

4. QUALITY ASSURANCE

4.1 QUALITY ASSURANCE OVERVIEW

Every measurement consists of four attributes: a value, a precision, an accuracy, and a validity (e.g. Hidy, 1985). The measurement methods described in the previous section are used to obtain the value. Quality assurance is the complementary part of the measurement process which provides the precision, accuracy, and validity estimates and guarantees that these attributes are within acceptable limits. The quality assurance component of SCAQS is essential to the attainment of Objective 1.

Quality assurance for the project will be a major responsibility of the Program Coordinator (PC). The PC must ensure that the final program design contains adequate quality control procedures and adequate external checks to assure that the data obtained will be adequate for their intended purposes. In addition, it is the responsibility of the PC to monitor the quality assurance activities during the project and to make certain that problems are rapidly identified and solved. A quality assurance program will be implemented for all repetitive measurements for which a standard operating procedure (SOP) can be developed.

The quality assurance program for SCAQS will include two types of activities: quality control (QC), and quality audits (QA). The QC activities will consist of written standard operating procedures to be followed during sample collection, sample analysis, data processing, and auditing. These procedures define schedules for periodic calibrations and performance tests. They specify pre-defined tolerances which are not to be exceeded by performance tests and the actions to be taken when they are exceeded. The QC activities are on-going activities of measurement and data processing personnel. The QC procedures will be developed, documented, and implemented by each measurement group, and reviewed for completeness by the quality auditor.

Quality auditing is an external function performed by personnel who are not involved in normal operations. The purpose of quality audits is to determine whether the QC procedures are adequate and are being followed and whether the tolerances for accuracy and precision are being achieved in practice. The quality auditing function consists of two components: systems audits and performance audits.

Systems audits will be performed for all measurements. They start with a review of the operational and QC procedures to assess whether they are adequate to assure valid data which meet the specified levels of accuracy and precision. After reviewing the procedures, the auditor examines all phases of the measurement or data processing activity to determine whether the procedures are being followed and the operational people are properly trained. The systems audit is intended to be a cooperative assessment resulting in improved data rather than a judgmental activity.

Performance audits (PA) establish whether the predetermined specifications are being achieved in practice. For measurements, the PA

involves challenging the measurement/analysis system with a known standard sample which is traceable to a primary standard. PAs will be performed for those measurements for which standards are available. For data processing, the PA consists of independently processing samples of the data and comparing the results.

For SCAQS, the position of Quality Assurance Manager (QAM) has been funded by the ARB. The QAM is responsible for the performance of systems audits and for the coordination of performance audits. Performance audits will be funded separately and may actually be performed in part by ARB, SCAQMD, or EPA staff. The QAM will report the audit findings to the PC, and QA reports will be distributed along with the data summary reports. Quality audit and quality control for the C-sites and for supplemental data will be the responsibility of the agencies operating the stations. The QAM will review and document the QA and QC procedures in use by those agencies and include such documentation with the audit reports to the PC.

For B-sites, the QAM will coordinate systems and performance audits for each appropriate measurement. In addition, standard QC procedures will be developed and implemented by the measurement groups. For A-sites, performance and systems audits will be performed for those measurement systems for which the operational procedures are standard and well documented. For more experimental measurements or those for which there is no other standard, only systems audits will be performed. It will be the responsibility of the measurement group to develop documentation and quality control procedures and to provide an assessment of the validity, accuracy, and potential sources of error in their data.

4.2 ROLE OF QUALITY ASSURANCE MANAGER

The Quality Assurance Manager (QAM) is responsible for the following tasks:

- work with investigators to determine the target specifications for accuracy and precision for each measurement;
- review the operational and QC procedures for each measurement and verify the assumptions on which the measurement is based;
- prepare systems audit procedures and submit to PC and measurement personnel for approval;
- perform preliminary systems audits at investigators' location with the help of the measurement groups;
- develop performance audit procedures for all core or routine measurements and submit to the PC and the investigators for approval. No performance audits will be done for experimental or special measurements since standards are not available;
- perform systems audits on field measurements and laboratory and data processing procedures during the field programs;

- coordinate performance audits on routine measurements during the field programs;
- for any problems identified in audits, inform the PC and review the issue with the investigator until auditor and investigator agree on the existence and extent of the problem. Try to determine a course of action for remedying the problem;
- prepare short letter audit reports for the PC and investigators within 2 or 3 days of each audit; and
- prepare detailed draft reports for the PC and investigator for each audit. Revise drafts after feedback from the PC and investigator. Submit final audit reports to the PC for inclusion in the data base.

4.3 DEFINITIONS

In developing a quality assurance plan, it is important that the project participants agree on the definitions of the terms used. These definitions are continually evolving (e.g. Mueller, 1980; Mueller and Hidy et al., 1983; Watson et al., 1983; Hidy, 1985), but the set to be used during SCAQS is presented below. These definitions will place all SCAQS measurement processes on a common basis.

- **Measurement:** An observation at a specific time and place which possesses four attributes: (1) value--the center of the measurement interval; (2) precision--the width of the measurement interval; (3) accuracy--the difference between measured and reference values; and (4) validity--the compliance with assumptions made in the measurement method.
- **Measurement Method:** The combination of equipment, reagents, and procedures which provide the value of a measurement.
- **Quality Assurance:** A combination of procedures, reference materials, and controlled tests which assure the precision, accuracy, and validity of the measurement and minimize the exceedance of pre-set tolerances for these attributes.
- **Quality Control:** Internal procedures, documentation, and performance tests which: (1) identify deviations from measurement assumptions and (2) identify measurement values which exceed pre-set tolerances when compared to internal reference materials. Quality control identifies and corrects measurement method deficiencies and provides the information needed to assign the precision and validity attributes to the measurement.
- **Quality Audit:** External procedures, documentation and performance tests which: (1) determine the adequacy of internal procedures, documentation and performance testing, (2) ascertain the degree to which internal quality control is following the prescribed procedures, and (3) challenge the measurement methods and internal reference materials with known values derived from an external reference material. Quality auditing identifies quality

control deficiencies and provides the information needed to assign accuracy attributes to the measurement.

- **Primary Standard:** A known quantity of a material which is derived from fundamental physical principles, is reproducibly quantified by many different measurement methods, maintains its integrity over time, is subject to periodic and documented verification, and is accepted by all measurement methods as a standard.
- **Primary Reference Material:** A known quantity of a material which is reproducible within individual measurement methods, but not among methods. A primary reference material is accepted by all measurement methods as being precise, but not necessarily as being accurate.
- **Transfer Standard:** A physically similar quantity of material which can be directly traced to an identified primary standard or primary reference material via periodic documentation of comparisons using a prescribed measurement method. Transfer standards are used for calibration, quality control performance tests, and performance audits.
- **Traceability Trail:** The documentation which establishes the relationship between any measurement and all of the primary standards or primary reference materials.
- **Measurement Method Validity:** The identification of measurement method assumptions, the quantification of effects of deviations from those assumptions, the ascertainment that deviations are within reasonable tolerances for a specific application, and the creation of procedures to quantify and minimize those deviations during a specific application.
- **Sample Validity:** Procedures which identify deviations from measurement assumptions and flag individual measurements as valid, valid but suspect, or invalid based on pre-defined criteria.
- **Developmental Status:** Indicates the degree to which a measurement method can be expected to yield values of known precision, accuracy, and validity. Measurement developmental status can be "established", "semi-established", or "unestablished." Established methods are those with accepted operating procedures, identified and quantified interferences, traceability to accepted primary standards, agreement with other established methods, and known levels of precision, accuracy, and validity. Semi-established methods are those with controversial operating procedures, partial characterization and quantification of interferences, traceability to one or more reference materials, disagreement with other established or semi-established methods, and known precision levels. Unestablished methods are those with incomplete or non-existent operating procedures, no traceability to primary reference materials

or standards, little or no inter-method comparison results, and unknown precision, accuracy and validity.

- Measurement Process: Established or semi-established measurement methods combined with quality control and quality auditing to provide values with known precision, accuracy, and validity.

4.4 STANDARD OPERATING PROCEDURES

Standard Operating Procedures (SOPs) codify the actions which are taken to implement a measurement process over a specified time period. These are both descriptive and prescriptive. The various SOP revisions are maintained so that subsequent users of the measurements may consult them to interpret measurements in light of new knowledge about the measurement methods being applied. Examples of this descriptive use were given in Section 2.2. The prescriptive role of SOPs is to incorporate state-of-the-art knowledge into current measurement practice. SOPs must undergo scheduled revisions in order to fulfill this prescriptive mandate.

Standard operating procedures will be created for routine field sampling, laboratory analysis, data processing, and quality audit activities planned for SCAQS. These procedures should include the following elements:

- A brief summary of the measurement method, its principles of operation, its expected accuracy and precision, and the assumptions which must be met for it to be valid.
- A list of materials, equipment, reagents and suppliers. Specifications should be given for each expendable item, and its storage location should be listed.
- Designation of an individual to be responsible for each part of the procedure.
- A general traceability path, the designation of primary standards or reference materials, tolerances for transfer standards, and a schedule for transfer standard verification.
- Startup, routine, and shutdown operating procedures and an abbreviated checklist.
- Copies of all data forms with examples of filled out forms.
- Routine maintenance schedules, maintenance procedures, and troubleshooting tips.
- Internal calibration and performance testing procedures and schedules.
- External performance auditing schedules.

- References to relevant literature and related standard operating procedures. The Program Coordinator is responsible for acquiring standard operating procedures from all measurement investigators and for scheduling procedure revisions. The Quality Assurance Manager is responsible for reviewing procedures and determining their completeness and accuracy.

4.5 SAMPLE VALIDATION

The results of several measurement method validation studies have been reported in Sections 2 and 3. Section 6 specifies several projects for the interpretation of the results of these studies. These results will be needed to provide a basis for the validation of individual samples taken within SCAQS. Three levels of validation will be applied with the result being a label of valid, valid but suspect, or invalid associated with every measurement.

Level I sample validation takes place in the field or in the laboratory and consists of: (1) flagging samples when significant deviations from measurement assumptions have occurred, (2) verifying computer file entries against data sheets, (3) eliminating values for measurements which are known to be invalid because of instrument malfunctions, (4) replacing data from a backup data acquisition system in the event of failure of the primary system, and (5) adjusting of measurement values for quantifiable calibration or interference biases. Each measurement investigator performs Level I validation on his measurements.

Level II sample validation takes place after data from various measurement methods have been assembled in the master data base. Level II applies consistency tests based on known physical relationships between variables in the assembled data. Examples of these tests are: (1) the sum of all chemical species in a particulate matter sample should be less than or equal to the gravimetric mass of that sample, (2) size segregated particle concentrations should be less than total particle concentrations, and (3) dew point should always be less than temperature. Data adjustments for quantifiable biases are made in Level II validation if they are discovered after assembly of the master data base. The Data Manager, cooperating with the measurement investigators, is responsible for Level II validation.

Level III sample validation is really a part of the data interpretation process. 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. Unusual values are usually identified during the data interpretation process as: (1) extreme values, (2) values which would otherwise normally track the values of other variables in a time series, (3) values for observables which would otherwise normally follow a qualitatively predictable spatial or temporal pattern. The Program Coordinator, with cooperation from the Data Manager and data interpretation investigators, is responsible for Level III validation.

All data validation actions at each level should be recorded in a data validation summary which accompanies the data volumes. Data base records

should contain flags to identify the level of validation which they have received at any point in their existence.

5. DATA MANAGEMENT

5.1 ROLE OF DATA MANAGER

The Data Manager (DM) will be responsible for assembling, archiving, reviewing, and distributing the data obtained during the study. Specifically, the DM will perform the following tasks:

- With the concurrence of project participants, develop a data exchange protocol. All participants must agree to abide by the protocol in order to use study facilities and to obtain data from the data archives before publication of the final report.
- With the help of the participants, identify all data to be considered part of the study. (Some participants or other groups may obtain data for their own use which are unrelated to the study.)
- Develop standardized data formats with the assistance and approval of the participants. All participants will submit their data to the DM in the agreed upon format and media after each study period.
- Review all data submitted to determine that formats are proper and documentation is adequate.
- Identify sources, formats, and quality of data available from existing data resources (National Weather Service, Federal Aviation Administration, AQMD, etc.) and prepare a list of data to be obtained for the study.
- For each sampling day, obtain routinely available data, convert to project format, and archive.
- For each intensive study day, obtain all project data.
- Archive all data in an easily reproducible and retrievable form. The data should be archived using a disk-based data base management system so that data required for specific analyses can be easily accessed.
- Perform simple consistency and validity checks (Level II) on the data submitted, and flag those data points which are suspect. When possible, review suspect data with the responsible group and resolve the status of the data.
- Correct or flag data points in the master data base when errors are identified by subsequent users of the data.
- Prepare a report which inventories the data base for each study period and which documents the data formats and data access procedures. Summaries of data capture rates and data validity should be included for each intensive study period. Provide report to all participating and sponsoring organizations.

- Provide data to participants on request as required for their analyses.
- Provide a copy of the complete data archive to ARB.

The DM will design formats for the data to be submitted that are useful for the modeling community. Except for the data from the existing data resources, the DM should not have to reformat the data obtained from the participating organizations.

5.2 DATA BASE DESCRIPTION

The data base will have two components. A core data base will be developed for modeling and data analysis use. The core data will consist of the emissions data, the available routine supplementary data, the data from the B- and C-sites, the aircraft data, the surface and upper air meteorology data, and data from the A-sites which are from regularly repeated measurements over extended time periods and which are of known accuracy and validity. The second component of the data base will be the special studies measurements such as the tracer studies and measurements from the A-sites which are more experimental in nature.

All data should be submitted in consistent and easily usable formats with like types of data being formatted similarly. Data formats should allow easy use of the data with graphics, statistical and modeling software. All data should be reviewed and validated (Level I) by the group submitting the data, and suspect data points should be flagged in the data records.

All data submitted to and assembled by the DM should be accompanied by reports which describe the data formats, uncertainties, detection limits, and accuracy estimates for the data. Much of this information should also be included in the data records. A hard copy printout should accompany all data. These data reports should also provide an inventory of the data submitted and a summary of the data validity and data capture rates for each intensive study period, and describe the data collection, quality control and validation procedures used to obtain and process the data. The report should discuss potential errors, interferences, or other caveats regarding the data.

The formats of the core data should be such that they can be included in a single large data base and are easily accessible by modelers. Data records should include space for validity flags and other similar notation. Formats of the special studies data will, by necessity, be more varied and less standardized. Whenever possible, however, data records should document the position, time, and sample averaging period.

Core data will be reviewed by the DM and subjected to simple consistency or validity checks. Flags for suspect data points will be added to the data records by the DM.

Core data should be submitted to the DM within six months of the end of each field study and special studies data as soon as possible after that. Data should be available to participants within about 3 months after receipt by the DM.

5.3 ACQUISITION OF SUPPLEMENTAL DATA

The DM with the assistance of ARB staff will be responsible for identifying and acquiring existing supplemental data. These data include NWS, FAA, and other available meteorological data and air quality data from SCAQMD, ARB, Ventura County Air Pollution Control District and other available sources. Such data obtained by the DM will be reformatted to be consistent with the core database formats for similar types of data. Potential sources of supplemental data are identified in Section 2.

5.4 DATA EXCHANGE PROTOCOL

A data exchange protocol has been prepared with input from the sponsors. The purpose of the protocol is to ensure timely and complete availability of the data collected as part of SCAQS and proper attribution for data used in analyses and publications. It will be a condition of participation in the program that sponsors and participants agree to abide by the protocol.

The approved protocol is shown in Figure 5-1.

Southern California Air Quality Study

Data Exchange Protocol

The following is the SCAQS Data Exchange Protocol. The purpose of this protocol is to ensure timely and complete availability of the data collected as part of SCAQS and proper attribution of data used in analyses and publications.

1. The data collected are to be available eventually to the scientific community. Before final publication, however, the data will be made available to the SCAQS participants. It is expected that each participant will submit at least the type B data from each field study to the Data Manager within 6 months of the end of each field study. Type A studies data may take a few months longer. Data should be submitted in the SCAQS-specified format and should be reviewed and validated by the participant prior to submission. Participants will keep the sampling and processing documentation for their own data for 5 years after the field study.
2. All data in the SCAQS data bank will be available to any participant on request. No participant should publish analyses or data sets which include data of other participants unless he/she has the permission of the other participants who provided the data or the data have been formally released to the public. Participants may distribute or publish their own data at any time subject to the conditions in 4, below.
3. The sources of data should be cited whenever data are used in publications. If a substantial amount of data from other participants is used, that participant should be given the option of being included as a co-author on resulting publications.
4. Prior to submission for publication or presentation, manuscripts resulting from SCAQS should be submitted to the participants and all SCAQS sponsors for comment. Each participant and sponsor will have 30 days from receipt of the manuscript to submit his comments to the senior author. The authors should give sincere consideration to all comments. If the comments are not incorporated in the manuscript, the commenting participant may submit his comments separately to the journal to which the original manuscript will be submitted.

We agree to abide by the principles of the SCAQS Data Exchange Protocol -

NAME

TITLE

ORGANIZATION

DATE

6. DATA ANALYSIS AND INTERPRETATION

6.1 ROLE OF DATA ANALYSIS COORDINATOR

In a study of this type with many investigators and many types of data analysis and interpretation, it is necessary to have one person who can keep track of the project objectives and coordinate the diverse analysis efforts so that the objectives are met. The Data Analysis Coordinator will have the following tasks.

- Identify data analysis methods to meet each of the final project objectives.
- Identify the participant who will perform each analysis task.
- Identify the information and data needs for each analysis task.
- Work with the various investigators to develop a critical path diagram and identify when the investigator will need which information or data.
- Identify milestones for review.
- Act as a facilitator to assure that the required data are made available to the investigators on schedule and that investigators are aware of complementary efforts by other investigators.
- Identify duplications of effort and work out agreements between investigators to minimize unproductive efforts and maximize the technical output from the resources available.
- Identify topics for presentation at a technical session and coordinate with the investigators to assure that papers are presented on all appropriate topics.
- Synthesize and integrate individual data interpretation efforts into a coherent whole.
- Assemble and edit technical papers in a published document.

6.2 DATA INTERPRETATION METHODS

Measurements, by themselves, say nothing about the causes of air pollution and the likely effects of emissions reductions. It is only when these measurements are interpreted that relationships can be observed and conclusions can be drawn. The data interpretation methods which address the objectives stated in Section 1 need to be defined, at least in a general manner, before the first measurement is taken in order to assure: (1) that all information needed by the method will be available at the interpretative stage, and (2) that scarce resources will not be expended on taking measurements which do not fit within the data interpretation framework.

Section 1 stated the issues which might be resolved by SCAQS. Section 2 specified the additional data needs which model developers and users feel are

currently lacking. Section 3 listed the feasible measurements which would fulfill those needs. The goal of this section is to identify the data interpretation methods which are expected to be used and to associate the proposed measurements with their use in these methods.

As a result of the literature survey in Section 2, it was found that data interpretation methods appropriate for attaining SCAQS objectives generally fall into one of five categories:

- Descriptive methods summarize the spatial, temporal and statistical distributions of individual observables. They include averages, standard deviations, maxima, minima, spatial isopleths and time series. A large number of measurements of each observable (typically greater than 50 to 100) is necessary to determine statistical distributions. The period between measurements needs to be smaller than that over which major changes occur, and the geographical spacing between measurements needs to be less than the spatial frequency of the observables. The results of these descriptive methods show which observables are reaching levels of concern. Descriptive methods do not yield cause and effect relationships nor do they anticipate how a change in one variable will affect the values of other variables. These descriptive methods are often useful for the display and comparison of results from other data interpretation methods.
- Co-variation methods calculate measures of association between two or more variables. These measures take on high absolute values when the variables change in the same manner over a period of time or over a geographical area; they take on low absolute values when this co-variability is lacking. Time series analysis, correlation coefficients, and principal components analysis are methods which provide these measures of association. By themselves, these co-variation methods only establish whether or not the values of a set of variables change in the same way. When these co-variational methods are combined with a physical understanding of the situation under study, cause and effect relationships among the variables may be inferred.
- Classification methods select specific periods of time, usually periods of high pollutant concentrations, and describe the physical cause and effect relationships using all data which can be acquired. Both qualitative and algorithmic classifications are possible. Regime analysis (Keith and Selik, 1977), discriminant analysis (Lin, 1982), and case studies (Blumenthal et al., 1978) have all been applied to data in the South Coast Air Basin. The case studies are particularly useful in determining the relative importance of different chemical and physical pathways. Cases can be separated into dichotomous groups in which a pathway is expected to dominate or in which it is expected to have a negligible effect. If the expected consequence is observed in the first group and not observed in the second group, then the pathway can be considered important. Most of the quantitative physical and chemical mechanisms present in current models have resulted from their identification in case studies. The importance of various reactive species, atmospheric moisture, and liquid water content of the aerosol remain to be examined by this method.

- Source oriented models contain mathematical descriptions of the interactions among variables. These models include transport and chemical mechanisms. Lloyd et al. (1979), Reynolds et al. (1976), Cass (1979), McRae et al. (1982a), and Seigneur et al. (1983b) have produced and tested such models appropriate for the SOGAB. Each of these source models requires three-dimensional wind fields (speed, direction, and dispersion characteristics at all points in the modeled area) over a period of one day or more. These wind fields can be interpolated from measurements (e.g. Goodin et al., 1980) or calculated from fundamental physical equations applied to a set of initial conditions (e.g. Pielke, 1984). Although the transport and chemical components are usually combined in the computer implementation of each model, it is possible to introduce alternative wind fields to simulate the transport mechanisms and alternative photochemical and aerosol mechanisms to simulate chemical interactions.
- Receptor models use chemical and physical measurements of sources and receptors. They require input data for the chemical compositions of the emitting sources and ambient concentrations of those same chemical species. Linear regression of species on principal components has been shown to relate sulfate concentrations to physical causes (Henry and Hidy, 1979). Chemical mass balance calculations (Gartrell and Friedlander, 1975; Miller et al., 1972; Cass and McRae, 1983; Feigley and Jeffries, 1979) can be applied in the SOGAB to determine the contributions of source emissions to receptors. Linear regressions of b_{scat} on selected chemical species or on source contributions can be applied to determine visibility extinction budgets (White and Roberts, 1977; Pratsinis et al., 1984).

Each of these data interpretation approaches has been designed around available data, with certain assumptions being made to compensate for the missing data. Most computer implementations of these models are quite flexible owing to their intended applications in many areas with varying data availability. There is no absolute list of data needs for any of these data interpretation methods. Presumably, the more data they have the better. In several cases (e.g. Seigneur et al., 1981a, 1981b), the effects of more or less data on the results of the data interpretation method have been evaluated. There is as yet, however, no objective means of defining the optimum set of data required by a data interpretation method, nor is it possible to generally determine when additional measurements would be redundant (unless those measurements are already available).

6.3 DATA USES

Data can be used for four purposes in the data interpretation process:

- Input data. Every interpretation method requires some data on which to operate for the period of time being examined. Descriptive methods require values of the variables of interest in space and time. Source models require boundary and initial conditions of precursor, intermediate, and end-product species as well as three-dimensional wind fields and atmospheric stability estimates. Receptor models require ambient concentrations and source composition. When these variables are measured for the time being simulated, they are considered input data.

- Parameters. Parameters are constants supplied to the data interpretation process by a theoretical calculation, by measurements made elsewhere and assumed to be appropriate for the place and time being studied, or by tacit assumption that the value of a variable is negligible. Reaction rates, emission rates, transformation rates, dispersion parameters, and source compositions are common parameters in source and receptor models. Values for these variables are rarely measured over the period of time being modeled. Parameters normally carry higher levels of uncertainty than input data because they are not specific to each case being studied.

- Testing data. Values yielded by the data interpretation method can be compared with measurements of the same observable to test the extent to which the interpretation represents reality. The most common test measurements are ambient concentrations of an observable which are compared with the prediction of a source model. These two values are often uncorrelated, and they often tell little about the reasons for differences between predictions and measurements. Measurements of intermediate species over the appropriate time-scales are better tests of the data interpretation method. More complete (in space and time) measurements of model input variables can also be classified as test data when they would not be available during a routine application. The difference between model calculations with and without these input data provides an estimate of the accuracy to be attached to the model results. The final use of test data is to verify that the data interpretation method is valid for a specific application. Test data can be used to quantify deviations from model assumptions. In many cases, these deviations from assumptions can be directly related to deviations of model predictions from their true values. Parameters and neglected effects are amenable to this quantitative testing of model principles and assumptions.

- Uncertainty estimation. The numerical values determined by any data interpretation process differ from reality because of both model uncertainty and measurement uncertainty. Model uncertainty results from deviations from the principles and assumptions of the model during its application. This model uncertainty is quantified using data in its testing role, as described earlier. The measurement uncertainty of a model calculation results from the fact that each input datum and parameter does not define a single value, but an interval within which the true value of the observable should fall. The combination of all of these measurement intervals should yield an interval around the model calculation. Very few air quality models in use today provide for the estimation of this interval, and methods to calculate it are still in their developmental stages (e.g, Efron 1979; McRae et al. 1982b; Freeman et al. 1986; Watson et al. 1984). Each one of these methods requires some estimate of the statistical distribution and width of the intervals associated with the input data and parameters. This interval is typically more than the uncertainty associated with an individual measurement. Most models assume that a single point measurement represents a volume or a period of time, and an estimate of the variability of the input data or parameter over that volume or time period is required to calculate the measurement uncertainty associated with a model calculation. Measurements which are "collocated" with a resolution finer than the temporal and

spatial scales of the data interpretation methods can be used to estimate the uncertainty of input data and parameters. These uncertainties can also be estimated from periodic performance tests of each measurement method (Watson et al. 1983). It is presumed that future model development will include methods to take advantage of this information and supply intervals associated with measurement uncertainty on model results.

6.4 SCAQS DATA INTERPRETATION PROJECTS

The measurements proposed in Section 3 can be used in an infinite number of combinations as input, to estimate parameters, to test the principles and assumptions of the data interpretation methods, and to estimate the uncertainty of the quantitative results of the interpretive efforts.

Data interpretation projects are described in this section which address the objectives and issues in Section 1. The projects which follow cannot identify every way in which the SCAQS data can be interpreted. The project descriptions are presented as examples to demonstrate that each piece of data collected does have a use for input, parameterization, testing, or uncertainty estimation. Although these projects are organized by the specific objectives and issues which they are intended to address, most of them are applicable to more than one objective.

Although Sections 2, 3, and 6 appear as separate entities in the program plan, they were actually formulated in an iterative fashion. Previous research in the SOCAB was studied to determine which data interpretation methods had been used in the past and the measurements they required. These were used to define an initial set of variables to be measured in SCAQS. These measurements were then incorporated into an interpretive framework which ultimately resulted in the projects described below. The measurement set was then modified to accommodate the anticipated data interpretation needs. This iterative process is not perfect, and it may still be found that the SCAQS measurements are not totally adequate for all purposes which might be identified a posteriori. It is expected that the number of these cases will be minimized, but not eliminated, by this iterative process.

6.4.1 Objective 1: Description of SOCAB Air Quality

The data base will contain individual numbers which have been validated, corrected, and flagged. In order to be of use to researchers, this data base needs to be described statistically, graphically and phenomenologically. While most researchers will do this to a certain extent by themselves, a number of summaries have been produced in past studies which have been useful in focusing the more detailed analysis of specific situations. The data description projects are intended to provide this common denominator for subsequent projects. It is recognized that no "descriptive" study can be separated from the posing and testing of hypotheses based on previous work, and it is expected that the researchers performing projects intended to address the first objective will implicitly address other objectives as well. No attempt is made to exclude this possibility in the descriptions of the SOCAB air quality data. This speculation on cause and effect relationships is considered a "bonus" of an otherwise mundane presentation of results.

Project 1.1: Data Description Summaries of Ground-based Measurements.

Prepare statistical summaries consisting minimally of maximum, minimum, average, standard deviation, and median values for each observable at each site for the duration of both sampling periods. Express these in tabular formats and as box plots. Composite and statistically summarize one hour samples for comparison with samples of longer duration. Calculate correlation coefficients among each of the variables over space and time. Prepare graphical displays which include spatial isopleths of each observable for each four-hour period, time series plots of each observable, and surface wind flow patterns for each period. Produce graphs of concentrations obtained on all aircraft traverses with the flight paths clearly indicated on a map of the Basin and appropriate time-markers denoted on those paths. Plot average vertical distributions from all the spirals at each location for each measured observable. Plot temperature and wind sounding data for every sounding site and time plot. Plot gridded emission rates for each pollutant for the aggregate totals, elevated and ground level sources, and mobile and stationary sources over four hour intervals. Prepare a map of all major single point and area sources coded for source type. Prepare isopleths of the spatial distribution of the most reactive hydrocarbon emissions. To determine how random measurement errors change the data summaries, create ten or more simulated SCAQS data sets by adding and subtracting random numbers proportional to the uncertainties of each measurement and generate selected statistical and graphical summaries for comparison. Distribute these randomized outputs with the real outputs so that subsequent studies can use them to evaluate the differences in data interpretation results which might result from measurement uncertainty.

The output of this analysis project is expected to be used in subsequent analyses. In general, each investigator will produce those graphical and statistical displays which are of greatest use to him. The displays described here are the lowest common denominator for subsequent interpretive efforts, yet they will result in reams of paper.

An alternative to the generation, compilation, and distribution of hardcopies of these statistical and graphical summaries is the creation of a micro-computer based hardware/software system and appropriate documentation which would allow each investigator to classify the data base in any way he chooses, including the definition of new variables from the raw data, and to display it by any of the graphical or statistical techniques which have been designated above. Communications packages are commercially available which would allow most investigators to transfer data from their microcomputers to their larger computers for more intensive computations, should they be necessary. ARB is currently sponsoring a project which will interface its routine meteorological, emissions, and air quality data bases to IBM-XT disks. Reformatting routines and appropriate user instructions are being developed to interface these data with commercially available computer programs which perform data base management (Ashton-Tate, 1984), air quality data summaries (Odessa Engineering, 1985), spreadsheet and graphics (Lotus Development Corporation, 1983), comprehensive statistical analyses (Dixon et al., 1983), Chemical Mass Balance modeling, and elementary UNAMAP dispersion modeling (Bowman, 1985).

Another alternative to hardcopy printout is being explored by Pitchford and McGown (personal communication, 1985) in the RESOLVE program. The spatial

and temporal distributions of variables have been generated on a microcomputer and recorded on video tape or a video disk. Hussey et al. (1983) applied this method to air pollution data from the SOGAB with striking results. Henry (personal communication with Ron Henry, USC, 1985) is investigating its use in visibility studies. The adaptation of such a graphics display to microcomputers and interfaces to the commercial software packages described earlier would facilitate data interpretation in the SCAQS and leave a lasting legacy for subsequent air quality measurement programs.

Project 1.2: Meteorological and Upper Air Descriptions. Describe in detail each of the episodes obtained from the SCAQS in the style of Smith et al. (1972, 1984) and Blumenthal et al. (1978). These descriptions of the meteorological evolution will provide a qualitative understanding of the transport situation, convergence zones, the potential for mixing from aloft, and carryover from previous days. This qualitative description can be used to test the assumptions of the quantitative mathematical models describing transport in the basin. Surface trajectories can be inferred from the surface wind plots. Draw cross-sections of observable values obtained from aircraft vertical soundings and estimate mixing heights. Plot isopleths of mixing height for each aircraft sampling period. Examine the synoptic weather maps and correlate with the surface and upper air observations. Examine the differences between daytime and nighttime spatial distributions and determine outflow and ventilation scenarios. Compare the SCAQS descriptions with those of earlier studies such as Blumenthal et al. (1978), Smith et al. (1972), Angell et al. (1976), and Edinger (1959, 1973).

Project 1.3: Aerosol Data Descriptions. This project consists of the examination of the chemical, spatial, temporal, and size distributions of ambient aerosols, the comparisons of ostensibly equivalent methods of aerosol measurement, and the comparison of the SCAQS aerosol distributions with those derived in previous studies of Whitby et al. (1972), Hidy and Friedlander (1972), Heisler et al. (1973, 1980), Hering and Friedlander (1982), and Stelson and Seinfeld (1981). Calculate the material balance of the fine and coarse mass for each sample by converting elemental, ionic, and carbon measurements to probable compounds, summing, and ratioing to the gravimetrically measured mass concentration. Display these ratios as a time series and identify those which differ substantially from unity. Sum the four-hour total masses and ratio to the TSP mass concentrations for simultaneous samples. Produce pie charts which show the relative contributions of different chemical species to each fine and total mass concentration. Locate these pie charts on maps of the Basin with radii proportional to the total mass concentration at a site, similar to the display in Shah (1981). Identify the predominant size range of measured chemical species and compare with earlier findings. Plot four hour average number, surface area, and volume distributions as a function of particle size as derived from electrical mobility and optical particle counter data. Identify commonly recurring size distributions. Classify each sample according to one of the size distribution patterns. Plot the mass median diameters and standard deviations for each mode of the volume distributions on maps for each sampling period. Describe the evolution of the size distributions by location and time of day and compare to hypotheses advanced in previous studies such as Whitby et al. (1972), Hidy and Friedlander (1972), Heisler et al. (1973), and Heisler and Friedlander (1977). Examine similar size distributions and temporal/spatial plots using the

chemically specific size distributions obtained from the multi-orifice impactors.

Project 1.4: Nitrogen, Sulfur, Carbon, and Oxidant Budgets. Plot pie charts of the gaseous and particulate nitrogen (NO , NO_2 , HNO_3 , PAN, NH_3 , HONO , NH_4^+ , NO_3^-), sulfur (SO_2 , SO_4^{2-} , organic sulfur), carbon-containing (elemental and organic particles, hydrocarbons, organic sulfur), and oxidizing (O_3 , OH, H_2O_2 , PAN, NO_3 , HO_2 , RO_2) species for each four hour period on a map of the Basin. The radius of each pie should be proportional to the total number of N, S, or C atoms in the budget. Also plot these totals as time series stacked bar charts for each station, with the bars divided in proportion to the species present. Compare the more completely speciated budgets at the A-sites with the less speciated budgets at the B-sites to estimate the potential magnitudes of the missing components at the more spatially representative sampling sites.

6.4.2 Objective 2: Source Characteristics for Receptor Models

Project 2.1: Identify Chemical and Physical Properties of Sources. Compile comprehensive primary emissions profiles for source types in the SOGAB from SCAQS source characterization tests and previous studies such as Taback et al. (1979), Mayrsohn et al. (1977), and Oliver and Peoples (1985). Classify these by source type (e.g. motor vehicle, fuel oil combustion, solvent use, natural sources, etc.), and construct comprehensive emission profiles which include gaseous as well as particulate chemical composition. Based on previous studies of chemical interactions, classify each of these species as transforming or non-transforming at distances close to and distant from an emissions source. Perform principal components analysis (e.g. Hopke, 1982 with the suggestions of Henry, 1985) on gaseous and particulate data sets at A-sites and determine whether or not the expected source composition patterns are reproduced. Examine the chemical species associated with each principal component and determine whether or not source categories other than those identified from the emission inventory are affecting the receptors. Create spatial plots of selected chemical species emissions patterns and superimpose trajectories obtained from Project 1.1 to determine sampling sites and times which are most likely to be influenced by source emissions. Apply the Chemical Mass Balance receptor model using the effective variance weighting and error propagation scheme (Watson et al., 1984) to the receptor data using the profiles and chemical species for sources which are most likely to affect the receptor and which will experience minimal fractionation between source and receptor. Apply the CMB to situations when meteorological and emissions conditions mitigate against a source affecting a receptor, evaluate the consistency of the calculated source contributions with this low-impact situation. Determine the variability of CMB calculations as a function of alternative, but equally valid, source profiles, the chemical species measured at the receptor and at the source, the grouping of individual sources into source types, and in response to randomized input data. Apply the singular value decomposition method of Henry (1982) to determine the collinearity of source profiles in different situations. Determine the minimal number of chemical species and the variability which can be tolerated in their measurement for the accurate apportionment of particulate matter, carbon monoxide, SO_2 , and hydrocarbon receptor concentrations in the absence of source profile fractionation.

Project 2.2: Source Profile Fractionation. Using simple equilibrium, reaction, decay, and deposition considerations (e.g. Stafford and Liljestrang, 1984), calculate the expected changes in source profiles as a function of meteorological variables and the presence of other species. Coordinate with source-modeling projects to obtain a better description of source profile evolution from the more comprehensive chemical transformation mechanisms included in these models, and compare the simple transformation estimates with these more complex ones. Calculate transport times below which no significant fractionation will have taken place and beyond which equilibrium will have been reached. Select those species for which fractionation estimates are reasonably robust. Select cases, using the results of Projects 1.1, 1.2, and 1.3, in which the constituents measured at one of the source-area sites follow a trajectory passing over several monitoring stations, and calculate the expected changes in the combination of source profile for the selected chemical species. Apply the CMB at each site along the trajectory. Linear combinations of fresh and aged source profiles, weighted by emission rates from the emissions inventory, should be constructed and applied to determine their value in the transport region for which equilibrium has not been reached. Determine the variability of the calculated source contributions to PM-10, NO₂, CO, hydrocarbons, and toxic substance concentrations as a function of the variables included in the CMB. Randomize the input data in proportion to their uncertainties and estimate the uncertainty which can be tolerated. Determine the collinearity of source profiles for various source contribution levels. Compare the effectiveness of source attribution by this method for highly reactive and non-reactive sampling periods.

Project 2.3: Attribution of PM-10 to Primary/Secondary and Natural/Anthropogenic Sources. Using the results of projects 2.1 and 2.2, construct source profiles for primary and secondary categories. Primary source profiles may consist of a number of individual source type profiles. Secondary source profiles may consist of those produced by several different conversion pathways. Similarly, construct source profiles for natural and anthropogenic source types. Apply the chemical mass balance receptor models to aerosol and gas data collected at urban and non-urban sampling sites for both the fall and summer periods and for the year-long 24-hour sampling periods. Calculate the contributions of each source type to the twenty-four hour and annual average concentrations of PM-10. Examine CMB diagnostics to determine the validity of each application. To determine the uncertainty of source attribution, compare the results derived from: (1) different combinations of sources and chemical species applied to the same receptor data, (2) randomized values for the receptor and source measurements, and (3) source apportionments derived from source models applied to the same samples.

6.4.3 Objective 3: Dependence of Particle and O₃ Formation on Meteorological and Precursor Variables

Project 3.1: Principal Components Analysis. Develop a list of phenomena which can be represented by each SCAQS variable. These phenomena may be different for the same observable measured at a different place or time in the SCAQS network (e.g. NO₂ measured at night or during the day, at ground level or above the inversion, etc.). Submit these variables, excluding particulate matter and O₃ concentrations, to principal components analysis (e.g. Henry and Hidy, 1979). Apply the PCA to various subsets of variables to (1) obtain a stable solution and (2) determine the variability within a stable solution

after the fashion of Watson et al. (1985). Randomize the PCA input data in proportion to their measurement uncertainties and estimate the effects on the certainty of model results. Apply various factor rotation methods to determine the variability caused by the selection of a rotation. Associate each mathematical factor with a physical phenomenon on the basis of the variables on which it is loaded. Calculate the linear regression coefficients of fine and coarse particulate matter and ozone on the factor scores of each factor. Generate scatterplots of the values predicted by these regression equations and observations to determine how well the factors explain the observations. Recalculate these regression coefficients with a reduced data set and compare them to the coefficients obtained from the entire data set. Use the coefficients from the reduced data set to estimate particulate and ozone values which were excluded and compare the predicted and observed values. Examine the products of regression coefficients and factor scores and select very high or low values. Examine the results of projects 1.1, 1.2, and 1.3 to ascertain whether or not the principal components analysis is consistent with the qualitative meteorological and air quality features for the high and low products.

Project 3.2: Case Studies of the Aerosol Dependence on Liquid Water.

Examine the temporal and spatial evolution of particle sizes and compositions yielded in Task 1.2 and explain them in terms of the variation of other atmospheric variables depicted by Task 1.1. Divide SCAQS data into periods which were preceded by or contain high and low RH, fogs and no fogs, rain and no rain. Examine the chemically speciated size distributions for these periods and determine whether or not there is a change in size or shape for ionic species. Calculate average size distributions and standard deviations for each of these dichotomous categories and determine whether or not they differ significantly to test the hypotheses of Hering and Friedlander (1982). Examine liquid water measurements to determine how the liquid water content of the particles varies according to the ionic composition, relative humidity, and the presence of other species, and compare this to calculations using theoretical formulations (e.g. Russell et al., 1983; Stelson and Seinfeld, 1982; Bassett and Seinfeld, 1983). Calculate ion balances for cases in which liquid water is present and when it is not and infer missing species. Determine those conditions under which liquid water content can be inferred from the ionic composition measured on a filter sample which has gone through normal filter processing procedures. Identify the potential for metal catalysts which might promote liquid-phase reactions. Stratify data by cases in which photochemical and liquid phase reactions should be dominant and estimate transformation rates for SO_2 and NO_x along trajectories, then compare the results.

Project 3.3: Case Studies of Ozone Formation. Stratify episodes by high and low photochemical potential days, and compare photochemical products along trajectories identified in Project 1.1. Further stratify these episodes by ROG/NO_x ratios in the morning at western and southern Basin sites and determine the extent to which this ratio affects the maximum ozone levels at the eastern and northern Basin sites. Recalculate ROG/NO_x ratios for specific reactivity classes, especially aromatics, and examine receptor area ozone concentrations for cases of high and low ratios in the source areas. Examine the emissions maps to compare the quantity of fresh hydrocarbon and NO_x injected along the trajectories, and determine the degree to which this might interfere with the conclusions drawn from ROG/NO_x ratios in the source areas.

Examine aircraft traverses and compare ozone, NO_x , and hydrocarbon concentrations to simple equilibrium calculations similar to those of Calvert (1976a, 1976b). Examine nighttime concentrations of O_3 and precursors above the inversion and off the coastline to determine the degree of carryover from the previous day. Compare ROG/NO_x ratios with those calculated from localized emissions grid squares near the western and southern sites; identify potential causes of the discrepancy. If documentable day-to-day changes in emissions patterns (temporal and spatial) occur, compare the oxidant and hydrocarbon concentrations among otherwise similar meteorological conditions (e.g. Davidson and Cassmassi, 1985). Compare oxidant values in cases with high ambient aromatic hydrocarbon concentrations to values obtained when aromatic hydrocarbon concentrations are low.

Project 3.4: Case Studies on Aerosol Sulfate, Nitrate, and Carbon Formation. Calculate equilibrium concentrations for sulfur, nitrogenous, and organic species in the gas and particle phases for each sampling site and time and compare with the aerosol measurements. Examine fine and coarse particle chemical compositions, and infer the compounds which are present. Verify these inferences via single particle analysis of selected filter samples and determine the extent to which the aerosol is internally or externally mixed. Stratify ground-based and airborne measurements by day and night and compare chemically speciated size distributions and their changes with respect to time, thereby testing the hypotheses of Richards (1983). Examine speciated particulate and gaseous concentrations of organic compounds to estimate the fractions of organic carbon which are of primary and secondary origins. Coordinate with Projects 2.1 and 2.2 to perform this primary/secondary attribution of organic carbon.

6.4.4 Objective 4: Dependence of Pollutant Spatial Distributions on Emission Height and Meteorology

Project 4.1: Case Studies of Natural and Injected Tracer Data. Examine the results of Projects 2.1 and 2.2 to differentiate between the primary emissions from elevated and ground level source at near-source and far-source receptors. Compare these estimates with the concentrations of perfluorocarbons and SF_6 injected at high and low elevations. Examine the vertical concentrations above ground stations to determine gradients which might be caused by elevated source emissions, and determine which sources might be the cause from the elevated emissions maps produced in Project 1.1. Examine aircraft measurements above sampling sites along well-defined trajectories between source and receptors to determine the travel time required for vertical mixing of elevated source emissions. Stratify this travel time by atmospheric stability categories, and identify significant differences. Estimate the quantity of ozone, NO_x , particulate matter, and hydrocarbons which are contributed to surface concentrations by mixing as the inversion rises; and estimate the vertical distance for which vertical homogeneity is achieved as a function of time of day. Compare the results of this analysis with the assumptions of source models, and determine those cases for which the model assumptions would be valid. Examine speciated hydrocarbon and CO concentrations during high and low temperature periods to infer higher or lower evaporative fuel emissions as a function of temperature; normalizing hydrocarbon species with respect to CO may minimize the effects of different weather conditions on absolute hydrocarbon levels.

6.4.5 Objective 5: Effects of Pollutants on Visibility, Atmospheric Acidity and Mutagenicity

Project 5.1: Visibility Case Studies and Extinction Budgets. Calculate the refractive indices for different aerosol samples and determine the effect of variations in these indices and in particle size distributions on extinction efficiencies. Include the measured fraction of liquid water in these calculations and compare the results with calculations which neglect liquid water or infer it from RH measurements. Repeat these calculations for internal and external mixtures, and compare the differences with these variabilities. Examine single particle analyses of selected samples to determine the degree of internal and external mixing in the aerosol population. Determine the extinction efficiency of each particle type, and estimate the contribution of each type to the total light extinction. Calculate extinction due to Rayleigh scattering, scattering using the chemical-specific size distributions, absorption by elemental carbon, and NO_2 ; and compare the total to the scattering and absorption measurements. Identify cases of disagreement between theory and measurement which exceed estimated uncertainties and ascertain which deviations from assumptions are causing those disagreements. Calculate visibility reduction via linear regression analysis (e.g. White and Roberts, 1977) and compare the inferred scattering efficiencies with the theoretical scattering efficiencies. Calculate the relative contributions from fine and coarse particles, particles and gases, and primary and secondary species. Identify meteorological characteristics which might cause different spatial and temporal distributions of visibility impairment.

Project 5.2: Case Studies of Atmospheric Acidity. Examine the spatial and temporal nature of atmospheric acidity and relate strong acid concentrations to sulfate, nitrate, and other ionic components in the aerosol and gas phases. Coordinate with Project 3.1 to determine differences between wet and dry oxidation mechanisms and ascertain whether or not significant differences in atmospheric acidity exist between these pathways. Compare measured acidity levels with those determined by chemical equilibrium models and determine which chemical and physical variables are required to make accurate equilibrium calculations. Apportion the acidity among the gas, particle, and droplet phases.

Project 5.3: Case Studies of Atmospheric Mutagenicity and Toxic Species. Determine which organic toxic air contaminants are present at different sites and times using the displays of Project 1.1, and compare these levels with those found in other urban areas and with levels which have been found to be harmful. Identify areas in the SOGAB where levels are consistently higher than in other areas, and examine the source emissions maps and wind flow patterns to estimate their potential origins. Identify which species are of primary or of secondary origin.

6.4.6 Objective 6: Accuracy, Precision, and Validity of Measurement Methods

Project 6.1: Evaluate Measurement Methods. Use the data from the ARB-sponsored nitrogen (Hering et al., 1987a) and carbon comparison studies (Hering et al., 1987b), SCAQS data obtained by multiple techniques, and SCAQS data obtained by duplicate measurements using the same techniques to assess

the accuracy, precision, and validity of the SCAQS sampling methods for acidic species, organic and inorganic carbon species, particle liquid water measurements, labile species measurements, and particle size measurements. Quantify differences between methods by non-parametric statistical tests, comparisons of uncertainty intervals, and linear regression analysis. Attribute differences between measurement methods which exceed precision intervals to standardization, interferences, sample validity, or other causes.

Project 6.2: Estimate Uncertainty of SCAQS Measurements. Combine the data from simultaneous measurements of the same observable by different methods and the results of measurement evaluations to quantify the variability about the measurement which would be found in a representative volume around the sampling point. List all of the assumptions which must be met by each measurement method in order to yield a valid value, and identify those periods of SCAQS sampling in which those assumptions were not complied with. Quantify the effects of deviations from these assumptions wherever possible.

6.5 COMPLEMENTARY MODELING PROJECTS

Although air quality modeling is not an integral part of SCAQS. The study has been designed to meet modeling needs. Several sponsors already have planned modeling uses for the SCAQS data and have made their data needs known during the planning process. These needs have been accounted for in this plan. In addition, the Model Working Group (MWG) was established to provide continuing technical input to the SCAQS design process. The MWG has served as an interface to the modeling community to assure that SCAQS data will be appropriate for modeling projects and to coordinate the modeling efforts of various participants.

The MWG has reviewed the current status of photochemical models (Seinfeld et al., 1987) and has made several recommendations for model improvements which should be made in anticipation of and using the SCAQS data. These recommendations are summarized in Section 6.5.1 below. Some of the modeling projects currently planned by the sponsors are summarized in Section 6.5.2.

6.5.1 Modeling Recommendations of the Model Working Group

Modeling Project 1: Improvements in Wind Field Descriptions. Currently, the major data inputs to primitive equation hydrodynamic models are synoptic geostrophic wind profiles (which can vary with time) and domain-scale initial profiles of temperature and moisture. These data are obtained from the NWS rawinsonde network which has a 12-hour temporal resolution and a spatial resolution on the order of 500 km. Given these initial domain-scale measurements, the primitive equation models calculate mesoscale fields of wind, temperature and moisture without mesoscale observational input. The high-quality SCAQS mesoscale observations can be used in conjunction with prognostic primitive-equation models. The resultant meteorological fields derived from the models should be superior to those obtained via either objective analysis of observations or from the model without such input data.

The SCAQS meteorological data can be used in two ways. In the first approach, the mesoscale model is run with the usual NWS derived initial conditions. Model results and observational data are then input together to an objective analysis algorithm which produces a set of "ultimate" gridded

meteorological fields. Research is needed to determine the sensitivity of the analysis scheme to model assumptions and parameter specifications which govern the relative weighting of modeled and observed wind fields.

The second approach involves the assimilation of mesoscale observational information during the model run. Data assimilation techniques have previously been applied in "regional-scale" (domain scale of 2000 km, grid scale of 50 km) numerical simulations. In one technique, artificial terms are added to the prognostic momentum and/or heat equations to "nudge" the model fields toward observations. In another technique, variational procedures are used at specified intervals to minimize the differences between model and observations subject to specified constraints. The model, thus, is used as a sort of dynamic interpolator/extrapolator.

The horizontal scales (domain scale of 200 km, grid scale of 5-10 km) are much smaller in the SOGAB than in previous data assimilation experiments, the gradients within the flow are larger (e.g., sea breeze convergence zones, inversion layers), and the effects of complex terrain are more important. The completion of this project would determine which data can be effectively assimilated; usually, a choice must be made between wind and temperature data.

Modeling Project 2: Planetary Boundary Layer and Mixing Prediction.

Planetary boundary layer (PBL)/inversion layer predictions by the numerical model need to be improved. Synoptic subsidence, which is a significant control on inversion height and strength is not included in current models. The behavior of the model planetary boundary layer height in complex terrain needs to be investigated and improved, especially if venting and recirculation of pollutants by slope flow circulations is of interest. The current formulation, based on the results of Deardorff's flat-terrain large-eddy simulation, is questionable in complex terrain. Two-dimensional simulations would be performed in this project to test improved PBL prediction techniques against SCAQS measurements. The mathematical descriptions would ultimately be applicable to three-dimensional simulations.

Modeling Project 3: Air Quality Model Testing. Mesoscale model input (winds and/or mixing heights) in air quality models (e.g., the Urban Airshed Model, UAM) needs investigation. The vertical resolution in mesoscale meteorological simulations is usually higher than that customary in air quality modelling. The sensitivity of the UAM to improved vertical resolution, especially in highly sheared atmospheres, should be tested to determine the extent to which air quality predictions are improved. Also, tests of UAM sensitivity to wind inputs in sparse-observation subregions should be carried out; if such sensitivity is demonstrated, this might justify the incorporation of primitive-equation meteorological models into air quality models used for control strategy assessment.

Modeling Project 4: Gas-Phase Hydrocarbon/NO_x Chemistry Model Testing. Due to the intensive research efforts carried out over the past 10-15 years, the atmospheric chemistry of anthropogenic emissions is reasonably well known. Under U.S. EPA funding, two detailed chemical mechanisms have recently been developed, one by Environmental Research & Technology/Statewide Air Pollution Research Center (ERT/SAPRC) based upon the earlier SAPRC mechanism, and the other the Carbon Bond IV developed by Systems Applications, Inc. The general features of the chemistry of these two mechanisms, are

similar, as expected since they are both based upon the laboratory kinetic, mechanistic and product data available. However, certain portions of the mechanisms, for example, those dealing with the aromatics chemistry, are different due to differing methods of parametrizing these presently unknown reaction mechanisms. At the present time, the major areas of uncertainty in the chemical mechanisms are those concerning the reactions of the aromatic hydrocarbons, the reactions of the longer chain alkanes, and of the ozone-alkene reactions.

The complete chemical mechanisms must then be tested against environmental chamber data. Uncertainties in the chamber light intensities and spectral distributions, and in the chamber effects (for example, the chamber dependent radical source and NO_x and organic off-gasing rates), together with the uncertainties inherent in the environmental chamber data themselves, lead to additional overall uncertainties in the predictive abilities of the chemical mechanisms. At the present time, the two latest mechanisms (the ERT/SAPRC and the Carbon Bond IV) agree with the environmental chamber maximum ozone yields to within approximately 30 percent. With reanalysis to take into account a reevaluation of the light intensities and spectral distributions of the University of North Carolina chamber, this 30 percent scatter may be reduced somewhat.

When used in urban airshed computer models for hydrocarbon control strategy applications, however, these two chemical mechanisms lead to different conclusions with regard to emissions reductions. SCAQS data should be used to compare against the intermediate reaction products of these mechanisms in order to resolve these differences.

Also, the performance of the several models which will be applied to and tested against SCAQS data should be compared. A protocol for such a comparison should be formulated, and the model applications should be designed such that a common set of performance measures is produced by each model.

Model Project 5: Transport/Deposition in Air Quality Models. A gap exists between the micrometeorology in air quality models and that in state-of-the-art planetary boundary layer models, and the treatment of micrometeorological phenomena in the air quality models applicable to the SOCAB should be improved. Dry deposition modules in these air quality models should be brought up to the most current level possible.

There is considerable room for improvement in the mixing layer determination and boundary-layer profiling in air quality assessment models. There also appears to be a need to adapt the models to more fully utilize the micrometeorological outputs from prognostic meteorological models. Improved micrometeorological data would improve the dry deposition velocities as well as the K_z profiles. SCAQS data should be used to test different mechanisms for prediction accuracy and to estimate several of the parameters required by the mechanisms.

Modeling Project 6: Emissions Inventory Grid Resolution. Simulations should be performed to assess the effect of the emissions inventory grid resolution on predicted concentrations. Grid nesting might be examined should finer resolution be called for in certain areas of the region.

Modeling Project 7: Aerosols and Acidic Species Model Development.
Prediction of PM-10, fine particles, visibility and acidic species will require a model capable of relating gaseous and particulate emissions to gaseous acidic substances, and particulate sulfate, nitrate, organics, and elemental carbon, ammonium, water, and metal and soil compound concentrations. There does not currently exist a three-dimensional model capable of predicting the airborne concentration of gaseous, particulate, and aqueous-phase acidic species.

The component parts are now in place to proceed with the development of a three-dimensional comprehensive acid deposition model. To produce such a model, the approach is to integrate modules for aerosol chemistry and physics and aqueous-phase chemistry (cloudwater, rain or fog) into a three-dimensional gas-phase photochemical model. The sub-model(s) becomes a computation carried out in each grid cell of the full model, updated at each time step akin to the gas-phase chemical kinetics.

The potential importance of aqueous-phase pathways leading to the incorporation of sulfate, nitrate, and acidity in cloudwater, fogwater, and rain is widely recognized. In order to determine the most important of these pathways to be included in a wet deposition module, a comprehensive aqueous-phase chemical mechanism must be assembled and tested over a wide range of environmental conditions. SCAQS data would be used for testing purposes.

Important areas that need to be examined are organic peroxide chemistry, trace metal catalyzed reactions, and free radical chemistry. In addition, the role of aqueous-phase organic chemistry in determining the chemical composition of cloudwater and rain is not adequately understood. These areas must be reviewed and reassessed at regular intervals.

6.5.2 Modeling Projects Planned by the Sponsors

Some of the modeling projects currently planned by the sponsors are outlined below.

- Southern California Edison may use the meteorological measurements to evaluate a prognostic one-layer sea breeze model which was developed by the University of Washington and the Pielke (1984) primitive equations model to describe wind fields. SCE will also use SCAQS data for continuing its organic aerosol receptor modeling project, and as input to and testing of the PLMSTAR (Godden and Lurmann, 1983) photochemical model.
- The Research Division of the Air Resources Board is sponsoring the California Institute of Technology (Dr. John Seinfeld) to develop model components for the formation and dynamics of aerosols for inclusion in the Caltech urban photochemical model. In addition, Dr. Seinfeld will use the SCAQS data to evaluate the ability to simulate ozone photochemistry of a hierarchy of models and to assess the ability of his aerosol model components to predict the size, spatial and temporal distribution, and dependence on the gas phase of the SOGAB aerosol.

- The Technical Support Division (TSD) of the Air Resources Board would like to use the SCAQS data in the development of control strategies for ozone and PM-10. Over the long-term, the data will also be useful for visibility, acid deposition, and toxic substance control strategy development as well. Specifically, given adequate resources, the TSD control strategy development tasks for O₃ and PM-10 would include the following steps.
 - Identify the characteristics of ozone and PM-10 episodes, and construct annual frequency distributions of these episodes.
 - Simulate the flow fields using wind models, and compare performance against wind measurements and tracer concentrations measured in SCAQS. Evaluate the performance of wind field models and improve them.
 - Develop a grid model with improved treatments of atmospheric chemical and physical processes, dry deposition, diffusion processes, and formation of nitrate, sulfate, and organic particles.
 - Apply the wind field and chemistry model to initial and boundary conditions acquired during SCAQS, and compare calculated values with those measured at SCAQS stations throughout the SOCAB. Evaluate the need for further model development.
 - Develop effectiveness factors for controls on particulate matter NO_x, SO_x, and hydrocarbons for each source type and receptor location.
 - Use cost-of-control figures, effectiveness factors, and PM-10 and ozone episode frequency distributions to derive cost-effective control strategies to reduce ozone levels and PM-10 levels throughout the SOCAB.
- General Motors Research Laboratories (GMR) will apply factor analysis techniques to estimate the major source contributions to PM-10 and PM-2.5 using the aerosol chemical composition data, routine gaseous pollutant data, meteorological data, emissions inventories, and emissions characterization results. GMR will also employ empirical and theoretical modeling to relate the chemical composition of the aerosol to the SCAQS visibility measurements using the chemical composition, impactor, visibility, and meteorological data. The mutagenic activity measurements will also be used in source apportionment models to identify their origins.

6.6 SYNTHESIS AND INTEGRATION OF SCAQS DATA INTERPRETATION RESULTS

The projects listed in Section 6.4 and 6.5 represent self-contained studies, yet to fully profit from the wealth of information in the SCAQS data, the results must be synthesized and presented in a cohesive form. A separate project, headed by the Data Analysis Coordinator, would provide this synthesis in the following manner. Projects 1.1, 1.2, and 1.3 would be performed first, and this descriptive information would be made available to all other researchers. Each researcher would use this information plus whatever he needs from the entire data base to perform the tasks specific to the project statement. All researchers would be known to each other, and communications

among researchers would be encouraged, but not required. The Data Analysis Coordinator would accommodate the needs of each researcher with respect to data needs and would act as a clearinghouse for information. After approximately two-thirds of the resources in each project have been expended, each researcher would document his results in writing and present them at a workshop. Interpretive results of one project which would enhance other projects would be identified at the workshop and collaborative agreements between researchers would be established. After this workshop, researchers would finish the final third of their projects with the appropriate incorporation of the work of others. The Data Analysis Coordinator would synthesize the papers and discussions of the workshop into a draft technical paper in the mode of Hidy et al. (1975). The paper would be reviewed by all participants and revised as appropriate. A general symposium would be established for the presentation of the final work, which would be peer-reviewed by external reviewers and published as a book or in one of the technical journals.

7. PROGRAM MANAGEMENT PLAN AND SCHEDULE

7.1 MANAGEMENT STRUCTURE

The SCAQS management structure is outlined in Figure 7-1. The major management functions are funded by ARB, and the Program Coordinator (PC) reports to the ARB. In a cooperative study such as this, however, the PC cannot have direct management authority over all phases of the study. In essence, his job is to manage by consensus, since direct fiscal responsibility will remain with ARB and the other sponsors for their respective contracts.

The PC receives guidance from a Management Advisory Group (MAG) consisting of representatives of the sponsors and technical advisors selected by the sponsors. The MAG decides the technical direction for the study. The principal role of the MAG is to ensure that the objectives of the study coincide with the needs of the sponsors and that the program plan is technically sound and is adequate to meet the objectives. This program plan has been prepared with the advice and approval of the MAG.

The PC works with the Field, Data, and Analysis Managers and ARB staff as a team to coordinate the activities of other ARB contractors. Although the PC does not have direct authority to manage the activities of participants funded by other sponsors, their decision to participate in the study and to follow the program plan should give the PC enough leverage to adequately manage the study.

During the study, the PC is responsible for the following tasks:

- Overall program coordination to keep the study on schedule and to resolve conflicts.
- Coordination of ARB contractor efforts.
- Coordination with the emissions contractor(s) and other complementary efforts.
- Coordination of quality assurance activities.
- Selection of sampling days.
- Monitoring achievement of defined milestones and periodic budgetary reviews to assure that the study goals can be met with the resources available.
- Periodic revision of the program plan to take into account technical, logistical, or budgetary issues or problems which might arise.
- Preparation of short periodic summaries of activities.
- Preparation of progress reports summarizing the progress, preliminary results, and conclusions to date of the study. These reports will require technical input from all participants.
- Coordination of periodic meetings of investigators.

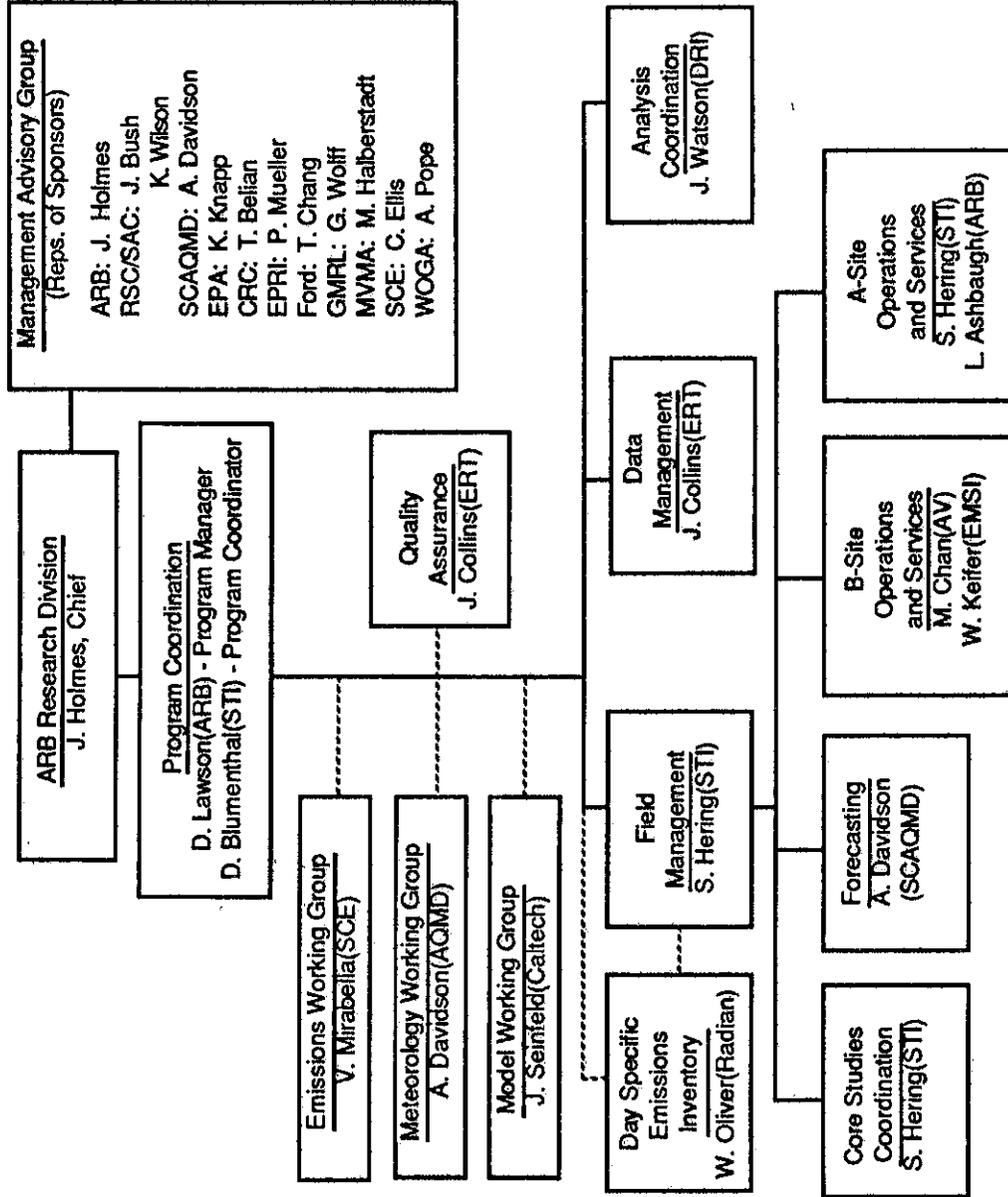


FIGURE 7-1. SCAQS Organization Chart

- Coordination of a technical session or meeting at which the final study results will be presented and coordination of the submittal of manuscripts for back-to-back publication in a selected journal.
- Preparation of a final summary report which presents the results and conclusions of the study and provides a bibliography of SCAQS publications. The last two tasks are not funded at this time and may be performed by ARB staff.

The roles of the Field, Data, and Analysis Managers shown in Figure 7-1 have been described in previous sections. The Field Manager (FM) will prepare a measurement protocol with the input and review of the participants. The FM will be responsible for coordination of forecasting activities, assessing sampling readiness and for the day-to-day interactions with the field participants. The FM will also coordinate the preparation and upkeep of the A- and B-sites and related facilities. The actual work, however, will be performed by other contractors as indicated in Figure 7-1.

The DM will be responsible for the assembly, archiving, and distribution of all study data. The DM will also assemble and format data from supplementary sources with the help of the ARB staff.

The Analysis Coordinator (AC) will work with the investigators to assure that all objectives are addressed by one or more analysis efforts and to identify and eliminate redundant efforts. The AC will facilitate communications between investigators and encourage synergistic efforts.

Some boxes in Figure 7-1 are connected by dashed lines, indicating a consultative or coordination function. The Quality Assurance (QA) function is separate from the measurement functions and reports its results directly to the PC. The QA effort is coordinated by a QA Manager, but the actual QA work will be split among more than one contractor or sponsor. The activities of the QA Manager are defined in Section 4. His efforts are coordinated by the PC, but his reports will be independent documents from the reports prepared by the PC. Copies of the QA reports will be provided to participants and sponsors. It is the responsibility of the PC to find a way to remedy any serious program deficiencies identified by the QA Manager.

The Emissions, Meteorology, and Model Working Groups are independent committees of participants and sponsors. Some members of these groups are planning research efforts which provide input to or make use of the SCAQS data base. The Emissions and Model Working Groups have been set up to be complementary to SCAQS and their functions will continue beyond the SCAQS field program. The function of the Meteorology Working Group has been primarily to help design the SCAQS meteorology measurements, the forecast protocol and to help focus the tracer studies. The input of all three groups has been required in the design of SCAQS to ensure that the objectives can be met. The working groups provide their recommendations and input directly to the Program Coordinator and the MAG.

The day-specific emissions inventory function shown on Figure 7-1 is actually an activity which is designed and coordinated by the Emissions Working Group. The inventory contractor must coordinate closely with the field

manager so that he is aware of the sampling schedule and is prepared to obtain the necessary real-time emissions information on the intensive study days.

Although the major elements of the management structure have been outlined above, most of the project work will be performed by contractors or participating sponsors. The study will involve more than 50 separate contracted tasks. These tasks, their estimated costs, and their sponsors are listed in Section 8.

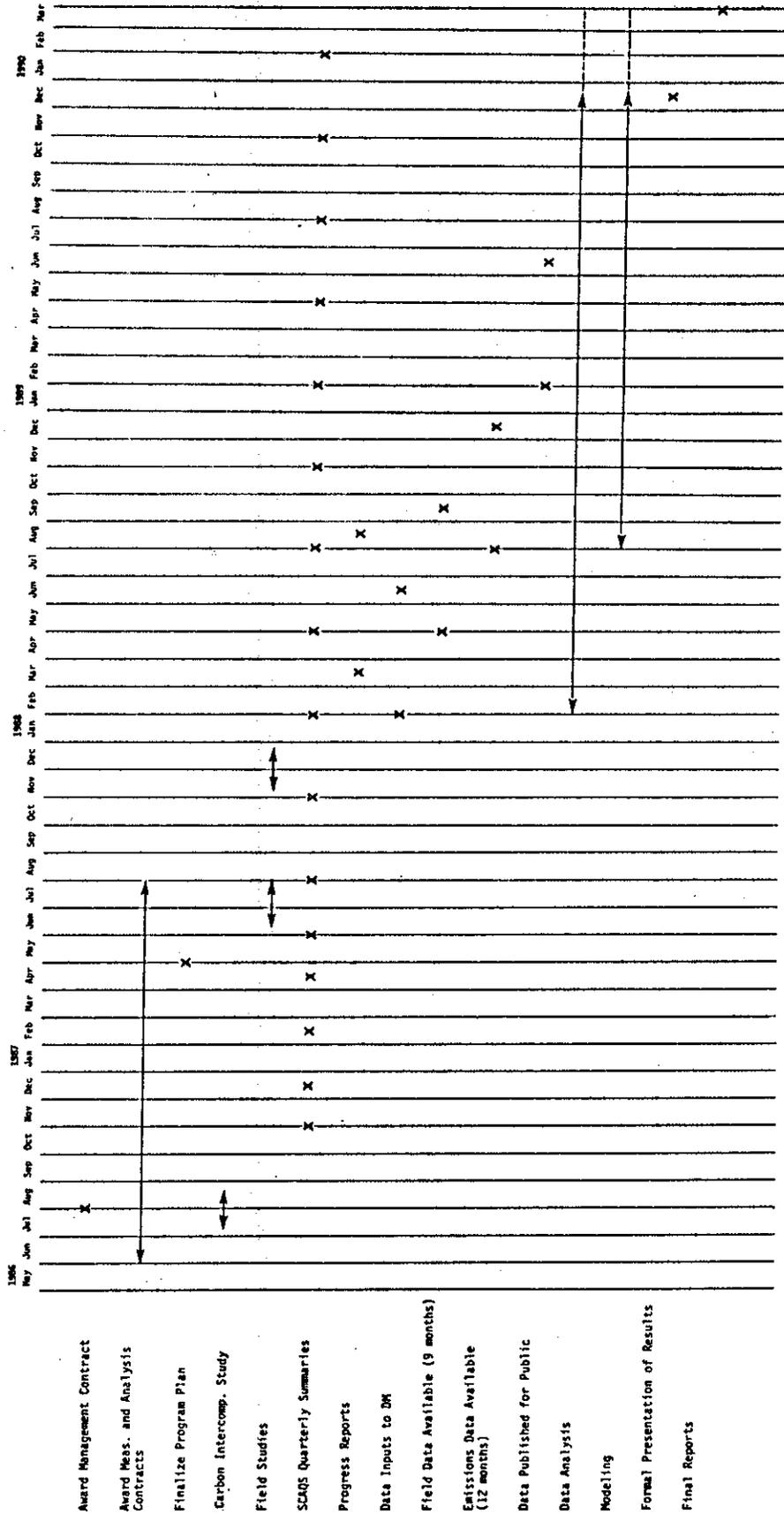
7.2 SCHEDULE

The SCAQS schedule is outlined in Figure 7-2. We expect the dates and durations to be modified depending on climatological and fiscal considerations. The dates shown here are to be considered only as general guidelines.

7.3 REPORTS AND PRESENTATIONS

One way to keep a study on schedule and to encourage productive results is to schedule periodic reports and presentations which summarize the results and conclusions. The following reports and presentations should be prepared as part of the study.

- Project Protocols - These should list the measurements to be made, the groups which perform each measurement, the logistical requirements of the measurement groups, the services to be provided by the Field Manager, summaries of the QC and QA activities, the types of data to be obtained, the formats in which data are to be submitted to the Data Manager, and the formats in which data will be available from the Data Manager.
- Periodic Summary of Activities - The Program Coordinator will prepare brief periodic summaries of project activities including meetings of the MAG and participants. In preparing the summaries, the PC will review the routine monthly or quarterly progress reports of the participants and identify any instances for which the work plan or schedule are not being met.
- Progress Reports - These reports will be prepared by the Program Coordinator with input from all participants. The summer and fall field study reports will summarize what happened during the field programs and include preliminary operating information on the major SCAQS equipment, preliminary data capture rates for data already reported, and information on the status and expected availability of all data for the field program. The purpose of these progress reports is to communicate what has been learned from the study to the sponsors in an ongoing fashion. It will be expected that all participants prepare their own reports which can then be used by the Program Coordinator in the preparation of his summary report.
- Quality Audit Reports - Quality audit reports will be prepared within two months after each field program which document the QC and QA activities of the study and which describe the results of the audits and performance tests.



- Data Summary Reports - These will be prepared by the Data Manager within 12 months after each field program. They will inventory the data available, document the data formats, and outline the procedures for accessing the data. The reports will also document the QA procedures and assess the validity, accuracy, and potential sources of error for the various portions of the data base.
- Data Base - The Data Manager will compile all data received into an easily accessible and reproducible form and make the data available to ARB and to all participants and sponsors within 15 months after the end of each field program. This data base and the data summary report will be made available to the public approximately 18 months after completion of each field study period.
- Emissions Reports - Within one year after each field program, the emissions contractor will report the results of his day-specific emissions inventory for the period. By the end of 1990, members of the EWG will prepare a formal 1987 emissions inventory for the study area. This report should document the procedures used to prepare the inventory and present graphic and tabular summaries. It should be accompanied by a data tape which includes the gridded, time-resolved emissions for the study days and by documentation of the data formats. Other analyses which are part of the emissions contracts should also be reported.
- Meeting Presentations - Within about 18-24 months of the end of the last field program, a session at a technical meeting should be organized for the presentation of the study results. Each participant who is responsible for some aspect of the data analysis will be expected to present his results. The manuscripts from the session should also be submitted to a technical journal. It is expected that other presentations will be made at earlier times as results become available.
- Final Reports - Each participant should prepare a final report which documents his work and summarizes his results and conclusions. The Program Coordinator should prepare a final report which describes all phases of the study and summarizes the results and conclusions.

8. SCAQS FUNDING

SCAQS is a cooperative study which is being funded by many different government agencies, industry groups, and individual corporate sponsors. These include the California Air Resources Board (ARB), the Environmental Protection Agency (EPA), the South Coast Air Quality Management District (SCAQMD), the Coordinating Research Council (CRC), the Electric Power Research Institute (EPRI), the Ford Motor Company, the General Motors Research Laboratories (GMRL), the Motor Vehicle Manufacturers Association (MWMA), Southern California Edison (SCE), and the Western Oil and Gas Association (WOGA). The overall project is estimated to cost about nine million dollars. This estimate does not include future data analysis or modeling efforts.

Figure 8-1 gives a short summary of the contributions of the various sponsors. Figures 8-2 through 8-4 give a more detailed listing of individual contracts and in-kind contributions. The bars in Figures 8-2 through 8-4 show the general time scales of the contracts. The text around the bars indicates the organization performing the work, the principal investigator, the sponsoring organization, the contract manager, and the approximate cost of the contract or in-kind service. Since the study is in constant flux, some of the details in Figures 8-2 through 8-4 may change.

SOUTHERN CALIFORNIA AIR QUALITY STUDY

Funding -- \$9,000,000

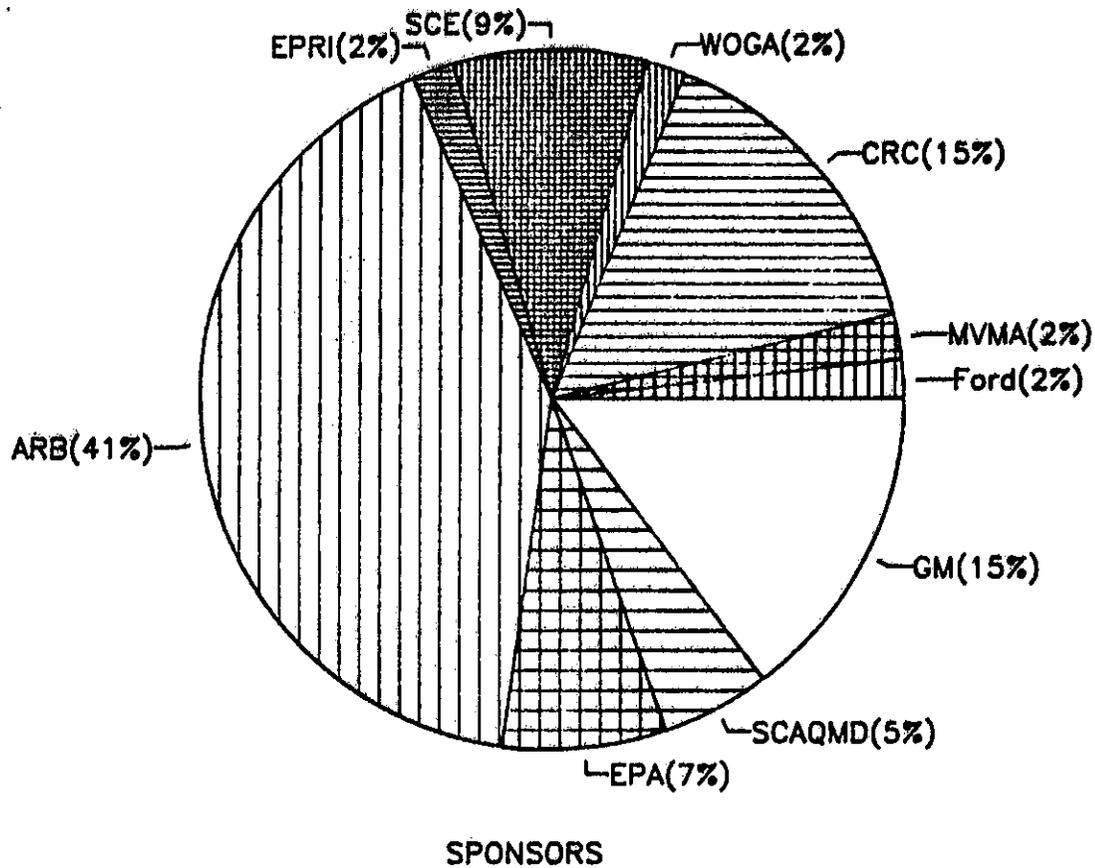
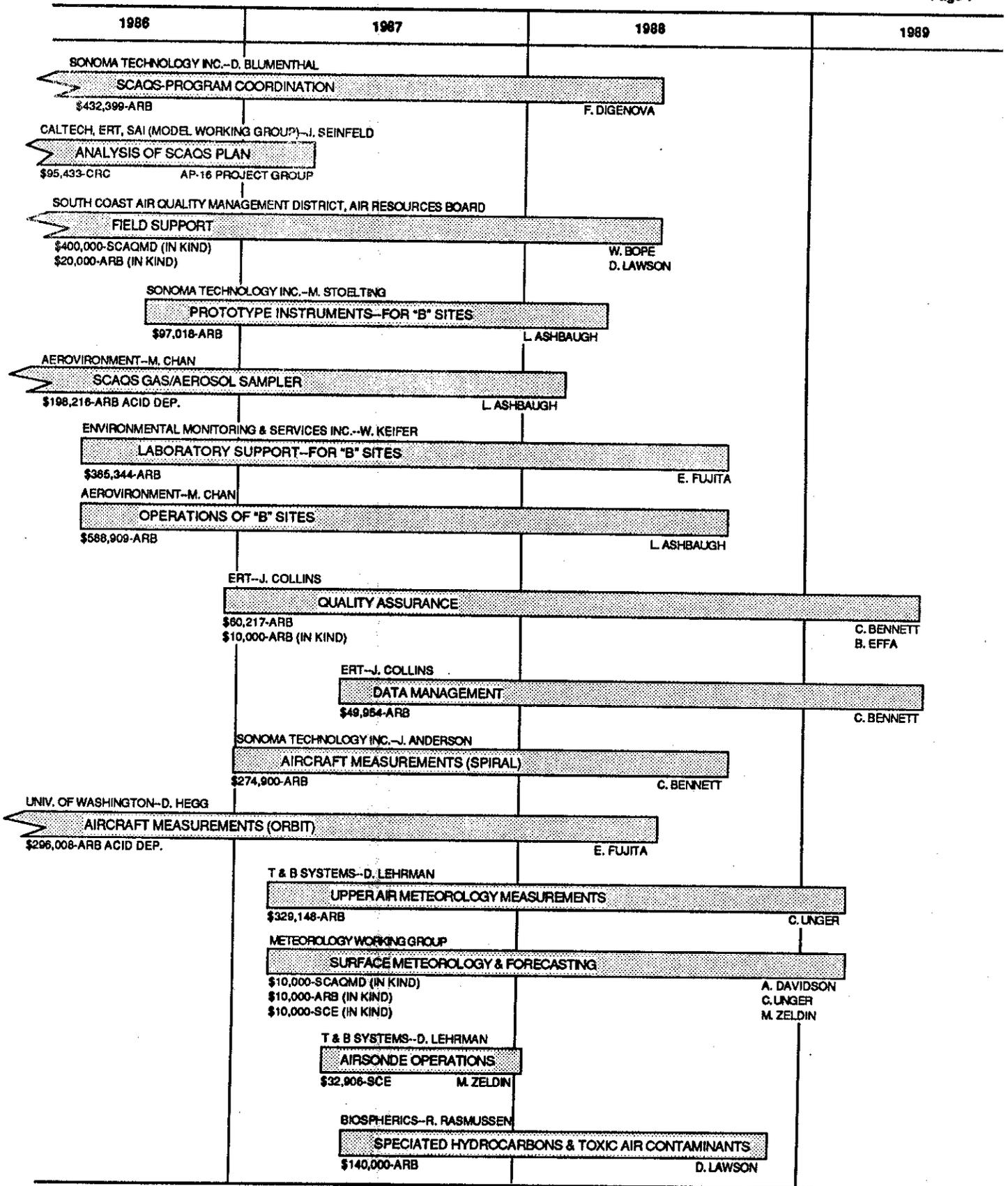


Figure 8-1. Summary of SCAQS Funding

Figure 8-2. SCAQS Core Program



(Continued)

Figure 8-2. SCAQS Core Program

(continued)

Page 2

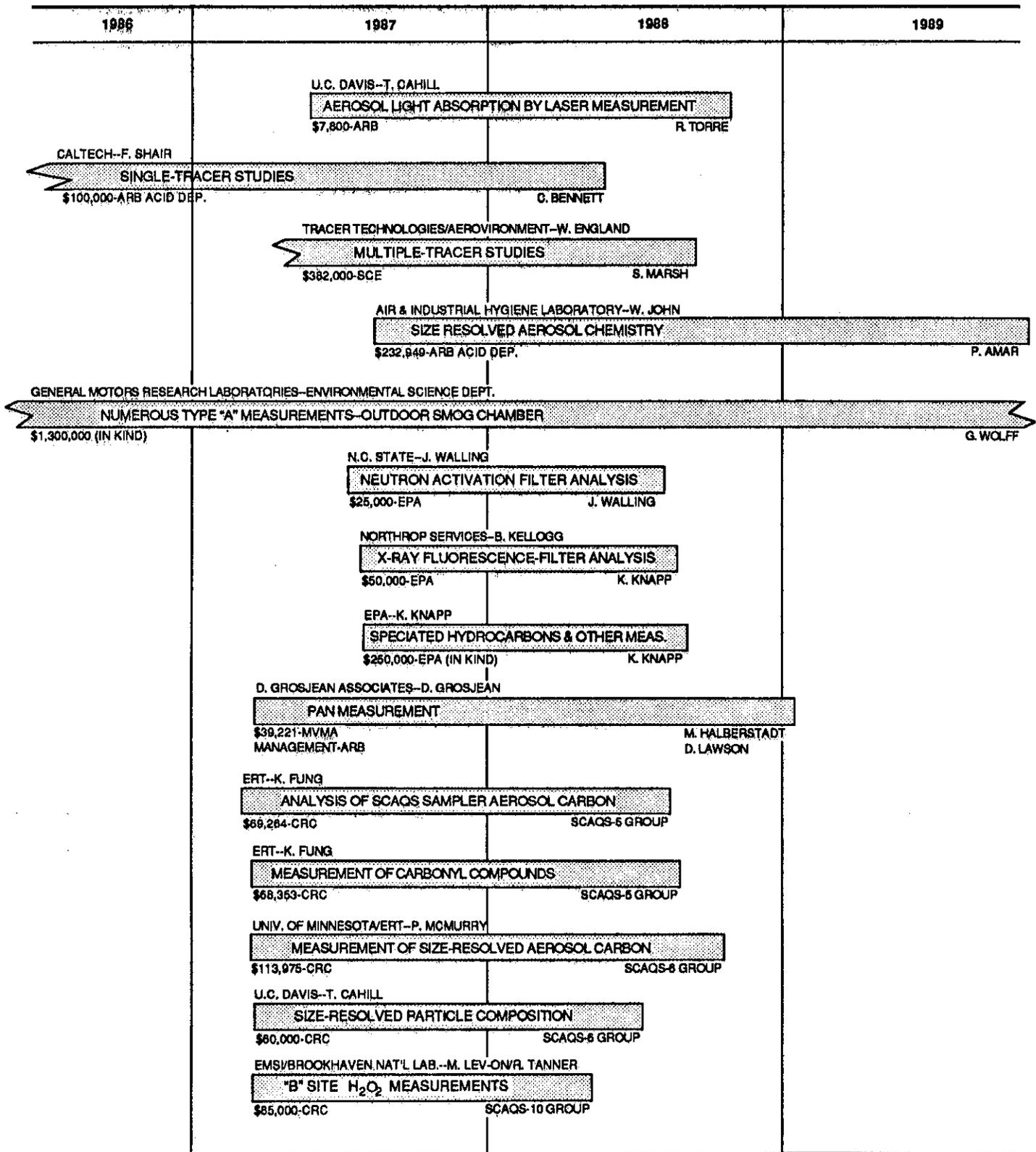


Figure 8-3. SCAQS A-Site Studies

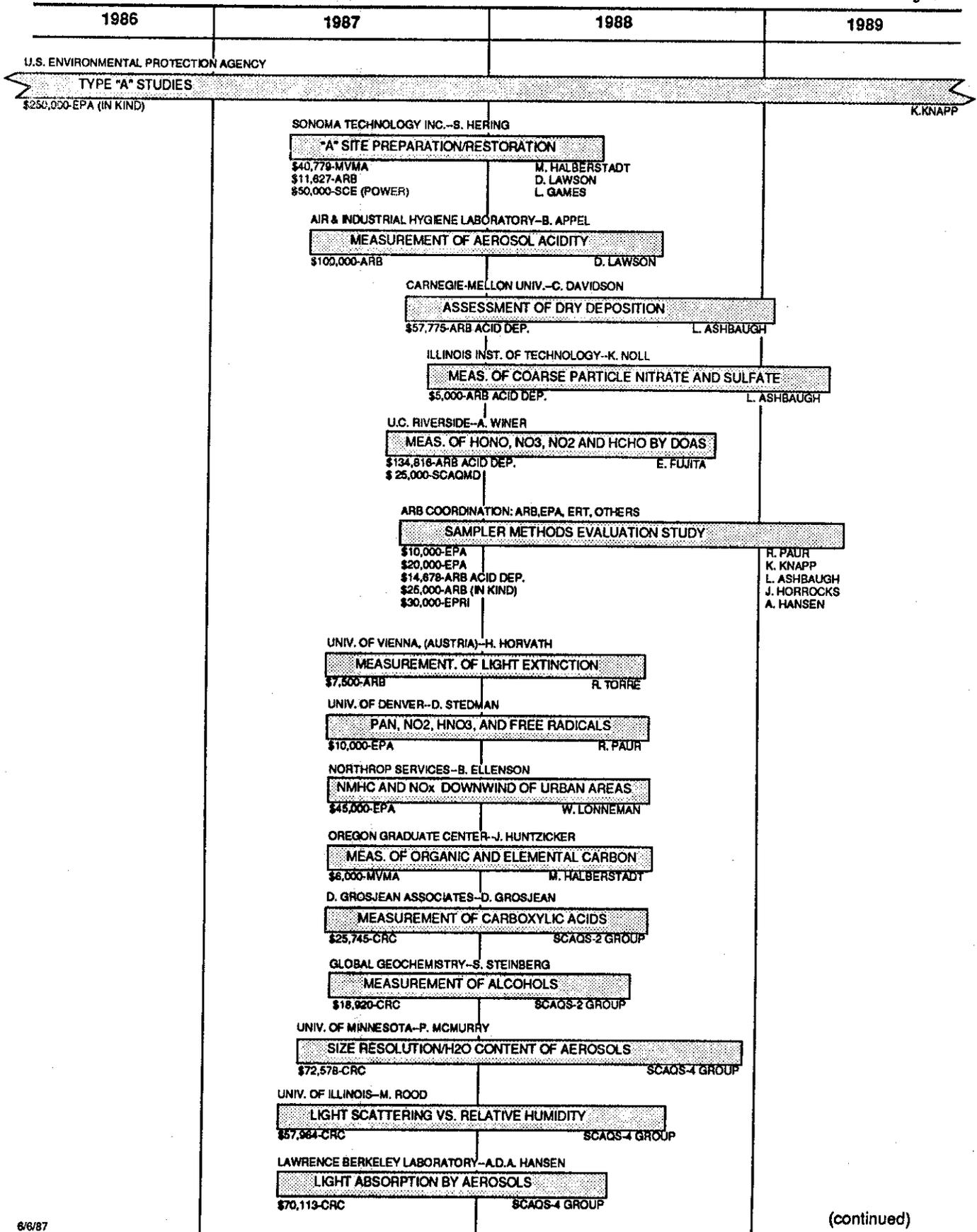


Figure 8-3. SCAQS A-Site Studies

(continued)

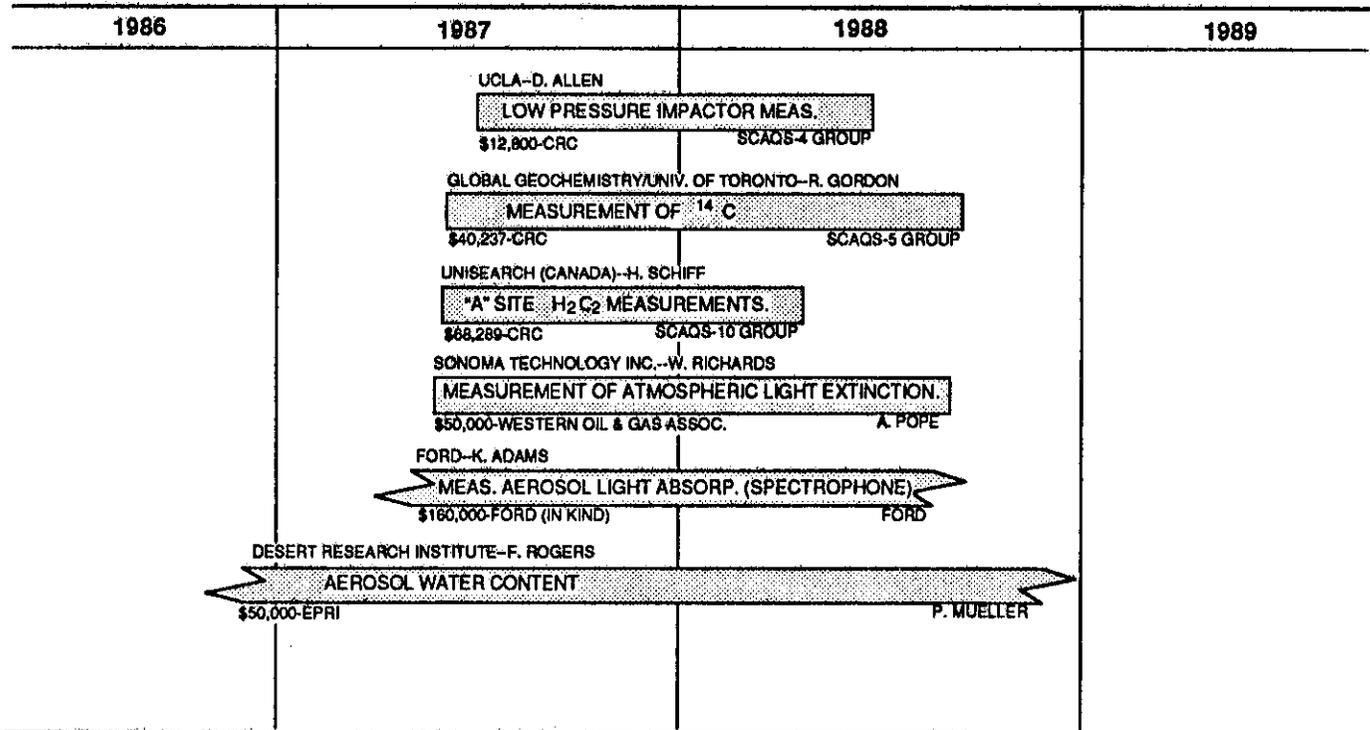
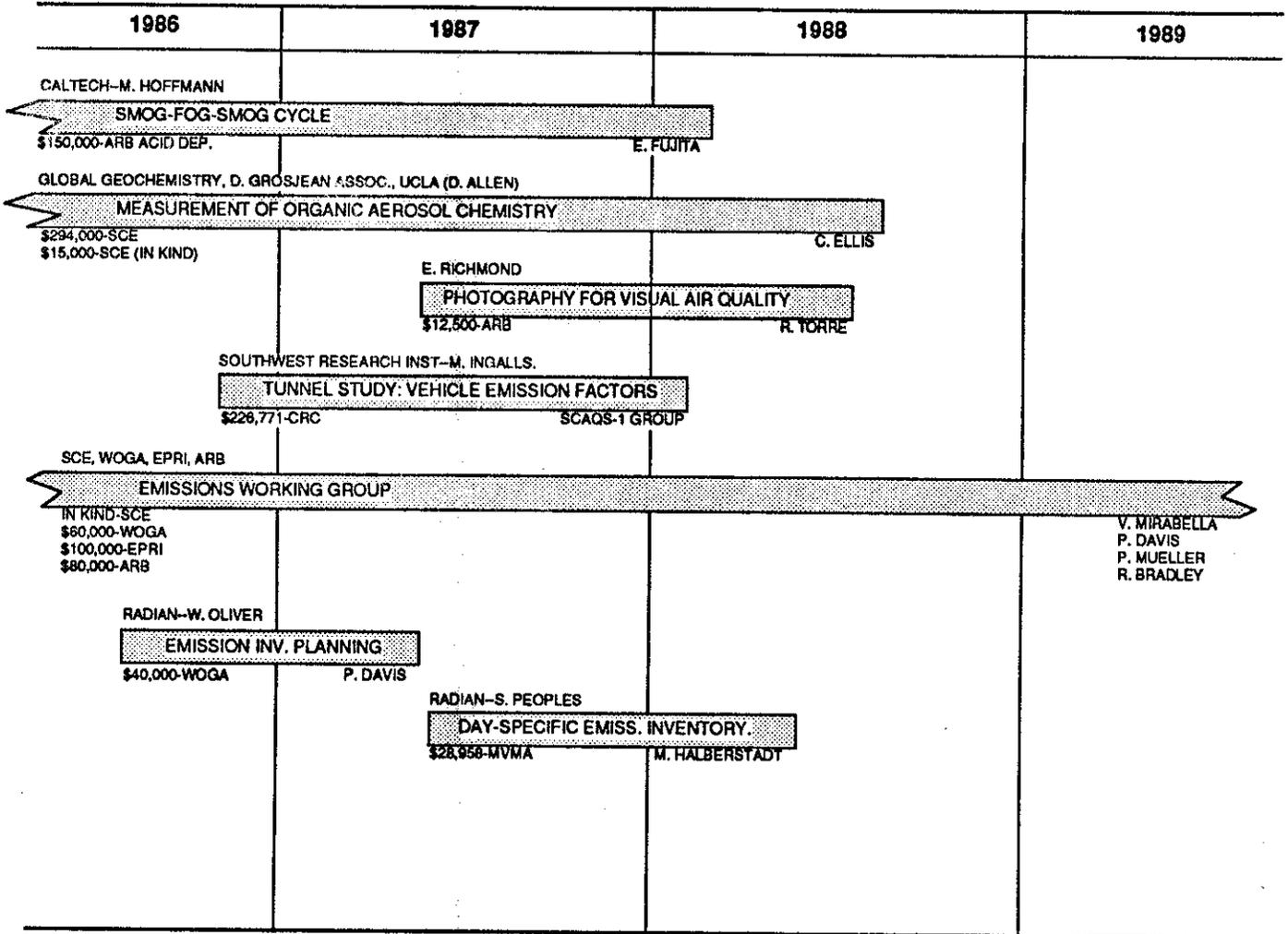


Figure 8-4. SCAQS Additional Studies



9. REFERENCES

- Ackerman, T. P. (1977) A Model of the Effects of Aerosols on Urban Climates with Particular Applications to the Los Angeles Basin. *Journal of the Atmospheric Sciences*, 34, 531.
- ARB - Air Resources Board (1983) California Air Quality Data, July, August, September, 1983. Aerometric Data Division, Volume XV, No. 3, California Air Resources Board, Sacramento, CA.
- ARB - Air Resources Board (1984) California Air Quality Data, Summary of 1984 Air Quality Data Gaseous and Particulate Pollutants. Aerometric Data Division, Volume XVI - Annual Summary.
- ARB - Air Resources Board (1986) State of California Air Resources Board Emissions Inventory 1983. Prepared by the Stationary Source Control Division Emission Inventory Branch, California Air Resources Board, Sacramento, CA.
- Alkezweeny, A. J. and Lockhart, T. J. (1972) Cloud Condensation Nuclei and Visible Pollution in Los Angeles. *Atmos. Environ.* 6, 481-486.
- Altshuller, A. P. and Bellar, T. A. (1963) Gas Chromatographic Analysis of Hydrocarbons in the Los Angeles Atmosphere. *J. of the Air Pollution Control Assn.* 13, 81.
- Altshuller, A. P. and McPherson, S. P. (1963) Spectrophotometric Analysis of Aldehydes in the Los Angeles Atmosphere. *J. of the Air Pollution Control Assn.* 13, 109.
- Altshuller, A. P., Ortman, G. C., Saltzman, B. E. and Neligan, R. E. (1966) Continuous Monitoring of Methane and Other Hydrocarbons in Urban Atmospheres. *J. of the Air Pollution Assn.* 16, 87.
- Altshuller, A. P., Lonneman, W. A., Sutterfield, F. D. and Kopczynski, S. L. (1971) Hydrocarbon Composition of the Atmosphere of the Los Angeles Basin--1967. *Env. Sci. Tech.* 5, 1009.
- Angell, J. K., Dickson, C. R. and Hoecker, W. H. Jr. (1975) Relative Diffusion Within the Los Angeles Basin as Estimated from Tetraon Triads. *J. of Appl. Met.* 14, 1490.
- Angell, J. K., Dickson, C. R. and Hoecker, W. H. Jr. (1976) Tetraon Trajectories in the Los Angeles Basin Defining the Source of Air Reaching the San Bernardino-Riverside Area in Late Afternoon. *J. of Appl. Met.* 15, 197.
- Appel, B. R., Colodny, P. and Wesolowski, J. J. (1976) Analysis of Carbonaceous Materials in Southern California Atmospheric Aerosols. *Env. Sci. Tech.* 10, 359.

- Appel, B. R., Hoffer, E. M., Kothny, E. L. and Wall, S. M. (1977a) Interference in 2,4-Xylenol Procedure for Nitrate Determination in Atmospheric Aerosols. *Env. Sci. Tech.* 11, 189.
- Appel, B. R., Hoffer, E. M., Haik, M., Wall, S. M. and Kothny, E. L. (1977b) Characterization of Organic Particulate Matter. California Air Resources Board Report No. ARB-R-5-682-77-72, Sacramento, CA.
- Appel, B. R., Kothny, E. L., Hoffer, E. M., Hidy, G. M. and Wesolowski, J. J. (1978) Sulfate and Nitrate Data from the California Aerosol Characterization Experiment (ACHEX). *Env. Sci. Tech.* 12, 418.
- Appel, B. R., Hoffer, E. M., Kothny, E. L., Wall, S. M., Haik, M. and Knights R. L. (1979) Analysis of Carbonaceous Material in Southern California Atmospheric Aerosols, 2. *Env. Sci. Tech* 13, 98.
- Appel, B., Tokiwa, and Haik (1981) Sampling of Nitrates in Ambient Air. *Atmos. Environ.* 15, 283-289.
- Appel, B. R., Hoffer, E. M., Tokiwa, Y. and Kothny, E. L. (1982) Measurement of Sulfuric Acid and Particulate Strong Acidity in the Los Angeles Basin. *Atmos. Environ.* 16, 589.
- Appel, B. R., Tokiwa, Y., Hsu, J., Kothny, E. L., Hahn, E. and Wesolowski, J. J. (1983) Visibility Reduction as Related to Aerosol Constituents. California Air Resources Board Report No. A1-081-32, Sacramento, CA.
- Aron, R. H. and Aron, I. M. (1978a) Statistical Forecasting Models: I. Carbon Monoxide Concentrations in the Los Angeles Basin. *J. of the Air Pollution Control Assoc.* 28, 681.
- Aron, R. H. and Aron, I. M. (1978b) Statistical Forecasting Models: II. Oxidant Concentrations in the Los Angeles Basin. *J. of the Air Pollution Control Assoc.* 28, 684.
- Aron, R. H. (1980) Forecasting High Level Oxidant Concentrations in the Los Angeles Basin. *J. of the Air Pollution Control Assoc.* 30, 1227.
- Ashton-Tate (1984) dBase III User's Manual. Ashton-Tate, 10150 W. Jefferson Blvd., Culver City. CA.
- Atkinson, R., Carter, W. P. L. and Winer, A. M. (1983) Evaluation of Hydrocarbon Reactivities for Use in Control Strategies. California Air Resources Board Report No. ARB-R-83-208, Sacramento, CA.
- Baboolal, L. B. and Farber, R. J. (1982) Investigation of the Heterogeneous Component of Sulfate Formation in the Los Angeles Basin. Presented at the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA.
- Bailey, B. S. (1975) Oxidant-HC-NO_x Relationships from Aerometric Data-- Los Angeles Studies. EPA-600/9-75-003, Research Triangle Park, NC.

- Barone, J. B., Cahill, T. A., Eldred, R. A., Flocchini, R. G., Shadoan, D. J. and Dietz, T. M. (1978) A Multivariate Statistical Analysis of Visibility Degradation at Four California Cities. *Atmos. Environ.* 12, 2213.
- Barth, D. (1970) Federal Motor Vehicle Emissions Goals for CO, HC, and NO_x Based on Desired Air Quality Levels. *J. of the Air Pollution Control Assoc.* 20, 519.
- Bassett, M., Gelbard, F. and Seinfeld, J. H. (1981) Mathematical Model for Multi-Component Aerosol Formation and Growth in Plumes. *Atmos. Environ.* 15, 2395.
- Bassett, M. and Seinfeld, J. H. (1983) Atmospheric Equilibrium Model of Sulfate and Nitrate Aerosols. *Atmos. Environ.* 17, 2237-2252.
- Blumenthal, D. L., White, W. H. and Smith, T. B. (1978) Anatomy of a Los Angeles Smog Episode: Pollutant Transport in the Daytime Sea Breeze Regime. *Atmos. Environ.* 12, 893.
- Blumenthal, D. L., Smith, T. B. and White, W. H. (1979) The Evolution of the 3-D Distribution of Air Pollutants During a Los Angeles Smog Episode: July 24-26, 1973 in Character and Origins of Smog Aerosols, edited by G. M. Hidy and P. K. Mueller, John Wiley and Sons, Inc., New York.
- Blumenthal, D. L., Watson, J. G. and Lawson, D. R. (1986) Southern California Air Quality Study (SCAQS) Suggested Program Plan, STI #10-95050-605, prepared by Sonoma Technology, Inc., Santa Rosa, CA 95401 for the California Air Resources Board under Contract #A4-114-32, June 1986.
- Bowman, J. T. (1985) Letter Instructions for ISC-ST, dated September 11, 1985. Bowman Environmental Engineering, P. O. Box 20972, Dallas, TX.
- Brenner, S., Brewer, R. L., Kaplan, I. R. and Wong, W. W. (1980) Chemical Measurements in the Los Angeles Atmosphere. Report EA-1466, Electric Power Research Institute, Palo Alto, CA
- Brewer, R. L., Gordon, R. J., Shepard, L. S. and Ellis, E. C. (1983) Chemistry of Mist and Fog from the Los Angeles Urban Area. *Atmos. Environ.* 17, 2267-2270.
- Broadbent, J., Shikiya, M. C. and Taylor, T. (1985) Acid Deposition in the South Coast Air Basin: Control Strategies. South Coast Air Quality Management District, El Monte, CA.
- Businger, J. A., Wyngaard, J. C., Izumi, Y. and Bradley, E. F. (1971) Flux Profile Relationships in the Atmospheric Surface Layer. *J. of Atmos. Sciences* 28, 181-189.
- Calvert, J. G. (1976a) Test of the Theory of Ozone Generation in Los Angeles Atmosphere. *Env. Sci. Tech.* 10, 248.
- Calvert, J. G. (1976b) Hydrocarbon Involvement in Photochemical Smog Formation in Los Angeles Atmosphere. *Env. Sci. Tech* 10, 256.

- Caporaletti, J. M., Myrabo, L. N., Schleifer, P., Stanonik, A. and Wilson, K. R. (1977) Statistical Oxidant Air Quality Prediction Model for Land Use and Transportation Planning. *Atmos. Environ.* 11, 449-458.
- Cass, G. R. (1975) Dimensions of the Los Angeles SO₂/Sulfate Problem. Environment Quality Lab. Memo 15. California Institute of Technology, Pasadena, CA.
- Cass, G. R. (1978a) Pollutant Exposure in the Los Angeles Coastal Zone Based on Measurement Made at Lennox, California (1965-1974). Consulting report to the Univ. of California at Irvine, School of Medicine, Irvine, CA.
- Cass, G. R. (1978b) Methods for Sulfate Air Quality Management with Applications to Los Angeles. Ph.D. Thesis, 1978, 2 volumes, 801 pp, California Institute of Technology, Pasadena, CA.
- Cass, G. R. (1979) On the Relationship Between Sulfate Air Quality and Visibility with Examples in Los Angeles. *Atmos. Environ.* 13, 1069.
- Cass, G. R. (1981) Sulfate Air Quality Control Strategy Design. *Atmos. Environ.* 15, 1227.
- Cass, G. R. and McRae, G. J. (1981) Source-Receptor Reconciliation of South Coast Air Basin Particulate Air Quality Data. California Air Resources Board Report No. ARB-R-82-156, Sacramento, CA.
- Cass, G. R., Boone, P. M. and Macias, E. S. (1982a) Emissions and Air Quality Relationships for Atmospheric Carbon Particles in Los Angeles. In Particulate Carbon, Atmospheric Life Cycle, edited by G. T. Wolff and R. K. Klimisch, Plenum Press, New York.
- Cass, G. R., Gharib, S., Peterson, M. and Tilden, J. W. (1982b) The Origin of Ammonia Emissions to the Atmosphere in an Urban Area. Open file report 82-6, Environmental Quality Laboratory, California Institute of Technology, Pasadena, CA.
- Cass, G. R. and McRae, G. J. (1983) Source-Receptor Reconciliation of Routine Air Monitoring Data for Trace Metals: An Emission Inventory Assisted Approach. *Env. Sci. Tech.* 17, 129.
- Cass, G. R. and Shair, F. H. (1984) Sulfate Accumulation in a Sea Breeze/Land Breeze Circulation System. *J. of Geophysical Research* 89, 1429.
- Chameides, W. L. and Davis, D. D. (1982) The Free Radical Chemistry of Cloud Droplets and Its Impact Upon the Composition on Rain. *J. Geophys. Res.* 87, 4863.
- Chan, T. and Lippmann (1977) Particle Collection Efficiencies of Sampling Cyclones: An Empirical Theory. *Env. Sci Tech* 11, 377-381.

- Chang, T. Y., Norbeck, J. M. and Weinstock, B. (1980a) NO₂ Air Quality-Precursor Relationship: An Ambient Air Quality Evaluation in the Los Angeles Basin. *J. of the Air Pollution Control Assoc.* 30, 157.
- Chang, T. Y., Norbeck, J. M. and Weinstock, B. (1980b) Ambient Temperature Effect on Urban CO Air Quality. *Atmos. Environ.* 14, 603-608.
- Chang, T. Y. and Norbeck, J. M. (1983) Wind Shear Effects on Air Column Trajectories in Urban Air Pollution Models. *J. of the Air Pollution Control Assoc.* 33, 488.
- Charlson, R. J., Ahlquist, N. C. and Horvath, H. (1968) On the Generality of Correlation of Atmospheric Aerosol Mass Concentration and Light Scatter. *Atmos. Environ.* 2, 455.
- Charlson, R. J. and Pierrard, J. M. (1969) Short Communication: Visibility and Lead. *Atmos. Environ.* 3, 479.
- Charlson, R. J., Ahlquist, N. C., Selvidge, H. and MacCready, P. B. (1969) Monitoring of Atmospheric Aerosol Parameters with the Integrating Nephelometer. *J. Air Pollution Control Assoc.* 19, 937.
- Charlson, R. J. (1972) Multiwavelength Nephelometer Measurements in Los Angeles Smog Aerosol. *J. of Colloid and Interface Science*, 39, 240.
- Chass, R. L. and George, R. E. (1960) Contaminant Emissions from the Combustion of Fuels. *J. of the Air Pollution Assn.* 10, 34.
- Chock, D. P. (1982) On the Non-Randomness of High-Pollution Days. *Atmos. Environ.* 16, 2855.
- Chock, D. P. (1985) Statistics of Extreme Values of Air Quality--A Simulation Study. *Atmos. Environ.* 19, 1713.
- Chock, D. P. and Levitt, S. B. (1976) A Space-Time Correlation Study of Oxidant and CO in the Los Angeles Basin. *Atmos. Environ.* 10, 107.
- Chock, D. P., Dunker, A. M., Kumar, S. and Sloane, C. S. (1981) Effect of NO_x Emission Rates on Smog Formation in the California South Coast Air Basin. *Env. Sci. Tech.* 15, 933.
- Chock, D. P., Kumar, S. and Herrmann, R. W. (1982) An Analysis of Trends in Oxidant Air Quality in the South Coast Air Basin of California. *Atmos. Environ.* 16, 2613-2624.
- Chow, J. C. (1985) A Composite Modeling Approach to Assess Air Pollution Source Receptor Relationships. Ph.D. Dissertation, Harvard University, Cambridge, MA.
- Chow, J. C. and Spengler, J. D. (1985) A Method to Composite Urban and Regional Source Models with Principal Component Analysis and Chemical Mass Balance Receptor Models. Receptor Methods for Source Apportionment: Real World Issues and Applications, Air Pollution Control Association, Pittsburg, PA.

- Colucci, J. M. and Begeman, C. R. (1969) Carbon Monoxide in Detroit, New York, and Los Angeles Air. *Env. Sci. and Tech.* 3, 41-47.
- Colucci, J. M., Begeman, C. R. and Kumler, K. (1969) Lead Concentrations in Detroit, New York and Los Angeles Air. *J. of the Air Pollution Control Assoc.* 19, 255.
- Cooper, J. A., Watson, J. G. and Huntzicker, J. J. (1979) Portland Aerosol Characterization Study: Application of Chemical Mass Balance Methods to the Identification of Major Aerosol Sources in the Portland Airshed. Prepared for the Oregon Department of Environmental Quality at the Oregon Graduate Center, Beaverton, OR.
- Costanza, V. and Seinfeld, J. H. (1982) Optimal Emission Control Strategies for Photochemical Smog. *Env. Sci. Tech* 16, 98.
- Covert, D. S., Charlson, R. J. and Ahlquist, N. C. (1972) A Study of the Relationship of Chemical Composition and Humidity to Light Scattering by Aerosols. *J. of Appl. Met.* 11, 968.
- Coyne, P. I. and Bingham, G. E. (1977) Carbon Dioxide Correlation with Oxidant Air Pollution in the San Bernardino Mountains of California. *J. of the Air Pollution Assn.* 27, 782.
- Crane, G., Panofsky, H. A. and Zeman, O. (1977) A Model for Dispersion from Area Sources in Convective Turbulence. *Atmos. Environ.* 11, 893-900.
- Cronn, D. R., Charlson, R. J., Knights, R. L. Crittenden, A. L. and Appel, B. R. (1977) A Survey of the Molecular Nature of Primary and Secondary Components of Particles in Urban Air by High-Resolution Mass Spectrometry. *Atmos. Environ.* 11, 929.
- Currie, L. A. et al. (1984) Interlaboratory Comparison of Source Apportionment Procedures: Results of Simulated Data Set. *Atmos. Environ.* 18, 1517-1537.
- Daum, P. H., Schwartz, S. E. and Newman, L. (1983) Acidic and Related Constituents in Liquid Water Stratiform Clouds. *J. Geophys. Res.* 89, 1447.
- Davidson, A. and Cassmassi, J. (1985) Ozone Reductions During Olympic Periods Due to Congestion Reducing Measures. *J. of the Air Pollution Control Assoc.* 35, 249.
- Decker, C. E. (1972) Ratio of Sulfur Dioxide to Total Gaseous Sulfur Compounds and Ozone to Total Oxidants in the Los Angeles Atmosphere--An Instrument Evaluation Study. U.S. Environmental Protection Agency, Research Triangle Park, NC.
- deNevers, N. and Morris, R. (1973) Rollback Modeling - Basic and Modified, presented at the 66th Annual Meeting of the Air Pollution Control Association, Chicago, IL.

- Dittenhoeffer, A. C. and dePena, R. G. (1978) A Study of Production and Growth of Sulfate Particles in Plumes from a Coal-Fired Power Plant. *Atmos. Environ.* 12, 297.
- Dixon, W. J., Brown, M. B., Engelman, L., Frane, J. W., Hill, M. A., Jennrich, R. I. and Toporek, J. D. (1983) BMDP Statistical Software University of California Press, Los Angeles, CA.
- Drivas, P. J. and Shair, F. H. (1974a) Dispersion of an Instantaneous Cross-wind Line Source of a Tracer Released from an Urban Highway. *Atmos. Env.* 8, 475-485.
- Drivas, P. J. and Shair, F. H. (1974b) A Tracer Study of Pollutant Transport and Dispersion in the Los Angeles Area. *Atmos. Environ.* 8, 1155-1163.
- Drivas, P. J. (1975) Investigation of Atmospheric Dispersion Problems by Means of a Tracer Technique. Ph.D. Dissertation, California Institute of Technology, Pasadena, CA.
- Drivas, P. J. (1982) A Study of Atmospheric Transport of Photochemical Oxidants and Related Precursors between Los Angeles and Ventura Counties. Report No. R-82-09092, Energy Resources Co., La Jolla, CA.
- Dunker, A. M., Kumar, S. and Berzins, P. H. (1984) A Comparison of Chemical Mechanisms Used in Atmospheric Models. *Atmos. Environ.* 18, 311.
- Duval, M. M. and Friedlander, S. K. (1981) Source Resolution of Polycyclic Aromatic Hydrocarbons in the Los Angeles Atmosphere: Application of a Chemical Species Balance Method with First Order Chemical Decay. EPA/600/2-81-161, U.S. Environmental Protection Agency, Research Triangle Park, NC.
- Dzubay, T. G., Stevens, R. K. and Richards, L. W. (1979) Composition of Aerosols over Los Angeles Freeways. *Atmos. Environ.* 13, 653.
- Dzubay, T. G., Stevens, R. K., Balfour, W. D., Williamson, H. J., Cooper, J. A., Core, J. E., DeCesares, R. T., Crutcher, E. R., Daltner, S. L., Davis, B. L., Heisler, S. L., Shah, J. J., Hopke, P. K. and Johnson, D. L. (1984) Interlaboratory Comparison of Receptor Model Results for Houston Aerosol. *Atmos. Environ.* 18, 1555.
- Edgerton, S. A. (1985) Gaseous Tracers in Receptor Modeling: Methyl Chloride Emission from Wood Combustion. Ph.D. Dissertation, Oregon Graduate Center, Beaverton, OR.
- Edinger, J. G. (1959) Changes in the Depth of the Mixing Layer over the Los Angeles Basin. *J. of Applied Met.* 16, 219-226.
- Edinger, J. G. and Helvey, R. A. (1961) The San Fernando Convergency Zone. *Bulletin of the American Meteorological Society*, 42, 626.

- Edinger, J. G., McCutchen, M. H., Miller, P. R., Ryan, B. C., Schroeder, M. J. and Behar, J. V. (1972) Penetration and Duration of Oxidant Air Pollution in the South Coast Air Basin of California. *J. of the Air Pollution Control Assoc.* 23, 882.
- Edinger, J. G. (1973) Vertical Distribution of Photochemical Smog in the Los Angeles Basin. *Env. Sci. Tech* 7, 247.
- Efron, B. (1979) Computers and the Theory of Statistics: Thinking the Unthinkable. *SIAM Review* 21, 460.
- Eldon, J. A. and Trijonis, J. C. (1977) Statistical Oxidant/Precursor Relationships for the Los Angeles Region Part I: Data Quality Review and Evaluation. California Air Resources Board Report No. A5-020-87. Sacramento, CA.
- Elkus, B. and Wilson, K. R. (1977) Photochemical Air Pollution: Weekend-Weekday Differences. *Atmos. Environ.* 11, 509-515.
- Ellis, E. C. and Novakov, T. (1982) Application of Thermal Analysis to the Characterization of Organic Aerosol Particles. *The Science of the Total Environ.* 23, 227.
- Ellis, E. C., Novakov, T. and Zeldin, M. D. (1984a) Thermal Characterization of Organic Aerosols. *The Science of the Total Environment* 36, 261.
- Ellis, E. C., Zeldin, M. D. and Novakov, T. (1984b) Determination of Primary and Secondary Organic Aerosols in Los Angeles. Presented at the 75th Annual Meeting of the Air Pollution Control Association, San Francisco, CA.
- Ellis, E. C., Zeldin, M. D., Brewer, R. L. and Shepard, L. S. (1984b) Chemistry of Winter Type Precipitation in Southern California in Meteorology of Acid Deposition, Air Pollution Control Association, Pittsburg, PA.
- Ensor, D. S. and Whitby, K. T. et al. (1972) Multi-wavelength Nephelometer Measurements in Los Angeles Smog Aerosol I: Comparison of Calculated and Measured Light Scattering. *J. of Colloid and Interface Science* 39, 240.
- Estoque, M. A. (1968) Discussion of the Marine Layer and its Relation to a Smog episode in Riverside, CA. *Atmos. Environ.* 2, 623.
- Evans, G. (1977) Summary of Continuous Pollutant Data. Presented at the Los Angeles Catalyst Study Symposium, Raleigh, NC, April 12-13, 1977.
- Farber, R. J., Murray, L. C. and Straughan, I. R. (1982a) An Objective Technique for Classifying Ambient Air Quality Parameters: Developed Using O₃ and NO₂ Episodes in the Los Angeles Basin. Presented at the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA.

- Farber, R. J., Huang, A. A., Bregman, L. D., Mahone, R. L., Eatough, D. J., Hansen, L. D., Blumenthal, D. L., Keifer, W. S. and Allard, D. W. (1982b) The Third Dimension in the Los Angeles Basin. *Sci. of the Total Environ.* 23, 345.
- Federal Register (1984) Proposed Revisions to National Ambient Air Quality Standards for Particulate Matter to Control Particles 10 Micrometers or Less. *Federal Register*, 49 FR 10408, March 20, 1984.
- Federal Register (1985) Regulations for Implementing Revised Particulate Matter Standards. *Federal Register*, 50 FR 13130, April 2, 1985.
- Feigley, C. E. (1978) Correspondence Concerning Effects of Inhomogeneity on Photostationary State Ozone. *Env. Sci. Tech* 12, 843.
- Feigley, C. E. and Jeffries, H. E. (1979) Analysis of Processes Affecting Oxidant and Precursors in the Los Angeles Reactive Pollutant Program (LARPP) Operation 33. *Atmos. Environ.* 13, 1369-1384.
- Ferm, M. (1979) Method for Determination of Atmospheric Ammonia. *Atmos. Environ.* 13, 1385.
- Fontjin, A., Sabadell, A. J. and Ronco, R. J. (1970) Homogeneous Chemiluminescent Measurement of Nitrogen Oxide with Ozone, Implications for Continuous Selective Monitoring of Gaseous Air Pollutants. *Analytical Chemistry*, 42, 575-579.
- Forrest, J., Garber, R. and Newman L. (1981) Conversion Rates in Power Plant Plumes Based on Filter Pack Data: The Coal-Fired Cumberland Plume. *Atmos. Environ.* 15, 2273-2282.
- Freeman, D., Egami, R. T., Robinson, N. F. and Watson, J. G. (1986) A Method for Propagating Measurement Uncertainties through Dispersion Models. *J. of the Air Pollution Control Assn.* 36, 235.
- Friedlander, S. K. (1973) Chemical Element Balances and Identification of Air Pollution Sources. *Env. Sci. Tech.* 7, 235.
- Gartrell, G. Jr. and Friedlander, S. K. (1975) Relating Particulate Pollution to Sources. The 1972 California Aerosol Characterization Study. *Atmos. Environ.* 9, 278.
- Giauque, R. D., Goda, L. Y. and Brown, N. E. (1974) Characterization of Aerosols in California by X-Ray-Induced X-Ray Fluorescence Analysis. *Env. Sci. Tech.* 8, 436-441.
- Giauque, R. D., Garrett, R. B., and Goda, L. Y. (1979) Determination of Trace Elements in Light Element Matrices by X-Ray Fluorescence Spectrometry with Incoherent Scattered Radiation as an Internal Standard. *Analytical Chemistry* 51, 511.
- Gillani, N. V. and Wilson, W. E. (1983) Gas-to-Particle Conversion of Sulfur in Power Plant Plumes---II. Observations of Liquid-Phase Conversions. *Atmos. Environ.* 17, 1739.

- Gillani, N. V., Colby, N. A. and Wilson, W. E. (1983) Gas-to-Particle Conversion of Sulfur in Power Plant Plumes---III. Parameterization of Plume-Cloud Interactions. *Atmos. Environ.* 17, 1753-1763.
- Glasson, W. A. (1981a) Smog Chamber Simulation of Los Angeles Pollutant Transport. *J. of the Air Pollution Assn.* 31, 648.
- Glasson, W. A. (1981b) Effect of Hydrocarbon and NO_x on Photochemical Smog Formation under Simulated Transport Conditions. *J. of the Air Pollution Control Assoc.* 31, 1169.
- Gloria, H. R., Bradburn, G., Reinisch, R. F., Pitts, J. N., Behar, J. V. and Zafonte, L. (1974) Airborne Survey of Major Air Basins in California. *J. of the Air Pollution Assn.* 24, 645.
- Godden, D. A. and Lague, J. S. (1983) Assessment of the Transport of Ozone and its Precursors between Los Angeles and Ventura Counties. Environmental Research and Technology Report No. P-B528-100, prepared for the Western Oil and Gas Association, Westlake Village, CA.
- Godden, D. and Lurmann, F. (1983) Development of the PLMSTAR Model and Its Application to Ozone Episode Conditions in the South Coast Air Basin. *Env. Research and Technology Document #PA702-200*, Westlake Village, CA.
- Goodin, W. R., McRae, G. J. and Seinfeld, J. H. (1979) A Comparison of Interpolation Methods for Sparse Data: Application to Wind and Concentrations Fields. *J. of Appl. Met.* 18, 761.
- Goodin, W. R., McRae, G. J. and Seinfeld, J. H. (1980) An Objective Analysis Technique for Constructing Three-Dimensional Urban-Scale Wind Fields. *J. of Appl. Met.* 19, 98.
- Gordon, R. J., Mayrsohn, H. and Ingels, R. M. (1968) C₂-C₅ Hydrocarbons in the Los Angeles Atmosphere. *Env. Sci. Tech.* 2, 1117-1120.
- Gordon, R. J. and Bryan, R. J. (1973) Patterns in Airborne Polynuclear Hydrocarbon Concentrations at Four Los Angeles Sites. *Env. Sci. Tech.* 7, 1050.
- Gordon, R. J. (1976) Distribution of Airborne Polycyclic Aromatic Hydrocarbons Throughout Los Angeles. *Env. Sci. Tech.* 10, 371.
- Gray, H. A., Cass, G. R., Huntzicker, J. J., Heyerdahl, E. K. and Rau, J. A. (1985) Characteristics of Atmospheric Organic and Elemental Carbon Particles in Los Angeles. To be published in *Env. Sci. Tech.* 19.
- Grisinger, J. E. (1982a) Air Quality Management Plan 1982 Revision: Appendix No. VI-C, Nitrogen Dioxide, Sulfur Dioxide and Sulfate Analyses for the South Coast Air Basin, South Coast Air Quality Management District, El Monte, CA.

- Grisinger, J. E. (1982b) Appendix No. VI-D, Total Suspended Particulate and Lead Analyses for the South Coast Air Basin, 1982 AQMP Revision. South Coast Air Quality Management District, El Monte, CA.
- Grisinger, J. E., Yamada, M. Thomas, G., Maloney, J., Wuebben, P. and Bradley, R. (1982) 1979 Emissions Inventory for the South Coast Air Basin-Revised October 1982. South Coast Air Quality Management District, El Monte, CA.
- Grosjean, D. (1975) Solvent Extraction and Organic Carbon Determination in Atmospheric Particulate Matter: the OE-OCA Technique. *Analytical Chemistry* 47, 797.
- Grosjean, D. and Friedlander, S. K. (1975) Gas to Particle Distribution Factors for Organic Pollutants in the Los Angeles Atmosphere. *J. of Air Pollution Control Assoc.* 25, 1038.
- Grosjean, D. (1982a) Distribution of Nitrogenous Pollutants During Photochemical Smog Episodes. Presented at the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA.
- Grosjean, D. (1982b) Formaldehyde and Other Carbonyls in Los Angeles Ambient Air. *Env. Sci. Tech.* 16, 254.
- Grosjean, D. (1983) Distribution of Atmospheric Nitrogenous Pollutants at a Los Angeles Area Smog Receptor Site. *Env. Sci. Tech.* 17, 13-18.
- Grosjean, D., Swanson, R. D. and Ellis, E. C. (1983) Carbonyls in Los Angeles Air: Contribution of Direct Emissions and Photochemistry. *Sci. of the Total Env.* 29, 65-85.
- Grosjean, D. (1984) Particulate Carbon in Los Angeles Air. *Sci. of the Total Env.* 32, 133-145.
- Grosjean, D. and Fung, K. (1984) Hydrocarbons and Carbonyls in Los Angeles Air. *J. of the Air Pollution Control Assoc.* 34, 537.
- Gundel, L. A. and Novakov, T. (1984) Characterization of Particles from Several Sources and Three Urban Areas by Solvent Extraction. *Atmos. Environ.* 18, 273-276.
- Gutfreund, P. D., Hayes, S. R., Oliver, W. R., Reynolds, S. D. and Roth, P. M. (1981) Assessment of NO_x Emission Control Requirements in the South Coast Air Basin: A Preliminary Report for Consideration in Preparing the AQMP, Volume I: Overview. SYSAPP-81/277, Systems Application, Inc., San Rafael, CA.
- Hammerle, R. H. and Pierson, W. R. (1975) Sources and Elemental Composition of Aerosol in Pasadena, California by Energy-Dispersive X-ray Fluorescence. *Env. Sci. Tech.* 9, 1058.
- Hamming, W. J., MacPhee, R. D. and Taylor, J. R. (1960) Contaminant Concentrations in the Atmosphere of Los Angeles County. *J. of the Air Pollution Control Assn.* 10, 7-16.

- Hamming, W. J. and Dickinson, J. E. (1966) Control of Photochemical Smog by Alteration of Initial Reactant Ratios. *J. of the Air Pollution Assn.* 16, 317.
- Hamming, W. J., Chass, R. L., Dickinson, J. E. and MacBeth, W. G. (1973) Motor Vehicle Control and Air Quality: The Path to Clean Air for Los Angeles. Presented at the 66th Annual Meeting of the Air Pollution Control Association, Chicago, IL.
- Haney, J. L. and Seigneur, C. (1985) Investigation of Reactive Hydrocarbon to NO_x Ratio in the South Coast Air Basin. Technical memorandum from Systems Applications, Inc., San Rafael, CA December 31, 1985.
- Hanna, R. S. (1977) Model Prediction and Observations of Clouds Formed by Oil Refineries in Los Angeles. Sixth AMS Conference on Planned and Inadvertant Weather Modification, Champaign, IL.
- Hansen, D. A., Young, J. R. and Hidy, G. M. (1982) Review of Acid Deposition Research in California. Environmental Research and Technology Report #PB501-000, Newbury Park, CA.
- Hanst, P. L., Wong, N. W. and Bragin, J. (1982) A Long-Path Infra-Red Study of Los Angeles Smog. *Atmos. Environ.* 16, 969.
- Hard, T. M., O'Brien, R. J., Chan, C. Y. and Mehrabzadeh, A. A. (1984) Tropospheric Free Radical Determination by FAGE. *Env. Sci. Tech.* 18, 768.
- Harker, A. B., Richards, L. W. and Clark, W. E. (1977) The Effect of Atmospheric SO₂ Photochemistry Upon Observed Nitrate Concentrations in Aerosols. *Atmos. Environ.* 11, 87-91.
- Harris, G. W., Carter, W. P. L., Winer, A. M., Pitts, J. N., Platt, U. and Perner, D. (1982) Observations of Nitrous Acid in the Los Angeles Atmosphere and Implications for Predictions of Ozone--Precursor Relationships. *Env. Sci. Tech* 16, 414.
- Heikes, B. G., Lazrus, A. L. and Kok, G. L. (1985) Measurements of H₂O₂ in the Lower Troposphere. Presented at the 17th International Symposium on Free Radicals, Aug. 18-23, 1985.
- Heisler, S. L., Friedlander, S. K. and Husar, R. B. (1973) The Relationship of Smog Aerosol Size and Chemical Element Distributions to Source Characteristics. *Atmos. Environ.* 7, 633-649.
- Heisler, S. L. and Friedlander, S. K. (1977) Gas-to-Particle Conversion in Photochemical Smog: Aerosol Growth Laws and Mechanisms for Organics. *Atmos. Environ.* 11, 157-168.
- Heisler, S. L., Henry, R. C., Mueller, P. K., Hidy, G. M. and Grosjean, D. (1980) Aerosol Behavior Patterns in the South Coast Air Basin with Emphasis on Airborne Sulfate. ERT Report PA085-1, Environmental Research and Technology, Westlake Village, CA.

- Heisler, S. L. (1985) The EPRI 1982 National Air Pollutant Emission Inventory, presented at the 78th Annual Meeting of the Air Pollution Control Association, Detroit, MI.
- Henry, R. C. and Hidy, G. M. (1979) Multivariate Analysis of Particulate Sulfate and Other Air Quality Variables by Principal Components Part I, Annual Data from Los Angeles and New York. *Atmos. Environ.* 13, 1581.
- Henry, R. C. (1982) Stability Analysis of Receptor Models that Use Least Squares Fitting in Receptor Models Applied to Contemporary Pollution Problems, edited by S. L. Dattner and P. K. Hopke, Air Pollution Control Association, Pittsburgh, PA.
- Henry, R. C. and Hidy, G. M. (1982) Multivariate Analysis of Particulate Sulfate and Other Air Quality Variables by Principal Components-- II. Salt Lake City, Utah and St. Louis, Missouri. *Atmos. Environ.* 16, 929-943.
- Henry, R. C. (1985) Fundamental Limitations of Receptor Models Using Factor Analysis. In Receptor Methods for Source Apportionment: Real World Issues and Application, Air Pollution Control Association, Pittsburg, PA.
- Hering, S. V. and Friedlander, S. K. (1982) Origins of Aerosol Sulfur Size Distributions in the Los Angeles Basin. *Atmos. Environ.* 16, 2647.
- Hering, S. V., Pettus, K., Gertler, A., Brewer, R. L., Hoffman, M., Kadlecsek, J. A. and Blumenthal, D. L. (1986a) Field Intercomparison of Five Types of Fogwater Collectors. Submitted to *Env. Sci. Tech.*
- Hering, S. V., Lawson, D. R., et al. (1986) The Nitric Acid Shootout: Field Comparison of Measurement Methods, Department of Chemical Engineering, University of California at Los Angeles. Submitted to *Atmospheric Environment*, December 19, 1986.
- Hering, S. V., et al. (1987) Comparison of Sampling Methods for Particulate Carbon, Department of Chemical Engineering, University of California at Los Angeles. To be presented at the Third International Conference on Carbaceous Particles in the Atmosphere, Berkeley, California, October 5-6, 1987.
- Hester, N. E., Stephens, E. R. and Taylor, O. C. (1974) Fluorocarbons in the Los Angeles Basin. *J. of the Air Pollution Control Assoc.* 24, 591.
- Hicks, B. B., Wesely, M. L. and Durham, J. L. (1980) Critique of Methods to Measure Dry Deposition. EPA-600/9-80-050, Research Triangle Park, NC.
- Hidy, G. M. (1985) Jekyll Island Meeting Report. *Env. Sci. Tech.* 19, 1032.
- Hidy, G. M., Green, W. D. and Alkazweeny, A. J. (1971) Inadvertent Weather Modification and Los Angeles Smog. *J. of Colloid and Interface Science*.

- Hidy, G. M. (1972) Aerosols and Atmospheric Chemistry, Academic Press, New York.
- Hidy, G. M. and Friedlander, S. K. (1972) The Nature of the Los Angeles Aerosol. Second IUAPPA Clean Air Congress, Washington, DC.
- Hidy, G. M., Mueller, P. K., Wang, H. H., Karney, J., Twiss, S., Imada, M. and Alcocer, A. (1974) Observations of Aerosols over Southern California Coastal Waters. *J. of Appl. Met.* 13, 96.
- Hidy, G. M., Appel, B. R., Charlson, R. J., Clark, W. E., Friedlander, S. K., Hutchison, D. H., Smith, T. B., Suder, J., Wesolowski, J. J. and Whitby, K. T. (1975) Summary of the California Aerosol Characterization Experiment. *J. of the Air Pollution Control Assoc.* 25, 1106.
- Hidy, G. M. and Mueller, P. K. (1979) Character and Origin of Smog Aerosols. John Wiley and Sons, Inc., New York.
- Hinds, W. T. (1970) Diffusion Over Coastal Mountains of Southern California. *Atmos. Environ.* 4, 107.
- Ho, W., Hidy, G. M. and Govan, R. M. (1974) Microwave Measurements of the Liquid Water Content of Atmospheric Aerosols. *J. of Appl. Met.* 13, 871.
- Hoffmann, M. R., Morgan, J. J., Jacob, D. J., Munger, J. W. and Waldman, J. M. (1983) Characterization of Reactants, Reaction Mechanisms and Reaction Products leading to Extreme Acid Rain and Acid Aerosol Conditions in Southern California. California Air Resources Board Report No. ARB-R-83-200, Sacramento, CA.
- Hoffmann, M. R. (1984) Reply to Comment on Acid Fog. *Env. Sci. Tech.* 18, 61.
- Hoggan, M. C., Davidson, A., Brunelle, M. F., Nevitt, J. S. and Gins, J. D. (1978) Motor Vehicle Emissions and Atmospheric Lead Concentrations in the Los Angeles Area. *J. of the Air Pollution Control Assoc.* 28, 1200.
- Hoggan, M., Shikiya, M. and Davidson, A. (1983) 1982 Summary of Air Quality in California's South Coast Air Basin. South Coast Air Quality Management District, El Monte, CA.
- Hoggan, M., Davidson, A. and Wong, P. (1984) 1983 Summary of Air Quality in California's South Coast Air Basin. South Coast Air Quality Management District, El Monte, CA.
- Hopke, P. K. (1982) Application and Verification Studies of Target Transformation Factor Analysis as an Aerosol Receptor Model in Receptor Models Applied to Contemporary Pollution Problems, Air Pollution Control Association, Pittsburgh, PA.
- Horie, Y. and Mirabella, V. (1982) Estimating Future NO₂ Levels in the Greater Los Angeles Area by Source-Type Contribution. *J. of the Air Pollution Assn.* 32, 267.

- Houck, J. E., Cooper, J. A. and Larson, E. R. (1982) Dilution Sampling for Chemical Receptor Source Fingerprinting. Presented at the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA.
- Huang, A. H. and Head, S. J. (1978) Estimation of Fugitive Hydrocarbon Emissions from an Oil Refinery by Inverse Modeling. Third Symposium on Fugitive Emissions: Measurement and Control, U.S. Environmental Protection Agency. (Also, Technical Paper TP 8162, AeroVironment, Inc., Monrovia, CA).
- Huang, A. A., Farber, R. J., Mahoney, R. L., Eatough, D. J., Hansen, L. D. and Allard, D. W. (1982) Chemistry of Invisible Power Plant Plumes in Southern California--The Airborne Perspective. Presented at the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA.
- Huang, A. A., Ellis, E. C., Games, L. V., Hawley, J. G., Fletcher, L. D. and Wallace, G. F. (1983) Remote Plume Measurements by Use of a Correlation Spectrometer and a Differential Absorption LIDAR. *The Science of the Total Environ.* 29, 87.
- Husar, R. B., Whitby, K. T. and Liu, B. Y. H. (1972) The Physical Mechanisms Governing the Dynamics of Los Angeles Smog Aerosol. *J. of Colloid and Interface Sci.* 39, 211.
- Husar, R. B., White, W. H. and Blumenthal, D. L. (1976) Direct Evidence of Heterogeneous Aerosol Formation in Los Angeles Smog. *Env. Sci. Tech.* 10, 490.
- Husar, R. B., Patterson, D. E., Blumenthal, D. L., White, W. H. and Smith, T. B. (1977) Three-Dimensional Distribution of Air Pollutants in the Los Angeles Basin. *J. of Appl. Met.* 16, 1089-1096.
- Hussey, K. J., Blackwell, R. J., McRae, G. J. and Seinfeld, J. H. (1983) Environmental Data Display. *Env. Sci. Tech.* 17, 78A.
- Jacob, D. J. and Hoffmann, M. R. (1983) A Dynamic Model for the Production of H^+ , NO_3 , SO_4 in Urban Fog. *J. Geophys. Res.* 88, 6611.
- Jacob, D. J., Waldman, J. M., Munger, J. W. and Hoffmann, M. R. (1985) chemical Composition of Fogwater Collected Along the California Coast. *Env. Sci. Tech.* 19, 730-736.
- Johnson, W. B. and Singh, H. B. (1976) Oxidant Layers Aloft: Their Origin and Significance. In proceedings of the International Conference on Photochemical Oxidant Pollution and Control, EPA 600/3-77-0016, Research Triangle Park, NC.
- Kauper, E. K. and Hopper, C. J. (1965) Utilization of Optimum Meteorological Conditions for the Reduction of Los Angeles Automotive Pollution. *J. of the Air Pollution Assn.* 15, 210.
- Kauper, E. and Niemann, B. (1975) Los Angeles to Ventura Over Water Ozone Transport Study. California Air Resources Board Report, Sacramento, CA.

- Kauper, E. and Niemann, B. (1977) Los Angeles to San Diego Three-Dimensional Ozone Transport Study. California Air Resources Board Report, Sacramento, CA.
- Kawamura, K. and Kaplan, I. R. (1983) Organic Compounds in the Rainwater of Los Angeles. *Env. Sci. Tech.* 17, 497-501.
- Kawamura, K. and Kaplan, I. R. (1986) Biogenic and Anthropogenic Organic Compounds in Rain and Snow Samples Collected in Southern California. *Atmos. Environ.* 20, 115.
- Keith, R. W. and Selik, B. (1977) California South Coast Air Basin Hourly Wind Flow Patterns. South Coast Air Quality Management District El Monte, CA.
- Kessler, R. C., Hogo, H., and Whitten, G. Z. (1986), Sensitivity of Urban Airshed Model Wind Fields to Changes in Input Observational Wind Data, in Seinfeld, J. H., et al. (1986) Analysis of the Southern California Air Quality Study (SCAQS) Measurement Plan.
- Killus, J. P., Oliver, W. R., Gutfreund, P. P., Langstaff, J., Tesche, T. W. and Su, H. J. (1981) Simulation of Impacts of Nitrogen Oxide Control Strategies Under Oxidant Episode Conditions. Systems Applications Inc. Report Nos. 81165 and 81173, San Rafael, CA.
- Killus, J. P. and Whitten, G. Z. (1983) Effects of Photochemical Kinetic Mechanisms on Oxidant Model Predictions. EPA-600/S3-83-111, Research Triangle Park, NC.
- Killus, J. P., Meyer, J. P., Durran, D. R., Anderson, G. E., Jerskey, T. N., Reynolds, S. D., Ames, J., Lamb, R. G., Shu, W. R., Seinfeld, J. H., Reid, L. E. and Gelbard, F. G. (1985) Continued Research in Mesoscale Air Pollution Simulation Modeling. EPA-600/S3-84-095, Research Triangle Park, NC.
- Kok, G. L. (1980) Measurements of Hydrogen Peroxide in Rainwater. *Atmos. Environ.* 14, 653.
- Kok, G. L. (1983) Measurements of Formaldehyde and Hydrogen Peroxide in the California South Coast Air Basin. EPA-600/S3-83-030, Research Triangle Park, NC.
- Kok, G. L., Heikes, B. G. and Lazrus, A. L. (1986) Gas and Aqueous Phase Measurements of Hydrogen Peroxide. Symposium on Acid Rain, American Chemical Society Meeting, New York, Apr. 13-18, 1986.
- Kopczynski, S. L., Lonneman, W. A., Sutterfield, F. D and Darley, P. E. (1972) Photochemistry of Atmospheric Samples in Los Angeles. *Env. Sci. Tech.* 6, 342.
- Kotin, P., Falk, H. L., Madar, P. and Thomas, M. (1954) Aromatic Hydrocarbons. I. Presence in the Los Angeles Atmosphere and the Carcinogenicity of Atmospheric Extracts. *Archives of Industrial Hygiene* 9, 153-163.

- Lawrence, E. N. (1972) Discussion: Aerometric Data Analysis - Time Series Analysis and Forecast and an Atmospheric Smog Diagram. *Atmos. Environ.* 6, 782-783.
- Lazrus, A. L., Kok, G. L., Lind, J. A., Gitlin, S. N., Heikes, B. G. and Shetter, R. E. (1986) Automated Fluorometric Method for Hydrogen Peroxide in Air, *Analytical Chemistry*, in press.
- Lazrus, A. L., Haagenson, P. L., Kok, G. L., Huebert, B. J., Kreitzberg, C. W., Likens, G. E., Mohnen, V. A., Wilson, W. E. and Winchester, J. W. (1983) Acidity in Air and Water in a Case of Warm Frontal Precipitation. *Atmos. Environ.* 17, 581.
- Lea, D. A. (1968) Vertical Ozone Distribution in the Lower Troposphere Near an Urban Air Pollution Complex. *J. of Appl. Met.* 1, 252-267.
- Leonard, M. J., Fisher, E. L., Brunelle, M. F. and Dickinson, J. E. (1976) Effects of the Motor Vehicle Control Program on Hydrocarbon Concentrations in the Central Los Angeles Atmosphere. *J. of the Air Pollution Control Assoc.* 26, 359.
- Leone, J. A. and Seinfeld, J. H. (1984a) Evaluation of Chemical Reaction Mechanisms for Photochemical Smog Part II: Quantitative Evaluation of the Mechanisms. EPA-600/S3-84-063, Research Triangle Park, NC.
- Leone, J. A. and Seinfeld, J. H. (1984b) Analysis of the Characteristics of Complex Chemical Reaction Mechanisms: Application to Photochemical Smog Chemistry. *Env. Sci. Tech.* 18, 280.
- Levin, J. O., Andersson, K., Lindahl, R. and Nilsson, C.-A. (1985) Determination of Sub-Part-per-Million Levels of Formaldehyde in Air Using Active or Passive Sampling on 2,4-Dinitrophenylhydrazine-Coated Glass Fiber Filters and High-Performance Liquid Chromatography.
- Levine, S. Z. and Schwartz, S. E. (1982) In-Cloud and Below-Cloud Scavenging of Nitric Acid Vapor. *Atmos. Environ.* 16, 1725.
- Levitt, S. B. and Chock, D. P. (1976) Weekday-Weekend Pollutant Studies of the Los Angeles Basin. *J. of the Air Pollution Control Assoc.* 26, 1091.
- Liljestrang, H. M. and Morgan, J. J. (1978) Chemical Composition of Acid Precipitation in Pasadena, CA. *Env. Sci. Tech.* 12, 1271.
- Liljestrang, H. M. and Morgan, J. J. (1981) Spatial Variations of Acid Precipitation in Southern California. *Env. Sci. Tech.* 15, 333.
- Lin, G. Y. (1982) Oxidant Prediction by Discriminant Analysis in the South Coast Air Basin of California. *Atmos. Environ.* 16, 135.
- Lioy, P. J., Mallon, R. P., Lippmann, M., Kneip, T. J. and Samson, P. J. (1982) Factors Affecting the Variability of Summertime Sulfate in a Rural Area Using Principal Components Analysis. *Journal of the Air Pollution Control Association*, 32, 1043.

- Lissaman, P. B. S. (1973) A Simple Unsteady Concentration Model Explicitly Incorporating Ground Roughness and Heat Flux. Presented at the 66th Annual Meeting of the Air Pollution Control Association. (Also, Technical Paper TP 311, AeroVironment, Inc., Monrovia, CA).
- Littman, F. E., Ford, H. W. and Endow, N. (1956) Formation of Ozone in the Los Angeles Atmosphere. *J. of the Air Pollution Assn.* 6, 171.
- Liu, C.S. (1986) Considerations in Selecting SCAQS Study Days, in Seinfeld, J. H., et al. (1986) Analysis of the Southern California Air Quality Study (SCAQS) Measurement Plan.
- Liu, M. K. and Roth, P. M. (1973) Urban Airshed Photochemical Simulation Model Study. Volume I: Development and Evaluation. Appendix C. Microscale Model of Local Vehicular Source Contributions to Measured Pollutant Concentrations. EPA-R4-73-030d, U.S. Environmental Protection Agency, Research Triangle Park, NC.
- Liu, C. Y. and Goodin, W. R. (1976) A Two-Dimensional Model for the Transport of Pollutants in an Urban Basin. *Atmos. Environ.* 10, 513.
- Liu, C. S. (1982) Level III EKMA Ozone Modeling Screening Analysis for 1982 AQMP Revision in the South Coast Air Basin. Technical Paper No. 61 1982 AQMP Revision, south Coast Air Quality Management District, El Monte, CA.
- Liu, C. S. and Grisinger, J. E. (1982a) Air Quality Management Plan 1982 Revision: Appendix No. VI-E, Summary of Model Analyses for the South Coast Air Basin 1982 AQMP Revision. South Coast Air Quality Management District, El Monte, CA.
- Liu, C. S. and Grisinger, J. E. (1982b) Level II EKMA Trajectory Model Sensitivity Study. Technical Paper No. 7, 1982 AQMP Revision, South Coast Air Quality Management District, El Monte, CA.
- Liu, C. S., Grisinger, J. E. and Cassmassi, J. (1982) Air Quality Management Plan 1982 Revision: Appendix No. VI-A Ozone Analysis for the South Coast Air Basin 1982 AQMP Revision. South Coast Air Quality Management District, El Monte, CA.
- Lloyd, A. C., Lurmann, F. W., Godden, D. K., Hutchins, J. F., Eschenroeder, A. Q. and Nordsieck, R. A. (1979) Development of the ELSTAR Photochemical Air Quality Simulation Model and its Evaluation Relative to the LARPP Data Base. Environmental Research and Technology Report P-5287-500, Westlake Village, CA.
- Lonneman, W. A., Bellar, T. A. and Altshuller, A. P. (1968) Aromatic Hydrocarbons in the Atmosphere of the Los Angeles Basin. *Env. Sci. Tech.* 2, 1017-1020.
- Lotus Development Corporation (1983) Lotus 1-2-3- User's Manual. Lotus Development Corporation, 161 1st St., Cambridge, MA.

- Ludwig, F. L. and Robinson, E. (1968) Variations in Size Distributions of Sulfur-Containing Compounds in Urban Aerosols. *Atmos. Environ.* 2, 13.
- Ludwig, F. L., Javitz, H. S., Valdes, A., Maxwell, C. and Patterson, R. (1981) Estimation Exceedances and Design Value from Urban Ozone Monitoring Network Data. TRB/NCHRP/REP-238, Transportation Research Board, Washington, DC.
- Ludwig, F. L., Javitz, H. S. and Valdes, A. (1983) How Many Stations are Required to Estimate the Design Value and the Expected Number of Exceedances of the Ozone Standard in an Urban Area. *J. of the Air Pollution Control Assoc.* 33, 963.
- Lundgren, D. A. (1971) Determination of Particulate Composition, Concentration and Size Distribution Changes with Time. *Atmos. Environ.* 5, 645-651.
- Lurmann, F. W., Godden, D. et al. (1979) A Lagrangian Photochemical Air Quality Simulation Model. EPA-600/8-79-015, Research Triangle Park, NC.
- Lurmann, F. W., Godden, D., Lloyd, A. C. and Nordsieck, R. A. (1982) The Development and Selected Sensitivity Tests of the PLMSTAR Reactive Plume Model. Presented at the AMS Third Joint Conference on Applications of Air Pollution Meteorology, San Antonio, TX.
- Lurmann, F. W., Lloyd, A.C., and Atkinson, R. A. (1986) Suggested Gas-Phase Species Measurements for the Southern California Air Quality Study, in Seinfeld, J. H., et al. (1986) Analysis of the Southern California Air Quality Study (SCAQS) Measurement Plan.
- MacPhee, R. D. and Bockian, A. H. (1967) Suspended Particulates in the Los Angeles atmosphere. *J. of the Air Pollution Assn.* 17, 580.
- Madar, P. P., MacPhee, R. D., Lofberg, R. T. and Larson, G. P. (1952) Composition of Organic Portion of Atmospheric Aerosols in the Los Angeles Area. *Industrial Eng. Chemistry* 44, 1352.
- Malm, W. C. (1985) Application of Principal Component Analysis for Purposes of Identifying Visibility Source Receptor Relationships. In Receptor Methods for Source Apportionment: Real World Issues and Applications, Air Pollution Control Association, Pittsburgh, PA.
- Marple, V. A. and Rubow, K. L. (1984) Development of a Microorifice Uniform Deposit Cascade Impactor - Final Report to Department of Energy. Particle Technology Laboratory Publication No. 532.
- Marsh, S. T. and Bregman, L. D. (1984) Meteorological Factors Influencing the Acidity of Fog in the Los Angeles Basin. Southern California Edison, Rosemead, CA.
- Martin, L. R. (1983) Kinetic Studies of Sulfite Oxidation in Aqueous Solution in Acid Precip., edited by J. G. Calvert, Ann Arbor Science Publication, Ann Arbor, MI.

- Martinez, J. R. (1971a) Further Development of the Photochemical Smog Model for the Los Angeles Basin. General Research Corp., CA. Final Report No. CR-1-191, Santa Barbara, CA.
- Martinez, J. R. (1971b) Concepts and Applications of Photochemical Smog Models. General Research Corp., CA. Technical Memo No. 1516, Santa Barbara, CA.
- Martinez, J. R., Maxwell, C., Javitz, H. S. and Bawol, R. (1983) Evaluation of the Empirical Kinetic Modeling Approach. EPA-600/S3-83-003, Research Triangle Park, NC.
- Mayrsohn, H. and Crabtree, J. H. (1976) Source Reconciliation of Atmospheric Hydrocarbons. Atmos. Environ. 10, 137.
- Mayrsohn, H., Crabtree, J. H., Kuramoto, M., Sothorn, R. D. and Mano, S. H. (1977) Source Reconciliation of Atmospheric Hydrocarbons 1974. Atmos. Environ. 11, 189-192.
- McElroy, J. L., Richardson, E. L., Hankins, W. H. and Pearson, M. J. (1982) Airborne Downward-Looking Lidar Measurements During the South Coast Air Basin/Southeast Desert Oxidant Transport Study. Data Dept. Env. Mon. Systems Lab., U.S. Environmental Protection Agency, TS-AMD 82133.
- McFarland, A. R., Ortiz, C. A. and Rodes, C. E. (1979) Characteristics of Aerosol Samplers used in Ambient Air Monitoring. 86th National Meeting of the American Institute of Chemical Engineers, Houston, TX. April 1-5, 1979.
- McFarland, A. R. and Ortiz, C. A. (1985) Response to Comment on A Field Comparison of PM-10 Inlets at Four Locations. J. of the Air Pollution Control Assoc. 35, 950.
- McKee, H. C. (1976) Collaborative Testing of Methods to Measure Air Pollutants: III. The Chemiluminescent Method for Ozone: Determination of Precision. J. of the Air Pollution Assn. 26, 124.
- McMurry, P. H. and Wilson, J. C. (1980) Growth Laws for the Formation of Secondary Ambient Aerosols: Implications for Chemical Conversion Mechanisms. Atmos. Environ. 16, 21.
- McRae, G. J., Shair, F. H. and Seinfeld, J. H. (1981) Convective Downmixing of Plumes in a Coastal Environment. J. of Appl. Met. 20, 1312.
- McRae, G. J., Goodin, W. R. and Seinfeld, J. H. (1982a) Development of a Second-Generation Mathematical Model for Urban Air Pollution--I. Model Formulation. Atmos. Environ. 16, 679.
- McRae, G. J., Goodin, W. R. and Seinfeld, J. H. (1982b) Mathematical Modeling of Photochemical Air Pollution. Env. Quality Laboratory Report No. 18, California Institute of Technology, Pasadena, CA.

- McRae, G. J. and Seinfeld, J. H. (1983) Development of a Second-Generation Mathematical Model for Urban Air Pollution--II. Evaluation of Model Performance. *Atmos. Environ.* 17, 501.
- Merz, P. H., Painter, L. J. and Ryason, P. R. (1972) Aerometric Data Analysis--Time Series Analysis and Forecast and an Atmospheric Smog Diagram. *Atmos. Environ.* 6, 319-342.
- Miguel, A. H. and Friedlander, S. K. (1978) Distribution of Benzo(a)pyrene and Coronene with Respect to Particle Size in Pasadena Aerosols in the Submicron Range. *Atmos. Environ.* 12, 2407.
- Miller, A. and Ahrens, D. (1970) Ozone Within and Below the West Coast Temperature Inversion. *Tellus*, 22, 328.
- Miller, M. S., Friedlander, S. K. and Hidy, G. M. (1972) A Chemical Element Balance for the Pasadena Aerosol. *J. of Colloid and Interface Sci.* 39, 165.
- Morgan, J. J. and Liljestrang, H. M. (1980) Measurement and Interpretation of Acid Rainfall in the Los Angeles Basin. California Air Resources Board Report ARB/R-80/124, Sacramento, CA.
- Mosher, J. C., MacBeth, W. G., Leonard, M. J., Mullins, T. P. and Brunelle, M. F. (1970) The Distribution of Contaminants in the Los Angeles Basin Resulting from Atmospheric Reactions and Transport. *J. of the Air Pollution Control Assoc.* 20, 35.
- Mueller, P. K. (1980) Comments on Advances in the Analysis of Air Contaminants. *J. of the Air Pollution Control Assn.* 30, 983.
- Mueller, P. K., Hansen, D. A. and Watson, J. G. (1986) The Subregional Cooperative Electric Utility, Department of Defense, National Park Service, and EPA Study (SCENES) on Visibility: An Overview, EPRI Special Report EA-4664-SR, Electric Power Research Institute, Palo Alto, CA 94304, July 1986.
- Mueller, P. K. and Hidy, G. M. et al. (1983) The Sulfate Regional Experiment: Report of Findings. Electric Power Research Institute Report No. EA-1901, Palo Alto, CA.
- Mueller, P. K., Mosley, R. W. and Pierce, L. B. (1972) Chemical Composition of Pasadena Aerosol by Particle Size and Time of Day. IV. Carbonate and Noncarbonate Content. In Aerosol and Atmospheric Chemistry, New York Academic Press, New York.
- Munger, J. W., Jacob, D. J., Waldman, J. M. and Hoffmann, M. R. (1983) Fogwater Chemistry in an Urban Atmosphere. *J. of Geophysical Research*, 88, 5109-5121.
- Neiburger, M. and Wurtele, M. G. (1949) On the Nature and Size of Particles in Haze, Fog, and Stratus of the Los Angeles Region. *Chemistry Review*, 44, 21.

- Neligan, R. E. (1962) Hydrocarbons in the Los Angeles Atmosphere. Archives of Env. Health 5, 67.
- Neuroth, G. R. (1979) Comment on Statistical Forecasting Models: I. Carbon Monoxide Concentrations in the Los Angeles Basin. J. of the Air Pollution Control Assoc. 29, 163.
- Noll, K. E., Mueller, P. K. and Imada, M. (1968) Visibility and Aerosol Concentration in Urban Air. Atmos. Environ. 2, 465.
- Novakov, T. (1982) Soot in the Atmosphere. In Particulate Carbon, Atmospheric Life Cycle, edited by G. T. Wolff and R. K. Klimisch, Plenum Press, New York.
- Novakov, T., Mueller, P. K., Alcocer, A. E. and Otvos, J. W. (1972a) Chemical Composition of Pasadena Aerosol by Particle Size and Time of Day. J. of Colloid and Interface Sci. 39, 225.
- Novakov, T., Mueller, P. K., Alcocer, A. E. and Otvos, J. W. (1972b) Chemical States of Nitrogen and Sulfur by Photoelectron Spectroscopy. J. of Colloid and Interface Sci. 39, 225.
- Odessa Engineering, Inc. (1985) Environmental Aide: Air Quality and Meteorological Data Analysis, Version 1.0. Odessa Engineering Inc., P. O. Box 27537, Austin, TX.
- Olin, J. G. and Bohn, R. R. (1983) A New PM-10 Medium Flow Sampler. Presented at the 76th Annual Meeting of the Air Pollution Control Association, Atlanta, GA.
- Oliver, W. R., Hogo, H. and Saxena, P. (1983) Assessment of NO_x Emission Control Requirements in the South Coast Air Basin: Volume IV, Appendix C--Emission Inventory Review and Development. Report SYSAPP-83/053, Systems Applications, Inc., San Rafael, CA.
- Oliver, W. R. and Peoples, S. H. (1985) Improvement of the Emission Inventory for Reactive Organic Gases and Oxides of Nitrogen in the South Coast Air Basin Volume I: Main Report. Systems Applications, Inc., Report No. SYSAPP-85/080, San Rafael, CA.
- Oliver, W. R., Tesche, T. W., Peoples, S. H., Boyd, R. R., and Tate, R. (1987) Planning Study for the Emission Inventory for the Southern California Air Quality Study, Final Report #87-264-013-02 submitted by Radian Corporation, Sacramento, CA to SCAQS Emissions Working Group, April 17, 1987.
- Pack, D. H. and Angell, J. K. (1963) A Preliminary Study of Air Trajectories in the Los Angeles Basin as Derived from Tetron Flights. Monthly Weather Review 91, 583.
- Pandolfo, J. P. and Jacobs, C. A. (1973) Tests of an Urban Meteorological Pollutant Model Using CO Validation Data in the Los Angeles Metropolitan Area: Volume I. Center for the Environment and MON, Report EPA-R4-73-025a, U.S. Environmental Protection Agency, Research Triangle Park, NC.

- Pandolfo, J. P., Jacobs, C. A., Ball, R. J., Atwater, M. A. and Sekorski, J. A. (1976) Refinement and Validation of an Urban Meteorological Pollutant Model. EPA-600/4-76-037, U.S. Environmental Protection Agency, Research Triangle Park, NC.
- Panofsky, H. A. (1975) A Model for Vertical Diffusion Coefficients in a Growing Urban Boundary Layer. *Boundary Layer Met.* 9, 235-244.
- Parungo, F. P., Pueschel, R. F. and Wellman, D. L. (1980) Chemical Characteristics of Oil Refinery Plumes in Los Angeles. *Atmos. Environ.* 14, 509-522.
- Paskind, J. J. and Kinoshian, J. R. (1974) Hydrocarbons, Oxides of Nitrogen, and Oxidant Pollutant Relationships in the Atmosphere over California Cities. Presented at the 67th Annual Meeting of the Air Pollution Control Association, Denver, CO.
- Phadke, M. S., Tiao, G. C. and Hillmer, S. C. (1977) Statistical Evaluation of the Environmental Impact of the Catalytic Converter. Presented at the 70th Annual Meeting of the Air Pollution Control Association, Toronto, Canada.
- Pielke, R. A. (1984) Mesoscale Meteorological Modeling. Academic Press, New York.
- Pilinis, C., and Seinfeld, J. H. (1986) Aerosol Measurements in the Southern California Air Quality Study, in Seinfeld, J. H., et al. (1986) Analysis of the Southern California Air Quality Study (SCAQS) Measurement Plan.
- Pitts, J. N., Sprung, J. L., Poe, M., Carpelan, M. C. and Lloyd, A. C. (1976) Corrected South Coast Air Basin Oxidant Data: Some Conclusions and Implications. *Env. Sci. Tech.* 10, 794.
- Pitts, J. N. and Grosjean D. et al. (1978) Detailed Characterization of Gaseous and Size-Resolved Particulate Pollutants at a South Coast Air Basin Smog Receptor Site: Levels and Modes of Formation of Sulfate, Nitrate and Organic Particulates and their Implications for Control Strategies. Final Report, California Air Resources Board Contracts, ARB-5-384 and A6-171-30, Sacramento, CA.
- Pitts, J. N., Fitz, D. R., Harger, W., Lokensgard, D. M. and Shaffer, S. D. (1981) Geographical and Temporal Distribution of Atmospheric Mutagens in California. California Air Resources Board Report No. ARB-R-82/166, Sacramento, CA.
- Pitts, J. N., Lokensgard, D. M., Fitz, D. R., Dodd, M. C. and Fisher, T. S. (1982) Chemical Nature of Particulate Atmospheric Mutagens in California's South Coast Air Basin. California Air Resources Board Report No. ARB-R83-210, Sacramento, CA.

- Pitts, J. N., Winer, A. M., Atkinson, R. and Carter, P. L. (1983) Comment on Effect of Nitrogen Oxide Emissions on Ozone Levels in Metropolitan Regions, Effect of NO_x Emission Rates on Smog Formation in the California South Coast Air Basin, and Effect of Hydrocarbon and NO_x on Photochemical Smog Formation under Simulated Transport Conditions. *Env. Sci. Tech.* 17, 54.
- Pitts, J. N., Winer, A. M., Biermann, H. W. and Tuazon, E. C. (1984) Direct Measurements of Nitrous Acid, Nitrogen Dioxide and Formaldehyde in Auto Exhaust by Differential Optical Absorption Spectroscopy. California Air Resources Board Report No. A1-089-32, Sacramento, CA.
- Pitts, J. N., Sweetman, J. A., Zielinska, B., Winer, A. M. and Atkinson, R. (1985) Determination of a 2-Nitrofluoranthene and 2-Nitropyrene in Ambient Particulate Organic Matter. Evidence for Atmospheric Reactions. *Atmos. Environ.* 19, 1601.
- Platt, U., Perner, D., Harris, G. W., Winer, A. M. and Pitts, J. N. (1980). *Nature* 285, 312.
- Platt, U. and Perner, D. (1980a) Detection of NO_3 in the Polluted Troposphere by Differential Optical Absorption. *Amer. Geophysical Union*, 7, No. 1.
- Platt, U. and Perner, D. (1980b) Direct Measurements of Atmospheric CH_2O , HNO_2 , O_3 , NO_2 , and SO_2 by Differential Optical Absorption in the Near UV. *J. of Geophysical Research*, 85, 7453-7458.
- Platt, U., Winer, A. M., Biermann, H. W., Atkinson, R. and Pitts, J. N. Jr. (1984) Measurement of Nitrate Radical Concentrations in Continental Air. *Env. Sci. Tech.* 18, 365.
- Porch, W. M. and Ellsaesser, H. W. (1977) Cyclic Trends in Los Angeles Fine Particulates. *J. of the Air Pollution Control Assoc.* 27, 134.
- Pratsinis, S., Novakov, T., Ellis, E. C. and Friedlander, S. K. (1984) The Carbon Containing Component of the Los Angeles Aerosol: Source Apportionment and Contributions to the Visibility Budget. *J. of the Air Pollution Control Assoc.* 34, 643.
- Pueschel, R. F., Parungo, F. P., Barrett, E. W., Wellman, D. L. and Proulx, H. (1979) Environmental Effects of Oil Refinery Operations in Los Angeles. NOAA Technical Memorandum APCL-22, Boulder, CO.
- Reible, D. D., Ouimette, J. R. and Shair, F. H. (1982) Atmospheric Transport of Visibility Degrading Pollutants into the California Mojave Desert. *Atmos. Environ.* 16, 599.
- Renzetti, N. A. and Romanovsky, J. C. (1956) Comparative Study of Oxidants for the Los Angeles Atmosphere. *J. of the Air Pollution Control Assn.* 6, 154.
- Renzetti, N. A. and Bryan, R. J. (1961) Atmospheric Sampling for Aldehydes and Eye Irritation in Los Angeles Smog-1960. *Atmos. Environ.* 11, 421.

- Reviatt, G. H. (1978) Ozone Forecasting Using Empirical Modeling. J. of the Air Pollution Control Assoc. 28, 338.
- Reynolds, S. D., Liu, M. K., Hecht, T. A., Roth, P. M. and Seinfeld, J. H. (1973) Urban Airshed Photochemical Simulation Model Study. Volume I. Development and Evaluation. EPA-R4-73-030a, U.S. Environmental Protection Agency, Research Triangle Park, NC.
- Reynolds, S. D., Liu, M. K., Hecht, T. A., Roth, P. M. and Seinfeld, J. H. (1974) Mathematical Modeling of Photochemical Air Pollution--III. Evaluation of the Model. Atmos. Environ. 8, 563-596.
- Reynolds, S. D., Ames, J., Hecht, T. A., Meyer, J. P. and Whitney, D. C. (1976) Continued Research in Mesoscale Air Pollution Simulation Modeling: Volume II; Refinements in the Treatments of Chemistry, Meteorology, and Numerical Integration Procedures. EPA-600/4-76-016b, U.S. Environmental Protection Agency, Reserach Triangle Park, NC.
- Reynolds, S. D., Ames, J. Lundberg, G. W. and Mundkur, P. V. (1978) Application of the SAI Airshed Model to the Evaluation of Alternative Population Growth Forecasts for the South Coast Air Basin. SYSAPP-78/124, Systems Applications, Inc., San Rafael, CA.
- Reynolds, S. D. (1979) Photochemical Modeling of Transportation Control Strategies: Volume I, Model Development, Performance Evaluation and Strategy Assessment. EF 79-37, Systems Applications, Inc., San Rafael, CA.
- Richards, L. W. (1983) Comments on the Oxidation of NO₂ to Nitrate-Day and Night. Atmos. Environ. 17, 397.
- Richards, L. W., Anderson, J. A., Blumenthal, D. L., McDonald, J. A., Kok, G. L. and Lazrus, A. L. (1983a) Hydrogen Peroxide and Sulfur (IV) in Los Angeles Cloud Water. Atmos. Environ. 17, 911-914.
- Richards, L. W., Anderson, J. A., Blumenthal, D. L., Duckhorn, S. L. and McDonald, J. A. (1983b) Characterization of Reactants, Reaction Mechanisms, and Reaction Products Leading to Extreme Acid Rain and Acid Aerosol Conditions in Southern California. Final Report No. STI 83 FRD-200, submitted to the California Air Resources Board, Contract No. AO-140-32, Sacramento, CA.
- Richards, L. W., Anderson, J. A., Blumenthal, D. L. and McDonald, J. A. (1985) Characterization of the Composition and Three Dimensional Distribution of Acidity in Southern California Clouds - Final Report to the California Air Resources Board, Contract No. A2-125-32.
- Richards, L. W., Avol, E. L. and Harker, A. B. (1976) The Chemistry, Dispersion and Transport of Air Pollutants Emitted from Fossil Fuel Power Plants in California, Ground Level Pollutant Measurement and Analysis. California Air Resources Board Report No. ARB-R-3-916-64, Sacramento, CA.

- Richards, L. W., Wang, H. H. and Harker, A. B. (1977) Motor Vehicle Sampling Experiment. California Air Resources Board Report No. ARB-R-4-335-77-73, Sacramento, CA.
- Riggan, P. J., Lockwood, R. N. and Lopez, E. N. (1985) Deposition and Processing of Airborne Nitrogen Pollutants in Mediterranean-Type Ecosystems of Southern California. *Environ. Sci. Tech.* 19, 781.
- Roberts, P. T. (1975) Gas to Particle Conversion: Sulfur Dioxide in a Photochemically Reactive System. Ph.D. Dissertation, California Institute of Technology, Pasadena, CA.
- Roberts, P. T. and Friedlander, S. K. (1975) Conversion of SO₂ to Sulfur Particulate in the Los Angeles Atmosphere. *Env. Health Perspective*, 10, 103-108.
- Rodes, C. E. and Holland, D. M. (1981) Variations of NO, NO₂, and O₃ Concentrations Downwind of a Los Angeles Freeway. *Atmos. Environ.* 15, 243-250.
- Rodes, C. E., Holland, D. M., Purdue, L. J. and Rehme, K. A. (1985) A Field Comparison of PM-10 Inlets at Four Locations. *J. of the Air Pollution Control Assoc.* 35, 345.
- Rogers, L. H. (1958) Nitric Oxide and Nitrogen Dioxide in the Los Angeles Atmosphere. *J. of the Air Pollution Control Assn.* 8, 124.
- Rogers, L. H., Renzetti, N. A. and Neiburger, M. (1956) Smog Effects and Chemical Analysis of the Los Angeles Atmosphere. *J. of the Air Pollution Control Assn.* 6, 165.
- Rose, A. H., Smith, R., McMichael, W. F. and Kruse, R. E. (1965) Comparison of Auto Exhaust Emissions in Two Major Cities. *J. of the Air Pollution Control Assn.* 15, 362.
- Rosen, H., Hansen, A. D. A., Dod, R. L., Gundel, L. A. and Novakov, T. (1982) Graphitic Carbon in Urban Environments and the Arctic. In Particulate Carbon Atmospheric Life Cycles, edited by G. T. Wolff and R. K. Klimisch, Plenum Press, New York.
- Roth, P. M. (1972) Development of a Simulation Model for Estimating Ground Level Concentrations of Photochemical Pollutants. Appendix E. Air Quality Data used in Model Validation. Systems Applications, Inc. Beverly Hills, CA.
- Roth, P. M., Roberts, P. W., Liu, M. K., Reynolds, S. D. and Seinfeld, J. H. (1974) Mathematical Modeling of Photochemical Air Pollution - II. A Model and Inventory of Pollutant Emissions. *Atmos. Environ.* 8, 97-130.
- Roth, P. M., Reynolds, S. D., Tesche, T. W., Gutfreund, P. D. and Seigneur, C. (1983a) An Appraisal of Emissions Control Requirements in the California South Coast Air Basin. *Env. Intl.* 9, 549.

- Roth, P. M., Seigneur, C., Reynolds, S. D. and Tesche, T. W. (1983b) Assessment of NO_x Emission Control Requirements in the California South Coast Air Basin, Volume 3: Results, Findings, and Implications for Control Requirements Based on Short-Term Modeling Studies. SYSAPP-83/157, Systems Applications, Inc., San Rafael, CA.
- Russell, A. G., McRae, G. J. and Cass, G. R. (1983) Mathematical Modeling of the Formation and Transport of Ammonium Nitrate Aerosol. Atmos. Environ. 17, 949.
- Russell, A. G., McRae, G. J. and Cass, G. R. (1985) The Dynamics of Nitric Acid Production and the Fate of Nitrogen Oxides. Atmos. Environ. 19, 893.
- Russell, A. G. (1985) Formation and Control of Atmospheric Aerosol Nitrate and Nitric Acid. Ph.D. Dissertation, California Institute of Technology, Pasadena, CA.
- SCAQMD - South Coast Air Quality Management District (1981) Summary of Air Quality in the South Coast Air Basin of California, South Coast Air Quality Air Management District, Planning Division, El Monte, CA.
- SCAQMD - South Coast Air Quality Management District (1982) Final Air Quality Management Plan: 1982 Revision. South Coast Air Quality Management District, El Monte, CA.
- SCAQMD - South Coast Air Quality Management District (1983) Suspended Particulate Matter in the Atmosphere of the South Coast Air Basin and Southeast Desert Areas 1981, Technical Service Division, South Coast Air Quality Management District, El Monte, CA.
- Sackinger, P. A., Reible, D. D. and Shair, F. H. (1982) Uncertainties Associated with the Estimation of Mass Balances and Gaussian Parameters from Atmospheric Tracer Studies. J. of the Air Pollution Control Assn. 32, 720-724.
- Saltzman, B. E., Cholak, J., Schafer, L. J., Yeager, D. W., Meiners, B. G. and Svetlik, J. (1985) Concentrations of Six Metals in the Air of Eight Cities. Env. Sci. Tech. 19, 328.
- Schuck, E. A., Pitts, J. N. and Wan, J. K. S. (1966) Relationships Between Certain Meteorological Factors and Photochemical Smog. Intl. J. of Air and Water Pollution 10, 689-711.
- Schuetzle, D., Crittenden, A. L. and Charlson, R. J. (1973) Application of Computer Controlled High Resolution Mass Spectrometry to the Analysis of Air Pollutants. J. of the Air Pollution Control Assoc. 23, 704.
- Schuetzle, D., Cronn, D., Crittenden, A. L. and Charlson, R. J. (1975) Molecular Composition of Secondary Aerosol and its Possible Origin. Env. Sci. Tech. 9, 838.

- Schultz, P. and Warner, T. T. (1982) Characteristics of Summertime Circulations and Pollutant Ventilation in the Los Angeles Basin. *J. of Appl. Met.* 21, 672.
- Seigneur, C., Tesche, T. W., Roth, P. M. and Reid, L. E. (1981a) Sensitivity of a Complex Urban Air Quality Model to Input Data. *J. of Appl. Met.* 20, 50.
- Seigneur, C., Tesche, T. W., Reid, L. E., Roth, P. M., Oliver, W. R. and Casmassi, J. C. (1981b) The Sensitivity of Complex Photochemical Model Estimates to Detail in Input Information. Appendix A: A Compilation of Simulation Results. EPA-450/4-81-0316, U.S. Environmental Protection Agency, Research Triangle Park, NC.
- Seigneur, C., Tesche, T. W., Roth, P. M. and Liu, M. K. (1983a) On the Treatment of Point Source Emissions in Urban Air Quality Modeling. *Atmos. Environ.* 17, 1653.
- Seigneur, C., Saxeena, P. and Roth, P. M. (1983b) Modeling Studies of Acid Rain Chemistry. Presented at the 76th Annual Meeting of the Air Pollution Control Association, Atlanta, GA.
- Seigneur, C., Reynolds, S. D., Roth, P. M., Haney, J. L., Hogo, H., Dudik, M. C., Oliver, W. R. and Tesche, T. W. (1983c) Assessment of NO_x Emission Control Requirements in the California South Coast Air Basin, Volume IV: Appendix D, Model Simulations on the Effect of ROG and NO_x Emission Reductions on Short-term O₃ and NO₂ Ambient Concentrations. SYSAPP-83/159, Systems Applications, Inc., San Rafael, CA.
- Seigneur, C. and Saxeena, P. (1984) A Study of Atmospheric Acid Formation in Different Environments. *Atmos. Environ.* 18, 2109.
- Seigneur, C., Saxeena, P. and Mirabella, V. A. (1985) Diffusion and Reactions of Pollutants in Stratus Clouds: Application to Nocturnal Acid Formation in Plumes. *Env. Sci. Tech.* 19, 821.
- Seinfeld, J. H. et al. (1986) Analysis of the Southern California Air Quality Study (SCAQS) Measurement Plan. Model Working Group Report, submitted by California Institute of Technology, Pasadena, CA 91125 to Coordinating Research Council, December 22, 1986.
- Seinfeld, J. H. et al. (1987) Photochemical Model Development Needs for the Southern California Air Quality Study, Model Working Group Report, submitted by California Institute of Technology, Pasadena, CA 91125 to Coordinating Research Council, March 18, 1987.
- Severs, R. K. (1975) Simultaneous Total Oxidant and Chemiluminescent Ozone Measurements in Ambient Air. *J. of the Air Pollution Assn.* 25, 394.

- Shah, J. J. (1981) Measurements of Carbonaceous Aerosol Across the US: Sources and Role in Visibility Degradation. Ph.D. Dissertation, Oregon Graduate Center, Beaverton, OR.
- Shair, F. H., Sasaki, E., Carlan, D., Cass, G. R., Goodin, W. R., Edinger, J. and Schacher, G. E. (1982) Transport and Dispersion of Airborne Pollutants Associated with the Land Breeze/Sea Breeze System. *Atmos. Environ.* 16, 2043.
- Shettle, E. P. (1972) The Transfer of Near Ultraviolet Irradiances through Smog Over Los Angeles. *Atmos. Environ.* 6, 165-180.
- Shikiya, M. C., Broadbent, J., Nelson, E. and Taylor, T. (1984) Acid Deposition in the South Coast Air Basin: An Assessment. South Coast Air Quality Management District, El Monte, CA.
- Simmonds, P. G., Kerrin, S. L., Lovelock, J. E. and Shair, F. H. (1974) Distribution of Atmospheric Halocarbons in the Air Over the Los Angeles Basin. *Atmos. Environ.* 8, 209-216.
- Singh, B. P., Gordon, R. J. and Brewer, R. L. (1985) Characterization of Organic Aerosols from the Southern California Air Basin. Prepared for Southern California Edison by Global Geochemistry Corp., Canoga Park, CA.
- Sklarew, R. C., Fabrick, A. J. and Prager, J. E. (1972) Mathematical Modeling of Photochemical Smog Using the PICK Method. *J. of the Air Pollution Assn.* 22, 865-869.
- Smith, T. B., Blumenthal, D. L., Stinson, J. R. and Mirabella, V. A. (1972) Climatological Wind Survey for Aerosol Characterization Program. Meteorology Research, Inc., Report MRI 72 FR-1000, Altadena, CA.
- Smith, T. B., Marsh, S. L. and White, W. H. (1976) Analysis of the Data from the Three-Dimensional Gradient Study. California Air Resources Board Report, Sacramento, CA.
- Smith, T. B. and Shair, F. (1983) The Impact of Transport from the South Coast Air Basin on Ozone Levels in the Southeast Desert, Volume II. California Air Resources Board Report No. A0-145-32, Sacramento, CA.
- Smith, T. B. and Edinger, J. G. (1984) Utilization of Remote Sensing Data in the Evaluation of Air Pollution Characteristics in the South Coast/Southeast Desert Air Basin. California Air Resources Board Report No. ARB-R-84-236, Sacramento, CA.
- Smith, T. B., Saunders, W. D. and Takeuchi, D. M. (1984) Application of Climatological Analysis to Minimize Air Pollution Impacts in California. Prepared for the California Air Resources Board by Meteorology Research, Inc., Canyon Country, CA.
- Spicer, C. W. (1977) Photochemical Atmospheric Pollutants Derived from Nitrogen Oxides. *Atmos. Environ.* 11, 1089-1095.

- Spicer, C. W., Joseph, D. W. and Ward, G. F. (1983) Studies of NO_x Reactions and O₃ Transport in Southern California, Fall 1976. EPA-600/S3-83-026, Env. Sci. and Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC.
- Stafford, M. A. and Liljestrang, H. M. (1984) On the Distinction of Secondary Species in Acid Deposition. Presented at the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA.
- Stedman, D. (1983) A Continuous Total Atmospheric Free Radical Detector. Paper A51-04 presented at the Fall Meeting of the American Geophysical Union, San Francisco, CA.
- Stelson, A. W. and Seinfeld, J. H. (1981) Chemical Mass Accounting of Urban Aerosol. *Env. Sci. Tech.* 15, 671.
- Stelson, A. W. and Seinfeld, J. H. (1982) Relative Humidity and Temperature Dependence of the Ammonium Nitrate Dissociation Constant. *Atmos. Environ.* 16, 983-992.
- Stephens, E. R. (1968) The Marine Layer and its Relation to a Smog Episode in Riverside, California. *Atmos. Environ.* 2, 393-396.
- Stephens, E. R. (1969) Author's Reply to the Comments of Prof. Brewer and Dr. Estoque on the paper "The Marine Layer and its Relation to a Smog Episode in Riverside, California. *Atmos. Environ.* 3, 238.
- Stephens, E. R. (1969b) *Adv. Env. Sci. Technol.* 1, 119-146.
- Taback, H. J., Brienza, A. R., Macko, J. and Brunetz, N. (1979) Fine Particle Emissions from Stationary and Miscellaneous Sources in the South Coast Air Basin - Final Report. California Air Resources Board Report No. ARB-R-A6-191-30-79-94, Sacramento, CA.
- Tang, I. N., Wong, W. T. and Munkelwitz, H. R. (1981) The Relative Importance of Atmospheric Sulfates and Nitrates in Visibility Reduction. *Atmos. Environ.* 15, 2463.
- Tesche, T. W. and Burton, C. S. (1978) Simulated Impact of Alternative Emissions Control Strategies on Photochemical Oxidants in Los Angeles. 78-22R, Systems Applications, Inc., San Rafael, CA.
- Tesche, T. W. (1983) Photochemical Dispersion Modeling: Review of Model Concepts and Applications Studies. *Env. Intl.* 9, 465-489.
- Tesche, T. W., Oliver, W. R., Hogo, H., Saxena, P. and Haney, J. L. (1983a) Assessment of NO_x Emission Control Requirements in the California South Coast Air Basin, Volume IV: Appendix A, Performance Evaluation of the Systems Applications Airshed Model for the 26-27 June 1974 O₃ Episode in the South Coast Air Basin, SYSAPP-83/037, Systems Applications, Inc., San Rafael, CA.

- Tesche, T. W., Oliver, W. R., Hogo, H., Saxena, P. and Haney, J. L. (1983b) Assessment of NO_x Emission Control Requirements in the California South Coast Air Basin, Volume IV: Appendix B, Performance Evaluation of the Systems Applications Airshed Model for the 7-8 November 1978 NO₂ Episode in the South Coast Air Basin, SYSAPP-83/038, Systems Applications, Inc., San Rafael, CA.
- Tesche, T. W., Seigneur, C., Oliver, W. R. and Haney, J. L. (1984) Modeling Ozone Control Strategies in Los Angeles. *J. of Environ. Eng.* 110, 208.
- Thielke, J. F., Charlson, R. J., Winter, J. W., Ahlquist, N. C., Whitby, K. T., Husar, R. B. and Liu, B. Y. H. (1972) Multiwavelength Nephelometer Measurements in Los Angeles Smog Aerosols. II. Correlation with Size Distributions, Volume Concentrations. *J. of Colloid and Interface Sci.* 39, 252.
- Thomas, M. D. (1962) Sulfur Dioxide, Sulfuric Acid Aerosol and Visibility in Los Angeles. *Intl. J. of Air and Water Pollution* 6, 443.
- Tiao, G. C., Box, G. E. P. and Hamming, W. J. (1975a) Analysis of Los Angeles Photochemical Smog Data: A Statistical Overview. *J. of the Air Pollution Control Assoc.* 25, 260.
- Tiao, G. C., Box, G. E. P. and Hamming, W. J. (1975b) A Statistical Analysis of the Los Angeles Ambient Carbon Monoxide Data 1955-1972. *J. of the Air Pollution Control assoc.* 25, 1129.
- Tiao, G. C., Phadke, M. S. and Box, G. E. P. (1976) Some Empirical Models for the Los Angeles Photochemical Smog Data. *J. of the Air Pollution Control Assoc.* 26, 485.
- Tiao, G. C. and Hilmer, S. C. (1978) Statistical Models for Ambient Concentrations of Carbon Monoxide, Lead, and Sulfate based on the LACS Data. *Env. Sci. Tech* 12, 820.
- Tilden, J. W. and Seinfeld, J. H. (1982) Sensitivity Analysis of a Mathematical Model for Photochemical Air Pollution. *Atmos. Environ.* 16, 1364.
- Tombach, I. (1982) Application of Receptor Modeling Methods to Volatile Organic Gases. Proceedings, Receptor Models Applied to Contemporary Pollution Problems, Specialty Conferences, Air Pollution Control Association, Denver, MA.
- Tombach, I. and Pettus, R. (1982) A Survey of the Acidity and Chemical Composition of Precipitation in the Los Angeles Urban Area in Processing Atmospheric Deposition, Air Pollution Control Association, Pittsburg, PA.
- Trijonis, J. C. (1972) An Economic Air Pollution Control Model Application: Photochemical Smog in Los Angeles County in 1975. Ph.D. Dissertation California Institute of Technology, Pasadena, CA.
- Trijonis, J. C. (1974) Economic Air Pollution Control Model for Los Angeles County in 1975. *Env. Sci. Tech.* 8, 811.

- Trijonis, J. C. and Arledge, K. W. (1975) Utility of Reactivity Criteria in Organic Emission Control Strategies for Los Angeles. U.S. Environmental Protection Agency, Research Triangle Park, NC. Contract 68-02-1735 with TRW Environmental Services, Redondo Beach, CA.
- Trijonis, J. C., Richard, G., Crawford, K., Ten, R. and Wada, R. (1975a) An Implementation Plan for Suspended Particulate Matter in the Los Angeles Region. U.S. Environmental Protection Agency, Contract No. 68-02-1384, Research Triangle Park, NC.
- Trijonis, J. C., Peng, T. K., McRae, G. J. and Lees, L. (1975b) Emissions and Air Quality Trends in the South Coast Air Basin. Environmental Quality Lab. Memo No. 16, California Institute of Technology, Pasadena, CA.
- Trijonis, J. C. and Eldon, J. A. (1978) Statistical Oxidant/Precursor Relationships for the Los Angeles Region. Final Report. Creation of Empirical Oxidant/Precursor Models. California Air Resources Board Report No. ARB-R-A5-020-87-82, Sacramento, CA.
- Trijonis, J. C., Dimitriades, B. and Arledge, K. (1978a) Impact of Reactivity Criteria on Organic Emission Control Strategies for Los Angeles. J. of the Air Pollution Control Assoc. 28, 1021.
- Trijonis, J. C., Peng, T., McRae, G. J. and Lees, L. (1978b) Oxidant and Precursor Trends in the Metropolitan Los Angeles Region. Atmos. Environ. 12, 1413.
- Trijonis, J. C. (1982a) Impact of Light Duty Diesels on Visibility in California. J. of the Air Pollution Control Assoc. 32, 1048.
- Trijonis, J. C. (1982b) Visibility in California. J. Air Pollution Control Assn. 32, 165-169.
- Trijonis, J. C. and Mortimer, S. (1982) Validation of the EKMA Model Using Historical Air Quality Data. EPA-600/S3-82-015, Research Triangle Park, NC.
- Trijonis, J. (1983) Analysis of Historical Ozone Trends Sorted by NMHC/NO_x Ratio--A Way to Test the Effects of Future Hydrocarbon Emission Reductions. California Air Resources Board Report No. A1-056-32, Sacramento, CA.
- Tuazon, E. C., Graham, R. A., Winer, A. M., Easton, R. R., Pitts, J. R. and Hanst, P. L. (1978) A Kilometer Pathlength Fourier-Transform Infrared System for the Study of Trace Pollutants in Ambient and Synthetic Atmospheres. Atmos. Environ. 12, 865-875.
- Tuazon, E. C., Winer, A. M. and Pitts, J. N. (1981) Trace Pollutant Concentrations in a Multiday Smog Episode in the California South Coast Air Basin by Long Path Length Fourier Transform Infrared Spectroscopy. Env. Sci. Tech. 15, 1232.
- Ulbrich, E. A. (1968) Adaptive Air Pollution Control for the Los Angeles Basin. Socio-Economic Planning Science 1, 423-440.

- U.S. EPA - United States Environmental Protection Agency (1981) Guideline for Use of City-Specific EKMA in Preparing Ozone SIPS. EPA-450/4-80-027, U.S. Environmental Protection Agency, Research Triangle Park, NC.
- Vaughn, L. M. and Stankunas, A. R. (1974) Field Study of Air Pollution Transport in the South Coast Air Basin. Technical Report No. 197, Metronics Associates, Inc., Palo Alto, CA.
- Volz, F. E. (1973) Note on Satellite Remote Sensing of Atmospheric Aerosol. J. of the Air Pollution Control Assn. 23, 527.
- Wadley, M. W., Witz, S., Bope, W. and MacPhee, R. D. (1978) Size Distribution Measurements of Particulate Matter in Los Angeles and Anaheim Using High Volume Andersen Samplers. J. of the Air Pollution Control Assoc. 28, 364.
- Wakimoto, R. M. and Wurtele, M. G. (1984) Project BASIN. Bulletin of the American Meteorological Society 65, 1210.
- Waldman, J. M., Munger, J. W., Jacob, D. J., Flagan, R. C., Morgan, J. J. and Hoffmann, M. R. (1982) Chemical Composition of Acid Fog. Science 218, 677.
- Waldman, J. M. (1984) Letter to the Editor: Acid Fog. J. of the Air Pollution Control Assoc. 34, 13.
- Waldman, J. M., Munger, J. W., Jacob, D. J. and Hoffmann, J. R. (1985) Chemical Characterization of Stratus Cloudwater and its Role as a Vector for Pollutant Deposition in a Los Angeles Pine Forest. Tellus, 37B, 91-108.
- Walker, H. M. (1985) Ten Year Ozone Trends in California and Texas. J. of the Air Pollution Assoc. 35, 903.
- Wall, S., Ando, J. and John, W. (1984) Strong Acid Aerosol Size Distributions in the Los Angeles Air Basin. Presented at the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA.
- Watson, J. G. (1979) Chemical Element Balance Receptor Model Methodology for Assessing the Sources of Fine and Total Suspended Particulate Matter in Portland, OR. Ph.D. Dissertation, Oregon Graduate Center, Beaverton, OR.
- Watson, J. G., Liroy, P. J. and Mueller, P. K. (1983) The Measurement Process: Precision, Accuracy and Validity in Air Sampling Instruments for Evaluation of Atmospheric Contaminants, 6th Edition, American Conference of Governmental Industrial Hygienists, Cincinnati, OH.
- Watson, J. G. and Rogers, C. F. (1985) An Evaluation of California's Method P for the Measurement of PM-10. DRI Document #8019.2F. Prepared by the Desert Research Institute, Reno, NV for the Western Oil and Gas Association.

- Watson, J. G., Cooper, J. A. and Huntzicker, J. J. (1984) The Effective Variance Weighting for Least Squares Calculations Applied to the Mass Balance Receptor Model. *Atmos. Environ.* 18, 1347.
- Watson, J. G., Gertler, A. W., Prowell, G. H., Chow, J. C., Hering, S. V., Richards, L. W. and Blumenthal, D. L. (1985) Causes of Secondary Aerosol in the San Joaquin Valley Determined from the WOGA Aerosol Data Base. DRI Document 667-4P2, prepared by the Desert Research Institute, Reno, Nevada for the Western Oil and Gas Association.
- Wayne, L., Danchik, R., Weisburd, M., Kokin, A. and Stein, A. (1971) Modeling Photochemical Smog on a Computer for Decision Making. *J. of the Air Pollution Control Assn.* 21, 334.
- wedding, J. B., Kim, Y. J. and Lodge, J. P. (1986) Interpretation of Selected EPA Field Data on Particulate Matter Samplers: Rubidoux and Phoenix II. *J. of the Air Pollution Control Assn.*, 36, 164.
- wedding, J. B., Weigand, M. A. and Kim, Y. J. (1985) Evaluation of the Sierra-Andersen 10 um Inlet for the High-Volume Sampler. *Atmos. Environ.* 19, 539.
- Whitby, K. T., Husar, R. B. and Liu, B. Y. H. (1972) The Aerosol Size Distribution of Los Angeles Smog. *J. of Colloid and Interface Sci.* 39, 177.
- White, W. H., Husar, R. B. and Friedlander, S. K. (1973) A Study of Los Angeles Smog Aerosol Dynamics by Air Trajectory Analysis. Presented at the 66th Annual Meeting of the Air Pollution Control Association, Chicago, IL.
- White, W. H. and Husar, R. B. (1976) A Lagrangian Model of the Los Angeles Smog Aerosol. *J. of the Air Pollution Control Assoc.* 26, 32.
- White, W. H. and Roberts, P. T. (1977) On the Nature and Origins of Visibility-Reducing Aerosols in the Los Angeles Basin. *Atmos. Environ.* 11, 803.
- White, W. H., Heiser, S. L., Henry, R. C. and Hidy, G. M. (1978) The Same-Day Impact of Power Plant Emissions on Sulfate Levels in the Los Angeles Air Basin. *Atmos. Environ.* 12, 779.
- Winer, A. M., Peters, J. W., Smith, J. P. and Smith, J. N. (1974) Response of Commercial Chemiluminescent NO-NO_x Analyzers to Other Nitrogen-Containing Compounds. *Env. Sci. Tech.* 8, 1118.
- Winer, A. M., Fitz, D. R., Miller, P. R., Atkinson, R. and Brown, D. E. (1983) Investigation of the Role of Natural Hydrocarbons in Photochemical Smog Formation in California. California Air Resources Board Report No. ARB-R-83-211, Sacramento, CA.
- Witz, S. and Moore, A. B. (1981) Effect of Meteorology on the Atmospheric Concentrations of Traffic-Related Pollutants at a Los Angeles Site. *J. of the Air Pollution Control Assn.* 31, 1098.

- Witz, S., Larm, A. M., Elvin, B. M. and Moore, A. B. (1982) The Relationship Between Concentrations of Traffic-Related Pollutants and Meteorology at a Los Angeles Site. *J. of the Air Pollution Control Assn.* 32, 643.
- Witz, S. and Wadley, M. W. (1983) Suspended Particulate Matter in the Atmosphere of the South Coast Air Basin and Southeast Desert Areas, 1981. South Coast Air Quality Management District, El Monte, CA.
- Witz, S. and MacPhee, R. D. (1977) Effect of Different Types of Glass Filters on Total Suspended Particulates and their Chemical Composition. *J. of the Air Pollution Control Assoc.* 27, 239.
- Witz, S. and Wendt, J. G. (1981) Artifact Sulfate and Nitrate at Two Sites in the South Coast Air Basin. *Env. Sci. Tech* 15, 79.
- Witz, S., Smith, T. B., Shu, M. and Moore, A. B. (1982) A Comparison of Mass, Lead, Sulfate and Nitrate Concentrations in a Field Study Using Dichotomous, Size-Selective and Standard Hi-Vol Samplers. *J. of the Air Pollution Control Assoc.* 32, 276.
- Wolff, G. T. and Korsog, P. (1985) The Use of Multivariate Statistical Methods to Identify Sources of Inhalable Particulate Matter in Southeastern Michigan. Receptor Methods for Source Apportionment: Real World Issues and Applications, Air Pollution Control Association, Pittsburgh, PA.
- Wolff, G. T., Groblicki, P. J., Cadle, S. H. and Countess, R. J. (1982) Particulate Carbon at Various Locations in the United States. In Particulate Carbon: Atmospheric Life Cycle, edited by G. T. Wolff and R. K. Klimisch, Plenum Press, New York.
- Yoong, M. (1981) Measurement of Ambient Ammonia Concentrations in Southern California. California Air Resources Board Report EMSC 4069.60FR, Sacramento, CA.
- Young, J. R., Lurmann, F. W. and Godden, D. A. (1983) The Potential Role of Mobile Source Emissions in the Fogwater Chemistry of the Los Angeles Basin. Environmental Research and Technology Report P-B542-001, prepared for the Motor Vehicle Manufacturer's Assoc., Westlake Village, CA.
- Zafonte, L., Rieger, P. L., and Holmes, J. R. (1977) Nitrogen Dioxide Photolysis in the Los Angeles Atmosphere. *Env. Sci. Tech.* 11, 483.
- Zak, B. D. (1982) *Advances in Environmental Science and Technology*, 12.
- Zeldin, M. D. and Meisel, W. S. (1977) Use of Meteorological Data in Air Quality Trend Analysis. Technology Service Corp. TSC-PO-152-4. Prepared for Monitoring and Data Analysis Div., Office of Air Quality Planning and Standards, EPA.

- Zeldin, M. D., Farber, R. J. and Keith, R. W. (1983) Statistical and Case Study Meteorological Relationships for Sulfate Formation in the Los Angeles Basin. Presented at the 76th Annual Meeting of the Air Pollution Control Association, Atlanta, GA.
- Zeldin, M. D. and Ellis, E. C. (1984) Trends in Precipitation Chemistry in Southern California. Presented at the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA.

APPENDIX A. SCAQS PARTICIPANT AND MAILING LISTS

Many sponsors, participants, and potential users of the SCAQS data have contributed their ideas and their time for review and comment during the planning process. This Appendix includes lists of members of the SCAQS Management Advisory Group, of the SCAQS Technical Advisory Group, of the Emissions, Meteorology, and Model Working Groups, and of the CRC-APRAC SCAQS Coordination Group. Also included is a list of SCAQS projects and project managers and a current SCAQS mailing list.

Table A-1. Southern California Air Quality Study Management Advisory Group

<u>Organization</u>	<u>Representative</u>
California Air Resources Board	John Holmes
ARB Research Screening Committee and Scientific Advisory Committee	Jan Bush Katherine Wilson
South Coast Air Quality Management District	Art Davidson
Environmental Protection Agency	Ken Knapp
Coordinating Research Council	Tim Belian
Electric Power Research Institute	Peter Mueller
Ford Motor Company	Tai Chang
General Motors Research Laboratories	George Wolff
Motor Vehicle Manufacturer's Association	Marcel Halberstadt
Southern California Edison	Carol Ellis
Western Oil & Gas Association	Art Pope

Table A-2. Emissions Working Group

<u>Members</u>	<u>Organization</u>
Vince Mirabella	SCE Chairman
Paul Allen	ARB
Tim Belian	CRC
Rich Bradley	ARB
Glen Cass	Caltech
Anton Chaplin	UnoCal (WOGA)
Art Davidson	SCAQMD
Paul Davis	Chevron (WOGA)
Marty Ferman	GM Research Laboratories
John Grisinger	SCAQMD
Marcel Halberstadt	MVMA
Steve Heisler	ERT
Kent Hoekman	Chevron
Ken Knapp	EPA
Ron Lantzy	Exxon
Peter Mueller	EPRI
Mike Nazemi	SCAQMD
Bill Oliver	Radian
Jack Paskind	ARB
Bill Pierson	DRI (formerly Ford)
Art Pope	Arco (WOGA)
Andy Ranzieri	ARB
Paul Roberts	STI (formerly Chevron)
Christian Seigneur	Bechtel
John Watson	DRI
George Wolff	GM Research Laboratories
Wayne Zwiacher	SCAQMD

Table A-3. Meteorology Working Group

<u>Members</u>	<u>Organization</u>
Art Davidson	SCAQMD Chairman
Chuck Bennett	ARB
Don Blumenthal	STI
Joe Cassmassi	SCAQMD
Frank DiGenova	ARB
Eric Fujita	ARB
Jack Horrocks	ARB
Bob Kessler	SAI
Bill Knuth	T&B Systems
Doug Lawson	ARB
Don Lehrman	T&B Systems
Frank Ludwig	SRI International
Stan Marsh	SCE
Ken Schere	EPA
Fred Shair	Caltech
Ted Smith	Ted B. Smith and Associates
Jack Suder	ARB
Mel Zeldin	SCE

Table A-4. Model Working Group

<u>Members</u>	<u>Organization</u>
John Seinfeld	Caltech Chairman
Praveen Amar	ARB
Roger Atkinson	UC Riverside
Glen Cass	Caltech
Tai Chang	Ford
Anton Chaplin	UnoCal (WOGA)
Alan Dunker	GM Research Laboratories
Michael Fosberg	US Forest Service
Robert Kessler	SAI
Chung Liu	SCAQMD
Alan Lloyd	ERT
Fred Lurmann	ERT
Vince Mirabella	SCE
Andrew Ranzieri	ARB
Philip Roth	WOGA
Kenneth Schere	EPA
Christian Seigneur	Bechtel
Christine Sloane	GM Research Laboratories
Thomas Tesche	Radian
Gary Whitten	SAI

Table A-5. SCAQS Technical Advisory Group

Roger Atkinson	UCR
Glen Cass	Caltech
Sheldon Friedlander	UCLA
Daniel Grosjean	DGA
George Hidy	DRI
Warren Johnson	SRI
Peter McMurry	University of Minnesota
Ted Smith	Ted B. Smith and Associates

Table A-6. CRC-APRAC SCAQS Coordination Group

Dr. George T. Wolff, Leader
General Motors Research Laboratories

Dr. Karen M. Adams Ford Motor Company	Dr. Marcel L. Halberstadt Motor Vehicle Manufacturers Association
Dr. Lowell Ashbaugh State of California Air Resources Board	Dr. S. Kent Hoekman Chevron Research Company
Dr. Steven H. Cadle General Motors Research Laboratories	Dr. Steven M. Japar Ford Motor Company
Dr. Tai L. Chan General Motors Research Laboratories	Dr. Nelson A. Kelly General Motors Research Laboratories
Dr. T. Y. Chang Ford Motor Company	Dr. Douglas R. Lawson State of California Air Resources Board
Mr. Anton S. Chaplin Unocal Corporation	Dr. Jerry D. Rogers General Motors Research Laboratories
Dr. Jean M. Dasch General Motors Research Laboratories	Mr. Charles H. Schleyer Mobil Research & Development Corp.
Dr. Alan M. Dunker General Motors Research Laboratories	Dr. Dennis Schuetzle Ford Motor Company
Dr. E. Carol Ellis Southern California Edison Company	Mr. Jim Shikiya State of California Air Resources Board
Dr. Richard S. Fein Consultant	Mr. John W. Shiller Ford Motor Company
Mr. Martin A. Ferman General Motors Research Laboratories	Dr. Christine S. Sloane General Motors Research Laboratories
Mr. Eric Fujita State of California Air Resources Board	Dr. Eric E. Wigg Exxon Research & Engineering Company
Dr. Robert A. Gorse, Jr. Ford Motor Company	

Table A-7. SCAQS PROJECTS AND PROJECT MANAGERS

6/6/87		PROJ. MANAGER./PRIN. INVESTIGATOR	
ORGANIZATION	FUNCTION	Name	Phone
ARB	Project Officer, QA audits, trailer, etc	Doug Lawson	(916) 324-8496
EPA	HC gases, XRF, etc	Ken Knapp	(919) 541-3085
SCAQMD	B-sites, C-sites, QA audits, etc	Bill Bope	(818) 572-6398
SCAQMD	Forecasting, Meteorology Working Group	Art Davidson	(818) 572-6421
AeroVironment	SCAQS sampler design, construction; B-site oper.	Mike Chan	(818) 357-9983
AIHL	Acid deposition studies	Bruce Appel	(415) 540-2477
AIHL	Berner impactor & chemistry	Walter John	(415) 540-2644
ARB	Acid sampling methods comparison	Lowell Ashbaugh	(916) 445-0753
ARB-El Monte	Long Beach B-site, acid sampling	John Kowalski	(818) 575-6856
Biospherics	Canisters for HC analysis, QA; toxics	Rei Rasmussen	(503) 690-1077
Caltech	Fog/smog/fog studies	Michael Hoffmann	(818) 356-4391
Caltech	Model Working Group	John Seinfeld	(818) 356-4635
Caltech	Tracer studies	Fred Shair	(818) 356-6811
Carnegie-Mellon U	Dry deposition measurements	Cliff Davidson	(412) 268-2951
Daniel Grosjean & Asso.	Organic acids, PAN	Daniel Grosjean	(805) 644-0125
DRI	Acid sampling	John Bowen	(702) 972-1676
DRI	Long range transport from LA	David Rogers	(702) 972-1676
DRI	Aerosol water content	Fred Rogers	(702) 972-1676
DRI/STI	Analysis Coordinator	John Watson	(702) 972-1676
EMSI	SCAQS sampler analysis, B-site data vol	Bill Keifer	(805) 388-5700
EMSI-BNL	H2O2 @ B-sites	Miriam Lev-On	(805) 388-5700
EPA/Northrop	Acids and organic toxics	Bill Lonneman/Ellenson	(919) 541-2829
EPA/Northrop Services	XRF elements	Bob Kellogg	(919) 541-2895
EPALV	LIDAR aircraft	Jim McElroy	(702) 798-2260
ERT	Aerosol carbon, carbonyls, acid species, PAN	Kochy Fung	(805) 499-1922
ERT	Quality Assurance Manager, Data Manager	John Collins	(805) 499-1922
Ford	Spectrophone	Karen Adams	(313) 594-2612
Global Geochem	Alcohols, carbon 14	Bob Gordon	(818) 992-4103
GM Research Labs	A/B van, special PM-10, captive air studies, etc	George Wolff	(313) 986-1599
Illinois Inst of Tech	Coarse particle measurements	Ken Noll	(312) 567-3538
LBL	Aerosol absorption	Tony Hansen	(415) 486-5319
OGC	Continuous aerosol carbon	James Huntzicker	(503) 690-1072
Radian	Day-specific emissions	Bill Oliver	(916) 362-5332
S W Research	Motor vehicle emissions study	Mel Ingalls	(512) 522-2645
SCE	Power at A-sites, organic aerosol measurements	Carol Ellis	(818) 302-1866
SCE	Tracer Study, met. soundings, forecasting	Stan Marsh/Mel Zeldin	(818) 302-2272
SCE	Emissions Working Group	Vince Mirabella	(818) 302-6593
STI	Program Coordinator, aerosol instruments, etc	Don Blumenthal	(707) 527-9372
STI	Field Manager	Susanne Hering	(213) 206-6193
STI	Spiral aircraft	Jerry Anderson	(707) 527-9372
STI	Long path light extinction by radiance difference	Will Richards	(707) 527-9372
T & B Systems	Upper air soundings	Don Lehman	(707) 526-2775
Unisearch	Continuous H2O2	Gervase Mackay	(416) 669-2280
UC Davis	Drum impactors for elements, babs by LIPM	Tom Cahill	(916) 752-1120
UC Riverside	HONO and NO3 by DOAS	Arthur Winer	(714) 787-4651
UCLA	Impactor SO4, NO3, FTIR	David Allen	(213) 206-0300
UCLA	Impactor Pb, dichots	Sheldon Friedlander	(213) 825-2206
Univ. of Denver	Acid sampling	Don Stedman	(303) 871-3530
Univ. of Illinois	Temperature/RH nephelometer	Mark Rood	(217) 333-6963
Univ. of Minnesota	MOUDI impactor for carbon, aerosol water	Peter McMurry	(612) 625-3345
Univ. of Vienna	Light ext by telephotometer	Helmut Horvath	
Univ. of Vienna	Detailed fine particle size distr.	Axel Berner	
Univ. of Washington	Orbit aircraft	Dean Hegg	(206) 545-1984

Table A-8. SCAQS Mailing List

Karen M. Adams
Ford Motor Company
P.O. Box 2053
Dearborn, MI 48121

Tim Belian
Coordinating Research Council, Inc.
219 Perimeter Center Pkwy
Atlanta, GA 30346

David T. Allen
UCLA/Chem. Engineering Dept.
405 Hilgard Ave.
Los Angeles, CA 90024

Chuck Bennett
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Paul Allen
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Axel Berner
Institute for Experimental Physics
Strudelhofgasse 4
A-1090 Vienna, AUSTRIA

Praveen Amar
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Heinz Biermann
Statewide Air Pollution Rsch. Cntr.
U.C. Riverside
Riverside, CA 92521

Jerry Anderson
Sonoma Technology Inc.
3402 Mendocino Ave.
Santa Rosa, CA 95401

Don Blumenthal
Sonoma Technology Inc.
3402 Mendocino Ave.
Santa Rosa, CA 95401

Bruce Appel
AIHL - CA Dept. of Health Services
2151 Berkeley Way
Berkeley, CA 94704

Bill Bope
SCAQMD
9150 Flair Drive
El Monte, CA 91731

Lowell Ashbaugh
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

John Bowen
Desert Research Institute
P.O. Box 60220
Reno, NV 89505

Roger Atkinson
Statewide Air Pollution
Research Center
UC Riverside
Riverside, CA 92506

Rich Bradley
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

B. Bardswick
Ontario Ministry of the Environment
880 Bay Street
Toronto, Ontario M5S 1Z8

Jan Bush
P.O. Box 1238
Ventura, CA 93002

Table A-8. (continued)

Tom Cahill
Crocker Nuclear Laboratory
University of California
Davis, CA 95616

Paul Davis
Chevron Research Company
576 Standard Ave.
Richmond, CA 94802

Glen Cass
138-78 Caltech
Pasadena, CA 91125

Frank DiGenova
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Joe Cassmassi
SCAQMD
9150 Flair Drive
El Monte, CA 91731

Alan Dunker
General Motors Research Laboratories
Environmental Science Dept.
Warren, MI 48090-9055

Michael Chan
AeroVironment
825 Myrtle Avenue
Monrovia, CA 91016

Bill Ellenson
Northrop Services
P.O. Box 12313
Research Triangle Park, NC 27709

Tai Chang
Ford Motor Company
P.O. Box 2053
Dearborn, MI 48121

Carol Ellis
Southern California Edison Co.
P.O. Box 800
Rosemead, CA 91770

Anton Chaplin
Union Oil Center
UNOCAL
1201 West Fifth St.
Los Angeles, CA 90051

Marty Ferman
General Motors Research Laboratories
Environmental Science Dept.
Warren, MI 48090-9055

John Collins
ERT
975 Business Center Circle
Newbury Park, CA 91320

Dennis Fitz
Aerovironment
825 Myrtle Ave.
Monrovia, CA 91016

Richard Countess
Environmental Monitoring &
Services, Inc.
4765 Calle Quetzal
Camarillo, CA 93010

Michael Fosberg
USDA Forest Service
4955 Canyon Crest Dr.
Riverside, CA 92507

Art Davidson
SCAQMD
9150 Flair Drive
El Monte, CA 91731

Sheldon Friedlander
UCLA/Chem. Engineering Dept.
5531 Boelter Hall
Los Angeles, CA 90024

Cliff Davidson
Department of Civil Engineering
Carnegie-Mellon University
Pittsburgh, PA 15213

Eric Fujita
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Table A-8. (continued)

Kochy Fung
ER&T
975 Business Center Circle
Newbury Park, CA 91320

Kent Hoekman
Chevron Research Company
576 Standard Ave.
Richmond, CA 94802

Bob Gordon
Global Geochemistry Inc.
6919 Eton Ave.
Canoga Park, CA 91303

Michael Hoffmann
138-78 Caltech
Pasadena, CA 91125

John Grisinger
SCAQMD
9150 Flair Drive
El Monte, CA 91731

John Holmes
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Daniel Grosjean
Daniel Grosjean and Associates
4526 Telephone Road, Ste 205
Ventura, CA 93003

Jack Horrocks
Air Resources Board
9528 Telstar Ave.
El Monte, CA 91731

Marcel Halberstadt
Motor Vehicle Manuf. Assn.
300 New Center Building
Detroit, MI 48202

Helmut Horvath
Institute for Experimental Physics
University of Vienna
Boltzmannngasse 5
4090 Vienna, AUSTRIA

Tony Hansen
University of California
Lawrence Berkeley Lab. - 73
Berkeley, CA 94720

David Howekamp
Air Management Division
US EPA - Region X
215 Fremont St.
San Francisco, CA 94132

Dean Hegg
Dept. of Atmospheric Science
AK-40
University of Washington
Seattle, WA 98125

James Huntzicker
Oregon Graduate Center
19600 NW Von Neumann Dr.
Beaverton, OR 97006-1999

Steve Heisler
ERT
975 Business Center Circle
Newbury Park, CA 91320

Mel Ingalls
South West Research
6220 Culebra Rd.
San Antonio, TX 78284

Susanne Hering
Sonoma Technology Inc.
2035 Kelton Ave.
Los Angeles, CA 90025

Walter John
AIHL - CA Dept. of Health Services
2151 Berkeley Way
Berkeley, CA 94704

George Hidy
Electric Power Research Institute
3412 Hillview Ave.
Palo Alto, CA 94303

Warren Johnson
SRI International
333 Ravenswood, Bldg. 302N
Menlo Park, CA 94205

Table A-8. (continued)

Bill Keifer
EMSI
4765 Calle Quetzal
Camarillo, CA 93010

Chung Liu
SCAQMD
9150 Flair Dr.
El Monte, CA 91731

Bob Kellogg
Northrup Services
P.O. Box 12313
Research Triangle Park, NC 27709

Alan Lloyd
ERT
975 Business Center Circle
Newbury Park, CA 91320

Nelson Kelly
General Motors Research Laboratories
Environmental Science Dept.
Warren, MI 48090-9055

Bill Lonneman
US EPA
MD-84
Research Triangle Park, NC 27711

Bob Kessler
Systems Applications Inc.
101 Lucas Valley Rd.
San Rafael, CA 94903

Frank Ludwig
SRI International
Bldg. 320N
333 Ravenswood
Menlo Park, CA 94025

Ken Knapp
US EPA
MD-46
Research Triangle Park, NC 27711

Fred Lurmann
ERT
975 Business Center Circle
Newbury Park, CA 91320

Bill Knuth
T & B Systems
859 Second Street
Santa Rosa, CA 95404

Gervase Mackay
Unisearch Associates
222 Snidercroft Rd.
Concord, Ontario L4K 1B5
CANADA

John Kowalski
Air Resources Board
9528 Telstar Avenue
El Monte, CA 91731

Hillery Main
UCLA/Chem. Engineering Dept.
5531 Boelter Hall
Los Angeles, CA 90024

Doug Lawson
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Stan Marsh
Southern California Edison
P.O. Box 800
Rosemead, CA 91770

Don Lehrman
T & B Systems
859 Second Street
Santa Rosa, CA 95404

Jim McElroy
US EPA
AMS, EMSL-LV
P.O. Box 15027
Las Vegas, NV 89114

Miriam Lev-On
EMSI
4765 Calle Quetzal
Camarillo, CA 93010

Table A-8. (continued)

Peter McMurry
University of Minnesota
Dept. of Mech. Eng.
111 Church St., SE
Minneapolis, MN 55455

Art Pope
Atlantic Richfield Company
1990 W. Crescent
Anaheim, CA 92801

Vince Mirabella
Southern California Edison Co.
P.O. Box 800
Rosemead, CA 91770

Andy Ranzieri
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Peter Mueller
Electric Power Research Institute
3412 Hillview Ave.
Palo Alto, CA 94303

Rei Rasmussen
Oregon Graduate Center - Chem. Dept
19600 N.W. Von Neumann Dr.
Beaverton, OR 97006

Bill Munger
137-78 Caltech
Environmental Engineering Sci.
Pasadena, CA 91125

Will Richards
Sonoma Technology Inc.
3402 Mendocino Ave.
Santa Rosa, CA 95401

Mike Nazemi
SCAQMD
9150 Flair Drive
El Monte, CA 91731

Paul Roberts
Sonoma Technology Inc.
3402 Mendocino Ave.
Santa Rosa, CA 95401

Kenneth Noll
Illinois Institute of Technology
Dept. of Environmental Engineering
3200 South State St.
Chicago, IL 60616

David Rogers
Desert Research Institute
P.O. Box 60220
Reno, NV 89505

John O'Gara
Naval Weapons Center
Code 2632
China Lake, CA 93555

Fred Rogers
Desert Research Institute
P.O. Box 60220
Reno, NV 89505

Bill Oliver
Radian
10395 Old Placerville Rd.
Sacramento, CA 95827

Mark Rood
Rm 3207 - Newmark Civil Eng. Lab.
208 N. Romine Street
Univ. of IL, Urbana-Champaign
Urbana, IL 61801

Jack Paskind
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Phil Roth
21 Catskill Ct.
San Anselmo, CA 94960

William R. Pierson
Desert Research Institute
P.O. Box 60220
Reno, NV 89505

Table A-8. (continued)

Christian Seigneur
Bechtel
Environmental Science Dept.
50 Beale St.
San Francisco, CA 94119

Thomas Tesche
Radian
10395 Old Placerville Rd.
Sacramento, CA 95827

John Seinfeld
206-41 Caltech
Chemical Engineering
Pasadena, CA 91125

Barbara Turpin
Oregon Graduate Center
19600 NW Von Neumann Dr.
Beaverton, OR 97006-1999

Fred Shair
208-41 Caltech
Pasadena, CA 91125

John Watson
Desert Research Institute
University of Nevada
P.O. Box 60220
Reno, NV 89506

Kenneth Schere
Environmental Protection Agency
MD-80
Research Triangle Park, NC 27711

Gary Whitten
Systems Applications, Inc.
101 Lucas Valley Rd.
San Rafael, CA 94903

Christine Sloane
General Motors Research Laboratories
Environmental Science Dept.
Warren, MI 48090-9055

Katherine Wilson
c/o Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Ted Smith
Ted B. Smith and Associates
1491 Linda Vista Ave.
Pasadena, CA 91103

Arthur Winer
Statewide Air Pollution
Research Center
UC Riverside
Riverside, CA 92521

Chester Spicer
Battelle Lab
405 King Ave.
Columbus, OH 43201

George Wolff
General Motors Research Laboratories
Environmental Science Dept.
Warren, MI 48090-9055

Don Stedman
University of Denver
Dept. of Chemistry
University Park
Denver, Co 80208-0179

Mel Zeldin
Southern California Edison
P.O. Box 800
Rosemead, CA 91770

Roger Tanner
Brookhaven National Lab
Environmental Chemistry Div.
Dept. of Applied Science, Bldg. 426
Upton, Long Island, NY 11973

Wayne Zwiacher
SCAQMD
9150 Flair Drive
El Monte, CA 91731

APPENDIX B
SUMMARY OF AIR QUALITY STUDIES

Summary of Selected Past South Coast Air Basin Studies

<u>Study Objectives</u>	<u>Sampling Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
<p>Reference: Miller et al. (1972), Topic: Aerosol</p> <p>To apply the chemical mass balance model to estimate source contributions to atmospheric aerosol</p>	<p>Pasadena, CA Sept. 1969</p>	<p>11-hr TSP mass Ions (NH₄⁺, SO₄⁼, NO₃⁻)</p> <p>Carbon</p> <p>Elements</p> <p>Source sampling for soil, fuel oil, fly ash</p>	<p>Tracer solution to the chemical mass balance</p>	<p>Tracer species can be used to estimate source contributions to ambient elemental concentrations</p> <p>Major source contributions in Pasadena:</p> <ul style="list-style-type: none"> Carbon (17%) Soil (9.8%) Automobile (8.2%) Sea Salt (2.5%) Fuel-Oil Combustion (0.2%) <p>57% of TSP mass was unexplained</p>
<p>Reference: Friedlander (1973), Topic: Aerosol</p> <p>To state the fundamental principals of the chemical mass balance model</p> <p>To apply a carbon balance to estimate secondary conversion of organic vapors</p>	<p>Pasadena, CA Sept. 1969</p>	<p>11-hr TSP mass</p> <p>Carbon and carbon components</p> <p>Elements</p> <p>Source Sampling for soil</p>	<p>Least squares solution to the chemical mass balance</p>	<p>Secondary aerosol (40%) was the major contributor. Other significant contributions were 25% from primary manmade and 15% from primary natural sources</p> <p>Particle size distribution is important since the chemical composition is an average over the size spectrum</p> <p>Limitations of CMB involve chemical/physical processes, particle fractionation and variability in time and space</p>

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
Reference: Hidy et al. (1975), Topics: Aerosol, Visibility				
To characterize the chemical & physical properties of urban and non-urban aerosols	12 sites for mobile labs-Berkeley, Richmond SFOAF, Fresno, Hunter-Liggett Military Reservation, Freeway Loop, Pomona, Goldstone, Pt. Arguello, W. Covina, Robidoux (Riverside), and Domingue Hills	Aerosols Total aerosol number concentrations Aerosol size distribution Size and chemically classified particles	Descriptive graphical & statistical methods Several models applied to data by other researchers	Found simplified approaches for the study of atmospheric particles Showed urban and rural aerosol mass is probably distributed bimodally in small (dp<3 μm) and large (3μm<dp<20μm) plus giant (dp<20 μm) particles
To attribute ambient concentrations to primary & secondary pollutant sources				
To identify major causes of production & visibility reduction				
To estimate the extent of ambient air quality standards that can be achieved by existing technologies	July to Nov. 1972 July to Oct. 1973	Light scattering Liquid water content Particulate fallout mass and organics		Discovered that the two mass modes have independent sources and interact minimally in the atmosphere Found that particles formed by chemical reactions in the atmosphere add to the small particle size mode
To evaluate the applicability of aerosol instrumentation in the study for use in monitoring networks		Gases (SO ₂ , H ₂ S, NO, NO ₂ , NH ₃ , Total HC, HC, CH ₄ , C ₂ H ₄ , C ₂ H ₂ , CO and O ₃)		Pioneered the application of receptor models
To elucidate the photochemistry of aerosol formation		Meteorology (WS, WD, T°, RH, radiation and rainfall)		

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Sampling Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
Reference: White et al. (1978), Topic: Sulfate				
To examine the relationships between daily power plant SO ₂ emissions and ambient sulfate concentrations in Los Angeles Basin	Azusa, Downtown LA, LAX, Long Beach Airport W. Covina May - Oct., 1975	Ions (24-hr SO ₄ ²⁻) Gaseous (1-hr O ₃) Meteorological parameters (RH, T850, TLA) Daily SO ₂ emissions from power plants	Linear roll-back model	Lack of correlation between power plant SO ₂ emissions and ambient SO ₂ levels was found Power plant emissions on an average day account for 17% of the average sulfate concentrations at W. Covina (a high sulfate site) Factors other than sulfur emissions affect sulfate production in SOCAB

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Sampling Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
<p>Reference: Henry and Hidy (1979), Topic: Sulfate</p> <p>To empirically identify the underlying chemical and physical process for sulfate production</p> <p>To apply a principal components model which is unaffected by intercorrelations of the variables</p>	<p>Southern California sites: Anaheim, Garden Grove, Glendora, Santa Monica, Thousand Oaks, Vista, W. Covina, CA</p> <p>Jan. 1974 to Jan. 1975</p>	<p>24-hr TSP mass</p> <p>Gases (SO₂, NO_x, O₃, NMHC, total HC)</p> <p>Meteorological variables (RH, temp, WS, WD, inversion, ventilation)</p>	<p>Regression on principal components</p>	<p>Photochemical processes, SO₂ sources and atmospheric dispersion and transport are the three major causes of southern California sulfate levels</p> <p>Photochemical activity variance of (17-32%) and atmospheric moisture content variance of (9-15%) account for more than half of the sulfate variability</p>

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Sampling Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
<p>Reference: Tombach (1982), Topic: Hydrocarbon Sources</p> <p><u>Receptor Model</u></p> <p>To apply the chemical mass balance model to volatile organic compounds (VOC)</p> <p>To determine the major contributions of ambient VOC levels in the South Coast Air Basin</p>	<p>(I)</p> <p>Los Angeles Air Basin</p>	<p>3 times/day ambient samples</p> <p>Nonmethane hydrocarbon compounds</p> <p>Source samples included: auto exhaust gasoline, gasoline vapor, natural gas, liquified petroleum gases</p>	<p>Ordinary weighted least squares chemical mass balance</p>	<p>Receptor modeling can be used for VOC source attribution studies with good understanding of experimental method and chemical process</p> <p>Relative changes in concentration between inert and reactive VOC species from the same source-type can identify sources</p> <p>The VOC source contributions varied with time of day</p>
<p><u>Tracer Release</u></p> <p>To quantify the total VOC emissions from various operations in a refinery</p>	<p>(II)</p> <p>16 sites at down-town and upwind</p>	<p>Tracer release of SF₆ gas</p>	<p><u>Dispersion Model</u></p> <p>(AUGUAL, Lissaman, 1973; Huang & Head 1978)</p>	<p>Auto exhaust (53%), natural gas (19%), gasoline (12%) and gasoline vapor (10%) were the major contributors of hydrocarbons to receptors</p> <p>Process areas and emulsion plant (58%) and floating roof storage tanks (38%) were the major contributing operations in the refinery to the ambient NMHC levels</p>

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Sampling Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
<p>Reference: Cass and McRae (1983), Topic: Aerosol</p> <p>To develop better source apportionment techniques</p> <p>To assess the effects of different model structures on estimated source contributions</p>	<p>5 SCAQMD sites: Azusa, Lynwood, Pasadena, Reseda, W. Los Angeles</p> <p>5 NASN sites: Anaheim, Lennox, Los Angeles, Pasadena, San Bernardino</p> <p>1976 to 1977</p>	<p>24-hr TSP mass</p> <p>ions (SO₄⁻, NO₃⁻, NH₄⁺)</p> <p>Elements</p>	<p>Emission Inventory/Rollback</p> <p>Tracer solution to chemical Mass balance receptor model</p> <p>Ordinary weighted least squares solution to the chemical mass balance receptor model</p> <p>Multiple linear regression</p>	<p>Emissions Inventory for fine particle trace metals can be constructed by superimposing size and chemical source compositions (resulted from source test) onto conventional TSP inventory</p> <p>Identifying key tracer elements of emission sources is important and can be used as input to CMB Model, thereby compensating for the deficiency in H1VOL data</p> <p>Consistent results were yielded by model/model comparisons</p>

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
<p>Reference: Henry and Hidy (1979), Topic: Sulfate</p> <p>To empirically identify the underlying chemical and physical process for sulfate production</p> <p>To apply a principal components model which is unaffected by intercorrelations of the variables</p>	<p>Southern California sites: Anaheim, Garden Grove, Glendora, Santa Monica, Thousand Oaks, Vista, W. Covina, CA</p> <p>Jan. 1974 to Jan. 1975</p>	<p>24-hr TSP mass</p> <p>Gases (SO₂, NO_x, O₃, NMHC, total HC)</p> <p>Meteorological variables (RH, temp, WS, WD, inversion, ventilation)</p>	<p>Regression on principal components</p>	<p>Photochemical processes, SO₂ sources and atmospheric dispersion and transport are the three major causes of southern California sulfate levels</p> <p>Photochemical activity variance of (17-32%) and atmospheric moisture content variance of (9-15%) account for more than half of the sulfate variability</p>

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Sampling Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
<p>Reference: Tombach (1982), Topic: Hydrocarbon Sources</p> <p><u>Receptor Model</u></p> <p>To apply the chemical mass balance model to volatile organic compounds (VOC)</p> <p>To determine the major contributions of ambient VOC levels in the South Coast Air Basin</p>	<p>(I)</p> <p>Los Angeles Air Basin</p>	<p>3 times/day ambient samples</p> <p>Nonmethane hydrocarbon compounds</p> <p>Source samples included: auto exhaust gasoline, vapor, natural gas, liquified petroleum gases</p>	<p>Ordinary weighted least squares chemical mass balance</p>	<p>Receptor modeling can be used for VOC source attribution studies with good understanding of experimental method and chemical process</p> <p>Relative changes in concentration between inert and reactive VOC species from the same source-type can identify sources</p> <p>The VOC source contributions varied with time of day</p>
<p><u>Tracer Release</u></p> <p>To quantify the total VOC emissions from various operations in a refinery</p>	<p>(II)</p> <p>16 Sites at downtown and upwind</p>	<p>Tracer release of SF₆ gas</p>	<p><u>Dispersion Model</u></p> <p>(AQUAL, Lissaman, 1973; Huang & Head 1978)</p>	<p>Auto exhaust (53%), natural gas (19%), gasoline (12%) and gasoline vapor (10%) were the major contributors of hydrocarbons to receptors</p> <p>Process areas and emulsion plant (58%) and floating roof storage tanks (38%) were the major contributing operations in the refinery to the ambient NMHC levels</p>

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Sampling Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
<p>Reference: Cass and McRae (1983), Topic: Aerosol</p> <p>To develop better source apportionment techniques</p> <p>To assess the effects of different model structures on estimated source contributions</p>	<p>5 SCAQMD sites: Azusa, Lynwood, Pasadena, Reseda, W. Los Angeles</p> <p>5 NASN sites: Anaheim, Lennox, Los Angeles, Pasadena, San Bernardino</p> <p>1976 to 1977</p>	<p>24-hr TSP mass</p> <p>Ion_s (SO₄⁻, NO₃⁻, NH₄⁺)</p> <p>Elements</p>	<p>Emission Inventory/Rollback</p> <p>Tracer solution to chemical Mass balance receptor model</p> <p>Ordinary weighted least squares solution to the chemical mass balance receptor model</p> <p>Multiple linear regression</p>	<p>Emissions Inventory for fine particulate trace metals can be constructed by superimposing size and chemical source compositions (resulted from source test) onto conventional TSP inventory</p> <p>Identifying key tracer elements of emission sources is important and can be used as input to CMB Model, thereby compensating for the deficiency in HiVOL data</p> <p>Consistent results were yielded by model/model comparisons</p>

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Sampling Site/Location/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>																								
Reference: Spicer et al. (1983), Topic: Photochemical Measurements	Los Angeles Air Basin	(0900 to 1700 PST)	Graphical and statistical descriptions	Average daytime distribution of NO _x at 3 sites was:																								
To determine the spatial and temporal distribution of oxidized nitrogen species in the Los Angeles Air Basin	3-ground sampling sites: Rubidoux, Upland, Temple City	Ions (NO ₃ ⁻ , SO ₄ ⁼ , NH ₄ ⁺)		<table border="1"> <thead> <tr> <th></th> <th>Temple City</th> <th>Upland</th> <th>Rubidoux</th> </tr> </thead> <tbody> <tr> <td>NO</td> <td>19%</td> <td>10%</td> <td>--</td> </tr> <tr> <td>NO₂</td> <td>78%</td> <td>66%</td> <td>78%</td> </tr> <tr> <td>PAN</td> <td>3%</td> <td>22%</td> <td>10%</td> </tr> <tr> <td>HONO₂</td> <td>--</td> <td>--</td> <td>--</td> </tr> <tr> <td>NO₃⁻</td> <td>1%</td> <td>1%</td> <td>1%</td> </tr> </tbody> </table>		Temple City	Upland	Rubidoux	NO	19%	10%	--	NO ₂	78%	66%	78%	PAN	3%	22%	10%	HONO ₂	--	--	--	NO ₃ ⁻	1%	1%	1%
	Temple City	Upland	Rubidoux																									
NO	19%	10%	--																									
NO ₂	78%	66%	78%																									
PAN	3%	22%	10%																									
HONO ₂	--	--	--																									
NO ₃ ⁻	1%	1%	1%																									
To determine the extent to which measured NO _x products can account for NO _x removal from the air (i.e., nitrogen mass balance)	Oct. to Nov., 1976	Gases (SO ₂ , O ₃ , NO, NO _x , PAN, total nitrogen, NHHC, CO, CH ₄ , C ₂ H ₂ , C ₂ H ₄ , Freon-11)		* 11 Photochemically active days																								
To investigate differences in the transformation processes for NO _x relative to SO _x	42 aircraft flights over 22 days	Temperature		Particulate NO ₃ ⁻ exhibits a strong east-west gradient which is in contrast to SO ₄ ⁼ (relatively uniform) in the Los Angeles Air Basin																								
To estimate the rate of NO _x transformation under photochemically reactive conditions				70-85% of the total nitrogen can be accounted for as NO ₃ ⁻ and NH ₄ ⁺																								
To investigate the transport of O ₃ and precursors from urban areas				Most of the urban NO ₃ ⁻ is present in the gas phases. Gaseous NO ₃ ⁻ /Total NO ₃ ⁻ ratio is 0.75, 0.96 and 0.45 for Temple City, Upland and Rubidoux, respectively																								
				NO _x transformation rate of 0.02-0.03 h ⁻¹ and removal rate of 0.16 h ⁻¹ are calculated in the study																								

Summary of Selected Past South Coast Air Basin Studies (cont'd)

<u>Study Objectives</u>	<u>Sampling Site/Period</u>	<u>Observables</u>	<u>Model Used</u>	<u>Major Findings</u>
Reference: Pratsinis et al. (1984), Topics: Carbon Measurements, Visibility Reduction	Duarte and Lennox	8-hr Particulate Mass	Thermal analysis	Major source contributions to the carbon containing component of the fine aerosol
To estimate primary and secondary carbon contributions at receptors	July, 1980 to May, 1981	HIVOL with cascade impactor (dp < 15 μm, 3.5 μm < dp < 7.2 μm, and dp < 3.5 μm)	Emission Inventory scaling	
To calculate a visibility extinction budget for Los Angeles		Dichotomous sampler (3.5 μm < dp < 15 μm and dp < 3.5 μm)	Regression analysis	Automobile 68% 36%
		Elements (PIXE)		Industrial Sources 1% 26%
		Ions (NH ₄ ⁺ , SO ₄ ²⁻ , NO ₃ ⁻ , Cl ⁻)		A high correlation (R=0.72) was found between ozone and secondary carbon, and low correlation (R=0.65) was found between sulfate and secondary carbon
		Organic compound (volatile carbon black carbon)		The carbon containing component was responsible for 27 and 4% of the incident light extinction at Lennox and Duarte, respectively

