EXECUTIVE SUMMARY

Study Purpose

Technical & Business Systems (T&B Systems) has been charged with characterizing the meteorology and air quality experienced during the 2000 field program. This analysis is a collaborative effort with major contributions by Dr. Charles Blanchard of ENVAIR and Dr. David Fairley of the BAAQMD. The general objectives of the characterization analyses are to provide:

1. Information required to support regional SIP analyses as well as SJV update
2. CCOS Technical Committee with characterizations of meteorology and air quality
3. Information to support model applications, and
4. Develop and improve conceptual model

The first phase of the CCOS characterization was an accelerated analysis motivated by an immediate need to provide information for assessment purposes that necessitated using whatever data were available at the time. Two interim reports resulted. This phase of the CCOS analyses is intended to expand upon the results of the initial accelerated analyses and prior relevant studies using the full CCOS database. The various analyses components undertaken for this study cover a wide-range of topics that reflect the diverse matters needed to be addressed by Technical Committee members. Components included are:

- A description of the synoptic-scale meteorological setting over the CCOS field campaign and within this broader context where the intensive operational periods (IOPs) occurred.

- Descriptive and analytical analyses of two select CCOS IOPs that are the candidates for SIP design days, July 27 to August 2, and September 17 to 21. This entailed a detailed examination of meteorological and air-quality conditions at the initiation, during the evolution, and end of the episode on both regional and local scales.

- Determination of the character of the meteorology and air quality during the IOPs and their interrelation.

- An examination of the historical (medium-term) meteorology and air-quality experience comparing the "severity" or representativeness of air-quality impacts during IOPs and overall field campaign.

- An analysis of historical ozone and precursor concentration measurements to determine how ozone levels have responded to changing precursor concentrations by examining spatial differences in the relationships between precursor and ozone levels.

Summary of Findings

The two episode periods selected for extensive analyses and modeling encompass ozone peaks in the seasonal records. Exceedances of both the State and Federal Ozone Standards were experienced in the Sacramento Valley (SacV) and San Joaquin Valley (SJV) air basins during the July/August episode. The Bay Area experienced exceedances of the State Ozone Standard but narrowly missed exceeding the Federal Standard (Livermore had a 124 ppb). During the September episode, both the State and Federal Ozone Standards were exceeded in the SJV but only the State Standard was exceeded in the other two basins (although the greater

Sacramento area reached ozone levels as high as 123 ppb). The maximum ozone experienced during CCOS was 165 ppb on September 18th at Parlier, a site in the central SJV. The patterns of peak surface ozone concentrations during the two episodes are depicted on Figure ES-1.

The July/August episode was initiated due to a high-pressure weather system centered over Four Corners---a weather pattern commonly associated with severe ozone episodes in California. However, as the episode progressed, the high-pressure system drifted west, interrupting regional meteorological processes typically associated with ozone episodes in Central California such as the nocturnal jet and "Fresno" eddy.

The meteorology during the September episode was quite different in that there was significant longitudinal variation in the synoptic pattern along the west coast and the forces that drive local winds were less pronounced owning to seasonal features (e.g., reduced insolation). Pressure gradients in the central and southern SJV were relaxed resulting in only light boundary layer winds. In contrast, a moderate to strong northerly flow persisted in the SacV during the first half of the episode and the predominant flow in the Delta region was offshore. A more typical onshore wind developed later in the episode that penetrated upvalley as far as the greater Sacramento area. Salient features of the conceptual meteorological model such as the nocturnal jet and Fresno eddy ranged from light or non-existent during this episode.

The regional meteorology during the July/August episode was similar in many respects to the conceptual model on which the field program was designed. Prevailing flows were characterized by persistent inflow to the Central Valley from the central coast through the Carquinez Strait, passes, and lower gaps in the coastal ranges. Winds in the Delta region split providing ozone and precursor transport opportunities upvalley in both the SacV and SJV, with the major flux directed into the latter region. Estimates are that approximately 90 percent of the total low-level flux into the SJV entered from the Carquinez Strait and 10 percent from the Altamont Pass area. Relative contributions and volume flow rates did vary considerably over the diurnal cycle. Peak inflow occurred in the afternoon. Minimum inflow was observed in the predawn hours. Nocturnal jet-like winds developed in the SJV peaking at ~ 22 PST. A reverse downvalley flow developed on the east side of the SJV in the late night/early morning resulting in an anticyclonic circulation in the Fresno area. Flows in the southern SJV were generally lighter and less organized. In the SacV, low-level winds tended to peak in the evening and early morning followed by a slack until noon. Cross-valley shears were measured after sunrise providing the mechanism to form the so-called Shultz eddy in the southern SacV.

In contrast, the features most commonly associated with the current conceptual model were not observed during the September episode. Synoptic pressure gradient forces were greater, overwhelming the regional terrain-driven winds. In the SacV, the flow was generally downvalley throughout the diurnal cycle. Flow in the central and southern SJV were generally weak providing little ventilation processes, whereas the northern SJV experienced winds more common with the SacV. Although the September episode exhibited very different characteristics that the July/August episode and the two AUSPEX/SJVAQS episodes on which the conceptual model was predicated, the meteorology was likely not uncharacteristic of late summer conditions.

Surface slope flows behaved in a consistent manner apparently unaffected by changes in the synoptic-scale meteorology. Differences measured in the two episodes were due to the reduction in slope heating resulting from shorter days rather than regional or synoptic scale gradients. The effects of the slope-induced flows at distances away from the Sierra were reduced as well owing to seasonal insolation variation.

SIP design days ideally occur when there are widespread regional ozone standard exceedances which at the same time are not aberrations in the sense of unusual meteorological events (i.e., benchmarks relative to the historical record) or emission events (i.e., catastrophe). To determine the representativeness of the CCOS episodic periods, a number of statistical approaches were taken that included classifying weather patterns over a medium-length period (13 years), and using CART analyses to establish relationships between weather types and routinely measured meteorological parameters, and sub-basin peak ozone levels. The resulting CART decision trees weighted the weather types as relatively unimportant, and at the same time did an excellent job of identifying outliers in the historical record. With regards to the CCOS modeling episodes, peak ozone levels in the six Central California sub basins were, for the most part, historically representative of other periods with similar meteorology. All but five instances fell within 68 percent of the historical population--all in different sub basins. Of those five, one instance (165 ppb at Parlier on September 18) fell outside of the 95 percentile. It is noteworthy that the meteorological conditions on that day were not particularly unusual, and therefore cannot explain the high ozone experienced.

A variety of air quality and meteorological data sets were analyzed for long-term trends. Ozone and precursor concentrations were examined to determine how ozone levels have responded to changing precursor concentrations, and for evidence of spatial differences between those relationships. Synoptic-scale meteorological patterns were examined for trends in the periodicities of major features.

For the period from 1980 through 2000, most monitoring locations in the San Francisco Bay Area, SJV, SacV, North Central Coast, and South Central Coast showed downward trends in either CO (41 of 43 sites; 30 statistically significant at $p<0.01$) or NO_x (51 of 57 sites; 25 statistically significant at $p<0.01$) concentrations, and usually in both. Declining concentrations of alkanes, alkenes, aromatics, ethylene, propylene, toluene, ethane, and benzene occurred during one or more sampling hours at NMOC-monitoring sites with at least five years data (Sacramento - Del Paso, Parlier, Arvin, Fresno - 1st Street, Clovis, and Bakersfield - Golden State Highway) during the period 1994 to 2000, though statistical significance levels for these trends varied widely.

The majority of monitoring sites in the Bay Area and the South Central Coast showed reductions of annual 4th-highest peak 8-hour ozone in the range of 15 to 25 percent per decade over 1980 to 2000. Most sites in Kern County showed small (less than 5 percent) decadal reductions of peak 8-hour ozone during the same 20-year period. Many sites near Fresno (3 of 6) and in the northern SacV (5 of 9) showed increasing peak 8-hour ozone levels.

The trends in regional peak 8-hour ozone concentrations were correlated with regional trends in ambient NO_x levels (though the regional 8-hour ozone trends in the Bay Area were greater than in other areas with comparable NO_x declines). NMOC reductions in the southern SacV and the SJV were not matched by reductions in peak ozone levels.

The trends in the sites' annual 4th-highest 8-hour maxima were correlated with population changes. The mean decline in the annual 4th-highest 8-hour maxima was about 2 percent per year when no population change occurred, diminishing to no trend for population increases greater than about 22 percent per decade.

Based on a 1957 to 2002 record of measured 500 mb heights at Oakland, California, there is no evidence of a regular periodic pattern in the occurrence of high and low pressure systems during the ozone season. There is weak evidence that the time between 500 mb height peaks

is getting larger rather than shorter which was the hypothesis tested. However, there is a clear trend toward increasing frequency of 500 mb heights greater than 5910 meters. Because high surface-level ozone is generally associated air-mass stability that, in turn, is associated with high-pressure systems, this suggests that there has been a trend toward greater meteorological ozone potential.

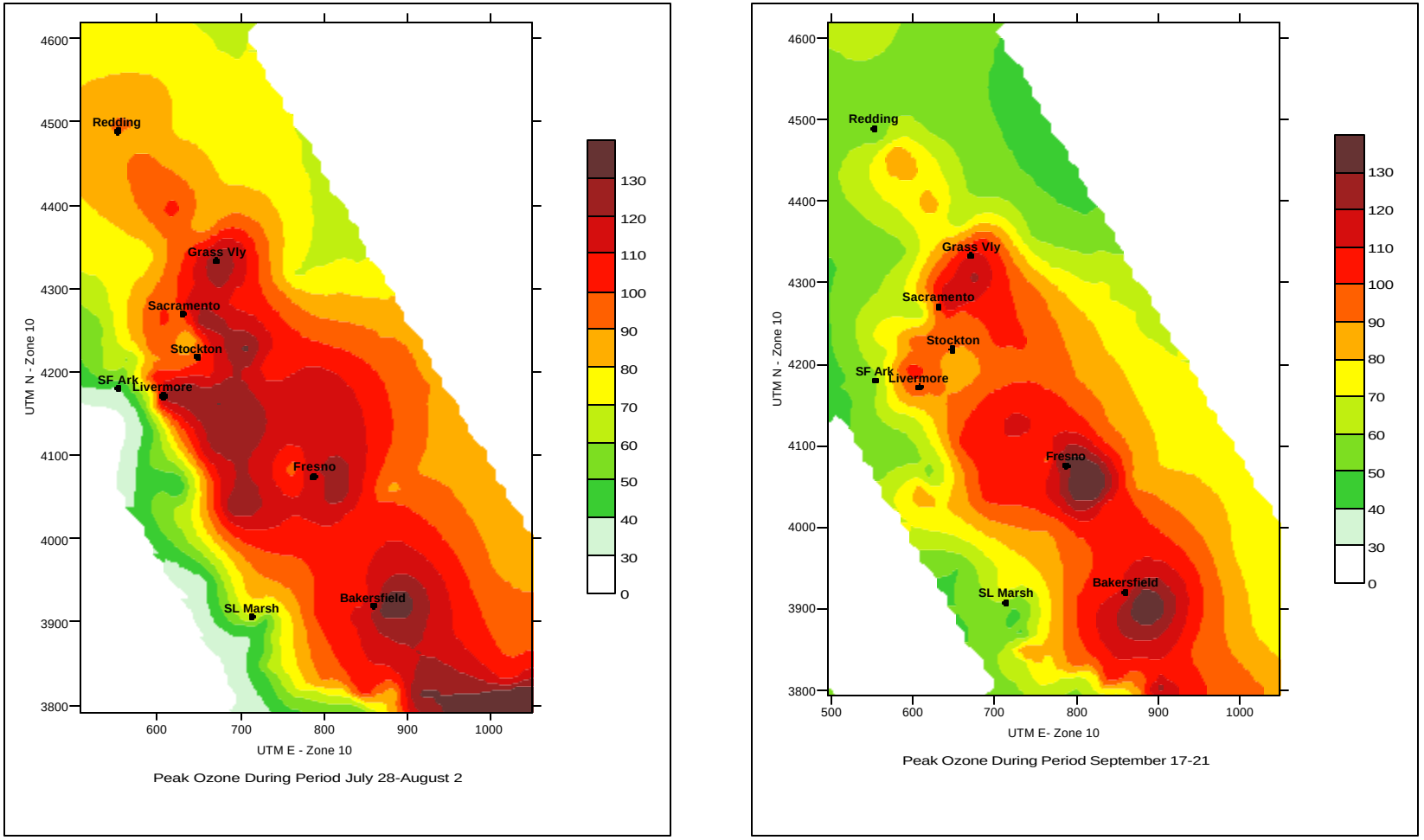

Figure ES-1. Maximum Hourly Ozone Concentrations During CCOS Episodes on July 28 to August 2 (left panel) and September 17 to 21 (right panel)