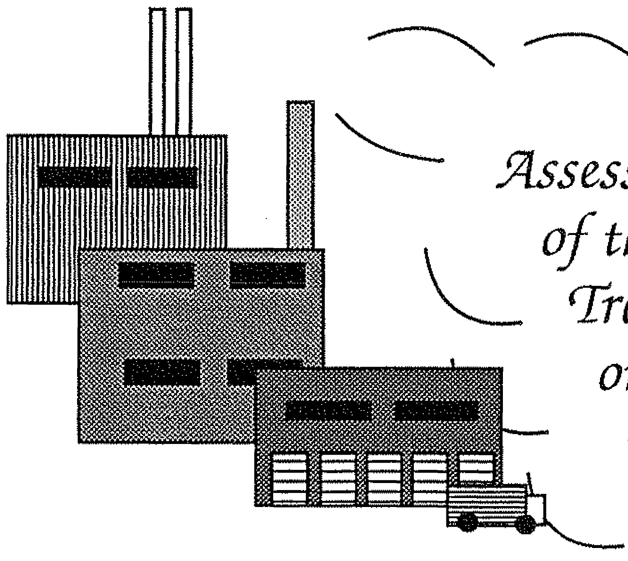
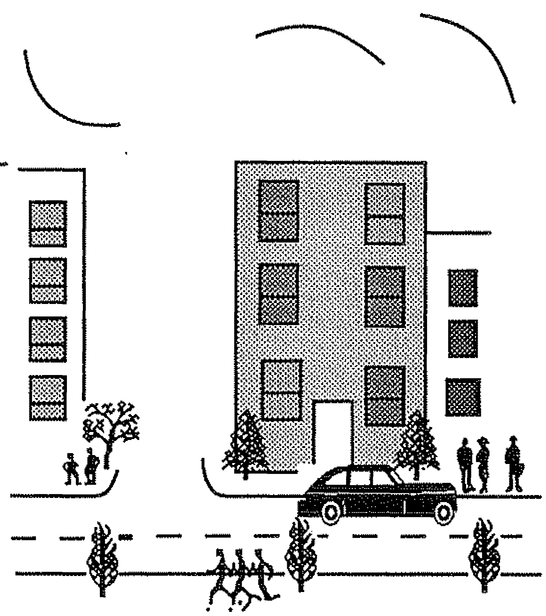


Assessment and Mitigation of the Impacts of Transported Pollutants on Ozone Concentrations within California



State of California
AIR RESOURCES BOARD
Staff Report
June 1990

Prepared by:
Technical Support Division
and
Office of Air Quality Planning and Liaison

State of California
AIR RESOURCES BOARD

SUPPLEMENT TO THE JUNE 1990 STAFF REPORT

"ASSESSMENT AND MITIGATION OF THE IMPACTS OF TRANSPORTED POLLUTANTS ON OZONE CONCENTRATIONS WITHIN CALIFORNIA"

August 9, 1990

Prepared by

Air Quality Analysis Section
Air Quality Data Branch
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SUPPLEMENT TO THE JUNE 1990 STAFF REPORT "ASSESSMENT AND MITIGATION OF THE IMPACTS OF TRANSPORTED POLLUTANTS ON OZONE CONCENTRATIONS WITHIN CALIFORNIA"

Summary

The staff performed additional analyses[1] subsequent to the release of the June 1990 staff report entitled "Assessment and Mitigation of the Impacts of Transported Pollutants on Ozone Concentrations within California" ("June 1990 staff report"). Based on these analyses, the staff is recommending two transport contribution findings in addition to those contained in the June 1990 staff report.

First, the staff recommends that transport from the San Francisco Bay Area Air Basin (SFBAAB) to the North Central Coast Air Basin (NCCAB) also be classified as "Significant" on some days.

Second, the staff recommends that transport from the Broader Sacramento Area (Broader Sac) to the Upper Sacramento Valley (Upper Sac) also be classified as "Overwhelming" on some days.

The bases for recommending these additional transport classifications are presented in the remainder of this supplement to the June 1990 staff report.

1. The analyses described in this report incorporate preliminary findings from work performed by Sonoma Techology Inc. under contract number A932-129: "A Study to Determine the Nature and Extent of Ozone and Ozone Precursor Transport in Selected Areas of California."

Assessment of Transport Contribution for the 1989 Exceedance Days in the North Central Coast Air Basin

This section presents an assessment of the contribution of ozone and ozone precursor emissions from the San Francisco Bay Area Air Basin (SFBAAB) to exceedances of the state ozone standard on four days during 1989 in the North Central Coast Air Basin (NCCAB). A summary of the days, ozone concentrations, and findings regarding the transport contribution is presented in Table 1.

Table 1

ASSESSMENT OF THE 1989 OZONE EXCEEDANCES IN THE NORTH CENTRAL COAST AIR BASIN*

Location	Date	Max Ozone Conc	Hour of Maximum	Time Above Standard	SFBAAB Transport Contribution
Davenport	April 9	0.10	11 am	11 am - 1 pm	Overwhelming
Carmel Valley	April 9	0.10	2 pm	2 - 3 pm	Significant
Carmel Valley	June 21	0.11	3 pm	2 - 6 pm	Significant
Carmel Valley	July 6	0.13	4 pm	3 - 5 pm	Significant
Hollister	Nov. 12	0.10	2 pm	2 - 3 pm	Significant

* The state ozone standard is exceeded if an hourly concentration exceeds 0.09 parts per million (ppm); ozone concentrations are in ppm

In the June 1990 staff report, the staff based the assessment of overwhelming transport from the SFBAAB to the NCCAB on a review of the 12 days during the three year period of 1986 through 1988 when the state standard for ozone was exceeded in the NCCAB only at Hollister. However, the conditions leading to the exceedance at Hollister on November 12, 1989 were substantially different than conditions on the 12 days in 1986-1988. The air mass with the high ozone concentrations on November 12, 1989, had an overwater route rather than an overland route up the Santa Clara Valley.

The 1989 data indicate a more extensive distribution of high ozone concentrations in the NCCAB than in the previous three years. While the exceedances during 1986 through 1988 in the NCCAB were confined to the monitoring site at Hollister, the exceedances in 1989 occurred at two sites in addition to Hollister. At these three sites, ozone concentrations in the NCCAB exceeded the state ozone standard for ten hours on four days during 1989. As shown in Table 1 above, ozone concentrations in 1989 exceeded the state standard for seven hours on three days at Carmel Valley, for two hours on one day at Davenport, and for one hour on one day at Hollister. The maximum one-hour concentrations at these monitoring sites in the NCCAB in 1989 were 0.13 ppm at Carmel Valley and 0.10 ppm at Hollister and Davenport.

For the assessment of transport contribution to the exceedances in 1989, the staff relied primarily on data for winds at the surface and aloft, temperatures at the surface and aloft, surface pressure differences between San Francisco and Reno, and ozone concentrations at sites in and around the NCCAB. The staff generated plots of back trajectories for each exceedance both by computer and by hand because each method has strengths and weaknesses. If the results from both trajectory methods for a particular day were similar, the staff had greater confidence in the results suggested by the trajectories. Although upper air wind data are critical to determining the potential for transport aloft, the nearest source of upper air wind data was the rawinsonde soundings conducted twice daily at Oakland. Therefore, the staff only used the Oakland sounding data to assess qualitatively the potential for transport. If the sounding data indicated the airflow had a large northerly component, then transport was deemed possible. Airflow aloft had a northerly component on several of the violation days. The data supporting the assessment for each day are presented below in the discussion of each exceedance episode.

<u>April 9, 1989</u>

On April 9, 1989, the state ozone standard was exceeded at Davenport and Carmel Valley in the NCCAB. The maximum-hour concentration at both sites was 0.10 ppm. Based on an assessment of the available meteorological data, the staff concluded that the exceedance at Davenport was the result of overwhelming transport from the SFBAAB. The staff also concluded that the exceedance at Carmel Valley was the result of the contribution of ozone precursor emissions and ozone from both the SFBAAB and the NCCAB.

Meteorological conditions indicated airflow that could transport pollutants from the SFBAAB to the NCCAB. Subsidence heating caused by a high pressure system resulted in unusually high surface temperatures on April 8 throughout the SFBAAB and the NCCAB, including the coastal areas. These high temperatures indicated an airflow that could carry pollutants offshore. An offshore airflow can also be inferred by the difference in atmospheric surface pressures at San Francisco and Reno. Normally, the morning pressure is higher in San Francisco than in Reno, but on April 8 and 9, the pressure was 4.4 and 4.1 millibars (mb) higher, respectively, in Reno than in San Francisco. Therefore, the higher pressure at Reno than San Francisco suggests an airflow from the east during the two days.

By the afternoon of April 9, surface winds throughout the region were from the northwest as were the winds aloft at Oakland. This airflow meant that ozone and ozone precursor emissions which had moved offshore that morning and the previous day could now be transported southeastward to the NCCAB. A decrease in maximum temperatures from the 90's on April 8 to the 70's and 80's on April 9 at Salinas, Santa Cruz, and Monterey provides further evidence of a change to an onshore flow in the Monterey Bay area.[2]

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2. All temperatures in this document are stated in degrees Fahrenheit.

A back trajectory generated by the CALTECH-WIND2D model indicated that air arriving at Davenport on April 9 at the time of the 0.10 ppm ozone exceedance (11 am), had moved very slowly during the morning near the coast (see Figure 1). The trajectory indicates that ozone and ozone precursor emissions originated in the San Francisco Bay area on April 8 were transported to the Davenport area on April 9.

Another back trajectory analysis indicated that air arriving at Carmel Valley on April 9 at the beginning of the 0.10 ppm ozone exceedance (2 pm), had been along the coast north of Davenport the day before (see Figure 2). This air had moved southeastward from the San Francisco Bay area along the coast on April 8 and came onshore around 8 pm just south of Moss Landing. During the night of April 8 and the following morning, the air drifted offshore with the drainage flow and then back onshore over Monterey late in the morning of April 9, arriving in Carmel Valley at 2 pm. This trajectory suggests that air with ozone and ozone precursor emissions originally from the SFBAAB came onshore near Moss Landing late in the evening of April 8. While onshore, the air accumulated ozone precursor emissions from nearby emissions sources and then drifted out over the Monterey Bay overnight. During the morning of April 9 the air moved onshore over Monterey picking up additional ozone and ozone precursor emissions before arriving at Carmel Valley by 2 pm.

The offshore flow from the SFBAAB on April 8, as indicated by pressure differences and warm coastal temperatures, combined with onshore flow in the NCCAB on April 9, as indicated by cool coastal temperatures and the back trajectory analyses, provide strong support for finding that the exceedance at Davenport was the result of an overwhelming contribution of ozone and ozone precursor emissions from the SFBAAB. The offshore flow from the SFBAAB on April 8 combined with the oscillating onshore, offshore, onshore pattern in the NCCAB on April 9, as indicated by the back trajectory analysis, supports a finding that the exceedance at Carmel Valley resulted from ozone precursor emissions and ozone from both the SFBAAB and the NCCAB.

June 21, 1989

On June 21, 1989, ozone concentrations at Carmel Valley exceeded the state standard for four hours between 2 and 6 pm. The maximum concentration of 0.11 ppm occurred between 3 and 4 pm. Based on a review of the aerometric data for June 20 and 21, 1989, the staff concluded that ozone precursor emissions and ozone from both the SFBAAB and the NCCAB contributed to the exceedance at Carmel Valley.

Ozone concentrations on June 21 in the NCCAB exceeded the state standard only at Carmel Valley. Ozone concentrations at Santa Cruz did not exceed the standard but peaked at 0.09 ppm between 4 and 5 pm. Maximum concentrations at Davenport, Hollister, and Salinas were 0.06 ppm. The time of maximum concentrations at Carmel Valley and Santa Cruz are inconsistent with typical times for maximum ozone concentrations from local emissions. The staff reviewed aerometric data to investigate the potential for transport to have caused the high concentration at Carmel Valley.

Ozone concentrations on the previous day, June 20, in the SFBAAB were low--the maximum concentration was 0.08 ppm at Gilroy. Concentrations on June 21 remained relatively low with maximums in the South Bay of 0.10 ppm at Gilroy, 0.09 ppm at Mountain View, and 0.08 ppm at San Jose. Ozone concentrations on June 20 and 21 were also low in the Sacramento and northern San Joaquin Valleys. Except at Carmel Valley and Gilroy, exceedances of the standard in California only occurred from Fresno southward. Thus, the spatial and temporal distribution of ozone concentrations in northern and central California as well as the magnitude of the concentrations indicate that conditions were not conducive to the transport of high ozone concentrations in the surface layer of air. However, ozone precursor emissions may have been transported near the surface. Hydrocarbon and oxides of nitrogen concentrations on the evening of June 20 and the following morning were the highest of the month at many SFBAAB sites.

Meteorological conditions caused precursor concentrations to increase. Increasing high pressure aloft caused temperatures at the 950 mb pressure level (about 1800 feet above sea level) to increase dramatically on June 20 from 59 degrees in the morning to 75 degrees in the afternoon. The Oakland sounding indicates that the inversion did not break and allowed ozone precursors in the SFBAAB to accumulate. The temperature sounding at Oakland on the morning of June 21 indicated a strong surface-based inversion up to about 1500 feet. The precursor emissions in the SFBAAB likely were confined to a shallow layer during the early morning. Temperatures in the 90's throughout most of the SFBAAB were sufficient to break the inversion and prevent the build-up of high ozone concentrations throughout the SFBAAB.

In addition, the pressure difference between San Francisco and Reno had changed from 3.4 mb (indicating onshore flow) on the morning of June 20 to minus 9.2 mb (indicating offshore flow) on the morning of June 21. Offshore flow which could carry ozone and ozone precursor emissions offshore likely developed during the evening of June 20. Maximum temperatures along the coast west and southwest of the SFBAAB were high on June 21, 76 at Half Moon Bay (up from 66 the day before), 90 at San Gregorio, and 96 at Santa Cruz. These warm coastal temperatures also indicated offshore surface airflow. Surface winds at Monterey, Salinas, and Fort Ord were generally onshore except during the early morning hours on June 21 when offshore flow occurred. Thus, pollutants that moved offshore from the SFBAAB were carried onshore in the NCCAB by the afternoon seabreeze on June 21.

A surface wind trajectory generated by the CALTECH-WIND2D model indicated that the air parcel associated with the first hour of the exceedance (2 pm) on June 21, 1989, at Carmel Valley was near the Farallon Islands about 10 pm on June 20. The parcel moved southeastward off the coast of the San Francisco Peninsula, over the Monterey peninsula, and into Carmel Valley (see Figure 3).

Vertical soundings of temperature and wind at Oakland, the pressure difference between San Francisco and Reno, and the warm coastal temperatures indicate that a polluted layer of air near the surface likely moved offshore from the SFBAAB where it became entrained in the airflow along the coast that later impacted Carmel Valley. Thus, emissions in the SFBAAB likely contributed to the ozone loading of the air mass associated with the exceedance of the state ozone standard at Carmel Valley. Because this air mass passed over the Monterey Peninsula and could have accumulated additional ozone precursors from emission sources around the peninsula, the staff concluded that emissions from both the SFBAAB and the NCCAB contributed to the exceedance of the ozone standard on June 21, 1989, at Carmel Valley.

July 6, 1989

On July 6, the maximum concentration in the NCCAB (0.13 ppm) occurred at Carmel Valley at 4 pm; the state ozone standard was exceeded for two hours, from 3 pm till 5 pm. The late afternoon peak is a strong indication that the elevated ozone concentrations were caused primarily by transport rather than local photochemical production. However, the staff was unable to make a definitive assessment of the sources of ozone and ozone precursors causing the July 6 exceedance at Carmel Valley. The staff suspects that emissions from both the SFBAAB and the NCCAB contributed to the exceedance.

Ozone concentrations on July 5 were below the standard in both the SFBAAB and the NCCAB; the peak ozone concentration for the two air basins was 0.09 ppm and occurred at Gilroy in the southern portion of the Santa Clara Valley in the SFBAAB. Exceedances of the ozone standard on July 6 occurred throughout the SFBAAB, including Fremont (0.12 ppm), San Jose (0.12 ppm), and Gilroy (0.13 ppm). Carmel Valley was the only site in the NCCAB where an exceedance of the ozone standard was measured on July 6.

On the afternoon of July 5, the surface winds at Moss Landing were from the northwest throughout the afternoon and evening with peak speeds of 15 mph in the afternoon. Surface winds at Monterey were from the north-northwest at 5 to 10 mph throughout the afternoon hours but were calm by late evening.

Morning temperatures at 2000 feet above Salinas increased 15 degrees from July 4 to July 5, from 60 to 75. The temperature at 2000 feet continued to increase to 82 degrees on July 6. These warm temperatures aloft helped to create a strong inversion that limited the dispersion of pollutants to less than 2000 feet. In the San Francisco Bay Area, temperatures at 1800 feet were also warm and increased 8 degrees, from 81 on July 5 to 89 on July 6.

The high temperatures aloft also caused maximum surface temperatures in inland valleys and along the coast to be higher than average on July 6. Monterey and Salinas had maximum temperatures in the 80's and Santa Cruz in the 90's while Gilroy and Hollister in the inland valleys had maximum temperatures in the 100's. Maximum temperatures were also high along the coast of the SFBAAB on July 6 (71 at Half Moon Bay and 76 at San Gregorio). Although high coastal temperatures usually indicate an offshore airflow, coastal wind observations for July 6 did not indicate a strong flow offshore. Some wind data for Davenport indicated offshore flow from late on July 5 until mid-morning of July 6. The pressure difference between San Francisco and Reno indicated only a potential weak offshore flow

(-1.1 mb) on July 5 and moderate offshore flow (-3.5 mb) on the morning of July 6. Because there was no clear indication of an offshore air flow, the staff was uncertain whether the air mass from the SFBAAB was moved offshore.

The staff next reviewed the data for winds aloft over Oakland. But for the morning of July 6, the winds aloft over Oakland were not indicative of transport aloft. However, if the air mass moved offshore from the SFBAAB, the data for winds on the coast of Monterey Bay indicated that the air mass would have moved onshore in the NCCAB. Surface winds at Monterey during the early morning hours of July 6 were calm but they increased in speed from the northwest throughout the morning and afternoon hours. Moss Landing winds speeds were light from the northwest during the early morning of July 6, but increased to 5-10 mph during late morning and afternoon.

A back trajectory based on surface winds indicated that the air parcel arriving at Carmel Valley at 4 pm on July 6 had been in an area near the Farallon Islands and San Francisco on the afternoon of July 5 (see Figure 4). The back trajectory indicates that the air parcel travelled along the coast to the Monterey Bay area. Because ozone concentrations were low in the SFBAAB on July 5, the air parcel most likely contained primarily ozone precursor emissions. Total hydrocarbon and oxides of nitrogen concentrations at sites in the SFBAAB were high on July 5 and, at many sites, were the highest of the month on July 6. The air parcel then passed over the Monterey urban area one to two hours prior to the time of the peak ozone concentrations at Carmel Valley. As the air parcel travelled over the urban area, additional ozone precursor emissions could have been added before the air parcel arrived at Carmel Valley a couple of hours later.

If the ozone precursors were carried offshore from the SFBAAB on July 5 and 6, the staff believes the precursors were likely caught up in the airflow arriving later at Carmel Valley. The staff believes that additional precursors from the NCCAB could have been added into the air as it passed over the Monterey urban area. Therefore, the staff suspects that the exceedance on July 6 at Carmel Valley was caused by ozone and ozone precursors from both the SFBAAB and the NCCAB.

November 12, 1989

On November 12, 1989, ozone concentrations at Hollister exceeded the state standard with a peak concentration of 0.10 ppm at 2 pm. Based on a review of the aerometric data for November 11 and 12, the staff concluded that ozone precursor emissions from both the SFBAAB and the NCCAB contributed to the exceedance at Hollister. This exceedance was classified different (significant) than those during the previous three years (overwhelming) because the surface wind data indicated a different airflow pattern. The exceedances in 1986-1988 were associated with air from the SFBAAB travelling through the Santa Clara Valley to Hollister in the NCCAB. On November 12, 1989, the airflow south through the Santa Clara Valley was opposed by airflow from the Monterey Bay. These winds from opposite directions met or converged in the region between San Martin and Gilroy. Thus, the air containing the ozone causing the exceedance at Hollister did not come through the Santa Clara Valley.

Ozone concentrations on November 12 in the NCCAB exceeded the state standard only at Hollister. Ozone concentrations at other sites did not exceed 0.04 ppm. In the Santa Clara Valley of the SFBAAB, ozone concentrations on November 12 peaked at 0.07 ppm at 2 pm at Gilroy and did not exceed 0.04 ppm elsewhere. Ozone concentrations did not exceed the standard on the previous day (November 11) in either the NCCAB or SFBAAB. The staff reviewed the available aerometric data to investigate the potential for transport to have contributed to the exceedance at Hollister.

Ozone concentrations on November 11 and 12 were also low in the Sacramento and northern San Joaquin Valleys; exceedances of the state ozone occurred only in Fresno County and southward. Thus the spatial and temporal distribution of ozone concentrations in northern and central California as well as the magnitude of the concentrations indicate that conditions were not conducive for the transport of ozone in the surface layer of air. However, ozone precursor emissions may have been transported in the surface layer or aloft. Hydrocarbon and oxide of nitrogen concentrations were higher than the monthly average on November 10 and 11 at most sites in the south portion of the SFBAAB.

The temperature sounding at Oakland on the morning of November 11 indicated a surface-based inversion up to about 3000 feet. The inversion was particularly strong up to about 1000 feet. Precursor emissions likely remained relatively close to the surface until late morning when warming temperatures caused turbulence and mixing of the air. Data from the 4 pm Oakland sounding indicated that the turbulence and mixing extended to about 2500 feet late on November 11. Because the ozone precursors likely were confined below the inversion, the concentrations remained relatively high. The low sun angle in November diminished the intensity of the ultraviolet radiation and the rate of the photochemical reactions. Thus, ozone precursors likely were moved out of the SFBAAB before high ozone concentrations could be formed.

The Oakland sounding indicated that winds were from the northeast between about 1000 and 5000 feet on the morning of November 11 and between 1000 and 3000 feet that afternoon. These wind measurements suggest that winds aloft could have transported ozone and ozone precursors offshore from the SFBAAB. On November 12, both the 4 am and 4 pm soundings at Oakland indicated west through northwest winds at the surface and aloft. The northwest and west winds would carry the air mass that originated in the SFBAAB onshore into the NCCAB on November 12. The 12 degree drop in maximum temperatures along the coast from November 11 to November 12 also indicate a return to onshore airflow.

A surface wind trajectory generated by the CALTECH-WIND2D model indicated that air associated with Hollister at the hour of the exceedance (2 pm) on November 12 was near Davenport most of November 11 and arrived at Moss Landing by 7 pm. The air then drifted southward to Salinas, northeastward over San Juan Bautista, and finally into Hollister (Figure 5). A hand-drawn trajectory showed that air from the north end of Salinas Valley flowed to Hollister by 2 pm on November 12 (see Figure 5).

A review of the wind data from Gilroy and San Martin appears to indicate that airflow from the SFBAAB did not penetrate the NCCAB to Hollister. Apparently, airflows from the SFBAAB and NCCAB were converging in the southern Santa Clara Valley between Gilroy and an area south of San Martin. Winds at San Martin were generally from the north during all 15 hours from midnight until 3 pm on November 12. While this indicates airflow up the Santa Clara Valley from the SFBAAB, little of this airflow penetrated the NCCAB because data for Gilroy (between San Martin and the NCCAB) indicated only five hours of northerly winds during the same 15 hours. Although the winds at San Martin were also northerly during the three hour period preceding the exceedance at Hollister, the winds at Gilroy were only northerly during one hour. In addition, winds at Moss Landing were generally from the west for seven hours during this same period. Thus, the exceedance at Hollister appears to be associated with airflow from the coast rather than the Santa Clara Valley.

In summary, vertical soundings of temperature and wind at Oakland and coastal temperatures indicate that an air mass likely moved offshore from the SFBAAB. This same air mass later returned onshore further south through Monterey Bay and impacted Hollister. Thus, emissions in the SFBAAB likely contributed to the exceedance of the state ozone standard at Hollister. Because this air mass was in the NCCAB much of the day and could have accumulated additional ozone precursors from emission sources there, the staff concluded that emissions from both the SFBAAB and the NCCAB contributed to the exceedance of the ozone standard on November 12, 1989, at Hollister.

Figure 1
Computer-generated Back Trajectory
for the April 9, 1989 Exceedance at Davenport

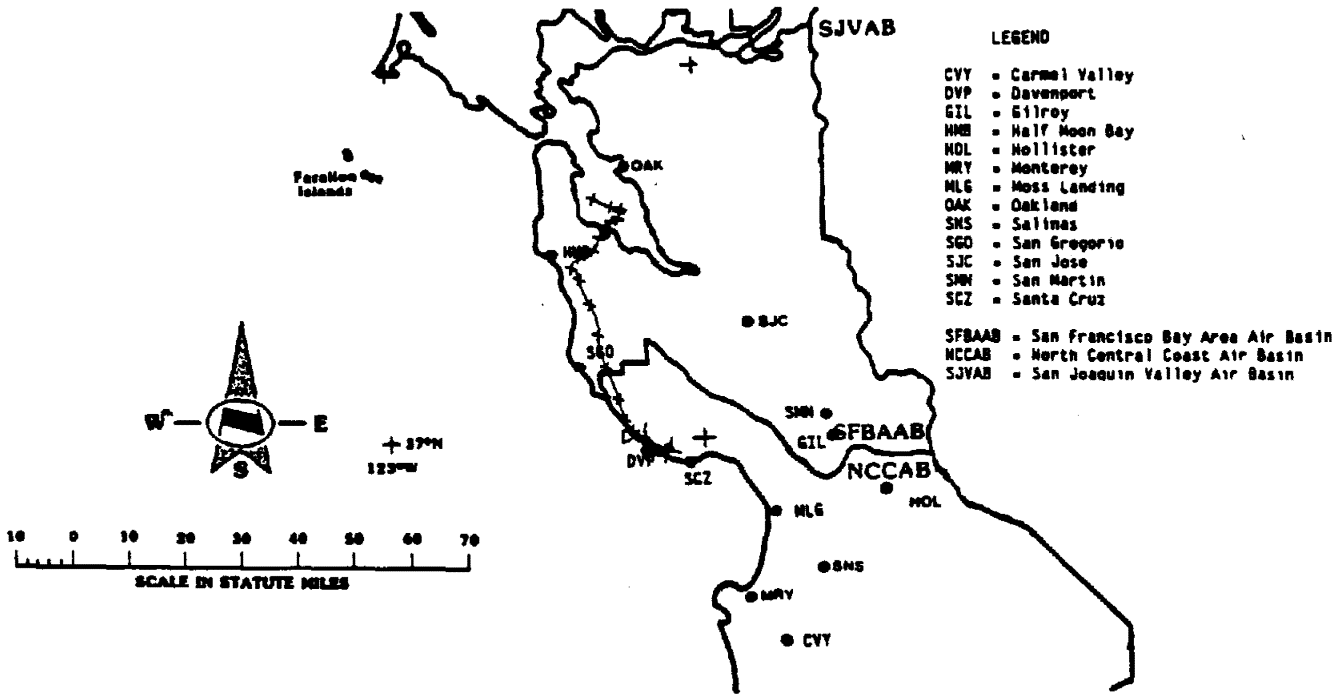


Figure 2
Computer-generated Back Trajectory
for the April 9, 1989 Exceedance at Carmel Valley

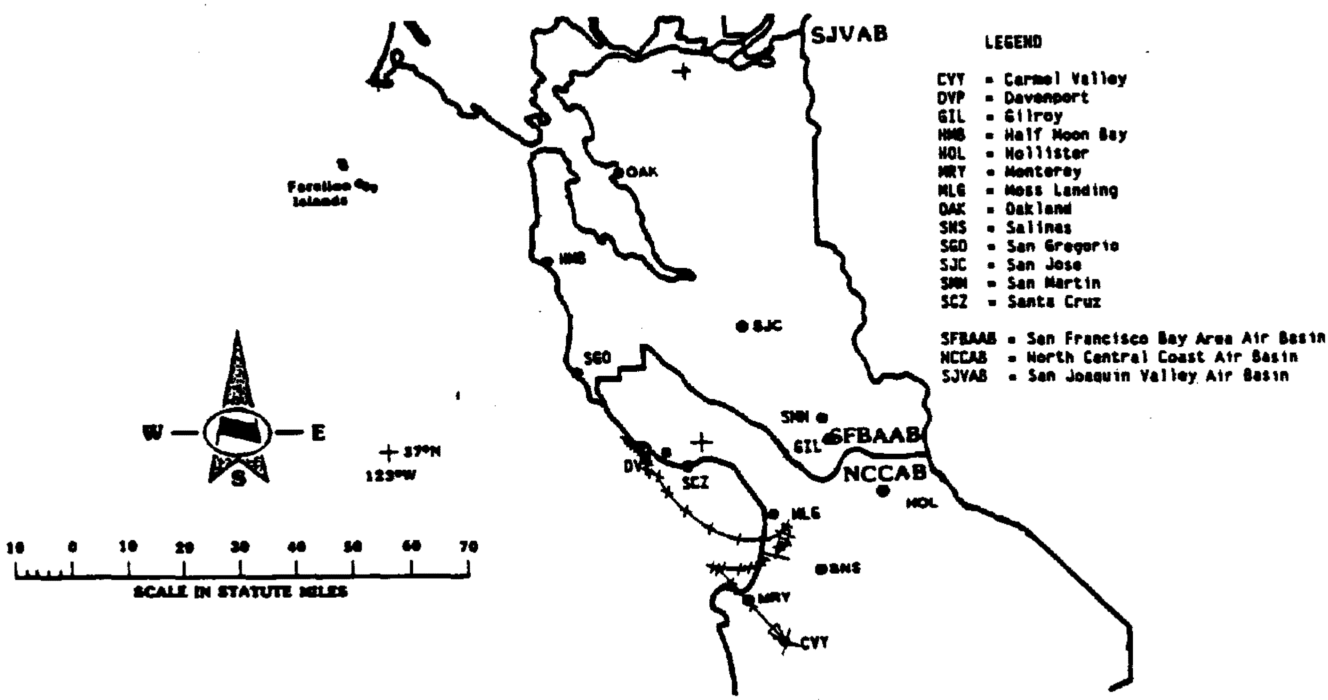


Figure 3
Computer-generated Back Trajectory
for the June 21, 1989 Exceedance at Carmel Valley

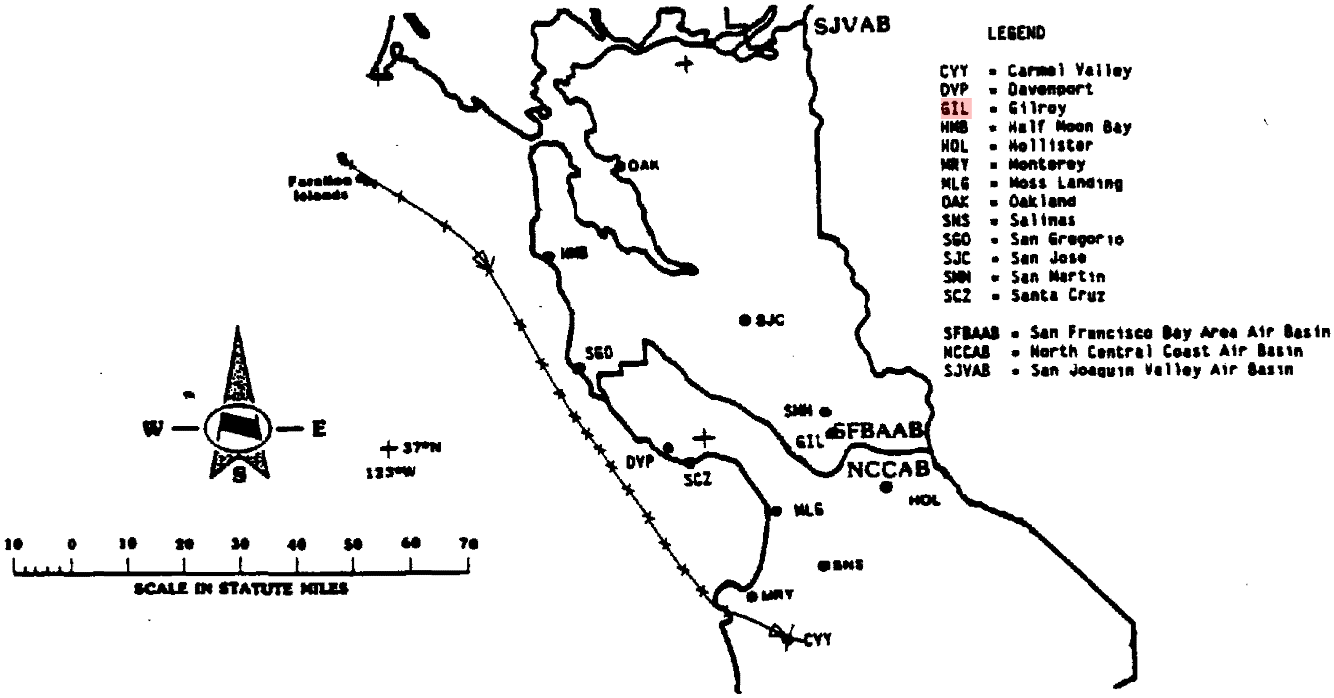


Figure 4
Computer-generated Back Trajectory
for the July 6, 1989 Exceedance at Carmel Valley

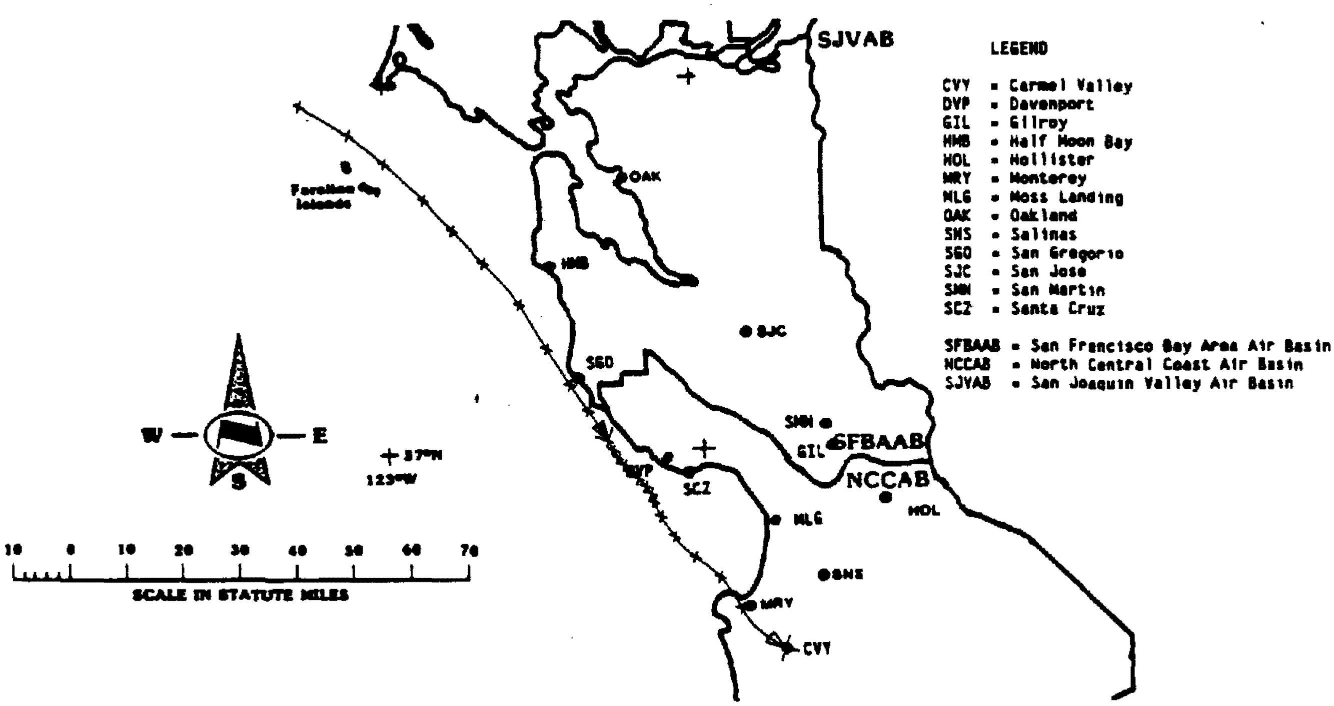


Figure 5
Computer-generated Back Trajectory
for the November 12, 1989 Exceedance at Hollister

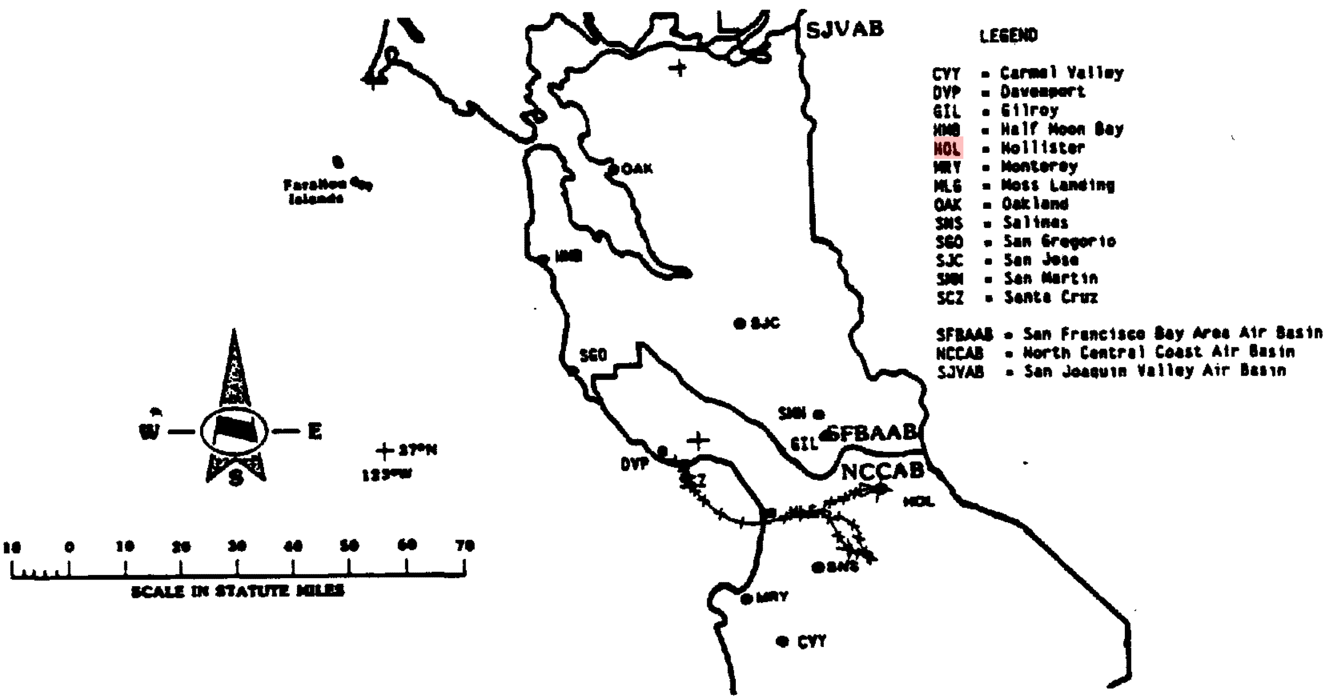
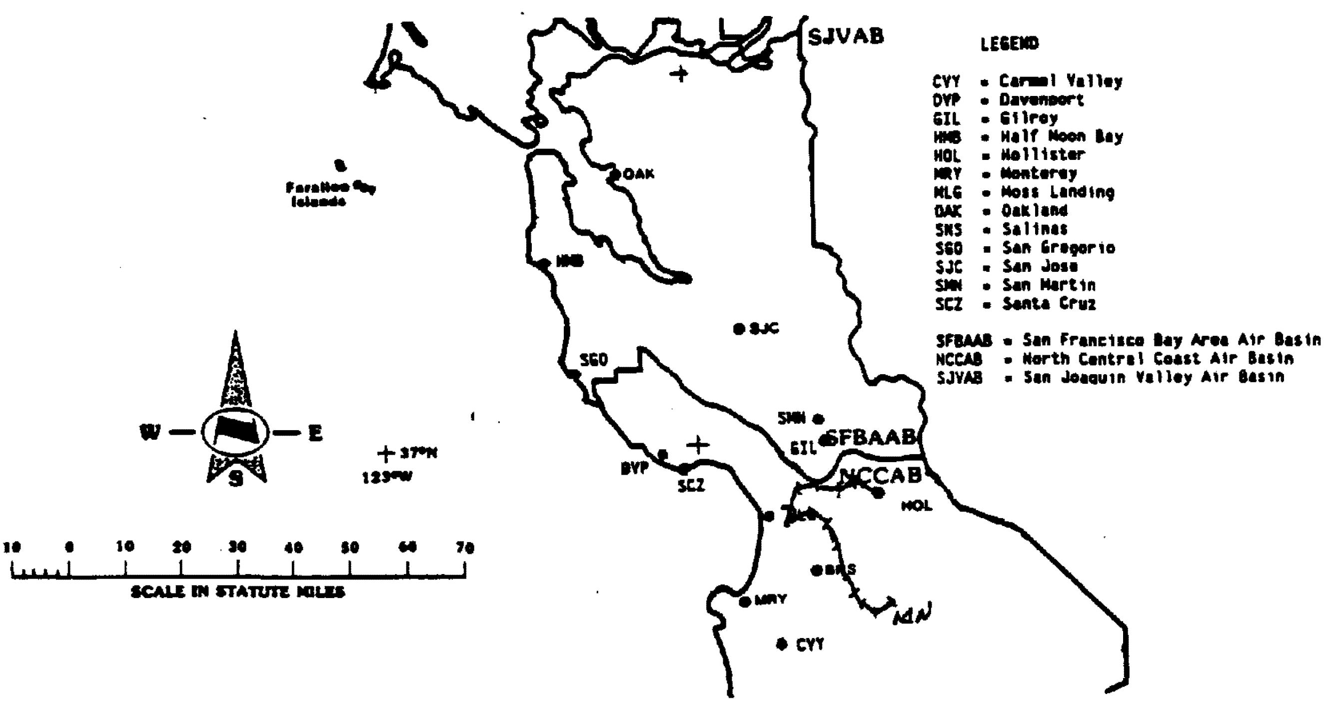


Figure 6
Hand-drawn Back Trajectory
for the November 12, 1989 Exceedance at Hollister



Further Assessment of Transport Contribution on Days During 1986-1988 When the Ozone Standard was Exceeded in the Upper Sacramento Valley

This section presents a summary of additional transport analyses undertaken to identify a day when transport from the Broader Sacramento Area was the overwhelming cause of ozone exceedances in the Upper Sacramento Valley. A discussion of October 7, 1987, is presented below to provide an example of overwhelming transport.

October 7, 1987

The only exceedances of the ozone standard in the Upper Sacramento Valley on October 7 were at Arbuckle (Colusa County) and Willows (Glenn County). On October 7, the ozone concentration in Arbuckle reached 0.10 ppm at noon, peaked at 0.11 ppm at 1 pm, and remained at 0.10 ppm through 5 pm. Ozone concentrations on the same day in Willows reached 0.10 ppm at 1 pm, peaked at 0.12 ppm at 2 pm, and dropped to 0.10 ppm at 4 pm. Although ozone concentrations that peak in the early afternoon frequently indicate locally produced ozone, the airflow on October 6 and 7 indicates the exceedances were likely caused by overnight transport of ozone and ozone precursors from Broader Sacramento Area.

A comparison of the ozone concentrations in the Broader Sacramento Area on October 6 with ozone concentrations on October 7 appears to indicate overnight transport. Several sites in the Broader Sacramento Area had maximum ozone concentrations from 0.09 through 0.11 ppm on October 6. But the only maximum ozone concentration on October 7 over 0.06 ppm in the Broader Sacramento Area was 0.10 ppm at Yuba City, which is located in the northern part of the Broader Sacramento Area.

The staff then reviewed the available wind data for October 6 through October 8 for evidence of airflow that could have moved an air mass containing elevated ozone concentrations up the Sacramento Valley. The staff noted that from October 3 through October 6 the winds were from the north. During that period, the ozone standard was exceeded only in the Broader Sacramento Area. However, during the evening of October 6, the winds in the Broader Sacramento Area changed from north to south. Thus, on October 7 the wind moved the air mass containing ozone and ozone precursors that was in the Broader Sacramento Area during the evening of October 6 into the southern portion of the Upper Sacramento Valley. The data for October 7 indicate that exceedances of the ozone standard only occurred at Arbuckle and Willows in the Upper Sacramento Valley and at Yuba City in the northern Broader Sacramento Area. This provides further evidence of the northward movement of the air mass from the Broader Sacramento Area. The air mass continued moving north into the northern portion of the Upper Sacramento Valley where the standard was exceeded at Anderson on October 8.

The difference between the 4 am surface pressures at Sacramento and Red Bluff also provide evidence of a change in the airflow pattern from October 6 to October 7. On the morning of October 6, the pressure at Red Bluff was 2.8 mb higher than the pressure at Sacramento and indicated a tendency for the air to move south. But by the morning of October 7, the pressure at Red Bluff was only 0.2 mb higher than at Sacramento and allowed the marine air to begin penetrating up the Sacramento Valley.

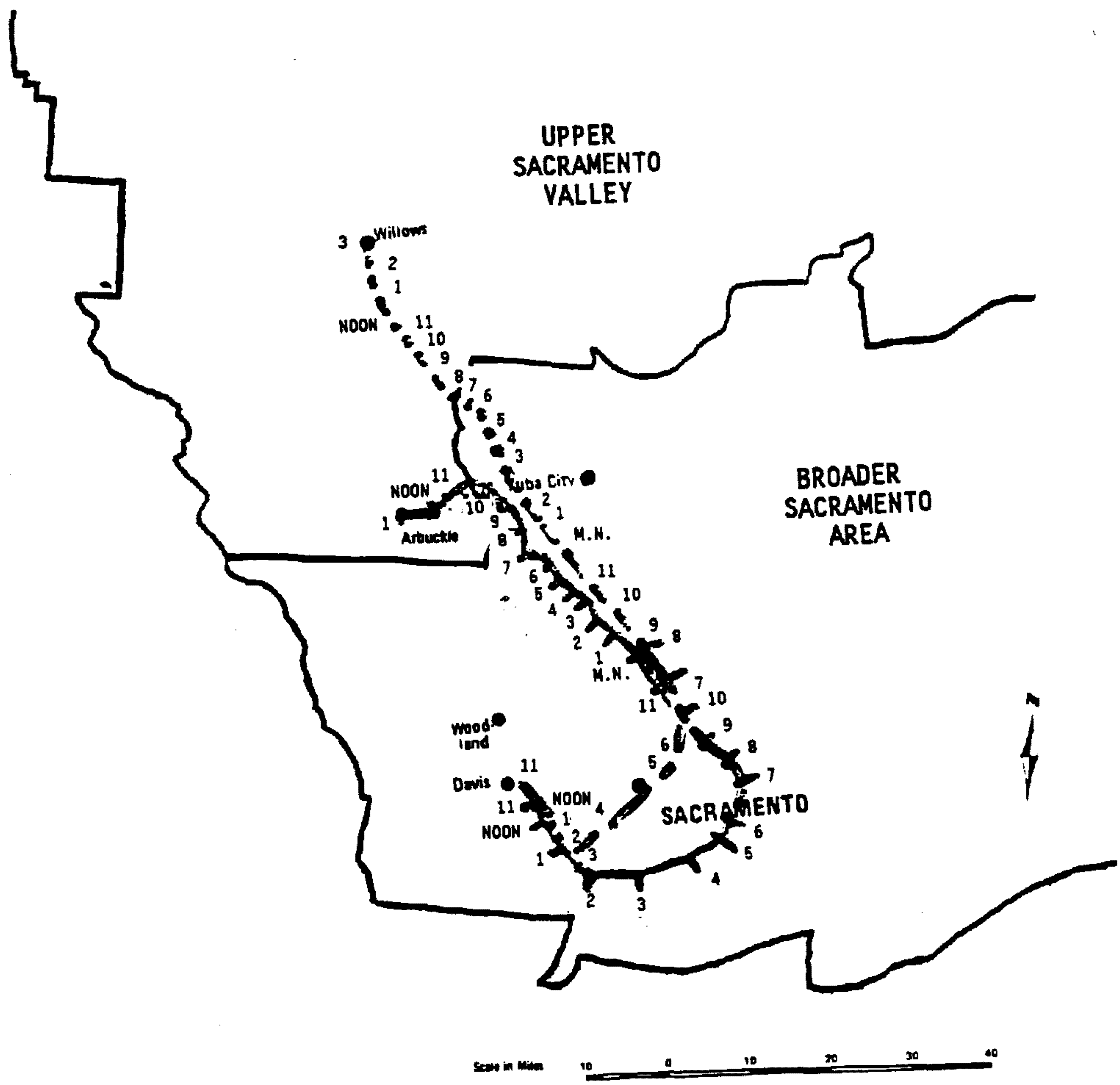
The spatial and temporal pattern of maximum temperatures also indicated that the air mass with high ozone concentrations in the Broader Sacramento Area on October 6 moved progressively north. Maximum surface temperatures were in the 90's throughout the Sacramento Valley on October 6. Some marine air penetrated the Sacramento Valley during the evening and caused temperatures to decrease rapidly at some sites. Maximum temperatures on October 7--85 degrees in Sacramento and 97 degrees at Willows--however indicated that the marine influence persisted in the Sacramento urban area but not further north. Maximum temperatures on October 8 dropped to 85 degrees at Willows in the southern portion of the Upper Sacramento Valley but the maximum temperature at Redding in the northern portion of the Upper Sacramento Valley was still warm--95 degrees.

The staff prepared back trajectories from Arbuckle and Willows (see Figure 7). The trajectories indicated that the air parcels which arrived at Arbuckle and Willows at the times of maximum concentration had been over the Sacramento urban area the evening before.

The staff also reviewed ozone precursor emission data for the Upper Sacramento Valley. Despite emissions being higher on the eastern side of the Upper Sacramento Valley than on the western side, the ozone concentrations on October 7 at sites on the eastern side did not exceed the ozone standard. Thus, the staff concluded that if precursor emissions in an area of higher emissions did not produce exceedances of the ozone standard, it was unlikely that the lesser emissions on the western side of the Upper Sacramento Valley would make a significant contribution to the ozone exceedances at Arbuckle and Willows.

Based on the meteorological assessment, the trajectories, and the limited emissions of ozone precursors on the west side of the Upper Sacramento Valley, the staff believes that the contribution of transport from the Broader Sacramento Area to the Upper Sacramento Valley was overwhelming on October 7, 1987.

Figure 7
Hand-drawn Back Trajectories
for the October 7, 1987 Exceedances in the Upper Sacramento Valley



State of California
AIR RESOURCES BOARD

ASSESSMENT AND MITIGATION OF THE IMPACTS OF TRANSPORTED POLLUTANTS ON OZONE CONCENTRATIONS WITHIN CALIFORNIA

June 1990

Staff Report

Prepared by

Technical Support Division and
Office of Air Quality Planning and Liaison

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ASSESSMENT AND MITIGATION OF THE IMPACTS OF TRANSPORTED POLLUTANTS ON OZONE CONCENTRATIONS WITHIN CALIFORNIA

SUMMARY AND OVERVIEW

The movement or transport of pollutants from one (upwind) area frequently causes or contributes to exceedances of the state ambient ozone air quality standard (state ozone standard) in another (downwind) area. In some instances, this transport is nearly the sole cause of such exceedances.

The California Clean Air Act of 1988 (the "Act") requires the Air Resources Board to take specific actions related to transport. At a hearing on December 14, 1989, the Board adopted a regulation identifying 14 transport couples in which transported air pollutants from upwind areas may contribute to exceedances of the state ozone standard in downwind areas. Each combination of upwind area and downwind area was designated a transport couple in the regulation based on the staff report "Identification of Districts Affected by Transported Air Pollutants which Contribute to Violations of the State Ambient Air Quality Standard for Ozone" (October 1989). The 14 couples are listed in Table 1 on page 3.

Under Section 39610(b) of the Act, the ARB must assess the relative contributions of upwind emissions to ambient pollutant levels in downwind areas to the extent permitted by available data. The Act also requires the ARB to establish mitigation requirements commensurate with the degree of contribution [also Section 39610(b)].

The Subject of This Report

This report describes the assessments of transport made and proposes regulations to mitigate the effects of transported air pollutants on ozone exceedances in the downwind areas. The staff's assessments of transport contained in this report drew from all available evidence, and it was performed in cooperation with the affected air pollution control districts. The staff examined individual, representative days upon which the state ozone standard was exceeded in downwind areas. However, because of the limitations of the data and the inherent difficulties in explaining the mechanisms that result in ozone formation, the staff's findings are in qualitative rather than quantitative terms. The staff has characterized the impact of transported emissions as "overwhelming", "significant," or "inconsequential" as related to impacts on ozone levels in the downwind area. The staff has studied transport as related to ozone levels in excess of the state ozone standard since lower levels do not require mitigation.

Table 2, on page 4, summarizes the staff's findings for the 14 transport couples identified by the Board. Many couples have more than one classification. This means that the transport contribution varies. On some days, transport from upwind areas may be overwhelming; on others, local emissions are the dominant cause of violations or play a significant role in creating the violations.

The proposed mitigation regulations in this report are for upwind areas which are the source of overwhelming or significant transported emissions. (For upwind areas that fall into two or more classifications, the most stringent requirements would apply.) The staff recommends that such districts be required to adopt emission control measures for ozone precursors (reactive organic gases and nitrogen oxides). Specifically, the staff recommends two measures: 1) the application of Best Available Retrofit Control Technology (BARCT) to existing sources, and 2) the implementation of a permitting program which prevents increases in ozone precursor emissions from new or modified facilities. The former would be required as expeditiously as possible, with a deadline of January 1, 1994. The latter would be required by July 1, 1991.

For upwind areas that are the source of overwhelming transport, the staff recommends one additional measure. Such districts would be required to demonstrate that their ozone attainment strategies are sufficient to attain the state ozone standard in their districts and the applicable downwind receptor areas. This measure could have the effect of requiring an upwind district to adopt controls which are more stringent than the downwind area. The staff believes this requirement is appropriate and equitable. By definition, "overwhelming transport" means that the standard is violated in a downwind district solely due to upwind area emissions.

The transport mitigation requirements may be expanded or modified by subsequent rulemakings. The staff hopes to refine the transport assessments presented in this report over time as more data are collected and analyzed and photochemical modeling studies are completed. By law, the Board must revisit its transport assessments at least once every three years. Better assessments will enable the staff to propose more specific mitigation requirements in future years. For example, the staff may ultimately be able to determine what percent reduction in ozone precursors is required to fully abate downwind ozone standard exceedances, and may be able to translate those reductions into a ton per day figure. However, this goal is an ambitious one which will take a great deal of time and effort to achieve.

TABLE 1

TRANSPORT COUPLES IDENTIFIED IN SECTION 70500 OF HEALTH AND SAFETY CODE *

	AREA IMPACTED BY TRANSPORT (Downwind Area)	AREA ORIGINATING TRANSPORT (Upwind Area)
1.	North Central Coast	San Francisco Bay Area
2.	South Central Coast	South Coast
3.	California Coastal Waters	" "
4.	South Coast	South Central Coast
5.	San Diego	South Coast
6.	Upper Sacramento Valley	Broader Sacramento Area
7.	Broader Sacramento Valley	San Francisco Bay Area
8.	" " "	San Joaquin Valley
9.	San Joaquin Valley	San Francisco Bay Area
10.	" " "	Broader Sacramento Area
11.	Great Basin Valleys	Undetermined
12.	Southeast Desert	South Coast
13.	" "	San Joaquin Valley
14.	San Francisco Bay Area	Broader Sacramento Area

* In October 1989, the ARB staff published a report entitled: "Identification of Districts Affected by Transported Air Pollutants Which Contribute to Violations of the State Ambient Air Quality Standard for Ozone." The transport "couples" described in that report and listed in this table were formally designated by the Board at a public hearing on December 14, 1989; were approved by the Office of Administrative Law on April 9, 1990; and are set forth in the California Code of Regulations, Title 17, Subchapter 1.5, Article 5, Section 70500.

TABLE 2

THE FINDINGS OF THE IMPACT OF TRANSPORTED AIR POLLUTANTS FROM UPWIND AREAS ON DOWNWIND OZONE LEVELS

Transport Couple	Overwhelming	Significant	Inconsequential
San Joaquin Valley to Great Basin Valleys	X		
Broader Sacramento to San Joaquin Valley		X	X
San Joaquin Valley to Broader Sacramento		X	X
Broader Sacramento to Upper Sac. Valley		X	X
Broader Sacramento to SF Bay Area		X	X
SF Bay Area to Broader Sacramento		X	X
SF Bay Area to North Central Coast	X		
SF Bay Area to SJV		X	X
San Joaquin Valley to Southeast Desert	X		X
South Coast to Southeast Desert	X		X
South Coast to San Diego	X	X	X
South Coast to South Central Coast		X	X
South Central Coast to South Coast		X	X
Coastal Waters to South Central Coast		X	

I. INTRODUCTION

A. Legal Requirements

Under Section 39610(b) of the California Clean Air Act, the ARB must assess the relative contribution of upwind emissions to downwind ozone levels, in cooperation with the districts, to the extent permitted by available data. Once this assessment is complete, the ARB must establish mitigation requirements commensurate with the degree of contribution [also Section 39610(b)]. The ARB is to make every reasonable effort to supply air pollutant transport information to the districts most affected by transport prior to the development of plans to achieve the state ozone standard [Section 39610(c)].

In preparing plans to attain the state ozone standard, each district must consider the effect of transport contributions [Section 40913(a)(3)]. Each district's air pollution problem is deemed "moderate," "serious," or "severe" based on the length of time needed to achieve the state ozone standard (Sections 40918-40920) after subtracting the transport contribution (Section 40921). The plans for districts *responsible for or affected by* transport must provide for attainment and maintenance of the ozone standard in both the upwind and downwind district (Section 40912, emphasis added). At a minimum, the upwind district's plan must contain all mitigation requirements established by the ARB, and the downwind district's plan must contain sufficient measures to reduce local emissions below the level at which violations of the standard would occur in the absence of transport (also Section 40912).

When reviewing plans for districts affected by transport, the Board must determine whether the requirements of Section 40912 have been satisfied. In other words, the ARB must find that the plans meet the minimum control requirements, and that the plans are sufficient to attain the state ozone standard in both the upwind and downwind districts.

The ARB must review and update its transport analyses at least once every three years [Section 39610(d)]. Districts must assess their progress toward attainment at least once every three years and amend their plans as necessary to incorporate new information or requirements (Sections 40924 and 40925).

B. Terminology Used in This Report

Throughout this report, the staff will refer to ozone levels as "ozone concentrations," a more precise term. Ozone concentrations are produced by the chemical reaction of nitrogen oxides and hydrocarbons in the presence of sunlight. For the purposes of this report, "nitrogen oxides" include nitric oxide and nitrogen dioxide. The terms "hydrocarbons," "reactive hydrocarbons," and "reactive organic gases" are used generally and inter-changeably to mean all organic compounds which may participate in the ozone formation process.

This report assesses the impact of transported emissions for each transport couple identified in Section 70500, Title 17, of the California Code of Regulations. The upwind and downwind areas that comprise these transport couples are air basins, with three exceptions. "Coastal Waters" (one source of transport into the South Central Coast) is a three mile-wide region of the Pacific Ocean, stretching from Mexico to the California-Oregon border. The "Upper Sacramento Valley" is a five-county area encompassing Colusa, Butte, Glenn, Tehama, and Shasta County Air Pollution Control Districts. And the "Broader Sacramento Area" includes Nevada County, Sacramento Metropolitan Air Quality Management District, Yolo-Solano Air Pollution Control District, and the Sutter, Yuba, El Dorado, and Placer County Air Pollution Control Districts (excluding the portions which are located within the Lake Tahoe Air Basin).

C. Transport Assessment Approach

The transport of air pollutants can occur near the earth's surface or in layers of the atmosphere above the surface. Hence, the assessment of transport requires meteorological and air pollution information. This information must be sufficiently detailed to describe wind fields and pollutant concentration fields in spatial and temporal dimensions. Because meteorological data are sparse above the surface in California, transport contributions are sometimes difficult to assess.

The problem of assessing transport is complicated by the fact that ozone is a secondary pollutant. Ozone is not directly emitted; it forms in the atmosphere. Furthermore, the concentrations of ozone and its precursors are dynamic and non-linear. That is, ozone concentrations are not necessarily additive, but depend on the concentrations of all compounds involved in atmospheric chemistry.

Using various data analysis techniques, the staff was able to confirm that transport between identified transport couples took place. The staff was also able to gauge the approximate magnitude of the transport for the days studied. However, the staff was not able to precisely quantify the relative contributions of transported air pollutants to exceedances of the state ozone standard in the downwind areas.

Since the data available to assess transport are limited in most cases, the staff's assessments in this report are semi-quantitative. Where the staff determined that upwind emissions did not contribute significantly to exceedances of the state ozone standard in the downwind area, the transport was described as "inconsequential." Where the staff determined that ozone exceedances in the downwind area (other than very near the boundary between upwind and downwind areas) occurred without any emissions contribution or with only a very small emissions contribution from the downwind area, the transport was described as "overwhelming." Where the staff determined that emissions from both the upwind and downwind areas contributed to exceedances of the state standard, the transport was described as "significant."

The techniques used by the staff to assess relative transport contributions are described in Chapter IV. The assessment studies for each transport couple are presented in Chapter V.

D. Ozone Chemistry

The impact of transported emissions on downwind ozone concentrations is governed by meteorology, surface deposition, and the mix of pollutants transported. Ozone is a product of chemical reactions requiring sunlight, hydrocarbons, and nitrogen oxides. Some of these reactions are well known. Mathematical models containing detailed descriptions of the important chemical reactions have been developed.

Both locally generated and transported ozone, as well as locally emitted and transported hydrocarbons and nitrogen oxides, impact ozone concentrations in a downwind area. The hydrocarbon-to-nitrogen oxides ratios in both the transported air and in the downwind area are important for understanding how transported pollutants impact downwind ozone concentrations. The fact that many areas downwind of large cities have high emissions of biogenic hydrocarbons (emitted from trees and other vegetation) suggests that control of nitrogen oxides, in such upwind areas, is an important strategy to mitigate impacts on downwind air basins. As discussed further in Chapter III, biogenic hydrocarbon emissions can produce ozone concentrations of almost 0.12 parts per million if sufficient quantities of nitrogen oxides are available. Many air basins in California have potentially large burdens of biogenic hydrocarbons.

E. Mitigation Policy and Requirements

The primary mandate of the California Clean Air Act is to attain state standards by the earliest practicable date. The staff believes that steps to abate the impacts of transport should be taken as quickly as possible so that districts can meet this primary obligation. The staff also believes that through the Act, it was the legislature's intent that the ARB make an informed judgment on the basis of currently available evidence. The legislature clearly intended that the transport assessments and mitigation requirements will be modified over time. This suggests that preliminary mitigation requirements can and should be established on the interpretation of existing data, though those data are neither as certain nor detailed as is desirable.

Although transport impacts cannot be precisely quantified at this time, three general conclusions about mitigation can be drawn. The first is that control measures are needed in upwind areas; transport will not abate itself. The second conclusion drawn by the staff, based on the ozone chemistry discussed above, is that the control of nitrogen oxides could be critical to reducing ozone concentrations downwind. Nitrogen oxides may in fact be more dominant than hydrocarbons in transport situations. The final conclusion is that upwind areas must bear full responsibility, in some instances, for violations of the state ozone standard in downwind areas.

When transport is overwhelming, the downwind area can do nothing to abate the exceedance. If the state standard is to be attained in such circumstances, the upwind district must take the necessary steps. Given the mandate for expeditious attainment, the staff concludes that initial steps should be taken now.

The staff is proposing transport mitigation requirements for upwind districts that are the source of significant or overwhelming transport emissions. Such districts would be required to adopt and implement control measures for existing stationary sources that represent Best Available Retrofit Control Technology. These upwind areas would also be required to establish permitting programs for new and modified sources that require no net increase in precursors of ozone. The staff's proposal is an equity-based approach. The recommended control measures are expected to be required in nearly all of the downwind areas that receive pollutant transport. The text of the proposed regulation, a description of its provisions, and a discussion of general issues and policy concerns expressed as of June 1, 1990, by districts and other parties is provided in Chapter II.

F. Public Consultation Process

The staff held a public consultation meeting on April 17, 1990, to discuss the assessment of transport impacts and the proposed mitigation requirements. A list of meeting participants is shown in Appendix A.

At the April meeting, the staff presented the preliminary results of the transport assessment studies for each couple. Draft mitigation regulations were also presented. Several oral comments were made at the public meeting; more oral and written comments have been received since. After the public meeting, the staff made follow-up phone calls and scheduled meetings with staff from each affected area. All comments are discussed in the sections of this report to which they pertain. The text of each written comment recieved by June 1, 1990, are contained in Attachment B.

II. DISCUSSION OF POLICY ANALYSIS AND PROPOSED REGULATIONS FOR MITIGATING THE IMPACT OF UPWIND EMISSIONS ON DOWNWIND OZONE CONCENTRATIONS

This Chapter describes the need for transport mitigation, the legal responsibilities of the ARB and districts, the proposed framework for assigning transport responsibility, and the transport mitigation policies developed by the staff in order to develop the proposed regulations for Board consideration. This Chapter also presents issues raised by districts and industry representatives prior to June 1, 1990, in written or oral comments, and the staff response.

A. Need for Transport Mitigation

The goal of the California Clean Air Act is clear: expeditious attainment of the state air quality standards. Accordingly, the Act requires each district with an air quality problem related to ozone, carbon monoxide, sulfur dioxide or nitrogen dioxide to develop a plan and an emission control program to attain the standards. For one pollutant -- ozone -- the Act specifically recognizes that meeting this goal would require the cooperation of several districts. This is because ozone, ozone precursor emissions, and intermediate products emitted from or forming in one district can cross district boundaries and produce or contribute to violations of the ozone standard elsewhere. The Act recognizes the impact of transport and sets in motion a multi-part process to ensure that districts shoulder the responsibility for mitigating air quality problems caused by emission sources within their jurisdictions.

B. ARB and District Responsibilities

The Act's transport provisions assign specific responsibilities to the Board and affected districts. The ARB is to complete several discrete tasks and generally oversee implementation. The districts must address transport in their air quality plans and must satisfy both statutory standards and ARB requirements.

The first major task assigned to ARB was to identify the districts affected by transport [Section 39610 (a)]. This responsibility was initially fulfilled at the December 1989 Board meeting. The ARB formally identified 14 known transport couples (upwind emission source areas and the downwind receptor areas), and designated a number of potential couples for future study. As new information or data become available, the Board will expand and refine the identification of transport affected areas.

The ARB's second major task is to identify the relative contribution of emissions from upwind areas to downwind ozone concentrations [Section 39610 (b)]. The staff's initial assessments are the subject of this report, and are discussed in Chapter V. Available data do not permit a precise, quantitative analysis of relative transport contributions. However, there is sufficient information to determine the approximate magnitude of transport contributions, particularly at the extremes. The staff believes this information provides the necessary basis for moving ahead with transport mitigation requirements.

The third major task assigned to the ARB is to establish transport mitigation measures which are commensurate with the relative transport contributions [Section 39610 (b)]. The regulations proposed in this report are designed to fulfill this requirement. The proposed regulations and associated issues are discussed below.

The ARB is to consult with the affected upwind and downwind districts in developing its proposals related to transport. The staff has had extensive discussions with districts and other parties about the proposed regulations. A public workshop on the transport assessments and proposed mitigation requirements was conducted on April 12, 1990. The ARB's senior management participated in a joint working session on transport at the California Air Pollution Control Officers Association (CAPCOA) Spring Conference, May 31, 1990. The CAPCOA's staff level Planning Managers Committee discussed transport issues with ARB staff at several meetings. Finally, several meetings and telephone conferences were held between ARB's technical staff and affected districts.

When ARB reviews the air quality plans prepared by districts next year, the Board must make certain findings related to transport. The ARB must determine whether each district plan contains, if applicable, all transport mitigation requirements established by the Board [Section 41503(c)]. The Board must also determine whether the plans for transport couples, when considered together, are sufficient to attain the state ozone standard in both the upwind and downwind area [Sections 40912 and 41503(a)].

The responsibilities of transport related districts differ, depending on whether the district is an upwind emission source area or a downwind receptor area. Upwind districts have the broad obligation to "*adopt and enforce rules and regulations to achieve and maintain the state and federal ambient air quality standards in all areas affected by emission sources under their jurisdiction . . .*" (Section 40001). The plans prepared by upwind districts must contain, at a minimum, all mitigation measures established by the ARB (Section 40912). Downwind districts' plans must contain sufficient measures for the district to attain the state ozone standard in the absence of the transport contribution (also Section 40912). [The staff notes that downwind districts may have a greater obligation where the transport contribution from upwind districts cannot be reduced to zero.]

C. Framework for Determining Transport Contributions

The transport provisions of the Act would work best if precise quantification of transport impacts were possible. However, it is recognized by all parties that such quantification is not currently feasible and, for most areas, remains several years away. This is unfortunate in the staff's view, but not an absolute barrier to near-term action.

Existing information is adequate to determine the relative magnitude of transport contributions. The Board can use this information to make informed judgments about transport impacts and to establish initial and reasonable steps to mitigate those impacts. The staff has grouped transport impacts into three broad categories: overwhelming, significant, or inconsequential. Staff is proposing that mitigation requirements be adopted which are commensurate with these impact categories and their degree of specificity. Each category is described more fully below.

The staff deemed the transport contribution "overwhelming" if emissions from the upwind area independently caused a violation of the state ozone standard in the downwind area, on any single day (of the days studied). Three tests were applied before placing any upwind districts in this category. First, there had to be strong evidence that transport occurred. Second, the transport had to be traceable to the upwind area. Third, all significant emission sources in the downwind area had to be out of the pathway of the air parcel that was transported from the upwind area. The third test was to ensure that the ozone concentrations measured by downwind monitors were in fact produced by upwind emissions, and were not the product of emissions in both areas.

The transport contribution was deemed "significant" if the upwind emissions contributed measurably to violations of the ozone standard in the downwind area, on any single day. For this category, tests one and two were also applied, but test three was reversed. If emissions from sources within the downwind receptor area mingled with the incoming air parcel, the problem was considered to be shared. The significant transport category was used by staff for two separate situations: 1) where there was clear evidence of upwind and downwind contributions to the ozone exceedences; and 2) where there was strong evidence of upwind transport but insufficient data to make an overwhelming finding.

The transport contribution was deemed "inconsequential" if upwind emissions were not transported at all or did not appear to contribute significantly to the violation of the ozone standard in the downwind area. Before placing districts in this category, the staff concluded there was no evidence of a significant pollutant burden from the upwind area. The staff also evaluated whether local emissions were large enough to account for the ozone violation. The inclusion of what are effectively non-transport days in the transport classification scheme is confusing to some. The staff wants only to point out that downwind receptor areas can be totally responsible for some of the ozone violations occurring in their jurisdictions. If the inconsequential transport category were discarded, people might conclude that all violations occurring in transport receptor areas are caused by transported emissions. That is not the case.

Because the transport impacts were evaluated for individual ozone violation days, some areas fall into more than one category. For example, the South Coast Air Basin is the source of overwhelming transport into San Diego County on some days; while on a greater number of days, South Coast and San Diego both contribute to ozone violations in San Diego; and on still other days, San Diego violates the state ozone standard without any contribution from the South Coast Air Basin.

The categorization of transport impacts was based on a review and interpretation of all available data. The staff's analytical techniques are described in the Chapter IV. The application of those techniques to actual transport studies and the results of staff's analyses are presented in Chapter V.

D. Transport Mitigation Requirements

The staff is proposing that the Board establish transport mitigation requirements that are directly linked to the magnitude of transport contributions. This is consistent with Section 39610(b) of the Act, which indicates mitigation measures must be "commensurate with the level of contribution." The staff recommends that mitigation be required in upwind areas that are the source of overwhelming or significant transport. No mitigation is recommended for inconsequential transport since, by definition, downwind emission sources are responsible for ozone violations under such conditions.

Specific requirements for five upwind areas are proposed by the staff. The affected areas are: the Broader Sacramento Area, San Joaquin Valley, San Francisco Bay Area, South Central Coast (south of the San Luis Obispo-Santa Barbara county border), and the South Coast Air Basin. These transport producers impact each other to varying degrees, and cause or contribute to ozone violations in five additional downwind receptor areas: the Upper Sacramento Valley, North Central Coast, Great Basin Valleys, Southeast Desert, and San Diego.

The staff is proposing two mitigation requirements: the application of best available retrofit control technology (BARCT) and a permitting system for new and modified sources that achieves no net increase in ozone precursors. These mitigation requirements would apply to sources of hydrocarbons and to sources of nitrogen oxides. Staff is also recommending that full attainment responsibility be transferred, from the downwind receptor area to the upwind transport producer, on ozone violations days when the transport contribution is overwhelming.

The permitting and BARCT requirements are both defined by statute and required of serious and severe nonattainment areas (sections 40919 and 40920). The staff proposal would cause them to be implemented expeditiously, to begin mitigating the contribution of transported pollutants to downwind areas. The permit requirement would prevent growth in the upwind area from exacerbating downwind violations; the BARCT measures would begin to reduce the magnitude of transport.

Adoption and implementation of the BARCT requirement would be required for all stationary sources as expeditiously as practicable. To ensure prompt action and attention to the largest emission sources, staff is recommending two supplemental criteria. First, that the regulations explicitly require BARCT for the source categories that comprise 75 percent of the 1987 hydrocarbon emission inventory and 75 percent of the 1987 nitrogen oxides emission inventory for permitted stationary sources. Second, that these BARCT requirements for permitted stationary sources be adopted by January 1, 1994.

Staff is proposing a procedure to allow districts to limit the application of BARCT where it is unnecessary for expeditious attainment of the ozone standard in the upwind and downwind areas. This provision recognizes that some individual sources in large air basins may not cause or contribute to ozone problems downwind. For example, a facility in Placer County may not cause or contribute to ozone violations recorded at Bethel Island, although the former is within the Broader Sacramento Area (a transport producer) and the latter is within the San Francisco Air Basin (the downwind receptor). In these cases the district may, if controls are not needed as part of its own air quality plan, exempt the source from the application of BARCT. This would be done initially as part of the district's air quality plan, and would be ratified later in the context of a specific rulemaking to implement the BARCT requirement on a category of sources. The BARCT exemption could also be employed where the upwind district wishes to pursue a hydrocarbon-based attainment strategy, and demonstrates the effectiveness of that strategy to the Board. The staff wants to emphasize that the BARCT exemption procedure discussed in this paragraph applies only within the context of transport mitigation. The proposed exemption process could not be used to waive any other applicable BARCT requirements of the California Clean Air Act.

Adoption and implementation of the permitting program requirement would be required by July 1, 1991. Staff believes that, at an absolute minimum, transport producers should prevent increases in the emissions which contribute to downwind ozone violations. The short-term deadline for new and modified source permitting is intended to achieve this goal, at the earliest practicable date.

Producers of overwhelming transport would have to demonstrate that their plans will achieve attainment of the ozone standard in downwind areas during the types of episodes in which overwhelming transport occurs, or otherwise satisfy the requirements of the Act in lieu of the attainment demonstration. [Staff note: the Act authorizes ARB to approve district plans that do not demonstrate attainment, provided every feasible control strategy or measure to ensure progress toward attainment is included. See Section 41503(d).]

The proposed regulations establishing mitigation requirements are presented at the end of this Chapter. Section 70600 of the regulations contains the emission control requirements for each of the five transport producers. Section 70601 clarifies that BARCT need not be applied to every source in the district, provided specified criteria are met.

The practical effect of the proposed regulations will depend on two factors: the nature of the ozone problem upwind, and the type of attainment strategy each transport producer would pursue in the absence of transport mitigation requirements. Staff believes that the proposed transport mitigation requirements will not require any additional controls in the South Coast and San Joaquin Valley Air Basins, or in the Broader Sacramento Area. All of the proposed mitigation requirements need to be met in order for these areas to comply with the Act regardless of transport.

However, the regulations may have an appreciable impact on transport producers that are within striking distance of attainment in their own jurisdictions, yet have to continue reducing emissions for the benefit of downwind neighbors. This may be the case in the South Central Coast Air Basin and the Bay Area Air Basin, both of which have less severe ozone problems than their downwind impact areas (the South Coast and San Joaquin Valley Air Basins, respectively). The proposed regulations could also have a significant impact on upwind districts that intend to pursue a hydrocarbon-based ozone attainment for their district. In such a case, the BARCT and permitting requirements will trigger the concurrent control of nitrogen oxides, unless the upwind district can demonstrate that a hydrocarbon-based strategy will be as effective in the downwind receptor areas as control of both precursors.

The staff considered several alternative control requirements. During the workshop process, staff proposed the concept of equivalent controls in the upwind area. Under that approach, upwind areas would have been required to adopt controls which were at least as stringent as those already implemented by downwind areas or committed to in downwind areas' plans. Other approaches were considered, including a total percent reduction target for each ozone precursor, mandatory rulemaking calendars, and individual control measures with specified performance standards.

In response to workshop comments and after additional internal analysis, the staff concluded that the "equal control" concept was not workable (see Subsection E, below, for discussion of issues). With respect to the other approaches, staff concluded that the transport impact assessment was not precise enough to support an absolute reduction target. The staff also felt that mandatory rulemaking calendars would deny upwind districts the flexibility they need to satisfy other critical elements of the Act, such as the five percent annual emissions reduction requirement. The measure-by-measure approach was rejected, because staff was concerned that defining control measures in great detail would prejudge the control technology evaluation process approved by the Board this April (see "California Clean Air Act Guidance for the Determination of Reasonably Available Control Technology and Best Available Control Technology," prepared by the ARB Stationary Source Division, March 1990).

Staff believes the proposed mitigation requirements are the most specific controls that can be supported at this time. However, the proposed requirements may not be sufficient to fully mitigate the impact of transport contributions on downwind areas. Staff will recommend adjustments to the transport mitigation requirements, as quickly as available evidence permits.

E. Major Issues and Staff Response

1. Excessive Control: Santa Barbara, San Diego, and the Bay Area expressed concern that the equivalent control concept would force upwind areas to achieve more mitigation than is actually needed. These districts pointed out that if the South Coast was the receptor area, transport producers would have to adopt controls that were designed to abate 0.36 ppm ozone concentrations (the highest in the nation). Santa Barbara was particularly concerned about having to adopt the most advanced measures in the South Coast's 1989 plan.

STAFF RESPONSE: Based on this concern and others, staff modified the proposal and dropped the equivalent control approach. The revised proposal will require the application of BARCT and the no net increase permit requirements in upwind areas. As was noted previously, these requirements will be applicable to many upwind areas, regardless of the consideration of transport.

2. Capricious Rulemaking by Downwind Districts: Some districts and industry representatives feared that the equivalent control approach would prompt downwind districts to adopt regulations for sources they did not have, so as to compel regulatory action upwind.

STAFF RESPONSE: This possibility has been precluded with the modified approach to that requires the implementation of BARCT and no net increase in ozone precursors.

3. Cost-Effectiveness: The Bay Area believes that the proposed regulations would preclude districts from meeting California Clean Air Act mandates pertaining to cost-effectiveness review. The District also asked that ARB make a finding of cost-effectiveness prior to adopting any transport mitigation requirements.

STAFF RESPONSE: Nothing in the proposed regulations precludes or hinders cost-effectiveness analyses. The districts will consider cost-effectiveness in making BARCT determinations and in revising their permit programs. In addition, the proposal contains a provision to allow exemptions from BARCT when emissions reductions are not needed for attainment. Staff believes the proposed mitigation requirements do not in any way alter or interfere with the districts' ability to comply with the cost-effectiveness requirements of the Act.

4. Extent of Local Responsibility: The Monterey Bay Unified APCD believes that staff has taken an overly narrow view of local contributions. Staff is proposing that transport be deemed overwhelming unless the incoming air parcel passes over significant emission sources in the downwind area. Monterey argues that any single emission source is significant, and that

overwhelming transport days should be reclassified as a shared problem. Monterey also points out that staff's proposal is a departure from the "cause or contribute" standard used in industrial permitting situations (wherein very small emissions are deemed significant).

STAFF RESPONSE: There is some merit in the District's viewpoint. It is a matter of judgement regarding the point at which local emissions should be treated as significant. However, staff believes that the overwhelming dominance of upwind transport needs to be recognized in several cases. A very small amount of local emissions mixing with a much larger mass of pollutants from an upwind area has negligible impact on ozone. Local control will not be highly effective in reducing ambient ozone concentrations under such conditions. Therefore, the staff continues to support the concept of overwhelming transport as applied in the proposal.

5. Insufficient Evidence to Establish Mitigation Requirements: The Bay Area and Santa Barbara districts believe that ARB should delay adoption of transport mitigation requirements until the Board is able to provide a reliable quantitative analysis of the relative contribution of upwind emissions to downwind ozone concentrations. Bay Area argues further, that unless ARB can precisely quantify transport impacts it does not have the legal basis for adopting mitigation measures "commensurate" with those contributions.

STAFF RESPONSE: Staff believes that the existing evidence is sufficient to identify transport producers and to determine the relative magnitude of transport contributions. Staff further believes that the lack of precise quantification was foreseen in the drafting of the Act, and was not meant to preclude timely action to begin mitigation of transport impacts in the first round of plans. The staff believes that the Board is on firm legal grounds in establishing transport mitigation requirements, and that the staff's proposal satisfies the commensurate test because it imposes control requirements based on the relative magnitude of transport impacts.

6. Disbenefits of NOx Control in Upwind Areas: The Bay Area, Chevron and others have expressed concerns that the transport mitigation requirements may result in control measures that are harmful to the upwind district. In essence, they are worried that NOx control would increase Bay Area ozone levels. Bay Area argues that ARB should not require NOx controls until it has proven that NOx reductions will be beneficial to both the upwind and downwind areas.

STAFF RESPONSE: As discussed in Chapter III of this report, there is convincing evidence that a combined hydrocarbon and NOx control strategy is more effective in reducing ozone than control of hydrocarbons, only. The evidence is strongest when ozone precursors are transported over long distances. The ozone reductions due to scavenging by nitrogen oxides in the vicinity of NOx-emitting sources are also well documented. However, there is considerable disagreement as to the extent of the scavenging domain. Once outside the scavenging domain, there is little disagreement that NOx emissions will ultimately produce more ozone.

Even if the NOx scavenging domain for the Bay Area were to include that entire air basin, and NOx control were to simultaneously increase Bay Area ozone concentrations while reducing ambient ozone levels downwind, staff is convinced that combined hydrocarbon and NOx control would be -- on balance -- the most effective control for the basin and its downwind neighbors. The Bay Area had 41 daily exceedences of the state ozone standard in 1988 (representing 131 violation hours), with a peak reading of 0.15 parts per million. The San Joaquin Valley Air Basin violated the state standard 154 days in the same year (representing 934 hours), with peak readings of 0.19 ppm. Even when relative population density is taken into account, the exposure of San Joaquin Valley residents to health endangering ozone levels dwarfs the unhealthful exposure in the Bay Area.

Staff believes that the Act contemplated control of both ozone precursors, unless the effectiveness of an alternative strategy could be demonstrated to the Board's satisfaction. Accordingly, it is both technically and legally appropriate to require control of both precursors as a transport mitigation measure. Furthermore, the proposed regulations are not absolute. Districts may avoid the implementation of NOx controls if it can be demonstrated that such controls are unnecessary (or counterproductive) in the upwind and downwind area.

The Board can and must revisit the transport mitigation requirements if new technical information invalidating the staff's approach becomes available through the ongoing transport and modeling work.

F. Alternative Mitigation Proposals

As indicated above, staff considered several different alternatives prior to recommending the proposed mitigation requirements. Santa Barbara and the Bay Area advanced two additional alternatives, which are described and analyzed below.

1. Santa Barbara Proposal: The District suggests that ARB use the moderate, serious, and severe classifications (Sections 40918-40920) for the 1991 plans, and delay additional controls until 1993. Santa Barbara also prefers that mitigation requirements be expressed in ton per day reduction targets.

STAFF ANALYSIS: Under the Act, districts are classified as moderate, serious or severe after the effect of transport has been identified and factored out (Section 40921). For this reason, the District's proposal is contrary to statutory direction. The staff hopes to ultimately express mitigation requirements in ton per day reduction targets, but that is not possible at the present time.

2. Bay Area Proposal: The Bay Area recommends that transport mitigation requirements be delayed until completion of the San Joaquin Valley and AUSPEX air studies; that the Modeling Advisory Committee set a protocol for evaluating transport impacts; and that cost-effectiveness be demonstrated prior to ARB adoption of mitigation requirements. For the 1991 planning cycle, the District recommends that ARB use the transport findings to provide relief to downwind receptor areas. That is, where transport impacts are significant or overwhelming, the downwind district would be excused from statutory planning and/or regulatory requirements.

STAFF ANALYSIS: Delay and cost-effectiveness issues have been addressed in preceding sections. The staff will consider the appropriateness of involving the Modeling Advisory Committee in future transport assessments; for this round, several techniques other than modeling were used to assess transport contributions. Regarding the District's proposal for 1991, the staff believes it runs counter to statutory requirements. As staff interprets the Act, one or more districts must be held accountable for ozone violations at any given time. It is not permissible for the ARB to exempt a downwind receptor area from that obligation without conferring a corresponding responsibility on the upwind source of the transported emissions.

G. Text of Proposed Regulations

Amend Subchapter 1.5. Air Basins and Air Quality Standards, Title 17, California Code of Regulations by adding Article 6. Transport Mitigation Requirements, Sections 70600 and 70601, as follows:

ARTICLE 6. TRANSPORT MITIGATION

70600. Emission Control Requirements

Districts within the areas of origin of transported air pollutants, as identified in section 70500(c), shall include sufficient emission control measures in their attainment plans for ozone adopted pursuant to Chapter 10 of the Health and Safety Code, Part 3, Division 26, beginning with Section 40910, to mitigate the impact of pollution sources within their jurisdictions on ozone concentrations in downwind areas. At a minimum, the attainment plans for districts within the air basins or areas specified below shall conform to the following requirements:

1. Broader Sacramento Area (as defined in Title 17, Section 70500 (c) of the California Code of Regulations) shall:

   (a) require the adoption and implementation of best available retrofit control technology, as defined in Health and Safety Code section 40406, on all existing stationary sources of ozone precursor emissions as expeditiously as practicable. At a minimum, the plan shall provide for the adoption of rules that represent best available retrofit control technology for source categories that collectively amount to 75 percent of the 1987 actual reactive hydrocarbon emissions inventory for permitted stationary sources, and 75 percent of the 1987 actual nitrogen oxides emissions inventory for permitted stationary sources, no later than January 1, 1994.

   (b) provide for a permitting program designed to achieve no net increase in emissions of ozone precursors from all new or modified permitted stationary sources. Such program shall be adopted and implemented no later than July 1, 1991.

2. San Francisco Bay Area Air Basin shall:

   (a) require the adoption and implementation of best available retrofit control technology, as defined in Health and Safety Code section 40406, on all existing stationary sources of ozone precursor emissions as expeditiously as practicable. At a minimum, the plan shall provide for the adoption of rules that represent best available retrofit control technology for source categories that collectively amount to 75 percent of the 1987 actual reactive hydrocarbon emissions inventory for permitted stationary sources, and 75 percent of the 1987 actual nitrogen oxides emissions inventory for permitted stationary sources, no later than January 1, 1994.

(b) provide for a permitting program designed to achieve no net increase in emissions of ozone precursors from all new or modified permitted stationary sources. Such program shall be adopted and implemented no later than July 1, 1991; and

(c) include measures sufficient to attain the state ambient air quality standard for ozone by the earliest practicable date within the North Central Coast Air Basin, except as provided in Health and Safety Code section 41503(d), during air pollution episodes which the state board has determined meet the following conditions:

(1) are likely to produce a violation of the state ozone standard in the North Central Coast Air Basin;

(2) are dominated by transported pollutants from the San Francisco Bay Area Air Basin; and

(3) are not measurably affected by emissions of ozone precursors from sources located within the North Central Coast Air Basin.

3. <u>San Joaquin Valley Air Basin</u> shall:

(a) require the adoption and implementation of best available retrofit control technology, as defined in Health and Safety Code section 40406, on all existing stationary sources of ozone precursor emissions as expeditiously as practicable. At a minimum, the plan shall provide for the adoption of rules that represent best available retrofit control technology for source categories that collectively amount to 75 percent of the 1987 actual reactive hydrocarbon emissions inventory for permitted stationary sources, and 75 percent of the 1987 actual nitrogen oxides emissions inventory for permitted stationary sources, no later than January 1, 1994.

(b) provide for a permitting program designed to achieve no net increase in emissions of ozone precursors from all new or modified permitted stationary sources. Such program shall be adopted and implemented no later than July 1, 1991; and

(c) include measures sufficient to attain the state ambient air quality standard for ozone by the earliest practicable date within the Southeast Desert Air Basin and the Great Basin Valleys, except as provided in Health and Safety Code section 41503(d), during air pollution episodes which the state board has determined meet the following conditions:

(1) are likely to produce a violation of the state ozone standard in the Southeast Desert Air Basin or the Great Basin Valleys;

(2) are dominated by transported pollutants from the San Joaquin Valley Air Basin; and

(3) are not measurably affected by emissions of ozone precursors from sources located within the Southeast Desert Air Basin or the Great Basin Valleys, as applicable.

4. <u>South Central Coast Air Basin</u> south of the Santa Barbara-San Luis Obispo County border shall, for sources located in that portion of the Basin:

(a) require the adoption and implementation of best available retrofit control technology, as defined in Health and Safety Code section 40406, on all existing stationary sources of ozone precursor emissions as expeditiously as practicable. At a minimum, the plan shall provide for the adoption of rules that represent best available retrofit control technology for source categories that collectively amount to 75 percent of the 1987 actual reactive hydrocarbon emissions inventory for permitted stationary sources, and 75 percent of the 1987 actual nitrogen oxides emissions inventory for permitted stationary sources, no later than January 1, 1994.

(b) provide for a permitting program designed to achieve no net increase in emissions of ozone precursors from all new or modified permitted stationary sources. Such program shall be adopted and implemented no later than July 1, 1991.

5. <u>South Coast Air Basin</u> shall:

(a) require the adoption and implementation of best available retrofit control technology, as defined in Health and Safety Code section 40406, on all existing stationary sources of ozone precursor emissions as expeditiously as practicable. At a minimum, the plan shall provide for the adoption of rules that represent best available retrofit control technology for source categories that collectively amount to 75 percent of the 1987 actual reactive hydrocarbon emissions inventory for permitted stationary sources, and 75 percent of the 1987 actual nitrogen oxides emissions inventory for permitted stationary sources, no later than January 1, 1994.

(b) provide for a permitting program designed to achieve no net increase in emissions of ozone precursors from all new or modified permitted stationary sources. Such program shall be adopted and implemented no later than July 1, 1991; and

(c) include measures sufficient to attain the state ambient air quality for ozone by the earliest practicable date within the portions of the South Central Coast Air Basin south of the Santa Barbara-San Luis Obispo County border, the San Diego Air Basin, and the Southeast Desert Air Basin, except as provided in Health and Safety Code section 41503(5), during air pollution episodes which the state board has determined meet the following conditions:

(1) are likely to produce a violation of the state ozone standard in the South Central Coast Air Basin south of the Santa Barbara-San Luis Obispo County border, or the San Diego Air Basin, or the Southeast Desert Air Basin;

(2) are dominated by transported pollutants from the South Coast Air Basin; and

(3) are not measurably affected by emissions of ozone precursors from sources located within the South Central Coast Air Basin south of the Santa Barbara-San Luis Obispo County border, the San Diego Air Basin, or the Southeast Desert Air Basin, as applicable.

NOTE: **AUTHORITY CITED: SECTIONS 39601, 39610(b), H&SC. REFERENCES CITED: SECTIONS 39610, 40912, 40913, 40921 and 41503, H&SC.**

70601. Procedure For Limiting the Application of Best Available Retrofit Control Technology

A district may exclude one or more sources from the requirement to apply best available retrofit control technology as transport mitigation pursuant to section 70600 provided that the district plan prepared pursuant to Part 3, Chapter 10 of the Health and Safety Code and approved by the Board pursuant to Part 4, Chapter 1 of the Health and Safety Code demonstrates that emissions from the source do not contribute to ozone violations in any downwind area, or emissions reductions from the source are not needed to attain the ozone standard in any downwind area.

NOTE: **AUTHORITY CITED: SECTIONS 39601, 39610(b), H&SC. REFERENCES CITED: SECTIONS 39610, 40912, 40913, 40921 and 41503, H&SC.**

III. THE IMPACT OF TRANSPORTED POLLUTANTS ON DOWNWIND OZONE CONCENTRATIONS

The impact of transported pollutants on downwind ozone concentrations is governed by meteorology, surface deposition, and the composition and relative amounts of pollutants emitted in the upwind and downwind area. Atmospheric chemistry determines how the transported pollutants affect downwind ozone concentrations.

A. The Ozone Cycle

Ozone is formed through a series of reactions requiring sunlight along with emissions of hydrocarbons and nitrogen oxides. The following three chemical equations show the fundamental ozone cycle.[1] The only important reaction leading to the formation of ozone (O_3) begins with the photodissociation of nitrogen dioxide (NO_2) to nitric oxide (NO) and atomic oxygen (O):

$$NO_2 + \text{sunlight} \rightarrow NO + O \qquad (1)$$

The atomic oxygen then quickly combines with molecular oxygen (O_2) to form ozone:

$$O + O_2 \rightarrow O_3 \qquad (2)$$

These two reactions combine into the following reversible reaction:

$$NO_2 + O_2 + \text{sunlight} \longleftrightarrow NO + O_3 \qquad (3)$$

It is helpful to note here that about 90 to 95 percent of the nitrogen oxides (NO_x) are actually emitted as NO. Hydrocarbon emissions lead to the conversion of NO to NO_2 without consuming ozone, driving reaction (3) to the right. As concentrations of reactive hydrocarbons increase, the ozone formed from a given amount of NOx emissions also increases but only up to a certain point. As hydrocarbon emissions increase further, ozone concentrations do not increase appreciably unless more nitrogen oxides are introduced. An atmosphere such as this is called hydrocarbon rich, and ozone production is limited by the emissions of nitrogen oxides.

Reaction rates for nitrogen oxides are faster than the average hydrocarbons in a typical atmosphere. As a result, as a parcel of polluted air leaves an urban area, nitrogen oxides are removed from the atmosphere faster than hydrocarbons. Downwind, the air mass becomes NOx deficient, and ozone production is limited by the amount of available NOx.[2] Thus, reducing upwind NOx emissions will reduce downwind ozone concentrations.

Another effect of NOx emissions can be seen from equation (3). The NO molecules react quickly with ozone, reducing ozone concentrations near the NO emission source while increasing NO_2 concentrations. This phenomenon is referred to as "ozone scavenging". As the pollutants are carried downwind, the increased NO_2 leads to higher ozone concentrations. Thus reducing NOx emissions in the upwind area will help decrease ozone concentrations downwind. Because of decreased ozone scavenging, this NOx emission reduction may lead to increased ozone concentrations near the source of the NOx emissions. However, hydrocarbon emission controls near the source of NOx reductions can be used to offset the ozone increase.

Transported ozone, hydrocarbons, and nitrogen oxides--all affect ozone concentrations in a downwind basin. Hydrocarbon-to-NOx ratios are important indicators for precursor control in urban areas; high ratios favor NOx control while low ratios favor hydrocarbon control. But the hydrocarbon-to-NOx ratio may have little impact on ozone in relation to transport. Sillman[3] has shown that at low NOx concentrations, (up to 5 ppb), the rate of production of ozone increases proportionately with NOx and shows only a slight positive dependence on the hydrocarbon concentration. This finding is very different from ozone chemistry in the urban atmosphere where ozone formation depends on both NOx and hydrocarbons.

B. The Effect of Biogenic Hydrocarbon Emissions on Transported Ozone

The emissions of biogenic hydrocarbons are high in many parts of California. A recent study conducted by Winer[4] identified a wide variety of hydrocarbons in biogenic emissions from plant species growing in the Central Valley. These hydrocarbons include alcohols, acetates, aldehydes, ketones, ethers, esters, alkanes, alkenes, and aromatics. The most prevalent species found in biogenic emissions are isoprene and alpha pinene (a monoterpene). These two compounds, which comprise a large portion of the total biogenic emissions, have very high reactivity in terms of their potential to form ozone.

Isoprene emissions tend to increase with light intensity and with temperature.[4] Isoprene emissions thus peak when the potential to form ozone is at a maximum. Alpha pinene tends to be emitted at night as well as during the day, and these emissions also peak in the early afternoon.

Trainer _et al_.[5] used a simple model to show that ozone concentrations of almost 12 pphm can occur if biogenic hydrocarbon emissions are combined with concentrations of nitrogen oxides from typical emission sources. His study assumed no anthropogenic emissions of hydrocarbons. Since many areas in California have potentially large emissions of biogenic hydrocarbons, the control of nitrogen oxides is a potentially powerful strategy for reaching the state (or federal) ozone standard in areas downwind of urban areas.[6]

Chamiedes has studied the relationship of hydrocarbons, NOx, and ozone found in atmospheres varying from industrialized urban areas to tropical rain forests.[7] Chamiedes concludes that ozone concentrations are primarily a positive function of NOx concentrations. Based on the ubiquitous presence and high reactivity of biogenic hydrocarbons such as isoprene, he concludes that the ozone formation potential from hydrocarbons is about the same in urban, rural, and remote areas. He notes that the differences in ozone concentrations in these environments are largely the result of differences in the nitrogen oxides emissions. These results are important because isoprene is primarily associated with hardwood trees, and they are abundant in many areas of California. Chamiedes results support NOx controls as an important consideration to mitigate ozone concentrations and not only in regards to urban ozone problems but also regarding the impact of transport.

Sillman[3] reports that biogenic emissions of isoprene are an important source of hydrocarbons in the eastern U.S. and concludes that these biogenic emissions are the reason that hydrocarbon control measures have been ineffective in reducing ozone concentrations in many areas. The presence of biogenic hydrocarbons in the air in many areas of California has important implications pertaining to ozone attainment planning. The efficiency of controlling hydrocarbon emissions as a means to reduce ozone concentrations is diminished due to biogenic emissions.

An inventory of biogenic hydrocarbon emissions in California has been developed by the Air Resources Board's Emission Inventory Branch staff using emission factors developed by Winer[4] and biomass data collected by Engineering Science, Inc.[8] Many areas in California have relatively high rates of emissions of biogenic hydrocarbons compared to anthropogenic emissions.

The magnitude of the uncertainties associated with the estimates of biogenic hydrocarbon emissions is such that these emissions may be best expressed in a qualitative manner. However, despite the uncertainties related to the biogenic emission inventory, the implications of biogenic emissions for upwind emission control strategies are clear. In cases where transport is from urban areas to areas with high biogenic emission inventories, the upwind area must include nitrogen oxides controls.

Researchers have measured ambient concentrations of biogenic hydrocarbons even in the State's most populated air basins. A comprehensive air quality and meteorological data monitoring program was conducted in the South Coast Air Basin during the summer of 1987. Hydrocarbon species were measured at three sites at various times during summer days by Lonneman of the U.S. EPA.[9] The sites were Claremont, Central Los Angeles, and Long Beach. Isoprene and alpha pinene concentrations were detected at each location, and the only known significant source of these compounds is biogenic emissions. Claremont represents the area with the basinwide peak ozone. At Claremont during the peak ozone period (from 1 to 4 p.m.), isoprene accounts for up to 20 percent of the total hydrocarbon reactivity (excluding oxygenated compounds). On days when isoprene concentrations are high, the effectiveness of hydrocarbon emission reductions as an ozone control strategy is diminished.

In summary, ozone precursor control must focus on both hydrocarbon and NOx to reduce downwind ozone concentrations. The reduction of hydrocarbon emissions may be effective in reducing ozone build-up in urban areas. However, downwind, non-urbanized areas with an abundance of reactive hydrocarbons (from both anthropogenic and biogenic sources) are likely to be more responsive to control of NOx emissions than previously recognized. The reduction of NOx will always reduce downwind ozone even though ozone may increase somewhat in the vicinity of the NOx reductions. NOx reductions may have to be accompanied by hydrocarbon reductions to offset these increased ozone concentrations near the NOx reductions. However, NOx controls will be effective in reducing the effects of transport in regions downwind that have low NOx emissions and relatively high biogenic emissions. Such NOx control is appropriate in both upwind, urbanized, and downwind areas.

C. Trends of Ozone and Precursors

The staff analyzed air quality history and compared the changes in the daily maximum-hour ozone concentrations with changes in the emissions of reactive hydrocarbons (RHC) and nitrogen oxides in the South Coast Air Basin[10] (SCAB). The comparison focused on three different patterns of emissions that occurred from the mid-1960s to the mid-1980s: 1) initially, RHC emissions decreased at a moderate rate and nitrogen oxides emissions increased at a moderate rate, 2) during the middle period, RHC emissions decreased at a rapid rate and nitrogen oxides emissions were relatively constant, and 3) during the most recent period, RHC emissions decreased at a rapid rate and nitrogen oxides emissions decreased at a moderate rate.

The trend of ozone concentrations in the eastern portion of the SCAB (normally downwind of the bulk of the precursor emissions) was different under each of these emission patterns. Ozone concentrations generally increased during the first period when RHC emissions decreased and NOx emissions increased. Ozone concentrations did not change appreciably during the second period when RHC emissions decreased and NOx emissions remained constant. Ozone concentrations downwind decreased during the third period when RHC and NOx emissions decreased. The staff concluded that NOx as well as hydrocarbon reductions in upwind areas are an important component of an ozone control strategy for downwind areas.

In updating this ozone trend study, the staff found that the ozone concentrations in the eastern portion of the SCAB decreased at a slower rate after 1984 and changed slightly after 1986. This trend does not necessarily conflict with a recent study by Zeldin, et al.[11] that showed ozone concentrations continuing to improve. Zeldin's study was based on extreme value statistics such as annual maxima and the number of days when ozone concentrations exceeded 19 pphm. Different analyses based on the different parts of the ozone frequency distribution can show different trends. This observation in ambient data could be explained by emission data which shows that the rate of decline in emissions of NOx in the basin has been less in recent years than it was in the early 1980's.

The staff also reviewed ozone concentrations since the early 1970s at two sites in the Southeast Desert Air Basin (Banning and Palm Springs). These sites are frequently impacted by transport from the SCAB. The trend of ozone concentrations for these sites was similar to the trend noted earlier for the eastern portion of the SCAB. Thus, these data tend to confirm the conclusion that upwind reductions in NOx emissions result in downwind reductions in ozone concentrations--even for transport over distances as long as 120 miles.

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IV. TECHNIQUES USED TO ASSESS THE RELATIVE CONTRIBUTIONS OF UPWIND EMISSIONS TO DOWNWIND OZONE CONCENTRATIONS

A. Introduction

The transport of ozone and its precursors from an upwind to a downwind area occurs when winds of a sufficient speed, direction, and duration are present. Transport can take place either at the surface or aloft. Pollutants transported aloft reach the surface when the low level inversion disappears as a result of surface and convective heating. A coastal marine layer typically intrudes as far inland as 100 miles or more into most of California resulting in temperature inversions within the lowest several thousand feet of the atmosphere. Ozone generated near the surface on sunny days disperses throughout this mixed, marine layer. As the sun sets and the air near the ground cools, a ground-based inversion develops. The pollutants aloft remain in a layer which is now separated from the surface layer, and these pollutants can be transported in different directions than surface winds may indicate.

At night, the ozone concentrations near the ground decrease because without sunlight the photochemical process stops and no further ozone can be formed. Ozone is then removed from the atmosphere through deposition on vegetation or other surfaces or through reaction with nitric oxide. However, the ozone aloft remains. As the air is heated the next morning, heat-induced turbulence causes the nighttime inversion to gradually erode, and the mixed layer increases in height. As the mixed layer increases in height, ozone aloft (which may have been transported at night from another area) is carried to the surface.

This Chapter describes the techniques used to assess the transport of air pollutants based upon the available data. Specifically, this chapter explains the three methods of assessment: meteorological data analysis, air quality data analysis, and air quality modeling. The transport couples identified in Section 70500, Title 17, California Code of Regulations are listed in Table 4 below. For each transport couple Table 4 identifies the type of analysis used for assessing impacts on downwind areas. One couple, the San Francisco Bay Area Air Basin to the San Joaquin Valley Air Basin, has been studied using both techniques.

The results from two or more of the analytical approaches can be used to infer whether transport occurs or not. The more analyses which provide results confirming transport, the stronger the staff's conclusion that transport occurred. The comparison of emissions between upwind and downwind areas is important only in a relative sense. For instance, if a wind trajectory analysis indicates that transport winds move air from an upwind area to a downwind area, the potential impact on the downwind area's ozone concentration is dependent on the relative emissions between the two areas. If the upwind area has twenty times higher emissions than the downwind area, the conclusion regarding the potential impact is different than if the upwind area has twenty times lower emissions than the downwind area.

Sometimes different analytical approaches will yield conflicting results. In these cases, the recommendations are based on the staff's judgement of the most reliable approaches and information best confirmed by other approaches. Also, for many transport couples there will be limited capability to quantify the impact of transported pollutants on downwind ozone concentrations. The recommendations in some cases will be more qualitative than in others.

TABLE 4

TYPE OF ANALYSIS UNDERTAKEN FOR EACH TRANSPORT COUPLE

Couple	Data Analysis	Modeling
SF Bay Area to North Central Coast	X	
SF Bay Area to Broader Sacramento	X	
SF Bay Area to San Joaquin Valley	X	X
Broader Sacramento to SF Bay Area	X	
Broader Sacramento to Upper Sacramento Valley	X	
Broader Sacramento to San Joaquin Valley	X	
San Joaquin Valley to Broader Sacramento	X	
San Joaquin Valley to Southeast Desert	X	
South Coast to San Diego	X	
South Coast to Southeast Desert	X	
South Coast to South Central Coast		X
South Central Coast to South Coast		X
Undetermined to Great Basin Valleys	X	
Coastal Waters to South Central Coast		X

B. Meteorological Data Analysis Techniques

1. Analysis of Surface Winds

The staff used hourly surface wind speed and direction data to establish whether the surface air flow could transport pollutants from upwind to downwind areas. The staff made a determination of potential transport from upwind to downwind areas if: 1) wind directions were similar in the upwind and downwind area, and 2) the wind speeds were persistent and fast enough to move emissions from the upwind area to the downwind area in a period of time consistent with the time of maximum ozone concentrations in the downwind area.

2. Analysis of Winds Aloft

The staff reviewed winds aloft data to establish whether the air flow aloft could transport pollutants from the upwind and downwind areas. For each transport couple, the staff reviewed the wind speed and direction data collected at sites nearest the upwind and downwind areas. Upper air data were only routinely collected twice per day at three stations within California (Oakland, Vandenberg AFB, San Diego). Therefore, winds aloft for a given transport couple were typically available from one station only. Some supplemental winds aloft data for limited periods were also available from military, air quality, or research projects. The staff made a determination of potential transport from an upwind to a downwind area if the direction, speed, and persistence of winds aloft indicated air movement from the upwind to the downwind area.

3. Calculation of Estimated Transport Time

Transport time was defined as the length of time required to move an air parcel from an upwind to a downwind area. The time was computed by dividing the distance between the two areas by the mean wind speed. The staff made a determination of potential transport from an upwind to a downwind area if the transport time for upwind emissions would lead to their arrival in the downwind area near the time of maximum ozone concentrations in the downwind area.

4. Review of Daily Streamline Analyses

The ARB staff drew daily streamline charts for 4 a.m., 10 a.m. and 4 p.m. Streamlines are lines drawn parallel to plotted wind directions which depict air flows of differing scales throughout most of California. The staff reviewed daily streamline analysis charts to identify whether the general air flow directions were conducive to movement of air from the upwind to the downwind area. The staff made a determination of potential transport between upwind and downwind areas if the air flow direction was from the upwind to the downwind area.

5. Review of Surface Air Flow Types

The staff also drew daily streamline analyses of surface air flow directions based on winds observed at 4 a.m., 10 a.m., and 4 p.m., Pacific Standard Time. The staff also classified the streamline patterns in the San Francisco Bay Area, Sacramento Valley, San Joaquin Valley, and South Coast Air Basin into surface air flow patterns by wind direction. The staff made a determination of potential transport from an upwind to a downwind areas if the general wind direction by the air flow type was from the upwind to the downwind area.

6. Trajectory Analysis

Trajectory analysis is a pictorial technique which estimates the path an air parcel took over a specified period of time. The technique used hourly or two hourly surface streamline charts to estimate the average speed and direction of the air parcel for a one-hour or two-hour increment. Segments were drawn for each one-hour increment for a predetermined period (typically 12-24 hours) to simulate the path of an air parcel. Forward trajectories traced the path of an air parcel forward in time from a site to determine where the air parcel ended up after a specified period of time. Back trajectories traced the path of an air parcel backward in time from a site to determine where the air parcel originated. The staff made a determination of potential transport from an upwind to a downwind area if the forward trajectories showed that the air parcel moved from the upwind area to the downwind area. Conversely, the backward trajectories needed to show that an air parcel at the exceedance site in the downwind area originated in the upwind area.

7. Surface Pressure Gradient Analysis

The staff analyzed surface pressure gradient data to estimate the strength and direction of the wind over an area when wind data were missing. A pressure gradient is the difference in surface atmospheric pressure at two sites divided by the horizontal distance between the two sites. Pressure gradients exert a force on air that results in air movement (wind) from an area with high pressure to an area with low pressure. The staff made a determination of potential transport from an upwind to a downwind area if the surface pressure was higher in the upwind than the downwind area.

8. Presence of the Marine Air Layer

The staff used the temperature data from the 4 a.m. and 4 p.m. soundings at Oakland to detect the presence of and to estimate the depth of the marine air layer. The marine air layer is confined to a coastal setting and is the cool, moist air at or near the surface that extends to the top of the inversion layer. An increase in the depth of the marine air layer from morning to afternoon is a strong indication of onshore air flow. The depth of the marine air layer is used to indicate the intensity of the onshore flow. The staff made a determination of potential transport from a coastal environment if an inversion existed at or near the surface, the top of the inversion in the upwind area was higher than the elevation of the site at which the exceedance occurred, and the direction of the winds was from the upwind to the downwind area.

9. Review of Daily Maximum Temperature

The staff reviewed the daily maximum temperatures to estimate how far inland the marine air may have penetrated during the day. A downwind site with a significantly different maximum temperature than the maximum temperature at the upwind site was a strong indication of a different air mass at each site. However, if the downwind and upwind sites had similar maximum temperatures, it is suggested that both sites may have shared the same air mass. The staff made a determination of potential transport if the maximum temperature in a coastal upwind area was similar to the maximum temperature in a portion of the downwind area.

In addition, a change in the maximum temperature from one day to the next at a site typically exposed to the marine air layer may indicate a related change in the flow of the marine air layer inland. For example, if the maximum temperature increased from one day to the next, the staff concluded that the potential for transport decreased.

C. Air Quality Data Analysis Techniques

1. Analysis of the Geographic Extent of Exceedances

The staff analyzed the size and shape of the area(s) exceeding the state ozone standard to obtain some information about the source of the ozone and precursors contributing to the exceedances. Exceedances that occurred only in an area downwind of major emission sources in the downwind basin indicated that emissions in the downwind basin most likely caused the high ozone concentrations. The staff made a determination of potential transport if exceedances occurred in contiguous portions of the upwind and downwind air basins.

2. Estimating the Source of Emissions Based on Time of Daily Maximum Ozone Concentration

Maximum ozone concentrations in a downwind area resulting from photochemical reactions involving "local" emissions typically occur around solar noon but can range between 11 a.m. and 2 p.m. Maximum concentrations occurring before 11 a.m. may be the result of the fumigation of ozone trapped aloft from the previous day. The staff made a determination of potential transport if maximum concentrations in the downwind area occurred late in the afternoon or early evening, or if the winds aloft data indicated that an upwind area was a potential source of the fumigated ozone, or if the surface winds indicated a potential for the transport of ozone precursors from the upwind area to the downwind area by early afternoon.

3. Similarity of Daily Maximum Ozone Concentrations

The staff compared the daily maximum ozone concentrations in the upwind and downwind areas because similar daily maximum concentrations may indicate that the same air mass had affected both areas. The staff made a determination of potential transport if similar maximum ozone concentrations occurred in the upwind and downwind areas and the air flow was conducive to transport from the upwind area to the downwind area.

4. Review of the Hour of the Daily Maximum Ozone Concentration

The staff reviewed the progression of the daily maximum ozone concentration along a potential transport path to identify the potential transport of ozone from an upwind area to a downwind area. The progression of the time of maximum ozone concentration indicated the movement of a polluted air mass from an upwind area to a downwind area. The staff made a determination of potential transport if the time of the daily maximum ozone concentration at air monitoring stations was progressively later along a candidate transport path from an upwind area to a downwind area.

5. Time Series Analysis

The staff conducted time series analyses to identify the likelihood that ambient ozone concentrations originated from local or from transported emissions. Time series analyses involves plotting the hourly concentrations of ozone for a three-day period centered on the exceedance day. Hourly ozone concentration plots are drawn for air monitoring stations in both the upwind and downwind areas. Daily profiles of ozone concentrations for the air monitoring stations in the upwind and downwind basin are compared to determine similarities. The staff made a determination of potential transport if the shapes of the diurnal plots of ozone concentration are similar in the upwind and downwind air basins, especially if there are similar bimodal maximums and consistent maximums for several successive hours.

6. Comparison of Ozone Precursor Emissions in the Upwind and Downwind Areas

The staff used data from the 1987 ARB emission inventory to compare the magnitude of ozone precursor emissions (reactive organic gases (ROG) and nitrogen oxides (NOx)) in the upwind and downwind areas. The staff made a determination of significant contribution if the meteorological data indicated the potential for transport between the upwind and downwind areas and the magnitude of emissions were relatively similar in both areas. The staff made a determination of overwhelming contribution if the meteorological data indicated the potential for transport between the upwind and downwind areas and the emissions in the upwind area were high while emissions in the downwind area were low.

D. Photochemical Grid Modeling

Photochemical grid models (PGMs) use mathematical equations to simulate the physical and chemical mechanisms that produce ozone in the atmosphere. The modeling domain is a 3-dimensional array of grid cells covering the area of interest. Typical grid cells are 5 by 5 kilometers (about 3 by 3 miles) in the horizontal and 50 to 500 meters (about 165 to 1640 feet) thick in the vertical dimension. A modeling domain may require 10,000 cells to cover an area of interest. Meteorological data such as wind speed, wind direction, turbulence, and temperature must be input into the model for each cell and for each hour of simulation. The PGM then calculates the hourly concentrations of precursors of ozone within each cell taking into account emissions, the movement of pollutants among cells, the chemistry that occurs among chemical species within each cell, and the meteorological variables such as temperature that influence chemical reaction rates. A PGM cannot quantify the air quality impacts that result from emissions transported from outside of the modeling domain.

The meteorological data required to run a PGM must be collected in sufficient detail to describe the spatial and temporal variability that may exist within the modeling domain. Since it is not feasible to collect meteorological data for each cell, data values for most cells must be interpolated from the available surface and aloft monitoring data. In most areas of California that are close to mountains or to the ocean, values for meteorological variables change rapidly over relatively short distances. Also, wind speed and direction, and temperature change with height. Existing surface and aloft meteorological monitoring networks are not adequate to describe these changes, and special monitoring programs are required to supplement these networks where a PGM will be used.

A PGM will calculate pollutant concentrations within each cell. The results of these calculations are influenced by initial and boundary conditions. The initial conditions are the pollutant (ozone and precursor) concentrations in each cell of the modeling domain at the beginning of the simulation. The boundary conditions are pollutant concentrations at the edges of the modeling domain, and they represent the concentrations in air entering the modeling domain. Even clean air has some pollutants (the "background" concentration of ozone over the Pacific Ocean is about 4 pphm), and where areas upwind of the modeling domain have high emissions, boundary concentrations may also be high. As with meteorological data, boundary conditions must be provided as input for a PGM for each hour of simulation. Special monitoring programs are almost always required to supplement routine monitoring networks where a PGM will be used.

There are a number of factors that may contribute to inaccurate results from a PGM. In many areas of California, it is difficult and expensive to collect data, particularly where geography causes extreme variability of meteorological and air quality measurements. Inaccurate quantification of these variables can lead to inaccurate estimates of how the pollution is moving or mixing. PGM simulations are frequently started a day before the time period of interest to allow the PGM to diminish the impact of the initial conditions. These simulation results may differ from measured air quality because pollutant concentrations are assumed uniformly distributed within each cell while observed pollutant concentrations are measured at a single point. Therefore, absolute comparisons between simulation results and observed concentrations will depend on the variability in actual pollutant concentrations within the volume represented by the grid cell.

When the upwind and downwind areas of a transport couple are both contained within the same modeling domain, transport between the upwind and downwind areas can be directly calculated. However, for most transport couples, upwind and downwind areas are not contained in the same modeling domain, and the impact of transport must be determined indirectly from the simulation results.

When the upwind portion of a transport couple is not within the modeling domain, the impact of upwind emissions on receptors within the domain can be evaluated by perturbing boundary concentrations. Pollutant concentrations at the modeling domain boundaries are based on observed air quality and are input into the model to represent air quality in areas upwind of the domain. The differences in simulation results between the base case and a simulation in which pollutant concentrations on the boundaries are set to clean or background values can be attributed to emissions in the upwind source areas.

When the downwind portion of a transport couple is not within the modeling domain, the impact of the upwind emissions within the modeling domain on pollutant concentrations in downwind areas cannot be determined directly. To evaluate this impact, the transport of pollutants across a plane at the boundary of the two areas forming the transport couple is estimated using the PGM. Amounts of ozone, nitrogen oxides, and hydrocarbons leaving the modeling domain can be estimated. The differences between the pollutant amounts calculated from base case simulations and from zero emissions simulations can be attributed to emissions in the upwind area. These differences can then be compared with emission inventory estimates in the downwind area to evaluate relative impacts.

A. San Francisco Bay Area to North Central Coast

1. Summary and Recommendation

The staff's analysis shows that transport from the San Francisco Bay Area Air Basin (SFBAAB) to the North Central Coast Air Basin (NCCAB) occurred on all days during 1986 through 1988 when the state ozone standard was exceeded. The analysis also shows that emissions within the NCCAB had little or no impact on the exceedances, all of which occurred at the Hollister air monitoring station.

The staff recommends that the SFBAAB's transport to the NCCAB be classified "Overwhelming" and that the Bay Area Air Quality Management District be held accountable for developing in its 1991 plan a control strategy for attaining the state ozone standard at Hollister.

2. Conclusion

The staff believes that the contribution of the SFBAAB emissions to exceedances of the state ozone standard in the NCCAB is overwhelming.

The staff's conclusion is based on the meteorological and air quality data for the 12 days during 1986 through 1988 when the state standard was exceeded in the NCCAB. The staff found evidence of transport from the SFBAAB to the NCCAB on all days when the state standard was exceeded in the NCCAB. The staff also found that most of the emissions from the NCCAB (from the Monterey Bay Area) on the exceedance days did not reach the location where the exceedances occurred. Finally, the staff found that on days when transport from the SFBAAB to the NCCAB did not occur, the NCCAB did not exceed the state standard for ozone.

3. Geographic Setting

The NCCAB includes Monterey, San Benito, and Santa Cruz Counties. The SFBAAB comprises Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, and Santa Clara Counties and parts of Solano and Sonoma Counties. A map of these areas is provided in Figure 2.

The dominant geographic feature influencing air flow in the SFBAAB and the NCCAB is the Coast Range. The Coast Range comprises a series of parallel northwest to southeast oriented ridges and valleys. The ridges range in elevation from 2000 feet at the coast to over 3000 feet inland. Between the ridges lie the San Francisco Bay, the Santa Clara Valley, the San Benito Valley, and the Salinas Valley. Beginning at the south end of the San Francisco Bay, the Santa Clara Valley extends southeastward for 35 miles from San Jose until it merges with the San Benito Valley at the Santa Clara County line. The San Benito Valley extends southeastward from the Santa Clara County line for approximately 35 miles to the Pinnacles National Monument. The Santa Clara-San Benito Valley combination gently slopes upward from an elevation of 80 feet at San Jose to an elevation of 300 feet some 45 miles southeastward to Hollister. The two valleys

V. TRANSPORT ASSESSMENT STUDIES

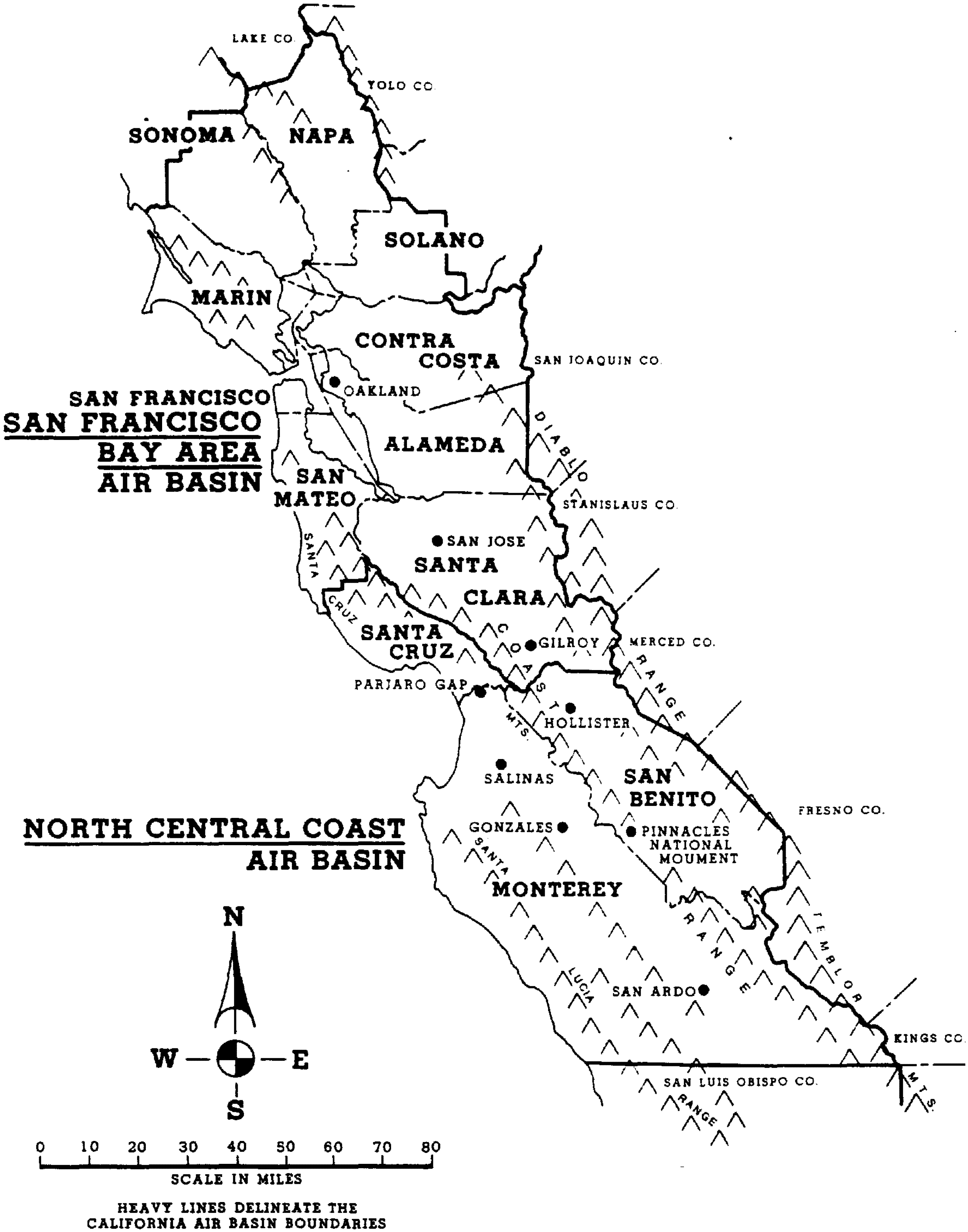
As discussed in Chapter IV, data analysis and photochemical grid modeling are different approaches to transport assessment. The results from the two approaches offer information that can be used differently. Modeling studies are capable of yielding objective and direct answers to the important questions. Data analysis usually provides more qualitative answers. This chapter will discuss the conclusions from all the transport assessment studies conducted using available information.

The conclusions from the assessment of transport are the basis for the proposed mitigation policy and regulations. The mitigation requirements included in the proposed regulations are based on the transport categories found during the assessment studies for each couple. The contribution of upwind emissions to exceedances of the state ozone standard in downwind areas can be either inconsequential, significant, or overwhelming. In addition, transported pollutants may be the overwhelming reason for a downwind ozone exceedance for one episode and be an inconsequential part of an exceedance on a different day. This means that all three transport categories may be documented and assigned to each transport couple. The mitigation policy and regulations must ensure that ozone concentrations are reduced for all three transport categories.

Figure 2

TRANSPORT COUPLE

SAN FRANCISCO BAY AREA to NORTH CENTRAL COAST



without any physical barrier to the flow of air between them provide the topographic setting for transport from the SFBAAB into the NCCAB. At Hollister, the San Benito Valley continues southward for approximately another 25 miles toward the Pinnacles National Monument.

The Salinas Valley lies to the west of and parallel to the San Benito River Valley. The Salinas Valley extends approximately 75 miles southeastward from Salinas to San Ardo. The ridge dividing the Salinas Valley and the San Benito Valley ranges in elevation from 200 feet at the Pajaro Gap northwest of Hollister to 3400 feet northeast of Gonzales.

4. Summary of Previous Transport Studies

Previous studies have shown strong evidence of transport from the SFBAAB to the NCCAB. Preliminary studies such as Blumenthal, et al.[1] demonstrated the movement of air pollutants from the SFBAAB southeastward past San Jose.

Dabberdt[2] in a 1980 field study found transport up the Santa Clara Valley to Hollister although the occurrence was sporadic. He found that the movement of two separate marine air masses, one eastward from Monterey Bay and the other southeastward through the Santa Clara Valley, apparently sets up a convergence zone in the northern San Benito Valley (refer to discussion in assessments section). He found on most occasions that the marine air from the Monterey Bay inhibited material transported from the SFBAAB from going south of Gilroy. On other occasions, he saw the marine intrusion break down for short periods enabling transport of air from the SFBAAB to Hollister.

Dabberdt also found no significant ozone transport from Los Gatos to Scotts Valley and Aptos. He detected another transport route where significant amounts of ozone and ozone precursors were transported offshore from San Mateo County into the NCCAB where ozone exceedances were measured at several locations in the NCCAB.

5. Data

The staff's assessment of transport was based on data for 1986 through 1988 ("study period"). During the study period, there were only 12 days during which the state standard was exceeded in the NCCAB (see Table 5). Of the six ozone monitoring sites in the NCCAB operated by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) during the study period, only Hollister recorded ozone exceedances. Hollister is the ozone monitoring site located nearest the SFBAAB.

In addition to ozone data collected by the MBUAPCD, the staff reviewed ozone monitoring data for 1987 from a site in the Pinnacles National Monument. The site was operated by staff of the National Park Service, who gathered the data as part of a special study of air quality on public lands. The ozone monitor was located at the Monument

TABLE 5

AMBIENT OZONE AND METEOROLOGICAL DATA FOR HOLLISTER FOR DAYS ON WHICH THE STATE STANDARD WAS EXCEEDED 1986-1988

Date	Max-Hour Ozone Conc. (pphm)	Wind Direction/ Speed (mph) Aloft+ at Oakland--4 p.m.	Mixing Height* at Oakland 4 a.m.	Temperature** Difference (Hollister - Monterey)
10/07/86	10	315/09	0	16
04/15/87	10	310/10	0	15
04/16/87	12	295/12	0	16
05/06/87	11	310/13@	0	12
06/01/87	11	310/10	m	15
09/20/87	10	315/10	0	20
09/30/87	10	340/09	0	19
10/03/87	11	290/08	0	23
09/03/88	10	305/09	500	29
09/04/88	10	305/09	500	29
10/16/88	10	290/04#	0	05
10/17/88	10	315/10	0	06

+ Aloft wind data for 1000 feet above ground level; directions are degrees from true north
* Mixing heights expresses as feet above sea level
** Temperature data are in degrees Fahrenheit
@ Winds at 3000 feet
# Surface winds
m Missing data

Headquarters at an elevation of 1200 feet. The Headquarters is sited on the western side of the ridge that forms the western boundary of the San Benito Valley. Because quality assurance reviews of these data have not yet been completed, the data cannot be regarded as having comparable quality to the data gathered at Hollister. The staff found that Pinnacles had 35 exceedance days in 1987. The Pinnacles data were considered in the transport assessment but used with caution because of data quality uncertainty.

6. Emission Inventory

Emission inventory data were available as statewide totals and as totals by air basin or by county. While emission totals provide only general information, they were useful for determining the relative difference in emissions between various areas. The staff used this information to gain a general indication of the potential for upwind and downwind areas to contribute to ozone concentrations.

Ozone precursor emissions consist primarily of emissions of reactive organic gases (ROG) and nitrogen oxides (NOx). The 1987 emission inventory data indicate that ozone precursor emissions in the SFBAAB are 1179 tons/day. This is more than six times the ozone precursor emissions for the NCCAB--174 tons/day.

Santa Clara and San Mateo Counties are the two counties in the SFBAAB located closest to the NCCAB and therefore have the greatest potential for impacting air quality in the NCCAB, especially San Benito County. When the ozone precursor emissions for the two SFBAAB counties are compared to those for San Benito County, the disparity is even greater than for the air basins as a whole. Ozone precursor emissions for Santa Clara and San Mateo counties (403 tons/day) are 40 times those for San Benito County (10 tons/day).

The staff did not make a quantitative determination of the relative contribution of the emissions in San Benito County versus the contribution of the emissions in Santa Clara and San Mateo Counties to the ozone concentrations measured at Hollister. The staff could not make a quantitative determination because the emission data are not resolved spatially or temporally and air quality models were not available for these areas. However, emissions of ozone precursors in Santa Clara and San Mateo Counties were 40 times greater than those emissions in San Benito County. Hence, the staff concluded that the emissions in San Benito County did not significantly contribute to ozone exceedances at Hollister.

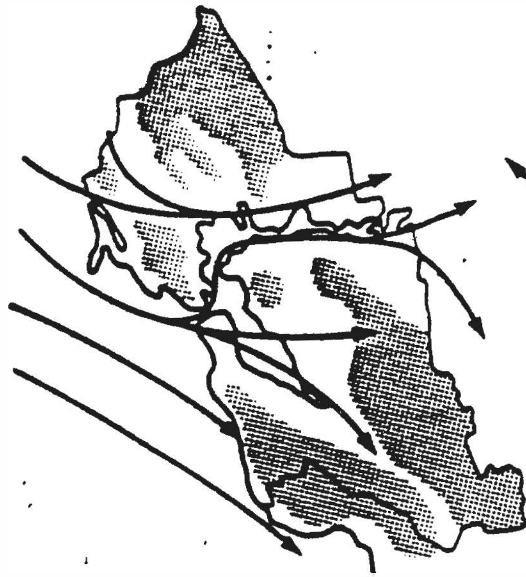
7. Transport Assessment

a. Meteorological Data Analysis Considerations and Results

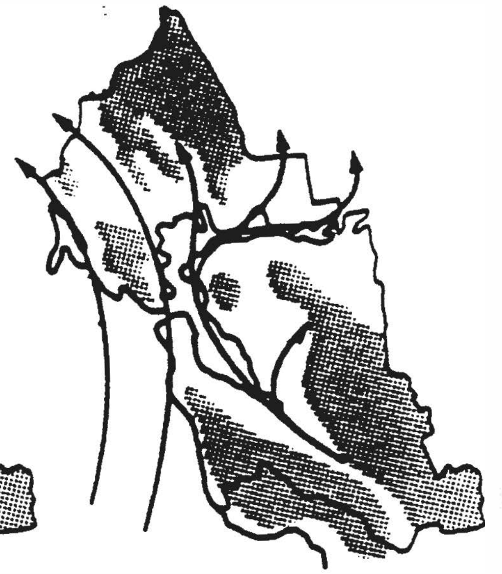
Surface Air Flow Types. The staff has classified the air flow types found in the San Francisco Bay Area. These air flow types are illustrated in Figure 3. Three air flow types--Northwesterly, Northeasterly, and Bay Outflow winds--are conducive to the transport of pollutants from the SFBAAB to the NCCAB. All exceedance days in the NCCAB were associated with one of these air flow types in the SFBAAB. To support the staff's belief that transport occurred, the air flow type would have to persist for at least one day to allow sufficient time for transport. The northwesterly flow type occurred most frequently while northeasterly and bay outflow types usually were intermixed with the northwesterly type. The occurrence of these flow types, individually or in combinations, over a period of at least one day for each exceedance day suggests that transport from the SFBAAB to the NCCAB did occur.

Figure 3 – BAY AREA AIR FLOW PATTERN TYPES

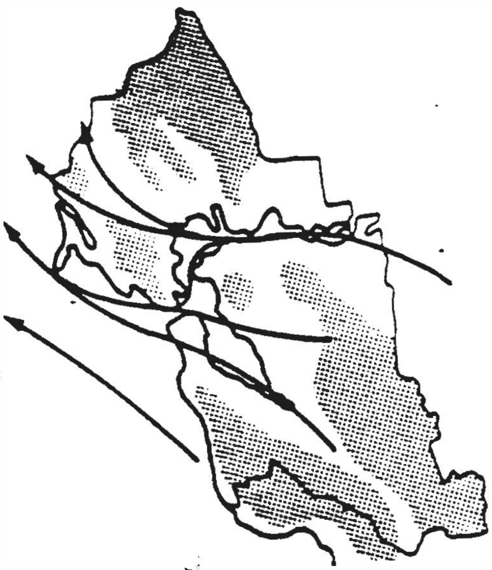
Ia Northwesterly
(weak)



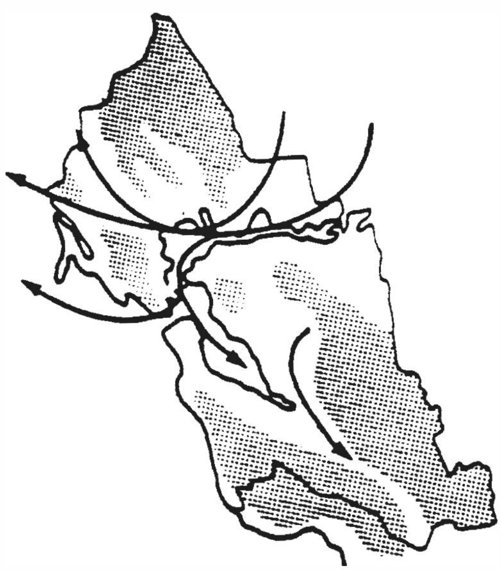
Ib Northwesterly
(moderate to strong)



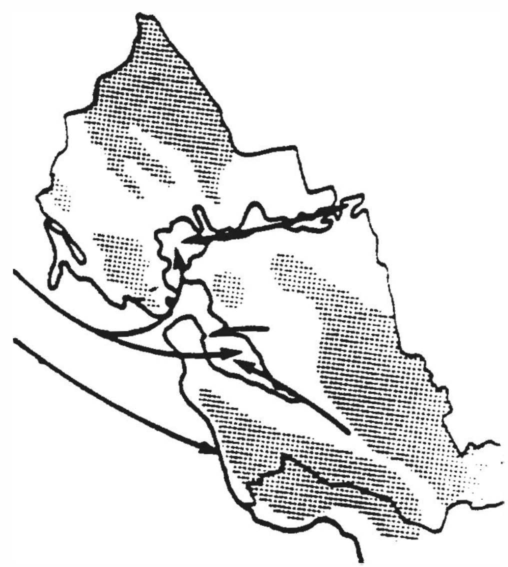
II Southerly



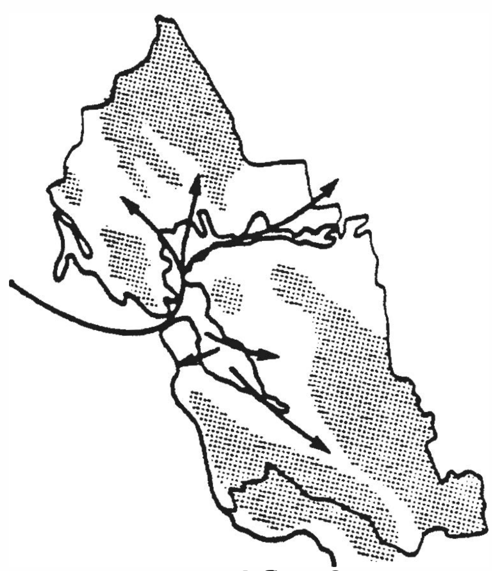
III Southeasterly



IV Northeasterly



V Bay Inflow



VI Bay Outflow

Winds Aloft. Oakland was the site nearest to the two air basins for which there were measurements of winds aloft. Two measurements were taken each day: one at 4 a.m. and one at 4 p.m. A review of the winds aloft (1000 feet above ground level) data showed that on 7 of the 12 exceedance days, upper air winds at 4 a.m. and 4 p.m. originated from the northwest through northeast. For these seven days, the persistence of the wind direction from the northwest through northeast supports the transport aloft of ozone and precursors from the SFBAAB to the NCCAB.

For the remaining five exceedance days, Oakland winds aloft at 4 p.m. were consistently from the northwest. However, at 4 a.m., Oakland winds aloft were from the west on three days, from the south-southwest on one day, and from the east-southeast on one day. Therefore, the afternoon wind directions for all five days support transport from the SFBAAB to the NCCAB. However, the morning winds aloft data do not support transport from the SFBAAB to the NCCAB on two of the five days.

Transport Time. To assess whether pollutants emitted during the 6-9 a.m. morning rush hour in San Jose could reach Hollister by the time of the maximum ozone concentration, the staff computed transport times between San Jose and Hollister based on Oakland winds aloft speed data. Based on the 4 a.m. winds aloft speed data, transport time between San Jose and Hollister ranged from 3 to 42 hours on 7 of the 12 exceedance days. These seven days had 4 a.m. winds generally from the north; therefore, the staff concluded the winds were conducive to transport from the SFBAAB to the NCCAB. Based on 4 p.m. winds aloft speed data, transport times between San Jose and Hollister range from 3 to 10 hours for all 12 exceedance days.

Morning rush hour in San Jose occurs between 6 a.m. and 9 a.m. The time of the daily maximum ozone concentration at Hollister during exceedance days ranged from 11 a.m. and 6 p.m. Therefore, the staff estimated that the morning emissions could be transported from San Jose to Hollister in approximately 5 to 10 hours. When the estimate of 5 to 10 hours is compared to computed transport times based on Oakland soundings, the staff concluded that afternoon winds aloft are of sufficient strength and from the right direction to transport ozone and ozone precursors from San Jose to Hollister on all 12 exceedance days. However, only half of the 12 exceedance days had winds sufficient in strength and direction to transport ozone and ozone precursors from San Jose to Hollister based on morning winds aloft at Oakland.

The staff also examined the wind data to determine whether emissions from San Jose during the day preceeding the exceedance could be the cause of exceedances at Hollister. The staff examined the wind data taken at the San Jose Airport by performing a wind run analysis for the day prior to an exceedance day at Hollister. A wind run analysis is a crude estimate of the distance an air parcel travelled based on a summing of the hourly wind speed at a specific location for a defined period of time. The analysis is based on the assumption that the observed one minute averaged wind speed persisted throughout the hour and equalled the distance the air would travel during the hour. The staff found that winds were persistent enough for the day preceeding each exceedance day to transport ozone and ozone precursors from San Jose to Hollister. Therefore, the exceedances at Hollister could have been the result of carryover of pollutants transported the previous day.

Presence of the Marine Layer. The staff reviewed data from the 4 a.m. sounding at Oakland to determine whether a marine layer was present. The marine layer is defined as the cool layer of air that extends from the surface upward to the top of the inversion layer. On all of the exceedance days, the morning marine layer was deep enough to penetrate up the Santa Clara Valley and into the NCCAB. The depth of the marine layer (from the surface to 900-2500 feet) on each exceedance day ensured that the ozone and precursors trapped in this layer were minimally dispersed vertically while transported from SFBAAB to NCCAB.

Daily Maximum Temperatures. On 10 of the 12 exceedance days, the daily maximum temperatures in the Santa Clara Valley (84 to 103 degrees F) were higher, typically by 5 to 10 degrees F, than temperatures at stations in the Monterey Bay area. Sometimes the temperature differences between the two areas were as much as 25 degrees F. This temperature difference indicates that the cooler marine air over the Monterey Bay remained near the coast instead of penetrating far inland. The lack of penetration inland also indicates that on these days there was very little if any surface transport of pollutants from the coastal area of Monterey and Santa Cruz Counties to Hollister. The temperature difference between Monterey and Hollister and the temperature similarity for the Santa Clara Valley and Hollister also suggests that the air mass over Hollister was similar to that over the lower Santa Clara Valley. This indicates that air had penetrated from San Jose up the Santa Clara Valley to Hollister instead of from the coastal part of the NCCAB into Hollister.

For the remaining two exceedance days, the daily maximum temperatures were similar throughout the Santa Clara Valley and Monterey Bay area (upper 80's and lower 90's). However, during these two exceedance days, high pressure building into eastern California caused northwest winds at the surface as evidenced at San Jose Airport and San Martin and at 1000 feet above Oakland in addition to the high temperatures. The northwest winds associated with this pressure pattern support a finding of transport from the SFBAAB to the NCCAB for these two days also.

Surface Wind Observations. In the Santa Clara Valley, San Jose has the most complete hourly surface wind measurements. However, surface wind data at San Jose was not the best indicator of winds throughout the Santa Clara Valley. Wind measurements at San Martin (five miles north of Gilroy) were available for 6 of the 12 exceedance days and indicated a persistence of moderate wind speeds from the northwest the day before and the day of each of the 6 exceedance days (see Table 6). The winds at San Martin during these six exceedance days support a finding of surface transport of ozone and ozone precursors up the Santa Clara Valley from San Jose to Hollister.

Table 6

WIND DIRECTION (degrees) AND WIND SPEED (mph) AT SAN MARTIN FOR SIX OZONE EXCEEDANCE DAYS*

HOUR	EXCEEDANCE DAY					
	9/20/87	9/30/87	9/3/88	9/4/88	10/16/88	10/17/88
12 a.m.	010/02	268/03	330/09	343/09	347/04	354/04
2 a.m.	346/04	062/03	331/10	344/07	029/03	057/01
4 a.m.	332/04	118/01	332/08	344/07	308/02	001/02
6 a.m.	339/03	345/03	332/08	340/07	039/03	345/03
8 a.m.	328/06	040/02	329/09	349/06	163/02	336/04
10 a.m.	336/07	350/04	343/11	336/07	331/06	330/10
12 p.m.	331/13	331/13	330/16	346/13	335/08	332/12
2 p.m.	334/13	331/15	332/14	333/13	322/12	333/13
4 p.m.	338/13	330/12	328/16	329/12	327/10	330/11
6 p.m.	332/08	166/08	335/12	344/07	338/08	348/07
8 p.m.	344/08	164/04	345/10	178/04	343/05	329/07
10 p.m.	326/03	164/02	351/09	207/02	003/03	328/04

* Wind data are not available for the remaining six exceedance days.

b. Air Quality Data Analysis Considerations and Results

Geographic Extent of Exceedances. On 10 of the 12 exceedance days, the geographic area over which the exceedances occurred extended throughout the Santa Clara Valley and included the San Jose, Gilroy, and Hollister ozone monitoring sites as shown in Table 7. This geographical extent suggests that all three stations were in the same air mass and further indicates the likelihood that air from the SFBAAB had penetrated the Santa Clara Valley from San Jose to Hollister. On the remaining two days, the geographic extent of ozone exceedances was confined to the Hollister and Gilroy monitoring sites.

Frequency of Occurrence of Exceedances. All but one of the ozone exceedance days in the NCCAB occurred in conjunction with exceedances in Santa Clara County on the same day or the previous day. The one exception was September 3, 1988, on which Hollister reached 10 parts per hundred million (pphm) and Gilroy reached 9 pphm as shown in Table 7. However, the shape of the diurnal concentration profile and timing of the maximum concentrations at Hollister and Gilroy were similar on this day. The similar profile implies a common upwind source area. Winds at San Martin were predominantly from the northwest on September 3, 1988, and the previous day. Northwest winds at San Martin the day of the exceedance and the day before support transport up the Santa Clara Valley to Hollister.

Magnitude of Daily Maximum Concentrations. The daily maximum ozone concentration at San Jose, Gilroy, and Hollister were similar in magnitude (within 2 pphm) for all exceedance days except September 4, 1988 as shown in Table 7. On September 4, 1988, the maximum ozone concentration at Gilroy was 4 pphm higher than the maximum at Hollister. The similarity in the maximum concentrations at San Jose, Gilroy, and Hollister when considered with the direction of the air flow suggested that all three stations were in the same air mass and supported a finding that transport from San Jose to Hollister had occurred.

The staff's review of the data from the Pinnacles National Monument showed that the daily maximum ozone concentration at this site typically occurred up to six hours after the daily maximum at Hollister. The times of the maximum concentrations at Pinnacles correlated with the winds aloft data suggest that the SFBAAB plume continued to travel southeastward past Hollister and arrived a few hours later at the Pinnacles. The exact arrival times depended on the speed of the transport wind. The higher frequency of exceedances at Pinnacles (1200 feet elevation) compared to Hollister (300 feet elevation) suggested that transport aloft was more significant than transport at the surface.

Comparing Times of Daily Maximum Hour Ozone. The staff examined the time of the daily maximum ozone concentration at air monitoring stations in the Santa Clara and San Benito Valleys. The staff found that no progressive movement southeastward or northwestward of the daily maximum hour concentrations in the two valleys. The daily maximum ozone concentration at Hollister on some occasions occurred up to four hours prior to the daily maximum concentration at San Jose. Typically, the daily maximum at Hollister occurred within two hours of the maximum at San Jose. This two hour difference is too short a time period for transport between San Jose and Hollister (separated by 42 miles) to occur.

This lack of progression in the time of the maximum concentration (measured near the surface) suggests that transport did not occur near the surface. However, transport aloft could have occurred. The erosion of the surface-based inversion by surface heating could have resulted in fumigation of ozone from layers aloft to the surface. However, there is insufficient data aloft at Hollister to support this finding.

Convergence Zone. Previous transport studies in the SFBAAB and NCCAB areas identified an air flow convergence zone in the northern San Benito Valley that generally inhibited transport south of Gilroy. A convergence zone is defined as an area where winds from different directions come together and form an updraft. The convergence zone in the northern San Benito Valley occurs when marine air flowing eastward from the Monterey Bay "converges" with air flowing southeastward from San Jose through the Santa Clara Valley. The convergence zone occurs most frequently in summer when hot temperatures inland and relatively cool temperatures offshore set up a strong pressure gradient across the Coast Range. The gradient results in strong onshore flow across the Coast Range, both at the surface and aloft.

Table 7

Maximum Daily Ozone Concentrations (pphm)
For Hollister Exceedance Days at
Selected SFBAAB and NCCAB Air Monitoring Stations

Air Monitoring Station	Hollister Exceedance Date											
	10/07/86	04/15/87	04/16/87	05/06/87	06/01/87	09/20/87	09/30/87	10/03/87	09/03/88	09/04/88	10/16/88	10/17/88
SFBAAB												
San Jose - 4th	9	10	12	10*	10	12	10	12*	7**	9	12	10
Gilroy	10	11	13	11	11	—	12	12	9	14	11	12
NCCAB												
Hollister	10	10	12	11	11	10	10	11	10	10	10	10
Pinnacles***	—	10	11	11	8	—	14	12	—	—	—	—
Santa Cruz	6	8	8	8	6	4	9	8	8	8	8	8
Davenport	—	4	4	4	4	5	5	3	5	4	7	6
Salinas	6	7	5	6	4	6	5	6	5	4	7	6
Carmel Valley	8	7	9	8	7	7	6	9	5	5	7	9

Notes:

* San Jose - Piedmont: 13 pphm.

** SFBAAB max ozone concentration at Livermore 11 pphm. No exceedances previous 4 days in SFBAAB or NCCAB.

*** Ozone data unofficial due to incomplete quality assurance testing.

— Data missing.

The implication of the convergence zone is that the onshore winds could transport ozone and ozone precursors from sources in the Monterey Bay area into the Hollister area. Whether transport actually occurred on the exceedance days in Hollister is not known because there was a lack of wind speed and wind direction data for 1986 through 1988 at the surface and aloft in the three-county area around the convergence zone. However, Dabberdt's (1983) finding of only sporadic cases of transport to Hollister from the Santa Clara Valley during the September-October 1980 field tests might explain why Hollister had fewer exceedances per year than Gilroy as shown in Tables 8 and 9.

Although Gilroy and Hollister are only 15 miles apart, Gilroy has four times more exceedance days than Hollister (Table 8). On most days, the convergence zone apparently blocks the polluted air from the Santa Clara Valley from reaching Hollister. Dabberdt (1983) found that the convergence zone breaks down on only a few occasions at which time air from the northwest (Santa Clara Valley) reaches Hollister. Conversely, Dabberdt also found that the convergence zone occurs on most days, even in September and October, and exposes Hollister to air from the Monterey Bay on those days.

Wind summaries from the mid-1940's (Table 10) indicate that surface winds at Hollister are from the southwest through west over 50 percent of the time from the spring through fall. The wind summaries can be interpreted to suggest that if the emission sources along the Monterey Coast could cause high ozone concentrations in Hollister there should be a higher number of exceedances at Hollister. However, the data show that the number of exceedances at Hollister are very small.

In addition, as shown in Table 9, the occurrences of exceedances at Hollister are confined to the spring and fall months instead of the summer months. The staff does not know why, however the convergence zone may be a major factor. The convergence zone is strongest and occurs most frequently in the summer months because the temperature gradient across the Coast Range is strongest then. However, the exceedances at Hollister occur during the seasons when the convergence zone is weaker and more likely to breakdown. The occurrence of convergence zone breakdown during the fall months was confirmed in Dabberdt's study in 1980.

The data in Table 8 further support a finding that exceedances at Hollister are linked to emissions from the Santa Clara Valley. Nine of the 12 exceedances at Hollister occurred when both San Jose and Gilroy had exceedances. Furthermore, none of the other five air monitoring stations in the NCCAB had exceedances in the 1986-1988 period when Hollister measured exceedances. Hence, the staff concludes that the exceedances at Hollister result from the breakdown of the convergence zone and the resulting air flow from the Santa Clara Valley and not as a result of the air flow from the Monterey Bay area.

TABLE 8

Number of Exceedance Days by Year (1986-1988)
for San Jose, Gilroy and Hollister

Year	San Jose-4th	San Jose-Pied	Gilroy	Hollister	Concurrent Exceedances at Gilroy & Hollister	Concurrent Exceedances at San Jose, Gilroy & Hollister
1986	10	5	5	1	1	0
1987	23	22	19	7	6	6
1988	12	13	23	4	3	3
Total	45	40	47	12	10	9

TABLE 9

Number of Exceedance Days by Month (1986-1988)
for San Jose, Gilroy and Hollister

Air Monitoring Station	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
San Jose-4th			3	8	9	5	4	5	5	8		
San Jose-Pied				8	7	5	4	6	4	6		
Gilroy				3	4	4	7	7	13	9		
Hollister				2	1	1			4	4		
Concurrent Exceedances at Gilroy and Hollister				2	1	1			2	4		
Concurrent Exceedances at San Jose, Gilroy, and Hollister				2	1	1			2	3		

TABLE 10

Frequency of Occurrence of Mean Wind Speed and Wind Direction by Season for Hollister

```
*****************************************************************************************
*              SURFACE WIND SUMMARY              *   Period of Record:    * Bias Index: 0.89 *
*  Station Name: HOLLISTER                       *                        * Speed Units: MPH *
*     Elevation: 200     Feet                    *  JUL 1943 - FEB 1945   *                  *
*                      Degrees  Minutes          *                        *    Source Code   *
*  North Latitude:       36       53             * Observations:   1,828  *      Data:  1    *
*  West Longitude:      121       24             *  3 OBS/DAY 08-16 PST   *    Summary:  E   *
*****************************************************************************************
```

DIRECTION	WINTER % OF TIME	WINTER MEAN SPEED	SPRING % OF TIME	SPRING MEAN SPEED	SUMMER % OF TIME	SUMMER MEAN SPEED	FALL % OF TIME	FALL MEAN SPEED	ANNUAL % OF TIME	ANNUAL MEAN SPEED
N	13.4	5.4	3.6	3.7	2.8	2.8	6.4	5.0	7.2	4.9
NNE	****	****	0.7	6.3	****	****	0.2	2.3	0.2	5.0
NE	3.9	3.2	3.3	4.9	****	****	0.9	1.8	1.9	3.5
ENE	****	****	0.4	11.5	****	****	0.2	3.5	0.1	7.5
E	17.5	4.3	9.1	3.1	6.3	2.7	13.2	2.8	12.1	3.4
ESE	0.7	11.8	0.7	9.2	0.4	6.3	0.9	6.2	0.7	8.4
SE	6.1	6.6	5.1	5.4	1.9	2.8	4.0	2.9	4.3	4.9
SSE	****	****	0.4	3.5	0.4	3.5	0.2	4.6	0.2	3.7
S	6.3	4.6	4.0	9.4	5.2	3.4	6.6	3.3	5.7	4.4
SSW	0.2	9.2	****	****	0.6	4.2	0.9	4.8	0.5	5.1
SW	3.5	10.2	30.4	13.8	24.4	15.1	15.6	13.1	16.5	13.9
WSW	0.4	5.2	3.3	13.6	10.8	13.8	5.9	11.6	5.1	12.8
W	32.8	5.6	26.4	10.1	38.2	11.4	31.7	6.8	32.9	8.2
WNW	1.3	7.9	1.8	11.3	3.2	7.1	4.6	5.5	2.8	6.8
NW	8.7	6.3	9.1	5.3	3.7	3.9	4.9	4.9	6.3	5.4
NNW	0.2	10.4	****	****	****	****	0.4	2.3	0.2	5.8
CALM	5.0		1.6		2.0		3.3		3.2	
ALL		5.3		9.4		10.5		6.5		7.6

	WINTER	SPRING	SUMMER	FALL	ANNUAL
RESULTANT WINDS					
DIRECTION:	285	243	249	251	251
SPEED:	1.5	6.6	9.0	4.4	4.9
PER. RATIO:	0.28	0.70	0.86	0.67	0.65
PREDOMINANT WINDS (Alternate Definition)					
DIRECTION:	W	SW	W	W	W
SPEED:	5.7	13.8	11.6	7.3	8.7
PERCENTAGE:	34.5	33.7	52.2	42.2	40.8
SECONDARY PREDOMINANT WINDS (Alternate Definition)					
DIRECTION:	E	NW	E	E	E
SPEED:	4.6	6.3	2.9	3.0	3.7
PERCENTAGE:	10.2	10.9	6.7	14.3	12.9

Prepared by: California Air Resources Board

8. District Comments

The Bay Area Air Quality Management District (BAAQMD) and Monterey Bay Unified Air Pollution Control District (MBUAPCD) submitted letters (See Attachment B) to the ARB, commenting on the documents distributed at ARB's April 17, 1990 workshop. The districts' comments on the assessment of transport and the staff's response are listed below.

a. BAAQMD Comments

Comment: "In its analysis of transport from the Bay Area to the NCC Air Basin, ARB staff assumed that afternoon winds at 1000 feet above Oakland are representative of the flow aloft between the Santa Clara Valley and Hollister. Were morning winds over Oakland also considered? Have any studies been done to verify that this assumption is valid on smoggy days?"

Staff Response: The morning (4 a.m.) winds over (1000 feet above ground level) Oakland were considered as discussed in the transport assessment in Section 4 under "Winds Aloft". Of the 12 exceedance days, ten days had winds over Oakland supporting transport aloft. Two morning winds aloft do not support transport from the SFBAAB to the NCCAB. However, for all 12 exceedance dates the Oakland afternoon (4 p.m.) winds aloft were from the west-northwest through north-northwest. However, afternoon winds for all the exceedance days do support transport aloft of ozone and ozone precursors from the SFBAAB to the NCCAB. No studies were identified or carried out to verify that Oakland winds aloft are representative of winds above Hollister.

Comment: "The Lawrence Livermore National Laboratory performed a photochemical modeling study of transport from the Bay Area to the NCCAB (Penner and Connell, 1988). This study, funded by the ARB, found NCCAB ozone to be insensitive to changes in Bay Area HC and NOx. How would ARB staff reconcile these findings with its own determination of 'overwhelming'?"

Staff Response: Even though the ARB funded the Lawrence Livermore Lab project, the staff found that the model had poor performance in terms of replicating measured concentrations of ozone. Without acceptable performance the results can be misleading. Therefore, the staff had deemed the Lawrence Livermore Lab model as unacceptable. Generally, the staff has found that the best available modeling information about the Bay Area has proven to be critically flawed and not acceptable, as well.

Comment: "As part of its reasoning that there is an 'overwhelming' impact, the ARB points out that emissions in Santa Clara and San Mateo counties exceeds San Benito County's emissions by a factor of 40. The ARB staff also states that it 'cannot assess the specific contribution of emissions from San Benito County.' Did ARB staff attempt to estimate the fraction of emissions from San Mateo and Santa Clara Counties which are actually transported to San Benito County?"

Staff Response: Reliable photochemical models could quantify the fraction of emissions which are transmitted from San Mateo and Santa Clara counties to San Benito county. However, such models were unavailable. Given the relatively sparse amount of air quality and meteorological data, the staff could only make a qualitative assessment of transport contribution from the SFBAAB to the NCCAB. Therefore, the staff did not attempt to estimate the fraction of the emissions from San Mateo and Santa Clara Counties actually transported to San Benito County.

Comment: "ARB staff studied 12 days in 1986-88 on which Hollister exceeded the State standard. We find no reference to any wind observations in the NCCAB. On six of the 12 days San Jose appears to have been the closest site with complete hourly wind measurements. Does ARB staff feel that it can assess the frequency and impact of transport in an area where there is no wind data at the surface or aloft?"

Staff Response: The staff believes it can qualitatively assess the frequency and impact of transport in an area where there are no wind data at the surface or aloft. Estimates of wind speed and direction could be based on an analysis of other indicators including pressure gradients and terrain configuration.

The staff recognizes that the NCCAB has few wind observing sites. However, several wind sites in the NCCAB were utilized in characterizing the air flow in the NCCAB, but they were not mentioned in the report. Surface wind observations from Davenport, Santa Cruz, Salinas, and Moss Landing within the NCCAB and Oakland, Moffet NAS, San Jose Airport, Morgan Hill, and San Martin within the SFBAAB were utilized in the transport analysis. Wind data were available for varying periods of time. The closest wind data to Hollister were at San Martin, not San Jose as mentioned in the comment. However, the data at San Martin was available for only 6 of the 12 exceedance days. San Jose wind data was available for all 12 days, however, the data was not deemed representative of surface conditions further southeastward in the Santa Clara Valley.

Comment: "On page 9, two episodes are described as having 'north through east winds over the two basins.' ARB staff concludes that 'north through east winds associated with this pressure pattern provide sufficient evidence to support a finding of transport of air pollutants from SFBAAB to the NCCAB.' Did ARB staff consider the possibility of transport aloft from the San Joaquin Valley?"

Staff Response: The staff reviewed again the wind observations at the surface and aloft for October 16-17, 1988. The staff found that the winds at the surface were northwest at San Jose for late morning through evening for both days and persistently northwest during daylight hours at San Martin. The winds at 1000 feet above Oakland were northwest at 4 p.m.. Therefore, the wind data support the SFBAAB as the source for ozone and ozone precursors at Hollister during the exceedance days of October 16-17, 1988.

Comment: "On page 10, ARB staff used persistent moderate northwest winds at San Martin on six exceedance days to 'support a finding of transport of ozone and ozone precursors up the Santa Clara Valley from San Jose to Hollister.' Beginning in August of 1989 the BAAQMD began recording wind data at Gilroy, about five miles SSE of San Martin. The data show numerous occasions on which there were simultaneous NW winds at San Martin and SE winds at Gilroy (confirming the existence of a convergence zone in this area). In view of this more recent information, does ARB staff consider it prudent to reevaluate the adequacy of San Martin as an indicator of Santa Clara winds?"

Staff Response: The adequacy of San Martin winds as indicator of Santa Clara Valley winds is addressed in the transport assessment section under Convergence Zone.

b. MBUAPCD Comment

Comment: "The North Central Coast Air Basin is currently being proposed as a receptor of overwhelming pollutant transport from the San Francisco Bay Area based on 1986-1988 data showing exceedances of the State ozone standard at Hollister. Realizing the limited meteorological data the ARB had to work with, the designation of overwhelming transport for the entire air basin should probably not be considered conclusive... There is a need to review and analyze data for exceedances or near exceedances which have occurred in other areas of the District."

Staff Response: The staff has expanded the study period and is currently reviewing exceedances for 1989. New data sources are also being used. The expansion of the period of study and additional data may increase our understanding of the complex meteorological conditions that take place between these two air basins.

REFERENCES

1 Blumenthal, D. L., White, W. H., Peace, R. L. and T. B. Smith, 1974: *Determination of the Feasibility of the Long-Range Transport of Ozone or Ozone Precursors*. Pub. No. EPA-450/3-74-061, Final Rep., Contract No. 68-02-1462, Meteorological Research Inc., 282 pp + 4 Appendices.

2 Dabberdt, Walter F., 1983: *Ozone Transport in the North Central Coast Air Basin - Executive Summary*. Final Rep. SRI Projects 1898 and 4637, ARB Contract A9-143-31, SRI Internat'l., 36 pp.

B. San Francisco Bay Area to Broader Sacramento Area

1. Summary and Recommendation

The staff's analysis indicates that transport from the San Francisco Bay Area Air Basin (SFBAAB) increases ozone concentrations in the Broader Sacramento Area (Broader Sac) on many of the days when the state standard for ozone is exceeded in the Broader Sac. However, emissions within the Broader Sac also have a significant impact on the exceedances. The staff's analysis also indicates that there are days when transport from the SFBAAB to the Broader Sac is inconsequential.

The staff recommends that transport from the SFBAAB to the Broader Sac be classified as "Significant" on some days and "Inconsequential" on other days. Because transport from the SFBAAB is "Significant" on some days, the Bay Area Air Quality Management District must include in its 1991 plan, a requirement for the application of best available retrofit control technology to existing stationary sources. The district must also include in its 1991 plan, a permitting program designed to achieve a no net increase in emissions of precursors of ozone from all new or modified stationary sources.

2. Conclusions

The staff believes that ozone precursors originating in the SFBAAB can contribute to exceedances of the state ozone standard in the Broader Sac. The staff also believes that exceedances of the state standard in the Broader Sac normally are substantially impacted by precursor emissions there.

The staff reviewed the meteorological and air quality data for the 16 days during 1986 through 1988 when the highest ozone concentrations in the Broader Sac occurred. This analysis led the staff to conclude that the exceedances were primarily due to emissions originating within the Broader Sac, but that emissions in the SFBAAB typically are transported into the Broader Sac where they can contribute to the maximum ozone concentrations observed.

The staff also reviewed meteorological and air quality data for June 2, 1987. This analysis showed that emissions solely within the Broader Sac can cause exceedances of the state standard.

The staff also reviewed the meteorological and air quality data for the 14 days during 1986 through 1988 when the state standard was exceeded at Vacaville. The staff determined that this set of days represented the most likely scenario for transport from the SFBAAB to have an overwhelming contribution to ozone concentrations in the Broader Sac. The staff found clear evidence only on June 25, 1987, that transport from the SFBAAB caused this exceedance at Vacaville. However, the staff believes that any assessment of the overwhelming nature of the transport contribution from the SFBAAB based on a 10 pphm ozone concentration at Vacaville would be inappropriate. The proximity of Vacaville to the boundary of the SFBAAB and the Broader Sac makes transport analysis for Vacaville unrepresentative of the SFBAAB transport contribution to the Broader Sac unless Vacaville was the location of the maximum ozone concentration on that day in the Broader Sac. Ozone concentrations at other sites in the Broader Sac on June 25, 1987, were as much as 4 pphm higher than at Vacaville. Precursor emissions in the Broader Sac contributed to these additional exceedances of the state standard. Thus, this analysis led the staff to conclude that ozone and ozone precursors from the SFBAAB do not make an overwhelming contribution to exceedances in the Broader Sac.

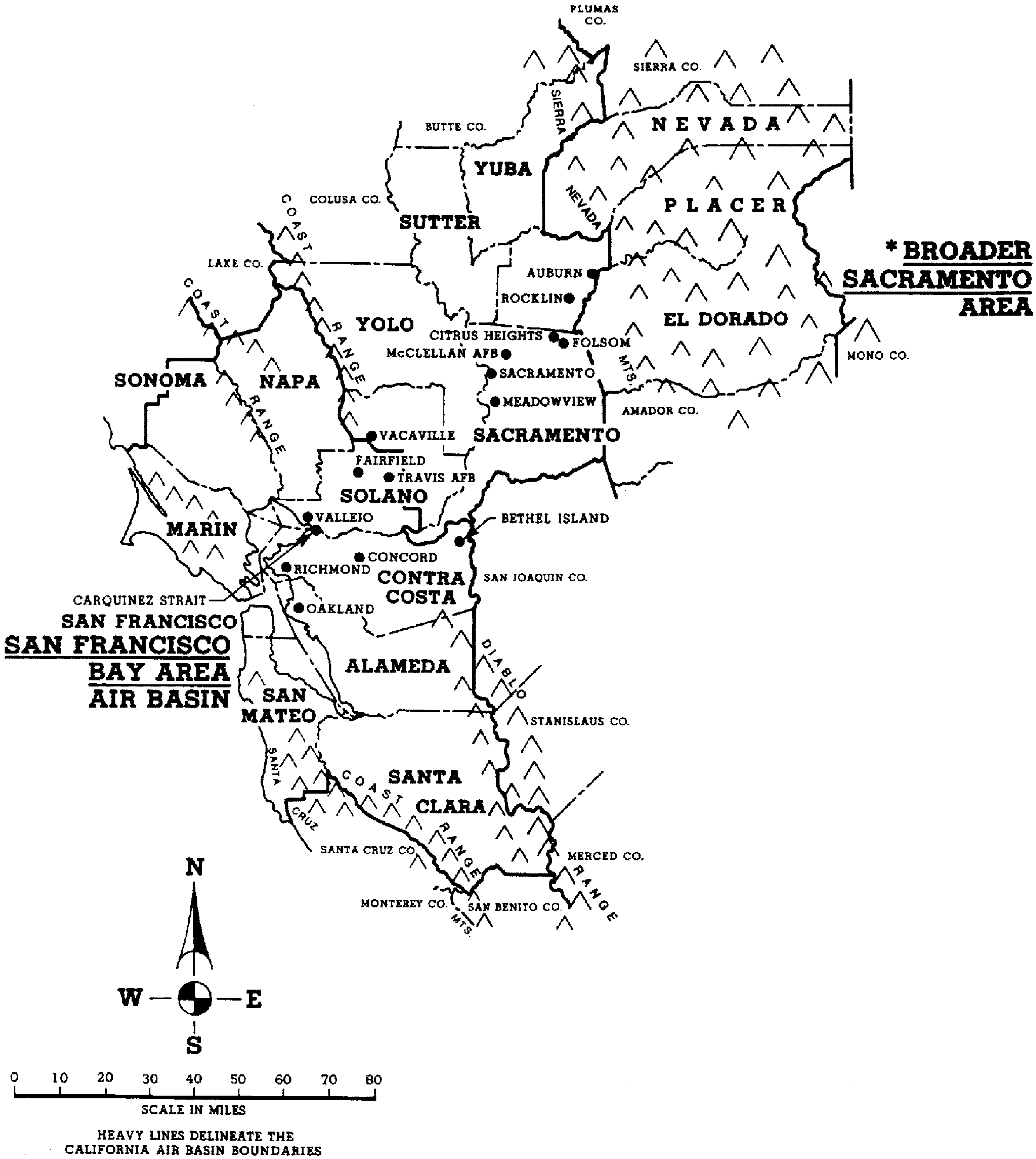
3. Geographic Setting

The Broader Sac comprises the southern part of the Sacramento Valley and a part of the western slope of the Sierra Nevada. The Broader Sac includes all of Nevada, Sacramento, Sutter, Yolo, and Yuba Counties and parts of El Dorado, Placer, and Solano Counties. The SFBAAB lies to the west and southwest of the Broader Sac. The SFBAAB comprises all or parts of nine counties. However, of these nine counties, Contra Costa, Marin, Napa, San Francisco, and Sonoma Counties and the western part of Solano County have the greatest potential to impact air quality in the Broader Sac via transport. Southerly air flow carrying emissions from the other counties in the SFBAAB into the Broader Sac occur about five percent of the time during the ozone season. A map of the two areas is provided in Figure 4.

The Coast Range has a northwest-southeast alignment and acts as a barrier between the cool, moist, marine air along the coast of northern California and the hot dry air in the Sacramento Valley. Frequently, maximum temperatures are in the high 50's (F^o) near the coast in the SFBAAB and in the high 90's (F^o) in the Broader Sac. The Carquinez Strait which provides a gap in the Coast Range is the dominant geographic feature influencing the potential for pollutant transport from the SFBAAB to the Broader Sac. The marine air routinely flows through the Carquinez Strait and into the delta region of the Sacramento River. The magnitude of this influx of marine air into the Broader Sac is controlled largely by the depth of the marine layer compared to the height of the Coast Ranges and the atmospheric pressure gradient between the SFBAAB and the Broader Sac.

During the summer, a thermal low pressure area frequently develops over the Sacramento and San Joaquin Valleys and causes air to flow from the SFBAAB into the Broader Sac. Consequently, Travis Air Force Base ("Travis AFB"), located in the Fairfield area on the northern edge of the delta, typically has strong southwesterly winds. This characteristic regional air flow has the potential to transport ozone and its precursors from the SFBAAB into the Broader Sac. The transport of ozone is not significant when a strong marine air influx occurs because the influx is associated with high wind speeds, cool temperatures, and fog. However, the transport of ozone precursors could be significant when a strong marine influx occurs because the emissions in the SFBAAB would tend to be trapped in the marine air and transported into the Broader Sac.

Figure 4
TRANSPORT COUPLE
SAN FRANCISCO BAY AREA to BROADER SACRAMENTO AREA



* "Broader Sacramento Area" includes Nevada County, Sacramento Metropolitan Air Quality Management District, Yolo-Solano Air Pollution Control District, and the Sutter, Yuba, El Dorado, and Placer County Air Pollution Control Districts.

4. Summary of Previous Transport Studies

Previous tracer and air quality studies have indicated the potential for transport of ozone and ozone precursors from the SFBAAB to the Broader Sac on days when the state standard is exceeded in the Broader Sac.[1,2] These studies also indicated the contribution of local emission sources to high ozone concentrations in the Broader Sac. Giorgis concluded that:

> "... the contribution to Sacramento Valley oxidant levels from SFBAAB precursor emissions is secondary to contributions from sources in the Valley. ... high oxidant concentrations at most Sacramento Valley stations result from stagnation or transport from Sacramento. ... In other words, Sacramento Valley precursor emissions are the prime determinant of oxidant air quality in the Sacramento Valley, with the exceptions in the delta area ..."[1]

5. Data

The staff's assessment of the air quality impact of transport from the SFBAAB to the Broader Sac was based on data available for 1986 through 1988. During this study period, ozone concentrations in the Broader Sac exceeded the state standard on 251 days. Time constraints and available staff resources precluded a review of all 251 days. However, the staff did not have to review all days with exceedances of the state standard because the evidence from the sample of days most likely to represent the three categories of transport impact indicated that transport from the SFBAAB can make an inconsequential or significant contribution but not an overwhelming contribution to ozone concentrations in the Broader Sac.

The assessment of the potential impacts of transport from the SFBAAB to the Broader Sac was based on a review of three sets of meteorological and air quality data which are representative of the three categories of transport: inconsequential, significant, and overwhelming. For inconsequential transport, the staff reviewed the data for June 2, 1987. This day was selected to provide a consistent example of inconsequential transport to the Broader Sac from all upwind transport couples. For significant transport, the staff reviewed the data for days when the Broader Sac recorded its 16 highest ozone concentrations during 1986-1988. Finally, the staff reviewed the 14 days during 1986-1988 which represented the most likely scenario for an assessment of overwhelming transport; however, the staff concluded that ozone precursor emissions in the Broader Sac contributed to the peak ozone concentrations in the Broader Sac on all 14 days.

6. Emission Inventory

Reactive hydrocarbons (RHC) and nitrogen oxides (NOx) are the primary emissions that undergo photochemical reactions to generate ozone. The staff compared the magnitude of emissions of these ozone precursors in those regions of the SFBAAB and the Broader Sac most likely associated with transport. Only RHC and NOx emissions in and north of San Francisco and Contra Costa Counties were included in the emission evaluation for the SFBAAB. Emissions from the central and southern portions of the SFBAAB typically are not carried by the air flow into the Sacramento Valley. Only RHC and NOx emissions in the southern Sacramento Valley Air Basin (Yolo, Sacramento, and portions of Placer and Solano Counties) were included in the emission evaluation for the Broader Sac. Emissions of RHC and NOx in the northern SFBAAB in 1987 were estimated at 264 tons/day each. Emissions of RHC and NOx in 1987 in the southern Sacramento Valley Air Basin were estimated at 164 and 140 tons/day, respectively.

The staff then assessed the potential of emissions originating within each region to generate ozone concentrations above the state standard. The staff concluded that emissions within each area are capable of generating ozone concentrations which exceed the state standard. Because the Sacramento urban area will contribute fresh ozone precursor emissions to any air mass from the SFBAAB, a finding of overwhelming impact by transport from the SFBAAB cannot be made unless the maximum ozone concentration in the southwest part of the Broader Sac is the highest in the Broader Sac and the standard is exceeded.

7. Transport Assessments

The staff completed two types of analyses to characterize the impact of pollutant transport from the SFBAAB to the Broader Sac: an air quality analysis and a meteorological analysis. The assessment of inconsequential transport consisted of determining that air flow did not occur from areas outside of the Broader Sac or that the air flow was insufficient to carry ozone precursors or ozone from outside the Broader Sac to the site(s) exceeding the state standard in the Broader Sac. The assessment of significant or overwhelming transport impact consisted of determining whether:

- the air flowed from areas in the SFBAAB with significant ozone precursor emissions or high ozone concentrations to ozone monitoring sites in the Broader Sac,

- the ozone concentrations in the Broader Sac developed in a manner consistent with the transport of ozone and ozone precursors, and

- the air mass passed over areas in the Broader Sac with significant ozone precursor emissions (significant contribution), or the air mass did not pass over areas in the Broader Sac with significant ozone precursor emissions (overwhelming contribution).

In this section, the staff provides an example of each transport category observed during the study period to demonstrate the analytical considerations the staff used in making its conclusions and recommendations.

a. Analysis Considerations

1. Meteorological Data

Ambient ozone concentrations near the surface of the earth are primarily a function of emissions and meteorology. Because emissions are relatively constant from day to day, most of the daily variation in ozone concentrations is attributed to variations in meteorology. Therefore, an assessment of meteorological conditions is important in understanding the nature and perhaps source or cause of high ozone concentrations. The following meteorological conditions were considered in the assessment.

<u>Surface Air Flow Types</u>. The staff daily drew streamline analyses of surface airflow directions based on winds observed at 4 a.m., 10 a.m., and 4 p.m. Pacific Standard Time. The staff also classified the streamline patterns in the SFBAAB and the Sacramento Valley into certain types of air flow. The SFBAAB and Sacramento Valley streamline analyses for the days with high ozone concentrations in the Broader Sac or at Vacaville were reviewed to determine whether the surface air flow pattern supported the potential for transport from the SFBAAB to the Broader Sac.

The SFBAAB air flow types most likely associated with transport from the SFBAAB to the Broader Sac are Types Ia and Ib--Northwesterly (strong and weak), Type II--Southerly, and Type VI--Bay Outflow. These air flow types are illustrated in Figure 5. During the summer and fall months (June through November) when the state standard is exceeded most frequently in the Broader Sac, the Northwesterly air flow types are observed more than 70 percent of the time. During the summer months (June through August) when the majority of exceedances occur, the Northwesterly air flow types are observed 87 percent of the time. The Bay Outflow type is observed four percent of the time. The Southerly air flow type is observed three percent of the time. Therefore, surface air flows are conducive to the transport of pollutants from the SFBAAB into the Sacramento River delta 94 percent of the time during the months with maximum ozone concentrations in the Broader Sac. Once the air flow from the SFBAAB reaches the delta region, it diverges. Some air then flows northward into the Sacramento Valley while some air flows southward into the San Joaquin Valley.

The Sacramento Valley air flow types most likely associated with transport from the SFBAAB to the Broader Sac are Type I--Full Sea Breeze, Type II--Upper Valley Convergence, Type III--Lower Valley Convergence, and Type VIII--Upslope. These air flow types are illustrated in Figure 6. During the summer and fall months (June through November) when the state standard is exceeded most frequently in the Broader Sac, the Full Sea Breeze air flow type is observed more than 35 percent of the time. During the summer months (June through August) when the majority of exceedances occur, the Full Sea Breeze air flow type is observed 55 percent of the time. The Upper Valley Convergence air flow type is observed 16 percent of the time. The Lower Valley Convergence air flow type is observed 13 percent of the time. The Upslope air flow type is observed only one percent of the time. Therefore, surface air flows in the Broader Sac are conducive to the transport of pollutants from the Sacramento River delta into the Broader Sac 87 percent of the time during the months with maximum ozone concentrations.

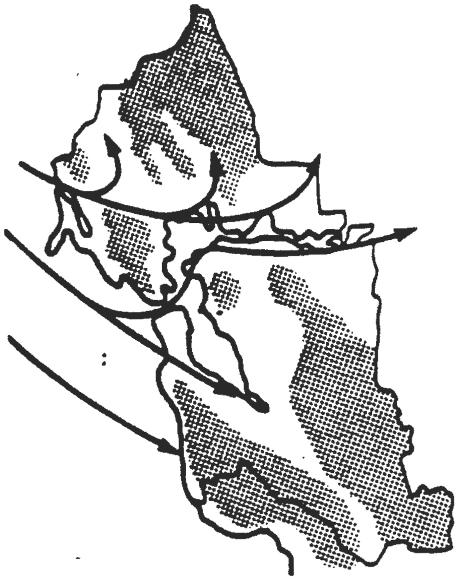
Winds Aloft. Oakland is the nearest location for which winds aloft data are routinely available. Two daily measurements are made at Oakland: one in the morning (4 a.m.) and one in the afternoon (4 p.m.). For this particular assessment, "winds aloft" is used in reference to winds measured at the 3000 foot level. Winds at 3000 feet above sea level are of most interest for this analysis because they are above the influence of the East Bay hills. Wind measurements at this level therefore indicate the direction pollutants would travel if transported aloft. If the direction of the winds aloft was consistent with potential transport from the SFBAAB to the Broader Sac, the staff estimated the length of time needed to transport pollutants aloft from Vallejo in the SFBAAB to Sacramento, a distance of approximately 50 miles. If the direction and speed of the wind at the 3000 foot level at 4 a.m. and 4 p.m. did not support the potential for transport aloft, transport aloft on that day was eliminated as a potential cause of the exceedance of the state standard.

Presence of the Marine Layer at Oakland. Temperature data from the 4 a.m. and 4 p.m. soundings at Oakland were reviewed to detect the presence of the marine air layer and to estimate its depth. In a coastal setting, the marine layer is defined as the cool layer of air at or near the surface and extending upward to the top of the inversion layer. An increase in the depth of the marine layer from morning to afternoon indicates an onshore air flow. The depth of the marine layer also can indicate the intensity of the onshore flow. Emissions in the SFBAAB likely would be trapped in the marine layer and then carried into the Broader Sac.

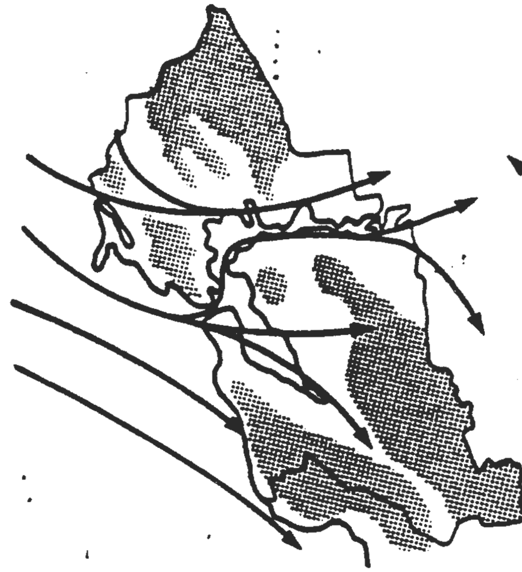
Daily Maximum Temperature. Daily maximum temperatures at Richmond, Fairfield, Vacaville, and Sacramento were reviewed to estimate the inland extent of the marine air intrusion during the day. Temperature data indicate that the marine layer generally extends east of Richmond. If the temperature at Fairfield was hot, the staff assumed that there was not a well defined marine air flow into the Broader Sac. On the 16 days during the study period with the highest ozone concentrations in Broader Sac, the daily maximum temperatures at Fairfield frequently were cooler than the daily maximum temperatures at Vacaville. The warmer temperatures at Vacaville indicated a smaller marine air influence at Vacaville than at Fairfield. The maximum temperatures at Vacaville and Sacramento on these 16 days generally were within a few degrees of each other. The similarity in maximum temperatures indicated that Vacaville generally was not exposed to significantly more marine air influence during the day than Sacramento.

Surface Wind Observations. The staff gave particular attention to the surface wind speeds and directions at Travis AFB in the delta region and at Sacramento Executive Airport and McClellan Air Force Base in Sacramento. Wind data for the days studied were evaluated to determine the strength (speed and duration) of the air flow into and through the Broader Sac.

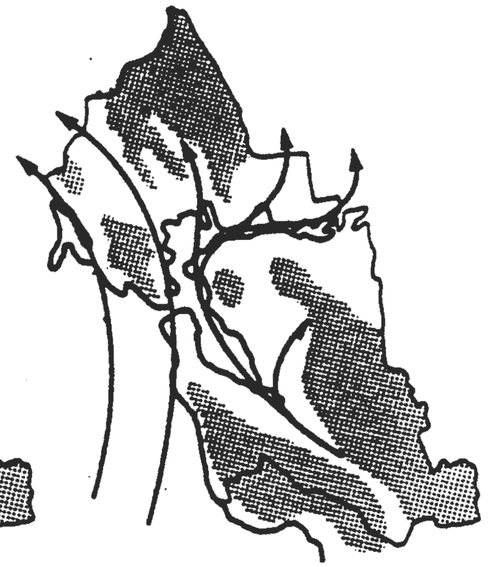
FIGURE 5 **BAY AREA AIR FLOW PATTERN TYPES**



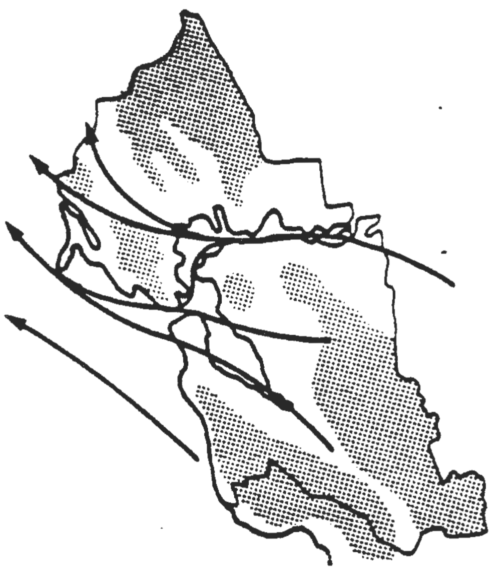
Ia Northwesterly (weak)



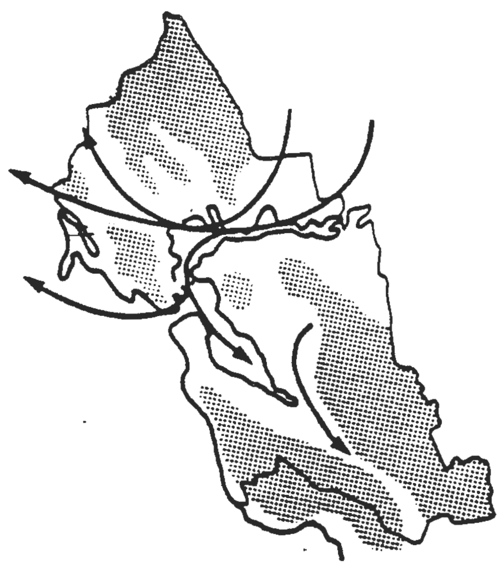
Ib Northwesterly (moderate to strong)



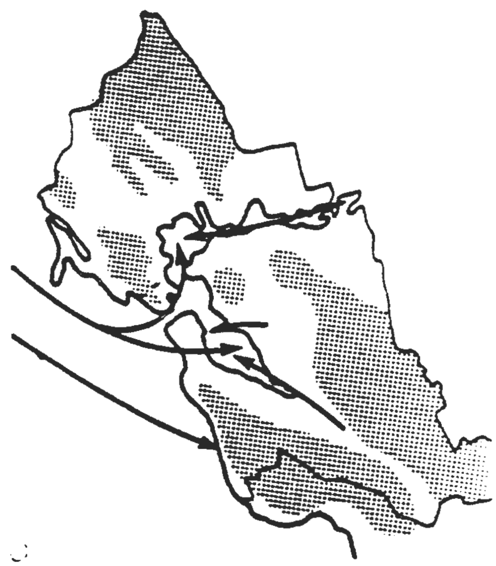
II Southerly



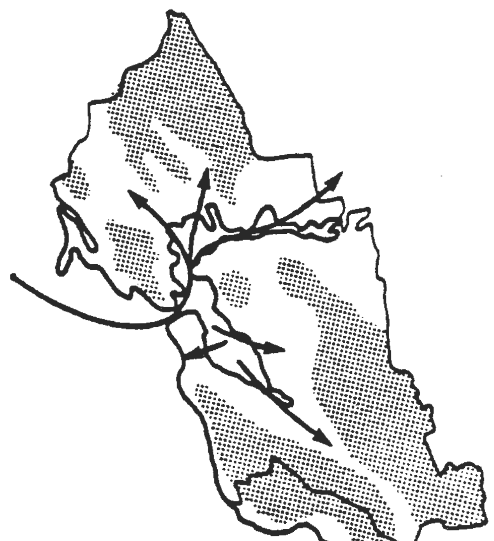
III Southeasterly



IV Northeasterly

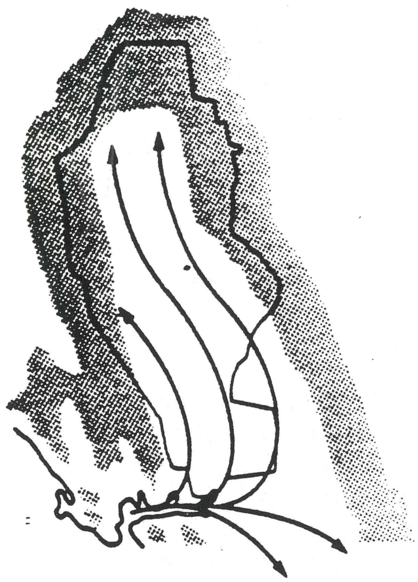


V Bay Inflow

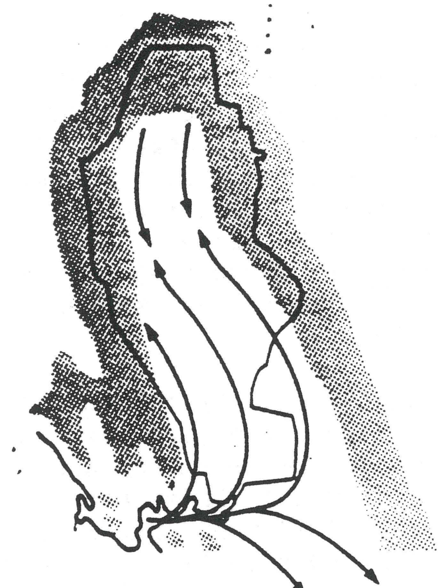


VI Bay Outflow

FIGURE 6 **SACRAMENTO VALLEY AIR FLOW PATTERN TYPES**

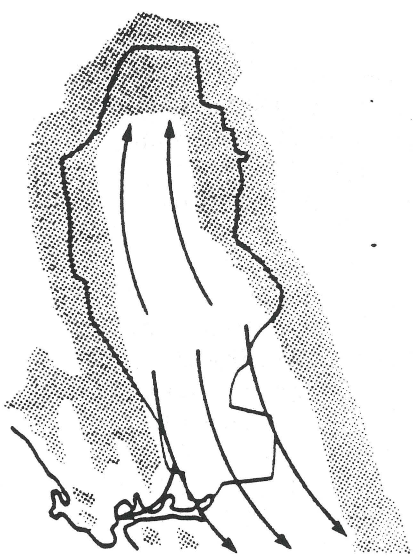


I Full Sea Breeze

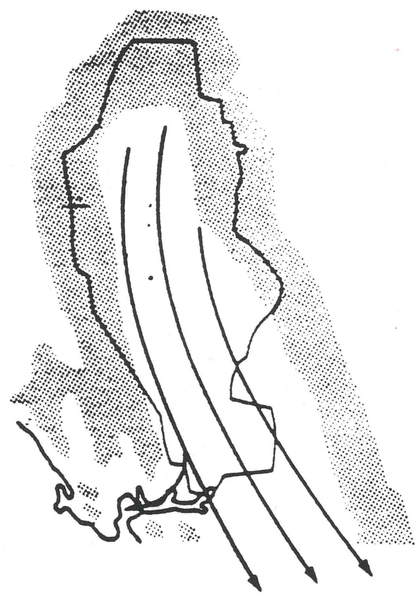


II Upper Valley Convergence

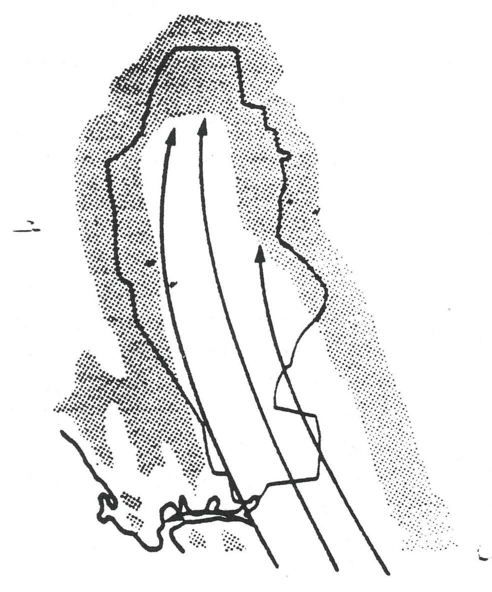
III Lower Valley Convergence



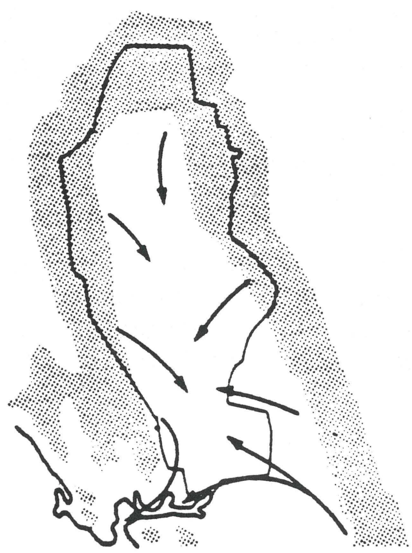
IV - Mid Valley Divergence



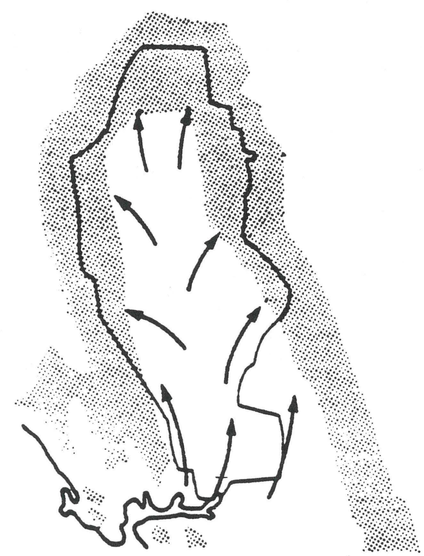
V - Northerly (Winds > 5 k)



VI Southerly (No Marine Air)



VII Downslope (Winds ≤ 5 k)



VIII Upslope (Winds ≤ 5 k)

The Vallejo/Carquinez Strait area and Sacramento are about 50 miles apart and are major areas of emissions in the SFBAAB and the Broader Sac, respectively. The amount of time required to transport pollutants from the SFBAAB to the Broader Sac in one day depends on the average wind speed from the southwest. The wind data for Travis AFB were used to characterize the strength of the air flow from the SFBAAB. A summary of 30 years of wind data at Travis AFB indicates that winds with a southwesterly component occur over 50 percent of the time at a mean speed of 15 mph. The frequency and speed of southwesterly winds during the summer would be higher than this.

A summary of 10 years of wind data at Sacramento Executive Airport indicates that winds from the south and southwest occur over 70 percent of the time at 8 a.m. during the summer at a mean speed of 9 mph. Similarly, winds conducive to transport from the SFBAAB occur over 60 percent of the time at 2 p.m. at a mean speed of 10 mph. Based on the climatological wind data for Travis AFB and Sacramento Executive Airport and streamline analyses which confirm that the air flow at Travis AFB typically continues into the Broader Sac, the staff concluded that pollutants from the SFBAAB could be transported to Sacramento in about five hours.

Wind runs were developed from data for Travis AFB, Sacramento Executive Airport, and McClellan AFB. A wind run is a crude estimate of the distance that a parcel of air travelled based on a summing of the wind speed at a site from a specified direction during a specified period of time. Small wind runs indicate limited movement of air and transport of pollutants past the site.

The staff also used more sophisticated estimates of transport between upwind and downwind areas. Trajectories were used on occasion to confirm transport. Wind data from several sites in the northern SFBAAB, the northern San Joaquin Valley, and the Sacramento Valley Air Basin were used to construct some back and forward trajectories. Back trajectories were used to trace the path of an air parcel from the site with the maximum ozone concentration to the area of origin. Forward trajectories were used to trace the path of an air parcel containing morning ozone precursor emissions to the area that air parcel affected.

2. Air Quality Data

The staff also reviewed various ozone air quality data in the Broader Sac and in the northeast SFBAAB to assess the nature and potential causes of the high ozone concentrations in the Broader Sac. Ozone concentrations are reported as hourly averages. As used in the following discussions, the term "maximum" concentration is synonymous with maximum-hour concentration. The time of the maximum concentration is identified by the beginning of the hour on Pacific Standard Time.

Geographic Extent of Exceedances. An evaluation of the size and shape of the area(s) in which the state standard is exceeded can indicate the source of ozone and ozone precursor emissions contributing to the high ozone concentrations. When exceedances occurred only downwind of

Sacramento, local emissions most likely caused the high ozone concentrations. However, when exceedances occurred at Vacaville or in the southwest part of the Broader Sac and the wind speeds and directions were consistent with transport of ozone and its precursors from the SFBAAB, the staff assumed transport from the SFBAAB contributed to the high ozone concentrations.

Concurrent Exceedances in the SFBAAB and the Broader Sac. Exceedances of the state ozone standard occurring on the same or successive days in contiguous portions of the SFBAAB and the Broader Sac indicate a potential for transport between the two areas. If this was the case, meteorological data were reviewed to determine whether there was evidence to suggest that the same air mass affected both areas.

Time of Daily Maximum Ozone Concentration. Daily maximum ozone concentrations occurring in the morning may result from fumigation of ozone trapped aloft from the previous day. Based on available meteorological data of conditions aloft, the source of ozone may be identified as local or transport. Maximum ozone concentrations occurring late in the afternoon or early evening may result from the transport of ozone into the area. Maximum ozone concentrations resulting from photochemical reactions involving "local" emissions typically occur around solar noon but can range between 11 a.m. and 2 p.m. However, the transport of ozone precursors could also cause maximum ozone concentrations to occur in the early afternoon because the photochemical reactions would peak at that time.

b. Analysis Results

The staff reviewed the data sets for all three potential categories of impact by transport from the SFBAAB to the Broader Sac: "significant," "inconsequential," and "overwhelming." The staff was able to identify only two categories in the sample of days analyzed--inconsequential and significant. The staff was unable to identify an overwhelming contribution by emissions in the SFBAAB in the western Broader Sac because emissions in the Broader Sac were too large to allow emissions from the SFBAAB to have an overwhelming contribution on ozone exceedances in the Broader Sac.

Some air flow from the SFBAAB to the Broader Sac occurred on every one of the 16 days with the highest ozone concentrations during the study period in the Broader Sac. A preliminary analysis of these days indicated at least three days in the inconsequential category and the remainder in the significant category. The following discussions of the air quality and meteorological assessments for the two categories focus on specific examples: significant, July 14, 1987; inconsequential, June 2, 1987.

1) Significant

A day exhibiting a significant contribution by the SFBAAB and the Broader Sac is July 14, 1987. The staff concluded that emissions in the SFBAAB and the Broader Sac contributed to the standard exceedance on this day because meteorological data indicated that air flowed from the SFBAAB to the Sacramento urban area and the maximum concentration occurred downwind of the ozone precursor emissions in the Sacramento urban area. The maximum concentration in the Broader Sac of 18 pphm occurred at 4 p.m. at Auburn. The maximum concentration in the northeast SFBAAB was 6 pphm. The maximum concentration in the SFBAAB on the previous day was 7 pphm.

Winds at the surface and aloft on July 14, 1987, were moderate from the southwest and capable of transporting pollutants from the SFBAAB to the Broader Sac. The marine layer was very deep--4000 feet in the morning and 4800 feet in the afternoon. The deepening of the marine layer indicates a strong influx of marine air into the Broader Sac. The very low ozone concentrations in the Carquinez Strait and the delta region also indicate strong marine layer flow into the Broader Sac.

The times of maximum concentrations in the Broader Sac on July 14, 1987, indicate some carryover of high ozone concentrations from the previous day when the maximum in Sacramento was 12 pphm. However, the disparity between maximum concentrations at Sacramento-Del Paso Manor (11 pphm) and at Citrus Heights (17 pphm) indicates the additional contribution from fresh local emissions. Winds in the Sacramento area were light from the southwest until early afternoon when the speeds increased. Consequently, the time of maximum concentrations associated with fresh emissions exhibited a progression to the northeast during mid-afternoon. The hour(s) when the maximum ozone concentration occurred at the sites where the state standard was exceeded on July 14, 1987, are shown in Table 11. The progressive delay in the time of maximum ozone concentrations from central Sacramento to the northeast and the increase in maximum concentrations with distance downwind from Sacramento indicate that the maximum concentration in the Broader Sac resulted primarily from emissions in the Broader Sac.

The maximum ozone concentration observed at Vacaville on July 14, 1987, was 6 pphm and occurred at 4 p.m. Apparently, high concentrations of ozone were not transported from the SFBAAB to the Broader Sac on July 14, 1987. However, the staff concluded that the impact of precursor transport from the SFBAAB to the Broader Sac on ozone concentrations this day was significant. The maximum ozone concentration at Sacramento-Meadowview (9 pphm) occurred at 11 a.m. and 1 p.m. Surface winds at Sacramento Executive Airport (2.5 miles northwest of the Sacramento-Meadowview site) were from the south at 5 mph until late morning when they began coming from the southwest. At 4 p.m., the winds were from the south again. Air flow charts and wind data for Travis AFB indicate that air flow throughout the day was from the SFBAAB. Because the Sacramento-Meadowview site was upwind of significant emissions in the Broader Sac and ozone concentrations there peaked at 9 pphm, the staff concluded that emissions in the SFBAAB were transported to the Broader Sac and contributed to the exceedances in the Broader Sac. If the polluted air entering the Sacramento urban area was capable of forming ozone concentrations just under the standard, then local emissions would need to be reduced to zero to prevent the standard from being exceeded. The staff concluded that a contribution of this magnitude by an upwind area to the regional ozone burden was significant. Therefore, the staff concluded that emissions from the SFBAAB had a significant contribution to exceedances of the ozone standard in the Broader Sac on July 14, 1987.

Table 11

Time of Maximum Ozone Concentration on July 14, 1987
at Sites in the Broader Sac Where the Ozone Standard Was Exceeded

Site	Maximum [ozone]	Hour(s) When Max Occurred (PST)
Pleasant Grove	10 pphm	1 p.m.
Broderick	11 pphm	2 p.m.
Sacto-Del Paso Manor	11 pphm	noon and 1 p.m.
North Highlands	11 pphm	noon, 1 p.m., and 2 p.m.
Citrus Heights	17 pphm	1 p.m.
Folsom	15 pphm	2 p.m.
Rocklin	13 pphm	2 p.m. and 3 p.m.
Auburn	18 pphm	4 p.m.

2) Inconsequential

An example of a day with an inconsequential impact of transport from the SFBAAB to the Broader Sac is June 2, 1987. The contribution by emissions in the SFBAAB to ozone exceedances in the Broader Sac was inconsequential because there was no evidence of air flow from the SFBAAB or other major precursor source areas into the Broader Sac.

The streamline analysis of surface winds on June 1, 1987, indicated that the typical air flow east from the SFBAAB was blocked by winds from the north in the Sacramento Valley. Thus, air from the Broader Sac moved into the San Joaquin Valley on June 1, 1987. The winds continued to blow from the north but at a slower speed on June 2. There was little evidence of transport from the SFBAAB into the Broader Sac until June 3. Back trajectory analyses of surface winds indicated that air in Sacramento at the time the maximum ozone concentration was recorded passed over southern Sutter County the night before and continued to move southward through June 2, 1987. Thus, the trajectory analysis indicated that ozone or ozone precursors originating in the SFBAAB or the San Joaquin Valley Air Basin (SJVAB) did not contribute to exceedances of the state standard in the Broader Sac on June 2, 1987.

In addition, the available winds aloft data for Oakland indicate that airflow at the 3000 foot level was from the northeast on June 1 and 2. The wind speed decreased from June 1 to June 2 and was light on the afternoon of June 2. By 4 a.m. on June 3, the winds were from the southwest at 14 mph. Thus, there was no indication of transport aloft from the SFBAAB or the SJVAB on June 2, 1987.

Daily maximum temperatures at Sacramento Executive Airport increased from 93 F^{o} on June 1 to 98 F^{o} on June 2. The temperature increase largely resulted from no marine air flow into the Broader Sac on June 1 and wind speeds decreasing from June 1 to June 2.

On June 1, 1987, the maximum ozone concentrations throughout the Broader Sac, the northeast SFBAAB, and the northern SJVAB were less than 10 pphm. The maximum concentration at several sites in the Broader Sac was 7 pphm. The maximum concentration in the northeast SFBAAB was 9 pphm at Pittsburg and Fairfield.

On June 2, 1987, the maximum ozone concentration in both the northeast SFBAAB and the Broader Sac was 11 pphm. In the Broader Sac, the maximum concentration occurred at Folsom and Sacramento-Meadowview. The standard was exceeded for six hours at Folsom and for four hours at Sacramento-Meadowview. On the north side of Sacramento, the standard was exceeded for one hour at North Highlands where the maximum concentration was 10 pphm. These exceedances of the state standard in the Broader Sac on the second day of north winds suggest that transport from the SFBAAB had an inconsequential impact on ozone air quality in the Broader Sac on June 2, 1987.

8. District Comments

The staff received comments on this assessment of transport from only the staff of the Bay Area Air Quality Management District (see Attachment B). The only comment specifically related to transport from the SFBAAB to the Broader Sac and the staff's response follows.

Comment: Extensive sets of meteorological data and air quality data, surface and aloft, were collected during the 1989 field studies in the Bay Area and in Sacramento. Was any of this information reviewed or evaluated for its potential to improve the transport assessment analysis?

Response: The meteorological and air quality data collected during field studies in 1989 were not considered in this assessment of transport from the SFBAAB to the Broader Sac. The staff did not consider the 1989 data in this transport assessment because the ozone air quality data had not been thoroughly reviewed and validated at the time the analysis began. The transport assessment was designed to examine in detail several days on which there were ozone standard exceedances. This analysis was based on air quality data collected during 1986 through 1988. Data from 1989 will be included in the next round of transport assessments which will occur by 1993.

The staff is unsure what the data from 1989 would add to the current assessment. The staff was able to identify significant and inconsequential impacts on air quality in the Broader Sac by emissions in the SFBAAB for selected days in the 1986-1988 period. The data for 1989 would not negate the findings from the study period, but new data might support a finding of overwhelming impact by emissions in the SFBAAB.

REFERENCES

1. Giorgis, R. B., 1983: "Meteorological Influences on Oxidant Distribution and Transport in the Sacramento Valley". Thesis, M. S. in Eng., UC-Davis, 315 pp.

2. Lehrman, D., Smith, T., Reible, D. D., and F. H. Shair, 1981: "A Study of the Origin and Fate of Air Pollutants in California's Sacramento Valley", Vols. I & II. Final Rep. MRI 81 FR-1842, Prepared for ARB, Meteor. Res., Inc., 25 pp. and 210 pp. respectively.

C. San Francisco Bay Area to San Joaquin Valley

1. Summary and Recommendations

The staff analysis shows that transport from the San Francisco Bay Area Air Basin (SFBAAB), which occurred on June 3, 1987, contributed to exceedances of the state ozone standard in the San Joaquin Valley Air Basin (SJVAB). Further analysis by the staff shows that on June 2, 1987, local emissions caused an exceedance of the state ozone standard without any significant transport from the San Francisco Bay Area.

The staff recommends that the San Francisco Bay Area's transport be classified as "significant" on some days and "inconsequential" on others. Since transport from the San Francisco Bay Area is "significant" on some days, the San Francisco Bay Area must include in its 1991 plan, a requirement for the application of best available retrofit control technology to existing stationary sources and a permitting program designed to achieve a no net increase in emissions of precursors of ozone from all new or modified stationary sources.

2. Conclusions

The staff believe that the Board find that the contribution of San Francisco Bay Area Air Basin emissions to exceedances of the state ozone standard (state standard) in the San Joaquin Valley Air Basin is both significant and inconsequential. This conclusion is based on a case study of one day representing significant transport, June 3, 1987, and on one day representing inconsequential transport, June 2, 1987. The staff used the available data for 1985 through 1988 in addition to the modeling and technical studies conducted for the San Joaquin Valley Air Quality Study to support these recommendations.

The staff's analysis is based on available air quality, meteorological, and emission data for 1985 through 1988, and on data analysis, modeling, and technical studies conducted during the design of an air quality study for the San Joaquin Valley. From 1985 through 1988, ozone exceedances were measured in the SJVAB, both on days when transport from the SFBAAB to the SJVAB occurred and on some days when transport did not occur. Wind flow types documented by the ARB staff show that surface winds favorable to transport from the SFBAAB to the SJVAB occur about 90 percent of the time during the summer months, while winds favorable to local days with inconsequential transport occur 3 percent of the time in both basins.

Two days were selected for case study analyses to demonstrate inconsequential and significant transport, June 2, 1987, and June 3, 1987. Since these are consecutive days, the analyses for both types of transport are discussed together. Meteorological, air quality, and emission analyses which support the staff recommendation are described below.

3. Geographic Setting

The SJVAB includes all of San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings and Tulare counties, and the western portion of Kern county. The SFBAAB lies to the west and northwest of the SJVAB. Emissions transported from Contra Costa, Marin, Napa, San Francisco, and Sonoma counties and the western portion of Solano County in the SFBAAB have the highest potential impact on ozone concentrations in the northern SJVAB. The remaining southern SFBAAB counties impact the SJVAB with transport across the Coastal Range through and near Pacheco Pass.

The routine influx of marine air through the Carquinez Strait and into the delta region of the San Joaquin River is the dominant feature influencing air flow and the probable path for transport from the SFBAAB to the SJVAB. The magnitude of the influx into SJVAB is controlled largely by the depth of the marine layer compared to the height of the Coast Ranges and the atmospheric pressure gradient between the SFBAAB and SJVAB. During the summer, a thermal low pressure area develops over the Central Valley and air generally flows into the SJVAB through a gap in the Coast Ranges. Consequently, winds in the Fairfield area typically are strong from the southwest. With this air flow, comes the potential for the transport of ozone and its precursors from the SFBAAB into the SJVAB.

The Coast Ranges have a northwest-southeast alignment and present an effective barrier between the cool, moist, marine air along the coast of northern California and the hot, dry air in the Central Valley. Frequently, maximum temperatures are in the high 50's (degrees Fahrenheit or F) near the coast and in the high 90's (F) in the SJVAB. When the depth of the marine layer exceeds the height of the Coast Ranges (2000-3000 feet), cool marine air can spill into the SJVAB. This influx of marine air can be much greater than that associated with air flow through the Carquinez Strait and delta region. Although it is likely the transport of ozone under a strong marine influx is not great, the transport of ozone precursors could be.

4. Meteorological Assessment

After screening the data for ozone exceedance days for 1986 through 1988, the staff chose to analyze June 2, 1987, as a "no transport" day and June 3, 1987, as a "transport" day. Both of these days were very hot in the valley--maximum temperatures were in the 90's and 100's (F) on both days. The Bay Area was hot on June 2 with maximum temperatures of 90 (F) and over. These temperatures cooled on June 3 to the 70's and 80's (F). Surface winds were light in both basins on June 2, and a sea breeze began in the late evening of June 2 and continued through the next day.

Morning (4 a.m.) winds aloft at elevations up to 3,000 feet--high enough to allow flow over the Coast Range--at Oakland were from the northeast on June 2 and from the southwest on June 3. Morning winds up to 3,000 feet above the surface at Fresno were from the southeast on June 2 and from the northwest on June 3. The directions of upper air flow at Oakland and Fresno on both dates suggests no transport on June 2 but transport from the SFBAAB of ozone or precursors aloft to the SJVAB on June 3. Southwest winds at Oakland flowed through the Carquinez Straits and mountain passes into the San Joaquin Valley.

The transport times from Vallejo in the SFBAAB, based on the 4 a.m. 3,000-foot winds at Oakland on June 3, range from 4 hours to Stockton to 6 hours to Modesto. With the morning rush hour traffic in the SFBAAB occurring between 7 a.m. and 9 a.m., a 4-6 hour transport time would put precursors and ozone from the SFBAAB into the Stockton area by 10 a.m. and into the Modesto area by 2 p.m. The time of peak ozone concentrations at Stockton ranged from 1 p.m. to 2 p.m. and at Modesto from 3 p.m. to 4 p.m., well within the transport time based on the 3,000-foot Oakland winds. Therefore, transport aloft from the SFBAAB to the SJVAB would be consistent with the time between the morning traffic peak near Vallejo and the Stockton and Modesto daily peak ozone concentrations.

On both June 1 and 2, surface wind flow in the SFBAAB was light northwesterly but not strong enough to intrude into the SJVAB. Flow types in the SJVAB were southerly or light northerly without marine air from the SFBAAB. Both of these flow types suggest stagnant conditions under which ozone would likely come from local sources. Late in the evening of June 2, the wind flow changed to types indicative of a well developed sea breeze from the SFBAAB to the SJVAB. This flow continued through June 3, strongly suggesting transport from the SFBAAB to the SJVAB.

The June 2 morning (4 a.m.) marine layer depth determined from the Oakland sounding (1,000 feet) and from the Fresno sounding (1,500 feet) was not deep enough to allow significant intrusion of ozone or precursors from the SFBAAB. However, on June 3 this marine layer thickened significantly to 4,000 feet at Oakland and 3,000 feet at Fresno. This allowed the unimpeded movement of ozone and its precursors through the coastal passes and across the lower portions of the Coastal mountains into the SJVAB.

Daily maximum temperatures were uniformly high in the SFBAAB (upper 80's and 90's (F)) and in the SJVAB (90's and 100's(F)) on June 2. With the onset of the sea breeze and transport from the SFBAAB, maximum temperatures fell to the 70's and 80's (F) in the SFBAAB on June 3. Temperatures remained high in the SJVAB with the beginning of the sea breeze on June 3, but dropped to 85 (F) at Stockton and 91 (F) at Modesto on June 4 and to the low 80's (F) on June 5. The significant cooling of the SFBAAB air and the advance of the cool air into the SJVAB shows the sea breeze penetrated into the valley and represents evidence that transport occurred on June 3-5 from the SFBAAB to the SJVAB.

Trajectories calculated backward from Stockton (Figure 7) and Modesto at maximum ozone occurrence times on June 2 show little air movement with beginning and end points not very far apart. However, on June 3 the trajectories indicate that air from near Vallejo in the SFBAAB (Figure 8) moved well into the SJVAB (reaching Stockton by 2 p.m.) and moved just west of Modesto by 4 p.m.

Transport Couple
San Francisco Bay Area to San Joaquin Valley

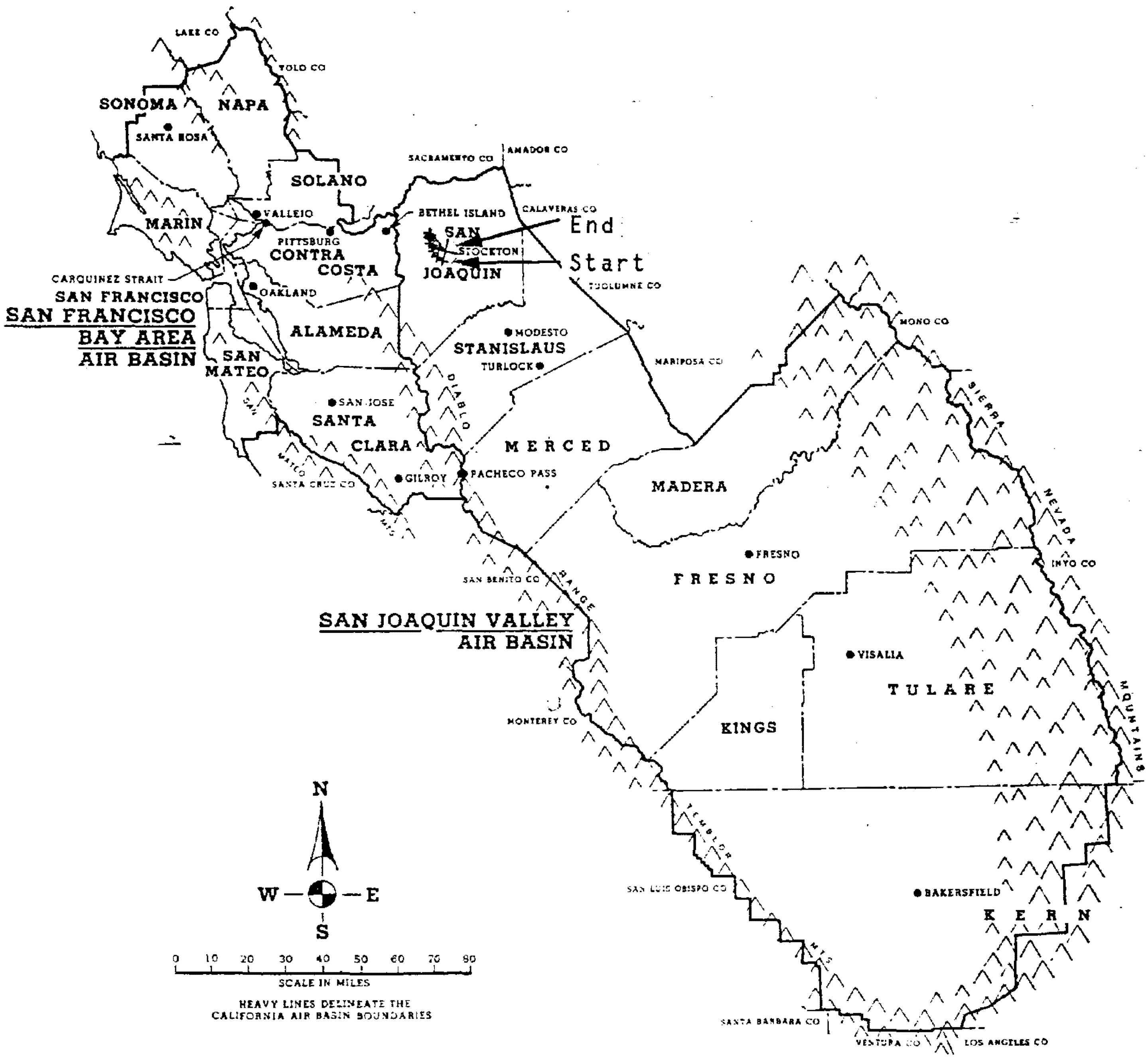


Figure 7: Trajectory constructed backward from Stockton starting at 2 p.m. on June 2, 1987, showing the near circular motion of the ambient air on this day.

Transport Couple
San Francisco Bay Area to San Joaquin Valley

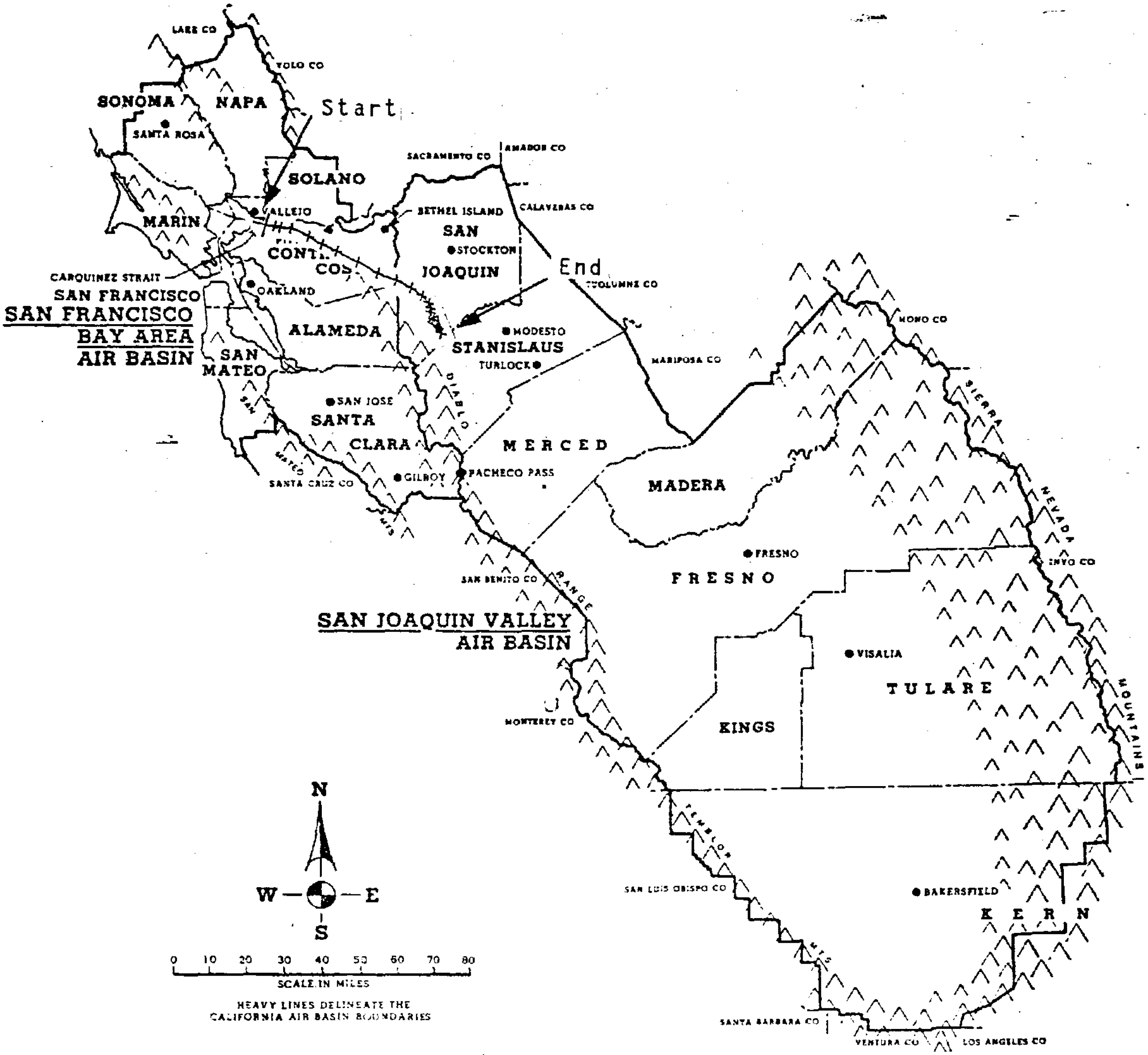


Figure 8: Trajectory constructed forward from near Vallejo starting at 6 a.m. on June 3, 1987, showing air movement from the SFBAAB well into the SJVAB ending southwest of Modesto.

5. Air Quality Assessment

The spatial distribution of ozone concentrations greater than the state standard extended throughout the southern and eastern portions of the SFBAAB and the entire SJVAB on June 2. Ozone concentrations dropped below the state standard in the SFBAAB on June 3 while increasing in the SJVAB. Ozone then remained low in the SFBAAB and decreased in the SJVAB on June 4. This suggests that ozone and its precursors were transported out of the SFBAAB on June 3, then across and eventually out of the SJVAB by June 4.

Daily peak ozone concentrations were similar in the SFBAAB and northern SJVAB on June 2. Peak values ranged from 9 to 14 pphm in the SFBAAB and from 9 to 12 pphm in the northern SJVAB. As the plume was blown out of the SFBAAB into the SJVAB on June 3, peak ozone values dropped to 9 pphm or less in the SFBAAB and increased to as high as 15 pphm in the northern portion of the SJVAB.

6. Emission Inventory

Based on 1987 emission data, the SJVAB emissions of ozone precursors, namely reactive organic gases (ROG) plus oxides of nitrogen (NOx), are about equal to those for the SFBAAB. The SFBAAB basinwide emissions are 1179 tons/day of ROG plus NOx while the emissions for the SJVAB total 1288 tons/day. The SFBAAB emissions are over four times the 281 tons/day of the three northern most counties of the SJVAB.

7. Results of Modeling and Analysis

A modeling and analysis study was performed using existing data in the San Joaquin Valley. The objectives of the modeling and analysis study were to: 1) develop, to the extent possible, a conceptual model of the mechanisms which lead to high ozone levels in the Valley, 2) determine which meteorological and emissions related parameters have the greatest impact on modeled ozone concentrations, and 3) ascertain where gaps in current understanding exist so that they can be addressed in future field programs.

a. Analysis

In order to assess transport from the SFBAAB into the SJVAB, the timing and magnitude of ozone peaks at various stations in the Valley were examined. The progression in the magnitudes and times of occurrences of peak ozone concentrations from Pittsburgh to Bethel Island to Stockton shows that transport occurred. The months of July and August of the years from 1983 to 1986 were examined for the frequency of days meeting these progression criteria. In July, out of a total of 67 days with adequate data, 34 were clearly identified as transport days. In August, 28 out of 76 days were classified as transport days, 29 and 36 days in July and August respectively were classified as days where the ozone maxima at the stations occurred too close together in time to be clearly identified as a transport case. Only 4 and 12 days in July and August respectively were determined to have no transport from the SFBAAB. On those days identified as transport influenced, however, peak ozone concentrations at Stockton and Modesto were no more than 1 to 2 pphm above those at Bethel Island. Based on lack of progression in the time and magnitude of ozone peaks, locations in the San Joaquin Valley south of Turlock did not appear to experience impacts from the SFBAAB on a same day basis. Carry over of pollutants however could be significant, but this effect could not be evaluated.

b. Modeling

Systems Applications Inc. used a photochemical grid model for the SJVAB. The modeling domain encompassed a region extending from Sacramento to the Tehachapis and from the Pacific Ocean to the crest of the Sierras. A variable grid approach was used with 5 km grid cells in the urban areas, increasing to 20 to 40 km grid cells in rural areas. Emissions were based on the 1985 Air Resources Board inventory augmented with mobile source running loss and biogenic emissions. The episode simulated was August 7 and 8, 1984. During this episode, peak observed ozone values ranged from 10 pphm in the northern Valley to 15 pphm in the southern Valley.

The simulations were first carried out to evaluate the model's performance for the base case. A number of simulations were then carried out to evaluate the sensitivity of the model to various input parameters. One run was conducted to specifically examine the effect of transport of SFBAAB pollutants on the SJVAB. This was accomplished by making a run with all Bay Area anthropogenic emissions set to zero and comparing it with the base case.

On the first day of the episode (August 7), the influence of Bay Area emissions on Valley ozone concentrations was seen as far south as Madera. Peak ozone was reduced by as much as .6 pphm in the vicinity of Stockton, approximately 1.5 pphm near Modesto, and approximately .2 pphm in Madera. No influences were seen south of Fresno.

On the second day of the episode (August 8), reductions in ozone were seen as far south as Bakersfield. Peak reductions in ozone ranged from 1.7 pphm near Stockton, to 3.6 pphm near Modesto, to .5 pphm in Fresno and Bakersfield. The greatest reductions were seen in the western portions of San Joaquin and Stanislaus counties where peak ozone concentrations were reduced 40 to 60 ppb.

Two distinct pathways for transport of pollutants from the SFBAAB to the SJVAB were identified: 1) through the Carquinez Straits, and 2) over the Diablo Mountains around Pacheco Pass. Of these two routes, the southern route through Pacheco Pass appeared to transport more pollutants into the Valley.

Two caveats apply to this analysis. First, the base case model performance did not meet traditionally accepted standards, with the model overall underpredicting peak ozone. Second, the results presented above are applicable only to the specific episode modeled. Different meteorological scenarios could produce different results. Nonetheless, for the purposes of qualitatively assessing transport from the SFBAAB to the SJVAB, the results are adequate.

8. Windfield Studies

In addition to the modeling and analysis described above, several other studies were also conducted. The objectives of one study were to evaluate methods for generating gridded windfields, provide support for the modeling, and design a monitoring network to support future windfield modeling efforts. The modeling approach used the Colorado State University Mesoscale Model, a prognostic meteorological model, combined with observations from the August 7 and 8, 1984, episodes and data from a July 1979 study to produce a gridded windfield.

During this study, a number of trajectories were generated to examine transport paths. The evidence for transport from the SFBAAB into the SJVAB is seen from trajectories initiated at 6:00 a.m., 12:00 p.m., and 5:00 p.m. from Pittsburgh and San Jose. Both surface and aloft trajectories beginning at Pittsburgh travel through the Carquinez Straits to Stockton, while those beginning at San Jose flow through the Pacheco Pass into the San Joaquin Valley west of Modesto.

Therefore, although the trajectories cannot be used to quantitatively assess the impact of SFBAAB emissions on SJVAB ozone concentrations, they show that SFBAAB emissions are transported into the SJVAB.

9. Direct Measurements of Transport

a. Description

During August 1988, a field study was conducted to: 1) develop and test a cost effective method to measure the meteorology and air quality conditions at the upwind boundary of the SJVAB, and 2) provide a preliminary assessment (for a few cases) of the amount and relative importance of pollutants transported into the Valley from the Bay Area. The study required development of a procedure to estimate the rate of pollutant transport into the northern SJVAB and to assess the potential contribution of these transported pollutants to air quality in the Valley. The rate of transport of pollutants into the northern SJV through the boundary was estimated using meteorological and air quality data. Incoming ozone concentrations at the boundary were compared to ozone concentrations in the SJVAB. The estimated rates of transport of NO_x, and ROG into the SJVAB were compared to the NO_x and ROG emission rates in the Bay Area and in the northern SJVAB.

The meteorological and air quality measurements were made at ground level and aloft at several sites and along the boundary, during two 36-hour intensive sampling periods on August 8-9, and August 16-17, 1988. Air quality measurements included concentrations of ozone, NO_x and ROG along with other parameters used to evaluate the consistency and representativeness of these data.

Figure 9. Sample site loactions and the flux plane boundary used in the San Joaquin Valley Boundary Study.

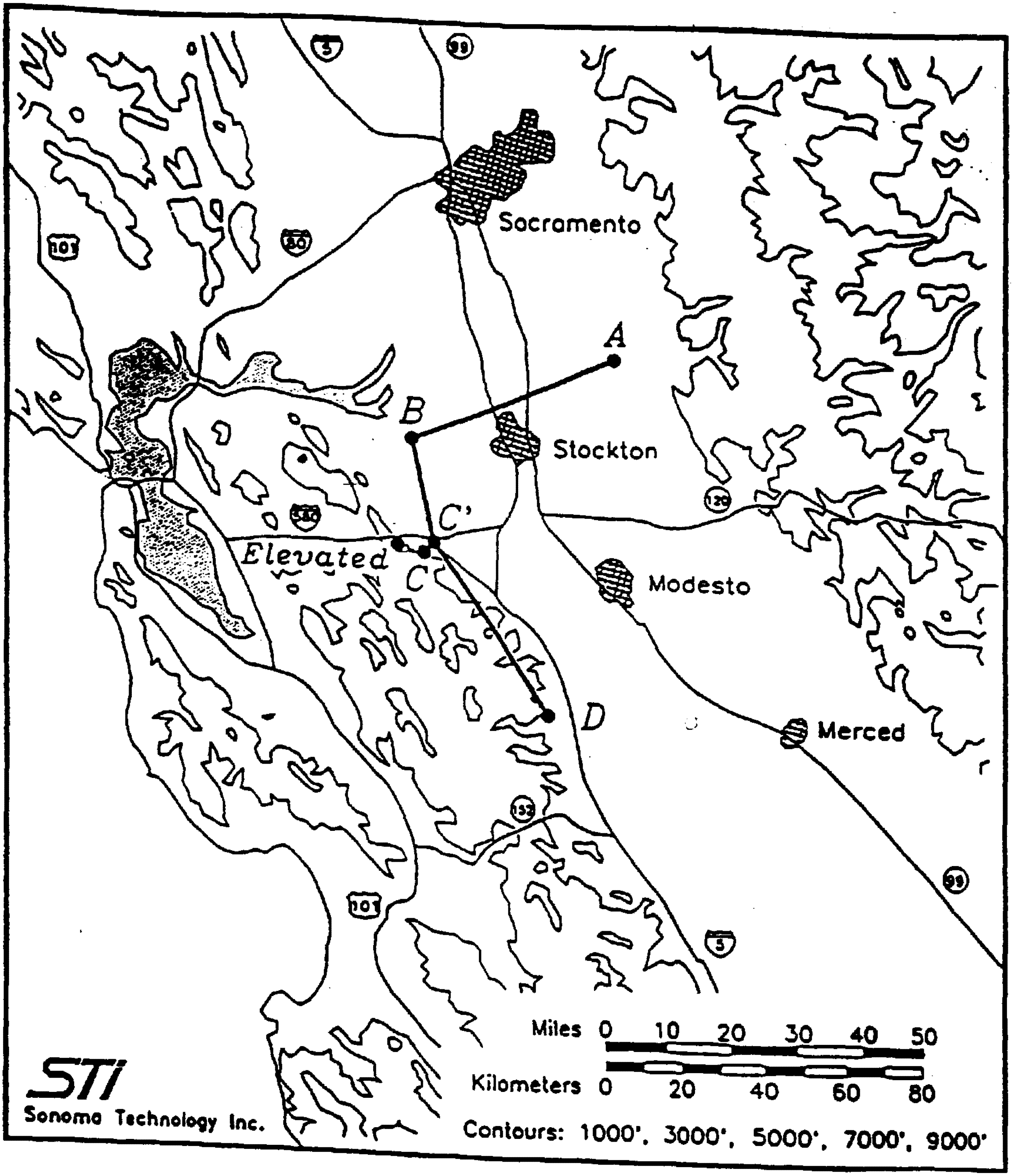


Figure 9 shows the study domain, sampling sites and the boundary used for these calculations.

b. Ozone Transport

The analysis indicates that a significant amount of ozone enters the Valley at the northwest boundary, but that additional ozone is formed in the northern Valley. On the field study days, ozone concentrations entering the Valley averaged 6 to 7 pphm while peak ozone concentrations in the Valley north of Fresno were 6 to 9 pphm. At sites from Fresno south, peaks ranged from 7 to 16 pphm.

Of the eight independent periods when measurements were made, one was in the morning, three were in the afternoon, and four were in the evening. The average rate of transport of ozone across the boundary in the morning was 29 lbs/sec (one sample), in the afternoon was 90 lbs/sec $\pm$ 46, and in the evening was 101 lbs/sec $\pm$ 46. Transport of 88 lbs/sec corresponds to an average ozone concentration of 7 pphm with an average wind speed perpendicular to the boundary plane of about 3.8 mph. The greatest transport occurred on the afternoon and evening of August 9. Between 5 and 50 percent of the pollutant mass was transported below 1000 feet. The variation between transport in all afternoon and evening data (7 data sets) was approximately 50 percent.

c. NO_x Transport

The rate of NO_x transport varied from a low of 7 lbs/sec to a high of 18 lbs/sec. A rate of 12 lbs/sec is equivalent to an average NO_x concentration of about 1 pphm transported into the Valley at about 3.8 mph perpendicular to the boundary plane. A significant amount of the NO_x transport (30 to 80 percent) occurred below 1000 feet. Uncertainties in the data are similar to those for ozone, except that some pockets of unusually high NO_x were observed. Most of these cases showed high NO and NO_x with low ozone indicating relatively fresh emissions. The high NO_x in these pockets, if included in the analysis, would suggest there might be 10 to 30 percent greater rate of NO_x transport than the estimates given here.

To put the rate of NOx transport in perspective, it may be compared to the NO_x emission rates for the SFBAAB and for the northern SJVAB. The estimated rate of NO_x transport was about the same as the hourly average NO_x emissions in the Bay Area. However, that the peak NO_x emission rates are higher than average rates. Transport at a rate of 7 to 18 lbs/sec is equivalent to about 12 to 32 tons/hr. For 1985, the total hourly average NO_x emissions were 23 tons/hr in the Bay Area.

The total hourly average northern SJVAB emissions (the total of Stanislaus, San Joaquin, Merced and Madera county emissions) for 1985 were 4.6 tons/hr. Thus, the estimated rate of transport of NO_x into the SJVAB was larger than the hourly average emission rate in the northern SJVAB, and transported NO_x was probably a significant contributor to northern SJVAB NO_x on the days sampled.

d. ROG Transport

The ROG data set was very limited, consisting of only two hourly average surface samples and four or five grab samples taken during each aircraft flight. Thus, only very rough estimates of the rate of transport of ROG can be made. To make these estimates, the NO_x and ozone concentration contour plots were used as guides to estimate the total ROG concentration distributions.

Very rough estimates of the rate of transport of ROG into the SJVAB for three independent cases were 4 to 9 lbs/sec, equivalent to 8 to 16 tons/hr total ROG, with an estimated uncertainty of 40 to 100 percent. SFBAAB total ROG emissions for 1985 were about 22 tons/hr, about the same order of magnitude as the estimated rate of transport. Average northern Valley ROG emissions for 1985 were about 6 tons/hr. Thus, transported ROG was probably a significant contributor to northern SJVAB ROG concentrations.

10. Other Transport Routes

Long range transport of ozone and precursors from the northern SJVAB to the southern SJVAB through a nocturnal jet has been documented in previous studies. It is possible that this nocturnal jet could transport pollutants brought into the northern SJVAB from the SFBAAB to the southern SJVAB. The effect of transport of pollutants by the nocturnal jet on ozone in the southern SJVAB was not evaluated for this report due to lack of sufficient data, but will be studied in the upcoming SJVAB Air Quality Study.

11. District Comments

The following four comments were received in a letter dated April 26, 1990, from Stanislaus County Department of Environmental Resources Air Pollution Control District:

1. "The preliminary draft of the Transport Assessment Findings categorizes the impacts of transport on ozone for the San Francisco Bay Area to Broader Sacramento as Overwhelming, Shared, and Inconsequential. However, the impacts of transport to the San Joaquin Valley by the Bay

Area are classified as only Shared and Inconsequential. This District is concerned that there was not a finding of Overwhelming Impact on the San Joaquin Valley. The marine influences that would transport Bay Area pollutants to the Broader Sacramento Area are the same ones that would transport pollutants to the San Joaquin Valley."

The ARB staff agreed that our conclusions should be consistent and the Overwhelming status should be listed as significant in both cases.

2. "Pacheco Pass is shown as one of the transport routes into the San Joaquin Valley in the October Report on page 26 (figure 7). This map delineates a transport route from the South Bay Area that joins near Hollister with a transport route from Monterey Bay and continues through the Pacheco Pass to the San Joaquin Valley. Transport from the Bay Area to Hollister in the North Central Coast Area was discussed at the workshop on April 17 and was described as overwhelming. No mention was made at this workshop nor in the Draft Assessment Findings of transport from the North Central Coast Area or the Bay Area to the San Joaquin Valley through Pacheco Pass."

The ARB staff has included a discussion of transport through Pacheco Pass in the modeling section of the report.

3. "Using the data from only one day to justify some of these qualitative transport rankings distorts impact that one area may have on another. The impact of transport from the SF Bay Area on the San Joaquin Valley appears to be accorded the same status as the impact of transport from the Greater Sacramento Area on the San Joaquin Valley. We also believe the San Joaquin Valley Air Quality Study has already developed useful information that should be considered in determining these Transport Assessment Findings."

The ARB staff reviewed data from 1986 through 1989, but chose only selected days for discussion in the report. Some preliminary San Joaquin Valley Air Quality Study information has also been included in the modeling section of the report.

4. "The District would appreciate a copy of relevant material and data that was used to determine the Transport Assessment Findings for the San Joaquin Valley Couples."

The ARB staff telephoned and invited the District staff to review and discuss all relevant material and data. Mark Macedo of the Stanislaus County APCD staff later visited and reviewed and discussed the material with the ARB staff. The material will be kept for any future review required.

The ARB staff attended a planning meeting of San Joaquin Valley APCDs working group in Fresno on May 9, 1990. The group's objective is to provide continuity and cohesiveness throughout the Valley for the CCAA attainment planning process. The purpose of staff's visit was to discuss transport assessment analyses and conclusions.

There were very few questions regarding the technical aspects of ARB's analyses. The representative from Stanislaus County APCD had questions regarding their letter of April 26, 1990. He asked if the "overwhelming" status for Bay Area to Broader Sacramento was dropped due to the letter. His letter did cause a reevaluation of that conclusion. He also asked about transport from Bay Area over the Hollister area and into the San Joaquin Valley, which is discussed in item 2 above.

12. References

1. Roberts, P.T. et. al., The Measurement of Pollutant and Meteorological Boundary Conditions: Technical Support Study 10, STI-98030-920 FR, Sonoma Technology Inc., 1989.

2. Roberts, P.T. et. al., Analysis of San Joaquin Valley Air Quality and Meteorology, STI-98101-1006 DFR, Sonoma Technology Inc., 1990.

3. Kessler, R.C. et. al, Numerical Simulation of Summer Mesoscale Airflow in the Central Valley of California, Systems Applications, Inc., 1989.

4. Douglas, S.G., Objective Combination of Prognostic Model Wind Fields and Observational Data for the San Joaquin Valley, Systems Applications, Inc., 1989.

5. Chinkin, L. et.al., Draft Report Emission Modeling Plan for AUSPEX/SJVAQS, Systems Applications, Inc., 1990.

D. Broader Sacramento Area to San Francisco Bay Area

1. Summary and Recommendation

The staff's analysis shows that transport from the Broader Sacramento Area (Broader Sac) to the San Francisco Bay Area Air Basin (SFBAAB) occurred on at least nine of the 126 days when the state ozone standard was exceeded during 1986 through 1988 in the northeastern part of the SFBAAB. Emissions within the northeastern part of the SFBAAB had a significant impact on the exceedances in the northeastern part of the SFBAAB. In addition, the staff's analysis shows that on the days ozone concentrations in the SFBAAB were the highest during 1986 through 1988, the transport from the Broader Sac to the SFBAAB was inconsequential.

The staff recommends that the Broader Sac's transport to the SFBAAB be classified as "Significant" on some days and "Inconsequential" on others. Because transport from the Broader Sac is "Significant" on some days, the districts within the Broader Sac must include in their 1991 plans a requirement for the application of best available retrofit control technology to existing stationary sources. These districts must also include in their 1991 plans a permitting program designed to achieve a no net increase in emissions of precursors of ozone from all new or modified stationary sources.

2. Conclusions

The staff beleives that on some days the contribution of the Broader Sac emissions to exceedances of the state standard for ozone ("state standard") in the SFBAAB is inconsequential. The staff believes that on other days the contribution of the Broader Sac emissions to exceedances of the state standard in the northeastern portion of the SFBAAB is shared.

The staff's conclusions are based on a review of meteorological and air quality data for the 126 days during 1986 through 1988 when the state standard was exceeded in the SFBAAB. The staff analyzed data for evidence of inconsequential transport from the Broader Sac to the SFBAAB for the 17 days when the highest ozone concentrations in the SFBAAB occurred.

The staff also analyzed data for the 43 exceedance days during 1986 through 1988 at Vallejo, Fairfield, Concord, Pittsburg, and Bethel Island. Initially, the staff found that this set of days represented the most likely to make an overwhelming or shared contribution from the Broader Sac to northeastern SFBAAB. The staff found that of the 43 days, 3 exceedances at Fairfield and 4 exceedances at Bethel Island were caused by overwhelming transport from the Broader Sac. However, the staff concluded that any assessment of the overwhelming nature of the transport contribution from the Broader Sac to the SFBAAB based on a 11 pphm ozone concentration at Fairfield and Bethel Island would be inappropriate. The proximity of Fairfield and Bethel Island to the boundary of the Broader Sac and the SFBAAB makes transport analysis for Fairfield and Bethel

Island unrepresentative of the Broader Sac transport contribution to the SFBAAB unless Fairfield or Bethel Island is the location of maximum ozone concentration on those days in the SFBAAB. However, on the days when transport caused the exceedances at Fairfield and Bethel Island, there were also exceedances at sites in the SFBAAB that had higher maximum concentrations (up to 4 pphm greater) and were the consequence of significant emissions within the SFBAAB. Thus, the staff did not find evidence of an overwhelming contribution by ozone and ozone precursors from the Broader Sac to the SFBAAB.

Of the 126 exceedance days in the SFBAAB during 1986 through 1988, the staff determined that nine were impacted by the transport of ozone and ozone precursors from the Broader Sac to the northeastern portion of the SFBAAB. The remaining exceedance days within the SFBAAB were found to have resulted from inconsequential transport from the Broader Sac.

3. Geographic Setting

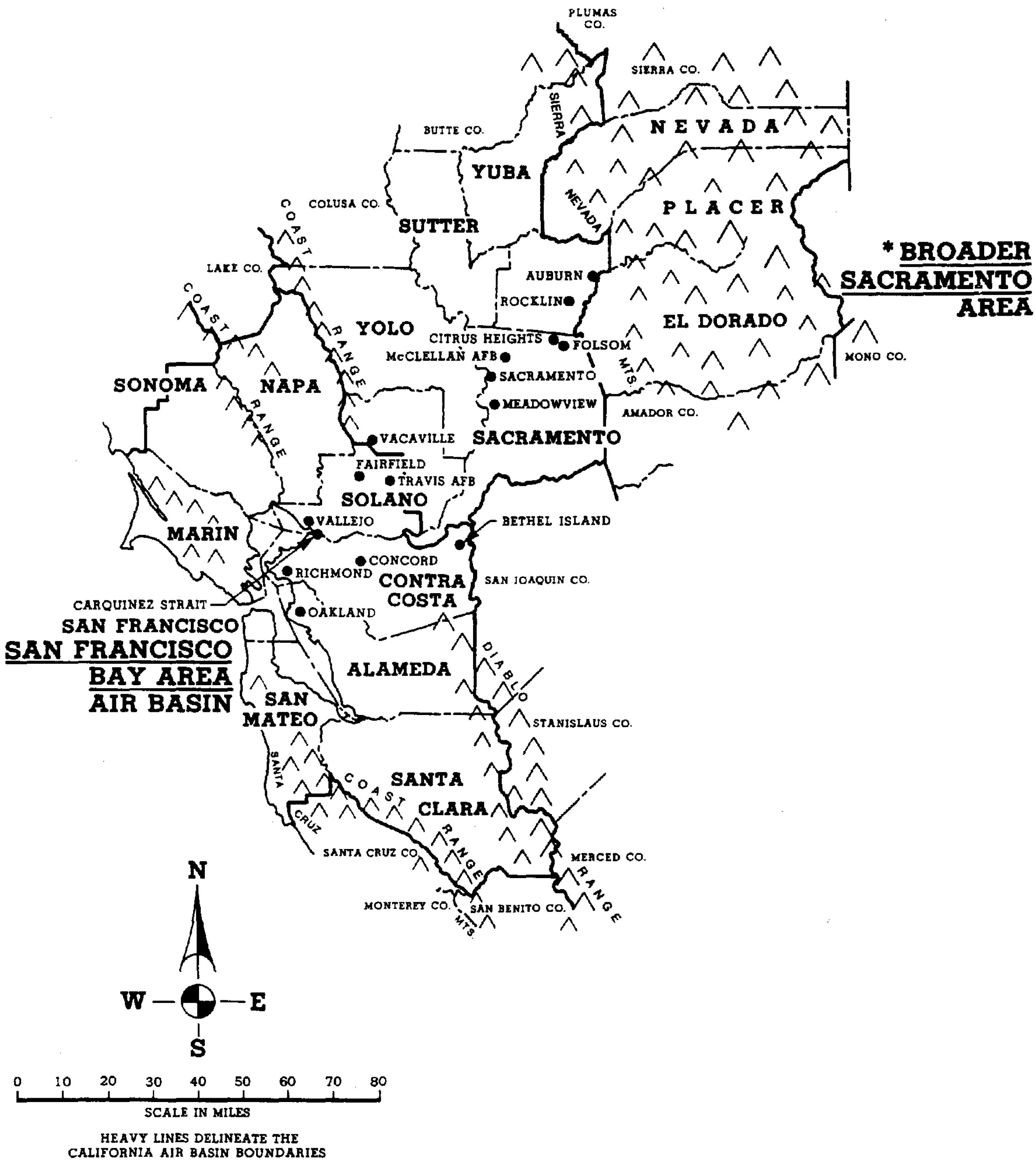
The SFBAAB comprises Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, and Santa Clara Counties and portions of Solano and Sonoma Counties. The Broader Sac is located to the east and northeast of the SFBAAB. It comprises the southern part of the Sacramento Valley and a part of the western slope of the Sierra Nevada. The Broader Sac includes Nevada, Sacramento, Sutter, Yolo, and Yuba Counties and parts of El Dorado, Placer, and Solano Counties. A map of the two areas is provided in Figure 10.

Between the SFBAAB and the Broader Sac, the Coast Range has a northwest-southeast alignment and acts as a barrier between the cool, moist, marine air along the coast of northern California and the hot dry air in the Sacramento Valley. The Carquinez Strait which provides a gap in the Coast Range through which the Sacramento River flows is the dominant geographic feature influencing the potential for transport from the Broader Sac to the SFBAAB. Marine air routinely flows through the Carquinez Strait and into the delta region of the Sacramento River. However, the air also can flow in the opposite direction. North through northeast winds flow from the Sacramento Valley into the Sacramento River delta and can penetrate the SFBAAB through the Carquinez Strait. The north through northeast winds generally result from high pressure systems that follow storms which pass through northern California during fall through spring. The strength of the high pressure system influences how far into the Strait the northerly winds penetrate. The degree of penetration determines whether the northeastern part of the SFBAAB receives air pollutants from the Broader Sac.

4. Summary of Previous Transport Studies

Previous studies of transport from the Broader Sac to the SFBAAB have indicated the possibility of transport. Air flow aloft from the Broader Sac to the SFBAAB ("return flow") sometimes occurs during the summertime as reported by Smith et al.[1] Holets[2] has also suggested that

Figure 10
TRANSPORT COUPLE
BROADER SACRAMENTO AREA to SAN FRANCISCO BAY AREA



* "Broader Sacramento Area" includes Nevada County, Sacramento Metropolitan Air Quality Management District, Yolo-Solano Air Pollution Control District, and the Sutter, Yuba, El Dorado, and Placer County Air Pollution Control Districts.

return flow aloft might be a transport mechanism. The Bay Area Air Quality Management District[3] has used back trajectory analysis to demonstrate that transport occurs from the Broader Sac to the SFBAAB.

5. Data

The staff's assessment of transport from the Broader Sac to the SFBAAB was based on data available for 1986 through 1988 ("study period"). During the study period, there were 126 days during which the state standard for ozone was exceeded in the SFBAAB. Time constraints and available staff resources precluded a thorough review of all these days. However, a review of all days with exceedances of the state standard for ozone was not necessary because evidence from a smaller number of days indicated transport from the Broader Sac contributed to the ozone problem in the SFBAAB.

The staff's evaluation for inconsequential contribution of transport from the Broader Sac to the SFBAAB focused on data for the 17 days when the maximum ozone concentration in the SFBAAB exceeded 13 pphm. Daily maximum ozone concentrations in the SFBAAB ranged from 14 to 17 pphm on these 15 days.

The evaluation for overwhelming and significant contribution of transport from the Broader Sac to the SFBAAB focused on data for the 43 days during the study period when ozone concentrations for Bethel Island, Concord, Fairfield, Pittsburg, and Vallejo exceeded the state standard. These five stations are located in the northeast part of the SFBAAB, close to the boundary between the Broader Sac and the SFBAAB. The results of the analysis of the 43 days provide the basis for the staff's finding of significant contribution from the Broader Sac to the SFBAAB.

Twenty-three ozone monitoring sites were in operation in the SFBAAB during the study period. All sites had exceedances of the state standard except the sites in San Francisco and San Leandro.

6. Emission Inventory

Reactive organic gases (ROG) and nitrogen oxides (NOx) are the primary precursor emissions that generate ozone. To determine the potential for emissions to generate ozone precursors and ozone concentrations above the state standard, the staff reviewed the relative magnitude of the precursor emissions in the upwind and downwind areas. The emissions assessment for the SFBAAB was limited to the emissions in Contra Costa County and a portion of Solano County because these counties are the primary area of impact from transport from the Broader Sac.

The ozone precursor emissions of ROG and NOx for the Broader Sac (398 tons/day) are one-third of the precursor emissions for the northeast part of the SFBAAB (1179 tons/day). The staff's assessment indicates emissions in both areas are capable of generating ozone concentrations that exceed the state standard in the respective areas. Therefore, when exceedances occur on days with transport from the Broader Sac into the northeastern SFBAAB, both areas contribute to the exceedances.

7. Transport Assessment

The staff completed two types of assessments to characterize the potential for transport of pollutants from the Broader Sac to the SFBAAB: a meteorological assessment and an air quality assessment. These assessments were based on two sets of data:

- The 17 days during the study period when maximum ozone concentrations in the SFBAAB exceeded 13 pphm, and
- The 43 days during the study period when the state standard for ozone was exceeded at Bethel Island, Concord, Fairfield, Pittsburg, and Vallejo.

a. Analysis Considerations

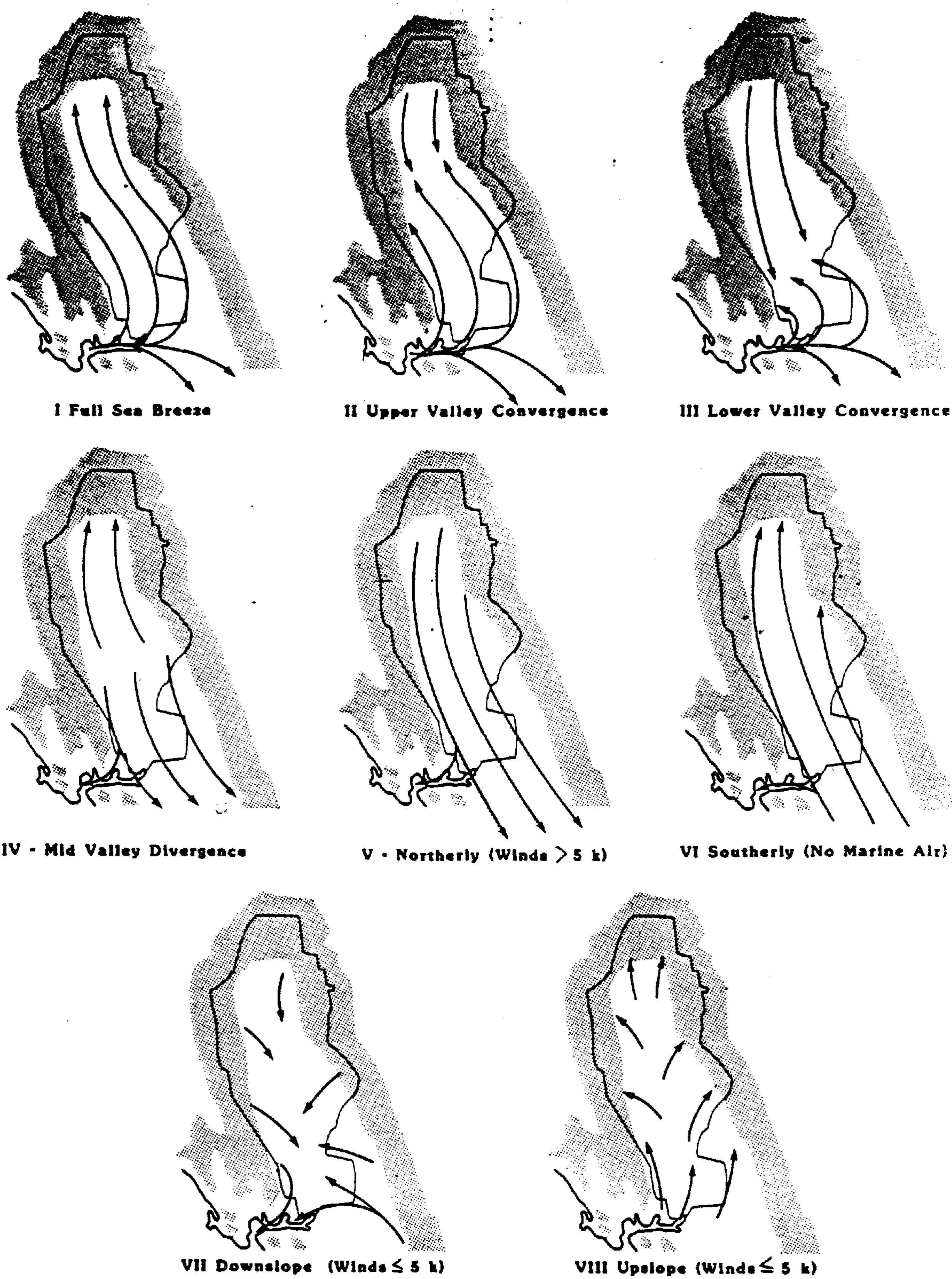
1. Meteorological Data

Ambient ozone concentrations near the surface of the earth are primarily a function of emissions and meteorology. Because emissions are relatively constant from day to day, most of the daily variation in ozone concentrations is attributed to variations in meteorology. Therefore, an assessment of meteorological conditions is important in understanding the nature and perhaps source or cause of high ozone concentrations. The following meteorological conditions were considered in the assessment.

<u>Surface Air Flow Types</u>. The staff has classified air flow types for the Sacramento Valley and the San Francisco Bay area. The air flow types are based on the 4 a.m., 10 a.m., and 4 p.m. surface streamline analyses. The staff reviewed the Sacramento Valley and SFBAAB streamline analyses for the days with high ozone concentrations in the SFBAAB and the Sacramento River delta region of the Broader Sac to determine whether the surface air flow pattern supported the potential for transport from the Broader Sac to the SFBAAB.

The Sacramento Valley air flow types most likely to be associated with transport from the Broader Sac to the SFBAAB are Mid Valley Divergence, Northerly, and Downslope (see Figure 11). These three air flow types occur most frequently during fall, winter, and spring. On an annual basis, Mid Valley Divergence, Northerly, and Downslope occur 3 percent, 20 percent, and 6 percent of the time, respectively. During the ozone season, Mid Valley Divergence occurs 3 percent, 2 percent, and 4 percent of the time during spring, summer, and fall, respectively. Northerly occurs 25 percent, 9 percent, and 23 percent of the time during spring, summer, and fall, respectively. Downslope occurs 5 percent, 1 percent, and 9 percent of the time during spring, summer, and fall, respectively.

FIGURE 11 **SACRAMENTO VALLEY AIR FLOW PATTERN TYPES**



The SFBAAB air flow type most likely associated with transport from the Broader Sac is Northeasterly (see Figure 12). This air flow type occurs most frequently during winter (10 percent of the time). Northeasterly occurs equally during the spring and fall (4 percent of the time).

Therefore, surface air flow conditions during the months of ozone exceedances in the northeastern SFBAAB are conducive to the transport of pollutants on only a small percentage of days.

Back Trajectory Analysis. Trajectory analysis involves computing from wind speed and direction data the route an air parcel would take over a specified time period. The analysis can be started at a site in the downwind area and run backwards in time (a back trajectory) to determine the path of the air parcel and the locations of potential ozone and ozone precursor sources. A back trajectory was used in this analysis to track the movements of air parcels from the SFBAAB to the Broader Sac.

Daily Maximum Temperature. The staff reviewed the daily maximum temperatures at Sacramento, Vacaville, Antioch, Richmond, and San Francisco to estimate the extent of penetration of air from the Sacramento Valley into the Sacramento River delta and San Francisco Bay on June 2, 1987. Maximum daily temperatures ranged from the upper 90s in the Sacramento area to over 100°F at Martinez. The San Francisco Bay area had slightly cooler maximums--low 90s. The similarity in daily maximum temperatures in the Sacramento and delta areas suggests that Sacramento Valley air had penetrated at least as far as the Martinez area of the Sacramento River delta. The extent of the penetration suggests that transport of air pollutants from the Broader Sac to the northeastern SFBAAB occurred.

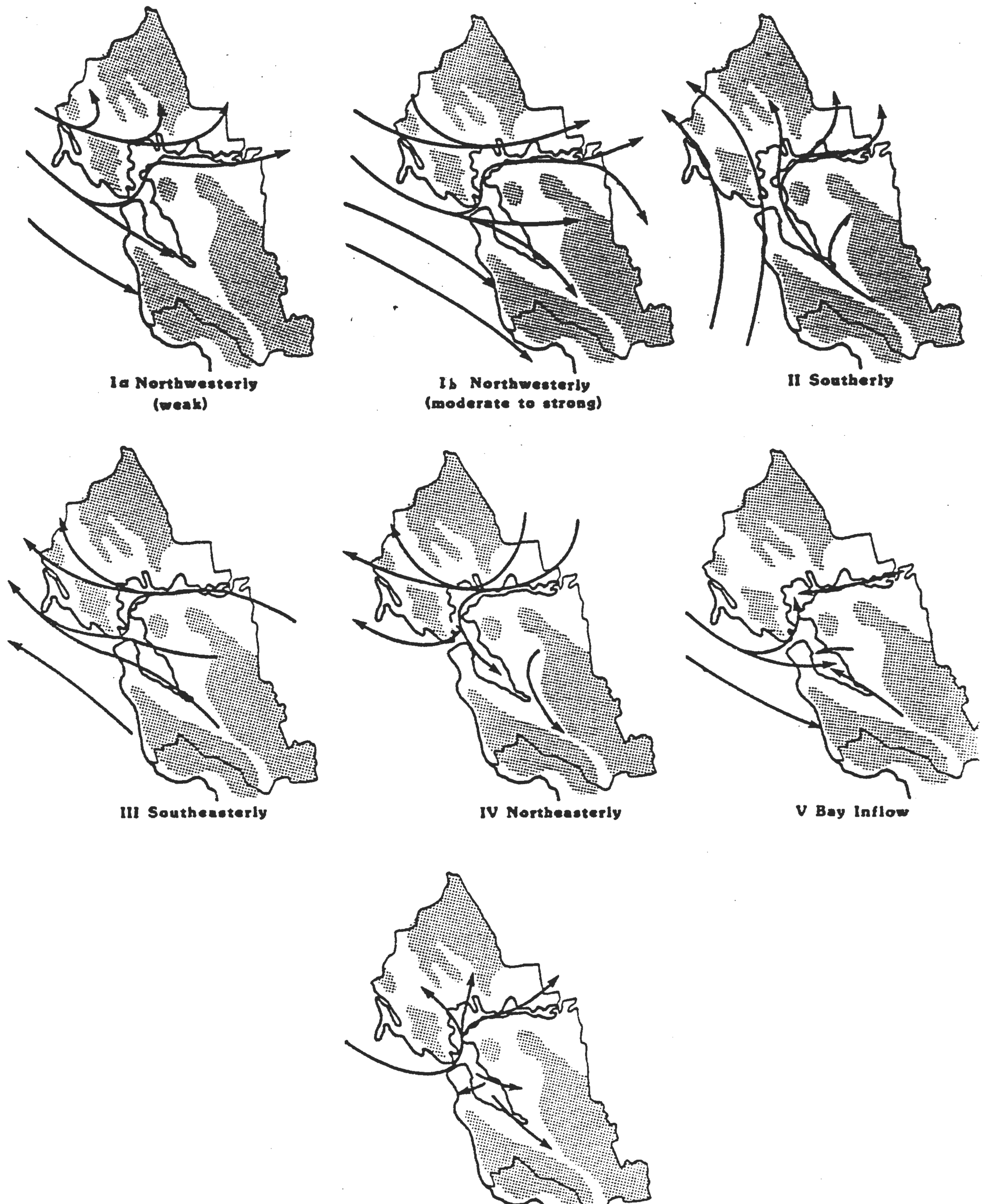
2. Air Quality Assessment

The staff reviewed ozone air quality data for the northeastern part of the SFBAAB and the Broader Sac to assess the nature and potential causes of the exceedance in the northeastern SFBAAB.

Geographic Extent of Exceedances. The size and shape of the area(s) where exceedances of the state standard for ozone occurred provides information about the source of the ozone and precursors contributing to the exceedances. Exceedances occurring only within the SFBAAB and not in the Broader Sac suggest such exceedances were caused by "local" emissions. However, if exceedances occurred in the southwestern part of the Broader Sac and in northeastern SFBAAB when northeastern SFBAAB was downwind from the Broader Sac, there is a strong indication of the contribution from the transport of ozone and ozone precursor emissions from the Broader Sac.

Time of Daily Maximum Ozone Concentration. Ozone concentrations resulting from "local" emissions typically occur around solar noon but can range between 11 a.m. and 2 p.m. Daily maximum concentrations occurring

FIGURE 12 **BAY AREA AIR FLOW PATTERN TYPES**



Ia Northwesterly (weak)

Ib Northwesterly (moderate to strong)

II Southerly

III Southeasterly

IV Northeasterly

V Bay Inflow

VI Bay Outflow

before 11 a.m. may be the result of fumigation of ozone trapped aloft from the previous day. Daily maximum concentrations occurring late in the afternoon or early evening may be the result of the transport of a polluted air mass into the area.

b. Analysis Results

The staff looked for three potential categories of transport contribution from the Broader Sac to the SFBAAB: Inconsequential, Overwhelming, and Significant. The staff was able to identify only two categories in the days analyzed--Inconsequential and Significant. A preliminary analysis of the 17 high days in the SFBAAB indicated that all days had inconsequential contribution by transport from the Broader Sac. The analysis of the 43 days when ozone concentrations exceeded the state standard in the Sacramento River delta of the SFBAAB indicated that 35 days were in the inconsequential category. The remaining days had a significant contribution from transport.

The following discussions of the air quality and meteorological assessments for the two categories recommended by the staff focus on the following specific cases:

- o Inconsequential - October 4, 1987
- o Significant - June 2, 1987

1. Inconsequential

The example day with an inconsequential contribution of transport from the Broader Sac to SFBAAB is October 4, 1987. The staff examined the geographic extent of the area where exceedances occurred in order to determine whether the exceedances were widespread or in isolated areas. The maximum ozone concentration in the SFBAAB on October 4, 1987, was 16 pphm at Fremont and occurred at 3 p.m. Other sites exceeding the state standard that day in the SFBAAB include Hayward, Redwood City, Mountain View, Los Gatos, San Jose, and Gilroy. Maximum ozone concentrations at Vacaville and Concord were 6 pphm, 7 pphm at Fairfield, and 8 pphm at Pittsburg. The sites with exceedances of the state standard on October 4, 1987, also had exceedances on the previous day, October 3. The maximum ozone concentration in the Broader Sac on October 4, 1987, was 11 pphm at the Sacramento-Del Paso site and occurred at 12 p.m. Sacramento-Del Paso was the only site in the Broader Sac which exceeded the state standard on that day. However, on the previous day, October 3, sites throughout Sacramento showed ozone exceedances. The geographic extent of the ozone exceedance area suggests that exceedances were isolated within the SFBAAB and the Broader Sac.

The staff also reviewed surface wind data in order to determine if there was sufficient air exchange between the two areas to support the transport of pollutants. The surface wind data indicated weak air flow over both areas. Surface streamline analyses indicated the convergence in the Sacramento River delta of a weak sea breeze flow from the west and a weak flow from the north throughout the case study day. On the previous day, the air flow was from the SFBAAB to the Sacramento Valley.

During the early morning hours of the previous day, October 3, the sea breeze penetrated the Sacramento River delta area. By mid-afternoon of that day, the sea breeze had penetrated the San Joaquin Valley as far south as Merced. In addition, SFBAAB surface air flow types for October 4, 1987, and the previous three days were not conducive to transport from the Broader Sac to the SFBAAB.

The staff reviewed the air quality data to determine whether there were ozone exceedances prior to and after the case day in order to assess whether the exceedance was the result of carryover of ozone and ozone precursor emissions from an upwind basin the previous day. A moderate sea breeze flowed through the San Francisco Bay area during October 3. Ozone concentrations for the two days prior to October 4, 1987, were below the state standard throughout the SFBAAB except at the Gilroy site. Ozone concentrations in the Broader Sac for the two days before the exceedance date were also below the state standard except at Yuba City. Ozone air quality continued to exceed the state standard the day after the case study date in both areas.

A review of the times of the daily maximum hour ozone concentrations for both the Broader Sac and SFBAAB on October 4, 1987, suggest the exceedances resulted from emissions within the respective areas. At the Sacramento-Del Paso site, the maximum ozone concentration occurred at 12 p.m. This time coincides with photochemical activity which peaks around solar noon and strongly suggests that ozone concentrations were caused by local emissions.

Within the SFBAAB, maximum ozone concentrations on October 4, 1987, occurred at 2 p.m. at Fairfield and Vallejo, between 11 a.m. and 2 p.m. at Concord, at 2 p.m. at Pittsburg, at 1 p.m. at Mountain View, at 2 p.m. at San Leandro, Hayward, Fremont, Redwood City, San Jose-4th Street, and Los Gatos, and at 4 p.m. at San Jose-Piedmont.

Winds aloft on October 4, 1987, were also not conducive to transport from the Broader Sac to the SFBAAB. Winds aloft data at Oakland at 4 p.m. that day were light and varied from the southwest through northwest at all elevations between the surface and 3000 feet above ground level. Moderate winds from the southwest were found above the 3000 foot level.

Based on the analysis presented above, the staff concludes that the contribution of transport from the Broader Sac to the SFBAAB on October 4, 1987, was inconsequential.

2. Significant

The example day with significant contribution of transport from the Broader Sac to Pittsburg in the SFBAAB is June 2, 1987. The geographic extent of the exceedance area was identified to assist in assessing whether exceedances may have been caused by local or transported pollutants. The maximum ozone concentration in the SFBAAB on June 2, 1987, was 14 pphm at Livermore. Other maximum ozone concentrations in the northeastern SFBAAB that day included 10 pphm at Bethel Island, Concord, Pittsburg, and Fairfield. The maximum concentrations on the previous day were 11 pphm at Gilroy and 10 pphm at Mountain View, San Jose-Piedmont, and San Jose-4th Street.

The maximum concentration in the Broader Sac on June 2, 1987, was 12 pphm at Yuba City. Other maximum concentrations in the Broader Sac that day were 11 pphm at Folsom, Sacramento-Meadowview, and Woodland, and 10 pphm at North Highlands and Vacaville. Ozone concentrations the previous day in the Broader Sac were 9 pphm or less.

The staff examined surface wind data in order to determine if the winds were conducive to transport from the Broader Sac to the SFBAAB. The winds at Travis AFB on June 2, 1987, were light to moderate and from the north while winds at Sacramento Executive Airport were light to moderate from the northwest through north during the morning and afternoon. On June 2, 1987, and the previous two days, the Sacramento Valley surface air flow type was Northerly. Surface streamline analysis for that day indicated that the air flow was northerly in the Sacramento River delta from Concord eastward during the early morning, late morning, and mid-afternoon.

Several back trajectories were constructed for the hours of the maximum ozone concentration at Pittsburg (1-5 p.m.) on June 2, 1987. The back trajectories were manually constructed using surface wind data. A back trajectory beginning at 1 p.m. indicated the air parcel came from the western part of the Broader Sac near the northeastern boundary of the SFBAAB. A second back trajectory beginning at 4 p.m. indicated that at 7 a.m. that morning the air parcel had been in an area approximately 10 miles west of Sacramento. Another back trajectory beginning at 4 p.m. in Fairfield indicated the air parcel had come from the western part of the Broader Sac. Finally, a back trajectory beginning at 4 p.m. at Bethel Island indicated the air parcel had come from Sacramento. These back trajectories support the case that transport from the Broader Sac to the SFBAAB occurred on June 2, 1987.

The surface winds were of sufficient strength to transport ozone and ozone precursor emissions from the Broader Sac to the SFBAAB. These emissions then contributed to a progression in the time of maximum ozone concentrations. For example, maximum ozone concentrations occurred at 2 p.m. in the Broader Sac at Sacramento-Meadowview, between 1-5 p.m. at Pittsburg, between 3-4 p.m. at Fairfield, and between 4-5 p.m. at Concord and Bethel Island.

Based on these data, the staff concluded that the contribution of ozone and ozone precursor emissions from the Broader Sac to exceedances of the state standard at Pittsburg in the northeast SFBAAB on June 2, 1987, was significant.

8. District Comments.

The Bay Area Air Quality Management District (BAAQMD) submitted a letter (See Attachment B) on April 30, 1990, to the ARB commenting on the documents distributed at the staff's public workshop on April 17, 1990. Below is the BAAQMD comment related to the transport contribution of the Broader Sac to the SFBAAB and ARB's response to the BAAQMD comments.

BAAQMD Comment: "Extensive sets of meteorological data and air quality data, surface and aloft, were collected during the 1989 field studies in the Bay Area and in Sacramento. Was any of this information reviewed or evaluated for its potential to improve the transport assessment analysis?"

Staff Response: Meteorological and air quality data collected during field studies in 1989 were not considered in this assessment of transport from the Broader Sac to the SFBAAB. The staff did not consider 1989 data in this transport assessment because the ozone air quality data had not been thoroughly reviewed and validated at the time the analysis began. The transport assessment was designed to examine in detail several days on which there were ozone standard exceedances. This analysis was based on air quality data collected during 1986 through 1988. Data from 1989 will be included in the next round of transport assessments which will occur by 1993.

The staff believes that data for 1989 would not change the current assessment. The staff was able to identify significant and inconsequential impacts on air quality in the SFBAAB by emissions in the Broader Sac for selected days in the 1986-1988 period. Data for 1989 could not negate findings for the days studied. However, the staff also acknowledges the potential for additional data to support a finding for overwhelming. The on-going assessment work will review more recent data to determine if changes to the recommended findings would be appropriate.

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1. Smith, T. B., Lehrman, D. E., Knuth, W. R., and D. L. Blumenthal, 1985: *Climatological, Meteotological, and Dispersion Study of Regional and Selected Local Environments of Northern California, Vol. I: Technical Report*. Rep. STI-90034-24, prepared for OptiMetrics, Inc. and U. S. Army Atmospheric Sciences Laboratory, White Sands Missile Range, 121 pp + 4 Appendices.

2. Holets, S. H., 1976: *A Case Study of High Ozone in the San Francisco Area*. Thesis, M. S., Dept. of Meteor., CSU-San Jose, 88 pp.

3. Letter from Milton Feldstein of the Bay Area Air Quality Management District to the Air Resources Board, December 4, 1989.

E. Broader Sacramento Area to Upper Sacramento Valley

1. Summary and Recommendation

The staff's analysis shows that transport from the Broader Sacramento Area (Broader Sac) to the Upper Sacramento Valley (Upper Sac) occurred on at least 57 of the 63 days when the ozone standard was exceeded during 1986 through 1988 in the Upper Sac. Emissions within the Upper Sac also had a significant impact on the exceedances there. In addition, the staff's analysis shows that for the remaining six days, three days had evidence of inconsequential transport from the Broader Sac and three days had insufficient evidence to determine whether transport had occurred from the Broader Sac.

The staff recommends that the Broader Sac's transport to the Upper Sac be classified as "Significant" on some days and "Inconsequential" on others. Because transport from the Broader Sac is "Significant" on some days, the districts within the Broader Sac must include in their 1991 plans, a requirement for the application of best available retrofit control technology to existing stationary sources. These districts must also include in their 1991 plans, a permitting program designed to achieve a no net increase in emissions of precursors of ozone from all new or modified stationary sources.

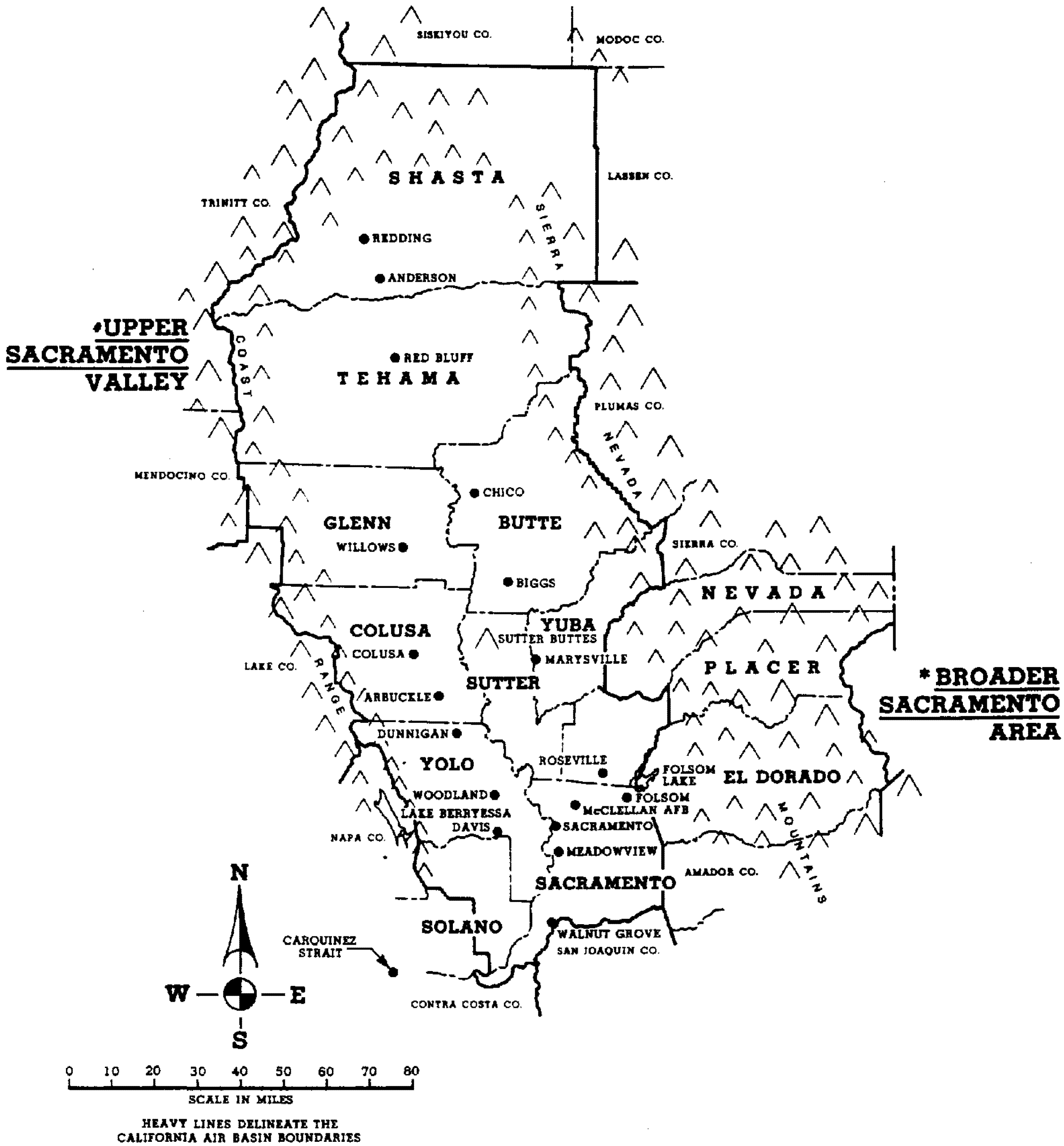
2. Conclusions

The staff believes that the contribution of the Broader Sac emissions to exceedances of the state standard for ozone ("state standard") in the Upper Sac is significant and inconsequential.

Limited resources precluded a thorough examination of the 57 transport days. Instead the staff selected for further analysis a subset of 25 exceedance days. Twelve of the 25 days were the days with the highest ozone concentrations in the Upper Sac. To increase the potential for finding a day with inconsequential transport, the staff selected the 13 days when transport from the Broader Sac to the Upper Sac was least likely, based on a review of air flow patterns. The staff's review of the 25 days showed several days of inconsequential transport although the detailed assessment focussed on only one day. The remaining days were significant.

In the detailed assessment of a subset of days, the staff found evidence that the transport of emissions from the Broader Sac was the cause for an exceedance at Arbuckle. However, the staff believes that any assessment of transport contribution from the Broader Sac to the Upper Sac based on the data only for Arbuckle would be inappropriate. The proximity of Arbuckle to the boundary of Broader Sac and Upper Sac makes the transport analysis based only on data for Arbuckle unrepresentative of the Broader Sac transport contribution to the Upper Sac.

Figure 13
TRANSPORT COUPLE
BROADER SACRAMENTO AREA to UPPER SACRAMENTO VALLEY



\# "Upper Sacramento Valley" is a five-county area encompassing Colusa, Butte, Glenn, Tehama, and Shasta County Air Pollution Control Districts.

* "Broader Sacramento Area" includes Nevada County, Sacramento Metropolitan Air Quality Management District, Yolo-Solano Air Pollution Control District, and the Sutter, Yuba, El Dorado, and Placer County Air Pollution Control Districts.

3. Geographic Setting

The Upper Sac is located in the central and northern portion of the Sacramento Valley and represents a subsection of the Sacramento Valley Air Basin ("SVAB"). The Upper Sac includes Butte, Colusa, Glenn, Shasta, and Tehama Counties. The Broader Sac comprises the southern portion of the Sacramento Valley and a portion of the western slope of the Sierra Nevada. The Broader Sac includes all of Nevada, Sacramento, Sutter, Yolo, and Yuba Counties and portions of El Dorado, Placer, and Solano Counties. A map of the two areas is provided in Figure 13.

The dominant features influencing air flow and potential transport from the Broader Sac to the Upper Sac are the Coast Range, the Sierra Nevada, and the Sacramento Valley. Both the Coast Range and Sierra Nevada are oriented northwest to southeast. The Coast Range forms the western boundary of the Upper Sac and the Broader Sac. Except in the area of the Carquinez Strait, the Coast Range provides an effective barrier to marine air from the west. The Carquinez Strait, located southwest of the Sacramento Valley, provides a gap in the Coast Range through which cool marine air routinely flows into the Sacramento Valley. This air flow is driven by the prevailing northwest winds from the Pacific Ocean and by the low air pressure formed as the valley air is heated by the sun-warmed ground, especially in summer. This flow of marine air frequently results in transport from the Broader Sac to the Upper Sac. On the eastern side of the Sacramento Valley, the Sierra Nevada rise gradually from the valley floor.

The Sacramento Valley is a long, broad, flat area with no significant geographic features to impede air flow from the Broader Sac to the Upper Sac. In the northern portion of the Sacramento Valley, the terrain rises to a plateau which forms another outlet for valley air. The most notable geographic feature in the Sacramento Valley is the Sutter Buttes, located near the boundary of the Broader Sac and the Upper Sac. However, the Sutter Buttes have little impact on air flow because of their limited size relative to the width of the valley.

4. Summary of Previous Transport Studies

Several research groups have studied the transport of ozone and ozone precursors in the Sacramento Valley. The studies most important to this analysis are summarized here. Bell and Waggoner[1] studied the 1960 fall agricultural burn season and measured oxidant, soiling index, hydrocarbons, and visibility. They concluded that metropolitan Sacramento, Roseville, and Woodland were the most significant sources of oxidant, hydrocarbons, and particulate matter in the Broader Sac. Furthermore, they concluded that on the days studied, ozone exceedances were related "entirely to these urban sources."

In another study, H. B. Schultz[2] studied wind patterns in the Sacramento Valley. Schultz analyzed winds above the surface up to 2000 feet at the Walnut Grove TV tower and the Sutter Buttes and up to

3000 feet at several pibal balloon launch sites. These winds were above the influence of the terrain. Schultz found the speed of the winds at about 500 feet above the ground could be as high as 20 to 30 mph when the surface wind speeds were only 5 to 10 mph. The presence of strong upper air winds indicates pollutants could be carried aloft long distances at times when surface conditions do not indicate such transport.

Schultz also described a unique, localized wind pattern in the lower portion of the Sacramento Valley. This wind pattern has since been termed the "Schultz Eddy." The "Schultz Eddy" flows to the east-northeast in a counter-clockwise direction from Davis to Sacramento where it curves to the north-northwest from Sacramento to Dunnigan, and then curves to the south-southeast from Dunnigan to Woodland and Davis. During the summer, the "Schultz Eddy" frequently begins around sunrise and continues until about noon. The "Schultz Eddy" is an important mechanism for transporting ozone and ozone precursors to the west side of the Sacramento Valley from the Sacramento metropolitan area ("Sac metro area"). The term Sac metro area is used here to refer to the contiguous urbanized area around the City of Sacramento and extends from West Sacramento to Folsom and from Elk Grove to Rocklin.

The staff also has studied ozone concentrations downwind of the Sac metro area[3]. The time period of the study included July and August 1978. The results indicated evidence of transport from the Sac metro area to Willows and Chico in the Upper Sac.

In yet another study, Lehrman et al.[4] studied ozone concentrations, air flow (via tracer releases), and the upper air during August 1980. Lehrman confirmed that the "Schultz Eddy" often transported ozone and ozone precursors from the Sac metro area to Colusa and Arbuckle in the Upper Sac and then back southward and eastward to Sacramento. Lehrman also demonstrated that pollutants from the Sac metro area can be transported far into the Upper Sac. He found tracer material released at Sacramento between 6 a.m. and 11 a.m. present at Marysville and Colusa between 1 to 2 p.m., at Willows between 3 to 6 p.m., and at Redding between midnight and daybreak. Lehrman also found evidence of tracer material lingering in the Sacramento Valley overnight at heights up to 2500 feet. This suggests that pollutants could be mixed down to the surface the next day as the air heats up and mixing takes place.

Giorgis[5] also studied the potential for transport in the Sacramento area. His study indicated there was a contribution from emission sources within the Sacramento Valley to high ozone concentrations in the Sacramento Valley. Giorgis concluded that:

> "... the contribution to Sacramento Valley oxidant levels from Bay Area precursor emissions is secondary to contributions from sources in the Valley. ... high oxidant concentrations at most Sacramento Valley stations result from stagnation or transport from Sacramento."

The staff[6] prepared a brief description of a trajectory analysis which indicated the potential for transport from the North SJV to the Broader Sac.

5. Data

The staff's assessment of transport from the Broader Sac to the Upper Sac was based on data for 1986 through 1988 (the "study period"). Six ozone monitoring sites were operating in the Upper Sac during the study period: Arbuckle, Colusa, Willows, Chico, Anderson, and Redding. During the study period, the state standard was exceeded on 63 days and at all sites in the Upper Sac.

6. Emission Inventory

Emission inventory data were available as statewide totals and as totals by air basin or by county. While such emission totals provide only general information, they were useful for determining the relative difference in emissions between various areas. This information provided a general indication of the potential for the emissions in each area to contribute to ozone concentrations.

Ozone precursor emissions primarily consist of emissions of reactive organic gases (ROG) and nitrogen oxides (NOx). The 1987 emission inventory data indicate that ozone precursor emissions in the Broader Sac are 398 tons/day. This is close to twice the ozone precursor emissions for the Upper Sac--209 tons/day.

The staff did not make a quantitative determination of the relative contribution of the emissions in the Upper Sac versus the contribution of the emissions in the Upper Sac to the ozone exceedances in the Broader Sac. The staff could not make a quantitative determination because the emission data are not resolved spatially or temporally and air quality models were not available for these areas. The staff made a qualitative conclusion, however, that emissions in each area were capable of generating ozone concentrations that exceed the state standard.

7. Transport Assessment

The staff completed two types of assessments to characterize the potential for transport of pollutants and precursors from the Broader Sac to the Upper Sac: a meteorological assessment and an air quality assessment. Both assessments were based on data for the subset of 25 days described previously.

a. Analysis Considerations

1. Meteorological Data

Emissions and meteorology determine ozone concentrations. Because emissions are relatively constant from day to day, most of the daily variation in ozone concentrations can be attributed to variations in meteorology. An assessment of meteorological conditions therefore is important to understanding the nature and perhaps source or cause of high ozone concentrations.

Surface Winds. Surface wind speeds and directions were evaluated to determine the strength of the air flow from the Broader Sac to the Upper Sac. Particular attention was given to surface wind data for Marysville, Chico, and Sacramento (McClellan Air Force Base). The Sacramento wind data were used to confirm the Broader Sac as an upwind contributor and to characterize the speed and persistence of the air flow from the Broader Sac to the Upper Sac.

Winds Aloft. Upper air wind data (winds aloft) for the Broader Sac and Upper Sac were available from Davis for several days during the study period. The staff also used winds aloft data collected by the National Weather Service in Oakland. To supplement this winds aloft data, the staff calculated air pressure gradients. The air pressure gradient data for this study were based on the difference in sea level air pressure between Oakland, Sacramento, and Stockton. The air pressure gradients provide a general indication of the direction and strength of air flow between the Broader Sac and the and Upper Sac.

Trajectory Analysis. The staff used trajectory analysis to describe the route that an air parcel would take over a specified time period. The analysis can be started at a site in the downwind area and run backwards in time (back trajectory) to determine the origin of the air parcel. Alternatively, a trajectory analysis can begin at a site in the upwind area and run forward in time (forward trajectory) to determine the destination of the air parcel. Both back and forward trajectories were used in this analysis to track the movement of air parcels.

2. Air Quality Data

Various ozone air quality parameters for sites in the Upper Sac and the Broader Sac were reviewed to assess the nature and potential causes of the high ozone concentrations in the Upper Sac.

Geographic Extent of Ozone Standard Exceedances. The size and shape of the area(s) where exceedances of the state standard occurred provide some information about the source of the ozone and precursors contributing to the exceedances. Exceedances occurring only in portions of the Upper Sac separated from a potential upwind emission area by an area of low ozone concentration suggest such exceedances were caused by "local" emissions. However, exceedances occurring in contiguous portions of the Broader Sac and the Upper Sac indicate there may have been transport from the Broader Sac to the Upper Sac.

Time of Daily Maximum Ozone Concentration. Maximum ozone concentrations resulting from "local" emissions typically occur around solar noon but can range between 11 a.m. and 2 p.m. If maximum concentrations occur before 11 a.m., they are usually caused by the mixing down of the ozone trapped aloft from the previous day. However, winds aloft data would be needed to confirm the source of this ozone. Maximum concentrations occurring late in the afternoon or during the early evening are usually caused by the transport of a polluted air mass into the area.

b. Analysis Results

The staff identified two categories of transport contribution from the Broader Sac to the Upper Sac: "Inconsequential" and "Significant." The following discussions of the meteorological and air quality assessments will focus on the two days listed as examples for "Inconsequential" and "Significant."

Inconsequential -- October 3, 1987
Significant -- June 24-26, 1987

1. Inconsequential

The staff determined that there was an inconsequential contribution by the Broader Sac to the Upper Sac if there was evidence of no or very little transport of ozone or ozone precursors from the Broader Sac to the sites in the Upper Sac which exceeded the state standard for ozone. Most cases of inconsequential transport occurred at Redding or Anderson. An example of an inconsequential transport day is October 3, 1987 at Anderson and Redding.

a. Meteorological Assessment

Forward and back surface wind trajectories for October 3, 1987, and the two previous days indicated that the air mass in the Anderson and Redding areas at the time of the ozone exceedance did not pass over the Broader Sac. Surface wind data for Marysville indicated north winds on October 2 and 3, 1987. Air flow calculated from pressure gradient data also indicated north winds from the morning of October 1, 1987, through October 3, 1987.

The available meteorological data support a finding that transport from the Broader Sac was inconsequential to the ozone exceedances at Anderson and Redding on October 3, 1987.

b. Air Quality Assessment

A maximum ozone concentration of 10 pphm occurred at noon on October 3, 1987, in both Anderson and Redding. Ozone concentrations generated from emissions in the local area generally would be expected to be highest around solar noon. Maximum ozone concentrations at all sites in the Upper Sac south of Shasta County were below 9 pphm. In the Broader Sac, the Sacramento-Meadowview site showed the highest ozone concentration in this area on October 3, 1987 (11 pphm). The occurrence of the highest concentration at a site in the southern portion of the Broader Sac is atypical and suggests that emissions from the Broader Sac drifted to the south rather than toward the Upper Sac on this day. The air quality data support a finding that transport from the Broader Sac had an inconsequential contribution to the ozone exceedances at Anderson and Redding on October 3, 1987.

2. Significant

The example with significant contribution of transport from the Broader Sac to the Upper Sac is June 24-26, 1987. The staff first identified the geographic extent of the exceedance area in order to determine whether the exceedances were the result of local or transported pollutants. The maximum ozone concentrations in the Upper Sac on June 24, 1987, were below the state standard. However, maximum ozone concentrations exceeded the state standard at several air monitoring stations in the Broader Sac as indicated in Table 12. On June 25, exceedances spread into the lower Upper Sac and spread yet further throughout the Broader Sac area. The following day, June 26, 1987, saw Broader Sac maximum ozone concentrations begin to decrease but Upper Sac concentrations continued to rise. By the end of the following day (June 27, 1987), the only exceedance in the two areas was at Anderson in the Upper Sac. The time lag of one day between a large number of exceedances in the Broader Sac on June 24 and 25 and Upper Sac on June 25 and 26 suggests that for this example, the time of transport of ozone and ozone precursors from Broader Sac to the Upper Sac could be at least one day.

The staff also examined surface wind data in order to determine if the winds were from a direction conducive to transport.

Winds would have to persist from the south for at least one day over an area from at least Sacramento to Willows. The winds would have to continue from the south the following day from at least Willows to Redding to support transport from Broader Sac to locations exceeding the standard in the Upper Sac. Winds measured at McClellan AFB were predominantly light (1-5 mph) and from the south for the period June 24 through 27. Winds measured at the Willows air monitoring station were light and predominantly from the north from June 24 through noon of June 25 then predominantly from the south until the evening of June 27. Winds at Chico were moderate (5-10 mph) from the south the morning through late afternoon on June 24, while on June 25 and 26 winds were moderate from the south only during the afternoon hours. Redding winds exhibited more of a diurnal pattern for each day of the period with moderate winds from the northwest from midnight through early afternoon, then reversing to south from early afternoon to late evening for June 24-26, 1987. Therefore, surface winds were conducive to transport from Broader Sac to the Upper Sac with transport northward within the Broader Sac beginning on June 24 and extending into the Upper Sac on the afternoon of June 25 through June 26.

Table 12

Daily Maximum Ozone Concentrations
for Air Monitoring Stations in the
Upper Sac Valley and Broader Sac Area
(parts per hundred million)

Air Monitoring Station	Date			
	6-24-87	6-25-87	6-26-87	6-27-87
Upper Sac Valley				
Redding	7	9	13	M
Anderson	6	8	10	10
Chico	7	9	10	9
Willows	8	10	10	8
Colusa	7	9	10	8
Arbuckle	7	10	11	9
Broader Sac Area				
Yuba City	8	10	11	8
North Highlands	9	12	11	7
Sacramento-Del Paso	12	12	10	6
Sacramento-Meadowview	10	14	7	6
Citrus Heights	12	12	12	7
Folsom	9	12	11	7
Rocklin	8	9	10	6
Auburn	8	11	12	8
Broderick	7	9	7	6
Woodland	9	13	10	9
Vacaville	8	10	7	5

M = Missing

On June 24, 1987, the Sacramento Valley air flow types at 4 a.m., 10 a.m., and 4 p.m. consisted of Upslope, Mid Valley Divergence, and Full Sea Breeze, respectively. On June 25, 1987, the air flow types consisted of Lower Valley Convergence, North winds, and Full Sea Breeze for 4 a.m., 10 a.m., and 4 p.m., respectively. On June 26 and June 27, 1987, the air flow type consisted of the Full Sea Breeze for all three hours. The air flow for June 24-25, 1987, indicate that the air in the Sacramento Valley was 'sloshing' north and south until by the afternoon of June 25, 1987, a full sea breeze began to push pollutants northward from Broader Sac into the Upper Sac. The full sea breeze on June 26, 1987, continued to push pollutants farther into the Upper Sac.

Light south winds throughout the morning of June 25, 1987, at McClellan AFB followed by an afternoon Sacramento Valley wide sea breeze pushed ozone and ozone precursors northward from Broader Sac. With this transport northward, maximum ozone concentrations on June 25 occurred between 2-5 p.m. at Arbuckle and at 11 a.m. at Willows. The earlier peak at Willows could have been the result of either transport or fumigation of pollutants to the surface from pollution layers aloft. The sea breeze continued throughout the Sacramento Valley and on June 26, 1987, transported pollutants northward, resulting in exceedances occurring at Arbuckle at 1-3 p.m., Colusa at 3-5 p.m., and Willows and Chico at 5 p.m. Exceedances at Anderson occurred at 11 a.m. to 2 p.m. and then Redding at 1 p.m. on June 26, 1987. The times (11 a.m. at Anderson and 1 p.m. at Redding) for the peak concentrations at these two locations suggest a combination of transport and local photochemistry as the causes of the high ozone concentrations. Ozone concentrations in the Upper Sac continued to be elevated on June 27, 1987. However, only the air monitoring station at Anderson recorded an exceedance.

Several back trajectories were constructed with one set originating from Chico, one set from Anderson, one set from Redding, and one set from 20 miles east-southeast of Redding. Each trajectory was begun at 12 p.m. or 2 p.m. for June 26, 1987, in order to determine the origin of the emissions in the air that contributed to maximum ozone concentrations. The back trajectory analysis for Chico was run for 12 hours and indicated that air arriving at the time of the Chico ozone maximum hour came from near Arbuckle. The back trajectory analysis for Anderson was run for 12 hours and indicated that air arriving at the time of the Anderson maximum hour came from near Chico. The back trajectory analysis for Redding was run for 36 hours and indicated that air arriving at Redding at 2 p.m. (1 p.m. hour of maximum ozone concentration) came from eight miles southwest of Chico.

The one day trajectories suggest that air parcels arriving in the Upper Sac at the time of the exceedance did not originate in the Broader Sac. However, late afternoon winds at McClellan AFB, Willows, and Chico on June 25, 1987, were persistently from the south and indicated that ozone and ozone precursors could be transported in two days into the southern and northern sections of the Upper Sac from Broader Sac.

Based on these data, the staff concluded that the contribution of emissions from the Broader Sac and Upper Sac to exceedances of the state standard in the Upper Sac for the period June 24-26, 1987, was significant.

8. District Comments

The staff received written comments in a April 26, 1990, letter from the Stanislaus County Air Pollution Control District (SCAPCD) (See Attachment B) and written comments in a May 18, 1990, letter from the Northern Sierra Air Quality Management District (NSAQMD) (See Attachment B). The staff also received additional comments from the Yolo, Yuba, Sutter, Placer, and El Dorado County Air Pollution Control Districts (APCD) during telephone conversations with the staff of each district. A summary of the comments and the staff response are provided below.

a. All Districts Comments

Comment: The Sacramento Metropolitan Area should be separated from the rural portions of the Broader Sacramento Area.

Staff Response: The staff did not assess the characteristics of transport within any identified upwind area of a transport couple. The Broader Sacramento Area was identified and the boundaries set at the Board meeting in December 1989. The Transport Assessment was limited in scope to assessing relative transport between areas identified by the Board in December, 1989. However, the California Clean Air Act requires that "The state board shall review and update its transport analysis at least once every three years." (Section 39610, Health and Safety Code.) By 1993, the staff will review the identification of transport couples and the assessment of the transport contribution.

b. NSAQMD Comments

Comment: "I am concerned that an obvious transport couple has, for whatever reason, been omitted from the list of areas needing additional research. I suggest that an eleventh couple be identified - the upper Mountain Counties, consisting of the upper portions of El Dorado, Placer, and all of Nevada County. These areas do not share the topography, population, industrial and motor vehicle inventory characteristics of the Sacramento Valley. ... they are the quintessential receptor areas."

Staff Response: See response to comment in subsection a. above.

Comment: "We are requesting ... That the Air Resources Board meets its assessment responsibilities by providing an ozone monitor for the Nevada City monitoring site for 1990."

Staff Response: The issue of setting up permanent monitors is outside the scope of the Transport Assessment. However, the staff has forwarded the NSAQMD's letter to the Monitoring and Laboratory staff and will work to ensure the AQMD's concerns are reflected in future monitoring priorities.

c. Yuba County APCD Comments

Comment: Yuba County has never violated the state standard for ozone when there was a north component to the prevailing wind direction. Also, the Schultz eddy does not impact or pass through Yuba County, but stays south of the Sutter Buttes.

Staff Response: See response to comment in subsection a. above.

Comment: The district needs more time for the proper political responses for growth management. Also, the district feels that "moderate" severity is appropriate for them.

Staff Response: This comment addresses issues beyond the scope of Transport Assessment. Such issues are properly addressed in the process for developing plans and implementing measures for attaining the standards.

d. Sutter County APCD Comments

Comment: There should be a study of the impact of the Sacramento Metropolitan Area on Sutter and Yuba counties.

Staff Response: A study of transport in the Sacramento Valley is currently underway. The results of this study will be incorporated into the transport assessment that will be done by 1993. The staff's response to the first comment above is also pertinent here.

e. Placer County APCD Comments

Comment: Why was the relative contribution of transport not assessed?

Staff Response: The staff could not provide for quantitative assessments of transport because of the limited data, limited resources, and the absence of modeling tools for the area. The staff could only provide a qualitative description of the transport impact.

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F. Broader Sacramento Area to San Joaquin Valley

1. Summary and Recommendation

The staff's analysis shows that transport from the Broader Sacramento Area (Broader Sac) to the northern San Joaquin Valley (North SJV) occurred on at least 9 of the 165 days during 1986 through 1988 when the state standard for ozone was exceeded in the North SJV. It also appears that emissions within the North SJV had a significant impact on these nine exceedances. In addition, the staff's analysis shows that there was at least one day during 1986 through 1988 when transport from the Broader Sac to the North SJV was inconsequential.

The staff recommends that transport from the Broader Sac to the North SJV be classified as "Significant" on some days and "Inconsequential" on other days. Because transport from the Broader Sac is "Significant" on some days, the districts in the Broader Sac must include in their 1991 plans, a requirement for the application of best available retrofit control technology to existing stationary sources. These districts must also include in their 1991 plans, a permitting program designed to achieve a no net increase in emissions of precursors of ozone from all new or modified stationary sources.

2. Conclusions

The staff believes that the contribution of the Broader Sac emissions to exceedances of the state standard for ozone ("state standard") in the North SJV is both significant and inconsequential.

The staff's conclusions are based on a review of meteorological and air quality data for the 165 days during 1986 through 1988 when the state standard for ozone was exceeded in the North SJV. Analysis of surface wind data indicated evidence of airflow from the San Francisco Bay Area (SFBAAB) to the Broader Sac on 150 days. The staff analyzed data for evidence of transport from Broader Sac to the SJV for the remaining 15 days. The staff found evidence of inconsequential transport from the Broader Sac to the North SJV on at least one of the days, significant transport on up to nine days, and air flow from the SFBAAB to the SJV on the remaining five days.

3. Geographic Setting

The San Joaquin Valley Air Basin (SJVAB) includes Kings, Fresno, Madera, Merced, San Joaquin, Stanislaus, and Tulare Counties and part of Kern County. While the SJVAB contains all or part of eight counties, the staff's assessment focussed only on the two counties in the northern part of the SJVAB: San Joaquin County and Stanislaus County. In the following discussion, these counties are referred to as the North SJV. The staff restricted its assessment to the North SJV because transport to this area is sufficient to demonstrate transport to the air basin. Furthermore, the North SJV has the greatest potential for receiving transport from the

Broader Sac. The Broader Sac comprises the southern part of the Sacramento Valley and a part of the western slope of the Sierra Nevada. The Broader Sac includes Nevada, Sacramento, Sutter, Yolo, and Yuba Counties and parts of El Dorado, Placer, and Solano Counties. A map of the two areas is provided in Figure 14.

The San Joaquin Valley and Sacramento Valley together form a continuous, broad, flat valley with no significant geographic features to impede air flow from the Broader Sac to the North SJV. Other geographic features influencing air flow and potential transport from the Broader Sac to the North SJV are the Coast Range to the west and the Sierra Nevada to the east. Both ranges have a northwest to southeast orientation. The Sacramento-San Joaquin River Delta ("delta region") comprises the southwestern part of the Broader Sac and the northwestern part of the North SJV. The Carquinez Strait provides a gap in the Coast Range through which cool marine air routinely flows into the Sacramento and San Joaquin Valleys. Air flow through the Carquinez Strait is driven by the prevailing northwest winds from the Pacific Ocean and by the low air pressure formed as the valley air is heated by the sun-warmed ground, especially in summer. This flow of marine air through the Carquinez Strait tends to overwhelm transport from the Broader Sac to the North SJV.

However, transport from the Broader Sac to the North SJV does occur. Winds from the north through northeast can flow from the Broader Sac into the North SJV while effectively blocking air flow from the San Francisco Bay Area. These north through northeast winds usually result from high pressure systems that follow storms which pass through northern California during the fall through spring months.

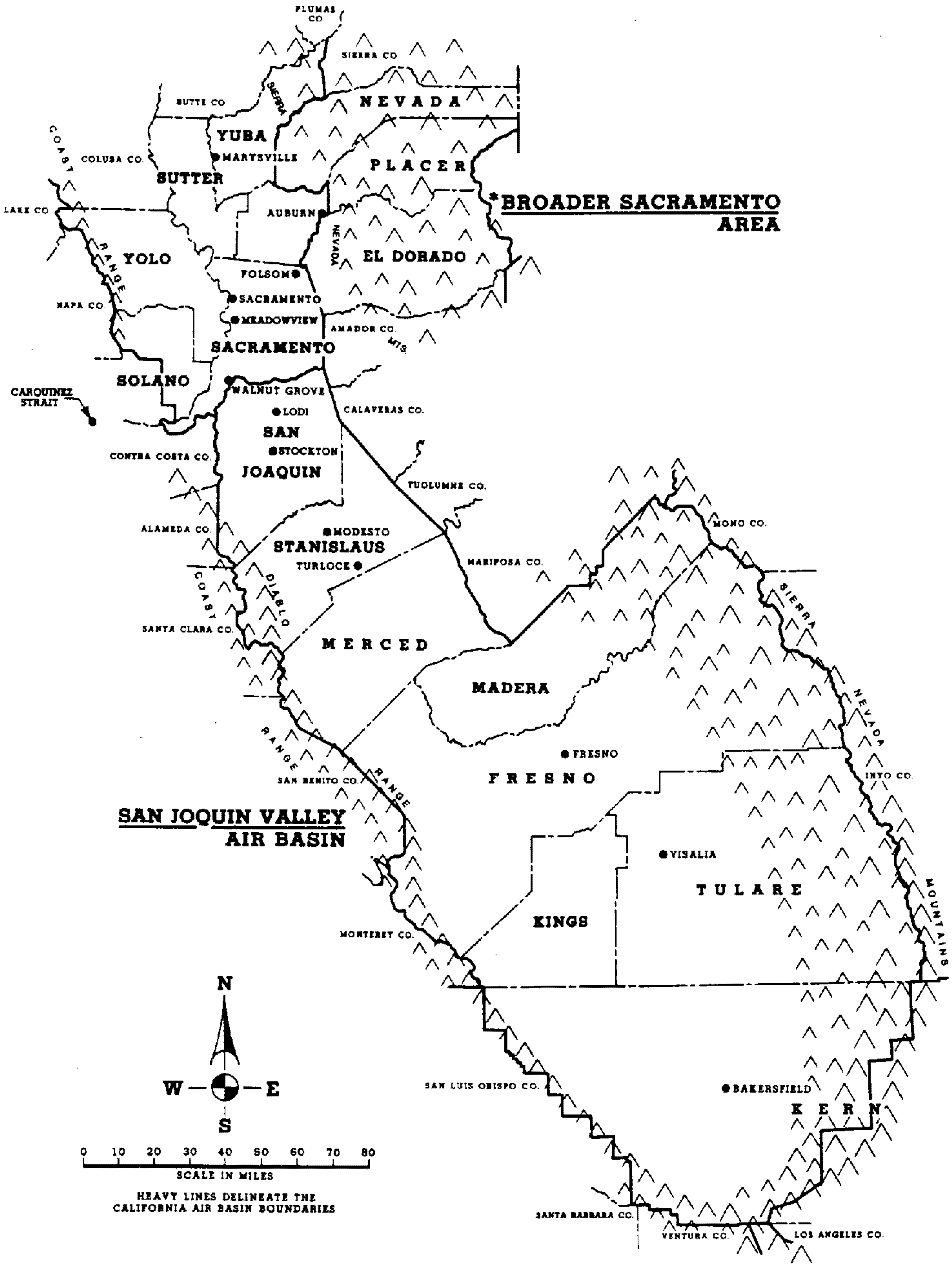
4. Summary of Previous Transport Studies

Several groups have studied ozone and ozone precursor transport in the Broader Sac, North SJV, and the SFBAAB over the last 30 years. These studies focussed on the air movement from the SFBAAB to either the Sacramento Valley or the San Joaquin Valley, rather than on air movement between the Sacramento and San Joaquin Valleys. Only two studies contained references to transport from the Broader Sac to the SJV. First, Fosberg and Schroeder[1] in their discussion of marine air penetration published an air flow chart for August 15, 1962, which demonstrated transport from the Broader Sac to the North SJV. Second, the ARB[2] prepared a brief description and chart of a trajectory analysis which indicated potential transport from the Broader Sac into the San Joaquin Valley on June 1, 1987. The value of the remaining studies to the assessment of transport from the Broader Sac to the SJV is limited to general or theoretical discussions.

5. Data

The staff's assessment of transport was based on data for 1986 through 1988 ("study period"). The state standard for ozone was exceeded in North SJV on 165 days during the study period. Ozone was monitored at

Figure 14
TRANSPORT COUPLE
BROADER SACRAMENTO AREA to SAN JOAQUIN VALLEY



* "Broader Sacramento Area" includes Nevada County, Sacramento Metropolitan Air Quality Management District, Yolo-Solano Air Pollution Control District, and the Sutter, Yuba, El Dorado, and Placer County Air Pollution Control Districts.

14 sites in the Broader Sac. All five sites in San Joaquin and Stanislaus Counties--Stockton-Hazelton, Stockton-Mariposa, Crows Landing, Modesto, and Turlock--had exceedances of the state standard.

6. Emission Inventory

Emission inventory data were available as statewide totals and as totals by air basin or by county. While such emission totals provide only general information, they were useful for determining the relative difference in emissions between various areas. This information provided a general indication of the potential for each area to contribute to ozone concentrations.

Ozone precursor emissions primarily consist of emissions of reactive organic gases (ROG) and nitrogen oxides (NOx). The 1987 emission inventory data indicate that ozone precursor emissions in the Broader Sac are 398 tons/day. This is almost twice the ozone precursor emissions for the North SJV--214 tons/day.

The staff did not make a quantitative determination of the relative contribution of the emissions in the Broader Sac versus the contribution of the emissions in the North SJV to the ozone exceedances in the North SJV. The staff could not make a quantitative determination because the emission data are not resolved spatially or temporally and air quality models were not available for these areas. The staff made a qualitative conclusion, however, that emissions in each area were capable of generating ozone concentrations that exceed the state standard.

7. Transport Assessment

a. Analysis Considerations

The staff completed two types of assessments to characterize the potential for transport of pollutants and precursors from the Broader Sac to the North SJV: a meteorological assessment and an air quality assessment. Both assessment focussed on data for the 15 ozone exceedance days mentioned previously.

1. Meteorological Data

Ambient ozone concentrations near the surface of the earth are primarily a function of emissions and meteorology. Because emissions are relatively constant from day to day, most of the daily variation in ozone concentrations can be attributed to variations in meteorology. Therefore, an assessment of meteorological conditions is an important step to understanding the nature and perhaps the source or cause of high ozone concentrations. The following meteorological conditions were considered in the assessment.

Surface Winds. The staff reviewed surface wind speeds and directions to determine the strength of the air flow from the Broader Sac to the North SJV. In the Broader Sac and North SJV, there were 9 airports and 16 air quality monitoring sites that measured winds during the study period. Hourly data for winds at airports are based on one brief observation. Air quality monitoring sites report the average wind over the previous hour; the average wind is preferred for assessing transport. In addition, the wind data from Travis AFB and Livermore airport were used to identify the days when there was air flow from the SFBAAB to the Broader Sac.

Winds Aloft. Upper air wind data (winds aloft) for the Broader Sac and North SJV were available from Davis and Fresno for several days during the study period. The staff also used winds aloft data collected in Oakland by the National Weather Service. The staff also calculated air pressure gradients to supplement the winds aloft data. The air pressure gradient data for this study were based on the difference in sea level air pressure among Oakland, Sacramento, and Stockton and provide a general indication of the direction of air flow between the SFBAAB, the Broader Sac, and the North SJV.

Trajectory Analysis. The staff used trajectory analysis to compute the route an air parcel followed over a specified time period. The analysis can be started at a site in the downwind area and run backwards in time (a back trajectory) to determine the path the air parcel and the locations of potential ozone and ozone precursor sources. Alternatively, a trajectory analysis can begin at a site in the upwind area and run forward in time (forward trajectory) to determine the path of the air parcel from a known or suspected source to (potentially) impacted areas downwind. Both back and forward trajectories were used in this analysis to track the movement of air parcels.

2. Air Quality Data

The staff reviewed various ozone air quality parameters for sites in the North SJV and the Broader Sac to assess the nature and potential causes of the high ozone concentrations in the North SJV.

Geographic Extent of Ozone Standard Exceedances. The size and shape of the area(s) with measurements exceeding the state standard for ozone provide information about the source of the ozone and precursors contributing to the exceedances. Exceedances occurring only in parts of the North SJV separated from a potential upwind emission area by an area of low ozone concentration suggest such exceedances were caused by "local" emissions. However, exceedances that occurred in contiguous parts of the Broader Sac and the North SJV indicate there may have been transport from the Broader Sac to the North SJV.

Time of Daily Maximum Ozone Concentration. Maximum ozone concentrations resulting from "local" emissions typically occur around solar noon but can range between 11 a.m. and 2 p.m. Maximum concentrations occurring in the morning before 11 a.m. may be the result of fumigation of ozone trapped aloft from the previous day, and depending on airflow aloft, could be from sources within or outside of the area being assessed. Maximum concentrations occurring late in the afternoon or during the early evening may result from the transport of ozone into the area.

b. Analysis Results

The staff identified two categories of impact from transport from the Broader Sac to the North SJV: "Inconsequential" and "Significant." The following discussions of the meteorological and air quality assessments for each of the two categories focus on examples of specific days:

Inconsequential -- June 2, 1987, and
Significant -- October 5, 1987.

1. Inconsequential

The staff determined there was an inconsequential contribution from emissions in the Broader Sac to ozone exceedances in the North SJV if the evidence indicated no or very little transport of emissions from the Broader Sac or other upwind areas into the North SJV. An example of an inconsequential transport day is June 2, 1987.

a. Meteorological Assessment

Streamline analysis of surface wind data indicated that on June 1, 1987, the day prior to the case study day, transport from the SFBAAB to the North SJV was blocked by north winds from the Sacramento Valley. The north winds were strong for the most of the day but then declined abruptly to calm at 9 p.m. For example, winds in Stockton were 18 miles per hour (mph) at 9 a.m., 20 mph with gusts up to 28 mph in Sacramento at 2 p.m., and calm in Sacramento at 9 p.m. The high winds on June 1 suggest that any emissions from the Broader Sac would have been well diluted upon arrival in the North SJV. Because transport from the SFBAAB would preclude a finding of transport only from the North SJV to the Broader Sac, the staff ensured there was no evidence of transport from the SFBAAB into the North SJV on June 1-2, 1987.

On June 2, 1987, the winds at Sacramento and Stockton were calm until 8 a.m. and then varied between 3 to 8 mph for the remainder of the day. The lack of early morning winds and modest wind speeds during the remainder of the day indicate little potential for transport from the Broader Sac by the time of the exceedance in Stockton.

Back trajectory analyses of surface winds indicated that the air mass in the Stockton area at the time the maximum ozone concentration was recorded on June 2, 1987, had been in Lodi shortly after midnight the night before. The trajectory analysis suggests that the exceedances in the North SJV on June 2, 1987, did not include a contribution of ozone or ozone precursors from the Broader Sac or from the SFBAAB.

b. Air Quality Assessment

On June 1, 1987, maximum ozone concentrations were below 10 pphm throughout the Broader Sac, the north SFBAAB, and the North SJV. For example, on June 1, the maximum ozone concentration was 7 pphm at Sacramento-Meadowview and 8 pphm at Stockton-Mariposa. On June 2, maximum ozone concentrations of 12 pphm occurred at 3 p.m. at both Stockton and Turlock. On June 2, Turlock first exceeded the state standard at 11 a.m. and the peak showed a gradual rise and decline similar to the peaks expected on days when transport is inconsequential. Also, Turlock was separated from the exceedances in Stockton and the Broader Sac by the lower ozone concentration (9 pphm) at Modesto. As mentioned earlier, the separation of exceedance at Turlock from the Broader Sac by relatively clean air suggests that emissions from the Broader Sac had an inconsequential impact on the exceedance at Turlock.

2. Significant

The staff would determine there was a significant contribution to exceedances in the North SJV if there was evidence of transport from the Broader Sac into the North SJV and evidence of a contribution from emission sources in the North SJV. Additionally, there must be evidence that ozone transport from the SFBAAB did not interfere with the assessment. An example of a significant transport day occurred October 5, 1987.

a. Meteorological Assessment

Streamline analysis of surface winds for October 4-5, 1987, indicated that north winds prevailed on both days. Wind speeds were about 6 mph at several wind reporting sites which were sufficient for transport, but not so strong that the ozone or ozone precursors originating in the Broader Sac were diluted before reaching the North SJV. Winds aloft (500 feet) data measured at Chico at 5 a.m. on October 5 indicated that the winds aloft were also from the north at about 7 mph. The consistent north winds at the surface and aloft throughout the Broader Sac and North SJV on October 4-5 indicates potential transport from the Broader Sac to the North SJV. Because transport from the SFBAAB would preclude a finding of transport only from the North SJV to the Broader Sac, the staff ensured there was no evidence of transport from the SFBAAB into the North SJV on October 4-5, 1987.

b. Air Quality Assessment

Both Stockton-Mariposa and Turlock had ozone peaks of 12 pphm at 1 p.m. Both ozone monitoring sites are south of the largest population centers in the North SJV and downwind on October 5. The time of the maximum ozone concentrations and the locations of monitors downwind of local emission sources suggest a local contribution to the measured exceedances.

The staff made a finding of significant transport based on the transport contribution indicated in the meteorological assessment and the local contribution indicated in the air quality assessment.

8. District Comments

The staff received written comments in an April 26, 1990, letter from the Stanislaus County Air Pollution Control District (SCAPCD) (See Attachment B) and written comments in a May 18, 1990, letter from the Northern Sierra Air Quality Management District (NSAQMD) (See Attachment B). The staff also received additional comments from the Yolo, Yuba, Sutter, Placer, and El Dorado County Air Pollution Control Districts (APCD) through telephone conversations with the staff of each district. A summary of the comments and the staff response are provided below.

a. All Districts Comment

Comment: The Sacramento Metropolitan Area should be separated from the rural portions of the Broader Sacramento Area.

Staff Response: The staff did not assess the characteristics of transport within any identified upwind area of a transport couple. The Broader Sacramento Area was identified and the boundaries set at the Board meeting in December 1989. The transport assessment was limited in scope to assessing relative transport between areas identified by the Board in December, 1989. However, the California Clean Air Act requires that "The state board shall review and update its transport analysis at least once every three years." (Section 39610, Health and Safety Code.) By 1993, the staff will review the identification of transport couples and the assessment of the transport contribution.

b. NSAQMD Comments

Comment: "I am concerned that an obvious transport couple has, for whatever reason, been omitted from the list of areas needing additional research. I suggest that an eleventh couple be identified - the upper Mountain Counties, consisting of the upper portions of El Dorado, Placer, and all of Nevada County. These areas do not share the topography, population, industrial and motor vehicle inventory characteristics of the Sacramento Valley. ... they are the quintessential receptor areas."

Staff Response: Same as staff response in a.

Comment: "We are requesting ... That the Air Resources Board meets its assessment responsibilities by providing an ozone monitor for the Nevada City monitoring site for 1990."

Staff Response: The issue of setting up permanent monitors is outside the scope of the transport assessment. However, the staff has forwarded the AQMD's letter to the Monitoring and Laboratory staff and will work to ensure the AQMD's concerns are reflected in future monitoring priorities.

c. Yuba County APCD Comments

Comment: Yuba County has never violated the state standard for ozone when there was a north component to the prevailing wind direction. Also, the Schultz eddy does not impact or pass through Yuba County, but stays south of the Sutter Buttes.

Staff Response: Same as staff response in b.

Comment: The district needs more time for the proper political responses for growth management. Also, the district feels that "moderate" severity is appropriate for them.

Staff Response: This comment addresses issues beyond the scope of transport assessment. Such issues are properly addressed in the process for developing plans and implementing measures for attaining the standards.

d. Sutter County APCD Comment

Comment: There should be a study of the impact of the Sacramento Metropolitan Area on Sutter and Yuba counties.

Staff Response: A study of transport in the Sacramento Valley is currently underway. The results of this study will be incorporated into the transport assessment that will be done by 1993. The staff's response to the first comment above is also pertinent here.

e. Placer County APCD Comment

Comment: Why was not the relative contribution of transport assessed?

Staff Response: The staff could not provide for quantitative assessments of transport because of the limited data, limited resources, and the absence of modeling tools for the area. The staff could only provide a qualitative description of the transport impact.

f. Stanislaus County APCD Comments

Comment: "Using the data from only one day to justify some of these qualitative transport rankings distorts impact that one area may have on another. The impact of transport from the SF Bay Area on the San Joaquin Valley appears to be accorded the same status as the impact of transport from the Greater Sacramento Area on the San Joaquin Valley."

Staff Response: The transport assessment findings now include a brief discussion of the number of days found to be in the various categories of days that staff reviewed.

Comment: "We also believe the San Joaquin Valley Air Quality Study has already developed useful information that should be considered in determining these Transport Assessment Findings."

Staff Response: Meteorological and air quality data collected during field studies in 1989 were not considered in this assessment of transport from the North SJV to the Broader Sac. The staff did not consider 1989 data in this transport assessment because the ozone air quality data had not been thoroughly reviewed and validated at the time the analysis began. The transport assessment was designed to examine in detail several days on which there were ozone standard exceedances. This analysis was based on air quality data collected during 1986 through 1988. Data from 1989 will be included in the next round of transport assessments which will occur by 1993.

REFERENCES

1. Fosberg, M. A., and M. J. Schroeder, 1966: *Marine Air Penetration in Central California. J. Appl. Meteor.*, 5, 573-589.

2. Air Resources Board, 1989: *Proposed Identification of Districts Affected by Transported Air Pollutants which Contribute to Violations of the State Ambient Air Quality Standard for Ozone.* Staff Rep., ARB/Meteorology Section (principle author), October 1989, 57 pp. + 4 Appendices.

G. San Joaquin Valley to Broader Sacramento Area

1. Summary and Recommendation

The staff's analysis shows that transport from the northern San Joaquin Valley (North SJV) to the Broader Sacramento Area (Broader Sac) occurred on at least one of the 251 days during 1986 through 1988 when the state standard for ozone was exceeded in the Broader Sac. Emissions within the Broader Sac also had a significant impact on the exceedances there. In addition, the staff's analysis shows that on the days with the highest ozone concentrations in the Broader Sac during 1986 to 1988, the transport from the North SJV was inconsequential.

The staff recommends that transport from the Broader Sac to the North SJV be classified as "Significant" on some days and "Inconsequential" on other days. Because transport from the Broader Sac is "Significant" on some days, the districts in the Broader Sac must include in their 1991 plans, a requirement for the application of best available retrofit control technology to existing stationary sources. These districts must also include in their 1991 plans, a permitting program designed to achieve a no net increase in emissions of precursors of ozone from all new or modified stationary sources.

2. Conclusions

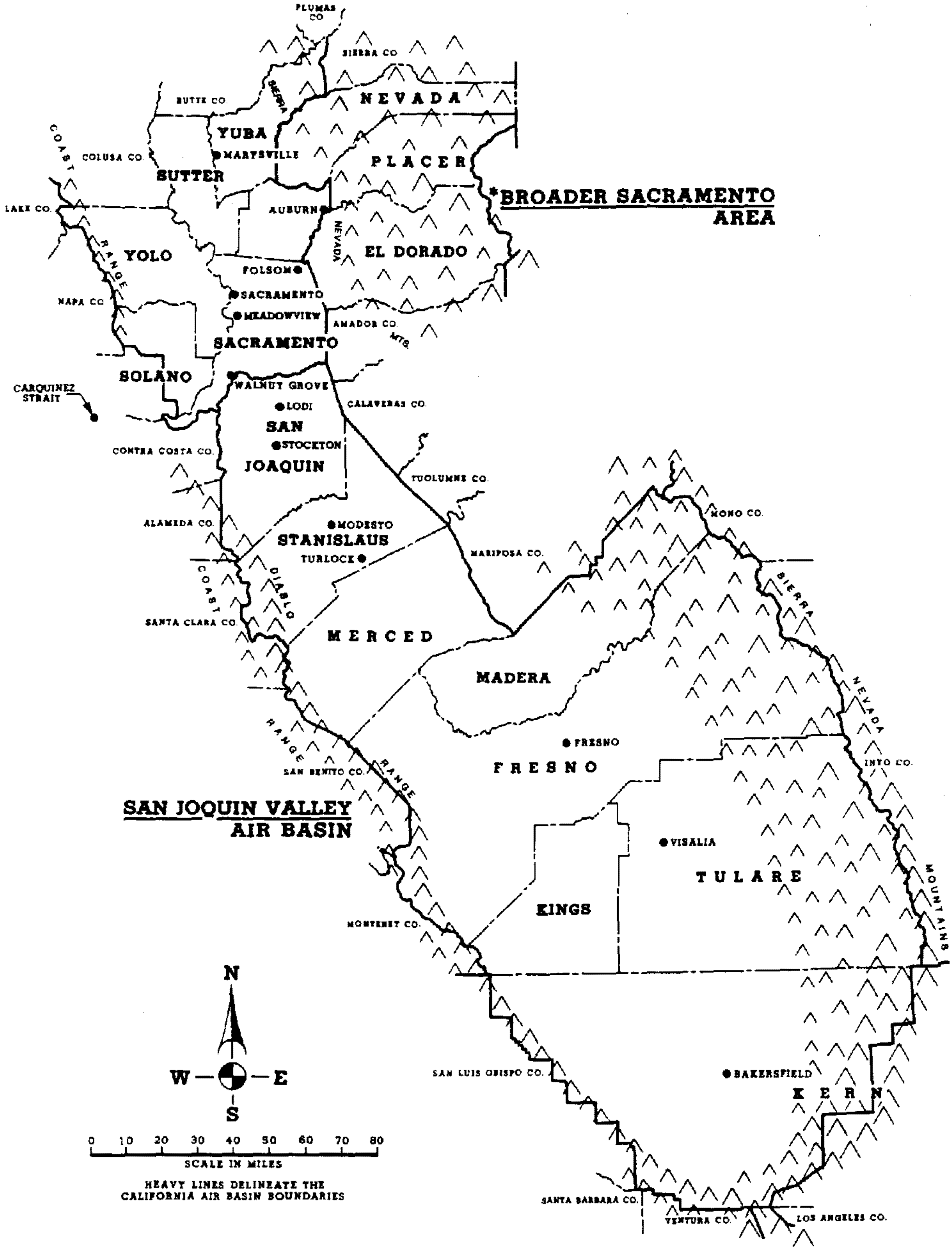
The staff believes that the contribution of the the SJVAB emissions to exceedances of the state standard for ozone ("state standard") in the Broader Sac is both significant and inconsequential.

The staff's conclusions are based on a review of meteorological and air quality data for the 251 days during 1986 through 1988 when the state standard for ozone was exceeded in the Broader Sac. Analysis of surface wind data indicated evidence of airflow from the San Francisco Bay Area Air Basin (SFBAAB) to the Broader Sac on 218 of the 251 days. Therefore, the staff analyzed in greater detail the data for the remaining 33 days to ensure the assessment focussed on days with a potential for transport from only the SJVAB to the Broader Sac. The staff found evidence of significant transport from the SJVAB to the Broader Sac on one day and inconsequential transport on 14 days. For the remaining 18 days, the detailed analysis indicated air flow from the SFBAAB to the Broader Sac. The 18 days were then removed from further evaluation for transport contribution from the SJVAB to the Broader Sac.

3. Geographic Setting

The Broader Sac comprises the southern portion of the Sacramento Valley and a portion of the western slope of the Sierra Nevada. The Broader Sac includes Nevada, Sacramento, Sutter, Yolo, and Yuba Counties and portions of El Dorado, Placer, and Solano Counties. The San Joaquin Valley Air Basin (SJVAB) comprises Kings, Fresno, Madera, Merced, San Joaquin, Stanislaus, and Tulare Counties and a portion of Kern County. A map of the two areas is provided in Figure 15. While the SJVAB contains

Figure 15
TRANSPORT COUPLE
SAN JOAQUIN VALLEY to BROADER SACRAMENTO AREA



* "Broader Sacramento Area" includes Nevada County, Sacramento Metropolitan Air Quality Management District, Yolo-Solano Air Pollution Control District, and the Sutter, Yuba, El Dorado, and Placer County Air Pollution Control Districts.

all or part of eight counties, the staff's assessment focussed only on the two counties in the northern portion of the SJVAB: San Joaquin County and Stanislaus County. In the following discussion, these counties are referred to as the northern San Joaquin Valley ("North SJV"). The staff restricted its assessment to the North SJV because this area suffices to demonstrate transport from the air basin. Furthermore, the North SJV provides the greatest potential for transport to the Broader Sac.

The Sacramento Valley and San Joaquin Valley together form a continuous, broad, flat valley with no significant geographic features to impede air flow from the North SJV to the Broader Sac. Other geographic features influencing air flow and potential transport from the North SJV to the Broader Sac are the Coast Range to the west and Sierra Nevada to the east. Both ranges have a northwest to southeast orientation. The Sacramento-San Joaquin River Delta ("delta region") comprises the southwestern portion of the Broader Sac and the northwestern portion of the North SJV. The Carquinez Strait provides a gap in the Coast Range through which cool marine air routinely flows into the Sacramento and San Joaquin Valleys. Air flow through the Carquinez Strait is driven by the prevailing northwest winds from the Pacific Ocean and by the low air pressure formed as the valley air is heated by the sun-warmed ground, especially in summer. This flow of marine air through the Carquinez Strait usually overwhelms transport from the North SJV to the Broader Sac.

However, transport from the North SJV to the Broader Sac does occur. Winds from the south through southeast can flow from the San Joaquin Valley into the Broader Sac while effectively blocking air flow from the San Francisco Bay Area. These south through southwest winds usually occur as storms approach northern California during the fall through spring months. Consequently, this type of airflow did not influence air quality during the peak ozone season.

4. Summary of Previous Transport Studies

Several groups have studied ozone and ozone precursor transport in the Broader Sac and San Joaquin Valley, but they emphasized transport from the SFBAAB to the Broader Sac. The staff reviewed previous studies but found only one with a description of transport from the North SJV to the Broader Sac. In that study, the ARB[1] prepared a brief description of a trajectory analysis which indicated the potential for transport from the North SJV to the Broader Sac. The value of the remaining studies to the assessment of transport from the SJVAB to the Broader Sac is limited to general or theoretical discussions.

5. Data

The staff's assessment of transport from the North SJVAB to the Broader Sac was based on data available for 1986 through 1988 ("study period"). The state standard was exceeded in the Broader Sac on 251 days during the study period. During the study period, 14 ozone monitoring sites were operating in the Broader Sac and 5 sites in the North SJV. Exceedances were recorded at all 14 sites in the Broader Sac.

6. Emission Inventory

Emission inventory data were available as statewide totals and as totals by air basin or by county. While such emission totals provide only general information, they were useful for determining the relative difference in emissions between various areas. This information provided a general indication of the potential for the emissions in each area to contribute to ozone concentrations.

Ozone precursor emissions consist primarily of emissions of reactive organic gases (ROG) and nitrogen oxides (NOx). The 1987 emission inventory data indicate that ozone precursor emissions in the SJVAB are 1289 tons/day. This is more than three times the ozone precursor emissions for the Broader Sac--398 tons/day. However, ozone precursor emissions for the two counties in the North SJV are only 214 tons/day. The staff made a qualitative conclusion that emissions in each area were capable of generating ozone concentrations that exceed the state standard.

The staff did not make a quantitative determination of the relative contribution of the emissions in the North SJV versus the contribution of the emissions in the Broader Sac to the ozone exceedances in the Broader Sac. The staff could not make a quantitative determination because the emission data are not resolved spatially or temporally and air quality models were not available for these areas.

7. Transport Assessment

a. Analysis Considerations

The staff completed two types of assessments to characterize the potential for transport of pollutants and precursors from the North SJV to the Broader Sac: a meteorological assessment and an air quality assessment. Both assessments focussed on data for the 33 ozone exceedance days mentioned previously.

1. Meteorological Data

Ambient ozone concentrations near the surface of the earth are primarily a function of emissions and meteorology. Because emissions are relatively constant from day to day, most of the daily variation in ozone concentrations can be attributed to variations in meteorology. Therefore, an assessment of meteorological conditions is an important step to understanding the nature and perhaps the source or cause of high ozone concentrations. The following meteorological conditions were considered in the assessment.

Surface Winds. The staff reviewed surface wind speeds and directions to determine the persistence and strength of the air flow from the North SJV to the Broader Sac. In the Broader Sac and North SJV, there were about 9 airports and 16 air quality monitoring sites that measured winds during the study period. Airports report winds that are observed for a few minutes. Air quality monitoring sites report the average wind over the previous hour; the average wind is preferred for assessing transport. In addition, the wind data from Travis AFB and Livermore airport were used to identify the days when there was air flow from the SFBAAB to the Broader Sac.

Winds Aloft. Upper air wind data (winds aloft) for the Broader Sac and North SJV were available for several days during the study period at Davis and Fresno. The staff also used winds aloft data collected in Oakland by the National Weather Service. The staff also calculated air pressure gradients to supplement the winds aloft data. The air pressure gradient data for this study were based on the difference in sea level air pressure between Oakland, Sacramento, and Stockton and provide a general indication of the direction of air flow between the SFBAAB, the Broader Sac, and the North SJV.

Trajectory Analysis. The staff used trajectory analyses to compute the route an air parcel would take over a specified time period. The analysis can be started at a site in the downwind area and run backwards in time (a back trajectory) to determine the path of the air parcel and the locations of potential ozone and ozone precursor sources. Alternatively, a trajectory analysis can begin at a site in the upwind area and run forward in time (forward trajectory) to determine the path of the air parcel from a known or suspected source to (potentially) impacted areas downwind. Both back and forward trajectories were used in this analysis to track the movement of air parcels.

2. Air Quality Data

The staff reviewed various ozone air quality parameters for sites in the Broader Sac and the North SJV to assess the nature and potential causes of the high ozone concentrations in the Broader Sac.

Geographic Extent of Ozone Standard Exceedances. The size and shape of the area(s) where exceedances of the state standard occurred provide some information about the source of the ozone and precursors contributing to the exceedances. Exceedances occurring only in portions of the Broader Sac separated from a potential upwind emission area by an area of low ozone concentration suggest such exceedances were caused by "local" emissions. However, if exceedances occurred in contiguous portions of the North SJV and the Broader Sac, this indicates there may have been transport from the North SJV to the Broader Sac.

Time of Daily Maximum Ozone Concentration. Maximum ozone concentrations resulting from "local" emissions typically occur around solar noon but can range between 11 a.m. and 2 p.m. Maximum concentrations occurring in the morning before 11 a.m. may be the result of fumigation of ozone trapped aloft from the previous day, and depending on airflow aloft these could be from sources within or outside of the area being assessed. Maximum concentrations occurring late in the afternoon or the early evening may result from the transport of ozone into the area.

b. Analysis Results

The staff identified two categories of impact from transport from the North SJV to the Broader Sac: "Inconsequential" and "Significant." The following discussions of the meteorological and air quality assessments for each of the two categories focus on examples of specific days:

Inconsequential -- June 2, 1987, and
Significant -- October 16, 1988.

1. Inconsequential

The staff determined that there was an inconsequential contribution by the North SJV to ozone exceedances in the Broader Sac if the evidence indicated no or very little ozone or ozone precursors transported from the North SJV or other ozone precursor source areas into the Broader Sac. An example of an inconsequential transport day is June 2, 1987.

a. Meteorological Assessment

Streamline analysis of surface winds indicated that on June 1, 1987, air flow from the SFBAAB was blocked by north winds from the Sacramento Valley. These north winds also moved air from the Broader Sac into the San Joaquin Valley. Winds became calm the same evening but resumed at a slower speed on June 2, 1987. Back trajectory analyses of surface winds indicated that air at the Sacramento-Meadowview monitoring site at the time the maximum ozone concentration was recorded passed over southern Sutter County the night before and continued to move southward through June 2, 1987. Therefore, the trajectory analysis suggests that the exceedances in the Broader Sac did not include a contribution of ozone or ozone precursors from the North SJV or from the SFBAAB.

In addition, the winds aloft data for Oakland show that air flow at the 3000 foot level was from the northeast on June 1 and 2. Like the surface winds, the winds aloft decreased from June 1 to June 2 and were light on the afternoon of June 2, 1987. The winds aloft data for Oakland suggest that the winds aloft in the Broader Sac and North SJV were similar to the surface winds described in the preceding paragraph. Therefore, the winds aloft data, like the surface wind data, suggests that the exceedances in the Broader Sac did not include a contribution of ozone or ozone precursors from the North SJV or from the SFBAAB.

b. Air Quality Assessment

On June 1, 1987, maximum ozone concentrations throughout the Broader Sac, the north SFBAAB, and the North SJV were below 10 pphm. In the Broader Sac, the maximum concentration was 7 pphm at several monitoring sites.

On June 2, 1987, maximum concentrations of 11 pphm occurred at Folsom and Sacramento-Meadowview. Ozone concentrations above the state standard occurred from 11 a.m. to 4 p.m. at Folsom and from noon through 3 p.m. at Sacramento-Meadowview. In the north portion of the Broader Sac, the standard was exceeded (10 pphm) for one hour at 4 p.m. at North Highlands. The short duration of the exceedance in the north portion of the Broader Sac and the longer duration of the exceedance on the south side is consistent with a pattern of air flow from north to south. North to south air flow indicates that transport from either the North SJV or the SFBAAB is inconsequential.

2. Significant

The staff found a significant contribution by the North SJV to exceedances in the Broader Sac if there was evidence of transport from the North SJV into the Broader Sac accompanied by a contribution from emission sources in the Broader Sac. An example of a day with significant transport is October 16, 1988.

a. Meteorological Assessment

Streamline analyses of surface winds indicate that emissions from the SFBAAB did not influence the air quality in the Sacramento and San Joaquin Valleys on October 15-16, 1988. The data indicate that at 4 a.m. on October 15, air flow from the SFBAAB had penetrated the Sacramento and San Joaquin Valleys as far as approximately Davis in Yolo County and Bethel Island in Contra Costa County only. The northwest air flow through the Sacramento and San Joaquin Valleys during the afternoon of October 14 had also given way by 4 a.m. on October 15 to light drainage winds flowing from the Coast Range, the Sierra Nevada, and the San Joaquin Valley. Winds were from the southeast at 1-3 miles per hour (mph) between Stockton and Sacramento. By 10 a.m., winds on the west side of the Broader Sac and the North SJV began to blow from the northwest at 5 to 8 mph. At 4 p.m., winds were from the northeast at 5 mph in the Sacramento Valley portion of the Broader Sac, but winds in the North SJV were essentially calm.

By 4 a.m. on October 16, light drainage winds from the south-southeast were again evident in the North SJV. Winds were calm in Sacramento County and in the Sacramento-San Joaquin River delta. By 10 a.m., the south-southeast winds in the North SJV had increased to 5 mph. South winds at about 5 mph also had developed in Sacramento County and continued until at least 4 p.m. In the North SJV, however, the air flow reversed from the south-southeast to the north-northwest at 5 mph. There was no evidence of air flow from the SFBAAB into the Sacramento or San Joaquin Valley, nor did the Oakland sounding indicate the presence of a marine layer.

Winds aloft on the morning of October 16 were essentially from the north at up to 15 mph above Oakland and up to 12 mph above Chico. Winds from the surface to 3500 feet above Fresno were from the southeast at up to 7 mph. Although one wind measurement per day does not allow an assessment of the persistence of the winds aloft, the winds aloft data at

Fresno suggests that there could have been an air flow aloft from the North SJV to the east portion of Sacramento County even during the times when surface winds were calm or from the north. For example, on October 15, 1988, the 4 a.m. surface wind at Fresno was calm, but winds aloft were from the southeast at 10 mph or more.

The meteorological data indicate no transport from the SFBAAB on October 16, 1988, and no influence on air quality in the Sacramento and Stockton areas on October 15. The surface wind data for Sacramento and Stockton suggest that emissions in the Stockton area were carried to the Broader Sac. The data for winds aloft at Fresno also indicated possible transport aloft from the North SJV to the Broader Sac.

b. Air Quality Assessment

Maximum ozone concentrations were below the state standard throughout the Broader Sac, the north SFBAAB, and the North SJV during the five days prior to October 16, 1988. With relatively clean air throughout the Central Valley during the preceeding five days, any significant transport was likely limited to October 16. Ozone concentrations at many sites increased about 3 pphm from October 15 to October 16. The maximum concentration in the Broader Sac was 12 pphm and occurred at 2 and 3 p.m. at Sacramento-Del Paso Manor and at 3 p.m. at Folsom. Concentrations at Del Paso Manor already exceeded the state standard at 11 a.m. Consistent with the south winds at Sacramento, the time of maximum concentrations exhibited a progression across town to the north-northeast. Ozone concentrations at Sacramento-Meadowview on the south side of the urban area peaked at 9 pphm and remained at that level for five hours beginning at noon. Maximum concentrations throughout the Broader Sac were quite uniform, a typical pattern when ozone concentrations are the result of both local and transported ozone precursor emissions.

The maximum ozone concentration in the North SJV was 10 pphm and occurred at both Stockton and Modesto. These concentrations are comparable to those at Meadowview, and when combined with the air flow from the south support a finding that ozone and ozone precursor emissions from the North SJV caused the air flowing into the Broader Sac to have an additional potential for high ozone concentrations. Therefore, the staff concluded that emissions in the San Joaquin Valley had a significant impact on the ozone concentrations in the Broader Sac and contributed to widespread exceedances of the state standard for ozone on October 16, 1988.

8. District Comments

The only written comments received from the North SJV counties were contained in a April 26, 1990, letter from the Stanislaus County Air Pollution Control District (SCAPCD) (See Attachment B). The staff also received additional comments from SCAPCD staff during a telephone conversation. A summary of the comments and the staff response are provided below.

SCAPCD Comment 1: "Using the data from only one day to justify some of these qualitative transport rankings distorts impact that one area may have on another. The impact of transport from the SF Bay Area on the San Joaquin Valley appears to be accorded the same status as the impact of transport from the Greater Sacramento Area on the San Joaquin Valley."

Response: The Transport Assessment Findings now include a brief discussion of the number of days found to be in the various categories of days that staff reviewed.

SCAPCD Comment 2: "We also believe the San Joaquin Valley Air Quality Study has already developed useful information that should be considered in determining these Transport Assessment Findings."

Response: Meteorological and air quality data collected during field studies in 1989 were not considered in this assessment of transport from the North SJV to the Broader Sac. The staff did not consider 1989 data in this transport assessment because the ozone air quality data had not been thoroughly reviewed and validated at the time the analysis began. The transport assessment was designed to examine in detail several days on which there were ozone standard exceedances. This analysis was based on air quality data collected during 1986 through 1988. Data from 1989 will be included in the next round of transport assessments which will occur by 1993.

REFERENCES

1. Air Resources Board, 1989: *Proposed Identification of Districts Affected by Transported Air Pollutants which Contribute to Violations of the State Ambient Air Quality Standard for Ozone*. Staff Rep., ARB/Meteorology Section (principle author), October 1989, 57 pp. + 4 Appendices.

H. San Joaquin Valley to Southeast Desert

1. Summary and Recommendations

The staff analysis shows that transport from the San Joaquin Valley Air Basin (SJVAB) caused the state ozone standard to be exceeded in the Southeast Desert Air Basin (SEDAB) on June 26, 1987. Further analysis shows that on April 29, 1989, local emissions caused an exceedance of the state ozone standard without any significant transport from the San Joaquin Valley.

The staff recommends that the San Joaquin Valley's transport be classified as "Overwhelming" on some days and "Inconsequential" on others. Since transport from the San Joaquin Valley is "Overwhelming" on some days, the staff recommends that the San Joaquin Valley be held accountable for developing a control strategy for attaining the state ozone standard for those types of days.

2. Conclusions

The staff believes that the contribution of San Joaquin Valley Air Basin emissions to exceedances of the state ozone standard (state standard) in the Southeast Desert Air Basin is both overwhelming and inconsequential. This conclusion is based on a review of past studies and a case study of a day representing overwhelming transport, June 26, 1987, and a day representing inconsequential transport, April 29, 1989.

The staff's analysis is based on data collected for past studies and on an analysis of the available air quality and meteorological data from 1986 through 1989. Transport from the SJVAB to the SEDAB is well documented in past transport studies. During the 1986-1989 period ozone exceedance days were measured in the SJVAB by monitoring networks operated by the ARB and the local APCDs.

The exceedances of the state ozone standard were also recorded in the SEDAB on some days when transport from the SJVAB to the SEDAB did not occur. ARB Meteorology Section wind flow type charts and other data were reviewed to select days for case study analysis. Wind flow types documented by the ARB staff show that surface winds favorable to transport from SJVAB to SEDAB occur 90 percent of the time during the summer months. Winds favorable to local days and inconsequential transport occur 3 percent of the time in the SJVAB and 11 percent of the time in the SCAB. Wind flow types are not routinely prepared for the SEDAB, thus, frequencies for wind flow types are not available to characterize SEDAB wind flow types at this time.

Figure 16
TRANSPORT COUPLE
SAN JOAQUIN VALLEY to SOUTHEAST DESERT

Two days were selected for case study analyses to demonstrate inconsequential and overwhelming transport impacts, April 29, 1989, and June 26, 1987. The analyses for April 29, 1989, demonstrating inconsequential transport, are presented in the South Coast Air Basin to SEDAB section of this report. The meteorological and air quality analyses which substantiate the staff recommendation for overwhelming transport are described below. Although only overwhelming and inconsequential transport were identified, the staff believes it is likely that significant transport also occurs.

3. Geographic Setting

The SJVAB includes all of San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings and Tulare counties, and the western portion of Kern county. The SEDAB includes all of Imperial County, Riverside County east of the San Bernardino Mountains, San Bernardino County east of the San Gabriel Mountains, Los Angeles County east of the San Gabriel Mountains, and Kern County east of the San Gabriel and Tehachapi Mountains. The SEDAB is bounded on the north by the basin ranges, on the northeast by the Nevada state line, on the east by the Arizona state line including the Colorado River, and on the south by the Mexican border. The basin is bounded on the east and south by desert.

Many small mountain ranges dot the SEDAB--more in the east than in the west--with elevations greater than 5,000 feet. However, the topography of the basin is generally flat and slopes from 2,500 feet in the west to below sea level in the east. Overall, the SEDAB encompasses all of the Mojave Desert of southeastern California. (see Figure 16).

The dominant features influencing air flow and potential transport from the SJVAB are the northwest to southeast aligned Coast Range, broad and flat Central Valley, and the Sierra Nevada Range bounding the Central Valley on the east. The Carquinez Strait links the San Francisco Bay to the delta region of the San Joaquin River in the Central Valley. The Carquinez Strait, a major gap in the Coast Range, routinely allows the influx of cool marine air from the ocean into the Central Valley. These winds from the northwest can flow over the San Joaquin Valley and exit through mountain passes and across lower portions of the mountain ranges that surround the west, south, and east sides of the SJVAB. Such northwest winds are the result of strong low pressure systems that develop in the Central Valley in summer and post frontal high pressure systems which pass through northern California in the spring and fall months. The strength of these systems dictates how strongly the northerly winds penetrate into the SEDAB. This penetration determines whether the northern portion of the SEDAB will receive air pollutants from the SJVAB.

4. Meteorological Assessment

After screening the data for ozone exceedance days for 1986 through 1989, the staff chose June 26, 1987, to analyze as a "transport" day. The screening showed that this is not an unusual day. Surface winds were very light in both basins on the morning of June 26. The wind increased in the San Joaquin Valley in the afternoon until outflow across the Tehachapi Pass into the SEDAB was steady from the northwest at 14 to 15 mph. This strong flow is consistent with transport from the SJVAB to the SEDAB.

The morning (5 a.m.) upper air winds at 3,000 to 4,000 feet above sea level (to allow flow over the Tehachapi Pass) were measured from Fresno and were from the northwest with speeds of 5 to 6 mph on June 25. There was a significant change on June 26 as winds increased to more than 20 mph from the northwest. This strong flow aloft continued through June 27, strongly supporting transport out of the SJVAB and into the SEDAB.

Transport times based on the velocity of winds at Tehachapi would, if calculated conservatively at 10 mph, bring air from about 260 miles upwind in the central SJVAB to the northern SEDAB within the 26 hours between the onset of northwest winds at Tehachapi and the 3 p.m. time of maximum ozone at Lancaster. If the stronger 20 mph winds over Fresno are used, air from anywhere in the SJVAB could have been transported into the SEDAB on June 26.

The morning 5 a.m. marine layer, determined from the Fresno aircraft temperature sounding, was nearly 1,500 feet thick on June 25, 1987. The thickness of this layer increased to 4,000 feet on the morning of June 26 and to nearly 6,000 feet by that afternoon. This thickness was enough to allow ozone and its precursors to move through the passes and over the lower portions of the Tehachapi Mountains into the SEDAB.

Daily maximum temperatures were high in both basins on June 26, the day leading into the transport--103 Fahrenheit degrees at Bakersfield, 94 at Tehachapi, and 101 at Lancaster. On the following two days, the temperatures continued to fall at all three locations--101 to 95 at Bakersfield, 87 to 85 at Tehachapi, and 96 to 89 at Lancaster--reflecting the cooler marine air moving through the SJVAB and into the SEDAB.

Trajectories calculated both forward from just south of Bakersfield (Fig: 17) and backward from Lancaster (Fig: 18) indicated that air parcels originated in the SJVAB and moved into the SEDAB near Lancaster.

The inconsequential transport day, April 29, 1989, is discussed in the South Coast Air Basin to Southeast Desert Air Basin section of this report.

5. Air Quality Assessment

The spatial distribution of ozone concentrations greater than the state ozone standard extended throughout the SJVAB and SEDAB on June 25 and 26, 1987 (see Table 13). The daily maximum ozone concentrations in the SJVAB were 16 to 18 pphm on June 25 and 26, respectively. The maximum ozone concentrations at Lancaster were 14 pphm on June 25 and 11 pphm on June 26. Although ozone concentrations at Lancaster declined, they remained above the state standard while transport from the SJVAB was impacting Lancaster.

6. Emission Inventory

Based on 1987 emission data the emissions of ozone precursors, reactive organic gases (ROG) plus nitrogen oxides (NOx), in the SJVAB of 1,288 tons/day are considerably greater than the 430 tons/day from the SEDAB. The Kern county portion of the SJVAB produces 639 tons/day while the SEDAB portion of Kern and Los Angeles counties account for only 100 ton/day combined.

7. District Comments SJVAB to SEDAB

Kern County APCD personnel expressed concern over the finding of overwhelming transport from the SJVAB to the SEDAB. They noted that there are stationary sources between the SJVAB and Lancaster which could contribute to the ozone exceedances and the transport should be classified as significant.

The ARB staff reviewed the emission inventory for the stationary sources in question and determined emissions are approximately 5 tons per day (based on 1987 data). When compared to total emissions in the SJVAB and in the Kern County portion of SJVAB, and considering that ozone concentrations throughout the SJVAB were greater than the state standard, the staff believes that this is insufficient evidence to classify the transport as significant.

Transport Couple
San Joaquin Valley to Southeast Desert

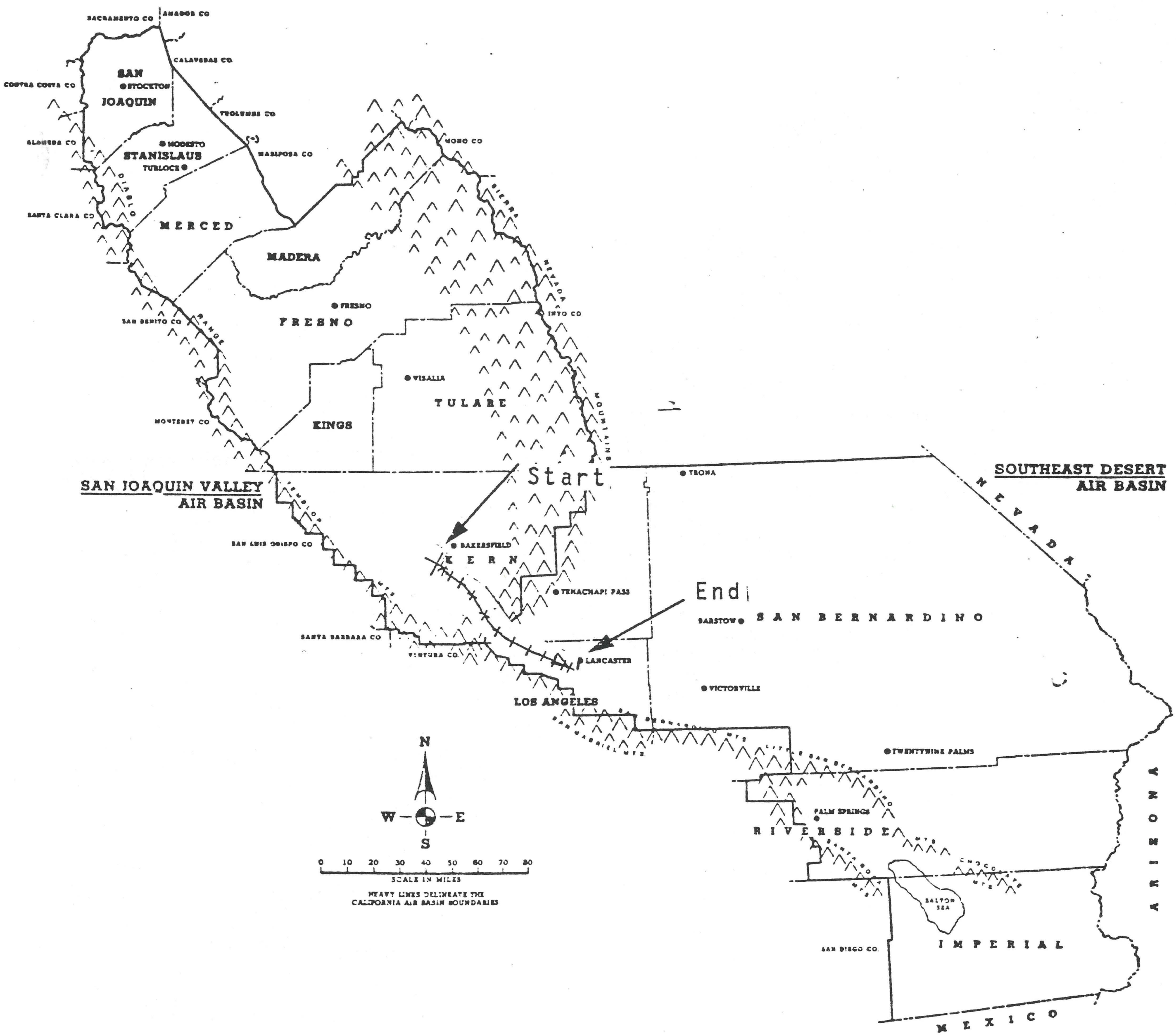


Figure 17: Trajectory constructed forward from just south of Bakersfield starting at 10 a.m. on June 26, 1987, Showing that air from near Bakersfield in the SJVAB moved across the Tehachapi mountains into the SEDAB near Lancaster. This independent forward trajectory gives the same results as the backward trajectory in figure WEW3.

Transport Couple
San Joaquin Valley to Southeast Desert

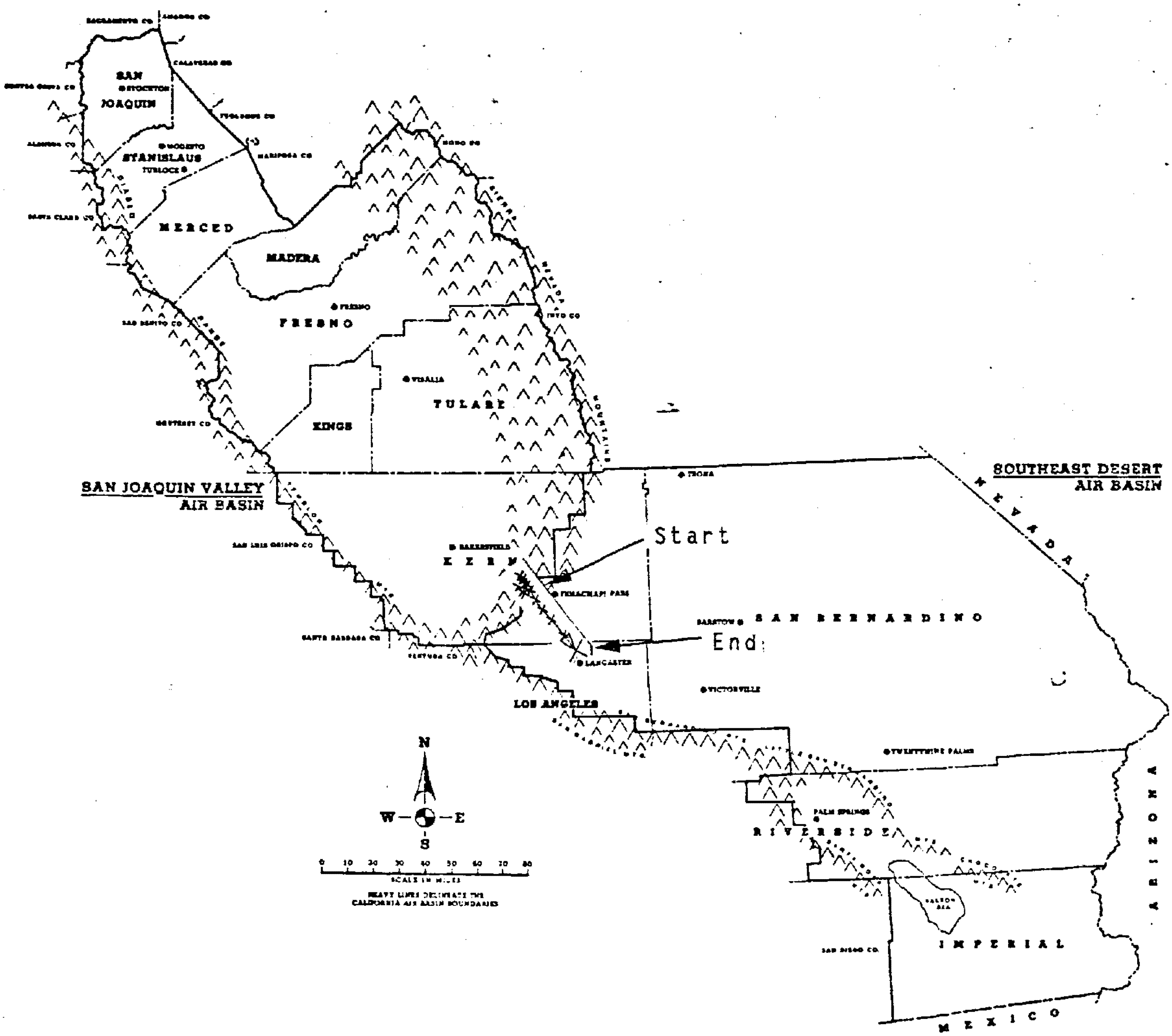


Figure 18: Trajectory constructed backward from near Lancaster starting at 3 p.m. on June 26, 1987, showing air arriving near Lancaster from a starting point near Tehachapi.

Table 13

Ozone Concentrations Measured in the SJVAB and the SEDAB

AREA	JUNE 25, 1987 Max Ozone (pphm)	Time	JUNE 26, 1987 Max Ozone (pphm)	Time
SAN JOAQUIN VALLEY				
Fresno County				
Fresno - Cal State #2	16	11 a.m.	17	12 p.m.
Fresno - Olive	12	10 a.m.	15	11-12 a.m.
Parlier	13	2 p.m.	18	4 p.m.
Kern County				
Bkrsfld - Chester St	12	12-3 p.m.	12	2-4 p.m.
Edison	14	12 p.m.	13	11-12 a.m.
McKittrick - Hwy 58&H	11	12-5 p.m.	12	4 p.m.
San Joaquin County				
Stockton - 13521 E Ma	10	12-3 p.m.	10	2 p.m.
Stanislaus County				
Modesto - 814 14th St	11	3 p.m.	12	1-2 p.m.
Turlock - Monte Vista	11	1-4 p.m.	14	3 p.m.
Tulare County				
Visalia - Church St	13	5 p.m.	18	5 p.m.
SOUTHEAST DESERT				
Los Angeles County				
Lancaster	14	6 p.m.	11	3 p.m.
Riverside County				
Banning - Allesandro	18	4 p.m.	19	3-4 p.m.
Palm Springs - Fire S	16	6 p.m.	17	4 p.m.
San Bernardino County				
Barstow	10	9 p.m.	9	11-12, 17-19
Hesperia - 17288 Oliv	14	7-8 p.m.	11	4-8 p.m.
Trona - Market St	10	10 a.m.	11	10-11 a.m.
Twentynine Palms - Ad	6	12 a.m.	7	10-12 a.m.
Victorville - Civic D	7	1-5, 10-11 p.m.	10	2-3, 9, 11 p.m.

I. South Coast to San Diego

1. Summary and Recommendations

A joint analysis by the staffs of the ARB and the San Diego Air Pollution Control District (SDAPCD) shows that transport from the South Coast Air Basin (SCAB) caused exceedances of the state ozone standard in the San Diego Air Basin (SDAB) on some days. The analysis also shows that on other days transport from the SCAB contributed to exceedances in the SDAB. In addition the analysis shows that some exceedances of the state ozone standard in San Diego are caused entirely by local emissions without any significant transport from the South Coast Air Basin.

The staff recommends that the South Coast's transport be classified as "Overwhelming" on some days, "Significant" on some other days and "Inconsequential" on others. Since transport from the South Coast is "Overwhelming" on some days, the staff recommends that the South Coast be held accountable for developing a control strategy for attaining the state ozone standard on those types of days.

2. Conclusions

The staff believes that the contribution of South Coast Air Basin emissions to exceedances of the state ozone standard (state standard) in the San Diego Air Basin is overwhelming, significant, and inconsequential. This conclusion is based on the staff's review and analysis of the work performed by the San Diego County Air Pollution County District.

The staff's analysis is based on work performed by the San Diego County Air Pollution Control District and on the ARB staff's review and interpretation of that analysis.

Off the coast of Southern California, the prevailing winds are from the northwest, blowing parallel to the coast along the SCAB and the SDAB. On a smaller scale, a land-sea breeze circulation set up by differential heating of land and water works to transport pollutants offshore at night and back on shore during the day. However, the pollutants transported offshore from the SCAB at night by the land breeze are caught up in the prevailing northwesterly flow offshore and are subsequently blown toward the coastal area of the SDAB. Santa Ana wind conditions (strong winds from the east in the SCAB) will occasionally transport significantly more pollution offshore than the nocturnal land breeze. During the day, the pollutants located off the coast of San Diego County are then brought onshore by the sea breeze, thereby causing violations of the state ozone standard or adding to local emissions to cause high concentrations of ozone.

For the past 10 years or more, the San Diego County Air Pollution Control District (SDCAPCD) has categorized all violations of the state ozone standard at each site as the result of either transport from outside the County or the result of emissions from within the County. These categories, "transport" or "local", are based on extensive data analyses performed by the district staff and summarized here.

The SDCAPCD analysis method includes plotting hourly surface maps of the Western United States with pressure, temperature, wind speed, and wind direction. From these plots, pressure patterns and wind streamlines are drawn. In addition, upper air data are analyzed to produce three dimensional flow fields up to an altitude of 18,000 feet. From the upper air data, a determination of the mixing height over the area is made. These analyses are then used to create backward trajectories for each ozone monitoring site starting from the time of the maximum ozone concentration. If the backward trajectory ends in the SCAB, then the day is categorized as transport. If the backward trajectory ends in the SDAB, the day is categorized as local.

3. Geographical Setting

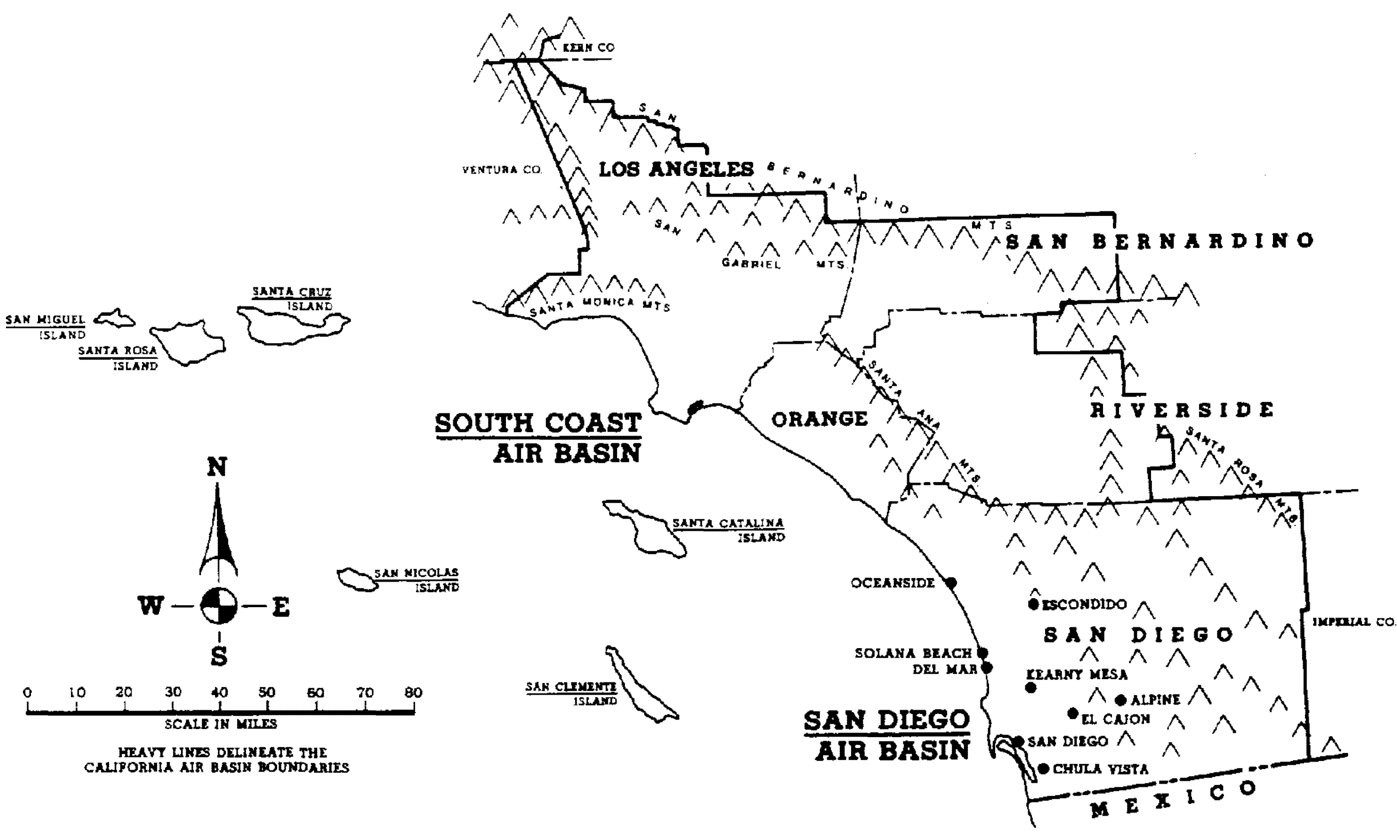
The SDAB consists of San Diego County. The SDAB is bounded on the north by the SCAB, on the east by the SEDAB, on the west by the Pacific Ocean, and on the south by the Mexican State of Baja Californiante. A map of the area is shown in Figure 19. The county is divided by the Laguna Mountain Range which runs approximately parallel to the coast about 45 miles inland and separates the coastal area from the desert portion of the county. The Laguna Mountains reach peaks of over 6000 feet with Cuyamaca Peak rising to 6515 feet, the highest point in the county. The coastal region is made up of coastal terraces which rise up from the ocean into wide mesas which then moving farther east change into the Laguna Foothills. Going farther east, the topography gradually rises up to rugged mountains. On the east side, the mountains drop off rapidly to the Anzo-Borrego Desert which is characterized by several broken mountain ranges with the desert valleys in between. To the north of the county are the Santa Ana Mountains which run along the coast of Orange County turning east to join with the Laguna Mountains near the San Diego-Orange County border, thereby providing an effective block to overland surface transport of pollutants from the SCAB.

At present, there are eight ozone monitoring sites located in San Diego County. These include downtown San Diego, Kearny Mesa, El Cajon, Chula Vista, Oceanside, Escondido, Del Mar, and Alpine all of which exceeded the state standard many times during the 1980-1989 study period. The most likely sites affected by transport from the SCAB are Oceanside and Del Mar located along the coast of San Diego County. Oceanside is located about 2 miles south of the San Diego-Orange County border. Del Mar is also predominantly influenced by transport from SCAB on exceedance days and is located about 20 miles north of San Diego and about 15 miles south of Oceanside. On days when Del Mar exceeds the ozone standard it is usually because of the transport of pollutants, originating in the SCAB, transported in from the ocean. All sites have been influenced by transport at one time or another, but Oceanside and Del Mar see most of the transported pollutants from SCAB. The site that regularly exceeds the state standard because of local emissions is Alpine located approximately

30 miles east of San Diego on Interstate 8 at an elevation of 1843 feet in the Laguna Foothills. Here pollutants from the metropolitan San Diego Area are carried by the daytime sea-breeze up the mountain canyons to Alpine. Alpine can also be affected by transport when pollutants are blown in from offshore via the same transport route mentioned above. These transported pollutants are added to the Metropolitan San Diego Area emissions to cause very high ozone concentrations, creating a significant problem. As all sites in the county have been influenced by transport, it is also true that all sites have been influenced by local emissions at one time or another.

Figure 19

TRANSPORT COUPLE
SOUTH COAST to SAN DIEGO



4. Analysis

The ARB staff has analyzed the SDCAPCD categories for the period 1980-1989 to determine whether both districts (South Coast and San Diego) share in the responsibility for exceedances of the state ozone standard. Day specific analyses were examined to determine whether the transport should be classified as overwhelming, significant, or inconsequential. The ARB staff found examples of each of the classifications. Table 14 shows the number of days in each classification.

Table 14
Number of Exceedances of the State Ozone Standard
in the San Diego Air Basin
by Transport Classification

	Year									
Classification	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Inconsequential	57	94	60	64	79	80	76	80	84	95
Significant	92	84	51	59	55	60	40	38	69	54
Overwhelming	19	14	9	2	12	8	15	9	7	7
Total violations	168	192	120	125	146	148	131	127	160	158

a. Inconsequential Transport

From 1980 to 1986, the SDCAPCD categorized each exceedance at each monitoring site as either "local" or "transport" impacted. For these years, the ARB staff classified a day as having an inconsequential transport contribution only when exceedances at all monitoring sites were categorized by SDCAPCD as local impacted. For 1987, 1988, and 1989, the ARB staff examined the data to identify days on which exceedances at all sites could be categorized as local impacted, and these days were designated as days of inconsequential transport. The number of inconsequential transport days for each year from 1980 through 1989 are shown in Table 14. The maximum ozone concentration that occurred on a day identified as inconsequential was 17 pphm occurring once during the 1980-1989 period. A concentration of 16 pphm occurred nine times on inconsequential days during the same period. The more recent data shows a maximum inconsequential day ozone concentration of 15 pphm occurring at least once in 1988 and at least once in 1989. A few examples of inconsequential transport days are in Table 15.

Table 15
Examples of Inconsequential Transport Days
in San Diego County

Date	Year	Site	Ozone Concentration (pphm)
Jul 31,	1980	Alpine	17
Jun 26,	1981	Alpine	16
Jul 23,	1982	Alpine	16
Jul 23,	1983	Alpine	16
Aug 4,	1984	Alpine	16
Jul 7,	1985	Alpine	15
Oct 29,	1986	Alpine, El Cajon	14
Jul 30,	1987	Alpine	15
May 22,	1988	Alpine	15
Jun 13,	1989	Alpine	15

b. Overwhelming Transport

To classify overwhelming transport days, the ARB staff looked at days identified by the SDCAPCD as transport impacted and on which the state ozone standard was exceeded at only the Del Mar and Oceanside stations. If any other site in the SDAB exceeded the standard, the day was not classified as overwhelming transport. This assessment is based on the staff's determination that the exceedances of the state ozone standard at Oceanside and Del Mar are caused entirely by transport from the SCAB and that there is no significant contribution of local emissions to these exceedances. Both Oceanside and Del Mar are located on the northern coast of San Diego County, and there are no San Diego County emission sources upwind. The number of overwhelming transport days for each year from 1980 through 1989 are shown in Table 14. Selected days classified as overwhelming by ARB staff are listed in Table 16.

Table 16
Examples of Overwhelming Transport Days
in San Diego Air Basin

Date	Year	Site	Ozone Concentration (pphm)
Mar 9,	1980	Solana Beach*	16
Feb 16,	1981	Solana Beach*	15
Apr 22,	1982	Solana Beach*	13
Nov 10,	1983	Del Mar	13
Nov 1,	1984	Del Mar	12
Apr 2,	1985	Del Mar	14
Jan 25,	1986	Del Mar	17
Jan 26,	1987	Del Mar	17
Mar 25,	1988	Del Mar	17
Feb 21,	1989	Del Mar	16

* Old Del Mar site

c. Significant Transport

The ARB staff analysis of the SDCAPCD data shows a significant number of ozone standard exceedances resulting from emissions from both the SDAB and the SCAB. Table 14 shows a large number of significant days during the 1980-1989 study period. Two types of significant days were identified by the staff. Transport days were classified by the ARB staff as significant when the SDCAPCD identified the day as transport impacted and at least one site in the SDAB other than Oceanside and Del Mar exceeded the state standard. On many days all of the sites were identified by SDCAPCD as transport impacted. On other days there was a split in the SDCAPCD identification where at least one SDAB interior site was determined to be local impacted while one or more other sites were designated transport impacted. In this case the day was also classified by the ARB staff as significant.

Although some sites were identified by the SDCAPCD as transport impacted while other sites were classified as local impacted on the same day, it is probable that local emissions contribute to the exceedances at all of these identified transport impacted sites. While a day may be classified as significant, it has not been possible to determine the relative amounts contributed by the SDAB and by the SCAB. A few examples of significant days for which all sites were identified as transport impacted by the SDCAPCD are shown in Table 17.

Table 17
Examples of Significant Transport Days
in San Diego Air Basin
(All Sites Categorized as Transport)

Date	Year	Site	Ozone Concentration (pphm)
Oct 4,	1980	Alpine	23
Jun 16,	1981	Oceanside	29
Oct 23,	1982	Kearny Mesa	23
Nov 3,	1983	Del Mar	22
Sep 5,	1984	Kearny Mesa	28
Apr 13,	1985	Kearny Mesa	22
Mar 27,	1986	Oceanside	19
Oct 3,	1987	Del Mar	29
Mar 26,	1988	Oceanside	25
Sep 14,	1989	Del Mar	25

Table 18 shows examples of days classified as transport for which at least one site was identified by the SDCAPCD as local impacted and at least one site other than Oceanside and/or Del Mar was identified as transport impacted. The ARB staff has classified these days as significant transport.

Table 18
Examples of Significant Transport Days in San Diego Air Basin
(Sites Categorized as Local and Transport)

Date	Year	Local		Transport	
		Site	Ozone (pphm)	Site	Ozone (pphm)
Jun 26,	1980	Alpine	15	Escondido	12
Oct 17,	1981	Kearny Mesa	10	Oceanside	12
Sep 21,	1982	Alpine	13	Escondido	13
Aug 28,	1983	Alpine	16	Escondido	16
Jun 16,	1984	Alpine	12	Del Mar	10
Jun 18,	1985	Alpine	15	Escondido	11
Aug 18,	1986	Alpine	14	Oceanside	16

J. South Coast to Southeast Desert

1. Summary and Recommendations

The staff analysis shows that transport from the South Coast Air Basin (SCAB) caused the state ozone standard to be exceeded in the Southeast Desert Air Basin (SEDAB) on August 2, 1986. Further analysis by the staff shows that on April 29, 1989, local emissions caused an exceedance of the state ozone standard without any significant transport from the South Coast.

The staff recommends that the South Coast's transport be classified as "Overwhelming" on some days and "Inconsequential" on others. Since transport from the South Coast is "Overwhelming" on some days, the staff recommends that the South Coast be held accountable for developing a control strategy for attaining the state ozone standard on those types of days.

2. Conclusions

The staff believes that the contribution of South Coast Air Basin emissions to exceedances of the state ozone standard (state standard) in the Southeast Desert Air Basin is both overwhelming and inconsequential. This conclusion is based on a case study of a day representing overwhelming transport, August 2, 1986, and a case study of a day representing inconsequential transport, April 29, 1989. For each day, the staff constructed trajectories which support the case for overwhelming and inconsequential transport, respectively.

The staff's analysis is based on case studies of transport contributions on days when the state ozone standard was exceeded in the SEDAB. The staff reviewed air quality data to identify days of state standard exceedances in the SEDAB. August 2, 1986, was chosen as a day to explore for possible overwhelming transport based on the ozone concentrations in the SEDAB and the SCAB and because the predominant wind flow pattern was a sea breeze. The staff used trajectories to support the conclusion that the SCAB contributed directly to the exceedances of the state ozone standard in the SEDAB. In addition to concluding that overwhelming transport occurs, the staff also concluded that the SEDAB is able to produce ozone concentrations that exceed the state standard without transport. April 29, 1989, represents such a day.

3. Geographical Setting

As shown in Figure 20, SEDAB includes all of Imperial County, Riverside County east of the San Bernardino Mountains, San Bernardino County east of the San Gabriel Mountains, Los Angeles County east of the San Gabriel Mountains, and Kern County east of the San Gabriel and Tehachapi Mountains. The basin is bounded on the north by the basin ranges, on the northeast by the Nevada state line, on the east by the Arizona state line including the Colorado River, and on the south by the Mexican border. The basin is bounded on the east and south by continued desert.

Many small mountain ranges dot the SEDAB--more in the east than in the west--with elevations greater than 5,000 feet. However, the topography of the basin is generally flat and slopes from 2,500 feet in the west to below sea level in the east. Overall, the SEDAB encompasses all of the Mojave Desert of southeastern California.

The SCAB includes all of Orange County, Riverside County west of the San Bernardino Mountains, San Bernardino County west of the San Gabriel Mountains, and Los Angeles County west of the San Gabriel Mountains. The basin is bounded on the west by the Pacific Ocean. Four important mountain passes lead into the SEDAB: Soledad Canyon between the Sierra Pelona and the San Gabriel Mountains, Cajon Pass between the San Gabriel Mountains and the San Bernardino Mountains, San Gorgonio Pass between the San Bernardino Mountains and the San Jacinto Mountains, and Tehachapi Pass in the Tehachapi Mountains. These passes offer paths for the transport of pollutants between air basins.

The SCAB is amphitheater shaped with elevations ranging from greater than 5,000 feet at the mountain ridgelines on the north, east, and south to sea level at the coastal and west-central area of the basin.

4. Overwhelming Transport Assessment

On August 2, 1986, exceedances of the state standard were found throughout the SCAB and the SEDAB. Table 19 lists locations, maximum ozone concentrations (pphm), and durations of exceedances. The table illustrates three points. First, it shows that the closer the SEDAB monitor was to the SCAB, the higher the ozone concentration. Second, the beginning times of exceedances in the SEDAB are two to four hours later than exceedances in the SCAB. And third, the duration of exceedances in the SEDAB decreases with increased distance from the SCAB. In other words, the ozone episodes in the SEDAB are more intense at monitors closer to the SCAB than those farther away. The geographic separation and later ozone exceedance times are both indicative of ozone exceedances due to transport as opposed to exceedances due to local sources.

Figure 20
TRANSPORT COUPLE
SOUTH COAST to SOUTHEAST DESERT

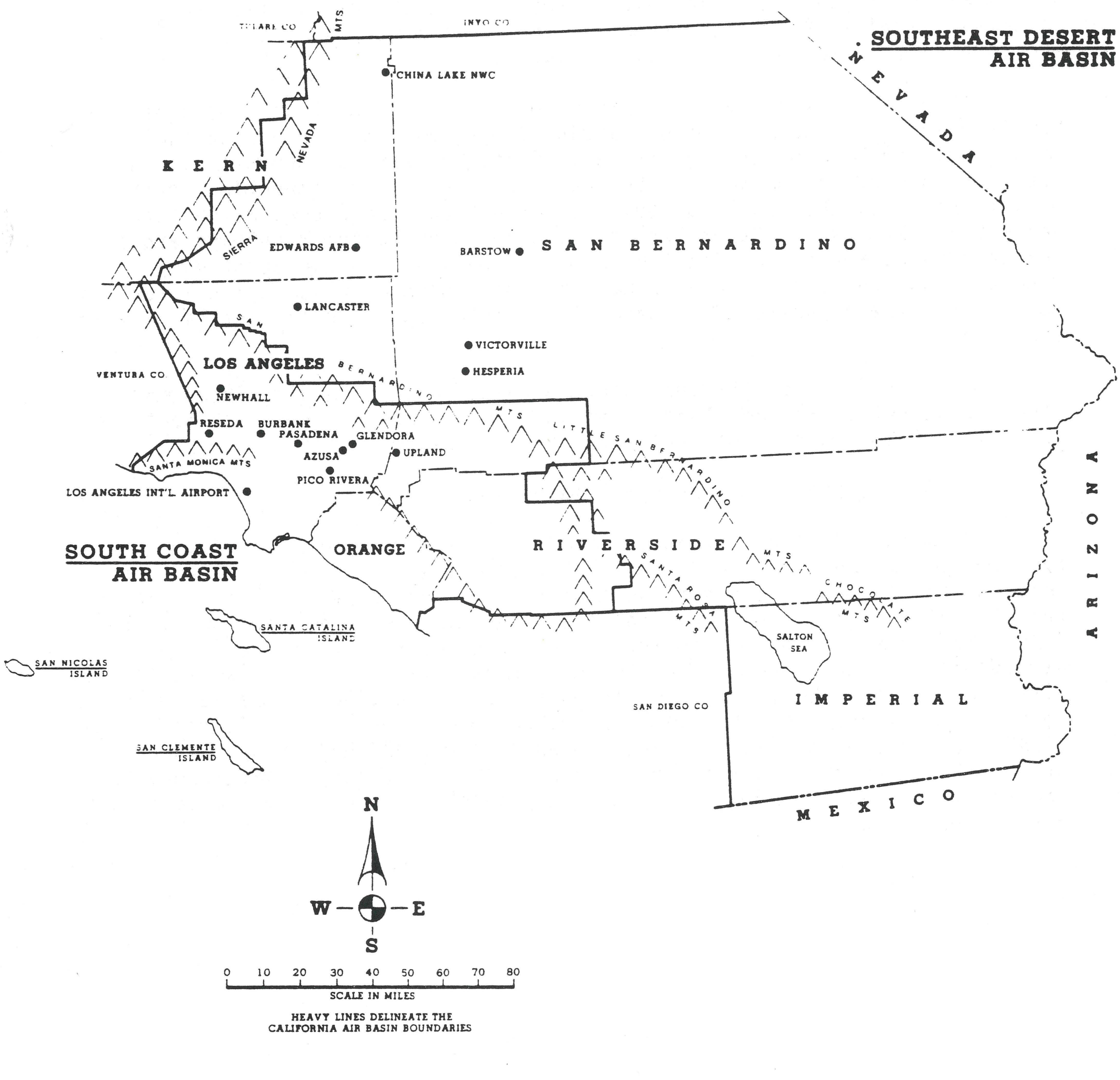


Table 19

List of State Ozone Standard Exceedances

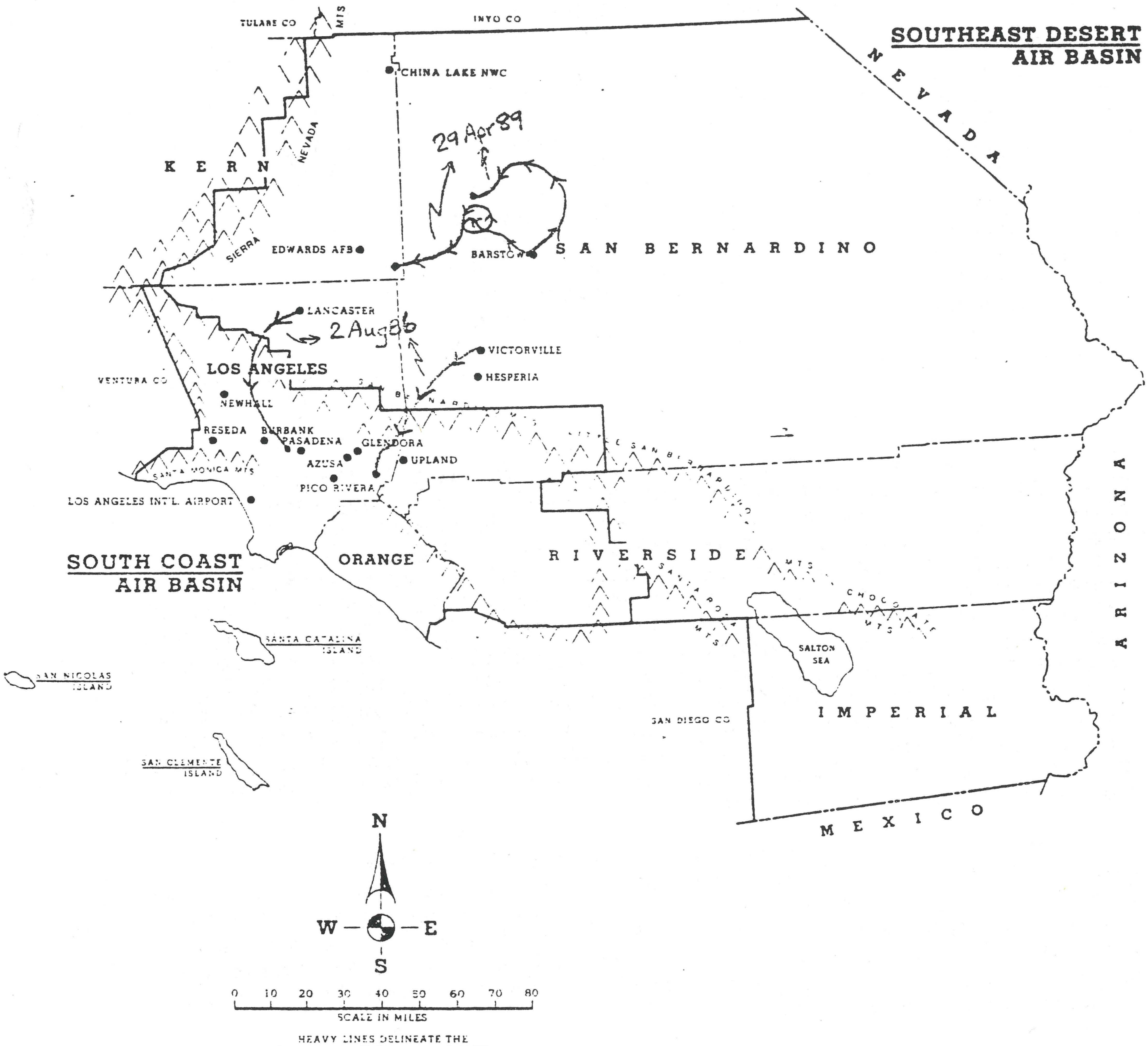
	Ozone Concentration (pphm)	Time of exceedance	Distance to Closest SCAB Boundary (miles)
SEDAB:			
Hesperia	18	1-9 p.m.	8-10
Victorville	13	2-8 p.m.	20
Barstow	11	3-7 p.m.	40
Lancaster	18	3-9 p.m.	10-12
SCAB:			
Azusa	21	11 a.m.-6 p.m.	
Burbank	23	11 a.m.-5 p.m.	
Glendora	23	10 a.m.-8 p.m.	
Newhall	20	noon-6 p.m.	
Pasadena	24	11 a.m.-6 p.m.	
Reseda	18	10 a.m.-2 p.m.	

The staff used wind trajectory analyses to identify the area of origin of pollutants transported into the SEDAB. The terrain barrier between the two air basins was the primary concern in constructing the August 2, 1986, trajectory between the SCAB and the SEDAB. Because of this, a brief study was made of temperature data at the surface to compare with temperature data at the top of the inversion as measured at Loyola Marymount University (LMU) near Los Angeles International Airport. The study revealed that on August 2, 1986, a temperature of 90 degrees Fahrenheit was necessary to break the existing inversion that had a top height of about 2,500 feet. Surface temperatures in the SCAB (Azusa, Pico Rivera, Los Angeles, Pasadena, and Upland) equaled this by about noon. This means that the air flow was not "trapped" below an inversion in the SCAB, nor was the air flow confined through canyons but instead was able to flow freely at heights greater than the terrain separating the basins.

The predominant surface wind flow in the SCAB on August 2 was characterized as a sea breeze. Hourly wind data in both basins were plotted from 10 a.m.-6 p.m. The beginning time was chosen because that is the time the morning drainage flow usually turns around to flow in the direction of the SEDAB. The end time was chosen as the last hour that a dependable sea breeze flows (to support transport) and as a time to include the state ozone standard exceedance duration in the SEDAB.

FIGURE 21

Transport Couple
South Coast to Southeast Desert



Two backward trajectories (Figure 21) were constructed from the SEDAB beginning at 6 p.m. backwards to 10 a.m. The backward trajectories were initiated at Lancaster and Victorville. The Lancaster trajectory crossed the basin boundary line within one hour and indicated a point of origin 3 miles northwest of Pasadena at 10 a.m. The Victorville trajectory crossed the basin boundary line within four hours and indicated a point of origin 9 miles south-southeast of Azusa at 10 a.m. These trajectories show that the polluted air originated in the SCAB in the morning hours and reached the SEDAB in the late afternoon hours. These types of days are typical of air flow between the two basins.

5. Inconsequential Transport Assessment

To select days for case study, the ARB staff reviewed the daily wind flow analyses for days when the state standard for ozone was exceeded at Barstow. April 29, 1989, was chosen because it was a day with wind flow patterns that did not indicate transport. Barstow was chosen as the focus because it is close enough to data sources to allow reliable analyses and far enough away from basin boundaries to show inconsequential transport. Based on a review of 1986 data, April 29, 1989, is representative of a meteorological condition that exist approximately 7 percent of the time (during 1986).

The next step involved a review of the hourly ozone concentration values to determine whether or not transport was likely. Barstow's April 29, 1989 hourly concentrations were below but near the state ozone standard most of the day with exceedances beginning early (2 p.m.). The duration of the exceedances was six hours and the concentration changes were gradual. This pattern is indicative of locally generated ozone. An abrupt change (especially a sharp rise) in the concentration from one hour to the next is indicative of transport either advected on the surface or mixed downward from a layer aloft. Neither surface advection nor vertical mixing were the cause of the exceedance on April 29, 1989, based on the hourly ozone concentration pattern.

After determining that wind flow and ozone conditions were right for inconsequential transport, the staff studied the event further by preparing detailed wind flow trajectories. Wind speed and direction were plotted for each hour for 24 hours prior to the exceedance time. Each hour of plotted data was analyzed using streamline techniques. From these analyses, two backward trajectories, from Barstow, were manually constructed (Figure 21) for April 29, 1989. One trajectory went backwards from 2 p.m., the other trajectory from 7 p.m. Those times were chosen because they were the beginning and ending times of the period of exceedances of the state ozone standard at Barstow. The 2 p.m. backward trajectory indicates that the parcel of air originated approximately 40 miles northeast of Edwards Air Force Base 19 hours earlier. The 7 p.m. backward trajectory indicates that the parcel of air originated approximately 25 miles east-northeast of Palmdale 24 hours earlier. It is unlikely that the April 29, 1989, exceedances measured at Barstow were caused by residual pollutants transported from the SCAB on the previous day since the winds aloft at China

Lake on the previous day were predominantly southeasterly, easterly, and north-northeasterly. These analyses suggest that the state ozone standard exceedance at Barstow was the result of locally generated emissions and that transported emissions from the SCAB were inconsequential.

6. Emission Inventory

The emission total in SEDAB for NOx and ROG combined is 430 tons/day. The emission total in SCAB for NOx and ROG combined is 2,380 tons/day which is over 5 times higher than the emissions from the SEDAB.

Emissions in the SEDAB are largely due to raw materials processing such as gas, cement, and granite, and industrial sources dealing with chemicals. The emissions in the SCAB are largely due to large scale urbanization including the associated mobile and heavy industrial sources.

7. District's Comments

The ARB staff met with personnel from the San Bernardino Air Pollution Control District (APCD) to discuss the inconsequential transport day identified at Barstow on April 29, 1989. The APCD staff contend that the state ozone standard exceedance in Barstow was due to transport from the SCAB and therefore should not be classified as inconsequential. The APCD provided meteorological data and time series analyses of ozone concentrations to support their contention. The ARB staff has studied the APCD's information, but still conclude that there is no evidence of transported pollutants from upwind areas contributing to ozone exceedances on April 29, 1989. Further analysis will be done in this area by ARB and APCD staff.

K. South Coast to South Central Coast.

1. Summary and Recommendations

The staff analysis shows that transport from the South Coast Air Basin (SCAB) contributed to exceedances of the state ozone standard in the South Central Coast Air Basin (SCCAB) on September 7, 1984, and September 13, 1985. Also, an analysis done by the staff of the Ventura County Air Pollution Control District for an ozone episode which occurred from May 9 to May 11, 1988, shows that local emissions caused an exceedance of the state ozone standard without any significant transport from the South Coast Air Basin.

The staff recommends that the South Coast's transport be classified as "significant" on some days and "inconsequential" on others. Since transport from the South Coast is "significant" on some days, the South Coast must include in its 1991 plan, a requirement for the application of best available retrofit control technology to existing stationary sources and a permitting program designed to achieve a no net increase in emissions of precursors of ozone from all new or modified stationary sources.

2. Conclusions

The staff believes that the contribution of South Coast Air Basin emissions to exceedances of the state ozone standard (state standard) in the Ventura and Santa Barbara Counties portion of the South Central Coast Air Basin is both significant and inconsequential. This recommendation is based on an assessment of September 6 and 7, 1984, and September 12 and 13, 1985, using the Urban Airshed Model with Carbon Bond II chemistry. Ozone concentrations simulated for September 7, 1984, and September 13, 1985, demonstrated that emissions in the South Coast Air Basin contributed to the exceedances in the South Central Coast Air Basin.

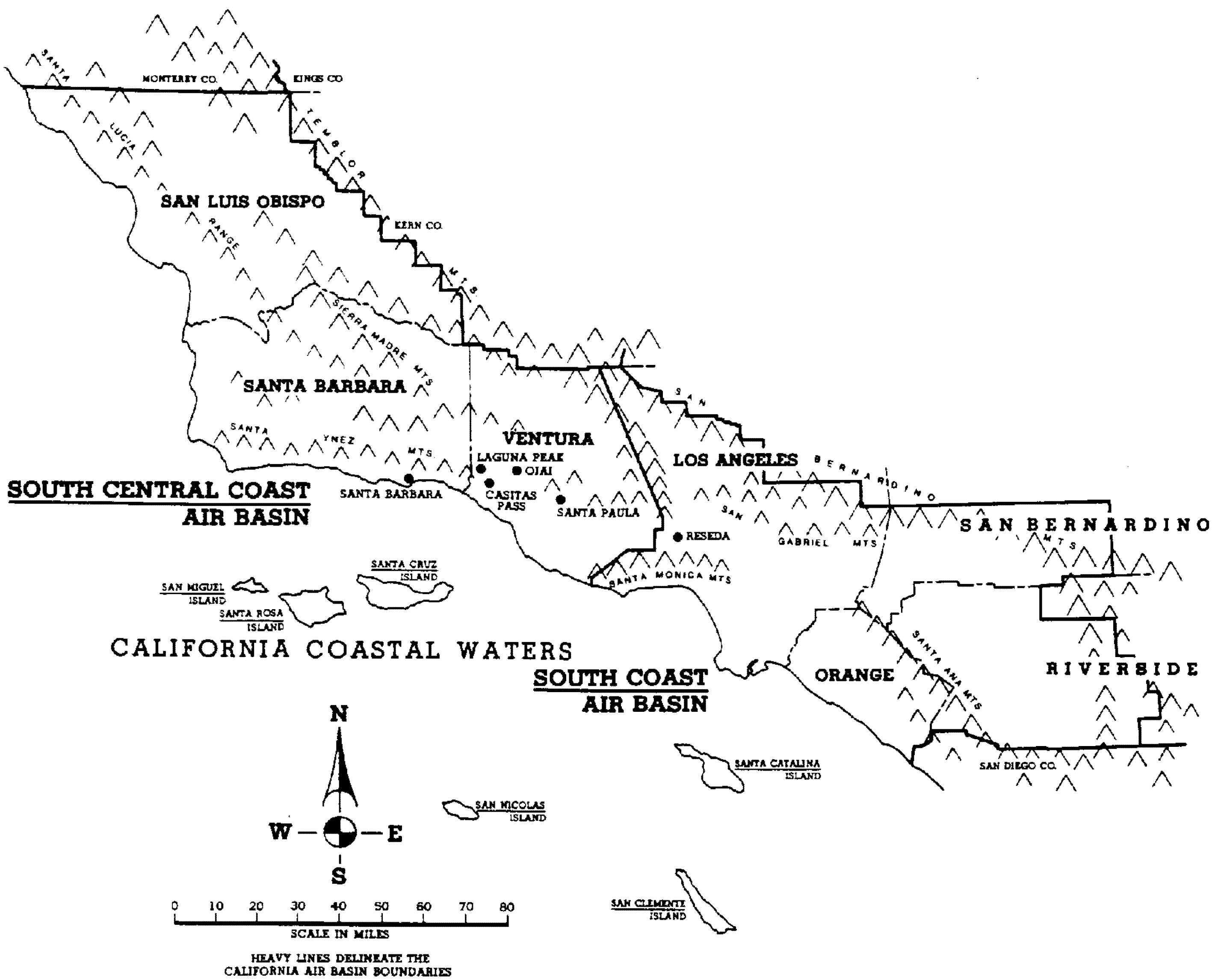
The assessment of transport from the SCAB to the SCCAB was performed using a photochemical grid model. Because the modeling domain did not include San Luis Obispo County, this assessment is not applicable to San Luis Obispo County. References in this section to the SCCAB are to the Ventura and Santa Barbara Counties portion of the SCCAB.

The transport of pollutants from the SCAB to the SCCAB is expected to have an impact on ozone concentrations in the SCCAB when surface winds are from the southeast. However, under conditions of light and variable winds at the surface, transport from the SCAB may also occur due to the presence of southeasterly winds aloft.

A comparison of high ozone days that occurred during the period 1981 through 1985 was used to categorize meteorological conditions that were correlated with high ozone concentrations in the SCCAB. This comparison showed that September 7, 1984, was typical of days with southeasterly winds at the surface and September 13, 1985, was typical of days with light winds at the surface and southeasterly winds aloft. Thus, these two days were analyzed to determine the impact of transport from the SCAB to the SCCAB. Meteorological and air quality data describing these high ozone episodes were collected as part of the South Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP). Radian[1,2] described the SCCCAMP meteorological and air quality data and the preparation of model inputs from this data.

The analysis of transport impact was based on simulations with the Urban Airshed Model (UAM) using Carbon Bond II chemistry.[3,4] To minimize the impact of initial conditions on results, simulations were begun on the day prior to the highest ozone. Thus, ozone concentrations in the SCCAB were simulated for September 6 and 7, 1984, and September 12 and 13, 1985.

Figure 22
TRANSPORT COUPLE
SOUTH COAST to SOUTH CENTRAL COAST



An analysis was done by the staff of the Ventura County Air Pollution Control District for an ozone episode which occurred from May 9 to May 11, 1988. They concluded that for this episode exceedances of the state ozone standard are caused by local emissions without any significant transport from the South Coast Air Basin. The ARB staff agree with this conclusion and have added an inconsequential designation to the impact of transport from the SCAB. The analysis performed by Ventura County staff is contained in Attachment B.

3. Geographical Setting

The SCAB is comprised of Orange County and portions of Los Angeles, San Bernardino, and Riverside Counties. The SCCAB is comprised of San Luis Obispo, Santa Barbara, and Ventura Counties. However, because of a limited study-area, only Santa Barbara and Ventura County were considered in this analysis.

The SCCAB lies west-north-west of the SCAB. The most populated areas of the SCCAB are the coastal plain areas of Santa Barbara and Ventura Counties. The east-west oriented Santa Monica Mountains limits most direct air exchange between the SCAB and the SCCAB; however, air pollutant transport in either direction between the two air basins has been documented.

There are two major transport routes for air pollutants between the SCAB and the SCCAB. Transport may occur overland between the San Fernando Valley, in the north-west SCAB, and eastern Ventura County. Transport may also occur overwater across Santa Monica Bay and into the Santa Barbara Channel.

4. Analysis

The results of the modeling simulations by the ARB staff for September 7, 1984, and September 13, 1985, were summarized by Wagner and Jackson.[5] To assess the impact of transport from the SCAB to the SCCAB, Wagner and Jackson compared base case simulations with UAM to clean boundary simulations using meteorological data from September 6-7, 1984, and September 12-13, 1985, as model inputs. For the base case simulations, pollutant concentrations on the modeling domain boundaries were determined from observations. Boundary concentrations represent pollution concentrations in areas upwind of the modeling domain. These boundary values vary in space and time along the boundary. The maximum values used on the boundary between the SCCAB and the SCAB are shown in Table 20. In the clean boundary simulations, boundary pollutant concentrations were set at clean air, or background concentrations also shown in Table 20. The differences in simulation results between the base case and the clean boundary simulations were attributed to emissions in the SCAB. The analysis included comparisons of predicted peak surface grid cell ozone concentrations and the number of surface grid cells in which ozone concentrations exceeded the state standard.

Table 20

SCCAB and SCAB Boundary Concentrations (pphm)

Date	Pollutant Species O_3	NO	NO_2	ROG
	Maximum Base Case Boundary Concentrations			
6-7 September, 1984	12	3.1	3.6	78.0
12-13 September, 1985	18	0.1	0.2	3.0
	Clean Boundary Concentration			
-- all dates --	4	0.1	0.1	3.0

The term "boundary" refers to those on the south, east and top of the modeling domain.

* The Carbon Bond II mix of reactive organic gases is 85% of the ROG concentration.

The analysis of the results of the simulation showed that on September 7 clean boundaries had a very small impact on peak ozone concentrations and a small impact on the number of grid cells exceeding the state standard. As shown in Table 21, the number of grid cells exceeding the state standard decreased from 1,463 in the base case to 1,220 with clean boundaries. A similar analysis by Radian[6] indicated that boundary concentrations on this day contributed to ozone concentrations only in eastern Ventura County and had little impact on concentrations in western Ventura County and Santa Barbara County.

Table 21

Peak Ozone (pphm) and Number of UAM Grid Cells Exceeding 9 pphm

Date	Base Case Peak O_3	Base Case No. Cells	Clean Boundaries Peak O_3	Clean Boundaries No. Cells
7 September, 1984	23.4	1,463	23.3	1,220
13 September, 1985	17.8	1,972	9.9	2

On September 13, 1985, however, clean boundaries had a marked impact on ozone concentrations in the SCCAB. Clean boundaries reduced the simulated peak concentration from 18 pphm to 10 pphm and the number of grid cells exceeding the state standard were reduced from 1,972 to 2.

Within the accuracy of the UAM, high concentrations of ozone and ozone precursors transported across the boundary between the SCAB and the SCCAB caused almost all of the exceedances of the state standard in the SCCAB that occurred on September 13, 1985. On September 7, 1984, however, boundary concentrations contributed a small fraction of the exceedances simulated in the SCCAB.

From the results of the modeling simulations, the ARB staff concluded that emissions in the SCAB contribute to the exceedances of the state standard in the SCCAB, resulting in a designation of significant.

5. References

1. Radian Corporation. 1985. "Analysis of the Data Collected in the 1984 SCCCAMP Field Program. Report to the South Central Coast Cooperative Aerometric Monitoring Program. No. SYSAPP-85/029.

2. Radian Corporation. 1988a. "Photochemical Modeling of Two SCCCAMP 1984 Oxidant Episodes: Volume II: Modeling Procedures and Evaluation Results." Report to US EPA Region IX. San Francisco, CA 94105.

3. Reynolds, S.D., et al., 1979. "An Introduction to the Airshed Model and its Usage", EF78-52R4 - EF79-31, Systems Applications, Inc., San Rafael, CA.

3. Whitten, G.Z. and H. Hogo, 1977. "Mathematical Modeling of Simulated Photochemical Smog", EPA-600/3-77-011.

5. Wagner, K. K. and B. S. Jackson. 1990. "The Assessment of Air Pollution Transport Between California Air Basins Using AIRSHED Sensitivity Studies." Air & Waste Management Association International Specialty Conference on Tropospheric Ozone and the Environment, March 1990, Los Angeles, CA.

6. Radian Corporation, 1988. "AIRSHED Model Simulations of the 6-7 September, 1984 Ozone Episode in Support of the Santa Barbara Air Quality Attainment Plan." prepared for Santa Barbara Air Pollution Control District, September 1988.

L. South Central Coast to the South Coast

1. Summary and Recommendations

The staff analysis shows that transport from the South Central Coast Air Basin (SCCAB) contributed to exceedances of the state ozone standard in the South Coast Air Basin (SCAB) on September 17, 1984. Further analysis by the staff shows that on September 13, 1985 local emissions caused an exceedance of the state ozone standard without any significant transport from the South Central Coast.

The staff recommends that the South Central Coast's transport be classified as "significant" on some days and "inconsequential" on others. Since transport from the South Coast is "significant" on some days, the South Central Coast must include in its 1991 plan, a requirement for the application of best available retrofit control technology to existing stationary sources and a permitting program designed to achieve a no net increase in emissions of precursors of ozone from all new or modified stationary sources.

2. Conclusions

The staff believes that the contribution of the Santa Barbara and Ventura Counties portion of the South Central Coast Air Basin emissions to exceedances of the state ozone standard (state standard) in the South Coast Air Basin both is significant and inconsequential. This is based on an assessment of three days of ozone concentrations using the Urban Airshed Model with Carbon Bond II chemistry--September 17, 1984, September 13, 1985, and September 7, 1984. Ozone concentrations simulated for September 17, 1984, indicate that emissions in the South Central Coast Air Basin contributed significantly to the exceedances in the South Coast Air Basin. Ozone concentrations simulated for September 13, 1985, indicate that the exceedances recorded for this day were the result of locally generated emissions.

The assessment of transport from the SCCAB to the SCAB was performed using a photochemical grid model. Because the modeling domain did not include San Luis Obispo County, this assessment is not applicable to San Luis Obispo County. References in this section to the SCCAB are to the Ventura and Santa Barbara Counties portions of the SCCAB.

The staff's analysis is based on the photochemical modeling of three ozone episodes in 1984 and 1985. Model input data were collected as part of the South Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP). Radian[1,2] described the SCCCAMP meteorological and air quality data and the preparation of model inputs from this data. The analysis was based on simulation results from the Urban Airshed Model (UAM) using Carbon Bond II chemistry.[3,4] To minimize the impact of initial conditions on results, simulations are begun on the day prior to the highest ozone.

During one ozone episode, modeled quantities of nitrogen oxides (NOx) and reactive organic gases (ROG) transported from the SCCAB to the SCAB made a significant contribution to state ozone standard exceedances in the San Fernando Valley portion of the SCAB. During another ozone episode, transported mass of NOx and ROG from the SCCAB were an insignificant contribution to state ozone standard exceedances in the SCAB.

3. Geographical Setting

The SCCAB is comprised of San Luis Obispo, Santa Barbara, and Ventura Counties. However, because of a limited study-area, only Santa Barbara and Ventura County were considered in this analysis. The SCAB is comprised of Orange County and portions of Los Angeles, San Bernardino, and Riverside Counties. However, because of the size of the SCAB, the impact of transport from the SCCAB on air quality in the SCAB was considered only for Los Angeles County.

The SCAB lies east and south-east of the SCCAB. The most populated areas and the most important sources of emission in the SCCAB are the coastal plain areas of Santa Barbara and Ventura Counties. The east-west oriented Santa Monica Mountains limits most direct air exchange between the SCCAB and the SCAB, however, air pollutant transport in either direction between the two air basins has been documented.

There are two major transport routes for air pollutants between the SCCAB and the SCAB. Transport may occur overland between the San Fernando Valley, in the north-west SCAB, and eastern Ventura County. Transport may also occur overwater across Santa Monica Bay.

4. Analysis

Ozone episodes on September 7, 1984, September 17, 1984, and September 13, 1985, were modeled using data collected during the SCCCAMP and model-based analysis was summarized by Wagner and Jackson[5]. To assess the impact of transport from the SCCAB on the SCAB, Wagner and Jackson calculated the net daily masses of ozone precursors transported across a vertical plane located, as shown in Figure 23, approximately on the boundary between the SCCAB and the SCAB. For this analysis, transported mass was calculated within the well mixed atmospheric layer near the earth's surface. The extent to which pollutant concentrations above the mixed layer contribute to surface ozone concentrations is unknown.

The transported masses calculated from base case simulations were compared to transported masses calculated from zero emissions simulations for the three episode days. The base case simulation used emissions for the SCCAB for the episode days. In the zero emissions simulation, all emissions for the SCCAB were set to zero. The differences between the transported mass of nitrogen oxides and reactive organic gases from the base case and the zero emission simulations were attributed to emissions in the SCCAB. These differences represent the contribution of SCCAB emissions to ozone exceedances in the SCAB.

Winds were westerly (from the SCCAB to the SCAB) during the late morning and early afternoon hours on September 7 and 17, 1984, but were more variable on September 13, 1985. The transported masses of nitrogen oxides and reactive organic gases between the SCCAB and the SCAB reflected these differences in wind patterns. Table 22 shows the net transported mass for the entire day for the base case and zero emission simulations. Some of the hours on each day have transport from the SCCAB to the SCAB (positive mass transport) while other hours have transport from the SCAB to the SCCAB (negative mass transport). As shown in Table 22 for the base case simulations, the largest net transported mass from the SCCAB to the SCAB of nitrogen oxides (24.3 ton/day) and of reactive organic gases (105.9 ton/day) occurred on September 17. Net transported mass on September 13, 1985, was from the SCAB to the SCCAB.

Figure 23
TRANSPORT COUPLE
SOUTH CENTRAL COAST to SOUTH COAST

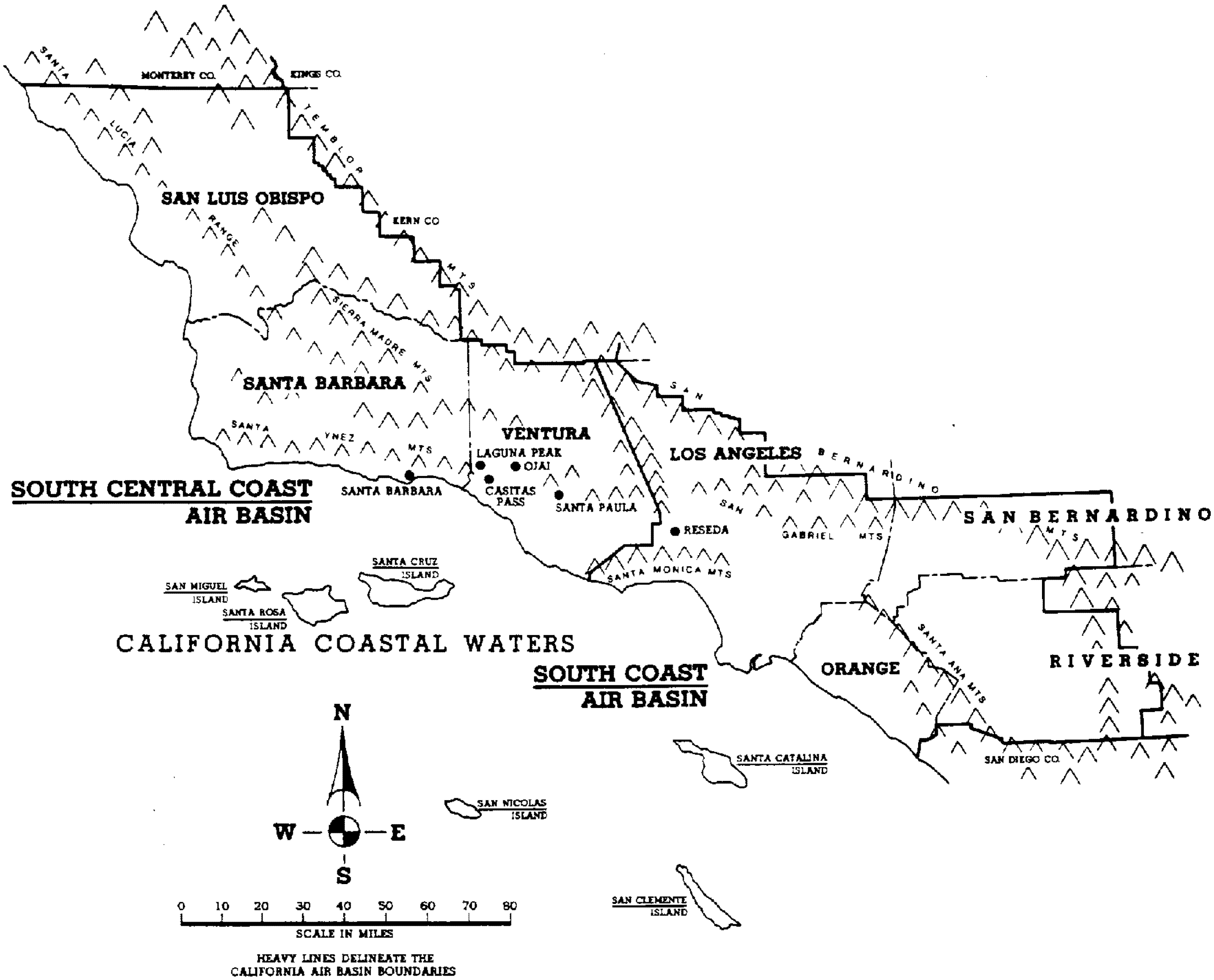


Table 22
Transported Air Pollution Mass (tons/day) Between SCCAB and SCAB

Date/ Pollutant	Base Case*	Zero Emissions*	Difference
September 7, 1984			
NOx	6.2	-1.4	7.6
ROG	83.9	54.3	29.6
September 17, 1984			
NOx	24.3	0.5	23.8
ROG	105.9	32.8	73.1
September 13, 1985			
NOx	-6.4	-8.9	2.5
ROG	-10.3	-20.0	9.7

* Positive values are transport from the SCCAB to the SCAB while transport from the SCAB to the SCCAB are negative values.

The zero emissions simulation resulted in smaller net transported mass from the SCCAB into the SCAB on September 7 and 17. The larger negative value on September 13 is the result of reduced positive mass transport for a few hours during the day. The most significant reductions occurred on September 17, 1984, when nitrogen oxides transport was reduced 23.8 ton/day and reactive organic gases transport reduced 73.1 ton/day. These reductions, calculated as the difference between base case and zero emissions simulation results, are the contribution of SCCAB emissions to the ozone concentrations occurring in the SCAB on September 7 and 17.

Transported mass of nitrogen oxides and reactive organic gases transported from the SCCAB represent only a small fraction of the total emissions inventory for the SCAB. In particular the staff believes that the emissions north of the Santa Ynez Mountains in Santa Barbara County contribute very little to the transport into the SCAB. Most of the transported mass from the SCCAB to the SCAB is from emissions in Ventura County. For Los Angeles County, where the influence of this transported mass is likely to be greatest, the nitrogen oxides transported from the SCCAB are approximately 4 percent of the emission inventory and the transported reactive organic gases are approximately 10 percent of the emission inventory. Peak ozone concentrations in the San Fernando Valley portion of Los Angeles County exceeded the ozone standard on all three of these episode days. Peak ozone at Reseda was 14 pphm on September 7, 1984, 16 pphm on September 17, 1984, and 11 pphm on September 13, 1985. The ARB staff concludes that, at least on September 17, transport contributed significantly to the ozone concentrations in Los Angeles County and responsibility for these ozone exceedances is shared between the two areas.

On September 13, 1985, the net transported mass of ozone precursors was from the SCAB to the SCCAB. Simulation results showed that transport from the SCCAB to the SCAB occurred for only a few hours late in the day. Thus, transport did not contribute to the peak ozone concentration of 11 pphm at Reseda which occurred in the afternoon on September 13, 1985. The staff concludes that transport of SCCAB emissions did not contribute to ozone standard exceedances in the SCAB on that day. Thus, this was an inconsequential transport day.

5. References

1. Radian Corporation. 1985. "Analysis of the Data Collected in the 1984 SCCCAMP Field Program. Report to the South Central Coast Cooperative Aerometric Monitoring Program. No. SYSAPP-85/029.

2. Radian Corporation. 1988a. "Photochemical Modeling of Two SCCCAMP 1984 Oxidant Episodes: Volume II: Modeling Procedures and Evaluation Results." Report to US EPA Region IX. San Francisco, CA 94105.

3. Reynolds, S.D., et al., 1979. "An Introduction to the Airshed Model and its Usage", EF78-52R4 - EF79-31, Systems Applications, Inc., San Rafael, CA.

4. Whitten, G.Z. and H. Hogo, 1977. "Mathematical Modeling of Simulated Photochemical Smog", EPA-600/3-77-011.

5. Wagner, K. K. and B. S. Jackson. 1990. "The Assessment of Air Pollution Transport Between California Air Basins Using AIRSHED Sensitivity Studies." Air & Waste Management Association International Specialty Conference on Tropospheric Ozone and the Environment, March 1990, Los Angeles, CA.

M. San Joaquin Valley to Great Basin Valleys

1. Summary and Recommendation

The staff's analysis shows that transport from the San Joaquin Valley Air Basin (SJVAB) to the Great Basin Valleys Air Basin (GBVAB) occurred on all days during 1986 through 1988 when the state ozone standard was exceeded in the GBVAB. Emissions within the GBVAB had little or no impact on the exceedances, all of which occurred at the Mammoth Lakes air monitoring station.

The staff recommends that the SJVAB's transport to the GBVAB be classified as "Overwhelming" and that the districts within the SJVAB be held accountable for developing in their 1991 plans a control strategy for attaining the state ozone standard at Mammoth Lakes.

2. Conclusions

The staff believes that the contribution of the SJVAB emissions to exceedances of the state standard for ozone ("state standard") in the GBVAB is overwhelming.

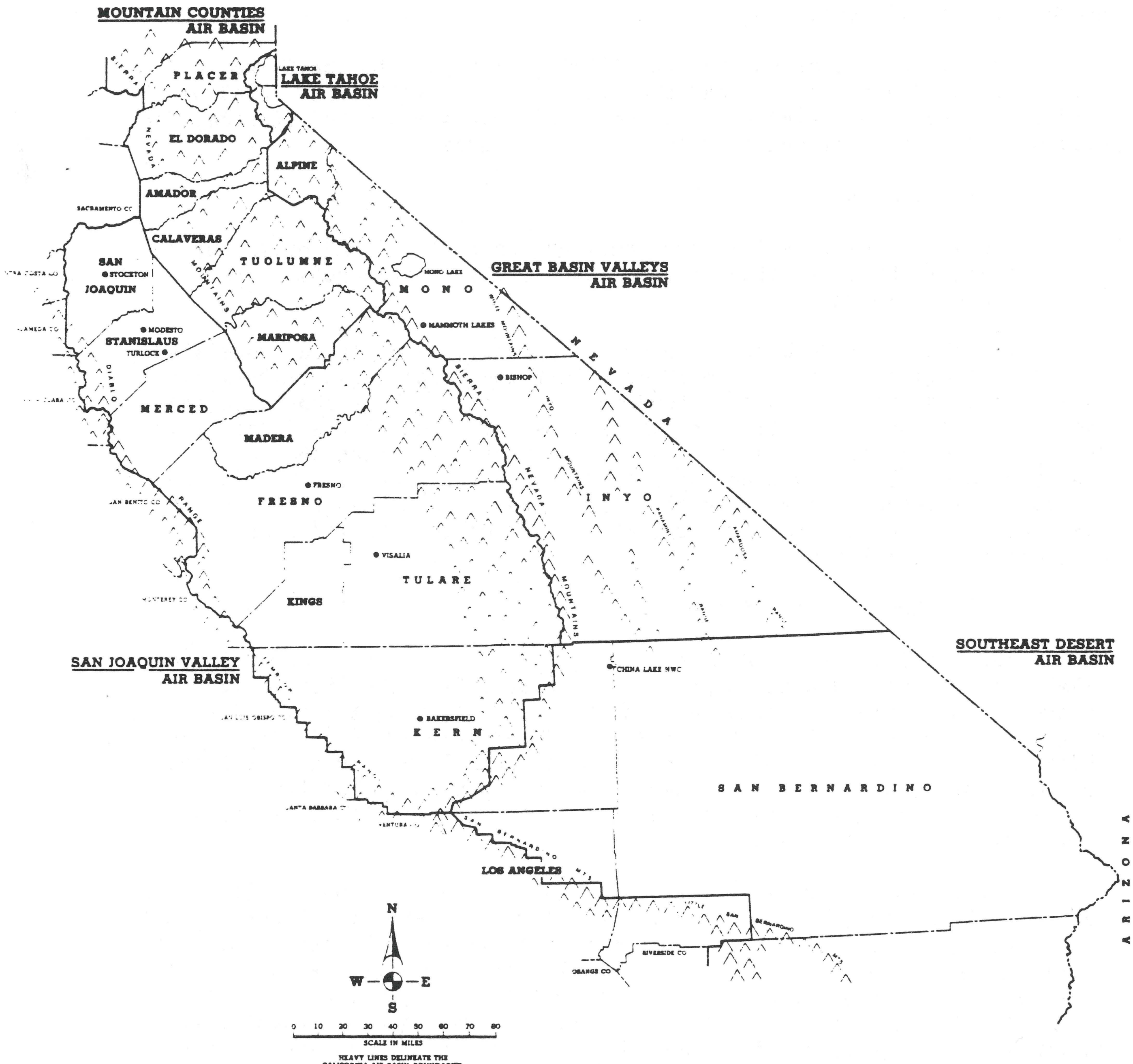
The staff's conclusion is based on an analysis of the air quality and meteorological data for the 12 days that the Great Basin Valleys Air Basin exceeded the state ozone standard. The time of exceedances strongly indicates transport; in addition, emission sources within the Great Basin Valleys could not have generated the exceedances. Although the area of transport contribution was not specified in the Transport Identification analysis presented to the Board at the December 1989 meeting, the staff concluded that the information supports a finding that the transport originated in the SJVAB.

3. Geographic Setting

The GBVAB comprises Alpine, Inyo, and Mono Counties. A map of the GBVAB and surrounding area is provided in Figure 24. The GBVAB is bounded on the north by the Lake Tahoe Air Basin, on the east by the state of Nevada, and on the south by the Southeast Desert Air Basin (SEDAB). The GBVAB is potentially "open" to air flow from the SEDAB through the Owens, Panamint, and Death Valleys. However, generally mountainous terrain provides an effective barrier to air flow into the GBVAB from the Lake Tahoe Air Basin or from Nevada.

The GBVAB is bounded on the west by the SJVAB and the Mountain Counties Air Basin (MCAB). Along this western boundary, the Sierra Nevada rise steeply to peaks more than 14,000 feet in height. Passes between the mountain peaks typically are 9000 to 10,000 feet above sea level. These high peaks and passes form a significant but penetrable barrier to air flow from the west into the GBVAB. The staff's assessment indicated the SJVAB provided the greatest potential for transport of emissions to the GBVAB. The SJVAB comprises Fresno, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare Counties and part of Kern County.

Figure 24
TRANSPORT COUPLE
SAN JOAQUIN VALLEY to GREAT BASIN VALLEYS



The Mammoth Lakes monitoring site was the only ozone monitoring site in the GBVAB during 1986 through 1988 (refer to Figure 24). Mammoth Lakes is located 7 miles east of the SJVAB boundary and 135 miles north of the SEDAB boundary. The monitoring site is situated just east of the crest of the Sierra Nevada at an elevation of 7900 feet above sea level. Approximately four miles west of Mammoth Lakes, a pass at 9200 feet above sea level links the Mammoth Lakes area with the canyon of the middle fork of the San Joaquin River. The San Joaquin River canyon in turn descends southwestward to the floor of the San Joaquin Valley (SJV) near Fresno. The proximity of the Mammoth Lakes monitoring site to the head of a well-defined river canyon that extends to the SJV indicates the Mammoth Lakes site is well situated for monitoring ozone and ozone precursors that may travel up the river canyon from the SJV.

4. Summary of Previous Transport Studies

The staff could not find any studies that focussed exclusively on pollutant transport into the Mammoth Lakes area. However, the results of previous studies of transport from the SJV into the Sierra Nevada provide some insight to the potential for transport over the Sierra Nevada into the GBVAB. For example, Lehrman[1] sampled ozone with aircraft flights over the San Joaquin River canyon to a pass just west of Mammoth Lakes. Although Lehrman's study area did not include the GBVAB, the fact that his study found high ozone concentrations at the boundary of the study area in the river canyon a short distance from Mammoth Lakes strongly suggests that transport from the SJVAB to the GBVAB occurs.

5. Data

The staff's assessment of transport was based on data for 1986 through 1988 ("study period"). During the study period, there were 12 days during which the state standard for ozone was exceeded in the GBVAB. These 12 exceedance days occurred at the Mammoth Lakes site, the only ozone monitoring site in the GBVAB during the study period. The staff assessed the potential for transport on all 12 exceedance days.

In addition to ozone data from the Mammoth Lakes site, data from the 19 ozone monitors in the SJVAB and six ozone monitors in the north part of the SEDAB were also used in the transport assessment. Some data were also available from the National Park Service. The National Park Service conducted a special ozone monitoring study in the Sequoia National Park from July 4, 1986, through September 30, 1988.

6. Emission Inventory

Emission inventory data were available as totals for the state, air basin, or county. While such emission totals provide only general information, they were useful for determining the relative difference in emissions between various areas. This information provided a general indication of the potential for the emissions in each area to contribute to ozone concentrations.

Ozone precursor emissions primarily consist of emissions of reactive organic gases (ROG) and nitrogen oxides (NOx). The 1987 emission inventory data indicate that ozone precursor emissions in the SJVAB are 1289 tons/day. This is more than 36 times the ozone precursor emissions for the GBVAB--35 tons/day.

The staff did not make a quantitative determination of the relative contribution of the emissions in the SJVAB versus the contribution of the emissions in the GBVAB to the ozone exceedances in the GBVAB. The staff could not make a quantitative determination because the emission data are not resolved spatially or temporally and air quality models were not available for these areas. The staff made a qualitative conclusion, however, that emissions in the GBVAB were not capable of generating ozone concentrations that exceed the state standard.

7. Transport Assessment

The staff completed a meteorological assessment and an air quality assessment to determine the potential for transport of emissions into the GBVAB during the 12 exceedance days. The assessments are described below.

a. Analysis Considerations

1. Meteorological Data

Surface Winds. Surface wind data were available for the Mammoth Lakes monitoring site, Bishop Airport, Mammoth-June Lakes Airport, and China Lake Naval Weapons Center. The surface wind data for Mammoth Lakes indicate generally west winds during all 12 exceedance days. Surface wind data were not available for sites between the Fresno area and Mammoth Lakes. Therefore, the staff could not directly assess the potential for transport of pollutants up the San Joaquin River canyon.

Winds Aloft. Oakland, California and Tonopah, Nevada are the nearest sites for which upper air wind ("winds aloft") data collected by the National Weather Service were available. However, the staff believes the distance and diverse terrain between each of these locations and Mammoth Lakes is too great for these data to provide a reliable indication of upper air flow for Mammoth Lakes. Therefore, as an alternative to directly measured upper air winds, the staff calculated pressure gradients between Fresno and Bishop to estimate upper air winds. The staff also estimated upper air winds using data from weather charts for 18,000 feet. Winds at this level provide information about the direction and speed of the air flow which occurs above terrain influences.

Streamline Analysis. The staff reviewed streamline charts depicting wind direction patterns in the SJVAB to detect instances of the "Fresno Eddy." The "Fresno Eddy" is a counter-clockwise, circulating wind pattern in the southern part of the SJVAB, generally between Fresno and Bakersfield. The "Fresno Eddy" is characterized by winds from the north on the west side of the San Joaquin Valley that follow the terrain at the south end of the SJV. The winds then curve to come from the south along the east side of the SJV. Because the San Joaquin River canyon opens to the south, the "Fresno Eddy" can move air from the SJVAB directly up the canyon. Therefore, this wind pattern facilitates potential transport from the SJVAB to the GBVAB.

2. Air Quality Data

Time of Daily Maximum Ozone Concentration. The maximum hour ozone concentrations resulting from emissions in the area surrounding a monitoring site typically occur around solar noon but could range from 10 a.m. to 2 p.m. The maximum hour concentrations occurring earlier in the morning (before 10 a.m.) may be the result of fumigation of ozone trapped aloft from the previous day. While it is possible that early morning exceedances could be caused by the carryover of local emissions, the staff believes emissions in the Mammoth Lakes area are not significant enough to cause such exceedances. Maximum concentrations occurring in the late afternoon or during the early evening are most likely caused by the transport of a polluted air mass into the area.

b. Analysis Results

The staff evaluated the available meteorological and air quality data and determined that the contribution of transport from the SJVAB to ozone exceedances in the Mammoth Lakes area was overwhelming on each of the 12 exceedance days. The results of the staff's assessment are summarized in Table 23 and described below.

1. Meteorological Assessment

The location of Mammoth Lakes relative to the crest of the Sierra Nevada and the series of ridges and valleys in the immediate area results in considerable variation in measured wind direction. Although the specific direction varied, the prevailing surface winds measured at Mammoth Lakes reflect a general air flow from the west on all 12 days with exceedances. Because the San Joaquin Valley has high ozone concentrations and west winds blow from the SJVAB up the San Joaquin River canyon to Mammoth Lakes, the staff concluded there is evidence to support a finding of transport from the SJVAB to the GBVAB.

Four of the 12 exceedance days showed evidence of the "Fresno Eddy." This indicates the potential for transport of ozone and ozone precursors from the SJV directly up the San Joaquin River canyon.

Pressure gradients on 9 of the 12 exceedance days suggest air flow from Fresno toward Bishop. This provides further support for the occurrence of transport from the SJVAB to the GBVAB.

On 7 of the 12 exceedance days, upper air winds near 18,000 feet were from the west--from the SJVAB into the GBVAB. Two other exceedance days had upper air winds from the south--from the SEDAB into the GBVAB. Because the ridges and valleys in the GBVAB have a north-south orientation and two exceedance days had upper air winds from the south, the staff looked for evidence of ozone transport from the SEDAB into the GBVAB. The lack of air quality and surface wind data in the southern GBVAB precluded any definitive findings. However, the two exceedance days in question followed days with low ozone concentrations in the SEDAB and suggest no long distance transport of ozone from the SEDAB into the Mammoth Lakes area.

Another area with potential for transport to the GBVAB is the Mountain Counties Air Basin (MCAB). The staff could not exclude the MCAB as a potential transport contributor. However, the predominately west winds on exceedance days and the relatively small amount of ozone precursor emissions in the southern part of the MCAB as compared to the SJVAB indicate a comparatively small potential for contribution from the MCAB into the Mammoth Lakes area.

TABLE 23

SUMMARY OF ASSESSMENT OF OZONE TRANSPORT INTO THE GREAT BASIN VALLEYS AIR BASIN

	Meteorological Assessment				Air Quality Assessment
Date	Winds at Mammoth Lakes	Fresno Eddy Present?	Favorable Pressure Gradient?	Winds at 18000'	Time of Maximum Ozone Concentration
1986					
Jun 13-14	West		Yes	West	9 p.m., 12 & 3 a.m.
Aug 2	West-SWest		Yes	West	10 p.m.-12 a.m.
Aug 14	West-NWest		Yes	West	7 p.m.
Sep 6	NWest			West	5-6 p.m.
1987					
Apr 17	West	Yes	Yes	West	3, 4, & 6 a.m.
Apr 17	West		Yes	West	7 p.m.
Jun 4	West		Yes	West	12 a.m.
Aug 3	West	Yes	Yes	South	7-8 p.m.
Sep 6	NWest	Yes	Yes	South	6-7 p.m.
1988					
Jul 20	West				7 p.m.
Jul 21	West				4 p.m.
Sep 16	West-SWest	Yes	Yes	West	6-11 p.m.

2. Air Quality Assessment

The strongest indication that ozone exceedances at the Mammoth Lakes site were caused by transport is the time of day when the maximum ozone concentration occurred. The highest ozone concentration measured at

Mammoth Lakes between 11 a.m. and 2 p.m. was 9 pphm, not an exceedance of the state standard. Maximum ozone concentration from locally generated emissions would be expected to occur around solar noon, generally between 11 a.m. and 2 p.m. The maximum hour ozone concentrations at Mammoth Lakes on the 12 exceedance days occurred between 4 p.m. and 6 a.m. On 8 of the 12 exceedance days, the maximum concentration occurred after 6 p.m.

The staff also reviewed air quality data for sites in the SJVAB that could be upwind of air flow up the mouth of San Joaquin River canyon. On 9 of the 12 exceedance days at Mammoth Lakes, there were exceedances at several sites in the SJVAB. On the remaining three days, the maximum ozone concentration in Fresno County was 9 pphm.

The staff concluded that the evidence strongly supports the finding that the exceedances at Mammoth Lakes were caused by transport from the SJVAB because the state standard was exceeded at Mammoth Lakes only during the late afternoon through very early morning. Furthermore, on days when the state standard was exceeded at Mammoth Lakes, there were elevated ozone concentrations in the SJVAB that were then transported by west winds to Mammoth Lakes.

8. District Comments

The staff received no written comments from the Great Basin Unified Air Pollution Control District but discussed the proposed findings with the District staff on the telephone. The District staff concurred with the staff's proposed findings of overwhelming transport.

REFERENCES

1. Lehrman, D., Smith, T. B., and S. Gouze, 1980: *Upper San Joaquin River Valley Impact Study*. Final Rep. MRI 80 FR-1745, USFS Contract No. 53-9158-9-6251, Meteorology Research, Inc., 121 pp.

N. California Coastal Waters to the South Central Coast

1. Summary and Recommendations

The staff analysis shows that transport from the California Coastal Waters (CCW) can contribute approximately one pphm to peak ozone concentrations in the South Central Coast Air Basin (SCCAB).

The staff recommends that California Coastal Waters' transport be classified as "significant". Since the CCW are outside the jurisdiction of the state of California, no mitigation measures are proposed.

2. Conclusions

The staff believes that the contribution of California Coastal Waters emissions to exceedances of the state ozone standard (state standard) in the Ventura and Santa Barbara Counties portion of the South Central Coast Air Basin is significant. This conclusion is based on the assessment of ozone modeling simulations for September 7, 1984, using the Urban Airshed Model (UAM) with Carbon Bond II chemistry.

The assessment of transport from the CCW to the SCCAB was performed using a photochemical grid model. Because the modeling domain did not include San Luis Obispo County, this assessment is not applicable for San Luis Obispo County. References in this section to the SCCAB are to the Ventura and Santa Barbara Counties portion of the SCCAB.

The CCW are defined as offshore areas from which emissions may be transported onshore and impact air quality. In this analysis, emissions of nitrogen oxides (NOx) and reactive organic gases (ROG) in the CCW are primarily from petroleum exploration and extraction operations located more than 3 miles offshore from the coast of Santa Barbara and Ventura Counties in the SCCAB. The impact of these emissions on ozone concentrations in the SCCAB was evaluated using the Urban Airshed Model (UAM), a photochemical grid model incorporating the Carbon Bond II chemistry.[1,2] The analysis indicated that emissions in the CCW can contribute approximately one pphm to peak ozone concentrations in the SCCAB.

Wind directions in the Santa Barbara Channel are predominantly from the west but often become southerly with flow conducive to transport from the CCW to the SCCAB. September 7, 1984, was a high ozone episode day studied as a part of the South Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP).[3] Wind data collected on this day indicated southerly flow; therefore, this day was selected to evaluate transport from the CCW to the SCCAB. The UAM has undergone extensive model performance evaluation using data from this day and has been found acceptable for evaluating emission controls.

3. Geographical Setting

The SCCAB is comprised of San Luis Obispo, Santa Barbara, and Ventura Counties. The CCW refers to that area offshore California from which offshore emissions impact onshore air quality. In this section, however, SCCAB refers to only Santa Barbara and Ventura Counties and CCW refers only to the area offshore of those counties. For this evaluation, emissions in the CCW refers to emissions from petroleum exploration and extraction operations further than 3 miles offshore. Most of these emissions are located in the Santa Barbara Channel, offshore of Santa Barbara County.

4. Analysis

The evaluation of the impact of transport was based on a comparison of results from a base case simulation and a zero CCW emissions simulation using meteorological data from September 6 and 7, 1984. In the base case simulation, CCW emissions (projected for the year 2000) were included as part of the emission inventory inputs for the model. The zero CCW emissions simulation was the same, except that petroleum related emissions in the CCW were set to zero. Differences in onshore ozone concentrations between the two simulations were attributed to emissions in the CCW. These differences represent the contribution of CCW emissions to onshore ozone concentrations.

Emissions of ROG and NOx in the CCW are significant compared to emissions from Santa Barbara and Ventura Counties within the SCCAB. Emission estimates shown in Table 24 for the CCW were 6.7 percent of the total NOx inventory and 5.2 percent of the total ROG inventory for the air basin.

Figure 25
TRANSPORT COUPLE
CALIFORNIA COASTAL WATER to SOUTH CENTRAL COAST

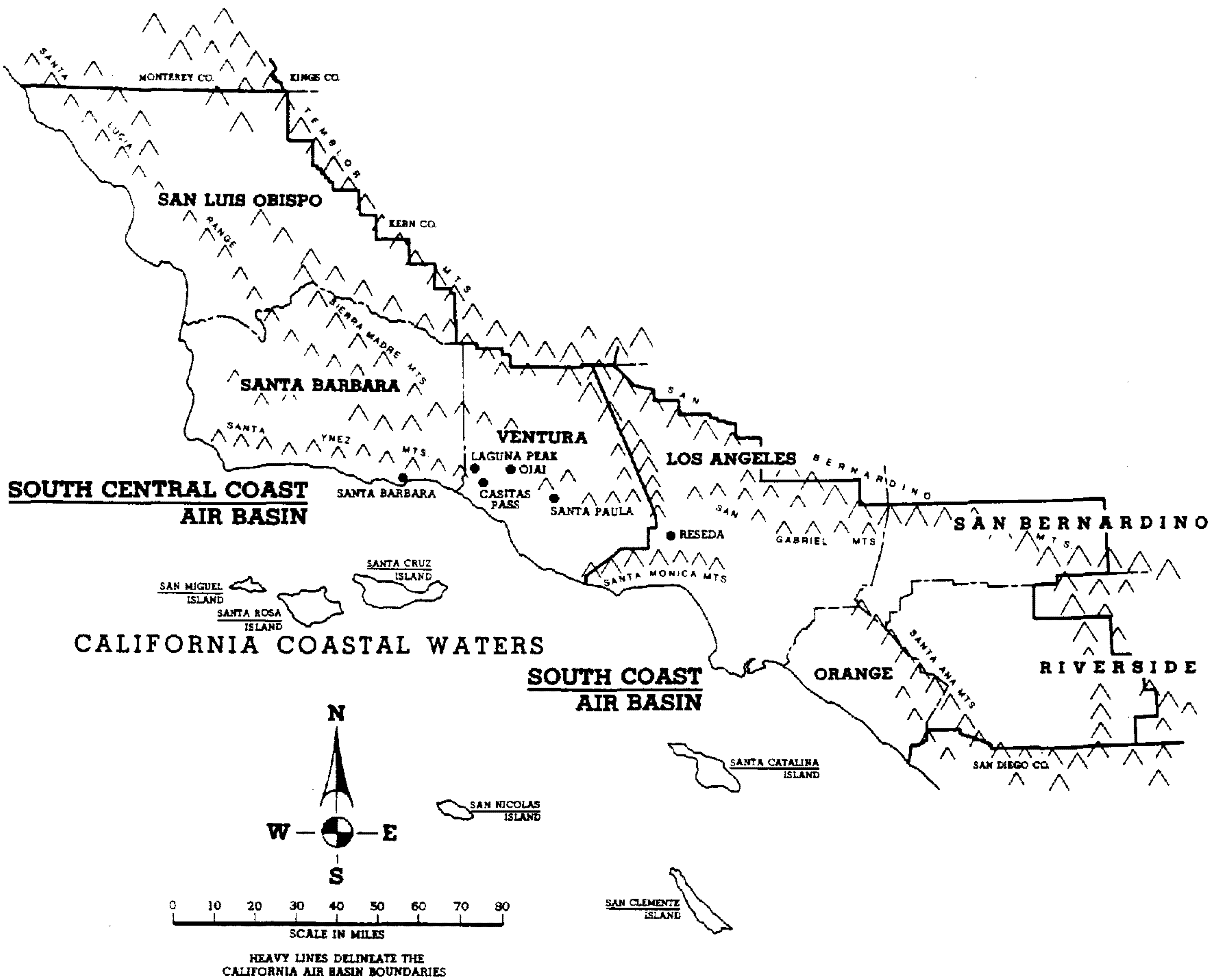


Table 24

Projected Year 2000 Emission Inventory for SCCAB and CCW*

County	Reactive Organic Gases (ROG) Emission ton/day	Reactive Organic Gases (ROG) Emission percent#	Nitrogen Oxides (NOx) Emissions ton/day	Nitrogen Oxides (NOx) Emissions percent#
Santa Barbara	49.2	34.0	34.7	34.0
Ventura	88.2	60.9	60.6	59.4
CCW	7.5	5.2	6.8	6.7
Totals	144.9		102.1	

* CCW emissions from petroleum extraction operations further than 3 miles offshore.

\# Percent of total Ventura, Santa Barbara and CCW emission inventory.

The comparison of simulation results in Table 25 indicates that emissions in the CCW increased peak ozone concentrations 0.7 pphm at Ojai and Santa Barbara and decreased peak ozone concentrations 0.1 pphm at Santa Paula. These changes are 5.5 percent of the peak at Ojai and 5.1 percent of the peak at Santa Barbara. From this analysis the ARB staff concludes that emissions in the CCW contribute to exceedances of the ozone standard in the SCCAB.

Table 25

Predicted Ozone for the Base Case and Zero CCW Emission Simulations

Monitoring Station	Peak Ozone Concentrations (pphm) Including CCW Emissions	Peak Ozone Concentrations (pphm) Excluding CCW Emissions	Difference	Percent Difference
Castro Peak	15.4	15.4	0.0	0.
El Capitan Beach	11.0	10.8	0.3	2.7
Oak Flat	12.5	12.0	0.5	4.0
Ojai	12.8	12.1	0.7	5.5
Santa Barbara	13.7	13.0	0.7	5.1
Santa Paula	15.5	15.6	-0.1	-0.6

References

1. Reynolds, S.D., et al., 1979. "An Introduction to the Airshed Model and its Usage", EF78-52R4 - EF79-31, Systems Applications, Inc., San Rafael, CA.

2. Whitten, G.Z. and H. Hogo, 1977. "Mathematical Modeling of Simulated Photochemical Smog", EPA-600/3-77-011.

3. Radian Corporation, 1985. "Analysis of the Data Collected in the 1984 SCCCAMP Field Program. Report to the South Central Coast Cooperative Aerometric Monitoring Program. No. SYSAPP-85/029.

VI. ALTERNATIVES

State law explicitly requires the Air Resources Board to assess the contribution of upwind emissions to downwind ozone levels, and to establish transport mitigation requirements that are commensurate with those contributions [Section 39610 (b)]. This mandate precludes consideration of the "no action" alternative. Various mitigation requirements are possible, however, and were considered by staff in developing this proposal. These alternatives are described and discussed in Chapter II (subsections D, E, and F). Staff believes that the recommended mitigation requirements are the most appropriate alternative, for the reasons stated in Chapter II.

VII. IMPACT OF PROPOSED REGULATION

A. Environmental Impacts

Adoption of the proposed transport mitigation regulations may result in both beneficial and adverse environmental effects.

As discussed extensively in Chapter III, NOx emissions both promote and inhibit the ozone formation process. When NOx emissions are reduced, ozone concentrations in the vicinity of the NOx sources may increase slightly. This is known as the "scavenging" effect; NOx emissions have the initial effect of breaking apart ozone molecules. However, as the air parcel drifts downwind and atmospheric processes continue, ozone reforms. During this process, the presence of greater NOx emissions leads to greater ozone formation.

In general, the staff believes that the impact of NOx controls will be positive on an overall basis both in the upwind and downwind area. Nevertheless, increased ozone (over the base case of no local NOx reductions) in the vicinity of NOx reductions is possible. However, this need not result in adverse health impacts. In some cases, these increases in ozone will still not result in violations of the health based standard. Where levels are increased and standard violations occur (or are simply not reduced) additional mitigation, in the form of more control of ozone precursors can be used to mitigate this impact. At worst, NOx control could delay attainment in a portion of the upwind area. If this is the case, the upwind district would be required to mitigate the effect of ozone scavenging, through the use of additional hydrocarbon or NOx controls.

Downwind areas, by contrast, have fewer options. Staff believes that upwind NOx reductions are necessary to decrease ozone concentrations in downwind areas, and that without such NOx reductions the likelihood of attainment is slim. Downwind districts need assistance from upwind transport-producers to overcome the violations of the state ozone standard that occur during transport conditions. When transport is overwhelming, downwind receptor areas, and all the persons residing within them, are completely dependent on their upwind neighbors.

The staff believes the proposed regulation offers the greatest environmental benefits with the fewest possible adverse impacts. Staff notes that the regulation has built-in flexibility; the NOx control requirement can be set aside by the upwind district upon a demonstration that NOx control is not needed for (or would be counterproductive to) attainment in the upwind and downwind area. Staff also notes that the mitigation requirements must be revisited at least once every three years, and may be revisited more frequently if new information suggests that different transport mitigation requirements are appropriate.

B. Economic Impacts

The Board's Executive Officer has determined that the proposed regulations will not create costs or savings [as defined in Government Code Section 11346.5(a)(6)] to any state agency or in federal funding to the state, costs, or mandate to any local agency or school district reimbursable by the state pursuant to Part 7 (commencing with Section 17500), Division 4, Title 2 of the Government Code, or result in other nondiscretionary costs or savings to local agencies except as noted below.

The air pollution control and air quality management districts responsible for areas designated nonattainment for ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide are required to develop and prepare plans pursuant to Health and Safety Code Section 40910 et seq. The costs incurred by the districts in connection with the planning process are not reimbursable by the state pursuant to Part 7 (commencing with Section 17500), Division 4, Title 2 of the Government Code because the applicable statutes do not mandate a new program or higher level of service of an existing program within the meaning of Section 6 of Article XIIIB of the California Constitution. In addition, districts have the authority to levy fees sufficient to cover their costs for planning, enforcement, and other district programs. See Health and Safety Code Sections 42311 and 41512.5

The adoption of regulations to mitigate the impact of transported pollutants is not expected, in itself, to result in any adverse economic effects. For this reason, the Executive Officer has determined that adoption of these regulations will not have a significant adverse economic impact on small businesses or on private persons or businesses (other than small businesses).

However, the regulations could result in district actions that have economic effects. Districts that are not otherwise required or have not otherwise chosen to adopt the prescribed control measures for reactive hydrocarbons and nitrogen oxides will be adopting and implementing such rules under the proposed regulations. Districts are required to include a preliminary assessment of the cost-effectiveness of control measures in their attainment plans adopted pursuant to Chapter 10 of the Health and Safety Code. Districts must also consider the cost-effectiveness of individual rules at the time of district rulemaking. An opportunity for public review and participation is provided on all district rulemakings. Any indirect economic effects resulting from the proposed regulations will be disclosed and addressed during the districts' proceedings.

The Board must determine, as part of its action on the proposed regulations, that no alternative considered by the agency would be more effective in carrying out the purpose for which the regulations are proposed, and that no alternative would be as effective and less burdensome to affected private persons than the proposed action.

ATTACHMENT A

PUBLIC MEETING NOTICE

Dear Sir or Madam:

Public Consultation Meeting to Discuss the Assessment and Mitigation of Pollutant Transport as Related to Ambient Ozone Concentrations within California as Required by the California Clean Air Act of 1988.

The Air Resources Board staff will hold a consultation meeting to discuss issues relating to the assessment of the impacts of transported pollutants on ambient ozone concentrations within California [see Section 39610(b and c) of the Health and Safety Code as amended by the California Clean Air Act of 1988]. The consultation will include a discussion of the proposed mitigation regulations for upwind and downwind areas also required by the Act.

The public consultation meeting will be held at the time and location noted below:

DATE: Tuesday, April 17, 1990

TIME: 10 AM to 3 PM

PLACE: Department of Consumer Affairs
1020 N Street
Room 102
Sacramento, CA 95814

Major topics for discussion include:

(1) the need for assessing the impact of tzansported pollutants within California;

(2) identification of models and other methods which can be used for this assessment;

(3) definition of the methodology which will be used to assess impacts of transported pollutants;

(4) proposed regulations covering mitigation required by both upwind and downwind air basins.

The purpose of the meeting is to obtain comments concerning the above issues. Should you have any questions, please contact Kit Wagner, Control Strategy Modeling Section manager at (916) 322-6156.

Sincerely,

Terry McGuire, Chief
Technical Support Division

Attachment

cc: Kit Wagner

pda/llb/T06200

AGENDA FOR THE PUBLIC CONSULTATION MEETING TO CONSIDER:

THE ASSESSMENT AND MITIGATION OF POLLUTANT TRANSPORT AS RELATED TO AMBIENT OZONE CONCENTRATIONS WITHIN CALIFORNIA AS REQUIRED BY THE CALIFORNIA CLEAN AIR ACT OF 1988

10:00	Welcome and Introductory Remarks	Gary Agid
10:15	Overview of Assessment Methods and Findings	Kit Wagner
10:30	Presentation of Transport Assessment and Findings	Steve Gouze Arndt Lorenzen Kit Wagner

Transport Couples

1 Undetermined to Great Basin Valleys
2 Broader Sacramento to San Joaquin Valley
3 San Joaquin Valley to Broader Sacramento Area
4 Broader Sacramento Area to Upper Sacramento Valley
5 Broader Sacramento Area to San Francisco Bay Area
6 San Francisco Bay Area to Broader Sacramento Area
7 San Francisco Bay Area to North Central Coast
8 San Francisco Bay Area to San Joaquin Valley
9 San Joaquin Valley to Southeast Desert
10 South Coast to Southeast Desert
11 South Coast to San Diego
12 South Coast to South Central Coast
13 South Central Coast to South Coast
14 California Coastal Waters to South Central Coast

12:00	Lunch	
1:15	Presentation of Transport Mitigation	Catherine Witherspoon
	Role of NOx Transport	Kit Wagner
	Mitigation Regulations	Patrick Nevis
2:15	Discussion	Moderator Gary Agid
3:00	Adjourn	

April 17, 1990 Transport Consultation Meeting Participants

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ATTACHMENT B

WRITTEN COMMENTS FROM THE PUBLIC

apcd
County of San Diego

R. J. Sommerville
Air Pollution Control Officer

Air Resources Board
RECEIVED
APR 25 1990
Office of Strategic Planning

April 20, 1990

TO: Catherine Witherspoon
Chief, Office of Air Quality Planning & Liaison
California Air Resources Board

FROM: R. J. Sommerville
Air Pollution Control Officer

TRANSPORT POLICY WORKSHOP

Draft Transport Assessment Findings

Characterizing Transport Cases

The terms being used are "Overwhelming", "Shared" (or "Substantial") and "Inconsequential". In discussion these were defined as meaning total transport, combination of local with transport and, no transport. While there was some indication that "Inconsequential" meant there may be some transport, perhaps an iota, the prevailing view was that this actually meant no transport, which was born out by the presented cases. I suggest "Inconsequential" be changed to "None". I think this more clearly makes the relevant point that these days represent smog levels caused by local emissions not influenced by transported pollutants from upwind sources.

Draft Regulations

Section 70600 (1b) (2b) (3b)

These pertain to the overwhelming case which requires upwind areas to totally mitigate the impact in downwind areas. The problem is in 70600(1)(b), (2)(b), and (3)(b), when taken in conjunction with 70601(2). The indicated provisions in 70600 require the specified upwind area to mitigate impacts "during meteorological conditions that are comparable to those observed on" specified dates. (Note that this language is loose. For example, who determines what is "comparable".) Since 70601(2) makes downwind areas responsible for everything not specified in 70600(1)(b), (2)(b), and (3)(b), that means a downwind area is responsible for "Shared" transport cases without regard to the level of contribution between the downwind and upwind area, and even "Overwhelming" cases if not explicitly enumerated in 70600 and not "comparable".

Unless ARB is willing to develop proposed policies to deal with the complexities of the "Shared" case, I suggest the focus be limited to mitigating overwhelming transport and nontransport days in transport impact areas in the 1991 Plan. This could be done by modifying 70601(2) to read "may consider those ozone exceedances in their jurisdiction caused by local emissions not influenced by transported pollutants".

AIR POLLUTION CONTROL DISTRICT
9150 Chesapeake Drive. San Diego, California 92123-1095
(619) 694-3307

Someone may point out that this may not allow the ARB to make a finding that the plan is adequate to meet requirements because, in theory, a "Shared" day may require a different or more rigorous control strategy in either or both the upwind and downwind area. If that's a critical issue, some realistic process for addressing the "Shared" case will have to be developed so ARB can make a finding in the context of an established process. If a process is not acceptable, then ARB will have to develop a policy to establish the level of responsibility between upwind and downwind areas based on the contribution to a violation. Since there is almost no way the necessary analysis can be done to quantitatively evaluate "Shared" days (and perhaps not "Overwhelming" days) by the time the 91 Plan is due, it doesn't seem reasonable to take this task on now.

The provisions of 70600(4)(5) have to be changed. It makes no sense to require the South Central Coast Air Basin to adopt a SCAQMD attainment plan simply because these are "Shared" days. I'm sure someone has pointed out that the SCAQMD Implementation Plan is based on a totally different scenario than the "Shared" one. The other thing is the subarea issue. There needs to be something to address this. It makes no sense to require certain control measures in comparatively rural areas within an air basin. I don't think this was the intent, but it needs to be remembered that after the regulation is adopted, it can be used for different agendas.

An interim way of dealing with this is to require coupled districts with "Shared" days with different attainment plans containing similar reactive hydrocarbon and oxide of nitrogen control measures, implement the most stringent control measures in the most expeditious period identified in either of the attainment plans.

In the final analysis, it will be necessary to come up with a policy based on the relative contribution to a violation occurring on a "Shared" event among coupled air basins.

R. J. SOMMERVILLE
Air Pollution Control Officer

RJS:vch

Mobil Exploration & Producing U.S. Inc.

P O BOX 9989
BAKERSFIELD, CALIFORNIA 93389-9989

(805) 321-3713

April 23, 1990

Catherine Witherspoon
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

7.01.2.6.2 CA Clean Air Act
Pollutant Transport Mitigation

Dear Ms. Witherspoon:

I appreciated the opportunity to attend your workshop of April 17, 1990 regarding proposed transport mitigation requirements. The mitigation of this intrastate pollutant transport is essential to air quality planning efforts throughout California to meet the state CAA requirements.

The simplicity of the proposed regulations, Section 70600 through Section 70601, is to be commended. Timing of the upwind district's compliance is one key aspect that I believe warrants specification. Though the state CAA often requires action as early as practicable, control measures adopted by the downwind districts should be adopted by the upwind districts within 6 months. Similarly, control measures in the downwind district's attainment plan should be contained in the upwind district's plan at the same time. That is, all measures in the June 1991 San Joaquin Valley plans should be contained in the 1991 San Francisco Bay Area plan. Attainment efforts in all coupled air basins must be contemporaneous in order to be equitable.

The implementation of these regulations will be problematic at best because of the numerous districts involved. I suggest that fuller implementation guidelines be issued as soon as possible to assure orderly development of the 1991 attainment plans.

Please add my name to any mailing lists for future distribution of transport assessment and mitigation workshop notices and proposed regulation.

Sincerely,

P.E. Brinkmann

Philip Brinkmann
Sr. Staff Environmental Engineer

trans.doc

cc: Tom Paxson, KCAPCD
Patrick Nevis, CARB

MONTEREY BAY
UNIFIED AIR POLLUTION
CONTROL DISTRICT
1164 Monroe Street, Suite #10
Salinas, California 93906-3596
(408) 443-1135
FAX (408) 443-1064

Rec'd
5/3/90

April 26, 1990

Rich Bradley, Chief
Air Quality Data Branch
Technical Support Division
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Subject: Comments on Preliminary Transport Assessment Findings for the California Clean Air Act

Dear Rich:

The Monterey Bay Unified Air Pollution Control District has reviewed the Air Resources Board's preliminary transport assessment findings for the California Clean Air Act. The North Central Coast Air Basin is currently being proposed as a receptor of overwhelming pollutant transport from the San Francisco Bay Area, based on 1986-1988 data showing exceedances of the State ozone standard at Hollister. Realizing the limited meteorological data the ARB had to work with, the designation of overwhelming transport for the entire air basin should probably not be considered conclusive.

There are several questions which need to be answered before such a definitive finding can be made. There is a need to review and analyze data for exceedances or near exceedances which have occurred in other areas of the District. If the emissions from the Monterey Bay Area do not impact the Hollister area on days of overwhelming San Francisco Bay Area transport, is it important to determine where they do impact. Previous studies have indicated the existence of a convergence zone between Hollister and Gilroy, where the Santa Clara Valley northerly winds meet the Monterey Bay westerly winds. Also, could there be any long range transport aloft from PG&E's Moss Landing power plant to San Benito County.

The District would like to work with the ARB in determining the extent of pollutant transport for all areas of the North Central Coast Air Basin which have the potential of exceeding the State ozone standard. If you have any questions, please call me or Bruce Katayama at (408) 443-1135.

Sincerely,

Douglas Quetin, Chief
Planning and Air Monitoring Divisior

Stanislaus County

Department of Environmental Resources

Air Pollution Control District

1716 Morgan Road
Modesto, California 95351
(209) 525-4152

April 26, 1990

Terry McGuire
Air Resources Board
P. O. Box 2815
Sacramento, CA 95812

RE: Comments on Preliminary Transport Assessment Findings

The preliminary draft of the Transport Assessment Findings categorizes the impacts of transport on ozone for the San Francisco Bay Area to Broader Sacramento as Overwhelming, Shared and Inconsequential. However, the impacts of transport to the San Joaquin Valley by the Bay Area are classified as only Shared and Inconsequential. This District is concerned that there was not a finding of Overwhelming Impact on the San Joaquin Valley. The marine influences that would transport Bay Area pollutants to the Broader Sacramento Area are the same ones that would transport pollutants to the San Joaquin Valley. The October 1989 staff report <u>Proposed Identification of Districts Affected by Transported Air Pollutants</u> on page 27 first paragraph states the following. *When studying transport from the Bay Area Air Quality Management District (BAAQMD) to air basins in the Central Valley, one must bear in mind that the BAAQMD includes not only the industrialized areas along the Carquinez Strait, but also a large area east of the coastal mountains in Solano, Contra Costa, and Alameda Counties. The boundary between the BAAQMD is an administrative one, unmarked by any topographical feature. Thus, there is nothing to prevent any pollutant originating in or transported to the eastern portion of the BAAQMD from being advected across this boundary.* What rationale and supporting data was used by ARB to determine the difference in impact of transported Bay Area pollutants on these two neighboring areas of the Central Valley.

Pacheco Pass is shown as one of the transport routes into the San Joaquin Valley in the October Report on page 26 (figure 7). This map delineates a transport route from the South Bay Area that joins up near Hollister with a transport route from Monterey Bay and continues through the Pacheco Pass to the San Joaquin Valley. Transport from the Bay Area to Hollister in the North Central Coast Area was discussed at the workshop on April 17 and was described as overwhelming. No mention was made at this workshop nor in the Draft Assessment Findings of transport from the North Central Coast Area or the Bay Area to the San Joaquin Valley through Pacheco Pass.

Using the data from only one day to justify some of these qualitative transport rankings distorts impact that one area may have on another. The impact of transport from the SF Bay Area on the San Joaquin Valley appears to be accorded the same status as the impact of transport from the Greater Sacramento Area on the San Joaquin Valley. We also believe the San Joaquin Valley Air Quality Study has already developed useful information that should be considered in determining these Transport Assessment Findings.

The District would appreciate a copy of relevant material and data that was used to determine the Transport Assessment Findings for the San Joaquin Valley Couples.

MARK BOESE
Deputy Air Pollution Control Officer

MB:DJ

cc: Arndt Lorenzen, ARB
Rich Bradley, ARB

MAY - 1 1990

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

April 30, 1990

Mr. James D. Boyd
Chief Executive Officer
California Air Resources Board
1102 Q Street
Sacramento, CA 95814

Dear Mr. Boyd:

I am extremely concerned at recent proposals from the California Air Resources Board staff regarding pollutant transport mitigation. Based upon my review of the documents distributed at ARB's April 17 workshop, I find that the transport mitigation proposals are inconsistent with the overall goals of the California Clean Air Act (CCAA).

Staff proposals, if adopted, would severely compromise all of the following CCAA goals: a) attaining standards at the earliest practicable date, 2) using efficient and cost-effective control strategies, 3) preparing plans that reflect the nature and extent of pollution in each region, and 4) coordinating planning activities with federal law. The ARB staff proposal would also defeat the potential benefits provided in the Act for iterative planning to incorporate information not previously available.

ARB proposals for transport mitigation--combined with other announced policies on annual emission reduction accounting, criteria for attainment, and alternate indicators--impose air quality planning by administrative proclamation. They preclude the rational planning process envisioned in the Act.

We have made major resource investments in monitoring, data analysis and modeling capabilities to provide a sound and quantitative technical foundation for the Bay Area planning process. Other districts and agencies have made similar efforts. An obvious example is the multi-million dollar San Joaquin Valley/AUSPEX study for this summer.

It now appears that ARB wants to short-cut the scientific studies necessary for sound policy. Specific ARB-funded projects to address transport are:

1. The San Joaquin Valley Air Quality Study.
2. Methods Development for Quantification of Ozone Transport for California.

939 ELLIS STREET • SAN FRANCISCO, CALIFORNIA 94109 • (415) 771-6000 • FAX (415) 928-8560

These studies are in their startup stages, yet ARB's proposals would ignore their existence and substitute an administrative mechanism to define control strategies for the seven-year period covered by the 1991 plans. We submit that this is poor science and poor policy.

While there is some information on windflow between California air basins, ARB has furnished no reliable quantitative analysis of the relative contribution of upwind emissions to downwind pollutant levels, and therefore has no reliable way to establish mitigation requirements commensurate with the level of contribution. ARB's proposed policies require simultaneous hydrocarbon and NO_x controls in all upwinds areas, with inventory reductions at the rate of five percent per year.

To our knowledge, there is no evidence that equal percentage control of HC and NO_x in the Bay Area (or elsewhere) is the most effective way to attain ozone standards in the upwind or downwind districts. If ARB has such analysis to support their proposals, we request that it be provided to us for review.

There is, in fact, a body of evidence that simultaneous HC and NO_x controls may be counterproductive, and can delay attainment while increasing total ozone exposure, health risks, and property damage. It is highly unlikely that five percent per year reductions in both HC and NO_x would provide an optimal path to ozone attainment in any given area, let alone for all the varied circumstances around the State.

We will analyze and develop control measures for both HC and NO_x control in the Bay Area, but it would be imprudent and improper to adopt control measures without an analysis and demonstration of their cost-effectiveness. Our planning process will provide that analysis and we will proceed accordingly in preparing our plan for submittal in 1991.

We share the ARB concern--and the Legislature's intent--to maintain progress in the quest for clean air. There is a very real risk, however, in imposing costly controls and painful lifestyle changes if little or no benefit is achieved. Hasty policy decisions, if ineffective, will erode credibility and cripple future legitimate control efforts.

The Act does not, in fact, require or encourage hasty action. Section 39610(a) does require a first cut at identification of receptor and source districts by December 31, 1989. ARB has met that deadline. The Act also requires (39610(c)) every reasonable effort to notify heavily impacted districts prior to the development of plans, so that they not be held accountable for the entire ozone concentration measured within their districts. This is a prudent and practical course of action, which ARB can also accommodate.

There is <u>no specific deadline</u> for specifying additional mitigational measures for upwind districts. Upwind districts, in planning for local attainment, will automatically reduce pollutant exports and thereby benefit downwind areas. We suggest that no additional mitigation measures be applied to upwind areas until peer-reviewed analyses show cost-effective benefits. Because many upwind areas already have aggressive control programs in place, applying costly additional controls without demonstrated benefits would be especially inequitable. Even given (a) a showing of transport contribution, and (b) a legal responsibility to alleviate downwind impacts, an upwind source operator might identify more cost-effective ways to reduce downwind ozone by an equivalent amount, for example by purchasing offsets somewhere along the transport path, including within the downwind district.

Based on these considerations, we request that:

1. ARB use analysis of non-transport or "inconsequential" exceedance days to define planning requirements for receptor areas, per Section 40921 of the Act.

2. ARB provide area-specific technical analyses to demonstrate the cost-effectiveness of proposed policies or, absent such demonstrations, that ARB refrain from specifying control strategies for upwind districts.

3. ARB use the results of the San Joaquin Valley/AUSPEX Study, the Methods Development for the Quantification of Ozone Transport, and other studies and modeling analyses as necessary to determine the most expeditious and cost-effective ways to reduce transport-induced exceedances of ambient air quality standards.

4. The State Modeling Center and the Modeling Advisory Committee provide or review protocols and analyses, because costly control decisions hinge on the results.

5. ARB include in its Staff Report to the Board, prior to the public hearing on these matters, responses to our requests, and to the more detailed comments and questions in the attachment to this letter.

Sincerely,

Milton Feldstein
Air Pollution Control Officer

MF:ey

Enclosure

cc: Roberta Hughan
Jack Lagarias
Terry McGuire
CAPOCOA

Bay Area Air Quality Management District
Comments on ARB's Preliminary Transport Assessment Findings

1. The transport assessment analysis performed by ARB staff involved some data-rich and some data-sparse areas (in terms of air quality and meteorological data). ARB should include in its report a statement on the uncertainty associated with each analysis. ARB should also provide recommendations for acquiring the needed information for cases of high uncertainty.

2. To what extent were prognostic and/or diagnostic wind models used to quantify 3-dimensional wind and thermal structures, particularly at times and places where observational data were unavailable?

3. Did ARB perform any photochemical model simulations to quantify transport impacts and to evaluate the sensitivity of down wind ozone to upwind and local changes in hydrocarbon and nitrogen oxide emissions? Shouldn't the model simulations be performed prior to the development of control scenarios?

4. Extensive sets of meteorological and air quality data, surface and aloft, were collected during the 1989 field studies in the Bay Area and in Sacramento. Was any of this information reviewed or evaluated for its potential to improve the transport assessment analysis?

5. Geographically, eastern portions of the Bay Area are in or adjacent to the San Joaquin Valley. On high ozone days in the Bay Area and Northern San Joaquin Valley, winds are often light and variable, sometimes with persistant weak east-to-west pressure gredients. In view of this, does ARB staff think it reasonable to assume that Bay Area portions of the northern SJU, such as Brentwood, are never impacted by transport from the east?

6. Prior to and after the 12/14/89 Air Resources Board meeting, BAAQMD submitted to ARB detailed analyses and trajectories showing transport from the North Central Coast (NCC) counties contributing to Bay Area ozone exceedances. ARB judged that the issue needed further study. Now ARB findings of "Overwhelming" and "Shared" transport are based on ARB analyses with less data and greater uncertainty. These are not adequate to support the sweeping policy recommendations. Wouldn't it be prudent to delay the findings until there is less uncertainty?

The following questions are in reference to the Draft of Chapter III: The Findings from Transport Assessment, dated 4/26/90.

7. In its analysis of transport from the Bay Area to the NCC Air Basin, ARB staff assumed that afternoon winds at 1000 feet above Oakland are representative of flow aloft between the Santa Clara Valley and Hollister. Were morning winds over Oakland also considered? Have any studies been done to verify that this assumption is valid on smoggy days?

8. The Lawrence Livermore National Laboratory performed a photochemical modeling study of transport from the Bay Area to the NCCAB (Penner and Connell, 1988). This study, funded by ARB, found NCCAB ozone to be insensitive to changes in Bay Area HC and NO_X. How would ARB staff reconcile these findings with its own determination of "overwhelming?"

9. As part of its reasoning that there is an "overwhelming" impact, the ARB points out that emissions in Santa Clara and San Mateo counties exceed San Benito County's emissions by a factor of 40. The ARB staff also states that it "cannot assess the specific contribution of emissions from San Benito County." Did ARB staff attempt to estimate the fraction of the emissions from San Mateo and Santa Clara Counties which are actually transported to San Benito County?

10. ARB staff studied 12 days in 1986-88 on which Hollister exceeded the State standard. We find no reference in the report to any wind observations in the NCCAB. On six of the 12 days San Jose appears to have been the closest site with complete hourly wind measurements. Does ARB staff feel that it can assess the frequency and impact of transport in an area where there is no wind data. at the surface or aloft?

11. On page 9, two episodes are described as having "north through east winds over the two basins." ARB staff concludes that "north through east winds associated with this pressure pattern provide sufficient evidence to support a finding of transport of air pollutants from SFBAAB to the NCCAB." Did ARB staff consider the possibility of transport aloft from the San Joaquin Valley?

12. On page 10, ARB staff used persistant moderate northwest winds at San Martin on six exceedance days to "support a finding of transport of ozone and ozone precursors up the Santa Clara Valley from San Jose to Hollister." Beginning in August of 1989 the BAAQMD began recording wind data at Gilroy, about five miles SSE of San Martin. The data show numerous occasions on which there are simultaneous NW winds at San Martin and SE winds at Gilroy (confirming the existence of a convergence zone in this area). In view of this more recent information, does ARB staff consider it prudent to reevaluate the adequacy of San Martin as an indicator of Santa Clara winds?

Northern Sierra Air Quality Management District

540 Searls Ave., Nevada City, CA 95959 (916) 265-139

AIR RESOURCES BOARD
Received
MAY 22 1990
Technical Support Division

May 18, 1990

Mr. Rich Bradley, Chief
Air Quality Data Branch
California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Re: Comments on Preliminary Transport Assessment Findings

Dear Mr. Bradley:

I have reviewed your April 19, 1990, information package on the preliminary transport assessment findings. I am concerned that an obvious transport couple has, for whatever reason, been omitted from the list of areas needing additional research. I suggest that an eleventh couple be identified - the upper Mountain Counties, consisting of the upper portions of El Dorado, Placer, and all of Nevada County. These areas do not share the topography, population, industrial and motor vehicle inventory characteristics of the Sacramento Valley. They are basically rural areas that are located up slope and down wind of the Sacramento Metro region. In my opinion, they are the quintessential receptor areas. Additionally, there is a general paucity of data on which to base a decision to include these areas in the Broader Sacramento area. Although including these areas may ameliorate your task of assessing transport fractions, it is not realistic to lump these areas into the Broader Sacramento area and, thereby, mandate control measures that are more applicable to a heavily populated and widely industrialized area. We are requesting the following:

1. That an additional transport couple for the areas previously outlined be developed and researched and that transport from Broader Sacramento to upper Mountain Counties be classified as overwhelming.

2. That the Air Resources Board meets its assessment responsibilities by providing an ozone monitor for the Nevada City monitoring site for 1990.

The mandates of the California Clean Air Act promise to be a difficult challenge for all of us to meet. It is essential that we make decisions based on the most accurate information available, so that the people affected will know that what they are being asked to do will, in fact, be an effective strategy for achieving the ambient air quality standards.

To this end, we are prepared to do our part, but will insist that our decisions be based on a sound and equitable rationale.

Sincerely,

Russell A. Roberts
Air Pollution Control Officer

RAR/jz

cc: Northern Sierra Air Quality Management District Board of Directors
Nevada County Board of Supervisors
Noel Bonderson, APCO, Placer County APCD
George Beland, Chairman, Placer County Board of Supervisors
John Cefalu, Chairman, El Dorado Board of Supervisors
Jim Thompson, El Dorado APCD
Catherine Witherspoon, Office of Air Quality Planning and Liaison

RESOURCE MANAGEMENT AGENCY
county of ventura

Air Pollution Control District

Richard H. Baldwin
Air Pollution Control Officer

AIR RESOURCES BOARD
Received
MAY 23 1990
Technical Support Division

May 21, 1990

Kit Wagner
California Air Resources Board
Technical Support Division
P.O. Box 2815
Sacramento, CA 95812

Dear Kit:

Enclosed is an analysis of an ozone episode in Ventura County which exceeded the CAAQS where transport from outside the South Central Coast Air Basin (SCCAB) was inconsequential. In addition to the shared and overwhelming transport categories already assigned by CARB, this analysis should be used as evidence to designate the SCCAB as having inconsequential transport.

If you have comments or need additional information regarding this analysis, please call me at (805) 654-2790.

Sincerely,

Evan M. Shipp

Evan M. Shipp
Air Quality Specialist II

cc Bill Mount, VCAPCD
Tom Murphy, SBAPCD

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Government Center, Administration Building
800 South Victoria Avenue, Ventura, CA 93009 (805) 654-2806 Fax Number (805) 654-2842

ANALYSIS OF AN EXCEEDANCE OF THE CALIFORNIA AMBIENT AIR QUALITY STANDARD WITH INCONSEQUENTIAL TRANSPORT FROM OUTSIDE THE SOUTH CENTRAL COAST AIR BASIN

The South Central Coast Air Basin (SCCAB) has been preliminarily classified by CARB as having both shared and overwhelming transport from the South Coast Air Basin (SCAB). The District believes that there are also days in the SCCAB that exceed the CAAQS where transport is inconsequential. ARB staff has indicated that determination of one inconsequential day would also place the SCCAB into the inconsequential category. This meteorological analysis contains an example of such a day.

The following example will document a westerly flow ozone event in the SCCAB. We believe that, during an episode where net westerly flow (both surface and aloft) is occurring, transport of ozone and ozone precursors from the SCAB to the SCCAB is inconsequential. Moderate easterly flow is required for both transport routes identified by CARB in "Proposed Identification of District's Affected by Transported Pollutants which Contribute to Violations of the State Standard for Ozone", 1989. Transport directly to the SCCAB from the San Fernando Valley requires moderate southeast winds aloft. The overwater transport route to the SCCAB, also identified by CARB, requires moderate to strong southeast winds followed by the onset of a seabreeze.

With the exception of the Santa Clara River Valley, complex terrain acts as a barrier to morning transport of pollutants on drainage winds. The eastern portion of the SCCAB is bounded by elevated terrain which is the source of localized drainage flow. This shallow flow does not transport pollutants from the SCAB.

We have selected May 9,10, and 11, 1988, as an example of an episode which exceeded the CAAQS for ozone and where transport from outside the basin was inconsequential. During this period, maximum daily ozone concentrations were 7,11, and 10 parts per hundred million (pphm) respectively. These maximum concentrations occurred at Simi Valley and Thousand Oaks. A tabular summary of the pollutant and meteorological parameters is shown in Table 1 at the end of this report.

During most of the three day period, the study days exhibit westerly flow both aloft and at the surface. The westerly wind is indicative of emissions moving from offshore and coastal areas of Ventura County to receptor areas inland. Winds exhibit the normal land/seabreeze circulation during the period.

Wind roses summarizing the surface winds throughout the period show that the majority of wind directions were in the western quadrant. We have included wind rose plots for Ventura, El Rio, and Simi Valley at the end of this report. These stations represent roughly the path pollutants would take to arrive at Simi Valley from the Oxnard Coastal Plain. We have also included an ozone rose of Simi Valley showing that during higher ozone concentrations the surface winds were from the west.

There were shallow drainage winds during morning hours of the study period; however, it does not appear that these winds were of sufficient strength to bring ozone and ozone precursors over terrain boundaries from the SCAB to the SCCAB.

Most upper level winds recorded in the first 5000 feet were westerly; however, there were some levels in the morning soundings which exhibited winds with easterly components. On the morning of the ninth southeast winds occurred at 1000 feet and northeast winds occurred at 2000 feet. On the morning of the eleventh, northeast winds occurred at 1000 and 2000 feet. In addition, on the morning of the eleventh northeast winds occurred at 1000 feet and east winds at 5000 feet. With the exception of the wind at 5000 feet, all morning speeds were less than 3 knots. Since easterly winds were of such low magnitude, it does not appear that there was significant transport from the east in these levels. With the exception of the winds at 5000 feet on the eleventh, all afternoon winds aloft were westerly. The layer at 5000 feet on the eleventh was decoupled from the lower levels by a strong inversion. Therefore, transport in this layer appears to be inconsequential. Table 2 summarizes Pt. Mugu upper air data for the period.

Table 2

Summary of Upper Air Data
For May 9, 10, 11, 1988

Date	5/9	5/9	5/10	5/10	5/11	5/11
Time	7:42	14:56	9:18	14:51	7:59	13:59
Inversion Base						
height(m)	2	151	2	139	98	134
temp (°C)	11.7	14.2	18.1	16.3	14.2	15.9
Inversion Top						
height(m)	1102	646	1087	623	365	600
temp (°C)	15.7	18.7	21.6	24.8	26.1	27.8
Winds						
1000 ft	130-02	249-07	081-02	279-04	010-02	279-09
2000 ft	034-03	313-08	006-03	296-06	330-07	279-16
3000 ft	299-06	293-14	303-06	297-08	323-07	263-04
4000 ft	300-11	280-12	287-08	308-04	339-03	231-04
5000 ft	303-09	290-09	269-08	328-03	086-05	094-02
1000 mb						
wind	296-00	275-10	255-01	282-10	352-05	310-10
height(m)	159	156	166	155	140	136
850 mb						
temp (°C)	13.9	15.9	18.2	19.6	20.8	21.8

Limited vertical mixing above Ventura County indicate that terrain in the eastern end of the county would act as a barrier to transport from the SCAB. Mixing heights on both days exceeding the CAAQS were low. Inversion bases recorded at Pt. Mugu at about 1400 PST on May 10 and 11 were 139 and 134 meters respectively.

The 850 millibar temperature, an indicator of ozone potential, were above the smog season (May-October) average of 18.0 degrees Celsius. 850 temperatures warmed through the study period. By 1400 PST on the eleventh the 850 millibar temperature was 21.8 degrees Celsius. This is an indication of increased subsidence through the period.

In conclusion we believe that May 9,10,11, 1988, was an example of a westerly transport day where emissions from outside the SCCAB had an inconsequential effect on ozone concentrations. We also believe that this transport pattern is quite common in our county during "exceedances" of the CAAQS. With more than 100 exceedances of the CAAQS a year, is seems very likely that this meteorological regime is not a rare event. Given this, we are requesting the ARB to designate the SCCAB as having shared, overwhelming, and inconsequential transport.

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Ventura County APCD Historical Report

TABLE 1

May 10, 1988

Station	Parameter	Units	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
VENT	NOX	PPHM	5	CAL	6	4	6	14	8	2	2	3	2	1	1	INV	INV	INV	1	1	1	1	1	2	5	5
	NO	PPHM	2	CAL	4	2	3	10	8	1	1	1	1	0	0	INV	INV	INV	0	0	1	0	0	0	1	1
	O3	PPHM	0	CAL	1	1	0	0	1	2	3	2	3	4	4	INV	INV	INV	4	4	4	4	4	3	1	1
	WSV	MPS	1	1	2	1	1	1	1	2	3	3	4	4	5	6	5	5	4	4	4	3	2	1	2	2
	WDV	DEGA	0	38	48	69	32	40	317	278	276	266	274	274	277	283	285	279	279	280	278	290	280	291	293	296
	TMP	DEGC	12	12	12	12	12	12	13	15	16	16	16	16	16	16	16	16	16	15	14	14	14	13	13	13
	HMD	%	95	90	93	94	94	93	87	82	77	81	82	84	83	83	83	80	82	88	93	93	99	99	99	99
SIMI	THC	PPTM	CAL	22	27	25	23	25	27	22	19	18	18	18	18	19	19	19	18	18	18	21	22	24	23	27
	SO2	PPHM	CAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CO	PPM	CAL	1	1	1	1	3	5	3	1	1	1	0	0	1	1	1	1	1	1	2	2	2	2	2
	NOX	PPHM	CAL	4	4	4	8	16	27	17	2	1	1	1	0	1	1	1	1	1	1	8	10	10	9	9
	NO	PPHM	CAL	0	1	0	4	12	21	12	0	0	0	0	0	0	0	0	0	0	0	2	4	5	4	4
	O3	PPHM	CAL	1	0	0	0	0	1	2	5	6	6	8	8	11	11	9	7	6	6	1	1	0	0	0
	WSV	MPS	0	0	0	0	0	0	0	0	0	1	1	2	4	6	5	4	4	3	1	0	0	0	0	0
	WDV	DEGA	77	66	100	78	84	90	102	175	217	266	257	256	256	265	259	251	252	269	229	71	65	77	71	90
	TMP	DEGC	14	13	12	12	11	13	18	24	29	30	31	32	33	31	29	29	29	29	25	21	19	18	17	17
	HMD	%	72	74	81	81	80	77	62	43	32	29	29	26	27	34	36	34	32	36	39	46	55	59	62	65
	SRA	LANM	0	0	0	0	0	6	34	62	86	109	124	131	129	119	103	81	55	27	4	0	0	0	0	0
ELRO	CO	PPM	CAL	1	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
	NOX	PPHM	CAL	4	3	3	3	4	5	5	6	5	3	3	2	2	2	2	2	2	2	2	3	4	3	3
	NO	PPHM	CAL	1	1	0	0	1	2	2	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	O3	PPHM	CAL	1	1	1	1	1	2	2	2	4	5	7	6	6	7	7	6	6	4	4	3	2	2	2
	WSV	MPS	0	0	0	1	2	3	4	2	0	2	3	4	5	5	4	5	3	2	1	1	0	0	3	1
	WDV	DEGA	129	99	81	32	32	25	26	24	256	256	253	254	253	253	242	249	240	240	250	248	253	23	25	3
	TMP	DEGC	12	12	11	11	11	13	15	19	22	23	23	22	21	21	21	21	21	20	17	15	14	14	16	16
	HMD	%	100	100	100	100	100	92	81	66	62	62	64	62	64	64	64	65	64	67	87	97	100	100	67	83
	SRA	LANM																								
ANAC	THC	PPTM																								
	NOX	PPHM	0	CAL	0	0	0	0	0	0	0	INV	INV	INV	0	0	0	0	0	0	0	0	0	0	0	0
	NO	PPHM	0	CAL	0	0	0	0	0	0	0	INV	INV	INV	0	0	0	0	0	0	0	0	0	0	0	0
	SO2	PPHM	0	CAL	0	0	0	0	0	0	0	INV	INV	INV	0	0	0	0	0	0	0	0	0	0	0	0
	O3	PPHM	4	CAL	4	4	4	3	3	4	4	INV	INV	5	4	5	5	5	6	7	7	6	6	6	5	5
	WSV	MPS	3	3	5	6	5	5	4	4	4	INV	INV	2	3	4	4	3	4	4	5	4	3	5	5	6
	WDV	DEGA	277	306	325	325	321	315	298	296	293	INV	INV	284	281	295	288	277	288	306	274	282	305	334	335	325
	TMP	DEGC	13	13	13	12	12	12	12	12	13	INV	INV	16	15	14	14	16	16	15	15	15	15	15	14	14
	HMD	%	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	SRA	LANM																								
THSO	O3	PPHM	CAL	1	1	1	1	1	1	1	INV	INV	CAL	CAL	10	11	9	6	6	7	6	3	1	1	1	2
PIRU	O3	PPHM	CAL	1	0	0	0	1	2	3	3	4	4	4	6	7	6	6	6	6	5	3	2	2	2	1
	WSV	MPS	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	WDV	DEGA	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	TMP	DEGC	13	12	12	11	11	12	16	21	25	28	31	33	33	31	30	31	31	28	24	21	18	17	16	15
	HMD	%	77	60	61	66	66	62	57	40	26	21	16	12	20	24	23	21	23	28	37	46	56	63	64	67
	SRA	LANM	0	0	0	0	0	10	37	68	95	114	132	140	137	126	110	86	56	28	3	0	0	0	0	0
OJAI	O3	PPHM	3	CAL	2	2	INV	INV	2	3	5	5	6	6	7	8	7	7	6	8	6	5	4	4	3	3
	WSV	MPS	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	WDV	DEGA	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	TMP	DEGC	12	12	11	10	10	11	16	21	24	27	29	30	30	29	30	30	29	26	26	22	20	18	17	16
	HMD	%	98	98	98	98	98	98	94	71	60	50	47	46	46	50	46	44	49	50	56	69	77	86	87	92
	SRA	LANM	-1	-1	-1	-1	0	6	30	59	86	106	124	131	131	122	106	84	56	29	4	-1	-1	-1	-1	-1

Ventura County APCD Historical Report

TABLE 1

May 11, 1988

Station	Parameter	Units	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
VENT	NOX	PPHM	3	CAL	CAL	2	5	8	2	1	0	0	1	0	1	1	0	1	1	1	1	1	1	4	3	4
	NO	PPHM	0	CAL	CAL	0	2	8	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1
	O3	PPHM	2	CAL	CAL	2	1	1	3	4	4	4	4	5	4	4	4	4	4	4	5	4	4	2	2	1
	WSV	MPS	2	3	2	2	1	1	2	2	2	2	3	5	5	6	6	6	6	6	6	5	4	1	1	1
	WDV	DEGA	295	291	290	269	359	25	268	279	266	272	268	278	278	282	266	287	287	287	284	287	269	59	276	355
	TMP	DEGC	13	13	13	13	12	12	14	15	15	13	13	13	13	13	15	15	15	14	14	14	14	14	13	13
	HMD	%	99	98	99	100	100	94	92	89	85	84	84	87	87	89	90	90	89	89	93	96	97	93	96	96
SIMI	THC	PPTM	CAL	CAL	24	26	24	25	30	28	20	18	18	18	18	18	17	18	18	18	19	20	22	22	25	25
	SO2	PPHM	CAL	CAL	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	CO	PPM	CAL	CAL	1	1	1	3	6	6	1	1	1	1	1	1	0	0	1	1	1	1	2	2	2	1
	NOX	PPHM	CAL	CAL	3	3	7	13	32	24	4	1	1	1	1	1	0	0	1	1	1	4	7	8	8	7
	NO	PPHM	CAL	CAL	0	0	2	8	26	16	1	0	0	0	0	0	0	0	0	0	0	0	2	2	2	1
	O3	PPHM	CAL	CAL	2	1	0	1	1	2	5	6	7	8	10	8	7	7	7	7	7	4	1	1	1	1
	WSV	MPS	0	0	0	0	0	0	0	0	1	2	4	4	6	5	5	5	5	3	3	1	0	1	0	0
	WDV	DEGA	84	71	73	22	84	84	102	207	251	255	249	257	265	256	251	266	278	271	269	293	83	77	81	354
	TMP	DEGC	18	16	16	14	15	17	22	28	31	33	34	35	34	32	32	32	30	30	27	24	21	20	19	18
	HMD	%	65	62	61	68	63	85	51	39	30	26	29	26	29	30	30	29	32	33	38	46	55	58	64	65
	SRA	LANM	0	0	0	0	0	8	34	63	89	110	125	131	128	119	104	83	56	27	4	0	0	0	0	0
ELRO	CO	PPM	CAL	1	0	0	0	1	1	2	2	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1
	NOX	PPHM	CAL	2	2	2	3	6	9	7	5	4	3	2	2	2	2	2	2	1	1	2	1	1	2	2
	NO	PPHM	CAL	0	0	0	1	3	5	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	O3	PPHM	CAL	2	2	2	1	1	1	2	3	4	5	5	5	5	5	4	4	5	4	4	4	3	2	2
	WSV	MPS	2	0	0	0	0	0	0	1	1	1	4	4	4	4	4	4	4	3	1	1	0	0	0	1
	WDV	DEGA	320	279	148	180	127	65	243	256	248	251	259	253	249	248	239	237	240	237	224	226	219	68	329	243
	TMP	DEGC	16	14	13	12	12	12	15	19	20	24	24	22	22	20	21	20	19	17	16	15	14	14	14	14
	HMD	%	83	95	100	100	100	100	94	78	76	63	62	69	69	76	74	76	80	85	90	97	99	100	100	100
	SRA	LANM																								
ANAC	THC	PPTM																								
	NOX	PPHM	0	CAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NO	PPHM	0	CAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SO2	PPHM	0	CAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	O3	PPHM	5	CAL	4	4	4	4	4	4	4	4	4	5	5	5	6	6	7	8	7	7	7	7	7	7
	WSV	MPS	5	6	5	6	5	5	4	3	4	4	5	5	6	5	6	5	5	5	5	7	8	9	8	7
	WDV	DEGA	312	309	302	301	317	314	291	314	293	295	288	281	288	298	290	276	295	277	284	277	274	269	272	287
	TMP	DEGC	13	13	13	13	13	13	13	13	14	14	14	15	15	15	17	17	18	18	17	19	20	20	20	20
	HMD	%	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	SRA	LANM																								
THSO	O3	PPHM	CAL	3	3	2	2	1	1	1	3	5	6	8	8	7	6	7	7	6	5	2	1	0	0	0
PIRU	O3	PPHM	CAL	3	2	1	0	0	2	2	4	5	5	6	8	7	6	6	6	6	3	2	2	1	1	1
	WSV	MPS	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	WDV	DEGA	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	TMP	DEGC	15	15	15	14	13	14	18	23	28	32	35	35	34	34	34	34	33	32	26	21	19	17	17	15
	HMD	%	66	61	62	67	70	68	49	36	24	17	11	15	21	20	20	19	21	23	42	55	65	77	78	88
	SRA	LANM	0	0	0	0	0	10	37	68	95	118	134	140	137	127	110	86	27	27	3	0	0	0	0	0
OJAI	O3	PPHM	2	CAL	3	2	2	2	1	3	4	5	6	7	7	6	6	6	7	8	6	5	4	3	3	2
	WSV	MPS	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	WDV	DEGA	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	TMP	DEGC	15	15	15	14	14	15	19	25	27	31	32	33	33	33	34	34	33	32	29	26	23	22	20	18
	HMD	%	95	[illegible]	87	91	90	81	70	57	49	41	38	41	40	38	35	38	42	46	52	61	68	73	79	92

Ventura County APCD Historical Report

TABLE 1

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Station	Parameter	Units	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
VENT	NOX	PPHM	3	CAL	2	4	6	10	9	3	2	2	1	1	1	INV	1	1	0	0	0	1	0	2	4	4
	NO	PPHM	1	CAL	1	3	4	9	6	2	1	1	1	1	0	INV	0	0	0	0	0	0	0	0	1	1
	O3	PPHM	0	CAL	0	0	0	0	0	1	2	2	3	3	3	INV	3	3	3	3	3	3	3	1	0	0
	WSV	MPS	2	2	2	2	2	2	1	2	2	2	3	3	4	4	4	4	3	3	1	1	1	1	1	1
	WDV	DEGA	40	39	39	45	51	52	50	259	239	253	263	266	274	274	271	274	266	262	255	148	154	275	290	298
	TMP	DEGC	10	10	9	9	9	9	11	13	14	15	15	15	15	16	16	15	15	14	14	13	13	13	13	12
	HMD	%	90	92	94	94	94	94	83	79	80	80	79	79	80	80	83	84	81	81	87	92	95	96	97	97
SIMI	THC	PPTM	CAL	27	24	25	32	32	28	23	20	19	19	19	19	18	18	18	19	19	19	19	21	22	23	24
	SO2	PPHM	CAL	0	1	1	1	1	1	1	2	1	2	2	1	1	1	1	1	1	1	1	1	1	2	2
	CO	PPM	CAL	1	1	1	2	3	4	2	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1
	NOX	PPHM	CAL	5	5	6	9	15	23	14	5	2	1	2	1	1	1	1	2	2	2	2	7	6	9	11
	NO	PPHM	CAL	2	2	3	6	12	18	9	2	0	0	0	0	0	0	0	0	0	0	0	1	1	3	5
	O3	PPHM	CAL	0	0	0	0	1	1	2	4	6	7	7	7	7	6	6	6	6	5	5	2	1	0	0
	WSV	MPS	0	0	0	0	0	0	0	0	0	2	1	3	4	4	4	3	3	4	3	0	0	0	0	0
	WDV	DEGA	74	90	76	82	86	102	174	245	259	274	266	260	261	261	254	260	274	260	259	234	63	66	71	93
	TMP	DEGC	9	9	8	8	8	9	15	18	20	22	24	25	25	25	25	25	25	23	20	18	16	15	14	14
	HMD	%	95	96	100	100	100	100	74	57	46	44	42	41	40	39	38	40	42	44	51	60	66	71	75	76
	SRA	LANM	0	0	0	0	0	6	33	61	87	106	123	129	129	119	103	81	54	26	3	0	0	0	0	0
ELRO	CO	PPM	CAL	0	0	0	0	1	1	1	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
	NOX	PPHM	CAL	1	1	1	2	3	4	4	5	3	4	3	2	2	2	2	2	1	2	2	3	3	3	3
	NO	PPHM	CAL	0	0	0	0	1	2	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
	O3	PPHM	CAL	2	2	2	2	1	2	2	3	4	4	5	6	6	6	5	5	5	4	3	2	2	2	1
	WSV	MPS	2	3	2	2	3	3	3	0	2	2	3	4	4	4	4	4	3	2	0	0	0	1	1	0
	WDV	DEGA	33	32	21	32	32	33	29	0	253	252	254	250	253	260	253	254	248	256	231	350	8	0	10	180
	TMP	DEGC	10	10	10	9	9	10	11	16	17	18	19	19	19	19	19	19	19	17	16	14	15	14	14	13
	HMD	%	99	96	99	100	100	99	92	77	75	74	69	66	65	67	64	65	67	77	83	90	85	87	86	93
	SRA	LANM																								
ANAC	THC	PPTM																								
	NOX	PPHM	0	CAL	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	NO	PPHM	0	CAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SO2	PPHM	0	CAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	O3	PPHM	4	CAL	3	4	3	3	4	4	4	4	4	5	5	5	5	5	5	5	5	4	4	5	4	4
	WSV	MPS	0	3	4	3	4	4	5	5	4	3	2	3	3	4	5	4	2	1	1	3	5	7	5	3
	WDV	DEGA	45	313	326	327	300	313	300	297	296	294	274	273	284	276	290	281	248	199	17	306	322	326	295	271
	TMP	DEGC	12	12	12	12	12	11	12	12	12	13	14	14	14	14	14	15	16	16	15	14	14	14	14	14
	HMD	%	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	SRA	LANM																								
THSO	O3	PPHM	CAL	0	1	0	0	0	0	2	3	4	5	6	6	6	6	6	6	6	6	3	0	2	2	2
PIRU	O3	PPHM	CAL	1	0	0	0	0	1	2	3	4	4	5	5	5	5	6	6	5	5	5	4	3	2	1
	WSV	MPS	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	WDV	DEGA	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	TMP	DEGC	8	8	7	7	7	8	12	16	20	22	23	24	25	25	25	25	25	23	20	17	16	14	14	13
	HMD	%	97	97	97	97	97	96	75	56	39	30	33	35	36	33	33	34	36	36	47	58	67	73	76	77
	SRA	LANM	0	0	0	0	0	9	36	66	94	116	130	136	134	125	108	84	56	26	3	0	0	0	0	0
OJAI	O3	PPHM	3	CAL	1	0	0	0	0	INV	INV	INV	INV	INV	6	6	7	7	7	7	7	4	3	3	2	2
	WSV	MPS	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	WDV	DEGA	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV	INV
	TMP	DEGC	8	8	7	7	7	7	12	16	19	21	22	22	23	24	24	24	24	23	20	17	16	15	13	13
	HMD	%	96	96	96	96	96	96	96	79	68	60	58	60	60	60	60	59	60	63	71	86	96	96	96	96
	SRA	LANM	-1	-1	-1	-1	0	6	31	56	84	106	121	128	127	119	103	81	55	27	3	-1	-1	-1	-1	-1

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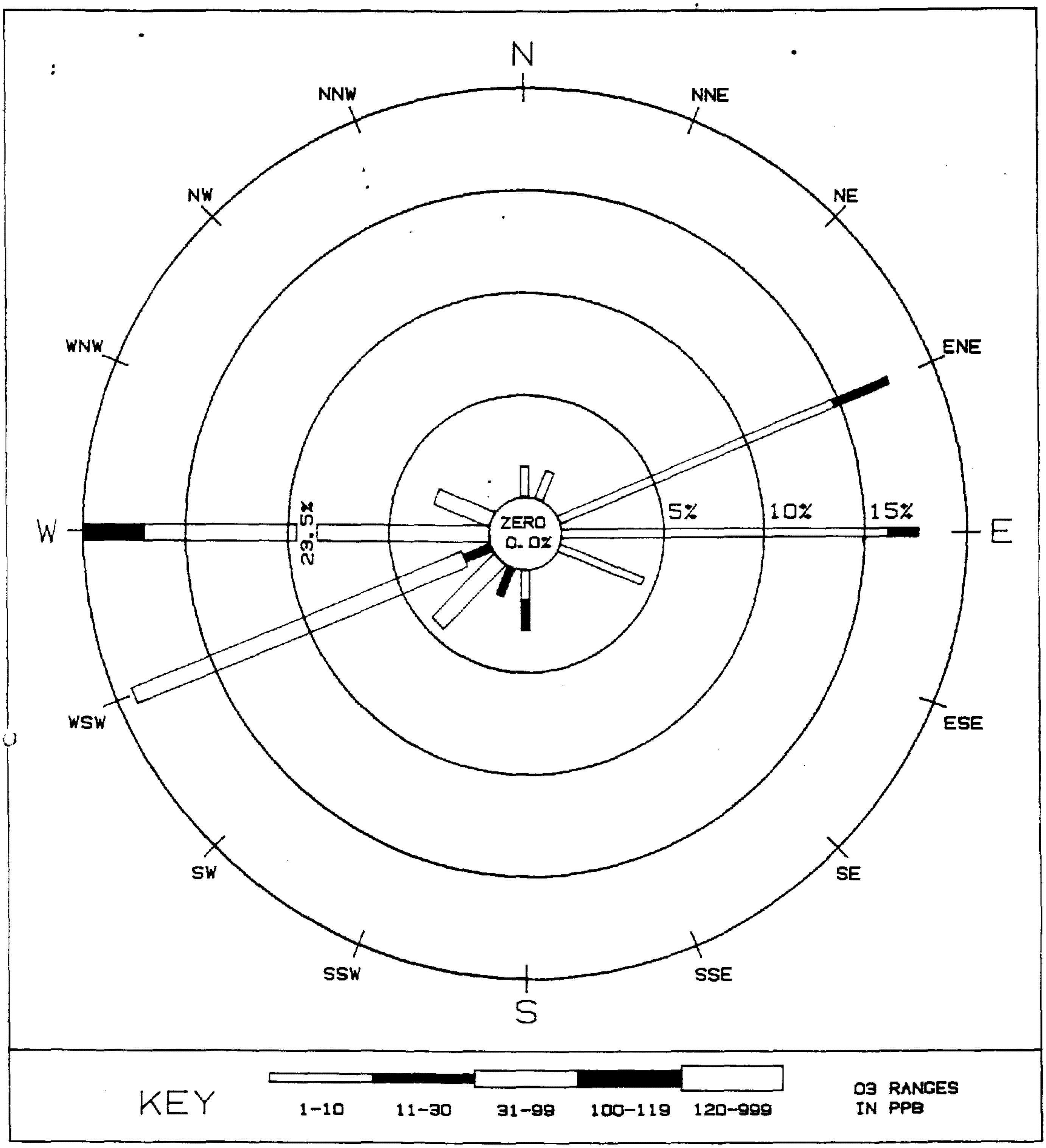
SIMI VALLEY

O3 ROSE

FREQUENCY OF OCCURRENCE (%)



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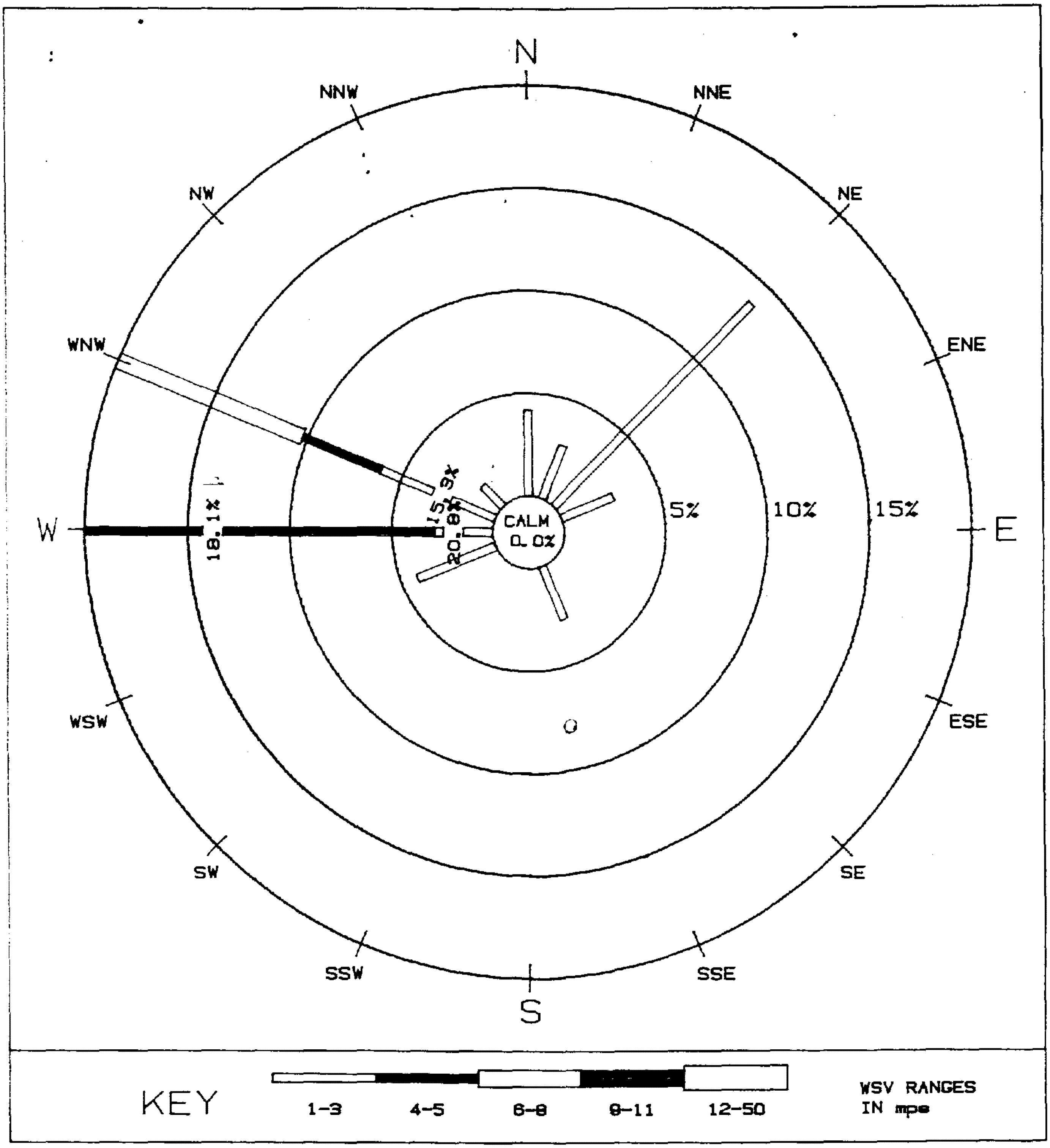
VENT URA-EMMA WOOD

WSV ROSE

FREQUENCY OF OCCURRENCE (%)



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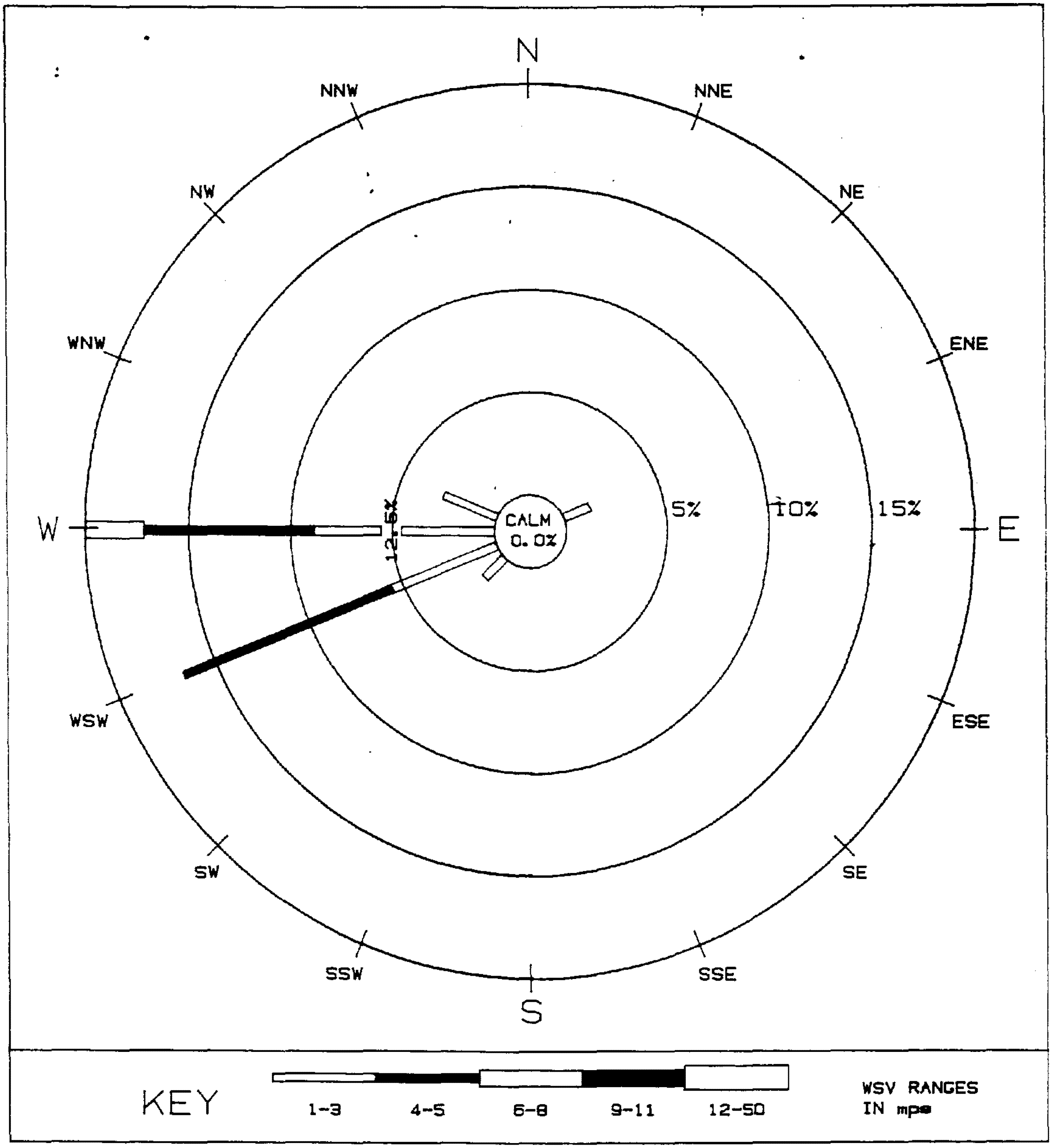
SIMI VALLEY

WSV ROSE

FREQUENCY OF OCCURRENCE (%)



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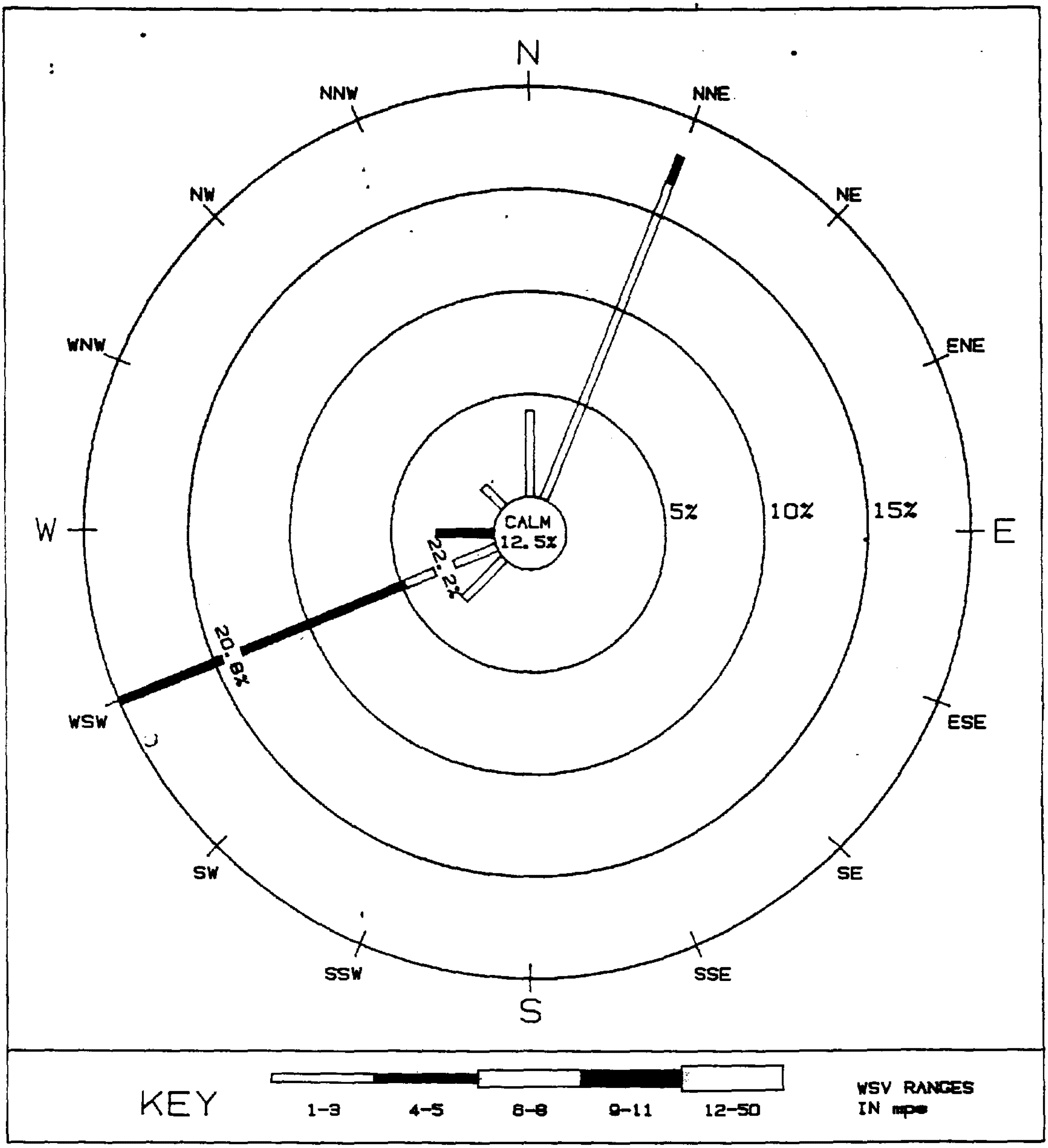
ELRO (EL RIO - RIO MESA HIGH)

WSV ROSE

FREQUENCY OF OCCURRENCE (%)



County of Santa Barbara
AIR POLLUTION CONTROL DISTRICT

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JAMES M. RYERSON
Air Pollution Control Officer

WILLIAM A. MASTER
Assistant Director

May 24, 1990

Ms. Catherine Witherspoon
Office of Air Quality Planning and Liaison
California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

SUBJECT: Assessment and Mitigation of Pollutant Transport as Related to Ambient Ozone Concentrations Within California as required by the California Clean Air Act of 1988.

Dear Catherine:

The District appreciates the ARB taking the time and effort to hold a workshop on the subject regulations. As District staff indicated during the workshop, the District is concerned about several aspects of the proposed transport regulations. The purpose of this letter is to clarify these concerns, and provide an alternative that we believe would better attain the goals sought by the proposed regulations. Our concerns are as follows:

1. The South Central Coast Air Basin is treated as a single air basin. This would result in the illogical situation where transport of emissions from Thousand Oaks or Moorpark to South Coast would require San Luis Obispo and the Santa Maria Valley to develop emission controls at least as stringent as the South Coast even though they are in different physical air basins.

2. The proposed regulations do not account for the relative contribution of an upwind air basin on a downwind air basin. An upwind area could contribute only very slightly to the problems of a downwind area, but would nonetheless be required to adopt emission controls at least as stringent as the downwind area. It is clear that under such situations, the proposed regulations would be unfair. The impacts of these regulations on South Central Coast Air Basin is a good example of this inequity.

3. The source characteristics of an upwind basin (age, type, and size of facilities) may make the uniform application of a control measure inappropriate and unworkable.

4. Control measures are highly dynamic as they proceed through the air quality plan development and adoption process. It is difficult enough to prepare one's own control measure, and assure they are consistent with comments received and board direction. Incorporating additional revisions to reflect control measures in an adjacent air basin would be difficult and would delay the rulemaking process.

5. The proposed regulations have potentially significant implications to the district plan preparation budgets, and district budgets for the preparation of the 1991 plans have already been established.

In light of these problems, the District proposes the following alternative course of action:

1. Districts would be required to meet the CCAA emission reduction required for the preparation of the 1991 plans (e.g., meet applicable "moderate, serious, or severe" requirements).

2. Given the complexity of the transport problem, the limited amount of existing data, and in light of the numerous air monitoring and modeling studies that are underway, ARB would be required by 1993 to further evaluate transport and identify control requirements necessary to mitigate the effects of transport.

3. By 1993, ARB would be required to notify those districts where plan revisions would be necessary to mitigate the effect of transport. Additional control requirements should be specified in terms of tons per day, if at all possible. If this proves technically infeasible, then transport areas should be classified (i.e., moderate, serious, or severe) at least as stringent as the affected downwind area.

The District looks forward to working on the California Clean Air act attainment plan. The District firmly believes that our suggested approach would better serve the goals of the act. Please do not hesitate to call me, Doug Allard, or Larry Rennacker of my staff, should you have any questions or comments.

Sincerely,

Doug Allard

for James M. Ryerson
Air Pollution Control Officer

cc: Mike Scheible, ARB
Bob Carr, San Luis Obispo APCD
Richard Baldwin, Ventura County APCD
Doug Allard, SBAPCD
Larry Rennacker, SBAPCD
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