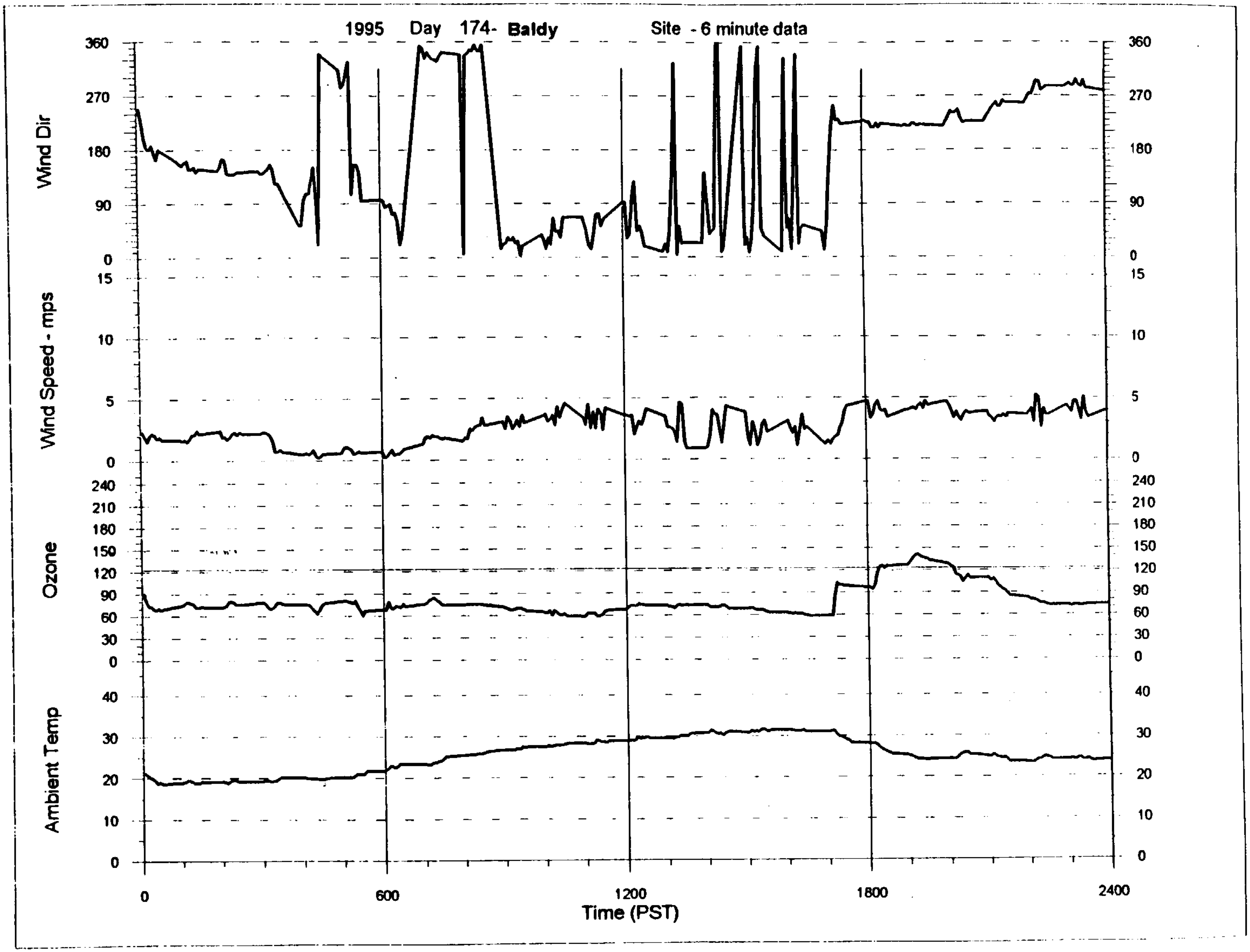


Fig. 2-2 Example of Strip Chart Plot for Data Review

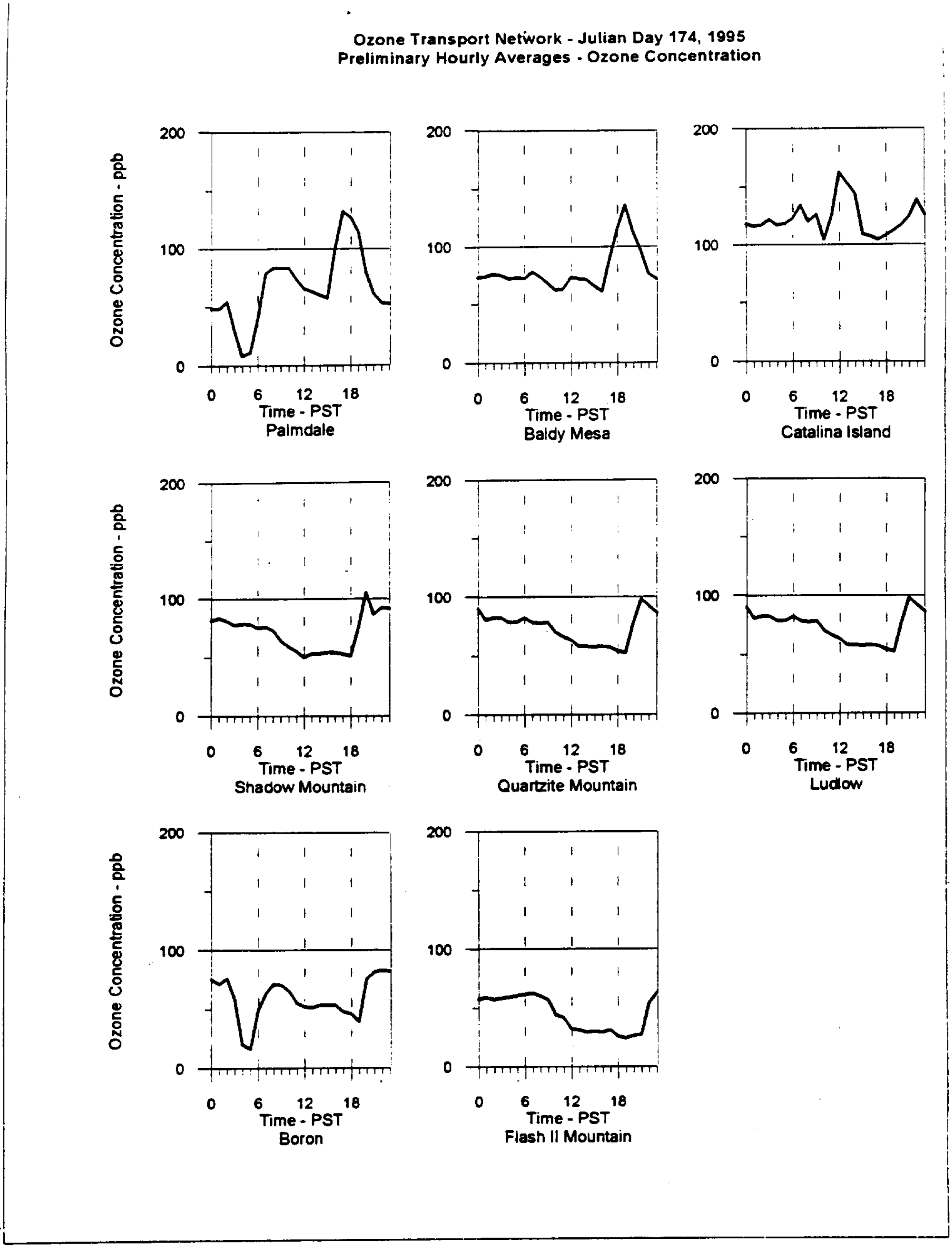


Fig. 2-3 Example of Time-Series Hourly Ozone Plots
(not shown full scale)

Table 2-2 Data Validation Codes		
Indicator Value	Code in Table	Code in File
Begin Monitoring	BM	-989
Calibration	CA	-990
End Monitoring	EM	-991
Instrument Malfunction	IM	-992
Interference (Acts of Nature)	IN	-993
Maintenance / Repair	MT	-994
Operator Error	OE	-995
Performance Audit	PA	-996
Site Failure	SF	-997
Station Check	SC	-998
No Monitoring	blank	-999

Data that has been invalidated or is missing has been replaced with one of the codes listed in Table 2-2. These codes indicate the reason the data were invalidated or the causes of missing data.

2.1.5 Data Presentation and File Format

Tabulated presentations of all of the monitoring data are available in *saroad* format in the previously issued monthly reports. Fig. 2-4 gives an example of the data in saroad format.

Data from the reporting period for each of the eight monitoring sites are contained in uniquely identified ASCII files which contain one month of data for one site. The file name template is SSMMMYY.HUR; where 'SS' is a two-letter site ID assigned each monitoring station (Table 2-3), 'MMM' is the common three-letter abbreviation for month, and 'YY' is the last two digits of the year in which the data were collected. Each file has the extension '.HUR' indicating that the data within these files are the hourly averaged data.

Each file contains the following nine header records.

Header record 1 - Site Name
Header record 2 - Site Latitude

OZONE TRANSPORT CORRIDORS STUDY | T & B SYSTEMS, INC.

SITE NAME : Catalina Airport | LATITUDE : 33 degrees 24 minutes 00 seconds | MONTH : August

ELEVATION : 1602 feet | LONGITUDE : 118 degrees 24 minutes 30 seconds | YEAR : 1995

PARAMETER : Ozone (parts per billion)

	HOUR (PST)																								
DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	MAX.
1	30	36	36	34	35	35	30	28	29	29	31	31	32	28	27	27	26	25	25	26	28	29	28	32	36
2	52	57	60	62	69	69	71	72	71	68	71	70	64	66	67	61	74	76	84	91	83	99	120	101	120
3	86	84	83	75	67	68	73	74	59	43	43	59	77	62	68	54	73	81	75	80	79	77	64	74	86
4	83	81	74	65	69	65	68	63	42	38	41	44	41	46	48	47	35	32	35	35	33	38	56	84	84
5	78	58	54	54	58	44	54	54	50	44	44	40	44	56	66	54	39	35	31	28	31	31	35	60	78
6	43	30	33	32	33	33	33	34	33	34	35	35	36	33	34	31	32	32	35	38	37	39	34	33	43
7	32	32	31	32	32	32	31	29	30	32	33	[SC]	[SC]	36	34	33	36	38	37	37	42	41	37	37	
8	38	40	42	40	39	40	40	44	48	42	37	37	37	42	42	53	69	84	94	121	146	128	153	144	153
9	142	102	85	84	92	98	98	81	68	58	56	54	53	56	58	65	62	55	46	45	49	46	50	52	142
10	52	48	50	53	52	53	51	37	32	34	36	35	36	30	40	47	51	61	63	97	100	87	71	75	100
11	68	77	80	79	69	58	56	50	49	49	47	51	54	51	57	65	69	64	77	63	51	54	51	46	80
12	46	42	38	37	37	43	46	41	37	41	35	33	33	36	41	47	52	47	52	52	53	52	50	51	53
13	53	53	53	50	42	43	52	52	50	47	43	43	47	47	49	54	58	60	59	59	61	62	61	63	63
14	64	63	59	61	63	61	53	52	43	40	40	41	42	42	41	41	40	56	72	72	65	59	58	36	72
15	37	41	42	44	43	43	46	47	46	43	44	42	42	40	40	39	39	40	60	76	72	51	39	40	76
16	37	41	43	43	52	50	49	48	50	54	52	[SC]	41	35	31	29	28	28	29	28	30	30	29	23	
17	20	23	27	30	31	29	28	29	30	32	33	32	32	32	31	31	50	66	49	33	30	31	35	36	66
18	41	40	40	38	32	32	32	33	30	32	32	32	33	35	43	53	45	44	45	46	78	103	96	80	103
19	66	65	69	71	71	72	70	64	61	47	46	48	47	44	41	40	38	46	63	62	66	60	41	58	72
20	65	56	69	59	49	62	60	42	41	46	47	46	46	47	52	49	48	45	46	67	78	81	78	73	81
21	73	44	88	84	80	73	70	43	40	43	41	35	33	33	36	43	45	54	55	58	53	47	46	50	88
22	52	56	63	55	48	47	44	45	47	47	46	44	43	45	45	42	40	34	33	29	25	22	26	24	63
23	22	22	22	26	27	30	28	29	33	31	29	[CA]	[CA]	[CA]	25	25	26	27	28	28	32	38	39	37	
24	43	35	31	30	29	32	33	28	36	36	37	38	40	38	43	40	43	48	50	51	50	51	52	49	52
25	50	49	50	51	50	50	49	47	46	44	43	46	47	49	49	44	42	43	43	45	47	49	47	45	51
26	42	41	42	40	40	41	41	41	39	38	41	41	48	52	47	43	43	40	41	51	55	56	53	46	56
27	45	47	48	51	51	51	49	49	49	44	48	46	49	50	59	58	59	60	62	65	66	61	68	70	70
28	70	67	68	68	65	64	65	63	60	53	55	56	59	61	62	65	60	55	56	55	52	55	57	43	70
29	45	41	42	40	39	44	43	42	44	46	50	58	61	56	70	80	74	66	62	59	57	50	46	48	80
30	49	53	52	46	50	47	48	46	47	46	49	52	59	[SC]	61	58	60	68	65	57	62	69	69	64	
31	57	58	53	52	52	56	67	67	64	62	57	49	59	65	65	71	74	72	66	58	67	63	65	64	74
AVG.	54	51	53	51	51	50	51	48	45	43	43	44	46	45	47	48	49	51	53	55	57	57	57	56	

Fig. 2-4 Example of Hourly Ozone Values for One Month

Header record 3 - Site Longitude
Header record 4 - Site Elevation
Header record 5 - Collection Year
Header record 6 - blank
Header record 7 - '----Channels----'
Header record 8 - Column headers
Header record 9 - blank

One data frame per hour follows the header records. The format of the data frames is described in Table 2-4.

Table 2-3 Two-Letter Site Codes

Site	Code	Site	Code
Baldy Mesa	BA	Ludlow	LU
Boron	BO	SE Palmdale	PA
Santa Catalina Island	CA	Quartzite Mt.	QU
Flash II Mt.	FL	Shadow Mt.	SH

Table 2-4 Record Format for Hourly Data

Column Number	Parameter
1	julian day
2	time (PST)
3	ozone (ppb)
4	ambient temperature (°C)
5	wind speed (ms^{-1})
6	wind direction
7	sigma theta
8	peak wind gust (ms^{-1})
9	data system voltage
10	shelter temperature (°C)

2.2 Results

2.2.1 Operations Summary

The eight monitoring stations were operated and maintained by Ogden and the data were quality checked daily by T&B Systems during a five month period from June-October 1995. All operations conformed to the published specification and guidelines of the EPA (USEPA 1987a, 1987b, 1987) and the ARB (CARB 1978, 1995). Logs of the operational activities at each of the monitoring sites during the monitoring program are presented in Appendix C.

2.2.2 Problems Encountered

As typical with field measurement programs, a variety of problems occurred during the five-month monitoring period. However, the daily QA procedures enabled early detection of all potentially serious problems and, therefore, no long durations of data loss occurred for any parameter at any site during the project.

The most prevalent problems that did arise were caused by short-term power outages, wind damage to equipment mounts, ozone monitor malfunctions, and shelter temperature fluctuations. Since the shelter temperature sensors were unaspirated and contained within the data logging equipment cabinet at each site, it is possible that some of the shelter temperature problems were due to high instrument readings rather than real temperature anomalies existent in the shelters.

Following is a synopsis of the problems encountered. The problems and associated data losses are described in greater detail in the monthly data reports.

- Abnormally low ozone levels were detected at the Boron site during routine telephone interrogation and data screening shortly after start-up. A sample line was found to be restricted, and the problem corrected on June 4.

- Daily routine checking of the Quartzite Mt. ozone data disclosed suspiciously low ozone levels during the first five days of operation after commissioning on June 1. A site visit on June 5 resulted in an inlet line adjustment. However, because of the lack of a transfer standard, a correction to the data prior to the flow adjustment could not be made and, hence, those data were invalidated. The flow rate and inlet lines were checked again on June 7 because ozone levels still seemed artificially low. No problems were detected. Multipoint calibrations of ozone on June 11 showed that there was a negative offset (nine ppb) that was likely contributing to the low readings. For the remainder of the reporting period, the analyzer functioned adequately. The data measured prior to the calibration were adjusted based on the *as-found* slope and intercept.

- The Santa Catalina Island site was operational on June 8, but, telephone communications had not yet been established. When the site was visited for the initial multipoint calibration on June 12, it was found that the airport manager had shut down the system because the instrument made too much noise. The ozone analyzer and data system were moved to another location at the request of the airport manager. An *as-found* multipoint calibration was performed June 22. The measured ozone concentrations were found to be outside ARB specifications (CARB 1978) but, due to time constraints (airport closure time), the analyzer offset and span were not reset. On June 27 both *as-found* and final multipoint calibrations were performed on the analyzer. The ozone data acquired prior to the final multipoint calibration were adjusted to account for the *as-found* condition of the analyzer.

- The wind sensor boom mount at the Flash II Mt. site was found to have slipped in its bracket and was positioned upside down during a calibration visit on June 10. It was determined from detailed examination of the wind direction data that the problem most likely occurred earlier the same day it was discovered. The wind data for that day were invalidated. The problem was corrected and additional mount supports were fabricated on site.

- The ozone analyzer at the SE Palmdale site began malfunctioning soon after the completion of the ARB/MLD audit on June 11. The unit was replaced on June 13, and a multipoint calibration conducted on the replacement unit. The malfunctioning analyzer (timing board malfunction) was replaced with a spare unit and removed for repair.

- A site power outage occurred at the Boron site during a thunderstorm on June 25. Ogden personnel were on site performing a ZPS check when the outage occurred. As a result, there was only a minor disruption to monitoring.

- Loss of ozone data occurred at the Quartzite Mt. site on July 1-2 due to an instrument malfunction.

- Power was out at the Flash II Mt. site for four hours on July 5 when a new air conditioner was being installed by the facility operator.

- There was a commercial power outage at Boron for several hours on July 29. Wind gusts to more than 50 mph were measured and lightning was reported in the area.

- There was a commercial power outage at the Baldy Mesa site for several hours on July 31.

- A blown fuse in the ozone analyzer at Flash II Mt. resulted in data losses lasting 36 hours during August 7-8.

- An area-wide commercial power failure, lasting six hours, occurred at the SE Palmdale site on August 14.

- A routine visit to the Flash II Mt. site on August 17 resulted in the discovery of a failed bracket which secured the anemometer and wind vane. As a result, the sensor was positioned upside down. For safety reasons, the problem was not corrected until there were two people at the site. A concerted effort was made during data validation to determine when the bracket failed. Direction (along the north-south axis) was 180 degrees off due to this condition. It was concluded that the bracket failed during a strong wind episode shortly before the problem was noticed. The wind data were determined invalid from 1700 PST on August 17 through 1300 PST on August 19.

- Recorded shelter temperatures at both the Boron and Flash II Mt. sites, although air conditioned, fluctuated more than expected reaching as high as 40 C° at times. At Boron, this problem was caused by inadequate building insulation and air conditioning, and was incorrectable without significant expense. At Flash II Mt. the problem was repeatedly reported to the facility operator who was unable to determine the cause. Despite these problems, the ozone analyzers at both sites always operated within the manufacturers' published operational range of 0 C° to 50 C°. Moreover, ARB acceptance testing procedures (CARB 1978) for the Dasibi analyzers require accuracy within ±0.01 ppm over a range of 4 C° to 44 C°.

- Four periods of ozone data losses, each of about 2-3 hours duration, occurred at the Ludlow site during September. Commercial power interruption was the likely the cause.

- Ozone readings were noisy due to possible RF interference at the Quartzite Mt. site from September 8 through September 13. The problem was corrected by insulating the electronic components with protective foil. Spikes in the 6-minute averaged data were removed. When at least 30 minutes of valid data remained after removing spikes, new hourly averages were computed as per EPA guidelines (USEPA 1978a).

- Recorded shelter temperatures dropped below accepted ARB/EPA guidelines (CARB 1978, USEPA 1987b) in the Boron site shelter during cool nocturnal ambient temperatures in October. Several trial and error adjustments to the shelter thermostat were made until the internal temperature was neither too cool at night nor too hot during the daytime. Ozone data were not invalidated.

- During a period of persistently strong winds at the Flash II Mt. site, debris collected in the inline filter to the ozone monitor causing artificially low readings. Data were disqualified from October 21 to October 23 when the problem was corrected during routine maintenance.

- Due to a faulty pump, the ozone monitor at the Quartzite Mt. site failed in its final ZPS check just prior to its removal on November 4. Data were disqualified from the date of the last ZPS check (October 27) to the end of the month.

- Artificially low ozone concentrations at nighttime were recorded at both the Boron and Ludlow sites throughout the monitoring period. It was determined that reactive emissions from local sources were the likely cause. For a further discussion on this matter, the reader is referred to Section 8 of Volume 2 of this report.

2.2.3 Data Recovery

The data recovery rate, sometimes called *completeness*, is defined as the ratio of the number of valid data-hours to the number of possible data-hours, multiplied by 100, which yields a percentage. The number of possible data-hours excludes data losses due to routine maintenance duties such as span checks, calibrations, and audits. Data losses due to any other causes reduce the data recovery rate.

The data recovery rate for this program is shown in Table 2-5. From the table it is evident that the data completeness was exceptionally high in this program in spite of the remoteness of many of the sites. The data recovery rate was in excess of 99% for all the meteorological parameters. The data recovery rate for ozone ranged from a high of 99% at Shadow Mt. to a low of 90% at Quartzite. Data recovery for ozone was 95% or greater at the other sites.

Table 2-5 Data Recovery Rates

Site	Ozone (%)	Temperature (%)	Wind Speed (%)	Direction (%)
Baldy Mesa	98.86	99.75	99.75	99.75
Boron	97.05	99.67	99.64	99.67
Santa Catalina Island	98.88	99.64	99.64	99.67
Flash II Mt.	94.58	99.92	98.45	98.45
Ludlow	98.75	99.86	99.86	99.81
SE Palmdale	97.71	99.89	99.86	99.86
Quartzite Mt.	90.25	99.92	99.92	99.89
Shadow Mt.	99.26	99.78	99.78	99.78

2.2.4 Audit Results

2.2.4.1 Internal Quality Assurance Audit

Between September 28 and October 4, 1995, Mr. Dominic Laniewicz of Ogden conducted internal quality assurance performance audits on instruments at the eight ozone transport monitoring stations. Ogden was a participant in the field study and teamed with T&B Systems, the prime contractor, to operate and maintain the network. The monitoring network collected continuous ozone, wind speed, wind direction and temperature data.

The auditing methods used were consistent with published U.S. Environmental Protection Agency guidelines and Ogden's own quality assurance program (Staff 1991) for meteorological stations. In brief, each meteorological instrument or measuring device was challenged with a known input from the appropriate audit equipment. The station's observed response was noted and the relative difference between the known audit input and observed station response was used to assess the instrument's accuracy. To maintain the element of independence, the auditor and the audit equipment used to perform the tests were not part of the normal station QC operations. Listed below are the auditing methods used to conduct the performance audit at the site. Table D-1, in Appendix D, identifies the performance audit methods and acceptance limits used to audit each parameter monitored by the stations.

Wind Speed: The sensor's anemometer was removed to permit a zero wind speed reference point. The sensor's starting torque threshold was measured by a torque disk. A motor device was then attached to the sensor shaft and a known rotational frequency (rpm) was input to the system. The rpm input was converted to an equivalent wind speed according to the manufacturer's calibration. The observed output reported by the station was compared to the known wind speed input. At least two different audit points plus the zero reference were input to the system during the audit.

Wind Direction: The wind direction sensor was audited in two ways. First, the sensor's alignment to true north was determined by a precision compass, a topographical map, protractor and the current magnetic declination for the area. The alignment of the north-pointing orientation rod along the north-south axis was determined by use of a precision compass and a siting device such as a surveyor's transit or binoculars. Once the true alignment of the rod was determined, the wind direction sensor was held at key positions to confirm it's orientation relative to the alignment rod. After the sensor's true alignment had been determined, the vane was rotated in discrete known intervals (e.g., 90 degrees) both clockwise and counterclockwise through 360 degrees. The difference between the known and observed incremental points established the sensor's accuracy and linearity. A torque gauge was used to measure the sensor's starting resistance threshold to a ten-degree deflection of the vane.

Temperature: The temperature probe was placed in a Dewar flask or an insulated container filled with water at a known temperature. The bath was agitated to assure thermal uniformity and the temperature was determined by a NIST-traceable mercury thermometer with 0.1 degree C division markings. At least three temperatures over the operating range of the system were input to the probe. The differences between the known audit input and observed station output were used to confirm the system's accuracy.

Ozone: A certified ozone transfer standard with an internal ozone source lamp (Dasibi 1003 PC) was used to challenge the station analyzer with a zero plus at least three upscale ozone concentrations over the station analyzer's operating range (0 - 500 ppb). The audit ozone gas concentrations were assayed simultaneously by the transfer standard unit and the station ozone analyzer. The known ozone audit input concentrations were compared with the station analyzer's observed response. The audit results were plotted as *x* and *y* coordinates by linear regression and evaluated by the resulting audit response curve (slope, intercept and correlation coefficient).

All of the instruments tested during the QA performance audits were found to be operating within acceptable audit limits. The wind speed and wind direction sensors at the Ludlow site could not be tested due to lack of adequate climbing safety equipment needed to retrieve the sensors from the platform on which they were mounted. Table D-2, in Appendix D, presents the summary of the performance audit Pass/Fail results. Refer to Appendix D for details regarding the performance audit results.

In general, all the monitoring stations appeared to have operated properly and have met acceptable siting criteria to collect representative ozone and meteorological data. With the exception of the Santa Catalina Island site, all of the ozone analyzers operated in temperature controlled environments. However, some of the stations experienced shelter temperature fluctuations. Boron, Flash II Mt. and Quartzite Mt. had some fluctuations outside of the normal operating range of 20 C°- 30 C°, but still well within the manufacturers specifications and ARB acceptance testing criteria. The Santa Catalina Island ozone analyzer was placed in the interior of the air traffic control tower building so temperature variances were minimal.

2.2.4.2 ARB Performance Audit

The California Air Resources Board/Monitoring and Laboratory Division (ARB/MLD) performed Quality Assurance Performance Audits at seven of the eight monitoring sites during the initial month of the monitoring program. Logistical problems precluded an eighth audit at the Santa Catalina Island site. The audits took place between June 14 and June 20, 1995.

The results of all the audits met the EPA PSD guidelines (USEPA 1987a) in the same manner as the Ogden Internal Audit described in Section 2.2.4.1 of this report. The final documented results of the audit have been submitted by the ARB/MLD, and are available from the ARB under separate cover.

2.3 Discussion

Table 2-6 gives the number of hours and days on which hourly-averaged ozone concentrations exceeded the State's standard at the sites within the project network. The maximum concentrations experienced and days on which the maximum occurred are also given. The two sites near the outflow from the passes leading into the Mojave Desert from the SoCAB (Baldy Mesa and SE Palmdale) had several hundred exceedance-hours which could be attributed principally to direct transport through the passes. The maximum levels measured in the network were at those two sites. The Quartzite Mt. and Shadow Mt. sites, located downwind of Baldy Mesa and SE Palmdale respectively, characterized conditions aloft and showed that the pollution plumes, even after dispersing vertically and horizontally, often produce concentrated levels. Ozone concentrations were reduced considerably at sites farther from the passes, and there were no exceedances experienced at the farthest downwind site, Ludlow.

Table 2-6 Number of Hours and Days the State Standard for Ozone was Exceeded

Site	# Hours	# Days	Maximum (ppb)	Date of Maximum
Baldy Mesa	479	86	210	Aug 01
Boron	31	15	114	July 06
Santa Catalina Island	101	27	157	July 26
Flash II Mt.	7	3	103	Sept 15
Ludlow	0	0	90	July 21
SE Palmdale	356	78	185	July 27
Quartzite Mt.	171	48	162	Aug 01
Shadow Mt.	86	36	150	July 25

Measurements within the network are examined more in detail in Section 3 of this report. In Section 3, the frequency of transport and transport patterns are examined, and the contribution to ozone concentration from sources within the desert are discussed.

A surprisingly large number of exceedances spread rather uniformly over the monitoring period occurred at the Santa Catalina Island site. About 60% of the exceedance hours occurred during five 24-hour periods. Those periods are examined in the analysis reported in Section 3

A major objective of this program was to determine the representativeness of the measurements made at *elevated* sites to conditions aloft in the free atmosphere. This issue is addressed in Section 3 as well. It was determined from comparisons with remote sensing instruments and aircraft measurements that those measurements were representative of ozone levels and wind flows aloft.

2.4 Summary

A network consisting of eight sites measuring ozone, temperature, and winds was established and operated for a five-month period (June-October) during the 1995 ozone season. The network was designed to: 1) provide additional measurements in transport corridors from the SoCAB to the Mojave Desert through Soledad Canyon and Cajon Pass, and offshore from the SoCAB to San Diego County; and 2) evaluate the use of *platforms of opportunity* such as prominent peaks for making continuous measurements of conditions aloft.

During the first phase of the program, a list of candidate sites was developed which were then field surveyed by experienced personnel to determine feasibility. The results of the site survey were submitted, along with recommendations, in an interim report. The ARB, in cooperation with the Mojave Air Pollution Transport Committee, made the final site selection.

Monitoring was successfully carried out at seven sites located in the Mojave Desert and at one site at the airport on Santa Catalina Island. One site was located at the inflow from Soledad Canyon to the desert and another at the entrance to the desert at Cajon Pass. Three other desert sites and the site at Santa Catalina Island were located on the top of prominent terrain ranging from 300 to 500 meters above surrounding terrain. The remaining two of the desert sites were placed at strategic locations which when combined with the measurements from other sources, more closely monitored other transport routes from the San Joaquin Valley and from the east Mojave Desert.

No major problems resulting in significant data loss occurred during the field monitoring phase of the project. The data recovery rates were greater than 99% for the meteorological measurements, and, with one exception, 95% or greater for ozone. The data recovery rate for the one exception was 90%, which is still within acceptable limits.

The sites near the Cajon Pass and Soledad Canyon transport corridors, and at Santa Catalina Island experienced numerous exceedences of the State's ozone standard. The most eastern site at Ludlow measured no exceedences. Section 3 of this final report provides the results of some limited analyses of the data.

3.0 DATA ANALYSIS

The results of a limited analysis of the study and routine network measurements is presented in this section. The objectives of this analysis were chiefly to address specific issues or concerns expressed by the ARB staff regarding transport into the Mojave Desert and features noted during the monitoring phase including exceedance events at Santa Catalina Island. A short-term (two week) demonstration project involving an ozone lidar, airplane measurements, and a radar wind profiler provided a comparison with one of the *elevated* sites established for this study. These results of the comparisons are given in this section as well.

3.1 Transport into the Mojave Desert

Pollution transport into the Mojave Desert from the SoCAB through Cajon Pass and Soledad Canyon has long been recognized, and numerous studies in addition to the present study have been carried out (Reible et al. 1983 and Smith et al. 1983 to name a few). Likewise transport into the Mojave Desert from the San Joaquin Valley (SJV) through Tehachapi Pass has been documented in a number of field studies (Blumenthal et al. 1987). Less understood, however, are the transport and dispersion conditions within the Desert which, although not the primary objective of this study, are nevertheless addressed in other sections of this report.

An important feature of the transport process during the ozone season is the regularity of air movement from the densely populated areas in Southern California into the more sparsely developed areas of the high desert. This is illustrated in the streamlines constructed from the prevailing winds shown in Fig. 3-1 through Fig. 3-3. Fig. 3-1, based on the 15-17 PST prevailing winds, shows the divergence of air into the Desert after exiting the passes. In the case of Soledad Canyon, transport in the desert continues to the east and northeast, and in the Cajon Pass area transport continues north. The 21-23 PST streamlines (Fig. 3-2) show continued transport into the Desert from the SoCAB and the SJV. Phelan, Baldy Mesa, and Hesperia winds are all aligned and from the southwest. Lancaster winds are aligned closely with those at SE Palmdale as well. Fig. 3-3 shows the 09-11 PST prevailing flows when regional pressure gradients are typically the most relaxed of the day and wind fields the weakest. Nevertheless, on a most frequent basis, transport through the Soledad Canyon and Cajon Pass corridors still occurs.

Winds at Mojave show a transport coupling between the SJV and the Desert through Tehachapi Pass. This transport feature generally prevails during the afternoon and evening but not from the sunrise to forenoon period.

A major characteristic of the wind in the Desert is the convergence zone of the westerly flows from the Soledad Canyon region and the northbound air flowing from Cajon Pass. This meteorological attribute has been known and exploited by soaring enthusiasts for some time, and is commonly called the El Mirage convergence zone (Section 3.1.4). The convergence zone is shown well developed at 15-17 PST (Fig. 3-1). Significant horizontal wind shear exists due to the converging flows which, in the June-October 1995 database, typically occurred between the Shadow Mt. and Quartzite Mt. sites.

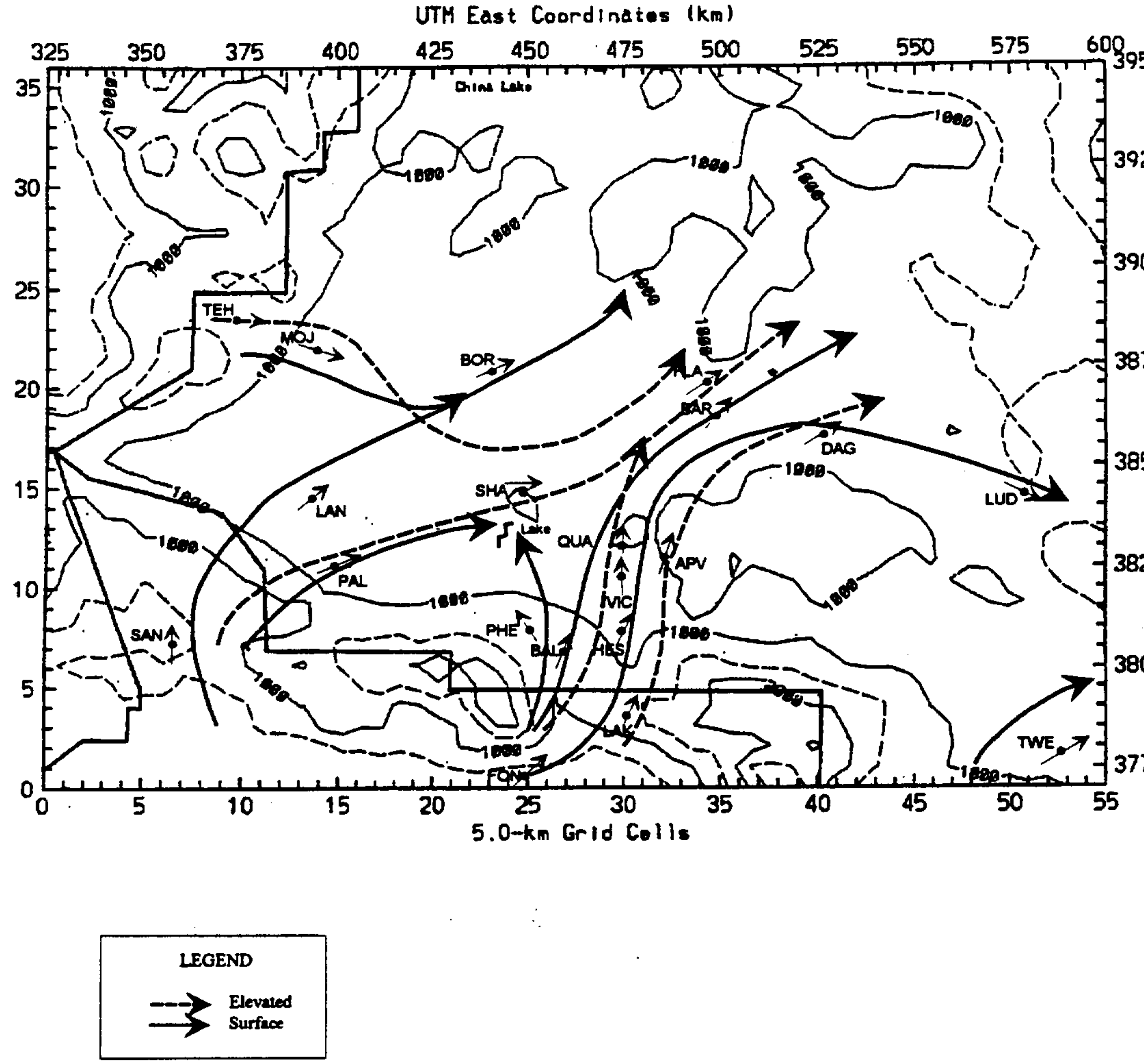


Fig. 3-1 Streamlines based on Prevailing Winds at 15-17 PST, June - October, 1995

f3-1fin.drw

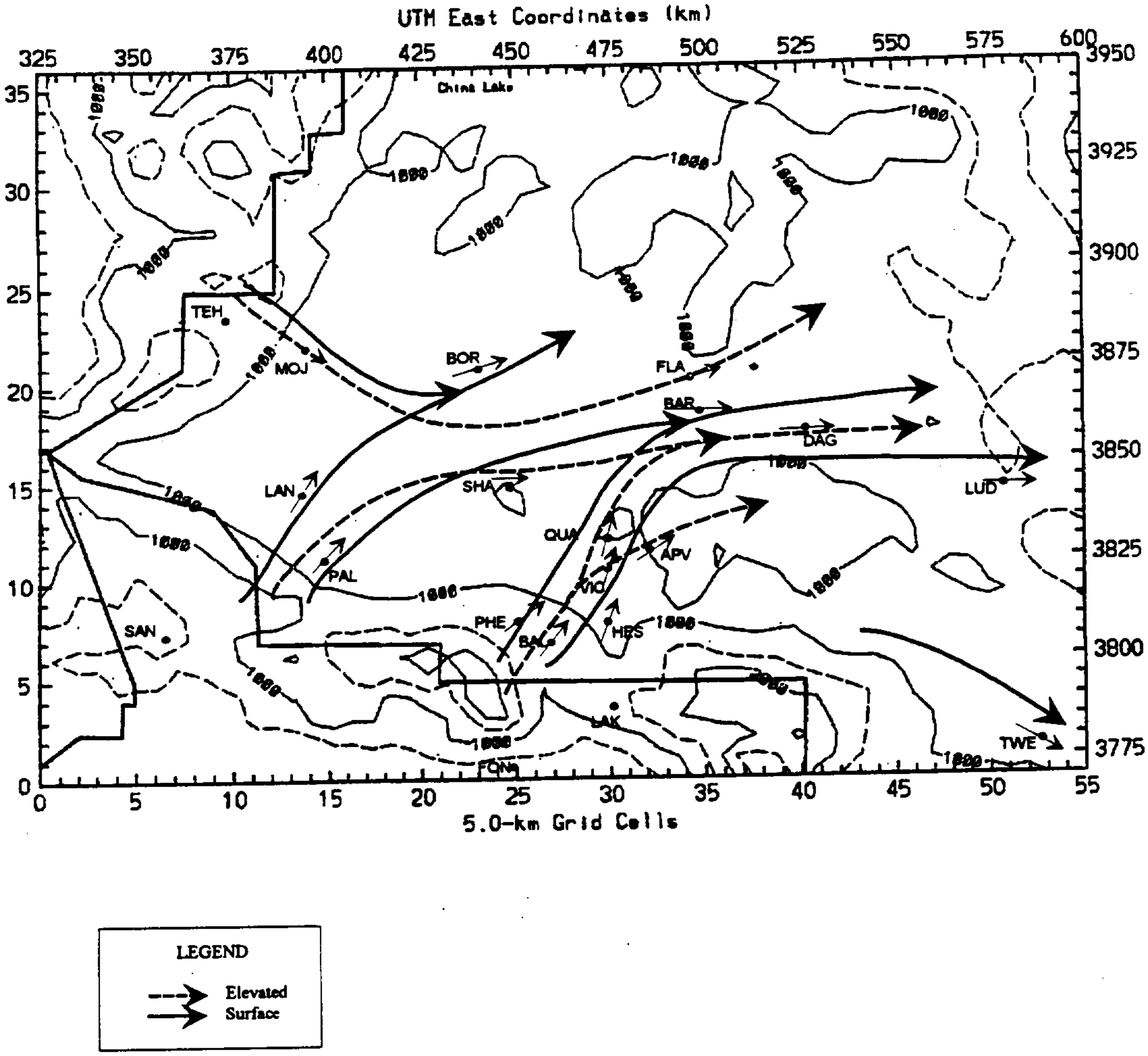


Fig. 3-2 Streamlines based on Prevailing Winds at 21-23 PST, June - October, 1995

f3-2fin.drw

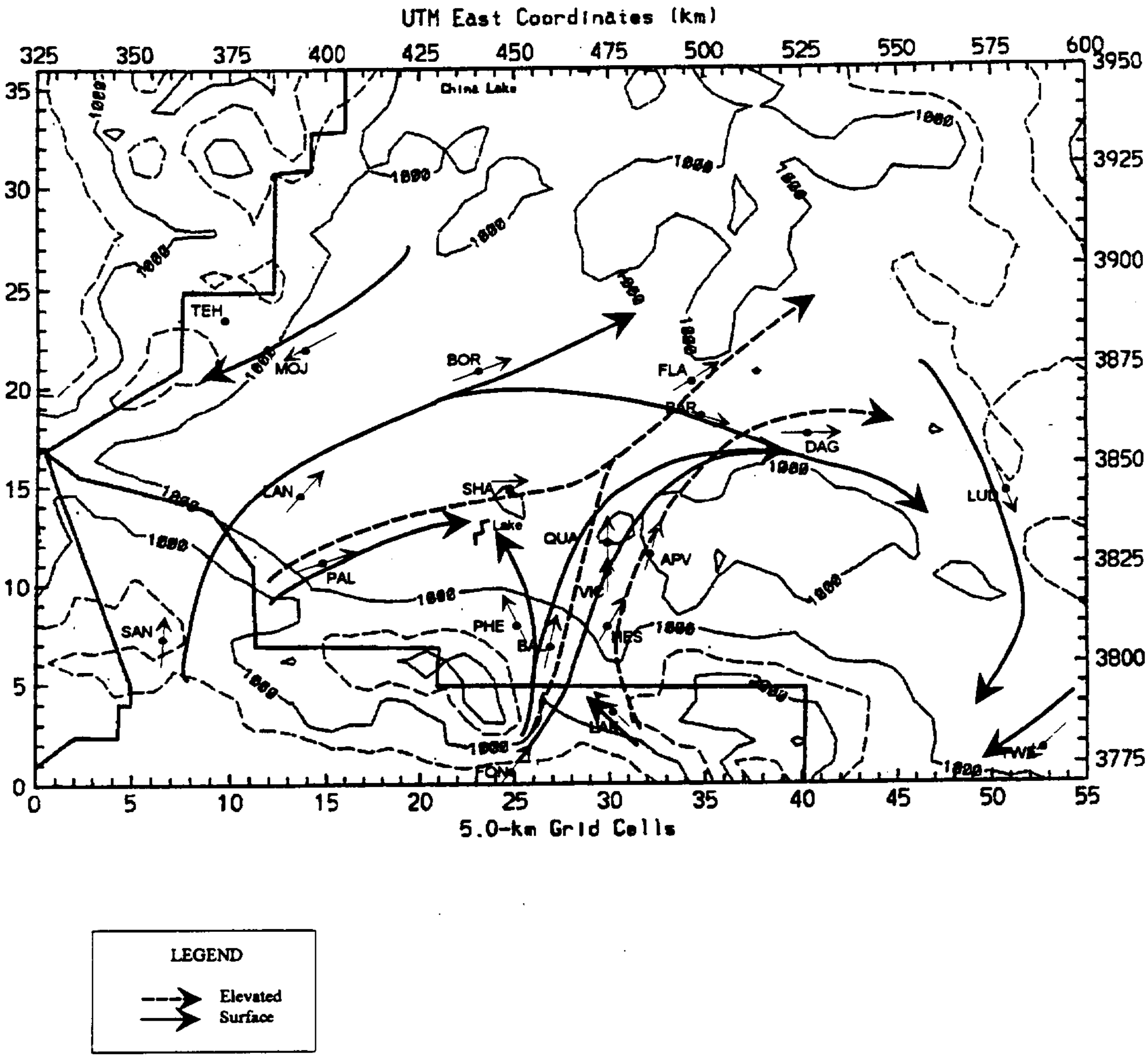


Fig. 3-3 Streamlines based on Prevailing Winds at 09-11 PST, June - October, 1995

f3-3hn.drw

North of the El Mirage zone and through the central part of the Desert the flow is westerly in response to the characteristic pressure gradients. In the eastern part of the observational grid (e.g., Ludlow) the flow is somewhat more variable. At 10 PST the predominant wind at Ludlow and 29 Palms was from the north.

Data collected by the ARB radar wind profilers at Apple Valley and Daggett frequently show a minimum wind flow in the late forenoon when the pressure gradients toward the interior reach a diurnal minimum. Under strong pressure gradient conditions, the westerly flow regime may extend throughout the Desert and to the California-Nevada border at all hours.

On a mean basis, wind speeds in the Desert reach their diurnal peak between 14 and 16 PST at the entrance locations of SE Palmdale and Baldy Mesa but generally somewhat later in the central and eastern regions. Wind speeds at Barstow reached a peak at about 17-18 PST and at Ludlow from 18-20 PST. Mojave had a somewhat later peak (about 17 PST) than the other entrance locations.

3.1.1 Flows through Cajon Pass, Soledad Canyon, and Tehachapi Pass

Table 3-1 shows the frequency of hours when flows were directed from Cajon Pass, Soledad Canyon and Tehachapi Pass to downwind sites at Baldy Mesa, SE Palmdale and Mojave, respectively. Baldy Mesa was considered to be downwind from Cajon Pass when site winds were from the S to SW. The source of air at SE Palmdale was considered to be from Soledad Canyon when the winds at the site were from the SSW through W. Winds from the WSW to NW at Mojave were considered to transport air from the SJV. The hourly winds were stratified into eight three-hour blocks to allow the diurnal character of the flows to be examined.

As the data in Table 3-1 show, air flows through the passes from the SoCAB into the Mojave Desert during a substantial portion of the day but especially in the afternoon and evening. The most frequent occurrence at both SE Palmdale and Baldy Mesa was late afternoon and early evening (15-17 PST and 18-20 PST) when the frequencies were 80% or greater. In the morning (6-8 PST) when air flowing through the passes was least frequent, the winds at Baldy Mesa were still directed from Cajon Pass more than 50% of the time. Correspondingly, the morning winds at SE Palmdale were directed from Soledad Canyon about 40% of time. Winds at Mojave between 18-23 PST were most frequently from the SJV. Transport from the SJV was more limited during the morning and early afternoon.

Also of interest are periods when there is no transport into the Desert from the SoCAB and SJV. One method for defining non-transport periods was to examine the wind data from the three entrance sites for continuous 24-hour intervals during which none of the hourly-averaged flows indicated transport into the Desert. The 24-hour interval encompassed from midnight to midnight. The results using this method are shown in Table 3-2. The SE Palmdale data show that everyday during the five-months of monitoring had at least one-hour when air flowed through Soledad Canyon into the Desert. At Mojave and Baldy Mesa, there were not any non-transport days from June through September (except for the last day of September at Baldy Mesa). During October at the latter two sites, several days met the non-transport criteria.

Table 3-1 Frequency (%) by Time of Day when the Site is Downwind of Pass, June - October 1995

Baldy Mesa (Cajon Pass)

	Hrs 0-2	Hrs 3-5	Hrs 6-8	Hrs 9-11	Hrs 12-14	Hrs 15-17	Hrs 18-20	Hrs 21-2
S-SW	69	63	56	69	80	84	85	76

SE Palmdale (Soledad Canyon)

	Hrs 0-2	Hrs 3-5	Hrs 6-8	Hrs 9-11	Hrs 12-14	Hrs 15-17	Hrs 18-20	Hrs 21-23
SSW-W	76	71	40	47	66	83	80	70

Mojave (Tehachapi Pass)

	Hrs 0-2	Hrs 3-5	Hrs 6-8	Hrs 9-11	Hrs 12-14	Hrs 15-17	Hrs 18-20	Hrs 21-23
WSW-NW	69	56	28	24	34	61	82	78

Footnote: Times are PST.

Table 3-2 24-Hour Periods During Which No Transport Occurred			
Month (1995)	SE Palmdale via Soledad Canyon	Baldy Mesa via Cajon Pass	Mojave via Tehachapi Pass
June	none	none	none
July	none	none	none
August	none	none	none
September	none	30	none
October	none	2, 5, 13, 17, 23	2, 13, 14, 19, 23

3.1.2 Ozone Transport From the SoCAB and the SJV

Exceedances of the state ozone standard (≥ 95 ppb) observed at the Baldy Mesa and SE Palmdale sites occurred almost exclusively when the flow was directed through the passes. Likewise, the elevated site at Quartzite Mt. was downwind of one of the two passes when exceedances occurred there.

Table 3-3 shows the frequency (%) of the exceedances at Baldy Mesa, SE Palmdale, and Quartzite Mt. that occurred when the flows at those sites were directed from Soledad Canyon or Cajon Pass. The number of exceedances is given within parentheses. Statistics are given by month and for the five months combined. The data show that Quartzite Mt., located at some distance from the passes, can be impacted by transport from either pass. Similar to Baldy Mesa, Quartzite Mt. was considered to be downwind from Cajon Pass when site winds were from the S to SW. Exceedances at Quartzite Mt. when there was westerly (WSW-W) flow were assumed to be the result of transport from Soledad Canyon.

From the table it can be seen that 96% of the exceedances which occurred at Baldy Mesa can be attributed to direct transport from Cajon Pass. When June is excluded, that percentage increased to 98-100%. All the exceptions to exceedances at Baldy Mesa owing to direct Cajon Pass transport were examined. These events all occurred during transitional periods when winds were either light and variable or a major wind shift occurred. These conditions happened during either the hour prior to or at cessation of flow through Cajon Pass from the SoCAB.

Quartzite Mt., located approximately 30 km northeast of Baldy Mesa, is representative of conditions aloft about 500 m above the surrounding terrain. Table 3-3 shows that most of the exceedances measured at Quartzite Mt. (90%) occurred when the site was directly downwind of Cajon Pass. Another group (four hours) of exceedances occurred during light and variable flow conditions following several hours of transport from Cajon Pass (August 19). Eleven hours (6%) of exceedances occurred when the winds indicated transport from the Soledad Canyon route. Transport from either Cajon Pass or Soledad Canyon clearly accounted for 99% of the exceedances. The remaining 1% (two hours) occurred when there were generally west winds suggesting a trajectory from Soledad Canyon but the direction was highly variable.

SE Palmdale like Baldy Mesa had numerous exceedances of the State's ozone standard, and, as seen from Table 3-3, these occurred predominately (90% of the time) when the flow at the site was from Soledad Canyon (SSW to W). During August through October, this frequency increased to 96-100%. There were 33 exceedance hours when the wind direction was not in the SSW to W sector. Of those, 13 were during periods of transition when the flow through Soledad Canyon stopped. The wind at one hour was an anomaly in that it occurred during a period of otherwise persistent flow through Soledad Canyon. The remaining exceedances occurred on four days (June 10, June 11, July 14, and August 19). Further investigation revealed that on those days the horizontal pressure gradients were very weak indicating that the area was not ventilated to the usual extent, and that there was possibly prior-day carryover either aloft or at the surface (Section 6).

Table 3-3 Percent of Ozone Exceedances (≥ 95 ppb) Attributable to Direct Transport

Location	Jun	Jul	Aug	Sep	Oct	Total
From SoCAB						
Baldy Mesa	90% (103)	98% (172)	98% (110)	98% (90)	100% (4)	96% (479)
SE Palmdale	88% (80)	89% (141)	92% (74)	96% (52)	100% (9)	91% (356)
Quartzite Mt.						
From Cajon Pass	71% (21)	95% (73)	86% (50)	100% (27)	- (0)	90% (171)
From Soledad Canyon	19%	5%	6%	0%	-	6%
From SJV						
Mojave	100% (14)	100% (14)	73% (26)	100% (12)	100% (5)	90% (71)

Footnote (1) Total monthly number of exceedances is shown in parentheses.
(2) SSW-W flow is assumed to be indicative of transport through Soledad Canyon.
S-SW flow is assumed to be indicative of transport through Cajon Pass.
WSW-NW flow is assumed to be indicative of transport through Tehachapi Pass

As indicated in Table 3-3 the exceedances at Mojave occurred with winds almost exclusively from the direction of Tehachapi Pass. The few exceptions were accompanied by winds from about 215° or SSW.

3.1.3 Comments on Local Observations

3.1.3.1 SE Palmdale / Lancaster

The median wind direction at 16 PST for SE Palmdale on days with afternoon exceedances at SE Palmdale was 239° for July-August 1995. The median direction at 16 PST in Lancaster on those days was 217°. The difference may represent the effects of the higher terrain to the southwest of Lancaster and the more direct route for the flow through Soledad Canyon toward SE Palmdale.

There were nine days during July-August when an exceedance was recorded at SE Palmdale without a similar exceedance at Lancaster. The median winds for these days were 240° at SE Palmdale and 247° at Lancaster. The Lancaster winds showed indications of a more westerly component than was characteristic of the days when both locations experienced exceedances. There appear to be two synoptic conditions which may favor this occurrence. One is an unusually strong pressure gradient from LAX to Las Vegas. The other condition is a moderately strong gradient directed from Bakersfield to LAX. Both conditions should lead to a more southerly transport route through the Soledad Canyon that is directed more to the east of Palmdale than toward Lancaster.

3.1.3.2 Mojave

The wind direction distribution during the summer of 1995 at Mojave was bimodal, centering on 215° and 295°. The proportion of 295° directions relative to the 215° events increased to a peak in the late afternoon/early evening when the peak velocities also occurred.

There were 71 hours of ozone exceedance at Mojave during the June-October 1995 sampling period. Sixty of the hours occurred with winds in the northwest sector. There were four hours with wind directions near 250° and seven cases were clustered near the 215° direction.

The data suggest that most of the high ozone concentrations at Mojave are carried toward the southeast, to the south of Boron since there is little evidence of a transport connection between the two locations on elevated ozone days. This is discussed in detail in Section 3.3.2.

3.1.3.3 Boron

The wind directions at Boron during the summer of 1995 were unusually uniform. Median directions were about 250° through most of the day into early evening, backing slightly during the late night and early morning. There were 31 hours of ozone exceedance during the June-October sampling period. The median direction during the exceedances was 248°. There was no significant difference in direction between the exceedance hours and the total data sample.

3.1.3.4 Barstow / Flash II Mt.

Median wind directions at Barstow during the summer of 1995 were generally from the west to west-northwest except in the late afternoon when the median wind backed to a WSW direction. Flash II Mt. was characterized by a median direction of WSW, comparable to Boron. Proximity of Barstow to the foothills to the north may influence the surface winds at Barstow to a greater extent than at Flash II Mt.

Barstow had 12 hours of ozone exceedances during the June-October period (none in July, September or October). The median direction when exceedances occurred was 232° but individual values ranged widely from 206° to 285°, perhaps representing different source regions.

Flash II Mt. exceedances occurred on only four hourly periods (two days). The winds at Flash II Mt. were southwest (median 217°) in all cases. Flash II Mt. exceedances occurred 1-2 hours earlier than the day's ozone peaks at Boron and transport between the two locations is not indicated. The peak ozone times at Flash II Mt. were identical to peak times at Barstow on the two exceedance days (August 4 and September 22) although the Barstow peak on September 22 was only 92 ppb.

3.1.3.5 Shadow Mt.

Wind directions at Shadow Mt. were primarily from the western sector. There were 82 hours of ozone exceedances at Shadow Mt. About 90% of the wind directions during exceedance hours were between WSW and WNW.

3.1.3.6 Exit Region from Cajon Pass

Locations on the northern side of Cajon Pass experience similar wind distributions. Southerly winds predominate. Because of its location in the lee of the San Gabriel Mts. and to the west of the Pass itself, Phelan observations have been of particular interest.

Table 3-4 summarizes the most frequent wind directions at Phelan for the hours of 12-23 PST.

Table 3-4 Most Frequent Wind Directions (July-August) - Phelan			
Time (PST)	Direction (degrees)	Time (PST)	Direction (degrees)
12	150-160	18	170-180
13	150-160	19	180
14	150-160	20	190-200
15	150-160	21	190-210
16	150-170	22	200-210
17	160-170	23	220

At about 16 PST the wind direction at Phelan begins to shift gradually toward the southwest. All of the locations immediately downwind of the Pass follow the same pattern.

There were 250 hours of ozone exceedances at Phelan during the June-October 1995 period. Because of this characteristic wind shift in the afternoons, the predominant wind direction during exceedances had a broader distribution than other locations. Of the associated wind directions, 79% were between 150° and 199°. The prevailing wind direction was 160° when exceedances occurred.

3.1.3.7 Ludlow

The winds at Ludlow were lighter and generally less organized that at the other measurement locations. During the late night and early morning rather consistent WSW to W winds were observed. In the late forenoon there was a weak trend toward NW to N winds which became disorganized during the afternoon without a distinct tendency. There were no ozone exceedances at Ludlow during the June-October period.

3.1.4 El Mirage Convergence Zone

Near the vicinity of El Mirage Lake, prevailing westerly flows in the western Mojave Desert merge on a frequent basis with the northbound air that has a trajectory through the passes in the San Gabriel Mts. into the Desert. On most days during the 1995 field study, this feature, the El Mirage convergence zone, formed between two of the 1995 monitoring sites: Shadow Mt. and Quartzite Mt. The distance between the sites is only about 30 km but the prevailing winds at the two sites are strikingly different. This is illustrated in Table 3-5 in which the most frequent winds are shown on a diurnal basis for both sites during June-October. The data in the table show that, beginning in the early afternoon and continuing into the night, the winds at Quartzite Mt. are from the S to SW between two-thirds and three-quarters of the time. Likewise, the winds at Shadow Mt. are equally persistent from the W-WSW. These flows are most often contemporary (63% of the time at 18 PST) which results in the convergence zone. On the other hand, when synoptic pressure gradients toward Las Vegas relax, flow through Cajon Pass is minimized and the westerly flow may reach Quartzite Mt. and eastward.

Table 3-5 Prevailing Wind Directions - All Days, June - October 1995

Hours (PST)	Shadow Mt.		Quartzite Mt.	
	Direction*	Frequency	Direction*	Frequency
00-02	W,WSW	75%	SW,SSW,S	69%
03-05	W,WSW	69%	SW,S,SSW	63%
06-08	W,WSW	51%	S,SW,SSW	56%
09-11	W,WSW	47%	S,SW,SSW	59%
12-14	W,WSW	51%	S,SW,SSW	71%
15-17	W	49%	S,SSW,SW	73%
18-20	W,WSW,WNW	80%	S,SSW,SW	74%
21-23	W,WSW	79%	SSW,SW,S	73%

* Directions are ordered by decreasing frequencies.

Quartzite Mt. experienced 171 exceedance hours during June-October 1995, the bulk (155) of which occurred when winds were southerly and transport was from the eastern SoCAB. Twelve exceedance hours occurred when the trajectory was from the western Mojave. Nine of those 12 hours occurred during two periods: six hours during June 22-24 and three hours on July 13. The other three instances were isolated events occurring on different days in August. All 12 exceedances occurred between the hours 17-02 PST and most (9) occurred between 20-23 PST. All were characterized by relaxed minimum synoptic-scale pressure gradients and in the absence or eastward shifting of the El Mirage convergence zone.

Of the remaining exceedances, all but four hours occurred when the trajectory was from the south to southwest (east SoCAB basin-Cajon Pass trajectory). The four hours of exceptions occurred on August 19 between 04-07 PST. August 19 was a special case for study (Section 3.5) as ozone layers aloft were observed at other elevated sites as well and resulted in a region-wide fumigation event. Winds during the four hours were very light and from an easterly direction.

The grouping of the Quartzite Mt. exceedances as either an east SoCAB basin trajectory, a western Mojave Desert trajectory, or the August 19 fumigation event is evident in the plot of wind direction and ozone concentration shown in Fig. 2-4.

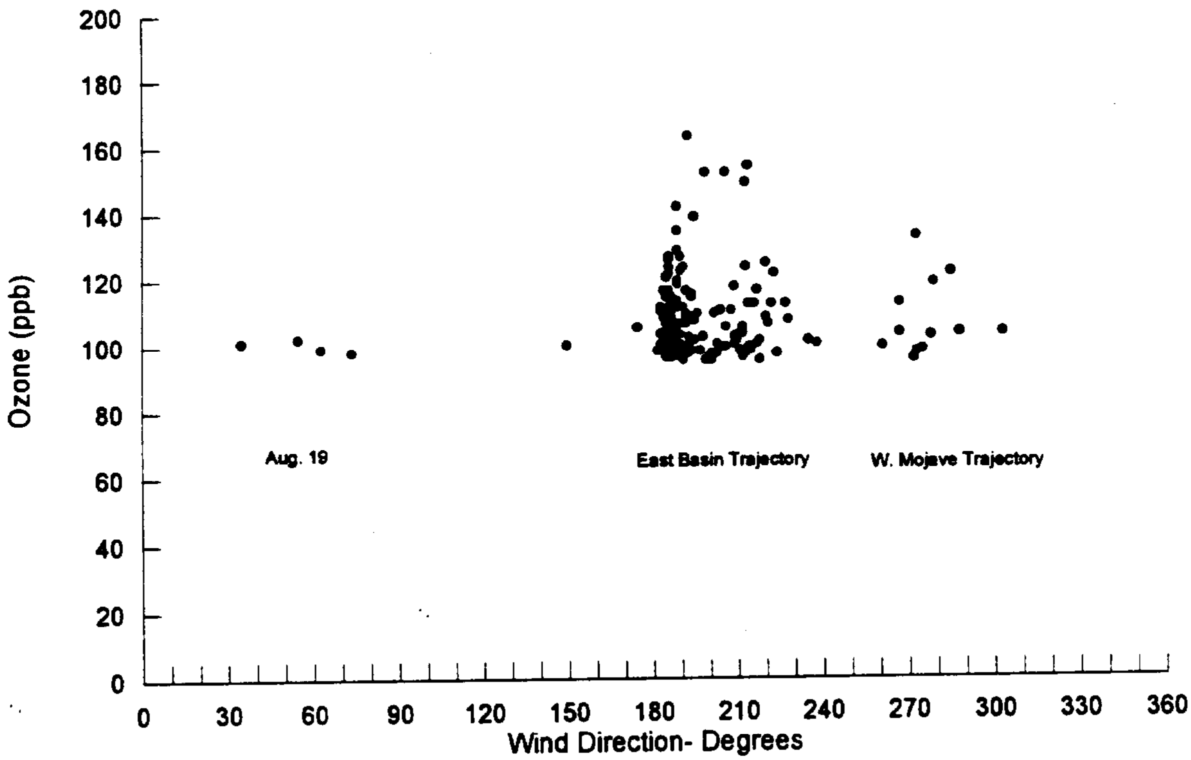


Fig. 3-4 Wind Direction During Ozone Exceedances at Quartzite Mt., June-October 1995

The structure of the El Mirage convergence zone is not discernible from the data collected during the program. However, it is apparent from soaring experiences that a sharp demarcation zone, marking the northwest edge of the Cajon Pass flow, moves to the northwest during the late afternoon reaching nearly to El Mirage on a most frequent basis. The wind shear zone in this area is reported as "usually" present during the day. The zone extends to the northeast during the afternoon as the Cajon Pass flow increases.

3.2 Timing of Peak Ozone Concentrations on Exceedance Days

Statistics on the time of ozone peak hourly average concentrations can be useful in defining ozone transport patterns and in describing the consistency of such patterns. For the present analysis an ozone peak was defined as the highest ozone concentration on days which experienced exceedances of the state ozone standard. Time of the peak concentration as well as associated wind direction and velocity were tabulated for each monitoring location and median values determined. Ludlow experienced no exceedances during the 1995 monitoring program and Flash II Mt. only three. They were excluded from this analysis because of an insufficient number of exceedance days.

Table 3-6 gives the timing statistics for the period June through October 1995 with the exception of Tehachapi Pass where the monitoring period was from July through September 1995.

Table 3-6 Median Characteristics of Ozone Peaks

Location	Peak Hours (PST)	Wind Direction (degrees)	Wind Speed (ms^{-1})	90% Hours*	Number of Days
SE Palmdale	16	243	6.8	5	80
Lancaster	15	236	5	4	57
Shadow Mt.	18	270	9.3	5	38
Tehachapi Pass	17	287	6	4	27**
Mojave	18	294	8	5	33
Boron	17	249	5.4	6	15
Barstow	17/18	232	8	4	6
Baldy Mesa	16	206	6.1	9	86
Phelan	16	170	6	7	64
Hesperia	16	193	7	4	46
Quartzite Mt.	18	189	7.1	7	47
Victorville	17	202	6	8	41

* 90% Hours gives the number of hours within which 90% of the peak times occurred.

** July through September only.

The difference in timing between SE Palmdale and Lancaster is a statistical artifact. If only those days when both sites experienced ozone exceedances are considered (48 days), the median time at both locations was the same (16 PST).

In the western part of the desert there is reasonable continuity in peak times from SE Palmdale/Lancaster to Shadow Mt. and from Tehachapi Pass to Mojave. Boron and Barstow do not fit the same type of scenario although the number of days is small. All of the locations in the west except Boron have compact peak time frequency patterns in which 90% of the days are included in 4-5 hour time periods.

For the flow through Cajon Pass the median timing peaks are in apparent agreement extending from 16 PST at Baldy Mesa to Quartzite Mt. and Victorville about one hour later. The 90% values, however, are considerably different from the western part of the desert, requiring nine hours at Baldy Mesa to include 90% of the peak times. The only exception is Hesperia for which 90% of the peak times are included in a four-hour period. Further examination revealed that Baldy Mesa times indicate two peaks, one at 15 and another at 18 PST. The time distribution of Phelan's peak ozone concentration is similar to Baldy Mesa's time distribution. However, rather than showing two distinct peaks, Phelan exhibits one broader peak over an extended period of time (14-18 PST). Both sites have median peak times of 16 PST (see Section 3.3). Quartzite Mt. and Victorville show unimodal peaks similar to but broader than found at Hesperia.

Narrow frequency distributions indicate a consistent meteorological/source pattern with limited variability. The broad peaks at Phelan and bimodal peaks at Baldy Mesa suggest at least two source patterns and/or meteorological differences. The frequency distributions of exceedances at Baldy Mesa, Phelan and Hesperia are further discussed in Section 4.

3.3 Transport Patterns as Determined from Time of Ozone Peaks

The temporal progression of ozone peak concentrations as a function of downwind distance can provide an indication of trajectory patterns. Limitations of the concept increase as the downwind distance increases and, particularly, when multiple sources may be involved. However, it is useful to consider the three principal transport corridors to the Desert (Tehachapi Pass, Soledad Canyon and Cajon Pass) and to extract as much information on downwind travel as the data permit. This has been done by considering peak concentrations on exceedance days from measurements at sites near each of the three entrance points (Mojave, SE Palmdale and Baldy Mesa) and by comparing the times of their peak concentrations with peaks at downwind locations. The analysis has been carried out in the form of couples, the entrance location and the closest downwind location, etc.

3.3.1 SE Palmdale - Shadow Mt. Transport Couple

These two sites are separated by about 50 km. Shadow Mt. is oriented at 070° from SE Palmdale. Median values of various parameters on exceedance days for the two locations are shown in Table 3-7. The wind equivalent, or direction the wind blows at Shadow Mt. when the site is directly downwind of SE Palmdale, is 250°.

Table 3-7 Median Values Associated with Peak Ozone Hours at SE Palmdale and Shadow Mt.

	SE Palmdale	Shadow Mt.
Hour (PST)	16	18
Wind Direction (degrees)	243	270
Wind Speed (ms^{-1})	6.8	9.3
Number of Exceedance Days	80	38

Data in the table indicate that Shadow Mt. lies almost directly downwind of SE Palmdale on a median basis. Although the Shadow Mt. wind is more westerly than SE Palmdale, lower level winds near and to the west of Shadow Mt. are likely to be more southwesterly due to surface friction (Petterssen, 1958).

At a distance of 50 km, a two-hour transport time requires a wind speed of about 7 ms^{-1}. Of the 80 exceedance days at SE Palmdale, 75 showed ozone peaks of various magnitudes with reasonable time delays to Shadow Mt. (1-3 hours). The primary characteristic (on four days) of the remaining five days was a large onshore pressure gradient which produced an exceedance at

SE Palmdale and none at Lancaster. Much of the ozone may have moved to the south of Shadow Mt. and also been diluted by the stronger than normal winds.

Fig. 3-5 shows the frequency distribution of peak concentration times on exceedance days at SE Palmdale and Shadow Mt. The distributions are unimodal and displaced by one to two hours in accordance with reasonable travel times.

3.3.2 Tehachapi Pass - Mojave - Boron Transport Couples

There is approximately a 20 km separation between Tehachapi Pass and Mojave, and approximately 50 km between Mojave and Boron. Mojave is oriented at 290° (wind equivalent) from Tehachapi Pass and Boron is oriented at 275° from Mojave (wind equivalent). Median values of interest on exceedance days are included in Table 3-8. Data in the table are limited to the period Tehachapi Pass was operational (July - September).

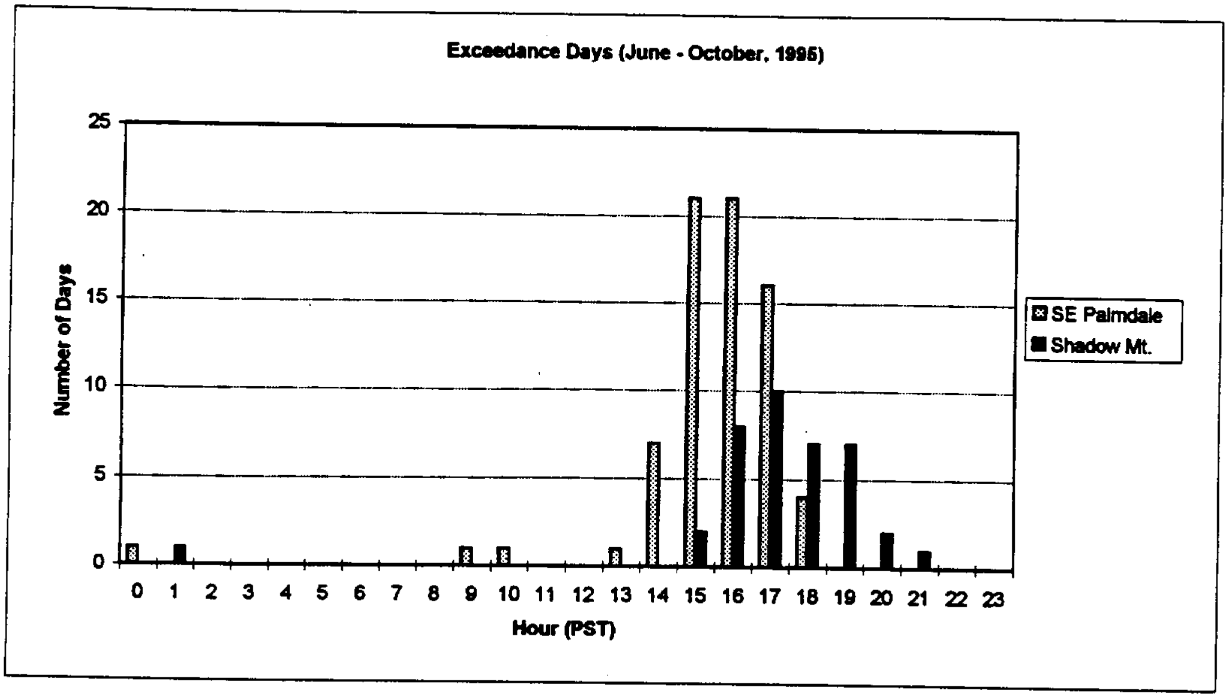
Table 3-8 Median Values Associated with Peak Ozone Hours at Tehachapi Pass, Mojave, and Boron

	Tehachapi Pass	Mojave	Boron
Hour (PST)	17	18	17
Wind Direction (degrees)	287	292	251
Wind Speed (ms^{-1})	5.5	7.7	5.3
Number of Exceedance Days	27	23	12

Note: July through September 1995

The data indicate that Tehachapi Pass and Mojave are aligned along median wind directions. However, the median wind direction at Boron represents a flow from a more southwesterly direction than at Mojave. Typical time delays between Tehachapi Pass and Mojave should be about one hour (20 km) while the delay time at Boron should be about two hours compared to Mojave. Data in the table conform to this pattern for the Tehachapi Pass-Mojave couple but not for Mojave-Boron.

Fig. 3-5 also shows the frequency distributions of peak concentration times for Tehachapi Pass and Mojave. The distributions are again unimodal with about one hour displacement in peak time.



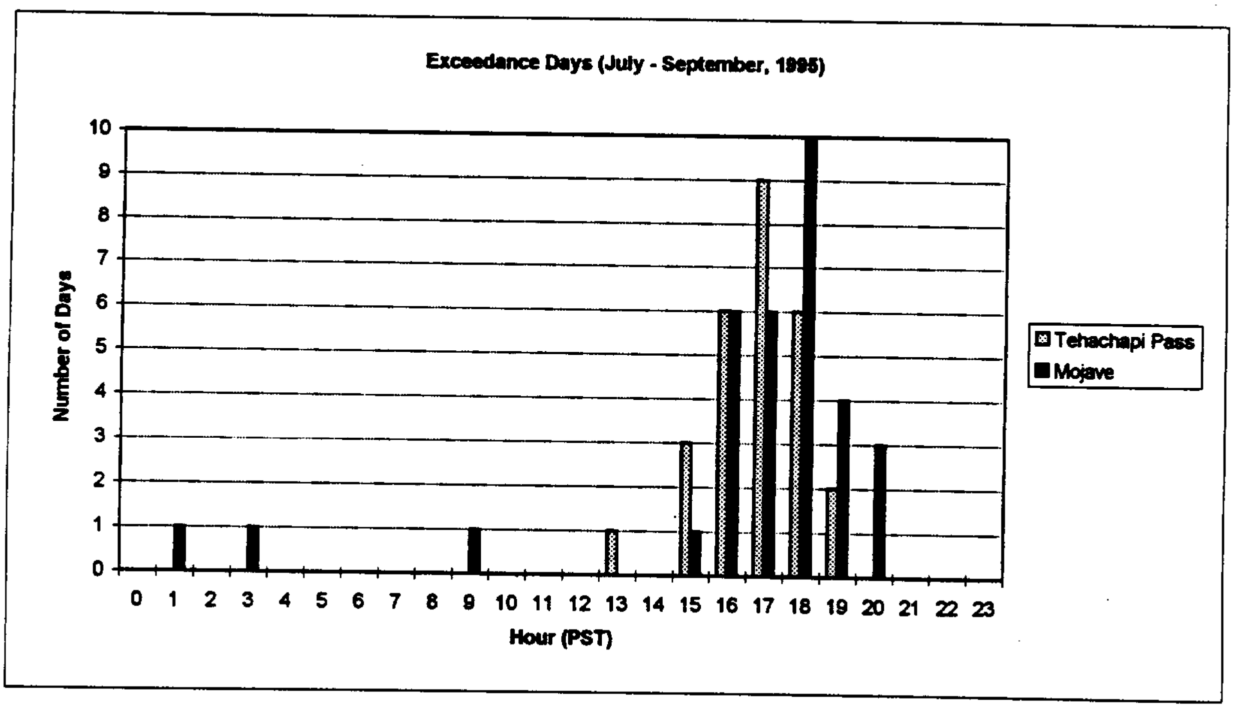


Fig. 3-5 Time of Peak Ozone Concentration on Exceedance Days
Top panel, SE Palmdale and Shadow Mt.; Bottom panel, Tehachapi Pass and Mojave.

There were 27 exceedance days at Tehachapi Pass from July through September 1995. On 25 of those days, an ozone peak was present at Mojave with an appropriate delay time of one or two hours. Both of the non-conforming days showed an ozone peak at Mojave which was one hour earlier than the Tehachapi Pass peak. Sixteen of the 25 days were also exceedance days at Mojave with peaks of 70 ppb or more on the remaining nine days. There were 33 exceedance days at Mojave during the June through October period and 14 afternoon (transport) exceedance days at Boron. Only one of the 33 days at Mojave corresponded to an exceedance day at Boron although peak timing differences suggest a possible connection between the two locations on five of the days when there was no exceedance at Boron. In contrast, there were exceedances at Lancaster on all but one of the 14 exceedance days at Boron.

Fig. 3-6 shows the peak frequency distributions for Mojave compared to Boron. Travel time from Mojave to Boron (50 km) should be about two hours. There is no significant shift in the frequency distribution that would support this time delay. The figure also gives the frequency distribution for Lancaster compared to Boron (50 km). There is a discernible time delay of about one hour in the peak frequencies.

Some median characteristics for the 14 Boron exceedance days are shown in Table 3-9.

Table 3-9 Median Characteristics Associated with Ozone Exceedances at Boron

	Mojave	Boron	Lancaster
Wind Direction (degrees)	250	249	214
Wind Speed (ms^{-1})	6.5	5.5	4.5
Peak Hour (PST)	17	17	15
Peak Ozone Concentration (ppb)	87	101	112

Boron exceedances are characterized by median wind shifts at Mojave and Lancaster toward a more southerly direction than characteristic of all Mojave or Lancaster exceedance days. The data in the table and the preceding discussion do not indicate consistent transport from Mojave to Boron on exceedance days at either location. A more plausible interpretation of the data suggests a more important contribution from Lancaster on days when Boron experiences an exceedance.

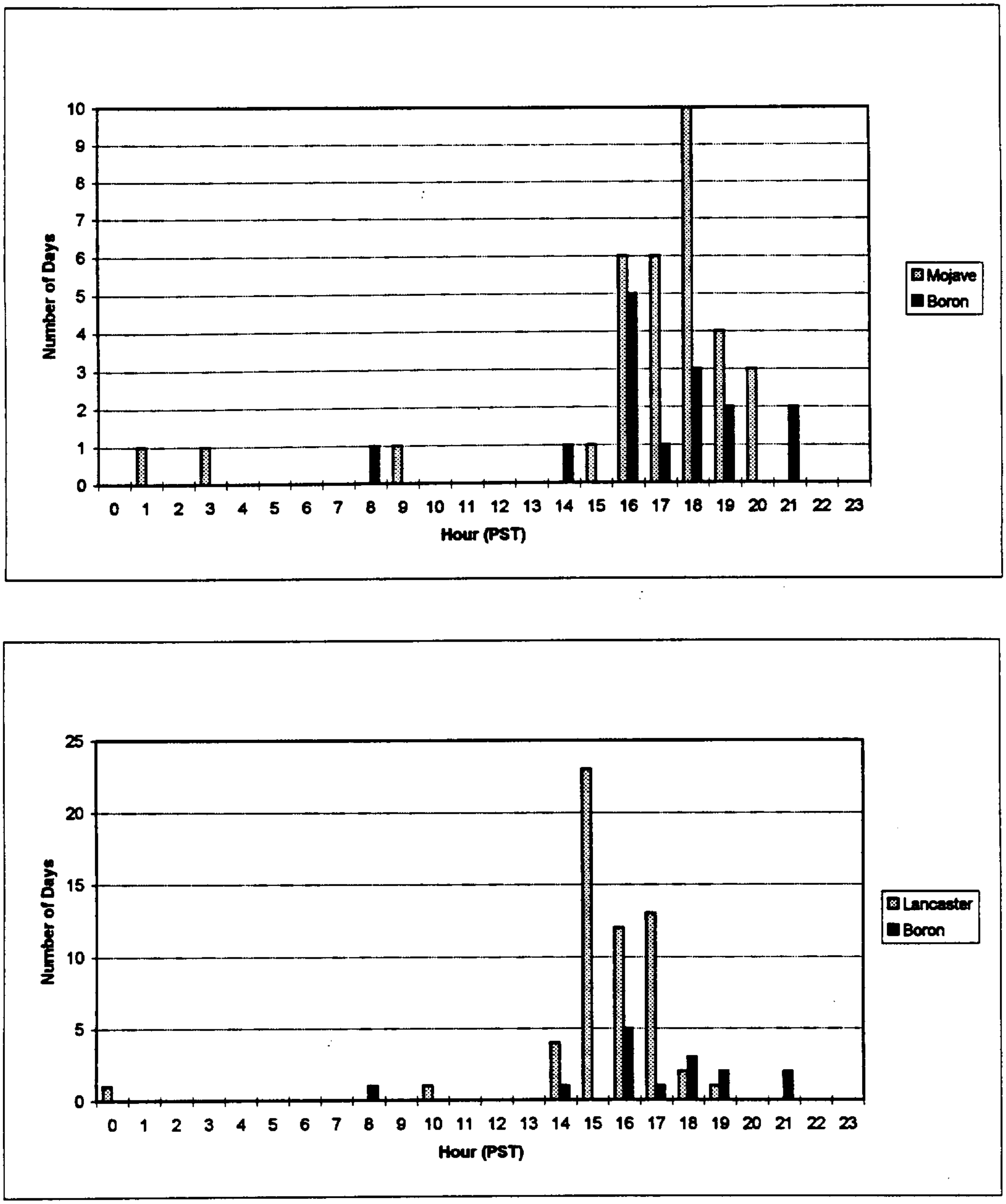


Fig. 3-6 Time of Peak Ozone Concentration on Exceedance Days (June - October, 1995)
Top panel, Mojave and Boron; Bottom panel, Lancaster and Boron

3.3.3 Transport downwind from Baldy Mesa

There were 86 days during June-October 1995 when Baldy Mesa experienced an exceedance of the state standard some time during the day. During the same period there were 46 days with exceedances at Hesperia. Thirty-nine of the Hesperia exceedances coincided with Baldy Mesa exceedances but seven days showed exceedances at Hesperia but peak values of only 70-90 ppb at Baldy Mesa. All of the 86 exceedances at Baldy Mesa were accompanied by nearly contemporaneous peaks at Hesperia. However, well over half of the Hesperia peaks were one to two hours earlier or later than the Baldy Mesa peaks. Hesperia is located about 15 km ENE of Baldy Mesa but with a downwind (south to north direction) separation of only about 5 km. Thus, there is frequently a surprising difference in peak concentration times between the two locations.

The number of days with exceedances at Baldy Mesa and Hesperia are compared hourly in Fig. 3-7. Baldy Mesa has two frequency peaks, at 15 PST and 18 PST. Hesperia shows a unimodal structure with a peak at 16 PST where Baldy Mesa has a marked minimum. Baldy Mesa also shows an additional frequency peak during the night at 00 PST. It is noteworthy that Baldy Mesa exceedances from 13-15 PST were much more frequent than at Hesperia.

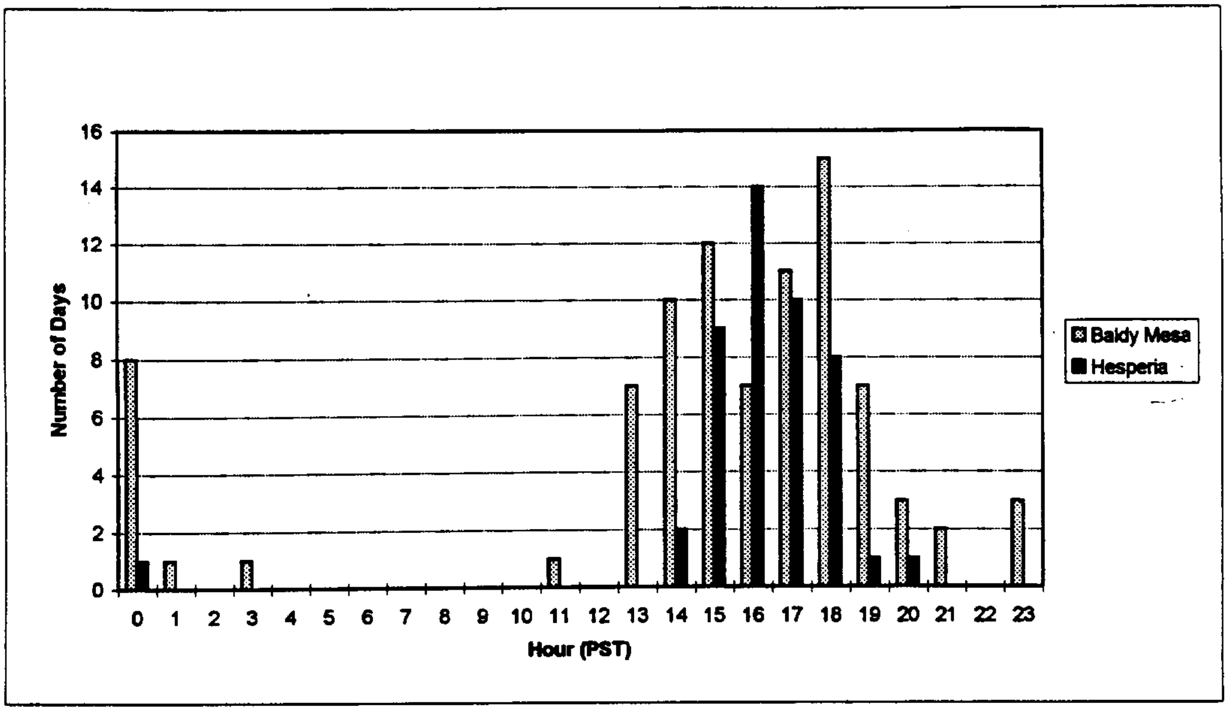
Fig. 3-7 also shows a comparison between exceedance days at Baldy Mesa and Phelan. The two frequency patterns are much more similar than Baldy Mesa vs. Hesperia. Ozone concentrations at Baldy Mesa and, to some extent, Phelan indicate bimodal distributions with a minimum at 16 PST. In contrast to the upper panel of Fig. 3-7, the frequency of exceedances at Baldy Mesa and Phelan from 13-15 PST are very similar.

There were 64 exceedance days at Phelan. Sixty of these days coincided with exceedance days at Baldy Mesa. Two of the non-coincident days at Phelan were accompanied by contemporaneous, non-exceedance peaks at Baldy Mesa (less than 95 ppb). The other two Phelan exceedances showed no comparable peak at Baldy Mesa (June 12 and July 26).

Some additional information comes from Table 3-10 in which hourly changes in wind direction and speed are examined.

The data in the table indicate a consistent shift toward a more southwesterly wind at all locations in the late afternoon. This shift appears to correspond to the data in Fig. 3-7 in which the SSE winds at Phelan contribute to early exceedances while the later Hesperia exceedances may be related to more southwesterly winds which persist in the late afternoon.

The data in Fig. 3-7 indicate that the pathway from Baldy Mesa to Phelan is more consistent than the Baldy Mesa - Hesperia route. With such short separation distances the lack of similarity in the frequency patterns at Baldy Mesa and Hesperia is quite striking. A comparison of same-day peaks shows that about one-third of the Hesperia peaks appear one hour prior to the Baldy Mesa peaks. Another 30% occur 2-3 hours after the Baldy Mesa peak. In contrast, about 80% of the Phelan peaks occur within one hour of the Baldy Mesa peak.



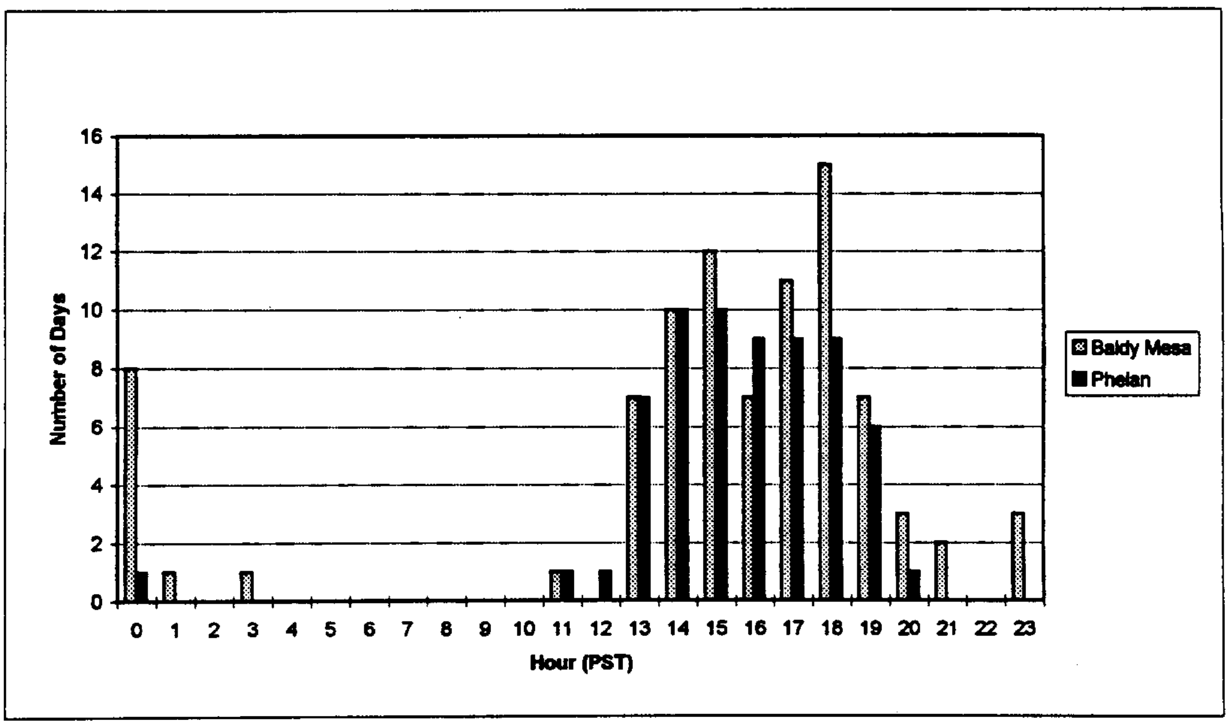


Fig. 3-7 Time of Peak Ozone Concentration on Exceedance Days (June - October, 1995)
Top panel, Baldy Mesa and Hesperia; Bottom panel, Baldy Mesa and Phelan

Table 3-10 Median Wind Directions and Speeds on Ozone Exceedance Days at Sites near Cajon Pass			
Time (PST)	Baldy Mesa (degrees / ms^{-1})	Phelan (degrees / ms^{-1})	Hesperia (degrees / ms^{-1})
12	194 / 6.2	156 / 5.0	192 / 6.0
13	194 / 6.4	156 / 5.5	190 / 6.0
14	192 / 6.6	158 / 6.5	190 / 6.5
15	196 / 6.5	161 / 6.5	191 / 7.0
16	199 / 6.6	171 / 6.0	193 / 6.5
17	206 / 6.3	178 / 5.5	194 / 6.0
18	212 / 5.9	184 / 5.0	197 / 5.0

Many of the exceedances at Phelan occur between 13 and 15 PST. By 16-18 PST, while there are still a number of peak concentrations recorded at Phelan, the wind direction becomes more southerly. In this case, Phelan lies immediately downwind (north) of the San Gabriel Mts. In 1981, a fortuitous airplane photograph at 1745 PST from over Cajon Pass shows two pollutant streams passing over the ridge to the east of Mt. San Antonio thence following the terrain downward into the desert in the lee of the ridge. Comparison with topographic data indicates that the plumes moved through two passes, each about 2200 m-msl. It should be noted that Phelan is located in relatively high terrain (approximately 1250 m-msl) and directly downwind of the ridge. This, together with the moderately strong winds at Phelan at this time of day (5-6 ms^{-1}), suggests lee slope flow with a capability of transporting air from the SoCAB into the surface layers of the desert.

Table 3-11 shows the frequency distribution of ozone concentrations classified by wind direction at Phelan for all hours during the June - October period. The first of the bottom two rows of the table gives the frequency distribution of wind direction for all hours combined without regard to ozone levels, and the other the wind direction frequency distribution for only those hours when ozone concentrations exceed the State's standard. As discussed above, nearly all of the exceedances at Phelan can be accounted for when transport is from either the SSE-SE (through Cajon Pass) or S-SSW (over the San Gabriel Mountains), and that the frequencies for each route are nearly equal. It is noteworthy that when the most frequent wind direction (SW) occurs, ozone concentrations rarely exceed the standard (two hours).

Fig. 3-8 shows the ozone concentration frequency patterns at Quartzite Mt. and Victorville on exceedance days compared to Baldy Mesa. As was the case at Hesperia (Fig. 3-7), there are

OZONE TRANSPORT CORRIDORS STUDY

T & B SYSTEMS, INC.

SITE NAME : Phelan

ELEVATION :

OZONE POLLUTION ROSE June 1 - October 31 1995

All Hours

Ozone Concentration (ppb)	Wind Direction																Total Hours	% Hours
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW		
0.0- 34.9	0	3	0	2	3	2	9	10	69	70	95	18	15	12	3	2	313	9.1
35.0- 64.9	41	59	103	69	37	37	73	98	192	290	496	141	85	102	122	66	2011	58.7
65.0- 94.9	17	26	37	31	16	13	59	161	144	103	68	31	31	27	54	23	841	24.6
95.0-124.9	0	0	0	0	1	0	9	73	64	30	2	1	2	6	6	3	197	5.8
125.0-154.9	0	0	0	0	0	0	3	17	25	3	0	0	0	0	0	0	48	1.4
155.0-184.9	0	0	0	0	0	0	0	1	6	0	0	0	0	0	0	0	7	0.2
185.0-204.9	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	4	0.1
205.0-224.9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.0
225.0-998.9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.0
Total Hours	58	88	140	102	57	52	153	364	502	496	661	191	133	147	185	94	3423	
% Hours	1.7	2.6	4.1	3.0	1.7	1.5	4.5	10.6	14.7	14.5	19.3	5.6	3.9	4.3	5.4	2.7		100.0
% Hours $O_3 \geq 95$ ppb	0	0	0	0	<1	0	4.6	36.8	37.6	12.8	<1	<1	<1	2.3	2.3	1.2		

Table 3-11 Frequency of Occurrence of Ozone Concentrations at Phelan, Categorized by Wind Direction, June 1 - October 31, 1995

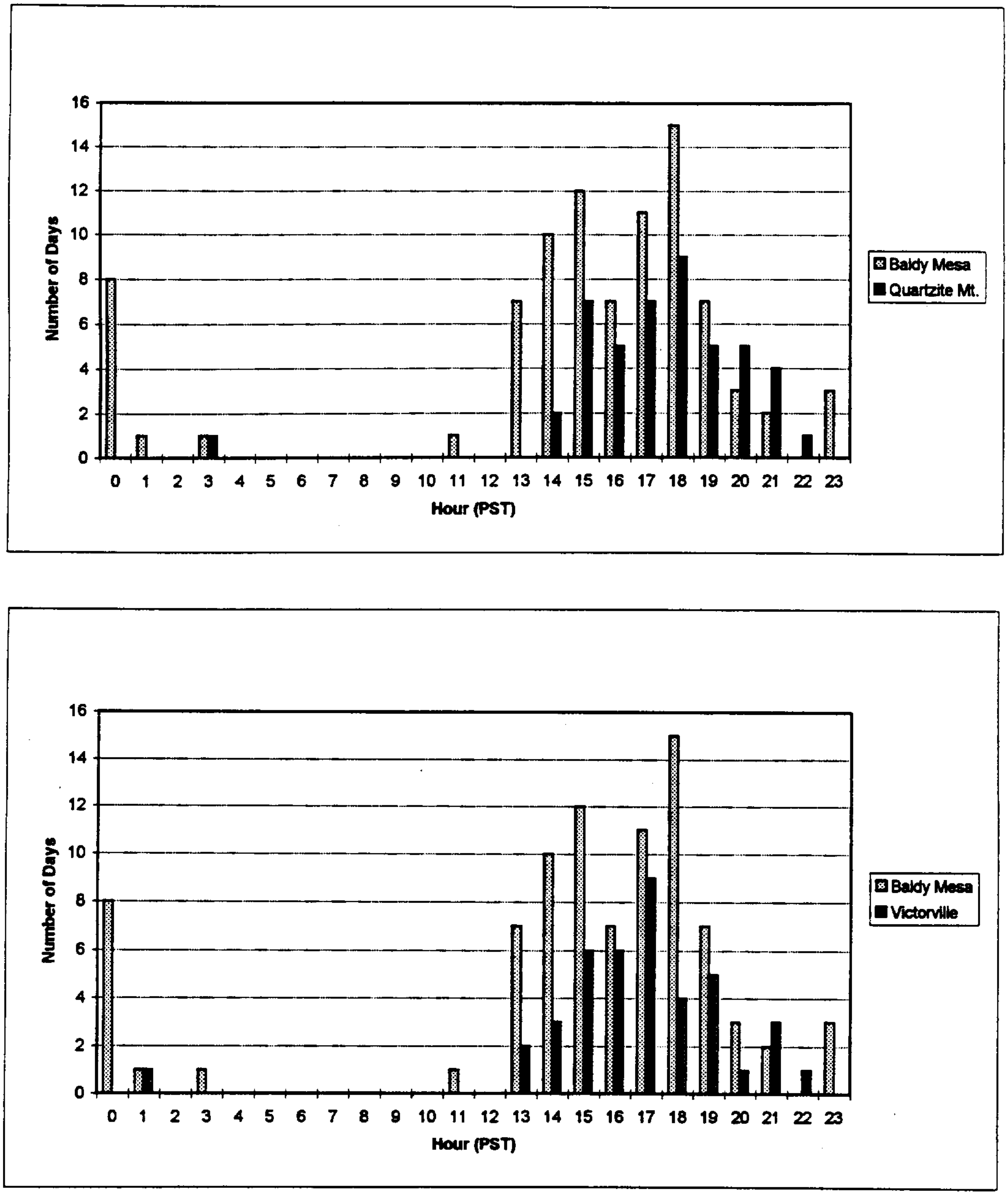


Fig. 3-8 Time of Peak Ozone Concentration on Exceedance Days (June - October, 1995) Top panel, Baldy Mesa and Quartzite Mt.; Bottom panel, Baldy Mesa and Victorville

notably higher exceedance frequencies from 13-15 PST at Baldy Mesa compared with Quartzite Mt. and Victorville The highest frequency of exceedances at Victorville is at 17 PST and at 18 PST at Quartzite Mt. The difference may be due, in part, to additional transport time to Quartzite Mt. under light winds and, and the reduction effects of ground-level NO emissions at Victorville in the late afternoon. This effect is treated in Section 7.

There were 29 cases (out of a total of 86 exceedance days) at Baldy Mesa when the peak ozone for the day occurred between 10 PST and 15 PST. On 15 of these 29 days, the peak was at least one hour prior to the same day's peak at Lake Gregory and on 10 days, 2-3 hours prior to the Lake Gregory peak. On the remaining 14 days, the Baldy Mesa peak (10-15 PST) occurred at the same time or slightly later than the Lake Gregory peak. The timing difference of ozone concentration peaks at the two sites is inconsistent with their locations as Lake Gregory is about 1.0-1.5 hours upwind of Baldy Mesa.

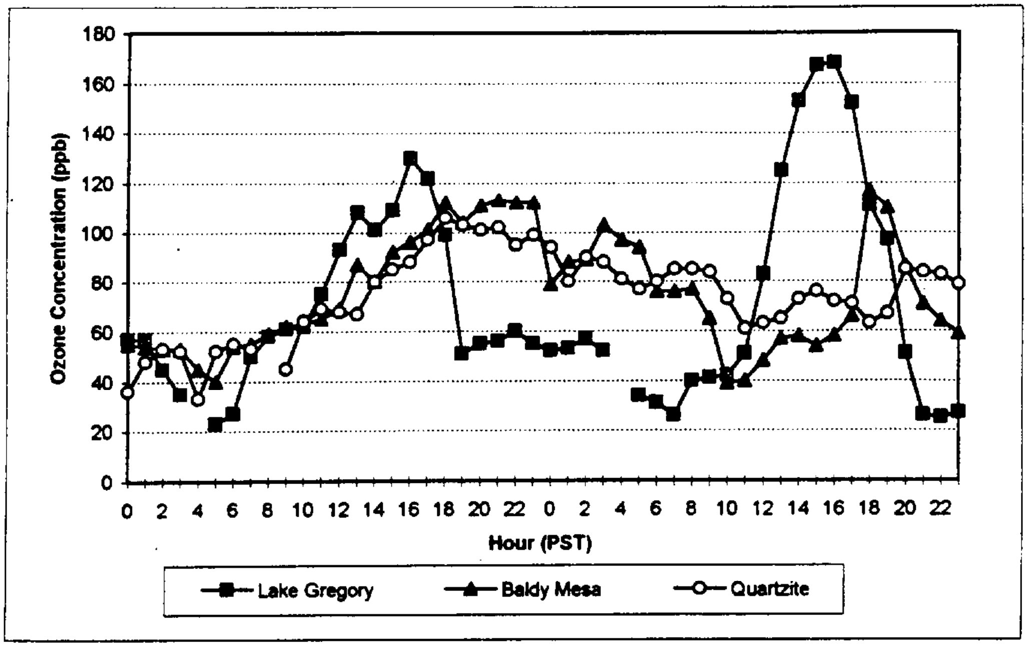
Two possibilities can be offered for the early ozone arrival at Baldy Mesa. On some days the wind velocities through the pass along the trajectory to Baldy Mesa may be somewhat stronger than the flow directed to Lake Gregory on the east side of the pass. This possibility, however, is not likely to account for 2-3 hour time differences in peak arrival time. It is suggested that residual ozone or ozone precursors in the east SoCAB or in the pass itself may contribute to the early occurrence of peak ozone concentrations at Baldy Mesa.

Another feature of interest is the occasional occurrence of high ozone concentrations at night at Baldy Mesa. There were 20 days with exceedances at Baldy Mesa between 00 PST and 04 PST. With one exception the wind directions at Baldy Mesa were southerly to southwesterly with a median velocity of 5.6 ms^{-1}.

Fig. 3-9 shows an example of one of the early morning exceedance events which occurred on July 13-14. The top panel of the figure compares Baldy Mesa with Lake Gregory and Quartzite Mt. The bottom panel compares Baldy Mesa with Hesperia and Phelan.

The hourly plots for Baldy Mesa and Quartzite Mt. track very closely together until the afternoon of July 14. Both show a late afternoon peak at 18 PST on July 13 followed by continuing high levels until the forenoon of July 14. In contrast the peak at Lake Gregory occurred at 16 PST but the concentration decreased to relatively low levels by 19 PST. On other occasions the concentrations at Lake Gregory also remained relatively high throughout the night.

In the lower portion of the figure, peak ozone concentrations at 16-18 PST on July 13 were followed by marked decreases at Hesperia and Phelan while the peak ozone concentrations at Baldy Mesa continued relatively high. The onset of vertical mixing at about 06 PST on July 14 brought Hesperia and Phelan concentrations in line with Baldy Mesa and clearly shows the source of the Hesperia / Phelan increases at that time. During the afternoon of July 14 the new ozone pulse from the SoCAB impacted Baldy Mesa and Phelan with similar concentrations but with a much lower influence at Hesperia.



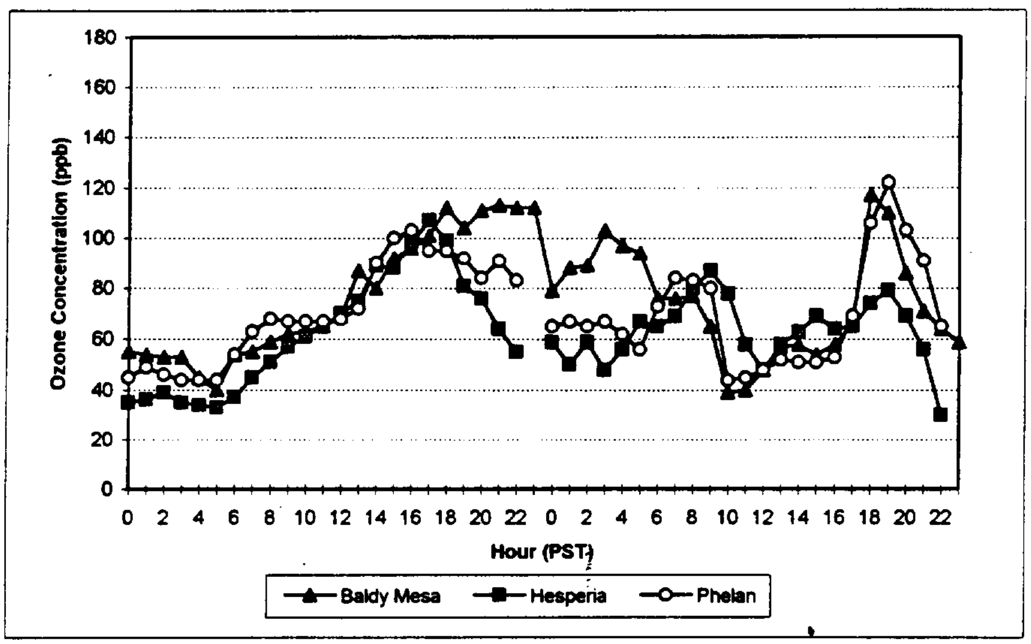


Fig. 3-9 Hourly Ozone Concentrations (July 13-14, 1995)
Top panel: Lake Gregory, Baldy Mesa, and Quartzite
Bottom panel: Baldy Mesa, Hesperia, and Phelan

In summary, for the July 13-14 case, the ozone concentrations at Baldy Mesa remained high through the night and this polluted air mass was transported downwind to Quartzite Mt. The early morning layer did not impact Hesperia or Phelan until the morning of July 14 when the layer was mixed downward to the surface. The effects of such layers aloft, created during the night, are discussed in Section 6.

It is of interest that the Victorville / Quartzite Mt. patterns do not show the frequent early (13-15 PST) exceedances characteristic of Baldy Mesa and Phelan. The patterns at Victorville / Quartzite Mt. more nearly resemble Hesperia with a time delay of one to two hours.

Of the 86 ozone-standard exceedance days at Baldy Mesa, 44 were also exceedance days at Quartzite Mt. and 39 days at Victorville. In addition there were four days on which exceedances occurred at Quartzite Mt. without an exceedance at Baldy Mesa, and likewise one day at Victorville. These non-coincident days were also non-coincident days at Hesperia. Transport from the Hesperia area to Quartzite Mt. / Victorville is indicated on these days.

3.4 Local Contributions to Ozone Concentrations

An important objective of the monitoring program was to explore the possibility of exceedances in the Desert which were not associated with direct, same-day transport from the SoCAB or SJV and which could not be attributed to the effects of carry-over from the previous day's transport. Barstow, Boron and Ludlow were the three surface monitoring sites which were located sufficiently far from upwind transport sources to have the potential of detecting local source effects. Ludlow, however, did not have any exceedances during the June-October 1995 period.

3.4.1 Barstow

During the period of June-October 1995, there were six days on which the state standard for ozone was exceeded at Barstow. Data for each event are summarized in Table 3-12.

Table 3-12 Ozone Exceedance Events - Barstow

	Quartzite Mt.		Barstow		
Date (1995)	Peak Time (PST)	Peak Conc. (ppb)	Wind Direction (degrees)	Peak Time (PST)	Peak Conc. (ppb)
Jun 28	18, 21	111	234	19	98
Jun 29	17	119	271	18	103
Aug 1	18	162	230	18	104
Aug 2	15	110	212	16	99
Aug 4	18	134	219	17	116
Aug 19	02	118	285	09	100
	SE Palmdale		Barstow		
Jun 29	15	149	271	18	103

Barstow is oriented at about 220° (wind equivalent) from Quartzite Mt. at a distance of about 40-45 km. Observed wind speeds indicate an air parcel transport time of about 1½ hours between the two sites. Four of the six Barstow ozone exceedances were preceded by southwesterly flow which is consistent with a trajectory from Cajon Pass. Table 3-13 illustrates an apparent relationship between wind direction and ozone concentration at Barstow on August 1.

High concentrations occurred on August 1 at Barstow only for a brief period when the wind direction backed to 225-230° indicating a trajectory from Quartzite Mt., before the more westerly winds returned. Four of the events in Table 3-12 occurred with an apparent trajectory from the Quartzite Mt. area.

Table 3-13 Hourly Data during the Afternoon and Evening of August 1, 1995

	Barstow		Quartzite Mt.
Time (PST)	Wind Direction (degrees)	Ozone Concentration (ppb)	Ozone Concentration (ppb)
14	299	66	85
15	300	64	88
16	279	66	120
17	225	93	141
18	230	104	162
19	253	77	151
20	253	79	117
21	278	67	75

One of the exceptions, the June 29 event, is somewhat anomalous since the wind direction at Barstow did not indicate a southwesterly wind at any time during the day prior to the ozone exceedance. A trajectory from SE Palmdale (three hours travel) with an intermediate peak at 16-17 PST at Shadow Mt. appears to be a more plausible scenario.

August 19 was a fumigation event at Barstow. The principal ozone flux into the Mojave Desert on August 18 occurred through Soledad Canyon. SE Palmdale exceeded the state standard from 16 PST through 21 PST with a peak of 170 ppb at 16 PST. Lancaster's peak was 139 ppb at 17 PST. An abrupt change in wind velocity at SE Palmdale from 1-2 ms^{-1} to 5-6 ms^{-1} accompanied the beginning of the high ozone concentrations. A similar pulse in wind speed was recorded at

Shadow Mt. from 19-22 PST. Shadow Mt. ozone increased abruptly at 19 PST and continued at high levels through 08 PST on the following day. Although ozone at SE Palmdale (in the surface layer) decreased after 21 PST, ozone at Shadow Mt. remained high throughout the night. From midnight through 08 PST wind velocities at Shadow Mt. averaged less than 2 ms^{-1} so that only limited transport aloft occurred overnight. There was no indication of an afternoon transport peak at Barstow on August 18 and the ozone flux apparently affected the southern portion of the desert primarily.

In contrast to the ozone experience at SE Palmdale and Lancaster, ozone transport through Cajon Pass on August 18 was quite limited. Baldy Mesa had only one hour with an exceedance (16 PST) as did Quartzite Mt. (17 PST). The peak ozone concentration at Victorville was 77 ppb at 17 PST. However, ozone concentrations increased at both Baldy Mesa and Quartzite Mt. during the night. Ozone exceedances began at Quartzite Mt. at 20 PST and continued through 07 PST. At Baldy Mesa exceedances were recorded from 21 PST through 01 PST on August 19. At Quartzite Mt. the wind shifted from southerly toward southwest from 20 PST through 03 PST. Beginning at 04 PST, the wind at Quartzite Mt. (as well as Shadow Mt.) shifted to the northeast.

There were no indications that the late evening ozone concentrations at Baldy Mesa and Quartzite Mt. came from the Cajon Pass area. The wind shift at Quartzite Mt. and the somewhat later appearance of the high ozone concentrations at Baldy Mesa suggest that the layer evident at Shadow Mt. was extensive enough and spread eastward sufficiently to reach Quartzite Mt. and Baldy Mesa.

The overall key to the developments of August 18-19 was an abrupt change in the surface pressure gradient. At 04 PST on August 18 the pressure gradient between LAX and Las Vegas was 3.8 mb. By the morning of August 19 the gradient had decreased to 0.6 mb and was even less on August 20. The effect of this change was to limit or terminate the eastward transport of the ozone layer which had appeared at SE Palmdale and Lancaster during the afternoon of August 18. Transport winds affecting this layer had a light westerly component until early morning shifting to northeasterly before sunrise. The layer aloft was apparently widespread in the western portion of the Mojave Desert. There were indications that fumigation occurred during the forenoon at SE Palmdale, Lancaster, Mojave, Boron, Barstow, Victorville, Hesperia and Ludlow. Early morning exceedances of the state standard occurred at SE Palmdale, Lancaster, Boron and Barstow.

The August 19 event was apparently unique during the 1995 monitoring period. The light winds at night at Shadow Mt. (required for stagnation of an upper layer) occurred on four other occasions in the period from June-September but without the high evening concentrations at Shadow Mt. which carried over into the following morning on August 19.

A point of considerable interest has been the question of local contributions to peak ozone concentrations at Barstow. One approach has been to examine only days when little or no transport into the desert was observed on the previous day. This procedure has certain limitations which include the small number of days when "little or no" transport into the desert occurs. In addition, the selected days may not be ones that favor the formation of ozone in Barstow.

An alternative approach has been attempted in this analysis which involves a consideration of the background concentrations in the desert. Fig. 3-10 gives a plot of the Barstow daily ozone concentrations at 09 PST compared with those simultaneously observed at Shadow Mt. (distance about 50 km). The time of 09 PST was chosen as the expected time when mixing in the lowest 500 m of the atmosphere could be expected, but before the onset of local ozone formation. The figure shows excellent correlation between the two data sets for both July and August. A similar plot comparing Boron and Shadow Mt. (not shown) indicates the same close relationship. Correlation coefficients between the surface and *elevated* sites and between the surface sites at 09 PST are shown in Table 3-14.

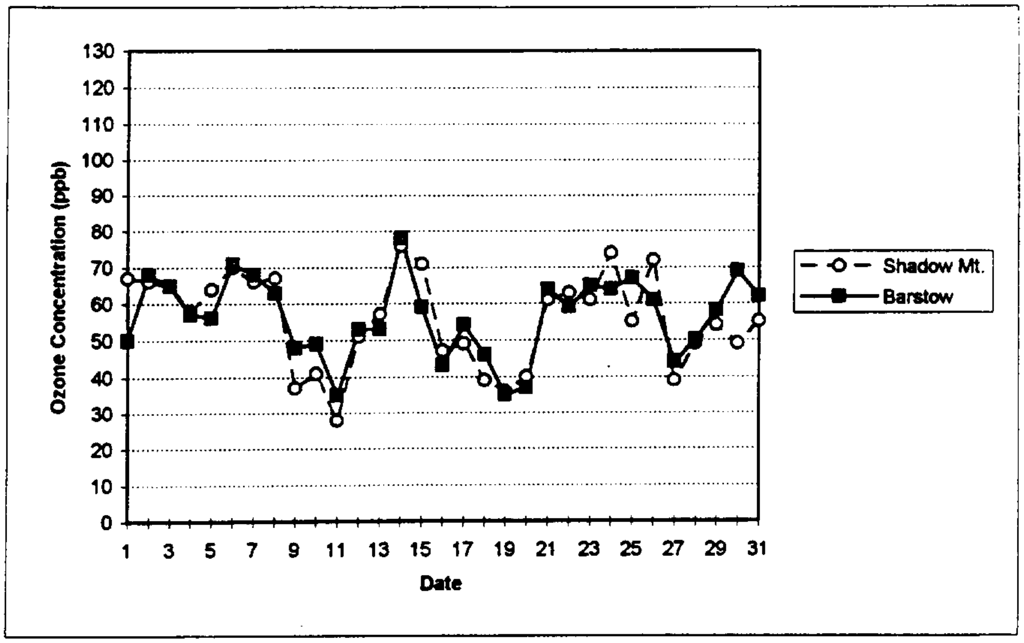
Table 3-14 Correlation Coefficients for Ozone Concentrations at 09 PST

	July - August 1995
Barstow vs. Shadow Mt.	0.75
Boron vs. Shadow Mt.	0.84
Barstow vs. Flash II Mt.	0.69
Barstow vs. Boron	0.84

The implication of the correlations is that, on most days, a regional background ozone concentration exists aloft (represented by Shadow Mt. and Flash II Mt.) which appears at Barstow and Boron by 09 PST as a result of vertical mixing. Although the correlation between Barstow and Flash II Mt. at 09 PST is also relatively high, the mean concentration at Flash II Mt. for the two months (09 PST) is about 20% below the Barstow concentration while Boron, Barstow and Shadow Mt. are nearly identical. Shadow Mt. is considered to be a more representative measure of the regional background in the western portion of the Mojave.

A similar analysis for ozone concentrations at 13 PST is shown in Fig. 3-11 and Table 3-15 for July and August 1995. The time of 13 PST was chosen to permit the potential for local ozone production which would be additive to the assumed background as indicated by Shadow Mt.

The correlations at 13 PST are lower than shown in Table 3-14 but, as indicated in Fig. 3-11, the differences on individual days are not generally great. In terms of this analysis, local contributions to the midday ozone concentrations at Barstow do not appear to be large on average.



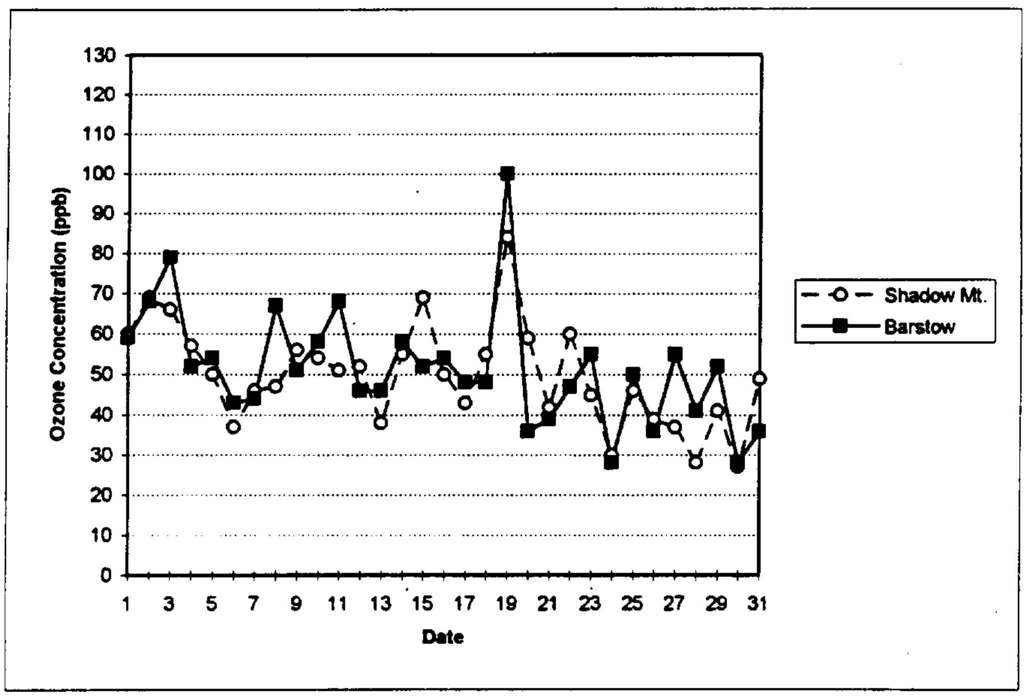
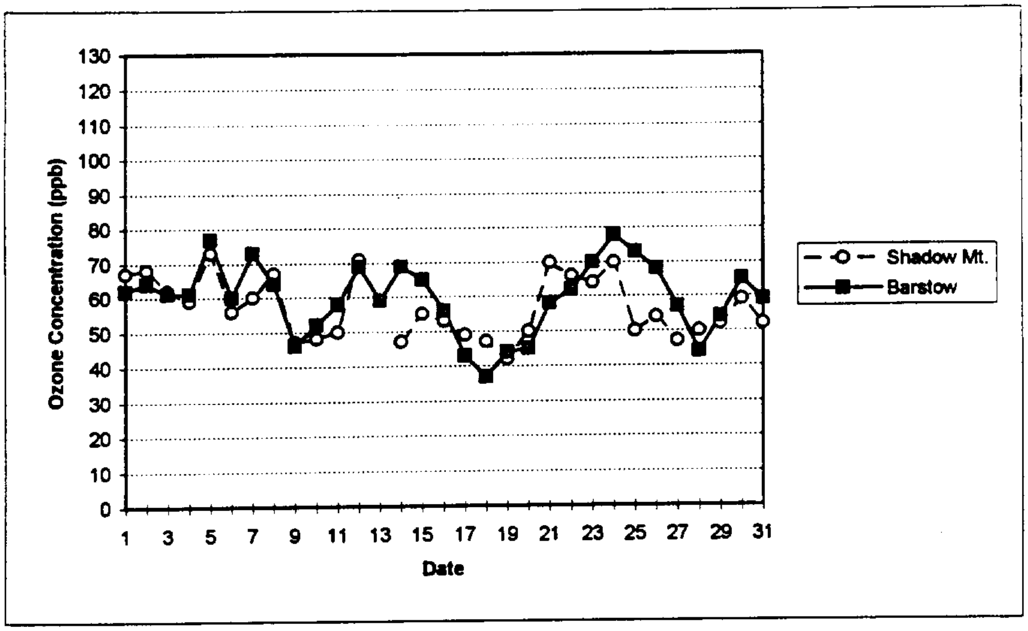


Fig. 3-10 Ozone Concentrations at 09 PST at Shadow Mt. and Barstow
Top panel July 1995; bottom panel August 1995



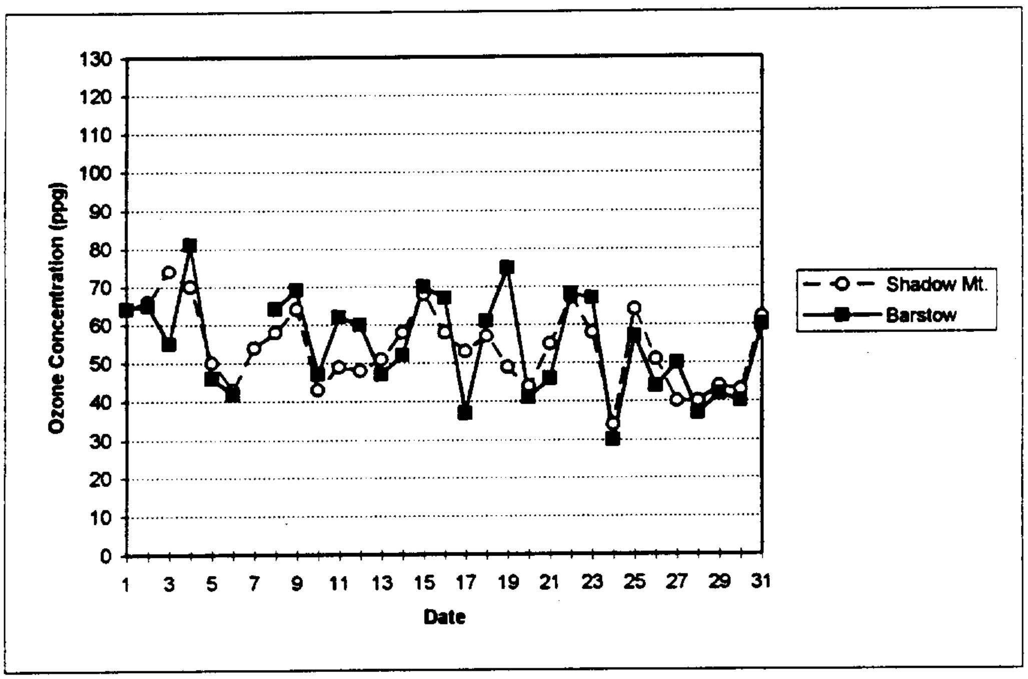


Fig. 3-11 Ozone Concentrations at 13 PST at Shadow Mt. and Barstow
Top panel July 1995; bottom panel August 1995

Table 3-15 Correlation Coefficients for Ozone Concentrations at 13 PST	
	July - August 1995
Barstow vs. Shadow Mt.	0.69
Boron vs. Shadow Mt.	0.70
Barstow vs. Flash II Mt.	0.65
Barstow vs. Boron	0.73

Diurnal profiles of ozone at Barstow characteristically show a peak some time between 09 and 15 PST which is frequently followed by a later peak attributed to transport from other air basins. The peak concentration at Barstow, usually 11-15 PST, was tabulated and compared to the concentration at Shadow Mt. at the time of the Barstow peak. Results of the comparison in Table 3-16 provide an indication of the local concentration effects compared with the regional background at Shadow Mt.

Table 3-16 Concentration Differences at Time of Peak Ozone Concentration at Barstow (June - September)

Difference* (ppb)	Number of Days
< -17 (-21)	1
-13 to -17	0
-8 to -12	8
-3 to -7	10
-2 to +2	22
3 to 7	28
8 to 12	15
13 to 17	10
18 to 22	5
> 22 (24 - 33)	5

* $[O_3]$ at Barstow - $[O_3]$ at Shadow Mt.; positive value indicates higher Barstow concentration

Most of the concentration differences between the Barstow peak and the assumed background at Shadow Mt. lie in the range of -2 to +7 ppb, showing a slight positive bias toward Barstow. However, most of the differences are small. The extreme values of more than 22 ppb probably represent marked regional variations in background. Four of the five cases more than 22 ppb occurred at 09 PST where Barstow showed an abrupt effect of fumigation (downward mixing) which was not reflected in a corresponding background at Shadow Mt. The fifth case (July 6) occurred at 11 PST and was the result of a decrease in the background at Shadow Mt. from 09 PST to 11 PST which was not observed at Barstow.

A group of days was identified by non-exceedances of the ozone standard at each of the locations: Lancaster, SE Palmdale, Baldy Mesa, Hesperia and Phelan. Since these sites measure transport through the major passes into the desert, the following morning/early afternoon period was considered to be relatively unaffected by transport. There were 20 such cases in the June-October sample. The maximum morning/early afternoon concentration on the day following non-exceedances was 75 ppb which occurred at 14 PST on July 12 and can be primarily attributed to a high regional background (Fig. 3-11). Only five of the 20 cases showed peak concentrations greater than 60 ppb during the following morning/early afternoon. Comparison with the background at Shadow Mt. at the time of the Barstow morning/early afternoon peak indicated a maximum ozone excess at Barstow of 18 ppb.

This analysis has attempted to place an upper limit on the diurnal development of local source effects in the Barstow area. The focus was confined to peak ozone concentrations occurring by 15 PST in order to minimize the effects of transport. Most of the ozone variations in Barstow during this diurnal time period appear to be associated with regional background levels as indicated by Shadow Mt. ozone concentrations.

3.4.2 Boron

There were 15 days on which there was an exceedance of the state standard for ozone at Boron during the June-October 1995 monitoring period. On one of the days (August 19) the exceedance occurred during the forenoon and was attributed to fumigation (Section 3.4.1). On 13 of the remaining days, exceedances were experienced in the afternoon but exceedances also occurred at Lancaster and same-day transport to Boron from SoCAB could not be ruled out. The remaining exceedance day at Boron (June 14) is discussed in the following paragraphs.

Peak concentration data for June 14 in the western part of the Desert are shown in Table 3-17. It should be noted that the ozone monitor at Boron was calibrated on June 7 at a level of 83 ppb with no zero adjustment required. A span check on June 15 indicated that the monitor value was 1% low at full span. Thus, there is a high degree of confidence in the measured levels there.

The data in Table 3-17 do not support a same-day transport scenario. The exceedance at Boron was an isolated event within the western part of the Desert. The second highest ozone value (86 ppb) in the desert on that day occurred at Barstow but at 13 PST. Peak ozone at Boron on the previous day was 124 ppb but the active wind flow on June 14 does not suggest the possibility of carry-over.

Table 3-17 Characteristics of Ozone Maxima on June 14

Location	Peak Concentration (ppb)	Peak Time (PST)	Wind at 14 PST (degrees / ms^{-1})
SE Palmdale	79*	16	232 / 7.7
Lancaster	76	15	214 / 2.6
Mojave	77	15	285 / 7.7
Boron	95	14	250 / 8.0
Barstow	86	13	284 / 8.7
Flash II Mt.	72	11	229 / 9.4
Shadow Mt.	80	12, 13	268 / 14.5

* Data Incomplete

Surface winds in the Desert were relatively strong on June 14. The morning pressure gradient (LAX-Las Vegas) was 6.8 mb with an 04 PST temperature of 20.2°C at 850 mb at Vandenberg Air Force Base. Conditions were conducive for significant lee wave action generated by the ridges to the west. Mojave, however, had a much lower ozone value than Boron and data from potential source areas to the west were not available. The monitor at Tehachapi Pass was not yet in operation.

3.5 Ozone Concentrations Aloft and Fumigation

Ozone concentrations during the night at the higher elevation sites (Shadow Mt., Quartzite Mt. and Baldy Mesa) provide an indication of the presence of layers aloft which might be mixed downward to the surface (i.e., fumigated) during the following day. One such example (August 19) was described in Section 3.4. The ozone concentration at 00 PST at the elevated sites is a useful indicator of the presence of such layers.

Table 3-18 shows the number of occurrences of high concentrations at 00 PST for each of the 1995 elevated sites with the exception of Flash II Mt. Ozone concentrations measured at Flash II Mt. during the 1995 field study suggest the site is not impacted significantly by either SoCAB or SJVAB ozone transport.

Table 3-18 High Ozone Concentrations at 00 PST (June - October 1995)

	Number of Days ≥ 95 ppb	Number of Days > 80 ppb
Baldy Mesa	15	31
Quartzite Mt.	3	14
Shadow Mt.	1	13

Overnight layers aloft can be formed in several ways. The occurrence of continuing high concentrations at Baldy Mesa during the night was discussed in Section 3.3. The development of stability in the low levels tends to keep this material aloft as it travels downwind from Baldy Mesa during the night. Another mechanism results from deep ozone layers which are transported into the desert during the previous afternoon. On most nights, as the surface stability becomes established, a low-level jet forms in much of the desert with peak velocities (more than 10 ms^{-1}) at elevations of the order of 300-500 m-agl. This tends to transport the lower layers rapidly eastward but may leave the higher layers behind. On a few occasions during the summer (e.g., August 19) the nocturnal wind velocities at locations such as Shadow Mt. and Quartzite Mt. are sufficiently low that substantial transport of the afternoon ozone out of the area is greatly reduced. Ozone concentrations in excess of 130 ppb were measured during the midnight to daybreak period on August 19 at Shadow Mt. and 118 ppb at Quartzite Mt. Surface removal mechanisms then may lead to a significant ozone layer aloft.

All three sites in Table 3-18 have elevations between 4000 and 4500 ft-msl. Most of the desert locations (e.g., Barstow and Victorville) are at elevations of 2000-2500 ft-msl. If fumigation from a layer aloft occurs at one of the lower elevation sites, a marked increase in hourly ozone concentrations should be apparent in the forenoon before any local sources can have a significant impact. Rapid increases around 09 PST have been used as an indicator that fumigation probably occurred.

Fumigation is likely to occur on most days in the desert and for the purpose of discussing the frequency of significant events a specific definition was chosen: 1) a peak concentration of at least 70 ppb must have occurred between 08 and 10 PST and, 2) the peak concentration must have exceeded the 06 PST concentration by at least 20 ppb as well. These criteria were intended to describe an abrupt and significant fumigation event. Other occasions when the peak concentration occurred at 11 PST were not included so that potential local generation could be avoided. Using these criteria, the number of fumigation events at the lower elevation desert sites was determined and the results are summarized in Table 3-19.

Table 3-19 Number of Fumigation Events (June - October)

	Number of Days When the Ozone Concentration was ≥ 70 ppb between 08 and 10 PST
Boron	24
Barstow	9
Lancaster	19
Ludlow	11
Mojave	19
Palmdale	23
Victorville	13

Data in the table suggest that somewhat more significant impact from fumigation occurs in the western section of the desert but that the process occurs fairly frequently elsewhere.

Three of the most significant fumigation events occurred on June 11, July 14 and August 19. In an environment of very light and variable morning winds, surface ozone concentrations increased abruptly to exceedance levels between 09 and 11 PST at a number of locations in the Desert. A summary of peak concentrations and times is shown in Table 3-20. An indicated impact from fumigation occurred throughout a wide area from SE Palmdale to Ludlow. In many of those instances, the ozone peak attributable to fumigation was the maximum level measured for that day.

Table 3-20 Surface Sites Significantly Impacted by Fumigation.
Ozone concentration units are ppb. Hour of peak ozone (shown in parentheses) is PST.

Site	June 11	July 14	August 19
SE Palmdale	103 (10)	112** (09)	118* (10)
Lancaster	79 (11)	76 (10)	101* (10)
Phelan	102* (11)	84* (07)	64 (08)
Hesperia	84 (10)	87* (09)	71 (09)
Victorville	92* (10)	83* (09)	76 (09)
Mojave	82* (09)	75 (09)	86 (10)
Boron	80* (09)	75 (10)	96* (08)
Barstow	82** (11)	78* (9-10)	100* (09)
Ludlow	78* (10)	incomplete record	86* (09)

* daily maximum
** equals daily maximum

It should be noted that three of the ozone peaks shown in the table occurred at 11 PST, and in those cases local ozone production may have contributed to the concentrations. Nevertheless, ozone levels increased abruptly earlier in the morning in a manner consistent with the fumigation process.

3.6 Representativeness of 1995 Measurements

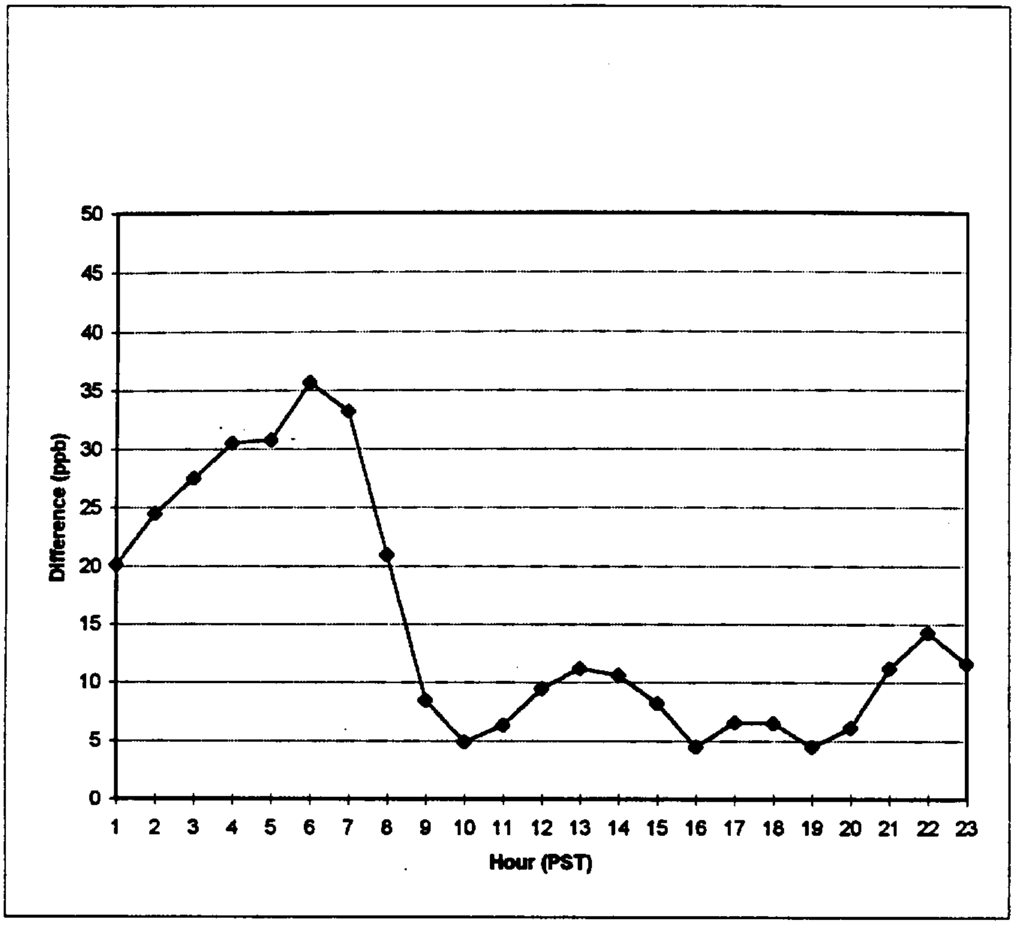
One of the project objectives was to evaluate the use of surrogate platforms for making continuous measurements of ozone and meteorology aloft. Shadow Mt., Flash II Mt. and Quartzite Mt. were selected as elevated monitoring sites during the network design phase. In the monitoring phase of the program, the sites were established and operated during the 1995 ozone season.

There are not sufficient supporting measurements to evaluate the representativeness of the first two sites as indicative of conditions aloft. However, a number of other measurements occurred in the vicinity of the Quartzite Mt. site which allow that data to be evaluated. Comparisons of the Quartzite Mt. data were made with routine hourly surface measurements at Victorville and the ARB wind profiler at Apple Valley airport. Short-term measurements of ozone by other contractors using lidar and aircraft, made in early August at the former George AFB about 5 miles from the Quartzite Mt. site, were also used for comparative purposes. The lidar is an experimental instrument and not traceable to any standard. Therefore, data from an instrumented aircraft were compared to that of the lidar. Vertical profiles of ozone were made by the airplane during periods when the lidar was operating. It is beyond the scope of this report to evaluate the lidar measurements using the aircraft data. Both sets of measurements are used herein only for the purpose of comparing with Quartzite Mt.

3.6.1 Quartzite Mt. and Victorville Ozone Measurements

The diurnal difference between average hourly ozone concentrations at Quartzite Mt. and the routine measurements from Victorville is shown in Fig. 3-12. June through August data were used as this period is when conditions are most likely conducive to vigorous surface mixing. During September and October, there were periods with extensive cloud cover which may have suppressed this process. The data show that during the nighttime hours, when the atmosphere is stable and the boundary layer shallow, significant differences occur (up to 35 ppb) due to ozone reduction by fresh NO_x emissions and deposition. As the boundary layer deepens during the day, the free-atmosphere becomes well-mixed and vertical distribution of ozone becomes more uniform. This behavior is evident in the figure; heating of the desert floor by insolation has caused good vertical mixing of the atmosphere by nine a.m. on average. The differences between ozone concentrations at the two sites in the late morning and afternoon are close to the accuracy of the measurements.

There were 51 days when a peak ozone concentration exceeding the State's standard occurred at Quartzite Mt. or Victorville and could be identified with a similar peak within one hour at the other site. In contrast, there were only four days when a peak at one site could not be identified with a corresponding peak at the other site. Analysis of the 51 cases showed about 80% of the ratios of peak concentrations were between 0.7 and 1.2 where a ratio of less than one indicates a higher concentration aloft. Timing of the peaks ranged from 13-22 PST. The comparable



Note: Daily instrument span check occurred at hour zero in Victorville.

Fig. 3-12 Quartzite Mt. - Victorville Hourly Average Ozone Difference (June - August, 1995)

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concentrations at the two sites from mid-morning through early evening suggests effective daytime mixing from the desert floor to at least the site elevation on Quartzite Mt. (~500 m-agl).

3.6.2 Quartzite Mt. and Airplane Ozone Measurements

The airplane flew spiral patterns in the vicinity of the base airfield at the former George AFB (Southern California International Airport) during the seven days in August when the lidar was operating. In this manner, profiles of the meteorological and air quality measurements including ozone were obtained several times each day. Ozone concentrations measured by the airplane at the elevation of the site at Quartzite Mt. (~1370 m-asl) were compared with the 6-minute averaged Quartzite Mt. data. Fig. 3-13 is a scatterplot showing the ozone concentrations. Perfect agreement between the two measurements is depicted by the straight line. The data cover the range of concentrations from 40 to 135 ppb, and in general there is good agreement. The largest differences in the measurements occurred between 14 and 15 PST on August 8 and August 10. At this time Quartzite Mt. was experiencing its peak ozone. It can be seen from the figure that the two airplane ozone profiles measured from 14-15 PST on August 8 measured significantly greater ozone concentrations than those measured at Quartzite Mt. It should be noted that the airplane soundings seemed unusual in that high ozone (>100 ppb) was measured from the surface to its maximum altitude of 3660 m-asl. On August 10, the ozone concentrations measured from the aircraft were significantly lower at the elevation of Quartzite Mt. than the measured values at the site monitor. The aircraft soundings also showed high ozone but in layers that exhibited extreme temporal variability. For example, the 14:01 PST sounding had a layer at about 1600 m-asl with 90 ppb ozone levels whereas the next sounding (14:38 PST) showed a 100 ppb layer below the elevation of the site. Another sounding several minutes later at 14:44 PST did not encounter any high ozone concentrations.

A statistical summary of the differences between the two types of measurements and their correlation coefficient are given in Table 3-21. Even with the inclusion of the aforementioned measurements on August 8 and August 10, the average difference is only 2 ppb, and two-thirds of the differences are less than 15 ppb. Moreover, the two sets of measurements were highly correlated.

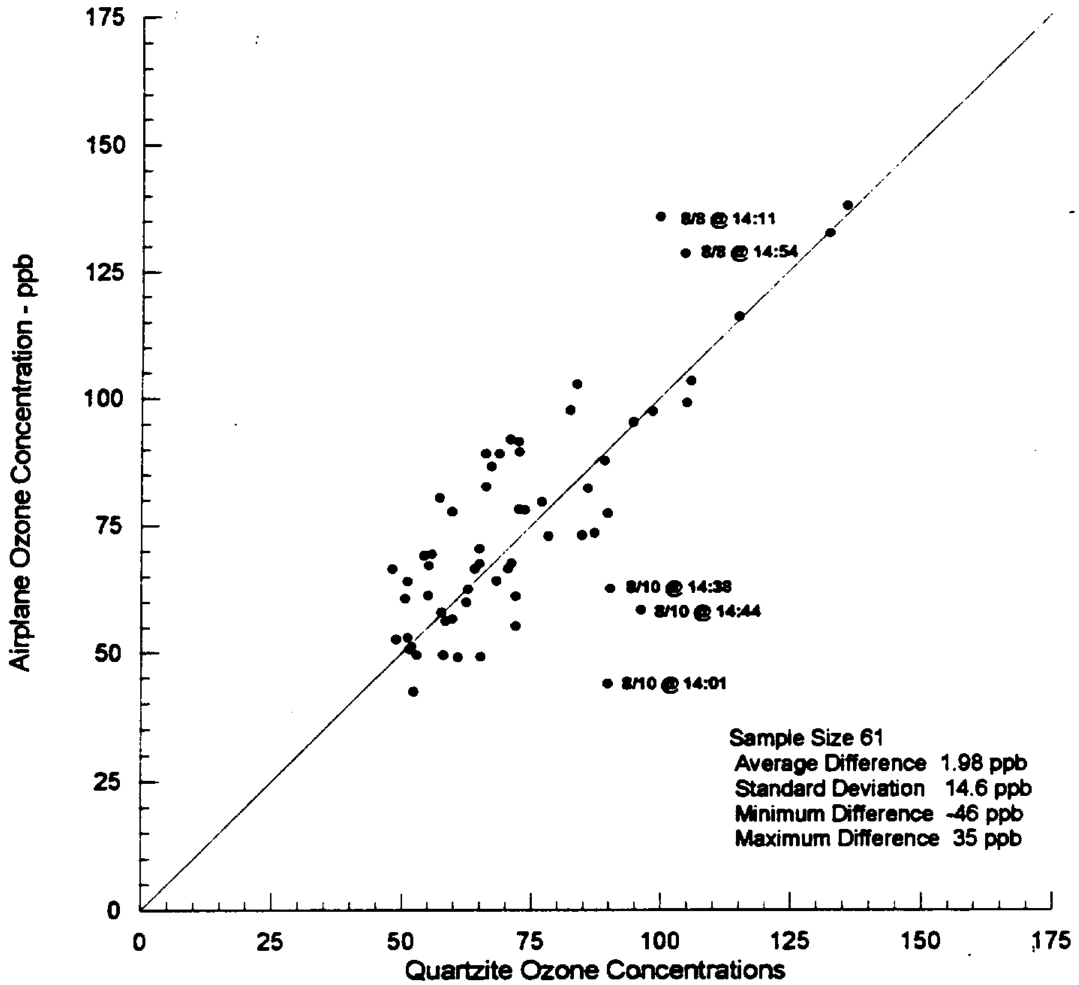

Fig. 3-13 Ozone Concentrations as Measured by Aircraft Compared with Six-Minute Averaged Measurements at Quartzite Mt.

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Table 3-21 Comparison of Lidar and Aircraft Ozone Measurements with Measurements at Quartzite Mt.		
	Quartzite Mt.-Aircraft	Quartzite Mt.-Lidar
Sample Size	61	202
Correlation (R)	0.77	0.62
Bias (Average Difference)	1.98 ppb	-16.41 ppb
Standard Deviation of Differences	14.6 ppb	19.5 ppb
Minimum Difference	-46 ppb	-57 ppb
Maximum Difference	35 ppb	40 ppb

3.6.3 Quartzite Mt. and Lidar Ozone Measurements

The NOAA lidar made measurements of ozone from George AFB on seven days during the period August 3-12. On operational days, multiple soundings were usually made during every operational hour beginning in the early morning (06-07 PST) and concluding at about 17 PST. As many as eight soundings were made during a one-hour period.

Ozone concentrations at the elevation of the Quartzite Mt. site determined from the lidar data were compared with the Quartzite Mt. six-minute averaged data. These data are plotted on Fig. 3-14 and summarized in Table 3-21. As both the figure and the table show, there is a bias for the lidar data to be about 16 ppb higher than the measurements on the surface at Quartzite Mt. The standard deviation of the differences between the lidar and surface monitor as well as the maximum/minimum differences are greater than for the aircraft-Quartzite Mt. comparison. Moreover, the lidar data are not as well correlated with the Quartzite Mt. data as the aircraft measurements were.

The soundings taken over an hour-period (usually six to eight) were averaged and the averages also compared with hourly-averaged data from Quartzite Mt. The results were very similar to the more highly-resolved data discussed above.

It was noted during the comparisons that there were significant differences in the vertical distribution of ozone between the lidar and aircraft measurements. Presumably, these discrepancies will be addressed by the project participants who were responsible for those measurements.

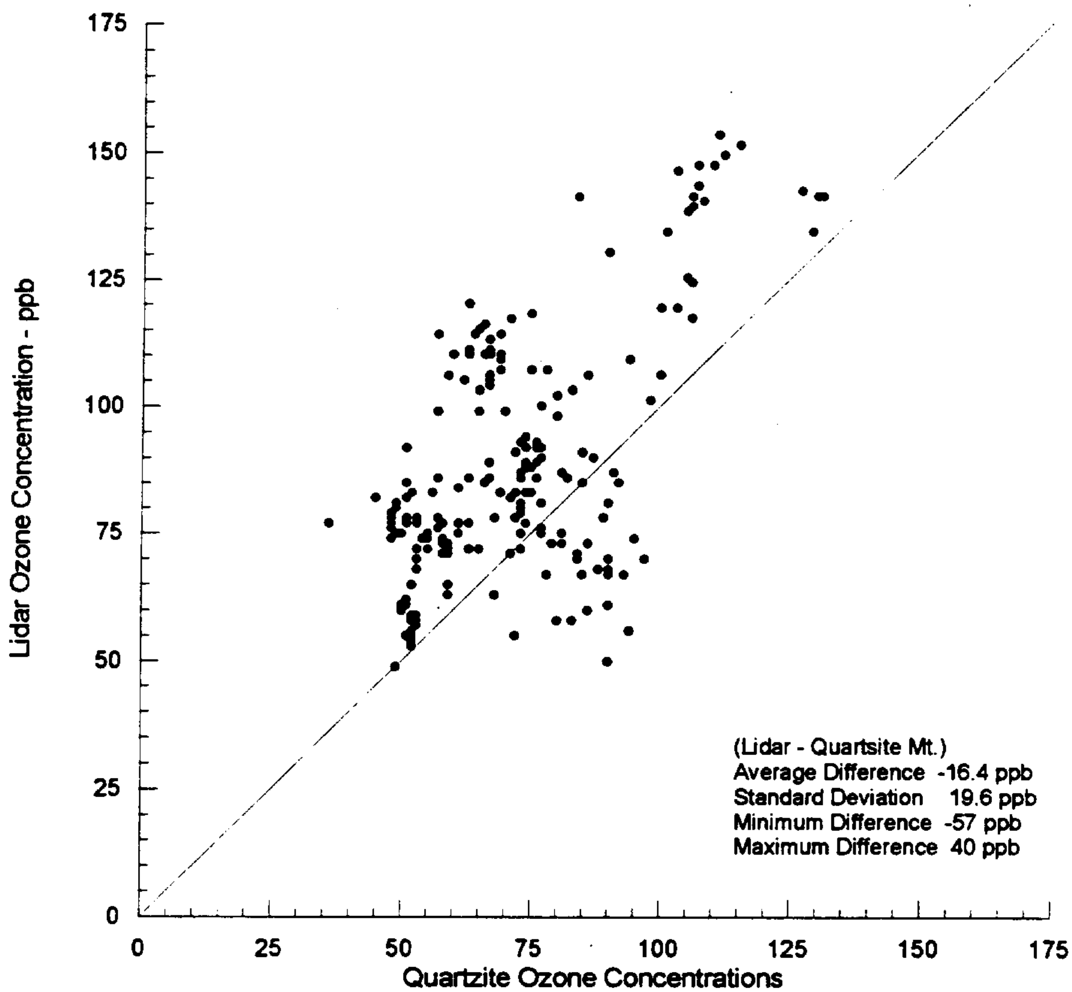

Fig. 3-14 Ozone Concentrations as Measured by the Lidar Compared with Measurements at Quartzite Mt.

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3.6.4 Quartzite Mt. and Apple Valley Profiler Wind Measurements

Statistics on the wind measurements at Quartzite Mt. and the 915-MHz radar wind profiler at the Apple Valley Airport are given in Table 3-22. Wind speed and direction are for the range-gate centered at 1369 m-asl, which corresponds to the elevation of the Quartzite Mt. site. In the table, the prevailing wind direction and average wind speed are shown for diurnal 3-hour blocks over the August-October period. Note that the secondary wind directions are given when significant. As can be seen from the table and Figs. 3-1, 3-2, and 3-3, the winds at Apple Valley were comparable but generally more westerly than at Quartzite Mt. owing to the air from Cajon Pass diverging as it flows into the desert. During the night (21-05 PST) , the wind directions at the two sites are even more comparable.

Prevailing wind direction at two desert floor sites, Victorville and Hesperia, are also given in the table. Victorville is located several miles upwind from Quartzite Mt. whereas Hesperia is several miles upwind of the Apple Valley airport. These data were included to show that the same wind bias between locations occurs at the surface as well, and that differences are not due to local deformation from the terrain at Quartzite Mt.

Table 3-22 Prevailing Wind Direction, Average Wind Speed, and Median Wind Speed

Period (PST)	Quartzite Mt. (1366 m-msl) Direction	Quartzite Mt. (1366 m-msl) Ave, Median Speed	Apple Valley (1369 m-msl) Direction	Apple Valley (1369 m-msl) Ave, Median Speed	Victorville Direction	Hesperia Direction
0 - 2	SW	5.1, 5.1	SSW to W	6.2, 5.9	SSW (SW)	SSW
3 - 5	SW (S)	4.6, 4.2	SSW (W)	5.1, 5.1	SSW	SSW
6 - 8	S	3.8, 3.4	SSW	4.3, 4.2	E	SSW (S)
9 - 11	S	3.7, 3.0	SSW	4.1, 3.7	S	SSW (S)
12 - 14	S	5.7, 5.1	SSW	6.7, 6.7	S	S-SSW
15 - 17	S	6.6, 6.4	SSW	8.1, 8.7	S	SSW
18 - 20	S	5.9, 5.9	SSW	7.7, 7.3	SSW	SSW
21 - 23	SSW-SW	5.5, 5.4	SSW (WSW)	6.7, 6.4	SSW (SW)	SSW

The diurnal average wind speeds are given for Quartzite Mt. and the wind profiler in the table. Both sites show similar trends with the minimum speeds occurring in the forenoon, and the highest speeds in the late afternoon. Wind speeds are, on the average, 10-30% lower at Quartzite Mt. than those measured by the profiler at Apple Valley. Differences can be real or result of the different measurement techniques. If real it is uncertain whether the difference is due to site separation distance or local effects of Quartzite Mt. (e.g., mechanical turbulence, flow distortion).

3.6.5 Summary

It can be concluded that ozone measurements at Quartzite Mt. are representative of conditions at that elevation in the free atmosphere and that ozone layers, when present at that elevation aloft will be detected with reasonable accuracy. There does not appear to be significant deformation in wind direction from local terrain at Quartzite Mt., thus that measurement is likely also to be representative of conditions aloft. Wind speed, however, may be decreased 10-30% by local terrain.

3.7 Boron and Ludlow Ozone Deficit

During the 1995 summer monitoring study, both Boron and Ludlow often experienced ozone levels less than what is normally considered natural background (i.e., 20-40 ppb). Deficit ozone levels are not unusual near NO_x or other reactive sources, and are common occurrences at urban sites. This effect is especially pronounced during nighttime hours when the atmosphere is stable and ozone production has ceased. Since neither site is in an urban setting, there was some concern over the frequency of low levels measured and probable causes. This concern is the focus of this section. Fig.3-15 shows the diurnal distribution of hourly-averaged ozone levels less than 10 ppb. Boron concentrations are shown on the top panel and Ludlow on the bottom panel of the figure.

Boron has instances of ozone concentrations less than 10 ppb beginning in the early evening when the atmosphere starts to stabilize and a nocturnal boundary layer begins to develop. The deficit peak occurrence occurs near daybreak when the nocturnal boundary layer is well developed. All instances of ozone less than 10 ppb occurred during this period (17-07 PST). The wind direction and speed frequency distributions (wind rose) at Boron when ozone levels were below 10 ppb are shown in Fig. 3-16. The winds were typically very light--less than 2 ms^{-1} more than 93% of the time and less than 0.5 ms^{-1} during 10% of the time--and with only a few exceptions had an easterly component. Highway 395, a major north-south traffic route, is approximately 0.6 miles due east from the site in Boron and a likely major source of reactants causing the low ozone levels. Traffic along Highway 58 due to the morning shift change at nearby Edwards AFB could contribute as well. The Boron site was at a State Fire Station and it was observed that vehicles there often ran continuously for long periods during routine maintenance. These activities could have contributed to ozone reduction as well.

The bottom panel of Fig. 3-15, shows the diurnal distribution of hourly-averaged ozone levels less than 10 ppb at Ludlow. Similar to Boron, all cases occurred during stable atmospheric conditions and when ozone production processes were not active. This site was located approximately 100 meters south of Highway 40, a west-east highway between Barstow and Needles that has significant truck traffic. (There was concern prior to the site installation about the proximity of the site to the highway. Nevertheless, based on CFR Part 58 and official traffic count estimates, it was determined that the siting was acceptable.) A noteworthy feature of the data shown in the figure is the peak frequency of low concentrations between 01-03 PST rather than just prior to daybreak as was the case at Boron. The wind rose for Ludlow when ozone concentrations were less than 10 ppb is shown in Fig. 3-17. Note that nearly all of the low ozone instances occurred when the flow was westerly--roughly parallel to the highway. Wind speeds were generally light to moderate. A possible scenario is that the plume from highway traffic remains relatively intact under stable atmospheric conditions and moves parallel to the highway spreading laterally enough to significantly impact the site when traffic is heavy. It is not clear why a significant number of cases (> 35%) occurred when the winds had a southerly component which should cause vehicular emissions to drift north of the highway, away from the site. One explanation is that there is a

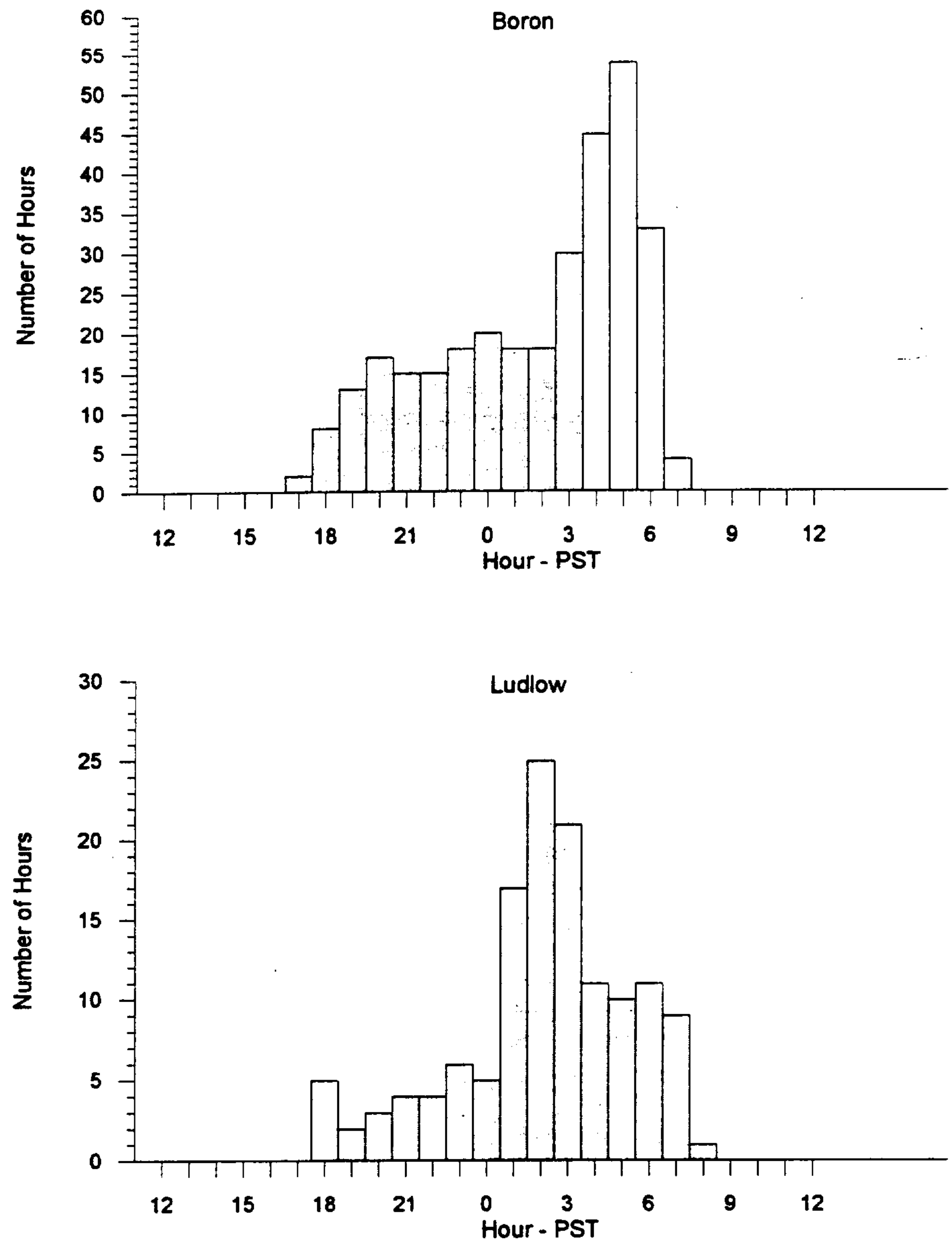

Fig. 3-15 Diurnal Variation of Ozone Concentrations Less Than 10 ppb
June 1 - October 31, 1995
Tip Panel Shows Boron, Bottom Panel Shows Ludlow

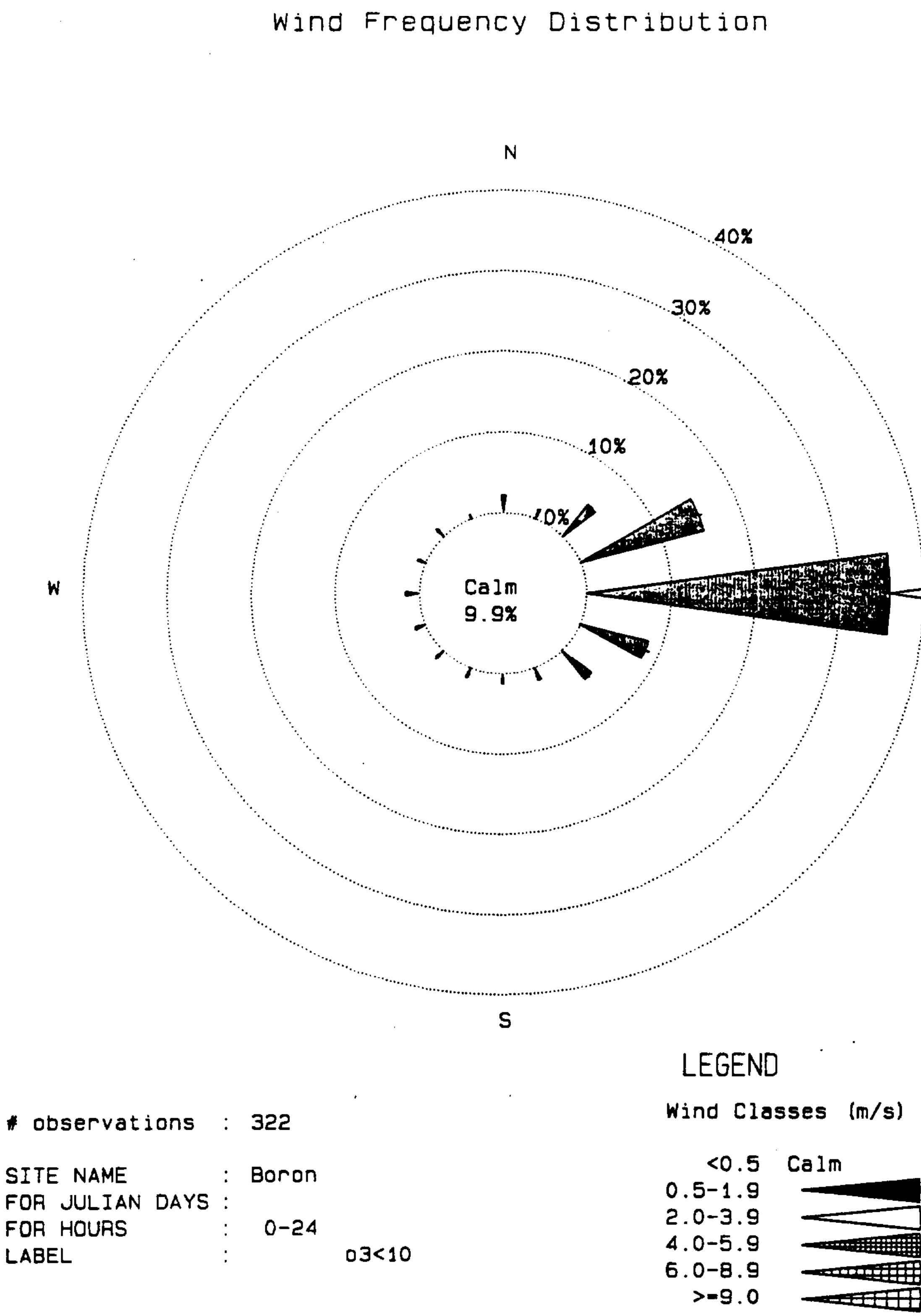

Fig. 3-16 Wind Frequency Distribution at Boron when Ozone Concentrations are Less Than 10 ppb, June 1 - October 31, 1995.

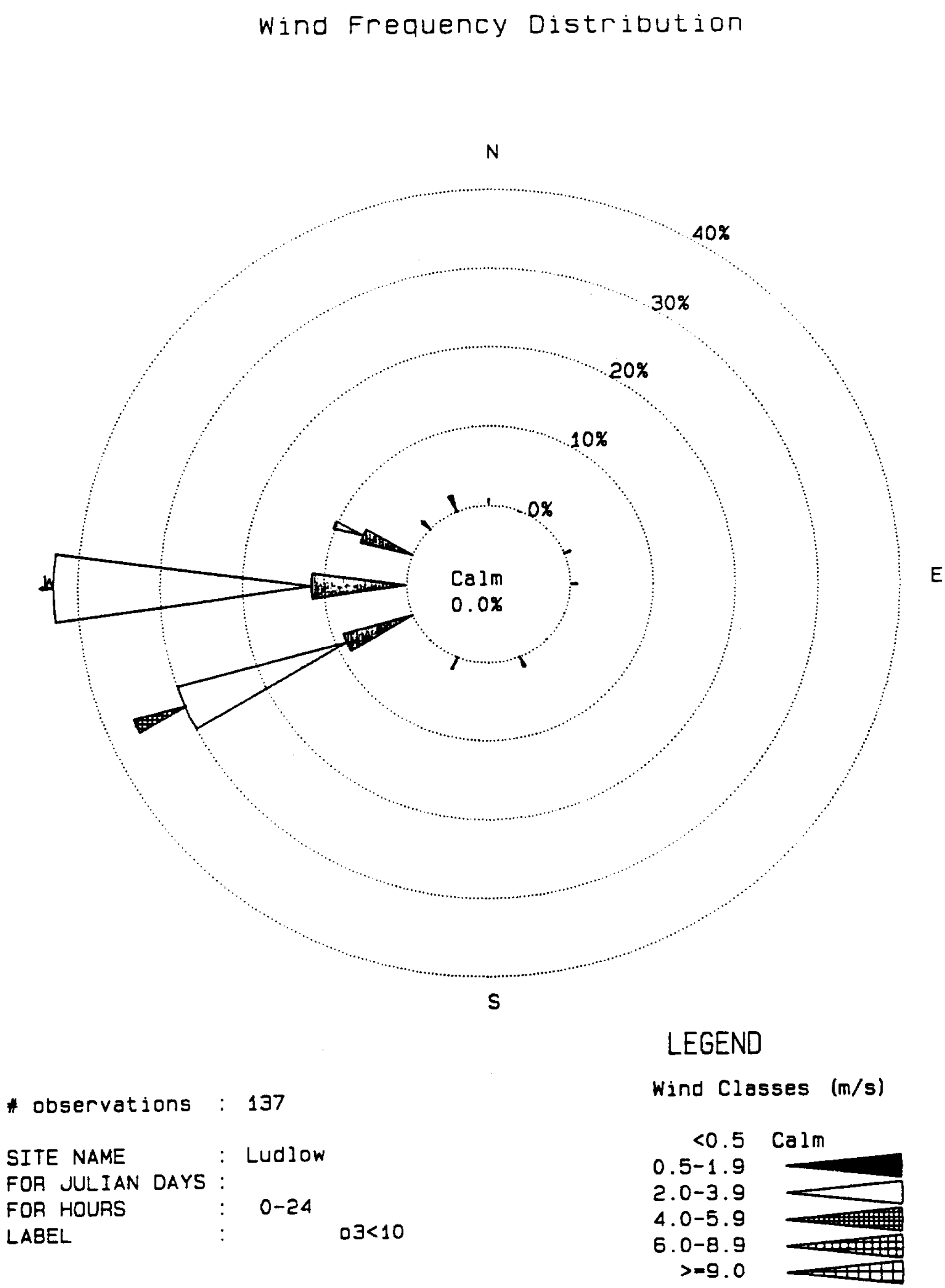

Fig. 3-17 Wind Frequency Distribution at Ludlow when Ozone Concentrations are Less Than 10 ppb, June 1 - October 31, 1995.

significant impact from a truck stop located upwind (to the west) less than ¼ mile from the site, and on the same side of the highway. Trucks were observed parked there with engines running for long periods at night.

3.8 Santa Catalina Island

During the period of operation (June 15-October 31, 1995) the site at Santa Catalina Island (elev. 488 m-msl) experienced 101 hours in which the state ozone standard was exceeded. Twenty-three of these hours were above the federal standard. About 60% of the state exceedances occurred during the five 24-hr. periods shown in Table 3-23.

Table 3-23 Principal Ozone Exceedance Periods at Santa Catalina Island

Date (1995)	Number of Hours	Peak Concentration (ppb)
June 24	11	215
July 25-26	16	157
August 8-9	9	153
September 14-15	15	140
October 12-13	10	108

Exceedances occurred on 19 other days but with smaller numbers of hours per day. Table 3-24 shows the distribution of wind directions by quadrant at Santa Catalina Island for all exceedance hours.

Table 3-24 Ozone Exceedance Hours at Santa Catalina Island by Wind Quadrant

Quadrant	Number of Hours
NW	54
NE	18
SE	13
SW	16

The wind direction at Santa Catalina Island was predominantly from the northwest during exceedance hours. The diurnal distribution of ozone exceedances at Santa Catalina Island is shown in Table 3-25.

Table 3-25 Diurnal Distribution of Ozone Exceedances at Santa Catalina Island

Time (PST)	Number of Hours
00-02	18
03-05	11
06-08	8
09-11	4
12-14	7
15-17	7
18-20	21 (19 occurred from 19-20)
21-23	25

Exceedances were most frequent from 19 to 05 PST with the highest frequency from 19 to 22 PST, using hourly values to supplement the data in Table 3-25. During the peak period of 20-22 PST, 57% of the wind directions were from the NW quadrant with another 29% from the SE. Median wind speed for these northwesterly wind directions was 2.4 m/s.

The northwesterly wind cases between 20 and 22 PST constitute potential (but not exclusive) candidates for impact in San Diego County on the following day. On the basis of observed wind velocities, transport to San Diego (about 130 km) could occur by midday. A list of dates on which these conditions occurred is given in Table 3-26.

Table 3-26 At Santa Catalina Island, Days in the 1995 Database with Ozone Exceedances Between the Hours 20-22 PST and Northwest Winds	
June 22	August 8*
June 23	August 10
July 14	August 18*
July 25*	September 14*
August 2*	October 2

* Multiple exceedance hours and may be more significant events

Three of the major exceedance events in Table 3-23 have been examined in a little more detail. Radio Acoustic Sounding System (RASS) and wind profiler data from the Los Angeles International Airport (LAX) for June 23-24, July 25-26 and September 14-15 were obtained from the South Coast Air Quality Management District (SCAQMD). The locations of the sites are shown on Fig. 3-18.

Warm temperatures aloft characterized all three cases. At Vandenberg AFB, 850 mb temperatures ranged from 26°C to 29°C on these days. Offshore pressure gradients between Los Angeles (LAX) and Las Vegas were present on June 23-24 and September 14-15 but the gradients were onshore for the July 25-26 event. The synoptic pattern in each case indicated high pressure ridging into central and northern California which tended to contribute to offshore winds in Southern California.

The base of the temperature inversion as indicated by the RASS data at LAX was below the elevation of the monitoring station at Santa Catalina Island Airport for all but a few hours of the three periods. The airport on Santa Catalina Island was situated within the inversion layer during all three of the major ozone exceedance events studied.

Figs. 3-19 and 3-20 show the LAX profiler data for June 23 and 24. The Santa Catalina Island winds and ozone concentrations are also plotted on the figure. The wind data at Santa Catalina Island are distinguished from the LAX winds by circles which are centered at the site elevation (488 m). Also included in the figures is the inversion height at LAX obtained from RASS data (dashed line). The vertical lines at about 11 PST and 18-20 PST represent the beginning and end of the sea breeze development which extends well above the temperature inversion.

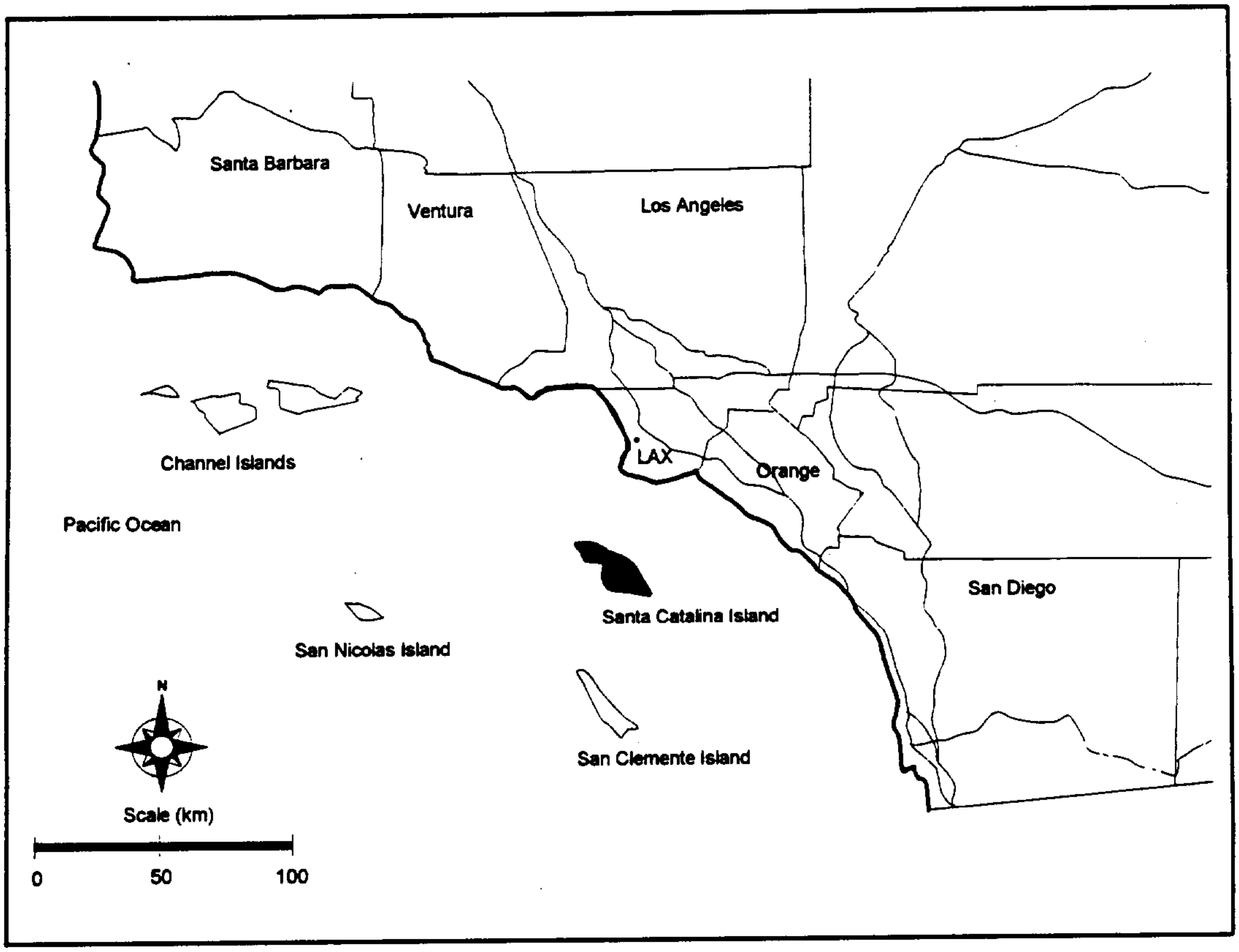

Fig. 3-18 Regional Map Showing the Locations of Santa Catalina Island, the Coastline, and the Wind Profiler/RASS Site at LAX

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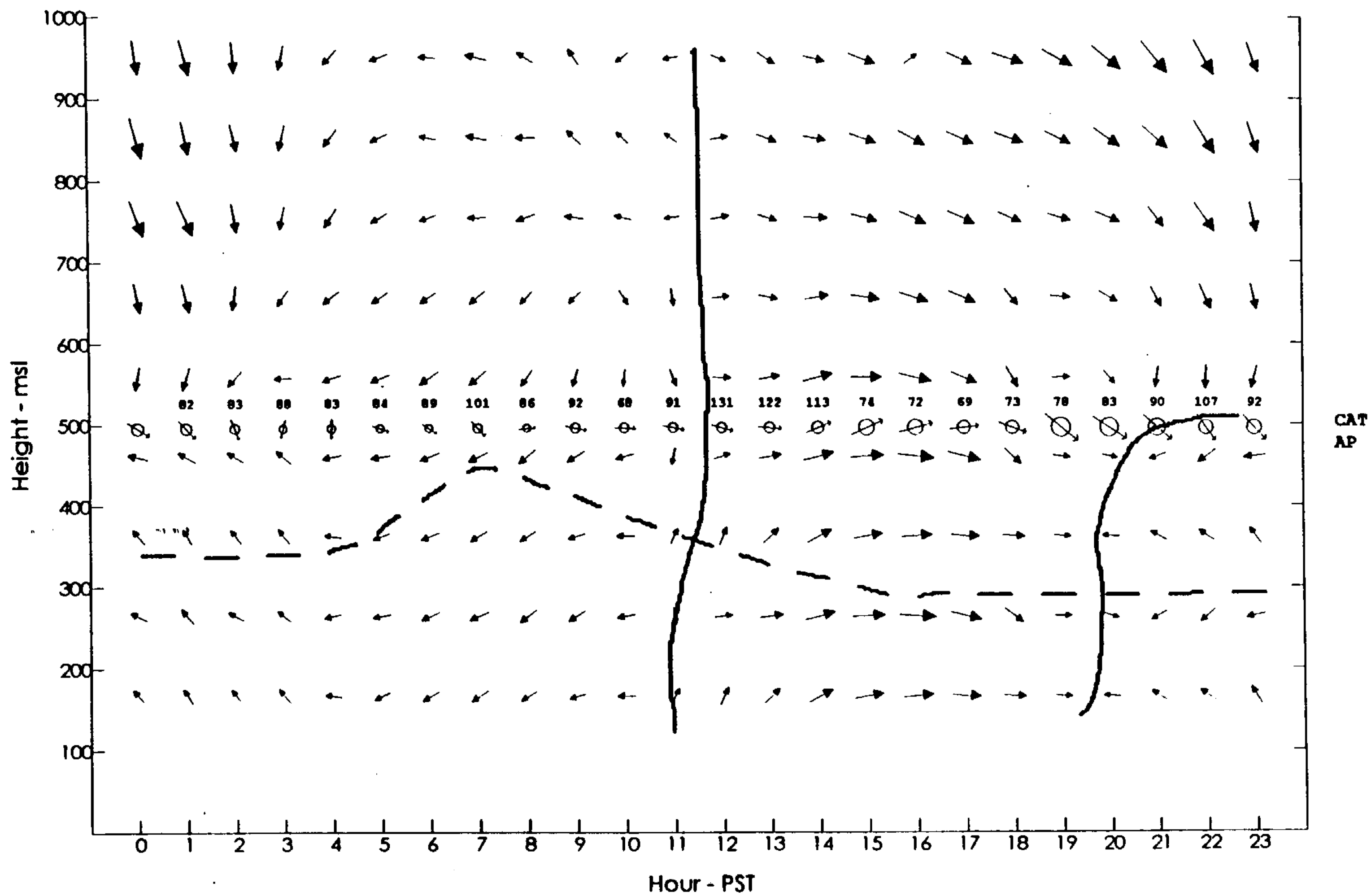

Fig. 3-19 June 23, 1995 Time Series of LAX Winds Aloft, and Santa Catalina Island Airport Surface Winds and Ozone. Inversion height at LAX shown by dashed line. Solid line depicts beginning and end of sea breeze at LAX. Wind speeds are proportional to size of arrow symbols. Ozone concentration in ppb.

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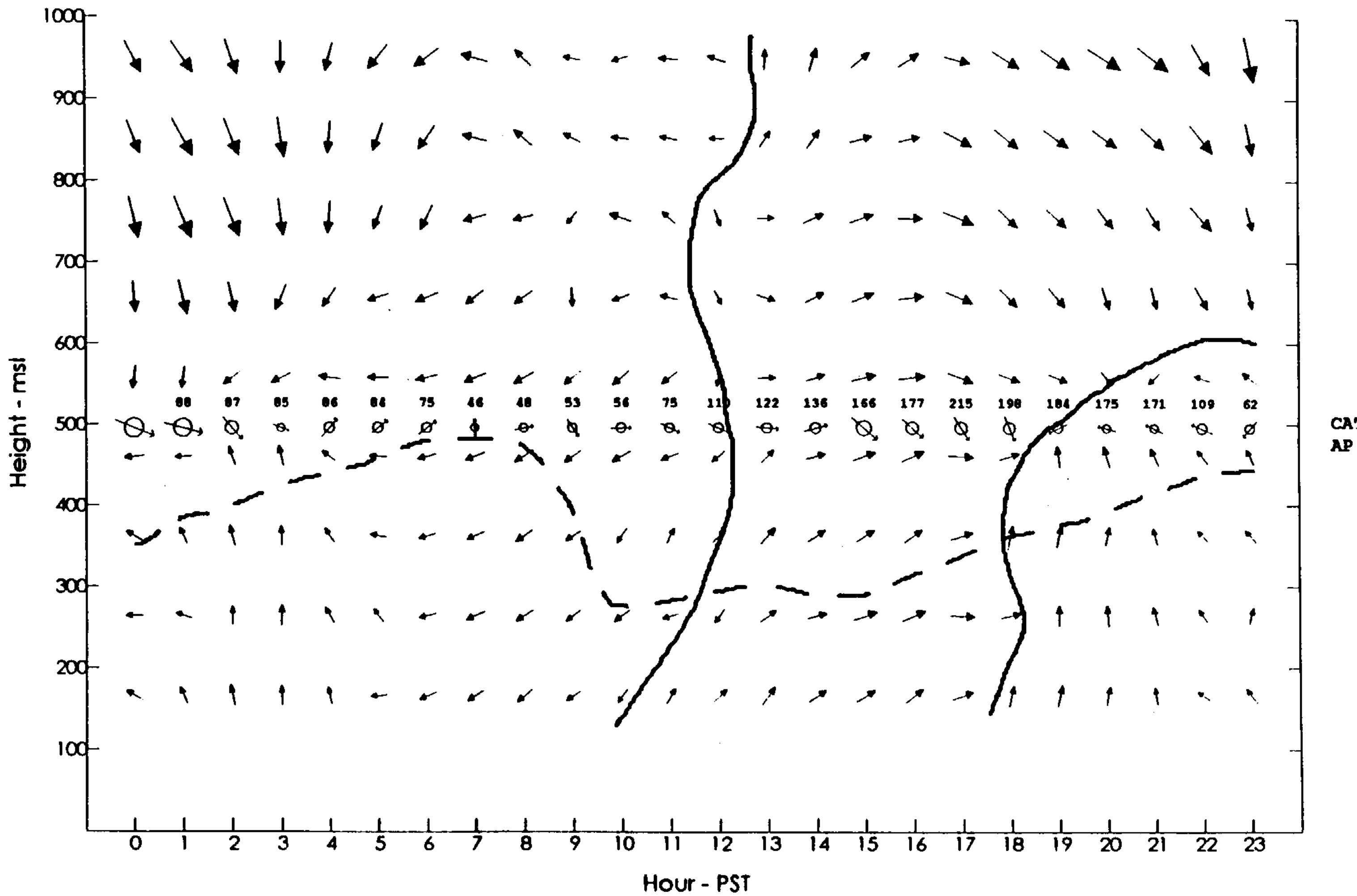

Fig. 3-20 June 24, 1995 Time Series of LAX Winds Aloft, and Santa Catalina Island Airport Surface Winds and Ozone. Inversion height at LAX shown by dashed line. Solid line depicts beginning and end of sea breeze at LAX. Wind speeds are proportional to size of arrow symbols. Ozone concentration in ppb.

6-24rev.wl

The principal wind developments on June 23 at LAX were the easterly flow in the first 500 m from 04-10 PST, the sea breeze from 11-20 PST and the return of easterly flow in the low levels after 20 PST. This basic pattern is characteristic of all three periods for which profiler data were available but with small timing differences. There was one exceedance at Santa Catalina Island on June 23 at 07 PST during the easterly flow regime. The balance of the exceedances on June 23-24 occurred during the sea breeze regime under west to northwest winds.

The diurnal ozone pattern on June 23-24 case does not correspond to the most frequent diurnal ozone pattern at Santa Catalina Island (Table 3-25). Peak ozone concentrations occurred near midday instead of the more frequent case where high concentrations begin about 19 PST. The June 23-24 concentrations may be owing to offshore transport on the previous day impacting Catalina in a westerly return flow.

The trajectory of the high concentrations which frequently begin about 19 PST is less clear. The beginning of the high concentrations coincides with a marked change in the circulation pattern at the end of the sea breeze and the beginning of the easterly flow regime (Fig. 3-19). However, the light winds characteristic of the easterly flow at the time do not imply transport as far offshore as Santa Catalina Island by 19-20 PST. Additional profiler data from coastal locations would help to define the effects of the circulation changes.

Ozone concentrations at sites in San Diego County were reviewed in connection with the ten Santa Catalina Island exceedance days with the greatest potential for transport (Table 3-26). The daily peak concentrations and time of occurrence were reviewed for the day before, day of, and day after each exceedance in the table which were all associated with northwesterly winds at Santa Catalina Island. Next day's peak concentrations at Alpine, the site that most often experiences the highest ozone levels in San Diego County, and time of occurrence are shown in Table 3-27. Although meteorological data were not analyzed for potential trajectories of the polluted air, ambient air quality data analyses indicate that the exceedances offshore at Santa Catalina Island did not cause any violations in San Diego County. Except for the July 25, September 14, and October 2, 1995 events, the only site in San Diego County exceeding the California ambient air quality standard was Alpine. The only forenoon peak at Alpine occurred on August 2, a full 11 hours before ozone concentrations peaked at Santa Catalina Island. The median peak time at Alpine for the 10 days in Table 3-27 was the same as the peak time for the complete set of Alpine exceedance days during the period June 21 to October 4, 1995.

This very limited analysis did not indicate any evidence of "overwhelming transport" (i.e., causing an exceedance). The offshore flow pattern is complex and subject to both diurnal and synoptic influences. Detailed analyses of the meteorological and air quality data will be necessary to ascertain whether (and if so, to what extent) San Diego County was impacted by transport from off-shore. This kind of effort was well beyond the scope of the present program.

Table 3-27 Next Day Alpine Peak Ozone Concentrations (San Diego County Air Basin)

Date (1995)	Concentration (ppb)	Time
June 23	107	14, 15
June 24	126	14
July 15	101	13
July 26	118	13
August 3	115	12
August 9	108	13
August 11	100	12
August 19	93	14
September 15	99	14
October 3	99	13

4.0 CONCLUSIONS

- The frequencies of flow into the Mojave Desert through Soledad Canyon, Cajon Pass and Tehachapi Pass were estimated. These frequencies ranged from 40-83% for Soledad Canyon (SE Palmdale), 56-85% for Cajon Pass (Baldy Mesa) and 24-82% for Mojave, depending on time of day. Peak frequencies occurred in the late afternoon.

- The flow patterns in and downwind of Cajon Pass are complex and not well documented by existing data. Baldy Mesa and Phelan have similar ozone impact characteristics but Hesperia is more closely related to Quartzite Mt. and Victorville than to the much closer location at Baldy Mesa. Baldy Mesa and Phelan have bimodal, peak ozone distributions, suggesting complex source and/or wind flow patterns.

- Air flow into the Desert is directed from the northwest at Mojave, from the southwest at SE Palmdale and from the south through Cajon Pass. These flows merge into a westerly current in the northern and eastern parts of the Desert. Between SE Palmdale and Victorville, in the southern part of the Desert, the westerly and southerly flows converge. Winds at Shadow Mt. and Quartzite Mt. reflect this pattern. The existing data do not resolve the structure of this convergence zone (i.e., sharp demarcation or merging) and the effect on pollutant transport.

- There were six days of ozone exceedances at Barstow during the monitoring period of June-October 1995. On five of the days, the exceedances occurred during the late afternoon and can be attributed to same-day transport from the SoCAB. The sixth day (August 19) was a widespread fumigation event (09-10 PST at Barstow) which resulted from overnight storage aloft of ozone concentrations from the previous day.

- There were 15 exceedance days at Boron during the monitoring period. Thirteen of the days were classified as transport days. On one of the 15 days (August 19), fumigation also occurred at Boron (08 PST). The remaining ozone exceedance day was June 14. The ozone exceedance on June 14 was a marginal (95 ppb), isolated event in the western part of the Desert although, in the south-central desert, Phelan had an exceedance and Quartzite Mt. recorded a value of 94 ppb. The wind speed at Boron was well above average during the exceedance hour (14 PST) but there was no other evidence supporting a transport scenario.

- The observed variations in regional Desert background ozone levels due to prior day transport from the SoCAB and SJV tend to dominate over the impact from local emission sources.

- The fumigation event of August 19 was preceded by extensive ozone transport from the SoCAB on August 18, primarily through Soledad Canyon. A sharply reduced onshore pressure gradient from August 18 to August 19 led to light winds aloft during the night and reduced transport. Ozone exceedances occurred at Shadow Mt. from early evening on August 18 until early forenoon on August 19. The layer aloft extended at least as far east as Quartzite Mt. An extensive layer of high ozone concentrations was thus present aloft on the morning of August 19 and was subsequently mixed to the surface by 09 PST.

- A surprisingly large number of low (<10 ppb) ozone concentrations were recorded at Boron and Ludlow. All of these occurred between 17 and 08 PST. The peak frequencies of low concentration were at 05 PST at Boron and 02 PST at Ludlow. The frequency distributions were attributed to a combination of nocturnal stability and the individual traffic patterns at the two sites.

- There were 24 days (101 hours) of ozone exceedances of the state standard at Santa Catalina Island during the monitoring period. About 60% of the exceedances occurred between 19 and 02 PST. More than half of the exceedances were associated with wind directions from the northwest quadrant with the remaining cases equally distributed among the other three quadrants. In three cases where RASS data were available, the high ozone concentrations occurred almost entirely within the inversion layer.

- Based on a comparison of the Quartzite Mt. data with Apple Valley wind profile data, aircraft measurements, and Victorville surface data, the 1995 measurements made at *elevated* sites were representative of ozone levels and wind flows aloft.

5.0 RECOMMENDATIONS

- The three-dimensional structure of transport in the Desert has not been addressed. Key questions are the depths of the ozone layers that were observed and the characteristics (and effects) of the El Mirage convergence zone. Analysis of other data collected during the Mojave Desert Transport Study in 1995 may help address these questions.

- Air flow and the influx of ozone observed at the Mojave site come from a consistent, northwesterly direction. The subsequent trajectory of this influx is not clear and was not apparent in the monitoring network. The strength and consistency of the flow from the northwest at Mojave argue against frequent transport northward toward the Naval Weapons Center at China Lake. This issue requires further investigation.

- The air flow and ozone impacts from Cajon Pass are complex. There are frequently two ozone peaks at Baldy Mesa. The early peak (often 12-13 PST) represents a different source region (probably east SoCAB) from the later peak which may be the primary pulse from the major SoCAB source regions. A better understanding of these effects and the lack of good correlation between Baldy Mesa and Hesperia requires a better analysis of the upwind areas in the SoCAB.

- Further analysis of the June 14 event at Boron should be undertaken. Similar cases of isolated, high ozone concentrations (non-exceedances) at Boron should be identified and examined for a common flow pattern.

- The offshore flow pattern near Santa Catalina Island, particularly above the inversion, is complex and poorly understood. It should be possible to get a better understanding of the flow regime during ozone exceedance hours through the use of wind profiler data along the coast and offshore. This complex air pollution meteorology should be addressed during the planning of the 1997 Southern California Ozone Study.

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APPENDIX A

MONITORING SITES DESCRIPTIONS

Site Name: Boron
Station Type: Surface level monitoring (ozone and meteorology)
Location: Instruments housed in a wooden 8 x 8 ft. insulated shelter located behind the Kern County Fire Station at 26965 Cote Street in Boron, 28 miles east of Barstow and 0.4 miles south of Highway 58.
Coordinates: 35° 00' 13" North, 117° 39' 04" West
Elevation: 2,460 feet (msl)
Operator/Owner of Site: Kern County Fire District
Contact Name: Battalion Chief (805) 822-5555
Fire Station (619) 762-6167
Local Topography: Surrounding terrain is generally flat. Ground surface around the monitoring location consisted of sandy dirt, grass and concrete service area for the fire station.
Instrument Exposure: The wind speed and direction sensor was mounted on a short mast extending above the top of the hose drying tower. Exposure was good with some possible influence from the nearby fire station and other buildings in the residential area. The temperature probe housing and ozone sample inlet were mounted on a mast attached to the side of monitoring shelter and extended approximately 1.5 meters above and 0.5 meters out from the shelter roof line. The inlet openings were 3.5 meters above ground level. Ground surface below the temperature probe was dirt and no significant influencing features were nearby.

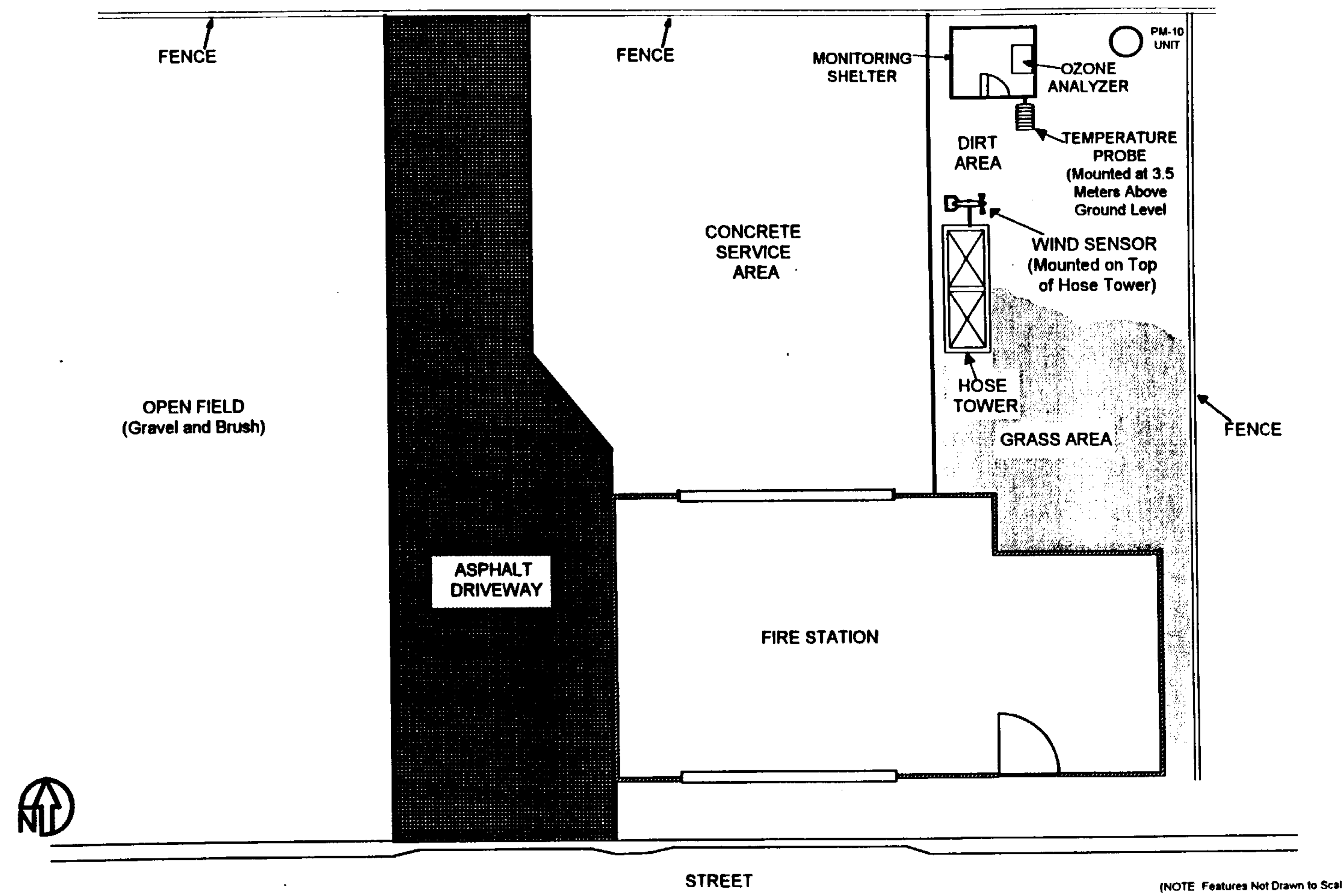

Fig. A-1 Site Diagram - Boron

Site Name: Ludlow

Station Type: Surface level monitoring (ozone and meteorology)

Location: Instruments housed in an existing, temperature-controlled cellular telephone relay station located in Ludlow, California, approximately 50 miles southeast of Barstow and 0.2 miles south of U.S. Highway 40.

Coordinates: 34° 43' 29" North, 116° 09' 28" West

Elevation: 1,782 feet (msl)

Operator/Owner of Site: LA Cellular

Contact Name: Rich Armstrong (213) 716-5389

Local Topography: Flat, desert-type terrain surrounds the site. Ground surface is sandy with desert brush and grasses. A chain-link fence surrounds the relay station.

Instrument Exposure: Instrument exposure was good for surface monitoring requirements. The wind sensor was mounted on a boom extending out from a telephone pole adjacent to the station. The Ozone sample inlet and temperature probe were mounted on a right-angled mast attached to the roof of the shelter and extending 1.5 meters above and 1.0 meters away from the shelter. No influencing obstacles or features were nearby.

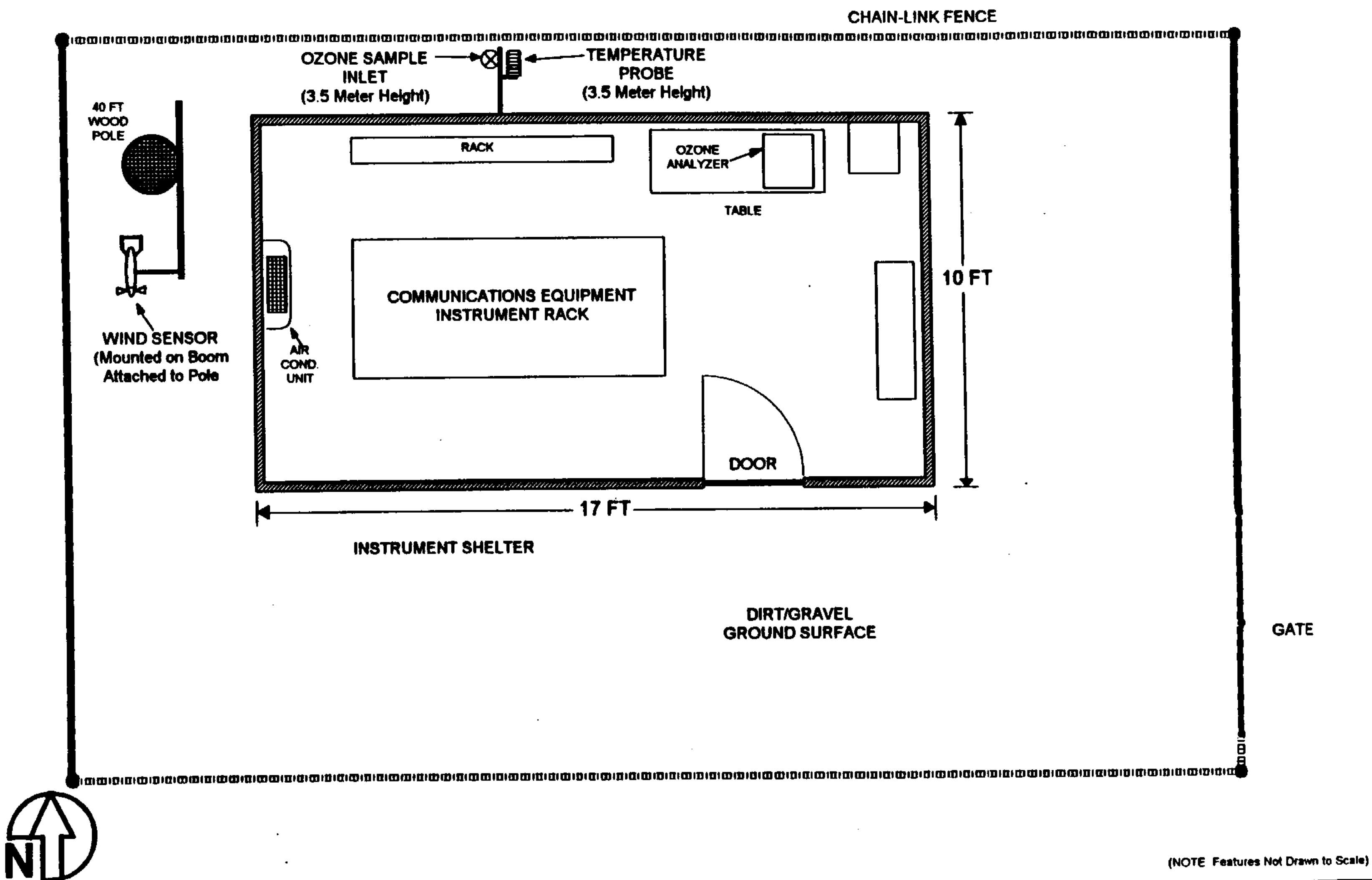

Fig. A-2 Site Diagram - Ludlow

Site Name: Shadow Mt.

Station Type: Elevated (ozone and meteorology).

Location: Located in an existing microwave relay station on top of Shadow Mountain, approximately 18 miles north of Victorville, California and 5.8 miles west of State Highway 395.

Coordinates: 34° 44' 15" North, 117° 33' 54" West

Elevation: 4,120 feet (msl) Station is 1,000 feet above the valley floor.

Operator/Owner of Site: Pacific Micronet

Contact Name: Chuck Crawford (800) 266-7483

Local Topography: The microwave station sits on top of a small mountain and is surrounded by desert on all sides. Ground surface around the station is rock and dirt.

Instrument Exposure: The meteorological sensors were mounted on a mast attached to and extending approximately 12 feet above one of the microwave towers. Monitoring height was 9.9 meters above ground level. The ozone sample inlet was attached to the meteorological mast and mounted on a short boom just below the temperature probe housing. Good exposure existed for all monitored parameters.

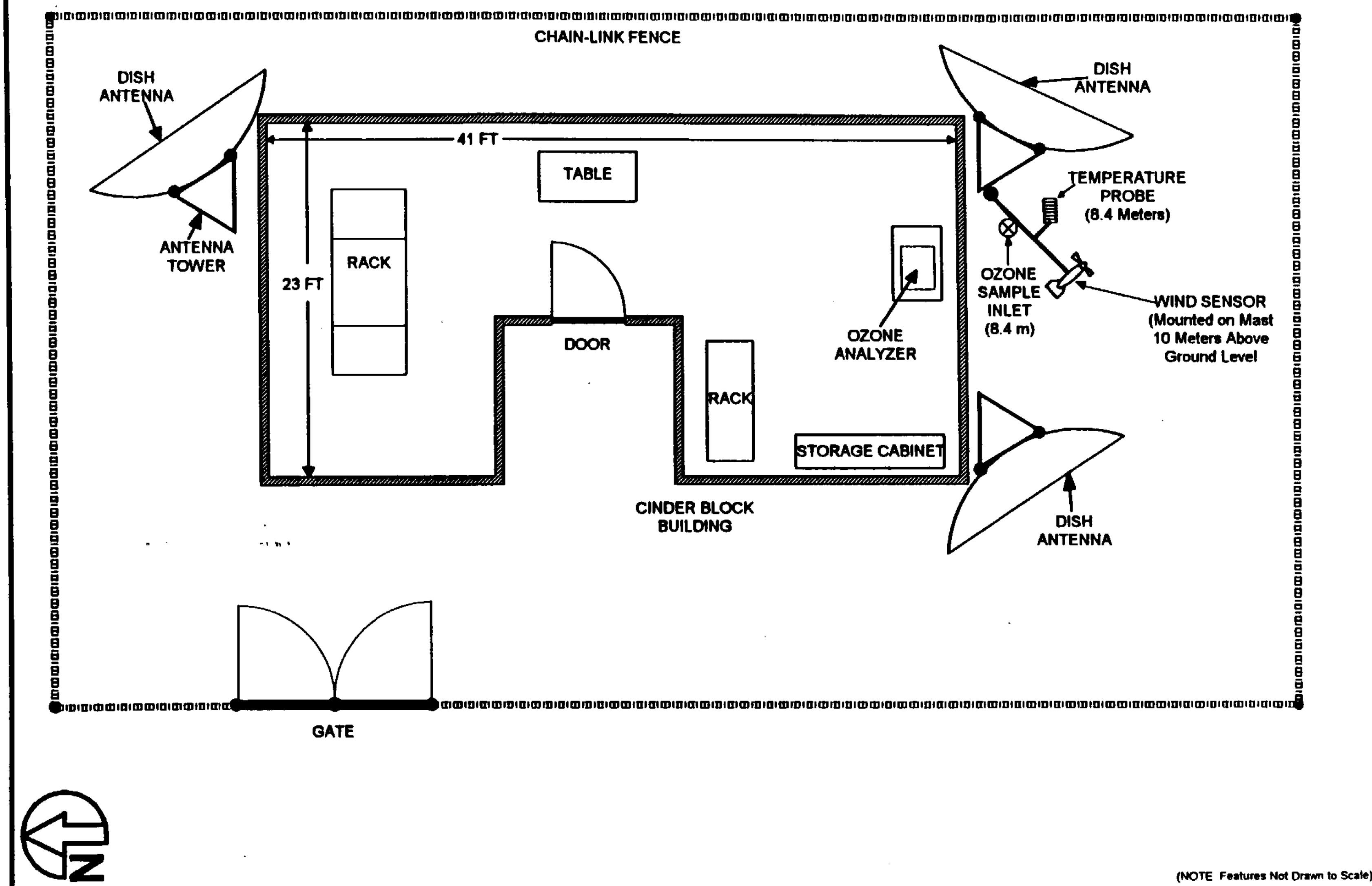

Fig. A-3 Site Diagram - Shadow Mt.

Site Name:	Baldy Mesa
Station Type:	Surface level monitoring (ozone and meteorology)
Location:	The instruments were housed in a rented, temperature-controlled, mobile construction office trailer parked on a vacant lot of a residential development area, just north of the summit of Cajon Pass, and three miles northwest of U.S. Interstate 15.
Coordinates:	34° 22' 30" North, 117° 26' 52" West
Operator/Owner of Site:	Summit Estates
Contact Name:	Dana A. Wigington (619) 949-5832
Elevation:	4,250 feet (msl)
Local Topography:	The topography surrounding the site was low, rolling terrain, with low bushes and scrub oak. Ground surface around the trailer and meteorological tower was sandy dirt, gravel and low grass.
Instrument Exposure:	The meteorological instruments were mounted on a 10-meter tower approximately 32 feet east of the monitoring trailer. The ozone sample inlet was mounted on a wooden mast attached to the side of the trailer and extended 1.5 meters above and 0.5 meters away from the trailer roof.

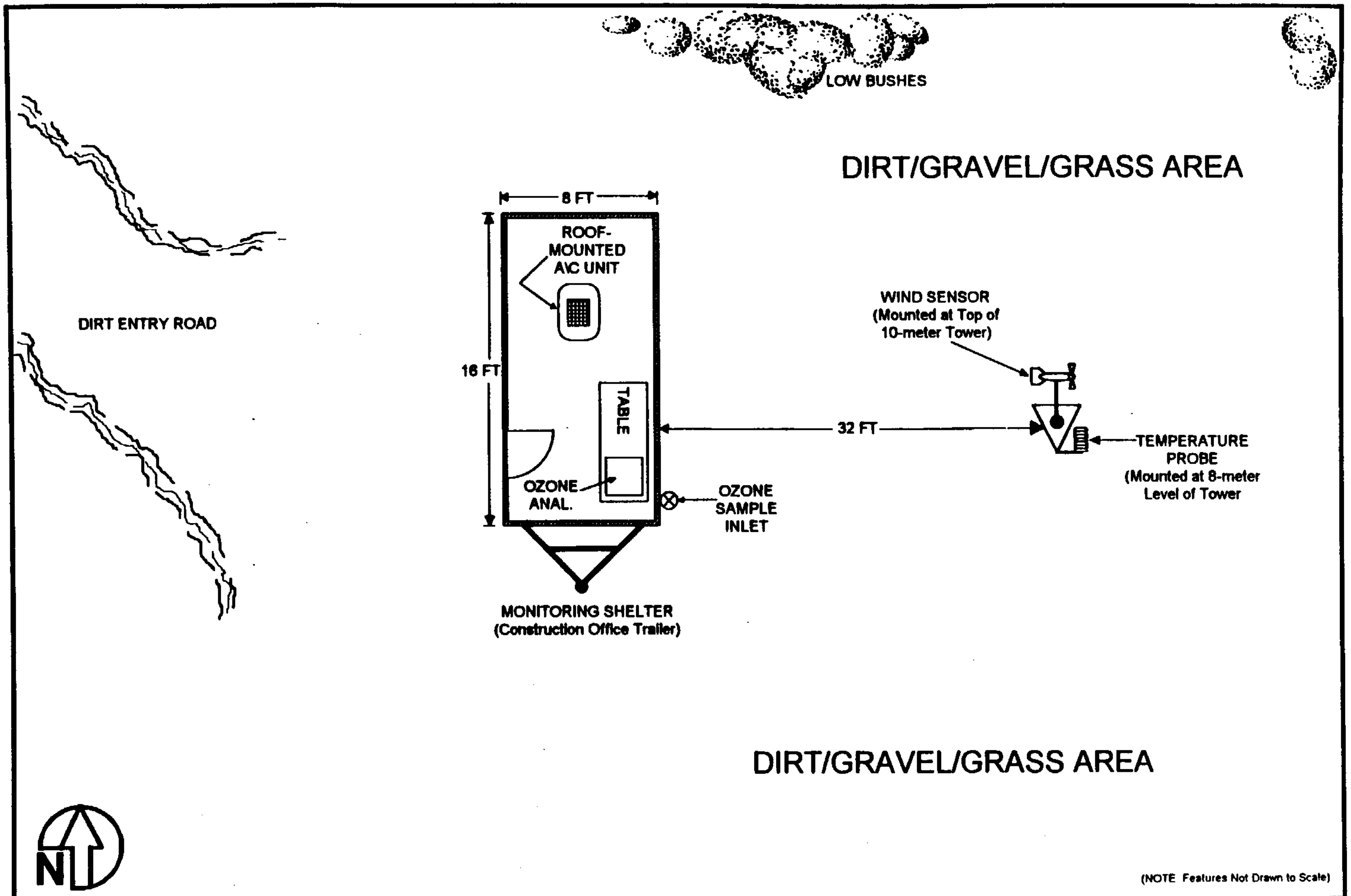

Fig. A-4 Site Diagram - Baldy Mesa

Site Name: SE Palmdale

Station Type: Surface level monitoring (ozone and meteorology)

Location: Installed in an existing, air conditioned, cable television control station, in a mobile home residential area at 1030 East Avenue "S" in SE Palmdale, California.

Coordinates: 34° 33' 25" North, 118° 06' 42" West

Elevation: 2,760 feet (msl)

Operator/Owner of Site: Northgate Communications

Contact Name: Fred Budmier (310) 284-3190

Local Topography: The area is generally flat with a few low rolling hills to the south. The station is positioned in the extreme southwest corner of an asphalt-surfaced parking area for recreation vehicles used by the residents of the mobile home trailer park. Dirt and low vegetation exist on three sides of the station.

Instrument Exposure: Wind speed and wind direction sensors were boom-mounted at the 10-meter level of an existing 16-meter tower. The temperature probe was mounted on the tower at 7.5 meters above ground level. The ozone sample inlet was mounted on a mast attached to the side of the control station and extended approximately 1.5 meters above roof line.

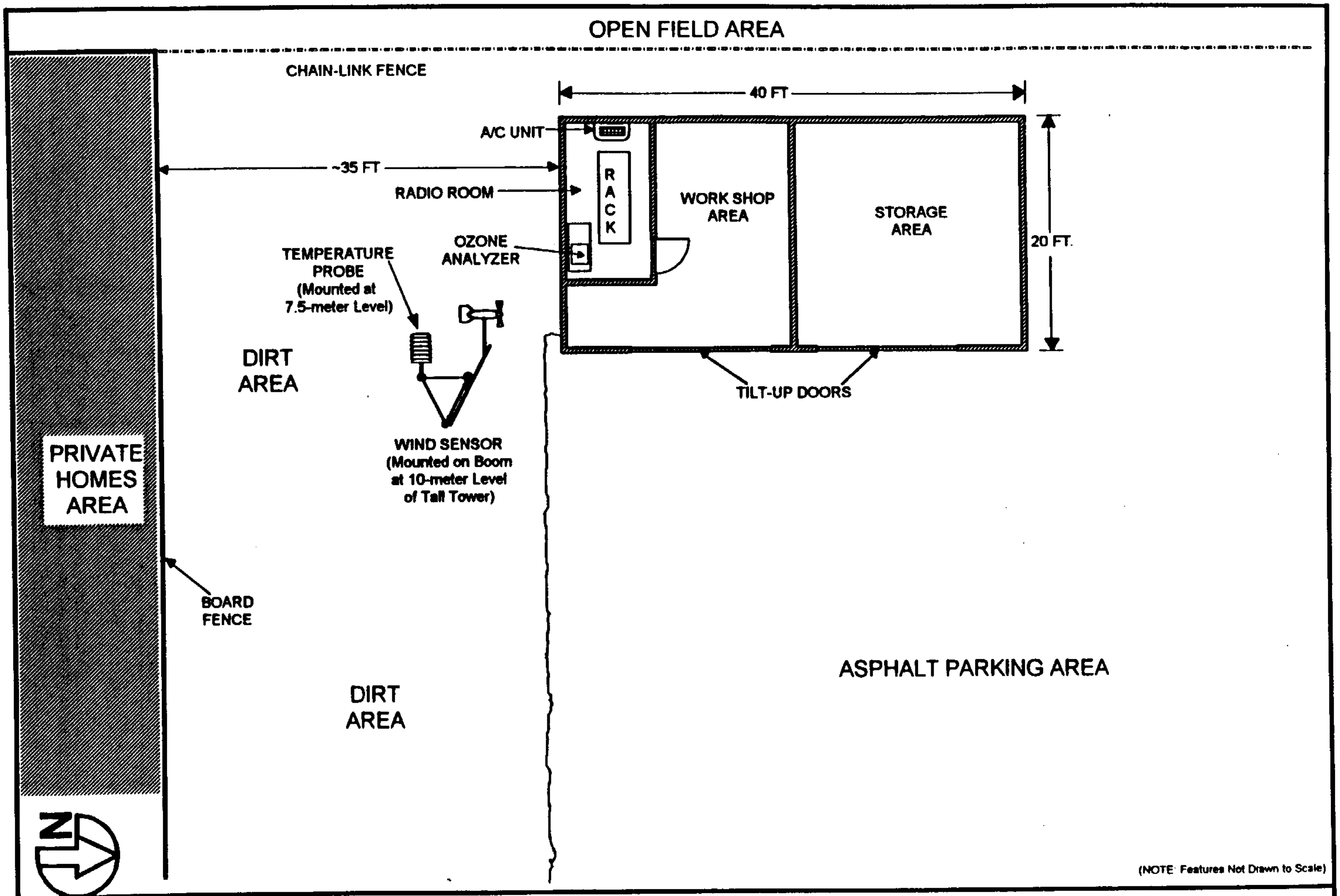

Fig. A-5 Site Diagram - SE Palmdale

Site Name: Flash II Mt.
Station Type: Elevated monitoring (ozone and meteorology)
Location: An existing, temperature-controlled radio and microwave relay station located on top of Flash II Mountain. The station is five miles north-northwest of Barstow, California.
Coordinates: 34° 58' 15" North, 117° 02' 23" West
Elevation: 3,325 feet (msl). The station is 1,300 feet above the valley floor.
Operator/Owner of Site: Jim Doering Communications
Contact Name: Jim Doering (818) 308-0398
Local Topography: At 1,300 feet above the surrounding terrain, Flash II Mountain is the most prominent topographical feature in the area which is mostly flat to rolling desert terrain. Ground surface surrounding the station is dirt, rock and gravel.
Instrument Exposure: The wind speed and direction sensor was boom-mounted at 10 meters above ground level on an existing microwave tower. The temperature probe was attached to a cable stanchion at a height of approximately 3 meters. The ozone sample inlet was mounted on a mast attached to the side of the relay station. The mast extended 1.5 meters above the roof line and was 4 meters above ground level.

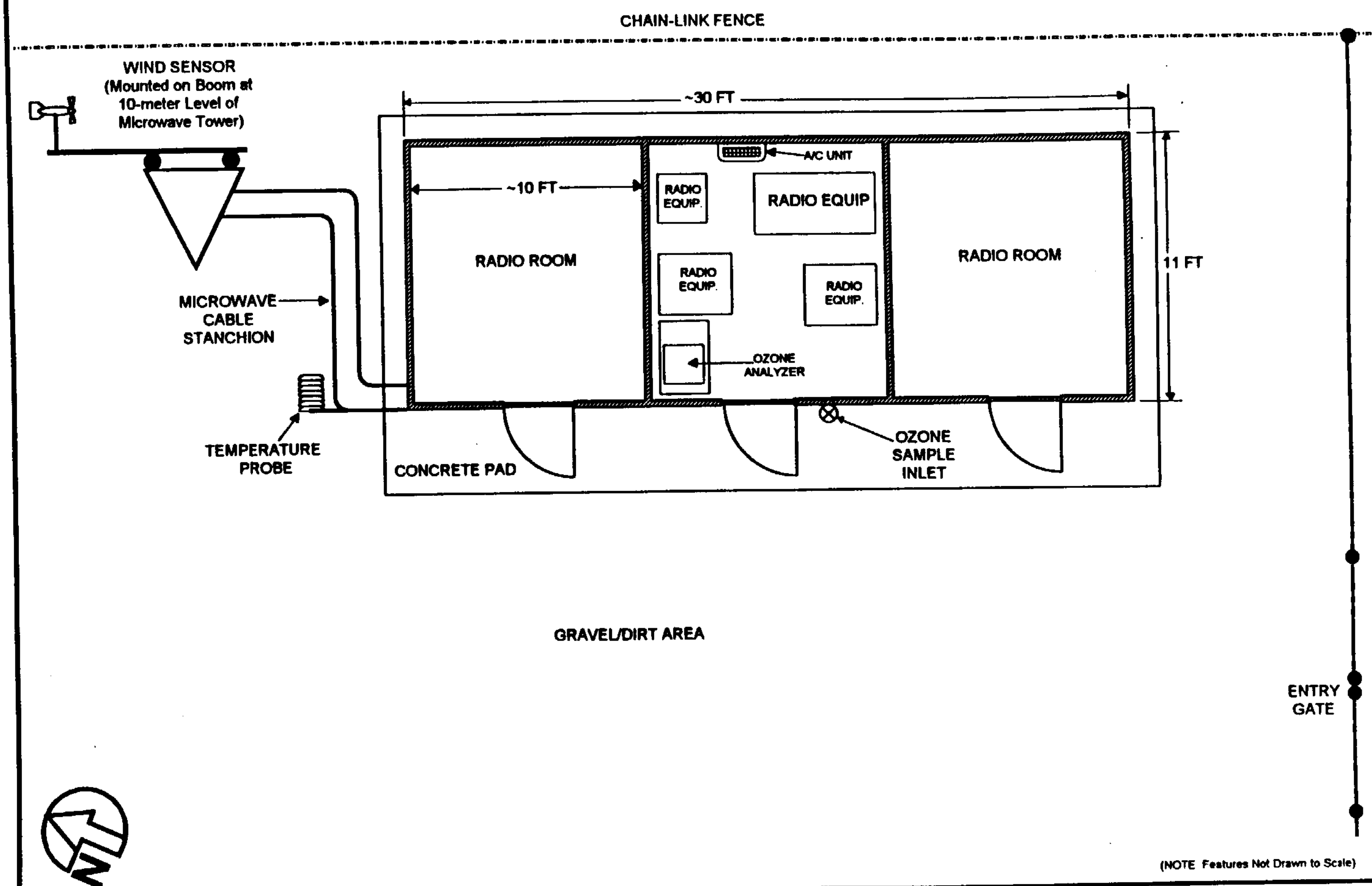

Fig. A-6 Site Diagram - Flash II Mt.

Site Name:	Quartzite Mt.
Station Type:	Elevated monitoring (ozone and meteorology)
Location:	Monitoring site is at an existing microwave relay station located on top of Quartzite Mt., approximately six miles north of Oro Grande, California and three miles west of Interstate 15 north of Victorville.
Coordinates:	34° 36' 42" North, 117° 17' 20" West
Elevation:	4,482 feet (msl). The station is 2,000 feet above the valley floor.
Operator/Owner of Site:	Jim Doering Communications
Contact Name:	Jim Doering (818) 308-0398
Local Topography:	Quartzite Mt. is mostly rock with very little vegetation. It is the most prominent terrain feature in the area. The terrain slopes downward on all sides except to the south.
Instrument Exposure:	The wind speed and direction sensor was mounted 10 meters above ground level at the top of an existing, unused tower adjacent to the station. The temperature probe was mounted on the same tower at height of 3.5 meters. The ozone sample inlet was mounted on a mast attached to the roof eves of the station and extended 1.5 meters above the level of the roof. Exposure was good for all instruments located at the station.

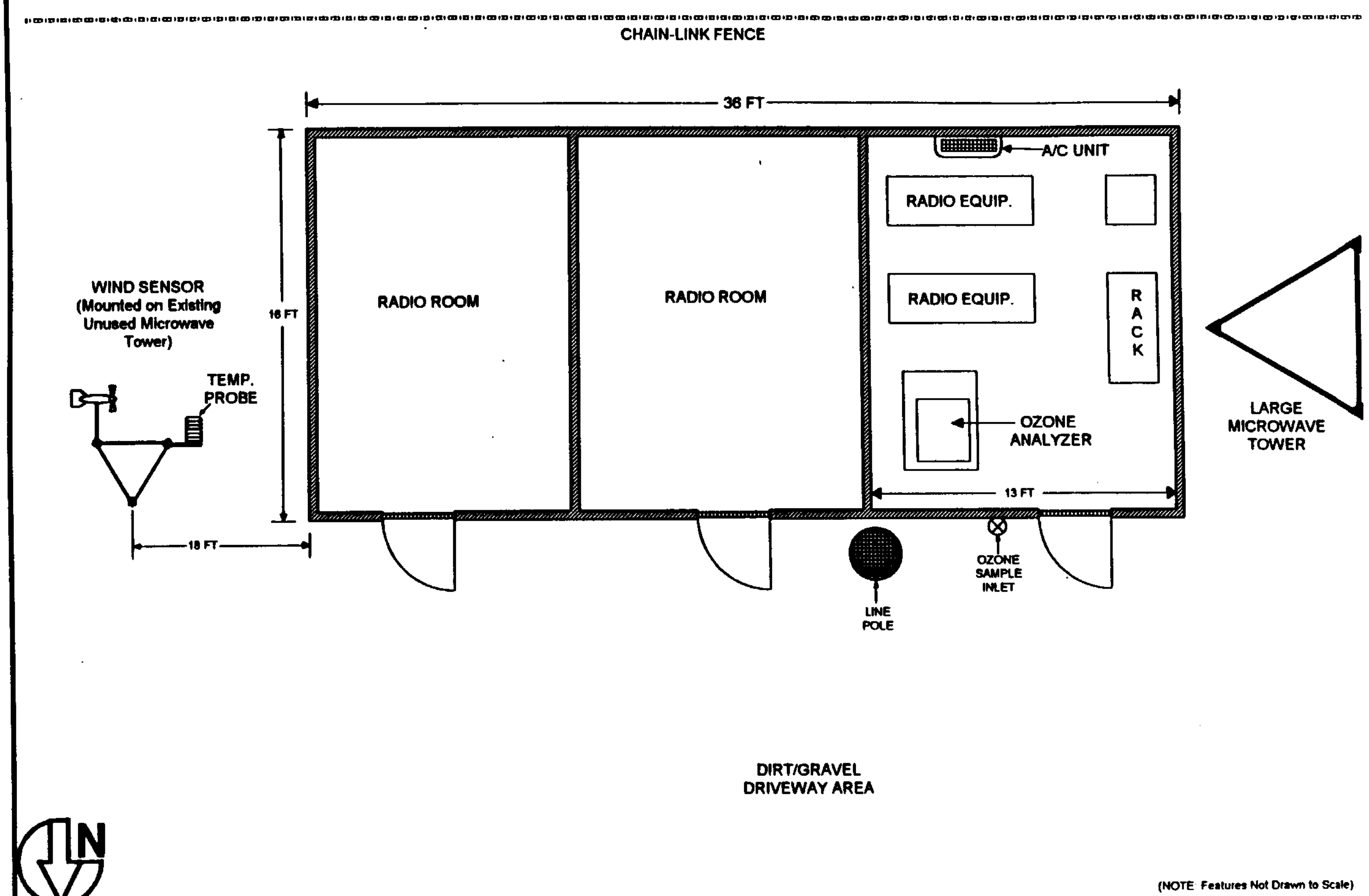

Fig. A-7 Site Diagram - Quartzite Mt.

Site Name: Santa Catalina Island

Station Type: Elevated monitoring (ozone and meteorology)

Location: Station instruments were installed in the electrical panel room of the Santa Catalina Island Airport building.

Coordinates: 33° 24' 00" North, 118° 24' 30" West

Elevation: 1,602 feet (msl)

Operator/Owner of Site: Airport Manager

Contact Name: Paul Moritz (310) 510-0143

Local Topography: The airport sits at the top a high ridge on the leeward side of the island and is surrounded by high relief covered with low vegetation.

Instrument Exposure: The wind speed and direction sensor was mounted on a mast attached to railing on the upper level outside deck of the air traffic control tower, a four-story structure which is part of the terminal building. The mast, which was located on the tower's west corned, extended approximately 12 feet above the tower roof. The temperature probe and ozone sample inlet were mounted on a boom attached to the deck railing and extended 1.5 meters out from the building approximately 30 feet above ground level.

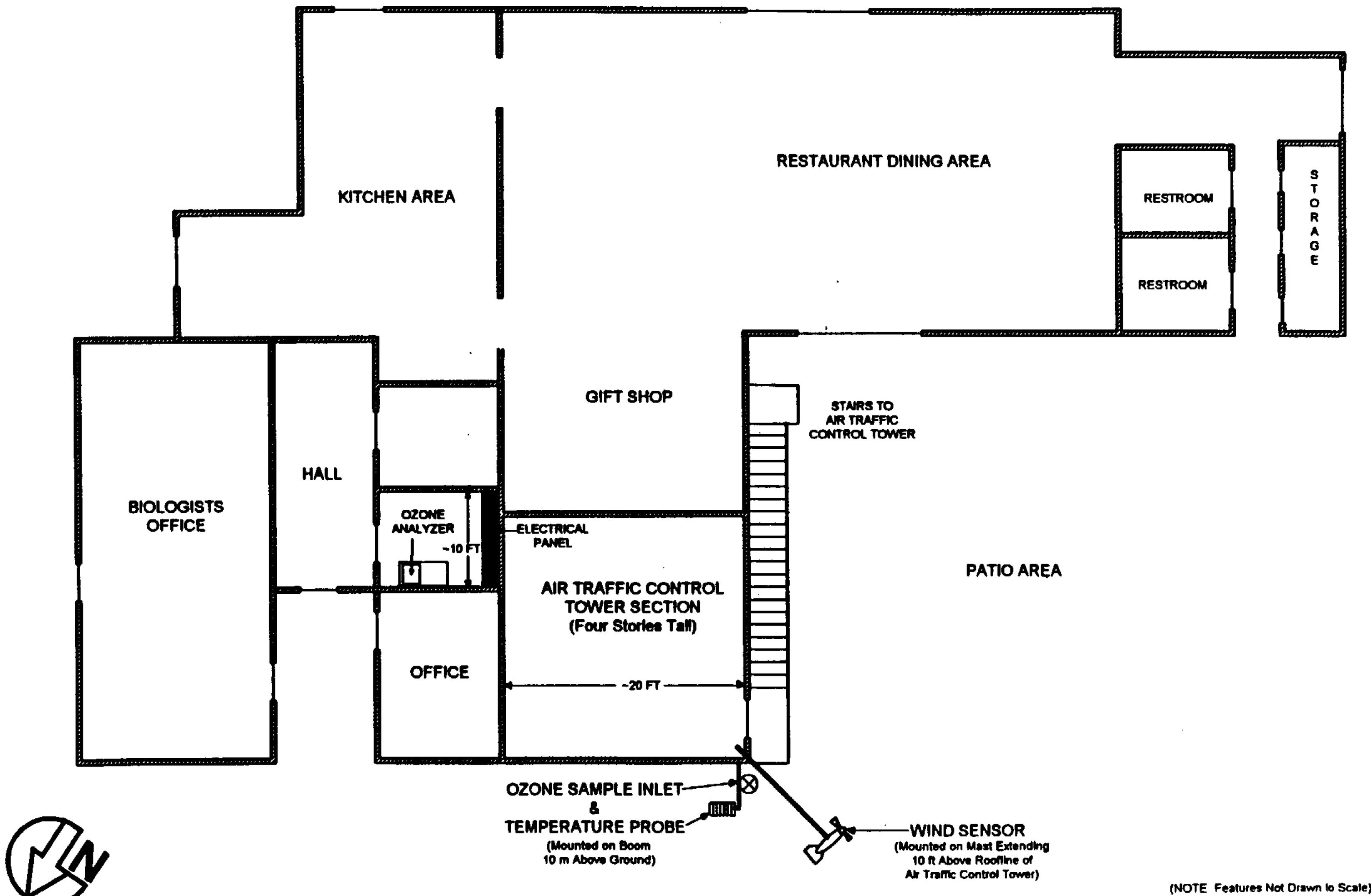

Fig. A-8 Site Diagram - Catalina Is.

APPENDIX B

MONITORING EQUIPMENT SPECIFICATIONS

Table B-1 Dasibi Model 1003AH Technical Specifications

Ranges	0.0 to 0.5 or 1.0 ppm
Operational Range	0.0 to 0.5 ppm
Linearity (0.0 to 1.0 ppm)	1%
Repeatability (precision)	0.005 ppm or 1 digit, whichever is greater
Zero Drift:	
Digital and BCD output	< 0.005 ppm in 24 hours
Analog output	< 0.0025 ppm in 24 hours
Span Drift:	
Digital and BCD output	< 0.1% in 24 hours
Analog output	< 0.1% in 24 hours
Lower detectable limit	0.001 ppm
Rise Time 90%	< 0.5 min
Fall Time 90%	< 0.5 min

Table B-2 R.M. Young Model 05305 Technical Specifications	
Operating Range	
Propeller	0.0 to 44.7 ms^{-1}
Vane	0 to 355° (5° electrically open)
Starting Threshold	
Propeller	< 0.4 ms^{-1}
Vane	< 0.5 ms^{-1}
Accuracy	
Propeller	± 0.3 ms^{-1}
Vane	± 3°
Distant Constant	
Propeller	2.7 meters (63% recovery)
Vane	1.2 meters (50% recovery)
Vane Damping Ratio	0.45
Propeller Time Constant	0.2 sec

Table B-3 Campbell Scientific Model 107, HMP35C and 41002 Technical Specifications	
Temperature Operating Range	-35° to +50° Centigrade ©
Temperature Accuracy	<± 0.4° C error (worst case)
Temperature Interchangeability Error	<± 0.2° C (0-60° C), <± 0.4° C @ -35°C
Temperature Linearization Error	<± 0.5° C over full range
Relative Humidity Sensing Element	Vaisala capacitive sensor
Relative Humidity Operating Range	0 to 100% RH
Relative Humidity Accuracy (at 20° C)	
vs factory references	± 1% RH
vs field references	± 2% RH, 0% to 90%
	± 3% RH, 90% to 100%
Relative Humidity Response Time	15 seconds
Sensor / Housing Clearance (41002)	1.14 inches diameter x 4.7
Radiation Error @ 1080 W/m^2	0.4° C at 3 ms^{-1} wind speed
	0.7° C at 2 ms^{-1} wind speed
	1.5° C at 1 ms^{-1} wind speed

Table B-4 Campbell Scientific Model CR10 Technical Specifications	
Analog Input Channels	6 differential or 12 single-ended
Pulse Counters	2 eight bit or 1 sixteen bit (selectable)
Scan Rate	Selectable (once per 1/64 sec. maximum)
Accuracy of Voltage Measurements	0.2% of FSR
Accuracy of Resistance Measurements	0.015% of full scale bridge output
Resolution (range dependent)	
± 2,500 millivolts	333 microvolts
± 250 millivolts	3.33 microvolts
± 25 millivolts	3.33 microvolts
± 7.5 millivolts	1.00 microvolts
± 2.5 millivolts	0.33 microvolts
Central Processor	Hitachi 6303
Memory	32 K ROM, 64 K RAM
Clock Accuracy	± 1 minute per month
Power Requirements	9.6 to 16 VDC

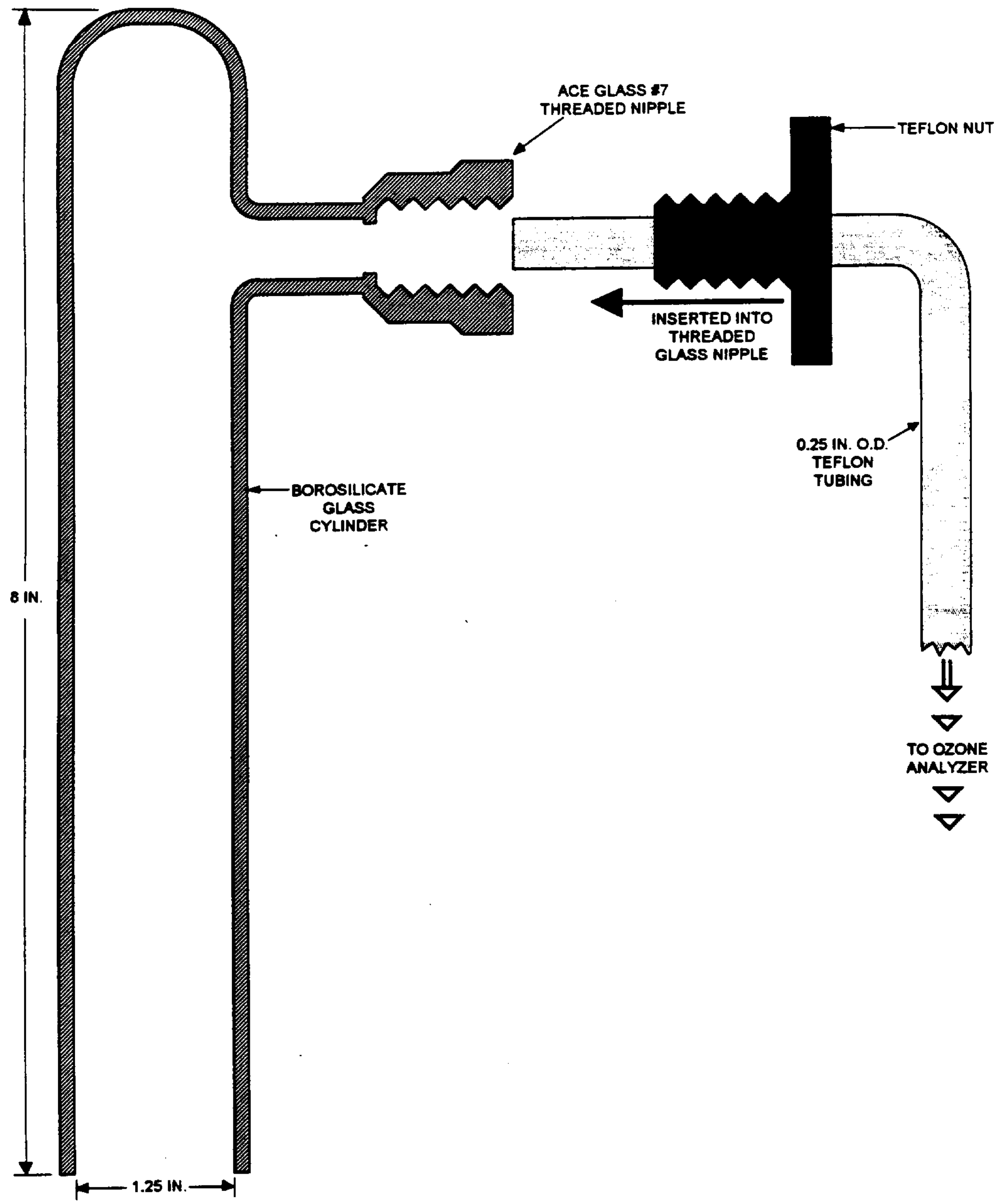

Fig. B-1 Ozone Sample Inlet

APPENDIX C

SITE OPERATION SUMMARIES

Operational activities at each site for the duration of the monitoring program are summarized below:

<u>Baldy Mesa</u> - Site became operational June 3 after an initial delay getting electric service hooked up at the site, and subsequent county inspections. A multipoint calibration was performed on ozone June 7. A QA audit was conducted June 14 by the ARB/MLD. There were no reported problems. A zero precision span (ZPS) check was performed June 24.

A multipoint calibration was performed on ozone July 12. ZPS checks were performed July 2, July 21, and July 25. There was an apparent site power outage for several hours on July 31.

A multipoint calibration was performed on ozone August 8. ZPS checks were performed August 16 and August 30. No problems were reported during the reporting period

A multipoint calibration was performed on ozone September 14. ZPS checks were performed September 8, September 21 and September 28. Internal audits of the ozone analyzer and the meteorological sensors were performed on September 28. No problems occurred during this reporting period.

A multipoint calibration was performed on the ozone analyzer October 11. ZPS checks were performed October 5, October 18 and October 26. A final multipoint calibration on ozone and the meteorology equipment was performed on November 1 after which the site was decommissioned. No problems occurred during this reporting period.

<u>Boron</u> - The site came online June 1. Abnormally low ozone levels were detected during routine telephone interrogation and data QC. Sample line was found to be restricted, and the problem corrected on June 4. An ozone multipoint calibration was performed June 7, and a ZPS check June 15. A QA audit by the ARB/MLD was completed June 20 with no reported problems. A power outage occurred during a thunderstorm on June 25. Ogden personnel were on site performing a ZPS check when the outage occurred, and, as a result, there was only a minor disruption to monitoring.

A multipoint calibration was performed on ozone July 13. ZPS checks were performed July 3, July 19, and July 26. There was an apparent site power outage for several hours on July 29. Wind gusts to more than 50 mph were measured and lightning was reported in the area.

A multipoint calibration was performed on ozone August 9. ZPS checks were performed August 18 and August 31. Shelter temperature maximums were inexplicably high (38-40°C) on August 19-21. Otherwise, there were no problems encountered during the reporting period.

A multipoint calibration was performed on ozone September 17. ZPS checks were performed September 9. September 21, and September 29. An internal audit of the ozone analyzer and of the meteorological sensors was performed on September 29. No problems occurred during this reporting period.

A multipoint calibration was performed on the ozone analyzer October 12. ZPS checks were performed October 5, October 19, and October 27. A final multipoint calibration was performed on the ozone and the meteorology equipment November 1 after which the site was decommissioned.

Shelter temperatures dropped significantly below accepted ARB/EPA guidelines when ambient temperatures cooled. We had to go through a couple of iterations adjusting the thermostat such that the temperature would not be too cool at night nor too hot during the daytime. The ARB may want to review shelter temperatures and ozone levels. Ozone data have not been disqualified in this data set when shelter temperatures were beyond limits. The ARB's recommendations on this matter would be appreciated.

Santa Catalina Island - On June 8 the initial installation was completed. The monitoring and data logging equipment were operational but telephone communications were not established. When the site was visited for the initial multipoint calibration on June 12, it was found that the airport manager had shut down the system because of the instrument noise, and had failed to notify us. The ozone analyzer and data system were moved to another location at the request of the airport manager. An *as-found* multipoint calibration was performed June 22. The measured ozone concentrations were found to be outside ARB specifications but, due to time constraints (airport closure time), the analyzer offset and span were not reset. On June 27 both *as-found* and final multipoint calibrations were performed on the analyzer. The ozone data acquired prior to the final multipoint calibration was adjusted to account for the *as-found* condition of the analyzer.

A multipoint calibration was performed on ozone July 24. ZPS checks were performed July 7, July 13, and July 17. No problems were reported during the reporting period.

A multipoint calibration was performed on ozone August 23. ZPS checks were performed August 2, August 7, and August 16. No problems were encountered during the reporting period.

A multipoint calibration was performed on ozone September 20. ZPS checks were performed September 6, September 11, and September 25. No problems occurred during this reporting period.

ZPS checks were performed October 4, October 9, October 20, and October 25. The multipoint calibration scheduled for October 25 was instead performed on November 3 when the site was decommissioned. An internal audit of the ozone analyzer and the meteorological sensors was performed on October 4. No problems occurred during this reporting period.

Flash II Mt. - The site was operational on June 1. An ozone multipoint calibration was performed June 10. At the time, it was found that the wind direction/anemometer mounting boom had slipped in its bracket and was positioned upside down. It was determined from examining the wind direction data that the problem most likely occurred earlier the same day it was discovered. The wind data was invalidated during that period. The problem was corrected and additional mount supports were fabricated on site. ZPS checks were performed on June 18 and June 27. The audit by ARB/MLD personnel occurred June 20. The auditors did not report any problems.

A multipoint calibration was performed on ozone July 14. ZPS checks were performed July 3, July 20, and July 27. Power was out at the site for four hours on July 5 when a new air conditioner was being installed by the facility operator.

A multipoint calibration was performed on ozone August 8. ZPS checks were performed August 17 and August 31. A blown fuse in the ozone analyzer resulted in a data loss lasting 36 hours (August 7-8). On a routine visit to the site on August 17, it was noticed that the bracket securing the anemometer and wind vane had failed resulting in the sensor positioned upside down. For safety reasons, the problem could not be corrected until there were two persons at the site. A concerted effort was made during data validation to determine when the bracket failed. Direction (along the north-south axis) would be 180 degrees off due to this condition, and this was the key factor looked at. It was concluded that the bracket failed shortly before the problem was noticed, when wind speeds were exceedingly strong.

A multipoint calibration was performed on ozone September 14. ZPS checks were performed September 7 and September 22.

Shelter temperatures were often higher than ARB/EPA guidelines, usually during the nighttime. This problem was repeatedly reported to the facility operator but they were unable to determine why this was occurring. The only action taken was to set the air conditioner thermostat lower. Otherwise, no problems occurred during this reporting period.

Multipoint calibrations were performed on the ozone analyzer October 13, and November 2 when the site was decommissioned. The meteorological sensors were calibrated at that time as well. ZPS checks were performed October 1, October 8, October 20, October 23, and October 29. An internal audit of the ozone analyzer and of the meteorological sensors was performed on October 1.

As discussed above, it appears that during a period of persistent strong winds debris collected in the inline filter to the ozone monitor causing artificially low readings. Data were disqualified from October 21 at 17 PST until October 23 at 14 PST when maintenance was performed and the problem corrected.

It should be noted that shelter temperature, which had been a problem, behaved reasonably well this period. An exception is on October 21-22 when temperatures raised significantly above accepted guidelines. It is uncertain if this event was tied to the high winds discussed above.

Ludlow - The site was operational on June 1. Cellular communications were established with the site June 7. On June 10 an ozone multipoint calibration was conducted and, on June 15, a ZPS check performed. The site was audited by the ARB/MLD on June 19. No problems were reported by the auditors. Another ZPS check was performed June 27.

A multipoint calibration was performed on ozone July 14. ZPS checks were performed July 3, July 20, and July 27. No problems were reported during the reporting period.

A multipoint calibration was performed on ozone August 9. ZPS checks were performed August 18 and August 31. No problems were encountered during the reporting period.

A multipoint calibration was performed on ozone September 15. ZPS checks were performed September 7, September 22 and September 30. An internal audit of the ozone analyzer and of the meteorological sensors was performed on September 30.

There were four period in which there were ozone data losses, each of about 2-3 hours duration. Site power outages were likely the cause since shelter temperature increased (due to an inoperative air conditioner) during each event. Otherwise, no problems occurred during September.

Multipoint calibrations were performed on the ozone analyzer October 13, and November 2 when the site was decommissioned. The meteorological sensors were calibrated at that time as well. ZPS checks were performed October 8, October 20 and October 29. No problems occurred during this reporting period.

SE Palmdale - The site was operational on June 1. An ozone multipoint calibration was performed June 11. Soon after the audit was completed, the ozone analyzer began malfunctioning. The unit was replaced June 13, and a multipoint calibration conducted on the replacement unit. The broken analyzer (problem was diagnosed as a timing board malfunction) was sent out for repair. The ARB/MLD audit was performed on June 14. No problems were reported by the auditors. A ZPS check was performed June 25.

A multipoint calibration was performed on ozone July 12. ZPS checks were performed July 2, July 19, and July 25. No problems were reported during the reporting period.

A multipoint calibration was performed on ozone August 17. ZPS check was performed on August 20. The site lost commercial power for a short period (six hours) on August 14.

A multipoint calibration was performed on ozone September 14. ZPS checks were performed on September 1, 8, 21, and 29. An internal audit of the ozone analyzer and the meteorological sensors was performed on September 29. No problems occurred during this reporting period.

Multipoint calibrations were performed on the ozone analyzer October 11 and again on November 4 when the site was decommissioned. On November 4, the meteorological sensors were calibrated as well. ZPS checks were performed on October 6, October 18, and October 26. No problems occurred during this reporting period.

Quartzite Mt. - The site was operational on June 1. Daily routine checking of the data disclosed suspect low ozone levels. The site was visited June 5, the inlet lines checked, and the flow rate adjusted. However, because the technician did not have a transfer standard at the time, a correction to the data prior to the flow adjustment could not be made with any certainty. Hence, that data were invalidated in the data base. The flow rate and inlet lines were checked again on June 7 because ozone levels still seemed artificially low. No problems were detected. Multipoint calibrations of ozone on June 11 showed that there was a negative offset (nine ppb) that was likely contributing to the low readings. For the remainder of the reporting period, the analyzer functioned adequately although noisier than has been our experience with other analyzers. The data measured prior to the calibration were adjusted based on the *as-found* slope and intercept. Another multipoint calibration on ozone was performed on June 14. The site was audited by the ARB/MLD on June 15. No problems were reported by the audit team. A ZPS check was performed on June 28.

The scheduled multipoint calibration was performed on ozone July 13. ZPS checks were performed July 2, July 21, and July 25. The ozone analyzer pump malfunctioned on June 30 and was replaced on July 2. A multipoint calibration was performed during the installation of the new ozone analyzer.

A multipoint calibration was performed on ozone August 17. ZPS check was performed on August 20. No problems were encountered during the reporting period.

A multipoint calibration was performed on ozone September 13. ZPS checks were performed on September 1, 8, 24, and 30. Internal audits of the ozone analyzer and of the meteorological sensors were performed on September 30.

Ozone readings were noisy during the period beginning September 8 until the problem was corrected on September 13. Spikes in the 6-minute averaged data were removed. When at least 30 minutes of valid data remained after removing spikes, new hourly averages were computed.

Multipoint calibrations were performed on the ozone analyzer October 12 and again on November 4 when the site was decommissioned. Prior to decommissioning, the meteorological sensors were also calibrated. ZPS checks were performed on October 8, October 19, and October 27.

Low flow rates caused the ozone monitor to fail the final audit. Because it was not possible to detect when analyzer first went outside acceptable limits, data was disqualified back to when the last ZPS check was made on October 27.

Shadow Mt. - The site was operational on June 1. Multipoint calibrations on the ozone analyzer were performed June 11 and 14. The site was subjected to a QA audit on June 15. No problems were reported by the audit team. A ZPS check was performed on June 28.

Multipoint calibrations were performed on ozone July 13. ZPS checks were performed July 4, July 21, and July 26. About 24-hours of wind direction were missed on July 12-13 due to a wiring problem.

Multipoint calibrations were performed on ozone August 10. ZPS checks were performed August 19, and August 31. No problems were encountered during the reporting period.

Multipoint calibrations were performed on ozone September 17. ZPS checks were performed September 9, September 22, and September 28. An internal audit of the ozone analyzer was conducted on September 28, and of the meteorological sensors on September 30. No problems were encountered during the reporting period.

Multipoint calibrations were performed on the ozone analyzer October 12 and again on November 3 prior to the removal of the equipment. The meteorological sensors were also calibrated when the site was decommissioned. ZPS checks were performed October 5, October 19, and October 28. No problems were encountered during the reporting period.

APPENDIX D

INTERNAL QUALITY ASSURANCE AUDIT

Table D-1 Performance Audit Methods and Acceptance Limits

Parameter	Audit Method	Acceptance Limits
Wind Speed WS starting torque threshold	Constant rpm motor Torque disk	±0.2 ms^{-1} wind speeds $5ms^{-1}$, and ±5% of input for speeds $>5ms^{-1}$ <0.5 meters per second
Wind Direction Alignment	Precision compass and USGS topography map	±3 degrees from true north
Wind Direction WD starting torque threshold	Cardinal direction inputs Torque gauge	±3 degrees mean absolute error, and ±5 degrees per direction input point <0.5 meters per second
Temperature	Mercury thermometer and water baths	±0.50 C
Ozone	Certified transfer standard	Slope = 1.0 ± 0.1 Intercept = < ± 3% of full scale Correlation = > 0.9950

Table D-2 Summary of Performance Audit Pass/Fail Results

Station Name	WS	WS Torque	WD	WD Torque	North Align.	Temp	Ozone
Baldy Mesa	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Boron	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Santa Catalina Island	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Flash II Mt.	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Ludlow	NA	NA	NA	NA	PASS	PASS	PASS
SE Palmdale	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Quartzite Mt.	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Shadow Mt.	PASS	PASS	PASS	PASS	PASS	PASS	PASS

1

HORIZONTAL WIND SPEED SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: BAL
Location: BALDY MESA, CA

Audit Date: 29 SEP 1995
Start Time: 0730 PST
End Time: 0748 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION WIND SPEED SENSOR IDENTIFICATION and APPLICATION***

Make: R.M.YOUNG **Model:** 05305 **SN:** 20409
Range: 0-50 mps **Measurement Height:** 10 meters **Last Calibrated:** 3 JUN 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Anemometer drive motor (100-10,000 rpm)
Make: R.M.YOUNG **Model:** 18801 **SN:** NA

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: 0.20 grams, or 0.23 mps.

AUDIT INPUTS		PRIMARY DAS			BACKUP SYSTEM		
RPM	mps	DAS mps	Error mps	Error %	DAS mps	Error mps	Error %
0.0	0.0	0.0	0.0	NA	—	—	NA
700	3.4	3.4	0.0	0.90	—	—	—
3,000	14.7	14.6	-0.1	-0.70	—	—	—
7,000	34.3	34.2	-0.1	-0.30	—	—	—
Mean Absolute Errors			0.06	0.63		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Instruments mounted on guyed 10-meter tower. Sensors have good exposure with no obstacles or features to affect the data.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

Primary	Slope	Intercept	Cor.Coef.	Backup	Slope	Intercept	Cor.Coef.
DAS	0.9964	0.004	1.0000	DAS	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Wind speed input ≤5mps	≤ ±0.2 mps error.	PASS	NA
Wind speed input >5mps	≤ ±5% of input speed.	PASS	NA
Starting torque threshold	≤ 0.5 mps.	PASS	

2 HORIZONTAL WIND DIRECTION SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: BAL
Location: BALDY MESA, CA

Audit Date: 29 SEP 1995
Start Time: 0805 PST
End Time: 0815 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION WIND DIRECTION SENSOR IDENTIFICATION and APPLICATION***

Make: R.M.YOUNG **Model:** 05305 **SN:** 20409
Range: 0-360 deg. **Measurement Height:** 10 meters **Last Calibrated:** 3 JUN 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Precision compass **Certification Date:** JULY 1993
Make: BRUNTON **Model:** POCKET TRANSIT **SN:** 024338

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: 6.00 grams, or 0.40 mps.
Local Magnetic Declination: 13.9 degrees east (GEOMAG 6/95)
Sensor True North Alignment Error: 0.00 degrees

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
Direction	Degrees	DAS Degrees	Error Degrees	DAS Degrees	Error Degrees
North	360	358	-2	---	---
East	90	90	0	---	---
South	180	178	-2	---	---
West	270	269	-1	---	---
North	360	359	-1	---	---
West	270	269	-1	---	---
South	180	178	-2	---	---
East	90	90	0	---	---
Mean Absolute Errors			1.1		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Instruments mounted on guyed 10-meter tower. Sensors have good exposure with no obstacles or features to affect the data.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.
Primary DAS	0.9961	-0.250	1.0000
Backup DAS	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±5 degrees error per audit direction input.	PASS	NA
Linearity	≤ 3 degrees mean absolute error.	PASS	NA
Alignment to true north	≤ ±3 degrees error from true north.	PASS	
Starting torque threshold	≤ 0.5 mps.	PASS	

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TEMPERATURE PROBE AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: BAL
Location: BALDY MESA, CA

Audit Date: 29 SEP 1995
Start Time: 0830 PST
End Time: 0850 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION TEMPERATURE PROBE IDENTIFICATION and APPLICATION***

Make: CAMPBELL SCIENTIFIC **Model:** 107 **SN:** NA
Range: -30 to +50 C **Measurement Height:** 8.0 meters **Last Calibrated:** 3 JUN 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Mercury in glass thermometer **Certification Date:** MAR 1995
Make: VWR **Model:** -1 to +51 C **SN:** 92-14463

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

(Note: Water baths are constantly agitated to assure uniform temperature within Dewar flask.)

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
Bath	Deg. C	DAS Deg. C	Error Deg. C	DAS Deg. C	Error Deg. C
Ice	2.5	2.5	0.0	---	---
Cool	18.7	18.7	0.0	---	---
Hot	36.5	36.5	0.0	---	---
Mean Absolute Errors			0.00		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = *x*
DAS response = *y*

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS	1.0000	0.000	1.0000	Backup DAS	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±0.5 degrees C error per audit temperature input.	PASS	NA

OZONE ANALYZER AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: BAL
Location: BALDY MESA, CA

Audit Date: 29 SEP 1995
Start Time: 0900 PST
End Time: 1015 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION OZONE ANALYZER IDENTIFICATION and APPLICATION***

Make: DASIBI
Range: 0-500 ppb
Span #: 60.550
Offset #: 4

Model: 1003 AH
Measurement Height: 3.0 meters
Samp. Freq. (40-48 kHz): 43.861
Cntrl. Freq. (21-28 kHz): 21.703

SN: 3150
Last Calibrated: 14 SEP 1995
Flow Rate: 2.0 lpm

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Ozone transfer standard
Make: DASIBI
Span #: 52.550
Offset #: 4

Model: 1003-PC
Samp. Freq. (40-48 kHz): 45.300
Cntrl. Freq. (21-28 kHz): 28.337
Cell Temp, C: 33.30

Certification Date: 9/4/95
SN: 5027
Trans.Std. Slope: 0.9916
Trans.Std. Inter.: 0.5020
Bar. Press., mmHg: 654.00

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Station STP Correction Factor: 1.1335

Trns. Std. Display ppb	Audit Input ppb	PRIMARY DAS			BACKUP SYSTEM		
		DAS ppb	Error ppb	Error %	DAS ppb	Error ppb	Error %
12	0.0	-3	-3	NA	---	---	---
96	95	91	-4	-4.2	---	---	---
183	193	187	-6	-3.1	---	---	---
414	452	442	-10	-2.2	---	---	---
	Mean Absolute Errors ⇨		5.8	3.17		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Sample inlet is glass with approximately 3 meters of ¼-inch Teflon tubing leading to ozone analyzer. Inlet extends 1 meter above shelter roof.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	0.9841	-2.816	1.0000	**Backup DAS ⇨**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Audit curve slope	≥ 0.90 and ≤ 1.10	PASS	NA
Audit curve intercept	≤ ±3% of full scale.	PASS	NA
Audit curve correleation coeff.	≥ 0.9950	PASS	NA

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HORIZONTAL WIND SPEED SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: BOR
Location: BORON, CA

Audit Date: 28 SEP 1995
Start Time: 0755 PST
End Time: 0810 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION WIND SPEED SENSOR IDENTIFICATION and APPLICATION***

Make: R.M.YOUNG **Model:** 05305 **SN:** 20518
Range: 0-50 mps **Measurement Height:** 10 meters **Last Calibrated:** 31 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Anemometer drive motor (100-10,000 rpm)
Make: R.M.YOUNG **Model:** 18801 **SN:** NA

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: 0.20 grams, or 0.23 mps.

AUDIT INPUTS		PRIMARY DAS			BACKUP SYSTEM		
RPM	mps	DAS mps	Error mps	Error %	DAS mps	Error mps	Error %
0.0	0.0	0.0	0.0	NA	---	---	NA
700	3.4	3.4	0.0	0.90	---	---	---
3,000	14.7	14.6	-0.1	-0.70	---	---	---
7,000	34.3	34.2	-0.1	-0.30	---	---	---
Mean Absolute Errors			0.06	0.63		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Sensor mounted on short mast extending above existing scaffolding used to dry fire hoses at fire station Sensors have good exposure with no obstructions to affect data.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = *x*
DAS response = *y*

Primary	Slope	Intercept	Cor.Coef.	Backup	Slope	Intercept	Cor.Coef.
DAS	0.9964	0.004	1.0000	**DAS**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Wind speed input ≤5mps	≤ ±0.2 mps error.	PASS	NA
Wind speed input >5mps	≤ ±5% of input speed.	PASS	NA
Starting torque threshold	≤ 0.5 mps.	PASS	

2 HORIZONTAL WIND DIRECTION SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: BOR
Location: BORON, CA

Audit Date: 28 SEP 1995
Start Time: 0815 PST
End Time: 0840 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION WIND DIRECTION SENSOR IDENTIFICATION and APPLICATION***

Make: R.M.YOUNG **Model:** 05305 **SN:** 20518
Range: 0-360 deg. **Measurement Height:** 10 meters **Last Calibrated:** 31 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Precision compass **Certification Date:** JULY 1993
Make: BRUNTON **Model:** POCKET TRANSIT **SN:** 024338

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: 6.00 grams, or 0.40 mps.
Local Magnetic Declination: 14.10 degrees east (GEOMAG 6/95)
Sensor True North Alignment Error: 0.00 degrees

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
Direction	Degrees	DAS Degrees	Error Degrees	DAS Degrees	Error Degrees
North	0	2	2	---	---
East	90	92	2	---	---
South	180	180	0	---	---
West	270	272	2	---	---
North	0	2	2	---	---
West	270	271	1	---	---
South	180	181	1	---	---
East	90	92	2	---	---
Mean Absolute Errors			1.5		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.
Sensor mounted on short mast extending above existing scaffolding used to dry fire hoses at fire station Sensors have good exposure with no obstructions to affect data.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.
Primary DAS	0.9967	1.950	1.0000
Backup DAS	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±5 degrees error per audit direction input.	PASS	NA
Linearity	≤ 3 degrees mean absolute error.	PASS	NA
Alignment to true north	≤ ±3 degrees error from true north.	PASS	
Starting torque threshold	≤ 0.5 mps.	PASS	

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TEMPERATURE PROBE AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: BOR
Location: BORON, CA

Audit Date: 28 SEP 1995
Start Time: 0715 PST
End Time: 0750 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION TEMPERATURE PROBE IDENTIFICATION and APPLICATION***

Make: CAMPBELL SCIENTIFIC **Model:** 107 **SN:** NA
Range: -30 to +50 C **Measurement Height:** 3.5 meters **Last Calibrated:** 31 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Mercury in glass thermometer **Certification Date:** MAR 1995
Make: VWR **Model:** -1 to +51 C **SN:** 92-14463

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

(Note: Water baths are constantly agitated to assure uniform temperature within Dewar flask.)

		PRIMARY DAS		BACKUP SYSTEM	
AUDIT INPUTS		DAS	Error	DAS	Error
Bath	Deg. C	Deg. C	Deg. C	Deg. C	Deg. C
Ice	0.7	0.7	0.0	---	---
Cool	18.6	18.6	0.0	---	---
Hot	46.1	46.0	-0.1	---	---
Mean Absolute Errors			0.03		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxiliary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Sensor mounted in naturally aspirated radiation shield.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

Primary	Slope	Intercept	Cor.Coef.	Backup	Slope	Intercept	Cor.Coef.
DAS	0.9977	0.017	1.0000	DAS	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±0.5 degrees C error per audit temperature input.	PASS	NA

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OZONE ANALYZER AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: BOR
Location: BORON, CA

Audit Date: 28 SEP 1995
Start Time: 0845 PST
End Time: 0925 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION OZONE ANALYZER IDENTIFICATION and APPLICATION***

Make: DASIBI
Range: 0-500 ppb
Span #: 57.550
Offset #: 4

Model: 1003 AH
Measurement Height: 3.8 meters
Samp. Freq. (40-48 kHz): 45.139
Cntrl. Freq. (21-28 kHz): 24.775

SN: 1805
Last Calibrated: 17 SEP 1995
Flow Rate: 2.0 lpm

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Ozone transfer standard
Make: DASIBI
Span #: 52.550
Offset #: 4

Model: 1003-PC
Samp. Freq. (40-48 kHz): 43.645
Cntrl. Freq. (21-28 kHz): 28.087
Cell Temp, C: 35.60

Certification Date: 9/4/95
SN: 5027
Trans.Std. Slope: 0.9916
Trans.Std. Inter.: 0.5020
Bar. Press., mmHg: 695.00

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Station STP Correction Factor: 1.0746

Trns. Std. Display ppb	Audit Input ppb	PRIMARY DAS			BACKUP SYSTEM		
		DAS ppb	Error ppb	Error %	DAS ppb	Error ppb	Error %
11	0.0	-6	-6	NA	---	---	---
104	100	93	-7	-7.0	---	---	---
193	194	180	-14	-7.2	---	---	---
425	442	426	-16	-3.6	---	---	---
Mean Absolute Errors			10.8	5.93		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.
Analyzer's overall response is approximately 6% low but still within audit limits.
Sample line consists of glass inlet with approximately 3 meters of ¼ Teflon tubing to ozone analyzer.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = *x*
DAS response = *y*

Primary DAS	Slope	Intercept	Cor.Coef.	Backup DAS	Slope	Intercept	Cor.Coef.
	0.9761	-6.344	0.9999		NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Audit curve slope	≥ 0.90 and ≤ 1.10	PASS	NA
Audit curve intercept	≤ ±3% of full scale	PASS	NA
Audit curve correleation coeff.	≥ 0.9950	PASS	NA

1 HORIZONTAL WIND SPEED SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: CAT
Location: CATALINA, CA

Audit Date: 4 OCT 1995
Start Time: 1143 PST
End Time: 1203 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- ***STATION WIND SPEED SENSOR IDENTIFICATION and APPLICATION***

Make: R.M. YOUNG **Model:** 05305 **SN:** 20521
Range: 0-50 mps **Measurement Height:** 10 meters **Last Calibrated:** 8 JUN 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Anemometer drive motor (100-10,000 rpm)
Make: R.M. YOUNG **Model:** 18801 **SN:** NA

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: 0.20 grams, or 0.23 mps.

AUDIT INPUTS		PRIMARY DAS			BACKUP SYSTEM		
RPM	mps	DAS mps	Error mps	Error %	DAS mps	Error mps	Error %
0.0	0.0	0.0	0.0	NA	---	---	NA
700	3.4	3.4	0.0	0.00	---	---	---
3,000	14.7	14.6	-0.1	-0.70	---	---	---
7,000	34.3	34.2	-0.1	-0.30	---	---	---
Mean Absolute Errors ⇨			0.05	0.33		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Sensor mounted on braced mast extending three meters above roof of 4-story air traffic control tower.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor. Coef.		Slope	Intercept	Cor. Coef.
Primary DAS ⇨	0.9968	-0.008	1.0000	**Backup DAS ⇨**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Wind speed input ≤5mps	≤ ±0.2 mps error.	PASS	NA
Wind speed input >5mps	≤ ±5% of input speed.	PASS	NA
Starting torque threshold	≤ 0.5 mps.	PASS	

2 HORIZONTAL WIND DIRECTION SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: CAT
Location: CATALINA, CA

Audit Date: 4 OCT 1995
Start Time: 1206 PST
End Time: 1220 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- *STATION WIND DIRECTION SENSOR IDENTIFICATION and APPLICATION*

Make: R.M.YOUNG **Model:** 05305 **SN:** 20521
Range: 0-360 deg. **Measurement Height:** 10 meters **Last Calibrated:** 8 JUN 1995

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Precision compass **Certification Date:** JULY 1993
Make: BRUNTON **Model:** POCKET TRANSIT **SN:** 024338

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

Sensor Starting Torque Threshold: 6.00 grams, or 0.40 mps.
Local Magnetic Declination: 13.8 degrees east (GEOMAG 6/95)
Sensor True North Alignment Error: 2.00 degrees east

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
Direction	Degrees	DAS Degrees	Error Degrees	DAS Degrees	Error Degrees
North	0	2	2	---	---
East	90	91	1	---	---
South	180	180	0	---	---
West	270	268	-2	---	---
North	0	1	1	---	---
West	270	268	-2	---	---
South	180	180	0	---	---
East	90	91	1	---	---
	Mean Absolute Errors ⇨		1.1		NA

- *AUDITOR COMMENTS or OBSERVATIONS*

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS.
Independent backup system not part of station.
Sensor mounted on braced mast extending above roof of 4-story air traffic control tower.

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	0.9872	1.850	1.0000	**Backup DAS ⇨**	NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±5 degrees error per audit direction input.	PASS	NA
Linearity.	≤ 3 degrees mean absolute error.	PASS	NA
Alignment to true north	≤ ±3 degrees error from true north.	PASS	
Starting torque threshold	≤ 0.5 mps.	PASS	

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TEMPERATURE PROBE AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: CAT
Location: CATALINA, CA

Audit Date: 4 OCT 1995
Start Time: 1143 PDT
End Time: 1200 PDT

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- *STATION TEMPERATURE PROBE IDENTIFICATION and APPLICATION*

Make: CAMPBELL SCIENTIFIC **Model:** 107 **SN:** NA
Range: -30 to +50 C **Measurement Height:** 10 meters **Last Calibrated:** 8 JUN 1995

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Mercury in glass thermometer **Certification Date:** MAR 1995
Make: VWR **Model:** -1 to +51 C **SN:** 92-14463

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

(Note: Water baths are constantly agitated to assure uniform temperature within Dewar flask.)

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
Bath	Deg. C	DAS Deg. C	Error Deg. C	DAS Deg. C	Error Deg. C
Ice	0.6	0.5	-0.1	---	---
Cool	23.5	23.4	-0.1	---	---
Hot	46.3	46.2	-0.1	---	---
Mean Absolute Errors ⇨			0.10		NA

- *AUDITOR COMMENTS or OBSERVATIONS*

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Temperature probe installed in naturally aspirated radiation shield mounted on mast. No flow restricitons present.

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	1.0000	-0.100	1.0000	**Backup DAS ⇨**	NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±0.5 degrees C error per audit temperature input.	PASS	NA

4

OZONE ANALYZER AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: CAT
Location: CATALINA, CA

Audit Date: 4 OCT 1995
Start Time: 1330 PDT
End Time: 1410 PDT

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- *STATION OZONE ANALYZER IDENTIFICATION and APPLICATION*

Make: DASIBI
Range: 0-500 ppb
Span #: 55.550
Offset #: 4

Model: 1003 AH
Measurement Height: 10 meters
Samp. Freq. (40-48 kHz): 39.945
Cntrl. Freq. (21-28 kHz): 22.079

SN: 2509
Last Calibrated: 20 SEP 1995
Flow Rate: 2.0 lpm

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Ozone transfer standard
Make: DASIBI
Span #: 52.550
Offset #: 4

Model: 1003-PC
Samp. Freq. (40-48 kHz): 43.558
Cntrl. Freq. (21-28 kHz): 27.289
Cell Temp, C: 37.25

Certification Date: 9/4/95
SN: 5027
Trans.Std. Slope: 0.9916
Trans.Std. Inter.: 0.5020
Bar. Press., mmHg: 756.00

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

Station STP Correction Factor: 0.9932

Trns. Std. Display ppb	Audit Input ppb	PRIMARY DAS			BACKUP SYSTEM		
		DAS ppb	Error ppb	Error %	DAS ppb	Error ppb	Error %
11	0.0	3	3	NA	---	---	---
90	78	84	6	7.7	---	---	---
194	181	185	4	2.2	---	---	---
416	399	402	3	0.8	---	---	---
Mean Absolute Errors ⇨			4.0	3.57		NA	NA

- *AUDITOR COMMENTS or OBSERVATIONS*

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Sample inlet is glass with Teflon tubing leading to ozone analyzer.

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	0.9973	4.445	1.0000	**Backup DAS ⇨**	NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Audit curve slope	≥ 0.90 and ≤ 1.10	PASS	NA
Audit curve intercept	≤ ±1% of full scale.	PASS	NA
Audit curve correleation coeff.	≥ 0.9950	PASS	NA

1

HORIZONTAL WIND SPEED SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: FLA
Location: FLASH MT., CA

Audit Date: 1 OCT 1995
Start Time: 0825 PST
End Time: 0850 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- *STATION WIND SPEED SENSOR IDENTIFICATION and APPLICATION*

Make: R.M.YOUNG **Model:** 05305 **SN:** 19672
Range: 0-50 mps **Measurement Height:** 10.0 meters **Last Calibrated:** 27 MAY 1995

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Anemometer drive motor (100-10,000 rpm)
Make: R.M.YOUNG **Model:** 18801 **SN:** NA

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

Sensor Starting Torque Threshold: 0.10 grams, or 0.16 mps.

AUDIT INPUTS		PRIMARY DAS			BACKUP SYSTEM		
RPM	mps	DAS mps	Error mps	Error %	DAS mps	Error mps	Error %
0.0	0.0	0.0	0.0	NA	---	---	NA
700	3.4	3.4	0.0	0.00	---	---	---
3,000	14.7	14.5	-0.2	-1.36	---	---	---
7,000	34.3	33.9	-0.4	-1.17	---	---	---
Mean Absolute Errors ⇨			0.15	0.84		NA	NA

- *AUDITOR COMMENTS or OBSERVATIONS*

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

WS/WD sensors are mounted on a boom at the 10-meter level of an existing microwave tower. The sensors extend approximately 3 meters away from the tower and have adequate exposure to the prevailing winds. Mimimal tower effects may influence winds from the direction of the tower (south).

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	0.9877	0.011	1.0000	**Backup DAS ⇨**	NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Wind speed input ≤5mps	≤ ±0.2 mps error.	PASS	NA
Wind speed input >5mps	≤ ±5% of input speed.	PASS	NA
Starting torque threshold	≤ 0.5 mps.	PASS	

2 HORIZONTAL WIND DIRECTION SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: FLA
Location: FLASH MT., CA

Audit Date: 1 OCT 1995
Start Time: 0900 PST
End Time: 0925 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- ***STATION WIND DIRECTION SENSOR IDENTIFICATION and APPLICATION***

Make: R.M.YOUNG **Model:** 05305 **SN:** 19672
Range: 0-360 deg. **Measurement Height:** 10.0 meters **Last Calibrated:** 27 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Precision compass **Certification Date:** JULY 1993
Make: BRUNTON **Model:** POCKET TRANSIT **SN:** 024338

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: 6.00 grams, or 0.40 mps.
Local Magnetic Declination: 13.9 degrees east (GEOMAG 6/95)
Sensor True North Alignment Error: 2.00 degrees west

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
		DAS	Error	DAS	Error
Direction	Degrees	Degrees	Degrees	Degrees	Degrees
North	0	2	2	---	---
East	90	90	0	---	---
South	180	181	1	---	---
West	270	267	-3	---	---
North	0	1	1	---	---
West	270	268	-2	---	---
South	180	181	1	---	---
East	90	90	0	---	---
Mean Absolute Errors ⇨			1.3		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS.
Independent backup system not part of station.
Refer to WS audit report for description of sensor siting conditions.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	0.9878	1.650	1.0000	Backup DAS ⇨	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±5 degrees error per audit direction input.	PASS	NA
Linearity	≤ 3 degrees mean absolute error.	PASS	NA
Alignment to true north	≤ ±3 degrees error from true north.	PASS	
Starting torque threshold	≤ 0.5 mps.	PASS	

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TEMPERATURE PROBE AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: FLA
Location: FLASH MT., CA

Audit Date: 1 OCT 1995
Start Time: 0715 PST
End Time: 0745 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- ***STATION TEMPERATURE PROBE IDENTIFICATION and APPLICATION***

Make: CAMPBELL SCIENTIFIC **Model:** 107 **SN:** NA
Range: -30 to +50 C **Measurement Height:** 3.5 meters **Last Calibrated:** 27 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Mercury in glass thermometer **Certification Date:** MAR 1995
Make: VWR **Model:** -1 to +51 C **SN:** 92-14463

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

(Note: Water baths are constantly agitated to assure uniform temperature within Dewar flask.)

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
		DAS	Error	DAS	Error
Bath	Deg. C	Deg. C	Deg. C	Deg. C	Deg. C
Ice	0.6	0.5	-0.1	---	---
Cool	16.7	16.6	-0.1	---	---
Hot	44.7	44.6	-0.1	---	---
Mean Absolute Errors ⇨			0.10		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Temperature probe is mounted in naturally aspirated radiation shield.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	1.0000	-0.100	1.0000	**Backup DAS ⇨**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±0.5 degrees C error per audit temperature input.	PASS	NA

4

OZONE ANALYZER AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: FLA
Location: FLASH MT., CA

Audit Date: 1 OCT 1995
Start Time: 0830 PST
End Time: 0940 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- ***STATION OZONE ANALYZER IDENTIFICATION and APPLICATION***

Make: DASIBI
Range: 0-500 ppb
Span #: 59.450
Offset #: 4

Model: 1003 AH
Measurement Height: 4.0 meters
Samp. Freq. (40-48 kHz): 41.031
Cntrl. Freq. (21-28 kHz): 22.780

SN: 3070
Last Calibrated: 15 SEP 1995
Flow Rate: 2.0 lpm

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Ozone transfer standard
Make: DASIBI
Span #: 52.550
Offset #: 4

Model: 1003-PC
Samp. Freq. (40-48 kHz): 43.521
Cntrl. Freq. (21-28 kHz): 27.904
Cell Temp, C: 33.76

Certification Date: 9/4/95
SN: 5027
Trans.Std. Slope: 0.9916
Trans.Std. Inter.: 0.5020
Bar. Press., mmHg: 675.00

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Station STP Correction Factor: 1.0999

Trns. Std. Display ppb	Audit Input ppb	PRIMARY DAS			BACKUP SYSTEM		
		DAS ppb	Error ppb	Error %	DAS ppb	Error ppb	Error %
11	0.0	9	9	NA	---	---	---
93	90	93	3	3.3	---	---	---
180	185	179	-6	-3.2	---	---	---
421	448	436	-12	-2.7	---	---	---
Mean Absolute Errors ⇨			7.5	3.07		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.
Sample inlet is glass with approximately 3 meters of ¼-inch Teflon tubing leading to the ozone analyzer.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	0.9543	6.756	0.9999	**Backup DAS ⇨**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Audit curve slope	≥ 0.90 and ≤ 1.10	PASS	NA
Audit curve intercept	≤ ±3% of full scale.	PASS	NA
Audit curve correleation coeff.	≥ 0.9950	PASS	NA

1 HORIZONTAL WIND SPEED SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: LUD
Location: LUDLOW, CA

Audit Date: 30 SEP 1995
Start Time: NA
End Time: NA

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- ***STATION WIND SPEED SENSOR IDENTIFICATION and APPLICATION***

Make: R.M.YOUNG **Model:** 05305 **SN:** 02523
Range: 0-50 mps **Measurement Height:** 9.0 meters **Last Calibrated:** 25 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Anemometer drive motor (100-10,000 rpm)
Make: R.M.YOUNG **Model:** 18801 **SN:** NA

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: --- grams, or NA mps.

AUDIT INPUTS		PRIMARY DAS			BACKUP SYSTEM		
RPM	mps	DAS mps	Error mps	Error %	DAS mps	Error mps	Error %
---	---	---	---	NA	---	---	NA
---	---	---	---	---	---	---	---
---	---	---	---	---	---	---	---
---	---	---	---	---	---	---	---
Mean Absolute Errors ⇨			NA	NA		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Wind speed/wind direction sensor is mounted on boom extending out from an existing power pole about 9 meters above ground level. The pole has climbing pegs, however adequate climbing safety equipment was not available at the time of the audit tests. An attempt was made to climb the pole and retrieve the WS/WD sensor to conduct audit tests, but it was deemed unsafe without proper climbing safety equipment, consequently audit tests were not performed on the WS/WD sensor.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	NA	NA	NA	**Backup DAS ⇨**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Wind speed input ≤5mps	≤ ±0.2 mps error.	NA	NA
Wind speed input >5mps	≤ ±5% of input speed.	NA	NA
Starting torque threshold	≤ 0.5 mps.	NA	

[2] HORIZONTAL WIND DIRECTION SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: LUD
Location: LUDLOW, CA

Audit Date: 30 SEP 1995
Start Time: NA
End Time: NA

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- *STATION WIND DIRECTION SENSOR IDENTIFICATION and APPLICATION*

Make: R.M.YOUNG **Model:** 05305 **SN:** 02523
Range: 0-360 deg. **Measurement Height:** 9.0 meters **Last Calibrated:** 25 MAY 1995

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Precision compass **Certification Date:** JULY 1993
Make: BRUNTON **Model:** POCKET TRANSIT **SN:** 024338

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

Sensor Starting Torque Threshold: --- grams, or NA mps.
Local Magnetic Declination: 13.7 degrees east (GEOMAG 6/95)
Sensor True North Alignment Error: 1.00 degrees east

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
Direction	Degrees	DAS Degrees	Error Degrees	DAS Degrees	Error Degrees
North	0	---	---	---	---
East	90	---	---	---	---
South	180	---	---	---	---
West	270	---	---	---	---
North	0	---	---	---	---
West	270	---	---	---	---
South	180	---	---	---	---
East	90	---	---	---	---
Mean Absolute Errors ⇨			NA		NA

- *AUDITOR COMMENTS or OBSERVATIONS*

WD sensor could not be audit tested. Refer to wind speed audit report for explanation.

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

Primary DAS ⇨	Slope	Intercept	Cor.Coef.	Backup DAS ⇨	Slope	Intercept	Cor.Coef.
	NA	NA	NA		NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±5 degrees error per audit direction input.	NA	NA
Linearity	≤ 3 degrees mean absolute error.	NA	NA
Alignment to true north	≤ ±3 degrees error from true north.	PASS	
Starting torque threshold	≤ 0.5 mps.	NA	

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TEMPERATURE PROBE AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: LUD
Location: LUDLOW, CA

Audit Date: 30 SEP 1995
Start Time: 1415 PST
End Time: 1432 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- ***STATION TEMPERATURE PROBE IDENTIFICATION and APPLICATION***

Make: CAMPBELL SCIENTIFIC **Model:** 107 **SN:** NA
Range: -30 to +50 C **Measurement Height:** 3.5 meters **Last Calibrated:** 25 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Mercury in glass thermometer **Certification Date:** MAR 1995
Make: VWR **Model:** -1 to +51 C **SN:** 92-14463

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

(Note: Water baths are constantly agitated to assure uniform temperature within Dewar flask.)

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
		DAS	Error	DAS	Error
Bath	Deg. C	Deg. C	Deg. C	Deg. C	Deg. C
Ice	3.3	3.3	0.0	---	---
Cool	25.7	25.6	-0.1	---	---
Hot	39.9	39.8	-0.1	---	---
		Mean Absolute Errors ⇨	0.07		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Temperature probe is mounted in a naturally aspirated radiation shield mounted on a boom extending 2 meters out from the station shelter on the north side of the shelter.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

Primary	Slope	Intercept	Cor.Coef.	Backup	Slope	Intercept	Cor.Coef.
DAS ⇨	0.9971	0.000	1.0000	DAS ⇨	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±0.5 degrees C error per audit temperature input.	PASS	NA

4

OZONE ANALYZER AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT | **Audit Date:** 30 SEP 1995 | **Auditor:** D.F. LANIEWICZ
Site ID: LUD | **Start Time:** 1455 PST | **Operator:** R. HILLESTAD
Location: LUDLOW, CA | **End Time:** 1529 PST | **Witness:** R. HILLESTAD

- ***STATION OZONE ANALYZER IDENTIFICATION and APPLICATION***

Make: DASIBI | **Model:** 1003 AH | **SN:** 3683
Range: 0-500 ppb | **Measurement Height:** 3.5 meters | **Last Calibrated:** 15 SEP 1995
Span #: 55.550 | **Samp. Freq. (40-48 kHz):** 41.703 | **Flow Rate:** 2.0 lpm
Offset #: 4 | **Cntrl. Freq. (21-28 kHz):** 23.843

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Ozone transfer standard | **Certification Date:** 9/4/95
Make: DASIBI | **Model:** 1003-PC | **SN:** 5027
Span #: 52.550 | **Samp. Freq. (40-48 kHz):** 43.518 | **Trans.Std. Slope:** 0.9916
Offset #: 4 | **Cntrl. Freq. (21-28 kHz):** 27.696 | **Trans.Std. Inter.:** 0.5020
Cell Temp, C: 39.50 | **Bar. Press., mmHg:** 712.00

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Station STP Correction Factor: 1.0622

Trns. Std. Display ppb	Audit Input ppb	PRIMARY DAS			BACKUP SYSTEM		
		DAS ppb	Error ppb	Error %	DAS ppb	Error ppb	Error %
11	0.0	0	0	NA	---	---	---
94	88	82	-6	-6.8	---	---	---
185	184	174	-10	-5.4	---	---	---
429	441	420	-21	-4.8	---	---	---
Mean Absolute Errors ⇨			9.3	5.67		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.
Sample inlet is glass attached to approximately 6 meters of ¼-inch Teflon tubing. Inlet extends one meter above roof of shelter. No obstructions of obstacles present.
Analyzer is operating approximately 6% low but is still within audit limits.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x / DAS response = y	Primary	Slope	Intercept	Cor.Coef.	Backup	Slope	Intercept	Cor.Coef.
	DAS ⇨	0.9538	-1.017	1.0000	**DAS ⇨**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Audit curve slope	≥ 0.90 and ≤ 1.10	PASS	NA
Audit curve intercept	≤ ±3% of full scale.	PASS	NA
Audit curve correleation coeff.	≥ 0.9950	PASS	NA

1

HORIZONTAL WIND SPEED SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT **Audit Date:** 29 SEP 1995 **Auditor:** D.F. LANIEWICZ
Site ID: PAL **Start Time:** 1230 PST **Operator:** R. HILLESTAD
Location: PALMDALE, CA **End Time:** 1250 PST **Witness:** R. HILLESTAD

- *STATION WIND SPEED SENSOR IDENTIFICATION and APPLICATION*

Make: R.M.YOUNG **Model:** 05305 **SN:** 20157
Range: 0-50 mps **Measurement Height:** 10 meters **Last Calibrated:** 29 MAY 1995

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Anemometer drive motor (100-10,000 rpm)
Make: R.M.YOUNG **Model:** 18801 **SN:** NA

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

Sensor Starting Torque Threshold: 0.20 grams, or 0.23 mps.

AUDIT INPUTS		PRIMARY DAS			BACKUP SYSTEM		
RPM	mps	DAS mps	Error mps	Error %	DAS mps	Error mps	Error %
0.0	0.0	0.0	0.0	NA	---	---	NA
700	3.4	3.4	0.0	0.90	---	---	---
3,000	14.7	14.6	-0.1	-0.70	---	---	---
7,000	34.3	34.3	0.0	0.00	---	---	---
Mean Absolute Errors			0.03	0.53		NA	NA

- *AUDITOR COMMENTS or OBSERVATIONS*

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Sensor mounted on boom extending 1.5 meters out from existing radio/TV tower at approximately 10-meter level. No obstructions or features present to affect wind flow patterns.

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS	0.9994	-0.009	1.0000	**Backup DAS**	NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Wind speed input ≤5mps	≤ ±0.2 mps error.	PASS	NA
Wind speed input >5mps	≤ ±5% of input speed.	PASS	NA
Starting torque threshold	≤ 0.5 mps.	PASS	

2 HORIZONTAL WIND DIRECTION SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT **Audit Date:** 29 SEP 1995 **Auditor:** D.F. LANIEWICZ
Site ID: PAL **Start Time:** 1300 PST **Operator:** R. HILLESTAD
Location: PALMDALE, CA **End Time:** 1340 PST **Witness:** R. HILLESTAD

- ***STATION WIND DIRECTION SENSOR IDENTIFICATION and APPLICATION***

Make: R.M.YOUNG **Model:** 05305 **SN:** 20157
Range: 0-360 deg. **Measurement Height:** 10 meters **Last Calibrated:** 29 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Precision compass **Certification Date:** JULY 1993
Make: BRUNTON **Model:** POCKET TRANSIT **SN:** 024338

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: 6.00 grams, or 0.40 mps.
Local Magnetic Declination: 14.1 degrees east (GEOMAG 6/95)
Sensor True North Alignment Error: 3.00 degrees east

		PRIMARY DAS		BACKUP SYSTEM	
AUDIT INPUTS		DAS	Error	DAS	Error
Direction	Degrees	Degrees	Degrees	Degrees	Degrees
North	0	2	2	---	---
East	90	93	3	---	---
South	180	181	1	---	---
West	270	267	-3	---	---
North	0	3	3	---	---
West	270	268	-2	---	---
South	180	181	1	---	---
East	90	92	2	---	---
Mean Absolute Errors			2.1		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.
Sensor mounted on existing radio/TV tower at approximately 10-meter level. No wind flow obstructions present
North alignment was at audit limit of ±3 degrees error.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = *x*
DAS response = *y*

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS	0.9817	3.350	1.0000	**Backup DAS**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±5 degrees error per audit direction input.	PASS	NA
Linearity	≤ 3 degrees mean absolute error.	PASS	NA
Alignment to true north	≤ ±3 degrees error from true north.	PASS	
Starting torque threshold	≤ 0.5 mps.	PASS	

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TEMPERATURE PROBE AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: PAL
Location: PALMDALE, CA

Audit Date: 29 SEP 1995
Start Time: 1200 PST
End Time: 1220 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- ***STATION TEMPERATURE PROBE IDENTIFICATION and APPLICATION***

Make: CAMPBELL SCIENTIFIC **Model:** 107 **SN:** NA
Range: -30 to +50 C **Measurement Height:** 7.5 meters **Last Calibrated:** 29 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Mercury in glass thermometer **Certification Date:** MAR 1995
Make: VWR **Model:** -1 to +51 C **SN:** 92-14463

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

(Note: Water baths are constantly agitated to assure uniform temperature within Dewar flask.)

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
		DAS	Error	DAS	Error
Bath	Deg. C	Deg. C	Deg. C	Deg. C	Deg. C
Ice	0.7	0.6	-0.1	---	---
Cool	23.5	23.4	-0.1	---	---
Hot	43.2	43.1	-0.1	---	---
Mean Absolute Errors			0.10		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Temperature probe mounted in natrually aspirated radiation shield.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS	1.0000	-0.100	1.0000	**Backup DAS**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±0.5 degrees C error per audit temperature input.	PASS	NA

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OZONE ANALYZER AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT **Audit Date:** 29 SEP 1995 **Auditor:** D.F. LANIEWICZ
Site ID: PAL **Start Time:** 1256 PST **Operator:** R. HILLESTAD
Location: PALMDALE, CA **End Time:** 1400 PST **Witness:** R. HILLESTAD

- *STATION OZONE ANALYZER IDENTIFICATION and APPLICATION*

Make: DASIBI **Model:** 1003 AH **SN:** 3297
Range: 0-500 ppb. **Measurement Height:** 4.0 meters **Last Calibrated:** 14 SEP 1995
Span #: 57.850 **Samp. Freq. (40-48 kHz):** 47.484 **Flow Rate:** 2.0 lpm
Offset #: 4 **Cntrl. Freq. (21-28 kHz):** 24.618

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Ozone transfer standard **Certification Date:** 9/4/95
Make: DASIBI **Model:** 1003-PC **SN:** 5027
Span #: 52.550 **Samp. Freq. (40-48 kHz):** 43.532 **Trans.Std. Slope:** 0.9916
Offset #: 4 **Cntrl. Freq. (21-28 kHz):** 27.814 **Trans.Std. Inter.:** 0.5020
Cell Temp, C: 40.30 **Bar. Press., mmHg:** 687.00

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

Station STP Correction Factor: 1.1037

Trns. Std. Display ppb	Audit Input ppb	PRIMARY DAS			BACKUP SYSTEM		
		DAS ppb	Error ppb	Error %	DAS ppb	Error ppb	Error %
11	0.0	6	6	NA	---	---	---
91	88	91	3	3.4	---	---	---
173	178	180	2	1.1	---	---	---
401	427	424	-3	-0.7	---	---	---
Mean Absolute Errors			3.5	1.73		NA	NA

- *AUDITOR COMMENTS or OBSERVATIONS*

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.
Sample inlet consists of glass inlet with approximately 4 meters of ¼-inch Teflon tubing. Inlet extends approximately 1.5 meters above roof-line.

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS	0.9799	5.487	1.0000	**Backup DAS**	NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Audit curve slope	≥ 0.90 and ≤ 1.10	PASS	NA
Audit curve intercept	≤ ±3% of full scale.	PASS	NA
Audit curve correleation coeff.	≥ 0.9950	PASS	NA

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HORIZONTAL WIND SPEED SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT **Audit Date:** 30 SEP 1995 **Auditor:** D.F. LANIEWICZ
Site ID: QUA **Start Time:** 0725 PST **Operator:** R. HILLESTAD
Location: QUARTZITE MT., CA **End Time:** 0755 PST **Witness:** R. HILLESTAD

- *STATION WIND SPEED SENSOR IDENTIFICATION and APPLICATION*

Make: R.M.YOUNG **Model:** 05305 **SN:** 20408
Range: 0-50 mps **Measurement Height:** 10 meters **Last Calibrated:** 26 MAY 1995

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Anemometer drive motor (100-10,000 rpm)
Make: R.M.YOUNG **Model:** 18801 **SN:** NA

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

Sensor Starting Torque Threshold: 0.20 grams, or 0.23 mps.

AUDIT INPUTS		PRIMARY DAS			BACKUP SYSTEM		
RPM	mps	DAS mps	Error mps	Error %	DAS mps	Error mps	Error %
0.0	0.0	0.0	0.0	NA	---	---	NA
700	3.4	3.4	0.0	0.00	---	---	---
3,000	14.7	14.5	-0.2	-1.36	---	---	---
7,000	34.3	33.9	-0.4	-1.17	---	---	---
Mean Absolute Errors			0.15	0.84		NA	NA

- *AUDITOR COMMENTS or OBSERVATIONS*

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Sensor mounted at top of existing microwave tower. Open exposure with no obstacles nearby.

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

Primary	Slope	Intercept	Cor.Coef.	Backup	Slope	Intercept	Cor.Coef.
DAS	0.9877	0.011	1.0000	DAS	NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Wind speed input ≤5mps	≤ ±0.2 mps error.	PASS	NA
Wind speed input >5mps	≤ ±5% of input speed.	PASS	NA
Starting torque threshold	≤ 0.5 mps.	PASS	

2 HORIZONTAL WIND DIRECTION SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: QUA
Location: QUARTZITE MT., CA

Audit Date: 30 SEP 1995
Start Time: 0800 PST
End Time: 0815 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- *STATION WIND DIRECTION SENSOR IDENTIFICATION and APPLICATION*

Make: R.M.YOUNG **Model:** 05305 **SN:** 20408
Range: 0-360 deg. **Measurement Height:** 10 meters **Last Calibrated:** 26 MAY 1995

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Precision compass **Certification Date:** JULY 1993
Make: BRUNTON **Model:** POCKET TRANSIT **SN:** 024338

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

Sensor Starting Torque Threshold: 6.00 grams, or 0.40 mps.
Local Magnetic Declination: 13.9 degrees east (GEOMAG 6/95)
Sensor True North Alignment Error: 0.00 degrees

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
Direction	Degrees	DAS Degrees	Error Degrees	DAS Degrees	Error Degrees
North	0	0	0	---	---
East	90	89	-1	---	---
South	180	180	0	---	---
West	270	270	0	---	---
North	0	2	2	---	---
West	270	271	1	---	---
South	180	180	0	---	---
East	90	90	0	---	---
Mean Absolute Errors			0.5		NA

- *AUDITOR COMMENTS or OBSERVATIONS*

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS.
Independent backup system not part of station.
Sensor mounted at top of existing microwave tower.

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS	0.9989	0.400	1.0000	**Backup DAS**	NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±5 degrees error per audit direction input.	PASS	NA
Linearity	≤ 3 degrees mean absolute error.	PASS	NA
Alignment to true north	≤ ±3 degrees error from true north.	PASS	
Starting torque threshold	≤ 0.5 mps.	PASS	

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TEMPERATURE PROBE AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: QUA
Location: QUARTZITE MT., CA

Audit Date: 30 SEP 1995
Start Time: 0656 PST
End Time: 0715 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- ***STATION TEMPERATURE PROBE IDENTIFICATION and APPLICATION***

Make: CAMPBELL SCIENTIFIC **Model:** 107 **SN:** NA
Range: -30 to +50 C **Measurement Height:** 4.0 meters **Last Calibrated:** 26 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Mercury in glass thermometer **Certification Date:** MAR 1995
Make: VWR **Model:** -1 to +51 C **SN:** 92-14463

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

(Note: Water baths are constantly agitated to assure uniform temperature within Dewar flask.)

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
		DAS	Error	DAS	Error
Bath	Deg. C	Deg. C	Deg. C	Deg. C	Deg. C
Ice	0.7	0.6	-0.1	---	---
Cool	15.2	15.2	0.0	---	---
Hot	44.9	45.0	0.1	---	---
Mean Absolute Errors			0.07		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Noted fluctuations (noise) in probe response probably caused by radio signal interference.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

Primary	Slope	Intercept	Cor.Coef.	Backup	Slope	Intercept	Cor.Coef.
DAS	1.0044	-0.088	1.0000	DAS	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±0.5 degrees C error per audit temperature input.	PASS	NA

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OZONE ANALYZER AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: QUA
Location: QUARTZITE MT., CA

Audit Date: 30 SEP 1995
Start Time: 0705 PST
End Time: 0810 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R. HILLESTAD

- ***STATION OZONE ANALYZER IDENTIFICATION and APPLICATION***

Make: DASIBI
Range: 0-500 ppb
Span #: 61.550
Offset #: 4

Model: 1003 AH
Measurement Height: 4.5 meters
Samp. Freq. (40-48 kHz): 45.524
Cntrl. Freq. (21-28 kHz): 24.024

SN: 2052
Last Calibrated: 13 SEP 1995
Flow Rate: 2.0 lpm

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Ozone transfer standard
Make: DASIBI
Span #: 52.550
Offset #: 4

Model: 1003-PC
Samp. Freq. (40-48 kHz): 43.548
Cntrl. Freq. (21-28 kHz): 27.770
Cell Temp, C: 40.90

Certification Date: 9/4/95
SN: 5027
Trans.Std. Slope: 0.9916
Trans.Std. Inter.: 0.5020
Bar. Press., mmHg: 650.00

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Station STP Correction Factor: 1.1687

Trns. Std. Display ppb	Audit Input ppb	PRIMARY DAS			BACKUP SYSTEM		
		DAS ppb	Error ppb	Error %	DAS ppb	Error ppb	Error %
10	0.0	7	7	NA	---	---	---
94	98	93	-5	-5.1	---	---	---
143	155	154	-1	-0.6	---	---	---
381	430	416	-14	-3.3	---	---	---
Mean Absolute Errors			6.8	3.00		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.
Glass sample inlet with approximately 5 meters of ¼-inch Teflon tubing running to ozone analyzer.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.
Primary DAS	0.9564	4.198	0.9998
Backup DAS	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Audit curve slope	≥ 0.90 and ≤ 1.10	PASS	NA
Audit curve intercept	≤ ±3% of full scale.	PASS	NA
Audit curve correleation coeff.	≥ 0.9950	PASS	NA

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HORIZONTAL WIND SPEED SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: SHA
Location: SHADOW MT., CA

Audit Date: 30 SEP 1995
Start Time: 1055 PST
End Time: 1112 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION WIND SPEED SENSOR IDENTIFICATION and APPLICATION***

Make: R.M.YOUNG **Model:** 05305 **SN:** 20404
Range: 0-50 mps **Measurement Height:** 9.9 meters **Last Calibrated:** 28 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Anemometer drive motor (100-10,000 rpm)
Make: R.M.YOUNG **Model:** 18801 **SN:** NA

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: 0.20 grams, or 0.23 mps.

AUDIT INPUTS		PRIMARY DAS			BACKUP SYSTEM		
RPM	mps	DAS mps	Error mps	Error %	DAS mps	Error mps	Error %
0.0	0.0	0.0	0.0	NA	---	---	NA
700	3.4	3.4	0.0	0.00	---	---	---
3,000	14.7	14.6	-0.1	-0.68	---	---	---
7,000	34.3	34.2	-0.1	-0.29	---	---	---
Mean Absolute Errors ⇨			0.05	0.32		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Wind speed/wind direction sensor is mounted on a pivoting mast that is attached to an existing microwave tower. The mast extends above the microwave tower approximately 4.5 meters and is exposed to wind flows from all directions.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

Primary	Slope	Intercept	Cor.Coef.	Backup	Slope	Intercept	Cor.Coef.
DAS ⇨	0.9968	-0.008	1.0000	DAS ⇨	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Wind speed input ≤5mps	≤ ±0.2 mps error.	PASS	NA
Wind speed input >5mps	≤ ±5% of input speed.	PASS	NA
Starting torque threshold	≤ 0.5 mps.	PASS	

2 HORIZONTAL WIND DIRECTION SENSOR AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: SHA
Location: SHADOW MT., CA

Audit Date: 30 SEP 1995
Start Time: 1117 PST
End Time: 1125 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION WIND DIRECTION SENSOR IDENTIFICATION and APPLICATION***

Make: R.M.YOUNG **Model:** 05305 **SN:** 20404
Range: 0-360 deg. **Measurement Height:** 9.9 meters **Last Calibrated:** 28 MAY 1995

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Precision compass **Certification Date:** JULY 1993
Make: BRUNTON **Model:** POCKET TRANSIT **SN:** 024338

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Sensor Starting Torque Threshold: 6.00 grams, or 0.40 mps.
Local Magnetic Declination: 14.0 degrees east (GEOMAG 6/95)
Sensor True North Alignment Error: 1.00 degrees

AUDIT INPUTS		PRIMARY DAS		BACKUP SYSTEM	
Direction	Degrees	DAS Degrees	Error Degrees	DAS Degrees	Error Degrees
North	0	2	2	---	---
East	90	89	-1	---	---
South	180	177	-3	---	---
West	270	268	-2	---	---
North	0	2	2	---	---
West	270	268	-2	---	---
South	180	178	-2	---	---
East	90	90	0	---	---
Mean Absolute Errors ⇨			1.8		NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.
Wind speed/wind direction sensor is mounted on a pivoting mast that is attached to an existing microwave tower. The mast extends above the microwave tower approx. 4.5 meters and is exposed to wind flows from all directions.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	0.9844	1.350	1.0000	**Backup DAS ⇨**	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±5 degrees error per audit direction input.	PASS	NA
Linearity	≤ 3 degrees mean absolute error.	PASS	NA
Alignment to true north	≤ ±3 degrees error from true north.	PASS	
Starting torque threshold	≤ 0.5 mps.	PASS	

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TEMPERATURE PROBE AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: SHA
Location: SHADOW MT., CA

Audit Date: 30 SEP 1995
Start Time: 1155 PST
End Time: 1220 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- *STATION TEMPERATURE PROBE IDENTIFICATION and APPLICATION*

Make: CAMPBELL SCIENTIFIC **Model:** 107 **SN:** NA
Range: -30 to +50 C **Measurement Height:** 8.4 meters **Last Calibrated:** 28 MAY 1995

- *AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION*

Item: Mercury in glass thermometer **Certification Date:** MAR 1995
Make: VWR **Model:** -1 to +51 C **SN:** 92-14463

PART B: AUDIT TEST RESULTS

- *KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE*

(Note: Water baths are constantly agitated to assure uniform temperature within Dewar flask.)

		PRIMARY DAS		BACKUP SYSTEM	
AUDIT INPUTS		DAS	Error	DAS	Error
Bath	Deg. C	Deg. C	Deg. C	Deg. C	Deg. C
Ice	1.1	1.0	-0.1	---	---
Cool	18.8	18.9	0.1	---	---
Hot	41.7	41.8	0.1	---	---
Mean Absolute Errors ⇨			0.10		NA

- *AUDITOR COMMENTS or OBSERVATIONS*

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Temperature probe is in naturally aspirated radiation shield mounted on the same mast that supports the WS/WD sensor.

- *AUDIT LINEAR REGRESSION CURVE RESULTS*

Audit input value = x
DAS response = y

	Slope	Intercept	Cor.Coef.		Slope	Intercept	Cor.Coef.
Primary DAS ⇨	1.0047	-0.063	.1.0000	**Backup DAS ⇨**	NA	NA	NA

- *AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS*

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Accuracy	≤ ±0.5 degrees C error per audit temperature input.	PASS	NA

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OZONE ANALYZER AUDIT REPORT

PART A: ANCILLARY INFORMATION

Project: CARB O3 TRANSPORT
Site ID: SHA
Location: SHADOW MT., CA

Audit Date: 30 SEP 1995
Start Time: 1300 PST
End Time: 1355 PST

Auditor: D.F. LANIEWICZ
Operator: R. HILLESTAD
Witness: R.HILLESTAD

- ***STATION OZONE ANALYZER IDENTIFICATION and APPLICATION***

Make: DASIBI
Range: 0-500 ppb
Span #: 60.550
Offset #: 4

Model: 1003 AH
Measurement Height: 8.4 meters
Samp. Freq. (40-48 kHz): 43.108
Cntrl. Freq. (21-28 kHz): 22.588

SN: 2359
Last Calibrated: 17 SEP 1995
Flow Rate: 2.0 lpm

- ***AUDIT EQUIPMENT IDENTIFICATION and CERTIFICATION INFORMATION***

Item: Ozone transfer standard
Make: DASIBI
Span #: 52.550
Offset #: 4

Model: 1003-PC
Samp. Freq. (40-48 kHz): 45.495
Cntrl. Freq. (21-28 kHz): 28.228
Cell Temp, C: 38.30

Certification Date: 9/4/95
SN: 5027
Trans.Std. Slope: 0.9916
Trans.Std. Inter.: 0.5020
Bar. Press., mmHg: 653.00

PART B: AUDIT TEST RESULTS

- ***KNOWN AUDIT INPUT vs. OBSERVED STATION RESPONSE***

Station STP Correction Factor: 1.1537

Trns. Std. Display ppb	Audit Input ppb	PRIMARY DAS			BACKUP SYSTEM		
		DAS ppb	Error ppb	Error %	DAS ppb	Error ppb	Error %
11	0.0	-4	-4	NA	---	---	---
91	92	89	-3	-3.3	---	---	---
170	182	183	1	0.5	---	---	---
394	439	443	4	0.9	---	---	---
Mean Absolute Errors ⇨			3.0	1.57		NA	NA

- ***AUDITOR COMMENTS or OBSERVATIONS***

Backup DAS system consists of auxillary data storage module (Campbell, SM192) operating as part of the Primary DAS. Independent backup system not part of station.

Glass inlet with approximately 12 meters of ¼ inch Teflon sample line. Sample flow is unrestricted in all directions.

- ***AUDIT LINEAR REGRESSION CURVE RESULTS***

Audit input value = x
DAS response = y

Primary	Slope	Intercept	Cor.Coef.	Backup	Slope	Intercept	Cor.Coef.
DAS ⇨	1.0188	-3.856	1.0000	DAS ⇨	NA	NA	NA

- ***AUDIT LIMIT CRITERIA and PASS/FAIL RESULTS***

Audit Limit Catagory	To PASS, the observed response must be....	Primary	Backup
Audit curve slope	≥ 0.90 and ≤ 1.10	PASS	NA
Audit curve intercept	≤ ±3% of full scale.	PASS	NA
Audit curve correleation coeff.	≥ 0.9950	PASS	NA