SIERRA OZONE IMPACT ASSESSMENT STUDY

Final Report
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ABSTRACT:

The purpose of the Sierra Cooperative Ozone Impact Assessment Study (SCOIAS) is to document the degree to which sensitive pine species in the Sierra forests are exposed to ozone and the amount of damage the exposed trees exhibit. The major cooperators are the U.S. Forest Service (USFS), the California Air Resources Board (ARB) and the University of California, Davis (UCD). This document reports progress made by the UCD cooperators during the first year of the project (April 16 1990 to April 15, 1991). The focus of this effort was on identification of suitable sites; instrumentation selection and procurement and the initial installation of instrumentation and equipment at the sites selected. As of this writing, five sites have been fully instrumented and have been operated in full data acquisition mode for at least five weeks. These five stations are Mountain Home within the Sequoia, Jerseydale in the Sierra, 5-mile Learning Center in the Stanilaus, Sly Park Learning Center in the El Dorado and White Cloud in the Tahoe National Forests. The five stations, cumulatively, have taken 433 days worth of data through March 20, 1991. During this period, 3.5% of the data were lost due to ozone monitor malfunctions, 2.8% due to computer problems and 1.4% due to wind sensor cable damage. The highest ozone concentrations observed through March, 1991 occurred last fall. In October, midday hourly averaged ozone concentrations in excess of 100 ppbv were observed on over half of the days at Mountain Home, and on several days each at Jerseydale and White Cloud. Contrary to expectations, elevated ozone concentrations persist into the nighttime periods and were sometimes uncorrelated with wind direction. The other two stations were not operating during the fall period. For the winter months, observed ozone concentrations were below 80 ppbv.

ACKNOWLEDGEMENTS:

The assistance of Sydney Thornton and the late Homero Cabrera of the ARB in the initial phases of this project is much appreciated. Trent Procter of the USFS has done a lot of work in finding suitable sites and working with site personnel, making our job in this regard very easy. Thanks are also due to Linda Mitchell and Jack Bohan and their staffs, at the two learning centers, who have provided help in many ways: space, facilities and enthusiasm. Dave Dulitz (Califirnia Division of Forestry) at Mountain Home has done the same, plus provided the labor needed to dig the tower base and trenches for the cable runs. His contributions are greatly appreciated. Last, but far from least, special thanks to Robert Nolan and his fire crew (USFS) at Jerseydale, who not only dug the hole for the tower base and the cable trenches, but poured the concrete and installed the tower for us. We have enjoyed a high level of cooperation and enthusiasm from the personnel at all the sites. The professional contributions of R.O. Judkins and A.J. Dixon of UCD and the assistance of graduate students M. Liu and J. Davis are gratefully

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Figure 10. Same as 9, but for Jerseydale.

Figure 11. Same as 9, but for 5-mile Learning Center. Data between February 14 and 26 are missing due to computer CPU hardware error.

Figure 12. Same as 9, but for Sly Park Learning Center.

Figure 13. Same as 9, but for White Cloud.

acknowledged. Special thanks are also due to undergraduates L. Padilla and M. Gough.

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DISCLAIMER:

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 either an actual or implied endorsement of such products.

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acquisition system. The system also monitors several additional variables such as A/D zero and enclosure temperature. After calibration at UCD, these systems were deployed, one at a time, starting in late September 1990. The stations are visited by project personnel approximately biweekly (i.e., every other week) at which time instrument maintenance is performed, as necessary, and the recorded data retrieved via diskette.

Data from the stations are only available since the latter part of September, 1990. The instrumentation was removed by mid-December from three of the sites at which winter access is not possible (cf. Table 1). Our objective was to get the stations established in fall 1990 to allow site testing of the systems and to gain experience with any operational problems. In this sense, our primary effort was on establishing these stations and getting them running rather than focusing on the monitoring results themselves. As we were successful in this effort, we anticipate no difficulties in reinstalling the systems in late spring 1991 and commencing a full season's operation.

In the fall months, peak hourly averaged ozone concentrations in excess of 100 ppbv were observed on a few days at several sites. At Mountain Home, this was true for more than one half of the days in October. During periods of elevated ozone concentrations, concentrations did not always show a correlation with wind direction or time of day, and often remained high or peaked during the nighttime hours. Between November and March, the maximum hourly averaged ozone concentrations remained below 80 ppbv at the sites operating. However, we have not operated all of the stations simultaneously for long periods of time, so we draw no conclusions regarding gradients of exposure or related questions at this time.

The design and operation of the network appears to have been fully successful. All of the major objectives have been met -- except for the actual installation at the sixth site due to the lack of permission to enter the property. Initial data suggest that serious to severe exposure (> 80 ppbv) of pines to ozone is likely, especially in the southern part of the Sierra. The latitudinal gradient implied by the data obtained to date may not be significant given the short period of simultaneous operation at the end of the high ozone season. The ozone differences may also be a result of altitude differences among the sites. The southernmost site is also the highest elevation site. These questions will be better addressed after a full season's observations are analyzed. The persistence of concentrations in excess of 80 ppbv at night suggests that complex three dimensional transport processes are important, probably enhanced by the trapping of pollutants within or between inversion layers that intersect the slopes.

Quality assessment and quality control are performed both by us and by a

SUMMARY AND CONCLUSIONS:

The purpose of the Sierra Cooperative Ozone Impact Assessment Study (SCOIAS) is to document the degree to which sensitive pine species in the Sierra forests are exposed to ozone, the meteorological processes that produce high ozone concentrations and the amount of damage the exposed trees exhibit. The major cooperators are the U.S. Forest Service (USFS), the California Air Resources Board (ARB) and the University of California, Davis (UCD). This document reports progress made by the UCD cooperators during the first year of the project (April 16 1990 to April 15, 1991). The primary tasks pursued in the effort were the identification of suitable sites; instrumentation selection and procurement and the initial installation of the instrumentation and equipment at the sites selected. The USFS cooperators will be monitoring plots of pine trees to document any acute damage and any long term effects of ozone. Available literature strongly indicates that needle damage occurs with exposure to ozone concentrations of 60 ppbv and is significant at and above 80 ppbv (Hogsett et al., 1985)

The work has progressed through several distinct phases. The first was the identification of suitable sites and then the specific installation requirements at each of these. The second was the identification of potential instrument and equipment vendors, the preparation of requests for quotations and vendor selection. The third was the design and development of data acquisition software, followed by the design and construction of the instrumentation enclosures. By September, 1990, most of the instrumentation had been delivered to UCD and was under test in our laboratory. The first site was installed during the last half of September and became operational on 21 September. The fifth site required the greatest amount of site preparation, including installation of an underground power feed and was not operational until December 6, 1990. In addition to maintaining the operating sites, the last four months of this project were spent developing data reduction and archiving procedures and software and in evaluating performance of the instrumentation, the operating software and maintenance procedures.

We have identified six sites which satisfy the needs of the biological effects researchers and meet the meteorological criteria necessary to characterize exposure of pine species in the immediate vicinity to ozone. We have obtained permission to use five of these sites for the next several years. Permission to use the sixth site is expected by the end of June, 1991. The sites range in elevation between 3750 and 6200 feet above mean sea level. Instrumentation for the measurement of ozone concentrations (differential UV absorption) and meteorological conditions (temperature, humidity, wind speed and wind direction) were obtained from several vendors and assembled along with a PC-based data

in several budget categories allowed us to continue our work for 12 months, with no additional funding. As a result, we have begun actual monitoring which was not a task contained in the original agreement.

SITE SELECTION:

The criteria for selecting sites were that the measurement sites and potential pine study plots be located within the same watershed and be separated not more than 500 feet in elevation or three miles in the horizontal. We also required that power, security and relatively easy access be available and that reasonable exposure for the measurement of representative winds be possible. The latter criteria implies that the sites must be open with little or no vegetative canopy for several hundred feet around or the canopy be open and low enough that wind instruments could be mounted on towers tall enough to extend to or above the local canopy.

Site selection actually began before the Agreement was concluded. Several sites were proposed and examined by Dr. Trent Procter, an air pollution specialist with the USFS. The Principal Investigator (P.I.), Dr. Procter and members of the ARB met in January, 1990 to review these potential sites and primary candidates were identified. With the conclusion of the Agreement in mid-April 1990, the P.I. and a departmental instrumentation engineer visited all of the first choice locations to determine their general suitability and to define specific locations within the selected areas for placement of the instrumentation systems and support equipment. We found all of the individual site managers and staff to be extremely cooperative and interested in the project. The general locations of these sites are shown in Figure 1. Site characteristics are listed in Table 1, and more detailed maps shown in Figures 2 through 8.

The northernmost site, White Cloud, is on the southern side of an elongated east-west oriented ridge, in a clearing and near a large heliport. The Sly Park site is on a relatively flat broad basin tilting up slope to the east-northeast. It is surrounded by moderately dense canopy but the site itself is near a parking lot and work area and access road giving it a fairly open exposure, except for winds from the east-northeast. The 5-Mile site is in a clearing near the top of a broad knoll close to a steep drop toward the south-southeast. The canopy surrounding the clearing is relatively thin and short (<30'). Jerseydale is within a moderately dense canopy on the top of a small hill which sits in a broad valley oriented in a south-southwest to north-northeast direction. The local canopy is about 50 feet tall. The potentially usable Shaver Lake site is the most open, being in a very broad basin in a meadow-like setting. The southernmost site, Mountain Home, is on the steepest slope, extending downward to the west-southwest. The canopy surrounding the site is very dense but is fairly open in

subcontractor from San Jose State University (SJSU). UCD maintains transfer standards for ozone, temperature and humidity and performs periodic checks of the wind sensors. Based on these calibration checks and other data recorded in the monitoring systems and from field logs, data quality information is recorded within the archived records. In addition, twice per year, the SJSU subcontractors perform independent audits of each of the stations and have the ozone transfer standard checked yearly by the Standards Laboratory of the ARB.

RECOMMENDATIONS:

We believe that some measure of solar radiation should be added to the network. Evidence in the literature suggests that damage to plant tissues is due to the flux of ozone into the leaves (Coyne and Bingham, 1981, Yang et al., 1983). While we can document external exposure and dosages, the key question seems to be the correlation between external ozone concentrations and stomatal conductance. Stomatal conductance is in turn a function of air temperature, humidity and the available sunlight. Relatively inexpensive photodetectors have been adapted to measure photosynthetically active radiation (PAR) and these could be easily added to the site instrumentation. With the addition of radiation data, we can use site measured variables to estimate stomatal conductance and compute an actual, internal exposure index.

A second set of issues is the question of spatial variability and the nature of three dimensional pollutant transport. Observations frequently show strong layering of ozone in the vertical, with elevated layers of high ozone concentrations (> 80 ppbv) persisting through the night. These layers can impact the slopes of major topographic features. Given the complexity of the topography at and near the sites under study, we strongly recommend that portable ground unit(s) and aircraft borne systems be used to supplement the fixed site measurements and assess whether three dimensional spatial variability is significant in these areas. The airborne observations are also needed to assess the three dimensional transport issues.

INTRODUCTION:

The work under this agreement consisted of six primary tasks: (1) site selection; (2) instrumentation selection and procurement; (3) integration of instrumentation and facilities; (4) installation of these at the sites; (5) development of data acquisition and data reduction software and (6) field testing of these systems. While the original contract was to be executed in six months, changes in the operational schedule due to late initial funding coupled with significant savings

failure. All repairs have been made under warrantee, but require us to deliver the faulty units to the vendor to accomplish these repairs. Another major problem has been to find battery back up clocks that keep time well. We are now installing a second set of these in an effort to obtain reliable time keeping within the data stream.

The ozone monitors and a transfer standard were purchased from DASIBI Corporation. Three of the delivered units and the calibrator worked well upon receipt. Two monitors needed minor repairs at UCD using factory supplied parts. One monitor was not repairable by us and was returned to the factory. Since these monitors are only certified by US Environmental Protection Agency (EPA) for operation within a limited instrument temperature range (20 - 30°C), we monitor the instrument enclosure temperature (Tb). The calibration of the ozone transfer standard was certified by the Standards Laboratory of the ARB in October 1990. On-site calibration checks using the ozone transfer standard are performed at intervals not exceeding six weeks at each station. Since operations began, we have had a failure of one ozone monitor pump resulting in the loss of eight days of data. Other mechanical problems have caused an additional seven days loss of ozone data. In addition, the April calibration of the ozone monitor at Sly Park was noisy and suggests a problem with either the calibrator or the monitor itself.

In parallel with the instrumentation procurement and testing, preparations for site installations were performed. Three of the sites have indoor facilities in which to house the electronic instrumentation. We constructed six instrument enclosures which are essentially the same. The three outdoor versions have extended roofs, weather proofing and insulation not needed for the indoor models. We decided to construct our own enclosures as commercially available ones were expensive, bulky and would require extensive alterations to suit our requirements. The taller towers are free standing and need their bases set in concrete several feet deep in the ground. The shorter towers are guyed and only require a small pad on which to sit. At several sites ditches were needed for the signal cables running between the towers and the data acquisition systems. At one site an underground power feed was required.

The data acquisition boards and meteorological instruments and equipment were all well within specifications upon delivery and have demonstrated trouble free performance as of this writing. A mechanical problem caused a mangled wind sensor cable at one site leading to the loss of six days of wind data.

All instruments were calibrated in-house through the data acquisition systems used in the field. The wind speed sensors were calibrated using fixed RPM synchronous motor calibrators corresponding to two wind speeds. Their starting

the immediate vicinity of the sensors.

Negotiations between the University and the site owners or operators were initiated to obtain formal permission to use each of these sites. We have reached formal agreements with the two school districts and California Department of Forestry (CDF). We have permission to use the two USFS sites with formal Special Use Permits to be issued soon. We were unable to conclude an acceptable agreement with Southern California Edison (SCE) on the use of a site on their land near Shaver Lake. The contentious issue is liability for injury to third parties. Dr. Procter and we have been examining nearby sites that are controlled by a government agency as an alternative to the Shaver Lake site. However, since the topography and general environment at Shaver Lake are unique for our network, we continue to pursue an agreement with SCE. Encouraging movement toward resolution of the key issues is occurring.

INSTRUMENTATION:

In addition to ozone, the measurement of air temperature (T), relative humidity (RH), wind speed (FF) and wind direction (DD) are needed to characterize exposure and to give some insight into the meteorological factors contributing to that exposure. The list of currently recorded variables is contained in Table 2. Given the delineation of the site requirements, instrument and equipment specifications were written and purchasing procedures initiated. Request for quotations were sent to manufacturers and distributors of quality products. Bids received from potential suppliers were reviewed and suppliers selected on the basis of lowest cost. Delivery of equipment varied between two weeks for the computer systems to 10 weeks for the meteorological instrumentation. The meteorological towers are larger and more complicated than originally proposed. This was necessary to allow the wind instruments to be located at or above the local canopy height while allowing easy servicing of the instruments. We are using telescoping, crank-up towers with extended heights of either 33 or 55 feet. These have been purchased directly from a major manufacturer at a significant discount. Table 2 lists the vendors used for the major components and the equipment or instrumentation supplied.

All equipment items were thoroughly checked upon receipt. The computer systems are MS-DOS generic systems (XT-clones) priced significantly below brand named systems. The use of off-brand computer systems was strongly recommended by the original ARB contract managers. We have experienced a number of difficulties with the computers, most of which have been successfully rectified. There have been partial failures of the computer power supplies and cooling fans in three of the units, and one of the units is inoperative due to an as yet unresolved hardware

transferred to a permanent archive in ASCII format and with appropriate data quality information recorded for each instrument. These data are five minute averages of one second samples and the standard deviation of each variable during the five minute averaging period. In addition, the frequency of occurrence of each wind direction and the average values of the primary variables distributed by wind direction are recorded each hour from the one second samples. These tabulated event roses are also quality controlled and archived with data quality information encoded in the records.

Data acquired at the sites is processed at UCD using the procedures outlined in Figure 9. Data quality control is assessed from scanning the data themselves, interpretation of the on-site log files and from the periodic calibration checks. The raw data are transferred to a permanent archive which includes a data quality word, as described below. The archive includes both the five minute data and the hourly, event-rose summaries. Each data record or set of records is marked by a data quality word. This word is set up so that each digit represents the data quality code for a particular instrument. For example, if we had seven instruments, there would be seven digits in the quality control word (QCW). For the five minute data and its derivatives, we have one QCW per record. For the event data we will have one QCW per grouped record. For the event data, if an instrument malfunctions for any part of the time, we flag the whole period with the most critical code for that instrument.

PRIMARY RECORD KEEPING:

We have several written records of operating procedures, instrument use, and calibration histories. One is the TRAVELING LOG, in which we record information on site visits, problems encountered, maintenance performed and other pertinent information. At each station is a STATION LOG in which we, the SJSU auditors and on site personnel make entries. The STATION LOG contains a detailed operational history, records of instruments in use (by serial number), calibration data, repair and maintenance data, systematic corrections made to the data and periods of applicability. Finally, we keep a MASTER BINDER at UCD in which we place instrument calibration summaries and results, printouts of station on-line log files, time plots of raw data for multi-day periods, and summaries of significant events transcribed from the STATION LOG. This binder contains explanations of QCW nonzero values added to the archived data sets. The binder also contains tables of the event roses averaged by time of day over multi-day periods of time.

SUB-CONTRACTOR ACTIVITY:

The primary functions of the Subcontractor at San Jose State University were to provide independent quality assurance audits and to develop a separate data

thresholds and the resistance of the wind direction sensors were checked using a torque watch. The temperature sensors were checked using a secondary standard, liquid in glass thermometer. The humidity sensor was calibrated with a high quality dew point hygrometer and a psychrometer. The ozone monitors were calibrates using both their internal self-checks and by use of a ozone calibrator/transfer standard. These checks along with cleaning and filter changes are part of the routine maintenance procedures. In addition, the bearings in the wind speed sensors are replaced after six months of field use.

SOFTWARE DEVELOPMENT AND DATA HANDLING:

Flexible, user friendly, data acquisition software was developed and tested. The program allows listing of recent data (the last 12 five minute averages or the last 16 hourly averages) to the screen at the sites with no interruption of the data acquisition function. This allows convenient access to these data by on-site personnel as well as by our service technicians. The software has error trapping capabilities and restarts itself following power failures as well as following miscues or unauthorized keyboard requests. The output of the data acquisition system consists of three types of files. The first contains five minute averages of the data sampled at one second intervals and the standard deviation of these data. The second contains a joint distribution table of the number of observations and the average of each variable by octant of wind direction. The third type of file is a log file in which automatic and manual entries can be made describing significant events related to the data logging function such as restarts after power interruptions, use of user interactive features (hot keys) and the like. The format of these files is shown in Table 4. These data are copied onto diskettes for transfer to UCD. The last data copied to the diskette is also saved in a backup directory on the hard disk and not deleted until the retrieved raw data has been successfully reduced.

The data logging and data reduction software were written using MS Quick BASIC. The data acquisition software allows user interrogation of the system while data logging continues and automatic error checking and restart capabilities. The data acquisition program also writes pertinent information to a log file which keeps track of various types of activity on the system. Aside from some minor computer firmware problems and one CPU failure, the systems have worked reasonably well (>96% data recovery). The instruments most susceptible to failure are the ozone monitors, which have periodic pump failures and exhibit short term instabilities.

Data quality evaluation is performed upon retrieval of a station's data files. The raw data are examined graphically to check for anomalous behavior. This review plus the written and computer generated logs and periodic calibration checks are all used to assess data quality. Following this review, the data are

and October 3-5). The wind fluctuations were somewhat diurnal but less so than most of the other sites. During the periods of elevated ozone concentrations, the ozone concentrations were not well correlated with wind direction.

Clearly, several of the sites experience ozone concentrations that can be injurious to vegetation. Since the periods of data coverage vary among stations, we cannot examine spatial patterns of this exposure from this initial set of observations. What is somewhat surprising is that in some cases, ozone concentrations remained high at night, even with downslope flows. There are many possible explanations for these observations but selecting among them at this point would be purely speculative. These observations point to the need to examine fairly complex three dimensional transport hypotheses and appropriate three dimensional sampling to verify those selected.

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archive in a dBASE IV environment. They have assisted with the certification of the transfer standard and have performed checks of several systems prior to their deployment. They have also prepared a manual describing specific quality control procedures and conducted two on-site calibration audits. A summary of their activity is contained in Appendix A. In accordance with the specific request of the original contract managers, they have been developing dBASE IV data handling protocols and have established some preliminary report generating programs usable within a dBASE IV environment.

PRELIMINARY MONITORING RESULTS:

At this writing, five stations have been established and each operated for at least five weeks. Their dates of operation are given in Table 1. The wintertime decommissioning of three stations is in accordance with our original operating plan. Continued operation at the two learning centers allows us to obtain information during winter, as was planned initially for only one station. We are keeping both operating to accommodate the centers' educational programs which now have instructional modules utilizing our systems. Each of the sites is located in a somewhat different topographic setting and this affects the details of some of the recorded information. Figure 9 shows data from Mountain Home. The most striking feature in the plots is the almost square wave like diurnal variation in the wind direction, being upslope (270) during the afternoon and downslope (90) in the night and morning hours. Also obvious were the high ozone concentrations, especially between October 10 and 16 which were only partially correlated with upslope flow.

At Jerseydale (Figure 11) the diurnal variation in wind direction was also quite obvious but not nearly as regular as at Mountain Home. High ozone concentrations (> 80 ppbv) were observed between September 28 and October 3 and again between October 10 and 15, and between 26 and 30, although not as high as at Mountain Home. In some of these periods of higher ozone concentrations, the variation in concentration appears to be correlated with upslope flow. However, on several days, the concentrations remained high at night.

At 5-mile, the last station installed, we have only winter and early spring data. Note that, at least during these seasons, the wind did not show a strongly diurnal pattern and ozone concentrations were below 80 ppbv. The wind patterns at Sly Park were again predominantly diurnal in character and for the winter-spring period covered, ozone concentrations were generally less than 80 ppbv.

The period of record at White Cloud was late summer and fall and showed several periods of elevated (> 80 ppbv) ozone concentrations (September 30 to October 1

TABLE 3.
DATA FILE STRUCTURES:

Definitions:

DD = Wind direction	FF = Wind speed
RH = Relative humidity	Ta = Temperature
O_3 = Ozone concentration	Tb = Enclosure temperature
v = South to north wind component	u = West to east wind component
Z = Reference zero volts	R = Reference 5 volts.

LOG FILES:

- Date and time of program restarts (e.g. after operational maintenance, or power failures); of data acquisition interruptions due to use of "hot keys"; counts of instrument's error flag and manually entered notes.

ON-LINE FIVE MINUTE FILES:

- Date
- time, DD,FF, u, v, Ta, RH, O_3, Tb, Z, R, rms(DD), rms(FF), rms(u), rms(v), rms(Ta), rms(RH), rms(O_3), rms(Tb), rms(Z), and rms(R)

⋮

Twelve entries per hour, 24 hours per day. Data appended to these files every five minutes.

ON-LINE HOURLY SUMMARY WIND/EVENT FILES:

- Month,day, year, hour, minute, station number
- Event distribution by octants in the wind direction:

Wind Dir.	CALM	22.6-67.5	67.6-112.5	....	292.6-337.5	337.6-22.5	Deg.
No of obs.	71	1647	1231	.....	36	179	count
Average FF	0	1.9	1.6	.....	1.9	1.8	m/s
Average RH	42	38	38	.....	37	38	%
Average Ta	12.5	13.6	13.5	.....	13.5	13.6	°C
Average O_3	55	59	59	.....	57	58	ppbv

ARCHIVED FIVE MINUTE FILES:

-- Date (julian day), year, station, number of records.
-- Time, Ave {DD,FF,u,v,Ta,RH,O }, RMS {DD,FF,u,v,Ta,RH,O_3},QCW

⋮

UP TO 24 HOURS WORTH

ARCHIVED HOURLY EVENT DATA:

-- Julian day, year, station, number of data blocks.

-- decimal hour, and QCW for the hour.
-- # of observations by wind direction.
-- Average wind speed "
-- Average humidity "
-- Average temperature "
-- Average ozone "

Repeat for each hour of the day for which data are available.

TABLE 1
SIERRA OZONE ASSESSMENT SITE CHARACTERISTICS

NUMBER	NAME	NATIONAL FOREST	ELEV. (FEET)	COOPER-ATOR	WIND TOWER HEIGHT	OPERATING DATES
1.	MT. HOME	SEQUOIA	6200	CDF	17m (56')	10/10-11/12/90
2.	(SHAVER LK.)	SIERRA	(6000)	(SCE)	12m (40')	---------
3.	JERSEYDALE	SIERRA	3750	USFS	17m (56')	9/21-12/18/90
4.	5-MILE LEARN-ING CENTER	STANIS-LAUS	4000	CLOVIS SCH. DISTRICT	12m (40')	12/5-present
5.	SLY PARK	EL DORADO	4200	SACRA. SCH. DISTRICT	17m (56')	10/30-present
6.	WHITE CLOUD	TAHOE	4350	USFS	12m (40')	9/26-11/28/90

TABLE 2.
INSTRUMENT AND EQUIPMENT VENDORS:

Vendor	Equipment	Model
Met-One Grants Pass, OR	Temperature, Humidity Wind Speed Wind Direction	083-1,1760TS-1760G 014-1,1680-1812 024-1,1690-2106
DASIBI Glendale, CA	Ozone Monitor Ozone Calibrator	1008 AH 1008 PC
DCL Computers Sacramento, CA	Data acquisition	DFID11XT
Tri-Ex Tower Corp, Visailia, CA	50' Telescoping Tower 33' Telescoping Tower	W7-51 MW-33
Keithly/Metrabyte Taunton, MA	8 channel MUX-A/D	STA-8PGA

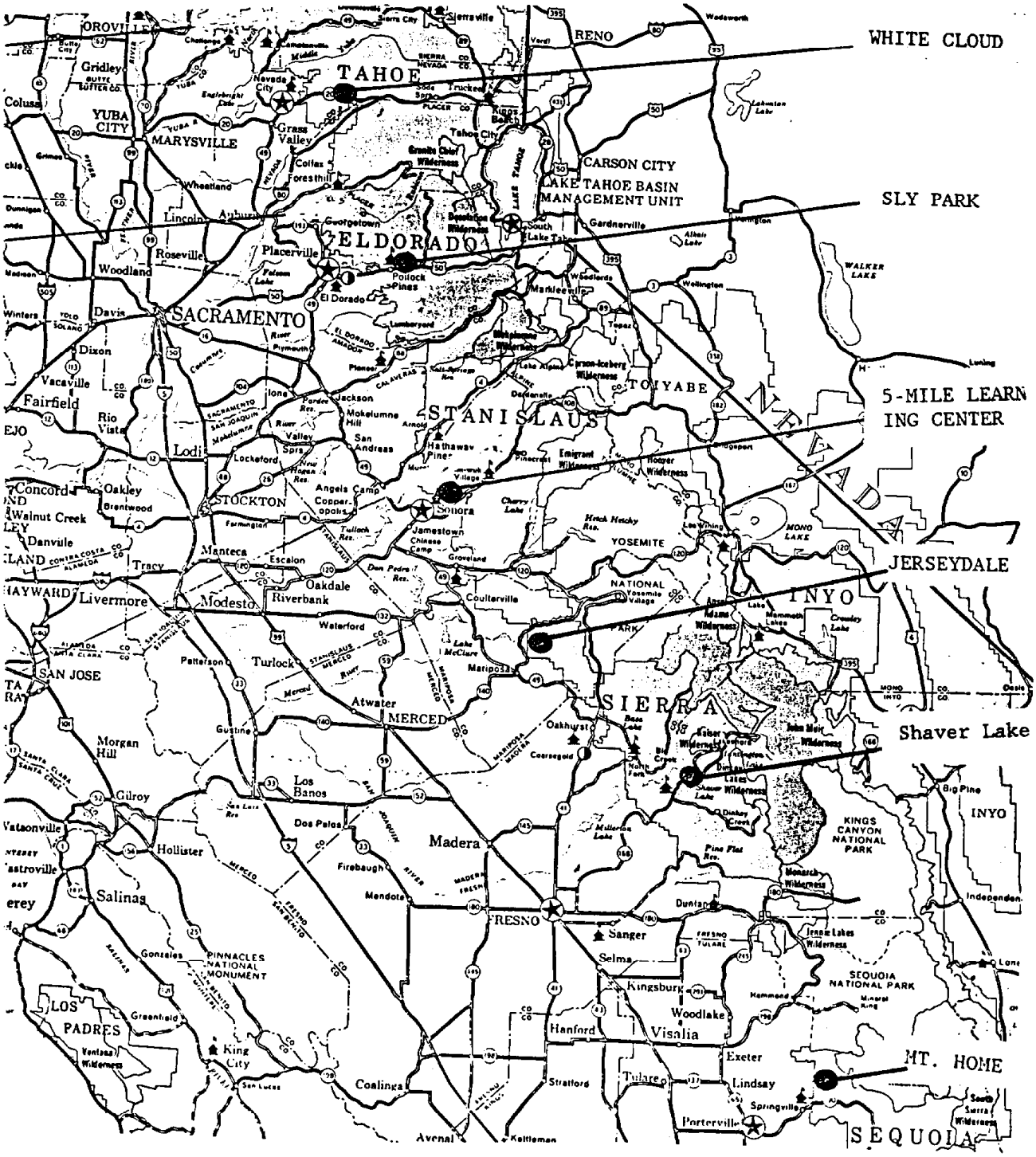


FIGURE 1. Map of central California showing the approximate locations of the Ozone monitoring sites.

TABLE 4.

SCOIAS DATA QUALITY FLAGS.

The values for the codes are as follows:

0 No known problems. Data should be fine.
1 Calibration corrections have been applied.
2 Systematic error adjustments applied.
3 Data not representative, non-standard exposure (test).
4 Data not representative, cold start/warm up period.
5 Data questionable, malfunction suspected.
6 Data is no good, instrument malfunction.
7 Data is no good, instrument not connected or inoperative.
8 Used for TBOX only, means shelter temperature is outside EPA specified limits for the DASIBI monitors.
9 N/A

Digit:	1	2	3	4	5	6	7
QCW =	spare	DD	FF	RH	TEMP.	OZONE	TBOX

NOTE: Due to instrument warmup requirements, ozone data are flagged 4 for one-half hour following restarting after a power failure.

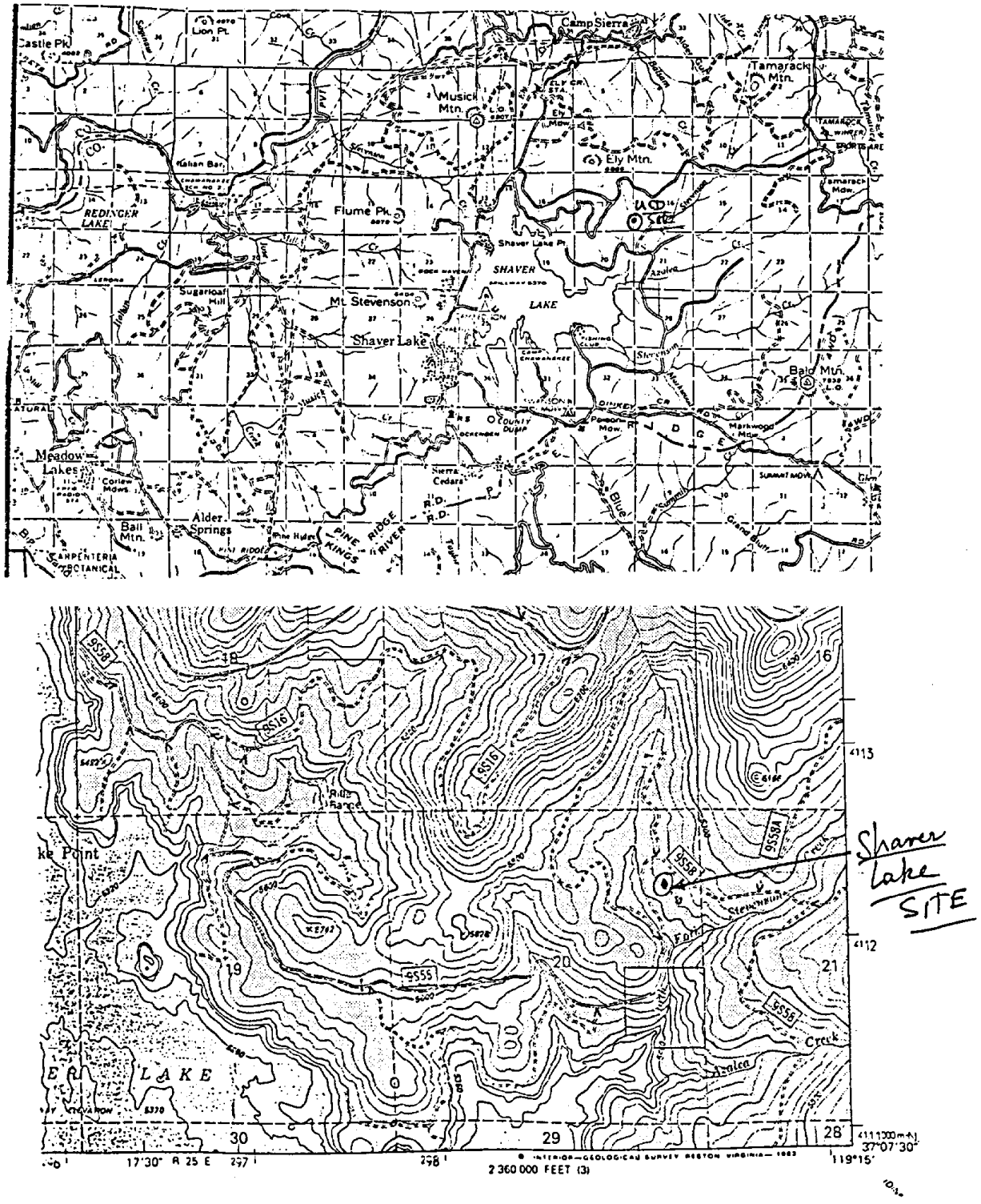


Figure 3. Detailed maps of the Shaver Lake area showing the proposed location of the UCD - SCOIAS instrumentation.

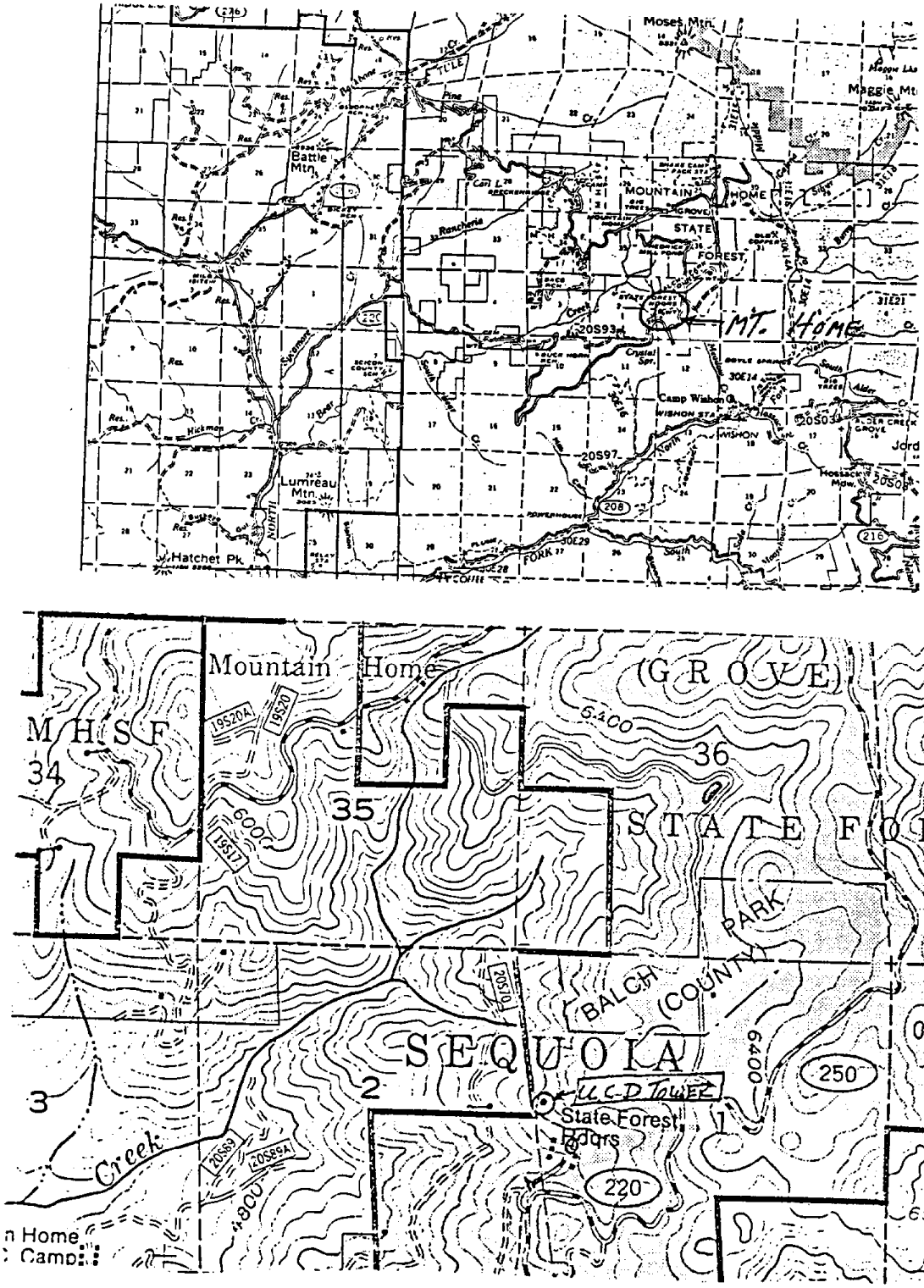


Figure 2. Detailed maps of the Mountain Home area showing the location of the UCD - SCOIAS instrumentation.

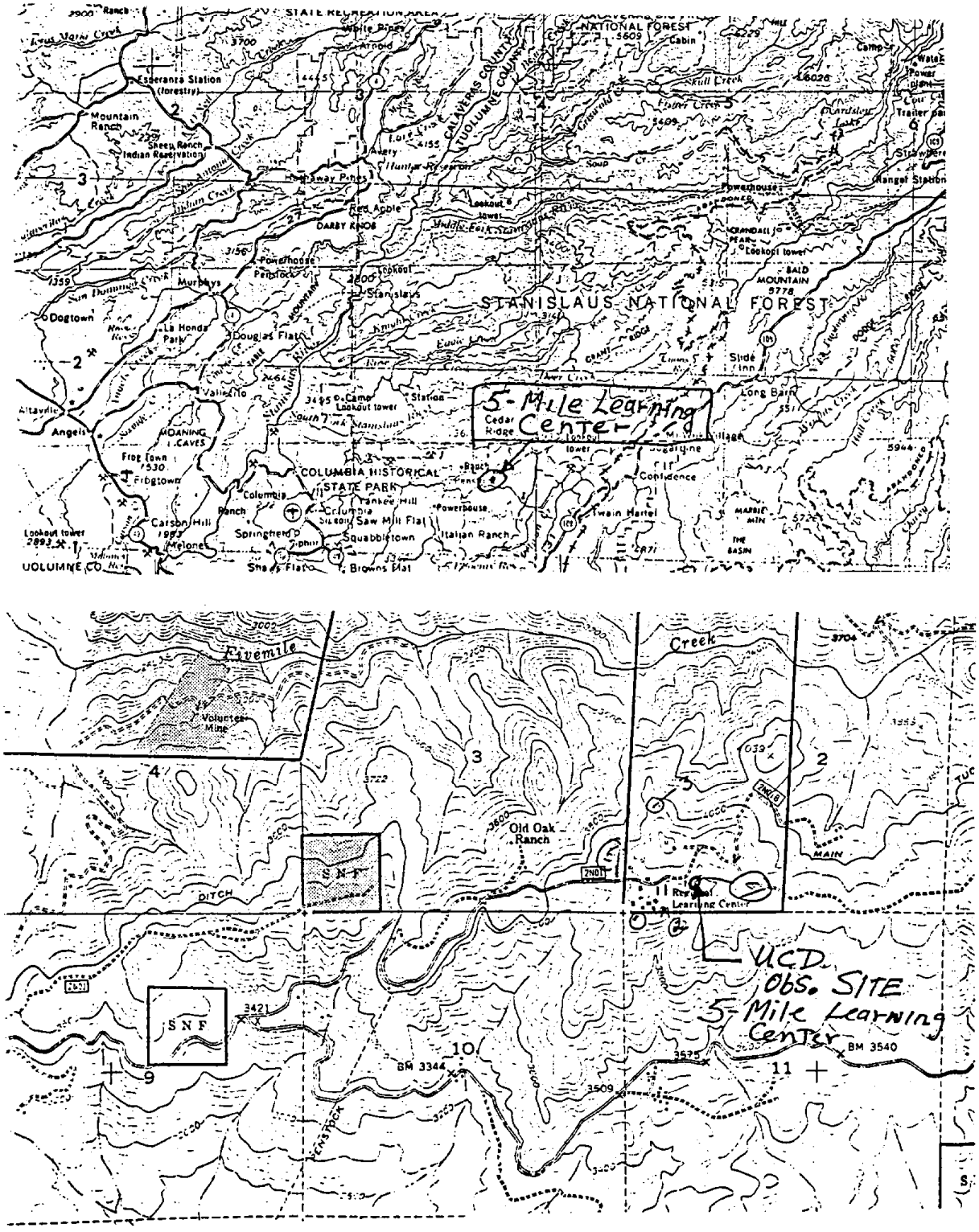


Figure 5. Detailed maps of the 5-mile Learning Center area showing location of UCD - SCOIAS instrumentation.

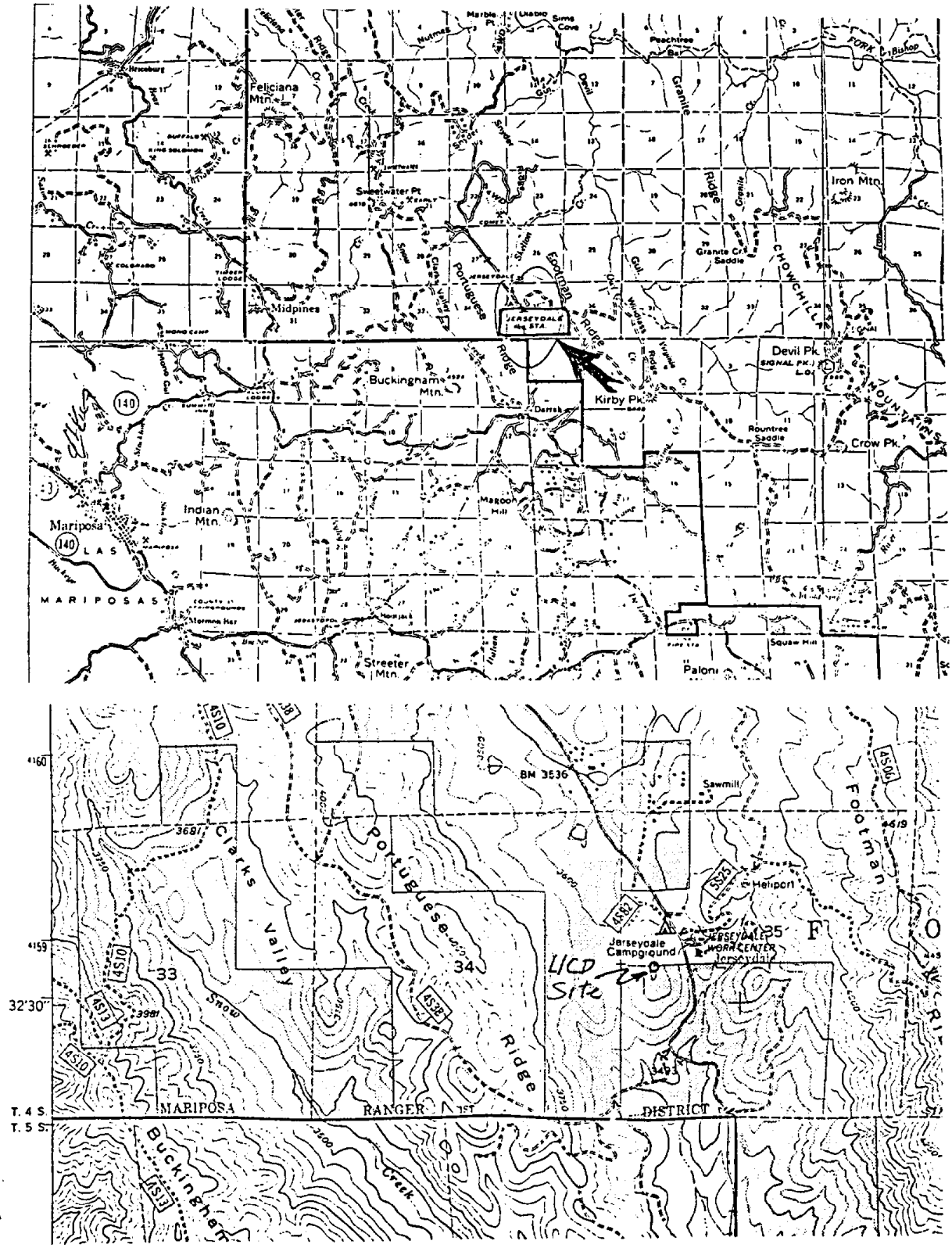


Figure 4. Detailed maps of the Jerseydale area showing the location of the UCD - SCOIAS instrumentation.

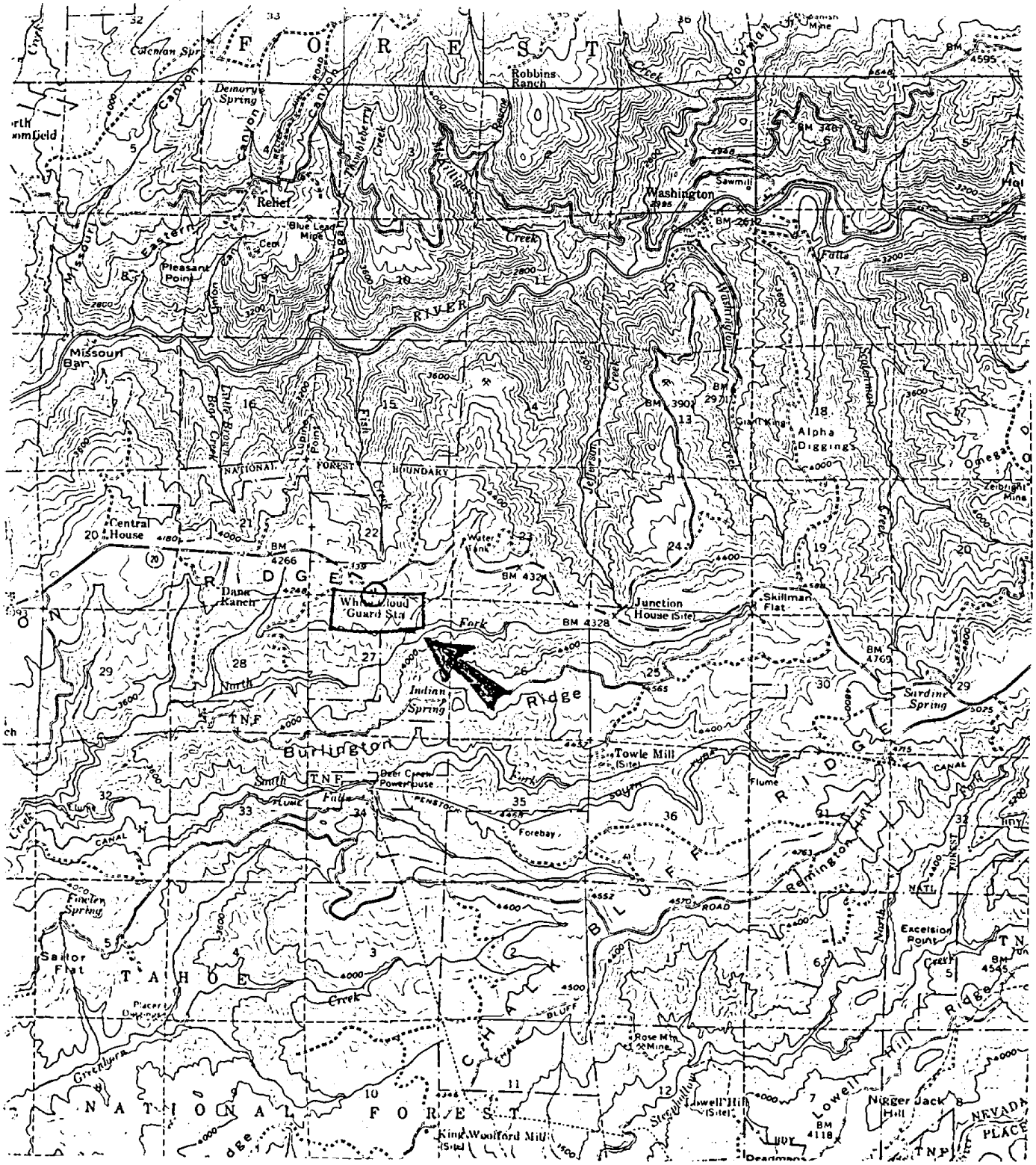


Figure 7. Detailed map of the White Cloud area showing the location of the UCD - SCOIAS instrumentation.

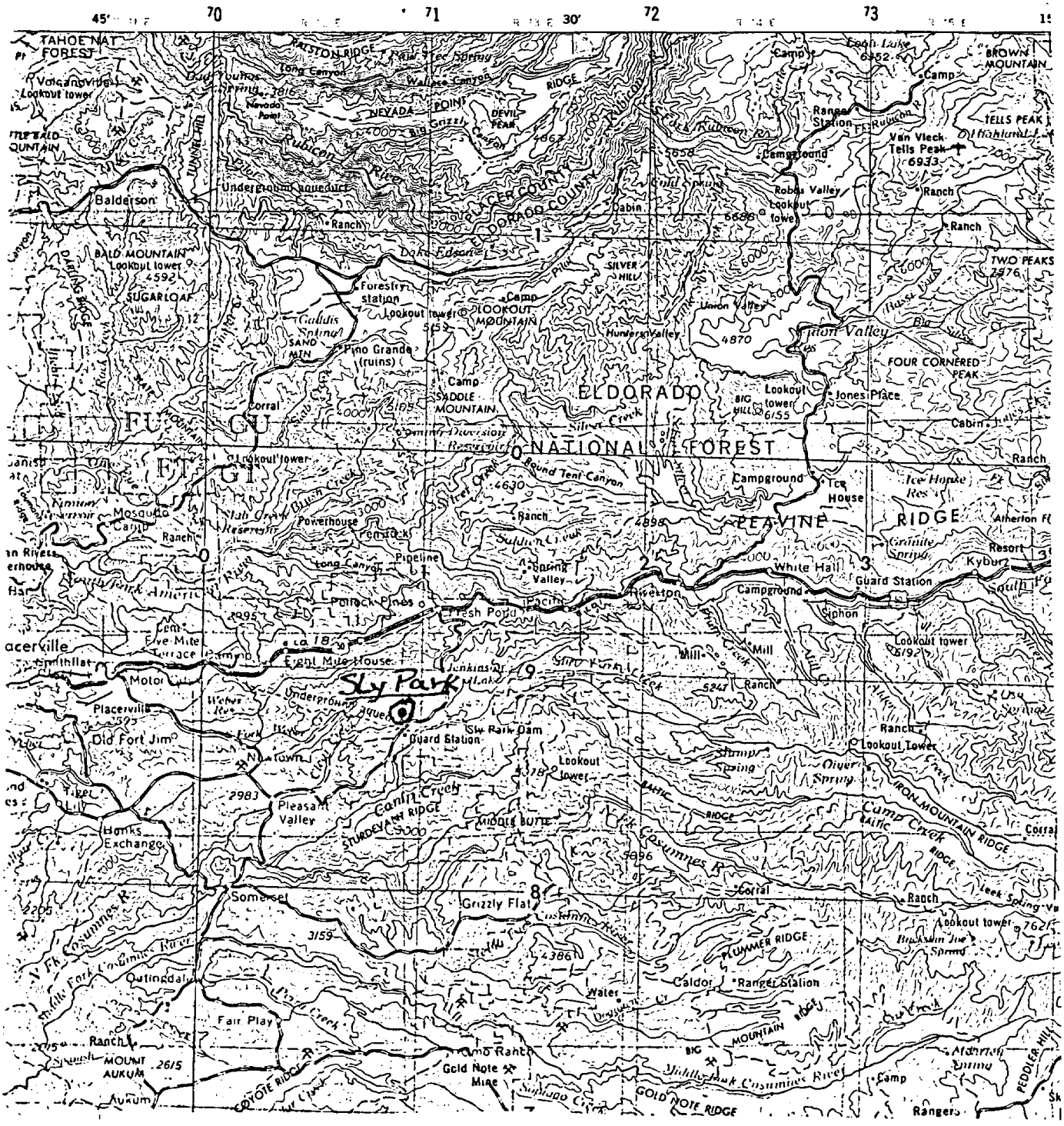


Figure 6. Detailed map of the Sly Park Learning Center area showing the location of the UCD - SCOIAS instrumentation.

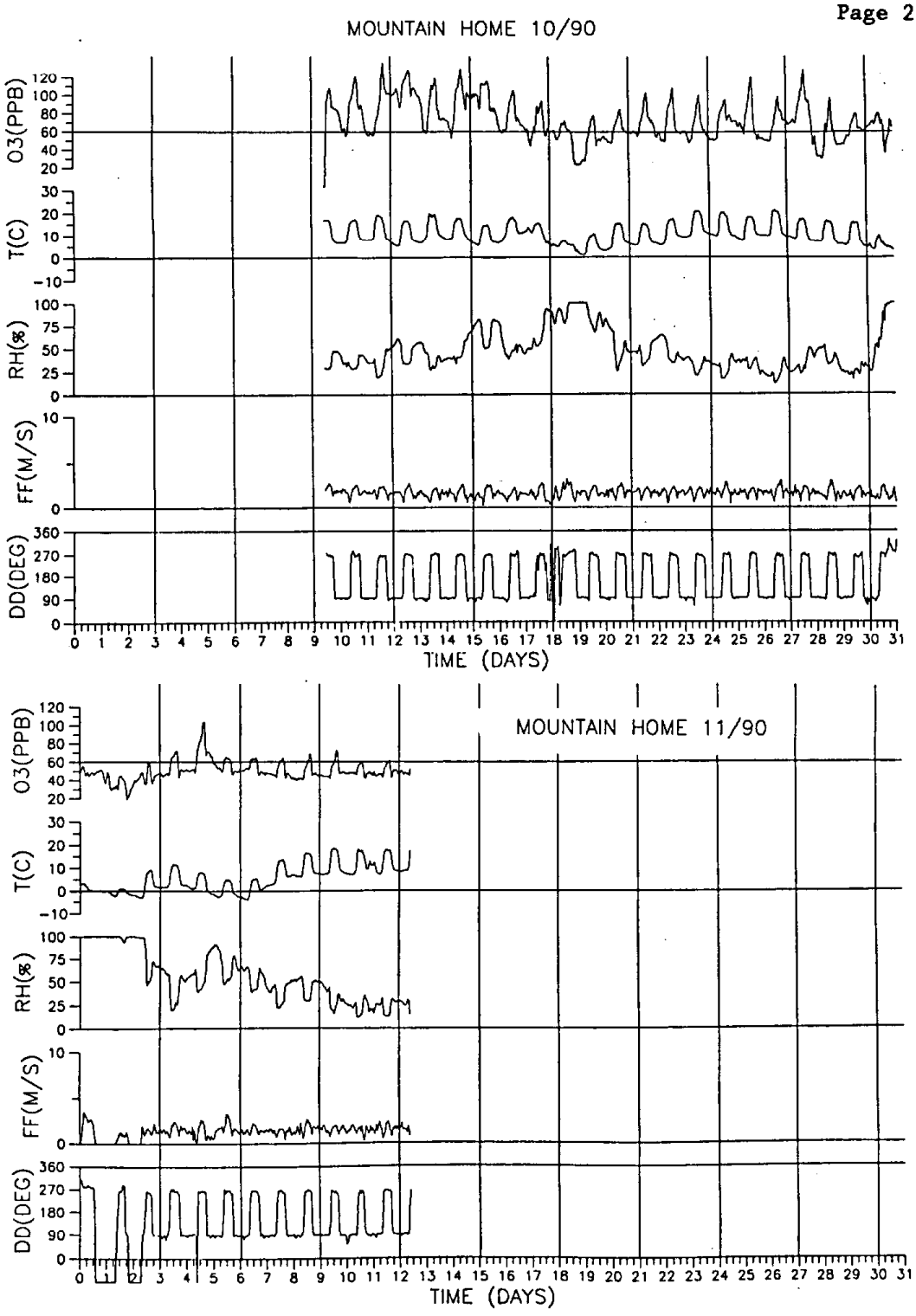


Figure 9. Time plots of hourly averaged wind direction (DD), wind speed (FF), relative humidity (RH), air temperature (T) and volumetric ozone concentration (O_3) normalized to standard conditions of temperature and pressure at the Mountain Home site. Wind direction value greater than 360 indicate calm conditions. Values of any variable less than 0 indicate missing or bad data.

SCOIAS DATA PROCESSING

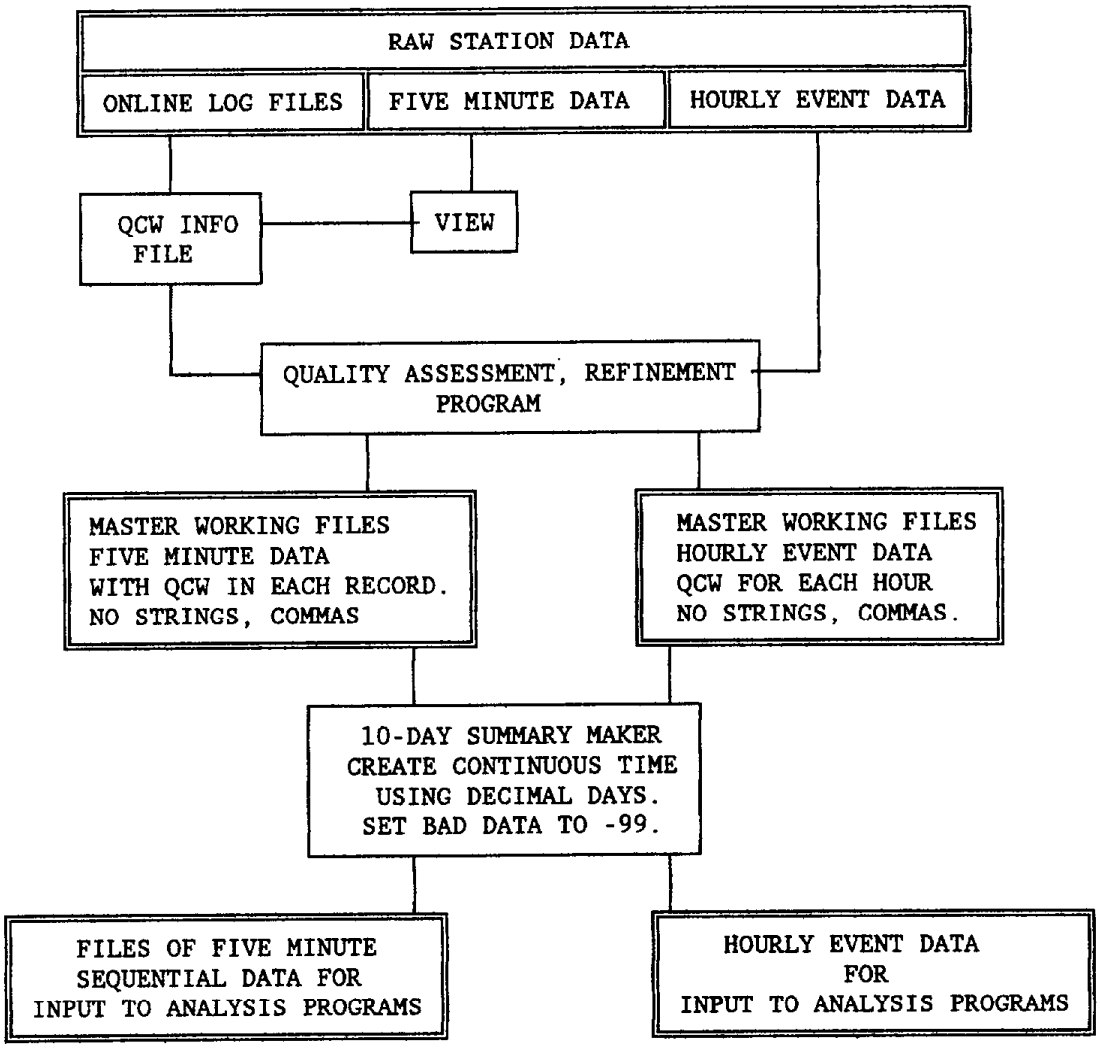
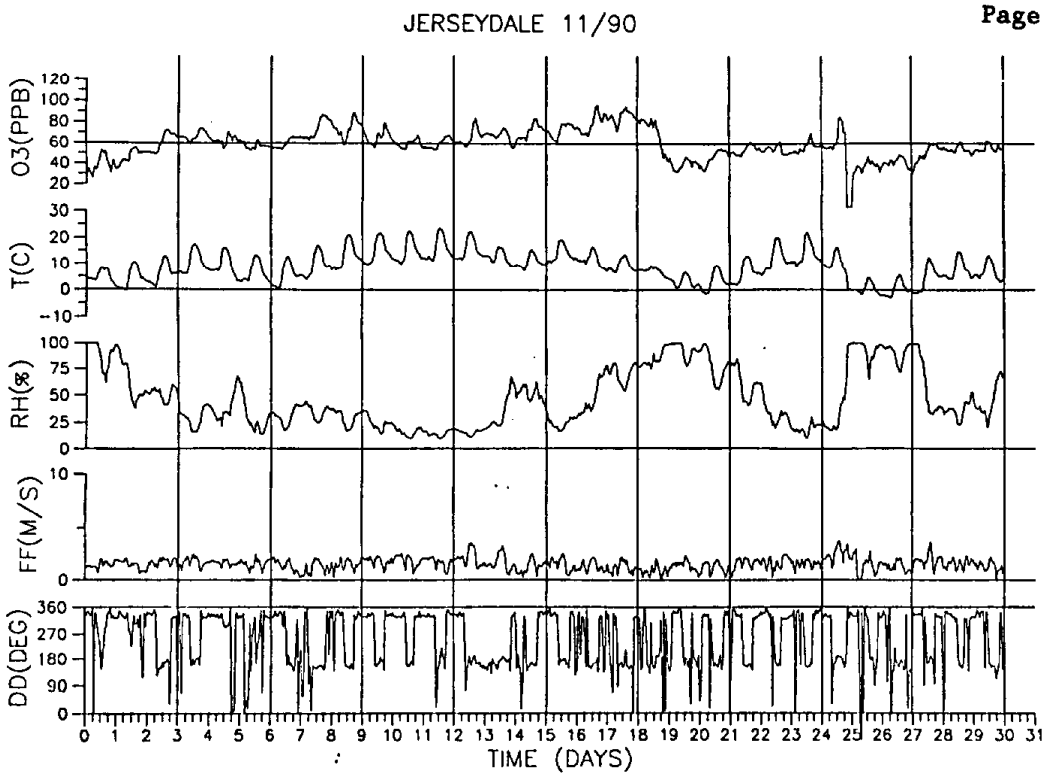


Figure 8. Summary of the SCOIAS data processing procedures. Boxes with double outline indicate data files. Boxes with single outlines represent data processing programs.



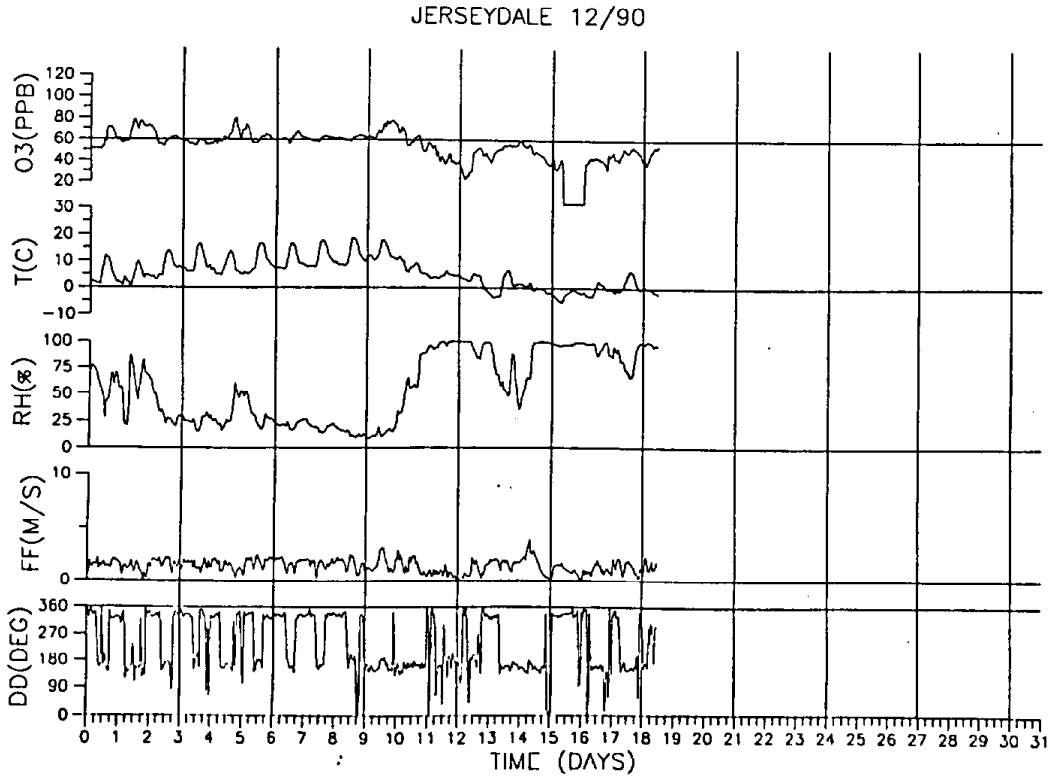


Figure 10, continued.

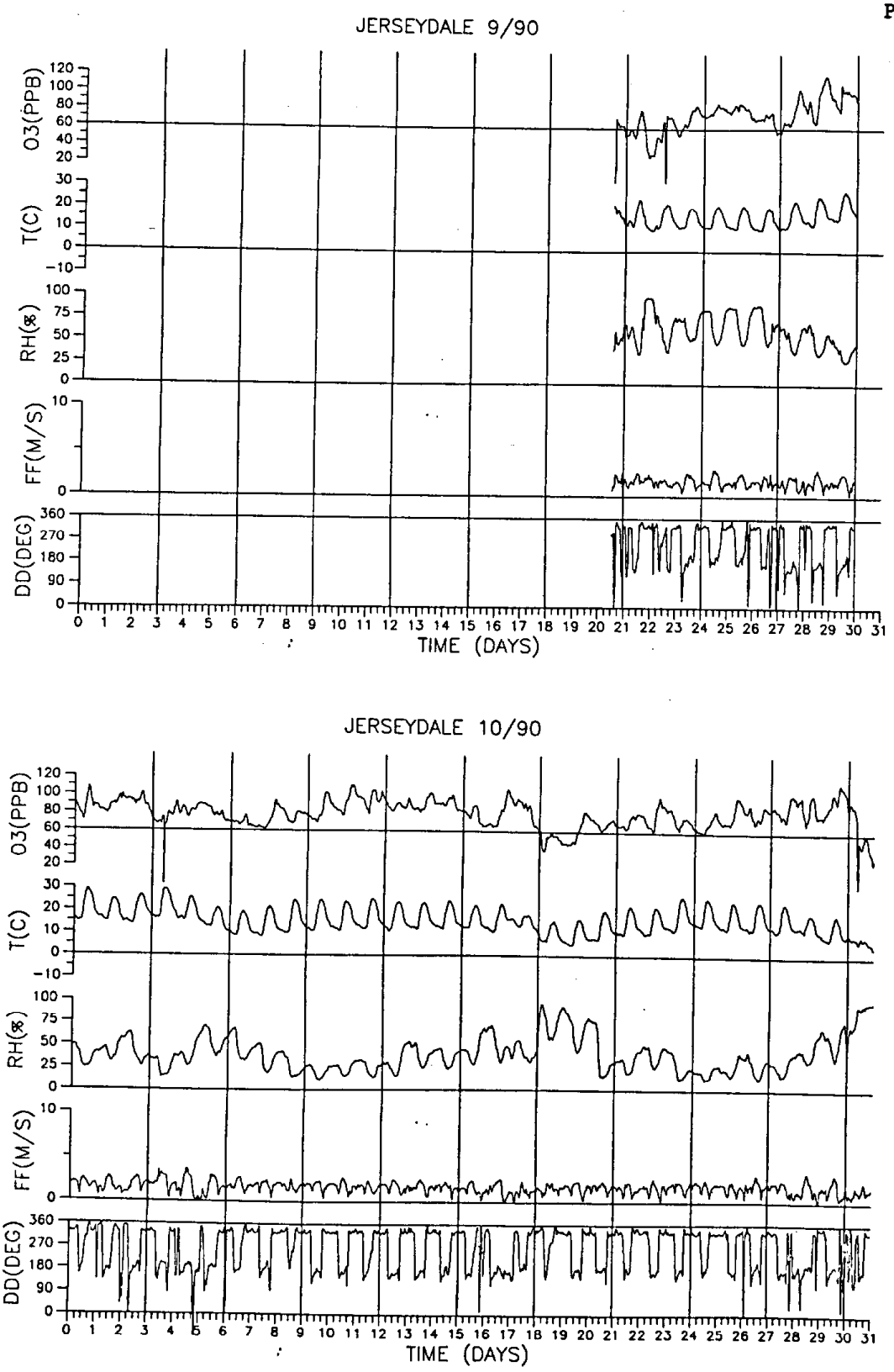
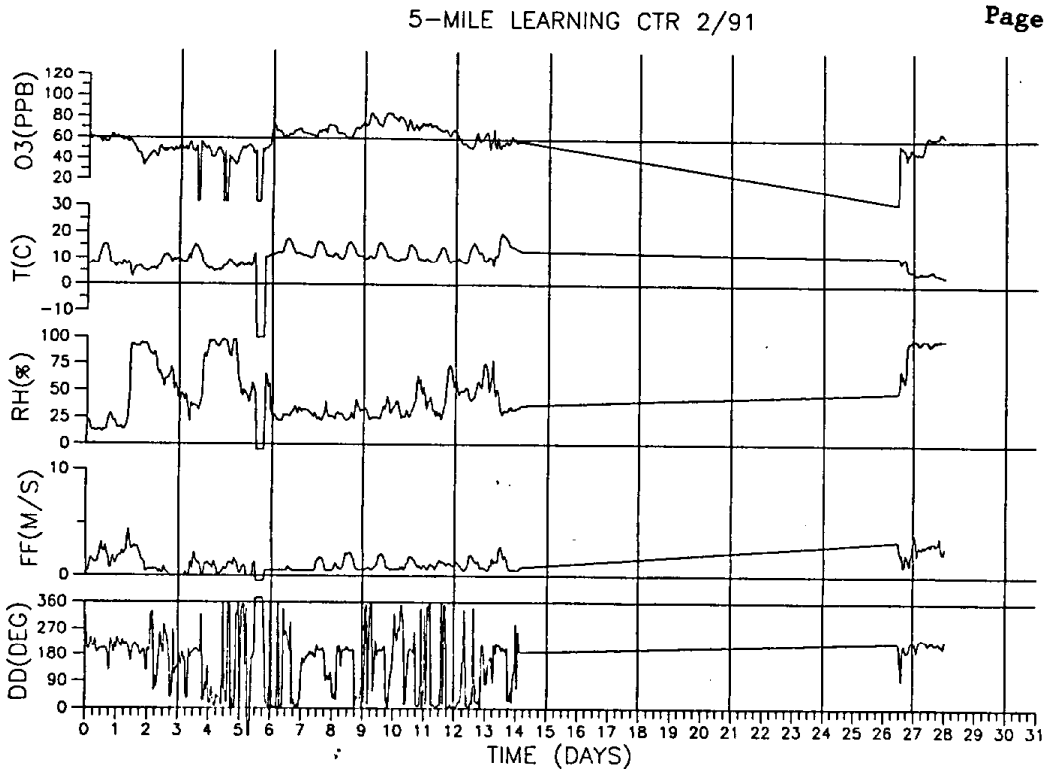


Figure 10. Same as 9, but for Jerseydale.



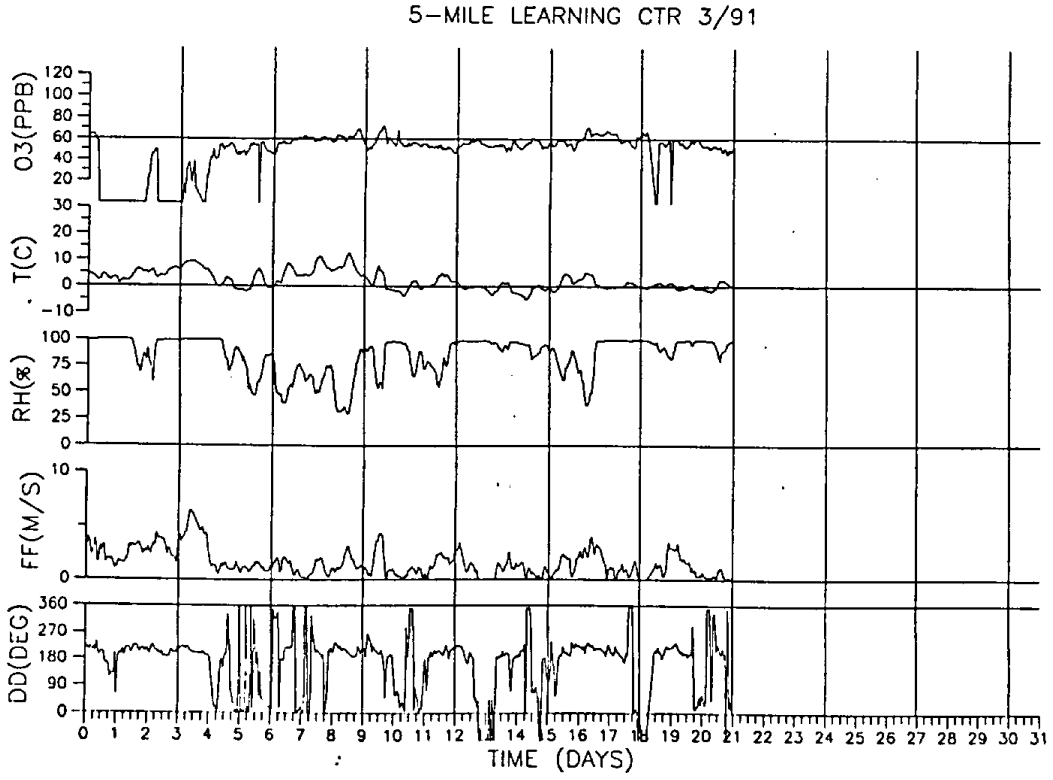


Figure 11, continued.

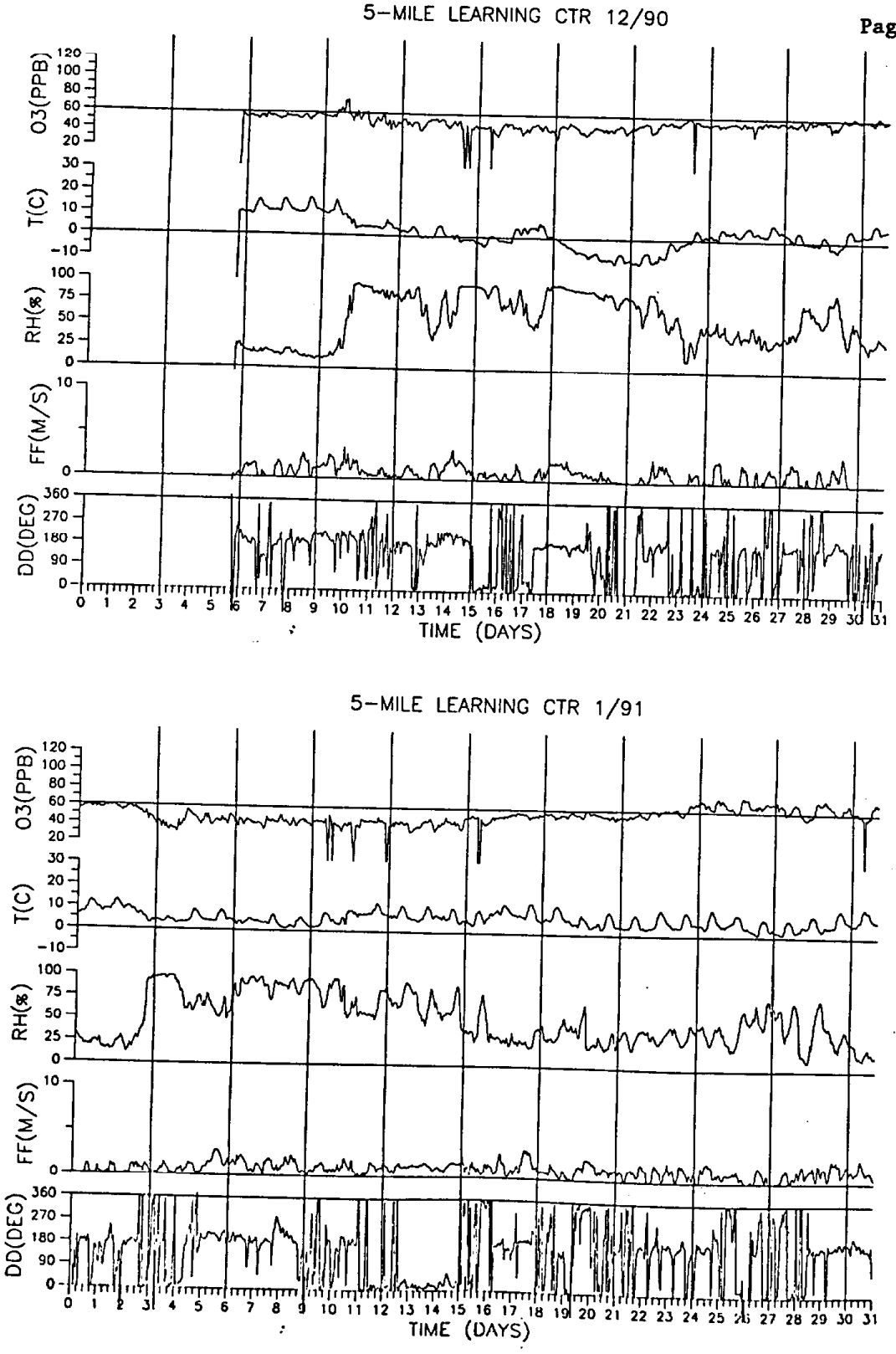


Figure 11. Same as 9, but for 5-mile Learning Center. Data between February 14 and 26 are missing due to computer CPU hardware error.

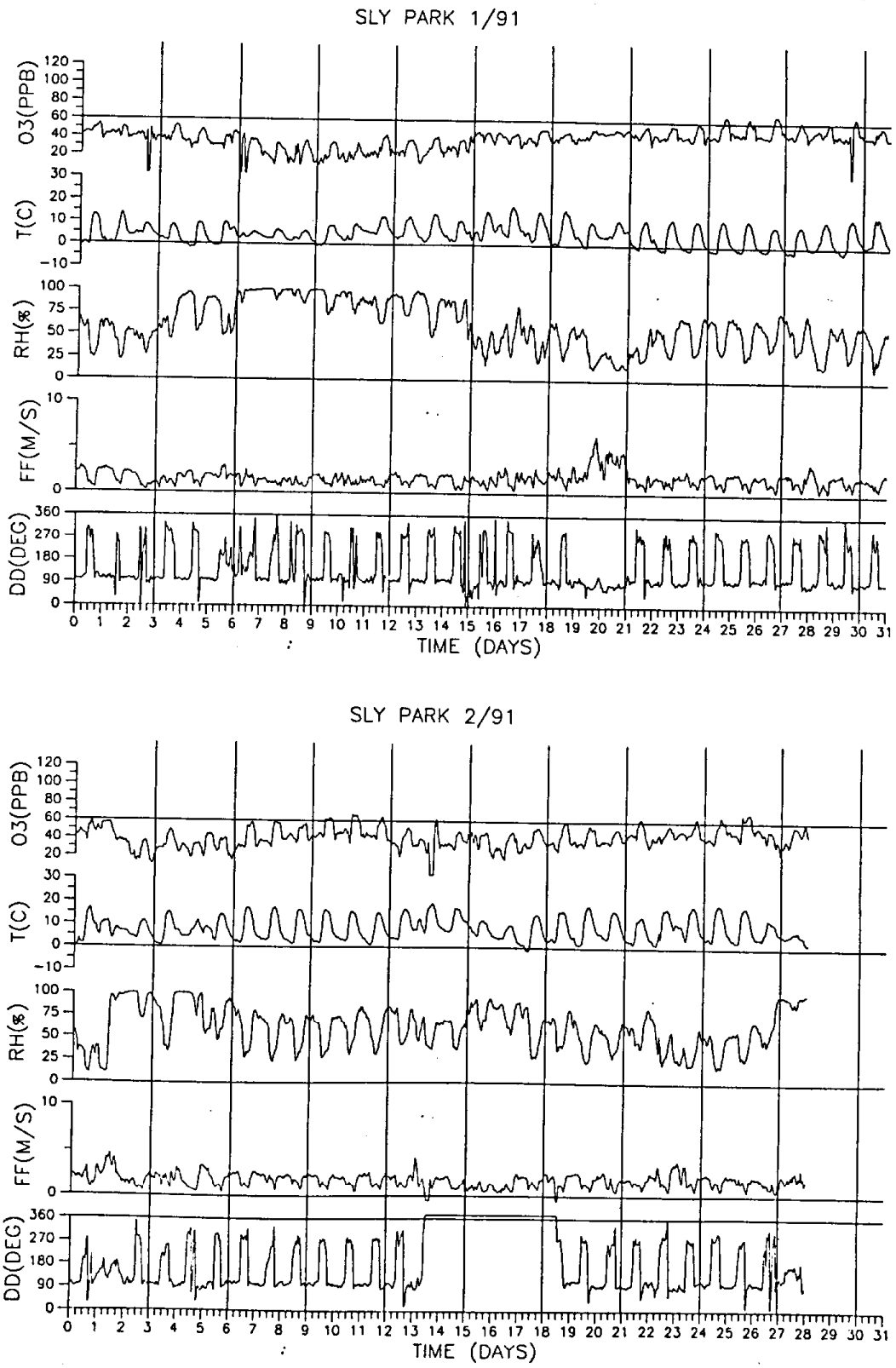


Figure 12, continued.

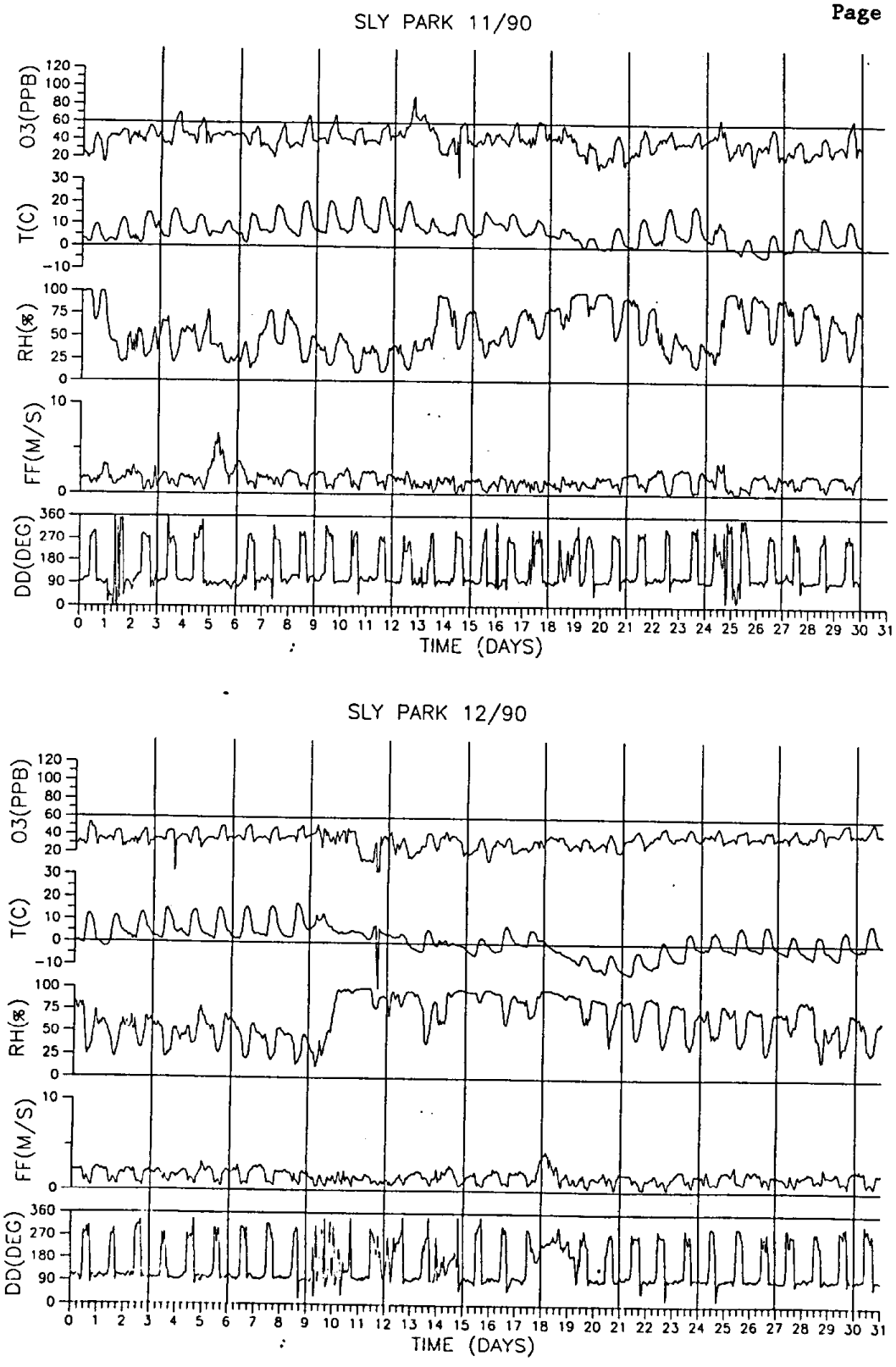
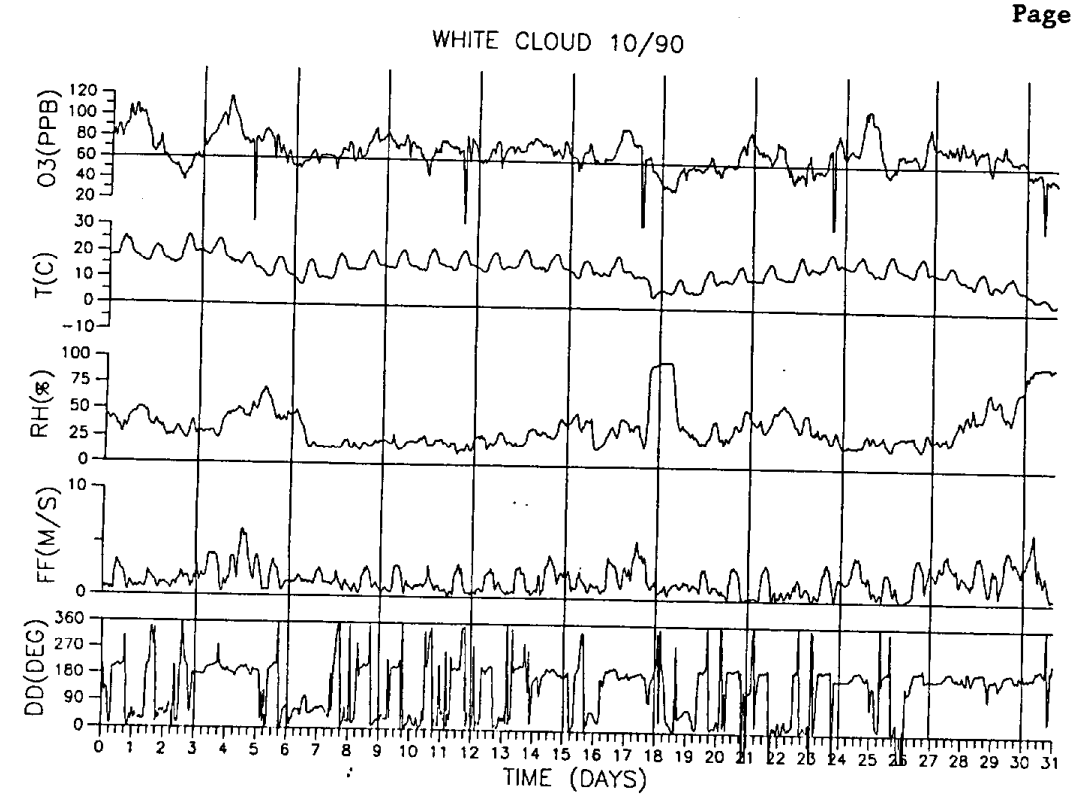


Figure 12. Same as 9, but for Sly Park Learning Center.



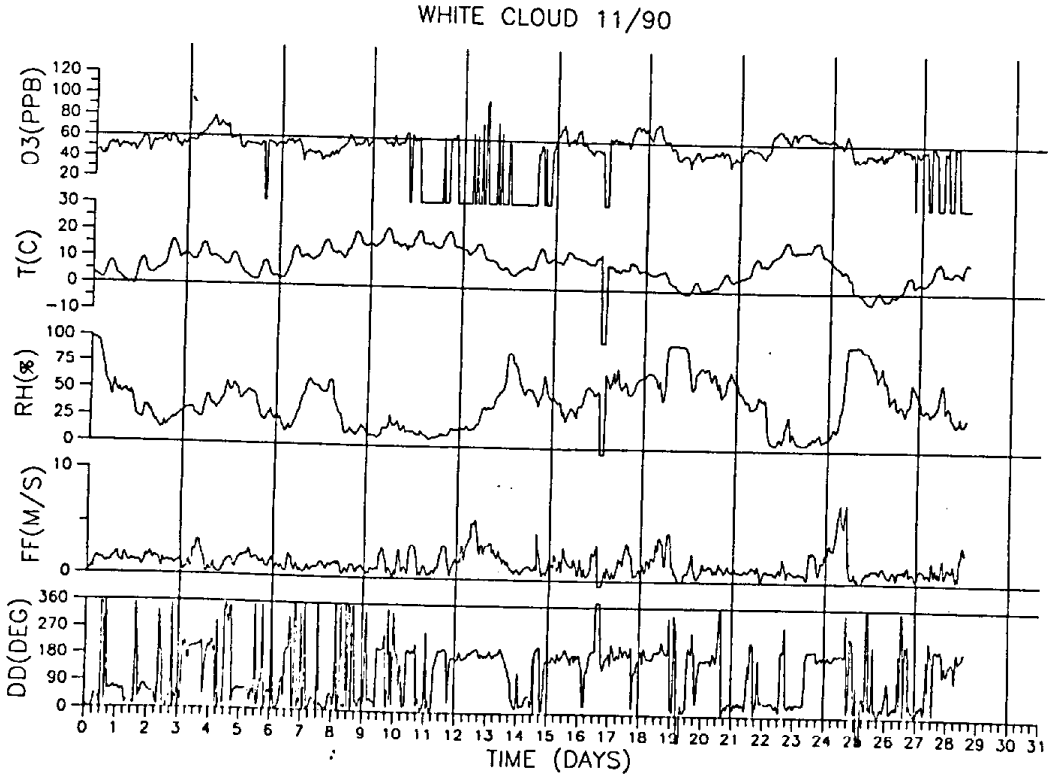


Figure 13. Same as 9, but for White Cloud.

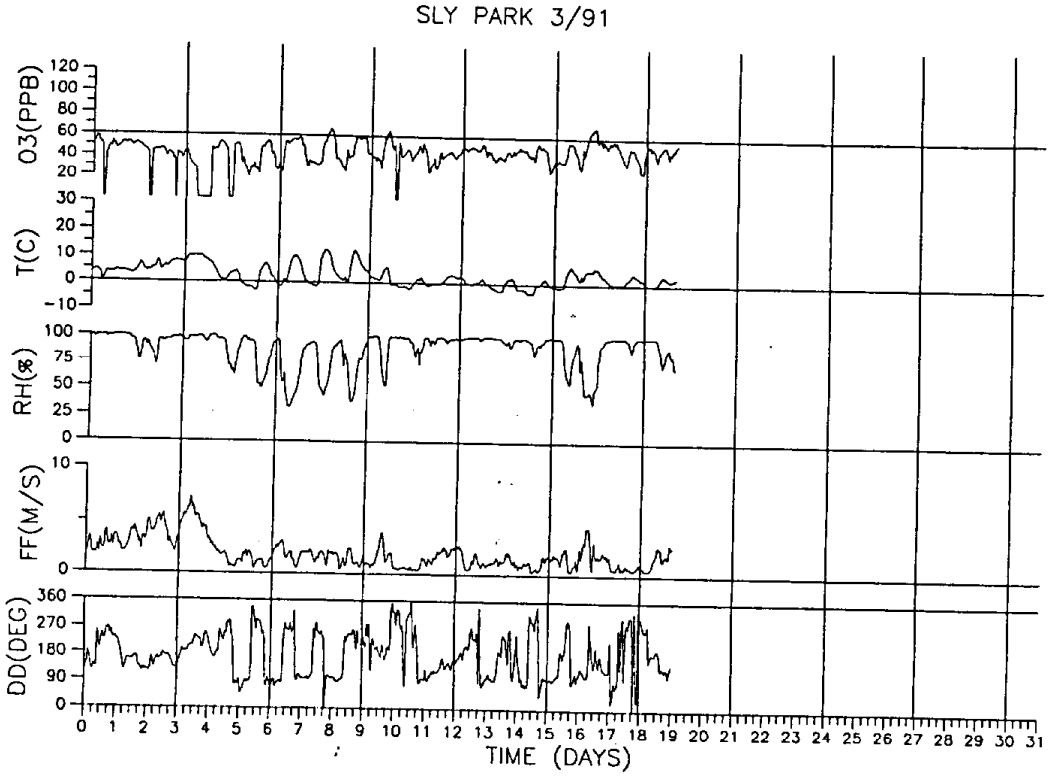


Figure 12, continued.

INTRODUCTION

The University of California, Davis, Department of Land, Air, and Water Resources (UCD) is installing a network of six stations to measure meteorological parameters and ozone along the western slopes of the Sierra Nevada. The San Jose' State University, Department of Meteorology (SJSU) has contracted with UCD to: (1) conduct a field quality assurance audit of network instrumentation to help insure the reliability of the data gathered and (2) to develop the software for a user-friendly data base of the measurements collected by this network. The originally proposed dates of the joint projects was to be 1 November 1989 to 30 June 1990. Due to funding delays, the project was not initiated until 4 April, 1990 and so some tasks originally proposed were modified slightly over the course of this project period. This report will summarize the progress made on completing the proposed tasks.

QUALITY ASSURANCE AUDITS

Background

The 1989 proposal to the Air Resources Board (ARB) states the following tasks to be subcontracted to SJSU concerning external quality assurance auditing: (1) as an independent agency, verify instrument calibrations at all air monitoring stations shortly after instrument installation; and thereafter, on a biannual basis, (2) deploy for short periods one or two additional portable ozone monitors within the forests surrounding selected primary stations to establish the degree to which each primary station represents conditions within the area of interest, and (3) certify the ozone calibrator by comparing it with a primary standard ozone monitor, using procedures outlined and adopted by the US Environmental Protection Agency (EPA).

Task (3) was actually arranged between UCD and the ARB Standards Laboratory. However, due to funding delays and the late start of the program, tasks (1) and (2) have been postponed. The six-station monitoring network was not fully operational prior to late fall.

This year has been dedicated to perfecting the following quality assurance (QA) audit procedures. This has involved the following: (1) laboratory calibration check of the Assmann psychrometer wet bulb/dry bulb mercury-in-glass thermometers; (2) laboratory audit dry runs; (3) field audit dry runs; and (4) field audit procedures. This section summarizes the accomplishments of each of these preliminary tasks.

Laboratory Calibration Check of the Assmann Psychrometer Thermometers

A calibration check and report was completed in July 1990 at the SJSU Meteorology Department observatory to certify the accuracy of these thermometers for use as a transfer standard for temperature and relative humidity calibration checks of site instrumentation. The wet bulb and dry bulb thermometers were compared to three precision thermometers certified by the National Bureau of Standards. Test results indicated accurate wet bulb/dry bulb readings.

APPENDIX A:

FIELD QUALITY ASSURANCE AUDITS AND DATA BASE DEVELOPMENT

FOR

THE U.C. DAVIS FIELD MONITORING PROGRAM
DRAFT FINAL REPORT

SUBMITTED TO

JOHN CARROLL
DEPARTMENT OF LAND, AIR AND WATER RESOURCES
UNIVERSITY OF CALIFORNIA, DAVIS

BY

KENNETH P. MacKAY
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SAN JOSE' STATE UNIVERSITY
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(408) 924-5203

Background

Task 2 of this subproject was to develop a procedure for archiving data in a user friendly format and to develop procedures for ready retrieval. The proposal stated that SJSU "develop the formats and procedures for data storage and retrieval such that they will be readily accessible to a wide range of users." We proposed to develop the following software:

> Software for reading raw data and storing same in user-friendly format.
> User access software.
> Software to compile and store monthly summaries of hourly-averaged data.
> Software to display and access monthly summaries.

Due to the schedule delay for the installation of the UCD network, only the first two software tasks have been essentially completed. However, once the storage and access software have been completely checked to see if the software package capabilities are those desired by users, then the development of software to compile and retrieve monthly summaries should be fairly straight forward.

The User Interface

The data base program so far developed accepts ASCII plain text files in the format generated by the data loggers in the field, converts these data to dBASE IV format and allows users to query the database for any subset of data values. This section describes the capabilities of the data base operations. Appendix I contains a more complete description of the methods of operation of the database operations.

The applications program, OZONE, performs all of the data base operations. When the program is initiated, the menu which first appears shows the following choices: File, Edit, Query, Maintenance and Graph. These options allow the user to: (1) import raw data and translate them to dBASE IV format; (2) edit or scan translated files; (3) query the files to create subsets of the data by any combination of station, observation time and parameter value; (4) perform maintenance on data archives; (5) produce simple graphs of the data. This subsection briefly describes the capabilities of the applications program, OZONE.

Importing and translating data files

Under the menu option "File" the user can choose the options: Import hourly data, Import five-minute data, Copy data files, Delete data files, Run DOS commands and Exit the program. The first two options read and translate the hourly and five-minute data respectively.

Data disks supplied by the UCD network contain three types of files: (1) STA-n.LOG contains string records of significant events in the system operation; i.e., scheduled maintenance, and other data interruptions. The database processing does nothing with these files. (2) Files with the generic names of yymmdd-n.DAT contain the five minute averages and root mean square (RMS) values of measured variables. The following naming convention is used by UCD: yy = last

Laboratory Audit Dry Runs

Two laboratory audit dry runs were performed during the past six months to simulate field conditions. In early October 1990, procedures were developed for the Met One 014A anemometer and the 024A wind vane using calibration check equipment for these instruments at the SJSU Department of Meteorology Observatory. In early November 1990, procedures were tested using the complete air quality instrument set-up at UCD Meteorology annex. Results from these dry runs allowed for significant audit procedure simplifications and modifications.

Field Audit Dry Runs

A total of four field trips to operating stations were completed during the past five months of this project. Three trips were completed with the assistance of one or two UCD staff research assistants (January, February, and March 1991). The other was completed with the SJSU Principal Investigator (Dr. K.P. MacKay) as technician overseer (November 1990). Three stations were visited: White Cloud (SJSU only), Sly Park, and 5-Mile Learning Center (two times). During these field trips, UCD personnel gave instructions for lowering and raising the 33' and 55' meteorological instrument towers; questions were answered and problems were avoided concerning equipment/instrument set-up/data collection, site log book entries, and data logger malfunctions; SJSU personnel performed practice audits.

Field Audit Procedures

Detailed, step-by-step field audit procedures have been established for use on the six-station network. The procedures were developed using EPA-recommended guidelines (Lockhart, 1990). Manufacturer equipment instructions were referenced, as well as laboratory audit dry runs and psychrometer calibration check results. Audit forms designed to maintain organized record keeping and uniform data collection are included in the procedural format. Other items include: labeled diagrams to aid the auditor in visualizing more complex instrument audit operations; and conversion factors, meteorological tables, required formulae, and referenced instructions located in an appendix to allow for easy access.

DATA BASE SOFTWARE

A dBASE IV applications program has been completed which imports raw data in ASCII text format, translates the data into dBASE IV format and allows the user to build subsets of the data by querying the database by station, observation time and values of the measured parameters. This section describes the database program and capabilities. A floppy disk with the dBASE applications program is included as a part of this final report. The program needs to be tested by potential users to determine if any modifications are needed.

File Maintenance

The maintenance functions included are : Create dBASE, Delete dBASE, Pack dBASE, Copy dBASE, Zap dBASE, Clean dBASE, Rebuild and Move Records.

Graphing: (This option is not yet implemented.)

Tasks to Finish

The database program is in a form such that it now needs to be tested by potential users in order to determine if there are any modifications needed. A preliminary User's Manual has been developed and will be refined and completed in the near future.

The following programming tasks remain: Complete the graphing functions and the Help screens in the program. Once the program has been completed, a Developer's Version of dBASE IV will be purchased by the project and an executable version of the application can be tested by potential users.

SUMMARY

This year, SJSU has dedicated itself to perfecting the QA audit procedures and reporting forms. The audit procedures manual is nearly complete and only lacks a required tools and equipment list. The list will include equipment model and serial numbers, and will provide the auditor with a pre-trip checklist. Expected completion date for this task is April 5, 1991.

As of March 1991, ozone calibrator certification has been completed by the ARB Standards Laboratory. However, due to funding delays, a six-station independent (SJSU) field audit of air quality instruments has been postponed. As a result, deployment of portable ozone monitors used for station representativeness of area conditions has been postponed. A dBASE IV data translation and archiving routine is ready for testing by potential users.