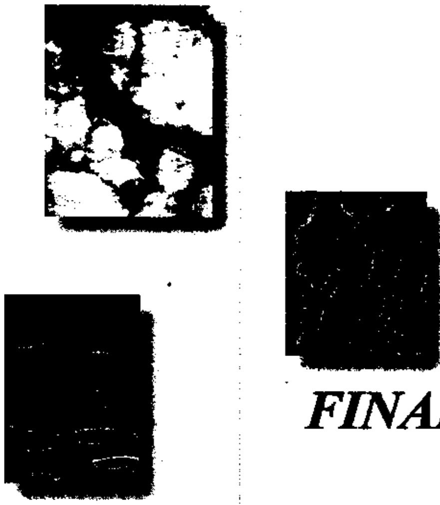
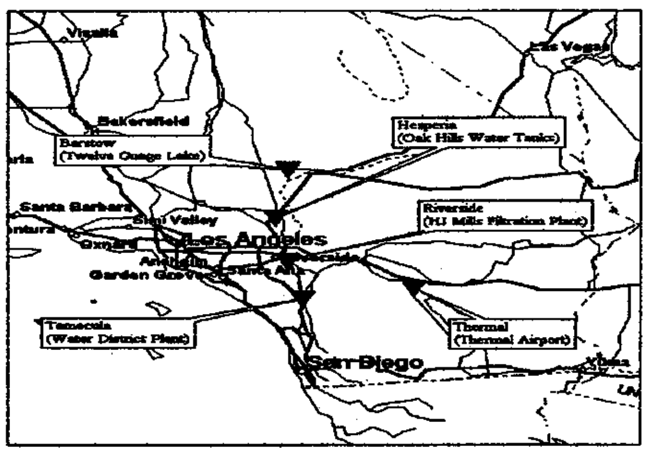


FINAL REPORT

ARB Contract #96-318 Enhancement of the Existing Radar Wind Profiler Network for the 1997 Southern California Ozone Study



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Prepared for:
California Air Resources Board and the
California Environmental Protection Agency

NOTICE

The statements and conclusions in this Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

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Principal Investigator:	George L. Frederick
Project Administrator:	D. Larry Best
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This Report was submitted in fulfillment of ARB Contract No. 96-318, Enhancement of the Existing Radar Wind Profiler Network for the 1997 Southern California Ozone Study, by Radian International under the sponsorship of the California Air Resources Board. Work was completed as of September 22, 1998.

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ACRONYMS AND ABBREVIATIONS

agl	Above ground level
ARB	Air Resources Board
BTW	Site ID for Barstow LAP/Met Site
C	Centigrade
CA	Postal code for the State of California
CDF	Common data format
CRADA	Cooperative Research and Development Agreement
EPA	Environmental Protection Agency
ETL	Environmental Technologies Laboratory
FCC	Federal Communications Commission
ft	Feet
HPA	Site ID for Hesperia LAP/Met Site
Hz	Hertz
ID	Identification
km	Kilometer
LAN	Local area network
LAP®	Lower Atmospheric Profiler (registered trademark of Radian International)
m	Meter
m/s	Meters per second
Mb	Millibar
MHZ	Megahertz
min	Minute
MWG	Meteorological Working Group
NARSTO	North American Research Strategy for Tropospheric Ozone
NE	Northeast
NOAA	National Oceanic and Atmospheric Administration
POP	Profiler online program
PSD	Prevention of Serious Deteriorization
PST	Pacific Standard Time
QA	Quality Assurance
QC	Quality Control
RASS	Radio Acoustic Sounding System
RH	Relative humidity
RSD	Site ID for Riverside LAP/Met Site
RWP	Radar wind profiler
SCOS	Southern California Ozone Study
SOP	Standard Operating Procedure
STI	Sonoma Technology, Inc.
TML	Site ID for Thermal LAP/Met Site
TCL	Site ID for Temecula LAP/Met Site
T_v	Virtual temperature
u	East-west component of wind
v	North-south component of wind
w	Vertical component of wind
w/m^2	Watts/square meter
WOFC	Weather Operations and Forecasting Center (STI Facility)

Enhancement of the Existing Radar Wind Profiler Network for the 1997 Southern California Ozone Study

Radian International and Sonoma Technologies, Inc.

ABSTRACT. Radian International, Electronic Systems, along with its primary teaming partner, Sonoma Technology, Inc. (STI) supported the enhancement of the existing southern California radar wind profiler network with five state-of-the-art LAP®-3000 profilers and accompanying Radio Acoustic Sounding System (RASS) components. Each site had a PSD standard surface met tower to measure temperature, winds, and relative humidity. This project was very similar to one sponsored by the Electric Power Research institute in the Northeastern US the past two years named NARSTO-NE. Radian and STI conducted activities for SCOS97-NARSTO in much the same manner as they did during the highly successful NARSTO-NE project. All equipment was ready for intensive observations by 13 June 97. Data collection and monitoring was performed by STI from its Weather Operations and Forecasting Center (WOFC) in Santa Rosa, CA. Under the supervision of Radian and STI, site operators performed preventive maintenance on the equipment and were on short notice to go to the sites to assist with any maintenance troubleshooting required. Data was made available in near real time and compiled on a daily, weekly, and project basis in the format specified by the project data manager. Upon completion of the project, all equipment was removed from the sites and the area returned to original condition.

1.0 INTRODUCTION

1.1 Scope and Purpose

Radian International (Radian), Electronic Systems, supported the State of California, Air Resources Board (ARB), under ARB Contract #96-318, in the enhancement of the existing radar wind profiler network for the 1997 Southern California Ozone Study. Radian teamed with Sonoma Technology, Inc.(STI) a California business, to bring state-of-art technology to bear on the project. In 1991, Radian and STI entered into a Cooperative Research and Development Agreement (CRADA) with the National Oceanic and Atmospheric Administration (NOAA) to commercially develop and enhance the radar wind profiler technology being produced by NOAA's Environmental Research Laboratories. The success of this CRADA was recently underscored when it was extended for an additional 5 years. As a result of this arrangement, NOAA research-grade radar wind profilers have been upgraded to commercial-grade instruments which Radian has manufactured and fielded at over 60 locations around the world. Along the way, upgrades in hardware and software have been incorporated into the equipment such that today the instruments exhibit outstanding reliability and performance.

ARB and some of its client districts have benefitted from this technology with seven (7) Radian-built LAP®-3000s purchased and planned for use on this project. Radian worked with those clients to ensure that the latest advances in software and hardware were available to them to support the study. The 11 NOAA-owned systems deployed in support of this study contain many Radian-built components and come under a common configuration management process jointly managed by NOAA, Radian, and STI. Finally, the Vandenberg AFB tropospheric profiler proposed for this project underwent an upgrade to 449 MHZ and used Radian-built electronics components common to the NOAA and Radian radar profilers. The four LAP®-3000s provided by Radian and one LAP®-3000 provided by STI were fully compatible with all of the other profilers used on this study. This was to ensure that analysts were provided consistent and correlated data for use in modeling and forecasting applications.

1.2 Project Objectives

Our fundamental project objective was to provide meteorological data from five radar wind profilers with Radio Acoustic Sounding Systems (RWP/RASS) at approved sites in southern California for the period 15 Jun 97 through 15 Oct 97. To meet this project objective we defined our work under the task objectives described below.

For Task 1—Field Equipment and Preparations—we efficiently and quickly fielded 5 radar wind profilers with Radio Acoustic Sounding Systems (RWP/RASS) and associated surface meteorological systems in support of the study within a month after contract award date. We intend to have all equipment operational 1-2 weeks in advance of the beginning of the observation period. Some delays in site preparation and acquisition affected this plan, but all sites were fully operational by the scheduled start date of 15 June. Advance planning based on our previous experience in this type of work and careful coordination with the Meteorological Working Group (MWG) facilitated achieving this objective. We installed Radian/STI owned LAP®-3000 radar wind profilers and associated electronics components and surface meteorological instrumentation on each site. Calibration of all instrumentation was done at the beginning and the end of the project. Prior to fielding the equipment it was functionally tested at the factory to ensure it met the highest performance and reliability standards. We worked closely with the MWG and the quality assurance manager to focus on the best observing sites in the area of interest and moved quickly to secure property leases and began site preparation once these decisions were made. FCC licenses were applied for upon contract award with modifications for changing site coordinates taking less time than the original approval.

For Task 2—Field Operations—we operated the five established sites in a manner which provided the highest quality data in the most efficient manner possible. To do this we managed the sites remotely with full time telecommunications to the instrumentation which provided indications on any potential problems. A daily status check was performed and information faxed to the Field Study Manager periodically on the operational readiness of the equipment. When problems were identified, an on-call site operator was dispatched to the site to assist with full diagnosis and repair. When intensive observations were anticipated because of an expected significant ozone event, more frequent monitoring of equipment status and operation was employed. Access to any and all sites for the purpose of program audits was readily granted. At the conclusion of the project the sites were dismantled and returned to previous condition within two weeks of the termination of the program.

For Task 3—Data Collection and Transfer—we collected and transmitted data to the appropriate data manager on time and on schedule. Sonoma Technology, Inc. employed their already established Weather Operations and Forecasting Center (WOFC) to manage data collection and transfer. This facility responded to all of the requirements specified in the request for proposal and flexible enough to respond to changing needs. The LAP®-3000 design allows for storage and remote retrieval of data files. We provided data in the correct format and delivered it to the correct location to meet the needs of the various groups involved in the study.

2.0 MATERIALS AND METHODS

2.1 Phases of Project

2.1.1 Site Activation

During the site activation phase, the orientation and level of each profiler was checked and adjusted as necessary. Data from each profiler and RASS were collected and checked for reasonableness and for internal and external consistency. The surface meteorological sensors were installed. At all the sites, the surface sensors were calibrated, and data were checked for reasonableness and internal and external consistency. See Paragraph 2.2, Project Design, for site-specific information.

2.1.2 Site Operator Training

Operator training sessions were held once the activation of the profiler, RASS, and surface meteorological tower were completed at each site. The site operators were responsible for maintaining both the LAP-3000 radar profilers and the collocated surface meteorological stations.

As part of the training, STI staff familiarized the operators with all components of the system and alerted them to the possible shortcomings and/or failure modes of each sensor. The operators were briefed on how the data acquisition system operated and how the Gateway computer interacted with the data loggers on the surface meteorological tower. Each operator was given a manual describing STI's standard operating procedures (SOP) for servicing both the surface meteorological equipment and the radar profiler, Appendix C.

Site operators visited the sites at least once every two weeks to inspect the instruments and to make backup copies of the data. In order to minimize downtimes, the site operators obtained the current status of the study by calling STI. Several times during the study, operators were sent to the sites by STI to conduct emergency maintenance or to troubleshoot problems.

During the routine site visits, the operators followed the SOP distributed by STI during training. Once the operators arrived on-site, they recorded their visit in a site log. Next, they inspected the instruments and recorded any problems, adjustments, or changes on a checklist. Any urgent problems were immediately reported to STI. Data (moments and surface) were then archived on 100 megabyte Iomega ZIP diskettes. The checklist and archive diskettes were then shipped to STI's office for final archiving.

Site operators visited the sites for maintenance once every two weeks (or more often, as required). Site and instrument maintenance activities consisted of:

- Mowing the grass (if grass was present) and removing unwanted vegetation where necessary.
- Assessing the integrity of the site fencing and overall security.
- Checking the integrity of the profiler tie-down cables and anchors.
- Visually inspecting the profiler radome and RASS acoustic sources.
- Verifying the orientation of the profiler by noting any changes in the position of the profiler feet.
- Checking the integrity of the cables from the profiler to the instrument shelter.
- Checking the integrity of the cables from the sensors to the data logger and from the surface meteorological tower to the instrument shelter.
- Verifying that the surface meteorological tower base was secure and that the tower was vertical.
- Assessing the functionality and the physical condition of the surface meteorological wind sensors.
- Cleaning and leveling the solar radiation sensor, if necessary.
- Checking that the airflow through the motor-aspirated radiation shield was not restricted.
- Checking that the tipping bucket in the rain gauge was moving freely, and clearing any insects or debris from the rain-collecting aperture.

When significant problems were found during a site visit, the operators called STI and discussed possible solutions with STI personnel.

2.1.3 Site Audits

To ensure that the profiler, wind, RASS, and surface meteorological data that were being collected met the data quality objectives established for the SCOS 1997 study, an independent QA contractor audited each site. Aerovironment conducted audits at each site from June 17 through 24, 1997. Each site audit consisted of two parts, a system audit and a performance audit. While performance audits were conducted at each site on the surface meteorological instrumentation, performance audits on the upper-air monitoring equipment were only conducted at the Temecula site.

The system audits provided an independent assessment of the quality assurance procedures that were implemented for the study. The performance audit, by definition, consisted of making a direct challenge to the performance of the instrument being audited using a known or reference standard. However, since it is not possible to audit the profilers or RASS with reference values for winds or temperature, the performance audit for the Temecula profiler and RASS was based on comparisons with data collected by a collocated Doppler sodar and a balloon sounding system (Lindsey et al., 1995). Detailed audit results can be found in Barnett and Baxter (1998).

2.1.4 Site Decommissioning

At the end of the study, STI and Radian staff removed all the instruments from October 19 through 28, 1997. The sites were returned to the same condition in which they were found, and final checks were performed on all of the surface and upper-air sensors.

2.2 Project Design

2.2.1 Network of Profiler Sites

The network of Radian/STI LAP®-3000/Met sites are shown in Figure 1.

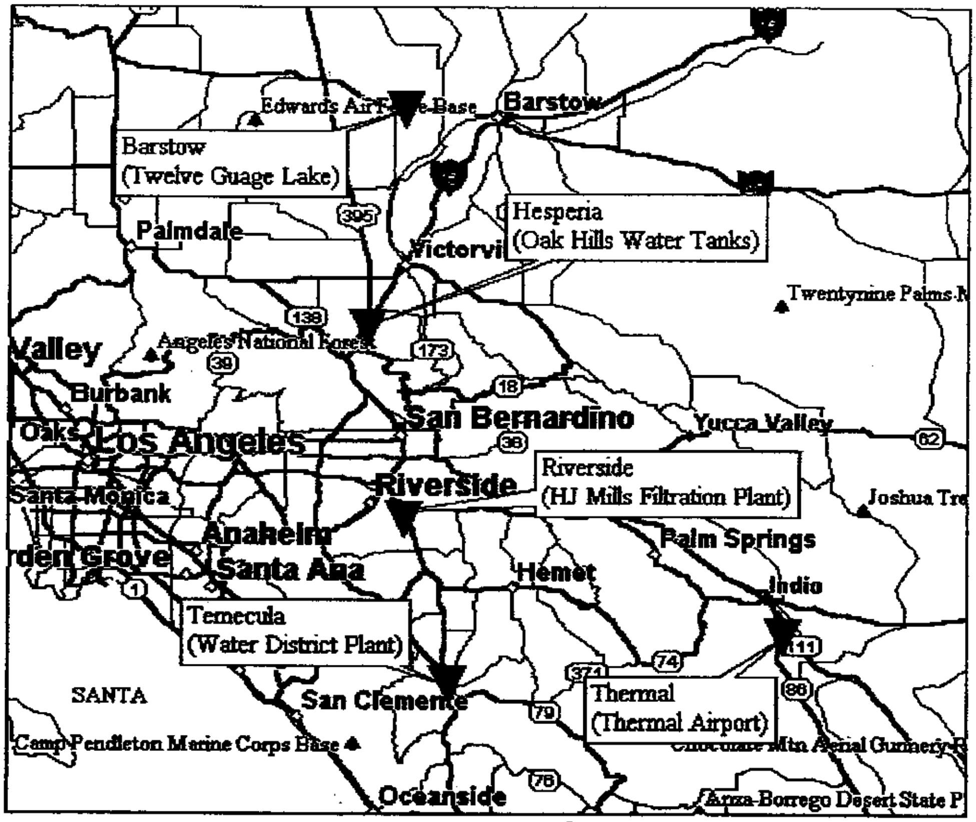

Figure 1. Radian/STI LAP® Sites Network

Sites shown are:

- Barstow (Twelve Gage Lake) at northernmost point in the network west of Barstow;
- Hesperia (Oak Hills Water Tanks) south of Victorville;
- Riverside (HJ Mills Filtration Plant) east of Riverside;
- Temecula (Water District Plant) just northwest of Temecula; and
- Thermal Airport at south and easternmost point in the network at Thermal.

Other site information and local maps showing their locations are provided at Appendix A. Table 1 provides geographical information summary.

Table 1. Geographical information for the 1997 SCOS radar profiler network.

Site Name	Site	Latitude (West)	Longitude (North)	Elevation (m)	Land Description Summary
Barstow	BTW	34° 55' 23"	117° 18' 25"	694	Sandy flat terrain surrounded by fencing. Oil piping to the north and northeast. Freeway oriented east-west, 150m to the north.
Hesperia	HPA	34° 23' 29"	117° 24' 17"	975	Sandy terrain covered with bushes and sage brush, enclosed by a fence. Two water towers, about 40 feet tall, located 60m to the southeast.
Riverside	RSD	33° 55' 00"	117° 18' 30"	488	Dirt covered terrain with two 20 to 30m tall water storage tanks 40m to the west-southwest. Water aqueduct building 15m tall located to the east-southeast.
Temecula	TCL	33° 30' 00"	117° 09' 40"	335	Gravel covered terrain surrounded by service road on all four sides. Chemical storage building along with three 15m tall storage tanks located 30m to the south-southwest.
Thermal	TML	33° 38' 25"	116° 09' 35"	-36	Open field with fenced-in, dirt covered terrain surrounded by bushes and sage brush. Mountains 2 kilometers to the southwest.

2.2.2 Equipment Used

The radar wind profilers used for this project were the LAP®-3000 with RASS as described in the paragraph below, Upper-Air Instruments. The surface met equipment were MET ONE and/or Climatronics wind, temperature, and relative humidity instruments as described in Paragraph 2.2.3.2, Surface Meteorological Instruments. Test equipment was specified by the respective manufacturer.

Radian supplied MET ONE and/or Climatronics wind, temperature and humidity instruments on 10 m towers to meet the surface met equipment requirement. These instruments along with those supplied by STI met Prevention of Significant Deterioration standards specified by US EPA.

Sonoma Technology provided one of the LAP®-3000 915-MHZ RWP/RASS systems as well as a surface meteorological station collocated with STI's RWP/RASS. The surface station measures, at a minimum, wind speed, wind direction, temperature, and relative humidity. STI also provided calibration equipment to calibrate all five of the surface meteorological stations and to align and level the antennas of the five RWP/RASS systems. This equipment was leased to the project using STI's standard lease rates. STI provided all of the computing and communications equipment and services needed to acquire the data from each RWP/RASS site and to process and deliver the data to the upper-air data manager. The computer systems were leased to the project using STI's standard lease rates for WOFC equipment. Other miscellaneous equipment, such as computer disks, station logbooks, field supplies, etc. were purchased as needed during the course of the project.

2.2.3 Instrumentation Description

2.2.3.1 Upper-Air Instruments

The 915-MHZ boundary layer radar profilers that were used for the 1997 SCOS study were pulsed Doppler radars that measured vertical profiles of wind in the boundary layer and lower troposphere. With the addition of RASS, the radar profilers were also able to measure profiles of virtual temperature (T_v). Virtual temperature is the temperature that a parcel of dry air would have if its pressure and density were equal to that of a moist air parcel.

The 915-MHZ boundary layer radar profiler was developed by researchers at the National Oceanic and Atmospheric Administration's (NOAA) Aeronomy Laboratory. The basic technology is described in Ecklund et al. (1990). RASS was developed in the 1970s by NOAA's Wave Propagation Laboratory and was adapted to the 915-MHZ radar profiler in 1987. Radian International manufactures the 915-MHZ Lower Atmospheric Profiler (LAP-3000) and RASS through a Cooperative Research and Development Agreement between Radian, STI, and NOAA. This section describes the radar profiler and RASS and discusses their operation.

The LAP-3000 consists of a single phased-array antenna. The radar beam is electronically pulsed vertically and 23 degrees from vertical in any of four orthogonal directions. A Aclutter fence,@ a rigid screen that is designed to suppress signals reflected from nearby obstacles, surrounds the antenna. The LAP-3000 includes electronic subsystems that control the radar's transmission, reception, signal processing, and RASS. The LAP-3000 also includes a communications computer that allows users to download data and to remotely control the profiler operations. A RASS consists of four vertically pointing acoustic sources (equivalent to high-quality loudspeakers) placed around the radar antenna, and an electronics subsystem consisting of an acoustic power amplifier and signal-generating circuit boards.

The principles of profiler operation are relatively straightforward and are described in a number of references (e.g., van de Kamp, 1988). Basically, the radar transmits an electromagnetic pulse along one of the beam directions. The duration that the radar transmits determines the length of the pulse emitted by the antenna, which in turn corresponds to the volume of air illuminated (in electrical terms) by the radar beam. These radio signals are then scattered by small-scale turbulent fluctuations that induce irregularities in the radio refractive index of the atmosphere. The radar is most sensitive to scattering by turbulent eddies whose spatial scale is ½ the wavelength of the radar, or approximately 16 cm for a 915-MHZ profiler. Signals can also be scattered by hard targets such as rain drops, trees, buildings, and birds. A receiver measures small amounts of the transmitted energy that are scattered back towards the radar (referred to as "backscattering"). These backscattered signals are received at a slightly different frequency than the transmitted signal. This difference, called the Doppler frequency shift, is directly related to the velocity of the air moving towards or away from the radar profiler along the pointing direction of the beam.

A profiler's ability to measure winds is based on the assumption that the turbulent eddies that induce scattering are carried along by the mean wind. The backscattered signals received by the profiler are many orders of magnitude smaller than the energy transmitted. However, if sufficient samples can be obtained and averaged, the atmospheric signal can be identified above the noise level and the mean velocity can be determined.

An averaged spectrum of the backscattered energy as a function of frequency is computed for each altitude, and the mean Doppler shift for each range gate is then calculated. The peak in the Doppler spectrum is identified and the zero, first, and second moments of that peak are computed. These moments represent the returned signal power, the radial velocity (the velocity of the air towards or away from the radar along the beam), and the spectral width of the peak (defined as the standard deviation of the radial velocities contained in the peak). This process is then repeated for the other beams. It takes approximately 1 minute to scan all beams.

The radial velocity measured by the tilted beams is the vector sum of the horizontal motion of the air towards or away from the radar and any vertical motion present in the beam. Using appropriate trigonometry, the three-dimensional meteorological velocity components (u,v,w), wind speed, and wind direction are calculated from the radial velocities with corrections for vertical motions. The LAP®-3000 uses a technique referred to as "consensus averaging" to compute averaged wind profiles (Fischler and Bolles, 1981). Using this technique, the software selects the largest subset of the radial velocities measured during the averaging period that fall within a user-selectable velocity window (typically 2 m/s). At least 60 percent of the radial velocities are required to fall within 2 m/s of each other; if they do not, the winds at that altitude fail the consensus test and no wind data are reported.

For the 1997 SCOS study, the LAP®-3000 profilers were cycled between so-called "low modes" and "high modes" for measuring winds aloft. The low mode had a low altitude coverage with a fine vertical resolution, while the high mode had a greater altitude coverage with a somewhat coarser vertical resolution. The radar profilers measured winds from about 110 m agl to 3-4 km agl with a combination of 57-m (low mode) and 101-m (high mode) vertical resolutions.

Virtual temperature was measured by RASS. Since the virtual temperature (T_v) of an air parcel is the temperature that a sample of dry air would have if its pressure and density were equal to those of the moist air parcel, an air parcel's virtual temperature is always higher than its dry bulb temperature. RASS consists of four vertically pointing acoustic sources (which are equivalent to high-quality loudspeakers) placed around the radar antenna, and an electronics subsystem consisting of an acoustic power amplifier and signal-generating circuit boards. The acoustic sources were enclosed by noise-suppression shields to minimize nuisance effects that might have bothered nearby neighbors or others working near the instrument. Each acoustic source transmitted approximately 75 watts of power and produced acoustic signals in approximately the 2020 to 2100 Hz range.

The principle of operation behind RASS is that when the wavelength of the acoustic signal matches the half wavelength of the radar (called the Bragg match), enhanced scattering of the radar signal occurs. During RASS operation, acoustic energy transmitted into the vertical beam of the radar produces the Bragg match and allows the radar profiler to measure the speed of the acoustic signals. By knowing the speed of sound as a function of altitude, T_v profiles can be calculated with appropriate corrections for vertical air motion. As a rule, a vertical velocity of 1 m/s can alter a T_v observation by 1.6°C. T_v was not adjusted for vertical air motion since the vertical velocities tended to be noisy and could have potentially introduced large, unrealistic temperature variations into the data set.

The profilers sampled for temperature with RASS for the first 5 minutes of each hour. During this period, about eight RASS profiles were obtained, which were then consensus-averaged by the LAP®-3000 software to produce a final, averaged T_v profile. RASS sampling was performed with a 57-m pulse length. The altitude of the first range gate varied from 110 to 124 m agl, and T_v was reported every 57 m at the center of the sampling volume. Because of atmospheric attenuation of the acoustic signals at the RASS frequencies, the maximum altitude that can be sampled is usually 1 to 2 km, depending on atmospheric conditions. High wind velocities (e.g., greater than 13 m/s) can limit RASS altitude coverage to below 500 m because the acoustic signals are blown out of the radar beam. When the 5 minute RASS sampling phase was completed, the LAP-3000 sampled for winds for the remaining 55 minutes of the hour.

Each site was equipped with two 486-based personal computers: a radar computer and a LAP®-3000 Gateway computer. The POP (Profiler On-line Program) software on the radar computer controlled all aspects of sampling, signal processing, and data reduction. POP generated three data types: spectral, moments, and consensus. Spectral data contained the Doppler power spectrum for each sampling altitude and for each beam. Spectral data files were too large to be routinely archived, except for occasional diagnostic purposes. Moments data files were archived onto the radar computer's disk, and contained profiles of radial velocities, signal-to-noise ratio

(SNR), and spectral width from each 20- to 30-second scan of a beam for both wind and RASS data. Consensus data contained hourly averaged wind speed, wind direction, and T_v data.

The LAP®-3000 Gateway computer was connected to the radar computer via a local area network (LAN) and was equipped with a modem and software that allowed users to remotely control the LAP®-3000 and download data. A data formatting program ran on the Gateway computer, which converted the raw consensus data produced by POP into the LAP-3000 common data format (CDF). Files written in the CDF have quality control codes, standard units, and descriptive information about the site. The data formatter ran hourly, a few minutes after the top of the hour, so that the most recent consensus data were always available for downloading via the Gateway computer.

Parameters Measured

Each radar profiler measured hourly averaged profiles of wind speed, wind direction, vertical velocity, and returned signal strength (signal-to-noise ratio). Each RASS measured virtual temperature. Virtual temperature was measured for the first 5 minutes of each hour; winds were measured during the remaining 55 minutes. Sampling specifications objectives for the wind and virtual temperature data are listed in Table 2. The data quality objectives for upper-air measurements are found in Table 14.

As discussed earlier, the radar profilers were operated in a so-called low and high mode, which produced two wind profiles each hour: the low mode winds had a 57-m vertical resolution and the high mode winds had a 101-m vertical resolution.

Table 2. Sampling configurations and data quality objectives for the radar wind profilers and RASS. Specifications are identical for all sites unless otherwise stated.

Specification	Winds	Virtual Temperature
Averaging period (min)	55	5
Reporting interval (min)	60	60
Time standard	PST	PST
Time convention	Begin	Begin
Vertical resolution (m)	57 m and 101 m	57
Minimum altitude (m agl)	110[a] m and 124[b] m for 57 m resolution 254 m for 101 m resolution	120[c] 135[d]
Maximum altitude (m agl)	3914	1477
Manufacturer's reported accuracy	≤1 m/s and ≤10°	≤1°C
Precision	2.5 m/s 20°	1°C
Data recovery rate (Percent of possible)	80% @ 1.5 km	80% @ 0.7 km
Percent of time operational (uptime)	≤90%	≤90%
Range	0 to 24 m/s (per beam) 0 to 360°	5 to 35° C
Sample frequency	~25 seconds	~15 seconds

a At Hesperia, Riverside, and Temecula.
b At Barstow and Thermal.
c At Hesperia, Riverside, and Thermal.
d At Barstow and Temecula

2.2.3.2 Surface Meteorological Instruments

Ten meter surface meteorological towers were installed at Barstow, Hesperia, Temecula, and Thermal. At the Riverside site, surface meteorological sensors were mounted on top of a building adjacent to the radar profiler. Wind speeds and wind directions were measured at the 10-m level on each of the ten meter towers. The temperature and relative humidity sensors were mounted in a motor-aspirated radiation shield at about 2 m agl. The pressure sensors were installed inside the data logger enclosures. In addition, at Barstow, a solar radiation sensor was also mounted at about 2 m agl and a tipping bucket rain gauge was installed on concrete blocks approximately 3 to 5 m from the tower.

The surface meteorological sensors that were used and their specifications are listed in Table 3. It should be noted that the specifications shown are quoted from the respective manufacturer's product literature.

The parameters measured by the surface meteorological stations are listed in Table 4. The data quality objectives for the surface meteorological data are listed in Table 14.

Table 3. Specifications of sensors used on the meteorological towers.

Site ID	Measured Parameter	Sensor Manufacturer	Sensor Model	Sensor Specifications	
BTW	Wind Velocity	R.M. Young	05305-AQ	Accuracy: Range:	±0.07 m/s 0-60 m/s
BTW	Wind Direction	R.M. Young	05305-AQ	Accuracy: Range:	±2° 0-360°
HPA, RSD, TML, TCL	Wind Velocity	Met One	010B	Accuracy: Range:	±0.2 m/s 0-50 m/s
HPA, RSD, TML, TCL	Wind Direction	Met One	020B	Accuracy: Range:	±3° 0-540°
BTW	Temperature	Climatronics	(P/N 100093-3)	Accuracy: Range:	±2° 0-360°
HPA, RSD, TML, TCL	Temperature	Met One	060A	Accuracy: Range:	±0.1°C ±50°C
BTW	Relative Humidity	Vaisala	HMP35	Accuracy: Range:	±4% RH 0-100% RH
HPA, RSD, TML, TCL	Relative Humidity	Met One	083C	Accuracy: Range:	±3% RH 0-100% RH
BTW	Solar Radiation	Licor	Li-200S	Accuracy: Range:	±5% 0-1400 W/m²
BTW	Pressure	Vaisala	PTB101B	Accuracy Range:	(20°C): ±0.5 mb 600-1060 mb
BTW	Precipitation	Sierra-Misco	2500	Accuracy:	±3% for rain rates of 1-6"/hr

Table 4. List of surface meteorological parameters measured at each site.

Parameter	Barstow	Hesperia	Riverside	Temecula	Thermal
Scalar wind speed	X	X	X	X	X
Scalar wind direction	X	X	X	X	X
Resultant wind speed	X	X	X	X	X
Resultant wind direction	X	X	X	X	X
Standard dev. of wind dir.	X				
Temperature	X	X	X	X	X
Dew point temperature	X				
Relative humidity	X	X	X	X	X
Atmospheric pressure	X				
Total solar radiation	X				
Precipitation	X				

Table 5. Data quality objectives for the surface meteorological stations.

Parameter	Data Quality Objective
Wind speed	±0.25 m/s (ws ≤5 m/s) ±5% (ws > 5 m/s)
Wind direction	±5 degrees
Temperature	±1.0°C
Equivalent dew point temperature[a]	±1.5°C
Atmospheric pressure	±0.5" Hg ±16.9 mb
Solar radiation	±0.1 Ly/min ±69.7 W/m^2
Precipitation	±10%

[a] Computed from pressure, temperature, and humidity.

2.2.4 Methodology

2.2.4.1 Upper-Air Data

Data Acquisition

Data from each of the five radar profiler sites were downloaded on a daily basis to STI's operations center by executing an automated process on the Hub computer. During this process, the Gateway computer at each site was called via modem, and the previous day's data were downloaded. STI staff reviewed the data each day to verify that all data had been retrieved. If the data were not received from a site, STI staff immediately called the site to determine the cause of the problem and to take corrective actions as required. The communications software on the Gateway computer at each site allowed STI staff to remotely diagnose potential problems with the profiler, change the profiler operating parameters, re-start the profiler, and re-boot either the radar or the Gateway computers. In some cases, STI summoned the operators to the site to perform repairs that could not be performed remotely. Once all the files were received and properly archived, their receipt was recorded in a QC log. Problems with instruments or missing data were also noted in the log.

The site operators sent copies of the moments and consensus data to STI approximately bi-weekly. Receipt of these data were recorded on a log form, and backup copies were made on an Iomega zip diskette. A copy of the data sent to STI by the site operators was stored in the operations center, with a backup copy stored offsite.

Data Processing and Quality Control

Once the data files were stored on the Hub computer, they were automatically subjected to quality control screening software and plotted. Plots of the radar profiler wind and the RASS virtual temperature data were reviewed daily for any problems. If any problems were encountered using this review, corrective actions were initiated as quickly as possible.

2.2.4.2 Surface Meteorological Data

Data Acquisition

At each site the radar profiler's Gateway computer was programmed to retrieve data from the data logger and to perform some preliminary processing. At approximately 20 minutes past each hour, the Gateway computer automatically downloaded the previous hour's 60-minute averaged data. If for any reason communications between the Gateway computer and the data logger had been interrupted (e.g., as a result of power failure), the Gateway computer transferred all the data accumulated since the last download. The 60-minute averaged data were written to a single data file on the Gateway's hard disk.

The Hub computer located at the STI operations center was programmed to automatically call the Gateway computers at each site every night to retrieve the surface meteorological data. During these calls, the Hub computer downloaded the surface data files and stored them on its hard disk. The ZMODEM protocol was used to transfer only data that had been appended to each file since the previous file transfer to STI.

Data Processing and Quality Control

Once the data files were stored on the Hub computer, STI staff used an STI-developed program called SurfDat to perform post-processing activities and quality control (QC) screening of the observations. On a daily basis, STI performed the following tasks:

- The surface data files were imported into SurfDat and converted to STI's common data format (CDF) for surface meteorological data; this step was performed automatically each night after all the sites had been polled and the data for the previous day retrieved.

- Once in SurfDat's common data format, SurfDat was used to plot all the parameters. These plots were produced automatically each night.

- STI staff reviewed the data files and the plots each morning to verify that all the data had been retrieved; if any calls had not gone through during the night, a data technician determined the cause of the problem and retrieved the data manually as soon as possible. The technician then posted the plots in STI's operations center so that they could be reviewed by STI meteorologists.

- An STI meteorologist reviewed the data plots (and data files, as appropriate) each morning to determine the operational status of the sites. If the reviewer found a problem (e.g., an apparently damaged relative humidity sensor), he contacted the site operator to determine the cause of the problem. Once the cause of the problem had been determined, corrective actions were taken as quickly as possible (e.g., replacement of a damaged sensor).

Once the data had been converted to STI's CDF, plotted, and reviewed, they were said to be at Level 0 validation, meaning that they were ready to be subjected to formal quality control screening and validation procedures. STI's CDF for surface meteorological data included "place holders" for QC codes for each data point, which were assigned as the data moved through the data validation process. These QC codes are defined in Table 6.

The next step in STI's quality control procedures was to perform what is referred to as Level 0.5 review of all data. Level 0.5 review meant that the data were subjected to automatic, quantitative QC screening, wherein the data were compared to expected values or ranges of values. These tests were performed by the SurfDat program; they involved comparing the observations to threshold values or performance criteria that were based on EPA guidance (U.S. Environmental Protection Agency 1987, 1989). The types of tests that were performed included comparing observations to expected minimum and maximum values; checking that rates of change with time did not exceed expected conditions or instrument performance characteristics; and comparing observations to climatological data.

Level 0.5 review of the surface meteorological data were performed monthly. Before the data were subjected to automatic QC screening, STI staff made sure that all data were in the CDF format and that the data set for each site was complete. Each data set was then processed by SurfDat's automatic QC screening functions. The results of the automatic screening were reported in a log file, which reviewers used to help them assess the quality and accuracy of the observations. In addition, the QC codes of the data points that failed to pass SurfDat's screening tests were set to indicate to reviewers that they should examine those observations carefully. Data that failed the QC tests were displayed by SurfDat (both on screen and in hard-copy versions) using colors different than those used to display data that passed the tests. After the Level 0.5 review was completed, new copies were made of each data file; backup copies were also maintained of all the Level 0.5 data files.

Table 6. Quality control (QC) codes used in the surface meteorological database.

QC Code	QC Code Name	Definition	Content of Data Field
0	Valid	Observations that were judged accurate within the performance limits of the instruments.	Data value
1	Estimated	Observations that required additional processing because the original values were suspect, invalid, or missing. Estimated data may be computed from patterns or trends in the data (e.g., via interpolation), or they may be based on the meteorological judgment of the reviewer.	Data value
2	Calibration applied	Observations that were corrected using a known, measured quantity (e.g., instrument offsets measured during audits).	Data value
5	Failed automatic QC check	Observations that were flagged with this QC code did not pass screening criteria set in the automatic QC software.	Data value
6	Failed audit criteria	Observations made by instruments or sensors which failed an audit.	Data value
7	Suspect	Observations that, in the judgment of the reviewer, were in error because their values violated reasonable physical criteria or did not exhibit reasonable consistency, but a specific cause of the problem was not identified (e.g., excessive change of temperature over a given time period). Additional review using other, independent data sets (Level 2 validation) should be performed to determine the final validity of suspect observations.	Data value
8	Invalid	Observations that were judged inaccurate or in error, and the cause of the inaccuracy or error was known (e.g., relative humidity greater than 100 percent).	-980
9	Missing	Observations that were not collected (because the meteorological station or individual sensor was not operating).	-999

The next step in the validation of the surface meteorological data was to have STI staff manually review the data, which is referred to as performing Level 1.0 quality control screening and data validation. Level 1.0 validation of the observations involved qualitative review of the observations by STI staff, who were thoroughly familiar with instrument characteristics and with the meteorological conditions expected to be contained in the data. Any changes to the data required as a result of the audit findings were incorporated into the data sets during the Level 1.0 validation process. The data plots and on-screen displays provided by SurfDat were used to perform Level 1.0 validation.

The reviewer always checked the data to confirm or reject automatic QC code settings made by SurfDat during the Level 0.5 review (data that failed the automatic QC screening tests were flagged as suspect by SurfDat). In some cases, the reviewer reversed SurfDat's actions because the screening criteria used by the program were too stringent and valid data had been erroneously flagged. Once the Level 1.0 review was completed, new versions of the data files were produced and backup copies were made as well. A complete backup of all the data was maintained both at STI's office and offsite.

Final Data Formats

The data comprising the deliverable database for the SCOS 1997 project were raw upper-air moments data and Level 1.0 QC'd surface meteorological data.

Upper-Air Data File Formats

The upper-air data were delivered in the raw moments data format. The moments files contain individual 20-30 second wind profiles with information about the Doppler shift, the spectral width, the noise power, and the signal-to-noise ratio measurements. The moments data consist of two types of files: header and data. The header files contain project and site specific information and the data files contain the actual data. These files are in a binary format and are produced by the radar software. The combined size of the header and data moments files are approximately 1000 to 1500 KB per day. The moments file naming convention is:

DYYJJJA.MOM (moments data)
HYYJJJA.MOM (moments header)

Where:

D = Data file
H = Header file
YY = Year
JJJ = Julian day
A = File sequencer in 1 MB steps
.MOM = Extension for moments files

For example a moments data file named "D97011A.MOM" would contain data for January 11, 1997. This file naming convention does not indicate from which site the data come. The delivered moments data were sorted by site using a directory structure based on each of the profiler sites' three letter site identifier (i.e., BTW = Barstow, HPA = Hesperia, RSD = Riverside, TCL = Temecula, and TML = Thermal).

Surface Meteorological Data File Formats

The surface meteorological data were delivered in the STI common data format (CDF) for surface data. This CDF format is an ASCII space separated format. The STI naming convention for the CDF format is

iiiH_V.CDF

where:

iii = Three letter site identifier

BTW = Barstow
HPA = Hesperia
RSD = Riverside
TCL = Temecula
TML = Thermal

H = Hourly averaged data

V = Validation Level

a = Level 0.0
b = Level 0.5
c = Level 1.0

.CDF = STI's common data format extension for surface data

For example, a file named "btwh_c.cdf" would contain Level 1.0 validated, hourly averaged data from Barstow in STI's common data format for surface data. Each surface data file consists of two parts: a header section and a data section. The header section is at the beginning of the file and consists of five subsections. These subsections describe: 1.) project information, 2.) station information, 3.) file information, 4.) raw file information, and 5.) data field definitions. The first two lines of the data section show the names and units for all of the data fields.

2.3 QA/QC Procedures

2.3.1 Profiler System and Performance Audits

To fulfill the SCOS 1997 quality assurance requirements, system and performance audits were conducted for the wind profiler and RASS at the Temecula site. The audits were conducted on June 21 and 22, 1997. The following text briefly describes how the system and performance audits were performed, and addresses all of the audit results that either affected the data quality or the method by which the data were collected.

<u>System Audit</u>

The system audits included a complete review of the study's quality assurance plan and the station's standard operating procedures. In addition, the following items were checked in conjunction with the system audits:

- The radar profiler antenna and controller interface cables were inspected for proper connection.
- The orientation of the phased-array antenna was checked. This was performed using a solar siting technique. The measured orientation of the antenna was compared to the system software settings. The antenna alignment criteria was ±2°, which is consistent with the wind direction vane alignment criteria required by the U.S. Environmental Protection Agency (1995).
- The level of the antenna was verified. The audit criteria was that the antenna must be within ±0.5° of vertical.
- "Vista" diagrams (Lindsey et al., 1995) were prepared documenting the surroundings of the site in 30° to 45° increments.
- The controller and data collection devices were checked to ensure that the instruments were operating in the proper mode and that the data being collected were those specified in the SOP.
- Station log books and checklists were reviewed for completeness and content to ensure that the entries were commensurate with the expectations in the SOP.
- The site operators were interviewed to determine their knowledge of the system operations and maintenance.
- The antenna and RASS enclosures were inspected for structural integrity as well as for signs of debris or animal or insect nests that may have caused drainage problems in the event of rain.
- Preventive maintenance procedures were reviewed for adequacy and implementation.

- The time clocks on the data acquisition systems were checked and compared to the National time standard. The audit criterion for all the clocks was within ±2 minutes of the reference time.

- Data collected over a several-day period were reviewed for reasonableness and consistency. The review included vertical consistency within given profiles and temporal consistency from period to period. Special attention was given to the possibility of ground clutter affecting data recovery and data quality.

Performance Audit

Performance audits of the radar profiler and RASS at the Temecula site were conducted by Aerovironment on June 21-24, 1997. The purpose of this audit was to assess how well the instruments met the data quality objectives for accuracy and precision established for the SCOS 1997 field study. However, determining the absolute accuracy of an upper-air instrument through an inter-comparison study is difficult because there is no "reference" instrument that can provide a known or true value of the atmospheric conditions. This is due in part to the large volume of air sampled by the upper-air systems and to inherent uncertainties caused by meteorological variability, spatial and temporal separation of measurements, external and internal interference, and random noise. Precision is a measure of mutual agreement among individual measurements of the same property under similar prescribed conditions.

No direct inter-comparisons were performed on the SCOS 1997 profilers or RASS other than the audits performed by Aerovironment at the Temecula site. However, comparisons from previous studies, as reported by Lindsey et al. (1995) and others, can be used to estimate the systematic differences (accuracy) and comparability (precision) of the SCOS 1997 systems. Comparisons between radar wind profilers and either Doppler acoustic sounders or rawinsondes have been performed in prior studies. The ranges of typical results from prior studies are shown in Table 7.

Table 7. Published comparisons of radar profiler and RASS performance.

Observable	Mean Difference	rms Difference
Wind speed (m/s)	0.5 - 1.4	2.1 - 2.9
Wind direction (degrees)	1 - 6	18 - 24
Virtual temperature (°C)	0.5 - 1.3	0.8 - 1.4

Audit Results

The performance audit of the Temecula profiler was conducted using a portable Aerovironment Model 2000 sodar and a VIZ W-9000 rawinsonde sounding system. Two rawinsonde launches were performed and the sodar was operated for a 48 hour period. Comparisons of the sodar and radar wind profiler high mode wind data were not possible due to the high mode data beginning above the vertical range of the sodar. The performance audit results showed that the data collected by the radar wind profiler, the Doppler sodar, and the rawinsonde system agreed well within the audit criteria. The detailed findings of the performance audit for the radar profiler at the Temecula site can be found in Barnett and Baxter, 1998.

All of the profiler and RASS instruments passed the system audit criteria established for the SCOS 1997 air quality study. Many of the findings that were made during the audits were either addressed at the time of the audit or as soon as possible after the completion of the audit.

Network-Wide Problems

A few systematic problems occurred during the study that reduced data recovery at the sites. These problems included:

- Interference from migrating birds. Migrating birds have been tracked by NWS weather radars for many years (Gauthreaux Jr., 1970). Recently, the profiling community has discovered that migrating birds can contaminate profiler signals and produce biases in the profiler's wind speed and direction measurements (Wilczak et al., 1995). Birds act as large radar "targets," thus signals from birds can overwhelm the weaker atmospheric signals. Consequently, the radar profiler measures bird motion instead of atmospheric motion. Migrating birds have no effect on RASS. Birds generally migrate year round, with peak migrations occurring during the spring and fall months. In the northeastern United States, most birds start migrating after sunset and continue until midnight or early morning. Most of the "bird" contamination in the 1997 data set occurred in mid- to late August. Winds contaminated by birds were flagged as invalid during the quality control process, which is described in Section 4.1. Staff at NOAA have developed signal-processing software to minimize the effects of migrating birds on profiler data, which was used during the 1997 study at all the sites except Rutgers. These new algorithms helped to reduce the number of data points contaminated by migrating birds.

- Precipitation. Radar profilers operating at 915 MHZ are sensitive to precipitation. During rain, the radar profiler measures the motion of the rain drops. Typically, precipitation interference causes the entire wind profile to fail the consensus test because the rain introduces large variations in the winds measured during that hour. Winds may pass the consensus test and be representative of atmospheric motions when the precipitation is steady (e.g., stratiform rain). Winds measured during precipitation were considered valid unless they violated the quality control criteria used in the data validation process discussed in Section 4.1.

- Vertical velocity correction for RASS. During convective periods, strong updrafts or downdrafts (>1 m/s) can produce an apparent, but artificial warming or cooling in a RASS temperature profile. As a rule of thumb, a vertical velocity of 1.0 m/s can alter a virtual temperature observation by 1.6°C. During the data validation process, virtual temperature data affected by this problem were flagged with the appropriate quality control (QC) codes.

- A bug in the profiler software occasionally caused a memory overflow error during RASS sampling that left the profiler in the RASS mode indefinitely. This problem occurred at several sites sporadically during the study, and was corrected by restarting the system. Wind and temperature data were lost when this problem occurred. Newer versions of the profiler software have corrected this problem.

Site-Specific Problems

Periods of downtime were typically due to factors such as software failures, operator error, or computer and instrument failures. In addition to unforeseen downtime, the profilers were periodically down for about 1 hour for scheduled maintenance. Tables 8 through 12 list the dates when problems occurred, system configurations were changed, or events adversely affected data recovery and/or data quality. The following text discusses downtimes that resulted in significant losses of data at each site.

Table 8. Summary of known problems and events that affected data recovery and/or data quality at the Barstow (BTW) profiler site.

Date(s)	Time(s) PST	Problem or Event	Effect on Data
6/17/97	0900-1000	Audits performed	Missing Wind and T_v data
7/8/97	0700-0800	Routine maintenance	Missing Wind and T_v data
7/15-7/16/97	1000-0900	Software malfunction	Missing Wind and T_v data
7/25/97	0000-1100	Bad fuse	Missing Wind and T_v data
7/28/97	0300-0700	Hardware Malfunction	Missing Wind and T_v data
8/11/97	0900, 1200	Routine maintenance	Missing Wind and T_v data
8/18-8/28/97	0000-1700	Hardware malfunction: phase shifter and final amp replaced	Missing Wind and T_v data
8/29/97	0900-2300	Hardware repair	Missing Wind and T_v data
8/31-9/6/97	0000-1000	Spectral data archived	No effect
9/6/97	0000-1000	Radar hard-disk full	Missing Wind and T_v data
9/11/97	0700-0800	Unknown	Missing Wind and T_v data
10/10-10/11/97	0600-2300	Radar hard-disk full	Missing Wind and T_v data

Table 9. Summary of known problems and events that affected data recovery and/or data quality at the Hesperia (HPA) profiler site.

Date(s)	Time(s) PST	Problem or Event	Effect on Data
6/16-6/27/97	0000-1200	No power to site	Data invalid
8/10/97	0100-1700	Break-in (equipment stolen)	Missing Wind and T_v data
8/19-8/21/97	1800-1900	Unknown	Missing Wind and T_v data
9/14/97	1800-2300	Unknown	Missing Wind and T_v data
9/15/97	0000-1300	Unknown	Missing Wind and T_v data
9/18/97	1600	Routine Maintenance	Missing Wind and T_v data
10/16/97	0000-2400	Site shutdown	Data invalid

Table 10. Summary of known problems and events that affected data recovery and/or data quality at the Riverside (RSD) profiler site.

Date(s)	Time(s)	Problem or Event	Effect on Data
6/8-7/10/97	0000-0800	Hardware malfunction: short in cable between phase shifter and final amp	Data invalid
7/17/97	0000-1200	Operator error	Missing Wind and T_v data
7/30/97	1600, 1700	Routine Maintenance	Extra data
9/12/97	1700, 1800	Routine Maintenance	Missing Wind and T_v data
10/16/97	0000-2400	Site shutdown	Missing Wind and T_v data

Table 11. Summary of known problems and events that affected data recovery and/or data quality at the Thermal (TML) profiler site.

Date(s)	Time(s) PST	Problem or Event	Effect on Data
6/13-6/26/97	0000-2400	No power to site	Data invalid
7/21/97	1600-1700	Routine Maintenance	Missing Wind and T_v data
8/5/97	1500-1800	Power Outage	Missing Wind and T_v data
8/10/97	1700	Routine Maintenance	Missing Wind and T_v data
8/25/97	1500	Routine Maintenance	Missing Wind and T_v data
9/15/97	0500-0600 1200, 1500	Unknown	Missing Wind and T_v data
9/15/97	1300-1400	Unknown	Missing Wind and T_v data
9/19/97	1200-1500	Computer malfunction	Missing Wind and T_v data
9/24/97	0200-0400 0600, 0800, 1600	Unknown	Missing Wind and T_v data
10/16/97	0000-2400	Site shutdown	Data invalid

Table 12. Summary of known problems and events that affected data recovery and/or data quality at the Temecula (TCL) profiler site.

Date(s)	Time(s) PST	Problem or Event	Effect on Data
6/11/97	1100	Unknown	Missing Wind and T_v data
7/17/97	0900	Unknown	Missing Wind and T_v data
7/17-7/18/97	1700-0900	Computer clock offset by 12 hrs	Missing Wind and T_v data
8/1/97	1300-2000	Power outage due to high temps (thermistor)	Missing Wind and T_v data
8/2/97	1200-2100	Power outage due to high temps (thermistor)	Missing Wind and T_v data
8/3/97	1200-2000	Power outage due to high temps (thermistor)	Missing Wind and T_v data
8/4/97	1100-1900	Power outage due to high temps (thermistor)	Missing Wind and T_v data
8/5/97	1100-1400	Power outage due to high temps (thermistor)	Missing Wind and T_v data
8/5/97	2000	Unknown	Missing Wind and T_v data
9/8/97	1000, 1300-2300	Software problems	Missing Wind and T_v data
10/9/97	1000-1100	Routine Maintenance	Missing Wind and T_v data

2.3.2 Surface Meteorological System and Performance Audits

To fulfill the SCOS 1997 quality assurance requirements, Aerovironment conducted audits of all of the surface meteorological instruments. At each site, the audits were broken into two parts, a system audit and a performance audit. The following text describes how the system and performance audits were conducted, and addresses all of the audit results that either affected the data quality or the method by which the data were collected.

System Audit

The following items were checked during the system audits:

- The alignment of the wind sensors was verified. This was performed using a solar siting technique. The alignment criteria was ±2°.
- The level of the solar radiation sensor was verified.
- Station log books and checklists were reviewed for completeness and content to ensure that the entries were commensurate with the expectations in the SOP.
- The site operators were interviewed to determine their knowledge of the system operations and maintenance.
- Preventive maintenance procedures were reviewed for adequacy and implementation.
- The time clocks on the data acquisition systems were checked and compared to the National Time Standard in Boulder, Colorado. The audit criteria was ±2 minutes.
- Data collected over a several-day period were reviewed for reasonableness and consistency.

Performance Audit

The performance audits were conducted to determine as completely as possible whether or not the instruments were producing data that met the SCOS 1997 data quality objectives. To do this, certified collocation transfer standards were used to audit the ambient temperature, relative humidity, and the atmospheric pressure sensors. To audit the wind speed, wind direction, and precipitation sensors, direct conversion techniques were used. Direct conversion techniques were implemented by applying a known input (i.e., torque, rate of rotation, or alignment) to a sensor and recording the sensor's output. All of the audit procedures used followed the recommendations of the U.S. EPA (1989).

Audit Results and Responses

Most of the surface meteorological sensors passed the performance audit criteria established for the SCOS 1997 air quality study, although a few problems were detected that required corrective action. Many of the findings that were made during the audits were addressed at the time of the audit. Some of the findings that had a lesser impact on the data were addressed at a later time.

Network-Wide Problems

One network-wide problem that affected the surface meteorological data was that from time to time the data loggers would lose their time. When this occurred, it was necessary to have the site operator manually reset the data logger times. The incorrect times that were recorded during these instances were corrected during the Level 1.0 validation of the data.

Site-Specific Problems

During the audits, a few problems were identified that affected the data. Table 13 lists the specific dates, times, and problems, and their effect on the data.

Table 13. Summary of known problems and events that affected data recovery and/or data quality at the surface meteorological sites.

Site	Date(s)	Time(s) (PST)	Problem or Event	Effect on Data
HPA	8/12/97	0800-2100	Unknown	No data
HPA	8/13-8/17/97	0800-0800	Software malfunction	No data
HPA	9/8/97	1400	Routine maintenance	No data
HPA	9/19-9/20/97	1300-0100	Hardware malfunction	No data
HPA	9/25-9/26/97	0100-0000	Software malfunction	No data
HPA	9/28-9/30/97	0100-0000	Unknown	No data
HPA	10/1/97	1400	Routine maintenance	No data
RSD	6/18-6/19/97	1400-0100	Hardware malfunction	No data
RSD	7/1-7/12/97	2300-0100	Hardware malfunction	No data
RSD	8/27/97	1500-1700	Routine maintenance	No data
RSD	9/12/97	1700-1900	Routine maintenance	No data
RSD	10/6/97	1500-1700	Routine maintenance	No data
TCL	6/21-7/1/97	0000-1400	Hardware malfunction	No data
TCL	7/6-7/7/97	0000-0100	Unknown	No data
TCL	7/17/97	0500-1800	Computer clock offset by 12 hours	All data set to invalid
TCL	8/6-8/7/97	0000-0100	Power outage due to high temperatures	No data
TCL	8/8/97	0000-1900	Software malfunction	No data
TCL	8/29-8/31/97	0000-1700	Software malfunction	No data
TCL	9/8-9/10/97	1000-0100	Software malfunction	No data
TCL	9/13-9/14/97	0000-0100	Unknown	No data
TML	7/4-8/5/97	0100-0900	Wind speed sensor malfunction	All WS data set to invalid
TML	7/9-7/10/97	0500-0100	Software malfunction	No data
TML	8/5/97	1500-2000	Power outage	No data
TML	8/10/97	1700-1900	Routine maintenance	No data
TML	8/25/97	1500-1700	Routine maintenance	No data
TML	9/24/97	2000-2200	Unknown	No data

3.0 RESULTS

Sonoma Technology, Inc. (STI) had the lead responsibility for performing Task 3, "Data Collection and Transfer," and for the overall management of the collection, processing, and distribution of the upper-air and surface data to be collected for SCOS97. Prior to the start of field operations, we worked with the SCOS97 upper-air data manager, the quality assurance (QA) manager, and other project team members to establish a data flow system that would meet the project's objectives. For example, we established sampling protocols for each of the RWP/RASS systems, which covered such items as pulse length (related to vertical resolution), maximum number of range gates (related to altitude coverage), delay times (related to the minimum altitude sampled), dwell times, spectral averaging intervals, beam sampling sequences, consensus averaging periods, etc. Likewise, we established sampling procedures and averaging intervals for the surface meteorological stations that were collocated with each RWP/RASS. In addition, we established data quality objectives (DQOs) for accuracy, precision, completeness, etc. for the surface and upper-air data (see Table 3-1 for a sample set of DQOs for the RWP/RASS and surface stations). We worked with the project's QA manager to establish procedures to monitor how well those objectives are met by the RWP/RASS and surface data.

Each of the RWP/RASS systems and surface stations were configured to sample in as close to the same manner as possible. This was to minimize any differences in the data sets that might be due solely to the use of different sampling protocols (e.g., used the same pulse lengths for each RWP/RASS so that the vertical resolution of the data was the same for all the instruments). We worked with the Meteorological Working Group (MWG) and other project personnel to ensure that our sampling configurations were consistent with those used by the other organizations collecting RWP/RASS data for SCOS97.

The profiler software operating system that runs a LAP-3000 RWP/RASS is referred to as the Profiler Online Program (POP). All of the RWP/RASS instruments deployed for SCOS97 used the latest version of POP (currently POP-4), which includes quality control algorithms to remove the effects of ground clutter contamination and migrating birds (Wilzak et al., 1995; Merritt, 1995). Additionally, we worked with the existing RWP/RASS network owners to ensure that the latest version of POP was available to them if they wanted it. The POP program controls the operation of the RWP/RASS, including the collection and computation of the samples that are used to produce the "moments" and "consensus" data. The moments data include the 20-30 second averaged values of radial velocity of air towards or away from each beam of the radar. The consensus data are the averaged profiles of winds and temperatures that are produced from the moments data (Fischler and Bolles, 1981). All of the moments and consensus data produced by POP-4 were stored on the radar computer, and on the LAP Gateway computer, which is connected to the radar computer via a local area network (LAN). The Gateway computer allows operators to communicate remotely with the site, to transfer data files to and from the site, and to remotely control profiler operations. The software that runs the LAP Gateway system was developed by STI and Radian, and so we were thoroughly familiar with all aspects of remote operations of LAP-3000 RWP/RASS systems.

Table 14. Quality assurance objectives for upper-air and surface meteorological measurements.

Parameter	Units	Collection-Averaging Period	Range	Accuracy	Precision	Data Recovery Rate (% of Possible)
Upper-Air Measurements						
Wind Speed	m/s	50-55 min.[a]	0-75 m/s	1 m/s	2.5 m/s	80% @ 1.5 km
Wind Direction	degrees true	50-55 min.[a]	0-360°	10°	20°	80% @ 1.5 km
Temperature[b]	°C	5-10 min.[a]	-40° - +40°	1°	1°	80% @ 0.7 km
Surface Measurements						
Wind Speed	m/s	Continuous - 60 min.	0-50 m/s	0.25 m/s @ speeds ≤ 5 m/s 5% of observed @ speeds > 5 m/s	1 m/s	85%
Wind Direction	degrees true	Continuous - 60 min.	0-360°	5°	5°	85%
Temperature	°C	Continuous - 60 min.	-40° - +40°	0.5°	0.5°	85%
Relative Humidity	%	Continuous - 60 min.	0-100%	0.5° as dewpoint	0.5° as dewpoint	85%

a) QA objectives for collection and averaging periods for upper-air measurements are based on operating characteristics of remote sensing systems such as radar profilers, RASS, and sodars. Collection and averaging intervals for balloon sounding systems depend on the number of soundings to be performed in a given time period.

b) If RASS is used to measure temperature, then the audit criteria are for virtual temperature.

Traditionally, for air quality studies like SCOS97, a LAP-3000 RWP/RASS is configured to sample for virtual temperature (T_v) for the first 5-10 minutes of each hour, then to sample for winds for the remaining 50-55 minutes. At the end of each set of samples, the POP program produces a consensus average of the moments data, from which the final averaged wind and temperature profiles are produced. Typically 5-10 sets of moments data from the vertical beam of the profiler are used to produce the temperature profile, and 20-30 sets of moments data (one set from each of the oblique and vertical beams of the radar) are used to compute the wind profile. In such a configuration, the POP program produces 24 averaged profiles of winds and temperatures each day. Shorter averaging intervals can be used to obtain finer time resolution. The consensus-averaged data can be downloaded from the Gateway computer to a central "hub" facility using a modem and standard telecommunications software. At the hub facility, additional quantitative and qualitative quality control (QC) screening of the data can be performed, and the data can be brought to Level 1 and Level 2 quality control validation (Lindsey et al., 1995). Typically, all of the moments data used to generate the consensus-averaged profiles are archived, and can be used to post-process the data using other averaging techniques. We have developed and followed these kinds of procedures for previous air quality studies with objectives similar to those of the SCOS97 project (e.g., Dye et al., 1995a).

For this project the radar profiler data in the LAP common data format (LAPCDF) and the surface meteorological data in STI's surface common data format (SURFCDF) were transferred at least once a day via dial-up telephone service to a hub computer located in STI's Weather Operations and Forecasting Center (WOFC). These data were used to monitor each of the profilers and surface meteorological stations operational status on a daily basis. At regular intervals raw radar profiler moments data were sent to STI by the site operators. At the end of the data collection period, the surface meteorological data were QC'd, by qualified meteorologist, to "Level 1" validation level and delivered along with the raw profiler moments data to the project's upper-air data manager via Compact Diskette (CD).

4.0 SUMMARY AND CONCLUSIONS

The SCOS 1997 radar profilers and surface meteorological towers were installed from June 2 through 13, 1997. At the conclusion of the study, data collection was terminated and all the sites were returned to their original condition. QA audits were conducted after the installation phase from June 17 through 24, 1997. All of the radar profilers and surface meteorological stations were routinely collecting data by July 4, 1997, the first intensive observation period (1OP). The upper-air and surface meteorological sites remained operational through October 15, 1997.

The profilers provided high spatial- and temporal-resolution wind profiles. Virtual temperature profiles from the RASS can be used to help determine the mixing depth. The profilers continuously monitored the winds from near the surface to a maximum height of 3.5 km AGL and the virtual temperature to a maximum height of 2.5 km AGL. Surface measurements of temperature, relative humidity, pressure, and wind speed and direction were also made to supplement the profiler data in the lowest levels.

Excerpts from monthly reports by the Principal Investigator are provided at Appendix B as a summary timeline of achievements, problems, and solutions.

5.0 REFERENCES

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APPENDIX A

Radian/STI LAP Sites' Information

RADIAN/STI LAP NETWORK

The relative locations of the five Radian/STI LAP®-3000/met sites are shown in Figure 2.

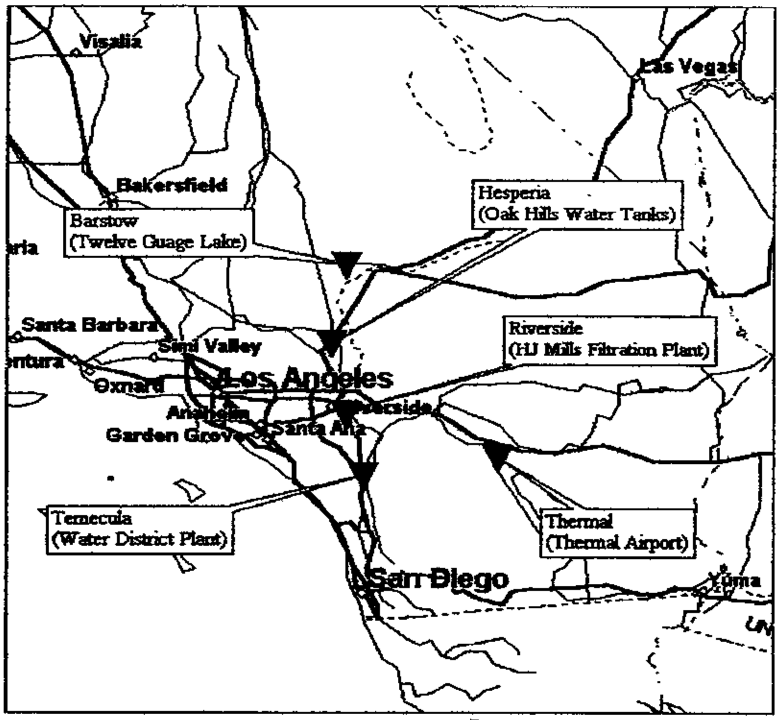

Figure 2. Radian/STI LAP® Sites Network

Following are detailed information on the individual sites to include zoom-in maps of Figure 2 locations. These zoom-in maps show the sites' relative position with respect to major and local roads and landmarks.

SCOS97 LAP/RASS/MET SITE INFORMATION

SITE NAME:	Barstow (Twelve Gauge Lake)
ESTABLISHED:	Radian International LLC (prime) and Sonoma Technology Inc. (STI)
AGREEMENT/LEASE WITH:	All American Pipeline Co. 10000 Ming Ave. Bakersfield CA 93311 Attn: Mike Madden, (805) 664-5343
SITE OPERATORS:	All American Pipeline Co. Lead: Larry Cusack (760) 247-2668
SITE POINT OF CONTACT:	Bill Koupeny (760) 256-4035
DIRECTIONS TO SITE:	This site is situated on a pipeline heater station approximately 500 feet south of state highway 58 and 1.4 miles east of Harper Lake Rd. It is 18 miles west of the I-15 & I-40 split and is about 40 miles north of Cajon Pass. From I-15 Northbound exit at Lenwood Rd and take it north approximately 6 miles to State Highway 58. Turn west (left) on 58 and go approximately 10 miles to the site which is on the south side of the highway. The highway has just divided at this point and you must turn off before reaching the site onto a desert road which takes you past the end of a fence line at which point you turn west and head for the site. Alternatively you can travel past the site to a turnaround point (possibly Harper Lake Road which is well marked) and return to the site (about 1.4 miles east of Harper Lake Rd.). Access to the site is through a gate in a cattle fence just east of the site or around the end of the fence about 1/4 mile east of the site. The site is easily recognizable from the highway because of the numerous pipes coming out of the ground and the large size of the fenced in area.
COORDINATES/ELEVATION:	117° 18' 25" W 34° 55' 23" N / 2276.48 ft (from on-site survey data plate)

EQUIPMENT SPECIFICATIONS:

- **915 MHz RWP/RASS**
  Winds
  3-beam 2 modes
  60 m resolution .124-1.443 km (25 gates) 100 m resolution .254-3.525 km (35 gates) 5-55 min consensus every hour
  RASS
  100 m resolution .135-1.275 km (20 gates) Temps 0-5 min consensus every hour

- **Surface Met**
  T,RH,WS,WD 3 m 10 sec sampling/60 min averages
  Note: vector averaged winds

- **Communications**
  Modem
  CNS and MOM files ftp'd to ET4 for ingest into data base every two weeks
  CDF files ftp'd to ET4 for ingest into data base every day

- **Data Display**
  (daily plots) www7.etl.noaa.gov/data www4.etl.noaa.gov/scosPics.html

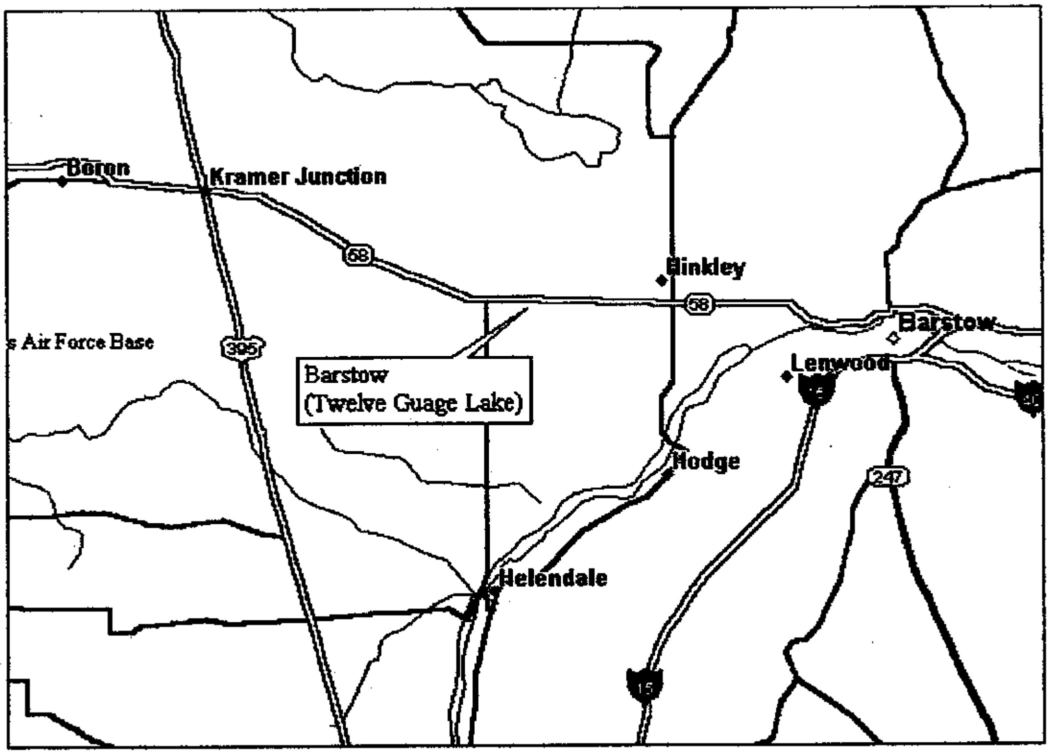

Figure 3. Barstow LAP site location with major roads and landmarks.

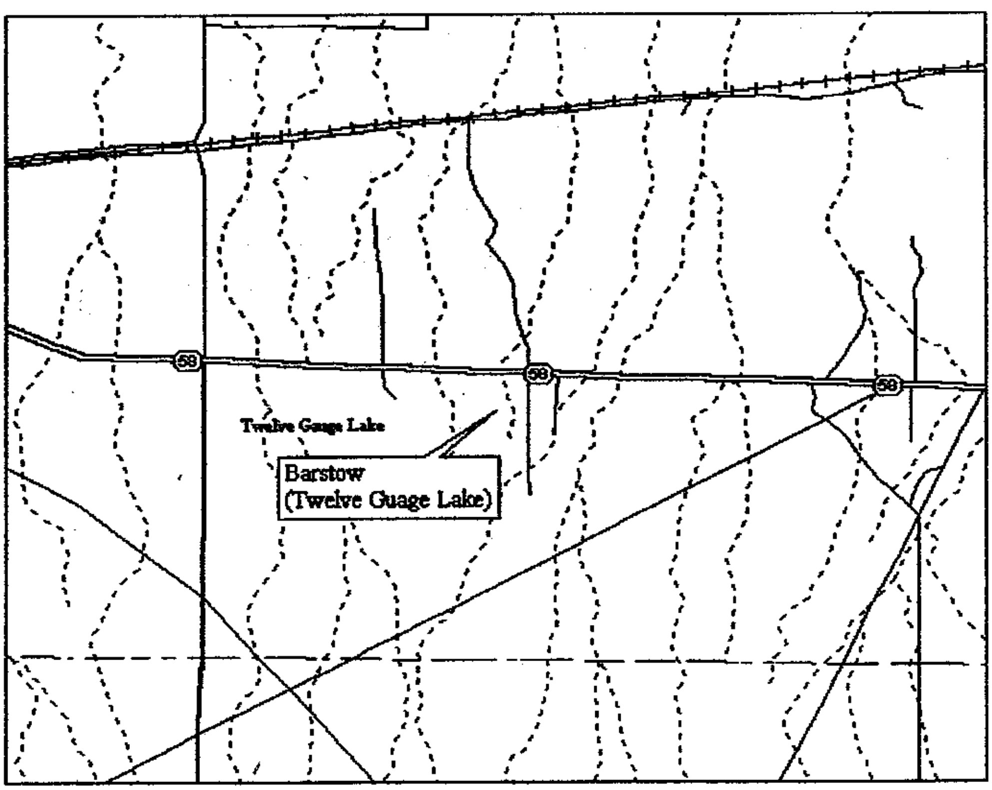

Figure 4. Barstow LAP site location with local roads and landmarks.

SCOS97 LAP/RASS/MET SITE INFORMATION

SITE NAME:	Hesperia (Next to Oak Hills Water Tanks)
ESTABLISHED BY:	Radian International LLC (prime) and Sonoma Technology Inc. (STI)
AGREEMENT/LEASE WITH:	Dr. Alvin Dunn General Partner of the I-15 Partnership 19709 Yanan Rd., Apple Valley CA 92307 (760) 247-2224
SITE OPERATORS:	Joe Guasti (760) 949-0480 and Larry Cusack (760) 247-2668
SITE POINT OF CONTACT:	Joe Guasti, Principal Operator
DIRECTIONS TO SITE:	This site is situated approximately 500 feet west of I-15, south of the US 395 exit. From Northbound I-15 take the Oak Hills Exit. Cross over to the feeder road on the west side of the Interstate and continue north for approximately 2 miles. There are two water tanks and a small building inside a fenced area just off the feeder road on a gravel road. Large wooden sign at the gravel road intersection with the feeder road indicating you are in Oak Hills. From southbound I-15 coming from Barstow or Victorville, exit at US 395, go west on the exit road passing through the US395 intersection to the feeder road. Go south approximately 2 miles. The Water tanks are on the right just past the railroad tracks (which are in a cut).
COORDINATES/ELEVATION:	117° 24' 17" W 34° 23' 29" N / Approx 3,200 ft.

EQUIPMENT SPECIFICATIONS:

- **915 MHz RWP/RASS**
  Winds
  3-beam 2 modes
  60 m resolution .120-1.429 km (25 gates) 100 m resolution .254-4.006 km (40 gates) 5-55 min consensus every hour
  RASS
  100 m resolution .120-1.260 km (20 gates) Temps 0-5 min consensus every hour

- **Surface Met**
  T,RH,WS,WD 3 m 10 sec sampling/60 min averages
  Note: vector averaged winds

- **Communications**
  Modem
  CNS and MOM files ftp'd to ET4 for ingest into data base every two weeks
  CDF files ftp'd to ET4 for ingest into data base every day

- **Data Display**
  (daily plots) www7.etl.noaa.gov/data www4.etl.noaa.gov/scosPics.html

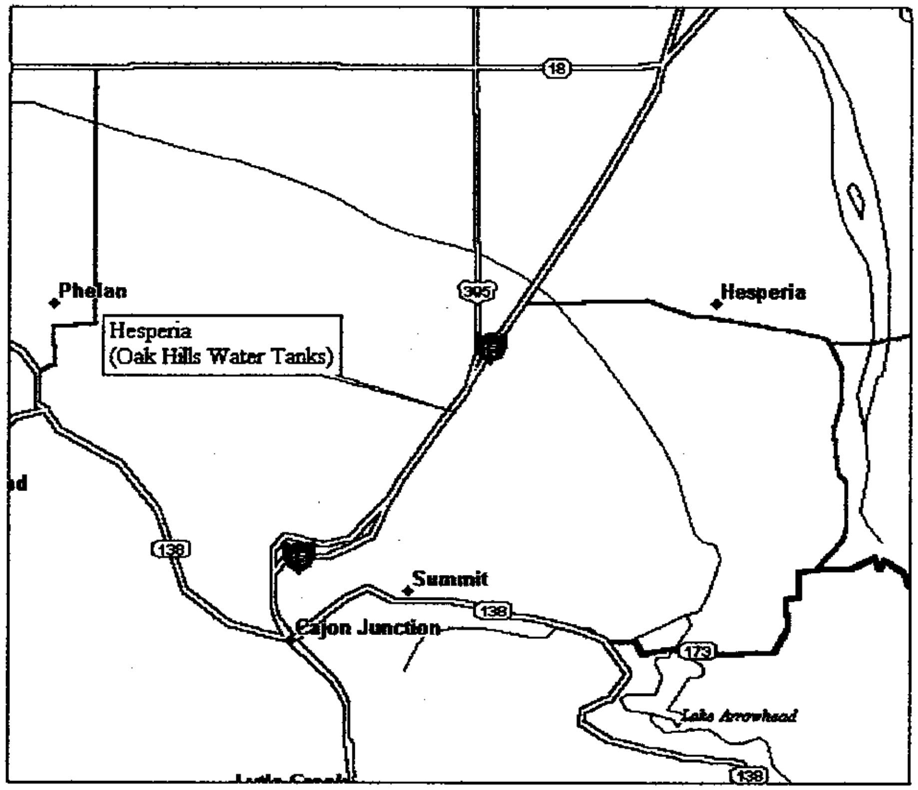

Figure 5. Hesperia LAP site location with major roads and landmarks.

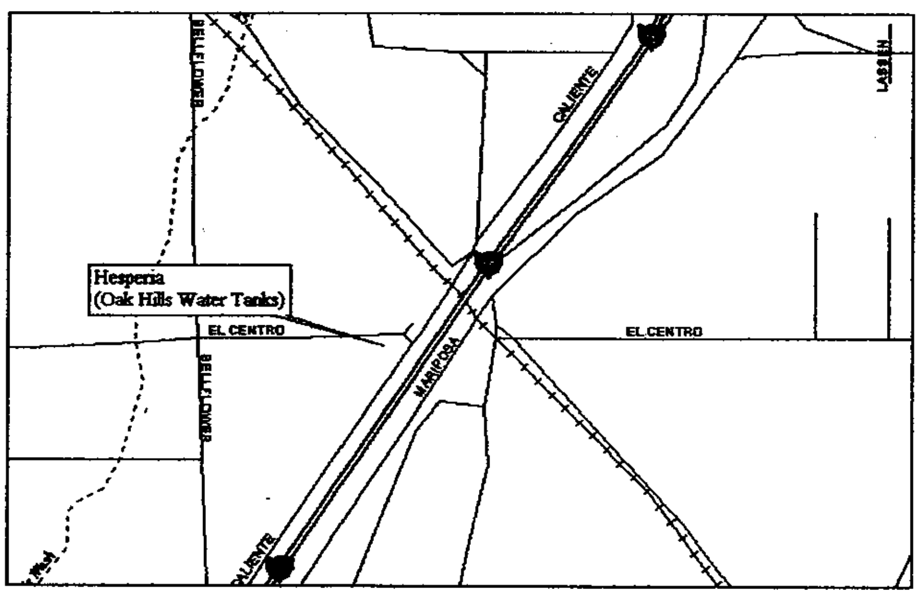

Figure 6. Hesperia LAP site location with local roads and landmarks.

SCOS97 LAP/RASS/MET SITE INFORMATION

SITE NAME:	Riverside (H.J. Mills Filtration Plant)
ESTABLISHED BY:	Radian International LLC (prime) and Sonoma Technology Inc. (STI)
AGREEMENT/LEASE WITH:	Metropolitan Water District 550 E. Alessandro Blvd., Riverside CA 92508 Attn: Paul Beswick (909) 392-2413
SITE OPERATOR:	Steve Lim (760) 251-1988
SITE POINT OF CONTACT:	Dennis Rushford (909) 780-1511
DIRECTIONS TO SITE:	The Metropolitan Water District of Southern California (MWD), a State agency, operates the Henry J. Mills Filtration Plant on a large plot of land north of Allesandro Blvd and west of I-215 in Riverside. From I-215 take the Alessandro Blvd exit. Travel west on Alessandro for approximately 1.5 miles until you reach the main gate of the Filtration Plant. Turn north (right) onto the property and through the security gate. The site is straight ahead up the hill on the left (south) portion of the property. It is 150 feet southwest of the first treatment building (approximately 3 stories tall) on the left as you get to the top of the hill. The area has earthen berms on the south and extreme west end.
COORDINATES/ELEVATION:	117° 18' 30" W; 33° 55' 00" N / Approx. 1600 ft.

EQUIPMENT SPECIFICATIONS:

- **915 MHz RWP/RASS**
  Winds
  3-beam 2 modes
  60 m resolution .110-1.429 km (25 gates) 100 m resolution .254-3.525 km (35 gates) 5-55 min consensus every hour
  RASS
  100 m resolution .120-1.260 km (20 gates) Temps 0-5 min consensus every hour

- **Surface Met**
  T,RH,WS,WD 3 m 10 sec sampling/60 min averages
  Note: vector averaged winds

- **Communications**
  Modem
  CNS and MOM files ftp'd to ET4 for ingest into data base every two weeks
  CDF files ftp'd to ET4 for ingest into data base every day

- **Data Display**
  (daily plots) www7.etl.noaa.gov/data www4.etl.noaa.gov/scosPics.html

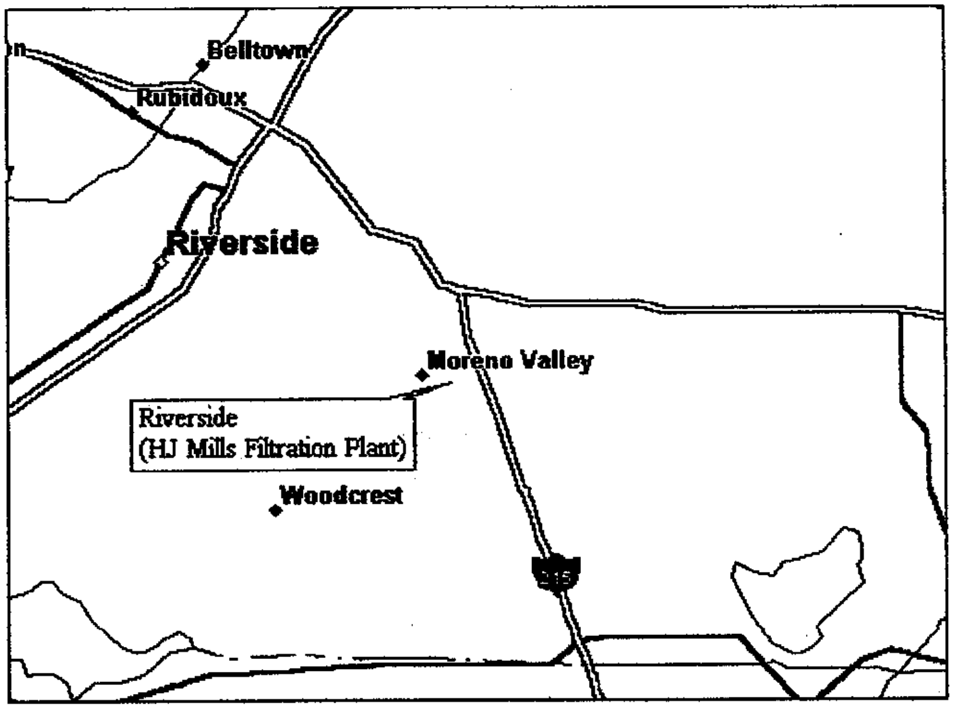

Figure 7. Riverside LAP site location with major roads and landmarks.

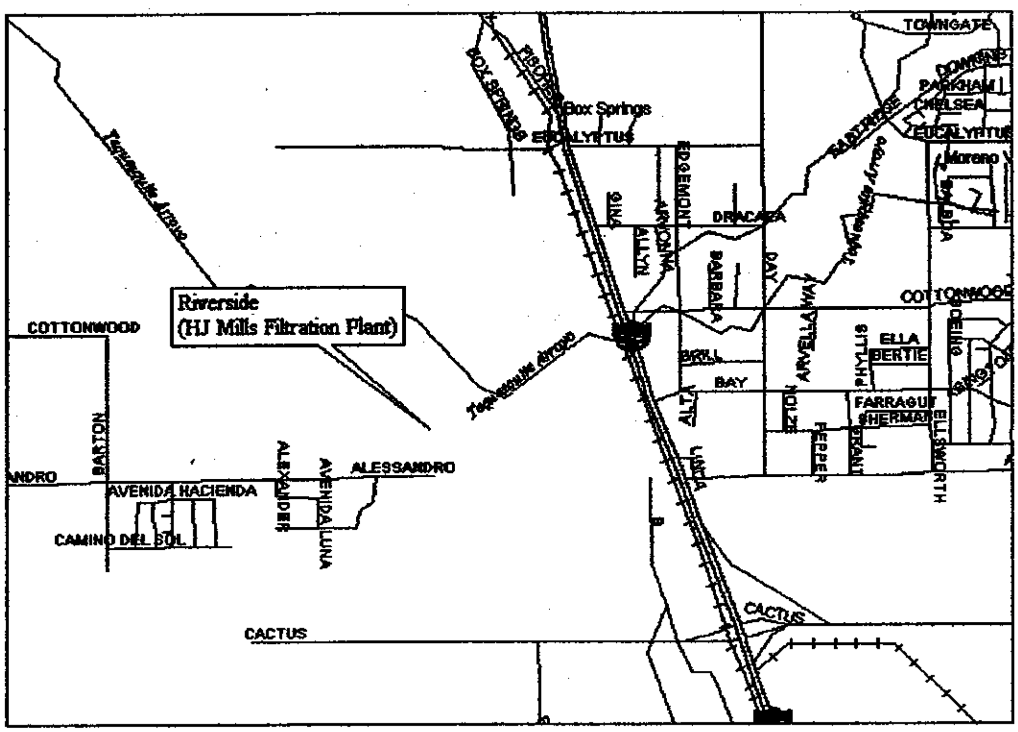

Figure 8. Riverside LAP site location with local roads and landmarks.

SCOS97 LAP/RASS/MET SITE INFORMATION

SITE NAME:	Temecula (Water District Plant)
ESTABLISHED BY:	Radian International LLC (prime) and Sonoma Technology Inc. (STI)
AGREEMENT/LEASE WITH:	Eastern Municipal Water District PO Box 8300 San Jacinto CA 92581-8300 Attn: Linda Ryder (909) 925-7676 X4266
SITE OPERATORS:	Mike Balkowski (909) 699-1895
SITE POINT OF CONTACT:	Chuck Norberg (909) 699-1895
DIRECTIONS TO SITE:	This site is located 3 miles south of the I-15 & I-215 split on an area owned by the Eastern Municipal Water District (a Riverside County entity). From I-15 take the Winchester (State Hwy 79) exit and go west approximately 1/2 mile to Diaz. Go south (left) on Diaz about a quarter mile to Avenido Alvarado. Turn west (right) on Alvarado and go about 3/4 mile to the entrance to the site which is clearly marked on the left as belonging to Eastern Municipal Water District. The road dead ends just past the entrance. Turn left onto the grounds and go to the far south end of the property. The radar will be situated in the southeast quadrant of the property in close proximity to their unused chemical building. That building houses some electronics monitoring equipment along with some unused holding tanks. It will be made available to house our electronics equipment.
COORDINATES/ELEVATION:	117° 09' 40" W 33° 30' 00" N / Approx 1,100 ft.

EQUIPMENT SPECIFICATIONS:

- **915 MHz RWP/RASS**
  Winds
  3-beam 2 modes
  60 m resolution .110-1.429 km (25 gates) 100 m resolution .254-4.006 km (40 gates) 5-55 min consensus every hour
  RASS
  100 m resolution .135-1.275 km (20 gates) Temps 0-5 min consensus every hour

- **Surface Met**
  T,RH,WS,WD 3 m 10 sec sampling/60 min averages
  Note: vector averaged winds

- **Communications**
  Modem
  CNS and MOM files ftp'd to ET4 for ingest into data base every two weeks
  CDF files ftp'd to ET4 for ingest into data base every day

- **Data Display**
  (daily plots) www7.etl.noaa.gov/data www4.etl.noaa.gov/scosPics.html

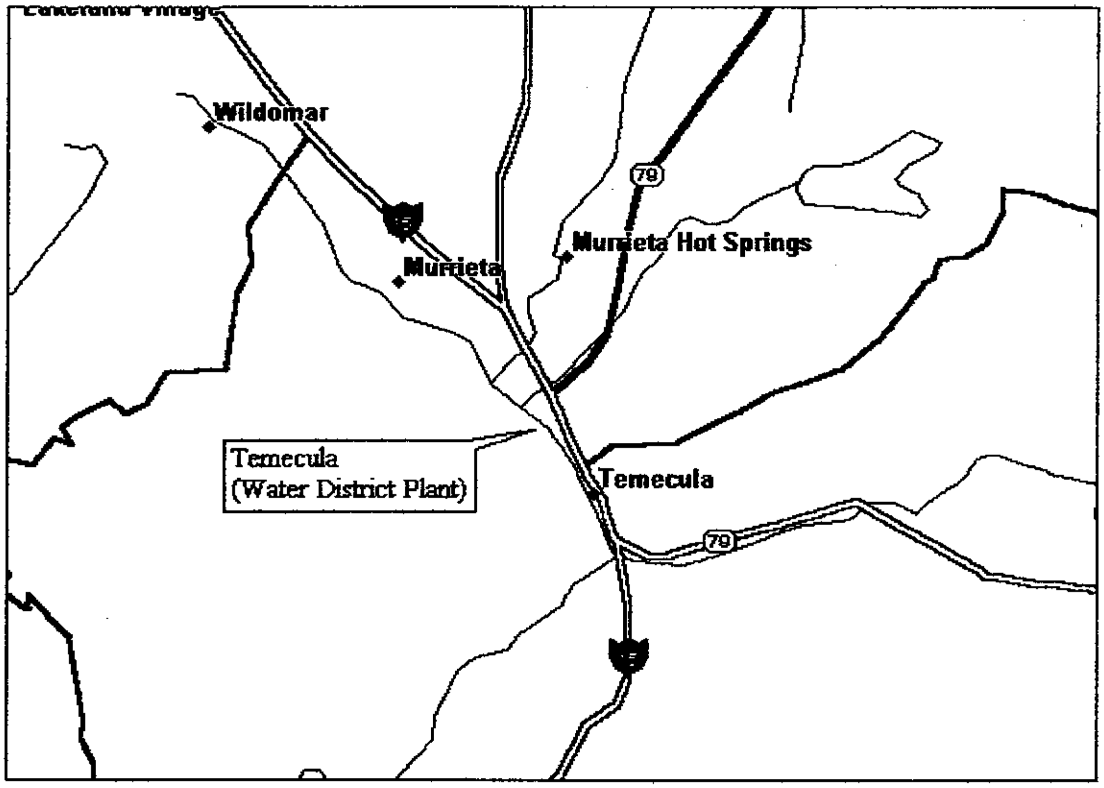

Figure 9. Temecula LAP site location with major roads and landmarks.

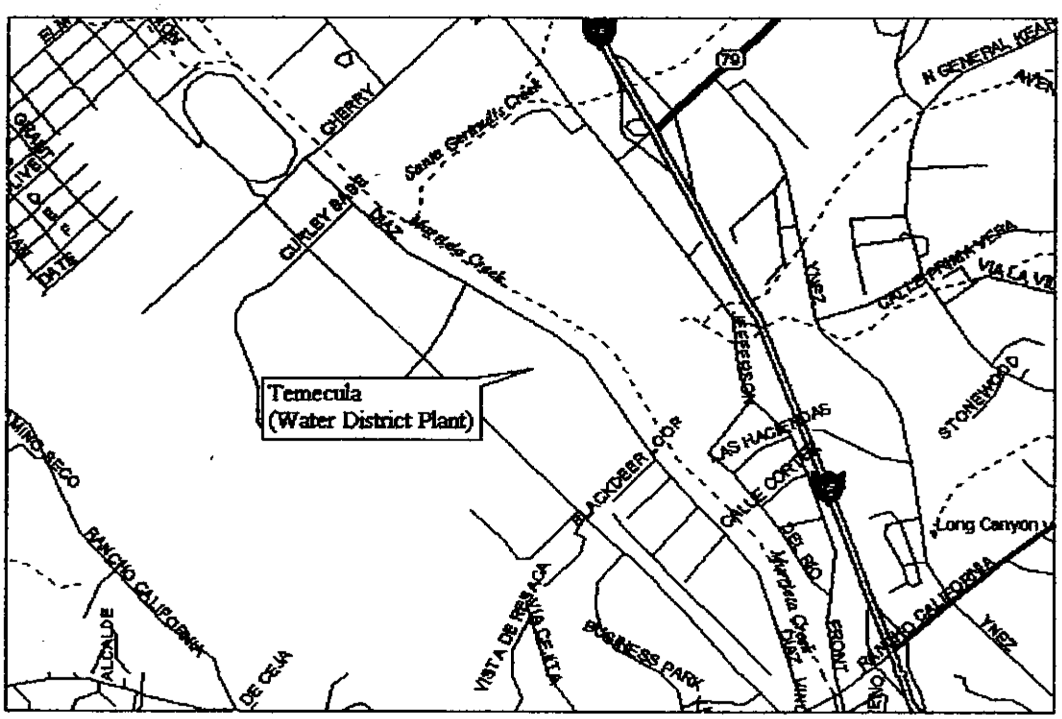

Figure 10. Temecula LAP site location with local roads and landmarks.

SCOS97 LAP/RASS/MET SITE INFORMATION

SITE NAME:	Thermal (Thermal Airport)
ESTABLISHED BY:	Radian International LLC (prime) and Sonoma Technology Inc. (STI)
AGREEMENT/LEASE WITH:	COMARCO 56860 Higgins Dr., P.O. Box 725 Thermal CA 92274 Attn: Richard Loomis (909) 596-2935
SITE OPERATORS:	Randy Bazua (760) 869-3180 [pager] Steve Lim (760) 251-1988
SITE POINT OF CONTACT:	Jake Godown (909) 696-2023
DIRECTIONS TO SITE:	From I-10 westbound through Palm Springs to Highway 111. Take Highway 111 south through Coachella to Airport Blvd. Go west on Airport Blvd about a mile to the entrance to Thermal Airport on the left (south). Go toward the main base operations building but after passing the fire station turn right (west) and follow the overhead lines into the desert area approximately 300 feet to the end of the power line. The site is immediately to the west of the end of the power line.
COORDINATES/ELEVATION:	116° 09' 35" W 33° 38' 25" N / - approximately 120 ft. below sea level

EQUIPMENT SPECIFICATIONS:

- **915 MHz RWP/RASS**
  Winds
    3-beam 2 modes
    60 m resolution .125-1.443 km (25 gates) 100 m resolution .254-4.006 km (40 gates) 5-55 min consensus every hour
  RASS
    100 m resolution .120-1.260 km (20 gates) Temps 0-5 min consensus every hour

- **Surface Met**
    T,RH,WS,WD 3 m 10 sec sampling/60 min averages
    Note: vector averaged winds

- **Communications**
    Modem
    CNS and MOM files ftp'd to ET4 for ingest into data base every two weeks
    CDF files ftp'd to ET4 for ingest into data base every day

- **Data Display**
    (daily plots) www7.etl.noaa.gov/data www4.etl.noaa.gov/scosPics.html

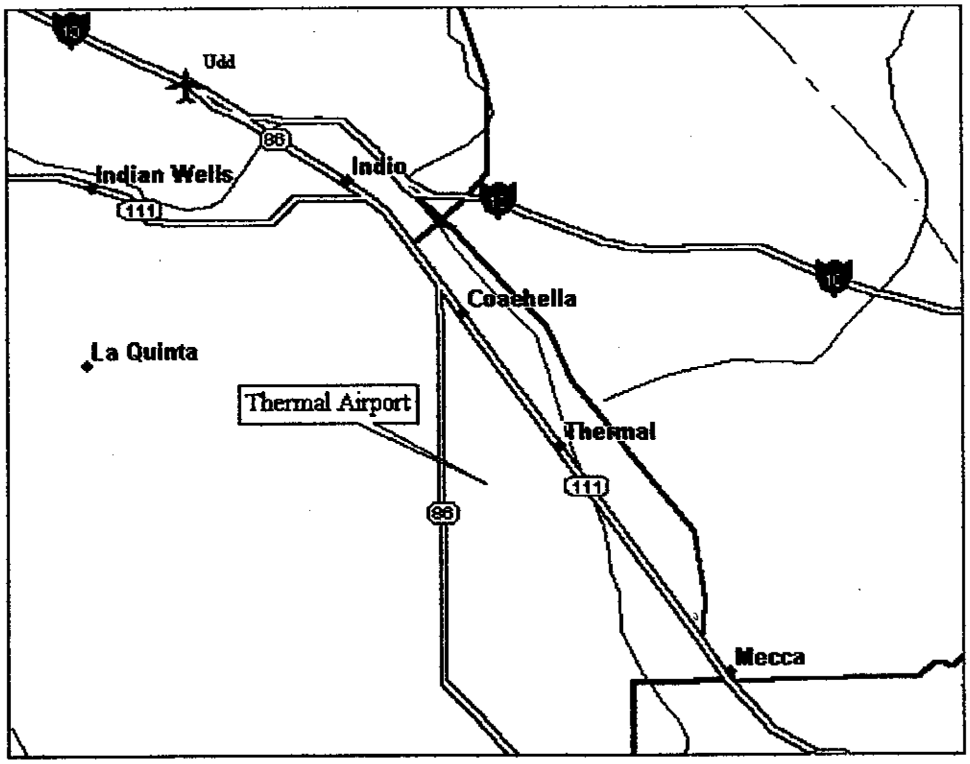

Figure 11. Thermal LAP site location with major roads and landmarks.

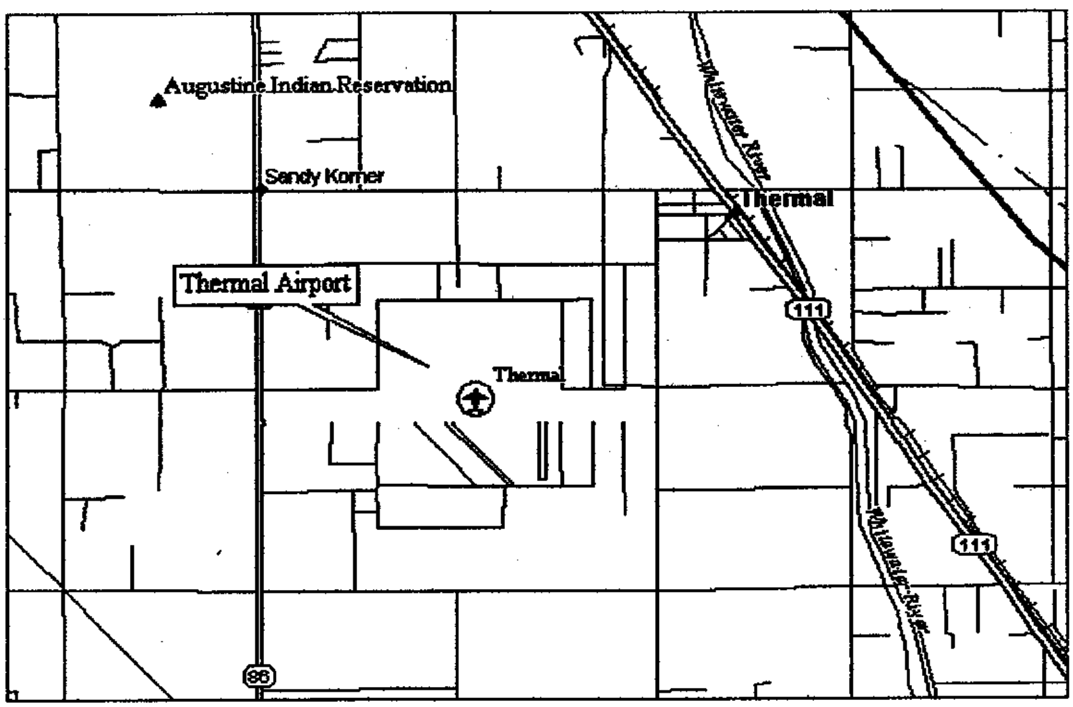

Figure 12. Thermal LAP site location with local roads and landmarks.

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APPENDIX B

Summary of Activities Accomplished by Task and Timeline

April-June 1997

Task 1

Preparation

- During this period, site surveys were completed, site preparations were completed and all 5 radar wind profilers with RASS (RWP/RASS) were installed.

- Systems audits were conducted for all sites and a performance audit was completed at Temecula.

Task 2

Operations

- All five sites were operational by the end of the quarter.

- Corrections to site audit findings were under way.

Task 3

Data Collection

- Data were being collected and stored on hard drives at each of the five sites by the end of the quarter.

- Details of data transfer were being worked with NOAA after the sites came on line.

- No IOPs were declared during the quarter although we were prepared to support them.

Problems

- Many minor problems relating to site preparation were encountered and handled during the quarter. No showstoppers were encountered.

- Audit results required us to send a technician to each site near the end of the quarter to ensure all of our equipment was performing properly and ready for IOPs.

July-September 1997

Task 1

Preparation

- During this period, all preparation tasks were complete and all systems were operational.
- Follow-up actions on system and performance audits were completed..

Task 2

Operations

- All five sites were operational by the end of the quarter.
- During the quarter all Intensive Observation Period (IOPs) were supported with data from all five sites.
- The Hesperia site accommodated the Penn State lidar during August and September.
- The Temecula site experienced record high temperatures during the middle of the quarter causing the thermal switch to shut down the radar during two IOP days. We disenabled the switch and monitored the site more closely for temperature impact on equipment—no further problems encountered during IOPs.

Task 3

Data Collection

- Data were collected and stored on hard drives and removable zip drives throughout the quarter.
- Data were transferred to the data manager in an after-the-fact mode for further processing.
- All IOPs were supported during the quarter with the only significant data problem noted above at Temecula during one IOP.

Problems

- No major problems. The Temecula thermal switch issue was addressed above.
- Audit results were addressed and suitable corrections made as required.

October-December 1997

Task 1

Preparation

- During this period, all preparation tasks were complete.

Task 2

Operations

- During this period, all operations tasks were completed.
- All five sites concluded operations on 15 Oct 98. Dismantling activity took place over the following two weeks with all sites closed and remediated by 31 Oct 98.

Task 3

Data Collection

- During this period, all data collection activities were completed.
- Final data files were transferred to NOAA for processing.

Problems

- None.

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APPENDIX C

STI's SOP

STANDARD OPERATING PROCEDURES FOR SERVICING A LAP™-3000 AND A METEOROLOGICAL TOWER

Version 1.0

STI-997171

Prepared by:

Sonoma Technology, Inc.
Santa Rosa, CA

MAY 1997

INTRODUCTION

This document provides step-by-step instructions for servicing the radar wind profiler and meteorological tower installed for the 1997 Southern California Ozone Study. Use these instructions in conjunction with the Site Logs and the Maintenance Checklist to record information during your site service visit.

SITE SERVICE VISIT FREQUENCY

The radar site should be serviced once every two weeks throughout the 1997 Southern California Ozone Study period (June 15 through October 15, 1996). If no problems are encountered, the site visit will take about one hour. You may be asked to service the site upon request when problems arise. If you have questions regarding the servicing schedule, the Maintenance Checklist, the radar, or the meteorological tower call:

Scott Ray or Joe Kwiatkowski: (707) 527-9372

SITE SERVICE VISIT TASKS

The major tasks involved in servicing the radar and tower are:

1. Recording your visit in the Site Log (see sample at end of SOP)
2. Completing the Maintenance Checklist (see sample at end of SOP)
3. Inspecting the RASS audio sources
4. Archiving the Radar's Moments and Consensus data
5. Archiving the Meteorological Tower's data
6. Stopping the Radar
7. Checking the Computer Clocks
8. Checking the Meteorological Data Logger Clock
9. Inspecting the Radar
10. Inspecting the Meteorological Tower
11. Restarting the Radar
12. Checking the Gateway Computer
13. Securing the Shelter

1. RECORDING YOUR VISIT IN THE SITE LOG

The function of the Site Log is to document everything that happens at the site. **Your first task when arriving at the site should always be to record:**

- **Date**
- **Arrival time (include the time zone, PST)**
- **Your name**
- **Reason for visit**
- **All observations**
- **Departure time (include the time zone, PST)**

As you progress through the following steps, record **all changes** in the Site Log.

2. COMPLETING THE MAINTENANCE CHECKLIST

- The Maintenance Checklist provides a place to record information during the bi-weekly site servicing. An example of a Maintenance Checklist is included at the end of this SOP.

3. INSPECTING THE RASS AUDIO SOURCES

Note: The Radio Acoustic Sounding System (RASS) only generates sound (runs) for the first five minutes of each hour.

- **Put on the ear protection**, exit the shelter, and check that all RASS sources are producing sound at approximately equal levels.
- Record your observations on the Maintenance Checklist.

WARNING:
DO NOT STAND NEXT TO RASS WITHOUT EAR PROTECTION WHILE RASS IS OPERATING

4. STOPPING THE RADAR

- On the radar computer press <Alt-Q>.
- Wait for the countdown in the bottom left-hand corner of the screen to stop.
- Press <Esc>.
- Record the down time on the Maintenance Checklist.

5. ARCHIVING THE RADAR'S MOMENTS AND THE GATEWAY'S CONSENSUS DATA

The Radar Computer stores moments data and consensus data. These data need to be backed up (archived) to prevent data losses. To archive these data you will use a Zip Drive system in conjunction with MS-Windows File Manager. To archive these data:

- On the Gateway Computer, open "File Manger".
- Go to the R:\RADAR\DATA directory.
- The moments and consensus data have the following filename formats:

Consensus filename format:

wyyjjj.cns (wind consensus data)
tyyjjj.cns (virtual temperature consesus data)

Moments filename format:

dyyjjja.mom (moments data file)
hyyjjja.mom (moments header file)

where:	**yy**	=	Last two digits of the year (96 = 1996)
	jjj	=	Day of Year
	a	=	File sequence leter that increments (a-z) when the file size reaches 1 Mbyte

- Insert a ZIP diskette into the ZIP-DRIVE.

- Using File Manager, copy all of the moments and consensus data to the ZIP disk that have been created since the last time the data were archived.

6. ARCHIVING THE METEOROLOGICAL TOWER'S DATA

To archive the meteorological tower data:

- Using "File Manager" on the gateway computer go to the C:\CSI directory, and copy the following two files to the ZIP-DRIVE:

  sssh.dat
  sssq.dat

where: sss = the three letter site identification code

BTW = Barstow	TCL = Temecula
HPA = Hesperia	TML = Thermal
RSD = Riverside	

7. CHECKING THE COMPUTER CLOCKS

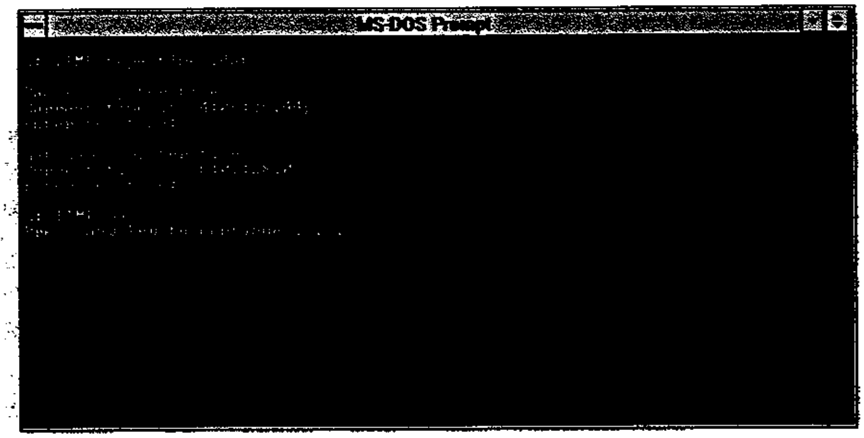
Checking the computer clocks is a very important procedure. The computer clock determines the times for which data are reported. If the computer clock is mis-set, all data will be mis-reported in time. Therefore, it is important that you take extreme care in checking and, if necessary, changing the computer clocks. Take your time and double check your work.

- Determine the time standard by calling WWV: (303) 499-7111.

Note: ***the time report on WWV is Coodinated Universal Time (UTC), which is 7 hours ahead of Mountain Standard Time (MST). To convert to MST, subtract 7 hours from the time reported by WWV.***

- Double click on the CheckTime icon.

- The following screen will appear:



- Record the time standard and the times on both the Radar and Gateway computers on the Maintenance Checklist. Calculate the difference.

- **<u>If</u> the difference on either the Radar or Gateway computers is more than ± 2 minutes, then synchronize the clocks by double clicking on:**

1. At the "Enter new time" prompt, type in the time obtained from the time standard. Use the 24-hour format type in the hours, minutes, seconds, each separated by a colon. Use the tables below to help convert 12-hr time to 24-hr time:

12 hr (PST)	Mid-night	01:00 a.m.	02:00 a.m.	03:00 a.m.	04:00 a.m.	05:00 a.m.	06:00 a.m.	07:00 a.m.	08:00 a.m.	09:00 a.m.	10:00 a.m.	11:00 a.m.
24 hr (PST)	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00
24 hr (UTC)	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00

12 hr (PST)	Noon	1:00 p.m.	2:00 p.m.	3:00 p.m.	4:00 p.m.	5:00 p.m.	6:00 p.m.	7:00 p.m.	8:00 p.m.	9:00 p.m.	10:00 p.m.	11:00 p.m.
24 hr (PST)	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
24 hr (UTC)	20:00	21:00	22:00	23:00	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00

- Note on the Maintenance Checklist and on the Site Log that computer clocks were changed and by how much they differed from the time standard.

8. CHECKING THE METEOROLOGICAL DATA LOGGER CLOCK

- Determine the time standard by calling WWV: (303) 499-7111.

  Note: the time report on WWV is Coordinated Universal Time (UTC), which is 8 hours ahead of Pacicic Standard Time (PST). To convert to PST, subtract 8 hours from the time reported by WWV.

- Double click on the Check Tower Time icon 

  Check Tower Time

- The current time of the meteorological data logger is displayed near the bottom of the screen.

- Record this time and the time standard on the Maintenance Checklist and calculate the difference between time standard and data logger time.

- **If the difference is more than ±2 minutes, do the following:**

  1. Press the **<Esc>** key: a menu will appear on screen.
  2. Press the **<K>** key.
  3. Press the **<Y>** key: for "Set data logger time to PC time?"
  4. Press the **<M>** key: the new time will appear.
  5. Press the **<Esc>** key: to exit current screen.
  6. Press the **<Q>** key: to quit program and return to Windows.
  7. Note on the Maintenance Checklist and Site Log that you changed the data logger clock and by how much it differed from the time standard.

- **If the difference is less than ±2 minutes, do the following:**

  1. Press the **<Esc>** key: to exit current screen.
  2. Press the **<Q>** key: to quit program and return to Windows.

9. INSPECTING THE RADAR

- Turn off the power to the Radar, by pressing the toggle switch on the UPS (uninterruptible power supply).

WARNING:
DO NOT INSPECT RADAR WHILE THE POWER IS ON

- Inspect each component described in the table on the following page. Record any problems, changes, or adjustments on the Maintenance Checklist. Report any problems or damage to Scott Ray or Joe Kwiatkowski at STI (707-527-9372).

Radar Checks to Perform During Maintenance Visit

Shelter:

- Look for signs of damage, animal nesting, or forced entry.
- Inspect the interior for any leakage.
- Check the air conditioner/heater.

Radar:

- Visually inspect the cables for any damage.
- Visually inspect the clutter screen assembly and support stand.
- Inspect position of antenna feet. Report any movement more than one (1) inch. Note which feet moved on the Maintenance Checklist.
- Visually inspect the 8 guy wires on the clutter screens for wear, lack of tension, or damage. Tighten loose guy wires.

- Ensure that guy-wire anchors are not loose. If they are, call STI.

- Place the ladder next to the antenna and climb high enough to visually inspect the radome and inside of clutter screens for damage.

- Visually inspect the under side of the antenna and final amplifier for any damage.

- Check level of the antenna frame with a bubble level. If the frame is more than half a bubble out of level, call STI.

RASS:

- Visually inspect the RASS support stands for wear or damage.

- Visually inspect the 3 guy wires on each RASS source for wear, lack of tension, or damage. Tighten loose guy wires.

- Place the ladder next to each RASS source and inspect the outside and inside of the enclosure, the feed horn, and the reflector for any damage.

- Remove any debris that blocks the drainage hole at the bottom of the RASS reflector.

- Visually inspect the transducer for moisture or water buildup.

- Inspect the RASS audio cables and cable connection.

- Check level of the RASS sources with a bubble level. If the frame is more than half a bubble out of level, call STI.

10. INSPECTING THE METEOROLOGICAL TOWER

Record any problems, changes, or adjustments in the bottom section of the Maintenance Checklist. Report any problems or damage to Scott Ray or Mark Stoelting at STI (707 527-9372). The physical condition of each component of the surface meteorological tower should be checked as described below:

WARNING:
DO NOT INSPECT MET. TOWER WHILE THE RADAR IS ON

Tower Checks to Perform During Maintenance Visit

Tower:

- Check that tower base is securely anchored to the ground.
- Generally check tower for signs of damage or excessive wear.
- Inspect all tower bolts at the base for any signs of corrosion (rust).

Wind Monitor:

- Note if any component (tail, propeller) is missing or has suffered obvious damage.
- Check that the whole sensor moves freely with changing wind direction and that the propeller rotates freely when windy.

Temperature/RH Sensor and Shield:

- Inspect hardware holding temperature/RH sensor shield assembly to tower and tighten bolts if necessary.
- Check that cable connections are secure.

Data Logger CR10 Enclosure:

- Verify the enclosure is locked and secured to tower.
- Check that cabling to the enclosure is secure and undamaged.

Cables:

- Check the integrity of the cables connecting the CR10 box to the trailer.
- Check that wind sensor cable is attached to tower.

Guy Wires:

- Check that guy wires are taut and attachment points are not loose.
- If they are loose, call STI for instructions on how to tighten them.

- After physically inspecting the meteorological sensors, record the current weather observations on the Maintenance Checklist. This observation should include general wind direction, wind speed, approximate temperature, clouds, current weather, and the time. For example, an observation might read:

  "Moderate southwest breeze, temps in the 50s F, damp with fog and rain at 1030 PST"

- Next, monitor data from the meteorological tower to check that the Gateway computer is communicating properly with the CR10 data logger by double clicking on the Check Sfc icon 

- Observe all of the meteorological data parameters on the screen and determine whether or not they are physically plausible and reasonable (i.e., is a value that should be positive negative, etc.).

- Monitor wind speed and wind direction on the screen and compare with visually estimated orientation of wind monitor and strength of wind.

  Note: The typical range for wind speed is from 0 m/s to 10 m/s. Use the following tables to help estimate wind speed and temperature.

Description	**Wind Speed Range** (m/s)	How to estimate speed
Calm	0 to 0.2	Calm, smoke rises vertically
Light air	0.3 to 1.5	Smoke drifts with the wind
Light breeze	1.6 to 3.3	Wind felt on face; leaves rustle
Gentle breeze	3.5 to 5.4	Leave and small twigs in constant motion; wind extends light flags.
Moderate breeze	5.5 to 7.9	Raises dust and loose paper; small branches are moved.
Fresh breeze	8.0 to 10.7	Small trees with leaves begin to sway.

	Temperature											
°F	25	30	35	40	45	50	55	60	65	70	75	80
°C	-4	-1	2	4	7	10	13	16	18	21	24	27

- If any parameter appears unreasonably high, low, or simply implausible, try to identify the cause (check cables, connections). If you cannot find the source of the problem, contact STI.

- When finished, press the <ESC> key and then press "Q" to exit from CheckSfc.

11. RESTARTING THE RADAR

- Restart the Radar by pressing the toggle switch on the UPS.
- Record the restart time on the Maintenance Checklist next to "Up Time."
- Make sure that the profiler completes several sampling "count downs."
- Check the final amp current on the Interface; it should be greater than 0.50 m amps.

12. CHECKING THE GATEWAY COMPUTER

- Make sure the communications software icon appears at the bottom of the screen.

- Make sure the software communicating with the CR10 data logger is functioning properly as follows:

    1. Double click on the Check Sfc icon. 

    2. Observe all of the meteorological data parameters on the screen and determine whether or not they are physically plausible and reasonable (i.e., is a value that should be positive negative, etc.)

    3. When finished, press the <ESC> key and then press "Q" to exit from CheckSfc.

13. SECURING THE SHELTER

- Turn off the display monitors on the Radar and Gateway computers.
- Record time leaving the shelter in the Site Log. Turn off shelter lights and lock shelter.

- Mail:

  -White copies of the Maintenance Checklist
  - White copies of the Site Logs
  - ZIP Diskette with the moments, consensus, and met tower data

To:

Joe Kwiatkowski
Sonoma Technology, Inc.
5510 Skylane Blvd., Suite 101
Santa Rosa, CA 95403

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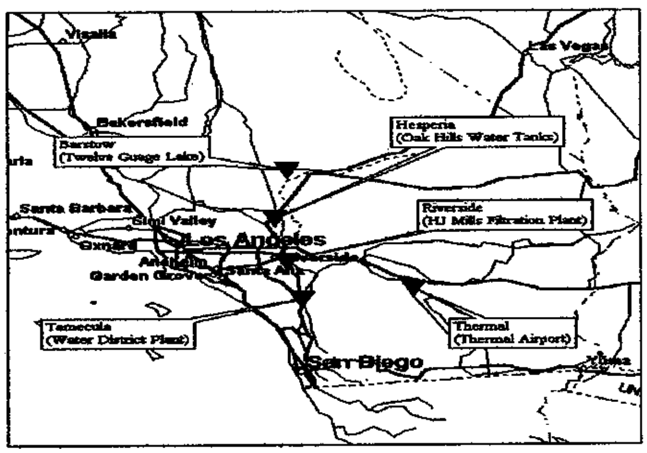
DRAFT

FINAL REPORT

ARB Contract #96-318 Enhancement of the Existing Radar Wind Profiler Network for the 1997 Southern California Ozone Study



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September 1998