

# 1. INTRODUCTION

Central California is a complex region from an air quality and meteorological perspective, owing to its proximity to the Pacific Ocean, its diversity of climates, and its complex terrain. Within central California, the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) and the Great Basin Air Pollution Control District (GBAPCD) have been designated to be in serious non-attainment of the 1987 National Ambient Air Quality Standards (NAAQS) for particulate matter (PM) and are required to implement emissions reduction measures. Although the area administered by the Bay Area Air Quality Management District (BAAQMD) has not been designated as non-attainment, measured 24-hour  $PM_{10}$  (suspended particles with aerodynamic diameters less than 10  $\mu\text{m}$ ) concentrations in San Jose have exceeded 150  $\mu\text{g}/\text{m}^3$ . Reduced visibility in the Mojave Desert, and even in the Grand Canyon, has been attributed, at least in part, to  $PM_{2.5}$  (suspended particles with aerodynamic diameters less than 2.5  $\mu\text{m}$ ) exiting the San Joaquin Valley through the Tehachapi Pass.

The California Regional  $PM_{10}/PM_{2.5}$  Air Quality Study (CRPAQS) was designed to improve scientific understanding of excessive PM levels in central California. Specifically, this understanding is needed to determine where and when populations experience excessive exposures, as defined by NAAQS and state air quality standards, and how to cost-effectively reduce those exposures to acceptable levels. CRPAQS is an integrated effort that includes air quality and meteorological field measurements, emissions characterization, data analysis and air quality modeling. CRPAQS activities are complementary to long-term monitoring and research activities being conducted by the California Air Resources Board (ARB) (Turkiweicz and O'Brian, 1998), the U.S. Environmental Protection Agency (EPA), the SJVUAPCD, the BAAQMD, the GBAPCD, and other air quality districts in the region.

This document describes field measurements of ambient air concentrations and meteorology that were taken in central California between December 1999 and January 2001 to meet the objectives of CRPAQS. It describes the study area, its emissions and meteorology, and hypotheses about the causes of high particle concentrations. It identifies measurement locations, observables, and monitoring methods. It specifies data management and reporting conventions and outlines the activities needed to ensure data quality.

This document provides an overview of the CRPAQS measurement approach, with an emphasis on when and where the measurements were conducted. More detailed descriptions of the measurement methods and approaches are available in reports prepared by the various scientific investigators. Detailed descriptions of each of the CRPAQS measurement sites, including photographs, maps, and site diagrams, are available in the CRPAQS Site Documentation Reports (McDade, 2002), which can be found on the CRPAQS website (<http://www.arb.ca.gov/airways/crpaqs/default.htm>).

## 1.1 $PM_{2.5}$ and $PM_{10}$ Air Quality Standards

PM has been shown to adversely affect public health when susceptible populations are exposed to excessive concentrations (U.S. EPA, 1996; Vedal, 1997). NAAQS for PM have been established to minimize the adverse effects of PM on the majority of U.S.

residents. The NAAQS apply to PM<sub>2.5</sub> and PM<sub>10</sub> mass concentrations and are described as follows (U.S. EPA, 1997):

- Twenty-four hour average PM<sub>2.5</sub> not to exceed 65 µg/m<sup>3</sup> for a three-year average of annual 98<sup>th</sup> percentiles at any community-representative site in a monitoring area.
- Three-year annual average PM<sub>2.5</sub> not to exceed 15 µg/m<sup>3</sup> concentrations from a single community-representative site or the spatial average of eligible community-representative sites in a monitoring area.
- Twenty-four hour average PM<sub>10</sub> not to exceed 150 µg/m<sup>3</sup> more than once a year (based on a three-year average) at any site in a monitoring area.
- Three-year average PM<sub>10</sub> not to exceed 50 µg/m<sup>3</sup> for three annual average concentrations at any site in a monitoring area.

The PM<sub>2.5</sub> NAAQS are relatively new. While the PM<sub>10</sub> NAAQS retain the same values as the prior NAAQS (U.S. EPA, 1987), their form is new. Previously, the PM NAAQS applied to the highest 24-hour or annual averages measured within a monitoring planning area. Monitoring networks were often designed to measure these highest values, even though these networks did not necessarily represent the overall exposure of populations to excessive PM concentrations. Some data from these networks were disregarded by epidemiologists as being unrelated to health indicators such as hospital admissions and death.

The new forms for these standards are intended to provide more robust measures for the PM indicator. While PM<sub>10</sub> network design and siting criteria are unchanged, new PM<sub>2.5</sub> monitoring networks to determine compliance or non-compliance are intended to best represent the exposure of populations that might be affected by elevated PM<sub>2.5</sub> concentrations (Watson et al., 1997).

The statistical form of these standards and the community-oriented monitoring sites used for PM<sub>2.5</sub> and PM<sub>10</sub> compliance give low importance to rare occurrences of high concentration values. In fact, the magnitudes of the highest measured concentrations are not even considered (although the existence of these high values determines the percentile values) for designating compliance with the 24-hour standards. The three-year averaging of highest values and 98<sup>th</sup> percentile concentrations attenuates the influence of an unusual event during a year.

Limited PM<sub>2.5</sub> measurements from central California indicate that the annual 15 µg/m<sup>3</sup> standard will probably be exceeded in several populated areas, especially in the San Joaquin Valley. These high annual averages are dominated by elevated concentrations in the cities and in non-urban locations during winter and fall. While a few PM<sub>2.5</sub> concentrations have exceeded 65 µg/m<sup>3</sup> during winter, their number is not sufficient, nor are the exceedances so consistent from year to year, that the 24-hour standard is in danger of exceedance. PM<sub>2.5</sub> constitutes ~80% of PM<sub>10</sub> during winter and ~50% of PM<sub>10</sub> during the rest

of the year. The annual  $PM_{2.5}$  standard is most likely to be exceeded in several parts of central California, and emissions reductions that lower  $PM_{2.5}$  concentrations will also lower many excessive  $PM_{10}$  levels.

Elevated  $PM_{10}$  concentrations with about equal  $PM_{2.5}$  and coarse particle ( $PM_{10}$  minus  $PM_{2.5}$ ) components are consistently found during the fall, from September through mid-November. Other  $PM_{10}$  exceedances have occurred as isolated events at one or two locations when a nearby activity contributed a large bolus of fugitive dust, or when wind speeds exceeded suspension thresholds over bare land or lake beds. These situations are typically dominated by the coarse particle fraction. Windblown dust excursions have been most often found in the southern San Joaquin Valley and in the high desert, especially in the vicinity of Owens Lake.  $PM_{10}$  24-hour  $PM_{10}$  concentrations during fall in the Hanford/Corcoran area are consistently higher than those measured elsewhere, and the 24-hour and annual  $PM_{10}$  NAAQS may be exceeded in this region of the San Joaquin Valley.

These NAAQS are being implemented according to the following schedule:

- **1997:**  $PM_{2.5}$  and  $PM_{10}$  NAAQS promulgated by EPA
- **1998-2000:**  $PM_{2.5}$  compliance networks are installed and operating.  $PM_{10}$  networks are revised. Several  $PM_{10}$  compliance sites in California are discontinued in favor of new  $PM_{2.5}$  sites.
- **1999:** Metropolitan Planning Areas (MPA) are defined and designated as unclassifiable with respect to  $PM_{2.5}$  and  $PM_{10}$  standards. Areas with existing or pending  $PM_{10}$  State Implementation Plans (SIP) are obligated to implement the measures in those plans.
- **1998-2003:** Compliance data are collected. Special studies are conducted to determine sources and develop control measures. Compliance data are  $PM_{2.5}$  and  $PM_{10}$  measurements with Federal Reference Methods (FRM) or Federal Equivalent Methods (FEM). Fifty sites in the U.S. will acquire  $PM_{2.5}$  samples amenable to chemical characterization for elements, ions, and carbon, year after year. Two hundred and fifty sites will acquire chemical data for shorter time periods and may be moved from one area to another. Several of these will be located in central California.
- **2002:** The five year evaluation of particulate matter health criteria is completed by EPA. By presidential order, no planning areas will be declared in non-attainment until the technical basis for the new standards is evaluated in light of new research.
- **2002-2005:** Presuming the current PM NAAQS are justified by the re-valuation, planning areas exceeding the standards will be assigned attainment or non-attainment status.

- **2005-2008:** SIPs are formulated and submitted to demonstrate how planned emissions reductions will bring the area into attainment of the standard.
- **2012-2017:** Emissions reduction measures are implemented and attainment is demonstrated by PM<sub>2.5</sub> and PM<sub>10</sub> concentrations below the NAAQS levels.

The regulatory schedule to implement these standards is on par with the three to ten year schedule needed to extract the science from a major field study. A major field study from 12/1999 through 1/2001 would have its data complete and validated by 2002. Data analysis projects would be completed and published in 2003. Model evaluation and performance testing could be completed by 2004, with modeled control strategy evaluations ready by the 2005 SIP deadline.

## **1.2 CRPAQS Field Study Objectives**

The CRPAQS programmatic goal is to provide additional and more comprehensive information than is currently available to explain the nature and causes of particulate concentrations and visibility impairment in and around central California. This information is especially needed within the San Joaquin Valley where the highest particle concentrations have been measured in the past. The CRPAQS programmatic goal will elucidate the implications of currently planned emissions reduction strategies and will focus future emissions reduction efforts in those areas where they will have the greatest benefit on air quality for the least cost. This goal is pursued by obtaining and using ambient data, source emissions data, mathematical simulations, and data analysis methods. Specific field study objectives were:

1. Obtain a documented data set, with appropriate data qualification statements, that is suitable for characterizing the nature and causes of particulate concentrations and visibility impairment in and around central California by supporting modeling and data analysis activities.
2. Evaluate the extent to which long-term PM monitoring networks represent the levels to which large populations are exposed and PM concentrations under a variety of emissions and meteorological conditions.
3. Document the current spatial distribution, temporal variation, and intensity of PM concentrations and visibility impairment within central California.
4. Measure and characterize the structure and evolution of the boundary layer and the nature of regional circulation patterns that determine the transport and diffusion of PM and its precursors in central California.
5. Further characterize the source zones of influence and quantify source contributions to community exposure for PM chemical components, including particles that are directly emitted and those that form from directly emitted gases.

6. Quantify source contributions to secondary aerosol, identify the limiting precursors, and assess the extent to which reductions in nitrogen oxides, ammonia, sulfur oxides, and volatile organic compounds would be effective in reducing PM concentrations.
7. Refine conceptual models that explain the causes of elevated PM concentrations and interactions between emissions, meteorology, and ambient PM concentrations.
8. Evaluate and improve the performance of emissions, meteorological, and air quality simulations. Apply simulation methods to estimate PM concentrations at receptor sites and to test potential emissions reduction strategies.

The development of air quality simulation models is not a CRPAQS objective, although the evaluation and use of mathematical simulations are a major CRPAQS activity. Field experiments are intended to acquire the measurements needed for model inputs, parameterizations, and evaluation. Simulation methods are tools that integrate and interpret the meaning of these measurements. CRPAQS field experiments must allow the mechanisms that cause elevated PM levels to be understood, and the mathematical simulations of those methods to be evaluated to determine how well they represent those mechanisms. The CRPAQS measurement strategy involves acquiring data that challenges a model causing a flawed model to reveal its weaknesses. Model improvements and re-evaluation follow, until the full range of challenges is presented and responded to successfully.

CRPAQS measurements are intended to support both source and receptor models. Use of both types of models promotes corroborative testing and analysis, providing added means of evaluation. A complementary CRPAQS Model Evaluation and Validation Plan (Magliano et al., 1998a) describes how models will be used, and this field study plan is completely coordinated with this modeling plan. A complementary CRPAQS Emissions Modeling Plan (Magliano et al., 1998b) describes how emissions estimates will be determined.

### **1.3 Overview of CRPAQS Field Measurements**

The CRPAQS field study consisted of a long-term campaign from December 1999 through January 2001, a winter episodic program in December and January of 2000/2001, and a fall episodic program in October and November of 2000. Several special experiments were also conducted during the summer of 2000. Details on these measurements are presented in Sections 4 through 7 of this report.

#### **1.3.1 Long Term Annual Average Campaign (December 1999-January 2001)**

Long-term measurements were intended to characterize annual average concentrations and their causes. Air quality and meteorological measurements were conducted over a study domain extending from the Pacific Ocean on the west into the

Mojave Desert and Owens Valley on the east and from the Tehachapi Mountains in the south to the Sutter Buttes in the north. The most detailed measurements were focused in the southern San Joaquin Valley where the highest PM concentrations are measured, between Bakersfield and Fresno. The components of the long term campaign were:

- **ARB backbone PM<sub>2.5</sub> network:** ARB, in collaboration with the California air quality management districts, has established PM<sub>2.5</sub> monitoring sites in central California, several of which acquire 24-hour mass concentrations every day while others monitor every third day. Several of these are chemical speciation sites that obtain samples amenable to elemental, ion, and carbon analyses every twelfth day. Most of these sites have been selected to be community representative and will be used for determining compliance with the PM<sub>2.5</sub> NAAQS.
- **ARB backbone PM<sub>10</sub> network:** More than 100 PM<sub>10</sub> monitors have operated, and will continue to operate, at community exposure and source-oriented sites throughout central California. Many, but not all, of these existing PM<sub>10</sub> monitors are collocated with PM<sub>2.5</sub> monitors.
- **ARB air quality network:** Hourly averages are measured throughout California by the ARB and the air quality districts for ozone, oxides of nitrogen, sulfur dioxide, light scattering, and light absorption.
- **Integrated surface meteorological network:** This network unifies monitoring data from 8 networks and includes approximately 157 wind speed and direction sites, 122 temperature sites, 60 relative humidity sites, 26 solar radiation sites, and 7 ambient pressure sites.
- **CRPAQS anchor PM<sub>2.5</sub> network:** This network consisted of a small number of sites that acquired aerosol and precursor measurements with high time-resolution instrumentation at community exposure, transport, and gradient sites. Site locations and instrumentation varied among seasons with the most complete measurements made during the winter. Continuous particle monitors for PM<sub>2.5</sub> mass, PM<sub>10</sub> mass, PM<sub>2.5</sub> carbon, PM<sub>2.5</sub> nitrate, PM<sub>2.5</sub> sulfate, PM<sub>2.5</sub> light scattering, and PM<sub>2.5</sub> light absorption were deployed with averaging times of 5 to 30 minutes. Daily 24-hour PM<sub>2.5</sub> filter samplers using Teflon and quartz filters were operated at most anchor sites throughout the year. Relative humidity and wind speed monitors were enhanced with more sensitive detectors and 5 minute averaging periods at most anchor sites.
- **CRPAQS satellite network:** Satellite sites, consisting of portable Airmetrics Minivol PM<sub>2.5</sub> samplers for 24-hour average samples amenable to chemical analyses and nephelometers for 5-minute average PM measurements, were located at interbasin transport sites, intrabasin gradient sites, background sites, and emissions source sites. Many interbasin transport sites were supplemented with surface wind measurements where they were lacking. Seven community exposure sites were equipped with satellite monitors for PM<sub>10</sub> measurements. Filter samples were acquired at satellite sites every sixth day throughout the

annual study period. The CRPAQS Study Plan had anticipated that battery-powered filter samplers and nephelometers would be required. In fact, line power was available at almost every site, with solar powered batteries used at only two sites. Although the Minivol filter samplers operate with a battery, they were constantly trickle-charged using line power.

- **CRPAQS upper air network:** Radar profiler wind sounders, RASS vertical temperature sounders, and Doppler sodar wind sounders acquired time-resolved measurements. These measurements complemented twice per day rawinsonde launches at Vandenburg, Oakland, Pt. Mugu Naval Air Station, and Edwards Air Force Base. Hourly ceilometer measurements were obtained from airports in the region that operate these instruments.
- **CRPAQS micrometeorological tower:** A 100 m tall tower at the non-urban Angiola site between Fresno and Bakersfield was instrumented with high time-resolution meteorological instruments at five levels, and with particle size and light scattering measurements at two levels during the annual campaign. These measurements were designed to detect vertical as well as horizontal dispersion and mixing characteristics, as well as windblown dust suspension characteristics near ground level, under a large variety of meteorological situations likely to occur throughout the year. The tower also served as an analysis platform for wintertime fog and aerosol chemistry studies. The Walnut Grove tower between Sacramento and Stockton was instrumented in a similar manner during the winter intensive measurement period.

The original CRPAQS Study Plan called for a 100 m scaffold-type tower with stairways for instrument access. However, during subsequent planning it was determined that, for a 100 meter tower, a conventional guyed design with instrument elevators would provide a more stable, more convenient structure than would a scaffold-type tower. It would not require climbing by non-professional climbers to access the instruments for calibration and maintenance, since they would be brought down on the elevators. Also, a guyed tower has a smaller cross section than does a scaffold-type tower, and thus presents a smaller perturbation to the meteorological measurements. Overall costs were judged to be less for the conventional tower design, considering both the construction costs and the costs associated with instrument maintenance throughout the study.

The original Study Plan also called for aerosol measurements at five levels on the Angiola tower, along with the meteorological measurements. However, due to weight constraints and instrument availability, aerosol measurements were conducted at only three levels on the Angiola tower, with instrument clusters at the top and at the midway point, and with a nephelometer at the base. Furthermore, weight constraints dictated the elimination of several measurements that were originally planned for the top level of the Angiola tower - continuous sulfate, nitric acid, and PAN/NO<sub>2</sub>. At Walnut Grove, instruments were placed at the base and at the midway point of the existing tower.

Three preparatory studies were undertaken prior to initiation of field measurements in December 1999. Several continuous and filter-based particle monitors were evaluated at the

Bakersfield/California Avenue site during January 1999 to determine the optimal combination to be deployed at anchor sites. A winter forecasting scheme was devised and evaluated during the winters of 1998-1999 and 1999-2000. Winter measurements with portable nephelometers were taken during the winter of 1998-99 at different elevations in the Sierra Nevada foothills east of Fresno to evaluate candidate sites for measurements to be taken near the top of the valleywide pollution layer during the winter monitoring campaign. Further details on these experiments are provided in subsequent sections of this report.

### 1.3.2 Summer Experiments (June - September, 2000)

Three experiments were conducted during the summer period:

- **PM<sub>2.5</sub> organic characterization study:** The purpose of this study was to provide a detailed particulate organic speciation of ambient air in an urban area during summer. This study provides a contrast to the annual and winter particle organic measurements and permits the assignment of summertime organic carbon to sources using receptor models. Particle samples amenable to organic speciation were acquired at the Fresno anchor site on the same sixth day schedule as the annual average chemical characterization. The species measured were intended to distinguish diesel-vehicle exhaust, gasoline-vehicle exhaust (cold start, hot stabilized, and malfunction), burning (agriculture, residential, and wildfire), meat cooking, suspended road dust, and secondary organic aerosol as separate contributors to PM<sub>2.5</sub>.
- **Anchor site at Edwards Air Force Base:** An anchor site oriented toward components of light extinction was operated in the Mojave desert to evaluate the timing and intensity of light extinction and the aerosol components that cause it.
- **Satellite transport sites from South Coast Air Basin and San Joaquin Valley into the Mojave Desert:** Satellite sites using portable nephelometers were located along transport pathways during the summer period to determine the magnitude, direction, and duration of visibility-reducing atmospheric constituents along pathways from the Los Angeles area for comparison with measurements of these constituents moving from the San Joaquin Valley into the desert.

### 1.3.3 Winter Campaign (December 2000-January 2001)

The winter campaign was intended to acquire measurements to increase the understanding of and the capability to simulate the secondary inorganic and organic fraction of PM<sub>2.5</sub>. In addition to continuous air quality measurements over the two month period, four episodes of three to four-day duration, for a total fifteen days, were selected according to a forecast of PM buildup. The long-term network operated throughout the two-month winter campaign period with the following enhancements:

- **Anchor network enhancements:** Several satellite sites were upgraded to anchor site status for the winter period. Long-term campaign monitors were supplemented with continuous monitors for nitrate, nitric acid, light absorption

(aethalometer), O<sub>3</sub>, NO<sub>y</sub>, and PAN/NO<sub>2</sub> at existing sites, along with time-integrated measurements of fine particle chemical composition and organic compound speciation. The original Study Plan called for hydrogen peroxide and free radicals to be measured at one non-urban site. However, it was judged that the expense and uncertainty of these measurements did not merit their use. Model input requirements can be met satisfactorily by using typical values for the region, as determined from prior studies. The original Study Plan also included continuous ammonia measurements during the winter intensive period. The January 1999 Bakersfield measurement evaluation study, combined with other evidence, revealed that the technology available for continuous ammonia measurements was not sufficient to meet the accuracy, precision, and detection limit requirements of CRPAQS. Thus, ammonia was measured using the more conventional filter-based methods.

- **Micrometeorological tower enhancements:** A number of continuous measurements were added to the Angiola tower for the two-month winter campaign. A nephelometer was added at the base of the tower to provide, along with existing nephelometers at the midpoint and top of the tower, a measure of the vertical gradient of light scattering. At the top of the tower, instruments were added to measure light absorption (aethalometer), NO<sub>y</sub>, O<sub>3</sub>, and PM<sub>2.5</sub> nitrate. Fog chemistry measurements at several levels on the tower were also added for the winter.
- **Upper air network enhancements:** Additional doppler sodar wind monitors were added to the annual network to better characterize transport and mixing aloft. Additional radar profilers were also deployed during the CCOS summer 2000 study and remained through the CRPAQS winter intensive study at Chico, Waterford, Fresno Air Terminal, and San Martin.

During the 15-days of episodic monitoring, the following measurements were acquired:

- **Backbone network measurements:** Twenty-four hour PM<sub>2.5</sub> duration samples were acquired for mass concentrations at all sites and for chemical characterization at speciation sites. Some backbone sites had a daily schedule as part of their normal operation. At most other sites samples were collected every third day, some of which fell within the episodic monitoring periods.
- **Satellite network enhancements:** Twenty-four hour PM<sub>2.5</sub> samples were acquired daily for chemical speciation at most satellite sites. As in the annual network, backup filters were installed to obtain integrated nitric acid and ammonia concentrations.
- **Anchor network enhancements:** Five PM<sub>2.5</sub> substrate-based samples per day were acquired at five anchor sites over the periods of 0000-0500, 0500-1000, 1000-1300, 1300-1600, and 1600-2400 PST to include elements, ions (water

soluble sulfate, nitrate, ammonium, potassium), and carbon (organic and elemental) by research-grade sampling and analysis systems. At three of these sites, gas samplers were added to quantify ammonia and nitric acid concentrations by denuder difference. Four of these sites also acquired four samples per day (0000-0500, 0500-1000, 1000-1600, and 1600-2400 PST) to be analyzed for light hydrocarbons, heavy hydrocarbons, carbonyls, and organic particles. The selected periods bracket emissions and meteorological events while allowing sufficient sample to be obtained for analysis (the 1000-1300 and 1300-1600 periods are combined for organic samples to obtain sufficient quantity).

- **Upper air network enhancements:** Remote sensors of upper air winds and temperature were supplemented with rawinsondes launched four times per day at Bakersfield and Fresno on each of the fifteen days. Also, the schedule of routine launches at Oakland was augmented to four launches per day on the fifteen episode days, rather than the normal two launches per day. These rawinsondes provided continuous relative humidity measurements as well as more detailed wind measurements in the mixed layers.
- **In situ single particle quantification:** This experiment examined individual particles to determine their formation mechanisms and sources. Time of flight mass spectrometers were deployed at the Fresno urban anchor site and at the Angiola rural site to quantify the composition and size of individual particles.
- **Fog characterization:** The main purpose of fog characterization was to understand the extent to which fog attenuates  $PM_{2.5}$  concentrations by occult deposition. Quantity and composition of fog that deposits to the surface were measured at Angiola, as well as fog composition in fog droplets of different sizes at different levels of the micrometeorological tower. Less detailed measurements were taken at several outlying sites when fog was present to obtain a horizontal distribution.
- **Layer depth variability and chemical composition:** The original study plan called for aircraft and/or balloon measurements to evaluate the variability of depth in the valleywide layer and to evaluate the changes in concentration of secondary aerosol and precursors with height. These airborne measurements were never implemented because the days of most interest for measurements would be too foggy and/or hazy to allow safe flying conditions. Also, it was judged that the value of the data did not merit the high cost of the flights, and that the funding could be put to better use in ground-based measurements.

#### 1.3.4 Fall Campaign (October-November, 2000)

The fall intensive monitoring program focused on a small area in and around the town of Corcoran. Corcoran is a small community situated midway between Fresno and Bakersfield in an area of intense agricultural production. This region has historically recorded some of the highest fall  $PM_{10}$  concentrations in the Valley. These exceedances are generally dominated by geological material, and coincide with the time period of increased

agricultural activity. Meteorological conditions also tend to be stagnant and conducive to pollution buildup.

The fall study was conducted from October 9 to November 14, 2000. Twenty-five satellite sites with portable, battery powered nephelometers were operated in and around Corcoran to detect the influence of nearby sources. These were accompanied at ten sites by PM<sub>10</sub> minivol filter samplers which were operated daily to determine chemical composition. One additional site had minivol samplers only. In addition, the routine monitoring site operated in Corcoran by the San Joaquin Valley Air Pollution Control District (SJVAPCD) was augmented during the fall period with the addition of an aethalometer for continuous light absorption measurements, PM<sub>10</sub> and PM<sub>2.5</sub> beta attenuation monitors for continuous mass measurement, and a continuous particulate nitrate monitor.

Some fugitive dust marker measurements were conducted during the fall study. Samples for Scanning Electron Microscopy were collected at the fall study speciation minivol sites, and U.C. Davis collected samples for biological markers at the SJVAPCD site in Corcoran and at several mobile sites in the Corcoran source area.

#### **1.4 Study Design Philosophy**

There are many ways to design a field study to accomplish the objectives stated above. CRPAQS field study design was guided by the following tenets:

- Conceptual models of high particle concentrations come before mathematical models. Measurements that refine conceptual models are as important as those to supply mathematical model input and evaluation data.
- A variety of source and receptor models will be used to develop source/receptor relationships and evaluate control strategies. No single existing aerosol model is sufficient to reliably describe annual and episodic particle concentrations in central California. Measurements that support a variety of independent source apportionment methods will be acquired.
- Winter weather and meteorology differ from spring, summer, and fall meteorology and they have not been as intensively studied. Flows are not well-defined or easily measurable, mixed layers are shallow, and residence times are longer. Horizontal and vertical dispersion may dominate over advection. Meteorological measurements in the vertical as well as horizontal are enhanced during winter.
- PM<sub>2.5</sub> concentrations are highest during winter, and less is known about wintertime meteorology and particle formation mechanisms than is known about

non-winter situations. The majority of field study resources were directed toward a winter study to acquire knowledge about this period.

- Much is already known about  $PM_{10}$  in central California from prior studies and the existing  $PM_{10}$  network is extensive. The coarse particle fraction is largely composed of primary geological material while the  $PM_{2.5}$  fraction contains particles directly emitted by combustion sources and secondary aerosol. The  $PM_{2.5}$  fraction of  $PM_{10}$  is favored for intensive study during the winter when it dominates the  $PM_{10}$  and the entire  $PM_{10}$  fraction is favored for intensive study in the fall when the coarse particle fraction is large.
- From limited historical data,  $PM_{2.5}$  standards are most likely to be exceeded in Fresno and Bakersfield. These areas will be more intensively examined than other parts of central California. Detailed aerosol measurements in these urban areas are preferable to less detail in a larger number of cities. Large spatial coverage is obtained with the satellite site network.
- Primary  $PM_{2.5}$  contributions derive mostly from the urban area in which they are measured during winter. Wintertime secondary ammonium nitrate and ammonium sulfate concentrations result from regional-scale transport and mixing of emissions from urban and non-urban areas above a shallow surface layer, but within a valleywide inversion layer. Regional monitoring favors secondary aerosol over primary aerosol.
- Understanding ammonium nitrate formation, sources and precursors takes precedence over understanding ammonium sulfate formation and sources. Sulfate concentrations are much lower than those from other  $PM_{2.5}$  components; its sources are well identified and probably the most accurate in the emissions inventory. The ammonium/nitrate/sulfate chemical system is inter-related, so sulfate is not ignored.