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THE CENTRAL CALIFORNIA OZONE STUDY

APPENDIX B: CENTRAL CALIFORNIA OZONE STUDY VOLUME 2: FIELD OPERATIONS PLAN

PIER FINAL PROJECT REPORT

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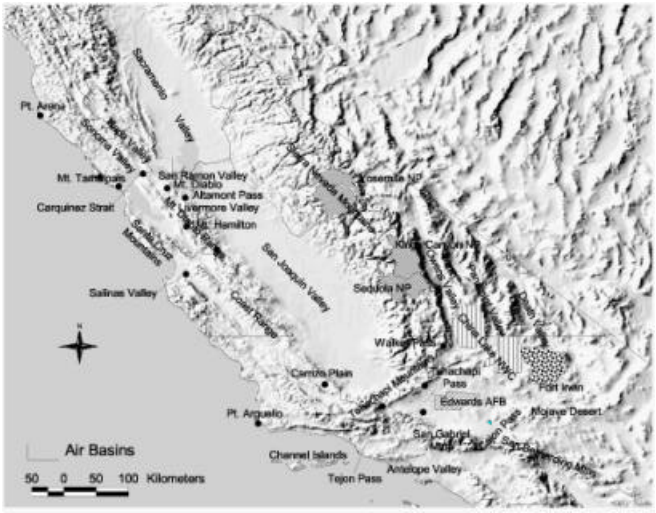

Central California Ozone Study (CCOS)

Volume II:
Field Operations Plan

Version 2
May 31, 2000

Central California Ozone Study – Volume II
Field Operations Plan

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1.0 INTRODUCTION

The Central California Ozone Study (CCOS) is a multi-year program of meteorological and air quality monitoring, emission inventory development, data analysis, and air quality simulation modeling. The goals of CCOS are to: 1) obtain suitable air quality, meteorological and emission databases to evaluate and improve air quality models for representing urban and regional-scale ozone episodes in central and northern California to meet the regulatory requirements for the state 1-hour and pending federal 8-hour ozone standards; 2) determine the contributions of transport and locally generated ozone and the relative benefits of hydrocarbon and nitrogen oxides emission controls in upwind areas; and 3) assess the relative contributions of ozone generated from emissions in one air basin to state and federal exceedances in neighboring air basins. The modeling domain for CCOS covers all of central California and most of northern California, extending from the Pacific Ocean to east of the Sierra Nevada Mountains and from Redding to the Mojave Desert. The selection of this study area reflects the regional nature of the state 1-hour and federal 8-hour ozone exceedances, increasing urbanization of traditionally rural areas, and a need to include all of the major flow features that affect air quality in central California. The CCOS field measurement program will be conducted in the summer of 2000 in conjunction with the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRPAQS), a major study of the origin, nature and extent of excessive levels of fine particles in central California (Watson et al., 1998).

The CCOS is a large-scale program involving many sponsors and participants. Three entities are involved in the overall management of the Study. The San Joaquin Valleywide Air Pollution Study Agency, a joint powers agency (JPA) formed by the nine counties in the Valley, directs the contracting aspects of the Study. A Policy Committee comprised of four voting blocks: State, local, and federal government, and the private sector, provides guidance on the Study objectives and funding levels. The Policy Committee approves all proposal requests, contracts and reports and is responsible for fund raising. A Technical Committee parallels the Policy Committee in membership and provides overall technical guidance on proposal requests, direction and progress of work, contract work statements, and reviews of all technical reports produced from the study. The technical committee comprises staff from the California Air Resources Board, U.S. Environmental Protection Agency, the California Energy Commission, local air pollution control agencies, and industry, with technical input from a consortium of university researchers in the University of California System and the Desert Research Institute (DRI). On a day-to-day basis, the California Air Resources Board is responsible for management of the Study.

The CCOS plan consists of a field study plan (Volume I) and this field operations plan (Volume II). These documents correspond to the two phases of the planning process for CCOS [1]. The CCOS field study plan (Version 3: 11/24/99) is a product of regular meetings of the CCOS Technical Committee and Working Groups over a six-month period and input from local air pollution control districts, academia, and industry reviewers on two earlier versions of the plan

[1] Parallel efforts are also underway to develop a broad conceptual model of ozone formation in central California based on San Joaquin Valley Air Quality Study and Atmospheric Utility Signatures, Predictions and Experiments Regional Model Adaptation Program (SARMAP) and other relevant studies and a "comprehensive" study plan that addresses the long-term research needs related to the ozone problem in central California (Roth, 1999a and 1999b).

(released on 6/11/99 and 9/7/99). The field study plan describes the goals and technical objectives to be addressed by the study, and describes alternative experimental, modeling, and data analysis approaches for addressing the study objectives. It presents a summary of the current knowledge of meteorology, emissions, and chemical and physical processes that affect the formation and accumulation of ozone in northern and central California. It also reviews the results from prior SAQM[2] modeling by ARB, and identifies the remaining uncertainties and their implications for the design of the CCOS field measurement program. The plan describes requirements for the modeling and data analysis approaches that are proposed to address CCOS technical objectives and specifies measurements for modeling and data analysis. It considers the merits of alternative measurement approaches and explains the rationale and criteria for measurement decisions. The field study plan is available in PDF format on the study web site at **http://www.arb.ca.gov/ccaqs/ccos/ccos.htm**.

The field study plan served as the basis for contracts with measurement groups and for developing the field operations plan for the summer 2000 field study. This field operations plan specifies the details of the field measurement program that will allow the field study plan to be executed with available resources. It identifies measurement locations, observables, and monitoring methods, specifies data management and reporting conventions, and outlines the activities needed to ensure data quality.

1.1 Basis for the Study Design

The goals of CCOS are to be met through a process that includes analysis of existing data; execution of a large-scale field study in summer 2000 to acquire a comprehensive database to support modeling and data analysis; analysis of the data collected during the field study; and the development, evaluation, and application of an air quality simulation model for northern and central California. Although air quality simulation modeling may be used to address CCOS goals, past experience has demonstrated the need for thorough diagnostic analyses and corroborative data analysis to assess the reliability of outputs from each part of the modeling system (i.e., emissions, meteorological, and air quality models). Corroborative data analysis is used to reinforce current understanding, identify gaps and improve the conceptual model of ozone formation, and to determine if measurement and modeling results are consistent with the conceptual model as revised by CCOS.

The reliability of model outputs is assessed through operational and diagnostic evaluations and application of alternative diagnostic tools. Operational evaluations consist of comparing concentration estimates from the model to ambient measurements. Diagnostic evaluations determine if the model is estimating ozone concentrations correctly for the right reasons by assessing whether the physical and chemical processes within the model are simulated correctly. This broad task also involves reconciliation of the corroborative data analysis results with modeling results. It includes evaluation of modeling uncertainties, processes, and assumptions and their effect on observed differences among model results, measurements, and data analysis results.

[2] SARMAP Air Quality Model

Operational model evaluations will focus on the determination of the extent of agreement between simulated and measured concentrations of ozone and its precursors in their spatial distribution and timing. The level of confidence that can be developed from this type of evaluation increases with the number and variety of episodes and chemical species that are examined. Measurements of the three-dimensional variations in ozone and ozone precursors also enhance the utility of the evaluations. Model simulations will be compared with airborne measurements of volatile organic compounds (total VOC, homologous groups, and lumped classes) along boundaries, above the mixed layer, and at the surface with measurements made at the supplemental measurement sites. A similar comparison will be made for the measurements of nitrogenous species concentrations. The temporal and spatial variability of the initial and boundary conditions will be evaluated to determine their effect on model output.

Diagnostic model evaluations examine the model's representations of gas-phase chemistry, photolysis rates, treatment of advection, deposition rates and the treatment of subgrid scale processes. The treatment of photolytic rate parameters will be evaluated by comparing the model default values with measurements. Comparisons of calculated secondary chemical product concentrations with measurements will be used to assess the chemical mechanisms. Other examples of chemical diagnostic tests include examining ratios of chemical species that are sensitive to specific processes within the model such as O_3/NOy, O_3/ NOz and comparing concentration changes from weekdays to weekends. Process analysis (Jeffries and Tonnesen, 1994) can be used to derive a detailed mass balance for each simulation. This allows the determination of the effect of each process on the concentrations of ozone and other air pollutants. Although it is not possible to use measurements to develop an independent, comprehensive mass balance throughout the study region, measurements (e.g., ratios of NO to NO_2 or a highly reactive VOC to a less reactive VOC) can be used to check key parameters within the simulations. Alternatively model calculated parameters such as HO could be used along with measured mixing ratios of VOC to estimate VOC to NOx ratios. Both approaches should provide strong tests of the conceptual model. Diagnostic evaluation of the transport is more difficult but comparisons of the horizontal and vertical distributions of ozone and its precursors will be required. Another test to evaluate the transport would be to compare measured and modeled fluxes of ozone and ozone precursors across interbasin transport corridors.

An important issue for air quality modeling in CCOS is the treatment of plumes from elevated point sources containing high mixing ratios of NOx. Ozone formation rate in the plume of an elevated point source will be different from the ambient air because of their very different VOC/NOx ratios. Although many models ignore the effect of plumes by simply mixing the plume emissions into typical grid cell volumes, some air quality models use a plume-in-grid (PiG) approach. In the PiG approach a Gaussian-shaped plume is simulated in a Lagrangian reference frame that moves with the local wind vector, superimposed on the Eulerian reference frame of the host grid model, and at some suitable time period the contents of the plume are mixed into the grid cells. Most current approaches are overly dispersive and do not treat the effect of turbulence on chemistry and they ignore the effect of wind shear on plume separation. A more advanced approach was developed under EPRI sponsorship, the Second order Closure Integrated PUFF model (SCIPUFF) with a chemistry module (SCICHEM). Their improved parameterizations of turbulent chemistry makes simulations more realistic than models using simpler approaches, particularly within the first few kilometers downwind of the smokestack, where plume confinement and turbulent chemistry have the greatest effect on local as well as

overall ozone production. The SCICHEM was evaluated favorably as part of the 1995 Nashville/Middle Tennessee Ozone Study. Since the composition of the plumes will be different for central California, these new modules should be evaluate using the CCOS database.

In principle, well-performing air quality modeling systems have the ability to quantify local and transported contributions to ozone exceedances in a receptor area. However, many of the interbasin transport couples in the CCOS study region involve complex flow patterns with strong terrain influences that are difficult to realistically simulate. The CCOS field campaign provides routine and supplemental measurements at locations where transport can occur. The proposed upper air network provides a "flux plane" method by which quantitative estimate is possible, with suitable assumptions. In combination with modeling, data analyses can improve the evaluation of modeling results and provide additional quantification of transport contributions. Methods that should be applied include timing of ozone where morning peaks indicate fumigation of carry-over aloft, peaks near solar noon indicate possible local contributions, and delayed peaks indicate transport, with later times corresponding to sites further downwind along the transport path. Other methods include back trajectory wind analysis and examination of ratios of hydrocarbons of varying reactivity (i.e., xylenes-to-benzene ratio). In addition, vertical planes intersecting the profiler sites downwind of and perpendicular to the transport path can be defined and provide estimates of transport through likely transport corridors. The analyses use surface and aircraft measurements of pollutant concentrations and surface, wind profiler, and aircraft meteorological data for volume flux estimations.

An important question for ozone control strategies is whether to focus on NOx or VOC control. To choose the proper control strategy it is necessary to know if ozone production is limited in a location more by the NOx or VOC available. Models and measurements have been applied to answer this question. One of the methods would be to determine ozone isopleths from measurements for each site in an airshed but usually not enough data are available. Therefore indicators for VOC or NOx limitation include ratios such as HNO_3/H_2O_2 and other ratios have been applied to both measurements and models. Within CCOS, NOx and VOC limitation will be investigated through the use of measurements, indicators and modeling analysis.

One of the most important tests of model simulations is the ability to simulate accurately weekday-weekend differences in precursors and ozone. One of the most important applications of this test is that it helps to probe the relative sensitivity of ozone concentrations to VOC and NOx. Since the mid-1970's it has been documented that ozone levels in California's South Coast Air Basin (SoCAB) are higher on weekends than on weekdays, in spite of the fact that ozone pollutant precursors are lower on weekends than on weekdays (Elkus and Wilson, 1977; Horie et al., 1979; Levitts and Chock, 1975; Zeldin et al., 1989; Blier and Winer, 1998; and Austin and Tran, 1999). Similar effects have been observed in San Francisco (Altshuler et al., 1995) and in the northeastern cities of Washington D.C., Philadelphia, and New York (SAIC, 1997). While a substantial "weekend effect" has been observed in these cities, the effect is less pronounced in Sacramento (Austin and Tran, 1999), and is often reversed in Atlanta (Walker, 1993) where VOC/NOx ratios are typically higher. Several of the above studies show that the "weekend effect" is generally less pronounced in downwind locations where ambient VOC/NOx ratios are higher.

Understanding the response of ozone levels to specific changes in VOC or NOx emissions is a fundamental prerequisite to developing a cost-effective ozone abatement strategy. The varying emissions that occur between weekday and weekend periods provide a natural test case for air quality simulation models. At the same time, the model performance and evaluation must be accompanied by an evaluation of the accuracy of the temporal and spatial patterns of precursor emissions. With the questions that still remain regarding the accuracy of emission inventories, the "weekend effect" emphasizes the need for observation-based data analysis to examine the relationship between ambient O3 and precursor emissions. The results of corroborative data analyses need to be reconciled with model outputs taking into consideration the various sources of uncertainties associated with both approaches.

The current conceptual model will be revisited and refined using the results yielded by the foregoing data analyses. New phenomena, if they are observed, must be conceptualized so that a mathematical model to describe them may be formulated and tested. The formulation, assumptions, and parameters in mathematical modules that will be included in the integrated air quality model will be examined with respect to their consistency with reality.

1.2 Technical Objectives

The study design and experimental approach for CCOS are defined in terms of specific technical objectives. A number of tasks are required to meet each of the technical objectives. These tasks are listed in this section and are described in greater detail in Sections 3 and 4 of the field study plan (Fujita et al., 1999).

<u>Preparation, Execution and Evaluation of Air Quality Simulation Modeling Systems (M)</u>

Objective M-1. Apply air quality models for the attainment demonstration portion of the SIP for the proposed 8-hour and state 1-hour ozone standards.

a. Select the most suitable modeling systems (for meteorology, emissions, and air quality) for representing photochemical air pollution in central and northern California. At least one of the models selected should have the ability to simulate both ozone and fine particles. Simulations with that model could be applied to both CRPAQS and CCOS. This will facilitate integration of results across both studies.

b. Analyze the data collected during the CCOS field measurement program and select a minimum of three ozone episodes to simulate.

c. Specify model domain boundaries, boundary conditions, initial conditions, chemical mechanisms, aerosol module, plume-in-grid module, grid sizes, layers, and surface characteristics.

d. Identify performance evaluation methods and performance measures, and specify methods by which these will be applied.

e. Evaluate the results of the meteorological model.

f. Perform operational evaluation of the air quality model.

g. Evaluate and improve the performance of emissions, meteorological, and air quality simulations. Apply simulation methods to estimate ozone concentrations at receptor sites and to test potential emissions reduction strategies.

h. Identify the limiting precursors of ozone and assess the extent to which reductions in volatile organic compounds and nitrogen oxides, would be effective in reducing ozone concentrations.

Objective M-2. Determine the relative contributions of ozone generated from emissions in one basin to federal and state exceedances in neighboring air basin.

a. Characterize the structure and evolution of the boundary layer and the nature of regional circulation patterns that determine the transport and diffusion of ozone and its precursors in northern and central California.

b. Identify and describe transport pathways between neighboring air basins, and estimate the fluxes of ozone and precursors transported at ground level and aloft under differing meteorological conditions. Reconcile results with flux plane measurements.

c. Determine the contribution of ozone generated from emissions in one basin to federal and state exceedances in neighboring air basin through emission reduction sensitivity analysis.

Objective M-3. Provide improve understanding of the role of thermal power plant plumes in contributing to regional air quality problems in central California.

a. Conduct measurements during CCOS Intensive Operational Periods (IOPs) in plumes from one or more power plants to allow reactive plume or plume-in-grid model to be evaluated.

b. Provide operational evaluation of a state-of-the-science reactive plume model component using data collected during the CCOS field study.

c. Using the modeling system developed by CCOS, provide a technical analysis appropriate to support the development of interbasin/intrabasin as well as interpollutant offset rules that could be applied to the central California region.

d. Run model simulations to estimate the air quality implications of different energy policies.

Objective M-4. Assess the reliability associated with air quality model inputs and formulation, and reconcile model results with observation-based and other data analysis methods.

a. Perform diagnostic evaluation of model results.

b. Quantify the uncertainty of emissions rates, chemical compositions, locations, and timing of ozone precursors that are estimated by emission models.

c. Quantify the uncertainty of meteorological and air quality models in simulating atmospheric transport, transformation, and deposition.

Data Analysis (D)

Objective D-1. Determine the accuracy, precision, validity, and equivalence of CCOS field measurements.

a. Evaluate the precision, accuracy, and validity of criteria pollutant data from routine monitoring stations.

b. Evaluate the precision, accuracy, and validity of PAMS and CCOS supplemental VOC measurements and nitrogenous species measurements.

c. Evaluate the precision, accuracy, validity, and equivalence of routine network and CCOS supplemental surface and upper-air meteorological data.

d. Evaluate the precision, accuracy, validity of data from instrumented aircraft and radiosonde/ozonesonde releases.

e. Evaluate the precision, accuracy, validity, and equivalence of routine and supplemental solar radiation data.

Objective D-2. Determine the spatial, temporal, and statistical distributions of air quality measurements to provide a guide to the database and aid in the formulation of hypotheses to be tested by more detailed analyses.

a. Examine average diurnal changes of surface concentration data during episodic and non-episodic periods.

b. Examine spatial distributions of surface concentration data.

c. Examine statistical distributions and relationships among surface air quality measurements.

d. Examine vertical distribution of concentrations from airborne measurements.

e. Examine the spatial and temporal distribution of solar radiation.

Objective D-3. Characterize meteorological transport phenomena and dispersion processes.

a. Examine the mechanisms for the movement of air into, out of, and between the different air basins in both horizontal and vertical directions.

b. Determine occurrence, spatial extent, intensity, and variability of phenomena affecting horizontal transport (low-level jet, slope flows, eddies, coastal meteorology and flow bifurcation) and vertical transport (convergence and divergence zones).

c. Characterize the depth, intensity, and temporal changes of the mixed layer and characterize mixing of elevated and surface emissions.

Objective D-4. Reconcile emissions inventory estimates with ambient measurements and "real-

a. Compare proportions of species measured in ambient air and those estimated by emission inventories for reactive and nonreactive species.

b. Estimate source contributions by Chemical Mass Balance using measured and modeled ambient VOC composition.

c. Conduct on-road remote sensing measurements of CO, HC, NOx and (PM if available) in Sacramento, Fresno, and the San Francisco Bay Area, and evaluate the effects of cold-starts, grade and geographic distribution of high-emitting vehicles.

d. Reconcile on-road motor vehicle emission inventory estimates and fuel-based emissions estimates.

e. Determine effects of meteorological variables on emissions rates.

f. Determine the detectability of day-specific emissions (e.g., fires) and variations in emissions between weekday and weekend.

Objective D-5. Characterize pollutant fluxes between upwind and receptor areas. Examine the orientations, dimensions, and locations of flux planes by using aircraft spiral and traverse data, and ground-based concentration data for VOCs, NOx, and O_3 coupled with average wind speeds that are perpendicular to the chosen flux planes.

a. Define the orientations, dimensions, and locations of flux planes.

b. Estimate the fluxes and total quantities of selected pollutants transported across flux planes. Test following hypotheses: 1) whether there is significant local generation of pollutants; 2) whether there is significant dilution within or turbulent exchange through the top of the mixed layer; and 3) whether there is substantial transport or dilution owing to eddies, nocturnal jets, and upslope/downslope flows.

Objective D-6. Characterize chemical and physical interactions in the formation of ozone.

a. Examine VOC and nitrogen budgets as functions of location and time of day.

b. Reconcile the spatial, temporal, and chemical variations in ozone, precursor, and end-product concentrations with expectations from chemical theory.

c. Apply observation-based methods to determine where and when ozone concentrations are limited by the availability of NOx or VOC.

d. Identify the composition and location of one or more power plant plumes and their surrounding air aloft so that the dispersion and chemical evolution of the plume(s) can be inferred.

Objective D-7. Characterize episodes in terms of emissions, meteorology, and air quality and determine the degree to which each intensive episode is a valid representation of commonly occurring conditions and its suitability for control strategy development.

a. Describe each intensive episode in terms of emissions, meteorology, and air quality.

b. Examine continuous meteorological and air quality data acquired for the entire study period, and determine the frequency of occurrence of days which have transport and transformation potential similar to those of the intensive study days. Generalize this frequency to previous years, using existing information for those years.

Objective D-8. Reformulate the conceptual model of ozone formation in the study domain using the results yielded by the foregoing data analyses and modeling. Examine the formulation, assumptions, and parameters in mathematical modules in the air quality model with respect to their consistency with reality.

1.3 Field Study Design Guidelines

The proposed measurement program incorporates the following design guidelines that combine technical, logistical and cost considerations, and lessons learned from similar studies.

1. CCOS is designed to provide the aerometric and emission databases needed to apply and evaluate atmospheric and air quality simulation models, and to quantify the contributions of upwind and downwind air basins to exceedances of the federal 8-hour and state 1-hour ozone standards in northern and central California. While urban-scale and regional model applications are emphasized in this study, the CCOS database is also designed to support the data requirements of both modelers and data analysts. Air quality models require initial and boundary measurements for chemical concentrations. Meteorological models require sufficient three-dimensional wind, temperature, and relative humidity measurements for data assimilation. Data analysts require sufficient three-dimensional air quality and meteorological data within the study region to resolve the main features of the flows and the spatial and temporal pollutant distributions. The data acquired for analyses are used for diagnostic purposes to help identify problems with and to improve models.

2. Since episodes are caused by changes in meteorology, it is useful to document both the meteorology and air quality on non-episode days. For this reason, surface and upper air meteorological data as well as surface air quality data for NOx and ozone will be continuously collected during the entire summer of 2000. The database will be adequate for modeling and a network of radar profilers will allow increased confidence in

assigning qualitative transport characterization (i.e., overwhelming, significant, or inconsequential) throughout the study period.

3. Many of the transport phenomena and important reservoirs of ozone and ozone precursors are found aloft. CCOS is designed to include extensive three-dimensional measurements and simulations because the terrain in the study area is complex and because the flow field is likely to be strongly influenced by land-ocean interactions. Several upper air meteorological measurements are proposed at strategic locations to elucidate this flow field.

4. Although specific advances have been made in characterizing emissions from major sources of precursor emissions, the accuracy of emission estimates for mobile, biogenic and other area sources at any given place and time remains poorly quantified. Ambient and source measurements (e.g., speciation profiles and remote sensing measurement of on-road vehicles), with sufficient temporal and chemical resolution, are required to identify and evaluate potential biases in emission inventory estimates.

5. Past studies document that the differences in temporal and spatial distributions of precursor emissions on weekdays and weekends alter the magnitude and distribution of peak ozone levels. Measurements are needed to evaluate model performance during periods that include weekends.

6. Measurements of documented quality and adequate sensitivity are needed along the western and northern boundaries of the modeling domain to adequately characterize the temporal and spatial distributions of ambient background levels of ozone, volatile organic compounds, and nitrogen oxides. Boundary conditions, particularly for formaldehyde, significantly affected model outputs in the SARMAP modeling resulting in over-prediction of ozone levels in the Bay Area. The same is true for NOx concentrations. SARMAP modeling shows that the western boundary has over 0.5 ppb of NO. These moderate NO concentrations over the ocean appear to be due to transport from the model's boundary. Airborne measurements are needed far enough off shore to better define the boundary conditions along the western boundary.

7. The measurements should be designed such that no single measurement system or individual measurement is critical to the success of the program. The measurement network should be dense enough that the loss of any one instrument or sampler will not substantially change analysis or modeling results. The study should be designed such that a greater number of intensive days than minimally necessary for modeling are included. This helps minimize the influence of atypical weather during the field program and decreases the probability of equipment being broken or unavailable on a day selected for modeling. Most measurements should be consistent in location and time for all intensive study days and during the entire study period (i.e., no movement of measurements). In this way, one day can be compared to another. Continuous measurements should be designed to make use of the existing monitoring networks to the extent possible.

8. For model evaluation, it is desirable to have measurement stations along the line running from the San Francisco Bay Area through Sacramento to the foothills of the Sierra Nevada and along the San Joaquin valley. The model predicts that ozone concentrations show strong variations over this region due to transport, deposition and chemistry. Measurement stations to measure ozone concentrations and the concentrations of precursors and other photochemical products placed along the west–east line will help to determine if the models represent a scientifically reasonable description of ozone formation and transport. The same can be said of an array of measurements through the San Joaquin valley.

9. It is also important to have measurement stations to the north and south of the Sacramento area because of the bifurcation in typical meteorological situations, where the flow fields from the west diverges toward the north and south. The ozone concentrations show several ozone hot spots one directly east of the San Francisco Bay Area with two more directly to the north and south. Measurements to the north and south in this area will help determine if the model predicted patterns are real. High ozone concentrations along and directly east and south of the San Joaquin valley. Measurement stations are required in this area as well.

10. The SAQM model predicts a rather complex vertical structure in ozone concentrations. The vertical structure of ozone concentrations along a north–south cross-section through the center of central California near Sacramento show that ozone is lost and transported to the north and south leaving an arc of ozone that extends aloft and to the east and west by midnight. The vertical structure of the ozone concentrations along the west–east cross section through central California along the line running from the San Francisco Bay Area through Sacramento to the foothills of the Sierra Nevada is similar in its overall behavior to the north–south line. The plots show evidence of transport of ozone and NOx from the west to the east. Ozone is lost in the lower levels and remains relatively high aloft as the time progresses from noon to midnight. Some of the parcels of high ozone are seen to travel from west to east in this sequence. Ozonesondes near San Francisco and Sacramento and aircraft measurements of ozone over the Sierra Nevada foothills and the western boundary are required to observe this complex ozone structure predicted by the models.

1.4 Guide to the CCOS Field Operations Plan

This field operations plan specifies the details of the field measurement program that will allow the field study plan to be executed with available resources. It identifies measurement locations, observables, and monitoring methods, specifies data management and reporting conventions, and outlines the activities needed to ensure data quality. Section 2 specifies the CCOS measurement parameters, methods, locations, averaging times, calibration methods. Section 3 describes the meteorological conditions associated with ozone episodes and transport scenarios of interests, and specifies the daily forecast and intensive operational period (IOP) decision-making protocols. Sections 4 and 5 describe the quality assurance and data management activities for the study, respectively. Section 6 summarizes the efforts to develop a temporally and spatially resolved emission inventory for the CCOS modeling domain, and Section 7 specifies the program schedule and budget.

2.0 CCOS FIELD MEASUREMENTS

Data requirements for CCOS are determined by the need to drive and evaluate the performance of modeling systems, which include three components. A meteorological model provides winds fields, vertical profiles of temperature and humidity, and other physical parameters in a gridded structure. Emissions inventory and supporting models provide gridded emissions for anthropogenic area and point sources and natural emissions. An air quality model simulates the chemical and physical processes involved in the formation and accumulation of ozone. In evaluating modeling system performance, the primary concern is replicating the physical and chemical processes associated with actual ozone episodes. This necessitates the collection of suitable meteorological, emissions, and air quality data that pertain to these episodes. The data requirements of CCOS are also driven by a need for complementary, independent and corroborative data analysis so that modeling results can be compared to current conceptual understanding of the phenomena replicated by the model.

2.1 Geographic Scope

Central California is a complex region for air pollution, owing to its proximity to the Pacific Ocean, its diversity of climates, and its complex terrain. Figure 2.1.1 show the overall study domain with major landmarks, mountains and passes. The CCOS domain includes most of northern California and all of central California. The northern boundary extends north of Redding and provides representation of the entire Central Valley of California. The western boundary extends approximately 200 km west of San Francisco and allows the meteorological model to use mid-oceanic values for boundary conditions. The southern boundary extends below Santa Barbara and into the South Coast Air Basin. The eastern boundary extends past Barstow and includes a large part of the Mojave Desert and all of the southern Sierra Nevada. The Bay Area, southern Sacramento Valley, San Joaquin Valley, central portion of the Mountain Counties Air Basin (MCAB), and the Mojave Desert are currently classified as nonattainment for the federal 1-hour ozone NAS. With the exception of Plumas and Sierra Counties in the MCAB, Lake County, and the North Coast, the entire study domain is currently nonattainment for the state 1-hour ozone standard. The Mojave Desert inherits poor air quality generated in the other parts of central and southern California.

2.2 Study Period

The CCOS field measurement program will be conducted during a four-month period from 6/1/00 to 9/30/00. A network of upper-air meteorological monitoring stations will supplement the existing routine meteorological and air quality monitoring network in order to identify and characterize meteorological conditions that are conducive to ozone formation during this four-month period. Supplemental air quality measurements will be made during a three-month period from 6/15/00 to 9/15/00 (***study period***), which corresponds to the majority of elevated ozone levels observed in northern and central California during previous years. Continuous surface and upper-air meteorological measurements and surface air quality

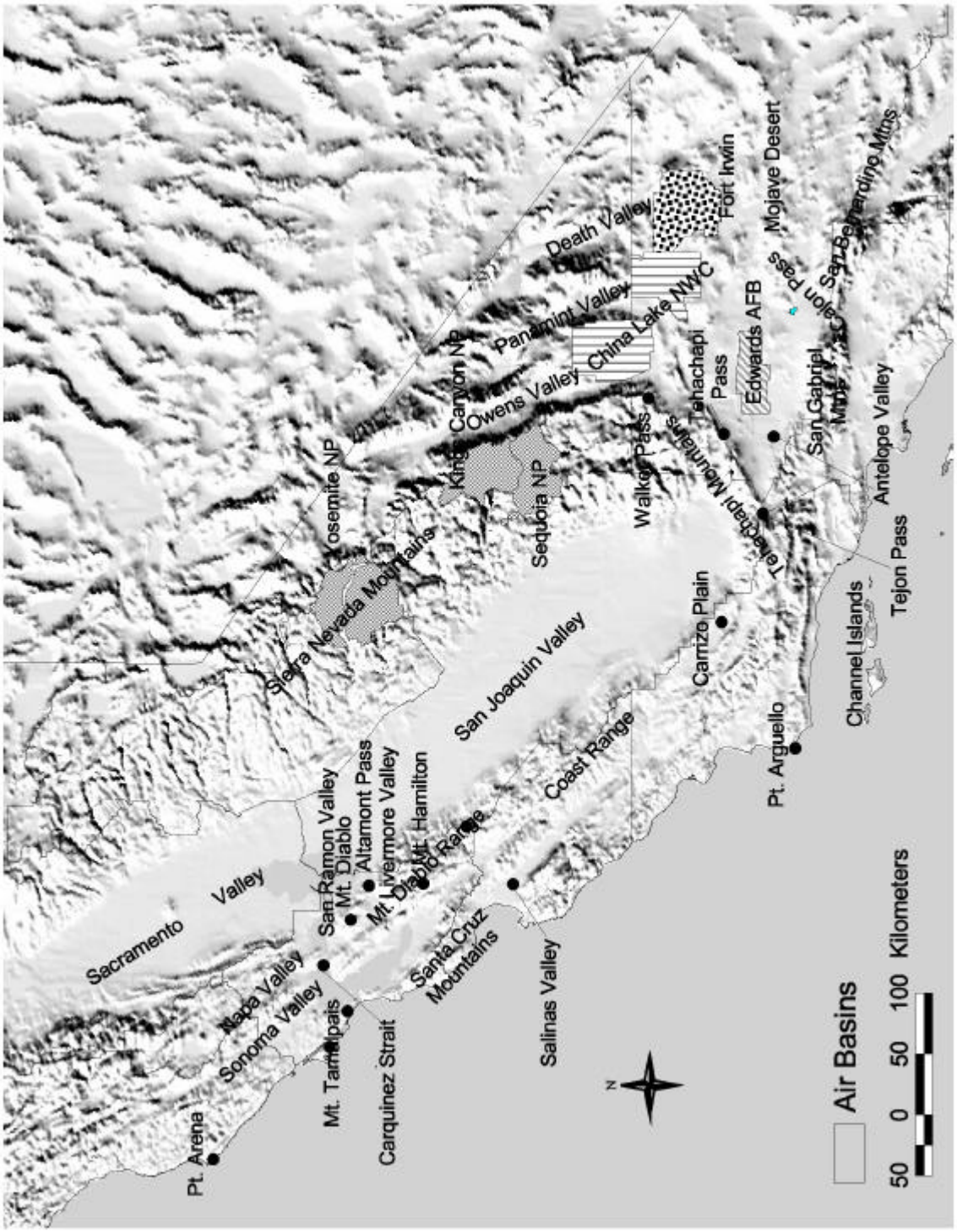

Figure 2.1-1. Overall study domain with major landmarks, mountains and passes.

measurements of O_3 NO, NOx or NOy[1] will be made hourly throughout the study period in order to provide sufficient input data to model any day during the study period. These measurements are made in order to assess the representativeness of the episode days, to provide information on the meteorology and air quality conditions on days leading up to the episodes, and to assess the meteorological regimes and transport patterns which lead to ozone episodes.

Additional continuous surface air quality measurements will be made at several sites during a shorter two-month study period from 7/6/00 to 9/2/00 (***primary study period***). These measurements include nitrogen dioxide (NO_2), peroxyacetylnitrate (PAN) and other peroxyacylnitrates (PAcN), particulate nitrate (NO_3^-), formaldehyde (HCHO), and speciated volatile organic compounds (automated gas chromatography with ion-trap mass spectrometer) [2]. These measurements allow detailed examination of the diurnal, day-to-day, and day-of-the-week variations in carbon and nitrogen chemistry at transport corridors and at locations downwind of the San Francisco Bay Area, Sacramento, Fresno, and Bakersfield where ozone formation may be either VOC- or NOx-limited depending upon time of day and pattern of pollutant transport. These data support operational and diagnostic model evaluations, evaluations of emission inventories, and corroborative observation-based data analyses.

Additional data will be collected during ozone episodes (***intensive operational periods***, ***IOPs***) to better understand the dynamics and chemistry of the formation of high ozone concentrations. The budget for CCOS allows for up to 15 days total for episodic measurements. With an average episode of three to four days, four to five episodes are likely. These measurements include instrumented aircraft, speciated VOC, and radiosonde measurements, which are labor intensive and require costly expendables or laboratory analyses. IOPs will be forecasted during periods that correspond to categories of meteorological conditions called scenarios, which are associated with ozone episodes and ozone transport in northern and central California. These intensive measurements will be made on days leading up to and during ozone episodes and during specific ozone transport scenarios. Forecast and decision protocols are described in Section 2. The IOP measurements are needed for operational and diagnostic model evaluation, to improve our conceptual understanding of the causes of ozone episodes in the study region and the contribution of transport to exceedances of federal and state ozone standards in downwind areas.

2.3 Existing Monitoring Networks

Field monitoring includes continuous measurements over several months and intensive studies that are performed on a forecast basis during selected periods when episodes are most likely to occur. This section describes the existing routine air quality and meteorological monitoring network in northern and central California, and the options for continuous and intensive air quality and meteorological measurements (surface and aloft) to be made during CCOS.

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[1] Reactive oxidized nitrogen (NOy) include nitric oxide (NO), nitrogen dioxide (NO2), nitrous acid (HONO), peroxynitric acid (HNO4), nitrate radical (NO3), nitrate aerosol (NO3-), dinitrogen pentoxide (N2O5), nitric acid (HNO3), peroxyacetylnitrate (PAN) and other PAN analogues, and organic nitrates (ORNI).

[2] These instruments will be installed during a two-week period from 6/12/00 to 6/23/00. Data collection will begin from the date of installation, one to two weeks prior to start of the primary study period.

2.3.1 Criteria Pollutant Air Monitoring Stations

The California Air Resources Board and local air pollution control districts currently operate 185 air quality monitoring stations throughout northern and central California. Of the active sites, 130 measure ozone and 76 measure NOx. Carbon monoxide and hydrocarbons are measured at 57 and 11 sites, respectively. Data from these sites are routinely acquired and archived by the ARB and Districts. This extensive surface air quality monitoring network provides a substantial database for setting initial condition for the model, and for operational evaluation of model outputs. ARB, in collaboration with the California air quality management districts, is establishing the $PM_{2.5}$ monitoring sites. The existing PM_{10} acquires filter samples every sixth day. Several of the PM_{10} sites have continuous monitors that measure hourly PM_{10} everyday. Watson et al. (1998) describes the PM measurement network.

2.3.2 Photochemical Assessment Monitoring Stations

Under Title I, Section 182, of the 1990 Amendments to the Federal Clean Air Act, the EPA proposed the implementation of a national network of enhanced ambient air monitoring stations. States with areas classified as serious, severe, or extreme for ozone attainment are required to establish photochemical assessment monitoring stations (PAMS) as par of their State Implementation Plan. Each station measures speciated hydrocarbons and carbonyl compounds, ozone, oxides of nitrogen, and surface meteorological data. Additionally, each area must monitor upper air meteorology at one representative site.

The program was phased in over a five-year schedule, beginning in 1994 at a rate of at least one station per year. A maximum of five PAMS sites are required in affected nonattainment areas, depending on the population of the Metropolitan Statistical Area/Consolidated Metropolitan Statistical Area (MSA/CMSA) or nonattainment area, whichever is larger. PAMS networks are based on selection of an array of site locations relative to ozone precursor source areas and predominant wind directions associated with high ozone events. Specific monitoring objectives associated with each of these sites result in four distinct site types.

Type 1 sites are established to characterize upwind background and transported ozone and its precursor concentrations entering the area and to identify those areas that are subjected to overwhelming transport. Type 1 sites are located in the predominant morning upwind direction from the local area of maximum precursor emissions during the ozone season. Typically, Type 1 sites will be located near the edge of the photochemical grid model domain in the predominant upwind direction from the city limits or fringe of the urbanized area.

Type 2 sites are established to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions are expected. These sites also are suited for the monitoring of urban air toxic pollutants. Type 2 sites are located immediately downwind of the area of maximum precursor emissions and are typically placed near the downwind boundary of the central business district. Additionally, a second Type 2 site may be required depending on the size of the area, and will be placed in the second-most predominant morning wind direction.

Type 3 sites are intended to monitor maximum ozone concentrations occurring downwind from the area of maximum precursor emissions. Typically, Type 3 sites will be located 10 to 30 miles downwind from the fringe of the urban area.

Type 4 sites are established to characterize the extreme downwind transported ozone and its precursor concentrations exiting the area and identify those areas that are potentially contributing to overwhelming transport in other areas. Type 4 sites are located in the predominant afternoon downwind direction, as determined for the Type 3 site, from the local area of maximum precursor emissions during the ozone season.

PAMS precursor monitoring is conducted annually in California during the peak ozone season (July, August and September). Eleven PAMS sites will be in operation during summer 2000 (four in Sacramento County, four in Fresno County, and three in Kern County). EPA methods TO-14 and TO-11 are specified by the EPA for sampling and analysis of speciated hydrocarbons and carbonyl compounds, respectively (EPA, 1991). Table 2.3-1 contains the minimum list of targeted hydrocarbon species. For carbonyl compounds, state and local agencies are currently required to report only formaldehyde, acetaldehyde and acetone. The ARB and districts laboratories may be able to quantify and report several C3 to C7 carbonyl compounds that appear in the HPLC chromatograms.

Under the California Alternative Plan, four 3-hour samples (0000-0300, 0600-0900, 1300-1600, and 1700-2000, PDT) are collected every third day during the monitoring period at all PAMS sites for speciated hydrocarbons and at Type 2 sites only for carbonyl compounds. These sampling periods are the same as the CCOS supplemental VOC sampling periods. In addition to the regularly scheduled measurements, samples are collected on a forecast basis during up to five high-ozone episodes of at least two consecutive days. Episodic measurements consist of four samples per day (0600-0900, 0900-1200, 1300-1600, and 1700-2000, PDT) for speciated hydrocarbons at all PAMS sites and for carbonyl compounds at Type 2 sites. Because the ARB laboratory has a limited number canisters and must recycle the them during the PAMS season, a relaxation of the regularly scheduled PAMS sampling is necessary to accommodate multi-day IOPs of three or more consecutive days. Instead of the sampling schedule in the California Alternative Plan, the U.S. Environmental Protection Agency has approved a request by the ARB to modify the normal PAMS sampling schedule in order to accommodate more episodic sampling in coordination with the CCOS IOPs.

The implementation of PAMS by the local APCDs in central California during summer 2000 is outlined in Table 2.3-2. The new sampling plan will retains only the 6-9 a.m (PDT) sample, every third day, to preserve the analysis of long-term trend. Up to 24 canister samples will be collected at PAMS sites in Central California during a maximum of three consecutive IOP days during any one-week period. Table 2.3-2 shows the tentative allocation of the 24 samples among the eleven PAMS sites in the CCOS domain. CCOS will also provide 100 canisters to the PAMS program for contingency use.

Table 2.3-1
PAMS Target Species

1	Ethylene	29	2,3-Dimethylpentane
2	Acetylene	30	3-Methylhexane
3	Ethane	31	2,2,4-Trimethylpentane
4	Propene	32	n-Heptane
5	Propane	33	Methylcyclohexane
6	Isobutane	34	2,3,4-Trimethylpentane
7	1-Butene	35	Toluene
8	n-Butane	36	2-Methylheptane
9	trans-2-Butene	37	3-Methylheptane
10	cis-2-Butene	38	n-Octane
11	Isopentane	39	Ethylbenzene
12	1-Pentene	40	m&p-Xylene
13	n-Pentane	41	Styrene
14	Isoprene	42	o-Xylene
15	trans-2-Pentene	43	n-Nonane
16	cis-2-Pentene	44	Isopropylbenzene
17	2,2-Dimethylbutane	45	n-Propylbenzene
18	Cyclopentane	46	1-ethyl 3-methylbenzene
19	2,3-Dimethylbutane	47	1-ethyl 4-methylbenzene
20	2-Methylpentane	48	1,3,5-Trimethylbenzene
21	3-Methylpentane	49	1-ethyl 2-methylbenzene
22	2-Methyl-1-Pentene	50	1,2,4-Trimethylbenzene
23	n-Hexane	51	n-decane
24	Methylcyclopentane	52	1,2,3-Trimethylbenzene
25	2,4-Dimethylpentane	53	m-diethylbenzene
26	Benzene	54	p-diethylbenzene
27	Cyclohexane	55	n-undecane
28	2-Methylhexane		Total NMOC

Table 2.3-2
PAMS Sites in the CCOS Area

		Sampling Schedule for 2000 (CCOS)					
Site	**Type of Site**	**HC [a]**	**Carb [b]**	**00**	**06**	**13**	**17**
Sacramento							
Elk Grove-Bruceville	PAMS - 1	x		1	1	0	0
Sacramento-Airport Rd.	PAMS - 2	x	x	0	1	0	1
Sacramento-Del Paso	PAMS - 2A	x	x	1	1	0	1
Folsom-50 Natoma Street	PAMS - 3	x		0	1	0	1
Fresno							
Madera	PAMS - 3/1	x		0	0	0	0
Clovis Villa	PAMS - 2	x	x	1	1	0	1
Fresno-1st Street	PAMS - 2	x	x	1	1	0	1
Parlier	PAMS - 3	x		0	1	0	0
Bakersfield							
Bakersfield-Golden State	PAMS - 2	x	x	1	1	0	1
Arvin	PAMS - 3/1	x		1	1	0	1
Shafter	PAMS - 1	x		1	1	0	0
				7	10	0	7

Type 1 - Upwind background.
Type 2 - Maximum precursor emissions (typically located immediately downwind of the central business district).
Type 3 - Maximum ozone concentration.
Type 4 - Extreme downwind transported ozone area that may contribute to overwhelming transport in other areas.
a - Canisters collected every third day (one 3-hr sample beginning at 0600 PDT) plus CCOS IOPs as indicated.
b - DNPH cartridges collected every third day (one 3-hr sample beginning at 0600 PDT) plus CCOS IOPs as indicated.

Total nonmethane hydrocarbon (NMHC) concentrations are also measured by analysis of the canister samples by preconcentration direct injection flame ionization detection (PDFID). Total NMHC is measured by passing the air sample through a chromatographic column to separate methane from other hydrocarbons and analyzing the bulk hydrocarbon sample by FID. In the FID, sample air is burned in a hydrogen flame creating a quantity of ions from the hydrogen molecules in the air sample. The ions conduct a small electrical current which is measured by an electrometer, which in turn produces an electronic signal proportional to the number of ions collected. Thus, the total hydrocarbon data are reported as parts per billion carbon (ppbC). Total nonmethane hydrocarbon (NMHC) concentrations are monitored continuously on an hourly basis at all Sacramento and San Joaquin Valley PAMS sites by either automated-Preconcentration Direct Injection Flame Ionization Detection (PDFID) (e.g., Xontech 850) or TEI 55C. Recent modifications of the TEI55C (Ventura option) provide improved limit of detection (from 150 ppbC to 75 ppbC).

2.3.3 Surface Meteorological Networks

The existing meteorological network in central California is extensive, but uncoordinated among the different agencies. Figure 2.3-1 shows the locations of surface meteorological monitoring sites operated by the Air Resources Board (ARB), the Bay Area Air Quality Management District (BAAQMD), the National Oceanic and Atmospheric Administration (NOAA), the California Irrigation Management Information Service (CIMIS), Interagency Monitoring of PROtected Visual Environments (IMPROVE), the National Weather Service (NWS), Pacific Gas and Electric Company (PG&E), the U.S. Coast Guard, Remote Automated Weather Stations (RAWS) for fire fighting, and a few miscellaneous monitors. Wind speed and direction, temperature, and relative humidity are the most common measurements. The network of surface pressure and solar radiation measurements is also extensive. Three sites measure ultraviolet radiation in the Sacramento Valley, in the San Joaquin Valley, and along the south coast in Santa Barbara County. Figure 2.3-2 shows the surface meteorological observables measured at each monitoring location, regardless of the network from which they are derived. The specific measurements at each site and the networks they belong to are documented in Appendix C of Watson et al., (1998).

Thuillier et al. (1994) document the methods used to acquire and report data in most of these networks with their similarities and differences. Wind speed measurements are taken at heights ranging from 2 m to 10 m agl at most sites and temperatures are measured by aspirated and unaspirated thermometers. The major limitations of existing network instrumentation are: 1) wind thresholds of ~1 m/s for most instruments. The existing meteorological network will be augmented with the CCOS supplemental sites described below. Ten meter meteorological towers at each of these sites will be equipped with low threshold (~0.3 m/s) wind sensors and high sensitivity relative humidity sensors. Section 10 describes the monitors available for these measurements. With these supplemental measurements and surface measurements at the upper air sites, the existing surface monitoring network provides adequate coverage for the northern and central California study domain.

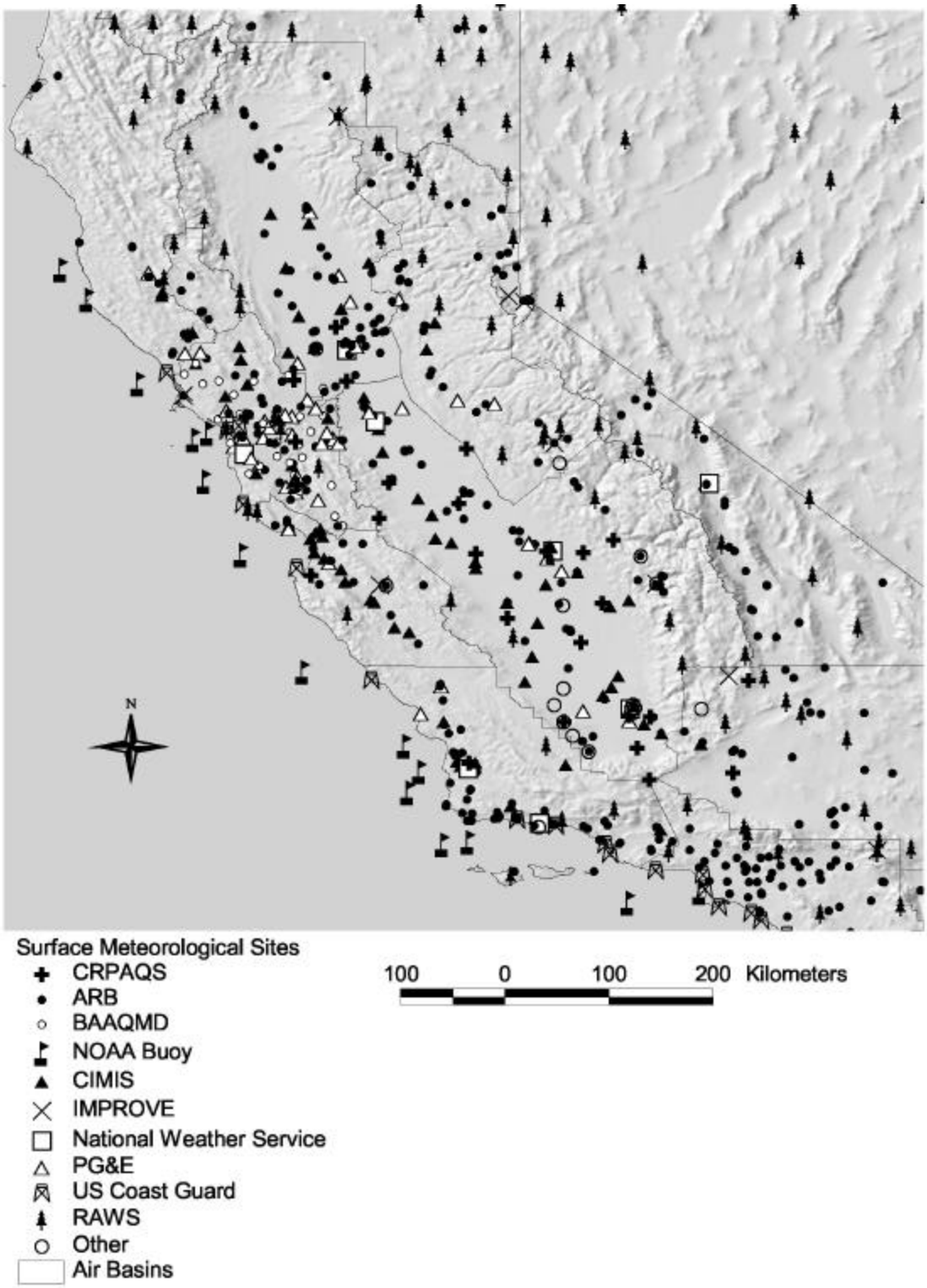


Figure 2.3-1. Central California surface meteorological networks and measurement locations.

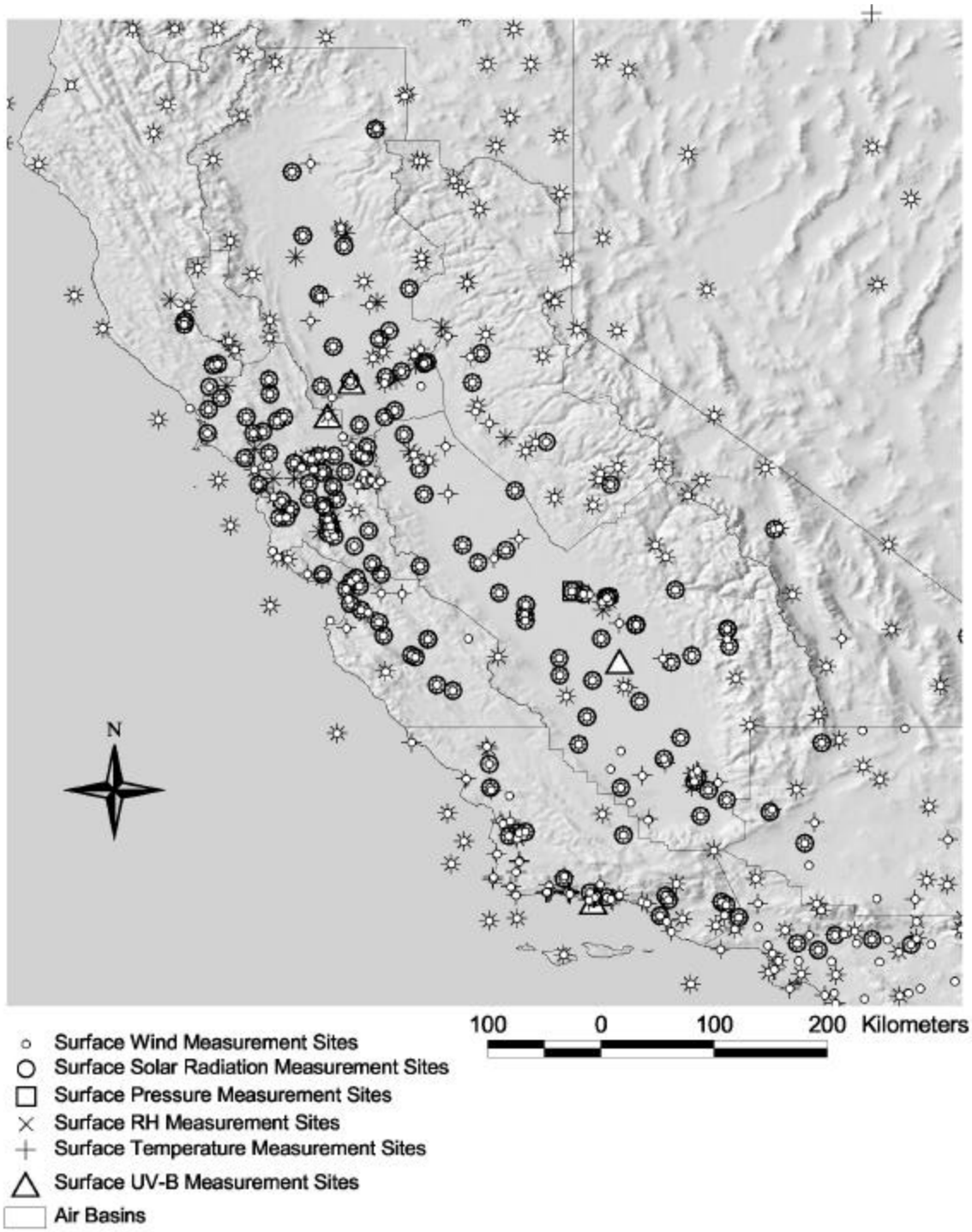


Figure 2.3-2. Surface meteorological observables measured in the combined central California meteorological network.

2.3.4 Solar Radiation Measurements

The US Department of Agriculture's UVB Radiation Monitoring Program was initiated in 1992, through a grant to Colorado State University, to provide information on the geographical distribution and temporal trends of UVB radiation in the United States.The climatology network of the USDA-CSREES monitoring program is designed to provide an adequate density of measurement sites to establish the spatial and temporal characteristics of UVB irradiance. The United States is divided into 26 regions of about equal area. The measurement sites are located primarily in rural areas near agricultural and forested regions. The US Department of Agriculture operates a UVB radiation measurement network with the following two sites in California.

Station Name	Closest town	Longitude	Latitude	Elevation
UC Davis Climate Station	(Davis)	121.8	38.5	18
Desert Research and Extension Center	(Holtville)	115.4	32.8	-18

The US Department of Agriculture's UVB Radiation Monitoring Program maintains one site, near Davis, California (Latitude: 38.529, Longitude: 121.761). The site is operated by the University of California at Davis. Co-location of one spectral radiometer for the measurement of actinic flux to this site will provide significant advantage to CCOS. There are two existing Multifilter Rotating Shadowband Radiometers (MFRSR) at the USDA, Davis site. A shadowband radiometer has a rotating metal band that periodically blocks the direct solar beam from entering the radiometer. This feature allows a measurement of the total horizontal, diffuse and direct normal components of the irradiance. One MFRS radiometer operates in the visible region and makes filter measurements at 415, 500, 610, 665, 862 and 940 nm and for the total visible radiation. The second MFRS operates in the UV and makes measurements at 300, 305.5, 311.4, 317.6, 325.4, 332.4, 368 nm. The sampling time for the visible MFRSR is 15 seconds and the sampling time for the ultraviolet MFRSR is 20 seconds however data from both MFRSR's are stored as 3-minute averages. There are several other measurements that support the UVB radiation measurements at this site including sensors for UVA, UVB-1 and surface reflection and measurements of relative humidity, temperature and barometric pressure. Sample data from this site may be obtained from:

http://uvb.nrel.colostate.edu/UVB/cgi_scripts/uvb_site_info_page.cgi?CA01&C.

Actinic flux in the troposphere depends most critically on the total ozone column, the aerosol loading, size and optical properties and the presence and characteristics of clouds. The UV and visible MFRSR will allow the total ozone column and the aerosol characteristics to be estimated. The total ozone column measured by an UV-MFRSR was compared with standard Brewer and Dobson spectrophotometers. The average ratio of ozone retrieved by the UV-MFRSR to that of the Brewer was found to be 1.02 and to the Dobson 1.03. The USDA's visible and UV-MFRSRs data provides an estimate optical depths as a measure of the total aerosol loading. These data together with the actinic flux measurements will allow a direct evaluation of the photolysis rate parameters calculated for use in air quality models.

The NOAA Integrated Surface Irradiance Study (ISIS) - A New Surface Radiation Monitoring Program. The Air Resources Laboratory (ARL) operates the NOAA national broadband solar radiation network collecting data in both the visible and ultraviolet (UV-B) wavebands. ISIS operates at two levels: Level 1 monitors incoming radiation only and Level 2 focuses on surface radiation balance. ISIS maintains a Level 1 site at Hanford, California in the central San Joaquin Valley. More detailed information is given in, "The NOAA Integrated Surface Irradiance Study (ISIS) - A New Surface Radiation Monitoring Program", B.B. Hicks, J.J. DeLuisi, and D.R. Matt. Bull. Amer. Meteor. Soc., 77, 2857-2864.

High quality data is available from the NSF UV Monitoring Network that maintains a site at San Diego approximately three miles from the Pacific Ocean. Although not in the CCOS domain it may provide some useful information on the effect of marine clouds on UV irradiance. The facility is used for calibration and intercomparison of UV and visible radiometers. The system has been operating since October 28, 1992. The use of UVB data from two other should be considered, the EPA stratospheric UV network and the EPA Exposure network.

Existing Networks for Solar Radiation

Examination of network data for global solar radiation may give some help in estimating the photolysis rate parameters of nitrogen dioxide. The California Air Resources Board and the NREL operates sites that measure solar radiation.

The ARB operates five sites and local APCDs operate 31 sites. Hourly averages are obtained by a thermopile or pyranometer with and accuracy of ± 5 %. These data are available from the Technical Support Division, Air Quality Data Branch, (916) 322-6076 or the U.S. EPA Aerometric Information Retrieval System (AIRS).

The NREL National Solar Radiation Data Base (NSRDB) contains a total of 56 Primary and 183 Secondary stations. The measurements made at these stations include global horizontal radiation in Wh/m^2, atmospheric pressure in millibars, direct normal radiation in Wh/m^2, wind direction in increments of 10 degrees, diffuse horizontal radiation in Wh/m2, wind speed in m/s, extraterrestrial radiation (ETR) in Wh/m2, horizontal visibility in km, direct normal ETR in Wh/m2 Ceiling height in decameters, total sky cover in tenths, present weather, opaque sky cover in tenths, total precipitable water in mm, dry-bulb temperature in ^oC, aerosol optical depth, dew-point temperature in ^oC, snow depth in cm, relative humidity in percent, and number of days since last snowfall. The stations located in California are Daggett, Fresno, Los Angeles, San Diego, and Santa Maria.

2.4 CCOS Surface Air Quality and Meteorological Monitoring Network

Supplemental air quality measurements are required at several existing monitoring sites to increase the extent of chemical speciation and in key areas of the modeling domain where routine monitoring stations do not currently exist. Measurements of documented quality and adequate sensitivity are needed along the western boundary of the modeling domain to adequately characterize the temporal and spatial distributions of ambient background levels of ozone precursors because boundary conditions can significantly affected model outputs. Background sites intend to measure concentrations that are not influenced by northern and

central California emissions. Interbasin transport sites are intended to evaluate concentrations along established or potential transport pathways between basins, including the Bay Area, the North Central Coast Air Basin, the Sacramento Valley, the San Joaquin Valley, Mountain counties, the South Central Coast Air Basin, and the Mojave desert. Intrabasin gradient sites are located in non-urban areas between routine network sites. They are intended to evaluate the extent to which one urban area affects ozone concentrations in another urban area, as well as the extent to which urban contributions arrive at suburban and rural locations.

2.4.1 Network Design and Measurements

The CCOS field measurement program consists of four categories of supplemental measurement sites with increasing levels of chemical speciation and time resolution – Type 0, 1, and 2 "supplemental" (S) sites and "research" (R) sites. Table 2.4-1 lists the measurements (described in Appendix C) to be made at each of type of supplemental monitoring sites along with operating period and the groups that are responsible for equipment procurement and testing, installation and training, and laboratory analysis. The measurement method and specific instruments that will be used in CCOS are given in Table 2.4-2. This table also provides nominal precision, detection limit, range, and averaging or sampling times. Tables 2.4-3a, 2.4-3b, and 2.4-3c show the instrument configuration at each of the CCOS supplemental air quality monitoring sites, using the letter designations introduced in Table 2.4-1. Figure 2.4-1 shows the locations of the existing monitoring stations measuring ozone and NOx. Figure 2.4-2 shows the locations of existing monitoring stations measuring carbon monoxide and PAMS speciated hydrocarbons and carbonyl compounds in relation to proposed CCOS supplemental monitoring sites. Site descriptions and information (e.g., local contact, mail and shipping addresses, phone number), equipment installation and operational responsibilities are documented in Appendix D1. Photographs of the sites are in Appendix D2.

Type 0 supplemental monitoring sites (S0) are intended to fill in key areas of the modeling domain where ozone and nitrogen oxides are not currently measured. Sites include McKittrick and Kettleman City (both along the western side of the San Joaquin Valley), Red Hills (along transport route between San Luis Obispo and the southern San Joaquin Valley), Lambie Road (in the Sacramento Delta downwind of the Bay Area between Fairfield and Rio Vista), and Bella Vista (northeast of Redding). Measurements at Bella Vista are designed to determine whether ozone precursors immediately upwind of Redding are largely transported or are attributable to local sources. One additional ozone-only site will be established in Shasta Lake, a resort community about ten miles north of Redding. In addition NO/NOy analyzers will be added at two existing monitoring sites that currently measure only ozone. These sites are San Martin (south of the Bay Area between San Jose and Hollister) and Sloughhouse (southeast of Sacramento).

Type 1 supplemental monitoring sites (S1) are intended to establish boundary and initial conditions for input into air quality models. These sites are needed at the upwind boundaries of the modeling domain, in the urban center (initial conditions) and at downwind locations (boundary conditions). The following aerometric parameters are measured at S1 supplemental monitoring sites.

1. Continuous surface wind speed and direction and temperature during study period.

Table 2.4-1
CCOS Supplemental Surface Measurements

Code	Observable and Method	Period	Site Types	Equipment Procurement & Testing	Equipment Installation and Training	Laboratory Analysis
A	Surface Meteorology (WS,WD, T and RH) at 10 m	6/15/00 to 9/15/00	S0, S1, S2, R	NOAA	NOAA	--
B	Ozone (ultraviolet absorption monitor)	6/15/00 to 9/15/00	S0, S1, S2, R	DRI	DRI	--
C	Trace level NO, NOx (chemiluminescent monitor)	6/15/00 to 9/15/00	R	CE-CERT	CE-CERT/DRI	--
D	NO, NOy (high sensitivity chemiluminescent monitor with external converter)	6/15/00 to 9/15/00	S0, S1, S2	CE-CERT	CE-CERT/DRI	--
E	NOy, NOy-HNO_3 (high sensitivity chemiluminescent monitor with dual converters w/ & w/o NaCl impregnated fiber denuder)	6/15/00 to 9/15/00	R	CE-CERT	CE-CERT	--
F	NO_2, PAcNs (GC - Luminol)	7/2/00 to 9/2/00	S2, R	CE-CERT	CE-CERT	--
G	NO_3^- (flash vaporization)	7/2/00 to 9/2/00	R	CRPAQS/AD	AD/DRI	--
H	CO (nondispersive infrared)	6/15/00 to 9/15/00	R	DRI	DRI	--
I	CO_2 (nondispersive infrared)	6/15/00 to 9/15/00	R	DRI	DRI	--
J; J'	CO, CO2, CH4, C_2-C_{12} hydrocarbons (canister/GC-FID); 55 target HC and NMOC for PAMS	15 IOP days	S1, S2; PAMS	DRI/BRC	DRI/BRC	DRI/BRC & ARB for PAMS
K	C_8-C_{20} hydrocarbons (Tenax GC-FID, MSD)	15 IOP days	R	DRI	DRI	DRI
L	VOC (Automated-GC/ion trap mass spectrometer)	7/2/00 to 9/2/00	R	DRI	DRI	DRI
M	HCHO (dihydrolutinine derivative/fluorescent detection)	7/2/00 to 9/2/00	S2, R	CE-CERT	CE-CERT	--
N; N'	C_1-C_7 carbonyls(DNPH-HPLC/UV); C_1-C_2 for PAMS	15 IOP days	S1, S2; PAMS	AtmAA	AtmAA	AtmAA & ARB for PAMS
P	NO_2, HNO_3 (TDLAS)	15 IOP days	R (Parlier)	CE-CERT	CE-CERT	--
Q	H_2O_2, HCHO (TDLAS)	15 IOP days	R (Parlier)	CE-CERT	CE-CERT	--
R	PM2.5 light absorption (aethalometer)	6/15/00 to 9/15/00	R	CRPAQS/DRI	DRI	--
S	PM2.5 light scattering (portable nephelometer)	6/15/00 to 9/15/00	R	CRPAQS/DRI	DRI	--
T	Scanning Radiometers	6/15/00 to 9/15/00	R	DRI	DRI	--
U	PM2.5 mass (beta attenuation)	12/1/99 to 1/31/01	CRPAQS Anchor	CRPAQS	CRPAQS	--
V	PM10 mass (beta attenuation)	12/1/99 to 1/31/02	CRPAQS Anchor	CRPAQS	CRPAQS	--
W	PM2.5 Organic and Elemental Carbon	12/1/99 to 1/31/03	CRPAQS Anchor	CRPAQS	CRPAQS	--

Table 2.4-2
Detection Limits, Ranges, and Averaging Times for CCOS Supplemental Measurements

Observable	Method (Instrument)	Expected 1 s Precision	Detection Limit	Range	Averaging or Samplng Time
O_3	UV absorption (API 400A)	± 10%	0.6 ppb	500 ppb	1 minute, 5 minutes, and 1 hour
NO/NOy	chemiluminescence (TEI 42C TL with external converter)	± 10%	0.1 ppb	500 ppb	1 minute, 5 minutes, and 1 hour
NOy/NOy*	chemiluminescence (TEI 42C TL with dual external converters and HNO3 denuder)	± 10%	0.1 ppb	500 ppb	1 minute, 5 minutes, and 1 hour
NO/NOx	chemiluminescence (TEI 42C TL)	± 10%	0.1 ppb	500 ppb	1 minute, 5 minutes, and 1 hour
CO	infrared gas filter correlation (TEI 48C TL)	± 10%	0.04 ppm	10 ppm	1 minute, 5 minutes, and 1 hour
CO_2	infrared gas filter correlation (TEI 41C HL)	± 10%	0.1 ppm	1000 ppm	1 minute, 5 minutes, and 1 hour
NO_2, PAN and PAcNs	chemiluminescence and luminol (CE-CERT)	± 20%	1 ppb	500 ppb	One instantaneous sample every 5 minutes
HCHO	dihydrolutidine derivative fluorescence (Alpha-Omega MA-100)	± 20%	0.5 ppb	50 ppbv	One 3 minute sample and 7 minute zero every 10 minutes
$PM_{2.5}$ nitrate	flash volatilization (R&P)	± 15%	0.1 µg/m3	100 µg/m3	10 minutes and 1 hour
Light scattering	nephelometers (Radiance Research M903)	± 10%	1 Mm-1	200 Mm-1	5 minutes and 1 hour
Light absorption	aethalometers (Andersen RTAA-1000, Magee Scientific AE31)	± 5 to 20%	35 ng (black carbon)/m3	1000 µg (black carbon)/m3	5 minutes and 1 hour
Actinic flux (280-700 nm)	spectro radiometer (Metcon 2-pi diode array spectrometer)	± 0.1% flux, ± 2.5 nm λ	1 % of full scale W/cm2/sec/nm	1000 W/m2 for entire λ range	10 sec, 5 minutes, 1 hour averages in 512 λ bins
C_2-C_{12} hydrocarbons and oxygenated organic compounds	automated GC/MS (Varian 3800 GC/ Saturn 2000 Ion Trap MS with Entech 7100 preconcentrator)	± 10%	0.2 ppbC	100 ppbC for individual HC	One hour
C_2-C_{12} hydrocarbons from canisters	gas chromatography with flame ionization detection	± 10%	0.2 ppbC	100 ppbC for individual HC	One three hour sample four times on intensive period days
C_8-C_{20} hydrocarbons from Tenax cartridges	thermal desorption into GC with FID or MSD (HP 5890 GC with HP 5970 MSD)	± 10%	0.2 µg/m3	50 µg/m3 for individual species	One three hour sample four times on intensive period days
C_1-C_7 carbonyls from DNPH cartridges	HPLC with UV detection	± 10%	0.2 ppbv	50 ppbv per compound	One three hour sample four times on intensive period day
Wind speed	anemometer	± 0.3 m/s	0.3 m/s	44.7 m/s	5 minutes and 1 hour
Wind direction	wind vane	± 10° from North	1 degree	0 to 360	5 minutes and 1 hour
Temperature	platinum resistance or thermister	±0.1 °C	0.1 °C	-30 to 50 °C	5 minutes and 1 hour
Relative humidity	capacitance	±2%		100%	5 minutes and 1 hour

Table 2.4-3a
CCOS Supplemental Surface Air Quality Monitoring Sites and Measurements in the Sacramento Valley and Northern Sierra Nevada Foothills

Site	Site Code	County	Type	Measurements			Facilites Installation	Operation			
				Existing or Special	CRPAQS	CCOS		Met	Continuous Analyzers	VOC Sampling (4)	VOC Analysis
Shasta Lake	SHL	Shasta	ozone only	B (ARB)		A	ENSR	NOAA	Shasta APCD		
Bella Vista	BEV	Shasta	S0	--	--	ABD	ENSR	NOAA	Shasta APCD		
Sutter Buttes	SUT	Sutter	S1	AB	--	DJN	ENSR	ARB	ARB	DRI	DRI, AtmAA
Lambie Road	LAR	Solano	S0	--	--	ABD	ENSR	NOAA	BAAQMD		
Walnut Grove Tower	WAG	Sacramento	ozone only	AB	--	--	Parsons	Parsons	Parsons		
Elk Grove	ELK	Sacramento	S1'	ABC'J'N'	--	D	SMAQMD	SMAQMD	SMAQMD	SMAQMD	ARB, ARB
Sloughhouse	SLU	Sacramento	S0	AB	--	D	SMAQMD	SMAQMD	SMAQMD		
Granite Bay	GRB	Placer	R	--	--	ABCEFGHI JKLMNORST	ENSR	NOAA	DRI	DRI (5,6)	DRI, AtmAA
White Cloud	WHC	Nevada	S1	AB	--	DJN	ARB	ARB	DRI	DRI	DRI, AtmAA

See footnotes at end of Table 2.4-3c.

Table 2.4-3b
CCOS Supplemental Surface Air Quality Monitoring Sites and Measurements in the San Francisco Bay Area

Site	Site Code	County	Type	Measurements			Facilites Installation	Operation			
				Existing or Special	CRPAQS	CCOS		Met	Continuous Analyzers	VOC Sampling (4)	VOC Analysis
Bodega Bay	BODB	Sonoma	S1	--	RSJ(1)	ABDJN	ENSR	CRPAQS	T&B	T&B	BRC, AtmAA
Pt Reyes	POR	Marin	Met only	--	--	A		NOAA			
Bethel Island	BTI	Contra Costa	S2	ABC'H'	S	DFJMN	BAAQMD/ ENSR	BAAQMD	BAAQMD	BAAQMD	DRI, AtmAA
San Leandro	SLE	Alameda	S1	ABC	--	JN	BAAQMD	BAAQMD	BAAQMD	BAAQMD	DRI, AtmAA
Lake Chabot	LAC	Alameda	S0	A		BD	BAAQMD	BAAQMD	T&B		
Livermore	LIV	Alameda	S0	ABC'H'		D	BAAQMD	BAAQMD	T&B		
Camp Parks	CAP	Alameda	ozone only	A		B	BAAQMD	BAAQMD	T&B		
Mobile Van	MOV	Livermore area	S1			ABDJ	BAAQMD	BAAQMD	BAAQMD	BAAQMD	BAAQMD
San Jose 4th Street	SJO	Santa Clara	S1	ABCH	S	J(2)N(2)	BAAQMD	BAAQMD	BAAQMD	BAAQMD	BA, AtmAA
Sunol	SUN	Alameda	R	--	S	ABCEFGHI JKLMNRT	ENSR	BAAQMD	UCB	DRI (5,6)	DRI, AtmAA
Patterson Pass	PAP	Alameda	S2	--	ASU	BDFJMN	ENSR	NONE	UCB	UCB	DRI, AtmAA
San Martin	SNM	Santa Clara	S0	AB	--	D	BAAQMD	BAAQMD	BAAQMD		
Pacheco Pass	PAP	Merced	S2	--	AS	BDJNMN	CRPAQS/ ENSR	CRPAQS	T&B	T&B	BRC, AtmAA

See footnotes at end of Table 2.4-3c.

Table 2.4-3c
CCOS Supplemental Surface Air Quality Monitoring Sites and Measurements
in the San Joaquin Valley , Central Sierra Nevada Foothills, and South Central Coast

Site	Site Code	County	Type	Measurements			Facilites Installation	Operation			
				Existing	CRPAQS	CCOS		Met	Continuous Analyzers	VOC Sampling (4)	VOC Analysis
Turlock	TSM	Stanislaus	S1	ABCH	--	DJN	SJVUAPCD	SJVUAPCD	T&B	T&B	BRC, AtmAA
San Andreas	SGS	Calaveras	S1	ABH	--	DJN	ARB	ARB	ARB	ARB	BRC, AtmAA
Kettleman City	KCH	Kings	S0	--	S	ABD	ENSR	NOAA	SJVUAPCD		
Angiola	ANGI	Tulare	S1+	--	ABDJ(1)S RUVW	JN	CRPAQS	CRPAQS	CRPAQS	SJVUAPCD	BRC, AtmAA
Trimmer	TRIM	Fresno	S2	--	A(3)S	BDFJMN	CRPAQS/ ENSR	CRPAQS	ARB	ARB	DRI, AtmAA
Parlier	PLR	Fresno	R'	ABC'J'N'	--	EFGHI KLMPQRST	SJVUAPCD/ ENSR	SJVUAPCD	SJVUAPCD	SJVAPCD (5,6) SJVAPCD	DRI, AtmAA ARB, ARB
Arvin	ARV	Kern	S2'	ABCJ'	--	DFM	ARB	ARB	ARB	ARB	ARB
McKittrick	MCK	Kern	S0	--	--	ABD	ENSR	NOAA	SJVUAPCD		
Red Hills	RDH	San Luis Obispo	S0	AB	S	D	SLOAPCD	SLOAPCD	SLOAPCD		
Camp Roberts	CRO	San Luis Obispo	S1	AB			SLOAPCD	SLOAPCD	SLOAPCD		
Piedras Blancas	PIB	San Luis Obispo	S1	--	--	ABDJN	ENSR	NOAA	SLOAPCD	SLOAPCD	BRC, AtmAA

(1) CRPAQS Annual Site, 24-hour canister sample every 6th day.
(2) Bay Area component of CCOS, samples collected and analyzed by BAAQMD.
(3) 10-m meteorological tower located nearby.
(4) Four canister and DNPH samples daily on 15 IOP days (0000-0300, 0600-0900, 1300-1600, 1700-2000, PDT).
(5) Two canister samples per day on 5 IOP days (0600-0900, 1300-1600, PDT) and daily auto-GC/MS from 7/2/00 to 9/2/00 (23 hourly on IOP days and seven 3-hr on non IOP days).
(6) Four Tenax and DNPH samples daily on 15 IOP days (0000-0300, 0600-0900, 1300-1600, 1700-2000, PDT).

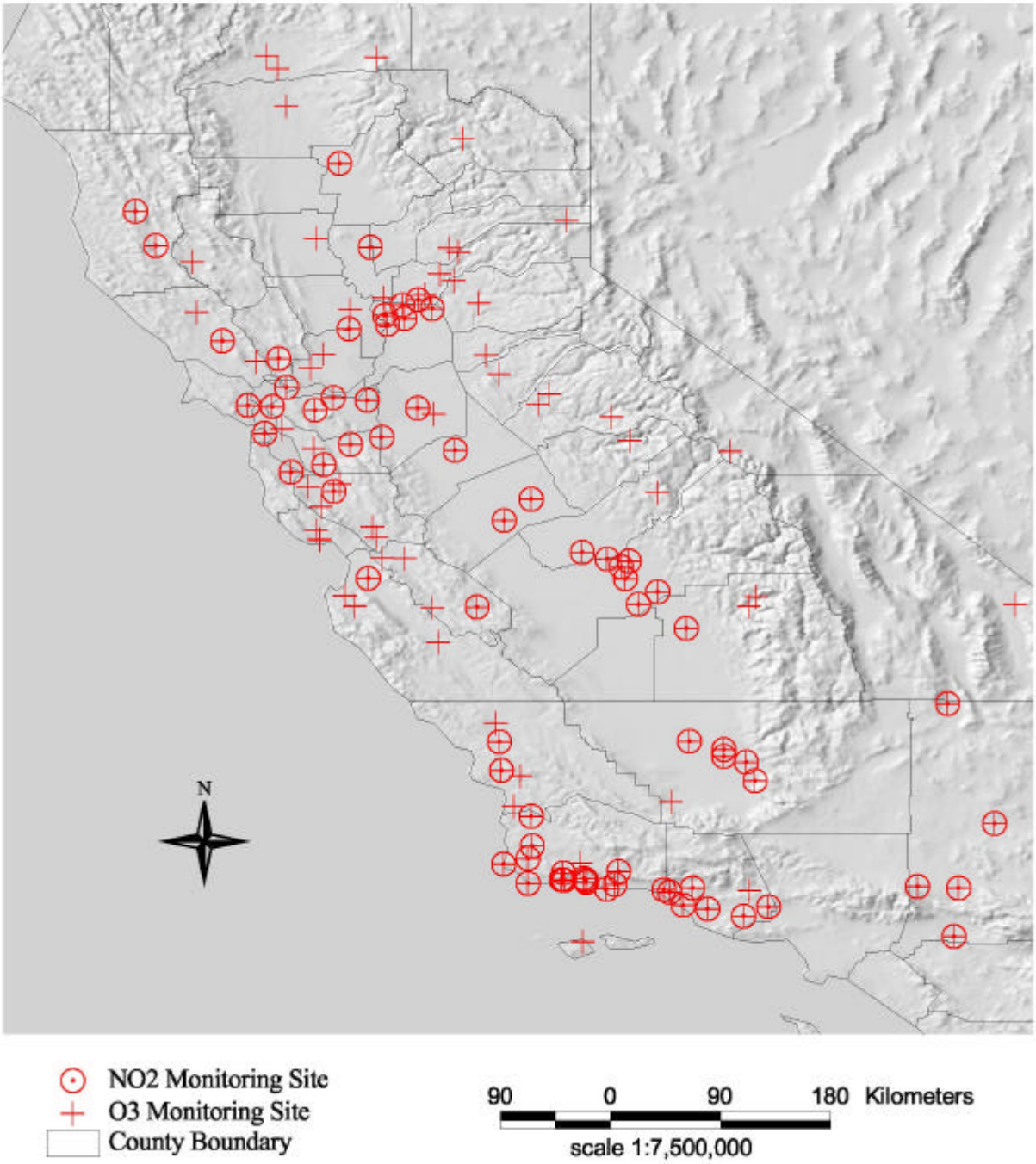


Figure 2.4-1. Existing routine O_3 and NOx monitoring sites

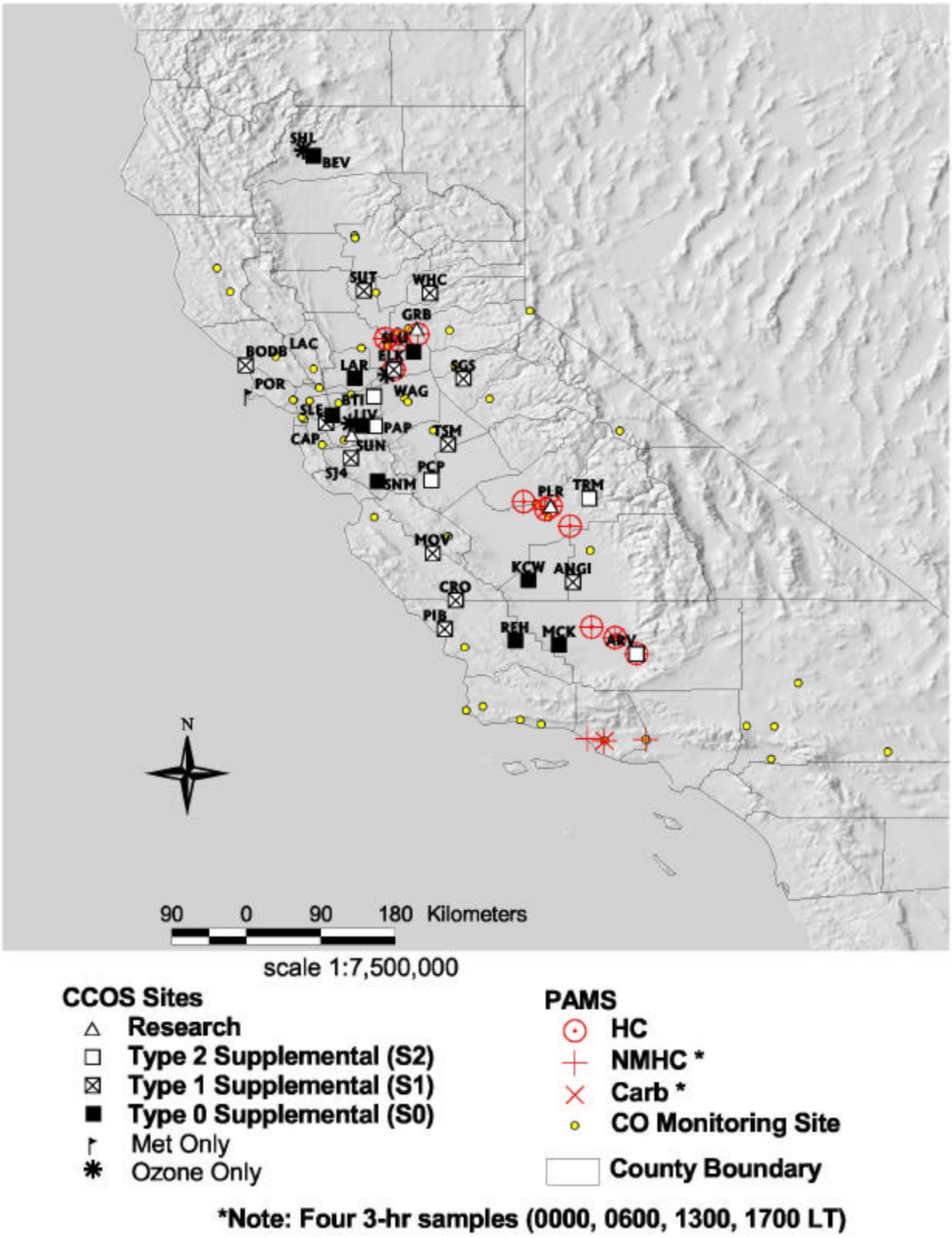


Figure 2.4-2. CCOS supplemental air quality and meteorological monitoring sites and Photochemical Assessment Monitoring Stations

2. Continuous ozone during study period.

3. Continuous NO and NOy during study period by a TEI 42S high sensitivity chemiluminescence analyzer with external converter near the sample inlet.

4. Four 3-hour (at 0000-0300, 0600-0900, 1300-1600, and 1700-2000, PDT) canister samples for up to 15 IOP days to CH_4, and analysis by flame ionization detection; and C_2-C_{12} hydrocarbons and MTBE by gas chromatography with flame ionization detection.

5. Four 3-hour (at 0000-0300, 0600-0900, 1300-1600, and 1700-2000, PDT) DNPH cartridge samples for up to 15 IOP days for C_1-C_7 carbonyl compounds by HPLC with UV detection.

With the exception of NOy measurements, S1 sites are equivalent to Photochemical Assessment Monitoring Stations (PAMS) sites. Measurements of speciated volatile organic compounds (VOC) made under CCOS (four 3-hour samples on 15 IOP days) supplement the 11 existing PAMS sites in the study area (four in Sacramento, four in Fresno, and three in Bakersfield). The ozone episodic samples that will be collected under PAMS will coincide with the CCOS IOP days. S1 sites are proposed for Bodega Bay and along the south central coast north of Morro Bay at Piedras Blancas to obtain background data near the western boundary of the CCOS modeling domain. Sutter Buttes and Turlock provide characterization of ambient air transported into the upper Sacramento Valley and into the northern San Joaquin Valley, respectively, as a function of the nature of the flow bifurcation downwind of the San Francisco Bay Area. Transport issues will be addressed in the Sierra Foothill communities by supplementing existing measurements at White Cloud (near Grass Valley) and at San Andreas. Type S1 measurements are also proposed for the CRPAQS Anchor site at Angiola. The Bay Area AQMD will operate the existing San Jose and San Leandro monitoring sites as S1 sites during CCOS.

Type 2 supplemental monitoring sites (S2) are located at the interbasin transport and intrabasin gradient sites, and near the downwind edge of the urban center where ozone formation may either be VOC or NOx limited depending upon time of day and pattern of pollutant transport. S2 sites also provide data for initial conditions and operation evaluations and some diagnostic evaluation of model outputs. The following aerometric parameters are measured at Type 2 supplemental monitoring sites.

1. Continuous surface wind speed and direction and temperature during study period.

2. Continuous O_3 during study period.

3. Continuous NO and NOy during study period by a high sensitivity TEI 42S chemiluminescence analyzer.

4. Continuous NO_2 and peroxyacylnitrate (PAcN) during primary study period by gas chromatography with Luminol detector. A second estimate of HNO_3 is obtained by the difference between NOy and the sum of NO, NO_2, and PAcN. This second

estimate is an upper-limit because NOy also includes other organic nitrates and particulate ammonium nitrate.

5. Continuous formaldehyde (HCHO) during primary study period by an instrument that continuously measures the fluorescent, dihydrolutidine derivative formed by the reaction of formaldehyde with 1,3-cyclohexanedione and ammonium ion (Dong and Dasgupta, 1994; Fan and Dasgupta, 1994).

6. Four 3-hour (at 0000-0300, 0600-0900, 1300-1600, and 1700-2000, PDT) canister samples for up to 15 IOP days for analysis of CO, CO_2, methane by gas chromatography, reduction of CO and CO_2 to CH_4, and analysis by flame ionization detection; and C_2-C_{12} hydrocarbons and MTBE by gas chromatography with flame ionization detection.

7. Four 3-hour (at 0000-0300, 0600-0900, 1300-1600, and 1700-2000, PDT) DNPH cartridge samples for up to 15 IOP days for C_1-C_7 carbonyl compounds by HPLC with UV detection.

These measurements allow more detailed assessments of VOC- and NOx-limitation by observation-driven methods during the entire two-month primary study period. S2 sites are proposed along the three main passes connecting the Bay Area and the Central Valley (Bethel Island, Altamont Pass, and Pacheco Pass. S2 measurements are also proposed Trimmer (downwind of Fresno at the Mouth of the Kings River) and downwind of Bakersfield at the existing PAMS site at Arvin.

Research sites (R) have the same site requirements as S2 sites. The sites are intended to measure a representative urban mix of pollutants, and must be carefully selected to minimize the potential influence of local emission sources. As with S2 sites, research sites are located where ozone formation may either be VOC or NOx limited depending upon time of day and pattern of pollutant transport. Research site are intended to provide the maximum extent of high-quality, time-resolved chemical and other aerometric data for rigorous diagnostic evaluation of air quality model simulations and emission inventory estimates. Research sites will be established at Parlier (south of Fresno), Granite Bay (downwind of Sacramento) Fresno, and at Sunol (between Fremont and Livermore). The following aerometric parameters are measured at Research monitoring sites.

1. Continuous surface wind speed and direction and temperature during study period;

2. Continuous ozone during study period;

3. Continuous NO/NOx analyzer during study period.

4. Continuous NOy and NOy* (NOy minus HNO_3) during study period with TEI42CY. Nitric acid estimated by difference between the signals with and without a NaCl impregnated fiber denuder.

5. Continuous NO_2 and PAcN during primary study period by gas chromatography with Luminol detector. A second estimate of HNO_3 is obtained by the difference between

NOy and the sum of NO, NO_2, and PAcN. This second estimate is an upper-limit because NOy also includes organic nitrates and particulate ammonium nitrate.

6. Continuous formaldehyde during primary study period by an instrument that continuously measures the fluorescent, dihydrolutidine derivative formed by the reaction of formaldehyde with 1,3-cyclohexanedione and ammonium ion (Dong and Dasgupta, 1994; Fan and Dasgupta, 1994).

7. Semi-continuous hourly organic compound speciation data during primary study period by gas chromatography with ion-trap mass spectrometry. VOC speciation includes C_2 to C_{12} hydrocarbons, carbonyl and halogenated compounds. Collect up to 10 sets of canister and DNPH samples for measurement comparisons with GC/MS and continuous HCHO analyzer.

8. Four 3-hour (at 0000-0300, 0600-0900, 1300-1600, and 1700-2000, PDT) Tenax cartridge samples for up to 15 IOP days for analysis C_8-C_{20} hydrocarbons

9. Continuous CO by TEI 48C and continuos CO_2 by TEI 41C during study period.

10. Actinic flux during study period by scanning radiometer. The radiometers will be located at the Sunol research site. The other two radiometers will be located at the US Department of Agriculture's UVB Radiation Monitoring site in Davis, 30 miles east of the Granite Bay research site (see justification below), and at White Cloud, a high elevation site.

11. Semi-continuous particulate nitrate during primary study period by Aerosol Dynamics Inc. (ADI) automated particle nitrate monitor. The monitor uses an integrated collection and vaporization cell whereby particles are collected by a humidified impaction process, and analyzed in place by flash vaporization with quantitation of the evolved gases by chemiluminescent analyzer.

12. Continuos total light absorption by aethalometer and total light scattering by ambient integrating nephelometer during primary study period.

13. Continuous NO_2, HNO_3, HCHO and H_2O_2 on twenty IOP days by dual tunable diode laser absorption spectrometers at the Parlier research site.

2.4.2 Complementary Measurement Programs

Because a Photochemical Assessment Monitoring Station (PAMS) network does not exist in the Bay Area, the density of air quality measurements (e.g., NO/NOy and VOC) in the Bay Area is lower than is needed to reliably understand and simulate the conditions that result in days exceeding the ozone standard in the Bay Area alone. The Bay Area AQMD is sponsoring additional measurements during CCOS to obtain the information needed to develop a Bay Area specific plan. The supplemental Bay Area measurements are primarily designed to increase the understanding of high ozone in the Livermore Valley, where the Bay Area's highest ozone levels and most frequent exceedances of the standards occur. For this purpose, four types of

measurements are proposed: 1) Monitoring of pollutant levels aloft on selected episode days with instrumented aircraft flights within and upwind of the Livermore Valley; 2) surface monitoring of ozone and precursor gases in the gaps through which air enters and exits the Livermore Valley; and 3) continuous aloft measurements of wind and temperature, using Doppler acoustic sounders and radar profilers, above the Livermore Valley and its entrance and exit gaps. The BAAQMD has contracted T&B Systems to implement the Bay Area component of CCOS. T&B System's effort involves the following tasks.

- Install and operate, from 6/15/00 to 9/15/00, ozone and NOy analyzers at the BAAQMD's Lake Chabot meteorological monitoring site.

- Install and operate, from 6/15/00 to 9/15/00, SODAR, surface meteorology and ozone at a site yet to be determined in the Dublin Canyon.

- Install and operate, from 6/15/00 to 9/15/00, ozone and NOy analyzers at the CCOS Livermore Valley radar profiler site (assuming that this site will be located in the undeveloped area between Livermore and Pleasanton and south of the Livermore airport). These instruments would be collocated with the Elight Ozone Profiler and radiosonde/ozonesonde measurements by the U.S. Navy.

- Install and operate, from 6/15/00 to 9/15/00, an ozone analyzer at the BAAQMD's Kregor Peak meteorological monitoring site.

- Install and operate, from 6/15/00 to 9/15/00, a SODAR with surface meteorology at a site yet to be determined in the San Ramon Valley.

- Install and operate, from 6/15/00 to 9/15/00, a SODAR at the CCOS Sunol research site.

- Assist District staff with installation and operation of mobile sampling equipment (possibly including ozone, NOx, VOC canister sampler, surface met.) on up to 15 IOP days. Measurements will be taken along the 580 corridor through Dublin Canyon and east past Altamont Pass.

The CCOS field measurement program will be conducted in conjunction with the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRPAQS). The CRPAQS includes air quality and meteorological field measurements, emissions characterization, data analysis and air quality modeling. The CRPAQS field study will consist of a long-term campaign from 12/1/99 through 1/31/01, a winter intensive study within the period of 11/15/00 through 1/31/01, and a fall intensive study within the period of 9/1/00 through 10/31/00. Several experiments will be conducted during the summer period of 7/1/00 through 8/31/00. These include chemical characterization of $PM_{2.5}$ at the Fresno site to estimate the fraction of fine particles that is attributable to secondary organic aerosol and source contributions of directly-emitted fine particles. Other experiments will examine the timing and intensity of light extinction in the San Joaquin Valley and the Mohave Desert. The baseline measurements for CRPAQS, which will begin in December 1999 and continue to the end of the study, are incorporated and leveraged into the CCOS field program. These include six upper-air meteorological measurement sites within the CCOS domain. Opportunities for cost sharing also exist for purchases of instruments

that are needed for both CCOS and the CRPAQS winter intensive study (e.g., NO_2, PAN, and NOy and continuous particulate nitrate). CCOS will also benefit from measurements that are available throughout the study region from existing federal, state, local, and private air quality and meteorological monitoring programs.

2.4.3 Equipment Procurement and Checkout

DRI and CE-CERT will develop the specifications of the equipment that are to be purchased. DRI will be responsible for the ozone analyzers, carbon monoxide analyzers, carbon dioxide analyzers, calibration systems, data loggers (at S0, S1, and S2 sites), and diode array spectrometers for actinic flux measurements. CE-CERT will be responsible for the NO/NOx analyzers, NO/NOy and NOy/NOy*[3] analyzers and the continuous formaldehyde (HCHO) analyzers. CE-CERT will also be responsible for the continuous nitrogen dioxide (NO_2) and peroxyacylnitrate (PacN) analyzers under a separate contract. A version of the computer-based data acquisition system (DAS) currently deployed in CRPAQS will be used at the three CCOS research sites. Additional CRPAQS DAS that are needed for the winter 2000/2001 study will be procured by Sonoma Technology, Inc. prior to the summer 2000 so that they may be used at the three CCOS Research sites. Use of CRPAQS DAS in CCOS will require that CRPAQS participants specify the components earlier than would have been necessary for the winter CRPAQS but should not require additional funding. The particulate nitrate analyzers will be purchased as part of CRPAQS and will be specified according to CRPAQS requirements. Availability of commercial units are assumed. The Aethalometers and nephelometers will also be purchased as part of CRPAQS and will be specified according to CRPAQS requirements.

DRI will acceptance test the ozone analyzers, carbon monoxide analyzers, carbon dioxide analyzers, Aethalometers, nephelometers, calibration systems, data loggers (at S0, S1, and S2 sites), and diode array spectrometers for actinic flux measurements. The ozone analyzers will be challenged with ozone generated by DRI's primary ozone standard, a Dasibi 1008 PC, which is annually compared to the long-path photometer maintained by ARB in Sacramento. The data acquisition systems will be tested for data collection (serial and analog), calibrator control, and telephone access. The flow controllers of the calibration systems will be compared to DRI's NIST-traceable flow meters. The ozone generators of the calibration systems will be calibrated with DRI's ozone standard and tested for stability. The particulate nitrate analyzers will be tested with NO generated with DRI calibration systems and gases. Nephelometers will be check with particle-free air and HFC-134a gas for scattering coefficient. The operations of the Aethalometers will be checked. DRI will also test the CRPAQS data acquisition system and adapt the current data collection method to the CCOS instruments.

CE-CERT will acceptance test the NO/NOx analyzers, NO/NOy analyzers, the NOy/NOy* analyzers, the NO_2/PacN analyzers (under a separate contract), the HCHO analyzers. The responses of the analyzers to known concentrations of the measured gases will be tested. The NO/NOy and NOy/NOy* analyzers will also be exposed to nitric acid and n-propylnitrate (NPN) to the measurement system and converters.

[3] NOy* = NOy minus HNO_3

Aerosol Dynamics (AD) will acceptance test the particulate nitrate analyzers under an existing contract for CRPAQS. AD will also assist DRI with the installation and initial calibration of instrument at the Sunol research site.

2.4.4 Facilities Installation

ENSR will be responsible for site preparation for the Central California Ozone Study. Four sites will be newly established for CCOS (McKittrick, Kettleman City, Piedras Blancas, Granite Bay, Altamont, Lambie Road, Bella Vista). In addition, several existing sites will be modified as necessary to accommodate CCOS measurements (Bethel Island, Bodega Bay, Pacheco Pass, Trimmer, and Sunol).

ENSR will make final arrangements with landowners to use their land for CCOS, and establish a written lease agreement. Establish written lease agreements or land use agreements, as necessary. Security fencing and trailer will be installed and electrical and phone service will be arranged. They will oversee the installation of facilities at each site, and travel to sites, as necessary, to direct the operations of contractors and to ensure that all facilities are placed properly.

2.4.5 Equipment Installation and Calibrations

Installation will be performed by DRI and CE-CERT and will be coordinated between the two groups so as to be at common sites at overlapping times. This will allow the placement of the instrumentation to be made for mutual advantage. It should also allow those site operators that will require training to effectively plan their schedules to limit the amount of time needed for training.

DRI will install the O_3 analyzers, CO analyzers, CO_2 analyzers, calibration systems, data loggers (at S0, S1, and S2 sites), CRPAQS DAS (at research sites), diode array spectrometers for actinic flux measurements, particulate nitrate analyzers, Aethalometers, and nephelometers. Full onsite calibrations will be performed on the O_3, NO/NOx, CO, CO_2 analyzers, particulate nitrate analyzers and the nephelometers. The diode array spectrometers will be calibrated in Reno before installation and onsite with a field lamp. Data loggers will be installed, instruments connected, and data collection confirmed at the site and at DRI's central computer in Reno. The data connections will also include those instruments that CE-CERT will install. Any connections of existing site instruments to the data loggers will be made. At those existing sites where a site calibrator is expected to supply NO and NO_2 (Bruceville, Turlock, Bethel Island, and Arvin), those connections will be made such that the current site operations are not adversely affected. The site operators will be trained in the operations of the supplemental instruments. Each measurement will have a standard operating procedure that lists the specific tasks required of the site operator. They will also contain information on procedure for handling problems and personnel to contact for assistance.

CE-CERT will install the NO/NOx analyzers, NO/NOy, NOy/NOy*, and HCHO analyzers at S2 and R sites as part of this contract and the NO_2/PacN analyzers. Full calibrations will be done for each analyzer. This will include NO, NO_2, nitric acid, and n-propyl nitrate (NPN) for the NO/NOy and NOy/NOy* analyzers, HCHO for the HCHO analyzers, and NO_2

and tridecane for the NO_2/PAcN analyzers. Each analyzer will be calibrated at zero and at up to five upscale points, except tridecane which will only be at one level. Each measurement will have a standard operating procedure that lists the specific tasks required of the site operator. They will also contain information on procedure for handling problems and personnel to contact for assistance. DRI will install NO/NOy analyzers at S0 and S1 sites.

T&B will be responsible for operating the Bodega Bay (S1), Turlock (S1), and Pecheco Pass (S2) sites. Personnel will be present during installation of equipment and will be available for training. Training for the Pecheco Pass site will also include training for the gas analyzers.

UCB will be responsible for operating the Sunol (R) and Altamont (S2) sites. Personnel will be present during installation of equipment and will be available for training. These two sites are heavily equipped but have several instruments in common.

The VOC canister samplers will be installed by Biospheric Research Corporation and Desert Research Institute for the sites indicated in Table 2.4-3. AtmAA will install carbonyl cartridge samplers at all CCOS supplemental sites. The site operators will need to be present during installation to provide assistance and to insure that the samplers are installed properly and do not adversely affect the current operations. Training of the site operators on sampler operations will be done at the time of installation.

DRI will perform final calibrations of the O_3 analyzers, CO analyzers, CO_2 analyzers, calibration systems, data loggers (at S0, S1, and S2 sites), CRPAQS DAS (at research sites), diode array spectrometers for actinic flux measurements, particulate nitrate analyzers, Aethalometers, and nephelometers. Full onsite calibrations will be performed on the O_3, NO/NOx, CO, CO_2 analyzers, particulate nitrate analyzers and the nephelometers. The diode array spectrometers will be calibrated onsite with a field lamp and in Reno after the study. The flow meters and ozone generators of the calibration systems will be checked after return to Reno.

CE-CERT will perform final calibrations of the NO/NOx analyzers, NO/NOy, NOy/NOy*, HCHO, and the NO_2/PacN analyzers analyzers at S2 and R sites. Full calibrations will be done for each analyzer. This will include NO, NO_2, nitric acid, and NPN for the NO/NOy and NOy/NOy analyzers; HCHO for the HCHO analyzers, and NO_2 and tridecane for the NO_2/PAcN analyzers. Each analyzer will be calibrated at zero and at up to five upscale points, except tridecane which will only be at one level.

T&B will assist in the final calibrations and instrument removal at the Bodega Bay (S1), Turlock (S1), and Pecheco Pass (S2) sites. UCB will assist in the final calibrations and instrument removal at the Sunol (R) and Altamont (S2) sites. VOC canister samplers and the carbonyl cartridge samplers will be removed by the respective contractors.

2.4.6 Site Operations

CCOS supplemental analyzers will be calibrated daily using automated calibration systems. Details of the calibration methods and standards that will be used are summarized in Table 2.4-4. Automatic calibration checks will be made daily for the O3, NO/NOX, NO/NOY,

Table 2.4-4
Primary, calibration, performance test and performance audit standards and frequencies for CCOS measurements

Observable	Expected Precision	Primary Standard	Calibration Standard	Calibration Frequency	Performance Test Standard	Performance Test Frequency	Performance Audit Standard	Performance Audit Frequency
O3 by ultraviolet absorption	±10%	Dasibi 1008PC UV photometer, referenced to ARB primary	Dasibi 1003PC UV photometer	At start and end of study	Span and precision check with calibrated ozone generator and zero with scrubbed air	Daily	Dasibi 1008PC with temperature and pressure adjustments	Once during study
NO/NOY by chemiluminescence	±10%	NIST-traceable NO	Certified NO w/ dynamic dilution and gas-phase titration	At start and end of study	Span and precision check with certified NO, converter check with NO2 by gas phase titration, and zero with scrubbed air	Daily	Certified NO w/ dynamic dilution and NO2 by gas-phase titration	Once during study
NOY/NOY* by chemiluminescence	±10%	NIST-traceable NO	Certified NO w/ dynamic dilution and gas-phase titration	At start and end of study	Span and precision check with certified NO, converter check with NO2 by gas phase titration, and zero with scrubbed air	Daily	Certified NO w/ dynamic dilution and NO2 by gas-phase titration	Once during study
NO/NOX by chemiluminescence	±10%	NIST-traceable NO	Certified NO w/ dynamic dilution and gas-phase titration	At start and end of study	Span and precision check with certified NO, converter check with NO2 by gas phase titration, and zero with scrubbed air	Daily	Certified NO w/ dynamic dilution and NO2 by gas-phase titration	Once during study
CO by infrared gas filter correlation	±10%	NIST-traceable CO	Certified CO w/ dynamic dilution	At start and end of study	Span and precision check with certified CO and zero with scrubbed air	Daily	Certified CO w/ dynamic dilution	Once during study
CO2 by infrared gas filter correlation	±10%	NIST-traceable CO2	Certified CO2 w/ dynamic dilution	At start and end of study	Span check at two levels with certified CO2 and zero with scrubbed air	Daily	-	-
NO2, PAcN by chemiluminescence and luminol	±20%	NIST-traceable NO2 and PAN	Certified NO w/ dynamic dilution and gas-phase titration	At start and end of study	Span check with NO2 by gas phase titration and zero with scrubbed air	Daily for NO2	Certified NO2 w/ dynamic dilution and gas-phase titration	Once during study
HCHO by methanalyzer	±20%	NIST-traceable HCHO	Certified HCHO permeation tube	At start and end of study	Internal zero check, HCHO permeation tube	Zero: once/10 minutes, HCHO at end of study	-	-
PM2.5 nitrate by flash volatilization	±15%	NIST-traceable NO	Certified NO w/ dynamic dilution and nitrate solution	At start and end of study	Span with certified NO and zero with scrubbed air	Weekly	Certified NO w/ dynamic dilution and nitrate solution	Once during study
Light scattering by nephelometers	±10%	HFC-134a refrigerant	HFC-134a, pure CO2, and particle free air	At start and end of study	HFC-134a, and particle free air	Weekly	HFC-134a, pure CO2, and particle free air	Once during study
Light absorption by aethalometers	±5 to 20%	Neutral density filters	Factory calibration	When out of spec	Internal electronic checks and neutral density filters	Weekly and monthly	Neutral density filters	Once during study

Table 2.4-4 (continued)
Primary, calibration, performance test and performance audit standards and frequencies for CCOS measurements

Observable	Expected Precision	Primary Standard	Calibration Standard	Calibration Frequency	Performance Test Standard	Performance Test Frequency	Performance Audit Standard	Performance Audit Frequency
Solar radiation by scanning spectrometer	±20 w/m2	NIST standard luminance	Factory calibration	Prior to installation	Portable certified lamp	At start and end of study and 3 times during study	-	-
C2-C12 hydrocarbons from canisters by cryofocusing, gas chromatography and flame ionization	± 10%	NIST CH4	Certified CH4 and reference gases	Each analysis session	Reference gases, replicates, and blanks	Every 10 samples	Certified NMHC sample introduced to sampler	Once during study
C8-C20 hydrocarbons from TENAX by thermal desorption, gas chromatography and flame ionization	± 10%	NIST CH4	Certified CH4 and reference gases	Each analysis session	Reference gases, replicates, and blanks	Every 10 samples	Certified NMHC sample introduced to sampler	Once during study
C8-C7 carbonyls from DNPH by high pressure liquid chromatography and ultraviolet detection	± 20	Aldehyde mixtures	Aldehyde mixtures	Each analysis session	Reference mixtures, replicates, and blanks	Every 10 samples	Certified NMHC sample introduced to sampler	Once during study
Wind speed by anemometer	±0.3 m/s	Certified wind tunnel	Factor calibration	Prior to installation	Visual check, synchronized motor when out of spec	Daily and when needed	Synchronized motor	Once during study
Wind direction by wind vane	±10° from North	Surveyor compass, solar azimuth	Surveyor compass, solar azimuth	Prior to installation	Visual check, realignment when out of spec	Weekly	Surveyor compass, solar azimuth	Once during study
Temperature by platinum resistance or thermister	±0.1 °C	NIST thermometer and water bath	Factory calibration	Prior to installation	Psychrometer	Weekly	Collocated temperature sensor	Once during study
Relative humidity by capacitance	±2%	NIST thermometer and dew cups	Factory calibration	Prior to installation	Psychrometer	Weekly	Collocated humidity sensor	Once during study

NOY/NOY* analyzers. Each O3 analyzer that is installed as part of CCOS will be challenged with zero air followed by with ozone concentrations near 400 ppb and 90 ppb to cover the span and precison levels, respectively. Each NO/NOX, NO/NOY, and NOY/NOY* will be challenged with zero air followed by NO concentrations near 400 ppb and 90 ppb to cover the span and precision levels, respectively. A mixture of NO at 30 ppb and NO2 at 60 ppb will be generated by gas phase titration to check the converter efficiency of the NO/NOX, NO/NOY, and NOY/NOY* analyzers. Data from calibration checks will be retrieved and reviewed daily.

The CCOS supplemental surface air quality and meteorological measurement sites will be operated by personnel from Desert Research Institute, T&B Systems, University of California Berkeley, California Air Resources Board, Bay Area AQMD, Sacramento Metropolitan APCD, San Joaquin Valley Unified APCD, San Luis Obispo County APCD or the Shasta County APCD. Table 2.4-5 provides a summary of the tasks required of local site operators at each type of supplemental site (S0, S1, S2 or R).

DRI will be responsible for operating the White Cloud (S1) and Granite Bay (R) sites. DRI personnel will make weekly visits to the Granite Bay Research site to perform maintenance tasks and to do a visual check of the instruments. Personnel will operate the VOC canisters and carbonyl cartridges during IOP's. They will install canisters and cartridges the day before the IOP starts, change canisters and cartridges each day, and remove the final samples at the end of the IOP. They will send the filled canisters and exposed cartridges to the proper parties at the expense of separate contracts. They will also perform minor repairs at the direction of the project manager or designee.

T&B will be responsible for operating the Bodega Bay (S1), Turlock (S1), and Pecheco Pass (S2) sites. Personnel will make weekly visits to the Pecheco Pass site to perform maintenance tasks (e.g., fill reagent reservoirs for NO_2/PAN and HCHO analyzers) and to do a visual check of the instruments. Personnel will operate the VOC canisters and carbonyl cartridges during IOP's. They will install canisters and cartridges the day before the IOP starts, change canisters and cartridges each day, and remove the final samples at the end of the IOP. They will send the filled canisters and exposed cartridges to the proper parties at the expense of separate contracts. Personnel will also be available for emergency site visits to investigate problems found during data review. They will also perform minor repairs at the direction of the project manager or designee.

UCB will be responsible for operating the Sunol (R) and Altamont (S2) sites. Personnel will make weekly visits to both sites to perform maintenance tasks (e.g., fill reagent reservoirs for NO_2/PAN and HCHO analyzers) and to do a visual check of the instruments. Personnel will operate the VOC canisters and carbonyl cartridges during IOP's. They will install canisters and cartridges the day before the IOP starts, change canisters and cartridges each day, and remove the final samples at the end of the IOP. They will send the filled canisters and exposed cartridges to the proper parties at the expense of separate contracts. Personnel will also be available for emergency site visits to investigate problems found during data review. They will also perform minor repairs at the direction of the project manager or designee.

Personnel from the California Air Resources Board and local districts (BAAQMD, SJVAPCD, Shasta County APCD, SLOAPCD) will provide operational support for the other

Table 2.4-5
CCOS Supplemental Site Operations Tasks and Operators

Site Operation Tasks	O_3 and S0	S1	S2	R
1. Perform weekly visual inspection of equipment to see that to see that visual indicators of operations are within tolerances.	x	x	x	x
2. Change inlet filters on NO/NOy and O3 analyzers weekly.	x	x	x	x
3. Drain water from air reservoir of zero air system once a week. Change Purafil and charcoal srubbing material in zero air system once a month as indicator dictates.	x	x	x	
4. Visit the site at unscheduled times when data review detects instrument failures.	x	x	x	x
5. Change inlet filters on CO, and CO2 analyzers weekly.				x
6. Change soda lime scrubbing material for CO2 analyzer once a month or as indicator dictates.				x
7. Perform additional manual span checks on NO/NOx and NOy/NOy* analyzers.				x
8. Install and remove HC canisters and carbonyl cartridges during 15 intensive period days (four samples per day).		x	x	
9. Install and remove HC canisters and carbonyl cartridges during five intensive period days (two samples per day 06-09 and 13-16,				x
10. Install and remove Tenax cartridges during 15 IOP days.				x
11. Change or replenish reagent for HCHO analyzer, dilute solution of 1,3 cyclohexanedione and ammonium. Instrument uses approximately 1.5 liters/week. Instrument may also require a periodic manual flushing through port on front of instrument.			x	x
12. Change or replenish reagent for NO2/PacN analyzer, dilute luminol solution. Instrument uses approximately 2 liters/month.			x	x
13. Perform weekly manual zero and span checks of continuous particulate nitrate analyzer.				x
14. Perform weekly manual zero and span checks of nephelometer using particle-free air and HFC-134a.				x
15. Change backup data diskette for aethalometer weekly. Check instrument flow rate once a month. Measure test strip once a month.				x

CCOS supplemental surface air quality sites that are not mentioned above. Details of the agency support are specified in Appendix D1.

DRI will transfer all continuous CCOS supplemental surface data (except meteorological data) and District ozone data from the CCOS sites to a central computer in Reno every day. Ozone data from other sites of interest for forecast will be provided by the ARB. These data will automatically be summarized and will be reviewed daily to track instrument performance. In particular, the calibration checks will be tracked on control charts. Any problems that arise during data review will be investigated. Local site personnel will be informed of the problems and solutions will be devised, either onsite or through an emergency site visit.

DRI will be available to provide technical assistance on the O3, CO, CO2 analyzers, calibration systems, data loggers (at S0, S1, and S2 sites), CRPAQS DAS (at research sites), diode array spectrometers for actinic flux measurements, particulate nitrate analyzers, Aethalometers, and nephelometers. The assistance will probably be through telephone or e-mail. Personnel will also be available for emergency site visits to investigate problems, found during data review, which cannot be resolved by on-site operators. DRI will be responsible for service calls (for all supplemental equipment) for all CCOS sites that are located north of the Merced/Madera county line.

CE-CERT will be available to provide technical assistance to DRI personnel and to site operators on the operations of the NO/NOx, NO/NOy, NOy/NOy*, HCHO, and NO_2/PacN analyzers. The assistance will probably be through telephone or e-mail. A catastrophic failure of one of these instruments may require a site visit by CE-CERT or DRI or the return of the instrument to CE-CERT. CE-CERT will also review summary data from the NO/NOy, NOy/NOy*,HCHO, and NO_2/PacN instruments for an additional check of their operations. CE-CERT will be responsible for service calls (for all supplemental equipment) for all CCOS sites that are located south of the Merced/Madera county line

2.4.7 Maintenance and Repair

Personnel will be available at DRI and CE-CERT for technical support during the CCOS field study for both routine operations and for problems as they arise. Field personnel will be able to communicate with technical support personnel through telephone and/or e-mail at any time. Field personnel will be notified as to the responsible support person for the various measurements. Support personnel will be designated to be available for non-working hours periods, particularly during IOP days.

The technical support personnel will also be available for consultation with those performing the daily data reviews. If a problem is found, technical support personnel will be notified. They will in turn determine how best to fix the problem, weighing both speed and cost of the solution. In most cases, the fastest and least expensive solution will involve directing the station operator to fix the problem. For major problems, such as an analyzer failure, it will be necessary for technical support personnel to visit the site and either repair onsite or arrange for replacement equipment.

2.4.8 Data Acquisition and Review

In general, data acquisition at existing sites consists of an onsite data logger to collect and average data, which are automatically transferred to a central computer through a telephone modem. The transfers can be as often as once an hour. Each time the site is polled, new data are appended to the data file for that site.

CCOS supplemental data will be obtained in a similar manner through data loggers that will be installed at the sites. A central CCOS computer located at DRI in Reno will be configured to call the sites once a day to obtain supplementary CCOS data. The calling times will be set so as not to interfere with site operations. In addition, the district data will be uploaded as well. Collection and screening of the district data will ensure the highest level of data completeness and will provide a complete picture of what is happening at all CCOS sites in near real time. These data also will be useful in supplementing forecast information.

Since there are over five different agencies involved in data collection, the manner in which the data are obtained may vary. Obtaining the data within 24 hours of collection will be a priority. One method will be to call the district data logger during a designated window and obtain the data directly. Another method is for the agency to transfer their data to an accessible file transfer protocol (FTP) computer daily and then the CCOS computer downloads data from the FTP site(s).

Due to the variability in formats of the district data, this portion of the data acquisition system will require the greatest amount of preparation. Information will need to be gathered for each site on: acquisition software, download windows, telephone numbers or FTP addresses and directories, parameters collected (name, order, units, averaging times, time stamps, delimiters, etc.), and calibration periods and target values.

Each morning new data collected by the central CCOS computer will be evaluated. Several electronic reports will be generated during the evaluation and will be available to the CCOS team on an area of the DRI network dedicated to the CCOS project. Each step in the evaluation will be automated to the extent possible. These screening checks are designed to catch a failure in a measurement system, which in turn triggers prompt corrective action to avoid large data losses.

The first step in the evaluation will be to verify that all sites were polled successfully. A simple error report will be generated that lists any sites where a connection was not made. Next, a running table will be updated that lists the start and stop times of the data collected with any gaps noted. Once the evaluation of data completeness is performed, simple statistics will be calculated (e.g. mean, max, min, etc.) and archived. The values will be scanned for outliers and if any are noted an error report will be generated.

Where feasible, rates of change and inter-parameter relationship checks will be calculated (e.g. temperature values that change too rapidly during a two hour period, relationship between ozone and NOY). The emphasis of rates of change checks will be applied with caution. Criteria used for rates of change are often difficult to set properly due to the variability of conditions at sites located in a large geographical region. If the criteria are set too narrow, unnecessary error

reports are generated resulting in wasted time investigating natural phenomena. If set too wide, real instrument malfunctions can be missed. Special summary reports tailored for forecasters will be generated each morning and made available to CCOS management.

Where applicable, calibration data will be extracted from the downloaded data. The data will be screened and evaluated for frequency and target values. A running calibration file will be archived and an error report will be generated if the frequency and found values do not meet requirements of target values. Each morning any error report(s) generated will be reviewed and the problem triggering the report will be investigated. This investigation may include manually polling the site to review the real time data and/or plotting the data (time series, interparameter plots, site comparison plots, etc.). If a potential or immediate problem is confirmed, the Principle Investigator and the site operator will be notified.

Following screening runs, non-CCOS supplementary data will be archived into weekly files and saved as backup data until project completion. CCOS data files will be concatenated into monthly files for data validation.

Data files will be constructed using specifications and formats described in:

Appendix C- Data Management of the CCOS Field Study Plan

(http://www.arb.ca.gov/ccaqs/ccos/ccosmtgsdocs_v3w.htm).

Averaged data will be re-timed to have a start hour time stamp (i.e. 0100 would represent an average that starts at 0100 and ends at 0105 for 5 minute averages or 0159 for hourly averages). All times will be Pacific Standard Time. Calibration/audit data will be set to missing in the validated database, as will any known invalid data.

Data screening is applied to level 0 data. Monthly level 0 files will be processed to validation Level 1B and merged with validated district data for each CCOS site. The cause of all missing values will be documented and flagged. Continuous data will be reviewed using time series plots. The graphs quickly reveal any data anomalies due to power failures or instrument malfunction. Copies of field logs will be obtained and reviewed. Significant events will be checked against the graphs and data reports for consistency.

Calibration data will be reviewed to assess the precision of the data. If the calibrations indicate invalid or low precision, data values will be deleted or re-scaled as necessary and appropriate flags will be applied. Only obvious invalid data will be deleted. Suspect data will be reported but flagged as suspect. Once data have been processed to this point, the outlier and rate of change checks applied to level 0 data will be reapplied to the processed data to ensure that no anomalous data remain. The areal distribution of select parameters will be reviewed for the entire network to check for values that appear spatially anomalous.

Final validated district data will be obtained and merged with the final supplementary CCOS data to form one database for submittal to the CCOS data manager. The format of the file will follow the conventions specified in Section 5. The final data base will include all continuous collected at the surface sites during CCOS except the meteorological data. The database will contain hourly averaged data from all measurements as well as data averaged over shorter

periods, probably five-minute averages. The one-hour database is dictated by the practice of the distrcts to report hourly data. The supplemental CCOS data will be also collected and reported at the shorter averaging time. Integrated data, such as from the VOC canister collection and the carbonyl cartridge collection will be reported separately.

2.5 CCOS Ground-Based Aloft Air Quality and Meteorological Measurements

Meteorological soundings will be used to obtain information on temperature, relative humidity, and wind at various levels of the atmosphere above ground level. Radiosondes releases during IOPs will provide in situ measurements of pressure, temperature, humidity, and wind speed and direction at various altitudes above ground. These balloons will also carry an ozonsonde that will provide a vertical profile of ozone. Two types of remote sounding, radar wind profilers and Doppler acoustic sounders, will provide continuous measurements of upper-air winds during the entire four-month CCOS measurement period (6/1/00 to 9/30/00). Table 2.5-1 provides a summary of the aloft meteorological measurements that are currently being made by local agencies and that will be made by during CCOS by the Environmental Technology Laboratory (ETL, Boulder, CO) and Air Resources Laboratory (ARL, Idaho Falls, ID) of the National Oceanic and Atmospheric Administration (NOAA), Sonoma Technology, Inc. (STI), and T&B systems. Figures 2.5-1 and 2.5-2 show the locations of the upper-air meteorological measurement sites.

2.5.1 Continuous Upper-Air Meteorological Measurements

Radar Wind Profilers (RWP) provide sequential horizontal and vertical wind components in data assimilation and model comparison on a sub-hour time scale. RWPs generally acquire measurements within 100 to 150 m thick layers between ~0.150 and 3 km AGL with a minimum vertical resolution of 60 meters. A radio-acoustic sounding system (RASS) are used to quantify virtual temperature to elevations of ~1 km AGL (up to 2 km AGL in ideal conditions), but this is insufficient altitude to characterize the daytime mixed layers of 2–3 km AGL often observed in much of the study area. Acoustic Sounders (Sodars), like RWPs, also acquire continuous measurements of winds aloft. Sodars have better vertical resolution (~30 m layers from ~50 to 600 m AGL) but less vertical range (750 m AGL maximum). Sodars are most applicable in locations with lower-level structure, such as that found in marine layers, in channeling through canyons and passes, and in nighttime radiation inversions.

Radar profilers, doppler sodars, and RASS are used at most sites because they acquire hourly average wind speed, wind direction, and temperature by remote sensing without constant operator intervention. Sodars are collocated with profilers at several locations because they provide greater vertical resolution in the first 100 m agl. Several radar profilers are being installed to acquire a multi-year database, and one of the important functions of the CCOS/CRPAQS supplements to this network is to relate these relatively sparse measurements tothe detailed meteorological patterns determined during CCOS. The ARB operates two profilers (with RASS) in the San Joaquin Valley, and the San Joaquin Unified APCD and Sacramento Metropolitan AQMD operate one profiler/RASS each as part of their PAMS monitoring program. Military facilities with operational profilers include Travis AFB, Vandenberg AFB, and the Naval Post Graduate School in Monterey. Because these profilers are

Table 2.5-1
Upper Air Meteorological Measurements for CCOS

Site ID	Name	Purpose	Justification	Operator[a]	Contractor	Radar[b]	RASS[b]	Sodar[b,c]	Sonde[b,d]	Nexrad
ABK	Arbuckle	Intrabasin transport	Location provides coverage of predominant summer flow through Sacramento Valley.	CCOS	NOAA-ETL	SC	SC			
ABU	N. of Auburn, S. of Grass Valley	Upslope/downslope flow, downwind of major area source	Site to monitor possible summer eddy flow, vertical temperature structure evolution, model input and evaluation data. Downwind of Sacramento area source.	CCOS	NOAA-ETL	SC	SC			
ACP	Angel's Camp	Upslope/downslope flow, complex terrain for challenging model evaluation	Served as site to capture eddy flow, mixing, vertical temperature structure, model input and evaluation data during SJVAQS/AUSPEX	CCOS	NOAA-ETL			SC		
ANGI	Angiola	Intrabasin transport, vertical mixing, micrometeorology	Positioned to monitor transport up the valley, low level nocturnal jet flow, and Fresno eddy flow patterns. Collocated with tall tower.	CRPAQS-rwp, CCOS-sodar	NOAA-ETL	AC	AC	SC		
BBX	Beale AFB-Oro Dam Blvd West	Northern boundary transport, synoptic conditions	Fulfill needs of National Weather Service and Beale AFB flight operations; existing long-term site.	BAFB						AC
BHX	Humboldt County	Onshore/offshore transport	Fulfill needs of National Weather Service; existing long-term site	NWS						AC
CAR	Carizo Plain	Interbasin tranport.	Monitor tranport between San Joaquin Valley and South Central Coast Air Basins.	CCOS	NOAA-ARL	SC	SC	SC		
CRG	Corning	Nothern Valley barrier, characterize Northern SV convergence zone.	To observe southerly barrier winds along the Sierra Nevada which may be a transport mechanism. May characterize extent of northerly flow into SV for some scenarios.	CCOS	NOAA-ETL	SC	SC			
DAX	Sacramento	Intrabasin transport	Fulfill needs of National Weather Service; existing long-term site	NWS						AC
EDI	Edison	Interbasin transport through Tehachapi Pass. Downwind of major source.	Site to observe possible divergence flow at southern end of the valley, low level jet flow, and eddy flows. Data from SJVAQS/AUSPEX taken at Oildale supports these observations. Downwind of Bakersfield area source.	ARB		AC	AC			
EDW	Edwards AFB	Intrabasin transport	Existing long term site. Transport through Tehachapi Pass, desert mixed layer, synoptic conditions.	EAFB					AS SE	

Table 2.5-1 (continued)
Upper Air Meteorological Measurements for CCOS

Site ID	Name	Purpose	Justification	Operator[a]	Contractor	Radar[b]	RASS[b]	Sodar[b,c]	Sonde[b,d]	Nexrad
EYX	Edwards AFB	Intrabasin transport	Fulfill needs of National Weather Service and Edwards AFB flight operations; existing long-term site.	EAFB						AC
FAT	Fresno Air Terminal	Intrabasin transport	Capture the Fresno eddy, characterize urban mixing heights, transport from major Fresno area source.	CCOS	NOAA_ETL	SC-449	SC	SC		
FSF	Fresno-First Street	Urban Heat Island, Intrabasin Transport, Synoptic Conditons. Characterize	Site to monitor possible summer eddy flow, vertical temperature structure evolution, model input and evaluation data. Flow out of Fresno.	CCOS	T&B				SE	
HNX	Hanford-edge of town between fairgrounds and municipal	Intrabasin Transport	Fulfill needs of National Weather Service; existing long-term site.	NWS						AC
HUR	Huron	Intrabasin transport	This is to monitor daily transport from north to south with average surface winds during afternoons and early evening and the low level nocturnal jet on the western side of the SJV; models should do well with topographic	CRPAQS or ARB	NOAA-ETL or ARB	AC	AC			
LGR	Lagrange	Upslope/downslope flow	This site represents valley/Sierra interactiion in northern SJV. Monitor possible upslope flow transport of pollutants during day and possible recirculation via Mariposa River Valley exit jet by night. Also completes the west to east transect across SJV from SNA to LIV sites.	CCOS	NOAA_ETL	SC	SC			
LHL	Lost Hills	Intra&interbasin transport across Carizo Plain	Situated east of the coastal range and represents uniform flow aloft at 1000m as opposed to a site on the Tremblor Range. Good position to detect the direction of flow between the Carrizo Plain and the SJV	ARB or NOAA		AC	AC			
LIV	Livingston	Intrabasin transport	Representative of mid SJV flow since variation in flow is small along the valley's central axis.	CRPAQS-rwp, CCOS-sodar	NOAA_ETL	AC	AC	SC		
LVR	Livermore	Intrabasin transport	Monitor flow through Castro Valley between San Leandro/Oakland and Livermore.	CCOS	STI	SC	SC			

Table 2.5-1 (continued)
Upper Air Meteorological Measurements for CCOS

Site ID	Name	Purpose	Justification	Operator[a]	Contractor	Radar[b]	RASS[b]	Sodar[b,c]	Sonde[b,d]	Nexrad
MJD	Mojave Desert	Interbasin transport	Chosen to monitor interbasin flow out of the San Joaquin Valley to the desert via Tehachapi Pass. Previous monitoring studies have shown a clear exit jet out of the SJV in this region. The exact site is to be determined.	CRPAQS	NOAA_ETL	AC	AC			
MKR	Mouth Kings River	Upslope/downslope flow	The current suspicion is that the mountain exit jets flow along the axis of the valley over Trimmer. A site between Academy and Humphrey's Station is more likely to observe the flow than a site at Piedra.	CRPAQS	NOAA_ETL	AC	AC			
MON	Monterey	Onshore/offshore transport	Existing long term site. Transport through Tehachapi Pass, desert mixed layer, synoptic conditions.	USNPGS		AC	AC			
MUX	Santa Clara	Interbasin transport	Fulfill needs of National Weather Service; existing long-term site.	NWS						AC
NTD	Point Mugu USN	Onshore/offshore transport, synoptic conditions.	Existing long term site	USN					AS SE	
OAK	Oakland airport	Onshore/offshore transport, synoptic conditions.	Fulfill needs of National Weather Service; existing long-term site.	NWS					AS SE	
PLE	Plesant Grove	Intra- and interbasin tranport.	Monitor transport between Sacramento and Upper Sacramento Valley and North Mountain	CCOS	NOAA-ETL	SC	SC			
POR	Pt. Reyes	On-shore flow, along coast flow	Coastal meteorology impacts air quality not only in coastal regions but by modulating the strength, and intrusion extent of the sea breeze.	CCOS	STI	SC	SC			
REV	Reno National Weather Service Office	Northern boundary transport, synoptic conditions	Fulfill needs of National Weather Service; existing long-term site.	NWS					AS	
RGX	Washoe County-Virginia Peak	Northern boundary transport, synoptic conditions	Fulfill needs of National Weather Service; existing long-term site	NWS						AC
RIC	Richmond	Onshore/offshore transport.	Monitor possible deeper mixed layer.	CCOS-p, CCOS-sodar	NOAA-ETL	SC	SC	AC		

Table 2.5-1 (continued)
Upper Air Meteorological Measurements for CCOS

Site ID	Name	Purpose	Justification	Operator[a]	Contractor	Radar[b]	RASS[b]	Sodar[b,c]	Sonde[b,d]	Nexrad
SAC	Sacramento	Intra and interbasin transport	Monitor N-S flow within Sacramento Valley, afternoon sea breeze intrusion, and flow from San Francisco Bay Area; help resolve northern boundary of SV/SJV divergence zone.	SMUAPCD/ARB		AC	AC		SE	
SHA	Shasta	Intrabasin transport	Monitor flow at the northern end of the Sacramento Valley. Eddy flows.	CCOS	NOAA-ETL	SC	SC			
SNA	Santa Nella, E of I-5 toward Los Banos	Interbasin transport from Pacheco Pass, model QA.	May represents flow through Pacheco pass during some coastal valley intrusions; represents along-valley flow on western side at other times. Models should handle channeled, along-valley flow well at this point.	CRPAQS or ARB	NOAA-ETL or ARB	AC	AC			
SNM	San Martin	Intra- and interbasin transport, flow through Santa	Monitor transport from SFBA to NCC via Santa Clara Valley south of San Jose.	CCOS	STI	SC	SC			
SOX	Orange County	Onshore/offshore transport.	Fulfill needs of National Weather Service; existing long-term site	NWS						AC
TRA	Travis AFB	Interbasin transport between San Joaquin Valley and Bay	Existing long term site	TAFB		AC		WC		
TRC	Tracy, W of Tracy, S of I-205, W of I-580	Interbasin transport through Altamont Pass.	Monitor flow through Altamont Pass for San Francisco Bay Area to SJV transport in p.m.; also help monitor less frequent off-shore flow.	CCOS	STI	SC	SC			
VBG	Vandenberg AFB	Onshore/offshore transport, synoptic conditions.	Existing long term site	VAFB		AC			AS SE	
VBX	Orcutt Oil field-Vandenberg	Onshore/offshore transport.	Fulfill needs of National Weather Service and Vandenberg operations; existing long-term site.	VAFB						AC
VIS	Visalia	Intrabasin transport.	Existing long term site	SJVUAPCD		AC	AC			
VTX	Ventura County	Intrabasin transport-onshore/offshore transport.	Fulfill needs of National Weather Service; existing long-term site.	NWS						AC
	Pittsburg	Plume Study		PG&E	PG&E	SC	SC			
	Moss Landing	Plume Study		PG&E	PG&E	SC	SC			

Table 2.5-1 (continued)
Upper Air Meteorological Measurements for CCOS

	Operator[a]	Contractor	Radar[b]	RASS[b]	Sodar[b,c]	Sonde[b,d]	Nexrad
Totals by Operator:	CCOS		13	13	5	2	
	CRPAQS		6	6			
	ARB/Districts		4	4	1		
	Military/U.S.		3	1		4	10
	TOTALS		26	24	6	6	10

Footnotes

[a]CCOS=Central California Ozone Study (this study), ARB=Air Resoures Board, BAAQMD=Bay Area Air Quality Management District; USNPGS=U.S. Navy Post Graduate School; SJVUAPCD=SJV Unified Air Pollution Control District, NWS=National Weather Service; SMAQMD=Sacramento Metropolitan Air Quality Management District, CRPAQS=California Regional PM10/PM2.5 Air Quality Study; VAF=Vandenberg Air Force Base, TAF=Travis Air Force Base, EAF=Edwards Air Force Base, USN=U.S. Navy.

[b]AC=Annual continuous measurements; AS=Annual sporadic measurements, SC=Summer continuous, 6/1/2000-9/30/2000; SE=Summer episodic measurements on forecasted days.

[c]Summer campaign sodars added at some sites as part of CRPAQS/CCOS except at RIC.

[d]Balloon launch on episode days. Frequency should be 4-8 times per day but include 0700 and 1900 PST.

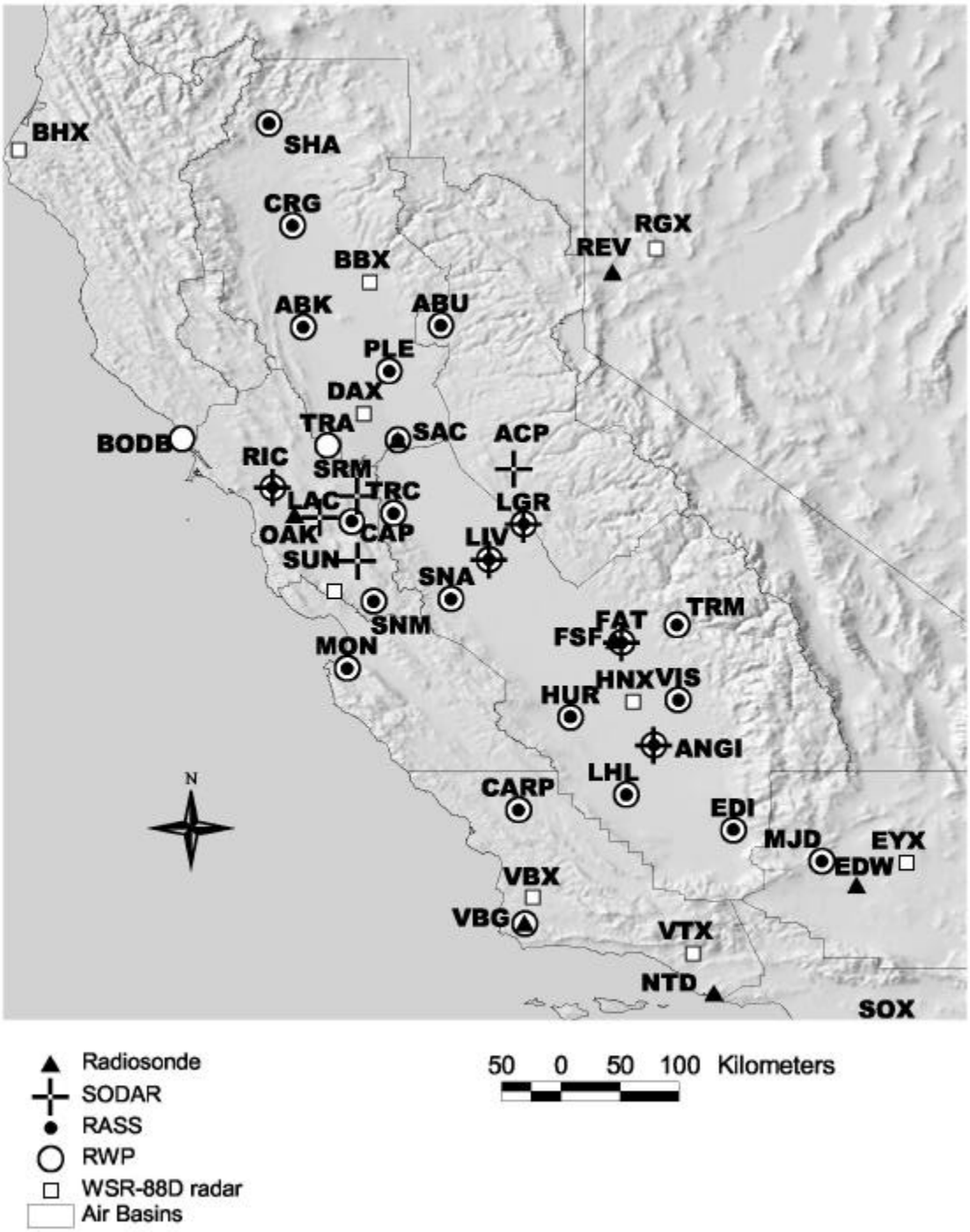


Figure 2.5-1. Upper air meteorological measurements during the summer campaign, including annual average study sites and NEXRAD (WSR-88D) profilers.

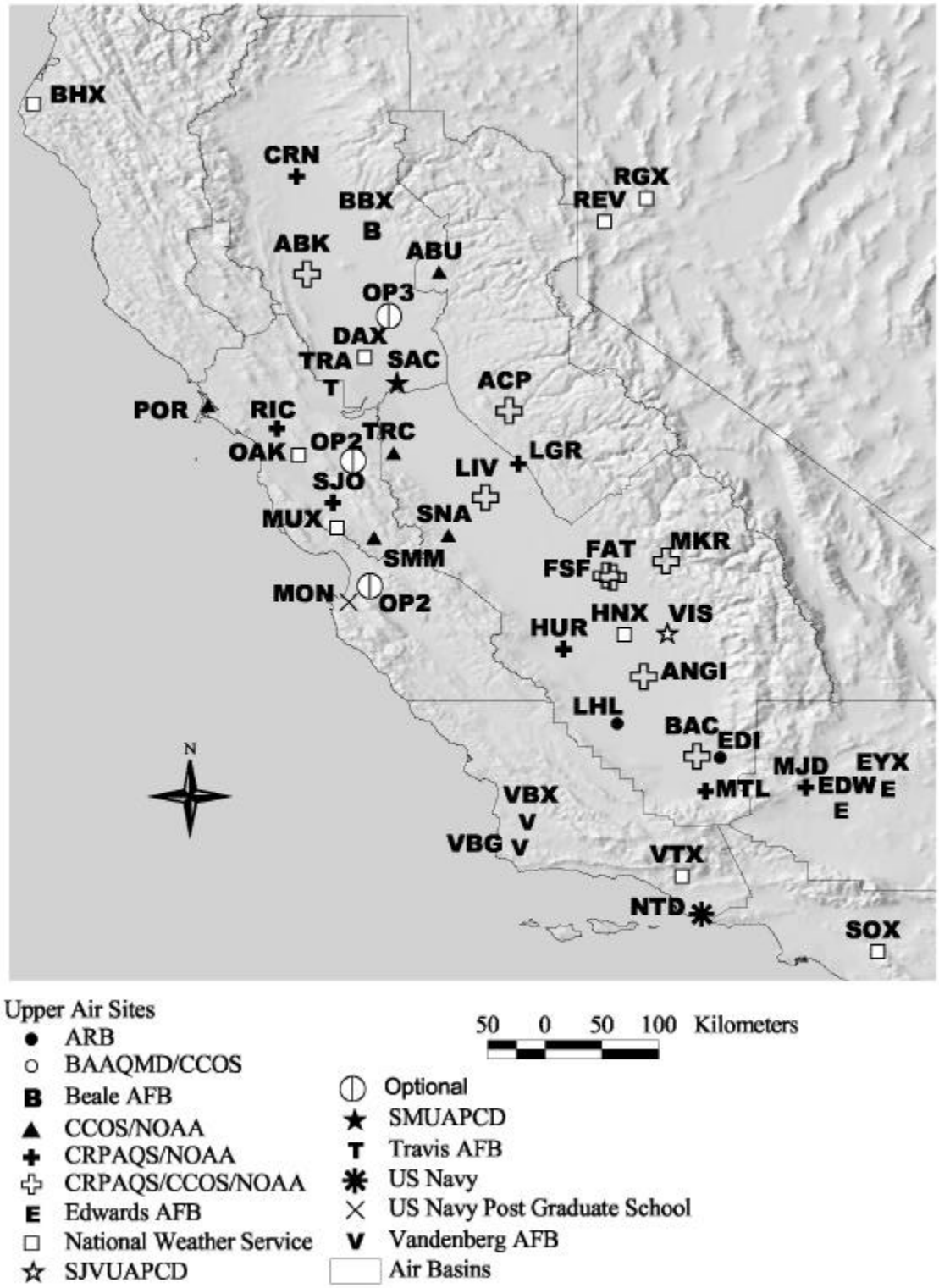


Figure 2.5-2. Upper air meteorological measurement network indicating operating agency. Note: Profiler at POR has moved to Bodega Bay and additional Sodars will be operated at San Ramon, Sunol and Dublin Canyon.

operated by different entities, equivalent methods of data evaluation and reporting need to be established among these entities prior to CCOS field study. As part of CRPAQS, NOAA will upgrade existing equipment, as required, at these facilities, and coordinate data collection to ensure compatibility with the CRPAQS/CCOS upper-air database. Six profiles/RASS will be installed and operational during summer 2000 as part of the CRPAQS. In addition, nine profilers/RASS and 5 sodars will be installed for the CCOS summer 2000 field study.

Another Sodar will be located in the vicinity of the power plant stacks selected for study to ensure that the local 3D winds are well defined for accurate model simulation during the crucial early stages of plume dispersion. Measurements are planned for the power plants at Moss Landing and at Pittsburgh and the radar/RASS profiler will be moved as necessary.

2.5.2 Radiosondes/Ozonesondes

Radiosondes are needed to determine changes in relative humidity and to quantify conditions at elevations above ~2000 m agl. They are also the only practical means of acquiring upper air measurements in cities where the noise and siting requirements of remote sensing devices make them difficult to operate. Radiosondes are routinely launched through the year at 0400 and 1600 PST from Oakland, with additional launches at Vandenberg, Edwards, and Pt. Mugu according to military mission requirements. None of these locations are within the Central Valley, so these will be supplemented by launches at Sacramento and in the southern San Joaquin Valley on 15 episodic days during summer with six radiosondes (with ozonesonde) releases per day. The 490 MHz RWP will be placed in the Fresno area to provide higher vertical soundings in the central San Joaquin Valley.

T&B Systems staff, assisted by in-kind personnel at the Sacramento site, will take six ozonesondes at one site and four ozonesondes at the other during each of 14 IOP days. On one IOP day (for a total of 15), six soundings will be performed at both Fresno and Bakersfield sites. Proposed sounding release times on the six/day schedule are 05, 08, 11, 14, 17, and 22 PDT. Proposed sounding release times on the four/day schedule are 05, 11, 14, 17, and 22 PDT. The schedule will be determined from the forecast episode characteristics. If the episode is expected have a greater impact the northern area of the Central Valley, the more frequent schedule will be carried out at Sacramento. Conversely, the frequent schedule will occur at Fresno if impacts are forecast to be greater in the south. On one day, it is anticipated that six soundings will be made at both sites.

Equipment will be installed and tested prior to commencement of primary study period. Ozonesonde conditioning and testing laboratory will be set up at an existing T&B facility at Modesto. Training will be conducted for two site technicians. At the same time, in-kind support personnel will gain experience assisting in balloon launches.

Ozonesonde data will be processed to Level 0 on-site immediately after the completion of each flight. The Level 0 data for will be transmitted to the T&B Systems electronic data base archives via internet after each flight. Initial Level 0 checks for completeness and accuracy will be conducted as possible after receipt by experienced personnel. Ozonesonde flight data will be validated by T&B to Level 1.

In addition to releases by T&B Systems, the Naval Air Warfare Center at Pt Mugu will release several radiosondes with ozonesonde in the Bay Area (Dublin) for comparison with the Elight ground-base ozone profiler and northern San Joaquin Valley (Tracy or Stockton) during CCOS IOPs.

In addition to ozonesondes mentioned in the previous section, aloft air quality measurements are available from fixed platforms that are part of the routine monitoring network (e.g., Walnut Grove radio tower and Sutter Buttes). CCOS will add NOy and speciated hydrocarbon measurements at Sutter Buttes to provide additional information on oxidants available as carry-over to mix-down on the following day.

2.5.3 Ozone LIDAR

The CCOS Technical Committee discussed the merits of using airborne and ground-based LIDARs to obtain vertical profiles of ozone concentrations, and reached the consensus that a small fleet of instrumented aircraft would provide a more cost-effective approach given the tradeoffs between temporal and spatial information and requirements for pollutant flux and plume measurements. The rationale for the Committee's recommendation is explained further in Section 4.8 or the CCOS Field Study Plan. Although ozone LIDAR was not included in the CCOS Field Study Plan (Fujita et al., 1999), Elight Laser Systems, a German company, will deploy their commercial Ozone Profiler during CCOS using in-kind resources. The profiler will be installed in Dublin and will make measurements for one month beginning in early August, 2000.

The Ozone Profiler measure vertical ozone profiles starting at approximately 50 m up to 2000 m with a detection limit of 5µg/m³ with 200 m range resolution. The system can be delivered as outdoor version with air-water cooling and with water-water cooling as indoor version. The optics and the electronics are integrated in an outdoors housing which allows system operation under different weather conditions. In the system a data analysis software package is implemented for the on-line determination of the ozone concentration as function of the height. This information can be delivered in form of ASII files or as graphical tables. Technical specification for the Elight Ozone Profiler is available at their web site at http://www.elight.de/profiler2.htm.

2.6 In-Situ Aircraft Measurements

Instrumented aircraft will be used to measure the three dimensional distribution of ozone, ozone precursors, and meteorological variables. For CCOS, aircraft data have five specific uses:

- Aloft boundary and initial conditions – direct input to model.
- Definition of temporal and spatial ozone patterns in layers aloft – model evaluation.
- Direct measurement of mixing depth during spirals – model evaluation and many corroborative studies.

- Flux plane estimation of transport - model evaluation and corroborative transport assessment.

- Reconciliation of aloft data with the conceptual model.

Specific objectives of the aircraft flights during CCOS are to collect data pertinent to the following chemical and meteorological conditions and processes.

1. Boundary conditions along western edge of the modeling domain.

2. Ozone and precursor fluxes into Livermore Valley

3. Ozone and precursor fluxes from Carquinez Strait, Altamont Pass and Pacheco Pass into Central Valley.

4. Transport of ozone and precursors to Sacramento and upper Sacramento Valley.

5. Transport of ozone and precursors within San Joaquin Valley via low-level jet plus circulation.

6. Intra-valley transport within the San Joaquin Valley by eddies and slope-flows.

7. Boundary condition along northern edge of the modeling domain.

8. Outflow of ozone and precursors from the San Joaquin Valley into San Louis Obispo County.

9. Outflow of ozone and precursors from the San Joaquin Valley into the southeast Desert.

10. Ozone layer aloft and interaction with surface.

11. Transport of pollutants in the nocturnal low-level jet.

12. Northern SLO Co. at Paso Robles transport impact from the San Francisco Bay area and/or SJV.

In order to quantify pollutant transport and to provide data for modeling and data analyses, surface and aloft measurements are needed at locations where transport can occur and at the times when transport is occurring. These monitoring locations include in and near mountain passes, along coastlines, offshore, and at various locations in the downwind air basin. Aloft measurements made by instrumented aircraft will be used to calculate transport across flux planes. Vertical planes, intersecting the profiler sites downwind of and perpendicular to the transport path, can be defined and provide estimates of transport through these passes using surface and aircraft measurements of pollutant concentrations and surface and wind profiler data for volume flux estimations.

Four instrumented aircraft will be used to measure the vertical and horizontal gradients of ozone, NOx, ROG, temperature, and humidity in the study region during CCOS IOPs. These

aircraft include two Cessna 182 operated by University of California, Davis (UCD), and a Cessa 182 and Piper Aztec operated by Sonoma Technology, Inc. (STI). These aircraft will provide information at the boundaries and will document the vertical gradients, the mixed layer depth, and nature of elevated pollutant layers throughout the CCOS modeling domain. The concentrations and (in conjunction with upper air wind soundings) the transport of pollutants across selected vertical planes will be measured to document transport of pollutants and precursors between offshore and onshore and between air basins.

In addition, the U.S. Department of Energy Gulfstream 159 (G-1) will participate in CCOS during a two-week period from 6/28/00 to 7/12/00 through the Atmospheric Chemistry Program (ACP). This collaborative effort is headed by Pacific Northwest National Laboratory (PNNL) with contributions from Argonne and Brookhaven National Laboratories. The issues of interest for the ACP investigation are formation of elevated ozone layers and their impact on surface concentration, differences in chemical processing between the elevated and mixed layers, and time-evolution of the chemical partitioning between chemically active and stable species. Other questions of secondary interest are the effects of local thermally driven circulation on the introduction of emissions into the mixed layer, chemical processes in up/down valley or slope flows, and the influence of advection of air into the Central Valley on the distribution of pollutants within the Valley. The G-1 will also characterize the boundary conditions along the western boundary of the CCOS modeling domain.

One additional aircraft (Twin Otter), flown by the Tennessee Valley Authority (TVA), will make measurements in power plant plumes. These data will be used to evaluate the plume-in-grid (PiG) parameterizations used in air quality models. The plume study is described in Addendix D of the CCOS Field Study Plan (Fujita et al., 1999).

2.6.1 Overview of Flight Plans

Alternate flight plans have been developed for the two UCD and two STI aircraft corresponding to the type of ozone episode that is forecast for the IOP day. The three types of ozone episodes are described in Section 3 and are summarized here.

Type 1 - The San Francisco Bay Area (SFBA) has its highest basin-wide ozone values, though still less in absolute magnitude than San Joaquin Valley. This scenario is characterized by the weakest sea breeze (lowest west-to-east component through Carquinez Strait), and the lowest Oakland inversion base heights.

Type 2 - The San Joaquin Valley (SJV) has its highest basin-wide values while the Bay Area and Sacramento Valley are relatively cleaner. A stronger sea breeze, relatively to Type 1, keeps the pollutants moving through the Bay Area and the Sacramento Valley, but may increase transport into the SJV. Mountain Counties have lower ozone levels during this scenario.

Type 3 – Sacramento Valley (SV) has its highest basin-wide ozone values, as does the Mountain Counties Air Basin. As with Type 2, a stronger sea breeze is present, relative to Type 1, but the daily maximum surface temperatures in Sacramento Valley are significantly higher, indicating less and/or later intrusion of the sea breeze, allowing more time for photochemistry before evening transport to the Mountain Counties.

All three types have some degree of stagnation (i.e., reduced SF to Reno pressure gradients) that reduces the effects of the marine intrusion. Types 2 and 3 have stronger marine-air intrusion relative Type 1. SJV experiences greatest stagnation with Type 2, while SV has greater stagnation with Type 3. It is easier to distinguish Type 1 from Type 2 and 3 and more difficult to forecast between Type 2 and Type 3. Therefore, lower confidence is associated with the Forecast Team's ability to predict ozone episode in the Redding Area.

Figures 2.6-1, 2.6-2, and 2.6-3 show diagrams of the flight paths for the two UCD Cessna, STI Aztec, STI Cessna, and PNNL G-1 (western boundary flights only). One UCD Cessna will capture the flow through the Carquinez Strait, through the delta and into the northern SJV, and the flow approaching and leaving Sacramento. The second UCD Cessna will document the conditions in the Bay Area in the morning and in locations east of the Berkeley Hills in the afternoon. It will also capture the flow in and around the Livermore Valley and the flow through Altamont Pass to Tracy. Both UCD aircraft will make several afternoon flights during non-IOP days to document conditions across and along the Sacramento Valley. The STI Piper Aztec will document conditions along the western and northern boundaries and the STI Cessna will cover the San Joaquin Valley. Boundary measurements will be made during both non-episode and episode days. When the Aztec is not flying along the boundaries, it will participate in flux plane measurements. The following sections describe the capabilities and objectives of each of the aircraft and proposed flight plan under different meteorological scenario.

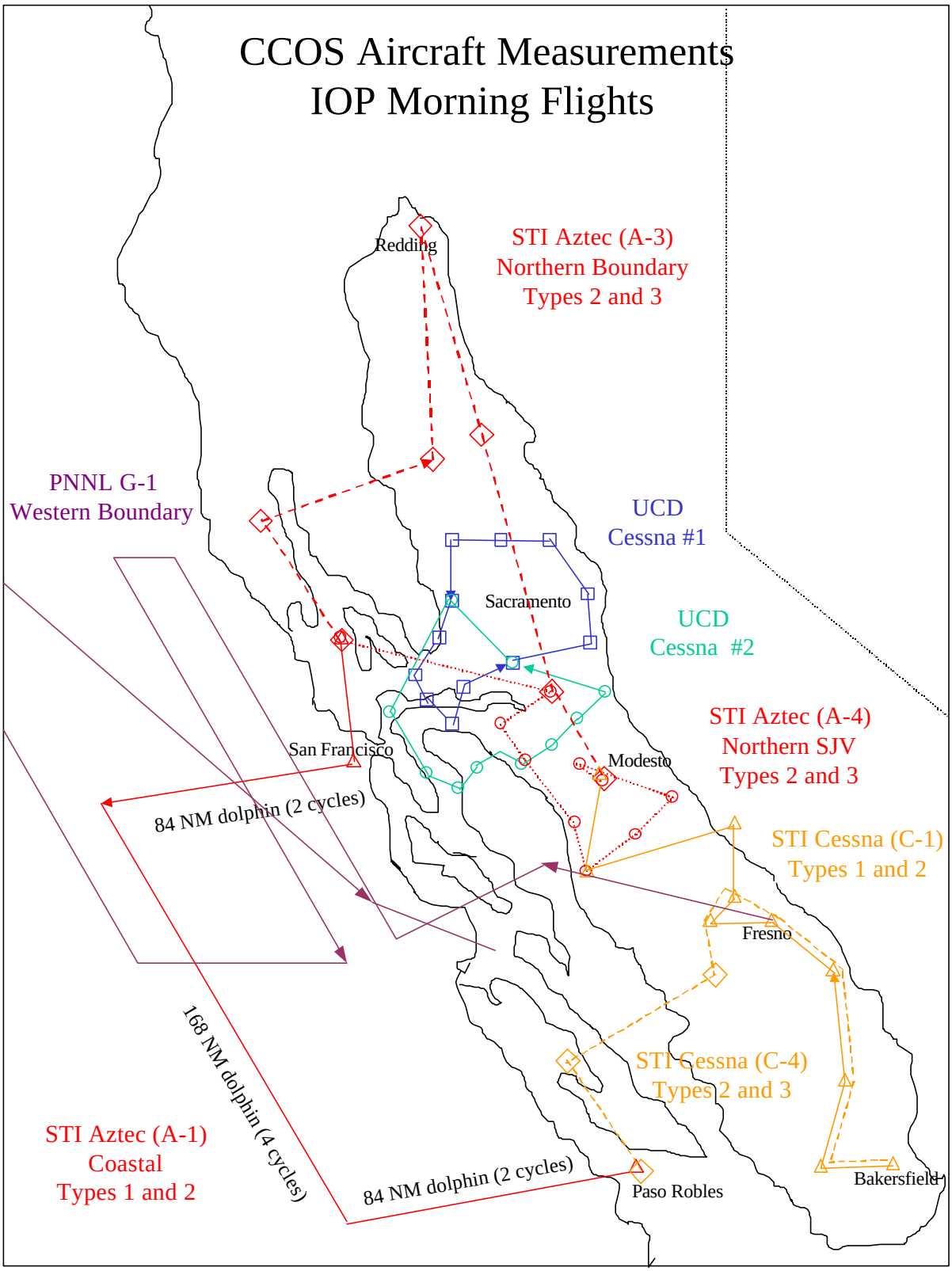


Figure 2.6-1. Morning flight paths for CCOS IOPS.

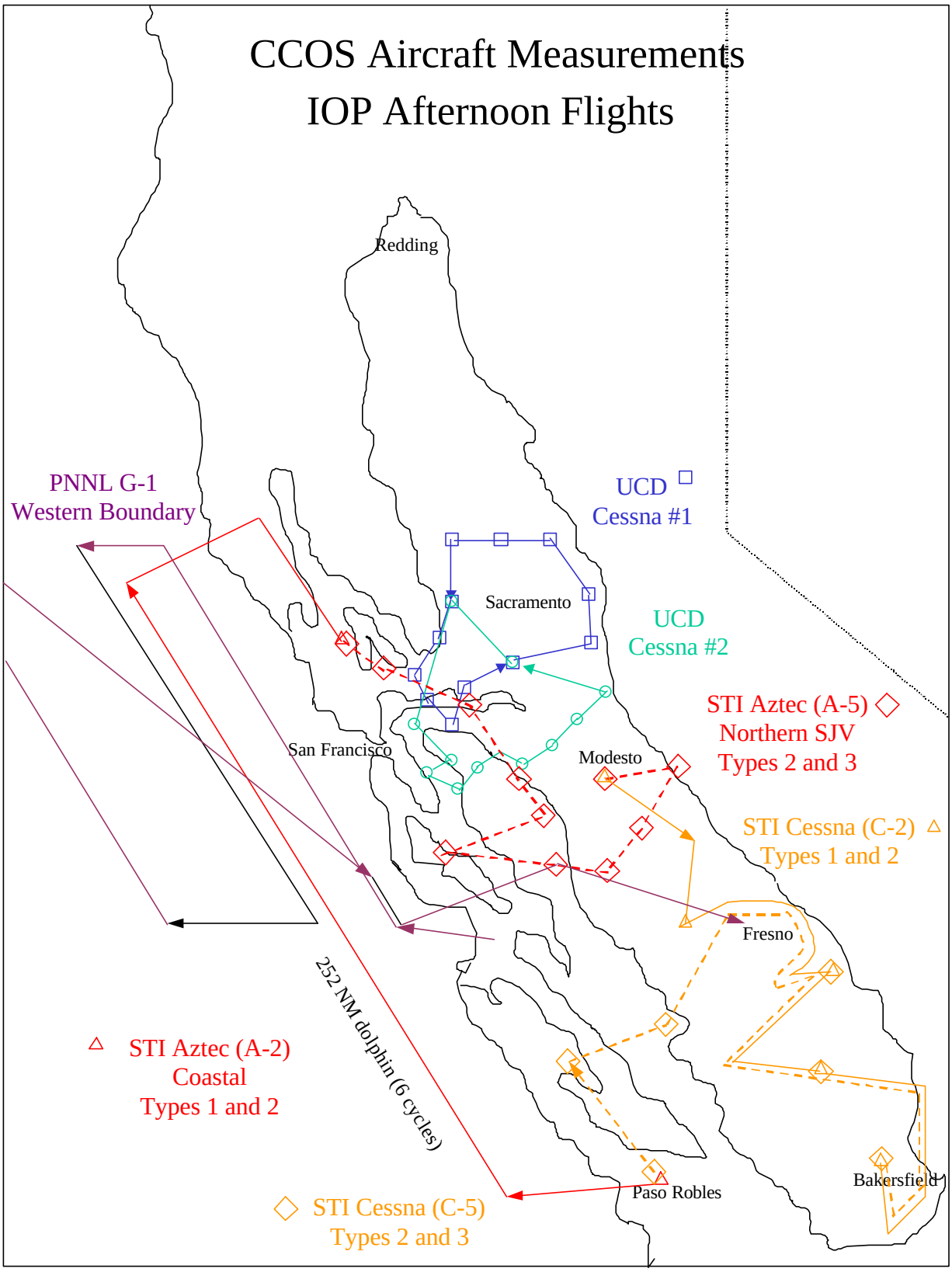


Figure 2.6-2. Afternoon flight path for CCOS IOPs.

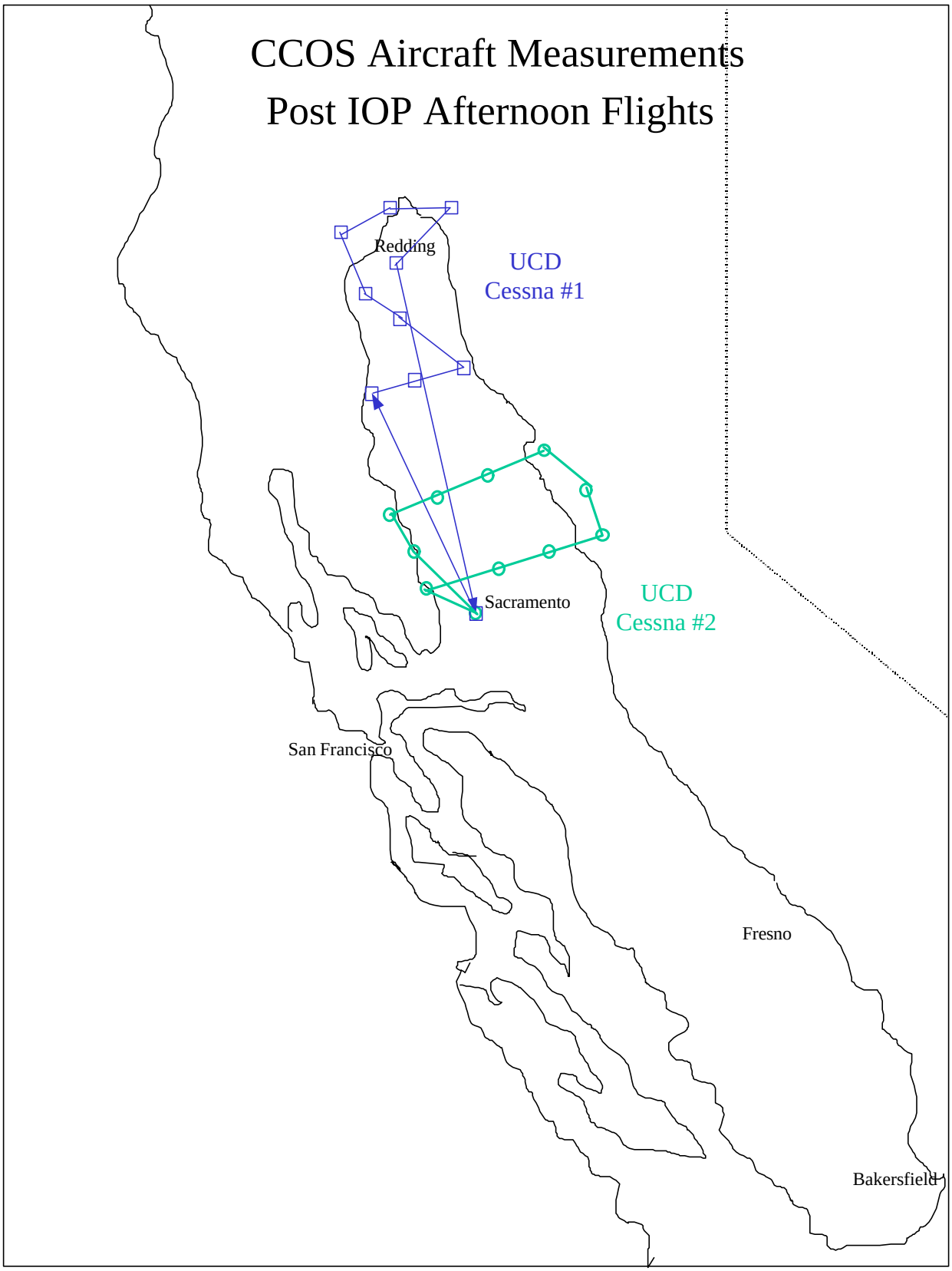


Figure 2.6-3. Afternoon flight path for post CCOS IOPs.

2.6.2 University of California, Davis Cessna 182 (UCD #1 and UCD #2)

Aircraft: Single engine.

UCD #1 Measurements: Position (Garmin GPS); humidity, temperature, wind speed, and wind direction (Aventech AIMMS-10); O3 (Dasibi 1008); NO, NOy (TEI 42S), particle concentration (Climet); hydrocarbons (3 canisters per flight, 90 total, analyzed by BRC); carbonyl compounds (3 DNPH cartridges from 40 liter Tedlar bags, 90 total, analyzed by AtmAA).
UCD #2 Measurements: Position (Garmin GPS); humidity, temperature, wind speed, and wind direction (Aventech AIMMS-10); O3 (Dasibi 1008); NO, NOy (TEI 42S), hydrocarbons (4 canisters per flight, 136 total, analyzed by BRC); carbonyl compounds (4 DNPH cartridges from Tedlar bags, 136 total, analyzed by AtmAA).

Hours Contracted: Each aircraft is budgeted for 120 hours during IOPs and additional flights on non-IOPs.
Base Airport: Davis for both aircraft.
Area of Coverage: Delta, Sacramento, and downwind of Sacramento include some flights in Sacramento Valley.
Objectives of flights during IOPs – all catagories:
1. Capture the flow through the Carquinez Strait
2. Capture the flow through the delta and into the Northern SJV
3. Capture flow approaching and leaving Sacramento.
4. Define conditions in the bay area in the AM and behind the Berkeley hills in the PM.
5. Capture conditions in and around Livermore AM and PM
6. Capture flow through Altamont pass and to Tracy
7. Have daily camparisions between both aircraft and the Elk Grove RASS (Franklin field)
Objectives of flight during non-IOPs Sacramento valley:
1. Capture conditions across and along the valley.

Operational Constraints: Standby period from 6/1/00 to 9/15/00.
Quality Assurance Audits: Performance audits of O_3 and NOy analyzers by ARB quality assurance section on 6/12/00 and 6/13/00 in Dixon.
Data Comparisons: Both UCD aircraft will depart within 5 minutes of each other to afford daily cross-comparisons on climb out. Coordinate parallel flight with STI aircraft and fly by radar wind profilers.
Flight Plans: Basic flight patterns to will be spiral climb over Davis followed by vertical saw tooth patterns: ascents along the straight lines shown in the figures and descending spirals (actually squares) at the rectangles shown. Note these boxes are approximately to scale or a little larger than the actual expected pattern. Altitude variation to be from (near) the surface to about 4500' AGL. While the aircraft paths sometimes cross or spiral near the same locations these will be displaced in time by 45 to 75 minutes.

Figure 2.6-1. 2.6-2, and 2.6-3 show the flight path for all IOPS for both aircraft during morning IOPs, afternoon IOPs and afternoon on post IOPs, respectively. All flights will require 3 to 3.5 hours to complete. Morning flights will depart at 0600, returning by 0930 PDT, and afternoon flights will depart 1300 and return 1630 PDT.

2.6.3 Sonoma Technology Inc. Piper Aztec

Aircraft: Twin engine

Measurements: Position (Garmin 250); humidity, temperature, wind speed, and wind direction (Aventech AIMMS-10); dew point (Cambridge Systems 137-C); Temperature (YSI/MRI); Temperature backup (Rosemont 102 (O3 (Monitor Labs 8410E); NO, NOy (TEI 42S); bscat (MRI 1560 modified by Waggoner) (particle concentration (Climet); hydrocarbons (4 canisters per flight, 136 total, analyzed by BRC); carbonyl compounds (4 DNPH cartridges from Tedlar bags, 136 total, analyzed by AtmAA). Approximately 2-5 minute VOC samples.

Hours Contracted: 136
Base Airport: Santa Rosa
Area of coverage: Western and Northern Boundaries
Operational Constraints: Standby period from 7/2/00 to 9/2/00.
Quality Assurance Audits: Performance audits of O_3 and NOy analyzers by ARB quality assurance section on 7/3/00 in Santa Rosa.
Data Comparisons: Coordinate parallel flight with UCD aircraft and fly by radar wind profilers.
Flight Plans: See Tables 2.6-1 to 2.6-5.

2.6.4 (Sonoma Technology Inc. Cessna 182

Aircraft: Single engine

Measurements: Position (Garmin 250); humidity, temperature, wind speed, and wind direction (Aventech AIMMS-10); dew point (Cambridge Systems 137-C); Temperature (YSI/MRI); Temperature backup (Rosemont 102 (O3 (Monitor Labs 8410E); NO, NOy (TEI 42S); bscat (MRI 1560 modified by Waggoner) (particle concentration (Climet); hydrocarbons (3 canisters per flight, 90 total, analyzed by BRC); carbonyl compounds (3 DNPH cartridges from Tedlar bags, 90 total, analyzed by AtmAA). Approximately 2-5 minute VOC samples.

Hours Contracted: 136
Base Airport: Bakersfield
Area of coverage: San Joaquin Valley
Operational Constraints: Standby period from 7/2/00 to 9/2/00.
Quality Assurance Audits: Performance audits of O_3 and NOy analyzers by ARB quality assurance section in early July.
Data Comparisons: Coordinate parallel flight with UCD aircraft and fly by radar wind profilers.
Flight Plans: See Table 2.6-6 to 2.6-10.

Table 2.6-1
A-1) Aztec Coastal Flight Plan, Santa Rosa to Paso Robles, Morning -- Takeoff 0600 PDT
For Episode Types 1 and 2

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Santa Rosa (STS)	Santa Rosa (STS)	spiral to	4000		0	8	38.51	122.81
Santa Rosa (STS)	San Francisco Bay	traverse	5000		44	22	37.85	122.38
San Francisco Bay	San Francisco Bay	spiral to	100		0	10	37.85	122.38
San Francisco Bay	N. Offshore	dolphin (2 cycles)	100-5000		84	44	37.22	124.57
N. Offshore	S. Offshore	dolphin (4 cycles)	100-5000	cycles 1 and 4: 100-1000 & 1500-2500	168	88	34.60	122.25
S. Offshore	S. Shoreline	dolphin (2 cycles)	100-5000		84	44	35.45	120.90
S. Shoreline	Paso Robles (PRB)	Climb	5000		25	12.5	35.67	120.63
Paso Robles (PRB)	Paso Robles (PRB)	spiral to	100		0	12	35.67	120.63
Total					405	240.5		

[a] Time enroute assumes a 120 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

Table 2.6-2
A-2) Aztec Coastal Flight Plan, Paso Robles to Santa Rosa, Afternoon -- Takeoff 1300 PDT
For Episode Types 1 and 2

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Paso Robles (PRB)	Paso Robles (PRB)	spiral to	5000		0	13	35.67	120.63
Paso Robles (PRB)	S. Coastal	descend to	100		30	15	35.32	121.38
S. Coastal	S.M. Coastal	dolphin (2 cycles)	100-5000	cycle 1: 100-1000 & 1500 2500	84	44	36.45	122.02
S.M. Coastal	N.M. Coastal	dolphin (2 cycles)	100-5000	cycle 2: 100-1000 & 1500 2500	84	44	37.98	123.03
N.M. Coastal	Point Arena	dolphin (2 cycles)	100-5000		84	44	38.97	123.72
Point Arena	Ukiah (UKI)	climb	6000		26	13	39.13	123.20
Ukiah (UKI)	Ukiah (UKI)	spiral to	100		0	13	39.13	123.20
Ukiah (UKI)	Santa Rosa (STS)	climb	5000		42	21	38.51	122.81
Santa Rosa (STS)	Santa Rosa (STS)	spiral to	100		0	12	38.51	122.81
Total					350	219		

[a] Time enroute assumes a 120 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

Table 2.6-3
A-3) Aztec Northern Boundry Flight Plan, Santa Rosa to Modesto, Morning -- Takeoff 0530 PDT
For Episode Types 2 and 3

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Santa Rosa (STS)	Santa Rosa (STS)	spiral to	5000		0	12	38.51	122.81
Santa Rosa (STS)	Ukiah (UKI)	traverse	5000		40	20	39.13	123.20
Ukiah (UKI)	Ukiah (UKI)	spiral to	surface		0	11	39.13	123.20
Ukiah (UKI)	Willows (WLW)	climb to	4000		52	26	39.52	122.22
Willows (WLW)	Willows (WLW)	spiral to	surface	2640-1640	0	9	39.52	122.22
Willows (WLW)	Redding (RDD)	climb to	10000		62	31	40.51	122.29
Redding (RDD)	Redding (RDD)	spiral to	surface	3000-2000 & 1500-surface	0	20	40.51	122.29
Redding (RDD)	Orville (OVE)	climb to	4000		70	35	39.49	121.62
Orville (OVE)	Orville (OVE)	spiral to	surface	2700-1700	0	9	39.49	121.62
Orville (OVE)	Lodi (O20)	climb to	4000		85	42.5	38.09	121.36
Lodi (O20)	Lodi (O20)	spiral to	surface		0	9	38.09	121.36
Lodi (O20)	Modesto (MOD)	climb to	3000		34	17	37.63	120.95
Modesto (MOD)	Modesto (MOD)	spiral to	surface		0	8	37.63	120.95
Total					343	249.5		

[a] Time enroute assumes a 120 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

Table 2.6-4
A-4) Aztec Northern San Joaquin Valley Flight Plan, Santa Rosa to Modesto, Morning -- Takeoff 0530 PDT
For Episode Types 2 and 3

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Santa Rosa (STS)	Santa Rosa (STS)	spiral to	5000		0	12	38.51	122.81
Santa Rosa (STS)	Lodi (O20)	traverse	5000		75	37.5	38.09	121.36
Lodi (O20)	Lodi (O20)	spiral to	surface		0	12	38.09	121.36
Lodi (O20)	Byron (4Q5)	traverse	2500		20	10	37.84	121.64
Byron (4Q5)	Byron (4Q5)	spiral to	5000		0	12	37.84	121.64
Byron (4Q5)	Tracy (TCY)	traverse	5000		12	6	37.69	121.44
Tracy (TCY)	Tracy (TCY)	spiral to	surface		0	12	37.69	121.44
Tracy (TCY)	NASA Crows Landing (NRC)	traverse	2500		22	11	37.42	121.10
NASA Crows Landing (NRC)	NASA Crows Landing (NRC)	spiral to	5000	surface-1000 & 1500-2500	0	12	37.42	121.10
NASA Crows Landing (NRC)	Gustine (3O1)	traverse	5000		12	6	37.26	120.96
Gustine (3O1)	Gustine (3O1)	spiral to	surface		0	12	37.26	120.96
Gustine (3O1)	Turlock (O15)	traverse	2500		20	10	37.49	120.70
Turlock (O15)	Turlock (O15)	spiral to	5000	2650-1650 & 1150-surface	0	12	37.49	120.70
Turlock (O15)	Don Pedro Reservoir	traverse	5000		20	10	0.00	0.00
Don Pedro Reservoir	Don Pedro Reservoir	spiral to	surface		0	12	0.00	0.00
Don Pedro Reservoir	Oakdale (O27)	traverse	2500		20	10	37.76	120.80
Oakdale (O27)	Oakdale (O27)	spiral to	5000		0	12	37.76	120.80
Oakdale (O27)	Modesto (MOD)	traverse	5000		11	5.5	37.63	120.95
Modesto (MOD)	Modesto (MOD)	spiral to	surface		0	12	37.63	120.95
Total					212	226		

[a] Time enroute assumes a 120 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

Table 2.6-5
A-5) Aztec Northern San Joaquin Valley Flight Plan, Modesto to Santa Rosa, Afternoon -- Takeoff 1300 PDT
For episode types 2 and 3.

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Modesto (MOD)	Modesto (MOD)	spiral to	5000		0	12	37.63	120.95
Modesto (MOD)	Don Pedro Reservoir	traverse	5000		28	14	37.73	120.40
Don Pedro Reservoir	Don Pedro Reservoir	spiral to	900		0	12	37.73	120.40
Don Pedro Reservoir	Castle (MER)	traverse	2500		21	11	37.38	120.57
Castle	Castle (MER)	climb / spiral	5000-surface	2700-1700	0	17	37.38	120.57
Castle	Los Banos (LSN)	traverse	2500		24	12	37.06	120.87
Los Banos (LSN)	San Louis Reservoir	traverse	2500		12	6	121.12	37.05
San Louis Reservoir	San Louis Reservoir	spiral to	surface-5000	2000-3000	0	12	121.12	37.05
San Louis Reservoir	San Martin (Q99)	traverse	5000		22	11	37.08	121.60
San Martin (Q99)	San Martin (Q99)	spiral to	surface	2800-1800	0	12	37.08	121.60
San Martin (Q99)	NASA Crows Landing (NRC)	climb	5000	5000	31	18	37.42	121.10
NASA Crows Landing (NRC)	NASA Crows Landing (NRC)	spiral to	surface		0	12	37.42	121.10
NASA Crows Landing (NRC)	Tracy (TCY)	traverse	2500		23	12	37.69	121.44
Tracy (TCY)	Tracy (TCY)	climb / spiral	5000-surface		0	17	37.69	121.44
Tracy (TCY)	Bethel Island	traverse	2500		22	11	38.01	121.64
Bethel Island	Bethel Island	climb / spiral	5000-surface		0	17	38.01	121.64
Bethel Island	Napa County (APC)	traverse	2500		33	17	38.21	122.28
Napa County (APC)	Santa Rosa (STS)	climb	5000		30	18	38.51	122.81
Santa Rosa (STS)	Santa Rosa (STS)	spiral to	surface		0	12	38.51	122.81
Total					246	251.5		

[a] Time enroute assumes a 120 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

Table 2.6-6
C-1) Cessna San Joaquin Valley Flight Plan, Bakersfield to Modesto, Morning -- Takeoff 0530 PDT
For episode types 1 and 2.

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Bakersfield (BFL)	Bakersfield (BFL)	spiral to	5000		0	12	35.43	119.06
Bakersfield (BFL)	Button Willow (L62)	traverse	4000		23	12	35.35	119.48
Button Willow (L62)	Button Willow (L62)	spiral to	surface	1300-surface	0	10	35.35	119.48
Button Willow (L62)	Angiola	traverse	2000		35	18	35.93	119.53
Angiola	Angiola	spiral	500-4000	3000-2000	0	11	35.93	119.53
Angiola	Reedley (O32)	climb	5000		45	23	36.67	119.45
Reedley (O32)	Reedley (O32)	spiral	surface		0	12	36.67	119.45
Reedley (O32)	Fresno-Chandler (FCH)	climb to	4000		22	11	36.73	119.82
Fresno-Chandler (FCH)	Fresno-Chandler (FCH)	spiral to	surface		0	11	36.73	119.82
Fresno-Chandler (FCH)	Mendota (Q84)	climb	4000		28	15	36.76	120.37
Mendota (Q84)	Mendota (Q84)	spiral to	surface		0	10	36.76	120.37
Mendota (Q84)	Madera (MAE)	traverse	2000		19	10	36.99	120.11
Madera (MAE)	Madera (MAE)	spiral	surface-4000	1750-2750	0	11	36.99	120.11
Madera (MAE)	Mariposa (O68)	climb	6000		32	17	37.51	120.04
Mariposa (O68)	Mariposa (O68)	spiral to	surface		0	12	37.51	120.04
Mariposa (O68)	Gustine (3O1)	traverse	2000		46	24	37.26	120.96
Gustine (3O1)	Gustine (3O1)	spiral	surface-4000		0	11	37.26	120.96
Gustine (3O1)	Modesto (MOD)	traverse	4000		22	11	37.63	120.95
Modesto (MOD)	Modesto (MOD)	spiral to	surface		0	11	37.63	120.95
Total					272	253		

[a] Time enroute assumes a 115 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

Table 2.6-7
C-2) Cessna San Joaquin Valley Flight Plan, Modesto to Bakersfield, Afternoon -- Takeoff 1330 PDT
For episode types 1 and 2.

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Modesto (MOD)	Modesto (MOD)	spiral to	5000		0	12	37.63	120.95
Modesto (MOD)	East Valley (Bonanza Hills)	descend to	2500		32	17	37.66	120.23
East Valley (Bonanza Hills)	Mendota (Q84)	traverse	2500		50	26	36.76	120.37
Mendota (Q84)	Mendota (Q84)	spiral	surface-5000		0	12	36.76	120.37
Mendota (Q84)	West	descend to	2500		14	7	36.65	120.23
West	Madera (MAE)	traverse	2500		46	24	36.99	120.11
Madera (MAE)	East	traverse	2500	2500	20	10	37.02	119.67
East	Selma (0Q4)	traverse	2500		40	21	36.58	119.66
Selma (0Q4)	Reedley (O32)	climb to	7000		12	6	36.67	119.45
Reedley (O32)	Reedley (O32)	spiral to	surface		0	16	36.67	119.45
Reedley (O32)	Kettleman City	traverse	2500		46	24	36.02	119.97
Kettleman City	Angiola	climb to	5000		22	11	35.93	119.53
Angiola	Angiola	spiral to	surface	3000-2000	0	11	35.93	119.53
Angiola	NE of Bakersfield	traverse	2500		33	17	35.68	118.93
NE of Bakersfield	SE of Bakersfield	traverse	2500		20	10	35.33	118.75
SE of Bakersfield	S of Bakersfield	traverse	2500	2500	16	8	35.20	119.08
S of Bakersfield	Bakersfield (BFL)	climb to	5000		15	8	35.43	119.06
Bakersfield (BFL)	Bakersfield (BFL)	spiral to	surface		0	12	35.43	119.06
Total					366	254		

[a] Time enroute assumes a 115 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

Table 2.6-8
C-3) Cessna Modified San Joaquin Valley Flight Plan, Modesto to Bakersfield, Afternoon -- Takeoff 1330 PDT
For episode types 2 and 3.

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Modesto (MOD)	Modesto (MOD)	spiral to	5000		0	12	37.63	120.95
Modesto (MOD)	Mendota (Q84)	traverse	2500		59	31	36.76	120.37
Mendota (Q84)	Mendota (Q84)	spiral	surface-5000		0	12	36.76	120.37
Mendota (Q84)	West Valley	descend	2500		14	7	36.65	120.23
West Valley	Madera (MAE)	traverse	2500		46	24	36.99	120.11
Madera (MAE)	East	traverse	2500	2500	20	10	37.02	119.67
East	Selma (0Q4)	traverse	2500		40	21	36.58	119.66
Selma (0Q4)	Reedley (O32)	climb	7000		12	6	36.67	119.45
Reedley (O32)	Reedley (O32)	spiral to	surface		0	16	36.67	119.45
Reedley (O32)	Kettleman City	traverse	2500		46	24	36.02	119.97
Kettleman City	Angiola	climb	5000		22	11	35.93	119.53
Angiola	Angiola	spiral to	surface	3000-2000	0	11	35.93	119.53
Angiola	NE of Bakersfield	traverse	2500		33	17	35.68	118.93
NE of Bakersfield	SE of Bakersfield	traverse	2500		20	10	35.33	118.75
SE of Bakersfield	S of Bakersfield	traverse	2500	2500	16	8	35.20	119.08
S of Bakersfield	South	traverse	2500		9	5	35.02	119.05
SS of Bakersfield	Caliente	traverse	2500		27	14	35.30	118.62
Caliente	Caliente	climb / spiral	6000-2500		0	7	35.30	118.62
Caliente	Bakersfield (BFL)	climb	5000		22	11	35.43	119.06
Bakersfield (BFL)	Bakersfield (BFL)	spiral to	surface		0	10	35.43	119.06
Total					386	269		

[a] Time enroute assumes a 115 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

Table 2.6-9
C-4) Cessna Southern San Joaquin Valley Flight Plan, Bakersfield to Paso Robles, Morning -- Takeoff 0530 PDT
For episode types 2 and 3.

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Bakersfield (BFL)	Bakersfield (BFL)	spiral to	5000		0	12	35.43	119.06
Bakersfield (BFL)	Button Willow (L62)	traverse	4000		23	12	35.35	119.48
Button Willow (L62)	Button Willow (L62)	spiral to	surface	1350-surface	0	10	35.35	119.48
Button Willow (L62)	Angiola	traverse	2000		35	18	35.93	119.53
Angiola	Angiola	spiral	500-4000	3000-2000	0	11	35.93	119.53
Angiola	Reedley (O32)	climb	5000		45	23	36.67	119.45
Reedley (O32)	Reedley (O32)	spiral to	surface		0	12	36.67	119.45
Reedley (O32)	Fresno-Chandler (FCH)	climb	4000		22	11	36.73	119.82
Fresno-Chandler (FCH)	Fresno-Chandler (FCH)	spiral to	surface		0	12	36.73	119.82
Fresno-Chandler (FCH)	Madera (MAE)	climb	5000		21	11	36.99	120.11
Madera (MAE)	Madera (MAE)	spiral to	surface	2750-1750	0	12	36.99	120.11
Madera (MAE)	Mendota (Q84)	climb to	5000		19	10	36.76	120.37
Mendota (Q84)	Mendota (Q84)	spiral to	surface		0	12	36.76	120.37
Mendota (Q84)	Five Points	climb to	5000		21	11	36.45	120.27
Five Points	Five Points	spiral to	surface		0	12	36.45	120.27
Five Points	San Ardo	climb to	5000		39	20	36.03	120.92
San Ardo	San Ardo	spiral to	surface		0	12	36.03	120.92
San Ardo	Paso Robles (PRB)	climb to	5000		27	14	35.67	120.63
Paso Robles (PRB)	Paso Robles (PRB)	spiral to	surface		0	12	35.67	120.63
Total					127	248.48		

[a] Time enroute assumes a 115 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

Table 2.6-10
C-5) Cessna Southern San Joaquin Valley Flight Plan, Paso Robles to Bakersfield, Afternoon -- Takeoff 1330 PDT
For episode types 2 and 3.

From	To	Pass Type	Altitude (ft MSL)	Hydrocarbon Sample Altitude (ft MSL)	Distance (NM)	Time[a] (min)	Latitude[b]	Longitude[b]
Paso Robles (PRB)	Paso Robles (PRB)	spiral to	5000		0	12	35.67	120.63
Paso Robles (PRB)	San Ardo	traverse	5000		27	14	36.03	120.92
San Ardo	San Ardo	spiral to	surface		0	12	36.03	120.92
San Ardo	Coalinga (CLG)	Climb	5000		28	15	36.16	120.36
Coalinga (CLG)	Coalinga (CLG)	spiral to	surface		0	12	36.16	120.36
Coalinga (CLG)	West Valley	Climb	2500		31	16	36.65	120.23
West Valley	Madera (MAE)	traverse	2500		46	24	36.99	120.11
Madera (MAE)	East	traverse	2500	2500	20	10	37.02	119.67
East	Selma (0Q4	traverse	2500		40	21	36.58	119.66
Selma (0Q4)	Reedley (O32)	Climb	7000		12	6	36.67	119.45
Reedley (O32)	Reedley (O32)	spiral to	surface		0	16	36.67	119.45
Reedley (O32)	Kettleman City	traverse	2500		46	24	36.02	119.97
Kettleman City	Angiola	Climb	5000		22	11	35.93	119.53
Angiola	Angiola	spiral to	surface	3000-2000	0	11	35.93	119.53
Angiola	NE of Bakersfield	traverse	2500		34	18	35.68	118.93
NE of Bakersfield	SE of Bakersfield	traverse	2500		20	10	35.33	118.75
SE of Bakersfield	S of Bakersfield	traverse	2500	2500	16	8	35.20	119.08
S of Bakersfield	Bakersfield (BFL)	Climb	5000		15	8	35.43	119.06
Bakersfield (BFL)	Bakersfield (BFL)	spiral to	surface		0	12	35.43	119.06
Total					357	261		

[a] Time enroute assumes a 115 Kt air speed.

[b] Latitudes and longitudes apply to ending locations.

2.6.5 Pacific Northwest National Laboratory Gulfstream 159 (G-1)

Aircraft: Twin engine turboprop

Measurements: Position (Trimble GSP/Loran C); temperature (Rosemount), pressure (Rosemount), wind (differential pressure gust probe and GPS), humidity (General Eastern chilled mirror; AIR Lyman-α), SO_2 (TEI 43S), O_3 (TEI 49-100), CO (TEI 48), particle size spectrum (PMS FSSP & PCASP-100X), particle concentration (TSI 3010), particle optical properties (TSI 3563 nephelometer, Radiance PSAP), PAN/NO_2 (ANL), formaldehyde (BNL), up/down total UV (Eppley TUV), HC canisters (ANL)

Note: ARB has agreed to provide a TEI 42S NO/NO_y instrument for use during CCOS but delivery date has not been confirmed.

Hours Budgeted: ~60 hours including ferry time.

Base Airport: Fresno Air Terminal

Area of Coverage: South-central San Joaquin Valley, mainly Fresno area. West of San Francisco over the Pacific Ocean to sample western in-flow boundary conditions.

Operational Constraints: Because the G-1 is considered a "heavy" aircraft, low altitude operations are governed by the provisions of the PNNL Flight Operations Manual (MA-530) and a waiver by the FAA of regulation 91.119(c). The waiver and our low-level operations manual will be submitted for the purview of the Oakland Flight Standards District Office. Permissions will be requested from the applicable agencies for low level flight for periods of 10-12 minutes down to 300 ft AGL over water within the boundaries of the offshore marine sanctuaries and for periods of less than 5 minutes down to 500 ft AGL over inland wildlife sanctuaries along the flight paths described below.

Quality Assurance Audits: Coordinate with ARB quality assurance section for audit on 7/6/00 in Fresno.

Data Comparison: The far higher sampling speed of the G-1 makes in-flight comparisons with other CCOS aircraft ineffective use of flight time. Ground audits by ARB of G-1 instruments will be needed to establish data comparability. When practical, the G-1 will fly by the Angiola tower and radar wind profilers.

Flight Plans: There are two sets of basic flight plans for the G-1 in CCOS: 1) Fresno and central San Joaquin Valley and 2) Western In-Flow Boundary. Within each there are separate morning and afternoon flight patterns. Timing of the morning and afternoon flights has to take into account the length of the duty day for the pilots (<12 hours) as well as the scientific objectives for each flight. Even with activation of our FAA Low-Level Waiver, operations below 1000 ft AGL over populated areas can only be done over an airport. Portions of the ferry flights between Pasco, WA and Fresno, CA, may be useful for sampling within the Central Valley; flight plans will be arranged at a later date.

Fresno - central San Joaquin Valley

Morning flights depart from the Fresno Air Terminal (FAT) between 6 and 7 a.m. PDT. Way points along the route of travel are listed in Table 2.6-11. Way point locations (airports) were chosen to be close to existing or planned air quality and wind profiling systems. The main objective of the morning flight is to document the vertical distribution of pollutants over the central SJV. This will be accomplished by flying between way points at an altitude of ~5000 ft MSL and making low-level passes over the airports at the indicated way points. Climbing turns (spirals) at an ascent rate ~500 ft/min after leaving the airport will backtrack the flight path to allow the next leg to be flown at the upper altitude before descending for the next low level pass. Therefore, the flight times for each leg will be longer than that given in the table. It is expected that each low-level pass plus climbing turn will add ~15 minutes to the flight time for the pattern.

Table 2.6-11. Fresno area morning flight with low-level passes or spirals over key way points.

		W Longitude		N Latitude		Distance		Time	Spirals
WP	Location	DD	MM	DD	MM	kilometers	naut. miles	(min)	(min)
0	Fresno (FAT)	119	42	36	47				
						108.6	58.6	18.1	
1	S#1 Los Banos (Santa Nella)	120	52	37	4				15
						44.4	24.0	7.4	
2	S#2 Turlock	120	51	37	28				15
						51.7	27.9	8.6	
3	Turlock Lake (turn only)	120	34	37	37				
						47.0	25.3	7.8	
4	S#3 Mariposa-Yosemite	120	3	37	31				15
						97.3	52.5	16.2	
5	S#4 Harris River (MKR)	119	27	36	47				15
						91.8	49.5	15.3	
6	S#5 Harris Ranch	120	14	36	15				15
						72.2	38.9	12.0	
7	S#6 Angiola tower	119	32	35	56				20
						64.8	35.0	10.8	
8	S#7 Woodlake	119	6	36	24				15
						52.8	28.5	8.8	
5	Harris River (MKR) (turn only)	119	27	36	47				
						22.3	12.0	3.7	
0	Fresno (FAT)	119	42	36	47				5
					Total	631.3	340.6	105.2	115.0

The afternoon flights depart from the FAT between 1 and 2 p.m. PDT. For these flights the objective is to map the distribution of pollutants across the SJV and to sample the air above the slope flows into the Sierra foothills. The way points in Table 2.6-12 shows the slightly different circuits for flight above and within the mixed layer. The initial climb will be to a level above the mixed layer (~3500 ft MSL) as best indicated by local radar wind profiler soundings. A complete circuit is flown at that altitude except that a spiral sounding is taken from ~3500 ft

MSL down to lowest permissible safe altitude (expected to be ~500 ft AGL) at the Angiola tower.

Table 2.6-12. Fresno area afternoon flight with circuits above and within mixed layer.

WP		W Longitude		N Latitude		Distance		Time	Spirals
	Location	DD	MM	DD	MM	kilometers	naut. miles	(minutes)	(min)
0	Fresno (FAT)	119	42	36	47				
First circuit - above mixed layer						108.6	58.6	18.1	
1	Los Banos (Santa Nella)	120	52	37	4				
						44.4	24.0	7.4	
2	Turlock	120	51	37	28				
						30.1	16.2	5.0	
3	Turlock Lake (turn)	120	34	37	37				
						47.0	25.3	7.8	
4	Mariposa-Yosemite	120	3	37	31				
						97.3	52.5	16.2	
5	Harris River (MKR)	119	27	36	47				
						91.8	49.5	15.3	
6	Harris Ranch	120	14	36	15				
						103.1	55.6	17.2	
7	S#1 Angiola tower	119	32	35	56				20
						94.6	51.1	15.8	
8	Woodlake	119	6	36	24				
						52.8	28.5	8.8	
5	Harris River (MKR)	119	27	36	47				
Second circuit - in the mixed layer						154.8	83.5	25.8	
4	Mariposa-Yosemite	120	3	37	31				
						97.3	52.5	16.2	
5	Harris River (MKR)	119	27	36	47				
						91.8	49.5	15.3	
6	Harris Ranch	120	14	36	15				
						72.2	38.9	12.0	
7	S#2 (optional) Angiola tower	119	32	35	56				20
						64.8	35.0	10.8	
8	Woodlake	119	6	36	24				
						52.8	28.5	8.8	
5	Harris River (MKR)	119	27	36	47				
						22.3	12.0	3.7	
0	Fresno (FAT)	119	42	36	47				
					Total	1168.2	630.4	194.7	40.0

The second circuit begins at way point #9 with a long transect parallel to the foothills of the Sierra Nevada at an altitude just below the top of the mixed layer. At the northern turn point (#10), the aircraft returns along the same transect but at the lowest safe and permissible altitude (500 to 1000 ft AGL) above the terrain. A spiral can again be flown around the Angiola tower from lowest safe altitude to above the mixed layer.

Figure 2.6-4 gives a schematic presentation of the form of the flight pattern without geographic reference. The northern-most way point is at Sonoma while the southern-most is the Angiola tower. The top portion is flown in a clockwise direction while the bottom portion is flown in a counterclockwise direction.

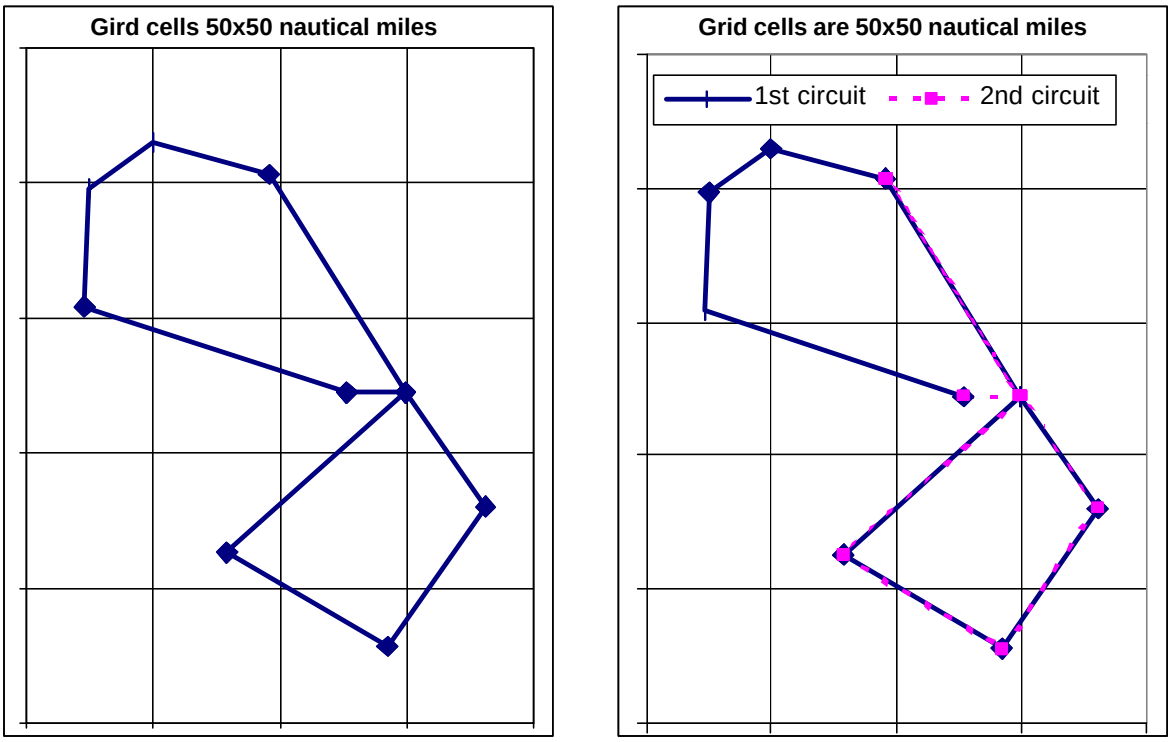


Figure 2.6-4. Fresno area flight patterns for morning flights with low-level passes or spirals at key way points (left) and afternoon flights with circuits above and within mixed layer (right).

Western In-Flow Boundary

Morning flights depart from FAT between 6 and 7 a.m. PDT. Way points for these flights are listed in Table 2.7-13 and are shown schematicaly in Figure 2.6-5. From FAT to the coast, the flights are at the recommended minimum altitude for clearing the terrain along the Pacheco Pass route toward Monterey Bay. Once over the coast, the flight descends to minimum allowable and safe altitude, which could be restricted to 2000 MSL because of the coastal marine and wildlife sanctuaries, but which, if permissions are granted, could be as low as 300 ft MSL. Minimum altitude could be further restricted by offshore fog and stratus cloud decks.

Turn point #3 begins the first of three long transects that are roughly parallel to and 10-20 nm, 40-50 nm, and 90-100 nm from the coast. The 1st transect intersects Class B airspace west of San Francisco and ATC may request routing around or below the controlled airspace. The 2nd and 3rd transects require entrance into several military warning areas. A continuing series of

dolphin patterns between the minimum altitude and ~5000 ft MSL begins at #3. The ascent phase is at ~950 ft/min whereas the descent phase is at only 300 ft/min. An 8 minute period of level flight is made at the maximum and minimum altitudes. Subsequent turns are made at whatever altitude is encountered when at the turn point. The dolphin pattern has a repeat period of about 35 min and 113 nm. The morning flight terminates at the Monterey airport for refueling and crew rest.

The afternoon flights depart from Monterey between 12 and 1 p.m. PDT and pick up the morning pattern again at way point #1 (#3 of the morning flight) beginning with the dolphin pattern from the minimum altitude. The over-water flight concludes after the turn at way point #8 and a climb to a minimum of 500 ft AGL on the route back to FAT through Pacheco Pass.

This day of flying comes very close to the 12-hour duty limit for our pilots (scientific crew as well). The plan is to fly the western in-flow boundary flights on two consecutive days. Ideally the day before and the day after are no-fly days to insure that the crew is adequately rested.

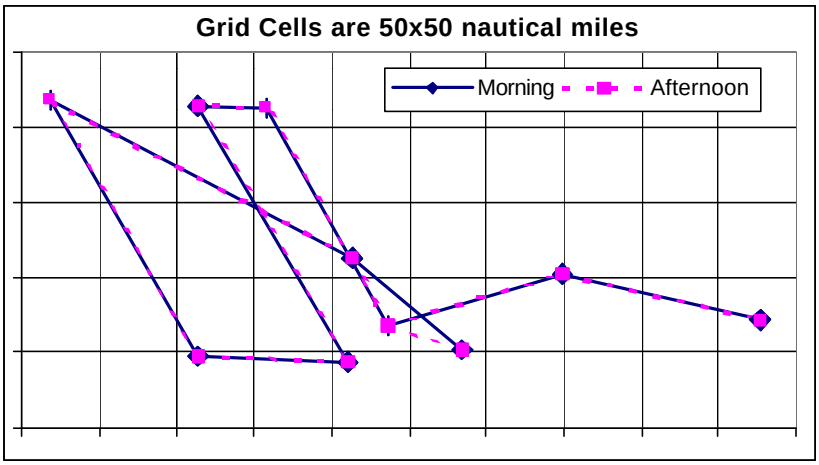


Figure 2.6-5. Schematic representation of the flight patterns for the morning and afternoon western in-flow boundary flights. Fresno Air Terminal is at the far right, Monterey near center.

Ferry flights

Tables 2.6-14 and 2.6-15 present flight plans for making measurements over the Central Valley during the ferry flights between Pasco WA and Fresno CA. Although these flights may not have the full complement of instruments operating, useful measurements within and above the mixed layer can be obtained over much of the length of the Central Valley.

Table 2.6-13. Western In-Flow Boundary flights

		W Longitude		N Latitude		Distance		Time	Turns
WP	Location	DD	MM	DD	MM	kilometers	naut. miles	(min)	(min)
Morning flight									
0	Fresno (FAT)	119	42	36	47				
	Leg #1 over central SJV					131.1	70.7	22	
1	T#1 SW San Luis reservoir	121	8	37	3				
	Leg #2 over Watsonville					117.5	63.4	20	
2	T#2 NW	122	23	36	43				0.5
	Leg #3 parallel coast 10-25 nm offshore					165.6	89.3	28	
3	T#3 W	123	20	38	0				0.5
	Leg #4 to ~30 nm offshore					44.0	23.7	7	
4	T#4 SE	123	50	38	0				0.5
	Leg #5 parallel coast 40-50 nm offshore					196.2	105.9	33	
5	T#5 W	122	40	36	30				0.5
	Leg #6 to ~90 nm offshore					97.2	52.4	16	
6	T#6 NW	123	45	36	30				0.5
	Leg #7 parallel coast 90-100 nm offshore					118.6	64.0	20	
7	T#7 ESE	124	55	38	0				0.75
	Leg #8 return toward coast					314.5	169.7	52	
8	T#8 SE	122	40	37	7				0.1
	Leg #9 return to airport					93.9	50.7	16	
9	Monterey (MRY)	121	51	36	35				
					Total	1147.3	619.1	191.2	3.35
Afternoon flight									
9	Monterey (MRY)	121	51	36	35				
	Leg #1 coast to ~18 nm offshore					50.0	27.0	8	
2	T#1 NW	122	23	36	43				0.5
	Leg #2 parallel coast 10-25 nm offshore					165.6	89.3	28	
3	T#2 W	123	20	38	0				0.5
	Leg #3 to ~30 nm offshore					44.0	23.7	7	
4	T#3 SE	123	50	38	0				0.5
	Leg #4 parallel coast 40-50 nm offshore					196.2	105.9	33	
5	T#4 W	122	40	36	30				0.5
	Leg #5 to ~90 nm offshore					97.2	52.4	16	
6	T#5 NW	123	45	36	30				0.5
	Leg #6 parallel coast 90-100 nm offshore					118.6	64.0	20	
7	T#6 ESE	124	55	38	0				0.75
	Leg #7 return toward coast					266.2	143.6	44	
8	T#7 SE	122	40	37	7				0.1
	Leg #8 parallel to coast					136.6	73.7	23	
2	T#8 NE	122	23	36	43				0.5
	Leg #9 over Watsonville					117.5	63.4	20	
1	T#9 SSE San Luis reservoir	121	8	37	3				0.1
	Leg #10 over central SJV					131.1	70.7	22	
0	Fresno (FAT)	119	42	36	47				
					Total	1322.8	713.8	220.5	4.0

Figure 2.6-6 shows that the fight plans differ mainly in the north. One the return ferry (7/12), the departure out of Redding swings out to the coast, then back inland to Klamath Falls to capture more information related to the northern inflow boundary. Both patterns provide two looks at the horizontal distribution of pollutants between Fresno and Bakersfield; these can be flown at different altitudes. Except for landings and takeoffs at Redding and Fresno, all flight segments will be at roughly constant altitude with no other low level passes or spirals. Redding serves as a refueling point for both flights.

Table 2.6-14. PSC-FAT ferry flight

		N Latitude		W Longitude		Distance		Time
WP	Location	DD	MM	DD	MM	kilometers	naut. miles	(minutes)
0	Pasco (PSC)	46	16	119	7			
						274.3	148.0	45.7
1	Redmond (RDM)	44	15	121	8			
						239.0	129.0	39.8
2	Kalamath Falls	42	9	121	43			
						187.5	101.2	31.3
3	Redding	40	31	122	18			
						237.9	128.4	39.7
4	Placerville	38	44	120	46			
						148.6	80.2	24.8
5	Mariposa-Yosemite	37	31	120	3			
						97.3	52.5	16.2
6	Harris River (MKR)	36	47	119	27			
						103.7	56.0	17.3
7	Porterville	35	55	119	1			
						94.8	51.1	15.8
8	Taft-Kern Co.	35	8	119	26			
						56.2	30.3	9.4
9	DiGiorgio	35	15	118	50			
						75.8	40.9	12.6
7	Porterville	35	55	119	1			
						103.7	56.0	17.3
6	Harris River (MKR)	36	47	119	27			
						22.3	12.0	3.7
10	Fresno (FAT)	36	47	119	42			
					Total	1641.2	885.6	273.5

Schedule of G-1 Activity

Table 2.6-16 gives our anticipated schedule for research flights. No flights are scheduled for the holiday weekend for two reasons. First, many CCOS surface sites may not be operational thereby reducing the value of data aloft. Second, high general aviation traffic during the Fourth of July weekend holiday (7/1-7/4) poses safety concerns for a fast, heavy aircraft like the G-1 operating at low altitude over an area (south central San Joaquin Valley) that is densely populated with small airports. Rest days bracket the pair of over ocean flights because of the

length of duty day these flights require. If an ozone episode is forecast during the period, every effort will be made to coordinate G-1 flights with other CCOS aircraft activities. The six days of research flying plus two long ferry flights will generate about ~60 hours of research data for future analysis.

Table 2.6-15. FAT-PSC ferry flgiht

		N Latitude		W Longitude		Distance		Time
WP	Location	DD	MM	DD	MM	kilometers	naut. miles	(minutes)
0	Fresno (FAT)	36	47	119	42			
						22.3	12.0	3.7
1	Harris River (MKR)	36	47	119	27			
						103.7	56.0	17.3
2	Porterville	35	55	119	1			
						75.8	40.9	12.6
3	DiGiorgio	35	15	118	50			
						56.2	30.3	9.4
4	Taft-Kern Co.	35	8	119	26			
						94.8	51.1	15.8
2	Porterville	35	55	119	1			
						103.7	56.0	17.3
1	Harris River (MKR)	36	47	119	27			
						97.3	52.5	16.2
5	Mariposa-Yosemite	37	31	120	3			
						148.6	80.2	24.8
6	Placerville	38	44	120	46			
						237.9	128.4	39.7
7	Redding	40	31	122	18			
						161.9	87.3	27.0
8	Arcata	40	58	124	7			
						91.4	49.3	15.2
9	Crescent City	41	47	124	14			
						212.0	114.4	35.3
12	Kalamath Falls	42	9	121	43			
						239.0	129.0	39.8
10	Redmond (RDM)	44	15	121	8			
						274.3	148.0	45.7
11	Pasco (PSC)	46	16	119	7			
					Total	1919.0	1035.5	319.8

Table 2.6-16. Schedule of G-1 Activity in CCOS

6/28	6/29	6/30	7/1	7/2	7/3	7/4	7/5	7/6	7/7	7/8	7/9	7/10	7/11	7/12
W	Th	F	Sa	Su	M-H	T-H	W	Th	F	Sa	Su	M	T	W
A	-	F	-	-	-	-	F	QA	WIB	WIB	-	F	F	D

A = arrive at FAT from PSC late-morning
D = depart FAT for PSC late morning
F = Fresno area research flights
WIB = Western In-flow Boundary flights
H = Holiday (PNNL)
QA = ARB QA audit

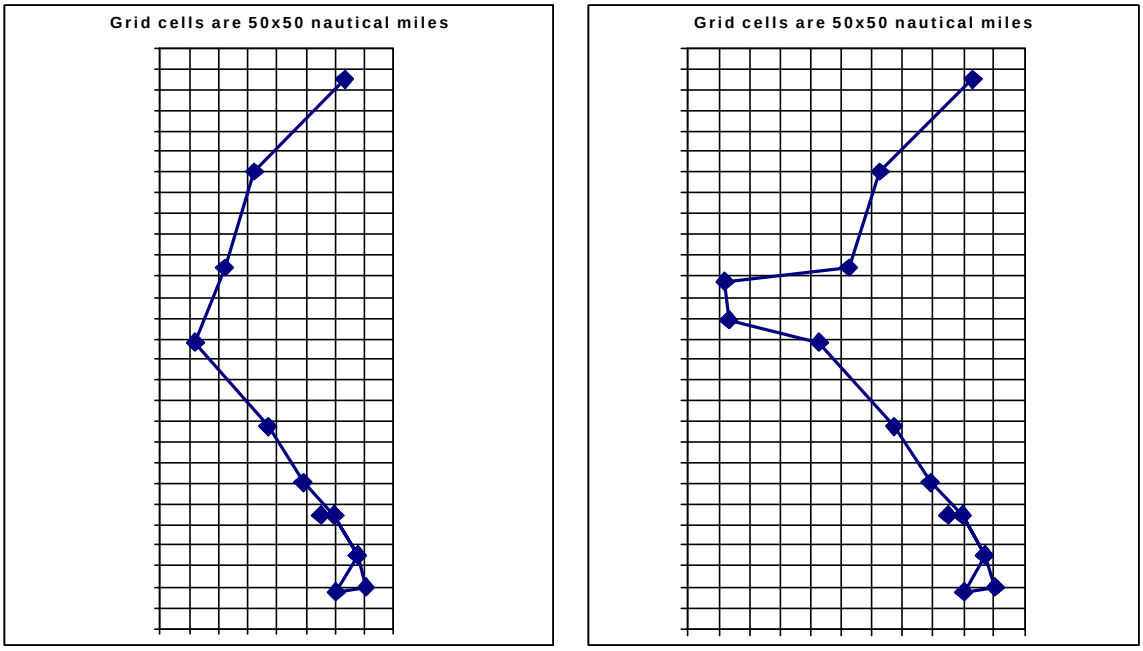


Figure 2.6-6. Flight patterns for ferry flights between Pasco, WA (PSC) and Fresno

2.6.6 Tennessee Valley Authority (TVA) Twin Otter

Aircraft: Twin engine turboprop.

Measurements: Position (Garmin GPS); altitude (barometric and GPS for backup) humidity, temperature; fast O_3 (reverse chemiluminescence), NOy (Gold tube & modified TEI monitor), fast total nitrate (Gold tube with nitric acid removal & modified TEI monitor), NO_2 (research photolytic cell), NO (fast chemiluminescence); SO_2 (modified TEI 43C) hydrocarbons (3 or 4 canisters per flight, analyzed by BRC); carbonyl compounds (DNPH cartridges as requested), analyzed by AtmAA).

Hours Contracted: 40 hours, with additional hours possible if time and budget permit

Base Airport: Livermore Airport

Area of Coverage: Power plant missions targeted at Moss Landing and Pittsburg natural gas generating stations.

Operational Constraints: Standby period from last week of July through second week of August. Final dates will be set based on customer requirements 8 weeks prior to field deployment.

Quality Assurance Audits: Performance audits of gaseous analyzers by ARB quality assurance section on 7/25/00 in Livermore.

Data Comparisons: Coordinate parallel flight with other aircraft as desired. TVA onboard calibrator can be used to intercompare with other aircraft when at the same airport.

Flight Plans:
Flight air speed will be near 125 kts for ferries and near 95 kts for plume traversing. Ferries will also provide detailed gaseous speciation. Start time may be adjusted depending on expected plume transport speed.

(1) Power Plant Mission**:** At 1100 PDT ferry from Livermore to target plant (Pittsburg or Moss Landing) at mid boundary layer. Spiral from minimum safe altitude to 5000' 5 km upwind of plant for upwind vertical profile. Circle plant at 5 km to establish actual plume centerline direction and for first traverse. Continue a series of plume traverses at mid boundary level at 5 km spacing out to distance where ozone chemistry has finished or plume is indistinguishable from background. Spacing of lagrangian plume traverses will be fixed for a given flight and set based on profiler mid boundary layer wind at flight time. Length of traverses will be adjusted in flight depending on horizontal mixing observed in real time. Downwind spiral to 5000' will be performed when last traverse completed. Ferry back to Livermore airport at completion.

(2) Supplemental Mission**:** As time and existing budget permits TVA Twin Otter may add regional survey legs to power plant missions to enhance data in the Livermore Valley, Sacramento Valley or SJV as desired for clusters 1, 2, or 3 to increase detail and parameters measured by collaborating aircraft. Basing at Livermore should permit efficient add-ons. Detailed NOy speciation can greatly improve knowledge of chemical age and processing of ozone rich airmasses. Supplemental missions will be coordinated at daily planning sessions.

Objectives and Rationale**:** Map detailed ozone, precursor, and products in power plant plumes and in regional airmasses during ferries and supplemental add-ons.

2.6.7 VOC Sample Collection Methods and Protocols

Hydrocarbon samples are collected in stainless steel canisters and will be analyzed for C_1 to C_{11} hydrocarbons, CO and CO_2 at Biospheric Research Corporation (Beaverton, OR) by gas chromatography with flame ionization detection. The aircraft samplers will be supplied by BRC. They will operate manually off 24-48 volts and be configured to collect 3.2 liters canisters over averaging times of several minutes to near instantaneous.

Carbonyl samples are collected in Tedlar bags and transferred to dinitrophenyl hydrazine impregnated cartridges on the ground at the conclusion of the flight. Samples will be collected by ramming air through a Telfon inlet tube into pre-cleaned 40-liter Tedlar bags that had been doped with excess NO to react with any O_3 in the air sample. Sampling times are approximately 2-5 minutes. The stainless steel valves attached to the Teflon bags are specially modified to permit rapid filling and all rubber seals have been replaced with inert Viton parts. Because the sample sizes for the aloft carbonyl samples (nominally 30 liters) are substantially less than for a typical surface sample, additional efforts are necessary to reduce blank variability in order to

achieve the required detection level. The samples will be analyzed for C_1-C_7 carbonyl compounds by HPLC with UV detection at AtmAA (Calabasas, CA).

The budget allows for collection and analysis of three or four sets of hydrocarbon and carbonyl samples per flight.

2.6.8 Intercomparison Flights

Intercomparison flights will be performed between (1) the STI Aztec and STI Cessna 182, (2) the two UCD Cessnas, (3) the STI 182 and one UCD Cessna, (4) the STI Aztec and the DOE G-1, and (5) one UCD Cessna and the TVA Twin Otter. The first three comparisons will be made near Sacramento, the fourth near Fresno, and the fifth near Livermore. Each aircraft will collect hydrocarbon and carbonyl samples in a clean location so that investigators can ensure that their sampling systems do not contaminate the samples. This can be done as part of the intercomparison flights or during initial test flights.

The intercomparison flights will compare measurements of ozone, NO, NOy, CO (when available) temperature, relative humidity or dew point, and winds (when available). The aircraft will compare clocks and GPS position systems on the ground prior to flight in order to facilitate subsequent data processing and analysis. Flights will include spirals up and down to document hysteresis and altitude effects, and will include traverses in the mixed layer and above the mixed layer to compare measured concentrations at varying concentration levels. The flights will be made downwind of urban areas in the mid-afternoon to increase the probability of encountering elevated ozone and NOy concentrations.

The first four comparisons listed above will include comparisons of wind measurements. These flights will involve a dog-leg pattern at at least one of the traverse altitudes in order to test whether the aircraft indicate the same winds using the orthogonal components of their wind measuring devices.

Comparison 1 will start from STI's base at Santa Rosa Airport (STS). Comparisons 2 and 3 will start from the UCD's base at University Airport (0O5) at Davis. Comparison 4 will start at the DOE base at Fresno Yosemite International Airport (FAT). Comparison 5 will start at the TVA base at Livermore (LVK). Before each flight the aircraft will meet at the starting airports to synchronize data system clocks, compare GPS position readings, and to coordinate flight plans among the pilots. The flights will include a spiral up from an airport to 5000 ft msl or more with one following the other about 500 ft apart and a similar spiral back down to about 2000 ft msl or less. The flights will also include a traverse at 2000-3000 ft msl along a path to intersect the local urban plume and a similar traverse at about 5000 ft msl or more. The aircraft will fly the traverses side by side for at least 20 NM.

For comparisons 1 through 3, the aircraft will climb from their starting airports to 5500 ft over University Airport. From there they will traverse side-by-side at 5500 ft msl to Sunset Skyranch (Q40, 23 NM) and then to Auburn Airport (AUN, 35 NM). Over Auburn, they will descend to 3000 ft msl, then traverse together at 3000 ft to Sunset Skyranch and then to Sacramento Executive (SAC, 10 NM). Over Sacramento, they will descend and do a low pass

over the airport, then spiral up to 5000 ft msl and spiral down to 2000 ft msl or below, before returning to their base airports.

For comparison 4 the aircraft will start at Fresno Yosemite Airport (FAT). The aircraft will climb to 5000 ft msl over either Harris River (13 NM) or Reedley (O32, 15 NM), then spiral down to the surface and back up to 6500 ft msl. The choice between Harris River and Reedley will depend on whether permission can be obtained to do a low pass at Harris River which is private. They will then traverse to Mariposa-Yosemite Airport (O68, 54 NM) at 6500 ft msl, descend to 3000 ft msl at a point about 10 NM SW of Mariposa, traverse back to Harris River (54 NM) (or Reedley) and then to Harris Ranch (3O8, 49 NM) at 3000 ft MSL. From Harris Ranch, the DOE G-1 will continue on its afternoon flight plan, and the STI Aztec will return to Santa Rosa.

Comparisons 1 through 3 will take place the week of June 26th. Comparison 4 is scheduled for July 5. Comparison 5 will take place soon after TVA's QA audit on July 25. The flight plan details for comparison 5 will be worked out between UCD and TVA after the earlier comparison flights are evaluated, in case changes in approach are needed.

Data from the comparison flights should be processed, discussed between the investigators, and sent to DRI and ARB for review within one week after the flights.

3.0 FORECAST AND IOP DECISION PROTOCOL

The decision to declare an IOP will be based on daily meteorological and air quality forecasts, and other information on current conditions and operational status. Intensive Operational Periods (IOP) will be forecasted during periods that correspond to categories of meteorological conditions called scenarios, which are associated with ozone episodes and ozone transport in northern and central California. This section describes the meteorological scenarios of interest in CCOS and the protocols for forecasting and decision-making.

3.1 Ozone Episode and Transport Scenarios of Interest

The classifications of ozone episodes in central and northern California are based upon identification of meteorological scenarios that foster the formation, accumulation and transport of ozone within the CCOS area. The goals of the CCOS Meteorological Working Group (MetWG) are to identify and characterize these meteorological scenarios, and to develop and evaluate suitable forecasting tools and protocol. Toward this end, the MetWG examined ozone episodes for three ozone seasons, May-October, 1996-1998. Subjective classification by inspection of Daily Weather Maps was compared to the objective classification technique of cluster analysis.

Previous investigators have used classification techniques varying from subjective inspection of weather charts (ETL 1994) and streamline plots (Hayes et al. 1984; Stoeckenius et al. 1994), to objective classification methods like linear regression (Roberts 1992), multivariate regression (Stoeckenius 1998), cluster analysis (Roberts et al. 1994; Smith 1994; Stoeckenius 1994; Fairley and De Mandel 1996), empirical orthogonal functions (Ludwig et al. 1995) and neural networks (Stoeckenius, 1998). A more detailed discussion is provided by Fujita et al. (1999). In each of the cited cluster analyses, the number and nature of the clusters has varied. However, as summarized by Stoeckenius et al. (1994), certain key variables remain statistically and conceptually linked to ozone formation in Central California. These are:

- The 850-mb temperature (i.e., the Oakland 0400 PST sounding)
- Fresno and Sacramento maximum temperatures
- San Francisco to Reno surface temperature gradient

The summer climatology of central California is summarized by Fujita et al. (1999). Briefly, summertime is dominated by the Eastern Pacific High-Pressure System, which fosters low-level divergence and therefore sinking motion aloft, bringing fair weather, abundant sunlight, and warm temperatures aloft. The shape of the 500-mb height contours over the Eastern Pacific is broad and flat and can extend inland for 100s of km. Accompanying the warm temperatures aloft, are warm temperatures on the Central Valley floor. Heating of the valley floor causes an inland thermal low-pressure trough, and the resulting pressure gradient enhances marine air intrusion through gaps in the coastal range and sometimes over the coastal range altogether. Pollutants from the SF Bay Area (SFBA) are carried inland with the marine air intrusion. Some combination of the transported pollutants and Sacramento Valley (SV) and San

Joaquin Valley (SJV) emissions cause frequent exceedances of the 1hr and 8hr standards at several sites in the interior of the Central Valley.

Ozone season days, May 1 – October 31, were classified for three recent seasons, 1996-1998, using inspection of 500-mb weather maps to establish gross features (Fujita et al. 1999). All 552 subject days were classified into eight synoptic categories, three of which are important for this study (arranged approximately in order of decreasing ozone impact):

1. Western U.S. high pressure – upper-level high centered over the Western U.S.
2. Eastern Pacific high pressure – upper-level high centered off the Western U.S. coast.
3. Monsoonal flow – upper-level high centered in the south-western U.S. or in northern Mexico such that southerly flow brings moisture north.

The Western U.S. High accounts for proportionately the greatest number of exceedances; 97% of days with highs centered over southern California have 8hr exceedances in the central San Joaquin Valley (SJV), where the frequency of exceedances on all subject days is 42%. Similarly, 90% of these days have southern SJV exceedances, where the season frequency is 38%. The Western U.S. High contributes to stagnation conditions throughout central California by fostering an off-shore gradient which weakens the marine air intrusion and in some cases even reverses the usual sea breeze. This tends to keep pollutants longer within respective source regions, although some transport can still occur. The SFBA has 8-hour exceedances on 29% of days when the Western U.S. High is centered over the Pacific Northwest, while the frequency of 8hr exceedances on all 1996-98 ozone season days is only about 4%. Also, this scenario has the lowest mixing heights to trap pollutants vertically all over central California. The Eastern Pacific high fosters greater transport inland, but has greater wind speeds which keep the ozone peak concentrations somewhat lower than the maximum observed values. Monsoonal flow can have both mitigating and exacerbating impacts on SJV air quality. Some monsoonal days are identified where SJV air quality is lower relative to the rest of Central California, but on other days, the southerly monsoonal flow can weaken the SJV exit flow, contributing to build-up.

During the high pressure ridge scenarios, when synoptic forcing over central California is weakest but ozone concentrations are greatest, mesoscale features become most important, and subtle synoptic differences fostering the formation and/or amplification of these features are even more difficult to classify. The following cluster analysis describes a more objective classification method to complement the top-down approach. (See Fujita et al. 1999 for more detail.)

Using the target criteria (128 ppb for SFBA, 129 ppb for SV, and 145 ppb for SJV), 43 days from over 85 days identified by local districts were selected for cluster analysis. With the exclusion of one outlier, three clusters are found for 1-hour exceedances. Three 8-hour clusters were also found, however the correspondence between 1-hour and 8-hour cluster days is not one-to-one. Statistical values of meteorological parameters for all 43 days and for each 1hr cluster were compiled. The 1-hour cluster results are presented here:

Cluster 1 – 22 of 43 days. The San Francisco Bay Area has its highest basin-wide ozone values, though still less in absolute magnitude than San Joaquin Valley. This cluster is characterized by the weakest sea breeze (lowest west-to-east component through Carquinez

Strait as represented by Bethel Island winds). Cluster 1 days also have a statistically lower surface pressure gradient between San Francisco and Redding.

Cluster 2 – 12 of 43 days. The San Joaquin Valley (SJV) has its highest basin-wide values while the Bay Area and Sacramento Valley are relatively cleaner. A stronger sea breeze, relative to Cluster 1, keeps the pollutants moving through the Bay Area and the Sacramento Valley, but may increase transport into the SJV. Among the cluster days, Mountain Counties ozone is lowest during Cluster 2.

Cluster 3 – 8 of 43 days. Sacramento Valley has its highest basin-wide ozone values, as does the Mountain Counties Air Basin. As with Cluster 2, a stronger sea breeze is present, relative to Cluster 1, but surface temperatures in Sacramento Valley are higher, indicating less and/or later intrusion of the sea breeze, allowing more time for photochemistry before evening transport to the Mountain Counties.

For SFBA, Cluster 1 is statistically different from 2 and 3, as are the decreased winds at BI. Differences for SV are statistically significant for all three clusters. None of the clusters are significant for SJV at the 95% confidence level, presumably due to less marine air penetration over the surrounding topography. Note that the clusters are distributed among the scenarios, but there is not an exact one-to-one correspondence (see Table 2.5-2 and 2.5-5 of the CCOS Field Study Plan, Fujita et al., 1999).

For the Forecast Team, it is relatively easier to forecast the difference between a coastal day (SFBA-cluster 1) and an inland day (SV and/or SJV-clusters 2 and 3) than it is among all three clusters as distinct scenarios. As the forecast ozone episode approaches, it may be possible to distinguish between cluster 2 and cluster 3 days, based on a SV forecast for higher daily maximum temperatures and relatively lower wind speeds. Flight plans can be changed accordingly as the day approaches.

3.2 Forecast Protocol

The Forecast Team will consist of five members and alternates (in parentheses) from five organizations as follows:

Saffet Tanrikulu (Kemal Gurer), team leader - California Air Resources Board
Evan Shipp (Steve Shaw), co-team leader - San Joaquin Valley Unified APCD
Avi Okin (on-duty meteorologist) – San Francisco Bay Area AQMD
John Ching (Ken Lashbrook and Bruce Katayama) – Sacramento Municipal AQMD
Robert Keislar – Desert Research Institute

The team will meet by conference call from 14:00 to 14:30 PDT every day, including weekends, from June 15, 2000 through September 15, 2000 (or sooner if the last episode is conducted before that date). The team will begin practicing on May 15, 2000 on weekdays only with one practice weekend June 3-4 or June 10-11, 2000. The team will use a consensus method of forecasting. In the event that consensus is not reached, the team leader will decide on the forecast recommendation.

Arising from discussions during the daily conference call, forecast products will be developed by the Forecast Team. The products will be delivered to the Management Team verbally by the Forecast Team leader at 15:00 PDT on each day. These products include:

- Alert Forecast – This is approximately a 3-day forecast for the intended ozone maximum of interest (72-hours if the forecast ozone maximum were to occur at 15:00 PDT on the third day following the Forecast Team product). Specifically, this product is available 57 hours before the commencement of canister sampling at midnight on the third day (48 hours + 9 hours from 15:00 PDT to midnight initiation of sampling on the first day of the episode) and 63 hours before the take-off of aircraft (48 hours + 15 hours from 15:00 PDT to 6:00 PDT on the first day of the episode). Note that if a ramp-up day is desired, the Forecast Team must make approximately a 4-day forecast (96-hours if the forecast ozone maximum were to occur at 15:00 PDT on the third day following the Forecast Team product). The purpose of this product is to put the field crews on alert.

- Standby Forecast – This is approximately a 2-day forecast for the intended ozone maximum of interest (48-hours if the forecast ozone maximum were to occur at 15:00 PDT on the third day following the Forecast Team product). Specifically, and using the same reasoning as in the Alert Forecast product discussion, this product is available 33 hours before the commencement of canister sampling at midnight on the third day and 39 hours before the take-off of aircraft. Note that if a ramp-up day is desired, the Forecast Team must make approximately a 3-day forecast. The purpose of this product is for field teams to prepare for operations.

- Confirmation Forecast – This is approximately a 1-day forecast for the intended ozone maximum of interest (24-hours if the forecast ozone maximum were to occur at 15:00 PDT on the third day following the Forecast Team product). Specifically, and using the same reasoning as in the Alert Forecast product discussion, this product is available 9 hours before the commencement of canister sampling at midnight on the third day and 15 hours before the take-off of aircraft. Note that if a ramp-up day is desired, the Forecast Team must make approximately a 2-day forecast (48-hours if the forecast ozone maximum were to occur at 15:00 PDT on the third day following the Forecast Team product). The purpose of this product is to cancel field operations if conditions change and to issue the intended flight paths for the following morning.

The status of each of these products will either be a go or no-go for the date of interest. The Forecast Team will use resources and products produced by other agencies as well as the forecasting expertise of local districts. The ARB has established the following CCOS web page of links to other web sites around the country that provide meteorological and air quality data/information to be used in the Forecast Team's decision making process for go or no-go days.

http://www.arb.ca.gov/themis/forecast.html

This web page currently contains the following links:

- Meteorological Observations
  - Surface
    - SF Bay Area
    - Northern CA
    - Southern CA
  - Surface Wind (sfc obs + a model like dwm)
  - Upper Air
    - Rawinsonde
      - Oakland
      - Vandenburg
    - Profilers in CA
    - Coastal Profilers (includes interpolated temp field)
      - NPS Fort Ord (includes PBL height estimates)
  - Satellite
    - 1km-Centered on CA
    - 4km -Regional
  - Latest analyses of all observations over the US

- Prognostic Model Outputs
  - ETA (0-2 day forecast)
    - NCEP (from UNISYS) (Continental USA)
      - surface
      - 1000 mb
      - 850 mb
      - 700 mb
      - 500 mb
      - Precipitation (24 hr)
      - Precipitation (48 hr)
    - NCEP (from COLA/IGES) (Continental USA)
      - Sea level pressure, 1000-500 mb thickness
      - 850 mb temperature, relative humidity, winds
      - 700 mb vertical velocity precip
      - 500 mb geopotential height and vorticity
    - NCEP (from UCAR)(Continental USA)
      - Temperature
      - Dew Point
      - MSLP
      - Wind
  - AVN (0-3 day forecast)
    - NCEP (from COLA/IGES) (Continental USA)
      - Sea level pressure, 1000-500 mb thickness
      - 850 mb temperature, relative humidity, winds
      - 700 mb vertical velocity precip
      - 500 mb geopotential height and vorticity

- MRF (0-6 day forecast)
    - NCEP (from COLA/IGES) (Continental USA)
        - Sea level pressure, 1000-500 mb thickness
        - 850 mb temperature, relative humidity, winds
        - 700 mb vertical velocity precip
        - 500 mb geopotential height and vorticity
- MM5 (0-1.5 day forecast) (from Naval Postgraduate School) (California)
    - Various model outputs (48 h forecast)
    - Surface wind (24 h forecast)

- Text based forecast discussions
    - SF Bay Area (Interactive) (from NWS)
    - California (Interactive) (from NOAA)
    - Western US (Interactive) (from NOAA)

- Current conditions and forecasts for selected cities (from weather.com)
    - Sacramento
    - San Francisco
    - Fresno
    - Bakersfield
    - Vallejo

- Air Quality Forecasts
    - For selected cities within the continental USA (from EPA)
    - Sacramento (from Sacramento APMD)
    - Bay Area (from Bay Area AQMD)
    - Fresno (from San Joaquin Valley APCD)

- Links to other state agencies/organizations
    - Sacramento Air Pollution Management District (Sacramento APMD)
    - San Joaquin Valley Air Pollution Control District (San Joaquin Valley APCD)
    - San Francisco Bay Area Air Quality Management District (Bay Area AQMD)

In general, it is intended that any product that cannot be accessed by a link through the web site, will be emailed to ARB and posted on the ARB CCOS web site by ARB computer support personnel. Other options include scanning in hand-drawn products and placing them in PDF format for posting on the ARB CCOS web site.

3.3 IOP Decision-Making Protocol

The members of the CCOS Management Team will consist of the following individuals:

Don McNerny and Andrew Ranzieri - California Air Resources Board
Dave Jones - San Joaquin Valley Unified APCD

Rob DeMandel - San Francisco Bay Area AQMD
Bridget Tollstrup - Sacramento Municipal AQMD

Technical Support
Saffet Tanrikulu (ARB) – Forecast Team recommendation
Eric Fujita (DRI) – Operational Status and Air Quality Data/IOP history

After the forecast team reaches a consensus forecast, a recommendation will be made by the forecast team leader to the Management Team. The go/no-go decision of the management team will be posted by 0300 PDT on the ARB CCOS site and pertinent information will be placed on the voicemail of a call-in line that each CCOS field study contractor is responsible to check on a daily basis.

IOP decision posted at web site: http://www.arb.ca.gov/themis/forecast_iop.doc
IOP decision call-in line: 916/324-1953

The following criteria will be used to decide whether or not to conduct IOP sampling:

- Forecasted meteorological conditions must be favorable for formation and accumulation of high ozone concentrations.
- Forecasted ozone concentrations of 125 ppb or higher, including a “ramp-up” day before the high-ozone day.
- Capture a minimum of one ozone episodes in each of the three major air basins within the - Bay Area, Sacramento Valley, and San Joaquin Valley. The location of the predicted high ozone will have less influence on the decision to call an IOP during the first ten IOP days than during the last five IOPs.
- Operational readiness.
- Aircraft crews require at least one day without sampling after three consecutive days of operation.

A daily schedule of forecasting and decision-making is shown in Table 3.3-1. The timeline is roughly as follows. Since we would like to get a ramp-up day in the episode, i.e., start measurements one day before the high-ozone, we need a 96-hour forecast (approximately 96 hours preceding the peak ozone of the episode) for the high-ozone day, permitting a 57-hour lead time to put the sampler field crew on alert and a 63-hour lead time to put aircraft pilots on alert. Aircraft operations can be performed with a 39-hour lead time, but 63 hours are desirable for the original alert status. The 24-hour forecast will also include a confirmation of a go decision, which could otherwise be canceled at if conditions change appreciable from those forecasted, permitting the sampler field crew only 9 hours to cancel the start of sampling.

Table 3.3-1
Chronology of Daily Forecast and IOP decisions

Time (PDT)	Daily Forecast and Decision-Making Activities
0200-0300	Download CCOS supplemental air quality site data (DRI – Bill Coulombe)
0800	Post summary of CCOS supplemental air quality data for the previous day at **www.dri.edu/projects/CCOS** (DRI – Bill Coulombe)
1000-1200	Flight crew e-mail plots of ozone soundings from designated spiral locations (Granite Bay, Livermore, Delta region, Fresno, and Bakersfield) from previous day's flights and report operational status for next day to Eric Fujita, CCOS field manager (**ericf@dri.edu**, **775/674-7084**).
1000-1200	Measurement Groups and Field Operators report operational results of previous day and status for next day to Eric Fujita (**ericf@dri.edu**, **775/674-7084**).
1300-1400	Review operational status (DRI – Eric Fujita)
1400-1425	Forecast team conference call to prepare daily meteorological and air quality forecasts.
1430-1450	Management team conference call to review operational status, meteorological forecast, current ozone concentrations, IOP episodes to date.
1500	Post IOP decision on message machine and ARB web site (**http://www.arb.ca.gov/themis/forecast_iop.doc**) and voicemail at (**916/324-1953**). Decision/Definition *No-go*: condition unfavorable for high ozone within next two days. *Go for Alert*: conditions becoming favorable for high ozone within next three days. Measurements groups should be prepared to begin intensive operations in two days *Go for Stand-by*: conditions favorable for high ozone within next two days. Prepare for field operations. *Go for Confirmation*: Begin intensive operations at 0000 PDT the following day. *End IOP*: Cease all intensive operations today at 0000 PDT. *Cancel IOP*: Cease all intensive operations immediately. Type of IOP Type 0: Ramp-up day Type 1: Coastal Day Type 2: Inland Day (SJV, if able to distinguish from SV) Type 3: Inland Day (SV, if able to distinguish from SJV)

4.0 QUALITY ASSURANCE

This section provides a summary of planned quality assurance tasks/activities for CCOS and delineates the responsibilities of the quality assurance team. The purpose of quality assurance (QA) is to provide a quantitative estimate of the uncertainty of the measurements through estimates of the precision, accuracy (or bias), and validity. In addition, QA ensures that the procedures and sampling methods used in the study are well documented and are capable of producing data that meet the specifications of the study. The QA team reviews the investigators' standard operating procedures (SOPs) and makes estimates of the precision and accuracy that might be expected from the measurement systems. Prior to or during sampling the QA team carries out quality audits and helps resolve any problems.

Quality assurance includes two types of activities: quality control (QC), and quality auditing. The QC activities are on-going activities of the measurement and data processing personnel. QC activities consist of written standard operating procedures to be followed during sample collection, sample analysis, and data processing. These procedures define schedules for periodic calibrations and performance tests (including blank and replicate analyses). They specify pre-defined tolerances that are not to be exceeded by performance tests and the actions to be taken when they are exceeded. The QC activities also include equipment maintenance, and acceptance testing, and operator training, supervision, and support.

Quality auditing consists of two components: systems audits and performance audits. Systems audits include a review of the operational and quality control (QC) procedures to assess whether they are adequate to assure valid data that meet the specified level of accuracy and precision. After reviewing the procedures, the auditor examines phases of the measurement or data processing activity to determine whether the procedures are being followed and that the operating personnel are properly trained. The system audit is a cooperative assessment resulting in improved data. Performance audits establish whether the predetermined specifications for accuracy are being achieved in practice.

Performance audit involves challenging the measurement/analysis system with a known standard sample that is traceable to a primary standard. Precision is quantified by periodically challenging a measurement device with known, identical input conditions. In evaluating precision and accuracy objectives, it is important to consider the methods used to determine the values. For example, a greater deviation may occur between replicates with real samples with complex matrices than with replicates of standards in simple matrices. Synthetic mixtures of hydrocarbons that are used in the Photochemical Assessment Monitoring Station Program for laboratory intercomparisons and through-the-probe audits are examples. An ambient sample yields a more complex chromatogram and greater potential for inconsistent identification. Analysis of a standard mixture of hydrazones does not address potential sampling artifacts that may be associated with carbonyl compound measurements using the DNPH derivitization method. Measurement intercomparisons are used to assess the representativeness, accuracy, and precision of measurements that preclude standard performance audits (e.g., PAN, NOy, ozone lidar, upper air meteorology).

4.1 Quality Assurance Organization, Responsibilities, and Tasks

Quality assurance will be under the overall direction of the CCOS QA manager, Mr. David Bush of Parsons Engineering Science. He is also the QA manager for CRPAQS, and is consequently already managing the external quality assurance efforts for many existing measurement efforts that will ultimately be part of the CCOS database. Due to the scope of the CCOS supplemental monitoring effort, Parsons has assembled a QA management team to specifically address the many aspects of the monitoring program. Mr. Robert Baxter (Parsons) will be responsible for overseeing the audits of the surface and upper air meteorological measurements. He will be responsible for coordinating the meteorological audits, interfacing with supporting subcontractors (Northwest Research Associates, Inc. and T&B Systems), and reviewing all data and reports associated with the meteorological audits. Much of the information in this section is a summary of the December 1999 proposal written by Parsons Engineering Science. The QA manager will also coordinate with QA staffs from the California Air Resources Board (Mr. Michael Miguel) and the Bay Area AQMD (Mr. Avi Okin). ARB and BAAQMD will conduct performance audits of the ozone, NO/NOx, NO/NOy analyzers at exiting monitoring stations and at CCOS supplemental monitoring sites within their area of responsibility.

The principle objective of the CCOS QA program is to ensure that the established data quality objectives (DQOs) are achieved. The overall responsibility of QA manager will be to inform the CCOS Program Manager and the CCOS Technical Committee of the steps being taken to control and quantify data quality, provide guidance to the study participants in carrying out their quality assurance responsibilities, and to provide a framework for using quality control test data to create data qualification statements for the data archive. The responsibilities of the CCOS QA manager include the following tasks.

Task 1: Evaluate sampling and analysis methods, and review system and performance audit procedures. The QA team will request from each CCOS measurement contractor a quality integrated work plan (QIWP), which covers all aspects of their work, as well as standard operating procedures (SOPs) for each specific operation. The QIWP and SOPs describe the approach for maintaining and quantifying data quality for each measurement, and will include descriptions of and specifications for calibration, standards, control limits, data processing, and other data quality related topics. As part of this effort, the QA team will provide guidance to measurement contractors in preparing the QIWP, using the QIWP guidance document previously prepared for CRPAQS. The QA team will review the data quality objectives in the QIWPs and verify the assumptions on which the measurements are based, and determine whether the methods are likely to meet the specifications for accuracy (or bias) and precision. Recommendations for revisions to the QIWPs and SOPs will be submitted to the measurement contractors. Once QIWPs and SOPs have been finalized, they will be submited to the CCOS data manager for the data archive.

Task 2: Prepare a quality assurance plan for CCOS. The QA manager will develop a quality assurance plan in conjunction with the CCOS field manager, field contractors, and QA personnel from the Districts and ARB. The plan will use the NARSTO-formatted Program Quality Management Plan (PQMP) developed for CRPAQS as a basis. The plan will include data quality objectives, descriptions of quality control procedures for each measurement group,

and specifications for systems and performance audits. As part of the PQMP development process, the QA manager will finalize the CCOS audit plan. This will include identifying quality auditing needs and resources, and establishing priorities and determining which sites require external systems and/or performance audits. Also at this time, audit procedures will be reviewed and further developed as required.

Task 3: Conduct systems and performance audits. The QA manager will coordinate the activities of the QA team, and schedule system and performance audits. He will be responsible for monitoring the results of the audits and laboratory comparisons, and providing appropriate follow-up. Audits will be required for following measurement categories.

Audits performed or arranged by Parsons Engineering

- CCOS upper-air meteorological measurements.
- Continuous HCHO analyzers at CCOS supplemental S2 and research monitoring sites.
- CO, CO2, aethalometer, nephelometers, and particulate nitrate at CCOS research monitoring sites.
- Audits of any sites not audited by the ARB due to scheduling limitations (see below for intended ARB auditing responsibilities).

Audits performed by ARB and BAAQMD QA staff

- Ozone, NO/NOx, and meteorological measurements at existing District and ARB monitoring stations.
- Ozone, NO/NOx and NO/NOy, NOy/NOy*, NO2 at CCOS supplemental monitoring sites.
- PAMS VOC measurements by ARB and supplemental hydrocarbon measurements by DRI, OGI, and the Bay Area AQMD and supplemental carbonyl measurements by AtmAA, and the Bay Area AQMD). Audit consists of a through-the-probe audit using a 25-component standard hydrocarbon mixture.
- Ozone and NO/NOy on up to six instrumented aircraft.

4.2 Schedule of QA Activity

The basic schedule for the QA management effort is as follows:

3/1/2000	Anticipated contract start date
5/15/2000	Receive draft QIWP and HASP
5/30/2000	Submit comments on draft QIWP and HASP
6/1/2000	Field measurements anticipated to begin for upper air meteorology
6/9/2000	Receive final QIWP and HASP
6/9/2000	All surface equipment anticipated to be installed and operational

6/15/2000 Field surface measurements begin
9/15/2000 Field surface measurements end
9/30/2000 Field measurements end for upper air meteorology
7/1/2001 Draft data quality summary and
Draft QA report (field and laboratory measurements)
10/1/2001 Final data quality summary and
Final QA report (field and laboratory measurements)

In general, audits of all measurement systems will be carried out as soon as the measurement systems are in place and operational in order to identify and correct potential problems before they impact the measurement DQOs. In addition, every attempt will be made to complete as many of the audits as possible prior to the start of the Primary Study Period (7/6/00), during which Intensive Operational Periods (IOPs) can occur. The following schedule takes into account this approach and the anticipated measurement start dates presented above. Delays in the starting of measurements may push some audits into the Primary Study Period.

Auditing effort	**Auditor**	**# of sites**	**Date to be conducted**
Air quality system and performance audits, S0, S1, and S2 sites	CARB/ BAAQMD	23	5/1/00 – 9/15/00
Air quality system and performance audits, S2 and research sites	D. Bush	8	6/20/00 – 7/7/00
Aircraft air quality system and performance audits	CARB/ D. Bush	4	6/12/00 – 7/5/00
Radar profiler/RASS system and performance audits	R. Baxter/ D. Bush	13	5/15/00 – 7/5/00
Sodar system and performance audits	R. Baxter	5	5/15/00 – 7/5/00
Surface meteorology (including surface measurements at each of the upper air sites)	R. Baxter/ D. Bush	15	5/15/00 – 7/5/00
Data processing audits	D. Bush	4	8/1/00 – 8/30/00

Table 4.2-1 specifies the audit schedule for the ARB QA audit teams (Van A and B).

4.3 Audit Standards And Certification

Radar Profilers / RASS

The radar profiler and RASS audits will be performed by releasing balloon borne sondes and comparing the calculated wind and virtual temperature (T*v*) profiles with that or the radar profiler and RASS, respectively. Prior to release, the sondes' output is verified against the surface pressure and temperature readings of an audit device. These barometers are certified by a single-point comparison to a standard barometer, as well as by periodic comparisons to airport

pressure readings in the field. Temperature is measured using a mercury-in-glass thermometer. These thermometers are certified against a laboratory standard thermometer, a Brooklyn Thermometer Company NIST-traceable mercury-in-glass thermometer.

Table 4.2-1
ARB Audit Schedule – Van A

	Monday	Tuesday	Wednesday	Thursday	Friday
May 7-13	(travel)Corcoran	Fresno-Drummond	Fresno-Sky Park	Maricopa/Taft	(travel)
May 14-20	Clofax	Grass Val.-Hend./Grass Val.-Lytton	Truckee/Glenshire	Portola/Loyalton/Chester/Quincy	Cool (travel)
May 21-27	(travel)	Anderson Springs	Glenbrook/Hobergs	Lakeport	(travel)
May 28 - June 3	HOLIDAY	Placerville/Jerseydale/Yosemite-Vil./Yosemite-Wawona	Sequoia-Ash/Sequoia-Lookout	Sequoia-Kaweah/Sequoia-Wolverton	(travel)
June 4-10	(travel) Shaver Lake	Jerseydale/Yosemite-Vil./Yosemite-Wawona			
June 11-17	(travel) Harveys	Incline Vil./Cave Rock	S. Lake Tahoe	Echo Summit	(travel)
June 18-24	Certification, Calibration, and Maintenance				
June 25-30	Certification, Calibration, and Maintenance (Possible June 30 Santa Rosa Plane)				
July 2-8	Dixon	HOLIDAY		Fresno (DOE plane)	(travel)
July 9-15	(travel)	Ojai	Santa Rosa Is.	Lompoc-Const. (?)	(travel)
July 16-22	(travel)	Lompoc-H St.	Vandenburg	Red Hills	(travel)
July 23-29	Sunol	Livermore (TVA plane)			
Aug 1-5		McKittrick	Kettleman City	Angiola	(travel)
Aug 6-12	(travel)	Paradise Rd.	Gaviota-Nojoqui		
Aug 13-19	Walnut Grove	Concord/S. Jose-4th/S. Jose-Tulley	S.F.-Ark/Redwood City	Fremont/Santa Rosa/Vallejo	
Aug 20-26	Altamont	Sutter Buttes	Tuscan Butte	Granite Bay	Altamont
Aug 27 - Sep 1		Bella Vista			
Sep 3-9	HOLIDAY	Madera	Fresno-1st. St.	Parlier	(travel)
Sep 10-16	(travel) Yosemite-	Visalia			
Oct 1-7	Certification, Calibration, and Maintenance				
Oct 8-14	Certification, Calibration, and Maintenance				
Oct 15-21	Lee Vining/Mono Lake	Mammoth/Mono-N. Shore	Lone Piner/Bishop	Keeler/Dirty Socks/Olancha	(travel)
Nov 5-11	Yuba City	Chico-Manzanita	Red Bluff-Oak/Red Bluff-Messer	Willows/Colusa-Sunrise/Colusa-Fairgnds.	(travel)
Nov 12-18	Gridley	Pleasant Grove	Arbuckle		(travel)
Dec 3-9	Stcton-Claremont/Stkton-March	Stkton-Hazelton	Sac.-El Camino		
Dec 10-16	Sac.-Health Dept.	Sac.-13th St.	Sac.-Branch Ctr.	Stkton-Mariposa/Stkton-Wagner Holt	

Table 4.2-2
ARB Audit Schedule – Van B

	Monday	Tuesday	Wednesday	Thursday	Friday
May 2-6	(travel)	Santa Maria	El Capitan	Santa Rosa Is.	(travel)
May 7-13	(travel) Jackson	Sonora/5 mi. Learning Ctr.	San Andreas		
May 14-20	(travel) Paso Robles	Nipomo-Guad.	Nipomo-Park	Arroyo Grande	(travel)
May 21-27	(travel) Morro Bay	San Luis Obispo	Atascadero	Grover City	(travel)
May 28 - June 3	HOLIDAY	Pinnacles	Salinas/Pacheco Pass	King City/Hollister	(travel)
June 4-10	(travel) Monterey	Watsonville/Moss Landing/Scotts valley	Davenport	Carmel Valley/Santa Cruz	(travel)
June 11-17	Davis (1 plane)	Davis (1 plane)	(EXPEDITION FOR N. COAST AUDITS)		
June 18-24	Certification/Calibration/Maintenance				
June 25-30	Certification/Calibration/Maintenance				
July 2-8	Santa Rosa (1P)	HOLIDAY	(travel)	Goleta C=O/Simi Val. NMOC	(travel)
July 9-15	(travel) Piedras Blancas NMOC/C=O	Piedras Blancas	Emma Woods NMOC	1000 Oaks	(travel)
July 16-22	(travel) Santa Ynez	El Rio NMOC/C=O	Simi Val./Simi-Upper Air	Casitas	(travel)
July 23-29		El Rio	Emma Woods	Goleta	(travel)
Aug 1-5		Bakersfield-Golden	Bakersfield-Golden NMOC/C=O	Arvin NMOC/C=O	(travel)
Aug 6-12		Angiola NMOC/C=O	Shafter NMOC	Clovis	(travel)
Aug 13-19	(travel) Shafter	Clovis NMOC/C=O	Trimmer	Parlier NMOC/C=O	(travel)
Aug 20-26	(travel) Madera NMOC	Trimmer NMOC/C=O	Fresno-1st NMOC/C=O	San Andreas NMOC/C=O, NOy	Sloughhouse/Granite Bay NMOC C=O
Aug 27 - Sep 1	Pacheco Pass NMOC C=O	Pacheco Pass	Bodega Bay NMOC/C=0	Bodega Bay	White Cloud/White Cloud NMOC C=O
Sep 3-9	HOLIDAY	Sac.-Airport Rd. NMOC/C=O	Sunol NMOC/C=O	Sac.-Del Paso NMOC/C=O	Sac.-Del Paso
Sep 10-16	Folsom NMOC	Turlock NMOC/C=O	Elk Grove NMOC		Patterson Pass NMOC/C=O
Sep 17-23	Folsom	Turlock	(travel)	Arvin	(travel)
Oct 1-7	Certification/Calibration/Maintenance				
Oct 8-14	Certification/Calibration/Maintenance				
Oct 15-21	Sac.-Airport	Elk Grove			

Surface Meteorology

Wind Speed - Anemometer Drive. An R.M.Young Model 18801 anemometer drive is certified quarterly. A photo tachometer is used to determine the actual rotational speed of the anemometer drive shaft for comparison with the rotational speed indicated by the anemometer drive display. Readings are made at six speeds evenly spaced through the entire operating range of the instrument. Additionally, the frequency output from the drive is verified against a digital frequency counter. Torque Disk (no certification required).

Wind Direction - Compass (no certification required). Torque Disk (no certification required).

Ambient Temperature - Mercury-in-glass thermometer. Audit mercury-in-glass thermometers are compared to an NIST-traceable standard thermometer when they are purchased. The two thermometers were immersed in water baths of approximately zero, 10°, 20°, 30° and 40°C. Periodic comparisons with the standard thermometer are not required if the operating ranges of the thermometers are not exceeded.

Relative Humidity and Dew-point Temperature – Psychrometer mercury-in-glass thermometers. The psychrometer mercury-in-glass thermometers are compared to an NIST-traceable standard thermometer when purchased. The two psychrometer thermometers and the standard thermometer were immersed in water baths of approximately zero, 10°, 20°, 30° and 40°C. Periodic comparisons with the standard thermometer are not required if the operating ranges of the thermometers are not exceeded.

Pressure - Audit barometer (Peet Brothers Ultimeter Model 3). The audit barometer is compared with a standard barometer on a yearly basis.

Total Solar Radiation – Pyranometer. Audit pyranometers are checked annually by comparing the pyranometers output with an independent pyranometer maintained by AVES's QA group. The voltmeter is used to read the audit pyranometer outputs is certified on an annual basis.

Rawinsondes. Audit barometer (Peet Brothers Ultimeter Model 3). The audit barometer is compared on a regular basis with a standard barometer maintained by AVES. The psychrometer mercury-in-glass thermometers are compared to an NIST-traceable standard thermometer when purchased. The two psychrometer thermometers and the standard thermometer were immersed in water baths of approximately zero, 10°, 20°, 30° and 40°C. Periodic comparisons with the standard thermometer are not required if the operating ranges of the thermometers are not exceeded.

Flow Measurements.

QA Standards - All flow meters used for the field audits will be compared against flow standards maintained by AVES/ATC Associaates at its QA laboratory in Monrovia, California, or against similar flow standards. These standards are used to certify the flow transfer standards that are used in the field. AVES's QA flow standards are summarized below:

departments. The zero air source will be either a cylinder of Ultra-Pure Air that will be supplied by Scott Specialty Gases or an Aadco 737R pure air system with CH4 burner and compressor capable of delivering a constant 20 lpm air supply. The span gases, except for the SUVA refrigerant, will be provided by Scott Specialty Gases. All gas standard analysis is performed in accordance with EPA Protocols and is traceable to National Institute of Standards and Technology (NIST) standards.) For the CCOS audits, Relative Accuracy Test Audits (RATA) Class cylinders will be used, which are certified to with ±1% of true. SUVA refrigerant will be used to audit the nephelometers. This compound has a known scattering coefficient that is within the nephelometer measurement range.

Ozone - All field ozone transfer standards will be certified against a primary standard. Procedures for certification and recertification of ozone primary and transfer standards are based on the EPA technical assistance document, Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone (EPA 1979), EPA-600/4-79-056. All ozone transfer standards used for

CCOS will be compared against the California ARB standard photometer prior to the audits. The ozone transfer standards used for CCOS will be an API 400, a Dasibi 5009 MC or a Dasibi 1003 PC ozone analyzer. These ozone analyzers have been converted to a transfer standard configuration in accordance with EPA guidelines (September, 1979). Ozone analyzers that are converted to a transfer standard configuration must be compared to a primary ozone standard by means of a 6 x 6 comparison as the final step in the conversion process. Ozone transfer standards that are in regular use must be compared by means of a 1 x 6 (zero and five upscale concentration points) comparison with the a primary ozone standard twice per quarter.

NMOC/carbonyl samplers

Laboratory performance audits of the analytical methods for non-methane organic hydrocarbons (NMOCs) and carbonyls will be conducted to assess the accuracy of the methods used by the laboratory to measure the ambient concentrations, as well as the sampling systems. Audits are conducted by supplying the laboratory with a cylinder containing a mixture of target organic hydrocarbons and carbonyl standards prepared by the National Institute of Standards and Technology (NIST). The laboratory analyzes the contents of the cylinder following their normal standard operating procedures.

4.4 System Audit Procedures

4.4.1 Radar Profilers and RASS

The system audit of the radar profiler begins with an inspection of the antenna and controller interface cables for proper connection. Antennas and enclosures or clutter fences are inspected for structural integrity. The orientation of the antennas are checked using a magnetic transit and tripod with the observed magnetic readings corrected to true directions using the local magnetic declination. The magnetic orientation measurements are also verified using solar azimuth measurements and latitude and longitude information obtained from handheld GPS. The inclinations of the antennas are measured using a Pro SMARTLEVEL. Measurements are made in at least two directions on the bottom of the antenna array's support structure. For the multiple antenna systems the inclination angle is also measured and compared to the software setting.

A vista diagram is prepared that documents the surroundings of the site. The diagram identifies potential reflective sources for the radar signal, as well as potential active sources that could generate interference. The diagram also provides a description of the view in 30-degree increments around the antenna, including the elevation angle and estimated distance to potential sources.

If the configuration of the system allows, an evaluation of the total noise spectrum is performed with the system "listening only," i.e., without transmitting a pulse. The results of this check should produce no measured winds or temperature, or data with very low reliability. If reliable data points are reported at any level, then there is probably an active noise source in the area that is generating frequencies in the operational region of the radar or RASS.

A scan of frequencies around the central operating frequency of the radar is performed using an RF scanner. This method has been successfully used in past RWP audits to confirm use of adjacent frequencies by nearby communication operations and to identify the sources of active noise contaminating the wind and virtual temperature data.

The settings of the controller and data collection devices are checked and noted to ensure that the instrument is operating in the proper mode and that the data being collected are those specified by the SOPs. This includes a check of all clocks for accuracy, verifying that they are within ±2 minutes of the standard. The site operator is interviewed to determine his/her knowledge of the system operation, maintenance and proficiency in the performance of QC checks. Emphasis is placed on verifying that preventive maintenance procedures have been implemented and are adequate. The station logbooks are reviewed for completeness and content. Finally, data collected over several days are reviewed for reasonableness and consistency.

An orientation accuracy criterion of ±2° will be used. For level and inclination angle of oblique antennas we will use ±0.5°. The overall procedures are consistent with recent EPA guidance (EPA 1999).

4.4.2 Sodars

The sodar system audit is divided into several tasks. A description of each task is provided below:

An evaluation of the site characteristics is performed. Passive and active noise sources are identified and noted to evaluate their impact on the sodar's ability to separate the return pulses from the background noise. Passive sources are objects that may reflect the pulse and contaminate the return spectra with what appears to be near-zero wind speeds. These sources include buildings, trees, nearby towers, etc. Active sources generate their own noise such as air conditioners, fans and industrial complexes. Low-level active white noise sources are not generally a problem except to reduce the maximum altitude. Active noise sources in the frequency spectrum of the sodar operations may affect the operations. General sound levels are measured using an integrating sound level meter and measuring levels, in dBA, in at least the four cardinal directions. A spectral analysis of the background noise is performed to determine if there are significant sources within the operating range of the sodar.

In addition to the evaluation of the total noise spectrum above, a system check is performed with the system "listening only," i.e., without transmitting a pulse. The results of this check should produce no measured winds, or winds with very low reliability. If reliable winds are reported at any level, then there is probably an active noise source in the area that is generating frequencies in the operational region of the sodar.

A vista diagram is prepared that documents the surroundings of the site. The diagram identifies potential reflective sources for the radar signal, as well as potential active sources that could generate interference. The diagram also provides a description of the view in 30-degree increments around the antenna, including the elevation angle and estimated distance to potential sources.

Alignment checks are performed on the sodar systems. The orientation of the antenna array or individual component antennas will directly affect the accuracy of the calculated wind directions. The orientation of the respective antenna arrays is checked using a tripod mounted Brunton Pocket Transit. The measured orientation is then compared to the software settings in the sodar. The criterion for acceptable orientation is ±2°. During the field audit, the compass alignment to magnetic north is compared against solar observations and the magnetic declination to verify the accuracy of the magnetic measurements.

The level of a phased sodar antenna array, or inclination angle of the horizontal component antennas directly affects the calculations of the component speeds. The array level (or inclination angle) is checked using a Pro SMARTLEVEL. The criterion for acceptable level (or angles) in any direction is ±0.5°, consistent with EPA (1999).

4.4.3 Surface Meteorological Measurements

The system audits of the surface meteorological sensing systems consist of an inspection of the site to assess proper siting of the instrument sensors, a review of the station check logs and other site documentation, as well as an interview with the site operator concerning his or her knowledge of the QIWP and applicable SOP sections. Sensor siting criteria for meteorological sensors are specified in the EPA Quality Assurance Handbooks for Air Pollution Measurement Systems, Volume IV (EPA, 1995). On-site forms and site logs are reviewed to check that the documentation conforms to the specifications of the plan. The subjects that are addressed by the system audits include:

<u>Network design and siting</u>
- network size and design
- sensor exposure
- review of station

<u>Resources and facilities</u>
- instruments and methods
- staff and facilities
- standards and traceability

<u>Quality assurance and quality control</u>
- status of quality assurance program
- audit participation
- precision and accuracy checks

Additionally, once the system audits of all sites are complete, the auditor checks for possible differences in operation among the various sites.

4.4.4 Rawinsondes

The system audits of the rawinsonde operations consist of watching a launch and comparing the procedures used to those specified in the SOP. Special attention is paid to ground station and sonde initialization procedures, balloon inflation (with regard to proper accent rate),

data acquisition, and flight termination. A rawinsonde system audit checklist is used during the system audit to ensure that all aspects of the audit are covered in a consistent manner.

4.4.5 NMOC/Carbonyl Samplers

The system audit of the NMOC/Carbonyl samplers consists of a review of the sampler siting and observation of sample loading and handling procedures. This includes observing the site technician during routine loading and unloading of the sampler to assure that procedures documented in the sampler's SOP's are being followed. The system audit verifies, at a minimum, the following:

- Sample chain-of-custody
- Sample labeling
- Sample loading procedures
- Sample storage
- Sample shipping procedures
- Sample blanks
- Flow calibration and measurement procedures
- Training received by the technician
- Sampler location
- Pump venting
- Presence of any obstructions or trees
- Sampler preventive maintenance and spare parts inventory
- Cyclone or impactor cleaning (if used)

A detailed system audit checklist is used during the system audit to assist the auditor and document the results. In general, system audit results are compared with existing EPA siting and sample handling guidelines for these samplers.

4.4.6 Continuous Gas/Particulate Analyzers

The system audits of the continuous gas/particulate analyzers, including particle counters and nephelometers, will incorporate review of the following:

- Probe height
- Probe exposure
- Proximity of sources
- Sample manifold and/or sampling line construction
- Sample residence time
- Calibration procedures
- Calibration standards and their certification
- Zero/span checks
- Preventive maintenance
- Spare parts inventory
- Data acquisition equipment and procedures

- Data chain-of-custody
- QC documentation (site logs, checklists, etc..)
- Support equipment, including station condition
- Training

Preparation and handling of the solutions used to calibrate the continuous analyzers will also be checked.

4.4.7 Additional Samplers and Analyzers

Specific audit procedures for specialized, research instrumentation will be developed as SOPs are received. This includes instrumentation such as automated VOC analyzers, HCHO dihydorlutinine derivative/fluorescent detection analyzers, TDLAS analyzers, and hydroxyl carbonyl samplers.

4.4.8 Data Processing/Management

Organizations' data processing audits will be conducted following a data processing checklist. The data processing audits will begin with a review of the chain-of-custody procedures used by each organization. The audit will examine the policies and procedures for logging in the field data, and the maintenance and archival of all data records. The audit will examine the procedures used to document the completeness and adequacy of the field data used in data processing and validation. The audit will also document the sites and parameters processed by the organization, and the personnel who perform the data acquisition, processing and validation. All members of the organizations' staff who perform data processing tasks will be personally interviewed by the auditor to ensure their familiarity with all aspects of their jobs.

The audit will also document all aspects of data acquisition. This will include: (1) a review of the data logger type, (2) who is responsible for the data logger initialization, (3) the scan rate, (4) the averaging time, and (5) the averaging method. The method of electronic data collection will also be confirmed. The audit will determine if the monitoring site is accessed by modem, whether the modems incorporate data correction protocols, the frequency of data polling, methods of verifying the data poll, the loading of the polled data into a data base, and the ability of the site data logger to store data for extended periods in case of telecommunications problems. The existence of backup strip charts will also be documented during the audit. The accuracy of the strip charts will be determined and the procedures for data recovery from strip charts will be examined.

The data processing and validation procedures of each organization will be reviewed in detail by the auditor. The control limits for the air quality parameters will be documented during each audit, and the frequency of instrument QC checks will be confirmed. Air quality analyzer Reference or Equivalent designations are frequently based upon defined station temperature limits. The audit will determine if the organization confirms that air quality data are collected within this temperature range, and how the organization handles the data validation during times where the shelter temperature was outside of this range.

The audit will examine the adequacy of field data such as station logs and checklists, and will determine how these are used in the data processing and validation procedures of each organization. The audit will check the organizations procedures designed to perform anomaly screening of the data. The audit will also confirm all steps taken to verify the accuracy of the polled data, and determine if the digital data are confirmed using the backup strip charts (and if so, what acceptance tolerance is defined).

The standard operating procedures of each organization will be reviewed with the data processing staff during the audit. Special attention will be paid to the decision-making chain-of-command of each organization. The chain-of-command will be discussed and confirmed for routine data processing and validation as well as for cases where problems are encountered. The resolution of problems by the data processing staff will be confirmed during the audit. The audit will also document the procedures used for data editing.

The data processing audits will also document the data management procedures of each organization. This includes confirming the data base structure and the proper entry of site, parameter, unit, and reporting precision codes by each organization. The audit will also determine the existence and adequacy of data backup procedures used by each organization.

4.4.9 Laboratories

The system audits of the organization laboratories will begin with the review of the QIWPs and SOPs. Comments from those reviews will serve to ensure that analyses are appropriate to achieve the stated program goals and that the laboratory QA programs and procedures are consistent with the selected analyses. The second step will be for the laboratory auditor to travel to each of the organization's laboratories. The system audits in this phase will consist of a detailed inspection of each of the organization's laboratory facilities along with an evaluation of the following program components, in accordance with the respective QIWP: sample logging, storage and identification methods; calibration procedures; preparation and storage of standards; quality control checks (such as blanks and duplicates); chain-of-custody protocols; data reduction, validation and reporting methods; and the documentation of all pertinent actions.

Systems audits will be similar for each of the three laboratories. A systems audit will provide qualitative evaluation of the overall operations of the laboratory. Emphasis is given to confirming that all project quality control (QC) procedures are preformed and that acceptance criteria are met. Preventive maintenance will be evaluated as well as corrective action procedures. Data traceably will be verified by randomly selecting a reported value and working back through intermediate calculations and supporting paper work to the raw values. This check confirms error free calculation and ensures that supporting documentation is present.

Also included in the system audits will be interviews of all laboratory staff working on the project. The interviews will focus on the staff’s familiarity with the job(s) they are performing for the project, how they track samples and assurance of data quality and to whom they report problems when a parameter or system is outside of the control limits.

4.5 PERFORMANCE AUDIT PROCEDURES

4.5.1 Radar Profilers

Two sets of performance audit procedures will be used that are specific to given sites. If the site is equipped with a collocated sodar, the profiling system will be audited by first establishing the on-site sodar as an audit device and then using the sodar data collected to audit the radar profiler data. Sites with a radar profiler only will be audited using a rawinsonde.

The new EPA guidance for QA on radar profilers defines a series of system checks inherent to the profiler electronics. Unlike the sodar where instrumentation exists for simulation of winds by introduction of "Doppler shifted frequencies" no such instrumentation exists for the profiler or RASS systems. Thus, to audit the data gathered by these profilers, the data are compared to measurements from multiple rawinsonde balloon launches. At least three launches are performed over the course of a day to collect data under a variety of meteorological conditions. The collected meteorological data are reduced into components along the radar wind profiler axes and the speeds compared with the radar data. This method is consistent with the newest EPA guidance (EPA 2000). Audit criteria for RWP and an overview of the procedures are presented in Table 4.5-1.

As a final part of the audit of the radar profilers, data from several days prior to the audit are reviewed for internal consistency. This type of review checks indicated flags for data reliability or quality codes for consistency, individual component intensity values to identify potential reflections, and the vertical profiles of the components and resultant values for internal consistency both in space and time. This is a subjective review and has proved useful in past audits as a "second set of eyes" reviewing the data.

4.5.2 RASS

Audits of the RASS measurements are performed using at least three launches of rawinsondes over the course of the day. The sondes measure pressure, temperature and relative humidity and are used to calculate the virtual temperature profiles (T*v*) for comparison to the RASS-derived T*v* values. The data collected from each launch are averaged to match the averaging intervals of the RASS. Audit criteria used for evaluating results are shown in Table 4.5-1. Experience gained in the LMOS, IMS-95 and NARSTO-Northeast and SCOS97-NARSTO studies showed this criterion is readily achievable. However, differences outside of this criterion do not mean the RASS system has failed. It indicates that the data need further analysis to determine the reasons for the differences and potential corrective action.

As in the wind profiles, data from several days prior to the audit will be reviewed. The review will focus on the internal consistency of the data in both space and time and look for the reasonableness of the T*v* profiles.

4.5.3 Sodars

Sodar performance audits depend, to some extent, on the type of sodar being employed. For most sodars, the audit is conducted by comparing the sodar data with simulated winds from an Acoustic Pulse Transponder (APT). Unlike conventional sensors where known wind speeds and directions can be input directly to the sensor through various rotational methods, the acoustic system relies on the measurement of time and frequency shift of the backscattered acoustic pulse. The only means of truly providing a known input is through the introduction of fixed audio frequencies at known times. The frequency shift will correspond to a simulated Doppler shift introduced by winds to or from an antenna. The timing of the simulated return will represent a known altitude based on the speed of sound. These simulations of the Doppler shifted signal will be performed with an (APT). However, if the sodars are of the phased array variety, the audit is conducted by comparing the sodar data with independent wind measurements. This comparison verifies that the beam steering is appropriate by assessing the reasonableness of the data. The collocated data will most likely be collected using an anemometer kite system.

All wind speed data will be evaluated in resultant vectors as well as converted to components along the sodar antenna axes. This is consistent with the newest EPA guidance and will help identify component related problems that may be missed by looking at the resultant data alone.

As a final check of the sodar data, data collected during several days prior to the audit is reviewed to establish the internal consistency of the values. As this is a qualitative check, there are no fixed evaluation criteria. The goal is to evaluate the following:

- Data reliability or quality codes for consistency
- Measured vertical intensity values for detection of potential fixed echoes
- Vertical profile of the individual wind components for detection of potential fixed echoes and consistency
- Vertical profile of the calculated vector winds for internal consistency
- Methods used to create hourly values from sub-hourly intervals

4.5.4 Surface Meteorological Measurements

Performance audit procedures and criteria are those recommended in the U.S. EPA Handbook for Air Pollution Measurement Systems, Volume IV (EPA, 1995). The audit standards used in the audits, audit standard accuracies and precision, as well as the audit criteria, are detailed in Table 4.5-1.

Wind Speed. The wind speed audit begins with the inspection of the wind speed cups or propeller(s) to ensure that they are intact. The cups are then removed to produce a zero point. Next, the R.M. Young selectable speed anemometer drive is connected to the sensor shaft to simulate wind speeds of approximately 5, 15 and 35 m/s. Actual values depend on the sensor model and are determined by multiplying the motor speed by a cup or propeller transfer coefficient supplied by the manufacturer. The data logger responses are compared to the calculated actual values and the differences compared to the audit criteria.

The sensor bearings are then checked for excessive wear by manually turning the sensor shaft to determine whether there is any bearing drag. Next, the sensor is removed from the crossarm and the R.M. Young torque disk mounted on the sensor shaft. A starting torque equivalent to the sensor starting threshold is applied by adding known weight screws to the disk. The starting threshold is determined from the manufacturer "k" value for the sensors.

Wind Direction. The wind sensor crossarm alignment relative to true north is checked using a Brunton surveyor compass mounted on a tripod. The angle of declination is taken into account when performing this check. This angle is verified using a solar siting. The wind direction vane is then pointed toward at least the four cardinal directions and the responses of the data logger and chart recorder are noted. The data logger and chart recorder responses are compared with the audit input values. The difference calculated for each input wind direction is then compared with the audit criteria (see Table 1).

The sensor bearings are checked for excessive wear, first by manually turning the sensor shaft to determine whether bearing drag is present and then by using an R.M. Young vane bearing torque gauge according to the manufacturer-recommended procedures.

Ambient Temperature. The temperature-sensing system is audited by immersing the system sensor and an NIST-traceable mercury-in-glass thermometer in the same water bath and comparing the readings of the thermometer with the data logger and chart recorder outputs at approximately zero, 20° and 40° C. The difference calculated for each point is compared with the audit criteria (see Table 5-1). If the sensor is of the non-immersible variety then both the audit and site sensor are placed in a waterproof sheath.

Relative Humidity and Dew-point Temperature. The muslin wick of the wet bulb thermometer of the motorized psychrometer is wetted with distilled water. The motorized psychrometer is then placed in close proximity to the relative humidity or dew point sensor and allowed to run for at least 5 minutes or until the thermometer readings stabilize. Once the readings stabilize, the audit psychrometer wet and dry bulb temperatures, the audit barometric pressure and the station relative humidity and ambient temperature or dew-point temperature are read simultaneously. These readings are used, along with a measure of pressure, to calculate the audit relative humidity and dew-point temperature. If the station reports relative humidity, it is converted to an equivalent dew-point temperature for comparison with the calculated audit dew-point temperature. If dew-point temperature is measured directly, the station value is directly compared with the calculated audit value. The difference between the station equivalent or measured dew-point temperature and the calculated audit dew-point temperature is compared with the audit criteria (see Table 5-1).

Solar Radiation. A certified LiCor pyranometer is collocated with the station solar radiation sensor and at least five simultaneous readings over the course of the audit are collected and the differences compared with the audit criteria.

Barometric Pressure. A certified Peet Bros. Ultimeter III is collocated with the station barometric pressure sensor and at least three simultaneous readings over the course of the audit are collected and the differences compared with the audit criteria.

4.5.5 General Performance Audit Procedures for Air Samplers

Sampler flow rates are audited using an appropriate field standard. All flows are measured as close as possible to the collection media. Audit flow rates will be compared against the measured or nominal flow rates supplied by the site technicians. Site comparison flow rates should correspond to the flow rates used to calculate sample concentrations. The ambient temperature and atmospheric pressure are recorded for each flow rate audited, allowing audit flow rates to be reported in either volumetric or standard units, using the following equations:

$$Q_{std} = Q_{vol} \times (P_a / 29.92) \times (298 / T_a)$$

$$Q_{vol} = Q_{std} \times (29.92 / P_a) \times (T_a / 298)$$

where Q_{std} is the flow rate at standard conditions (P = 29.92" Hg, T = 298°C)
Q_{vol} is the volumetric flow rate
P_a is the ambient pressure in inches of Hg
T_a is the ambient temperature in °C

A mercury-in-glass thermometer calibrated against an NIST-traceable thermometer and a transfer standard barometer is used to take readings of ambient temperature and barometric pressure, which are required for the flow calculations. The appropriate flow units are used when comparing audit and site flow rates. Audit flow rates and site flow rates should agree to with ±10%. Flow rates for FRM samplers should agree to within ±4% per current EPA criteria.

Whenever possible, additional flow measurements are made to check the sample system for leaks. This can be accomplished using two different methods. For many samplers, including the FRM samplers, the presence of leaks is check but plugging the inlet with the sampler running and verifying that the sample flow goes to zero. Some sampler designs, however, do not allow this type of check. For these samplers, flows will be measured both at the sampler inlet or immediately above the leak-prone area, and at the collection media. Any noted difference between these upstream and downstream measurements indicates a leak within the system. Taking into account the accuracy and precision of the flow measuring devices, any difference between upstream and downstream flows of greater than 2% of the upstream flow will be considered indicative of a leak.

In addition to the above measurements, flow rates of any other component vital for the operation of the sampler are also checked. This includes by-pass and inlet flow rates for samplers equipped with size selective inlets. Procedures used for the various auditing devices are summarized below.

<u>Mass Flow Meters</u>

- Turn on the mass flow meter and allow the flow meter to warm up for at least 15 minutes.
- With the ends of the flow element capped, obtain and record a zero reading.
- Attach the flow meter to the line being audited.
- Obtain a stable flow meter reading by waiting at least three minutes or until the flow meter quits showing any upward or downward trends.

- Calculate the corrected flow meter reading in standard liters per minute using the following equation:

  $Q_{std} = a \times (Q_o - (z_c - z)) + b$

  where Q_0 is the flow meter reading
  z is the measured mass flow meter zero reading
  z_c is the mass flow meter zero reading at the time of the certification
  a is the certification slope
  b is the certification intercept

Dry Test Meters

- Attach the dry test meter to the line being audited.
- Reset the audit stopwatch.
- At a convenient reference point on the dry test meter dial, start the stop watch and record the exact initial test meter reading.
- Allow at least 1 minute for the test to run.
- At a convenient reference point on the test meter dial, stop the stopwatch and record the exact final dry test meter reading.
- Repeat the above steps 2 times for the same volume as defined by the dry test meter.
- Calculate an average of the three times obtained from the stopwatch.
- Calculate the measured volumetric flow rate using the following equation:

  $Q_{vol} = V / t$

  where V is the volume measured by the dry test meter
  t is the average stop watch reading

4.5.6 NMOC/Carbonyl Samplers

Thru-the-probe performance audits will be conducted at each NMOC/Carbonyl monitoring site to assess the integrity of the sampling equipment and transport system, and the accuracy of the analytical methods used by the laboratory to measure the ambient concentrations of VOCs. In a TTP audit, a gaseous mixture of VOCs prepared by NIST is mixed with purified air under controlled conditions and introduced into the sampling probe of a air sampler. The sampler collects the audit gas mixture in a humidified stainless steel canister over the normal sample period. The audit sample is then shipped to the laboratory along with other regular ambient samples, where it is analyzed following normal standard operating procedures.

4.5.7 Continuous Air Quality Samplers

4.5.7.1 Audits Conducted by Parsons ES

Ozone. The audit zero air and ozone transfer standard are set up and allowed to warm-up for at least one hour. Once the audit equipment has reached a constant operating temperature,

the station ozone analyzer is taken off line. The station operator identifies the appropriate data channel and disconnects the sample line from the sample manifold. After plugging the open port of the sample manifold, the entire sample train of the ozone analyzer is connected to the Environics Series 100 ozone generator output via a glass manifold. Care is taken to introduce the ozone sample through as much of the normal sampling train (i.e., filters, and scrubbers) as possible.

Ozone concentrations are determined by ultraviolet photometric methods and are referenced to either CARB's or AVES's primary ozone standard. The zero air supplied by a zero air generator is split into two streams. One of the air streams is directed through an ozone generator that uses an ultraviolet lamp to convert diatomic air molecules into ozone. The second air stream is directed into the ozone transfer standard sample bench and serves as the reference air that determines the audit transfer standard baseline. This baseline value (which corresponds to zero) is compared (by the transfer standard's electronic systems) with the ozone bearing sample stream. The difference between the reference and sample air streams is the audit concentration as referenced to the AV primary ozone standard. The audit compares the readings of the audit transfer standard determined concentrations with the corresponding station analyzer DAS and chart recorder outputs. The audit transfer standard and the station ozone analyzer sample the same sample outputs from a glass manifold connected to the ozone generator output. Ten consecutive readings of the audit transfer standard and the station ozone analyzer DAS and chart recorder outputs are taken at each of the concentration ranges (specified in the next sub-section) and averaged. The averaged audit transfer standard readings are corrected for temperature and pressure and the correction factor from the certification with the AVES primary standard. These corrected audit values and the corresponding station ozone analyzer values are then compared by a least squares linear regression analysis and compared with the EPA recommended criteria (Table 4.5-2).

The ozone analyzers are challenged with specific concentrations of span gas as follows:

Audit Points	Concentration Range (ppm)
1	0.000
2	.03 to .08
3	.15 to .20
4	.35 to .45

Continuous Analyzers. The continuous analyzers (including NO/NO_x, NO/NO_y, CO, and CO_2) are all initially audited in a similar manner. The audits of the analyzers begin with the station technician identifying the appropriate data channel and taking it off line so that ambient data were no longer being collected. Next, the station technician disconnects the sample line of the corresponding analyzer from the sample manifold. After plugging the open port of the sampler manifold, the sample line or inlet filter is connected to the dilution system via a vented glass manifold through which the audit span gas is introduced to allow the audit test atmosphere to travel through as much of the normal sampling train (i.e., filters, scrubbers, etc.) as possible. The analyzer is challenged with specific concentrations of span gas as follows:

Audit Point	Concentration Range
	NO, CO, CO_2

1	.0
2	6 to 16% of full scale
3	30 to 40% of full scale
4	70 to 90% of full scale

All concentrations are generated by NIST-traceable cylinders and gas dilution.

Audit input concentrations and the corresponding analyzer values are compared by a least-squares linear regression analysis and compared with the EPA recommended criteria (Table 4.5-2).

NO/NO_x and NO/NO_y Analyzers. NO/NO_x and NO/NO_y analyzers are further challenged with concentration of additional nitrogen compounds. Nitrogen dioxide concentrations are introduced into the analyzer by gas-phase titration (GPT) of NO with O_3. Nitric oxide reacts completely with ozone to produce nitrogen dioxide and oxygen. The NO_2 input concentration are determined by:

$$[NO_2 \text{ input}] = \frac{[\text{NO input}] - [\text{NO reading}]}{\text{NO slope}}$$

where:

[NO input] = analyzer's NO channel response to the NO span prior to the addition of O_3

[NO reading] = analyzer's NO response after the addition of O_3

NO slope = slope of the curve generated by linear regression of the NO concentrations versus the analyzer's response during the audit of the NO channel, where the NO input is the abscissa and the NO response is the ordinate

The final stage of the analyzer audit is to determine the converter efficiency from the following relationships:

$$[NO_2 \text{ converted}] = [NO_2 \text{ input}] \frac{[NO_y \text{ initial}] - [NO_y \text{ final}]}{NO_y \text{ slope}}$$

where:

[NO_y initial] = analyzer's NO_y channel response before the addition of O_3

[NO_y final] = analyzer's NO_y response after the input sample of NO is titrated with O_3

NO_y slope = slope obtained from the audit of the NO_y channel

The converter efficiency for each audit point is:

$$\frac{[NO_2 \text{ converted}]}{[NO_2 \text{ input}]} \times 100$$

The converter efficiency is defined as the linear regression using the NO_2 source versus the NO_2 converted x 100. The converter efficiency must be greater than or equal to 96% to pass the audit. In addition to checking the converter efficiency for NO_2, the converter is also checked using NIST-traceable concentrations of n-propylnitrate. Concentrations of approximately 100 and 250 ppb are introduced into the analyzer, and the converter efficiency is calculated in the same manner as for NO_2. Finally, the analyzer's scrubber is challenged with approximately 200 ppb of ammonia to document the analyzer's response to common non-NO_y compounds. Ammonia concentrations are generated using NIST-traceable cylinders.

Carbon Analyzers. The continuous carbon analyzers are audited in much the same way as other continuous gas analyzers, such as the NO/NO_y analyzers (not including the GPT and additional supplementary checks). Input concentrations of CO_2 are generated using an audit dilution system and NIST-certified cylinders of CO_2.

Nephelometers. The nephelometers are audited by performing a check of the instrument zero and one upscale span point. The zero point is produced by inputting filtered zero air into the nephelometer's optical sampling chamber and noting the output readings after period of approximately 5 minutes. The span point is produced in the same manner as the zero point but with the introduction of the Suva refrigerant in place of the zero air. Audit criteria for the nephelometers are similar to those for other continuous analyzers, as presented in Table 5-2.

Aethelometers. The Aethelometer sample flow rate is audited using an appropriate flow standard. Responses should be within ±10% of audit values.

Additional Samplers and Analyzers. Specific audit procedures for specialized, research instrumentation will be developed as SOPs are received. This includes instrumentation such as automated VOC analyzers, HCHO dihydorlutinine derivative/fluorescent detection analyzers, TDLAS analyzers, and hydroxyl carbonyl samplers.

4.5.7.2 Audits Conducted by ARB

The California Air Resources Board (ARB) will be conducting audits of the majority of NOx, NOy, and ozone analyzers used for CCOS. While the auditing principles used by ARB are essentially the same as those presented above, the ARB introduces their audit gases directly into the sample probe using a mobile van equipped with the necessary calibration equipment that is parked immediately adjacent to the site. This auditing method is briefly summarized below:

The Quality Assurance Section (QAS) conducts thru-the-probe audit by diluting known quantities of National Institute of Standards and Technology (NIST) traceable gases with 25 liters of pure air to achieve ambient levels, then challenging the analyzers through the site's inlet

probe. This audit method tests the integrity of the ambient monitoring site's entire ambient air sampling system, from the probe inlet to the air monitoring equipment. In this method, a gas calibrator is used to control the dilution of high concentration gases from compressed gas cylinders containing CO, NO, SO2, CH4; CO, H2S; CO, CH4, and C6H14. The gas calibrator is also used as an ozone source. The API 400 ozone analyzer is used as a transfer standard for auditing the site's ozone analyzer. A TECO 48 CO analyzer is calibrated at two known ambient level concentrations, plus zero, and is used to trace the amount of CO present in the diluted sample. The amount of CO present in the diluted sample is then used to calculate the true concentrations of the other gases in the compressed gas cylinder at each audit level.

4.5.8 VOC Laboratory Audits

Performance audits will consist of through-the-probe audits using a 25-component hydrocarbon and 3-component carbonyl standard mixtures. These audits will be conducted by the ARB QA staff using the same procedures used at PAMS sites.

4.6 Approaches To Problem Resolution And Verification Of Corrections

The goal of the audits is to verify the function of each measurement system with respect to the DQOs. Given that the performance audits are comparisons between the audit standards and the individual measurement systems, deviations between the audit standards or audit standard inputs and the measurement outputs can be the result of a problem with the measurements, the audit standard, or both. The auditors will make every effort to verify the audit results on site. It is the auditor's practice not to leave the site until there is deviation within tolerance between the auditor and the site operator concerning the audit results. It should be noted that the agreement between the auditor and site operator may be an agreement to disagree. If this is the case, it will be necessary to further investigate the problem to achieve resolution.

For the radar profilers, RASS and sodars, the initial comparisons are qualitative and performed using level 0 validated data. If the indicated deviation exceeds the study DQOs, the auditor and site operator will review the audit equipment and measurement system setups. It is anticipated that periods when exceedances occur could be validated to level 1 within one week of the audit and a final resolution made. This assumes the data validation will not alter the values collected, it will only determine if they are valid.

For all field monitoring audits, the results of the audits will be reported to the on-site technician and the monitoring supervisor before leaving the sites. Problems noted will be discussed and an action plan for resolving them developed. If there is a question about the validity of the audit standard, it will be the responsibility of the auditor to test and correct, or replace the standard if necessary. If the problem is verified, its disposition will be documented. The auditor will follow up on each problem within a week of the audit.

Results from all audits will be compiled into a final report that will be submitted to CCOS Project Manager by October 1, 2001.

Table 4.5-1. Summary of Meteorolgy Audit Methods and Criteria.

Measurement Variable	Audit Criteria	Procedure Reference	General Procedure
Horizontal Wind Speed	Accuracy ±(0.2 m/s + 5% of observed) Equivalent wind speed starting torque to meet the wind speed starting thresholds for the respective sensors.	EPA-454/R-99-005-013 with 3/15/99 updates EPA/600/R-94-038d	Three wind speeds within the expected range of operation. If any points are outside of criteria then corrective action is necessary.
Horizontal Wind Direction	Accuracy ±3 degrees for linearity, ±2 degrees for alignment to known direction. Equivalent wind speed starting torque to meet the wind speed starting thresholds for the respective sensors.	EPA-454/R-99-005-013 with 3/15/99 updates EPA/600/R-94-038d	Depending on the mechanical sensor type from 4 to 36 points equally spaced around the compass will be compared. If any points are outside of criteria then corrective action is necessary. Torque measurements will be made to determine the mechanical sensor starting threshold. Sensor alignment will be verified using solar methods.
Temperature	±0.5°C	EPA-454/R-99-005-013 with 3/15/99 updates EPA/600/R-94-038d	Three temperatures within the expected range of temperatures (0 to 40°C). If any points are outside of criteria then corrective action is necessary.
Solar Radiation	± 5% of observed	EPA-454/R-99-005-013 with 3/15/99 updates EPA/600/R-94-038d	Five measurements within the range of operations on a given audit day will be made. If any points are outside of criteria then corrective action is necessary.
Barometric Pressure	±3 mb	EPA-454/R-99-005-013 with 3/15/99 updates EPA/600/R-94-038d	Three pressures over the period of the audit will be compared. If any points are outside of criteria then corrective action is necessary.
Relative Humidity	± 1.5°C equivalent dew point	EPA-454/R-99-005-013 with 3/15/99 updates EPA/600/R-94-038d	Three comparisons are made of the station sensor to an aspirated psychrometer. If any points are outside of criteria then corrective action is necessary. An alternate method is to use LiCl salt solutions for a direct evaluation of the response at know relative humidities. This method is preferred for the high accuracy systems since solutions can be selected at the

Measurement Variable	Audit Criteria	Procedure Reference	General Procedure
			extremes of the operating ranges where errors most frequently occur. The latter method will depend on the site sensor being amenable to the salt solution method.
Remote Sensing Horizontal Wind Speed and Direction	Antenna alignment to true -- ±2° Antenna level and/or zenith -- ±0.5° Sodar transponder response -- ±0.2 m/s for component Comparison systematic difference – Beam component, ±1.0 m/s, Resultant, ±1.0 m/s, ±10°, when wind speeds are greater than 2 m/s. Comparison RMS difference – Beam component, ±2.0 m/s, Resultant, ±2.0 m/s, ±30°, when wind speeds are greater than 2 m/s.	EPA-454/R-99-005-013 with 3/15/99 updates	Anticipated comparison instruments to be used may include a rawinsonde or anemometer kite. If an adjacent tall tower is available it will also be used. For any of the comparison methods, data will be collected over a 24-hour period to encompass a variety of meteorological conditions. For sodars that are amenable to a transponder audit, that may be used in place of the comparison.
RASS Virtual Temperature	RASS element level -- ±1° Comparison systematic difference – ±1.0°C Comparison RMS difference – ±1.5°C	EPA-454/R-99-005-013 with 3/15/99 updates	Anticipated comparison instruments to be used may include a rawinsonde or other temperature sounding device. Data will be collected over at least a 24-hour period to encompass a variety of meteorological conditions.

Table 4.5-2. Linear Regression Criteria

<u>Slope</u>		
Excellent	< ± 0.05	between analyzer response and audit concentration
Satisfactory	0.06 to 0.15	between analyzer response and audit concentration
Unsatisfactory	> ± 0.15	between analyzer response and audit concentration
<u>Intercept</u>		
Satisfactory	< ± 3%	of the analyzer range
Unsatisfactory	> ± 3%	of the analyzer range
<u>Correlation Coefficient</u>		
Satisfactory	0.9950 to 1.0000	linear analyzer response to audit concentrations
Unsatisfactory	<0.9950	nonlinear analyzer response to audit concentrations

Reproduced from EPA "Quality Assurance Handbook for Air Pollution Measurement Systems," Volume II, Section 2.0.12, Page 39.

5.0 DATA MANAGEMENT AND VALIDATION

The CCOS database will be compiled, documented, evaluated, and distributed by the Planning and Technical Support Division (PTSD) of the Air Resources Board (ARB). Common data management and validation conventions need to be assembled in a consistent and efficient manner. These conventions are described in this section. Greg O'Brien of the ARB will serve as the CCOS data manager. He will be responsible for establishing and maintaining computer-based data archives and managing the overall data storage and Level 1A-1B validation activities. The data manager will interact with the field manager and the program management and provide feedback to them concerning the status of unresolved data management problems and potential for resolution. Liz Niccum of T&B Systems will assist the CCOS data manager with data compilation and formatting. Eric Fujita of the Desert Research Institute will assist with Level 2 data validation. This draft version will be updated with more specific conventions and reporting structures after CCOS measurement investigators have provided their suggestions and recommendations. To the greatest extent possible, CCOS field data structures, processing, validation, and delivery procedures will be consistent with those being established for the CRPAQS (Watson et al., 1998).

5.1 Data Specifications

Data management conventions and methods for CCOS and CRPAQS build on experience from and development supported by the 1990 San Joaquin Valley Air Quality Study (SJVAQS) (Blumenthal et al., 1993), the 1995 Integrated Monitoring Study (IMS-95) (Solomon and Magliano, 1997), and the 1997 Southern California Oxidant Study (SCOS-97) (Fujita et al., 1997). The following specifications are maintained by the data manager and are to be made available to all project participants via the Internet:

- **Monitoring Sites:** Each site location for CCOS measurements is identified with a unique alphanumeric site ID accompanied by its name, address, coordinates, elevation, primary operator, and a summary of measurements taken at the site. The field manager with a Global Positioning System (GPS), pressure-based altimeter, and topographical maps verify the coordinates and elevations of each site. Immediate surroundings are recorded with a digital camera of the area surrounding the site to be displayed on the CCAQS web site.

- **Instruments:** The make, model and serial number of instruments used to acquire measurements at each site is recorded with its threshold, range, expected accuracy and precision.

- **Parameters:** Each observed parameter is assigned a unique code that is accompanied by its definition, units, averaging time, applicable temperature and pressure adjustments, and data reporting format.

- **Data validation flags:** Flags specific to each measurement investigator are translated into a common set of validation flags that are carried with each data point. These are listed in Section 5.3

- **Air Observation Data files:** Basic air observation data files are constructed in normalized formats that have the same structure for different types of data.

- **Time conventions:** Times are expressed in Pacific Standard Time (PST), hour or minute beginning. All dates as MM/DD/YYYY (note that years are four-digit codes:. 1999, 2000, 2001).

- **Missing data conventions:** A –99 or a "NULL" value replaces missing measurements. Invalidated data retain original data value and is flagged as invalid.

- **Investigator code:** Each measurement investigator or network operator is assigned a unique four-character code that is used to identify the source of the data. Data transmittals will carry this code as part of the filename when they are loaded into a raw data sub-directory, and a separate sub-directory on the CCOS Internet server.

5.1.1 Parameter Codes

Will be distributed by the CCOS data manager in June 2000 to CCOS participant. Includes table of VOC species

5.1.2 Investigator Codes

Will be distributed by the CCOS data manager in June 2000 to CCOS participant.

5.1.3 Measurement Codes

Will be distributed by the CCOS data manager in June 2000 to CCOS participant.

5.1.4 Methods Codes

Will be distributed by the CCOS data manager in June 2000 to CCOS participant.

5.2 Data Validation Levels

Mueller (1980), Mueller et al., (1983), and Watson et al. (1983, 1989, 1995) define a three-level data validation process that should be mandatory in any environmental measurement study. Data records are designated as having passed these levels by entries in the a column of each data file. These levels, and the validation codes that designate them, are defined as follows:

- **Level 0 (ZERO):** These data are obtained directly from the data loggers that acquire data in the field. Averaging times represent the minimum intervals recorded by the data logger, which do not necessarily correspond to the averaging periods specified for the database files. Level 0 data have not been edited for instrument downtime, nor have procedural adjustments for baseline and span changes been applied. Level 0 data are not contained in the CCAQS database, although they are consulted on a regular basis to ascertain instrument functionality and to identify potential episodes prior to receipt of Level 1 A data.

- **Level 1A (1A):** These data have passed several validation tests applied by the measurement investigator prior to data submission. The general features of Level 1A are: 1) data values flagged when monitoring instruments did not function within procedural tolerances; 2) flagging measurements when significant deviations from measurement assumptions have occurred; 3) verifying computer file entries against data sheets; 4) replacement of data from a backup data acquisition system in the event of failure of the primary system; 5) adjustment of measurement values for quantifiable baseline and span or interference biases; and 6) identification, investigation, and flagging of data that are beyond reasonable bounds or that are unrepresentative of the variable being measured (e.g. high light scattering associated with adverse weather).

- **Level 1B (1B):** Pre-programmed consistency and reasonability tests are applied by the data manager prior to integration into the CCAQS database. Consistency tests verify that file naming conventions, data formats, site codes, variable names, reporting units, validation flags, and missing value codes are consistent with project conventions. Discrepancies are reported to the measurement investigator for remediation. When the received files are consistent, reasonability tests are applied that include: 1) identification of data values outside of a specified minimum or maximum value; 2) values that change by more than a specified amount from one sample to the next; and 3) values that do not change over a specified period. Data identified by these filters are individually examined and verified with the data supplier. Obvious outliers (e.g. high solar radiation at midnight, 300 'C temperature) are invalidated. Others may be invalidated or flagged based on the results of the investigation. The bounds used in these tests will be determined in cooperation with measurement investigators and network operators.

- **Level 2 (2):** Level 2 data validation takes place after data from various measurement methods have been assembled in the master database. Level 2 validation is the first step in data analysis. Level 2A tests involve the testing of measurement assumptions (e.g. internal nephelometer temperatures do not significantly exceed ambient temperatures), comparisons of collocated measurements (e.g. filter and continuous sulfate and absorption), and internal consistency tests (e.g. the sum of measured aerosol species does not exceed measured mass concentrations). Level 2 tests also involve the testing of measurement assumptions, comparisons of collocated measurements, and internal consistency tests.

- **Level 3 (3):** Level 3 is applied during the model reconciliation process, when the results from different modeling and data analysis approaches are compared with each other and with measurements. The first assumption upon finding a measurement, which is inconsistent with physical expectations, is that the unusual value is due to a measurement error. If, upon tracing the path of the measurement, nothing unusual is found, the value can be assumed to be a valid result of an environmental cause. The Level 3 designation is applied only to those variables that have undergone this reexamination after the completion of data analysis and modeling. Level 3 validations continue for as long as the database is maintained.

A higher validation level assigned to a data record indicates that those data have gone through, and passed, a greater level of scrutiny than data at a lower level. All data in the CCOS data set will achieve Level 1B status prior to use in data analysis and modeling. The validation tests passed by Level 1B data are stringent by the standards of most air quality and meteorological networks, and few changes are made in elevating the status of a data record from Level 1B to Level 2. Since some analyses are applied to episodes rather than to all samples, some data records in a file will achieve Level 2 designation while the remaining records will remain at Level 1B. Only a few data records will be designated as Level 3 to identify that they have undergone additional investigation. Data designated as Levels 2 or 3 validations are not necessarily "better" than data designated at Level 1 B. The level only signifies that they have undergone additional scrutiny as a result of the tests described above.

5.3 Validation Flags

Procedure and investigator specific validation flags will be maintained in a separate validation file. These must be translated into the common flags listed below. A translation table (QCcodes) will be established as part of the database that associates each investigator flag with one of the following flags:

Table 5.3-1
Validation Flags

Code	Description
0	Valid
1	Estimated
2	Calibration
3	Instrument failure
4	Off-scale reading
5	Interpolated
6	Below detection limits
7	Suspect
8	Invalid
9	Missing
a	Hourly avg. (45 <->60 minutes)
b	Hourly avg. (<45 minutes)
d	Averaged data
e	Zero mode
f	Blank sample

5.4 Data Transmittal

Throughout the CCOS study many investigators will be collecting and submitting raw data to the ARB staff within the PTSD. The PTSD staff will have to deal with several data sources and measurement investigators (contractors). To make the job of collecting and processing of the submittal data easier, a data transmittal file format and transmittal file naming conventions have been established. *This will be included in the final CCOS document.*

5.4.1 Adherence to Specifications

Data are to be provided in electronic form, validated to Level 1A by the contractor, to the CCOS Data Manager. The data format from each contractor must follow the specifications *to be defined completely in the final document*, and must be approved by the CCOS Data Manager in advance of submittal.

The contractor will submit quality control data to the data manager along with air quality and visibility data. A precision value and a validation flag are to be reported with each measured value in the database.

5.4.2 Transmittal Files

Data will be acquired at set intervals via file transfer protocol (FTP) to a pre-defined location set up for each measurement investigator. The files are submitted as an ASCII comma delimited text files. Comma delimited files are defined as the following:

1. Records begin at position 0.
2. Records end with ASCII characters 13 (carriage return) and 10 (line feed).
3. Fields are delimited with ASCII character 44 (comma).
4. Character data are enclosed with ASCII character 34 (double quote).
5. The end of file is indicated by ASCII character 26 (control z).

The investigator must adhere to the CCAQS Data Transmittal Convention as outlined above.

5.4.3 Transmittal File Naming Convention

The investigator must adhere to the CCAQS File Naming Convention as outlined below. Raw data file naming conventions include the investigator code, a measurement type code, and an indicator for the period of data acquisition. FTP Transmittal file names are of the form CDDMMYYA.PLL. File name conventions are listed in Table 5.3-2.

5.4.4 Transmittal Files Content

The Data Transmittal Files content convention was designed so that the quality assurance process could properly identify the data source, the data of the submittal as well as quality assuring each row of information. To ensure that each row of information, for that matter the entire transmitted file, was accurately received and recorded it must contain some of validity checkpoints. The content convention is as follows:

1. First record, or header record, in the transmittal file identifies the record type, data source, transmittal date, and number of air observation records in the file.

2. The next X number of records are the air observation details, where X represents the number of air observation records defined in header record.

Table 5.3-2
FTP Transmittal file names

Position	Indicator	Description	Valid Codes
1	**C**	Investigator code	
2,3	**DD**	Data type code	
4,5	**MM**	Month code	JA,FE,MR,AP,MY,JN,JL,AU,SE,OC,NO,DE
6,7	**YYYY**	Year code	Year file was created
8	**A**	Averaging interval	**A** - 3 hour
			B - 6 hour
			C - 12 hour
			D - 24 hour
			H - 1 hour
			J - Jumps (every other hour)
			V - Hourly but varies, possibly less than 24 measurements per day
			I - Instantaneous (<1 min)
			F - 5 minute
			T - 10 minute
			M - 15 minute
			N - 30 minute
			P - Partial hour (< 60 min)
9	**.**	File extension separator	
10	**P**	Measurement platform	S = surface, U = upper air
11,12	**LL**	Data validation level	OA,OB, I A, I 13,2A,213,3,A

3. The last record in the transmittal file is the files footer. The footer recaps the file transmitted. It will contain the same information as the file header record. Although this may seem redundant this assures TSD team that the file was received in its entirety.

5.5 Internet Server and Internet Access

CCOS and CRPAQS data and communications will be received and made available on the Central California Air Quality Studies (CCAQS) web server maintained by the California Air Resources Board. The URL for this site is http://www.arb.ca.gov/airways/ccaqs.htm. This web site currently contains project documentation and will be developed to contain project status during field monitoring and project data. Data and communications web pages and related files are organized within directories on the CCAQS web site server. This organization will be transparent to most users who will access information through hyperlinks available via Internet Explorer or Netscape Navigator, versions 4.0 or greater.

6.0 EMISSION INVENTORY DEVELOPMENT AND EVALUATION

For a study covering as large of an area as CCOS, the development of the emission inventory will be a major effort. In addition to the size of the study domain, the emission inventory required for modeling is more detailed than the routine summer seasonal emission inventory. The emission inventory (EI) needed to support the CCOS modeling will be a series of day-specific, hourly, gridded emission inventories that cover each day of the ozone episodes captured during the field study. To help coordinate the EI development effort, the Emission Inventory Coordination Group (EICG) has been established to determine the process for preparing the emission inventories needed to support air quality modeling for CCOS. The EICG is chaired by Linda Murchison and Dale Shimp of the ARB. Participants in the group include many local air districts, several local councils of government, Caltrans, California Energy Commission, and the ARB. Local air districts participating to date include San Joaquin Valley Unified APCD, Bay Area AQMD, Sacramento Metropolitan AQMD, Mendocino County AQMD, Northern Sierra AQMD, Yolo-Solano AQMD, Placer County APCD, San Luis Obispo County APCD, and Monterey Bay Unified APCD. Other local air districts will also be participating.

There are about 30 districts in the CCOS modeling domain. Each local air district in the state updates a portion of the emission inventory for their area. An emission inventory is needed to estimate emissions for each day that will be modeled in the summer of 2000. Special effort is being made to assist smaller districts that have limited staffing resources. The following subsections the approach and schedule for developing and compiling the modeling emission inventory, and the specific studies that have been funded in order to support this effort for CCOS.

6.1 "Fast Track" and Final Modeling Inventory Development Process

A gridded emission inventory is a critical input to photochemical air quality models. Historically, modeling emission inventories have been criticized for using incomplete day-specific data and for lagging behind the development of other data such as meteorological and air quality data that are collected in air quality studies. This subsection describes a two-track approach.

To make a modeling inventory available in a shorter time frame, the EICG is taking a two-tier approach to the development of the modeling emission inventory that will provide modelers with a "fast track" inventory for preliminary modeling. This inventory will be followed by a more detailed modeling inventory that will incorporate all of the day-specific information collected during the field study.

The districts and ARB will prepare a seasonal emissions inventory for 1999 during calendar year 2000. The 1999 annual emissions for point sources will be forecasted to 2000 and then spatially and temporally distributed to create a modeling inventory for a summer weekday. Area source emissions for 1999 will also be forecasted to 2000. The forecasted emissions will be spatially distributed using the spatial surrogates used in the 1994 Ozone State Implementation Plans and temporally distributed to represent a summer weekday. On-road mobile sources will also be gridded based on the 1994 Plans. Modelers will use this "fast track" inventory to begin

testing the performance of the photochemical model. When the 2000 annual average inventory is ready, it will be gridded to replace the forecasted 2000 inventory. Day-specific data will replace the gridded annual average inventory. Results from contracts will be incorporated into the annual average inventory and/or the day-specific inventories.

6.2 Requirements for Quality Control and Quality Assurance of Emission Inventory

The EICG is placing special emphasis on ensuring consistency in emission inventory preparation procedures between all the districts in the modeling domain. The Air Resources Board will take the lead in coordinating and ensuring quality control and quality assurance standards for the emission inventory portion of the study. Specific guidelines will be outlined for assisting state and local agencies for implementing more uniform and systematic approaches to collecting, compiling (formats and accuracy), and reporting emission inventory data. Also, to ensure good quality control practices, the EICG will be developing a comprehensive quality control and quality assurance plan. The plan will include items such as:

- Quality control checks for collecting non-emission data, updating activity data, and using appropriate emission factors for calculating emissions;
- Emission calculation methodology;
- Updating or revising categories to ensure that the latest methodology is used;
- Data submittal;
- Data correction;
- Documentation; and
- Quality review of the entire inventory.

6.3 Proposed Contractor Studies for Emission Inventory Development

The collection of most of the emission inventory data discussed in the previous sections will be provided by public agencies as in-kind contributions to the CCOS study. However, there are some critical elements of the CCOS emission inventory that the members of the EICG do not have sufficient resources and /or expertise to provide. In general, these needs relate to the spatial and temporal distribution of emissions from motor vehicles and other area sources. The emission inventory elements, which will need to be supported by the CCOS study, are listed below.

6.3.1 Day-Specific Traffic Count Information

Day-specific traffic count information will be gathered during the field study. These traffic counts are used to create factors to adjust the travel demand volumes to hourly vehicle volumes. A scoping study is planned to review the availability of traffic data and develop a

sampling plan using statistical methods for the placement of traffic counters for CCOS. Based on the results of the scoping study, a field sampling plan will be developed to collect and analyze hourly traffic count information for the CCOS domain. The day-specific data will be incorporated into the transportation model.

6.3.2 Gridding of Area Source Emissions

Ozone and aerosol formation models require spatially distributed estimates of precursor emissions resolved over the entire geographic grid system that defines the modeling domain. In this project, Sonoma Technology, Inc. will develop base year and future year gridding surrogates for spatially distributing area source and off-road emission source categories. The spatial allocation factors will be used to geographically distribute emissions throughout the Central California Ozone Study (CCOS) domain at a spatial resolution of 1 x 1 km covering all of California from Shasta to Kern County.

Spatial allocation factors for area and off-road mobile sources will be developed for the years 2000, 2005, 2010, and 2020 using various sources of data that are representative of the spatial distribution of emissions activity. These data are referred to as surrogates and commonly include: demographic and socioeconomic data and land cover/land use data. STI will review existing area and off-road mobile source surrogate assignments and use new and innovative methodologies similar to those used in the 1997 South Coast Ozone Study (SCOS97) to assign surrogates to emissions sources.

Additionally, STI will review and recommend improvements to existing temporal distributions (hourly, daily, seasonal) of emissions activity for all area and off-road sources. In order to complete this project, local data will be acquired

6.3.3 Integration of Transportation Data for CCOS Domain and Run DTIM for Entire Modeling Domain

The goals of this project are: 1) create gridded, hourly on-road mobile source emissions estimates of PM, CO, NOx, and TOG which are representative of an ozone season episode and a winter episode for the base year 2000; 2) provide a cost and schedule estimate to create more refined PM estimates (i.e. EC, OC, SO2, SO4, NH3, Na, Ca, K, Mg, and other PM in lieu of a total PM estimate; and 3) transfer data and estimation software to the ARB and provide necessary training so that ARB staff can generate additional on-road mobile source emissions estimates using other data sets. The contractor is Alpine Geophysics.

6.3.4 Biogenic Emission Model Expansion

Biogenic emissions are calculated using BEIGIS, the ARB's geographic information system (GIS) model for estimating biogenic hydrocarbon emissions. Although most of the major input databases needed to run BEIGIS currently exist, several of these databases specific to the Central California Ozone Study (CCOS) domain require validation. The first database requiring field validation is the spatial distribution and identification of vegetation species in natural areas, as defined by the Gap Analysis Project (GAP). The second is a 1 kilometer resolution leaf area

index (LAI) database developed from satellite imagery. Validation of the GAP and LAI databases is critical as these are the primary input databases used in estimating the green leaf mass and spatial distribution of dominant plant species in the CCOS domain. This project will conduct field validation of the GAP and LAI databases at a number of sites in the CCOS study area.

6.3.5 Small District Assistance

This project is to provide assistance to small districts in the CCOS domain to review and update their point and area source emission inventories. Local air districts are responsible for estimating emissions from point sources. For purposes of this work plan, point sources will be defined as permitted sources that emit 10 tons or more per year of any criteria pollutant. The work plan will be expanded to include area sources. University of California, Davis and Sonoma Technology are the contractors.

6.4 Schedule for Emission Inventory Development

Figure 6.4-1 and 6.4-2 show the schedule of activities related to the development of the 1999 and 2000 Baseline Annual Average Emission Inventory, respectively. The Stationary Source Area portion of the inventory will be separated into two parts. One part will cover area source categories for which ARB is responsible and the other part will cover area source categories for which the districts are responsible. The tasks are different for the two parts and are reflected in the plan. Some districts will have their area source categories updated by STI as part of the small district assistance project. These districts include Lake, Northern Sonoma, Mendocino, those in the Mountain Counties Air Basin and those in the Sacramento Valley except Sacramento Metro. For the remaining districts, the EICG will decide which district area source categories should be updated based upon ranking of NOx and ROG emissions from area source categories, and the date that each category was last updated.

Table 6.4-1

				1999		2000				2001			
#	PROJECT	Agency		Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
I	**1999 BASELINE ANNUAL AVERAGE EMISSION INVENTORY DEVELOPMENT**												
Ia	**STATIONARY SOURCES - POINT**												
	Develop inventory preparation schedule	A											
	Review permit applications and verify compliance and inspection records	D											
	Decide which point sources will be updated based on criteria including the amount and type of emissions from the facility, large changes from previous years, facility closures and addition of new facilities	D											
	Send annual questionnaires/surveys /reports to facilities	D											
	Gather information needed to calculate emissions including process rates, source test data if available, emission factors, and control equipment	D											
	Incorporate findings from ARB, industry or local research contracts into inventory development	A, D											
	Identify point source processes that should be updated/revised and determine appropriate methodologies	D											
	Perform QA/QC activities (see IIIa)	D											
	Update/Revise point source data	D											
	Submit point source data to ARB	D											
Ib	**STATIONARY SOURCES - AREA**												
	Develop inventory preparation schedule	A											
	Decide which area sources will be updated based on criteria including the amount and type of emissions from each category, large changes from previous years, and application of controls	A, D											
	Gather information needed to calculate emissions including process rates, emission factors, and control equipment	A, D											
	Incorporate findings from ARB, industry or local research contracts into inventory development	A, D											
	Identify categories that should be updated/revised and determine appropriate methodologies	A, D											
	Perform QA/QC activities (see IIIb)	D											

Table 6.4-1 (continued)

				1999		2000				2001			
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
I	**1999 BASELINE ANNUAL AVERAGE EMISSION INVENTORY DEVELOPMENT (Continued)**	Agency											
	Update/Revise area source data	D											
	Submit updated total unreconciled emissions to ARB for district and ARB categories	A, D											
	Update total unreconciled emissions into CEIDARS	A											
	--point source emissions updated												
	--total unreconciled area source emissions updated												
	--area source emissions are calculated by subtracting point source emissions from total unreconciled area source emissions												
Ic	**FINALIZE AND DISTRIBUTE BASELINE INVENTORY**												
	Distribute the draft inventory and solicit comments from EICG participants	A, D											
	Make changes based on comments and recommendations and finalize the inventory	A, D											
II	**CONDUCT QA/QC ACTIVITIES**												
IIa	**DEVELOP QA/QC PLAN**												
	Develop draft emission inventory preparation plan	A	**C**										
	Collect district's QA procedures	A											
	Document ARB's QA procedures	A	**C**										
	Set data quality objectives	A, D											
	Identify areas in need of improvement based on EIIP	A, D											
	Identify problem areas from previous studies	A, D											
	Identify differences between districts	A, D											
	Identify ARB role and district roles	A, D											

Table 6.4-1 (continued)

				1999		2000				2001			
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
I	**1999 BASELINE ANNUAL AVERAGE EMISSION INVENTORY DEVELOPMENT (Continued)**	Agency											
	Draft outline of QA plans	A											
	Develop ARB audit/review process for district data	A											
IIb	**STATIONARY SOURCES - POINT**												
	Check the facility UTM data and assign UTM coordinates to facilities without them	D											
	Review facility UTM coordinates for accuracy	D	**C**[J]										
	Review stack data and stack UTMs	D											
	Verify SCC and SIC assignments	D											
	Review temporal data for completeness and accuracy (for example, monthly throughputs)	D											
	Ensure all the items from the QA plan are incorporated/implemented	A, D											
	QA the device and process information provided by each facility for reasonableness	D											
	QA emission calculation methodology	D, F											
	Quantify variability of all emissions estimates	D											
	Conduct visual checks, cross-check vital data, similar types of grouping	A, D											
	Engineering audit (for facilities failing QA/QC criteria)-verify supporting documentation, i.e. source tests, MSDS; verify district's databases; verify annual emission reports	D											
	Identify questionable emissions and reconcile errors	D											
	Review district data and conduct internal CEIDARS QA checks	A											
	Conduct a reality check by comparing with previous inventory	A, D											

Table 6.4-1 (continued)

				1999		2000				2001			
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
I	**1999 BASELINE ANNUAL AVERAGE EMISSION INVENTORY DEVELOPMENT (Continued)**	Agency											
II	**CONDUCT QA/QC ACTIVITIES (Continued)**												
	Determine if data quality objectives are met	A, D											
	Compare the 1999 inventory to previous modeling inventories	A, D											
	Compare 1999 gridded emissions vs. 1999 annual average emissions on selected categories	A											
IIc	**STATIONARY SOURCES - AREA**												
	Review temporal data for completeness and accuracy	A, D											
	Ensure all the items from the QA plan are incorporated/implemented	A, D											
	Check if appropriate surrogates were used to spatially allocate emissions	D											
	Ensure consistency between districts in calculating fugitive emissions	A											
	QA emission calculation methodology	A, D, F											
	Identify questionable emissions and reconcile errors	A, D											
	Conduct visual checks, cross-check vital data, similar types of grouping	A, D											
	Conduct a reality check by comparing with previous inventory and corresponding point sources	A, D											
	Review data and conduct internal CEIDARS QA checks	A											
	Compare 1999 gridded emissions vs. 1999 annual average emissions on selected categories	A											
IId	**MOBILE SOURCES - ON-ROAD**												
	Compare 1999 gridded emissions vs. 1999 summer seasonal emissions on selected categories	A											
	Validate the transportation model	C	??										
IIe	**MOBILE SOURCES - NON-ROAD**												
	Review OFFROAD model for reasonableness	A, D											

Table 6.4-1 (continued)

#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
I	**1999 BASELINE ANNUAL AVERAGE EMISSION INVENTORY DEVELOPMENT (Continued)**	Agency											
III	**DAY-SPECIFIC DATA COLLECTION**												
IIIa	**STATIONARY SOURCES - POINT**												
	Collect day-specific daily/hourly data for identified large point sources	D											
	Collect CEMS data for identified large point sources	D											
	Collect information on unusual events, breakdowns, variances, and temporary shutdowns for identified large point sources	D											
IIIb	**STATIONARY SOURCES - AREA**												
	Collect day-specific daily/hourly data for wildland fires/forest fires	A,CDF, BLM, BIA, NPS, USFS											
	Collect day-specific daily/hourly data for agricultural and prescribed burns	D											
IIIc	**MOBILE SOURCES - ON-ROAD**												
	Obtain hourly and daily traffic count data for freeways	CT,UCD											
???	Obtain daily average traffic count data (for surface streets)	C??											
???	Obtain heavy-duty truck traffic count data	C??											
IIId	**MOBILE SOURCES - NON-ROAD**												
	???												

Table 6.4-2

				1999		2000				2001			
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
IV	**2000 BASELINE MODELING INVENTORY DEVELOPMENT**												
IVa	**STATIONARY SOURCES - POINT**												
	SHORT-TERM												
	1. Create and review snapshot of most current growth and control factors	A,D							→				
	2. Grid 1999 point source emissions and project to 2000 using growth and control factors	A								→	→		
	LONG-TERM												
	1. Grid point source emissions from 2000 annual average inventory	A,D										→	
	2. Update the 2000 gridded inventory with day-specific 2000 emission data from large point sources	A,D	2002										
IVb	**STATIONARY SOURCES - AREA**												
	SHORT-TERM												
	1. Create and review snapshot of most current growth and control factors	A,D							→				
	2. Grid 1999 area source emissions and project to 2000 using growth and control factors	A								→	→		
	LONG-TERM												
	1. Grid area source emissions from 2000 annual average inventory	A,D										→	
	2. Update the 2000 gridded inventory with day-specific 2000 emission data from wildfires, agricultural and prescribed burns	A,D	2002										

Table 6.4-2 (continued)

				1999		2000				2001				
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
IV	**2000 BASELINE MODELING INVENTORY DEVELOPMENT (Continued)**													
IVc	**MOBILE SOURCES - ON-ROAD**													
	SHORT-TERM													
???	Run DTIM3 using EMFAC99	ALP												
	LONG-TERM													
	Create adjustment factors for freeway traffic count data	UCD	?											
	Check with each COG on schedule for transportation plan updates	ALP	?											
	Obtain inputs from COG and provide ARB with the inputs	ALP	?											
???	Develop inventory of heavy-duty diesel trucks	??												
	Run DTIM3 using EMFAC99	ALP												
IVd	**MOBILE SOURCES - NON-ROAD**													
	SHORT-TERM													
	1. Create and review snapshot of most current growth and control factors	A,D							→					
	2. Grid 1999 area source emissions and project to 2000 using growth and control factors	A								→	→			
	LONG-TERM													
	1. Grid area source emissions from 2000 annual average inventory	A,D										→		
	2. Update the 2000 gridded inventory with day-specific 2000 emission data from wildfires, agricultural and prescribed burns	A,D	2002											

Table 6.4-2 (continued)

				1999		2000				2001			
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
IV	**2000 BASELINE MODELING INVENTORY DEVELOPMENT (Continued)**												
IVe	**ALL OF THE ABOVE (STATIONARY AND MOBILE) SOURCES**												
	Compare 1999 gridded emissions vs. 1999 annual average emissions on selected categories	A											
	Compare 2000 gridded emissions vs. 2000 annual average emissions on selected categories	A	2002										
IVf	**BIOGENIC SOURCES**												
	Evaluate previous biogenic inventories for domain	A											
	Evaluate available vegetation distribution databases	A											
	Evaluate available land use data	A											
	Standardize vegetation and land use designations among data bases	A											
	Assemble biogenic and land use data on GIS platform	A											
	Conduct ground surveys to validate plant species distributions	COOP											
	Acquire 30 meter resolution satellite imagery from which LAI (Leaf Area Index) can be calculated	A?											
	Perform ground-based surveys to validate LAI developed from statellite imagery	COOP											
	Review existing literature and develop a database of leaf mass density values for the most important vegetation species	A											
	Perform field studies to experimentally determine leaf mass density values for those commonly occurring species for which leaf mass density values have not yet been measured	COOP?											
	Compile a database of VOC emission rates	A											
	Assign emission rates using a taxonomic method for those species for which emission rate measurements are not available.	A											

Table 6.4-2 (continued)

				1999		2000				2001			
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
IV	**2000 BASELINE MODELING INVENTORY DEVELOPMENT (Continued)**												
	Use GIS to develop domain-wide gridded green leaf mass inventory	A											
	Apply biogenic model to generate domain-wide speciated gridded biogenic emission inventory	A											
V	**INTEGRATION OF DAY-SPECIFIC INFORMATION**												
Va	**STATIONARY SOURCES - POINT**												
	Choose ~15 intensive days for data collection	TC											
	Compile emission and stack data for intensive days plus 1 day before intensive days	D											
	Choose episode days to model	TC											
	Convert and submit day-specific emission and stack data to ARB in MEDS records and stack format	D											
	Integrate day-specific inventory data	A	2002										
Vb	**STATIONARY SOURCES - AREA**												
	Choose ~15 intensive days for data collection	TC											
	Compile wildland/forest fires data for intensive days plus 1 day before intensive days	A											
	Compile agricultural and prescribed burn fires data for intensive days plus 1 day before intensive days	D											
	Choose episode days to model	TC											
	Convert day-specific wildland/forest fires data in MEDS records	A											
	Convert day-specific agricultural and prescribed burn fires data in MEDS records	D											
	Integrate day-specific inventory data	A	2002										

Table 6.4-2 (continued)

				1999		2000				2001			
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
IV	**2000 BASELINE MODELING INVENTORY DEVELOPMENT (Continued)**												
Vc	**MOBILE SOURCES - ON-ROAD**												
	Choose ~15 intensive days for data collection	TC											
	Compile freeway traffic count data, average daily street traffic data ??, and heavy-duty vehicle traffic data ?? for intensive days plus 1 day before intensive days	UCD											
	Choose episode days to model	TC											
	Develop travel adjustment factors for (freeways)traffic count collected data	UCD											
V	**INTEGRATION OF DAY-SPECIFIC INFORMATION (Continued)**												
???	Develop travel adjustment factors for (surface streets) from average daily traffic data	C											
???	Develop inventory of heavy vehicles	C											
	Submit day-specific data in MEDS records	ALP											
	Integrate day-specific inventory data	A	2002										
Vd	**MOBILE SOURCES - NON-ROAD**												
	???												

Table 6.4-2 (continued)

				1999		2000				2001			
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
IV	**2000 BASELINE MODELING INVENTORY DEVELOPMENT (Continued)**												
VI	**RESEARCH CONTRACTS**												
	1) Solvent Cleaning/Degreasing Source Category Emission Inventory	A, C	**C**										
	2) Industrial Surface Coating-Wood Furniture and Fixtures Emission Inventory	A, C	**C**										
	3) Improvement of Speciation Profiles for Architectural and Industrial Coating Operations	A, C	**C**										
	4) Improvement of Speciation Profiles for Aerosol Coating	A, C											
	5) Emission Forecasting System Redesign	A, C											
	6) Recreational Boating Activity Trends	A, C	**C**										
	7) Marine Vessel Emission Inventory & Control Strategies	C	**C**										
	8) CCOS Domain Traffic Count Scoping Study	UCD											
	9) Collection and Analysis of Day-Specific Traffic Count Information for the CCOS Modeling Domain	UCD											
	10) Integration of Transportation Data for CCOS Domain and Run DTIM for Entire Modeling Domain	ALP											
	11) Develop Baseyear and Future Year Gridding Surrogates for Spatial Distribution of Area and Off-Road Mobile Source Emission Categories	C											
	12) Emission Inventory Validation Studies Using On-Road Vehicle Remote Sensing	C											
	13) Development of VOC Speciation Profiles	C											
	14) Development & Validation of Databases for Modeling Biogenic Hydrocarbon Emissions in California Airsheds	UCLA											
	15) Leaf Area Index (LAI) Derived from Satellite Spectral Observation		**C**										

Table 6.4-2 (continued)

				1999		2000				2001			
#	PROJECT			Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
IV	**2000 BASELINE MODELING INVENTORY DEVELOPMENT (Continued)**												
	16) Whole Ecosystem Measurements of Biogenic Hydrocarbon Emissions	UCB	**?**										
	17) Leaf Mass & Vegetation Species Validation Field Study for San Joaquin Valley	COOP	**?**										
	18) Development of a Gas and Particulate Matter Organic Speciation Profile Database	C											
	19) Development of Emissions Activity Data in Support of CRPAQS Annual and Episocid Field Studies	C											
VII	**COMPUTER PLATFORM**												
	Agree on the format for data transfer	A, D	**C**										
	CEFS for forecasting the baseline inventory??	A											
VIII	**FUTURE YEAR GRIDDING EMISSION INVENTORY**												
IX	**FOOTNOTES**												
	A= ARB, D=District, STI=Sonoma Technology Inc., UCD=UC Davis, ALP=Alpine Geophysics, F=Facility, CT=Caltrans, C=Contractor,												
	COG=Council of Government, TC=CCOS Technical Committee, UCLA=University of California at Los Angeles, UCB=University of California at Berkeley,												
	COOP=University of California Cooperative Extension, EICG=Emission Inventory Coordination Group, EIIP=Emission Inventory Improvement Program												
	CDF=California Department of Forestry, USFS=United States Forest Service, NPS=National Park Service, BIA=Bureau of Indian Affairs,												
	BLM=Bureau of Land Management, CEFS=California Emission Forecasting System												
	C=Task Completed () = Proposed Responsible Agency	**C**^{S}= Task completed by Sacramento Metro AQMD											
	C^{J}= Task completed by San Joaquin Valley Unified APCD	**C**^{B}= Task completed by Bay Area AQMD											
	C^{A}= Task completed by ARB												

7.0 MANAGEMENT, SCHEDULE, AND BUDGET

This section specifies the management structure and the roles of CCOS committees and working groups, the responsibilities of field study participants, and the schedule of milestones for the CCOS field study and related activities. It also provides an itemized account of actual costs and an inventory of equipment purchased with CCOS funds.

7.1 CCOS Management Structure

The CCOS is a large-scale program involving many sponsors and participants. Three entities are involved in the overall management of the Study. The San Joaquin Valleywide Air Pollution Study Agency, a joint powers agency (JPA) formed by the nine counties in the Valley, directs contracting aspects of the Study. A Policy Committee comprised of four voting blocks: State, local, and federal government, and the private sector, provides guidance on the Study objectives and funding levels. The Policy Committee approves all proposal requests, contracts and reports. A Technical Committee parallels the Policy Committee in membership and provides overall technical guidance on proposal requests, direction and progress of work, contract work statements, and reviews of all technical reports produced from the study. The leadership roles in the CCOS field study include the principal investigators, the field coordinator, the quality assurance officer, the data manager, the measurement investigators, the CCOS/CRPAQS technical committee, and the CCOS/CRPAQS policy committee. On a day-to-day basis, the California Air Resources Board (ARB) is responsible for management of the Study under the direction of the Program Manager, Chief of the Modeling and Meteorology Branch, in the ARB's Planning & Technical Support Division.

7.1.1 Policy Committee

The policy committee is composed of senior management representatives from local, state, and federal regulatory agencies and private sector stakeholders. It provides the following policy and financial direction to the project.

- Provides the overall direction for the study and establishes study policy goals and objectives.
- Evaluates CCOS technical components for their relevance to future policy decisions and assure an adequate balance among those components.
- Monitors CCOS budgets, schedules, and product quality to assure fiduciary responsibility and fulfillment of commitments.
- Requests, justifies, and obtains sufficient sponsorship to complete defined activities that will achieve CCOS objectives.
- Reviews and evaluates policy-relevant CCOS findings, provides constructive recommendations for their expression, and conveys these findings to stakeholders.

8.0 REFERENCES

Altshuler, S.L., T.D. Arcado, and D.R. Lawson. (1995). Weekend vs. Weekday Ambient Ozone Concentrations: Discussion and Hypotheses with Focus on Northern California. *J. Air Waste Manage. Asso*c., 45, 967-972.

Blier, W., A.M. Winer, D. Hansen and R. Chavira (1998). Analysis of Weekday/Weekend Differences in Ambient Air Quality and Meteorology in the South Coast Air Basin. Draft final report prepared by the Department of Atmospheric Sciences and Environmental Science and Engineering, University of California, Los Angeles for the California Air Resources Board, Sacramento CA, under contract No. 95-334, February, 1998

Elkus, B. and K.R. Wilson (1977). Photochemical Air Pollution: Weekend-weekday differences. *Atmospheric Environmen*t, 11, 509-515.

Environmental Test Laboratory, 1994: A multi-year observational study of atmospheric transport corridors and processes in California. Prepared for the California Air Resources Board by ETL/NOAA 325 Broadway, Boulder CO 80303, May 1994.

EPA. Guideline for reporting of daily air quality – air quality index (AQI). EPA-454/R-99-010, July 1999. Research Triangle Park, NC, U.S. EPA, OAQPS.

Fairley, D. and R. DeMandel, 1996: An Analysis of SARMAP Episode Day Representativeness, Final report. Prepared for the SARMAP Data Analysis Project by the Bay Area Air Quality Management District, San Francisco, CA, Faust, B. C., Photochemistry of clouds, fogs and aerosols, Environ. Sci. Technol., 28A, 217, 1994.

Fan, Q., and P. K. Dasgupta (1994). Continuous automated eetermination of atmospheric formaldehyde at the parts per trillion level, *Anal. Che*m. 66, 551-556.

Fujita, E., R. Keislar, W. Stockwell, S. Tanrikulu, A. Ranzieri, H. Moosmuller, D. DuBois, D. Koracin, B. Zielinska, 1999: Central California Ozone Study, Volume I, Conceptual Program Plan, Version 3. Prepared for the California Air Resources Board by Desert Research Institute, Reno, NV, November 24, 1999.

Fujita, E.M., R.E. Keislar, J.L. Bowen, W. Goliff, F. Zhang, L.H. Sheetz, M.D. Keith, J.C. Sagebiel, and B. Zielinska (1999). 1998 Central Texas On-Road Hydrocarbon Study. Draft final report prepared for the Texas Department of Transportation, Austin, TX under subcontract to PBS&J, Austin, TX, March, 1999.

Hayes, T.P., J.J.R. Kinney and N.J.M. Wheeler, 1984: California Surface Wind Climatology, California Air Resources Board, Sacramento, CA.

Horie, Y., J. Cassmassi, L. Lai, and L. Gurtowski. (1979). Weekend/Weekday Differences in Oxidants and Their Precursors. Report prepared by Technology Services Corporation for the U. S. Environmental Protection Agency under Contract No. 68-02-2595.

Levitt, S.B., and D.P. Chock (1976). Weekend-Weekday Pollutant Studies of the Los Angeles Basin. *J. Air Poll. Control Asso*c., 26, 1091-1092.

Ludwig, F.L., J. Jiang, and J. Chen, 1995: Classification of Ozone and Weather Patterns Associated with High Ozone Concentrations in the San Francisco and Monterey Bay

Areas. Atmospheric Environment: Special Issues for the Regional Photochemical Measurement and Modeling Studies Specialty Conference, 29(21):2915-2928.

Mueller, P.K., G.M. Hidy, J.G. Watson, R.L. Baskett, K.K. Fung, R.C. Henry, T.F. Lavery and K.K. Warren (1983). *The Sulfate Regional Experiment: Report of Findings*, Volumes 1,2,3. EPRI Report EA-1901, Electric Power Research Institute, Palo Alto, CA.

Roberts, P. T., C.G. Lindsey, and T.B. Smith, 1994: Analyses of San Joaquin Valley Air Quality and Meteorology. Planning and Managing Regional Air Quality Modeling and Measurement Studies: A Perspective Through the San Joaquin Valley Air Quality Study and AUSPEX, ed. by P. A. Solomon. Published by Lewis Publishers, Chelsea, MI in conjunction with Pacific Gas and Electric Company, San Ramon, CA, pp. 483-506.

Roberts, P.T., S. Musarra, T.B. Smith, and F.W. Lurmann (1992) A Study to Determine the Nature and Extent of Ozone and Ozone Precursor Transport in Selected Areas of California. Prepared for California Air Resources Board, 2020 L Street, Sacramento, CA. Prepared by Sonoma Technology, Inc, Santa Rosa, CA, April 1992.

Smith, T. B., 1994: Ozone Episode Forecasting in the San Joaquin Valley. Planning and Managing Regional Air Quality Modeling and Measurement Studies: A Perspective Through the San Joaquin Valley Air Quality Study and AUSPEX, ed. by P. A. Solomon. Published by Lewis Publishers, Chelsea, MI in conjunction with Pacific Gas and Electric Company, San Ramon, CA, pp. 507-528.

Stoeckenius, T.E. (1998) Development of an Ozone forecasting Model for the San Joaquin Valley, Paper # 98-WA59.05. Presented at the Air and Waste Management Association's 91st Annual Meeting & Exhibition, June 14-18, 1998, San Diego, CA.

Stoeckenius, T.E., P.T. Roberts, and L.R. Chinkin (1994) Development of an objective classification procedure for the Bay Area flow types representing ozone-related source-receptor relationships. ARB/R-94/547. Prepared by Systems Applications International and Sonoma Technology, Inc. for the California Air Resources Board.

Stoeckenius, T.E., P.T. Roberts, and L.R. Chinkin (1994) Development of an objective classification procedure for the Bay Area flow types representing ozone-related source-receptor relationships. ARB/R-94/547. Prepared by Systems Applications International and Sonoma Technology, Inc. for the California Air Resources Board.

Walker, J.S. "Tropospheric ozone concentration trends by day of the week," Paper FM2-III6, presented at the International Conferences and Course: Regional Photochemical Measurement & Modeling Studies, San Diego, CA, November 8-12, 1993.

Watson, J.G., P.J. Lioy and P.K. Mueller (1995). The Measurement Process: Precision, Accuracy, and Validity. In *Air Sampling Instruments for Evaluation of Atmospheric Contaminants,* 8th ed., S.V. Hering, Ed. American Conference of Governmental Industrial Hygienists, Cincinnati, OH, pp. 187-194.

Watson, J.G., P.J. Lioy and P.K. Mueller (1989). The Measurement Process: Precision, Accuracy, and Validity. In *Air Sampling Instruments for Evaluation of Atmospheric Contaminants* (7th Ed.), S.V. Hering, ed. American Conference of Governmental Industrial Hygienists, Cincinnati, OH, pp. 51-57.

Watson, J.G., P.J. Lioy and P.K. Mueller (1983). The Measurement Process: Precision, Accuracy and Validity. In *Air Sampling Instruments for Evaluation of Atmospheric Contaminants*, p. L-2 (6th Ed.), P.J. Lioy and M.J.Y. Lioy, eds. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

Watson, J.G., D.W. DuBois, R. DeMandel, A. Kaduwela, K. Magliano, C. McDade, P.K. Mueller, A. Ranzieri, P.M. Roth, and S. Tanrikulu (1998). "Aerometric Monitoring Program Plan for the California Regional $P_{M2.5}/P_{M10}$ Air Quality Study." Prepared by the Desert Research Institute for the CRPAQS Technical Committee, December, 20, 1998.

Whittig, B, H.H Main, P.T. Roberts, S.B. Hurwitt (1999) Analysis of PAMS data in California Volume III: Trends analysis of California PAMS and long-term trend air quality data. Final Report STI-998393-1885-FR prepared by Sonoma Technology, Inc., Petaluma, CA. WMO, Scientific Assessment of Ozone Depletion: 1994, *World Meteorological Organization Global Ozone Research and Monitoring Project - Report 37*, Geneva, 1994.

Whittig, B, H.H Main, P.T. Roberts, S.B. Hurwitt, 1999: Analysis of PAMS data in California Volume III: Trends analysis of California PAMS and long-term trend air quality data. Final Report STI-998393-1885-FR prepared by Sonoma Technology, Inc., Petaluma, CA, May 1999.

- Approve contracts to be funded by the JPA.
- Direct fund-raising efforts.

7.1.2 Technical Committee

The CCOS is directed by a technical committee that comprises staff from the California Air Resources Board (ARB), the California Energy Commission (CEC), local air pollution control agencies, industry, and other sponsoring organizations with technical input from a consortium of university researchers in the University of California System and the Desert Research Institute (DRI). All contractors working on CCOS report directly to the Technical committee. Members of the planning subcommittee are listed on the title page of this conceptual program plan. This committee provides the following technical direction to the project.

- Reviews each of the plans and recommends the final technical scope of each of these program elements.
- Prepares and disseminates requests for proposals for necessary work elements and evaluates the proposals received.
- Commissions and evaluates CCOS technical reports and publications.
- Creates and monitors overall project schedules and budgets, evaluates compromises between project needs and budget allocations, and institutes remedial actions where needed.
- Institutes, facilitates, and coordinates CCOS research activities with complementary activities sponsored by the local air quality management districts (i.e. BAAQMD), California Air Resources Board, U.S. Environmental Protection Agency (Region IX, ORD, and OAQPS), the Department of Defense (Naval Weapons Center), Department of Agriculture, and industrial research sponsors (EPRI, CRC, WSPA, API).
- Participates in, to the extent possible, CCOS data acquisition, data analysis, and modeling activities.
- Disseminates CCOS scientific findings in scientific forums, national guidance documents, and peer-reviewed publications.

7.1.3 Principal Investigators

The principal investigators (Andrew Ranzieri and Saffet Tanrikulu of the California Air Resources Board and Eric Fujita of the Desert Research Institute) provide scientific and technical guidance for the Central California Ozone Study. Responsibilities include:

- Create initial study protocols for data analysis, modeling, emissions characterization, and field studies, and modify them in response to external evaluation and technical support study results.

- Prepare work statements for project components.

- Working with the Technical Committee, critically review CCOS technical products and provide constructive recommendations for improvement and focus on CCOS goals and objectives.

- Keep informed of developments and findings in programs external to CCOS and incorporate that knowledge into CCOS planning and execution.

- Devise and refine conceptual models of elevated ozone in central California and assess the extent to which mathematical models simulate the physical and chemical mechanisms embodied in these concepts.

- Disseminate CCOS scientific findings in scientific forums, national guidance documents, and peer-reviewed publications. Promote and facilitate the dissemination of specific research projects among other CCOS participants.

7.1.4 Field Study Management Team

The CCOS Management Team is responsible for making the go/no-go decisions during the CCOS primary study period (see Section 3.3). The Management Team consists of senior technical representatives from the ARB (Don McNerny and Andrew Ranzieri), BAAQMD (Rob DeMandel), SMAQMD (Bridget Tollstrup), and SJVUAPCD (Dave Jones) with input from the Forecast Team leader (Saffet Tanrikulu) and the CCOS Field Manager (Eric Fujita).

7.1.5 Meteorological Working Group and Forecast Team

A Meteorological Working Group (MWG) was established to update information regarding the meteorological scenarios associated with ozone exceedances in various areas of the modeling domain. This team includes representatives from the ARB, BAAQMD, SMAQMD, and SJVUAPCD (see page ii). The CCOS Forecast Team was formed from the MWG (see Section 3.2). The forecast team develops the Forecast Plan in conjunction with the field manager, reviews meteorological data, and provides consensus forecasts to the CCOS Management Team. The forecast team also documents the daily meteorological conditions during the study.

7.1.6 Field Manager

The implementation and coordination of the experimental phase of the CCOS will be the responsibility of the field manager (Eric Fujita, Desert Research Institute).

- Select sampling sites based on the monitoring purposes and criteria stated in this plan and document those sites with respect to their location and surroundings.

- Maintain current information on equipment procurement and installation, quality assurance, schedule, and budget sections of the field operations plan.

- Prepare work statements for different components of the field measurement program.

- Establish an efficient communications network, including a project roster of names, addresses, phone numbers, fax numbers, and e-mail addresses among other field study participants and apply that network to convey needed information among the participants.

- Participate in the evaluation of technical proposals from measurement investigators and provide perspective on the likelihood that different measurement alternatives will accomplish measurement objectives.

- Identify and resolve communications difficulties among measurement investigators, the data manager, and the quality assurance officer to assure that audit findings are corrected and documented and that data flow efficiently and smoothly into the project database.

- Develop a protocol to disseminate go/nogo and abort decisions.

- The field coordinator is responsible for seeing that the planned quality assurance program is implemented, measurement plans are followed, and corrective action is taken immediately as problems arise.

- Document measurement activities and field program activities in a formal report. This report will include site descriptions and a list of participants and measurement activities, as well as a daily log of events during intensive studies. It will incorporate the relevant information from the field protocol document, as well as the pertinent information from the field project log including but not limited to daily forecasts, and a daily log of measurement activities.

7.1.7 Field Facilities Coordinator

Installation of required infrastructure at CCOS supplemental air quality and meteorological sites is the responsibility of the Field Facilities Coordinator (Chuck McDade, ENSR). In addition to evaluating proposed study sites, the role of siting also includes obtaining all necessary permits, meeting indemnification and insurance requirements for access, ensuring compliance with local and state environmental and safety regulations, and arranging for study needs at the site, including trailers, fencing, power and telephone.

7.1.8 Quality Assurance Manager

The quality assurance manager provides direction, coordination, and documentation of measurement accuracy, precision, and validity. Specifically, the quality assurance officer will:

- Prepare a quality assurance program plan that specifies systems and performance auditing methods, intercomparison methods, primary and transfer standards, schedules, audit reporting formats, feedback to measurement investigators, and methods to verify that remedial actions have been taken.

- Assemble and direct a quality assurance team with specialized expertise and equipment in evaluating precision, accuracy, and validity of established and developing measurement methods. Deploy this team to conduct systems and performance audits, assemble the results, provide feedback to measurement investigators, and verify that remedial actions have been implemented.

- Analyze data from collocated or nearby air quality and meteorological measurement systems to estimate precision, equivalence, and predictability among measurements. Identify environmental and atmospheric composition conditions under which values for these attributes are acceptable and unacceptable.

- Identify, obtain, and evaluate standard operating procedures for methods to be applied during field studies.

- Evaluate data qualification statements prepared by measurement investigators.

7.1.9 Measurement Investigators

Measurement investigators are responsible for specialized CCOS measurements. Specifically, measurement investigators will:

- Specify and procure (or construct) monitoring devices and verify their adequacy for operation under conditions anticipated during CCOS field monitoring.

- Specify for the field manager space, power, supplies, storage, shipping/receiving, environmental, and communications requirements for each monitoring site at which the investigator's measurements will be acquired.

- Develop or adapt standard operating procedures and checklists and participate in training of site operators, or supply specially-trained site operators as needed.

- Install and calibrate instruments at the measurement sites and remove them after study completion.

- Supply expendables needed to maintain measurement schedules.

- Monitor network operations, in collaboration with the field coordinator, identify and remediate deficiencies.

- Evaluate and remediate system and performance audit findings and document that remediation.

- Regularly acquire raw measurements to evaluate monitor performance. Periodically reduce data, validate it at Level 1A, and deliver it in the prescribed formats to the data manager.

- Prepare a summary of monitoring methods, data and validation results, and measurement activities when measurements have been completed. Prepare data quality statements that evaluate the accuracy, precision, validity, and completeness of the measurements acquired during each phase of the field study.

7.1.10 Emissions Inventory Working Group

There are about 30 districts in the CCOS modeling domain. Each local air district in the state updates a portion of the emission inventory for their area. To help coordinate this effort, the Emission Inventory Coordination Group (EICG) has been established to determine the process for preparing the emission inventories needed to support air quality modeling for CCOS. Participants in the group include many local air districts, several local councils of government, Caltrans, California Energy Commission, and the ARB. Local air districts participating to date include San Joaquin Valley Unified APCD, Bay Area AQMD, Sacramento Metropolitan AQMD, Mendocino County AQMD, Northern Sierra AQMD, Yolo-Solano AQMD, Placer County APCD, San Luis Obispo County APCD, and Monterey Bay Unified APCD. The EICG is chaired by Linda Murchison and Dale Shimp of the Air Resources Board.

7.1.11 Data Manager

The data manager (Greg O'Brien, ARB) will establish and maintain computer-based data archives and communications. Specifically, the data manager will:

- Review and revise the data management section of this plan as changes are made to data reporting, structure, and retrieval conventions.

- Define and procure hardware and software needed to successfully complete the data management tasks.

- Prepare statements of work and direct data management support investigators to assist in the accomplishment of data management tasks.

- Establish a CCOS web page with links to: 1) long-term data archives; 2) electronic copies of CCOS reports and documents (electronic form); 3) CCOS participants' roster, roles, and websites (where available); and 4) standard operating procedures; 5) data receipt archives; 6) CCOS field study data archives; and 7) measurement sites and observables.

- Develop, apply, and document efficient and modern methods for receiving, processing, and delivering data from and to measurement, data analysis, and modeling investigators.

- Perform Level 1B validation tests. Apply Level II and III validation adjustments and flags.

7.1.12 Data Analysis and Modeling Investigators

Data analysis and modeling investigators will use the integrated data set to perform Level 2 and Level 3 data validation, to further answer the questions posed in Section 3, and to develop, evaluate, and apply source and receptor models. Several of the data analysis activities, especially those involved with determining Level 2 validation status of measurements and descriptive analysis of the measurements, are best performed by the measurement investigators. Specifically, data analysis and modeling investigators will:

- Evaluate the consistency of measurements, i.e. Level 2 validation.
- Describe statistical, temporal, and spatial distributions of measurements on average and during episodes.
- Interpret data to address data analysis objectives specified in Section 1.2.
- Recommend revisions to the conceptual models in Section 3 of the Field Study Plan (Fujita et al., 1999), elaborating on the dominance and validity of chemical and physical mechanisms and the importance of different pollution sources.
- Use field measurements in meteorological and air quality source and receptor models to evaluate the extent to which they represent the identified mechanisms and emissions.
- Use field measurements to establish base cases for several different episodes of maximum concentration to evaluate the effects of different emissions reduction strategies.
- Identify data deficiencies and initiate Level 3 validation checks and corrections with the data manager.
- Select the most suitable modeling systems (for meteorology, emissions, and air quality) for representing photochemical air pollution in central and northern California.
- Specify model domain boundaries, boundary conditions, initial conditions, chemical mechanisms, aerosol module, plume-in-grid module, grid sizes, layers, and surface characteristics.
- Identify performance evaluation methods and performance measures, and specify methods by which these will be applied.
- Evaluate the results of the meteorological model.
- Perform operational evaluation of the air quality model.
- Evaluate and improve the performance of emissions, meteorological, and air quality simulations. Apply simulation methods to estimate ozone concentrations at receptor sites and to test potential emissions reduction strategies.

- Identify the limiting precursors of ozone and assess the extent to which reductions in volatile organic compounds and nitrogen oxides, would be effective in reducing ozone concentrations.

- Characterize the structure and evolution of the boundary layer and the nature of regional circulation patterns that determine the transport and diffusion of ozone and its precursors in northern and central California.

- Identify and describe transport pathways between neighboring air basins, and estimate the fluxes of ozone and precursors transported at ground level and aloft under differing meteorological conditions. Reconcile results with flux plane measurements.

- Determine the contribution of ozone generated from emissions in one basin to federal and state exceedances in neighboring air basin through emission reduction sensitivity analysis.

7.2 Schedule

Table 7.2-1 provides milestones for CCOS field study and related activities. This schedule is integrated with the master project schedule that includes emissions and modeling activities. The overall time scale shown is four years.

7.3 Budget

The total budget for CCOS is $8,170,000. Contract and other costs are itemized in Table 7.3-1. Tables 7.3-2 and 7.3-3 itemize the cost of equipment and supplies purchased from the CCOS equipment and contingency funds, and equipment supplied through contracts and CRPAQS, respectively. In addition to the above contract costs, the ARB and the local APCD's are committing in-kind resources for planning and execution of CCOS. Estimates of in-kind costs are estimated by multiplying the projected level of effort (in hours) by a nominal hourly rate. In-kind costs include additional efforts that are specifically required during CCOS and does not include data collection and analysis associated with normal daily operations (e.g., PAMS and other aerometric monitoring programs). The in-kind costs total $1,369,000, which does not include substantial leveraging of resources that will be available from CRPAQS. Participation of the Department of Energy Gulfstream 159 (G-1) aircraft is funded through the Atmospheric Chemistry Program.

Table 7.2-1
CCOS Schedule of Milestones

Activity/Milestone	Completion Date
Planning and Preparation	
Preparation of preliminary scope of work by ARB.	1/31/99
Draft Field Study Plan presented	6/11/99
Revised draft of Field Study Plan available on CCOS web site	9/7/99
Release requests for proposals for field operations	11/15/99
Final Field Study Plan available on CCOS web site	11/30/99
Selection of supplemental monitoring sites	1/15/00
Contractor selection	1/7/00
Executable Contracts	2/15/00
Draft CCOS Field Operations Plan	5/5/00
Final CCOS Field Operations Plan	5/25/00
Supplemental air quality site installation	5/15/00 to 6/23/00
Practice forecast begin	5/15/00
CCOS Field Measurement	
CCOS meteorological measurements begin	6/1/00
Daily meteorological forecasts	6/15/00 to 9/2/00
S0 level measurements begin	6/15/00
S1, S2 and R level measurements begin	6/30/00
IOP (15 days)	7/6/00 to 9/2/00
CCOS air quality measurements end	9/15/00
CCOS meteorological measurements end	9/30/00
Draft documentation of field activities by DRI	10/15/00
Final summary of field monitoring activities by DRI	12/15/00
Data Validation, Data Analysis and Modeling	
Quality audit report by QA Contractor	12/15/00
Level 1 Data Archive	4/31/01
Level 2 Data Validation	6/30/01
Data Analysis/Emissions/Modeling	
Data analysis	12/31/01
Emission inventory development	9/31/01
Model improvements	9/31/01
Base-case simulations (model performance, diagnostic/sensitivity testing)	3/31/02
Future year emission inventory and sensitivity simulations	9/30/02

Table 7.3-1
CCOS Contracts and Other Costs

Project	Organization	Principal Investigator		Amount
Upper-air meteorology	NOAA-ETL	Bill Neff	$	570,000
Suface and upper-air meteorology	NOAA-ARL	Jerry Cresenti	$	122,801
Upper-air meteorology	STI	Tim Dye	$	425,000
Rawinsonde and ozonesondes	T&B Systems	Don Lehrman	$	195,125
Sodar and met station operations	PG&E	Sam Altshuller	$	19,800
Sonic Anemometer	UCD		$	7,700
Monitoring site set up	ENSR	Chuck McDade	$	232,000
CCOS field operations/contingency	DRI	John Bowen	$	672,000
Equipment purchase	JPA		$	1,382,000
CCOS field operations	T&B Systems	Don Lehrman	$	47,451
CCOS field operations	UC Riverside	Denis Fitz	$	62,916
CCOS field operations	UC Berkeley	Rob Harley	$	17,000
NOx, NH3, formaldehyde	CE-CERT	Denis Fitz	$	288,000
ELIGHT (Ozone Lidar)	ELIGHT		$	11,000
Bay Area AQ and Met	T&B Systems	Don Lehrman	$	254,461
Aircraft measurements	UCD	John Carrol	$	355,000
Aircraft measurements	STI	Don Blumenthal	$	483,150
Aircraft measurements (plume study)	TVA	Roger Tanner	$	253,437
Twin Otter rental for plume study	JPA		$	57,488
VOC Canister Analysis	BRC	Rei Rasmussen	$	307,000
Automated VOC measurements	DRI	Barbara Zielinska	$	419,187
VOC Canister Analysis	DRI	Barbara Zielinska	$	346,316
Carbonyl measurements	AtmAA	Kochy Fung	$	318,850
Planning and Field Management	DRI	Eric Fujita	$	150,000
Quality Assurance	Parsons Eng	Dave Bush	$	200,000
ARB-MLD travel funds for QA audits	ARB-MLD	Mike Miguel	$	23,000
Data Management			$	75,000
Data validation	DRI	Eric Fujita	$	160,000
Biogenic Emissions	UC Extension		$	80,000
District assistance - emission inventory	UC Davis		$	40,000
Power Plant source sampling	UCR CE-CERT	Denise Fitz	$	38,511
Area source emissions/district assistance	STI	Lyle Chinkin	$	210,000
Traffic counts	UCD	Debra Neimier	$	275,000
Plume modeling	AER	Christian Seigneur	$	19,800
Retrospective SIP	Envair	Phil Roth	$	50,000
Totals			$	8,168,993

Table 7.3-2
Equipment and Supplies from CCOS Equipment Budget and Contingency Fund

	Actual Purchases				Current Status Information		
Equipment	PO #	Unit Cost	Units	Total Cost [1]	No. Rcvd	Paid to Date	Notes
Ozone	2000-009	$ 5,503	11	$ 65,211	10		
NO, NOx	2000-004	$ 10,600	2	$ 22,843			
NO, NOy	2000-002	$ 15,740	19	$ 322,237			
NOy, NOy*	2000-003	$ 17,950	3	$ 58,023			
CO (High Sensitivity)	2000-008	$ 8,150	3	$ 26,345	3		Received complete order
CO2	2000-007	$ 7,995	3	$ 25,844	3		Received complete order
Auto GC/MS		$ 95,150	2	$ 205,050			
Cont. HCHO	2000-001	$ 16,482	8	$ 142,003			
2-pi Diode Array Spectrometer	2000-015		3	$ 78,882			
Calibrator I	2000-005	$ 7,755	15	$ 125,340	15		Received complete order
Calibrator II	2000-011	$ 14,500	3	$ 47,141	3		Received complete order
Data Logger I	2000-010	$ 2,556	19	$ 41,278	15		Received complete order
Zero Air 1	2000-006	$ 2,600	15	$ 42,023	12		
Zero Air 2	2000-020	$ 4,650	3	$ 15,532	3		Received complete order
Regulator 1	2000-012	$ 285	28	$ 8,618			
Regulator 2	2000-012	$ 162	3	$ 524			
Regulator 3	2000-012	$ 162	9	$ 1,571			
Cylinder 1 40 ppm NO	2000-013	$ 342	19	$ 7,170	19		Received complete order
Cylinder 2 20 ppm NPN	2000-013	$ 347	5	$ 1,914	5		Received complete order
Cylinder 3 400 ppm CO	2000-013	$ 253	3	$ 844	3		Received complete order
Cylinder 4 300 ppm CO2	2000-013	$ 322	6	$ 2,135	6		Received complete order
Cylinder 5 600 ppm CO2	2000-013	$ 322	6	$ 2,135	6		Received complete order
Cylinder 6 Ultrapure N2	2000-013	$ 262	6	$ 1,747	6		Received complete order
HNO3 Perm Tube	2000-014	$ 129	3	$ 427	3		Received complete order
Supplies (Teflon sampling lines, Teflon filters, ss tubing and connectors)	2000-016, -017, -019			$ 15,836			
Other supplies	2000-018, -021, -022			$ 1,372			
Data acquisition computer				$ 6,818			ARB purchase (4/28/00)
TOTAL				**$ 1,268,862**			
BUDGET				**$ 1,287,000**			
BALANCE				**$ 18,138**			

[1] Includes sales tax on all except shipping and handling.

~~Additional Required Equipment (Purchased from Contingency Funds)~~

TEI Model 146C calibration system	$ 7,925	4	$ 31,700	
Rack Mounts for Type C analyzers	$ 170	23	$ 3,910	
Rack Mounts for TEI Model 111 Zero Air System	$ 170	5	$ 850	
TEI Model 111 Zero Air System	$ 2,770	1	$ 2,770	
Refrigerators	$ 150	15	$ 2,250	
Chemical Waste Containers	$ 50	8	$ 400	
Soda lime (CO2 scrubber)	$ 75	3	$ 225	
Filter holders	$ 55	9	$ 495	
Data transfer cell phone	$ 630	3	$ 1,890	
Cell phone antenna	$ 157	3	$ 471	
			$ 44,961	

Table 7.3-3
Equipment from CCOS Contracts and CRPAQS Equipment Budget

Equipment	Group	Units	Unit Cost	Total Cost
NO2, PAcNs	CE-CERT	8	$ 17,000	$ 136,000
Cont. NO3-	CRPAQS (1)	3	$ 40,000	$ 120,000
aeth	CRPAQS (1)	3	$ 16,000	$ 48,000
neph	CRPAQS (1)	3	$ 6,000	$ 18,000
DAS	CRPAQS (1)	3	$ 7,000	$ 21,000
Automated GC/MS	DRI	1	(2)	
Canister/FID	BRC & DRI	13	(2)	
Tenax	DRI	3	(2)	
DNPH	AtmAA	13	(2)	
TDLAS NO2, HNO3	CE-CERT	1	(2)	
TDLAS HCHO, H2O2	CE-CERT	1	(2)	
Met	NOAA	8	(2)	

(1) CRPAQS equipment used in CCOS prior to winter 2000/01 intensive study.
(2) Equipment use included in contract.

Appendix A
CCOS Contact List [(a)]

Responsibility	Contact	Organization	Address	Phone	Fax	Email
Policy Committee Chair	Sup. Barbara Patrick	Kern County	1115 Truxtun Avenue Suite 503 Bakersfield, CA 93301	(661) 868-3670	(661) 868-3677	
Technical Committee Chair	Andrew Ranzieri	Planning & Technical Support Division, ARB	P.O. Box 2815 Sacramento, CA 95812	(916) 324-4069	(916) 327-8525	aranzier@arb.ca.gov
Program Manager	Don McNerny	Planning & Technical Support Division, ARB	P.O. Box 2815 Sacramento, CA 95812	(916) 322-6048	(916) 327-8524	Dmcnerny@arb.ca.gov
Project Manager	Saffet Tanrikulu	Planning & Technical Support Division, ARB	P.O. Box 2815 Sacramento, CA 95812	(916) 322-7298		stanriku@arb.ca.gov
Principle Investigator and Field Coordination	Eric Fujita	Desert Research Institute	2215 Raggio Parkway Reno, NV 89512	(775) 674-7084	(775) 674-7008	ericf@dri.edu
Legal	Phil Jay	San Joaquin Valley Unified APCD	1990 East Gettysburg Avenue Fresno, CA 93726	(559) 230-6033		Phil.jay@valleyair.org
Financial	Roger McCoy	San Joaquin Valley Unified APCD	1991 East Gettysburg Avenue Fresno, CA 93726	(559) 230-6020		Roger.mccoy@valleyair.org
Intensive Operational Period (IOP) Decision Making Team, Chair	Don McNerny	Planning & Technical Support Division, ARB	P.O. Box 2815 Sacramento, CA 95812	(916) 322-6048	(916) 327-8524	Dmcnerny@arb.ca.gov
IOP Decision Making Team	Andrew Ranzieri	Planning & Technical Support Division, ARB	P.O. Box 2815 Sacramento, CA 95812	(916) 324-4069	(916) 327-8524	aranzier@arb.ca.gov
IOP Decision Making Team	Dave Jones	San Joaquin Valley APCD	1990 East Gettsburg Avenue Fresno, CA 95812	(559) 230-6812	(559) 230-6064	dave.jones@valleyair.org
IOP Decision Making Team	Rob Demandel	Bay Area AQMD		(415) 749-4654		rdemandel@baaqmd.gov
	Brigette Tollstrup	Sacramento Metro APCD		(916) 874-4832		btollstrup@airquality.org
Forecasting Team, Chair	Saffet Tanrikulu	Planning & Technical Support Division, ARB	P.O. Box 2815 Sacramento, CA 95812	(916) 322-7298	(916) 327-8524	stanriku@arb.ca.gov
Forecasting Team	Evan Shipp	San Joaquin Valley APCD	1990 East Gettysburg Avenue Fresno, Ca 93726	(559) 230-5809	(559) 230-6064	Evan.shipp@valleyair.org
Forecasting Team	Avi Okin	Bay Area AQMD		(415) 749-4616		aokin@baaqmd.gov
Forecasting Team	John Ching	Sacramento Metro APCD		(916) 874-4839		jching@airquality.org
Facilities Installation	Chuck McDade	ENSR	1220 Avenida Acaso Camarillo, CA 93012	(805) 388-3775	(805) 388-3577	cmcdade@ensr.com
Quality Assurance Manager	Dave Bush	AVES	50 East Foothill Blvd. Third Floor Arcadia, CA 91006	(530) 642-2312	(530) 642-2398	bush52@atc_enviro.com
Air Quality Audits	Mike Miguel	Monitoring & Laboratory Division, ARB	P.O. Box 2815 Sacramento, CA 95812	(916) 324-6191		mmiguel@arb.ca.gov
Database Manager	Greg O'Brien	Planning & Technical Support Division, ARB	P.O. Box 2815 Sacramento, CA 95814	(916) 322-7063	(916) 327-8524	gbrien@arb.ca.gov
Field Operations	John Bowen	Desert Research Institute	2215 Raggio Parkway Reno, NV 89512	(775) 674-7044	(775) 674-7009	johnb@dri.edu
Field Operations	Ricky Tropp	Desert Research Institute	2215 Raggio Parkway Reno, NV 89512	(775) 674-7094	(775) 674-7009	rtropp@dri.edu
Site Survey, Use and Lease Arrangements	Dan Freeman	Desert Research Institute	2215 Raggio Parkway Reno, NV 89512	(775) 674-7048	(775) 674-7009	danf@dri.edu
Supplemental Site Data Acquisition	Bill Coulombe	Desert Research Institute	2216 Raggio Parkway Reno, NV 89512	(775) 674-7038	(775) 674-7009	billc@dri.edu

Appendix A
CCOS Contact List [a]

Responsibility	Contact	Organization	Address	Phone	Fax	Email
Nitrogen Species Measurements	Denis Fitz	University of California Riverside CE-CERT	UCR CE-CERT Riverside, CA 92521-0434	(909)781-5781 (909) 433-6534 pager	(909)781-5790	dfitz@cert.ucr.edu
Nitrogen Species Measurements	Bumiller, Kurt	University of California Riverside CE-CERT	UCR CE-CERT Riverside, CA 92521-0435	(909)781-5796 (909) 433-6539 pager	(909)781-5790	kurt.bumiller@ucr.edu
Nitrate Measurements	Susanne Hering	Aerosol Dynamics	2329 Fourth Street Berkeley, CA 94710	(510) 649-9360	(510) 649-9260	aerosol@dnai.com
CCOS Site Operations (Bodega Bay, Pacheco Pass and Turlock)	Don Lehrman	T&B Systems	859 Second Street Santa Rosa, CA 95404	(707) 526-2775	(707) 579-5954	donl@tbsys.com
CCOS Site Operations (Sunol and Patterson Pass)	Rob Harley	University of California Berkeley	631 Davis Hall #1710 Dept. of Civil & Environmental Engr. Berkeley, CA 94720	(510) 643-9168	(510) 642-7483	harley@ce.berkeley.edu
ARB Air Quality Monitoring Sites - Central Region	Peter Ouchida	Monitoring & Laboratory Division, ARB	P.O. Box 2815 Sacramento, CA 95812	(916) 322-3719	(916) 327-8217	Pouchida@arb.ca.gov
ARB Air Quality Monitoring Sites - Northern Region	Larry Molek	Monitoring & Laboratory Division, ARB	P.O. Box 2815 Sacramento, CA 95812	(916) 327-4889	(916) 327-8217	Lmolek@arb.ca.gov
Bay Area AQMD Monitoring Sites (Bethel Island, Lambie Road, San Leandro, San Jose, and San Martin)	Avi Oken	Bay Area AQMD	939 Ellis Street San Franciso, CA 94109	(510) 749-4616		Aokin@baaqmd.gov
Aircraft Measurements	Don Blumenthal	Sonoma Technology	1360 Redwood Way, Suite C Petaluma, CA 94954-1169	(707) 665-9900	(707) 665-9800	don@sonomatech.com
Aircraft Measurements	John Carroll	University of California, Davis	Dept. of Land, Air and Water Resources University of California Davis, CA 95616	(916) 752-3245	(916) 752-1552	jjcarroll@ucdavis.edu
Aircraft Measurements	Alan Dixon	University of California, Davis	Dept. of Land, Air and Water Resources University of California Davis, CA 95617	(916) 752-1459	(916) 752-1552	dixon@ucdavis.edu
Aircraft Measurements	Rich Barchet	Pacific Northwest National Laboratory		(509) 372-6158		rich.barchet@pnl.gov
Aircraft Measurements	Roger Tanner	Tennessee Valley Authority		(256) 386-2958		rltanner@tva.gov
Aircraft Measurements	Raph Valente	Tennessee Valley Authority		(256) 386-3649		rjvalente@tva.gov
Meteorological Sites	Bill Neff	NOAA Environmental Technology Laboratory	325 Broadway Boulder, CA 80303	(303) 497-6265		wneff@etl.noaa.gov
Meteorological Sites	Jerry Crescenti	NOAA ATL		(208) 526-2328		jerry.crescenti@noaa.gov
Hydrocarbon Analysis - Canisters	Rei Rasmussen			(503) 690-1094 (503) 621-1435		Rrasmus@ese.ogi.edu
Hydrocarbon Analysis - Canisters, Tenax and automated GC/MS	Barbara Zielinska	Desert Research Institute	2215 Raggio Parkway Reno, NV 89512	(775) 674-7066	(775) 674-7008	barbz@dri.edu
Carbonyl Compounds	Kochy Fung	AtmAA	23917 Craftsman Road Calabasas, CA 91302	(818) 223-3277	(818) 223-8250	kfung@earthlink.net

(a) Contact information for local operators at CCOS supplemental sites are found in Appendix D1

APPENDIX B

AIR QUALITY MONITORING SITES IN CENTRAL AND NORTHERN CALIFORNIA

APPENDIX B
Air Quality Monitoring Site in Northern and Central California

Site ID	Air Basin	City	Site Address	Land Use	Location Type	EL_MSL	Parameters Measured						
							CO	NMHC	Carb	HC	NO2	O3	PM10
CCY	NC	Crescent City	9th & H St Crescent City - Ch Annex	Residential	Urban / Center City	0							1
CCY2	NC	Crescent City	880 Northcrest Drive	Residential	Urban / Center City								1
EU6	NC	Eureka	Health Dept-6th & I St	Commercial	Urban / Center City	18							1
WEV	NC	Weaverville	Main Street	Residential	Urban / Center City	600							1
FTB	NC	Fort Bragg	416 N. Franklin St.	Commercial	Urban / Center City	14							1
WLF	NC	Willits	Fire Stn-Commercial & Humboldt	Not Available	Not Available	955							1
WLM	NC	Willits	899 So Main Street	Mobile	Suburban	1377	1				1	1	
UKC	NC	Ukiah	Library-105 N Main St.	Commercial	Suburban	192							1
UKG	NC	Ukiah	306 E. Gobbi Street	Mobile	Suburban	194	1				1	1	
YRE	NEP	Yreka	528 Foothill Dr.	Commercial	Suburban	800						1	1
LVB	NEP	Lava Beds	P.O. Box 867 Lava Beds	Agricultural	Rural	1451							1
ALW	NEP	Alturas	202 W. Fourth Street	Commercial	Urban / Center City	1334							1
MSO	NEP	Mount Shasta	3 North Old Stage Road	Residential	Suburban	0							1
RDH	SV	Redding	Hlth Ctr-2630 Hospital Ln	Commercial	Suburban	143						1	1
LNP	SV	Lassen Volcanic Nat Pa	Manzanita Lake Rs	Forest	Rural	1788						1	
ADN	SV	Anderson	2220 North Street	Industrial	Suburban	498						1	1
RBL	SV	Red Bluff	Messer Drive	Industrial	Suburban	98							1
RBO	SV	Red Bluff	502 Oak Street	Mobile	Urban / Center City	98						1	
CHM	SV	Chico	468 Manzanita Ave	Commercial	Suburban	61	1				1	1	2
CHL	SV	Chico	101 Salem St.	Mobile	Urban / Center City	61	1						
WLW	SV	Willows	420 E. Laurel St.	Mobile	Suburban	41						1	2
CSS	SV	Colusa	100 Sunrise Blvd.	Commercial	Rural	17						1	2
YAS	SV	Yuba City	773 Almond St.	Commercial	Suburban	20	1				1	1	2
PGV	SV	Pleasant Grove	4sw-7310 Pacific Ave	Agricultural	Rural	50						1	
SNH	SV	North Highlands	7823 Blackfoot Way	Residential	Suburban	27	1				1	1	1
FLN	SV	Folsom	50 Natoma Street	Residential	Suburban	0		1		1	1	1	
WSS	SV	Woodland	40 Sutter Street	Agricultural	Urban / Center City	17							1
	SV	Woodland	41929 E. Gibson Road	Residential	Suburban							1	
	SV	Sacramento	3801 Airport Road	Commercial	Suburban		1	1	1	1	1	1	2
SDP	SV	Sacramento	Del Paso-2701 Avalon Dr	Residential	Suburban	25	1	1	1	1	1	1	3
SEW	SV	Sacramento	3535 El Camino & Watt	Commercial	Suburban	18	1						
WSA	SV	West Sacramento	132 15th St.	Industrial	Urban / Center City	13							1
S13	SV	Sacramento	1309 T St.	Residential	Urban / Center City	7	1				1	1	3
SST	SV	Sacramento	Hlth Ctr-2221 Stockton Blvd	Commercial	Urban / Center City	8							2
SBR	SV	Sacramento	3711 Branch Center Rd.	Residential	Suburban	20							1
DVS	SV	Davis	Uc Davis-Campus	Agricultural	Rural	16	1				1	1	
SLU	SV	Sloughhouse	7520 Sloughouse Road	Agricultural	Rural	58						1	
VEL	SV	Vacaville	1001 Allison Drive	Residential	Suburban	55						1	
ELK	SV	Elk Grove	12490 Bruceville Rd	Agricultural	Rural	6		1		1	1	1	

APPENDIX B (continued)
Air Quality Monitoring Site in Northern and Central California

Site ID	Air Basin	City	Site Address	Land Use	Location Type	EL_MSL	Parameters Measured						
							CO	NMHC	Carb	HC	NO2	O3	PM10
FFD	SV	Fairfield	Baapcd-401 Gregory St	Residential	Urban / Center City	3						1	
LKL	LC	Lakeport	905 Lakeport Blvd.	Mobile	Suburban	405						1	1
CHE	MtC	Chester	222 First Avenue	Residential	Urban / Center City	1403							1
QUC	MtC	Quincy-East Quincy	267 N. Church St.	Commercial	Urban / Center City	1067						1	2
POL	MtC	Portola	220 Commercial St	Residential	Urban / Center City	1480							1
LOY	MtC	Loyalton	309 W. Third Street	Residential	Rural	1505							1
GFS	MtC	Truckee	Glenshire Fs-10900 Manchester	Residential	Suburban	1811							1
TRU	MtC	Truckee	Fs-10049 Donner Pass Rd	Residential	Urban / Center City	1676						1	2
WCM	MtC	Nevada City	26533 State Hwy 20-White Cloud Mtn	Forest	Rural	0						1	
GVL	MtC	Grass Valley	200 Litton Dr.	Residential	Suburban	853						1	1
GVH	MtC	Grass Valley	420 Henderson St	Residential	Urban / Center City	735							1
LTY	MtC	South Lake Tahoe	3337 Sandy Way	Commercial	Urban / Center City	0	1				1	1	1
LTS	MtC	South Lake Tahoe	Stateline-4045 Hwy 50	Commercial	Urban / Center City	1911	1						
CUS	MtC	Cool	1400 American River Trail	Agricultural	Rural	0						1	
ROC	MtC	Rocklin	5000 Rocklin Road	Residential	Rural	100						1	2
ROS	MtC	Roseville	151 No Sunrise Blvd	Mobile	Suburban	161	1				1	1	1
PGN	MtC	Placerville	3111 Gold Nugget Way	Residential	Suburban	0	1					1	1
JAC	MtC	Jackson	201 Clinton Road	Commercial	Suburban	377	1					1	
SGS	MtC	San Andreas	501 Gold Strike Road	Agricultural	Rural	0	1					1	1
FML	MtC	Sonora	15700 Old Oak Ranch Road	Forest	Rural	0						1	
SNB	MtC	Sonora	251 S Barretta	Residential	Urban / Center City	0	1					1	
YOY	MtC	Yosemite Nat Park	Visitor Ctr-Yosemite Village	Not Available	Not Available	1216							1
YOT	MtC	Yosemite Nat Park	Turtleback Dome	Forest	Rural	1605						1	
JSD	MtC	Jerseydale	6440 Jerseydale Road	Forest	Rural	0						1	
CLV	SFBA	Cloverdale	100 Washington St.	Commercial	Urban / Center City	91							1
HDM	SFBA	Healdsburg	Airport-200a Heidelberg Way	Commercial	Rural	30						1	
HDB	SFBA	Healdsburg	133 Matheson St.	Commercial	Urban / Center City	31							1
GUE	SFBA	Guerneville	Church And First Streets	Mobile	Urban / Center City	17							1
SRF	SFBA	Santa Rosa	837 5th St.	Commercial	Urban / Center City	49	1				1	1	1
VAC	SFBA	Vacaville	650 Merchant St.	Commercial	Urban / Center City	59							1
NJS	SFBA	Napa	2552 Jefferson Ave.	Commercial	Urban / Center City	12	1				1	1	1
VJO	SFBA	Vallejo	304 Tuolumne St.	Commercial	Urban / Center City	23	1				1	1	1
CKT	SFBA	Crockett	Kendall Ave.	Industrial	Suburban	63							
PBG	SFBA	Pittsburg	583 W. 10th St.	Residential	Urban / Center City	2	1				1	1	
MTZ	SFBA	Martinez	521 Jones St.	Residential	Urban / Center City	8							
BTI	SFBA	Bethel Island	5551 Bethel Island Rd	Agricultural	Rural	0	1				1	1	1
SRL	SFBA	San Rafael	534 4th Street	Commercial	Urban / Center City	1	1				1	1	1
SPE	SFBA	San Pablo	Unit 759 El Portal Shopping Center	Commercial	Urban / Center City	15	1				1	1	1

APPENDIX B (continued)
Air Quality Monitoring Site in Northern and Central California

Site ID	Air Basin	City	Site Address	Land Use	Location Type	EL_MSL	Parameters Measured						
							CO	NMHC	Carb	HC	NO2	O3	PM10
RMD	SFBA	Richmond	1065 7th St.	Industrial	Suburban	6							
CCD	SFBA	Concord	2975 Treat Blvd	Residential	Suburban	26	1				1	1	1
OKA	SFBA	Oakland	822 Alice St.	Commercial	Urban / Center City	7	1					1	
SFE	SFBA	San Francisco	939 Ellis St.	Commercial	Urban / Center City	38	1						
SFA	SFBA	San Francisco	10 Arkansas St.	Industrial	Urban / Center City	5	1				1	1	1
SEH	SFBA	San Leandro	Hospital-15400 Foothill Blvd	Residential	Suburban	36						1	1
LVF	SFBA	Livermore	2614 Old 1st St.	Commercial	Urban / Center City	146	1				1	1	2
HLM	SFBA	Hayward	3466 La Mesa Dr.	Residential	Rural	287						1	
FCW	SFBA	Fremont	40733 Chapel Way.	Residential	Suburban	18	1				1	1	1
RED	SFBA	Redwood City	897 Barron Ave.	Industrial	Suburban	5	1				1	1	1
SJD	SFBA	San Jose	935 Piedmont Road	Residential	Rural	0						1	1
MVC	SFBA	Mountain View	160 Cuesta Dr.	Residential	Suburban	24						1	
SJ4	SFBA	San Jose	120b N 4th St	Residential	Urban / Center City	24	2				1	1	3
SJK	SFBA	San Jose	Hlth Ctr-2220 Moorpark Ave	Residential	Suburban	360							1
SJT	SFBA	San Jose	528 Tully Rd.	Industrial	Suburban	38							1
LGS	SFBA	Los Gatos	306 University Ave.	Residential	Urban / Center City	183						1	
SMM	SFBA	San Martin	13030 Murphy Ave.	Residential	Rural	87						1	
GRY	SFBA	Gilroy	9th & Princeville	Residential	Suburban	55						1	
SOW	SJV	Stockton	8778 Brattle Place Stockton-Wagner Holt	Residential	Suburban	7							1
SOC	SJV	Stockton	4310 Claremont	Commercial	Suburban	13	1						
SOH	SJV	Stockton	Hazelton-Hd	Residential	Urban / Center City	13	1				1	1	3
SOM	SJV	Stockton	13521 E. Mariposa	Not Available	Not Available	17						1	
TPP	SJV	Tracy	24371 Patterson Pass Road	Agricultural	Rural	31					1	1	
MIS	SJV	Modesto	1100 I St	Other Unknown Reside	Urban / Center City	27							2
	SJV	Modesto	814 14th St-Modesto Rover	Commercial	Urban / Center City		1				1	1	
M14	SJV	Modesto	814 14th St.	Commercial	Urban / Center City	27	1				1	1	2
TSM	SJV	Turlock	900 S Minaret Street	Residential	Suburban	56	1				1	1	1
MRA	SJV	Merced	385 S. Coffee Avenue	Agricultural	Rural	86					1	1	
FNP	SJV	Shaver Lake	North Perimeter Road	Forest	Rural	0						1	
M29	SJV	Madera	Rd. 29 1/2 No. Of Ave 8	Agricultural	Rural	0		1		1	1	1	
FSS	SJV	Fresno	Sierra Skypark#2-Blythe & Chnnlt	Residential	Suburban	98	1				1	1	
CLO	SJV	Clovis	908 N Villa Ave	Residential	Urban / Center City	86	1	1	1	1	1	1	1
FIS	SJV	Fresno	1145 Fisher Street	Commercial	Urban / Center City	90	1						
FSF	SJV	Fresno	3425 N First St	Residential	Suburban	96	1	1	1	1	1	1	3
FSD	SJV	Fresno	4706 E. Drummond St.	Commercial	Suburban	162	1				1	1	1
PLR	SJV	Parlier	9240 S. Riverbend	Not Available	Not Available	166		1		1	1	1	
SLK	SJV	Sequoia Nat Park	Lower Kaweah-Sequoia NP	Forest	Rural	1890						1	
LMK	SJV		Lookout Point-Mineral King Road	Forest	Rural	0						1	

APPENDIX B (continued)
Air Quality Monitoring Site in Northern and Central California

Site ID	Air Basin	City	Site Address	Land Use	Location Type	EL_MSL	Parameters Measured						
							CO	NMHC	Carb	HC	NO2	O3	PM10
VCS	SJV	Visalia	310 N Church St	Commercial	Urban / Center City	92	1				1	1	3
HIR	SJV	Hanford	807 South Irwin Street	Residential	Suburban	99					1	1	1
COP	SJV	Corcoran	1520 Patterson Ave.	Residential	Suburban	0							2
COV	SJV	Corcoran	Van Dorsten Ave.	Not Available	Not Available	61							3
SHA	SJV	Shafter	548 Walker Street	Commercial	Suburban	126		1		1	1	1	
OLD	SJV	Oildale	3311 Manor St.	Industrial	Suburban	180					1	1	1
BGS	SJV	Bakersfield	1128 Golden State Highway	Commercial	Urban / Center City	123		1	1	1	1	1	1
BKA	SJV	Bakersfield	5558 California Ave	Mobile	Urban / Center City	120	1				1	1	5
EDS	SJV	Edison	Johnson Farm	Agricultural	Rural	128					1	1	
ARV	SJV	Arvin	20401 Bear Mtn Blvd	Agricultural	Rural	145		1		1	1	1	
TAC	SJV	Taft	College-29 Emmons Park Dr.	Commercial	Suburban	292							3
MCS	SJV	Maricopa	School-755 Stanislaus St.	Residential	Suburban	289						1	
MLK	GBV	Mono Lake	Simus Res-Hiwy 167	Not Available	Rural	1948							1
LEE	GBV	Lee Vining	Sms-Hwy 395	Not Available	Not Available	2071							1
MAG	GBV	Mammoth Lakes	Gateway Hc.	Commercial	Urban / Center City	2396	1					1	1
LPE	GBV	Lone Pine	501 E. Locust St.	Residential	Suburban	1128							2
DVL	GBV	Death Valley	Death Valley NP	Desert	Rural	125						1	
KCG	GBV	Keeler	190 Cerro Gordo Road	Residential	Rural	1097							4
OLW	GBV	Olancha	131 Walker Creek Rd.	Desert	Rural	1100							2
COS	GBV	Coso Junction	Rest Area On Hiwy 395	Not Available	Not Available	1010							2
CJN	GBV	Coso Junction	10 Mi E Of Coso Junction	Desert	Rural	1315							1
SVD	NCC	Scotts Valley	4859 Scotts Valley Dr #E	Commercial	Rural	122						1	
DVP	NCC	Davenport	Fire Dept.	Residential	Rural	0	1				1	1	1
SCQ	NCC	Santa Cruz	2544 Soquel Avenue	Commercial	Suburban	78						1	1
WAA	NCC	Watsonville	444 Airport Blvd	Commercial	Suburban	67						1	1
HST	NCC	Hollister	1979 Fairview Rd.	Residential	Rural	126						1	1
MLS	NCC	Moss Landing	7539 Sandholt Road	Commercial	Rural	10							1
SL2	NCC	Salinas	Ii-1270 Natividad Rd	Residential	Suburban	13	1				1	1	1
MON	NCC	Monterey	24580 Silver Cloud Ct.	Commercial	Rural	0						1	
CMV	NCC	Carmel Valley	35 Ford Rd-Tularcito Sch	Residential	Suburban	131						1	1
PIN	NCC	Pinnacles National Mon	Ne Entrance	Forest	Rural	335						1	
KCM	NCC	King City	750 Metz Road	Industrial	Rural	116						1	1
PRF	SCC	Paso Robles	235 Santa Fe Avenue	Residential	Suburban	100						1	1
ATL	SCC	Atascadero	6005 Lewis Avenue	Commercial	Suburban	262					1	1	2
MBP	SCC	Morro Bay	Morro Bay Blvd & Kern Ave	Commercial	Urban / Center City	18						1	1
SLM	SCC	San Luis Obispo	1160 Marsh St.	Commercial	Urban / Center City	66	1				1	1	1
GCL	SCC	Grover City	9 Le Sage Dr.	Residential	Suburban	4					1	1	
ARR	SCC	Arroyo Grande	000 Ralcoa Way	Commercial	Rural	300							1

APPENDIX B (continued)
Air Quality Monitoring Site in Northern and Central California

Site ID	Air Basin	City	Site Address	Land Use	Location Type	EL_MSL	Parameters Measured						
							CO	NMHC	Carb	HC	NO2	O3	PM10
NGR	SCC	Nipomo	1300 Guadalupe Rd.	Industrial	Rural	60						1	2
STL	SCC	Santa Maria	Library-420 S Broadway	Commercial	Urban / Center City	152							1
SMY	SCC	Santa Maria	500 S Broadway	Commercial	Suburban	76					1	1	1
LHS	SCC	Lompoc	Hs & P Facility-500 M Sw	Agricultural	Rural	244					1	1	
LOM	SCC	Lompoc	128 S H St.	Commercial	Urban / Center City	24	1				1	1	1
SYN	SCC	Santa Ynez	Airport Rd.	Agricultural	Rural	204						1	
VBS	SCC	Vandenberg Afb	Sts Power Plant	Agricultural	Rural	100	1				1	1	2
LPD	SCC	Los Padres National Fo	Paradise Rd	Agricultural	Rural	547					1	1	
GVB	SCC	Gaviota	Gtc B-Hwy 101-Near Nojoqui Pass	Agricultural	Rural	305					1	1	
CA1	SCC	Capitan	Lfc #1-Las Flores Canyon	Agricultural	Rural	0	1				1	1	1
CA2	SCC	Capitan	Lfc #2-Las Flores Canyon	Agricultural	Rural	0					1		2
GVW	SCC	Gaviota	Gaviota West-Nw Of Chevron Plant	Agricultural	Rural	91					1	1	1
GVE	SCC	Gaviota	Gaviota East-N Of Chevron Plant	Agricultural	Rural	94					1	1	1
GVC	SCC	Gaviota	Gtc C-1 Mi E Of Plant	Agricultural	Rural	70					1	1	2
CA3	SCC	Capitan	Lfc #3-Las Flores Canyon	Agricultural	Rural	0					1		
ECP	SCC	Capitan	El Capitan St Prk Hwy 101	Not Available	Rural	30					1	1	2
PCN	SCC	Concepcion	Point Conception Lighthouse	Agricultural	Rural	40					1	1	2
GNF	SCC	Goleta	380 N Fairview Avenue	Residential	Suburban	50	1				1	1	
SBC	SCC	Santa Barbara	3 W. Carrillo St.	Mobile	Urban / Center City	16	1				1	1	1
OJO	SCC	Ojai	1201 Ojai Avenue	Agricultural	Suburban	262					1	1	1
SBU	SCC	Isla Vista	Ucsb West Campus-Arco Tank	Agricultural	Rural	9					1	1	2
CRP	SCC	Carpinteria	Gobernador Rd	Agricultural	Rural	152					1	1	
PIR	SCC	Piru	2sw 2815 Telegraph Rd	Agricultural	Rural	182						1	1
VTA	SCC	Oak View	5500 Casitas Pass Rd-Near Oak View	Agricultural	Rural	319					1	1	
VTE	SCC	Ventura	Emma Wood State Beach	Mobile	Suburban	3		1			1	1	
SIM	SCC	Simi Valley	5400 Cochran Street	Residential	Suburban	310	1	1			1	1	2
ELM	SCC	El Rio	Rio Mesa School	Agricultural	Rural	34	1	1	1		1	1	1
THM	SCC	Thousand Oaks	9 2323 Moorpark Road	Residential	Suburban	232					1	1	1
SRI	SCC	Channel Islands Nation	Santa Rosa Island-Becher's Bay	Forest	Rural	0						1	
CLK	MD	China Lake	Powerline Rd.	Not Available	Rural	697							1
MOP	MD	Mojave	923 Poole Street	Mobile	Rural	853					1	1	1

APPENDIX C

MEASUREMENT METHODS

C. MEASUREMENT METHODS

Field monitoring includes continuous measurements over several months and intensive studies that are performed on a forecast basis during selected periods when episodes are most likely to occur. The continuous measurements are made in order to assess the representativeness of the intensive study days, to provide information on the meteorology and air quality conditions on days leading up to the episodes, and to assess the meteorological regimes and transport patterns which lead to ozone episodes. The intensive study components are designed to provide a detailed aerometric database which, along with the emission estimates and continuous monitoring data, can be used to improve our understanding of the causes of pollutant episodes in the study region and to provide data for input to the models and for model evaluation. This section describes the options for continuous and intensive air quality and meteorological measurements (surface and aloft) to be made during CCOS.

C.1 Surface Meteorology

The types of surface meteorological measurements needed for this study include measurements of wind speed, wind direction, and temperature. Measurements of humidity, pressure, visibility, solar radiation, and ultraviolet radiation are also available at some sites. Within the study area (modeling domain), these measurements are provided by several existing networks of sites operated by several organizations including:

- Surface Airways Observations sites from the National Weather Service (NWS), operating in conjunction with the Federal Aviation Administration
- California Irrigation Management Information System sites from the California Department of Agriculture
- Remote Automated Weather Station sites from the Bureau of Land Management, California Department of Forestry, National Park Service, and U.S. Forest Service
- APCD/AQMD Aerometric Monitoring Station sites from the Bay Area AQMD, Kern County APCD, San Joaquin Valley Unified Control District, Santa Barbara APCD, Ventura County APCD, Mojave Desert AQMD, and California Air Resources Board
- Military installations
- Private companies
- Public organizations such as universities

C.1.1 Surface Wind Speed and Direction

Wind speeds are measured with anemometers at 10 m above ground to minimize the effects of nearby structures and vegetation. Anemometers, both cup and propeller type, work on the principal that the rate of rotation about a vertical or horizontal shaft is proportional to the speed of the air flow past the sensor. Anemometers used for scientific monitoring should have a quick

response to changes in wind speed as well as a low threshold for rotation for conditions of very light winds. Acceptable precision levels for anemometers are ±0.5 m/s for most air quality studies (e.g., Thullier et al., 1993).

Wind direction measurements are made with wind vanes that orient themselves with the direction of the wind. High quality bearings are used for sensitivity and direction is resolved with an internal potentiometer that has a reference location of zero which must be physically aligned with true north when in position on the tower. The position of true north is determined with a sensitive compass or solar reference and the north position of the wind vane is then aligned in this direction. Care must be taken in the alignment procedure or in subsequent resolution of the wind direction vectors to account for the magnetic declination at the observation site.

Averaging can be done over intervals of a few points to the entire data record. The interval must be chosen with respect to the phenomena being observed. As shorter averaging intervals are chosen, periodic motion may be revealed when the period is significantly greater than the averaging period. The averaging process attenuates small-scale fluctuations due to turbulence. The averaging interval must contain sufficient data points to constitute a reasonable average, eliminating the small scale turbulent fluctuations and instrument derived errors such as response sensitivity and anemometer run-up and run-down. Five minutes is a reasonable compromise between the need to acquire a statistically valid number of samples and the nature of phenomena such as wind gusts and dispersion.

The time average of horizontal wind direction standard deviation (σ_θ) can be calculated as from one second observations over a period of 5 minutes or less (Greeley and Iversen, 1985). This minimizes the influence of the wind flow which may be non-stationary in both speed and direction over longer averaging periods.

C.1.2 Surface Relative Humidity

Humidity indicates the amount of water vapor in the air. The most common reference for this property of the air is the relative humidity (RH), the ratio of the amount of water vapor actually in the air to the amount the air could hold at a given temperature and pressure, that is, the ratio of the actual to the saturated vapor pressure.

Accurate measurements at high RH (>85%) is important to atmospheric transformations and to visibility reduction. An accuracy of 2-3% RH is needed to adequately estimate aerosol properties. A 2-3% accuracy for RH over the 90-100% RH is attainable by several RH sensors (e.g. Vaisala, Rotronics) and corresponds to ±0.5°C when expressed as dewpoint temperature. Motor-aspirated radiation shields ensure adequate ventilation and exposure rates (U.S. EPA, 1989).

C.1.3 Surface Temperature

Equivalent resistance temperature detectors (RTD (e.g., Vaisala, Rotronics, Climatronics, Campbell Scientific, etc.) are used at the meteorological sites. Motor-aspirated radiation shields ensure adequate ventilation and exposure rates, according to U.S. EPA quality assurance requirements (U.S. EPA, 1989). The accuracy (~0.15-0.5 °C) and functional precision (0.1°C) of

these sensors are sufficiently good and they can be used to infer lapse rates and thus stability (e.g., estimates of delta-T) when several sensors are used on a tower. Temperature sensors are normally located at 5 m above ground level. Table 10.1-1 presents specifications for the Vaisala and Campbell Scientific (CV) temperature (C) and relative humidity (%) sensors

C.1.4 Surface Pressure

Pressure is routinely measured by the National Weather Service in terms of altimeter setting or sea level pressure. The altimeter setting is the pressure value to which an aircraft altimeter scale is set so it will indicate the altitude above mean-sea-level of the aircraft on the ground at the location the pressure value was determined. The sea level pressure is the atmospheric pressure at mean sea level. It is either measured directly or obtained by the empirical reduction of station pressure to sea level. When the earth's surface is above sea level, it is assumed that the atmosphere extends to sea level below the station and that the properties of the fictitious air column are related to conditions observed at the station.

C.1.5 Solar Radiation

Solar radiation sensors are operated at several existing ARB sites throughout the region. The measurements employ a solar pyranometer that collects direct solar beam and diffuse sky radiation passing though a horizontal beam.

C.2 Upper-Air Wind Speed, Wind Direction, and Temperature

The types of upper-air meteorological measurements needed include wind speed, wind direction, temperature, and mixing height. Measurements of humidity are also useful where they are available at some sites. A comprehensive discussion of the accuracy and methodology of upper air measurements is provided in the SJVAQS/AUSPEX Meteorological Field Measurement Program report (Thuillier, 1994).

C.2.1 Radar Wind Profilers

Radar wind profilers (RWPs) provide continuous remote measurements of wind speed and direction to altitudes of ~3 km AGL. The profilers emit short pulses of generally 915 MHz electromagnetic radiation which scatter off inhomogeneities in the index of refraction of an air mass. By emitting energy directionally in three orthogonal components, the received scattered radiation provides estimates of wind speed and direction. Because of the finite length of the emitted pulse train, vertical resolution is limited to approximately 100 m. Echoes received during the detector downtime cannot be processed and this raises the threshold height to approximately 100 m above ground level. The typical five-degree beam width also limits the resolution of wind direction in a height dependent manner. There are general trade-offs between maximum range and vertical resolution and between averaging time and accuracy.

Radar wind profiler data are generally reported as 15-minute up to hourly averaged data and are representative of a three-dimensional cell. Because wind vectors may vary significantly over the course of an hour, the near-instantaneous radiosonde measurements may not compare well with radar wind profiler measurements on a case-by-case basis. However, if radiosondes and

wind profilers are deployed in areas with similar winds, the statistical distribution of winds may be expected to be reasonably similar. The RWP is highly sensitive to stray electromagnetic signals and stationary or solid objects in the beam paths or their side lobes. Thus, it should be sited away from large objects such as buildings and trees and away from frequent overflights by aircraft.

C.2.2 Radio-Acoustic Sounding Systems (RASS)

Temperature aloft up to 500-700 m can be characterized using a RASS. The RASS essentially uses collocated radio wave and acoustic sources such that radio waves are scattered off the acoustic wavefronts. The propagation velocity of the acoustic wave fronts is then measured, which can be related to the (virtual) temperature of the air. This effort could install one radar profiler with RASS at critical locations along major transport paths, such as mountain passes or the coastal shoreline, for example, near Cajon and Banning Passes and along the downwind shorelines in San Diego and Santa Barbara. There is considerably less accuracy in the RASS temperature profiles compared to the those obtainable from tethersonde measurements, particularly in areas of complex terrain where radar side lobes may present a problem. However, the RASS temperature data may be compared to QA radiosonde or tethersonde temperature data because the virtual temperature can also be calculated from the sonde measurements of ambient temperature, dew point or relative humidity, and pressure. A favorable comparison under representative conditions would increase confidence in the RASS data at these sites.

C.2.3 Acoustic Sounders (Sodars)

The sodar uses an observational process that is similar to the RWP except that the sodar uses pulses of acoustic instead of electromagnetic energy. The sodar then detects returned acoustic energy scattered from turbulent density fluctuation (instead of index of refraction fluctuations). It provides hourly averaged wind speed and direction up to a 500-600 m maximum range with a threshold height of approximately 50-60 m. The sodar can operate routinely with little or no on-site care, but compared to radiosondes it does not measure humidity, and the equipment is expensive. The sodar is highly sensitive to extraneous sources of sound. Thus, it should be sited away from substantial and continuous noise sources such as heavily traveled roads. The sodar acoustic emissions are audible and may disturb nearby residents, which can be a siting disadvantage compared with the RWP. With the lower vertical range, sodars should be deployed in areas of lower expected mixing heights, such as in marine layers.

C.2.4 Radiosondes

Upper-air wind speed, wind direction, and temperature can be collected by in-situ systems or by remote sensing instruments. The most commonly used in-situ systems rely on a balloon-borne sensor (radiosonde), carried aloft by a freely ascending weather balloon to measure atmospheric pressure, temperature, and moisture (relative humidity or wet bulb temperature). These thermodynamic variables are used to compute the altitude of the balloon. Wind speed and direction aloft are determined by measuring the position of the balloon as it ascends. The position data can be obtained by tracking the balloon from a fixed ground station using radio direction finding techniques (RDF) or optical tracking, or they can be obtained using one of the radio navigation (NAVAID) networks, such as loran or Global Positioning System (GPS). By measuring

the position of the balloon with respect to time and altitude, horizontal wind vectors can be computed that represent the layer-averaged wind speed and wind direction for successive layers. Balloons can also measure relative humidity, which is not detected by proven remote sensing methods.

The vertical resolution of the wind data is typically 50-200 m (depending on altitude and the type of sounding system used), and the range is from about 100 m above ground level (AGL) to altitudes as high as 10,000 m altitude or higher. Radiosondes provide wind data that are averaged over short vertical distances and are thus nearly instantaneous measurements at a particular location. Although the radiosonde directly measures temperature and humidity during the short balloon flight, it is only a "snapshot" at each level of the atmosphere. As the radiosonde rises, it is transported downwind, so measurements are not made above a fixed location, as within a wind profiler, for example.

For air pollution studies such as this, balloon sounding systems can provide relatively complete profiles of winds, temperature, and moisture in the boundary layer and lower troposphere. Balloon soundings usually can be made two to eight times per day on selected sampling days within reasonable budget contraints, but they are not cost-effective for long-term monitoring.

C.2.5 Sonic Anemometers

Sonic anemometers deployed at surface sites would provide estimates of turbulent fluxes for the modeling effort. The variations in sound propagation over a short (30 cm) path are typically sampled at 10 Hz, providing an estimate of turbulent fluctuations over that path. One-dimensional sonic anemometers measure vertical turbulent flux, while three-dimensional sonic anemometers include turbulent fluxes in the two horizontal dimensions. These data provide boundary layer characterization, representative of the type of terrain over which the measurement is taken. Urban effects could be better incorporated in the mesoscale model. The measurement could provide better dispersion estimates for models run in the data assimilation mode, and provide real-world measurements against which model estimates of turbulent flux are compared.

C.3 Routine Surface Air Quality

The California Air Resources Board and local air pollution control districts operate a network of sampling sites that measure ambient pollutant levels. This network consists of three types of surface air quality monitoring stations. The National Air Monitoring Stations (NAMS) were established to ensure a long term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trend analysis. The State and Local Air Monitoring Stations (SLAMS) allow state and local governments to develop networks tailored to their immediate monitoring needs. Special purpose monitors (SPM) fulfill very specific or short-term monitoring goals. SPMs are typically used as source-oriented monitors rather than monitors which reflect the overall urban air quality. Data from all three types are submitted by state and local agencies to EPA’s Aerometric Information Retrieval System (AIRS), which serves as the national repository for air quality, meteorological and emissions data.

Under Title I, Section 182, of the 1990 Amendments to the Federal Clean Air Act, the EPA proposed a rule to revise the current ambient air quality surveillance regulations. The rule requires implementing a national network of enhanced ambient air monitoring stations (Federal Register, 1993). States with areas classified as serious, severe, or extreme for ozone nonattainment are required to establish photochemical assessment monitoring stations (PAMS) as part of their State Implementation Plan (SIP). In the CCOS area, PAMS are required in Sacramento, Fresno and Bakerfield metropolitan areas. Each station measures speciated hydrocarbons and carbonyl compounds, ozone, oxides of nitrogen, and surface meteorological data. Additionally, each area must monitor upper air meteorology at one representative site. The program was phased in over a five-year schedule, beginning in 1994, at a rate of at least one station per area per year. Intended applications for the PAMS database include ozone and precursor trends, emission inventory reconciliation and verification, population exposure analyses, photochemical modeling support, and control strategy evaluation.

There are 185 active monitoring stations in northern and central California. Table A.1-2 contains a list of the monitoring sites and the air quality parameters measured at each site. Of the active sites, 130 measure ozone and 76 measure NO_X. Carbon monoxide and total hydrocarbons are measured at 57 and 14 sites, respectively. Data from these sites are routinely acquired and archived by the ARB and Districts. The following is a brief description of the measurement methods that are commonly used at routine air quality monitoring stations.

C.3.1 Ozone

Ozone is continuously measured either by ultraviolet absorption photometry or by gas-phase ethylene-ozone chemiluminescence. In the ultraviolet analyzer, a mercury vapor lamp is used to produce ultraviolet radiation at 254 nm which is absorbed by the ozone in the air sample. The ozone signal is determined by the difference between ambient air containing ozone and ambient air with the ozone removed or scrubbed. The ultraviolet analyzer is calibrated by comparison with an ozone photometer which is certified as a transfer standard. The transfer standard is certified against absolute ozone photometers located at the California Air Resources Board test and laboratory facilities. The minimum detectable level of UV monitors is about 2-5 ppbv. Accuracies and precisions are on the order of 10-15 percent or 2-5 ppbv, whichever is larger. Interferences with the UV measurement method include any gas or fine particle that absorbs or scatters light at 254 nm. Gaseous inorganic compounds normally found in the atmosphere, including NO_2 and SO_2, do not interfere, and particles are largely removed by a pre-filter. The most likely interferent is gaseous hydrocarbon compounds that are strong absorbers at 254 nm and are either partially or completely absorbed onto the scrubber. Examples are aromatic compounds, such as benzene and substituted benzenes. Interferences from hydrocarbons can account for a positive bias in the UV measurement for ozone of up to 40 ppb based on the concentration of the interferences occurring during peak ozone periods (Leston and Ollison, 1992). Kleindienst *et al*. (1993) observed about a 3 percent interference with ozone measurements under hydrocarbon loadings typical of ambient smoggy conditions. Water vapor may also interfere with the UV method when water vapor concentrations are high and variable. These interferences appear to be due to the condensation of water vapor on imperfect absorption cell windows.

The ozone/ethylene chemiluminescence method (ECL) is a Federal Reference Method for measuring ozone in ambient air (EPA, 1971). The ECL method is based on the reaction of ozone with ethylene, which produces formaldehyde in an electrically excited state and, on transition to the ground state, emits light in the visible range. This reaction is rapid and specific to ozone and takes place in a chamber coupled to a sensitive photomultiplier tube. Under controlled conditions, the signal produced by the ozone-ethylene reaction is proportional to the ozone concentration in the reaction chamber and with proper calibration it is proportional to ambient ozone concentrations. The chemiluminescence analyzer is calibrated in the same manner as the ultraviolet analyzers. The minimum detection level of commercial ECL monitors is about 2-5 ppbv. Accuracies and precisions are on the order of 10-15 percent or 2-5 ppbv, whichever is larger. The only major interference for measuring ozone by the ECL method is water vapor. The positive interference ranges from 3-12 percent. However, this interference can be adjusted for by calibrating the ECL monitors at humidities expected during peak ozone periods. In practice, this is rarely done.

The Air Pollution Control Districts measure ambient ozone concentrations with instruments made by several different manufacturers. All analyzers employ the UV photometric technique to determine ozone concentration. All analyzers have been designated as EPA Equivalent Methods. The following analyzers are deployed in the networks:

Thermo Environmental Inc., model 49
Dasibi Environmental, model 1003
Advanced Pollution Instrumentation, Inc., model 400

C.3.2 Nitrogen Oxides

Nitric oxide (NO) is continuously measured by the chemiluminescence nitric oxide-ozone method (OCM). This method is based on the gas-phase chemical reaction of NO with ozone. In this method an ambient air is mixed with a high concentration of ozone so that any NO in the air sample will react and thereby produce light. The light intensity is measured with a photomultiplier and converted into an electronic signal which is proportional to the NO concentration. To measure NO_x concentrations, the sum of NO and NO_2 (nitrogen dioxide), the air sample is first reduced to NO, either by a heated catalyst (molybdenum or gold in the presence of CO) or chemically using $FeSO_4$, adding to the NO already present in the sample, then into the reaction chamber for measurement as described above. The NO_2 concentration is derived by subtracting the NO concentration measurement from the NO_x concentration measurements.

Standard sensitivity instruments have detection limits of about 0.5 to 3 ppb (60 sec averaging times) and are suitable for air quality monitoring in urban and suburban areas. Thermo Environmental Instruments, Inc. (TEI) Model 42C and Monitor Labs 8440 and 8840 are examples of this type of instrument. These and similar instruments from Columbia Scientific and Bendix have been used widely by federal, state, and local agencies for routine monitoring of NO and NO_2 (actually NO_x minus NO plus other interfering nitrogen oxides). Trace level instruments, such as the TEI Model 42C-TL have detection limits of about 50 ppt (120 sec averaging times) and are better suited in rural and background sites, and onboard instrumented aircrafts.

The reduction of NO_2 to NO by these methods is not specific and a number of other nitrogen-containing species are reduced to NO that can interfere with the measurement of NO_2

(e.g., HNO_3, PAN, N_2O_5, HONO, and NO_3). Therefore the thermal catalytic method is used to measure NO, and then NO plus other nitrogen oxides as a group. If the group is not well defined, it is referred commonly as NO_x, since the species included in the group depend on factors such as inlet and line losses and environmental factors. HNO_3 is most prone to line losses. Placing the converter as close to the sample inlet as possible minimizes these losses. Chemiluminescence analyzers that are configured in this manner are commonly known as NOy analyzers. NOy, or reactive nitrogen oxides, consists of a variety of species, the most abundant of which are NO, NO2, PAN and HNO_3. TEI Model 42CY is configured with dual converters, which allows estimates of HNO3 by difference between the signals with and without an in-line nylon filter or NaCl impregnated fiber denuder.

C.4 Supplemental Measurements of Ozone

Supplemental air quality measurements are needed during intensive operational periods (IOPs) in order to examine the three-dimensional distribution of ozone in the study area and to quantify some of the important species, other than those routinely monitored, which participate in ozone photochemistry.

C.4.1 Ozonesondes

In addition to atmospheric pressure, temperature, and moisture (relative humidity or wet bulb temperature), balloon-borne radiosondes can be equipped with instrumentation to measure the vertical distributions of ozone mixing ratios. Ozonesondes have lower quantifiable limit of less than 15 ppb with precision of ± 5 ppb or ± 10%.

Ozonesondes provide ozone data that are averaged over short vertical distances and are thus nearly instantaneous measurements at a particular location. The data are only "snapshots" at each level of the atmosphere. As the radiosonde rises, it can be transported downwind, so measurements are not made above a fixed location. The typical response time of the instrument (> 80% of step change in 1 minute) may affect accuracy during ascent through sharp gradients in ozone mixing ratios. Balloon soundings usually can be made two to eight times per day on selected sampling days within reasonable budget contraints, but they are not cost-effective for long-term monitoring. Use of ozonesondes are most cost-effective when coupled to existing radiosonde releases.

C.4.2 Ozone Aloft ¾ Lidar Measurements

The Elight Ozone Profiler measure vertical ozone profiles starting at approx. 50 m up to 2000 m with a detection limit of $1 mg/m^3 * m$. This corresponds to a detection limit of $5 \mu g/m^3$ with 200 m range resolution. The system can be delivered as outdoor version with air-water cooling and with water-water cooling as indoor version. The optics and the electronics are integrated in an outdoors housing which allows system operation under different weather conditions. In the system a data analysis software package is implemented for the on-line determination of the ozone concentration as function of the height. This information can be delivered in form of ASII files or as graphical tables. Technical specification for the Elight Ozone Profiler is available at their web site at http://www.elight.de/profiler2.htm.

C.5 Supplemental Measurements of Oxidized Nitrogen Species

Accurate measurements of NO and NO_2 in the atmosphere are of considerable importance because of the role of these compounds in the production of ozone and other photochemically derived air pollutants, such as peroxyacetyl nitrate (PAN), the nitrate radical (NO_3), and nitric acid (HNO_3). Proper evaluation and exercise of photochemical models require low detection limits (<1 ppbv) and interference-free measurements of these species. Routine monitoring techniques for measurement of NO and NO_2 and other oxides of nitrogen do not meet these requirements, thus, the photochemical models are unable to reproduce the measured atmospheric concentrations of these species accurately. Recent improvements in routine monitors and the development of ultrasensitive and specific methods for measuring the nitrogen oxide species of interest (e.g., NO, NO_2, NO_X, NO_y, HONO, HNO_3, NO_3, and PAN) provide more accurate and reliable input data for photochemical models. Most of these methods were evaluated recently by Solomon (1995) during the SJVAQS/AUSPEX/SARMAP air quality study. Measurement of oxidized nitrogen species during CCOS will be made primarily by the commercially available instruments described below. Redundant measurements by alternative spectroscopic method such as a tunable diode laser absorption spectroscopy (TDLAS) or differential optical absorption spectroscopy (DOAS) would be desirable if sufficient funds are available.

C.5.1 NO_2 and PAN by Gas Chromatography with Luminol Chemiluminescence Detection

The Luminol NO_2 analyzer operates on the principle that gaseous NO_2 undergoes a surface reaction with a specially formulated solution containing water, luminol, sodium sulfate, sodium hydroxide, and alcohol ("Luminol II" solution). The luminol is oxidized and the product chemiluminesces in the 425 nm region. The luminol solution is presented to the air stream on a wick which is replenished with solution from a reservoir. The solution is introduced at the top of the wick and removed to a waste container by a two channel peristaltic pump. A 250 ml reservoir holds sufficient solution for about 3 days of operation. The light emitted by the chemiluminescence reaction is detected by a photomultiplier tube, amplified and output to a chart recorder and data logger. The signal is very sensitive, with a detection limit of 5 pptv if zeroed every 30 minutes or 50 ppt if zeroed daily.

Although luminol can produce chemiluminescence with other oxidants, these reactions usually require the presence of metal ion catalyst. Use of deionized water in the solution formulation prevents chemiluminescence from other oxidizers such as hydrogen peroxide. Only O_3 and PAN were found to produce luminescence, and addition of other substances to the solution, such as sodium sulfite, make the response to O_3 negligible for NO_2 mixing ratios above 1 ppbv. The interference by PAN is a constant fraction of the PAN mixing ratio, although the fraction may depend on the formulation, batch, and age of the luminol solution.

The LCM method has be adapted to measure PAN as well as NO_2. In this method, PAN is separated from NO_2 and other organonitrates by gas chromatography, thermally reduced to NO_2, and measured using the same luminol detector described above for the luminol chemiluminescence measurement of NO_2. The more reactive oxides of nitrogen, such as HNO_3, HONO, NO_3, and other reactive interfering species such as ozone are retained on the column. NO, while passing through the GC column, is not detected by the luminol detector. One major advantage of this

method is that the instrument can be calibrated in the field with NO_2 rather than the thermally unstable PAN, which is required for the GC/electron capture detector method.

C.5.2 NO2 and HNO3 by Tunable Diode Laser Absorption Spectroscopy

The TDLAS method takes advantage of the high monochromaticity and rapid tunability of a Pb salt diode laser to measure absorptions from single rotational-vibrational lines in the middle infrared spectrum of a molecule. Almost all gases absorb radiation in this spectral region. However, since many gases absorb in this region, very high spectral resolution is required to prevent interferences from other gases in the sampled air. The atmospheric sample is pumped rapidly at the reduced pressure through a White cell, which also provides the long optical path lengths required to achieve the desired detection limits. The tunable diode laser is a small Pb crystal with variable amounts of Sn, Se, Te or S. The wavelength region at which the laser emits radiation is governed by the proportions of the three elements in the crystal. Techniques of measuring NO, NO_2 and HNO_3 by TDLAS has been described by Hasties (1983) and Mackay (1993) and measuring H_2O_2 and HCHO by MacKay (1994).

The precision of the measurements is experimentally found to be better than ± 1 percent. The accuracy depends on the ability to accurately measure the various flows and on the ability to determine the mixing ratio of the calibration standard. The computed accuracy for H_2O_2, HCHO and HNO_3 is ± 15 percent (MacKay, 1994).

C.1.3 Automated Particle Nitrate Monitor

The Aerosol Dynamics Inc. (ADI) automated particle nitrate monitor (Aerosol Dynamics Inc., Berkeley, CA) is a new method being developed to provide automated, high-time-resolution measurements of fine particle nitrate concentration. The ADI Automated Particle Nitrate monitor uses an integrated collection and vaporization cell whereby particles are collected by a humidified impaction process, and analyzed in place by flash vaporization. The measurements for the Northern Front Range Air Quality Study (NFRAQS) in the Denver area represent the first deployment of the system (Chow et al., 1998). Fine particle nitrate concentrations were measured at the Brighton site with five measurements per hour during a three-to-four day pollution episode between 01/16/97 and 01/20/97. During the winter 1997 field campaign, the system operated over two, one-week periods yielding concentrations of fine particle nitrate with five determinations per hour. The automated particle nitrate monitor captured the time variability in fine particle nitrate concentrations with a time resolution of 12 minutes and a precision of approximately 0.5 µg/m3. The absolute accuracy of the nitrate concentrations, as indicated through comparison with nitric-acid-denuded particulate nitrate measurements on filter packs, showed agreement within ±0.6 µg/m3 for most measurement periods, but exhibited a discrepancy of a factor of two for the highest nitrate concentration measurement periods. The reason for this difference is not known, and additional data is needed to qualify the accuracy and precision of the method.

The approach for continuous nitrate measurements is similar to the manual method used for more than 20 years to measure the size distribution of sulfate aerosols (Hering and Friedlander, 1982). The difference is that the particle collection and analysis has been combined into a single cell, allowing the system to be automated. Particles are humidified, and collected onto a metal strip by means of impaction. The humidification essentially eliminates the rebound of particles

from the collection surface without the use of grease (Winkler, 1974; Stein et al., 1994). Interference from vapors such as nitric acid is minimized by using a nitric acid denuder upstream of the humidifier. At the end of the 10-minute particle sampling period, the valving is switched to stop particle collection and to pass a nitrogen carrier gas through the cell and into a gas analyzer. The deposited particles were analyzed for nitrate by flash-vaporization in a nitrogen carrier gas, with quantitation of the evolved gases by a chemiluminscent analyzer operated in NOx mode (Yamamota and Kousaka, 1992). The flow system is configured such that there are no valves on the aerosol sampling line. Details of the method are given by Hering (1997).

Field calibration and validation procedures include on-line checks of particle collection efficiency, calibration of analysis step with aqueous standards applied directly to the collection substrate, and determination of blanks by measurements of filtered, ambient air. Particle collection efficiencies were checked by means of an optical particle counter which operated between the collection cell and the pump. The analysis step of the monitor was calibrated by application of aqueous standards of sodium nitrate and ammonium nitrate applied directly to the metal collection substrate. To ensure that the system did not respond to ammonium ion, standards of ammonium sulfate were also applied. These calibrations were done in the field at the beginning and end of each intensive sampling period. Field blanks were determined by placing a Teflon-membrane filter at the inlet of the system, collecting for the 10-minute sampling period, and then analyzing the strip exactly as done for a normal sample.

The data are reduced based on the response of the system to aqueous nitrate standards which were applied at four concentration levels, corresponding to deposits of 0, 40, 80 and 160 ng of nitrate. Standards data from the beginning and end of the sampling episode are combined to generate a calibration curve in the form of “y=axn”. This method forces the least squares regression line to pass through the zero-nanogram level response. For the Denver data set the regression is nearly linear, with n=0.92. Additionally, the data are corrected for field blank based on the average reading obtained when sampling through a Teflon-membrane filter. The field blank corresponded to approximately 0.84 µg/m3 of fine-particle nitrate. This value is approximately 10 times higher than the analysis blank, presumably due to interference from a gaseous constituent. The data are corrected for 9% particle losses in the inlet, measured in the laboratory using monodisperse aerosol. These losses were observed to be independent of particle size in the range from 0.1 to 0.8 µm.

Level 1A data validation included a review of all logged system parameters and daily log sheets, and an inspection of time series display of the reduced data. System parameters that are automatically logged by the data acquisition system include temperature and relative humidity of the sample collection, and capacitor voltage prior to each vaporization step. Parameters recorded manually on the daily log sheets include flow and pressure meter readings such as the purge gas rotameter readings and the differential pressure at the inlet of the NOx analyzer. The reduced data are displayed as a time series to inspect for possible outliers. Potential level II validation checks include comparison to dried particle light scattering using a nephelometer, and comparisons to filter nitrate acquired on a quartz-fiber/sodium-chloride-impregnated cellulose-fiber filter pack in a PM2.5 sequential filter sampler equipped with an upstream nitric acid denuder.

C.6 Supplemental Measurements of Volatile Organic Compounds

A.7.1 Collection and Analysis of Hydrocarbons and Oxygenated Species

Canister Sampling

Stainless steel SUMMA™-polished canisters of 6-L capacity are customarily employed for volatile hydrocarbon (C_2-C_{12}) collection. These canister samples are to be analyzed for speciated hydrocarbons by a method consistent with EPA Method TO-14, as well as for CO, CO_2, methane, and oxygenated species. Prior to sampling, the canisters are to be cleaned by repeated evacuation and pressurization with humidified zero air, and certified as described in the EPA document "Technical Assistance Document for Sampling and Analysis of Ozone Precursors" (October 1991, EPA/600-8-91/215).

The sampling procedure should essentially follow the pressurized sampling method described by EPA Methods TO-12 and TO-14 and the EPA document "Technical Assistance Document for Sampling and Analysis of Ozone Precursors" (October 1991, EPA/600-8-91/215). A stainless steel Viton pump draws in ambient air from the sampling manifold to fill and pressurize the sample canisters. A flow control device maintains a constant flow into the canisters over the desired sample period. This flow rate is preset to fill the canisters to about 1 atm above ambient pressure at the end of the sampling period (as described by EPA Method TO-14). For automatic operation, the timer starts and stops the pump at the appropriate time. The timer also opens the solenoid valve when the pump starts and closes it when the pump stops. The use of the solenoid manifold valves permits the automatic selection of preloaded canisters. The multiple-event sampling systems, allowing unattended collection of up to six canister samples are recommended for this study.

After sampling, an identification tag should be attached to each canister with the canister serial number, sample number, and sampling location, date, and time recorded on this tag. In addition a field sampling form and chain-of-custody form should be filled out giving all pertinent information on the collection of the sample.

GC/FID Analysis

Gas chromatography with flame ionization detector is the established technique for monitoring volatile hydrocarbons, ozone precursors, in ambient air. An air sample is taken from the canister and passed through the sample concentration system. This system usually consists of a freeze-out loop, made from chromatographic-grade stainless steel tubing packed with 60/80 mesh deactivated glass beads, and a 10-port sampling valve. First, the sample is transferred from the canister through the loop immersed in liquid oxygen to the volume transfer measurement apparatus. The C_2 and heavier hydrocarbons are cryogenically trapped inside the loop when air is transferred to an evacuated flask of known volume. From the difference in pressure inside the flask, the volume of the air sample can be calculated, based on the ideal gas law. When a sufficient volume of the air sample has been transferred from the canister to the concentration system, the 10-port valve is switched to position 2, the liquid oxygen is replaced with boiling water, and the contents of the trap are injected into a chromatographic column where separation of the C_2-C_{12}

hydrocarbons takes place. No Perma-Pure permeable membrane or other moisture-removal device should be used prior to concentration, since the use of such drying devices results in the loss of certain volatile organic compounds of interest (all polar compounds and some olefins and aromatics). It can also introduce contaminants into the system and it lowers the total NMHC by 10-20% (Sagebiel and Zielinska, 1994).

The chromatographic column used for the C_2-C_{12} hydrocarbon analysis is usually a 60 m long DB-1 fused silica capillary column (or equivalent) with a 0.32 mm inside diameter and 1 μm phase thickness. However, the DB-1 column does not provide complete separation of the light C_2 and some important C_4 hydrocarbons. Therefore, a separate analysis of the canister sample is recommended to obtain accurate concentrations for ethane, ethylene, acetylene, 1-butene, and isobutylene. The chromatographic column used for this analysis is usually GS-Alumina PLOT fused silica capillary column (or equivalent) with an internal diameter of 0.53 mm and a length of 30 m. A separate gas chromatograph or two-dimensional (2D) chromatography could be used for this analysis.

The GC/FID response is calibrated in ppbC, using primary calibration standards traceable to the National Institute of Standards and Technology (NIST) Standard Reference Materials (SRM). The NIST SRM 1805 (254 ppb of benzene in nitrogen) is used for calibrating the analytical system for C_2-C_{12} hydrocarbon analysis, whereas 1 ppm propane in a nitrogen standard (Scott Specialty Gases), periodically traced to SRM 1805, is used for calibrating the light hydrocarbon analytical system. Based on the uniform carbon response of the FID to hydrocarbons, the response factors determined from these calibration standards are used to convert area counts into concentration units (ppbC) for every peak in the chromatogram.

Identification of individual compounds in an air sample is usually based on the comparison of linear retention indices (RI) with those RI values of authentic standard compounds, as well as with the RI values obtained by other laboratories performing the same type of analysis using the same chromatographic conditions. Appendix A-1 lists target species, together with other pertinent information. Note that all PAMS target compounds listed in the EPA document "Technical Assistance Document for Sampling and Analysis of Ozone Precursors" (October 1991, EPA/600-8-91/215) are also on this list.

The gas chromatographs should be connected to a data acquisition system. The software performs data acquisition, peak integration and identification, hardcopy output, post-run calculations, calibrations, peak re-integration, and user program interfacing. Typically, over 85% of total detectable C_2-C_{12} hydrocarbon mass is identified and quantified. The detection limit for hydrocarbon VOC is approximately 0.1 ppbC for each compound.

Methane (CH_4), carbon monoxide (CO), and carbon dioxide (CO_2) are to be measured from the canister samples using GC/FID. Since the FID does not respond to CO and CO_2, these species are to be converted to methane by a methanator, positioned after the GC column, but ahead of the FID. The minimum detection limit for both CO and CH_4 should be < 20 ppbv, whereas for CO_2 < 3 ppmv. The precision of measurements should be generally better than 10%.

Methyl t-butyl ether should be quantified from canister samples, using the method of analysis for C_3-C_{12} hydrocarbons. The individual response factor should be determined for MTBE and its concentration reported in ppbC.

A.7.2 Carbonyl Compounds

Formaldehyde and other volatile carbonyl compounds are to be collected, utilizing solid adsorbent cartridges coated with 2,4-dinitrophenylhydrazine (DNPH) reagents, by the method consistent with the EPA document "Technical Assistance Document for Sampling and Analysis of Ozone Precursors" (October 1991, EPA/600-8-91/215). The method is based on the specific reaction of organic carbonyl compounds with DNPH deposited on silica gel or C_{18} bonded SepPak cartridges in the presence of an acid to form stable derivatives, hydrazones, which are subsequently analyzed by high performance liquid chromatography (HPLC).

A carbonyl sampling system consists of a diaphragm pump capable of maintaining air flow through the cartridges of 500 - 1500 ml/min, flowmeter, six-port solenoid manifold allowing unattended collection of up to six carbonyl samples, needle valves for flow rate regulation, and check valves to protect cartridges from outside air when air is not being sampled through a given cartridge. For automatic operation, the timer starts and stops the pump at the appropriate time. The timer also opens the six-port solenoid valve when the pump starts and closes it when the pump stops. A charcoal filter is attached to the pump outlet in order to remove traces of acetonitrile from DNPH cartridges.

Carbonyl compounds collected in the cartridges (as hydrazones) are eluted with HPLC grade acetonitrile and analyzed by HPLC with UV detection at 360 nm. A reverse phase HPLC column is used. Identifications are made based on matching the HPLC retention times with those of authentic standards. A three-level calibration curve (plus blank) is constructed for each quantified hydrazone. C1-C7 carbonyl compounds are recommended for quantification as follows: formaldehyde, acetaldehyde, acetone, acrolein, propionaldehyde, crotonaldehyde, methyl ethyl ketone, methacrolein, butyraldehyde, benzaldehyde, valeraldehyde, tolualdehyde, and hexanaldehyde.

A.7.3 C8-C20 Hydrocarbons by Tenax Sampling and Analysis by GC/FID or GC/MS

Volatile hydrocarbons in the range of C_8-C_{20}, are usually collected using Tenax solid adsorbent. The Tenax sampling unit draws two parallel streams of air allowing for the collection of duplicate samples, with the pump downstream of the Tenax. The flow rates are controlled by a flow controller or are measured before and after each run using a calibrated mass flow meter and the mean value is used to calculate volumes of air sampled. Prior to use, the Tenax solid adsorbent is cleaned by Soxhlet extraction with hexane/acetone mixture, packed into Pyrex glass tubes and thermally conditioned for four hours by heating at 300 °C under nitrogen purge. Approximately 10% of the precleaned Tenax cartridges are tested by GC/FID for purity prior to sampling. After sampling, the Tenax cartridges are capped tightly using clean Swagelok caps (brass) with graphite/vespel ferrules, and placed in metal containers with activated charcoal on the bottom.

Tenax samples are usually analyzed by the thermal desorption-cryogenic preconcentration method, followed by quantification by high resolution gas chromatography with flame ionization detection (GC/FID) or mass spectrometric detection (GC/MSD) of individual hydrocarbons. In some cases, analysis may also include identification by Fourier transform infrared/mass spectrometric detection (GC/IRD/MSD). A 60 m (0.32 mm i.d., 0.25 mm film thickness) DB-1 capillary column (or equivalent) is usually used. For analytical system calibration, a set of standard Tenax cartridges is prepared by spiking the cartridges with a methanol solution of standard SVHC, prepared from high-purity commercially available C_9-C_{20} aliphatic and aromatic hydrocarbons. For the GC/FID system, the calibration is based on the uniform response of FID detector to carbon atoms. The FID response factor per one nanomole of carbon is determined experimentally, using n-dodecane and 1,3,5-trimethylbenzene deposited on Tenax cartridges. Three different concentrations (plus one blank) are used to construct calibration curves. The response factor per one nanomole of carbon for each compound used for calibration is averaged to give one uniform response factor for all hydrocarbons (both aliphatic and aromatic). For GC/MS, calibration is based on the response factors of authentic standards. In addition, Tenax cartridges spiked with paraffinic and aromatic hydrocarbons are periodically analyzed by GC/FID or GC/MS to verify quantitative recovery of these hydrocarbons from the cartridges.

A.7.4 Continuous Formaldehyde by Fluorescent Detection of Dihydrolutidine Derivative

Formaldehyde is measured by an instrument that continuously measures the fluorescent, dihydrolutidine derivative formed by the reaction of formaldehyde with 1,3-cyclohexanedione (CHD) and ammonium ion (Dong and Dasgupta, 1994; Fan and Dasgupta, 1994). The present instrument from AnalTech (Lubbock, TX) is a fully automated measurement system. The instrument is designed to operate continuously or more typically, alternate between a sample gas and zero air. The instrument is also configured to measure aqueous HCHO.

The product with CHD is substantially more sensitive and is used in the present instrument. The reaction with CHD proceeds at a rate that is first order in CHD concentration and first order in ammonium ion concentration. When a dilute formaldehyde solution is mixed with an equal volume of a reagent containing 10 mg% CHD and 1.3 M CH3COONH4 at pH 4.9 and heated to 95°C, the reaction is completed in under 3 min. The excitation and emission maximum of the fluorescent product are broadly centered at 395 and 465 nm, respectively.

For gas-phase formaldehyde measurements, the system is configured as a gas phase flow injection analyzer in which the gaseous analyte is continuously transferred to an aqueous stream by a Nafion membrane based diffusion scrubber (DS) and the resulting aqueous stream is continuously analyzed by the liquid phase analysis system.

A.7.5 Automated GC/MS System

A continuous gas chromatography – mass spectrometry (GC/MS) system with an initial sample preconcentration is proposed for the analysis of VOC in ambient air during Central California Ozone Study (CCOS). This system would allow for measurement of hydrocarbons, oxygenated hydrocarbons, halogenated compounds, and other volatile organic compound concentrations with a temporal resolution of approximately 1-hour. GC/MS system would allow

for identification and quantification of much broader classes of organic compound as compared with GC/FID system.

Preconcentration System. The analysis of VOC at levels found in ambient air requires an initial sample preconcentration to reach the detection limit on the order of 0.1 – 0.2 ppbv. Commercially available automatic preconcentration systems are usually based on combination of multisorbent traps, such as XonTech Model 930 organic vapor concentrator or Model 940 cryofocusing trap. The multisorbent traps usually contain a combination of Tenax, Carbotrap and Carbosieve S-III solid adsorbents in various amount and proportions. These sorbents are relatively strong and they may introduce some artifact when more reactive organic compounds are required to be quantified.

As an alternative, the automatic preconcentration trap could be custom build, utilizing cryofocusing loops filled with very week, inert adsorbent, such as glass beads. Such systems are being currently developed by the University of Miami (Rod Zika, personal communication), NCAR (Eric Apel, personal communication) and NOAA (Paul Goldan).

GC/MS Systems. Commercially available GC/MS system could be used for this project. A new Hewlett Packard GC/MSD system offers enhanced sensitivity over older HP5970 MSD. An ion trap Varian Saturn GC/MS is an alternative to a conventional quadrupole MS and offers very good sensitivity; 0.1 – 0.2 ppbv detection limit is a standard for most of the analytes.

To obtain data for C2 hydrocarbons without using excessive amount of liquid N2, a dual capillary column (2-D) chromatography is proposed. A PLOT type column (such as Al2O3 or GasPro GSC) would allow for separation of light C2-C4 hydrocarbons, whereas narrow bore DB-1 or equivalent capillary column assures separation of higher boiling organic compounds. Additional FID detector could be used in parallel with MS detector for the quantification of light (C2-C4) hydrocarbons.

C.7 Photolysis Frequencies and Rates

The photolysis of ozone, nitrogen dioxide, formaldehyde and other air pollutants are drivers for the production of photochemical air pollution. A photolysis rate is equal to the product of a photolysis rate parameter and the species concentration, Equation (1).

$$\frac{d[c]}{dt} = j_1[c] \qquad (1)$$

where [c] is the concentration of species, c, and j_1 is the photolysis rate parameter.

Photolysis rate parameters depend upon spherically integrated actinic flux (F_λ) and a species' absorption cross sections (σ_λ) and quantum yields (ϕ_λ). All of these quantities are wavelength dependent. Photolysis rate parameters are calculated from Equation (2).

$$j = \int_{l_1}^{l_2} F_l \times s_l \times f_l \, dl \qquad (2)$$

where the quantities are defined above and the integral is integrated over the wavelengths of available spherically integrated actinic flux.

Roughly speaking the spherically integrated actinic flux is the total amount of light entering a volume of space and it is what cause a molecule to photolyize in the atmosphere, Figure 1 (Madronich 1987; Finlayson-Pitts and Pitts, 1999).

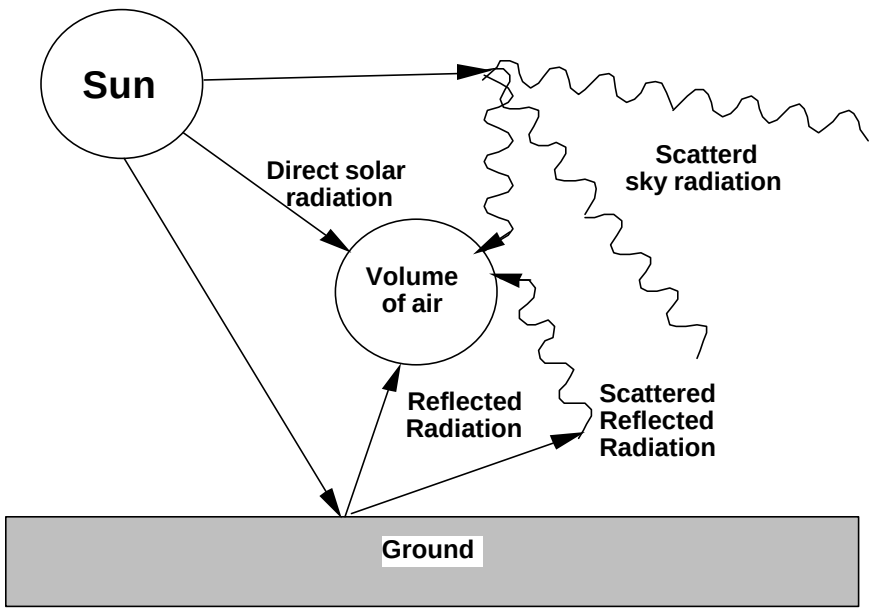
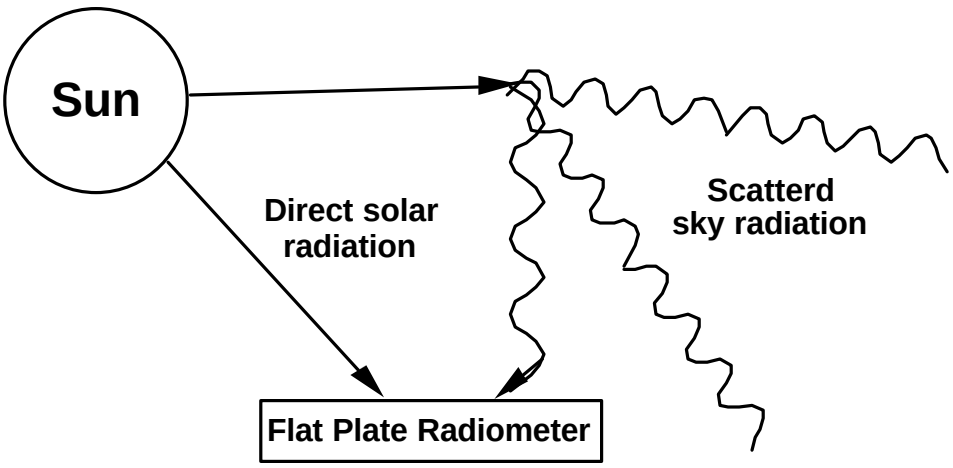


Figure 1. A schematic of actinic flux reaching a volume of air (adaptedfrom Finlayson-Pitts and Pitts (1999).

Unfortunately for atmospheric chemistry modeling the existing UVB and solar radiation networks measure irradiance rather than actinic flux. Irradiance is the net photon flux crossing a horizontal surface and it is expressed in units of the number of photons per unit area. The irradiance is related but not identical to actinic flux as can be seen by comparing Figure 2 with Figure 1.



The irradiance has a response factor of cos(θ) while the spherically integrated actinic flux does not. It is possible make estimates of spherically integrated actinic flux from irradiance measurements but the uncertainties may be at least ±40%. A complete discussion of the differences between actinic flux and irradiance is given in Madronich (1987).

Another difficulty in calculating photolysis rate parameters is that the wavelength dependent response of radiometer for the measurement of UVB and global solar radiation do not match the product (action spectrum) of any particular species' absorption cross sections (σλ) and quantum yields (ϕλ). For example a typical UVB radiometer response function is similar but not identical to the action spectrum of ozone,

Figure 3.

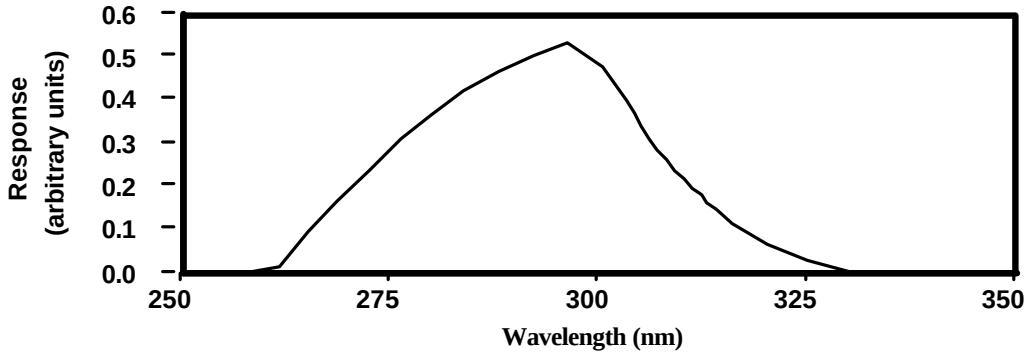


Figure 3. The response function of a Yankee brand UVB radiometer in arbitrary units as a function of wavelength.

The UVB radiometers can be used to provide an estimate of the photolysis rates of ozone to produce excited oxygen atoms, O(1D), and a small fraction of these react to produce HO radicals.

Global solar radiometers react to a broader spectrum of radiation at higher wavelengths; their response function is more like the action spectrum of NO2. For these reasons we propose to take advantage of existing networks of UVB and solar radiation measurements and to augment these with our own spectrally resolved actinic flux measurements.

A sample of solar radiance data including global solar radiation and UVB radiation measurements is given in Figure 4.

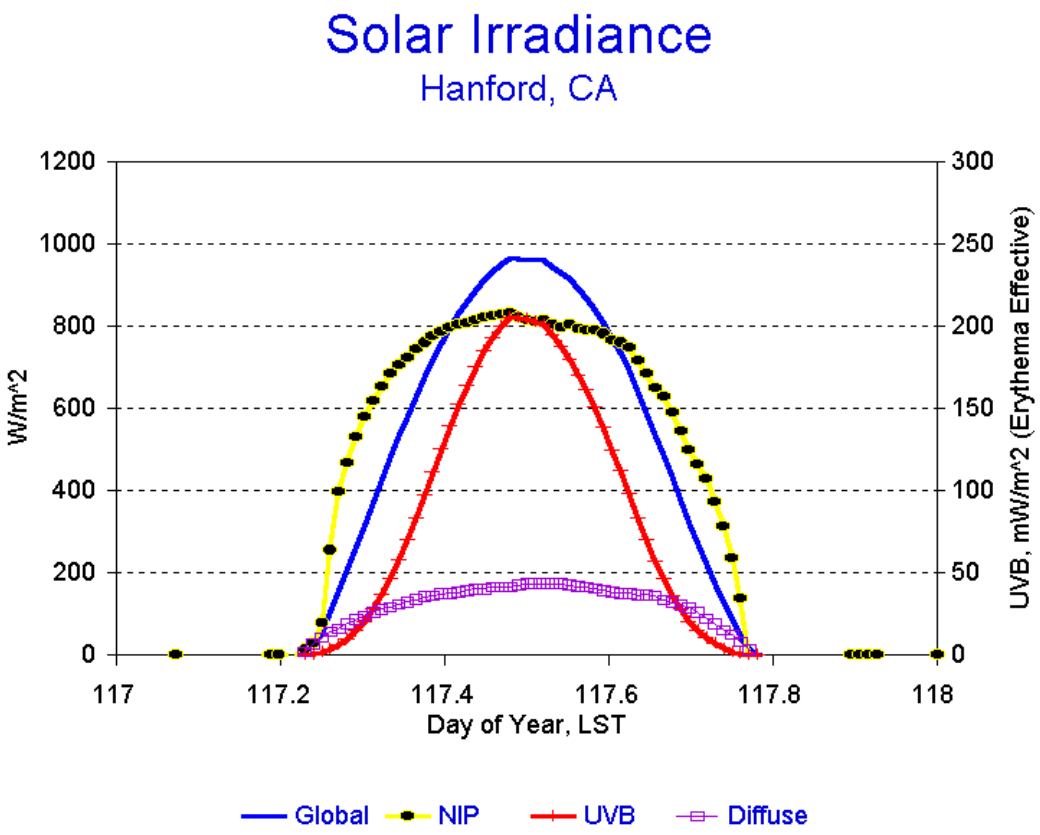


Figure 4. Solar irradiance measurements from Hanford, CA, from the NOAA monitoring program described below.

Appendix D-1

Supplemental Air Quality Site Descriptions and Installation Information

Site Information

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Bella Vista (S0)

Address: Bella Vista Water District
11368 Stillwater Way, Redding, CA

Location: From I5, east on Hwy 299E for about 4miles, then south on Stillwater Way for about 1 mile. Bella Vista Water District is on west side of Stillwater way.

Coordinates: Lat 40 37.134' N Lon 122 17.839' W (4496.3 N 559.5 E)

Elevation: 198.2 m

Description: Downwind maximum ozone site free of local sources.

Local Contact:
Name: Bob Dietz
Organization: Bella Vista Water District
Phone No: (530) 241-1085

Site Operator:
Name: Rita Cirulis
Organization: Shasta AQMD
Mailing Address: 1855 Placer St., Suite 101, Redding CA 96001
Shipping Address: Same
Office Phone: 530) 225-5156, or 225-5674
Cell Phone: None
Fax No: (530) 225-5237
Email: aqmd@co.shasta.ca.us

Existing Monitoring Equipment : None. New Site.

Supplemental Equipment:

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NO/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
Calibrator	TEI 146	DRI (Bowen)
Zero Air Supply	TEI 110	DRI (Bowen)
Data Logger	Campbell CR10X	DRI (Bowen)
Meteorology (WS, WD, T, RH)	Instrumented 10 m Tower	NOAA (Crescenti)

New Facilities:
8' X 10' shelter, power, 2 phone lines (DRI monitoring equipment, NOAA meteorology)
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI/NOAA
Calibrations	DRI
Local Site Operations	Shasta AQMD
Technical Support	Shasta AQMD
VOC Sample Collection	na
VOC Sample Analysis	na
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Lambie Road (S0)

Address: California Dept. of Health Services
6250 Lambie Road
Suisun City, CA 94585

Location: Lambie Road is off of Hwy 12, about midway between Rio Vista and Suisun. Site is at Goosehaven and Lambie Road.

Coordinates: Lat 38 13.212', Lon 121 50.809' N

Elevation: 145 m

Description:

Local Contacts:

Name:	Ron Babcock/Scott Hixon
Organization:	California Department of Health Services (land owner)
Phone No:	(707) 428-2045
Email:	rbabcock@dhs.ca.gov
Name:	Bob Franicevich, Senior AQ Specialist Bob will coordinate site operator training and site visits by other agencies.
Organization:	BAAQMD
Phone No:	(707) 553-8126

Site Operator:

Name:	Dan Borst
Organization:	BAAQMD
Mailing Address:	939 Ellis St. San Francisco, CA 94109-7799
Shipping Address:	Same (shipments will take 3 days to reach Dan Borst) Send ATTN: Dan Borst
Office Phone:	(707) 252-0870
Cell Phone (pager):	(415) 201-6679
Fax No:	(707) 252-0870
Email:	danborst@baaqmd.gov

Existing Monitoring Equipment: None. New Site.

Supplemental Equipment :

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NO/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
Calibrator	TEI 146	DRI (Bowen)
Zero Air Supply	TEI 110	DRI (Bowen)
Data Logger	Campbell CR10X	DRI (Bowen)
Meteorology (WS, WD, T, RH)	Instrumented 10 m Tower	NOAA (Crescenti)

New Facilities:

8’ X 10’ shelter, power, 2 phone lines (DRI monitoring equipment, NOAA meteorology)
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI/NOAA
Calibrations	DRI
Local Site Operations	BAAQMD
Technical Support	DRI
VOC Sample Collection	na
VOC Sample Analysis	na
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Sloughhouse (S0)

Address: Fire Station #58
7520 Sloughhouse Road
Sloughhouse, CA 95683

Location: If travelling SE on Highway 16 (Jackson Road), turn right (SW) onto Sloughhouse Road. Go about 1/3 mile. Site is located adjacent to American River Fire Department Station #58. Note: Sloughhouse Road is ½ to 1 mile west of the community of Sloughhouse on Highway 16 (Jackson Road).

Coordinates: Lat 83° 29' 41" N, Lon 121° 12" 36" W

Elevation: 58 m

Description:

Local Contact:

Name:	John Ching
Organization:	Sacramento Metro AQMD
Phone No:	(916) 874-4839
Email:	jching@airquality.org

Site Operator:

Name:	Ken Lashbrook (acting)
Organization:	Sacramento Metro AQMD
Mailing Address:	777 12th St., 3rd Floor, Sacramento, CA 95814
Shipping Address:	Same
Office Phone:	(916) 874-4840
Cell Phone:	None
Fax No:	(916) 874-4899
Email:	klashbrook@airquality.org

Existing Monitoring Equipment:

Observable	Instrument
Ozone	Dasibi 1003RS, with built-in calibration system
Data Logger	Sumx 445
Meteorology (WS, WD, Temp, Shelter Temp)	10 m Tower

Supplemental Monitoring Equipment:

Observable	Instrument	Installer
NO/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
Calibrator	TEI 146	DRI (Bowen)
Zero Air Supply	TEI 110	DRI (Bowen)
Data Logger	Campbell CR10X	DRI (Bowen)

New Facilities (shelter, fence, power, etc)
One additional phone line for Campbell data logger

Responsible Party: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI
Calibrations	DRI
Local Site Operations	SMAQMD
Technical Support	DRI
VOC Sample Collection	na
VOC Sample Analysis	na
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

San Martin (S0)

Address: San Martin Airport
13030 Murphy Avenue
San Martin, CA 95046

Location: At South County Airport in San Martin, approximately 20 miles SE of San Jose, along Hwy 101

Coordinates: UTM East 624.51 North 4104.4
Lat 37.0793 N, Lon 121.6 W

Elevation: 87 m

Description:

Local Contact:

Name:	Stan Yamaichi (Area Supervisor) or Avi Okin (Monitoring Manager)
Organization:	Bay Area AQMD
Phone No:	Stan Yamaichi (510) 656-5243 Avi Okin (415) 749-4616
Email:	syamaichi@baaqmd.gov, aokin@baaqmd.gov

Site Operator:

Name:	Tony Larsen
Organization:	Bay Area AQMD
Mailing Address:	120B No. Fourth St, San Jose, CA 95122 *or* Bay Area AQMD, 939 L St., San Francisco, CA 94109
Shipping Address:	Same
Office Phone:	(408) 295-0692
Cell Phone:	None
Fax No:	(510) 656-8970
Email:	tlarsen@baaqmd.gov (or alarsen@baaqmd.gov)

Existing Equipment:

Observable	Instrument
Ozone	TECO 49 with internal ozonator
Data Logger	ESC 8800
Meteorology* (WS, WD, Temp, Shelter Temp)	10 m Tower

* Separate tower, with download direct to BAAQMD

Supplemental Equipment:

Observable	Instrument	Installer
NO/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
Calibrator	TEI 146	DRI (Bowen)
Zero Air Supply	TEI 110	DRI (Bowen)
Data Logger	Campbell CR10X	DRI (Bowen)

New Facilities: None

Summary of Responsibilities:

Equipment Installation	DRI
Calibrations	DRI
Local Site Operations	BAAQMD
Technical Support	BAAQMD
VOC Sample Collection	na
VOC Sample Analysis	na
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Kettleman City (S0)

Address: None. Property belongs to Stone Land Company

Location: From Kettleman City, north on Highway 41, 8-10 miles, to Omaha Avenue, then left (west) on Omaha Avenue. Site is about 2-3 miles west of Highway 41, on north side of Omaha Avenue.

Coordinates: Lat 36 05.703' N, Long 119 57.017' W

Elevation: 103m

Description: Rural area, surrounded on all sides by cotton fields and irrigation ponds and a north/south irrigation canal immediately to the east. The nearest road is Omaha Avenue, an east-west rural road with very little traffic.

Local Contacts:

Name (land owner):	Bill Stone
Organization:	Stone Land Company P.O. Box 146 Stratford, CA 93266
Phone:	(209) 945-2205
Name (for access):	John Gallup/Evan Shipp
Organization:	SJVAPCD
Phone No:	(559) 230-5860/(559) 230-5809
Email:	john.gallup@valleyair.org/evan.shipp@valleyair.org

Site Operator:

Name:	Carl Camp
Organization:	SJVAPCD
Mailing Address:	1990 East Gettysburg Avenue, Fresno, CA 93726-0244
Shipping Address:	Same
Office Phone:	(559) 230-5864
Cell Phone:	None
Fax No:	(559) 230-6064
Email:	carl.camp@valleyair.org

Existing Monitoring Equipment (vendor/model if available): None, new site

Kettleman City Supplemental Equipment

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NO/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
Data Logger	Campbell CR10X	DRI (Bowen)
Meteorology (WS, WD, T, RH)	Instrumented 10 m Tower	NOAA (Crescenti)

New Facilities:

8' X 10' shelter, power, 2 cell lines (DRI monitoring equipment, NOAA meteorology)
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI/NOAA
Calibrations	DRI
Local Site Operations	SJVUAPCD
Technical Support	DRI
VOC Sample Collection	na
VOC Sample Analysis	na
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

McKittrick (S0)

Address: Unknown. Site is in a vacant lot near downtown McKittrick.

Location: From intersection of highways 58 and 33, near schoolhouse at east side of McKittrick, go south on Highway 33 about ½ mile, through "downtown McKittrick" (basically a junction with a grocery store and a hotel). The site is on the left in a vacant lot, about 1 block past hotel. Contact site operator for access.

Coordinates: Lat 35 18.158' N, Lon 119 37.304' W

Elevation: 390 m

Description: This is a compound formerly occupied by the West Side Operators Air Pollution Monitoring Station. It is located in an open area in the middle of McKittrick. Ground cover in the immediate area is chaparral. There are residences at distances of 100 to 200 m all around. California Highway 58 is about 100 to 200 m to the west. Photos in Appendix D-2 show views from the site toward 8 direction sectors.

Local Contacts:

Name: Sam Duran
Organization: Texaco (property owner)
Phone No: (661) 392-2200
Email:

Site Operator: (NOTE: Site operator will probably be a student, designated by Peter Ouchida.)

Name: Peter Ouchida
Organization: California Air Resources Board
Mailing Address: 13th and T, Sacramento, CA
Shipping Address:
Office Phone: (916) 322-3719
Cell Phone:
Fax No:
Email: pouchida@arb.ca.gov

Existing Monitoring Equipment: None. New Site

McKittrick Supplemental Equipment

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NO/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
Data Logger	Campbell CR10X	DRI (Bowen)
Meteorology (WS, WD, T, RH)	Instrumented 10 m Tower	NOAA (Crescenti)

New Facilities:

8' X 10' shelter, power, 2 phone lines (DRI monitoring equipment, NOAA meteorology)
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI (Bowen), NOAA(Crescenti)
Calibrations	DRI(Bowen)
Local Site Operations	ARB (Ouchida)
Technical Support	ARB (Ouchida)
VOC Sample Collection	na
VOC Sample Analysis	na
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Red Hills (East County Monitoring Site, S0)

Address: No physical address. Site is at summit of Gillis Canyon Road, 1.25 miles southeast of Cholame.

Location: From Highway 101, go east on Highway 46 to Bitterwater Road. Right on Bitterwater Road to Gillis Canyon Road. Right on Gillis Canyon Road 1.3 miles. Station is on right at summit

NOTE: Agreement with landholder is that vehicle access be curtailed if ground is wet.

Coordinates: Lat 35° 38' 37" N, Lon 120° 13' 50" W

Elevation: ~ 671 m (2200 ft)

Description: Site is on ridge top above the town of Shandon, with excellent exposure in all directions.

Local Contact:

Name:	Jay Courtney/Brian Aunger
Organization:	San Luis Obispo County APCD
Phone No:	(805) 781-4656/(801) 781-4666
Email:	jcourtney_apcd@co.slo.ca.us / baunger_apcd@co.slo.ca.us

Site Operator:

Name:	Jay Courtney
Organization:	San Luis Obispo County APCD
Mailing Address:	3433 Roberto Court San Luis Obispo, CA 93401-7126
Shipping Address:	Same
Office Phone:	(805) 781-4656
Cell Phone:	None
Fax No:	
Email:	jcourtney_apcd@co.slo.ca.us

Existing Monitoring Equipment :

Red Hills is a new site being installed by SLOCAPCD. It will be a permanent ozone site, operated by that agency. Ozone analyzer is a Dasibi 1003AH. Meteorology (WS,WD, Temp) will also be monitored. Site DAS is ESC 8800. Contact Jay Courtney or Brian Aunger for other details on permanent site equipment.

Red Hills Supplemental Equipment:

Observable	Instrument	Installer
NO/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
Calibrator	TEI 146	DRI (Bowen)
Zero Air	TEI 110	DRI (Bowen)

New Facilities (shelter, fence, power, etc): None specifically for CCOS

Summary of Responsibilities:

Equipment Installation	DRI (Bowen), NO_Y analyzer
Calibrations	DRI (Bowen), NO_Y analyzer
Local Site Operations	SLOCAPCD (Courtney)
Technical Support	SLOCAPCD (Courtney)
VOC Sample Collection	na
VOC Sample Analysis	na
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Sutter Butte (S1)

Address: South Butte, Building A

Location: From Highway 20, go north on Acacia Avenue. (There is a Minimart at the junction.) Go north on Acacia, through Sutter. Acacia turns into South Butte Road. Take sharp left turn at what looks like a storage yard. Go to white gate, 2-3 miles, on right (north) side.

NOTE: Access is very restricted. Property belongs to American Towers. Contacts at American Towers are Jim Pederson (cell phone (916) 768-8039), Jake Kley – Maintenance Supervisor ((530) 458-2118), or possibly Gabrielle Turner-Ayres – Access Coordinator ((510) 236-3803 ext 279). Refer to Rick Rigsby, ARB site operator. (Or contact Rick Rigsby first).

Coordinates: Lat 39° 9' 20" N, Lon 121° 43'00" W

Elevation: 659 m (2160 ft)

Description: Top of Butte

Local Contacts:

Name:	Jim Pederson/Jake Kley
Organization:	American Towers
Phone No:	(916) 768-8039/(530) 458-2118
Email:	

Name:	Larry Molek
Organization:	ARB
Phone No:	916) 327-4889
Email:	lmolek@arb.ca.gov

Site Operator (for **CCOS** Operations):

Name:	John Bowen
Organization:	Desert Research Institute
Mailing Address:	2215 Raggio Parkway Reno, NV 89512
Shipping Address:	Same
Office Phone:	(775) 674-7044
Cell Phone:	(775) 560-9246
Fax No:	(775) 674-7009
Email:	johnb@dri.edu

Site Operator (for **routine (Non-CCOS)** operations):

Name:	Rick Rigsby
Organization:	ARB
Mailing Address:	State of California Air Resources Board 773 Almond St. Yuba City, CA 95991
Shipping Address:	Same
Office Phone:	(530) 671-7615
Cell Phone:	(530) 755-9116
Fax No:	none
Email:	rrigsby@arb.ca.gov

Sutter Buttes Existing Equipment:

Observable	Instrument
Ozone	API 400 with Internal Zero/Span
Data Logger	ESC 8800
Meteorology (NOT ARB's, belongs to NowCasting	

Sutter Buttes Supplemental Equipment:

Observable	Instrument	Installer
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
C_2 - C_{12} HC from canisters	DRI Multi-Channel Sequential HC Sampler	DRI (Zielinska)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Outside Shelter for DRI HC sampler	DRI HC Sampler Shelter	DRI (Zielinska)

New Facilities: None

Summary of Responsibilities

Equipment Installation	DRI/AtmAA(Carbonyls)
Calibrations	DRI
Local Site Operations	DRI
Technical Support	DRI
VOC Sample Collection	DRI (canisters)/AtmAA (Carbonyls)
VOC Sample Analysis	DRI (canisters)/AtmAA (Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

White Cloud (S1)

Address: 26533 State Highway 20
Nevada City, CA

Location: From I80, take Nevada City exit (Highway 20). Site is on Highway 20 at the White Cloud Forest Service station, 12-15 miles east of Nevada City, on south side of highway. It is across from the White Cloud rest stop, on north side of highway. Gate is normally open.

Coordinates: Lat 39.3166 N, Lon 120.8444 W

Elevation: 1302 m

Description:

Local Contact:

Name:	Larry Molek
Organization:	ARB
Phone No:	(916) 327-4889
Email:	lmolek@arb.ca.gov

Site Operator (for **CCOS** Operations):

Name:	John Bowen
Organization:	Desert Research Institute
Mailing Address:	2215 Raggio Parkway Reno, NV 89512
Shipping Address:	Same
Office Phone:	(775) 674-7044
Cell Phone:	(775) 560-9246
Fax No:	(775) 674-7009
Email:	johnb@dri.edu

Site Operator (for **routine (non-CCOS)** operations):

Name:	Kent Breitwieser
Organization:	ARB
Mailing Address:	
Shipping Address:	
Office Phone:	(916) 784-8065
Cell Phone:	
Fax No:	
Email:	kbreitwi@arb.ca.gov

White Cloud Existing Equipment:

Observable	Instrument
Ozone	API 400 with Internal Zero/Span
Data Logger	ESC 8800
Meteorology	

White Cloud Supplemental Equipment:

Observable	Instrument	Installer
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
C_2 - C_{12} HC from canisters	DRI Multi-Channel Sequential HC Sampler	DRI (Zielinska)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Outside Shelter for DRI HC sampler	DRI HC Sampler Shelter	DRI (Zielinska)

New Facilities: None

Summary of Responsibilities

Equipment Installation	DRI/AtmAA(Carbonyls)
Calibrations	DRI
Local Site Operations	DRI
Technical Support	DRI
VOC Sample Collection	DRI (canisters)/AtmAA (Carbonyls)
VOC Sample Analysis	DRI (canisters)/AtmAA (Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Bodega Bay (S1)

Address: Bodega Bay Marine Lab
2099 Westside Road
Bodega Bay, CA 94923

Location: Highway 101 north to Santa Rosa, Highway 12 east through Sebastapol. Highway 12 turns into Bodega Highway. Go through Bodega to Highway 1. Turn right, through Bodega Bay. Turn left at East Shore Road, right at Bay Flat Road, past Marina. Look for "Housing" sign on right (gray units). Look for grove of cyprus trees on right, turn into Bodega Marine Lab driveway. Drive to end of road. Minivols are to the left. Hydrocarbon sampler (CRPAQS) is in greenhouse to the left of 3 portable buildings just before road end.

Coordinates:

Elevation:

Description:

Local Contact:

Name:	Peter Connors
Organization:	UC Davis
Phone No:	(707) 875-2020
Email:	pgconnors@ucdavis.edu

Site Operator:

Name:	Don Lehrman/Sue Hynek
Organization:	T&B
Mailing Address:	859 2nd St. Santa Rosa, CA 95404
Shipping Address:	Same
Office Phone:	(707) 526-2775
Cell Phone:	
Fax No:	(707) 579-5954
Email:	donl@tbsys.com

Existing Monitoring Equipment (vendor/model if available): None. This is a CRPAQS site, otherwise it is a new site. A meteorological tower has been installed for CRPAQS, and CRPAQS will be collecting the meteorological data.

Bodega Bay Supplemental Equipment:

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
C_2 - C_{12} HC from canisters	HC Canister Sampler	BRC (Rassmussen)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Data Logger	Campbell CR 10X	DRI (Bowen)

New Facilities:

8’ X 10’ shelter (in addition to the CRPAQS shelter), power, 1 phone line (DRI monitoring equipment)
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI/AtmAA(Carbonyls)/BRC(HC Canisters)
Calibrations	DRI (Bowen)
Local Site Operations	T&B(Lehrman)
Technical Support	
VOC Sample Collection	T&B
VOC Sample Analysis	BRC(HC canisters)/AtmAA(Carbonyls)
Data Acquisition	DRI(Bowen)
Level 0 Data Validation/Reporting	DRI(Bowen)

San Leandro

Address: 15400 Foothill Blvd
San Leandro, CA

Location: San Leandro County Hospital. See Bob Schusteritsch for site access.

Coordinates: Lat 37.7098 N, Lon 122.1164 W

Elevation: 43m

Description:

Local Contact:

Name:	Stan Yamaichi (Area Supervisor) or Avi Okin (Monitoring Manager
Organization:	Bay Area AQMD
Phone No:	Stan Yamaichi (510) 656-5243 Avi Okin (415) 749-4616
Email:	syamaichi@baaqmd.gov, aokin@baaqmd.gov

Site Operator:

Name:	Bob Schusteritsch (contact for site access)
Organization:	Bay Area AQMD
Mailing Address:	939 Ellis St. San Francisco, CA 94109
Shipping Address:	Same
Office Phone:	(415) 749-4632
Cell Phone:	None
Fax No:	(415) 621-0565
Email:	bschusteritsch@baaqmd.gov

San Leandro Existing Equipment:

Observable	Instrument
Ozone	TECO Model 49
toxins, NMOC	Xontech Model 910a
CH4, NMHC	TECO Model 55c
Data Logger	ESC 8800
Meteorology	

Supplemental Equipment (with vendor/model): None
New Facilities : None

Summary of Responsibilities:

Equipment Installation	No new equipment
Calibrations	BAAQMD
Local Site Operations	BAAQMD
Technical Support	BAAQMD
VOC Sample Collection	BAAQMD
VOC Sample Analysis	DRI(HC)/AtmAA(Carbonyls)
Data Acquisition	
Level 0 Data Validation/Reporting	

San Jose 4th Street

Address: 120 North 4th
San Jose, CA 95112

Location: Site is on 4th Street, just north of Santa Clara. Note: 4th Street is a one-way street going north to south, so you may have to take a parallel street and come back. Contact Stan Yamaichi or Tony Larsen (below) for access to shelter.

Coordinates: Lat 37.34 N, Lon 121.8875 W

Elevation: 25m

Description:

Local Contact:

Name:	Stan Yamaichi (Area Supervisor) or Avi Okin (Monitoring Manager
Organization:	Bay Area AQMD
Phone No:	Stan Yamaichi (510) 656-5243 Avi Okin (415) 749-4616
Email:	syamaichi@baaqmd.gov, aokin@baaqmd.gov
Pager:	(Yamaichi): (415) 998-1093

Site Operator:

Name:	Tony Larsen
Organization:	BAAQMD
Mailing Address:	120B No. Fourth St, San Jose, CA 95122 *or* Bay Area AQMD, 939 L St., San Francisco, CA 94109
Shipping Address:	Same
Office Phone:	(408) 295-0692
Cell Phone:	None
Fax No:	(510) 656-8970
Email:	tlarsen@baaqmd.gov (or alarsen@baaqmd.gov)

San Jose 4th St Existing Equipment:

Observable	Instrument
Ozone	TECO Model 49
CO	TECO Model 48
NO/NO2	TECO Model 42
THC,CH4	Comb Eng 8202
Gas Calibration	TECO Model 146
Data Logger	ESC 8800
Meteorology	

Supplemental Equipment: None

New Facilities: None

.

Summary of Responsibilities:

Equipment Installation	BAAQMD
Calibrations	BAAQMD
Local Site Operations	BAAQMD
Technical Support	BAAQMD
VOC Sample Collection	BAAQMD
VOC Sample Analysis	BAAQMD(HC)/AtmAA(Carbonyls)
Data Acquisition	
Level 0 Data Validation/Reporting	

Bruceville (S1)

Address: 12490 Bruceville Road
Elk Grove, CA 95758

Location: This is an existing SMAQMD site. From I5, take Twin Cities Road exit. Then go east on Twin Cities Road about 2 miles to intersection with Bruceville Road. Then go left (north) approximately ¾ mile. Gravel road on left is entrance to Franklin Field airstrip. Trailer is about 80 ft up this gravel road.

Coordinates: Lat 38° 18' 07" N, Lon 121° 25' 20" W

Elevation: 6m

Description:

Local Contact:

Name:	John Ching
Organization:	Sacramento Metro AQMD
Phone No:	(916) 874-4839
Email:	jching@airquality.org

Site Operator:

Name:	Gordon Sill
Organization:	Sacramento Metro AQMD, Air Monitoring Section
Mailing Address:	777 12th St, 3rd Floor Sacramento, CA 95814
Shipping Address:	Same
Office Phone:	(916) 874-4841
Cell Phone:	
Fax No:	(916) 874-4899
Email:	None

Bruceville Existing Equipment:

Observable	Instrument
Ozone	Dasibi Model 1003
NO/NO2/NOX	Teco Model 42c
HC(THC,CH4,NMHC)	Teco Model 55c
Gas Calibration	Dasibi 5008
Data Logger	ETC 6002
Meteorology(WS,WD,T,P,SR,Rad,RH)	

Bruceville Supplemental Equipment:

Observable	Instrument	Installer
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
Data Logger	Campbell CR 10X	DRI (Bowen)

New Facilities:

One phone line for DRI datalogger.
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI (Bowen)
Calibrations	SMAQMD/DRI(Bowen,NO_y)
Local Site Operations	SMAQMD
Technical Support	SMAQMD
VOC Sample Collection	SMAQMD
VOC Sample Analysis	ARB
Data Acquisition	DRI (Bowen)
Level 0 Data Validation/Reporting	DRI (Bowen)

San Andreas (S1)

Address: 501 Gold Strike Road, San Andreas

Location: 1-2 miles north of San Andreas on Gold Strike Road, or 1-2 miles south from Hwy 49 on Gold Strike Road. Gold Strike Road is an east turn from Hwy 49 3-4 miles north of San Andreas. It returns to Hwy 49 in downtown San Andreas.

Coordinates: 38° 12.2' N
120° 40.8 ' W

Elevation:

Description: The site is an existing SLAMS site operated by ARB. Exposure is excellent. Nearest road is Gold Strike Road, about 200 to 300 yards to the north and east. Traffic on Gold Strike Road is very light. The site is adjacent to a softball field. Photos show the shelter and views from the shelter towards 8 sectors surrounding the site.

Local Contact:
Name:
Organization:
Phone No:
Email:

Site Operator:
Name: James Frasche
Organization: ARB
Mailing Address:
Shipping Address:
Office Phone: (916) 445-1036
Cell Phone: (916) 799-9707
Fax No:
Email:

San Andreas Existing Equipment:

Observable	Instrument
Ozone	API 400 w/IZS
CO	Dasibi 3008
Meteorology(WS,WD,T)	Met One
Data Logger	ESC 8800

San Andreas Supplemental Equipment:

Observable	Instrument	Installer
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
C_2 - C_{12} HC from canisters	HC Canister Sampler	BRC (Rassmussen)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Data Logger	Campbell CR 10X	DRI (Bowen)

New Facilities: None

Summary of Responsibilities:

Equipment Installation	DRI (Bowen)
Calibrations	ARB/DRI (Bowen, NO_y)
Local Site Operations	ARB
Technical Support	ARB
VOC Sample Collection	ARB
VOC Sample Analysis	BRC(HC Canisters)/AtmAA(Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Turlock (S1)

Address: 900 South Minaret Street, Turlock, CA

Location: Contact John Gallup or Warren LeLeaux (below) for access to site.

From Golden State Blvd, downtown Turlock, go east on East Avenue 2-3 blocks. Then go south on South Minaret, which angles to the southeast. Stay on Minaret to Cottonwood. Site is south of the intersection of South Minaret and Cottonwood..

Coordinates: 37° 29.298' N Lon 120° 50.294' W

Elevation: 56m

Description: The site is located south of the intersection of S. Minaret and Cottonwood, in a residential area. Photos in Appendix D-2 show the shelter and views from the shelter towards 8 sectors surrounding the shelter. Streets in the immediate vicinity are very lightly traveled residential streets. The nearest major thoroughfare is Golden St. Blvd, 400 to 500 yards east of the site. A Railroad roughly parallels Golden St Blvd at this distance. Golden St Blvd is an elevated overpass at this distance, and can be seen in the "southwest" photo. The "View from Golden St. Blvd" photo was taken from this overpass looking back toward the shelter, which is roughly in the center of the photo.

Local Contact:

Name:	John Gallup (or Warren LeLeaux, below)
Organization:	San Joaquin Valley Unified APCD
Phone No:	(559) 230-5860
Email:	

Site Operator (for **CCOS** measurements):

Name:	Don Lehrman
Organization:	T&B
Mailing Address:	859 2nd St. Santa Rosa, CA 95404
Shipping Address:	Same
Office Phone:	(707) 526-2775
Cell Phone:	
Fax No:	(707) 579-5954
Email:	donl@tbsys.com

Site Operator (for **routine (non-CCOS)** measurements):

Name:	Warren LeLeaux
Organization:	San Joaquin Valley Unified APCD
Mailing Address:	ATTN: Warren LeLeaux 4230 Kiernan Avenue, Suite 130 Modesto, CA 95356-9321
Shipping Address:	
Office Phone:	(209) 557-6471
Cell Phone (pager):	(209) 569-6021
Fax No:	(209) 557-6475
Email:	warren.leleaux@valleyair.org

Turlock Existing Equipment:

Observable	Instrument
Ozone	Dasibi 1008-AH
CO	TECO Model 48c
NO_x	TECO Model 42c
Gas Calibration	Dasibi 5008
Meteorology(WS,WD,T)	Met One
Data Logger	SumX 445

Turlock Supplemental Equipment:

Observable	Instrument	Installer
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
C_2 - C_{12} HC from canisters	HC Canister Sampler	BRC (Rassmussen)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Data Logger	Campbell CR 10X	DRI (Bowen)

New Facilities:

One phone line for DRI datalogger.
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI(Bowen)/BRC(Rassmussen)/AtmAA(Fung)
Calibrations	DRI(Bowen), NOx
Local Site Operations	T&B(Lehrman)
Technical Support	
VOC Sample Collection	T&B(Lehrman)
VOC Sample Analysis	BRC(HC Canisters)/AtmAA(Carbonyls)
Data Acquisition	DRI(Bowen)
Level 0 Data Validation/Reporting	DRI(Bowen)

Piedras Blancas (South Central Coast, S1)

Address: Piedras Blancas Lighthouse

Location: Six miles north of San Simeon on Highway 1. West of highway.
Contact Jay Courtney for access.

Coordinates: Lat 35 39.882' N Lon 121 17.078' W

Elevation: 5m

Description: Coastal site with excellent background exposure.

Local Contact:

Name:	Jay Courtney/Brian Aunger
Organization:	San Luis Obispo County Air Pollution Control District
Phone No:	(805) 781-4656/(801) 781-4666
Email:	jcourtney_apcd@co.slo.ca.us / baunger_apcd@co.slo.ca.us

Site Operator:

Name:	Barry LaJoie
Organization:	SLOCAPCD
Mailing Address:	3433 Roberto Court San Luis Obispo, CA 93401-7126
Shipping Address:	Same
Office Phone:	(805) 781-5912
Cell Phone:	None
Fax No:	(805) 781-1002
Email:	jcourtney_apcd@co.slo.ca.us

Existing Monitoring Equipment : None, New Site.

Piedras Blancas Supplemental Equipment

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
C_2 - C_{12} HC from canisters	HC Canister Sampler	BRC (Rassmussen)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Data Logger	Campbell CR 10X	DRI (Bowen)
Meteorology	10m Tower	NOAA (Crescenti)

New Facilities:

Power, 2 phone lines (DRI Datalogger, NOAA Meteorology)
Installer: ENSR (McDade) .

Summary of Responsibilities:

Equipment Installation	DRI(Bowen)/BRC(Rassmussen)/AtmAA (Fung)/NOAA(Crescenti)
Calibrations	Bowen(DRI), NO_x, Ozone
Local Site Operations	SLOAPCD(Courtney)
Technical Support	SLOAPCD(Courtney)
VOC Sample Collection	SLOAPCD(Courtney)
VOC Sample Analysis	BRC(HC Canisters)/AtmAA(Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Angiola (S1)

Address: 36078 4th Avenue, Corcoran, CA 93212

Location: From Corcoran, go south on Highway 43 to 4th, then south on 4th to intersection with Tucson Avenue, where site is. Look for 100m tower. It is about 7 miles south of the California St. Prison on 4th.

Coordinates: Lat 35.9897 N Lon 119.4753 W

Elevation:

Description: Site is in cotton field area, with wide open exposure in all directions. Nearest road is 4th Avenue, a north-south road ~ 100 yards to the east. Site includes 100m tower operated by Sonoma Technology Inc. for CRPAQS.

Local Contacts:

Name:	Beth Wittig
Organization:	Sonoma Technology, Inc.
Phone No:	(661) 837-4219
Email:	beth@sonomatech.com

NOTE: Site operations for CRPAQS are being done by STI. This includes O_3 and NO_y analyzers, which overlap with CCOS operations. For inquiries regarding CRPAQS operations being done by STI, consult Beth Wittig, as site operator.

Site Operator:

Name:	Beth Wittig
Organization:	Sonoma Technology Inc.
Mailing Address:	2718 Ardee Circle, Bakersfield, CA 93304
Shipping Address:	Same
Office Phone:	(661) 837-4219
Cell Phone:	(661) 203-1082
Fax No:	Same as office number
Email:	beth@sonomatech.com

Site Phone: (559) 992-3794

Site Operator for Canister and Carbonyl Sampling

Name:	Carl Camp
Organization:	San Joaquin Valley Unified APCD
Mailing Address:	1990 E. Gettysburg, Fresno, CA 93726
Shipping Address:	Same
Office Phone:	(559) 230-5864

Existing Monitoring Equipment (vendor/model if available): This is an existing CRPAQS site, with 100m tower and extensive monitoring equipment for that study.

Angiola Supplemental Equipment:

Observable	Instrument	Installer

C_2 - C_{12} HC from canisters	HC Canister Sampler	BRC (Rassmussen)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)

New Facilities: None

.

Summary of Responsibilities:

Equipment Installation	BRC(Rassmussen)/AtmAA(Fung)
Calibrations	CRPAQS
Local Site Operations	CRPAQS
Technical Support	CRPAQS
VOC Sample Collection	
VOC Sample Analysis	BRC(HC Canisters)/AtmAA(Carbonyls)
Data Acquisition	
Level 0 Data Validation/Reporting	

Bethel Island (S2)

Address: 5551 Bethel Island Rd, Bethel Island

Location: From the town of Brentwood, go north on Highway 4 about 4 miles, then right on Cypress Road. Go 5 miles, at which point the road makes a sharp left and becomes Bethel Island Road. Just before the bridge, on the left, there is a boat self-storage building. (Don't look for boats, as they are inside the building). Instrument trailers are just north of the self-storage building.

Coordinates: Lat 38.0067 N, Lon 121.6414 W

Elevation: <5m

Description:

Local Contact:

Name:	Tom Conwell, Area Supervisor Tom will coordinate site operator training.
Organization:	Bay Area AQMD
Phone:	(707) 552-3515
Pager:	(415) 998-9412
Name:	Bob Franicevich, Senior AQ Specialist Backup for Tom
Organization:	Bay Area AQMD
Phone No:	(707) 553-8126

Site Operator:

Name:	Gary Owens
Organization:	Bay Area AQMD
Mailing Address:	BAAQMD
(Also shipping)	939 Ellis St. San Francisco, CA 94109
Home Address	110 Mackie Dr. Martinez, CA 94533
Office Phone:	(925) 439-1303
Pager:	(415) 201-6675
Fax No:	(925) 439-1303 (regular line)
Email:	gowens@baaqmd.gov

Backup Operator

Name:	Graham Scovell
Phone:	(925) 685-7947

Bethel Island Existing Equipment:

Observable	Instrument
CO	TECO Model 48
Ozone	TECO Model 49
NO/NO2/Nox	TECO Model 42
SO2	TECO Model 43A

Coefficient of Haze	RAC
Gas Calibration	TECO Model 146
Data Logger	ESC 8800
Meteorology	

Bethel Island Supplemental Equipment:

Observable	Instrument	Installer
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
NO_2/PAcN by chemiluminescence and luminol	CE-CERT	DRI (Bowen)/CE-CERT (Fitz)
C_2 - C_{12} HC from canisters	DRI Multi-Channel Sequential HC Sampler	DRI (Zielinska)
HCHO (Formaldehyde) by methanalyzer	Alpha-Omega MA100	CE-CERT (Fitz)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Data Logger	Campbell CR 10X	DRI (Bowen)

New Facilities:

8’ x 10’ shelter, power, 1 phone line for DRI datalogger.
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI(Bowen,Zielinska)/CE-CERT(Fitz)/ AtmAA(Fung)
Calibrations	BAAQMD(Ozone)/DRI(Bowen),Noy
Local Site Operations	BAAQMD
Technical Support	BAAQMD
VOC Sample Collection	BAAQMD
VOC Sample Analysis	DRI(HC Canisters),AtmAA(Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Patterson Pass (S2)

Address:

Location: Crest of Patterson Pass Road between Livermore and Tracy. Look for locked gate on the north side of the road at the top of the crest. Siet is located at a cable television antenna about a ¼ mile north of the road.

Coordinates:

Elevation:

Description:

Local Contact:

Name: Ron Deacon
Organization: Media One
Phone No:
Email:

Site Operator:
Name: Andrew Kean
Organization: University of California at Berkeley
Mailing Address: Department of Civil and Environmental Engineering
Davis Hall, Room 631
Berkeley, CA 94720-1710
Shipping Address: Same
Office Phone: (510) 642-6582
Fax No.: (510) 642-7483
E-mail: kean@newton.me.berkeley.edu

Name Rob Harley (Supervisor)
Office Phone: (510) 643-9168
Fax No: (510) 642-7483
Email: harley@ce.berkeley.edu

Existing Monitoring Equipment: None, New site.

Patterson Pass Supplemental Equipment:

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
NO_2/PAcN by chemiluminescence and luminol	CE-CERT	DRI (Bowen)/CE-CERT (Fitz)
C_2 - C_{12} HC from canisters	DRI Multi-Channel Sequential HC Sampler	DRI (Zielinska)
HCHO (Formaldehyde) by methanalyzer	Alpha-Omega MA100	CE-CERT (Fitz)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Data Logger	Campbell CR 10X	DRI (Bowen)

New Facilities:

Small trailer, power, 1 cell line (DRI Data Logger)
Installer: ENSR (McDade)

.**Summary of Responsibilities:**

Equipment Installation	DRI(Bowen,Zielinska)/CE-CERT(Fitz)/ AtmAA(Fung)
Calibrations	DRI (Bowen)
Local Site Operations	UCB(Harley)
Technical Support	UCB(Harley)
VOC Sample Collection	UCB(Harley)
VOC Sample Analysis	DRI(HC Canisters)/AtmAA(Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Pacheco Pass (S2)

Address: It's at Pacheco Pass!

Location: First you have to get the key from John Beam, or someone at California Department of Fish/Game (see below). To get to that office, get on West Henry Miller Avenue in Los Banos; the office is north of Los Banos, east of State Highway 165.

After you have the key you have to find the site. It's not trivial, and if you can get an escort it would be helpful. It can be done however. From Los Banos, go west on Highway 152, past San Luis Reservoir, to crest of pass. Near the crest, just west of Dinosaur Point Road, there is a small unmarked road that cuts off to the north. Take that road, go through the gate, and proceed to the site, which will be evident from the 10 meter met tower. It is less than a mile from the Highway.

Coordinates:

Elevation:

Description:

Local Contacts:

Name:	John Beam
Organization:	California Department of Fish/Wildlife 18110 West Henry Miller Avenue Los Banos, CA 93635
Phone No:	(209) 826-0463
Email:	

Site Operator:

Name:	Don Lehrman/Sue Hynek
Organization:	T&B
Mailing Address:	859 2nd St. Santa Rosa, CA 95404
Shipping Address:	Same
Office Phone:	(707) 526-2775
Cell Phone:	
Fax No:	(707) 579-5954
Email:	donl@tbsys.com

Existing Monitoring Equipment: Site is adjacent to existing CRPAQS site, with associated monitoring equipment and meteorological tower.

Pacheco Pass Supplemental Equipment:

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
NO_2/PAcN by chemiluminescence and luminol	CE-CERT	DRI (Bowen)/CE-CERT (Fitz)
C_2 - C_{12} HC from canisters	HC Canister Sampler	BRC (Rassmussen)
HCHO (Formaldehyde) by methanalyzer	Alpha-Omega MA100	CE-CERT (Fitz)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Data Logger	Campbell CR 10X	DRI (Bowen)

New Facilities :

Small trailer, 1 cell line (DRI Data Logger)
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI(Bowen)/CE-CERT(Fitz)/AtmAA (Fung)/BRC(Rassmussen)
Calibrations	DRI (Bowen), Ozone, Noy
Local Site Operations	T&B (Lehrman)
Technical Support	
VOC Sample Collection	T&B(Lehrman)
VOC Sample Analysis	DRI(HC Canisters)/AtmAA(Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Trimmer (S2)

Address: Trimmer Ranger Station
34849 Maxon Road
Sanger, CA 93657
(Note: the Ranger Station is actually nowhere near Sanger)

Location: From Fresno, take Highway 180 northeast to Trimmer Springs Road. Then go east on Trimmer Springs Road (keep heading toward Pine Flat Lake) for about 24 miles, until you get to Maxon Road. Then go left about 1 mile to the Trimmer Forest Service Station. Check in there for directions to the site, which is nearby.

Coordinates:

Elevation:

Description:

Local Contact:

Name:	Peter Ouchida
Organization:	California Air Resources Board
Phone No:	(916) 322-3719
Email:	pouchida@arb.ca.gov

Site Operator: Site operator will probably be a student, designated by Peter Ouchida.

Name:	Peter Ouchida
Organization:	California Air Resources Board
Mailing Address:	13th and T, Sacramento, CA
Shipping Address:	
Office Phone:	(916) 322-3719
Cell Phone:	
Fax No:	
Email:	pouchida@arb.ca.gov

Existing Monitoring Equipment : None, new site. Meteorology is being collected at the Trimmer CRPAQS site.

Timmer Supplemental Equipment:

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NOY/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
NO_2/PAcN by chemiluminescence and luminol	CE-CERT	DRI (Bowen)/CE-CERT (Fitz)
C_2 - C_{12} HC from canisters	DRI Multi-Channel Sequential HC Sampler	DRI (Zielinska)
HCHO (Formaldehyde) by methanalyzer	Alpha-Omega MA100	CE-CERT (Fitz)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Data Logger	Campbell CR 10X	DRI (Bowen)

New Facilities:

8’ x 10’ trailer, power, 1 phone line (DRI Data Logger)
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI(Bowen, Zielinska)/CE-CERT(Fitz)/ AtmAA(Fung)
Calibrations	DRI(Bowen),ozone,Noy
Local Site Operations	ARB(Ouchida)
Technical Support	ARB(Ouchida)
VOC Sample Collection	ARB(Ouchida)
VOC Sample Analysis	DRI(HC Canisters)/AtmAA(Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Arvin (S2)

Address: Arvin/Edison Water Storage District
20401 East Bear Mountain Blvd
Arvin, CA

Location: Located on property of Arvin/Edison Water Storage District on Bear Mountain Blvd 4-5 miles east of Arvin. Just past bridge.

Coordinates: Lat 35° 12.503' N Lon 118° 46.526' W

Elevation: 136m

Description: Site is an existing PAMS site. The nearest major road is the east-west Bear Mountain Blvd, roughly 200 m north of the shelter, which has moderate traffic. There are several Water District buildings immediately to the south, west, and north, and water storage ponds to the west. Otherwise surrounding terrain is predominantly orchards. Local exposure is good to excellent.

Local Contact:

Name:	Alvin Danque
Organization:	Air Resources Board
Phone No:	(661) 334-3994(office), (661) 854-2560(site)
Email:	adanque@arb.ca.gov

Site Operator:

Name:	Alvin Danque
Organization:	Air Resources Board
Mailing Address:	Monitoring and Laboratory Division 5558 California Ave., Suite 460 Bakersfield, CA 93309
Shipping Address:	Same
Office Phone:	(661) 334-3994
Cell Phone:	(661) 331-5621
Fax No:	(661) 334-3999
Email:	adanque@arb.ca.gov

Arvin Existing Equipment:

Observable	Instrument
Ozone	API Model 400
NOX/NO/NO2	TECO 44
CH4	
NMHC	TECO Model 55
Meteorology (ws,wd,at,sr,bp)	Met One
Data Logger	ESC 8800
Calibration Equipment	Environics 9100

Arvin Supplemental Equipment:

Observable	Instrument	Installer
NO/NO_Y by chemiluminescence	TEI 42C TL with external converter	DRI (Bowen)
NO_2/PAcN by chemiluminescence and luminol	CE-CERT	CE-CERT (Fitz)
HCHO (Formaldehyde) by methanalyzer	Alpha-Omega MA100	CE-CERT (Fitz)
Data Logger	Campbell CR10X	DRI (Bowen)
Calibrator	TEI 146	DRI (Bowen)

New Facilities: None

Summary of Responsibilities

Equipment Installation	DRI(Bowen)/CE-CERT(Fitz)
Calibrations	DRI(Bowen)
Local Site Operations	ARB(Danque)
Technical Support	ARB(Danque)
VOC Sample Collection	ARB(Danque)
VOC Sample Analysis	ARB (PAMS Site)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Sunol (Research)

Address:	Radio Bunker Hill 505 Paloma Sonoma, CA 94586 This is BAAQMD Meteorological Site #1904
Location:	Take Highway 680 south to Niles Canyon exit, then west. First intersection is Paloma. Go right. Access road to Sunol Hill is by General Store.
Coordinates:	Lat 37.594 N, Lon 121.876 W
Elevation:	140m
Description:	Top of Sunol Hill

Local Contact:

Name:	James Cordova/Rob DeMandel
Organization:	Bay Area AQMD
Address:	939 Ellis St. San Francisco, CA 94109
Phone No:	(415) 749-5104
Fax No:	(415) 749-4741
Email:	jcordova@baaqmd.gov

NOTE: Contact James Cordova for info on site access, e.g. gate locks, etc.

Site Operator:

Name:	Andrew Kean
Organization:	University of California at Berkeley
Mailing Address:	Department of Civil and Environmental Engineering Davis Hall, Room 631 Berkeley, CA 94720-1710
Shipping Address:	Same
Office Phone:	(510) 642-6582
Fax No.:	(510) 642-7483
E-mail:	kean@newton.me.berkeley.edu
Name	Rob Harley (Supervisor)
Office Phone:	(510) 643-9168
Fax No:	(510) 642-7483
Email:	harley@ce.berkeley.edu

Site Operator (for GC/MS on IOPs):

Name:	John Sagebiel
Organization:	Desert Research Institute
Mailing Address:	2215 Raggio Parkway, Reno, NV 89512
Shipping Address:	Same
Office Phone:	(775) 674-7064
Cell Phone:	
Fax No:	(775) 674-7060
Email:	johns@dri.edu

Existing Monitoring Equipment (vendor/model if available): This is an existing meteorological site operated by BAAQMD, with sensors on a 10m tower. Otherwise, all equipment is new (supplemental) equipment. See below.

Sunol Supplemental Equipment:

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NOY/NO_Y* by chemiluminescence	TEI 42C TL with 2 external converters and HNO_3 denuder	DRI (Bowen)
NO/NO_x by chemiluminescence	TEI 42C TL	DRI (Bowen)
NO_2/PAcN by chemiluminescence and luminol	CE-CERT	DRI (Bowen)/CE-CERT (Fitz)
$PM_{2.5}$ nitrate by flash volatilization	R&P	DRI (Bowen)
CO by infrared gas filter correlation	TEI 48C TL	DRI (Bowen)
CO_2 by infrared gas filter correlation	TEI 41C HL	DRI (Bowen)
C_2 - C_{12} HC from canisters	DRI Multi-Channel Sequential HC Sampler	DRI (Zielinska)
C_8 - C_{20} HC from TENAX	DRI Multi-Channel Sequential TENAX Sampler	DRI (Zielinska)
Gas Chromatography - Mass Spectrometry	Varian 3800 GC + Varian 2000 MS + ENTECH 7100 Pre-Concentrator	DRI (Sagebiel)
HCHO (Formaldehyde) by methanalyzer C_1 - C_7 carbonyls from DNPH	Alpha-Omega MA100	CE-CERT (Fitz) AtmAA (Fung)
Light absorption by aethalometer	Andersen RTAA-1000 (Magee Scientific AE31)	DRI (Bowen)
Light scattering by nephelometer	Radiance Research M903	DRI (Bowen)
Actinic flux by spectral radiometer	Metcon 2-pi diode array spectometer	DRI (Stockwell)

New Facilities:

8’ X 10’ shelter, power, 1 phone line, 1 DSL line
Installer: ENSR (McDade)

.

Summary of Responsibilities:

Equipment Installation	DRI(Bowen,Sagebiel,Zielinska,Stockwell),CE-CERT(Fitz), AtmAA(Fung)
Calibrations	DRI
Local Site Operations	UCB(Martien), DRI(Sagebiel, during IOPS)
Technical Support	UCB
VOC Sample Collection	UCB
VOC Sample Analysis	DRI(HC canisters, Tenax Cartridges), AtmAA(carbonyls)
Data Acquisition	DRI (Bowen)
Level 0 Data Validation/Reporting	DRI (Bowen)

Granite Bay (Research)

Address: Eureka School District
5455 Eureka Road
Granite Bay, CA 95746

Location: Take Sierra College exit off I-80, south to Eureka Rd, and east on Eureka Rd. to Eureka School Distrit Office. Site is located in a vacant 5-acre lot north of the school bus yard.

Coordinates: Lat 38 44.231' N Lon 121 12.010' W

Elevation: 227 m

Description:

Local Contact:

Name: David Freeman, Assistant Superintendent of Schools Organization: Eureka School District
5455 Eureka Road
Granite Bay, CA 95746
Phone No: (916) 791-4939
Email:

Site Operator:
Name: John Bowen/Barbara Zielinska
Organization: Desert Research Institute
Mailing Address: 2215 Raggio Parkway, Reno, NV 89512
Shipping Address: Same
Office Phone: (775) 674-7044/(775) 674-7066
Cell Phone:
Fax No: (775) 674-7009/(775) 674-7060
Email: johnb@dri.edu/barbz@dri.edu

Existing Monitoring Equipment : None, new site.

Granite Bay Supplemental Equipment:

Observable	Instrument	Installer
O_3 by ultraviolet absorption	API 400 A	DRI (Bowen)
NOY/NO_Y* by chemiluminescence	TEI 42C TL with 2 external converters and HNO_3 denuder	DRI (Bowen)
NO/NO_x by chemiluminescence	TEI 42C TL	DRI (Bowen)
NO_2/PAcN by chemiluminescence and luminol	CE-CERT	DRI (Bowen)/CE-CERT (Fitz)
$PM_{2.5}$ nitrate by flash volatilization	R&P	DRI (Bowen)
CO by infrared gas filter correlation	TEI 48C TL	DRI (Bowen)
CO_2 by infrared gas filter correlation	TEI 41C HL	DRI (Bowen)
C_2 - C_{12} HC from canisters	DRI Multi-Channel Sequential HC Sampler	DRI (Zielinska)

C_8 - C_{20} HC from TENAX	DRI Multi-Channel Sequential TENAX Sampler	DRI (Zielinska)
Gas Chromatography - Mass Spectrometry	Varian 3800 GC + Varian 2000 MS + ENTECH 7100 Pre-Concentrator	DRI (Sagebiel)
HCHO (Formaldehyde) by methanalyzer	Alpha-Omega MA100	CE-CERT (Fitz)
C_1 - C_7 carbonyls from DNPH	AtmAA Carbonyl Sampler	AtmAA (Fung)
Light absorption by aethalometer	Andersen RTAA-1000 (Magee Scientific AE31)	DRI (Bowen)
Light scattering by nephelometer	Radiance Research M903	DRI (Bowen)
Actinic flux by spectral radiometer	Metcon 2-pi diode array spectometer	DRI (Stockwell)
Data Logger	PC	DRI(Bowen)
Meteorology	10 m instrumented tower	NOAA (Crescenti)

New Facilities:

10’ x 32’ trailer, power, 2 phone lines (DRI, NOAA Met Tower), 1 DSL line (DRI)
Installer ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI(Bowen,Zielinska,Sagebiel,Stockwell)/CE-CERT(Fitz)/AtmAA(Fung)/ NOAA(Crescenti)
Calibrations	DRI
Local Site Operations	DRI(Bowen,Zielinska)
Technical Support	DRI
VOC Sample Collection	DRI
VOC Sample Analysis	DRI(HC Canisters, Tenax Cartridges)/AtmAA(Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Parlier (Research)

Address:	Kearney Agricultural Research Station 9240 South Riverbend Avenue Parlier, CA 93648
Location:	From Parlier, one block east on Manning, then right onto Riverbend, then second entrance on left. Contact Richard Nelson (below) for access.
Coordinates:	Lat 36 35 51 N Lon 119 30 13 W
Elevation:	
Description:	

Local Contacts:

Name:	Fred Swanson, Superintendent
Organization:	Kearney Agricultural Research Station
Phone No:	(559) 646-6060
Email:	fswanson@uckac.edu

Name:	John Gallup/Evan Shipp
Organization:	San Joaquin Valley Unified APCD
Phone No:	(559) 230-5860/(559) 230-5809
Email:	john.gallup@valleyair.org/evan.shipp@valleyair.org

Site Operator:

Name:	Richard Nelson
Organization:	San Joaquin Valley Unified APCD
Mailing Address:	1990 East Gettysburg Avenue, Fresno, CA 93726-0244
Shipping Address:	Same
Office Phone:	(559) 230-5863
Cell Phone:	None
Fax No:	(559) 230-6064
Email:	dick.nelson@valleyair.org

Site Operator (for GC/MS on IOPs):

Name:	Mark McDaniel
Organization:	Desert Research Institute
Mailing Address:	2215 Raggio Parkway, Reno, NV 89512
Shipping Address:	Same
Office Phone:	(775) 674-7180
Cell Phone:	
Fax No:	(775) 674-7060
Email:	mmcdan@dri.edu

Parlier Existing Equipment:

Observable	Instrument
Ozone	Dasibi Model 1008-H
NO_x	TECO Model 42
Methane, NMHC	TECO Model 55c
Gas Calibration	Dasibi Model 5008
Data Logger	ETC 6002
HC	Canister Samples
Meteorology (WD,WS,T,RH,P,SR)	10 m Tower

Parlier Supplemental Equipment:

Observable	Instrument	Installer
NOY/NO_Y* by chemiluminescence	TEI 42C TL with 2 external converters and HNO_3 denuder	DRI (Bowen)
NO_2/PAcN by chemiluminescence and luminol	CE-CERT	DRI (Bowen)/CE-CERT (Fitz)
$PM_{2.5}$ nitrate by flash volatilization	R&P	DRI (Bowen)
CO by infrared gas filter correlation	TEI 48C TL	DRI (Bowen)
CO_2 by infrared gas filter correlation	TEI 41C HL	DRI (Bowen)
C_8 - C_{20} HC from TENAX	DRI Multi-Channel Sequential TENAX Sampler	DRI (Zielinska)
Gas Chromatography - Mass Spectrometry	Varian 3800 GC + Varian 2000 MS + ENTECH 7100 Pre-Concentrator	DRI (Sagebiel)
HCHO (Formaldehyde) by methanalyzer	Alpha-Omega MA100	CE-CERT (Fitz)
Light absorption by aethalometer	Andersen RTAA-1000 (Magee Scientific AE31)	DRI (Bowen)
Light scattering by nephelometer	Radiance Research M903	DRI (Bowen)
Actinic flux by spectral radiometer	Metcon 2-pi diode array spectometer	DRI (Stockwell)
Data Logger	PC	DRI(Bowen)
TDLAS		CE-CERT

New Facilities:

10’ x 32’ trailer, power, 1 phone line (DRI), 1 DSL line (DRI)
Installer: ENSR (McDade)

Summary of Responsibilities:

Equipment Installation	DRI(Bowen,Sagebiel,Stockwell)/CE-CERT (Fitz)/AtmAA(Fung)
Calibrations	DRI
Local Site Operations	SJVUAPCD(Nelson)DRI(McDaniel),CE-CERT
Technical Support	DRI
VOC Sample Collection	SJVUAPCD(Nelson)
VOC Sample Analysis	DRI(Tenax Cartridges)/ARB(HC Canisters)/ARB(Carbonyls)
Data Acquisition	DRI
Level 0 Data Validation/Reporting	DRI

Shasta Lake (Other)

Address: Shasta Lake Fire District
13791 Lake Blvd
Shasta Lake, CA 96019

Location: From I5, take the State Highway 151 (Shasta Dam Blvd) exit. Go west ~ 4 miles to intersection with Lake Blvd. Turn south, go a short distance to the Fire District office on the east side of Lake Blvd.

This is a new site to be operated by Shasta AQMD. Equipment is located in an air-conditioned garage at the Fire Protection District facility. Contact Rita Cirulis for access.

Coordinates: Lat 40° 41.37' N, Lat 122° 24.14' W

Elevation: 361 m

Description: Residential

Local Contact:

Name:	Charles E. Dahlen, Battalion Chief/Fire Marshal
Organization:	Shasta Lake Fire Protection District 4126 Ashby Court Shasta Lake, CA 96019-9215
Phone No:	(530) 275-7474
Fax No:	(530) 275-6502
Email:	fire.district@ci.shasta-lake.ca.us

Site Operator:

Name:	Rita Cirulis
Organization:	Shasta AQMD
Mailing Address:	1855 Placer St., Suite 101, Redding CA 96001
Shipping Address:	Same
Office Phone:	(530) 225-5156, or 225-5674
Cell Phone:	None
Fax No:	(530) 225-5237
Email:	aqmd@co.shasta.ca.us

Existing Monitoring Equipment: Ozone (Dasibi 1003), meteorology on 10m tower.

Supplemental Monitoring Equipment:

New Facilities:

Responsibilities: Shasta AQMD is responsible for this site.

Camp Roberts (Other)

Address: No physical address.

Location: Site is on Camp Roberts National Guard property. See Jay Courtney or Brian Aunger for access.

Coordinates: Lat: 35° 47' 30" N, Lon 120° 45' 03" W

Elevation: 244 m (800 ft)

Description:

Local Contact:

Name:	Jay Courtney/Brian Aunger
Organization:	San Luis Obispo County Air Pollution Control District
Phone No:	(805) 781-4656/(805) 781-4666
Email:	jcourtney_apcd@co.slo.ca.us / baunger_apcd@co.slo.ca.us

Site Operator:

Name:	Jay Courtney
Organization:	SLOCAPCD
Mailing Address:	3433 Roberto Court San Luis Obispo, CA 93401-7126
Shipping Address:	Same
Office Phone:	(805) 781-4656
Cell Phone:	None
Fax No:	
Email:	jcourtney_apcd@co.slo.ca.us

Existing Monitoring Equipment: WS,WD,Ozone (API 400A)

Supplemental Monitoring Equipment: None

New Facilities:

Summary of Responsibilities:

Equipment Installation	SLOCAPCD
Calibrations	SLOCAPCD
Local Site Operations	SLOCAPCD
Technical Support	SLOCAPCD
VOC Sample Collection	NA
VOC Sample Analysis	NA
Data Acquisition	SLOCAPCD
Level 0 Data Validation/Reporting	SLOCAPCD

Table D-1. Procurers and Installers

Name	Organization	Mailing Address	Shipping Address	Phone No.	Cell Phone No.	FAX No.	email address
John Bowen	Desert Research Institute	2215 Raggio Parkway, Reno, NV 89512	Same	(775) 674-7044		(775) 674-7009	johnb@dri.edu
John Sagebiel	Desert Research Institute	2215 Raggio Parkway, Reno, NV 89512	Same	(775) 674-7064		(775) 674-7060	johns@dri.edu
William Stockwell	Desert Research Institute	2215 Raggio Parkway, Reno, NV 89512	Same	(775) 674-7058		(775) 674-7060	wstock@dri.edu
Barbara Zielinska	Desert Research Institute	2215 Raggio Parkway, Reno, NV 89512	Same	(775) 674-7066		(775) 674-7060	barbz@dri.edu
Dennis Fitz	CE-CERT[a]	1200 Columbia Avenue, Riverside, CA 92507	Same	(909) 781-5781	(909) 433-6534 (pager)	(909) 781-5790	dfitz@cert.ucr.edu
Kochy Fung	AtmAA	23917 Craftsman Road, Calabasas, CA 91302	Same	(818) 223-3277		(818) 223-8250	kfung@earthlink.net
Reinhold Rasmussen	Biospheric Research Corporation	17010 NW Skyline Blvd, Portland, OR 97231	Same	(503) 621-1435			rei@ese.ogi.edu
Jerry Crescenti	NOAA	1750 Foote Drive, Idaho Falls, ID 83402	Same	(208) 526-2328		(208) 526-2549	jerry@noaa.inel.gov
Chuck McDade	ENSR	1220 Avenida Acaso, Camarillo, CA 93012	Same	(805) 388-3775	(805) 377-1359	(805) 388 3577	CMcDade@ensr.com

[a] College of Engineering, Center for Environmental Research and Technology

Appendix D-2

Supplemental Air Quality Site Descriptions and Installation Information

Site Photos

S0 Sites

Bella Vista
Lambie Road
Sloughhouse
San Martin
Kettleman City
McKittrick
Red Hills (SLOAPCD)

S1 Sites

Sutter Butte
White Cloud
Bodega Bay
San Leandro
San Jose 4th Street
Bruceville
San Andreas
Turlock
Piedras Blancas (South Central Coast)
Angiola

S2 Sites

Bethel Island
Patterson Pass
Pacheco Pass
Trimmer
Arvin

Research Sites

Sunol
Granite Bay
Parlier

Other Sites

Shasta Lake
Camp Roberts

Bella Vista

Bella Vista Water District

]

North View

East View

South View

West View

Lambie Road

Lambie Road Site

North View

Northeast View

East View on Lambie Road

Southeast View

South View from Front Gate

Southwest View towards Site

West View from Lambie Rd

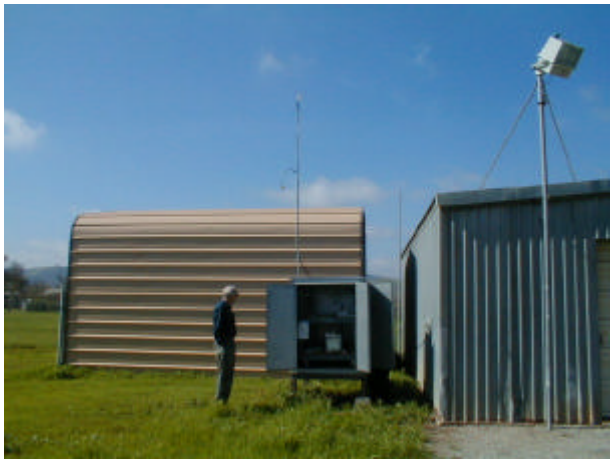
Northwest View

Sloughhouse

Sloughhouse Looking East

Sloughhouse Looking West

San Martin



San Martin Shelter with Probe

San Martin Shelter

Kettleman City

Kettleman Site

Site View from Omaha Road

North View

Northeast View

East View

Southeast View

South View

Southwest View

West View

Northwest View

McKittrick

McKittrick Monitoring Site

Compound Interior

North View

Northeast View

East View

Southeast View

South View

Southwest View

West View

Northwest View

Red Hills

Sutter Butte

White Cloud

ARB Shelter at White Cloud

Met Station at White Cloud

North View

Northeast View

East View

Southeast View

South View

Southwest View

West View

Northwest View

Bodega Bay

Bodega Bay Trailer Site, Looking North

Bodega Bay Met Tower, from SW

North View

East View

South View

West View

San Leandro

San Jose 4th Street

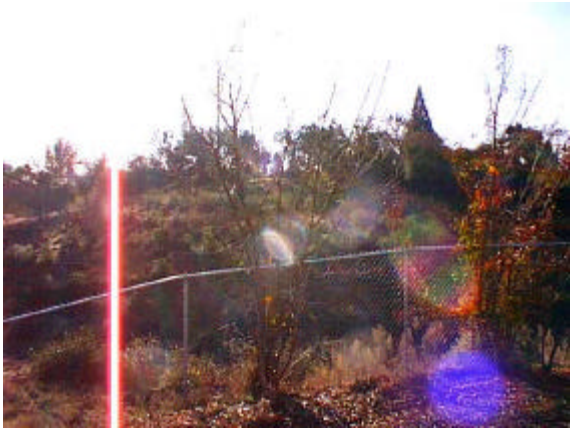
Bruceville

San Andreas

north view

northeast view

east view


southeast view

south view

southwest view

west view

northwest view

Turlock

Turlock Monitoring Site

View from Golden St. Blvd Overpass
(Monitoring Site in Distance)

North View

Northeast View

East View

Southeast View

South View

Southwest View

West View

Northwest View

Piedras Blancas

Piedras Blancas Building

Piedras Blancas Met Tower Area

Instrument Room at Piedras Blancas,
Looking Southwest

North View

East View

South View

West View

Angiola Tower

North View

Northeast View

East View

Southeast View

South View

Southwest View

West View

Northwest View

Bethel Island

Bethel Island Monitoring Site, Looking NW

North View

East View

South View

West View

Patterson Pass

Pacheco Pass

Pacheco Pass Site

Northeast View

East View

West View

Northwest View

Trimmer

North View

East View

South View

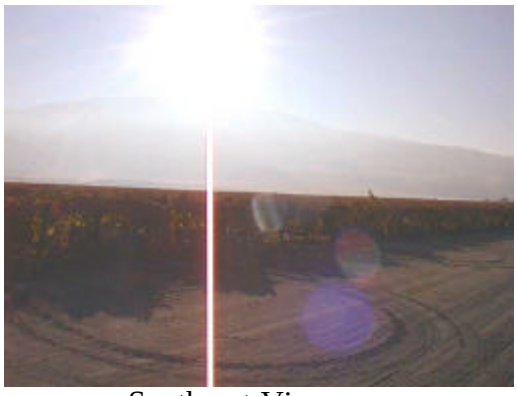
West View

Arvin

North View

Northeast View

East View


Southeast View

South View

Southwest View

West View

Northwest View

Sunol

Sunol Site, North View

East View

South View

Sunol Met Tower

Granite Bay

Granite Bay Site

North View

East View

Southeast View

South View

Southwest View

West View

Parlier

Parlier Instrument Shelter

North View

Northeast View

East View

Southeast View

South View

Southwest View

West View

Northwest View

Shasta Lake

North View

East View

South View

Shasta Lake Site

Camp Roberts