THE ORIGIN AND FATE OF AIRBORNE POLLUTANTS WITHIN THE SAN JOAQUIN VALLEY

VOLUME 4 - SUMMER FIELD STUDY

by

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ABSTRACT

An extensive observational program, lasting from November 1978 until October 1979, was carried out to investigate the origin and transport of pollutants in the San Joaquin Valley. Field studies were conducted during the winter, summer and fall. Volume 3 describes the results of the November 15, 1978-December 10, 1978 intensive field study, along with two additional tracer experiments conducted during relatively stagnant conditions in February 1979 and March 1979. The present volume (Volume 4) describes the summer (July 1979) program. Volume 5 describes the fall (September 1979) program. Participants in this study were Meteorology Research, Inc., California Institute of Technology, Rockwell International (EMSC) and Environmental Research and Technology (ERT).

Six tracer releases provided the core of the July 1979 field program. These releases were supported by supplementary meteorological observations and airborne air quality sampling. Three Rockwell International vans, located at Modesto, Merced and Madera, operated continuously to provide additional air quality data. Filter samples obtained at each of the vans were analyzed by ERT to investigate the particulate chemistry in the area.

The July 1979 field program was characterized by relatively warm temperatures at the 850 mb level compared to the previous five-year average suggesting conditions more conducive than average for pollutant buildup.

Maximum ozone concentrations observed during the July 1979 tracer studies ranged from 0.11 to 0.17 ppm and were relatively uniform throughout the valley. During the tracer studies, maximum carbon monoxide concentrations ranged from 2 to 5 ppm, and maximum NO_x concentrations ranged from 0.18 to 0.32 ppm; both the CO and NO_x concentrations reflected strong urban sources and were closely related to peak traffic periods.

During July, the average wind flow into the valley at Stockton and Los Banos was directed from Stockton to Bakersfield at all hours of the day. At Fresno and Visalia the low level winds were usually from the southeast during the early morning but from the northwest during the rest of the day; the duration of the southeasterly winds was longer at Visalia, associated

with the northward spreading of the "Fresno eddy" which develops during the night as a result of stable conditions in the southern end of the valley.

Tracer released from Manteca during the morning of 7/13/1979 was transported by northwesterly winds along Highway 99 for about 40 miles and then along the San Joaquin River (the lowest portion of the valley). The tracer released from Manteca during the afternoon of 7/16/1979 was also transported along the San Joaquin River. Horizontal and vertical rates of dispersion of the tracer were consistent with neutral or slightly unstable atmospheric conditions, during both tests.

Tracer released from Livermore during the afternoon of 7/18/1979 was transported by westerly winds over Altamont Pass and into the San Joaquin Valley. On the day following the release, the tracer "cloud" was transported down the western side of the valley in a manner similar to that found during the releases from Manteca.

Tracer released from Reedley during the afternoon of 7/25/1979 was initially transported by the upslope winds into the national forest and park areas of the Sierra Nevada Mountains. Some of the tracer was then transported by the nighttime downslope winds and finally impacted regions on the western side of the valley.

Tracer released aloft into the nighttime jet was transported to the extreme southern end of the San Joaquin Valley by late morning of the day following the release. The nocturnal jet appears to be an efficient mechanism of transport to the southern end of the valley, but minimal ground level impacts occur until the surface mixing layer deepens during the following day.

Tracer released from Pacheco Pass during the afternoon of 7/30/1979 was carried aloft and essentially none was detected at ground level within the valley.

In summary, pollutants transported into the San Joaquin Valley from the California Delta, San Francisco Bay and Livermore regions were found to primarily impact the western side of the northern half of the San Joaquin Valley.

The meteorological conditions during the summer are much less conducive to pollutant build-up than the relatively stagnant conditions which often occur during the winter.

The principal exit region for pollutants from the valley is the Tehachapi mountain ridge which forms the southeast border of the valley. The upslope flow along the north-south edges of the valley is relatively inefficient in removing pollutants because of its diurnal nature and the broad width of the valley. Consistent with the influx of air at the mouth of the valley, the transport within the valley was generally southward. The nocturnal jet enhances this southward movement and provides a mechanism for distributing pollutants throughout the valley.

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1. Introduction

Summer months in the San Joaquin Valley are characterized meteorologically by intense solar heating and generally clear skies. Strong frontal passages do not occur but weak cold air troughs move through the area resulting in changes in stability and fluctuating mixing heights. These changes are reflected in significant day-to-day variations in pollutant levels in spite of the apparently small changes occurring in the synoptic weather charts. Fresno-Olive Street, for example, showed maximum daily ozone concentrations ranging from .03 to .17 ppm during the month of July 1979.

The principal driving force for the low-level winds in the valley is the pressure gradient between the coast and the interior (east of the Sierra Nevadas, for example). The cold air trough passages serve to increase these surface pressure gradients and increase the flow into the valley from the northwest.

The strong solar insolation and the possibility of stagnation episodes within the valley raise serious questions concerning ozone formation during the summer months. Additional problems which were addressed during the summer field study were the transport of pollutants from the Bay area into the San Joaquin Valley, the role of the nocturnal wind jet in redistributing material throughout the valley and the effectiveness of upslope transport in removing pollution from the valley.

The summer field program consisted of six tracer releases as listed below. Each release was supported by pibal wind soundings and aircraft measurements. A network of five additional pibal stations was maintained independently during the field study by the California Air Resources Board (CARB). These stations were located at Stockton, Los Banos, Fresno, Visalia and Bakersfield, regardless of test location. Two pibal sounding stations supported by the field program itself were moved from test to test to obtain the best wind coverage possible.

Three Rockwell International vans were positioned to the east of Modesto, Merced and Madera to obtain surface air quality data. Environmental Research and Technology (ERT) provided filter samplers which were operated at each van. Analyses and interpretation of the filter samples were carried out by ERT. The Atmospheric Testing Branch of the CARB at El Monte obtained hydrocarbon samples several times daily at Stockton, Tracy, and at two locations in Fresno. A number of aircraft samples were also obtained. The samples were subsequently analyzed by CARB for C_2 through C_{10}.

The following tracer releases were carried out during July 1979:

Release Location	Date (July 1979)	Release Time (PDT)
Manteca	13	0700-1300
Manteca	16	1300-1900
Livermore	18	1510-2030
Reedley	25	1200-1700
Herndon to Chowchilla (airborne)	27-28	2330-0215
Pacheco Pass	30	1200-1725

The present volume (Volume 4) discusses the details of the July field program including all pertinent tracer and aircraft sampling data (Appendix to Volume 4). Surface and pibal wind data have been furnished to CARB on magnetic tape. Separate reports (Volumes 6 and 7) give the details of the Rockwell International and ERT work, respectively. Portions of these reports have been used in the present volume where appropriate.

Volumes 3, 4 and 5 of the report series cover the details of the three field programs. Volume 2 contains an extended summary of the entire program and a discussion of a number of special analysis topics which resulted from the field measurement program. Volume 1 is an Executive Summary of the program.

2. Overview of the Meteorology and Air Quality

2.1 Introduction

The following sections describe the general conditions which occurred during the July 1979 intensive field period. The overall meteorological conditions are summarized and compared to climatological records to determine the representativeness of the test period. Descriptions of air quality and particulate concentrations for the intensive period are summarized from the more extensive reports by Rockwell International and ERT which appear as Volumes 6 and 7 of this report series.

2.2 Meteorology

850 mb Temperatures

Temperatures at the 850 mb level provide a simple indicator of the regional air pollution potential. Warm temperatures aloft create the stability required to trap the pollutants in the lower layers.

Figure 2.2.1 shows the daily variation in 05 PDT temperatures at 850 mb for Vandenberg AFB and Oakland during the month of July 1979. The five-year average temperatures for Vandenberg and Oakland are also shown in the figure.

After the first seven days of the month, the temperatures at 850 mb were generally above normal. Test dates are indicated in the figure. All tracer tests were carried out under conditions of above normal temperatures aloft. As indicated, Test 3 was conducted with the 850 mb temperature eight degrees above normal and represents the most stable episode period encountered during July.

Surface Pressure Gradients

In the absence of major changes in synoptic weather patterns during July, the principal driving force for winds in the San Joaquin Valley results from lower surface pressures east of the Sierras relative to the coastal areas. Strong surface heating in eastern California and Nevada causes a low pressure, thermal trough to persist throughout most of the summer.

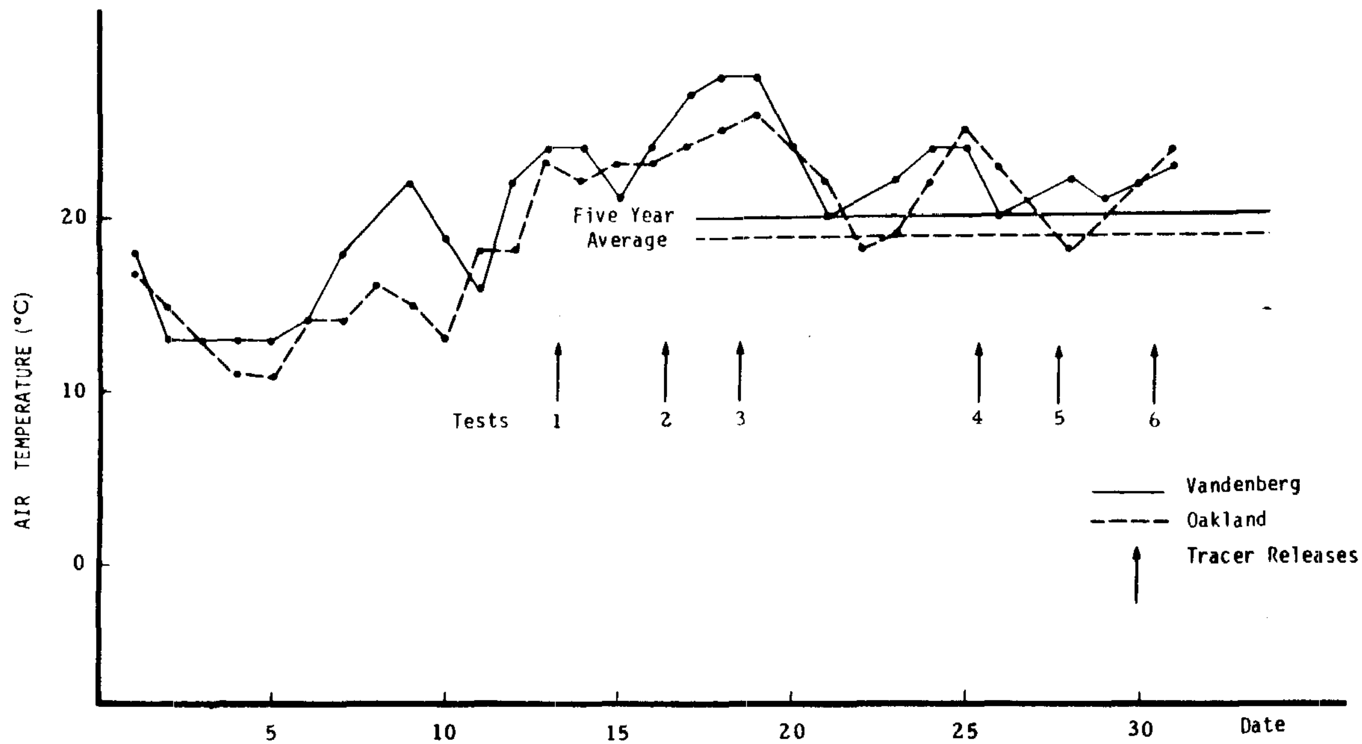

Figure 2.2.1 850 mb Temperatures - July 1979

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Table 2.2.1 gives the average surface pressure gradients during July 1979 between San Francisco Airport and Las Vegas. This parameter is one indicator of the strength of the surface pressure gradient affecting the valley. Other pressure differences could also be used. The table shows typical diurnal changes in pressure gradient with peak values in the late afternoon when the results of the afternoon heating have taken effect.

Day-to-day relationships between surface pressure gradients and wind speeds are apparent but are occasionally masked by local effects not adequately measured by the simple, single pressure gradient parameter being suggested above. Figure 2.2.2 shows the daily variations in pressure gradient for July 1979 at 1600 PDT related to the 600-m winds at Los Banos and Stockton at 1700 PDT. Wind speeds in the figure refer to the component directed along the valley axis with positive numbers referring to wind flow from Stockton toward Bakersfield.

Table 2.2.1

Average Surface Pressure Gradients (July 1979)
San Francisco-Las Vegas

Time (PST)	Pressure Difference (mbs)
00	6.0
03	5.6
06	4.6
09	4.4
12	5.2
15	6.3
18	6.7
21	6.2

The pressure gradients in Figure 2.2.2 indicate lower than average values throughout much of the month with the exception of two periods around the 10th and 27th. Reference to Figure 2.2.1 indicates that the warm temperature period during mid-month was associated with below average pressure gradients.

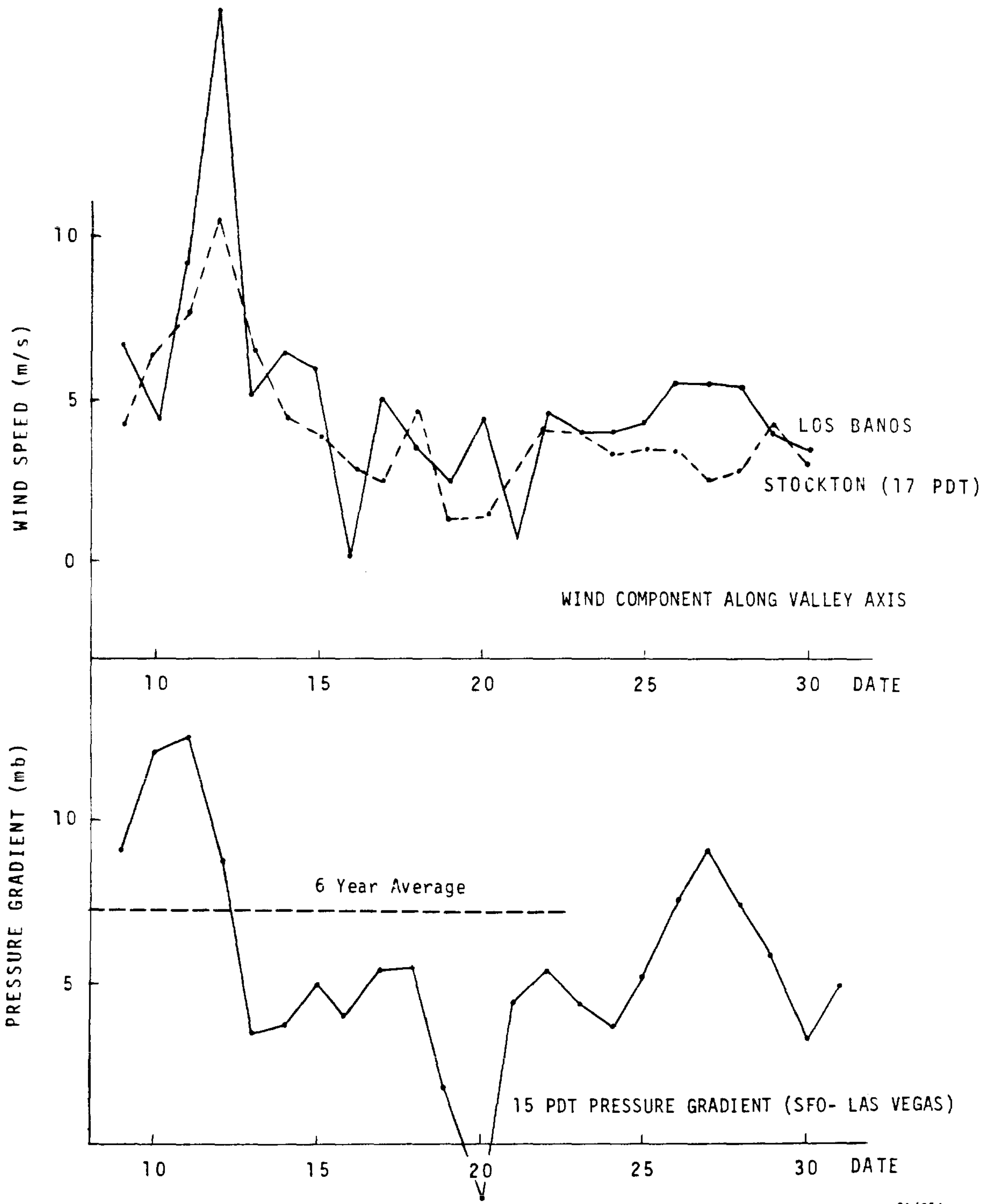


Figure 2.2.2 Comparison of Wind Component (600 m) and Pressure Gradient July 1979

There is considerable similarity between the pressure gradient variations and the wind speed characteristics for Stockton and Los Banos. In particular, the large pressure gradient values near the 10th resulted in unusually strong wind flow. The pressure gradient peak on the 27th is also somewhat reflected in the Stockton wind speeds. The primary difference between the two plots occurs near the 20th when the major drop in pressure gradient is only partly reflected in the Stockton-Los Banos winds.

A similar comparison of the San Francisco-Las Vegas pressure gradient and the Bakersfield wind at 600 m is shown in Figure 2.2.3. In this case, the minimum pressure gradient on the 20th shows up clearly as a negative wind component at Bakersfield. The similarities in the two plots, in fact, are quite pronounced with the exception of the peak pressure gradient on the 27th.

These figures indicate the association between surface pressure gradients and the flow along the valley axis but suggest that the details of the wind response to gradient fluctuation may not be entirely consistent throughout the valley. In particular, the northern and southern parts of the valley may respond in somewhat different ways.

Valley Wind Characteristics

Pibal wind coverage during July 1979 was carried out for 22 days at the five locations shown in Table 2.2.2. Observations were taken on virtually every day at the times shown in the table. Additional observations were made on test days but are not available for the entire 22 day period.

Resultant winds at 1000 feet (agl) for the 22-day period have been calculated by averaging wind components over the 22 days by time of day. Principal features shown in the table are:

- Northwest winds at Stockton and Los Banos at all hours.
- Southeast winds at Fresno (09 PDT) and Visalia (05 and 09 PDT) in association with the Fresno Eddy.
- Peak winds at 21 PDT for most locations.
- Light west to northwest winds at Bakersfield except for late afternoon and evening.

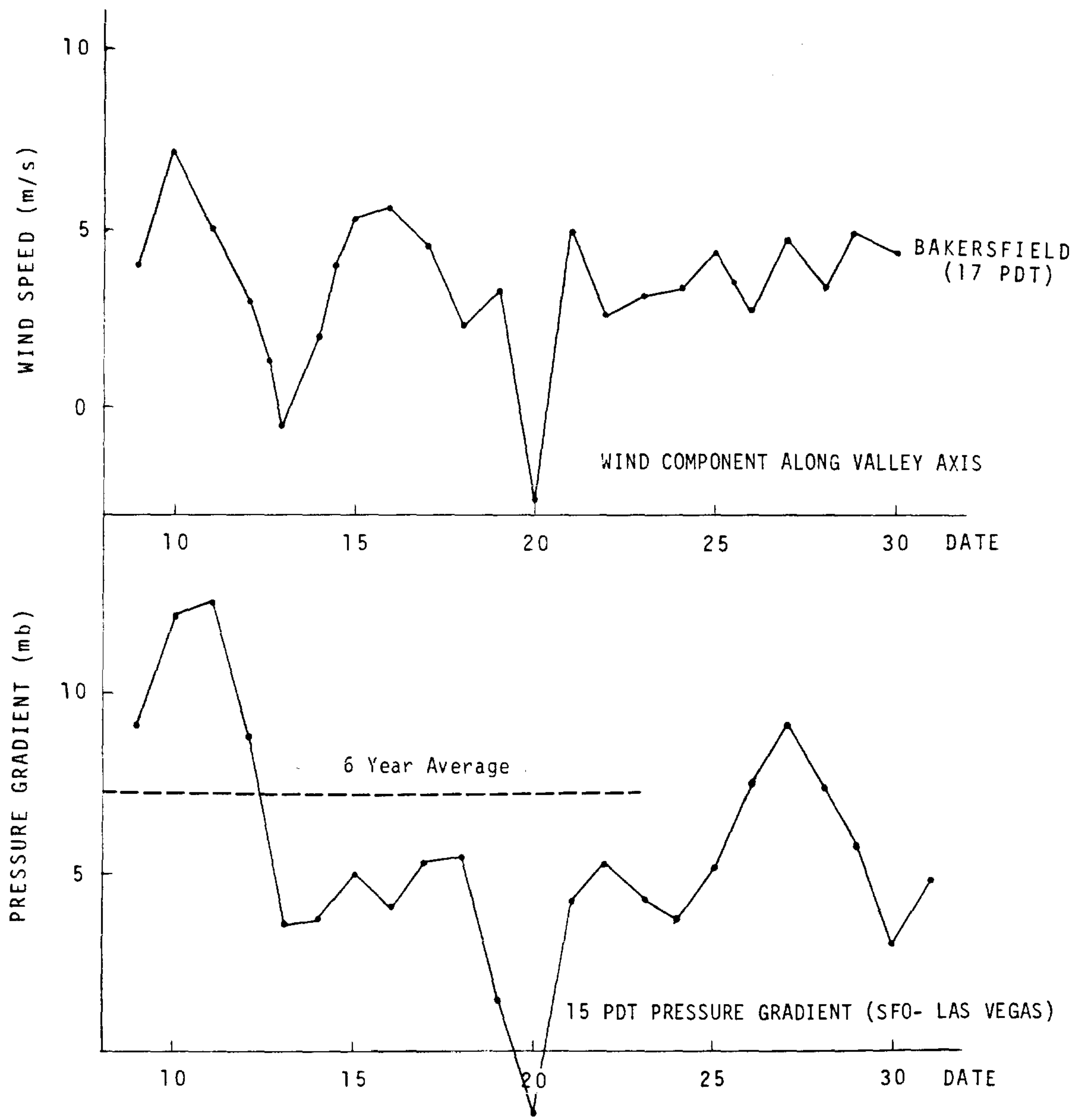


Figure 2.2.3 Comparison of Wind Component (600 m) and Pressure Gradient July 1979

Table 2.2.2

1000-foot Resultant Winds (m/s)
July 1979

PDT	05	09	13	17	21
Stockton	310°/4.4	319°/3.3	316°/3.5	321°/4.8	291°/7.4
Los Banos	304 /5.5	320 /4.1	341 /4.3	335 /5.1	328 /7.4
Fresno	338 /3.9	134 /2.9	282 /2.5	303 /4.5	313 /7.7
Visalia	167 /2.4	169 /3.5	285 /2.1	316 /3.9	320 /4.6
Bakersfield	316 /1.0	276 /0.4	309 /1.9	317 /3.9	330 /2.7

Table 2.2.3 shows the average wind components directed along the axis of the valley for July 1979. Surface wind components at Stockton are shown together with 1000-foot components at all pibal locations. Positive values indicate flow directed from Stockton to Bakersfield.

Table 2.2.3

Average Wind Components* Along Valley Axis (July)

a. Surface Winds (m/s)

Location	Time (PDT) 03	09	15	21
Stockton	2.0	2.7	3.9	3.5

b. 1000-foot Winds (m/s)

Location	Time (PDT) 05	09	13	17	21
Stockton	4.3	3.3	3.5	4.8	5.7
Los Banos	4.9	4.2	4.3	5.1	7.4
Fresno	3.8	-3.8	1.7	4.0	7.7
Visalia	-2.1	-3.3	0.9	3.8	4.7
Bakersfield	1.3	0.2	1.8	3.8	2.7

* Negative components refer to southeasterly winds

As indicated in the table, flow is directed into the valley in the lowest 1000 feet at all times of day. The negative values at Fresno and Visalia result from the influence of the Fresno Eddy. Peak flow into the valley occurs at 21 PDT. It is to be noted that the flow along the valley is relatively constant at all locations at 17 PDT, suggesting a constant flux into and out of the valley. For the other hours, however, continuity is not maintained and it is clear that major areas of convergence and divergence must exist.

The component values along the axis of the valley are shown in more detail in Figures 2.2.4 through 2.2.8. Average profiles of the axis wind component are shown for each location at 05, 09, 13, 17 and 21 PDT.

The principal features of interest in the figures are the following:

- The average profiles at 17 PDT (Figure 2.2.7) are similar at all locations.
- The average profiles at Stockton and Los Banos are similar at all times.
- At 21 PDT the Visalia profile is similar to Fresno but with slightly reduced speeds. The Bakersfield profile at 21 PDT, however, shows a marked decrease in velocity to 1000 m (agl) and an increase in speed above that height. This is interpreted as the first evidence of low-level blocking of the flow in the southern end of the valley by stability and terrain. It is apparent that a part of the flow is diverted aloft to a level where escape over the terrain is possible. This is considered to be the initiation of the Fresno Eddy.
- At 05 PDT the effect of the blocking has extended upstream to Visalia. Velocities are reduced in the lowest 1000 m at both Bakersfield and Visalia but increased aloft. This development is associated with the spreading of the Fresno Eddy to the north.

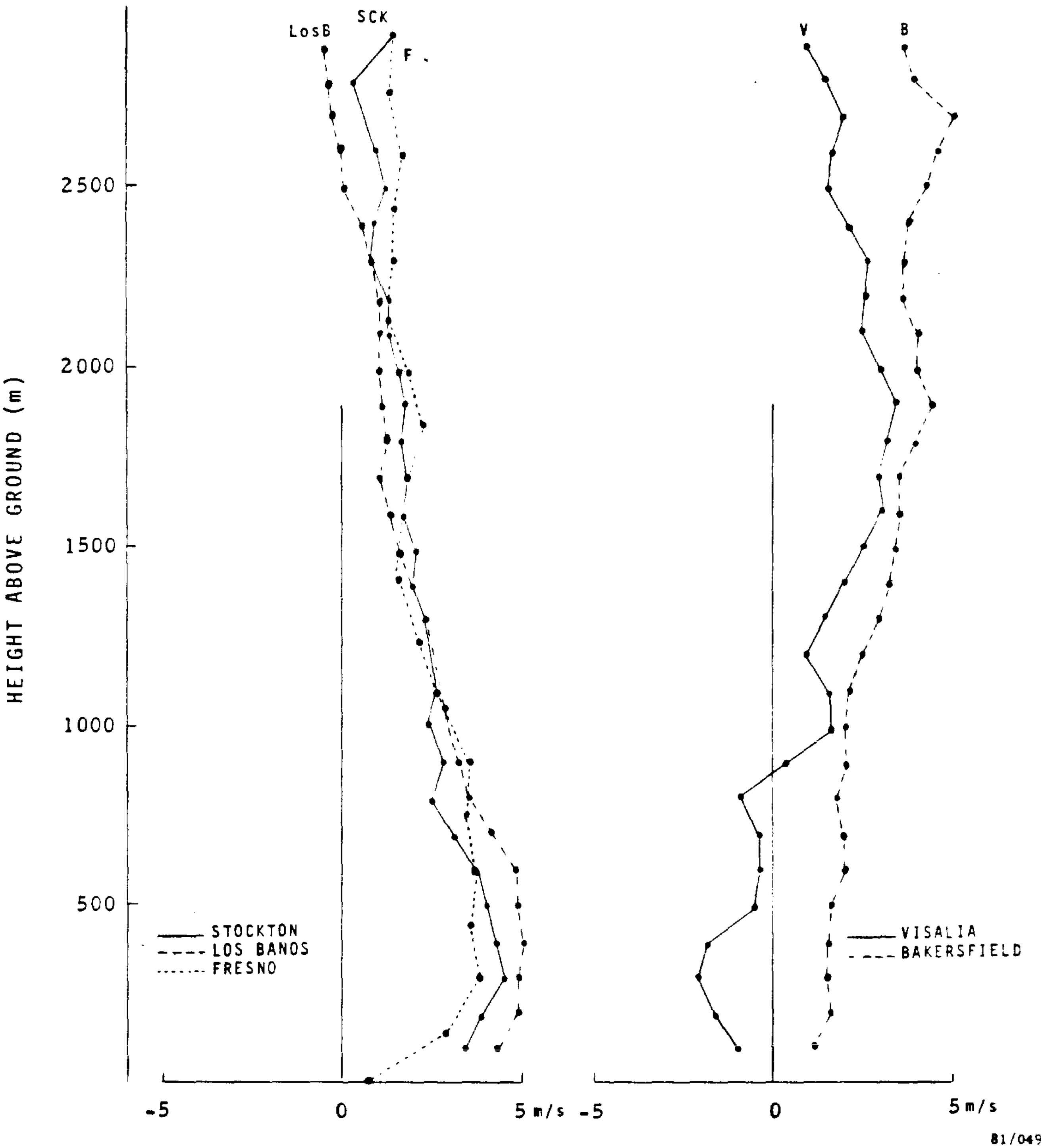


Figure 2.2.4 Average Wind Components Along Valley Axis
July 1979 (05 PDT)

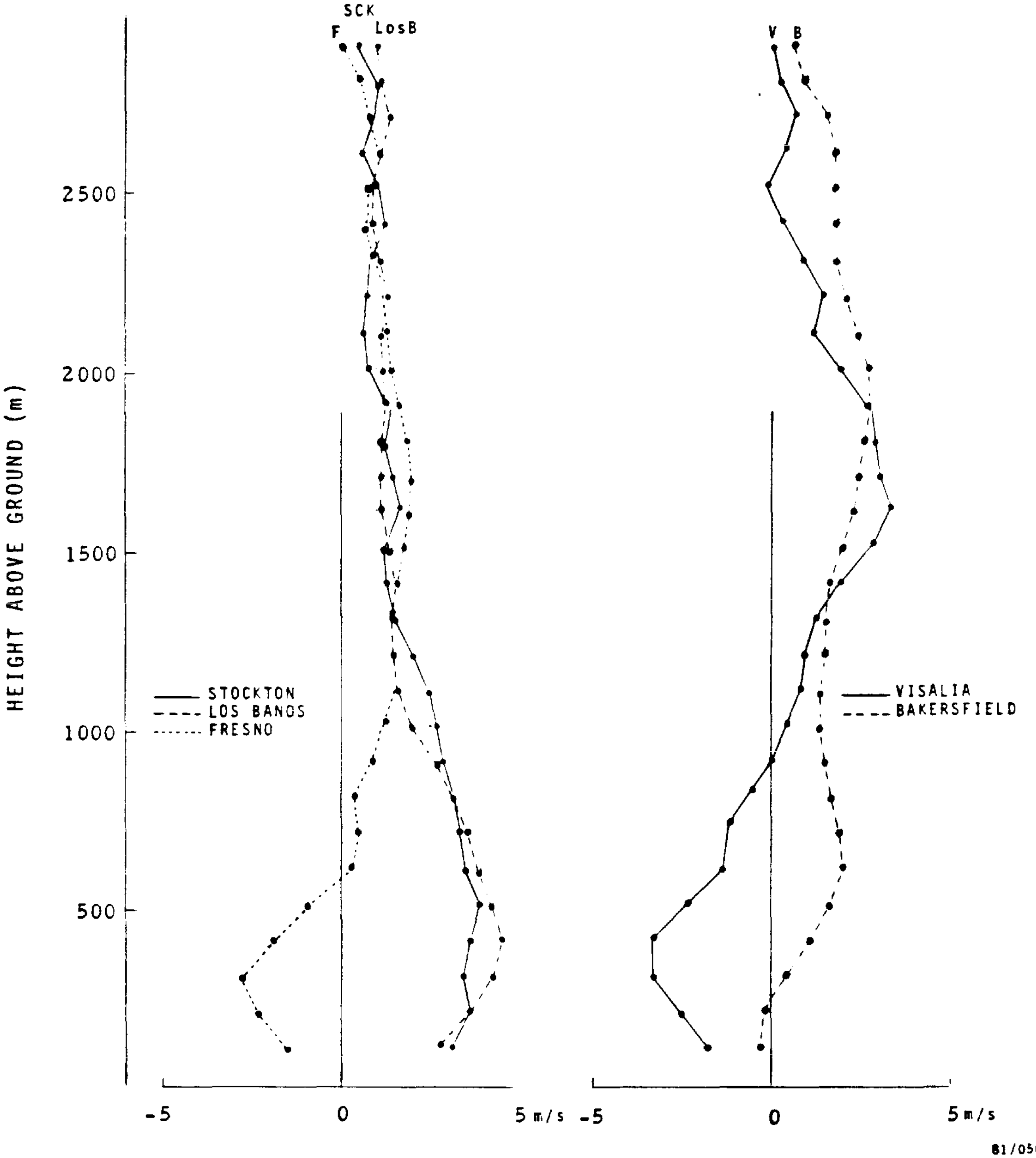


Figure 2.2.5 Average Wind Components Along Valley Axis
July 1979 (09 PDT)

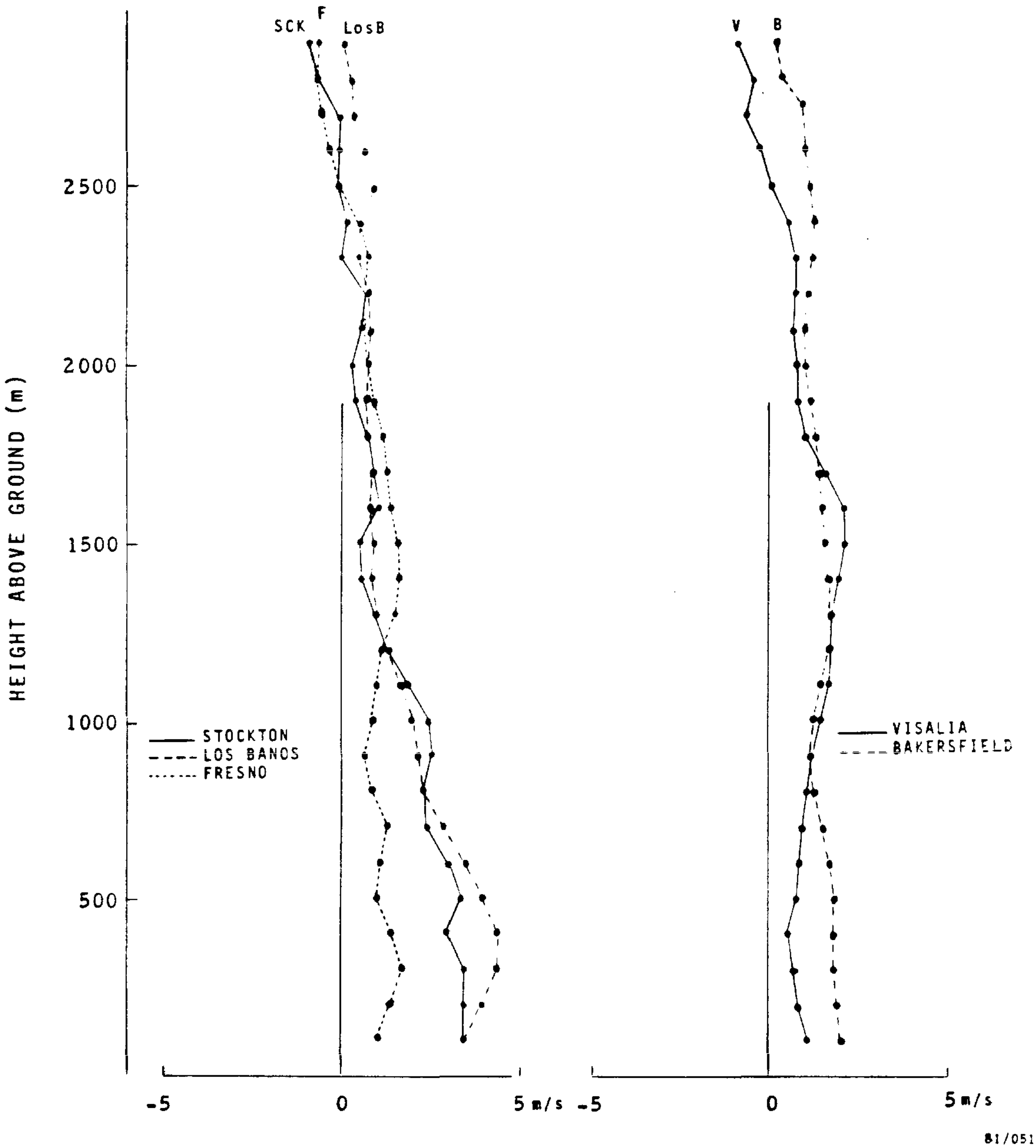


Figure 2.2.6 Average Wind Components Along Valley Axis
July 1979 (13 PDT)

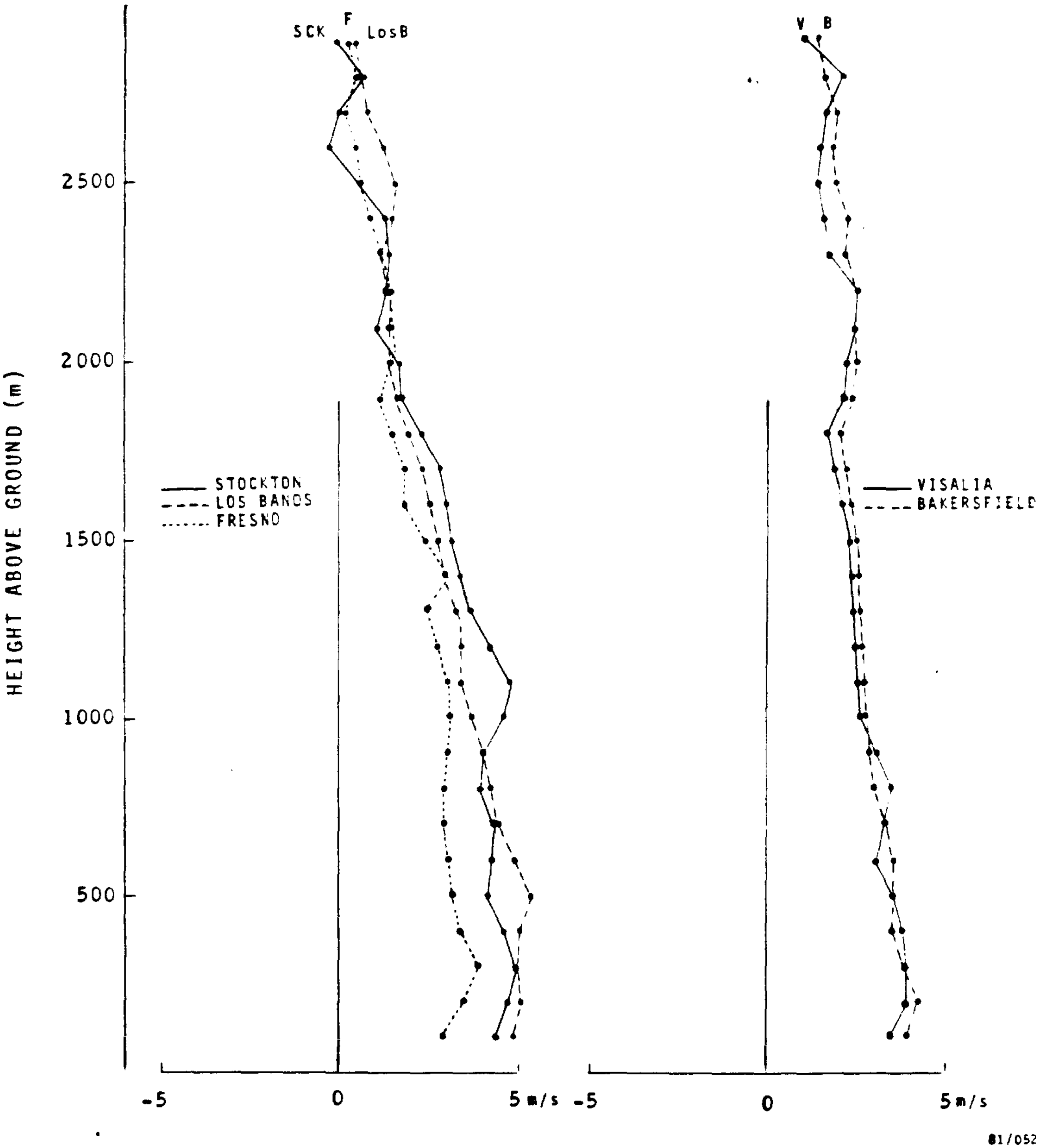


Figure 2.2.7 Average Wind Components Along Valley Axis
July 1979 (17 PDT)

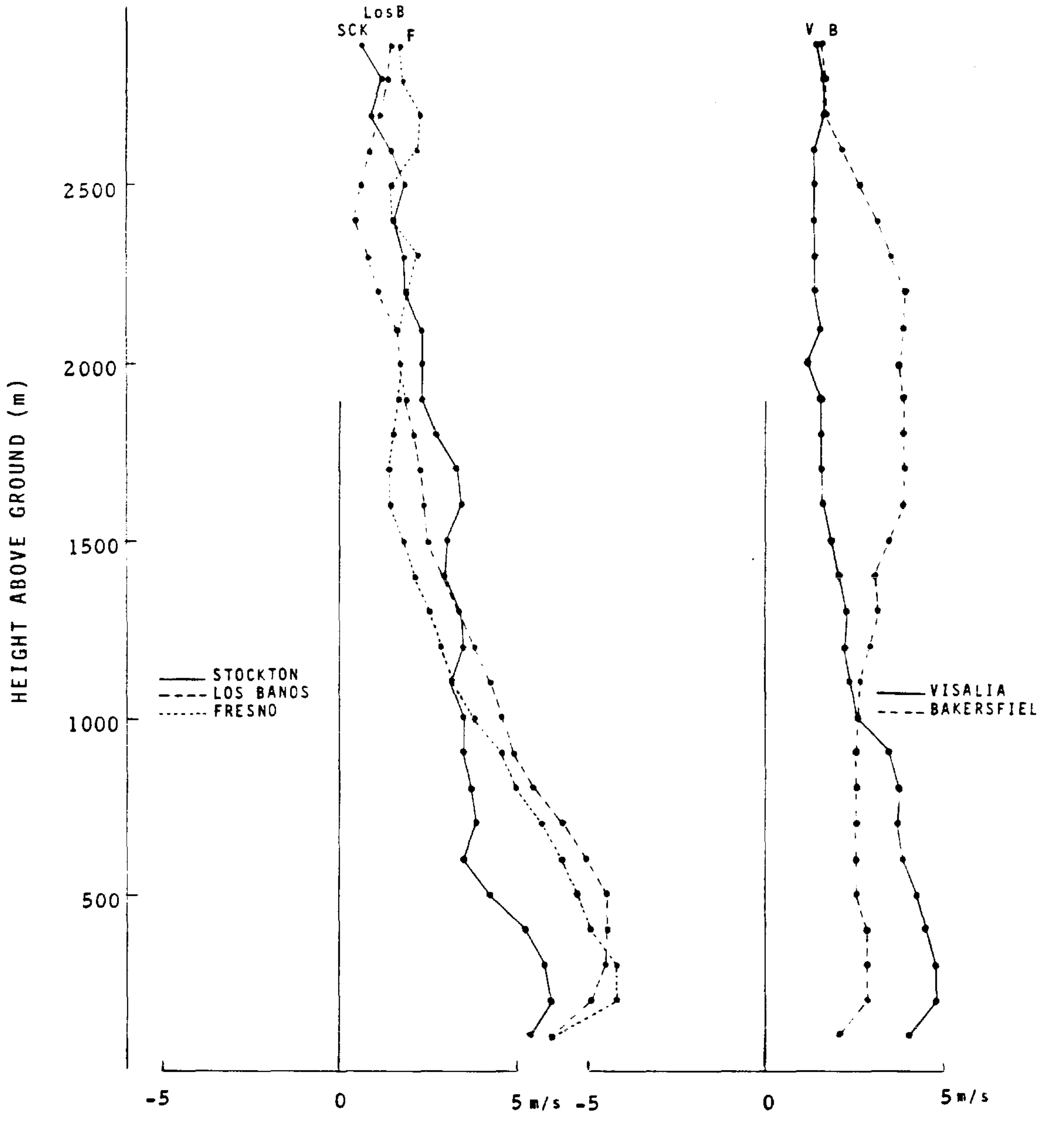


Figure 2.2.8 Average Wind Components Along Valley Axis July 1979 (21 PDT)

- By 09 PDT the blocking in the lowest 1000 m affects the wind flow at Fresno. Both Visalia and Bakersfield continue to show increased velocities above 1000 m.
- Remnants of the low level blocking and increased flow aloft continue as late as 13 PDT but to a reduced degree. By 17 PDT the flow becomes relatively uniform at all locations.

The foregoing leads to a physical picture in which the northwesterly flow is blocked in the southern part of the valley by terrain as low-level stability develops in the early evening. The low-level flow is diverted into a cyclonic eddy about 1000 m deep which gradually extends to the north as far as Fresno. Some of the northwesterly flow approaching this eddy is deflected aloft and is able to escape from the southern part of the valley at altitudes above 1000 m.

Two phases in this development are shown in Figures 2.2.9 and 2.2.10. At 21 PDT on July 18 (Figure 2.2.9) the flow in the valley was uniformly from the northwest at 1000 ft agl. The wind speed at Bakersfield (3.7 m/s), however, was considerably less than at locations to the north, indicating the onset of the blocking effect. By 05 PDT of the following morning (Figure 2.2.10) the eddy at 1000 ft had extended as far north as Fresno.

Of the 22 days in July 1979 for which detailed pibal data were available, the Fresno Eddy formed on 18 days. There was no significant eddy on July 10, 11, 26 and 28. Reference to Figure 2.2.1 indicates that these days were characterized by cold trough passages aloft, resulting in disruption of the stabilizing conditions required for the eddy formation. Under these slightly less stable conditions, wind flow can continue from the northwest all night, transporting air out of the southern part of the valley.

Nocturnal Wind Jet

On numerous nights a nocturnal wind jet is observed to form in the San Joaquin Valley, particularly in the Fresno area. Northwest winds increase in the low levels, peaking at 21 to 23 PDT. An example is shown in Figure 2.2.11 for the night of July 27-28 when a tracer release was made into the center of the jet. The time section of valley axis wind components

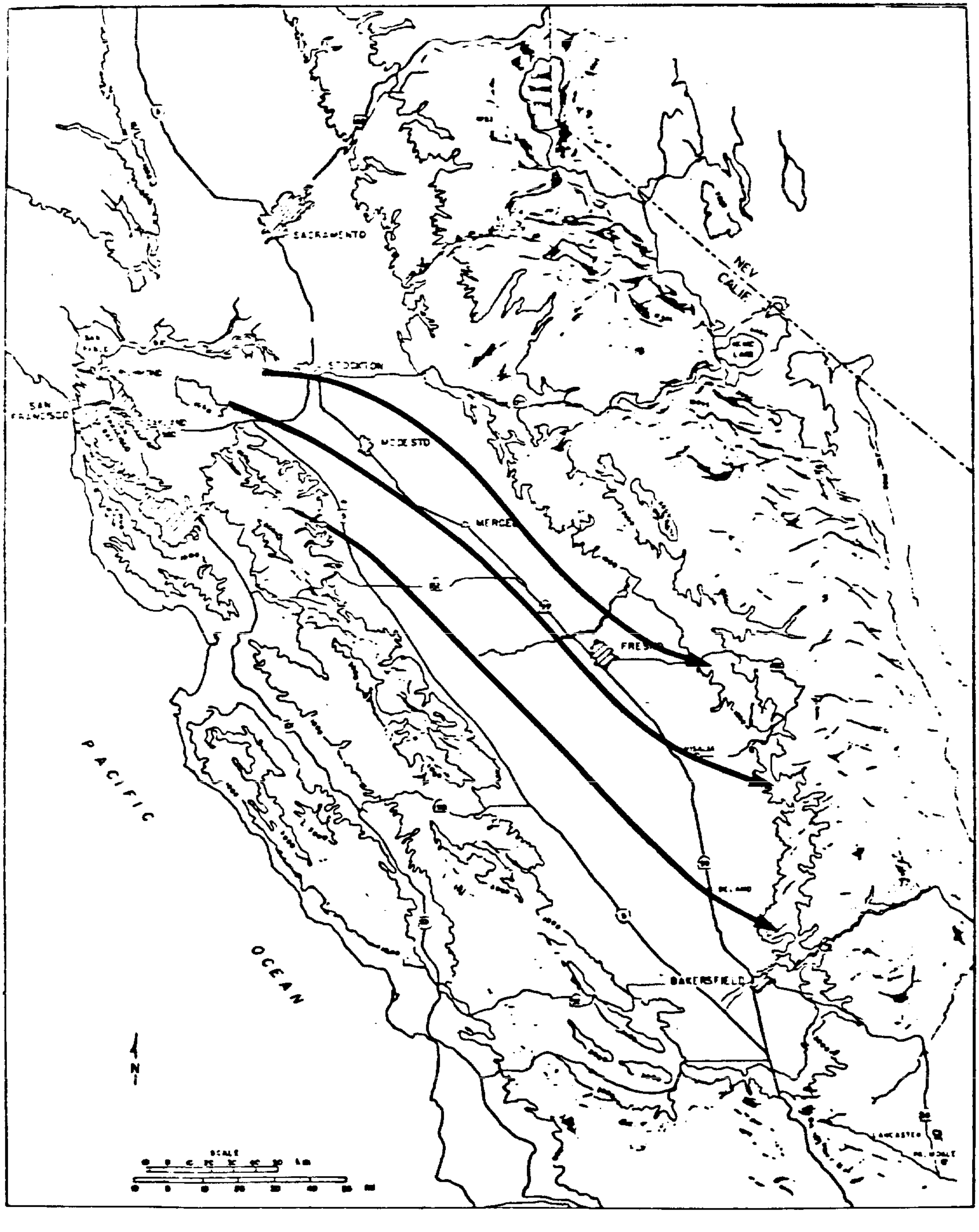


Figure 2.2.9 1000 Ft-agl Streamlines - 18 July 1979 (21 PDT)

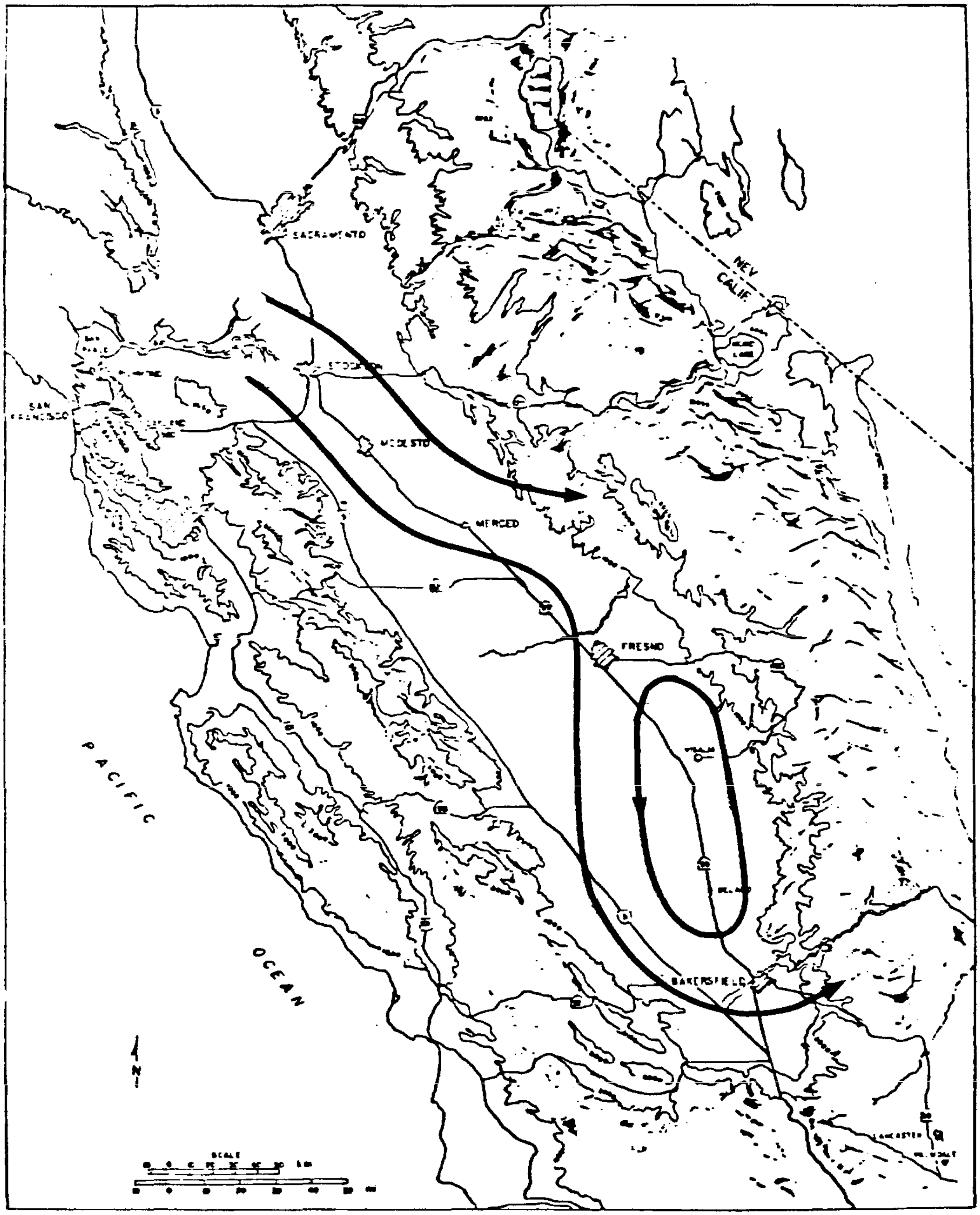


Figure 2.2.10 1000 Ft-agl Streamlines - 19 July 1979 (05 PDT)

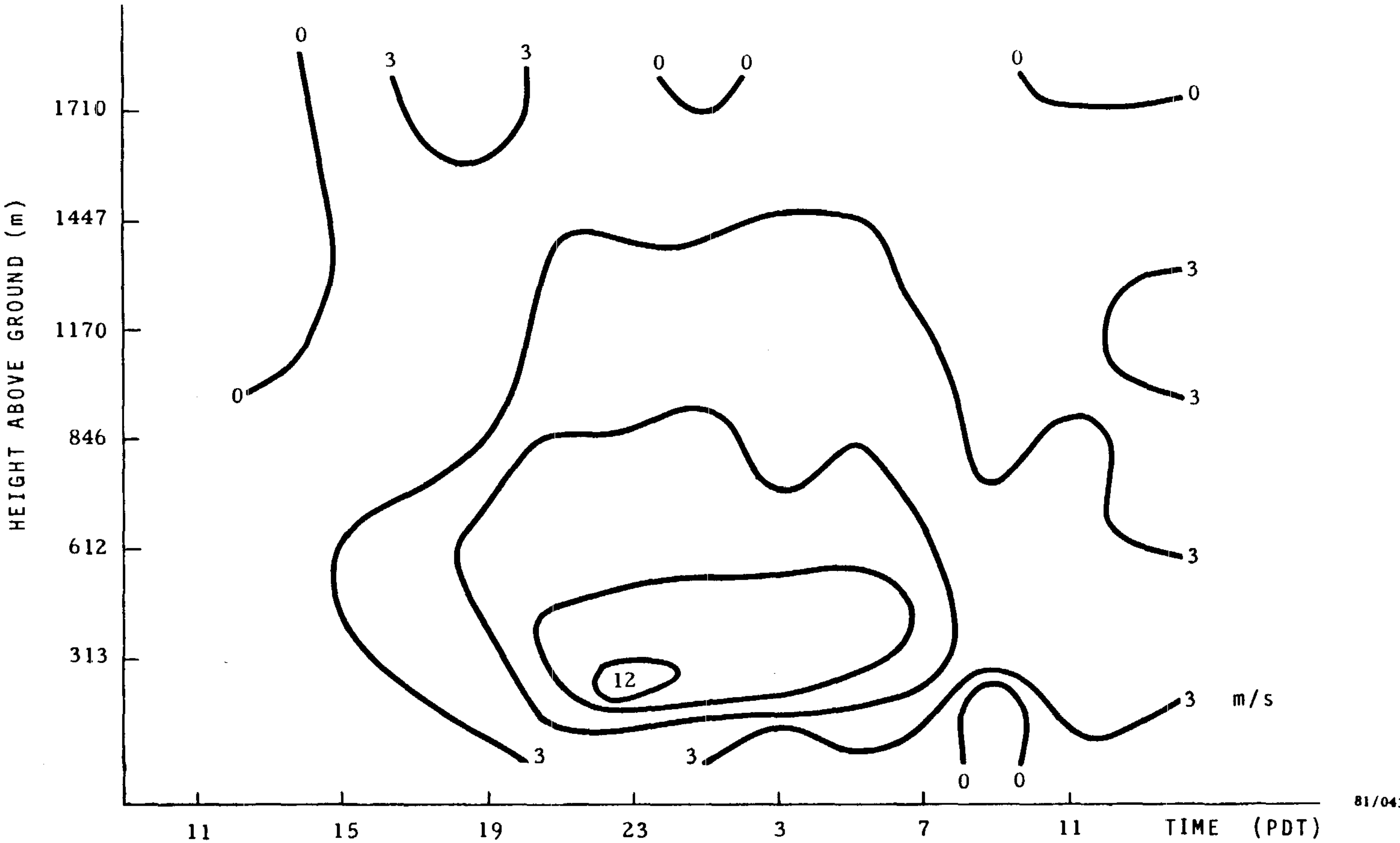


Figure 2.2.11 Component Winds Along Valley Axis (Fresno)
July 27-28, 1979

indicates increasing low level velocities beginning about 19 PDT with a peak near 300 m elevation at 23 PDT. The influence of the Fresno Eddy is shown by the negative wind values at 09 PDT.

The jet is caused by decreasing friction in the low layers accompanying the evening stabilization of the low levels. Under the influence of a strong driving force due to the existing pressure gradient, the air aloft accelerates resulting in relatively high velocities at low levels. During the 22 days of pibal data in July 1979, a strong jet occurred on nine nights while a moderate jet formed on four others. Further discussion of the nocturnal jet is given in Volume 2.

2.3 Air Quality

Tables 2.3.1 and 2.3.2 give the maximum hourly concentrations of various parameters as observed during the July 1979 intensive field program. Concentrations were observed at Modesto (RI), Merced (RI) and Madera (RI) by Rockwell International vans. The remainder of the concentration data were obtained from CARB Air Quality Data. Similar data for the months of July 1977 and 1978 are also included for comparison.

Comparison of July 1977, 1978 and 1979 indicates that peak hourly concentrations were very similar in all three years. It is therefore concluded that the pollutant conditions during the field period were as representative of July pollutant episode conditions as could reasonably be expected.

Ozone

Maximum hourly concentrations of ozone in Table 2.3.1 indicate rather uniform values throughout the valley but with slightly higher concentrations near the major urban areas. A number of locations on the eastern side of the valley show maximum values above the federal standard of 0.12 ppm. There were eight days of exceedances at the Modesto (RI) site during July 1979 and five and eight exceedances at the Merced and Madera sites, respectively. Lowest hourly maxima occur on the western side of the valley. There appears to be little change over the three-year period 1977-79. Maximum concentrations recorded at the regularly reporting stations were .16, .16 and .17 ppm in the three years. Shaver Lake shows a peak hourly value of .13 ppm for each year, indicating the importance of upslope flow from the valley.

Table 2.3.1

Maximum Hourly Concentrations (ppm)
July

Location	O_3 1977	O_3 1978	O_3 Field 1979	CO 1977	CO 1978	CO Field 1979
Bakersfield	.12	.13	.16	8	6	4
Coalinga		.10	.10		1	2
Five Points	.12	.08	.08	2		2
Fountain Springs		.13	.13			
Squaw Valley	.13	.16				
FNO-Butler						
FNO-CSU			.17			2
FNO-Downtown						
FNO-Olive	.16	.15	.17	8	4	5
Hanford	.12	.05	.11			
Lindsay	.11	.14				
Los Banos	.12	.13	.10			
McKittrick						
Merced	.14	.10		3	2	
Modesto		.12	.17		3	3
Oildale	.16	.14				
Shaver Lake	.13	.13	.18	2	2	1
Stockton	.16		.14	4		3
Taft	.09		.10			
Turlock	.15	.15	.16			
Visalia	.09	.13	.12	5	4	
Modesto (RI)			.19			0.6
Merced (RI)			.13			
Madera (RI)			.15			1.2

Table 2.3.2

Maximum Hourly Concentrations (ppm)
July

Location	NO_x			SO_2		
	1977	1978	Field 1979	1977	1978	Field 1979
Bakersfield	.38	.35	.27	.04	.08	.06
Coalinga		.04	.09			
Five Points				.02	.01	
FNO-CSU						
FNO-Olive	.43	.15	.18		.02	.02
McKittrick						
Merced	.24	.13				
Modesto		.22	.39			.02
Oildale		.15			.15	.07
Stockton	.23					
Visalia	.20	.17	.13			
Modesto (RI)			.04			
Merced (RI)			.03			
Madera (RI)			.02			

CO

The maximum CO concentrations during July 1979 show the strong influence of urban centers. Bakersfield and Fresno consistently record the highest values in the valley, ranging from a peak value of 5 to 8 ppm in the three-year period. Peak hourly values of 1-2 pm are typical for the rural areas and the west side of the valley.

Nitrogen Oxides

Nitrogen oxides (NO_x) concentrations also reflect the influence of urban areas. Generally, Fresno and Bakersfield report the highest hourly concentrations. In July 1979, however, there were four days at Modesto during the month which exceeded peak concentrations at any other location. With the exception of Modesto, the peak hourly NO_x concentrations during July 1979 appeared to be slightly lower than observed in 1977 and 1978. In the rural areas and the western side of the valley, NO_x concentrations tend to be very low, frequently not exceeding .10 ppm.

Sulfur Dioxide

Sulfur dioxide concentrations in the valley were generally low during July 1979. Highest values were recorded at Bakersfield and Oildale where .06 and .07 ppm, respectively, were observed. The remaining maximum values measured in the valley were .01 to .02 ppm. These background values were the same as observed in July 1977 and 1978 but the concentrations for Oildale and Bakersfield were slightly lower than observed in the previous two years.

Hydrocarbons

Non-methane hydrocarbons (NMHC) were measured at Stockton, Tracy and two locations in Fresno during July 1979. Samples were obtained and analyzed by the Atmospheric Testing Branch, California Air Resources Board (El Monte). Samples were usually taken three times per day and subsequently analyzed for C_2 through C_{10}.

Table 2.3.4 gives the average concentrations of various hydrocarbons measured during July. Total NMHC averaged less than 200 ppb with the exception of Riverside which was influenced by one large sample of propane. The automobile contribution to NMHC was low at all stations as suggested by the low values of acetylene. Propane was the largest contributor to the total NMHC concentration.

NO_x concentrations were not obtained at Stockton during July 1979. Concentrations of NO_x at Union Island between 06 ad 09 PST ranged from .01 to .04 ppm. Values at Stockton may have been somewhat higher. Use of the Union Island NO_x values yields an average NMHC/NO_x ratio of about 5 with a range from 2 to 14 on individual days. The small concentrations of NMHC, however, preclude the formation of much ozone, particularly in view of the low concentrations of the more reactive forms of NMHC.

Time of Peak Hourly Concentrations

Table 2.3.5 gives the principal periods of the day when peak ozone and NO_x concentrations were observed at several stations during July 1979. On some days, the peak concentrations occurred outside of the principal period indicated. If such occurrences were sufficiently frequent the time of day was included in the table in parentheses.

It is apparent from the table that there are two peak ozone periods in the northern part of the valley. One of these occurs near or slightly after noon and can be attributed to local sources. The second occurs between 15 and 20 PST and must be associated with transport of ozone or precursors into the area. It is to be noted that the late afternoon peak at the three Rockwell sites appears to be at about the same time of day. As a consequence, the evidence of a pulse of ozone moving from north to south along the valley axis is not particularly good. Anthropogenic activities along Highway 99 with associated urban influences may be a better source for the late afternoon peak.

The stong urban, local influence at Fresno is apparent from the timing of the peak at 11-13 PST.

NO_x peaks occur most frequently during the morning hours from midnight to 08 PST, reflecting the accumulation of combustion products during the most stagnant period of the day.

Table 2.3.4

Average NMHC Concentrations (ppb)
July 1979 (06-09 PST)

			Fresno	
Name	Stockton	Tracy	CSU	Riverside
Number of Samples	9	9	3	2
Ethane	11	11	22	20
Ethylene	8	7	11	9
Acetylene	7	6	10	9
Propane	45	18	49	209
Propylene	8	6	10	21
Propadiene	0	0	0	0
Isobutane	12	9	7	13
N-Butane	20	13	14	23
1-Butene	1	1	1	0
2-Butene	4	3	3	5
Isopentane	25	17	24	61
N-Pentane	13	8	16	39
Total	134	99	167	418

Table 2.3.5

Time of Maximum Concentration (PST)
July 1979

	O_3	NO_x
Modesto (RI)	17-20 (13-16)	06-08 (20-23)
Merced (RI)	16-20 (13-14)	00-07
Madera (RI)	11-14 (16-20)	00-06 (11-12)
Turlock	12-14 (15-17)	
Modesto	14-17	05-07
Madera	14-17	
FNO-CSU	11-13	

2.4 Particulates

2.4.1 Total Particle Composition

Average total particle concentrations from the July 1979 intensive are listed in Table 2.4.1. The major components on the average at all three sites were silicon, sulfate, and carbon with silicon tending to be the largest, and sulfate and carbon concentrations being nearly equal. Average concentrations of the crustal-like elements were highest at Merced and about equal at Modesto and Madera. Average concentrations of the other elements were not significantly different from one site to another. The average mass concentration at Merced was about 20 percent higher than at the other sites.

Table 2.4.1

Average Total Particle (diameter $<\sim 20\ \mu m$) Concentrations Measured During July 1979

Component	Location: Modesto (14 Samples) ($\mu g/m^3$)	Modesto (% Mass)	Merced (14 Samples) ($\mu g/m^3$)	Merced (% Mass)	Madera (7 Samples) ($\mu g/m^3$)	Madera (% Mass)
Mass	68.6		82.3		64.0	
$SO_4^{=}$	9.5	13.8	8.9	10.8	7.0	10.9
NO_3^{-}	3.1	4.5	2.7	3.3	2.4	3.8
NH_4^{+}	2.9	4.2	2.4	2.9	1.8	2.8
C	7.8	11.4	8.3	10.1	7.3	11.4
Al	3.5	5.1	4.8	5.8	3.9	6.1
Si	10	14.6	14	17.0	11	17.2
Cl	0.10	0.1	0.13	0.2	0.078	0.1
K	0.99	1.4	1.3	1.6	0.99	1.6
Ca	0.97	1.4	1.3	1.6	0.82	1.3
Ti	0.19	0.03	0.26	0.3	0.21	0.3
V	0.019	2.6	0.020	0.02	0.018	0.03
Fe	1.8	0.02	2.6	3.2	2.1	3.3
Ni	0.011	0.04	0.0086	0.01	0.0078	0.01
Zn	0.030	0.03	0.035	0.04	0.020	0.03
Br	0.020	0.2	0.021	0.03	0.019	0.03
Pb	0.13		0.10	0.1	0.093	0.1
Sum of Measured Components	41.1	59.9	46.9	57.0	37.8	59.0

2.4.2 Source Contributions to Total Particle Concentration

Averages of the estimated contributions of the source types to total particle samples for the July 1979 period are in Table 2.4.2. Emissions of crustal-like materials accounted for the largest fraction of the mass. Emissions from uncultivated land contributed substantially less material than did emissions from cultivated land.

Emissions of crustal-like materials accounted for the largest fraction of the mass. Emissions from uncultivated land contributed substantially less material than did emissions from cultivated land.

Contributions of particles emitted directly by motor vehicles and oil combustion were small, accounting for less than 1 percent of the mass at all sites.

Ammonium sulfate contributed 9 to 15 percent of the average mass, while ammonium nitrate contributed 3 to 6 percent. Carbon from unidentified sources accounted for about 10 percent of the average mass.

The source types in the calculations, including excess carbon, accounted for 96 to 102 percent of the average measured mass.

Table 2.4.2

Estimated Contributions of Source Types
To Average Total Particle Mass During July 1979

Source Type	Location: Modesto (14 Samples) ($\mu g/m^3$)	(%)	Merced (14 Samples) ($\mu g/m^3$)	(%)	Madera (6 Samples) ($\mu g/m^3$)	(%)
Cultivated land	37.0	54.0	57.0	70.0	49.0	74.0
Uncultivated land	6.0	9.0	3.0	4.0	-	-
Motor vehicles (primary)*	0.4	0.6	0.4	0.5	0.3	0.5
Oil combustion (primary)**	0.2	0.3	0.2	0.2	0.2	0.3
$(NH_4)_2 SO_4$	10.0	15.0	8.0	10.0	6.0	9.0
$(NH_4) NO_3$	4.0	6.0	3.0	4.0	3.0	5.0
Unidentified C	8.0	12.0	8.0	10.0	8.0	12.0
Sum	66.0	96.0	80.0	98.0	67.0	102.0
Measured Mass	69.0		82.0		66.0	

* Includes only motor vehicle exhaust. Resuspended road dust is not distinguishable from cultivated and uncultivated land. Conversion of NO_x emissions to nitrate is included with $NH_4 NO_3$.

** Sulfate formed from SO_2 emissions and nitrate formed from NO_x emissions are included with $(NH_4)_2 SO_4$ and $NH_4 NO_3$.

3. Tracer Summaries

3.1 Test 1 13-14 July 1979, Manteca Release (0700-1300 PDT)

3.1.1 Meteorology

General

The synoptic meteorology of the 13-14 July period was characterized by an extensive, flat high pressure region aloft over the southwestern states (Figure 3.1.1). Maximum heights at 500 mb were located just offshore of California inducing subsidence and warming of the air aloft over the region of interest. The warming and stabilization of the atmosphere is reflected in the 850 mb temperatures from Oakland and Vandenberg shown in Figure 2.2.1. At the surface, a thermal trough was established over the Central Valley and southern desert resulting in an on-shore pressure gradient. Clear skies prevailed throughout the San Joaquin Valley. Visibilities were greater than 20 miles in the northern region of the valley, but decreased to about 10 miles in the southern portions. Surface temperatures were near normal for the time of year; maximum temperatures near 100°F were measured at all locations in the valley with Bakersfield reporting a high of 104°F on the afternoon of the 14th.

Transport Winds

Surface winds at the tracer release site are tabulated in Table 3.1.1 from the start of the release until midnight when the northwesterly flow ceased and winds became light and variable. The winds at the release site were persistent from the northwest at speeds ranging from 2-4 m/sec throughout the morning and afternoon. Streamlines of the airflow at 1000 ft-agl, constructed from observed pibal winds, are depicted on Figures 3.1.2 through 3.1.6. At 0700 PDT on the 13th, a strong northwesterly flow was present on the west side, extending the entire length of the valley. At the southern end, a Fresno eddy had formed. Air was diverted and returned northward along the east flank of the valley. The formation of the eddy is a common occurrence in the summer months and is described in more detail in Volume 2 of this study.

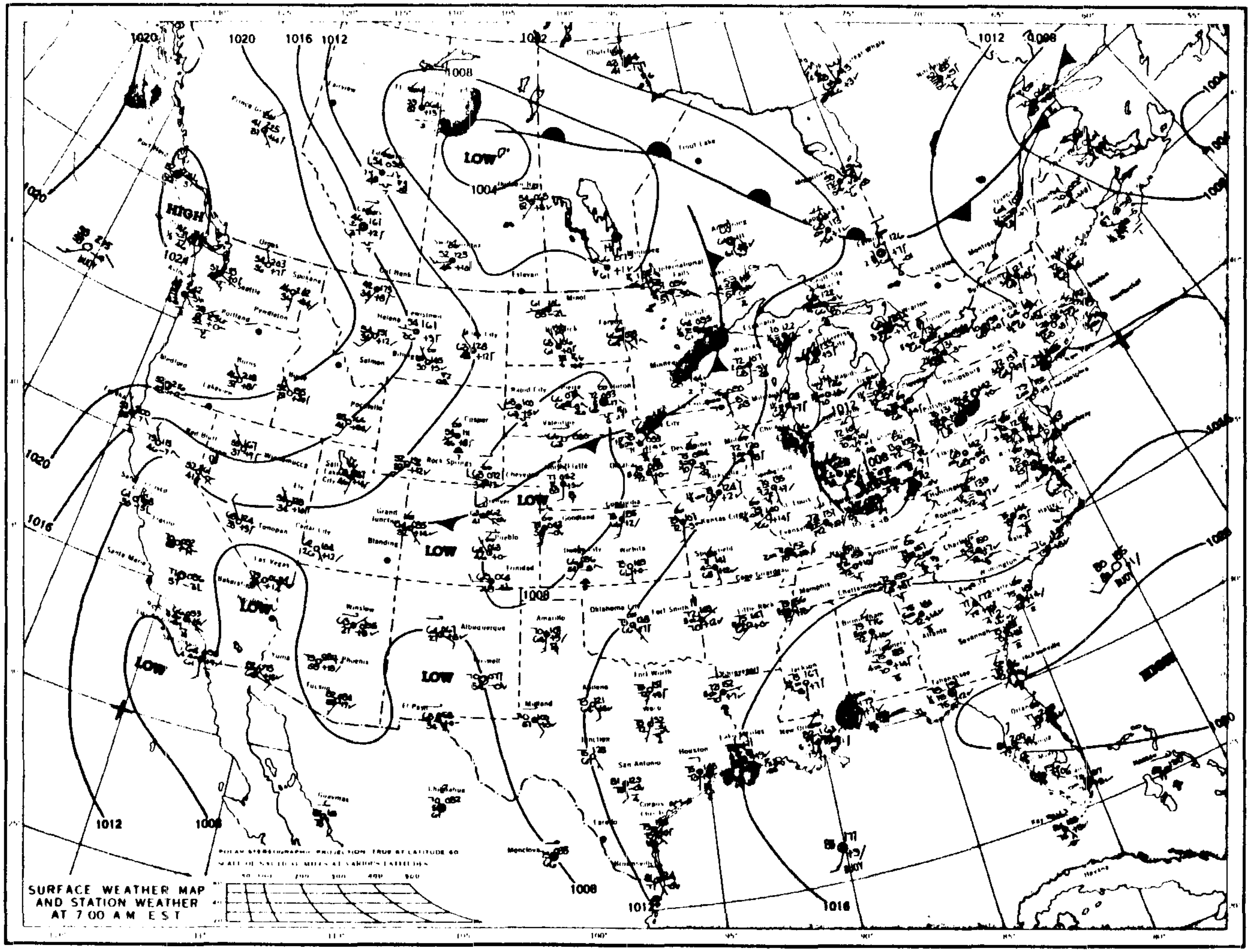


Figure 3.1.1 Surface Weather Charts - 13 July 1979 (05 PDT)

Table 3.1.1

SURFACE WINDS AT MANTECA
13 JULY 1979

Time (PDT)	Wind (m/s)
0700	290/2.4
0800	285/3.1
0900	295/4.2
1000	300/4.2
1100	300/3.8
1200	295/3.8
1300	300/3.6
1400	300/3.5
1500	300/3.3
1600	315/3.2
1700	305/2.9
1800	300/2.5
1900	305/1.8
2000	270/1.2
2100	290/1.3
2200	295/1.5
2300	005/0.6

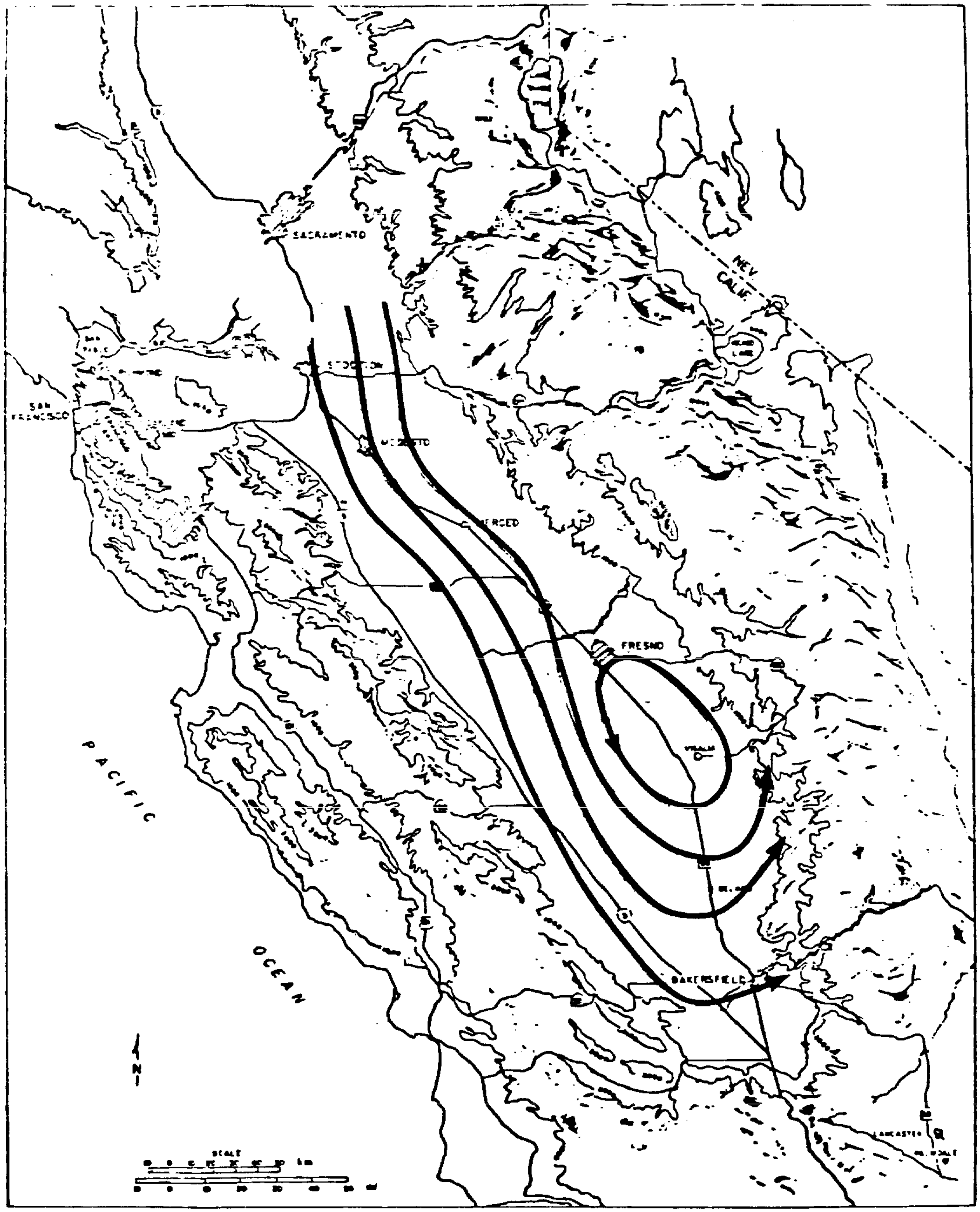


Figure 3.1.2 1000 Ft-agl Streamlines - 13 July 1979 (07 PDT)

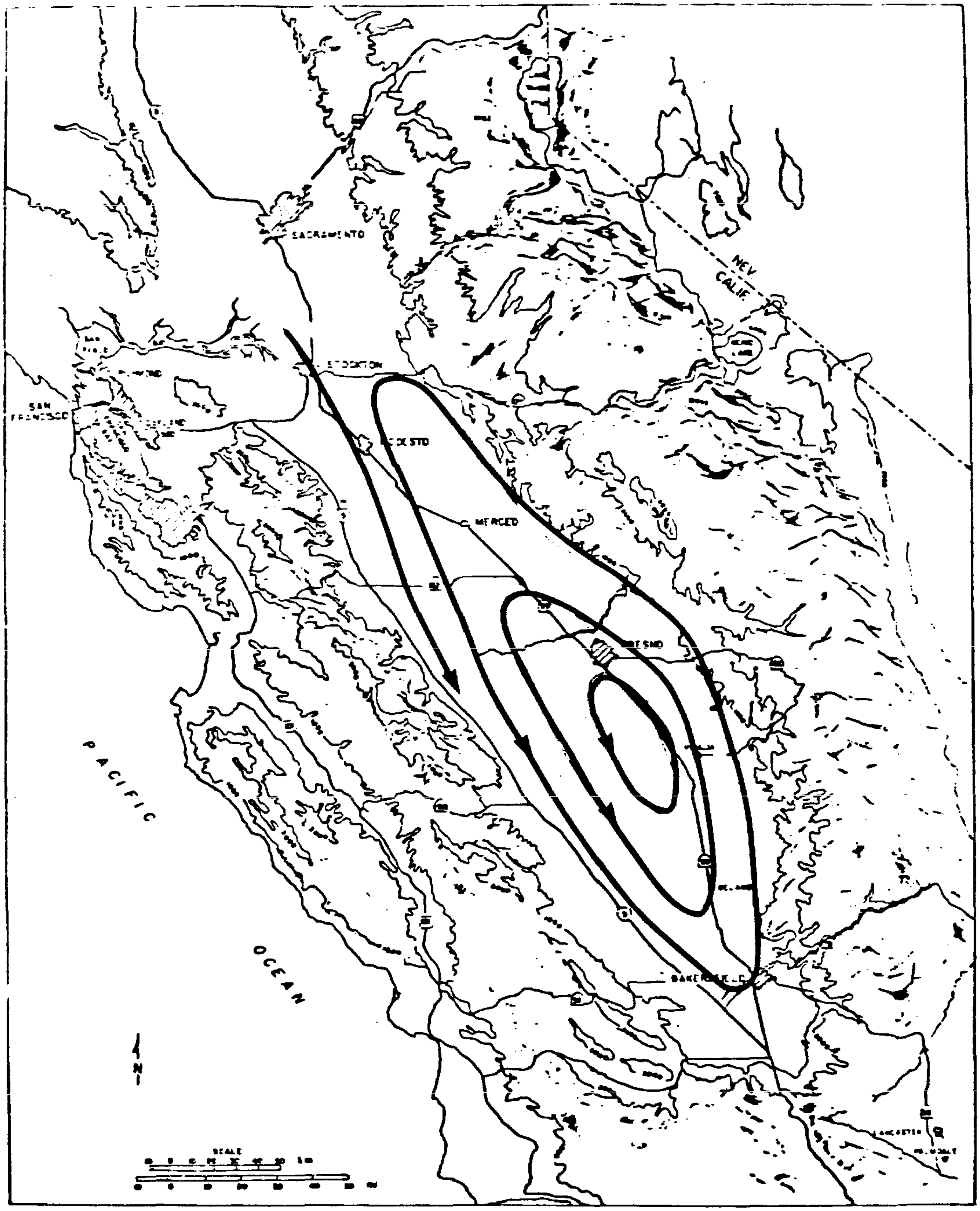


Figure 3.1.3 1000 Ft-agl Streamlines - 13 July 1979 (09 PDT)

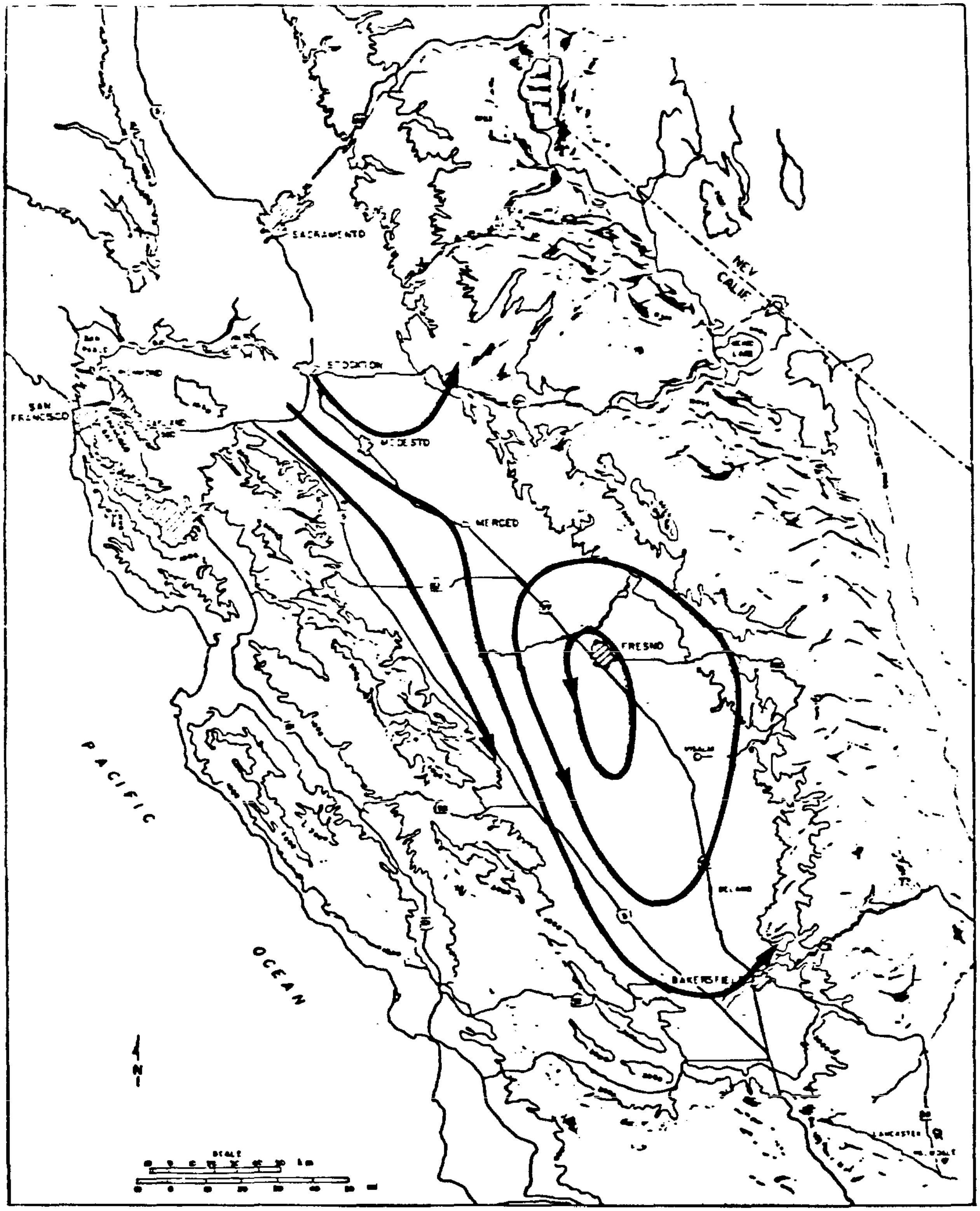


Figure 3.1.4 1000 Ft-agl Streamlines - 13 July 1979 (13 PDT)

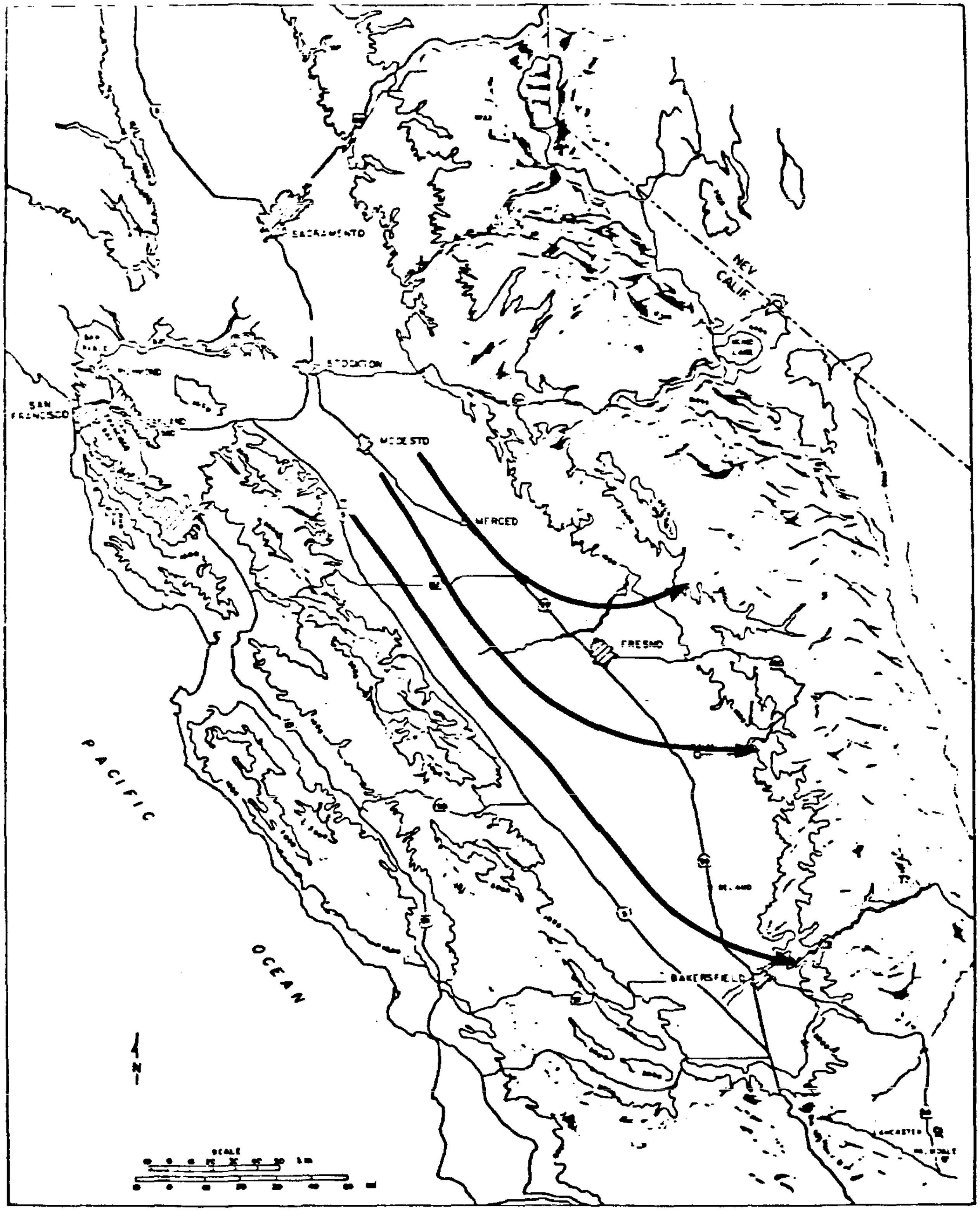


Figure 3.1.5 1000 Ft-agl Streamlines - 13 July 1979 (19 PDT)

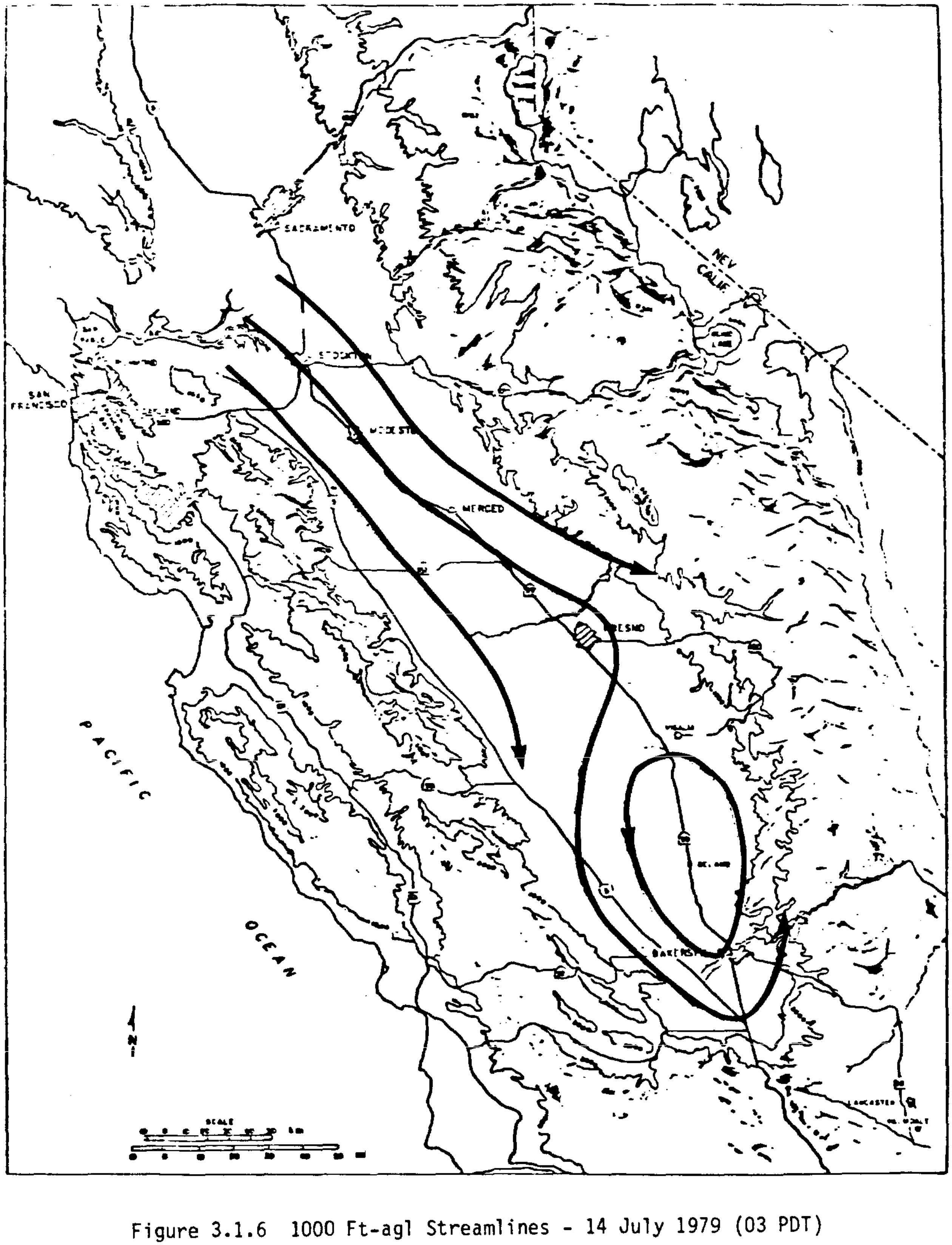


Figure 3.1.6 1000 Ft-agl Streamlines - 14 July 1979 (03 PDT)

By 0900 PDT (Figure 3.1.3) the southerly flow had extended as far north as Modesto Reservoir so that the eddy dominated the entire valley. This northward extension was unusual within the July observational period. Generally, the eddy does not extend very much beyond Fresno. The eddy persisted through most of the day (Figure 3.1.4) but was replaced by northwest winds throughout the valley by 1900 PDT (Figure 3.1.5). By 0300 PDT (Figure 3.1.6) on July 14, however, another eddy had developed in the southern end of the valley. This eddy continued to grow northward to encompass Fresno by 0900 but did not extend as far north as Modesto Reservoir.

The importance of the northward extension of the eddy on the morning of July 13 was that the normal northwesterly flux of air entering the valley was forced to the western side and was constricted in horizontal width. Velocities were consequently increased considerably compared to the flow field usually observed. This is shown dramatically in Figure 3.1.7 where a vertical cross section of the flow field from Modesto Reservoir to Los Banos has been constructed. Pibal winds were resolved into up and down-valley components at all levels to construct the figure. Winds of over 16 m/s are shown at Los Banos at 500 m as a result of the constricted flow.

Under these flow conditions the tracer released from Manteca was diverted to the west side of the valley and was carried rapidly southward. The eddy mechanism provides a means for redistributing the tracer throughout the valley by the following day.

Mixing Heights

Mixing heights were determined from aircraft soundings by noting the top of the pollutant or low-level turbulence layer. Table 3.1.2 gives the mixing heights for all soundings made on July 13.

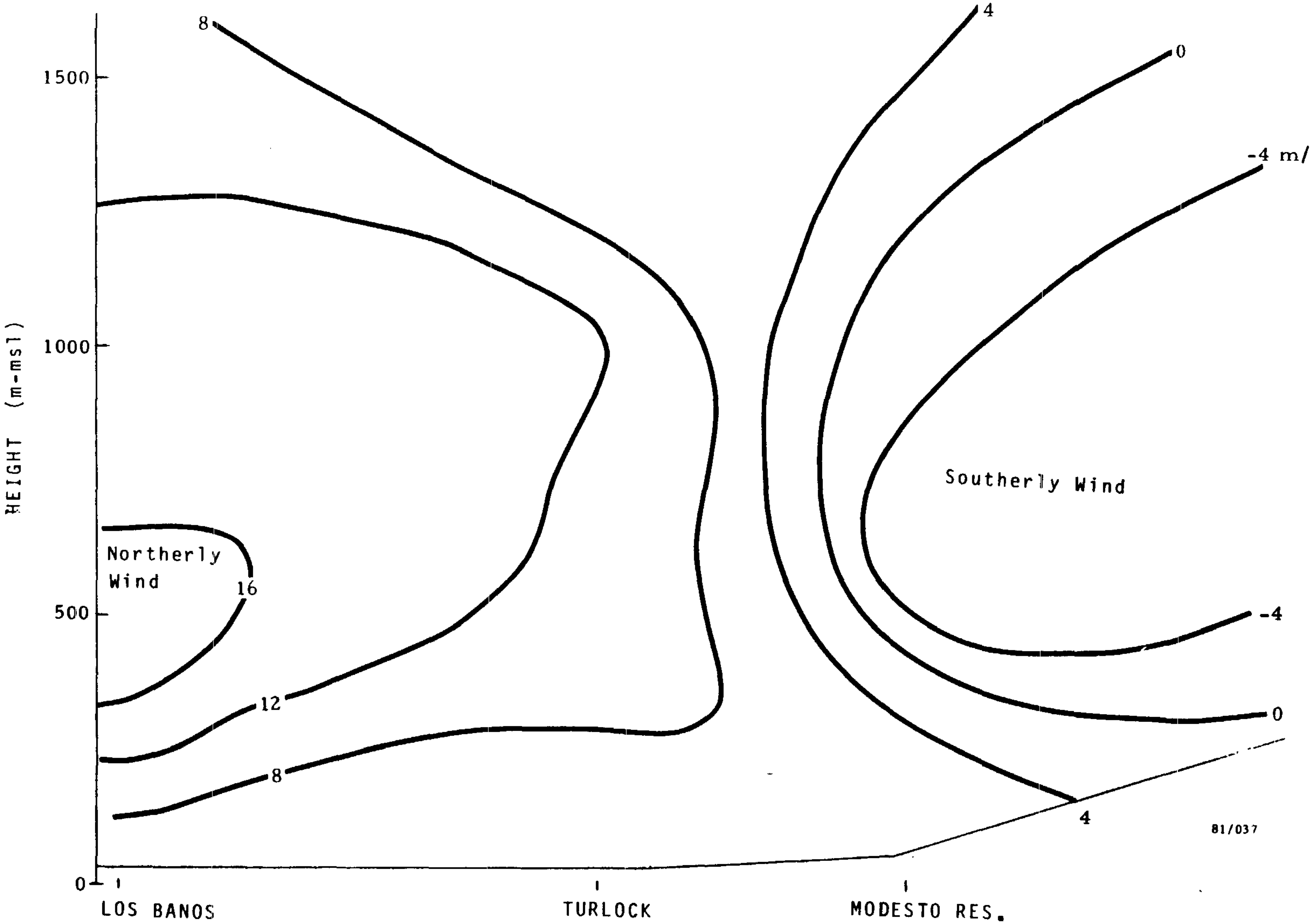


Figure 3.1.7 Vertical West-East Cross Section of Wind Component (m/s) to Valley Axis (Positive Component into Valley) - 13 July 1979, 07 PDT

Table 3.1.2

AIRCRAFT MIXING HEIGHTS
JULY 13, 1979

Time (PDT)	Location *	Mixing Height (m [above ground level])
0603	Modesto Airport	210
0842	7 W Livingston	480
0916	15 E Modesto Airport	270
1648	Modesto Airport	570
1919	7 W Livingston	720
1951	15 E Modesto Airport	480

(* Distances in miles)

3.1.2 Air Quality

Regional Pollutant Levels

Maximum measured hourly average ozone concentrations for July 13 are shown in Figure 3.1.8. Within the valley, on the 13th, exceedances of the California ambient air quality standard were experienced only at Fresno and Bakersfield. However, in the Sierra Nevada, downwind from both urban sources, violations of the standard also occurred. On the 14th, widespread exceedances of the ozone standard were experienced in the northern and eastern sections of the valley. Only on the extreme west side did concentrations remain less than .10 ppm.

Maximum hourly concentrations for CO, SO_2 and NO_x anywhere in the valley on July 13 are shown in Table 3.1.3. Maximum values for the Rockwell International sites are also included.

The effect of the southerly flow on the east side of the valley (Figure 3.1.3) on ozone concentrations is shown in Figure 3.1.9. This cross section across the valley between Los Banos and Modesto Reservoir was constructed from aircraft soundings and horizontal traverses. Low levels of ozone aloft (between Los Banos and Turlock) correspond to the northerly flow of air shown in Figure 3.1.7. On the eastern side of the valley, ozone concentrations were much higher in the southerly flow. The Fresno eddy therefore provides a mechanism for redistributing pollutant concentrations within the valley.

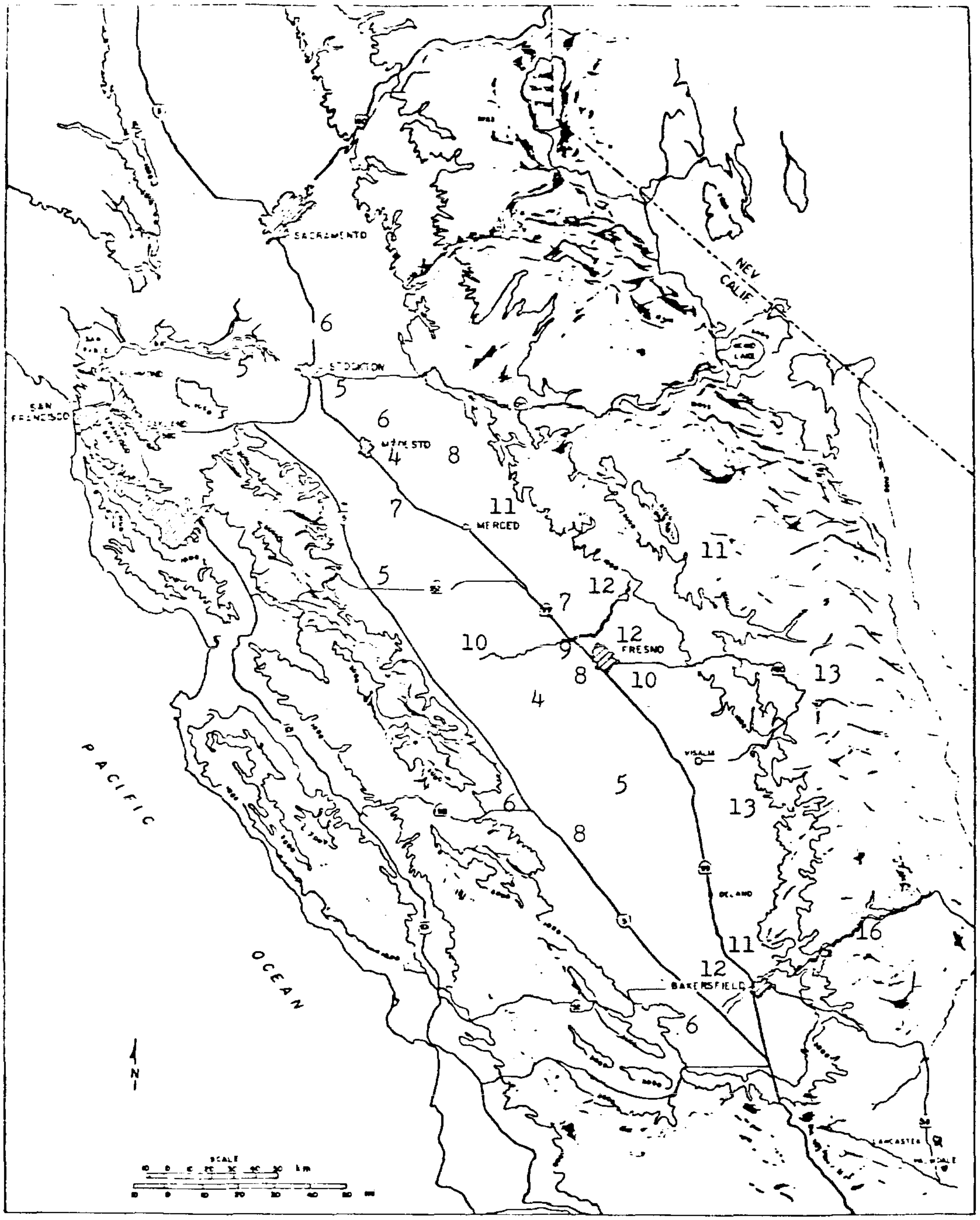


Figure 3.1.8 Maximum Hourly Ozone Concentrations (pphm) - 13 July 1979

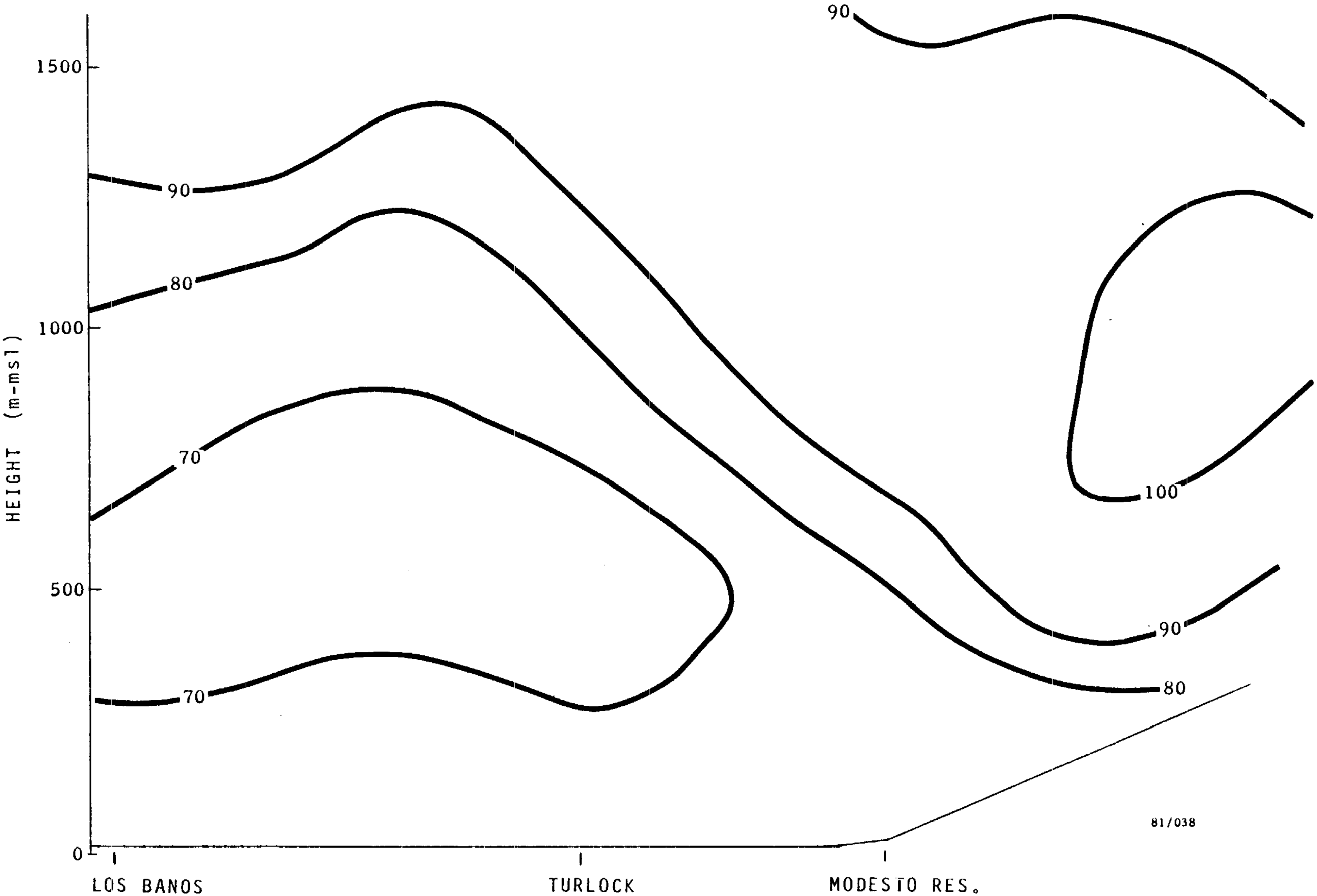


Figure 3.1.9 Vertical West-East Cross Section of Ozone Concentrations (ppb) Measured Between 0646-0916 PDT - 13 July 1979

Table 3.1.3

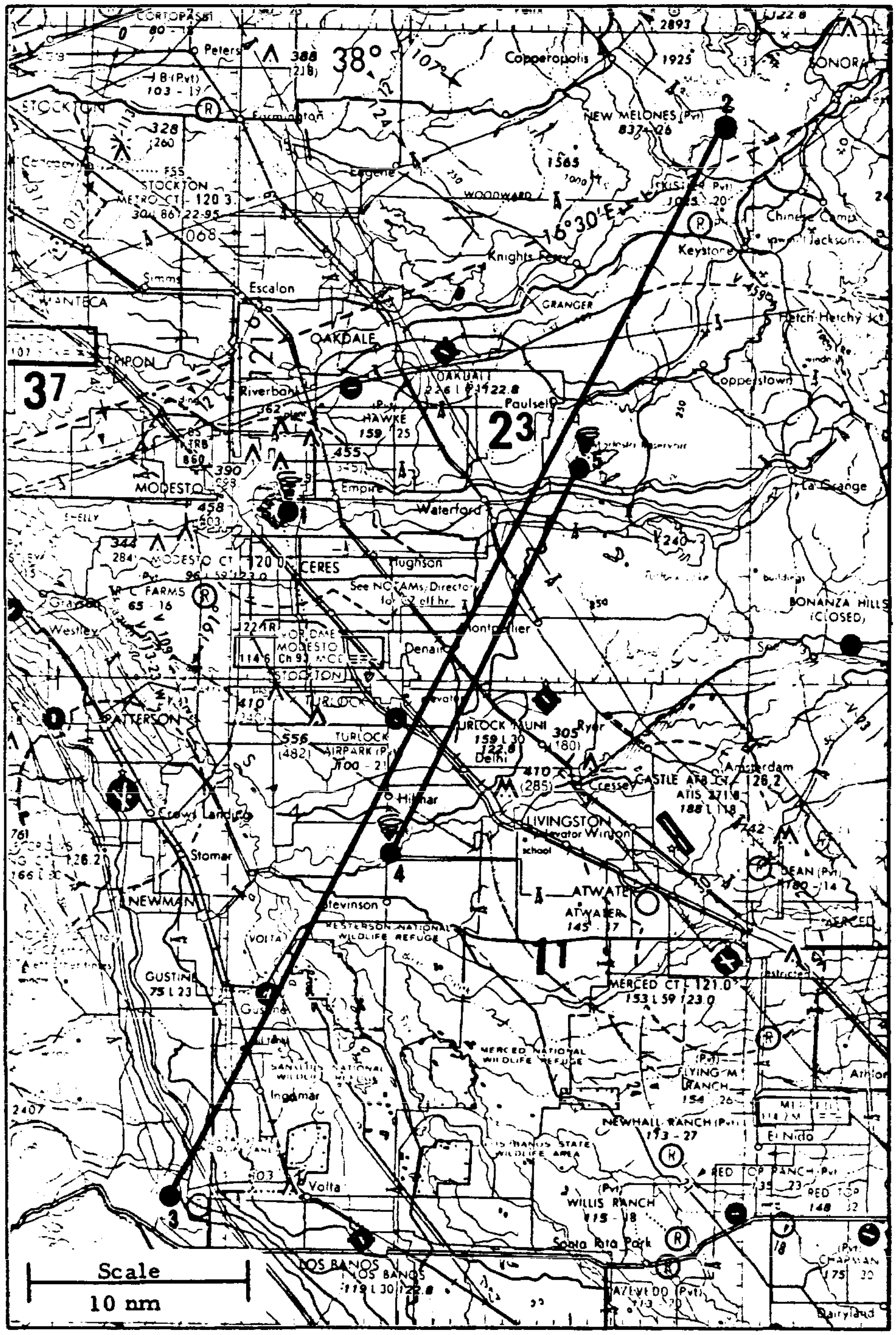
MAXIMUM HOURLY CONCENTRATIONS
JULY 13, 1979

Parameter	Location	Maximum Value (ppm)
SO_2	Fresno-Olive	.02
SO_2	Modesto	.02
CO	Bakersfield	4.
NO_x	Bakersfield	.20
SO_2	Modesto (RI)	< .01
SO_2	Merced (RI)	< .01
NO_x	Modesto (RI)	.02
NO_x	Merced (RI)	.01
NO_x	Madera (RI)	.01

Aircraft Sampling

Two sampling flights were made, one in the early morning (0603-0929 PDT), and again in the late afternoon (1648-2014 PDT). The sampling routes were designed to define the distribution of air quality meteorological conditions in a vertical cross section across the San Joaquin Valley. Traverses at four constant altitudes were flown along a valley transect passing near Turlock and Modesto Reservoir. Spirals were flown at locations roughly one-third and two-thirds distance along the traverse route and over the Modesto Airport. Figure 3.1.10 shows the sampling routes for both flights. Tables 3.1.4 and 3.1.5 give the general pollutant characteristics found on each part of the sampling route.

In the morning the horizontal distribution at 1500, 3000 and 5000 ft msl displayed the same general trends; ozone and b_{scat} were greatest on the east side of the valley, decreased to the center of the valley, then remained relatively constant on the west side.



SAMPLING ROUTES 13 JULY 1979 P.M.

Figure 3.1.10

Table 3.1.4

AIR QUALITY MEASUREMENTS CARB SAN JOAQUIN VALLEY PROJECT
JULY 13, 1979 SAMPLING

Start Time (PDT)	Location (Point)	O_3 Mean (ppb)	O_3 Max (ppb)	b_{scat} Mean ($x10^{-6}m^{-1}$)	b_{scat} Max ($x10^{-6}m^{-1}$)	SO_2 Mean (ppb)	SO_2 Max (ppb)	NO_x Mean (ppb)	NO_x Max (ppb)	NO Mean (ppb)	NO Max (ppb)
0603	1	79	103	55	164	1	2	5	17	3	10
0646	2-3	74	101	68	290	0	1	6	22	2	10
0721	3-2	85	111	54	114	0	1	4	13	2	10
0803	2-3	92	101	41	84	0	1	4	12	2	10
0842	4	95	114	49	124	1	2	4	12	2	9
0901	4-5	73	83	77	154	0	1	14	24	5	13
0916	5	104	186	86	190	1	3	6	22	3	13

Table 3.1.5

AIR QUALITY MEASUREMENTS CARB SAN JOAQUIN VALLEY PROJECT
JULY 13, 1979 SAMPLING

		O_3		b_{scat}		SO_2		NO_x		NO	
Start Time (PDT)	Location (Point)	Mean (ppb)	Max (ppb)	Mean ($x10^{-6}m^{-1}$)	Max ($x10^{-6}m^{-1}$)	Mean (ppb)	Max (ppb)	Mean (ppb)	Max (ppb)	Mean (ppb)	Max (ppb)
1648	1	106	139	44	154	1	2	10	40	5	17
1724	2-3	138	157	75	150	1	1	10	29	3	14
1801	3-2	123	176	53	140	0	1	7	23	4	15
1839	2-3	145	192	62	146	1	2	7	22	3	14
1919	4	110	141	57	150	0	1	9	44	5	34
1938	4-5	134	154	67	126	-1	0	9	22	3	10
1951	5	154	188	73	138	1	3	10	23	53	17

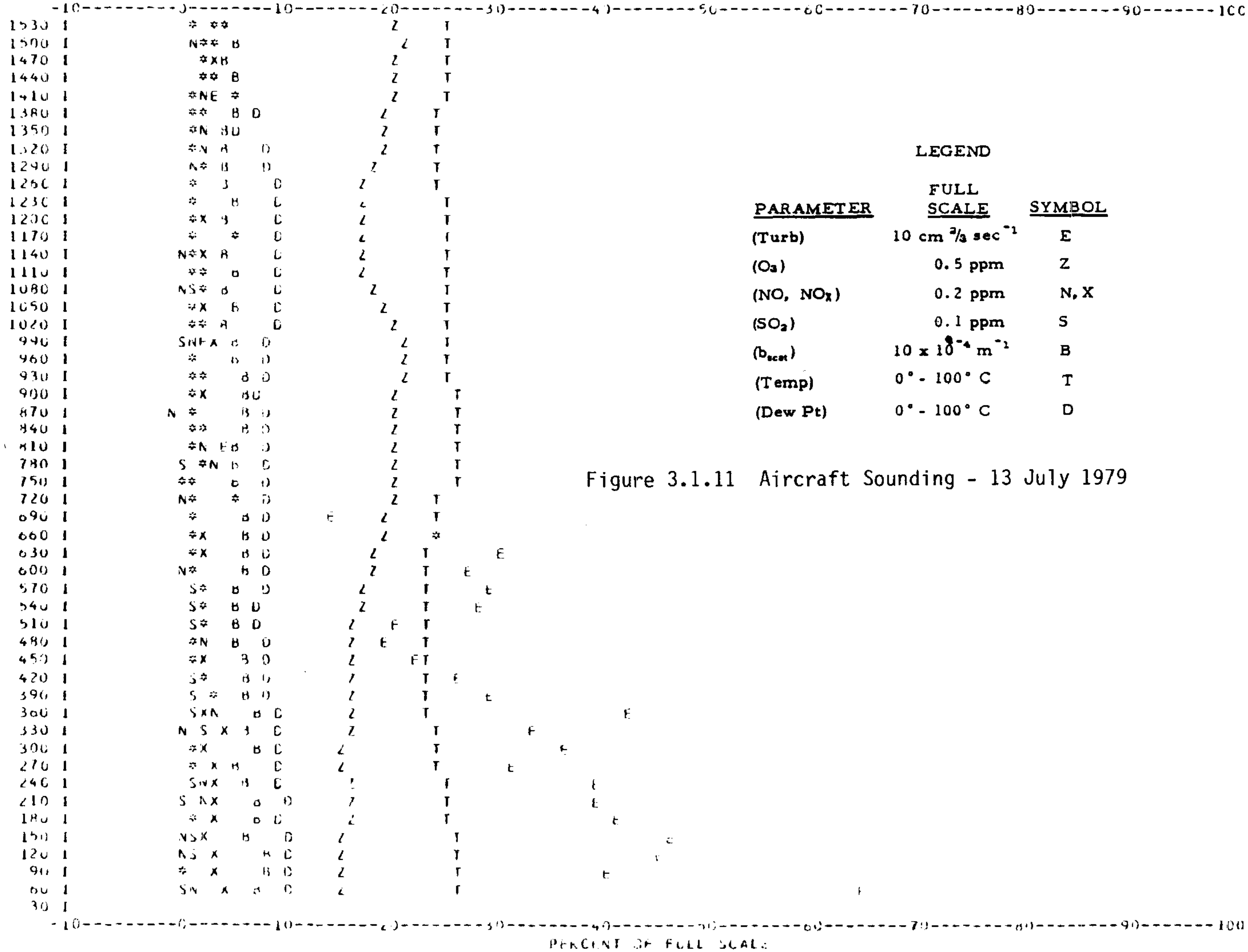
The contrast between the eastern and western sides of the valley is shown in Figures 3.1.11 and 3.1.12 which were taken to the west and east of Highway 99, respectively (see Figure 3.1.10). Figure 3.1.12 shows a marked ozone layer centered at 600 m (agl) with a peak concentration of .18 ppm. This layer also exhibits high b_{scat} values, indicating the aged nature of the pollutants. No such layer is shown in Figure 3.1.11 on the west side of the valley.

High concentrations of ozone continued to be present aloft over the eastern part of the valley during the afternoon. Figures 3.1.13 and 3.1.14 show soundings made at Points 1 and 4 (Figure 3.1.10) during the late afternoon. The observed mixing height was about 500-600 m for both soundings with ozone levels of .14 to .15 ppm within the mixing layer. On the east side of the valley, however, (Figure 3.1.14) the ozone concentrations aloft reached a maximum value of .18 ppm in contrast to .11 ppm over Point 1 (Figure 3.1.13). Southeast winds within the upper ozone layer continued through 1300 PDT but had shifted to north to northeast by the time of the sounding (Figure 3.1.14).

COFPLT VER 01 MOD 03   21-APR-80 52:19:03   PAGE 16

DATE: 7/13/79
CARTRIDGE/PASS: 0657 6
TIME: 8:42:15 TO 9:58:28

ROUTE: OVER POINT 4
MIN. GROUND ELEV.: 18 M(MSL)



LEGEND

PARAMETER	FULL SCALE	SYMBOL
(Turb)	10 $cm^{2/3}$ sec^{-1}	E
(O_3)	0.5 ppm	Z
(NO, NO_X)	0.2 ppm	N, X
(SO_2)	0.1 ppm	S
(b_{scat})	10 x 10^{-4} m^{-1}	B
(Temp)	0° - 100° C	T
(Dew Pt)	0° - 100° C	D

Figure 3.1.11 Aircraft Sounding - 13 July 1979

DATE: 7/13/79 ROUTE: OVER POINT 5 (CONTINUED)
CARTRIDGE/PASS: 5657 8
TIME: 9:16:11 TO 9:29:27 MIN. GROUND ELEV.: 67 M(MSL)

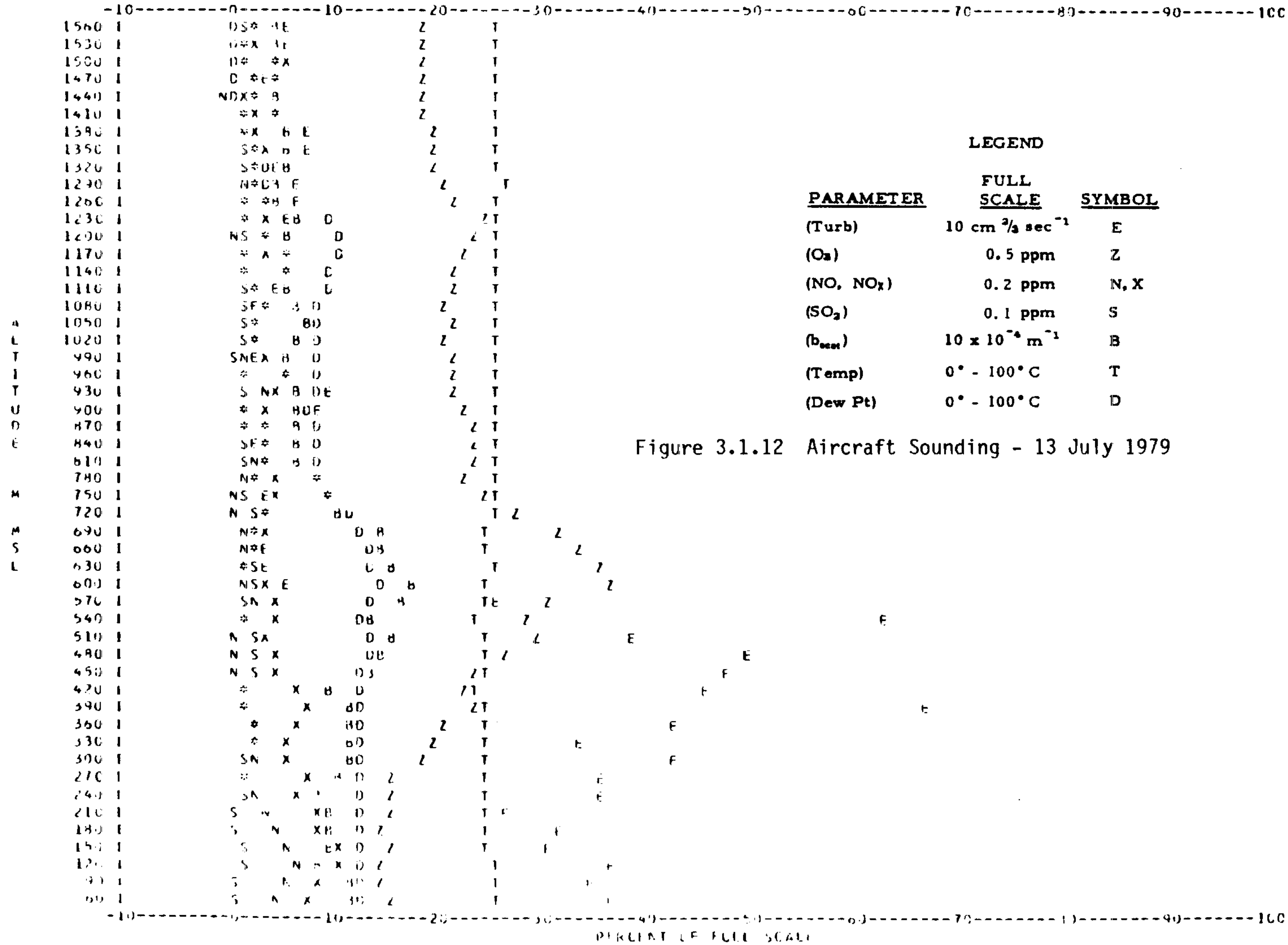
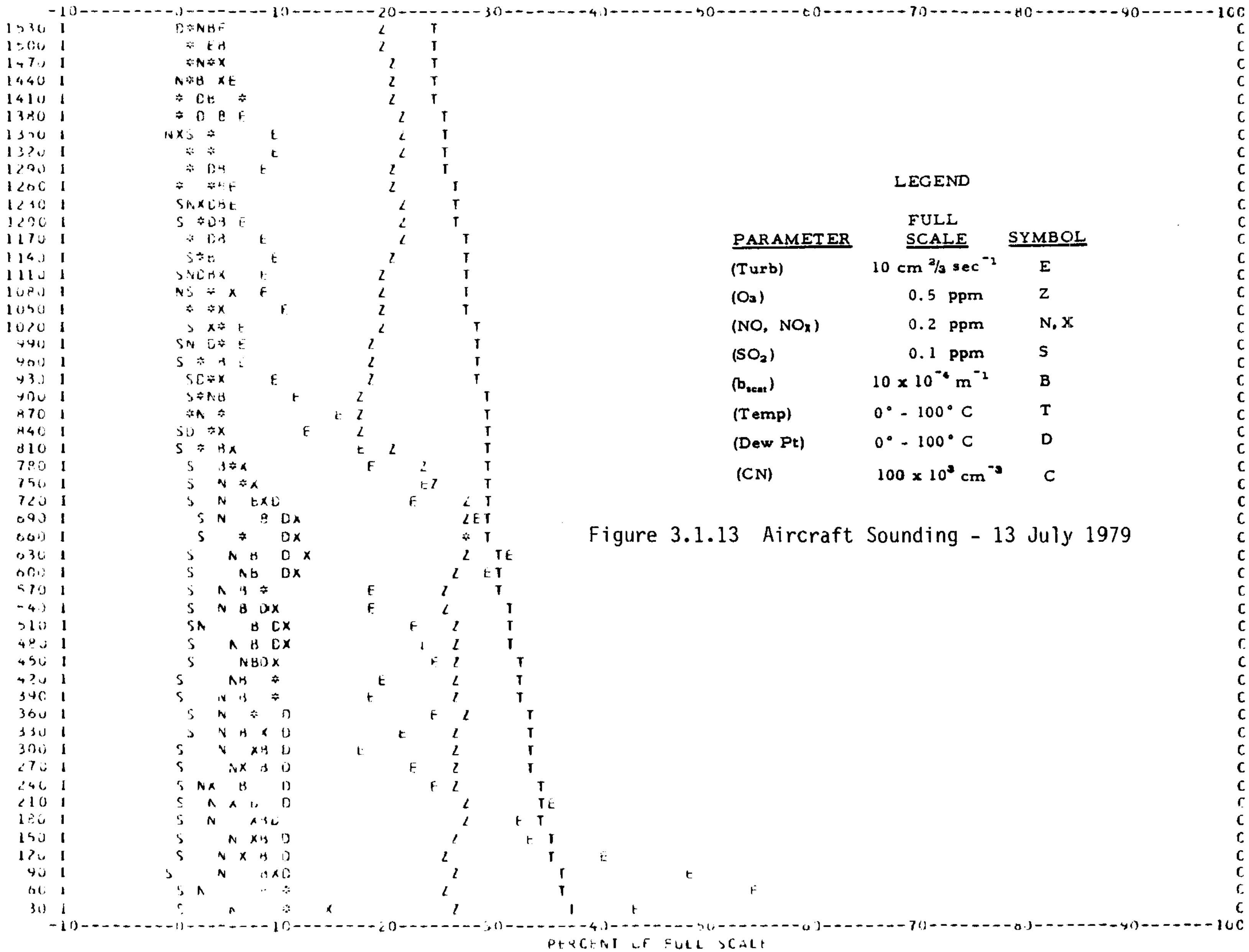


Figure 3.1.12 Aircraft Sounding - 13 July 1979

COFPLT VER 01 MOD 03   21-APR-80 53:22:34   PAGE 3

DATE: 7/13/79   ROUTE: OVER POINT 1
CARTRIDGE/PASS: 6097 1
TIME: 16:47:40 TO 17: 5:22   MIN. GROUND ELEV.: 29 M(MSL)



LEGEND

PARAMETER	FULL SCALE	SYMBOL
(Turb)	10 cm $^{2/3}$ sec $^{-1}$	E
(O_3)	0.5 ppm	Z
(NO, NO_x)	0.2 ppm	N, X
(SO_2)	0.1 ppm	S
(b_{scat})	10 x 10^{-4} m^{-1}	B
(Temp)	0° - 100° C	T
(Dew Pt)	0° - 100° C	D
(CN)	100 x 10^3 cm^{-3}	C

Figure 3.1.13 Aircraft Sounding - 13 July 1979

DATE: 7/13/79
CARTRIDGE/PASS: 6597 8
TIME: 19:51:14 TO 20: 5:13

ROUTE: OVER POINT 5
MIN. GROUND ELEV.: 67 M(MSL)

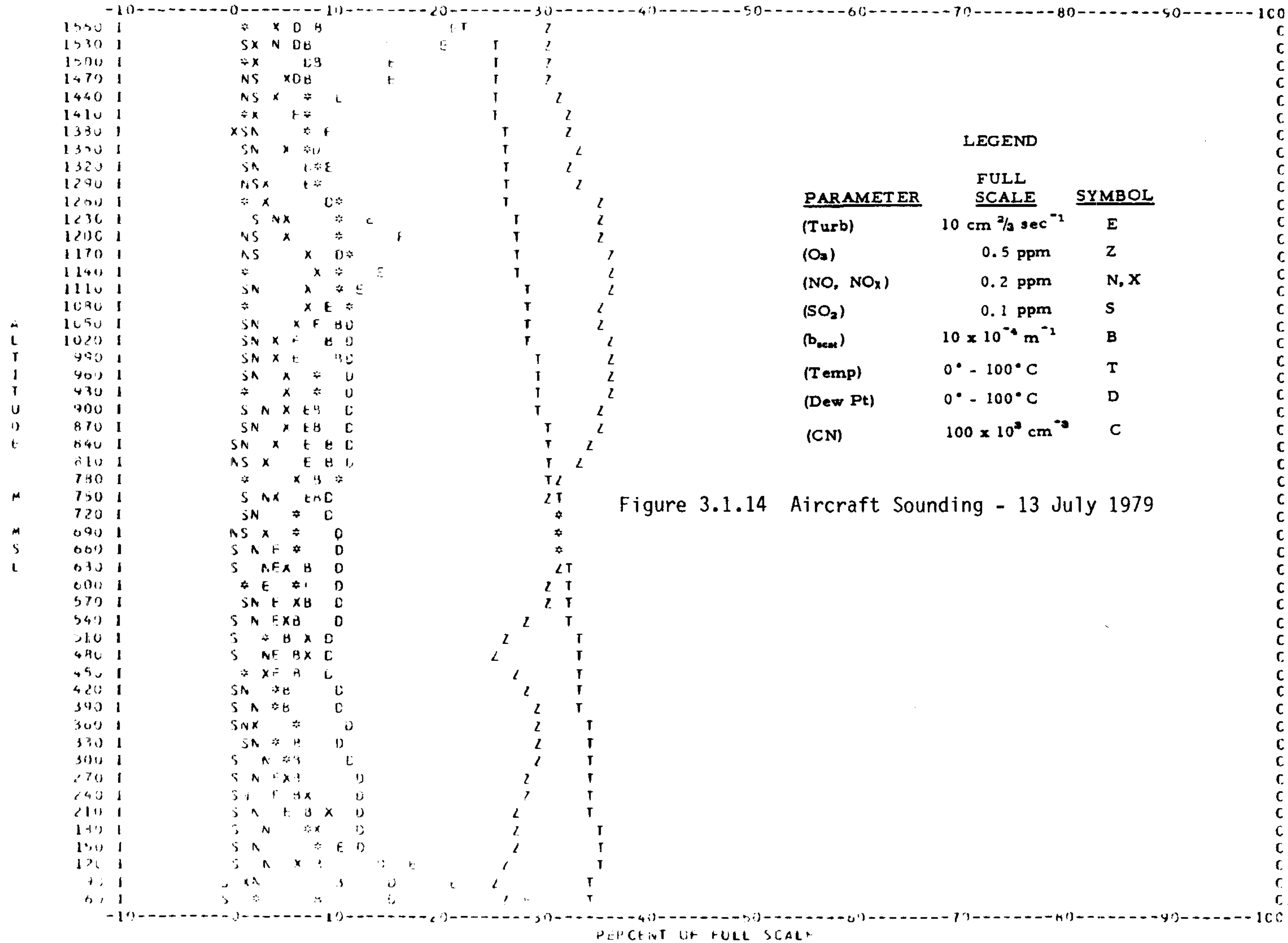


Figure 3.1.14 Aircraft Sounding - 13 July 1979

3.1.3 Tracer Test 1

Release Location: Manteca, San Joaquin County

Time and Date: 0700-1300 PDT, 7/13/79

Amount: 104 pounds of SF6 per hour

Release conducted during northwesterly winds of between 2 and 4 mps. Throughout the release day, winds on the western side of the valley were northerly while an opposing southerly flow was noted on the eastern side of the valley.

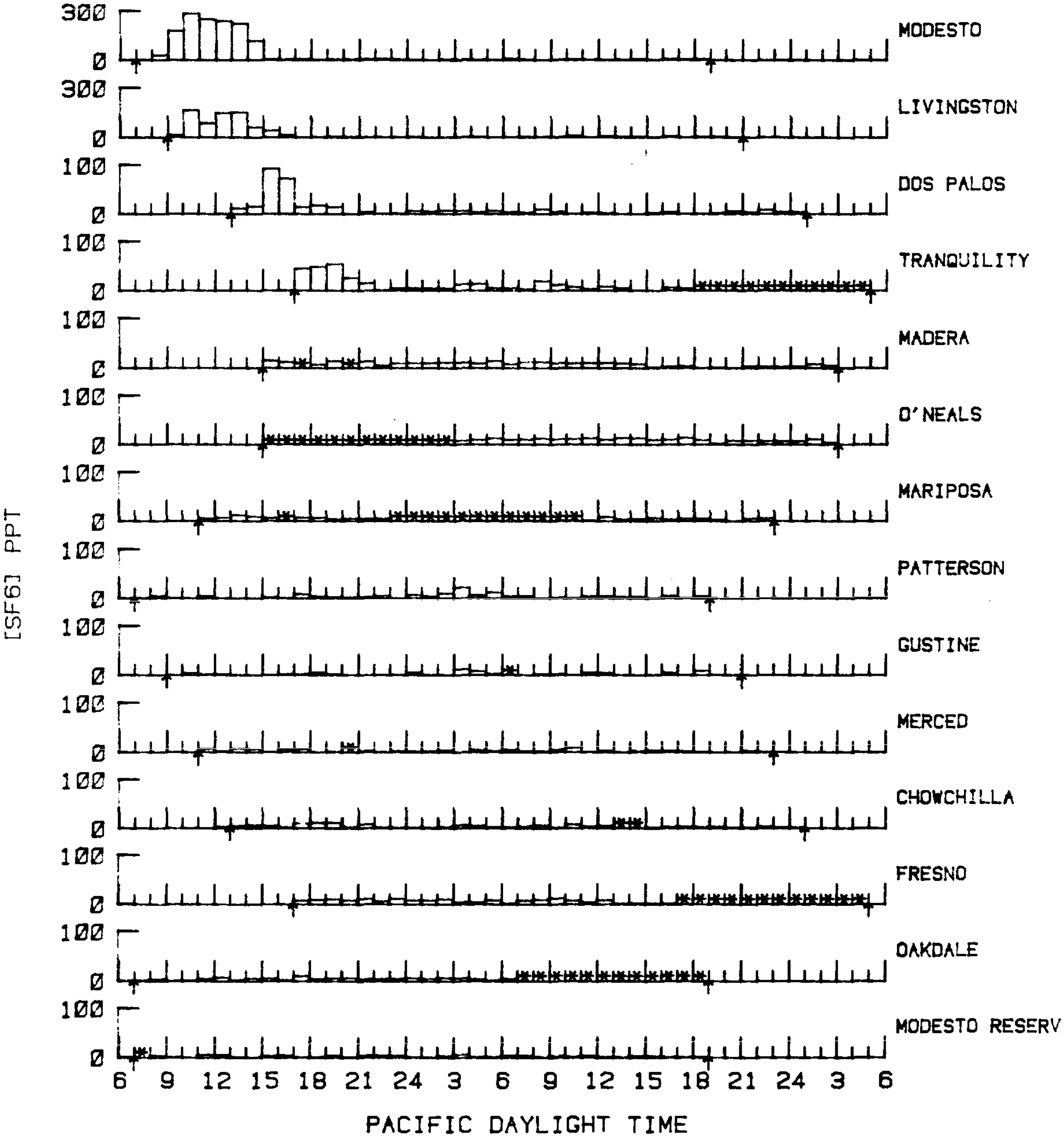
Initial transport southward

During Automobile Traverse 1-1, beginning about 0900 PDT, a maximum SF6 concentration of about 320 PPT (450 PPT/lb-mole of SF6 released/hr) was detected near Modesto along Hwy 132. 179 PPT of SF6 was detected during the 0900-1000 PDT automatic hourly-averaged sample at Modesto (see Figure 3.1.15). Modesto lies about 16 miles south of the release site thus the average tracer transport speed was at least 8 miles/hr (3.5 mps). This compares favorably with the 2-4 mps surface winds measured at the release site between 0700 and 0900 PDT. Automobile Traverses 1-2, 1-4, 1-5 and 1-8 all passed through Modesto on Hwy 132. The tracer plume retained the structure found during Traverse 1-1 until about 1400-1500 PDT, about 1-2 hours after the end of the release. At the Modesto hourly-averaged sampler, 250 +/- 30 PPT (350 PPT/lb-mole SF6 released/hr) was detected between 1000 and 1400 PDT. Only 117 PPT, however, was detected during the 1400-1500 PDT sample.

Continued southward transport during afternoon

The tracer was also detected further downwind during a number of automobile traverses. During Automobile Traverse 1-6, a maximum concentration of 240 PPT (340 PPT/lb-mole SF6 released/hr) was detected along Rd J17. During Traverse 1-9, 124 PPT of SF6 (174 PPT/lb-mole SF6 released/hr) was detected along Hwy 140, west of Merced. During Traverse 1-12, 161 PPT (226 PPT/lb-mole SF6 released/hr) was detected along Hwy 140 and concentrations as high as 116

SJV-1   7/13/79 - 7/15/79



RELEASE LOCATION: 623 LBS SF6 AT MANTECA
RELEASE TIME: 0700-1300 PDT, 7/13/79

Figure 3.1.15

* INDICATES MISSING DATA
ARROWS INDICATE BOUNDS OF SAMPLING PERIOD

SJV

1

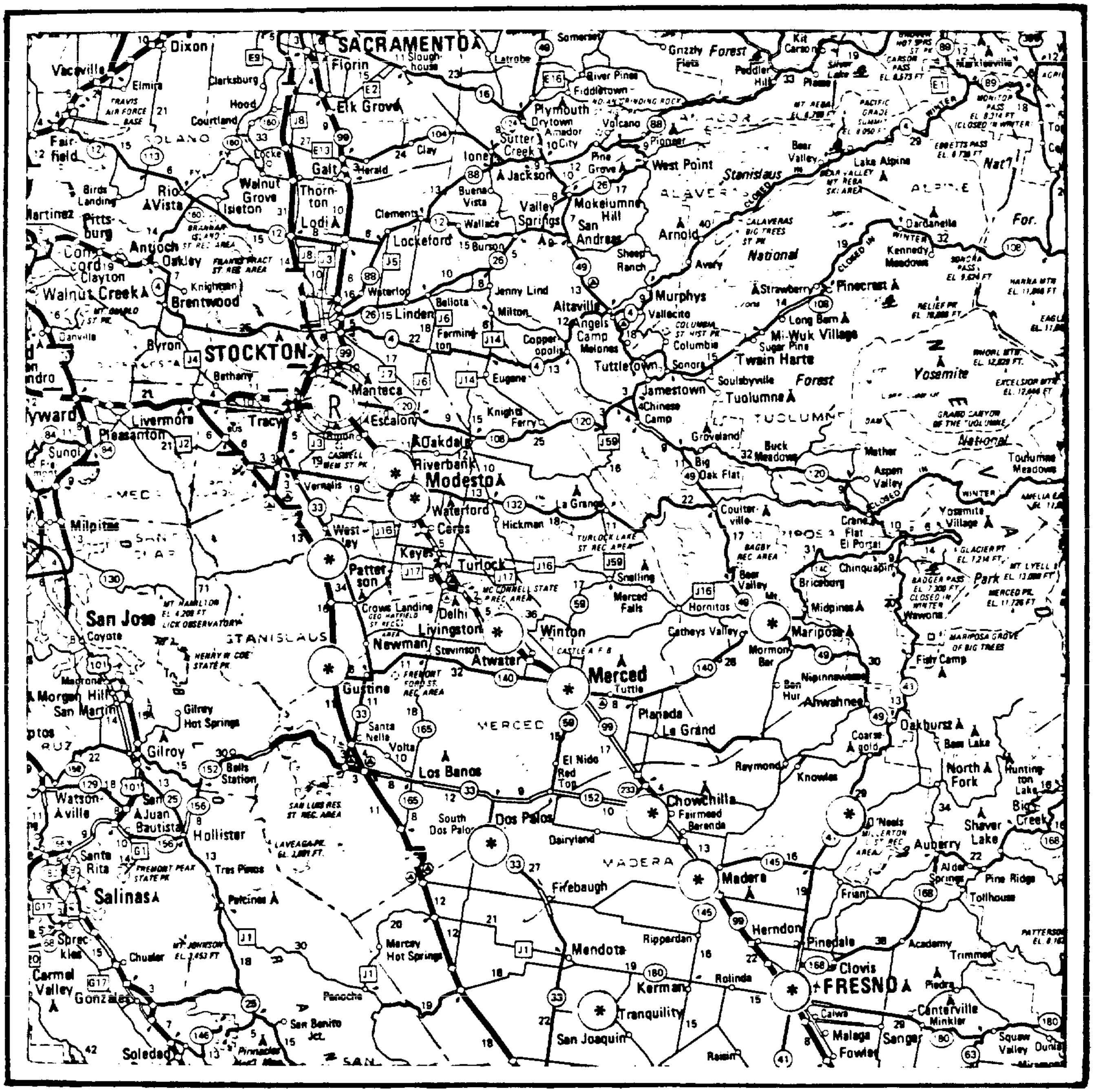


Figure 3.1.16

* INDICATES SAMPLER LOCATIONS

R IS THE RELEASE SITE

PPT (163 PPT/lb-mole SF6 released/hr) were detected along Hwy 152, west of Chowchilla. During Traverse 1-13, SF6 concentrations of about 90 PPT (125 PPT/lb-mole released/hr) were detected over a wide zone along Hwy 180, west of Fresno. The locations of the maximum concentrations detected during these traverses indicated that the tracer was initially transported southeasterly along Hwy 99. Along Hwy's 140, 152 and 180, however, the plume appeared to have shifted towards the west. This may have been due to the action of the southerly flow in evidence on the eastern half of the San Joaquin Valley. Because of the strength of the southerly flow on the eastern side of the valley, the northerly flow on the western side may have been diverted more towards the west.

Further evidence of the shift westward of the SF6 can be found in the hourly averaged data. All hourly-averaged data collected is included in Figure 3.1.15. SF6 was detected at Livingston, along Hwy 99, between 1000 and 1100 PDT. Livingston lies about 40 miles south of Manteca, suggesting a mean transport speed of about 10-13 miles/hr (4.4-6 mps). SF6 concentrations above 15 PPT were first detected at Dos Palos, about 70 miles south of the release site and 25 miles west of Chowchilla, during the 1500-1600 PDT sample, corresponding to a mean transport speed of about 8.8 miles/hr (3.9 mps). Finally, SF6 was detected at Tranquility, about 100 miles south of Manteca and 25 miles west of Fresno, during the 1700-1800 sample which corresponds to a mean transport speed of 10 miles/hr (4.4 mps). Maximum hourly-averaged tracer concentrations of 162 PPT (228 PPT/lb-mole of SF6 released per hour), 92 PPT (129 PPT/lb-mole released/hr) and 54 PPT (76 PPT/lb-mole released/hr) were detected at Livingston, Dos Palos and Tranquility, respectively. The maximum concentrations detected at these fixed sampling sites agreed favorably with the maximum concentrations detected during corresponding automobile traverses. Note that essentially no SF6 was detected at sites along Hwy 99, south of Livingston, or in the foothills on the western slope of the Sierra Nevada Mountains. Again, this is consistent with the apparent decoupling between air flow on the west and east sides of the San Joaquin Valley.

Comparison of plume dispersion to Gaussian plume model

The tracer was apparently transported by strong, unidirectional winds suggesting that the tracer transport and dispersion might be accurately modeled via the Gaussian plume model. As shown in Figure 3.1.17, the concentration profiles encountered during most traverses were essentially Gaussian in shape. The standard deviation in concentration was estimated to be about 1.81 +/- 0.26 miles for traverses along Hwy 132 through Modesto. The average trajectory from Manteca to the plume centerline at Modesto meets Hwy 132 at an angle of about 45 deg. Thus the crosswind standard deviation in concentration was about 1.81*sin(45 deg)=1.3 miles=2.1 km. Thus the horizontal dispersion of the tracer at this distance downwind corresponded to Pasquill-Gifford stability class C. The estimated crosswind standard deviations in concentration along other automobile traverse routes are included in Figure 3.1.18. The Pasquill-Gifford Stability Class curves presented are extrapolations of the curves presented in Turner (1970)*. The horizontal dispersion is consistent with Pasquill-Gifford Stability Class C or D for distances less than 100 km downwind of the source. The deviation at greater distances may be due to variations in wind speed or atmospheric stability that occurred near nightfall. Also included in Figure 3.1.18 is the vertical standard deviations in concentrations estimated from the crosswind integrated surface concentrations (see Turner, 1970). The data shows no significant tendency to increase with distance downwind of the source, suggesting that the tracer was well-mixed over an essentially constant height. The vertical standard deviation is 80% of the mixing height. Based on the traverses along Hwy's 140 and 152, the maximum mixing height was about 400/.8=500m or about 1640 ft.

Carryover into subsequent day

Low levels of SF6 (<5-10 PPT) were detected throughout the San Joaquin Valley north and east of Fresno on the day following the release. Due to the limitations of the SF6 measurement technique, it is not possible to quantitatively estimate the amount of carryover into this day.

* Turner, B. 1970: Workbook of Atmospheric Dispersion Estimates, PHS Publ. No. 999-AD-26, 84 pp.

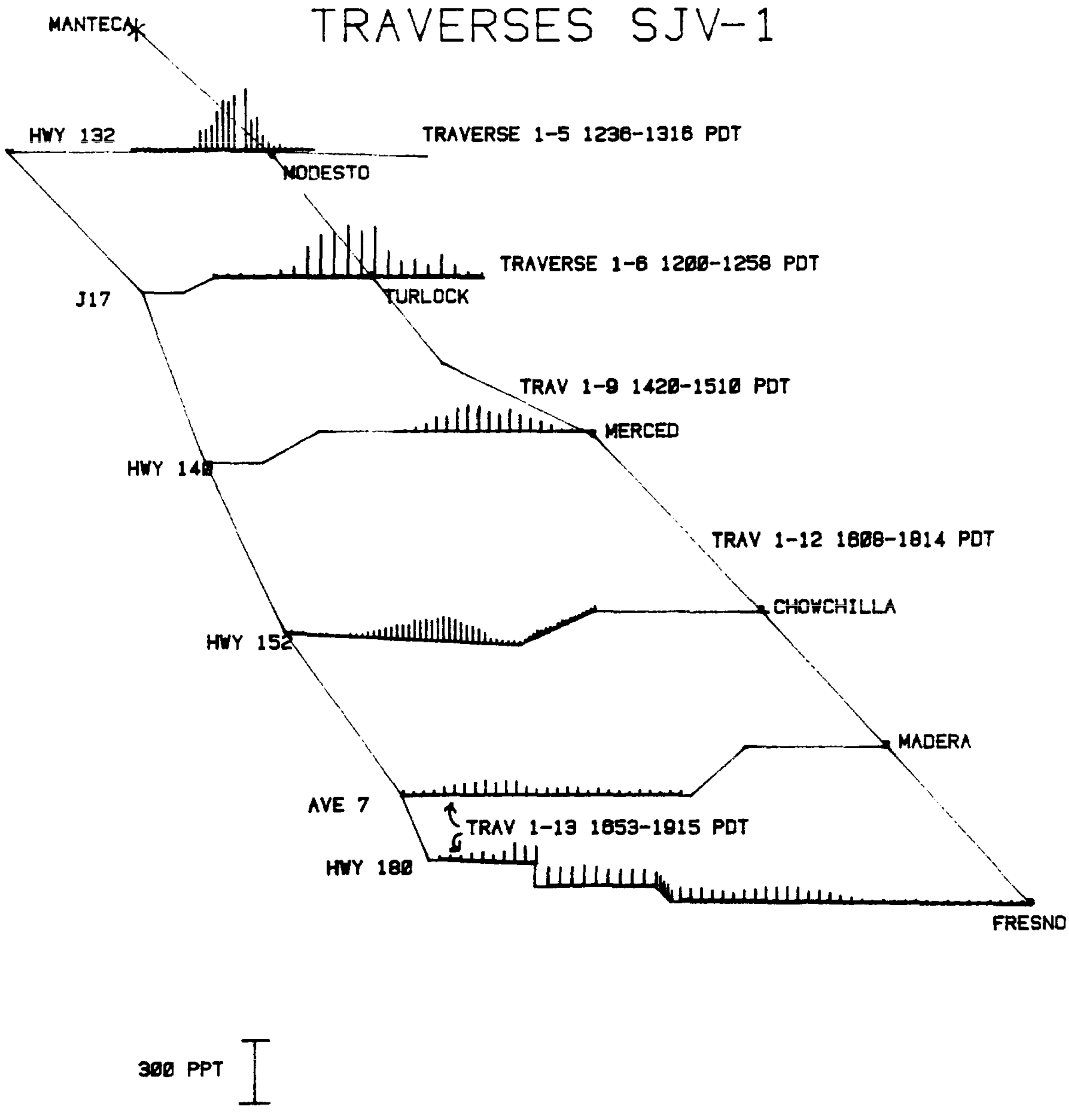

TRAVERSES SJV-1
MANTECA
HWY 132
TRAVERSE 1-5 1236-1316 PDT
MODESTO
TRAVERSE 1-6 1200-1258 PDT
J17
TURLOCK
TRAV 1-9 1420-1510 PDT
MERCED
HWY 140
TRAV 1-12 1608-1814 PDT
CHOWCHILLA
HWY 152
MADERA
AVE 7
TRAV 1-13 1853-1915 PDT
HWY 180
FRESNO
300 PPT
NORTHERN SJV SCALE - 1:208000

Figure 3.1.17

SJV-1 GAUSSIAN COMPARISON

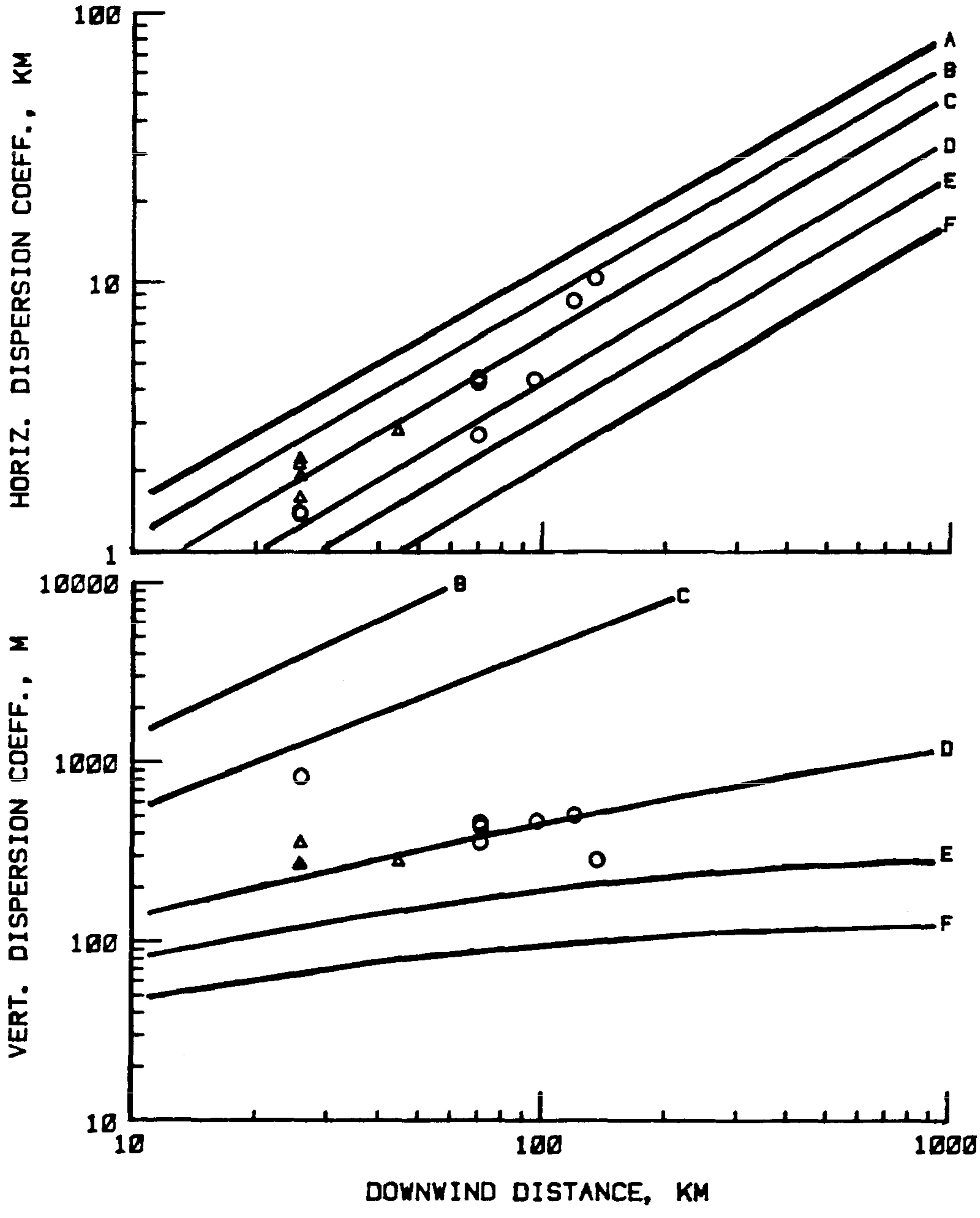


Figure 3.1.18

o DATA TAKEN AFTER END OF RELEASE

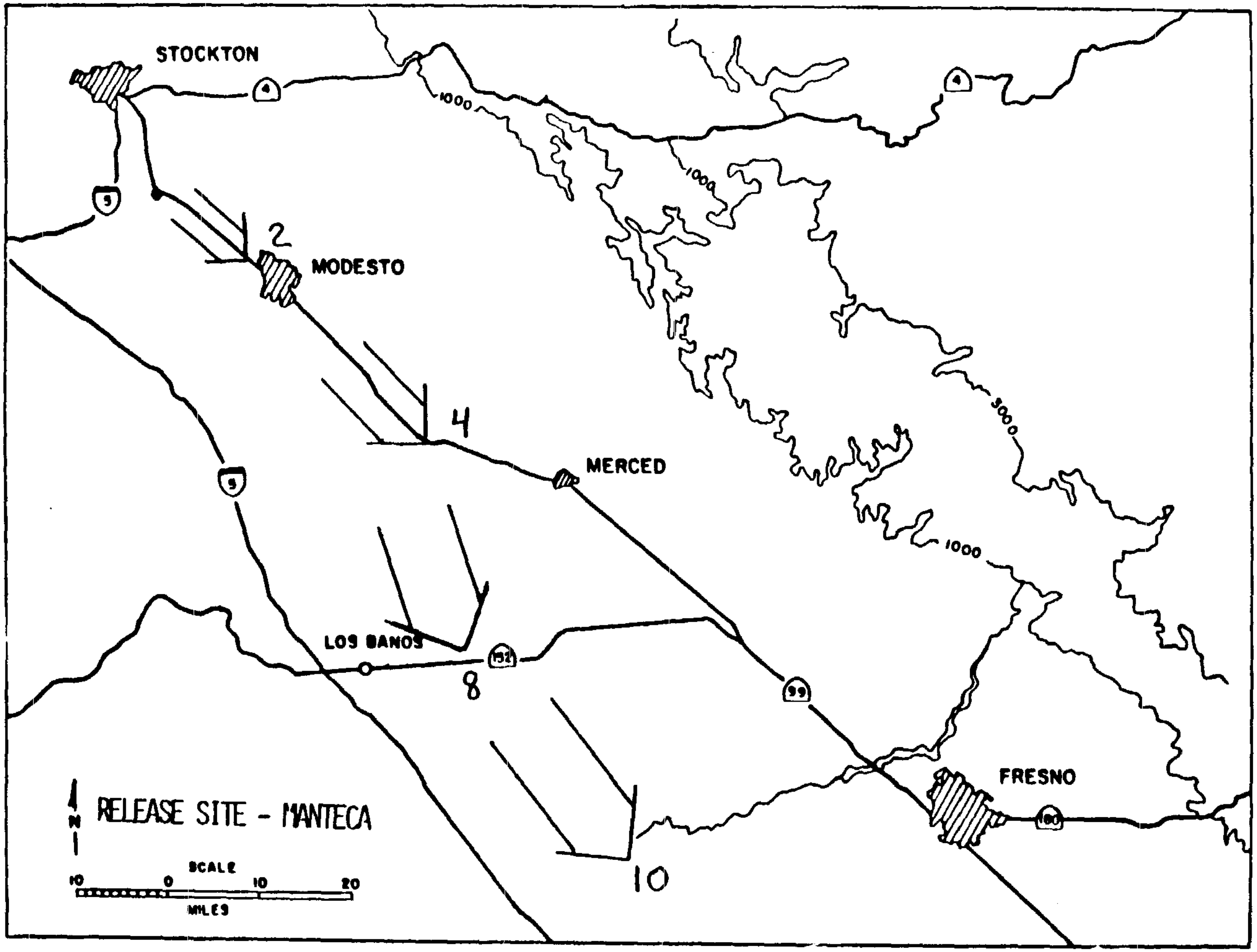
Summary

During this experiment, the tracer was released at the northern mouth of the San Joaquin Valley. In this vicinity, a northerly flow (blowing into the valley) persists essentially 24 hours per day during the summer. Pollutants generated in the San Francisco Bay Area and the California Delta can be transported into the San Joaquin Valley through this region.

During this test, the tracer was released during the morning. Typically, the atmosphere is more stable during the morning than during the afternoon. On the day of the test, however, the wind flow patterns detected in the valley suggested more unstable conditions than might normally be expected. High wind speeds were detected, for example, at Los Banos (16 mps at 0700, 1000 ft elevation). In addition, southerly winds were found on the entire eastern half of the valley while strong westerly winds were detected on the western side. At one time during the day, the velocity shear between the western and eastern sides reached as high as 24 mps. These conditions led to dispersal of the tracer at a somewhat higher rate than might be expected from meteorological data collected only at the release site.

The tracer was initially transported along Hwy 99. The tracer was then transported down the lowest part of the valley, along the San Joaquin River on the western side. There was no evidence of the tracer being influenced by the upslope winds along the Sierra Nevada on the east side of the valley. An overview of the tracer transport path is shown in Figure 3.1.19. Since the tracer tagging pollutants from the San Francisco Bay Area and the California Delta was preferentially transported down the western half of the valley, and since higher concentrations of ozone and other pollutants were found on the eastern side of the valley, the Bay Area apparently had little impact on pollutants in the San Joaquin Valley on this day.

The concentration profiles downwind of the release site were essentially Gaussian in shape. The horizontal dispersion of the tracer corresponded to the disperion expected for Pasquill-Gifford Stability Class C or D. This comparison to the Gaussian plume model was based on 12 different traverses along 5 different routes at various distances downwind. From automobile traverse data it was possible to estimate that the tracer was essentially well-mixed vertically to a height of about 1650 ft.



ARROW POINT INDICATES OBSERVED TRACER LOCATIONS
NUMBERS REFER TO HOURS AFTER RELEASE START (0700 PDT., 7/16/79)

Figure 3.1.19

Low concentrations of the tracer were detected over a wide area in the central and northern valley on the day after the release. At least some of the tracer released on the previous day was redistributed throughout the northern valley by the night and early morning wind flow patterns.

3.2 Test 2 16-17 July 1979, Manteca Release (1300-1900 PDT)

3.2.1 Meteorology

General

The synoptic meteorology of 16-17 July is depicted in Figure 3.2.1 and was characterized by a regional high pressure aloft over the western states. As can be seen from Figure 2.2.1, this period was the beginning of a significant warming trend aloft which was to continue for several days. At the surface a thermal trough was established over the California interior which created onshore pressure gradients. Skies were clear within the valley with only a few scattered cumulus reported over the higher mountains. Visibilities were reported down to 7-10 miles in the central and southern portions of the valley in the afternoon. Stockton reported restricted visibilities due to smoke on the morning of the 16th, but conditions improved later in the day. Surface temperatures were above normal in the valley for the time of the year. On the 17th, Fresno reported a high reading of 107°F and Bakersfield 109°F.

Transport Winds

Surface winds from the tracer release site at Manteca during the release period are summarized in Table 3.2.1. Winds were from the northwest at 2-3 m/sec. The regional flows in the San Joaquin Valley during the experimental period have been determined from the 1000 ft streamlines and are depicted on Figures 3.2.2 through 3.2.4. At the start of the tracer release (1300 PDT), the flow was generally from the northwest at speeds of 2-3 m/sec. In the central portion of the valley, the eddy which had been present during the early morning had drifted eastward, but the flow on the west side was still being diverted westward by the eddy influence. On the west side, northwest streamlines continued the length of the valley. This basic flow pattern continued until the 1900 PDT observations, when the flow became northwest throughout the valley at speeds ranging from 3-6 m/sec (Figure 3.2.3). The same general flow pattern continued for the following several hours, although wind speeds increased

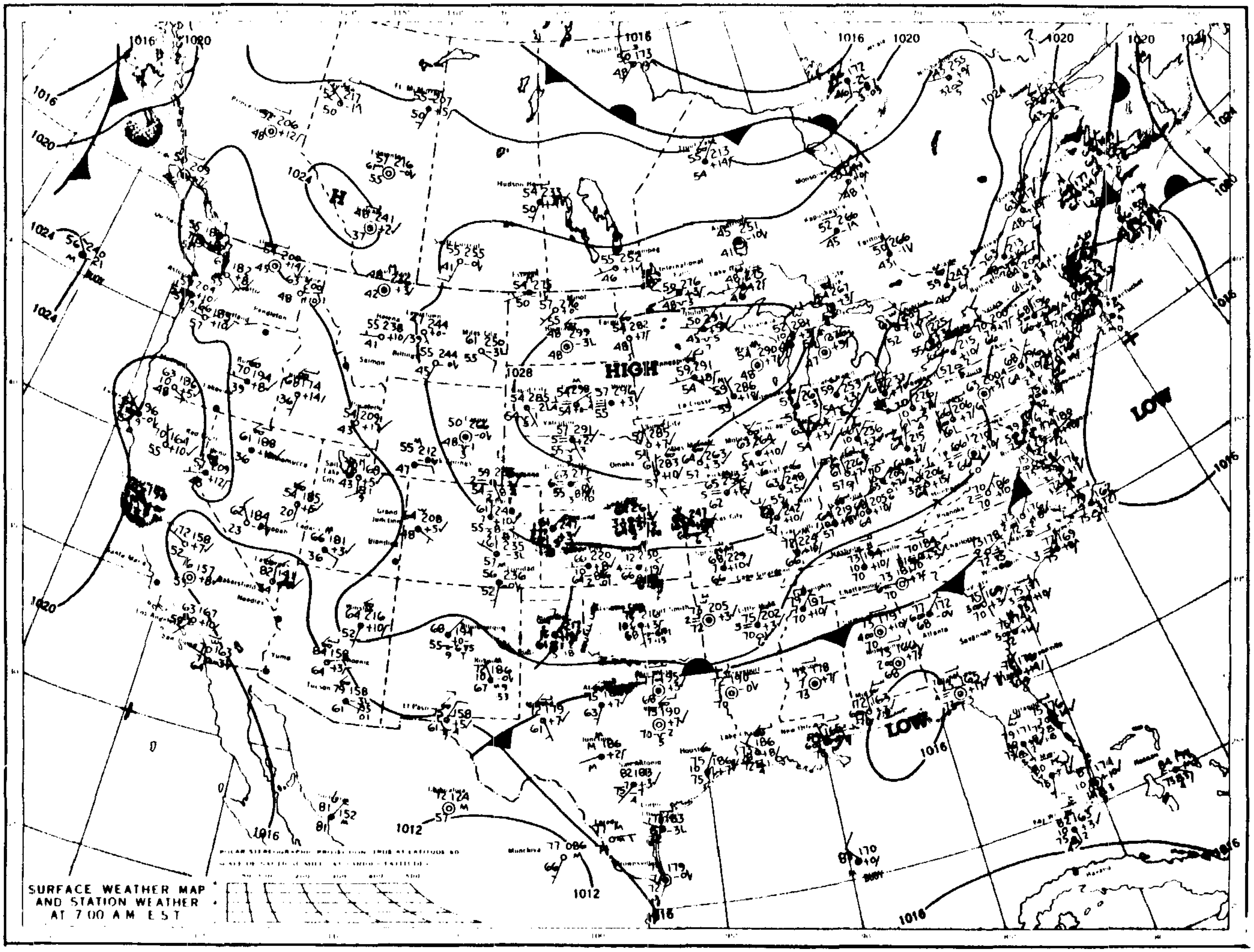


Figure 3.2.1 'Surface Weather Charts - 17 July 1979 (05 PDT)

Table 3.2.1

SURFACE WINDS AT MANTECA
16 JULY 1979

Time (PDT)	Wind (m/s)
1300	305/2.2
1400	300/2.7
1500	305/3.0
1600	325/2.7
1700	310/2.7
1800	305/2.8
1900	325/2.3

to a maximum (6-11 m/sec) at 2300 PDT. At 0300 PDT on the following morning, an eddy again formed in the southern portion of the valley and continued to develop, reaching a maximum between 0900 and 1200 PDT (Figure 3.2.4). By 1700 PDT the flow was generally from the northwest again. The vertical and temporal characteristics of the winds aloft can be characterized by the time-height cross section of the winds above Turlock given on Figure 3.2.5. The pibal winds have been resolved into components parallel to the valley axis which are shown in the cross section. The northwest flow was relatively shallow during the tracer release extending only through a 2000 ft layer above the ground. Flow with a southerly component prevailed above. A moderate to strong flow transporting air south into the valley persisted at low levels throughout the experimental period. Maximum speeds within the northwest flow of over 10 m/s were observed late in the evening of the 16th.

Mixing Heights

Mixing heights were determined from aircraft soundings by noting the top of the pollutant and/or turbulence layer. Table 3.2.2 gives the mixing layer depths for July 16-17. As indicated, there is a marked tendency for higher mixing depths at the edge of the valley compared to the center.

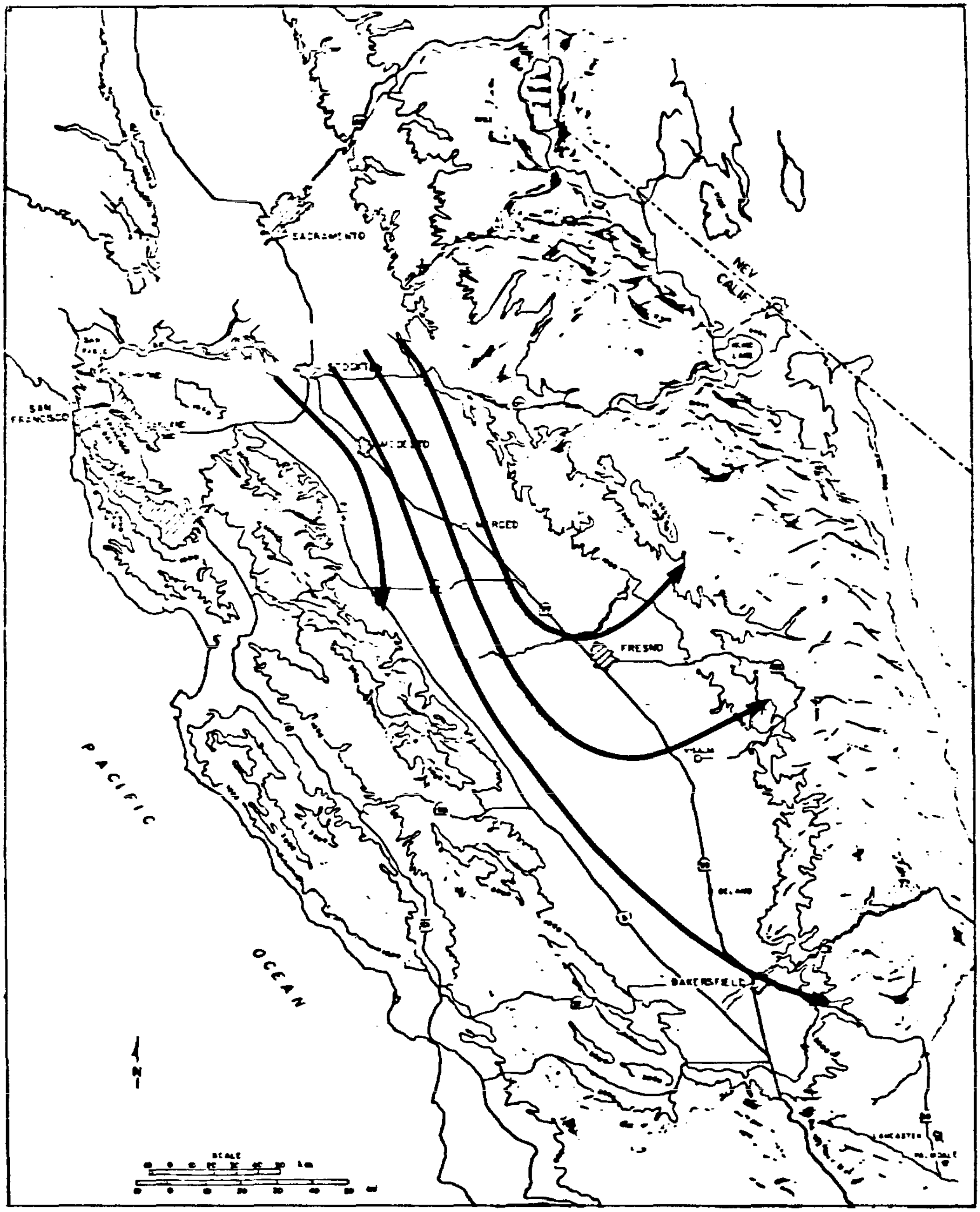


Figure 3.2.2 1000 Ft-agl Streamlines - 16 July 1979 (13 PDT)

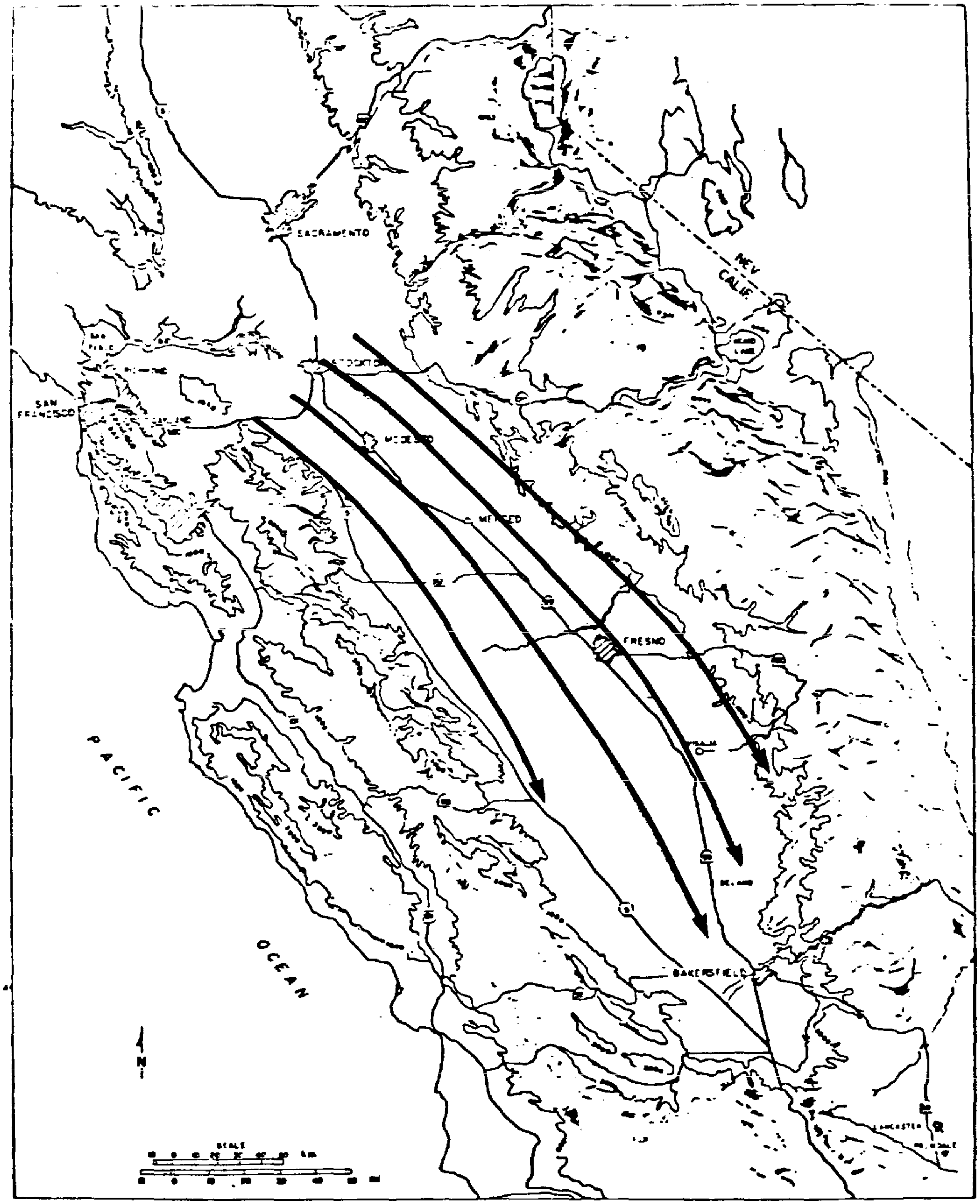


Figure 3.2.3 1000 Ft-agl Streamlines - 16 July 1979 (19 PDT)

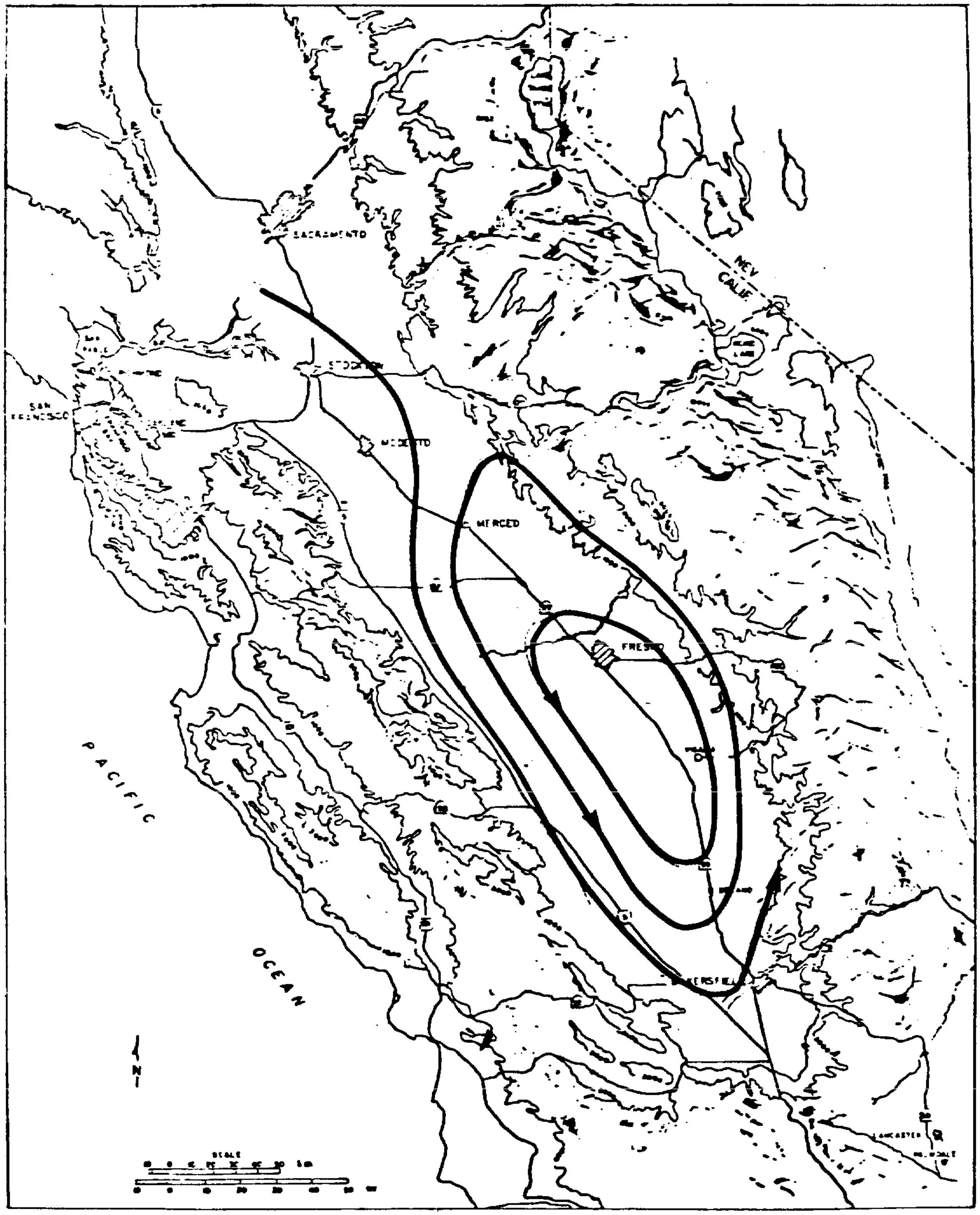


Figure 3.2.4 1000 Ft-agl Streamlines - 17 July 1979 (09 PDT)

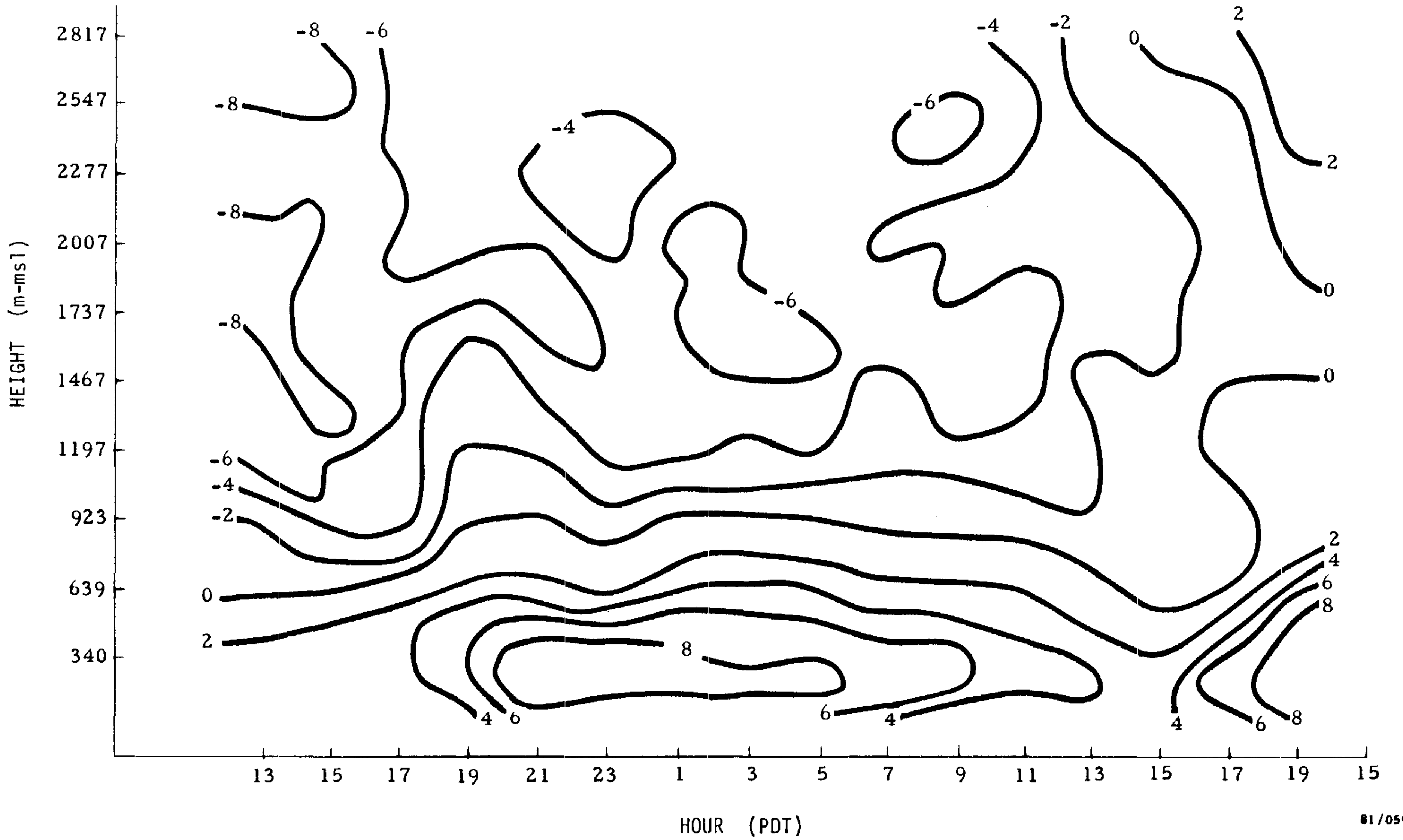


Figure 3.2.5 Component Wind (m/s) From Turlock - 16 July 1979
(Positive Represents Upvalley Flow)

Table 3.2.2

AIRCRAFT MIXING HEIGHTS
JULY 16-17, 1979

Time (PDT)	Location*	Mixing Height (m [above ground level])
July 16		
1653	Modesto Airport	600
1730	Modesto Reservoir	770
1755	Foothills (30 ENE Modesto)	990
1851	Patterson	970
1958	Modesto Airport	150
July 17		
0541	Modesto Airport	120
0618	Modesto Reservoir	80
0642	Foothills (30 ENE Modesto)	300
0732	Patterson	120

(* Distances in miles)

3.2.2 Air Quality

Regional Pollutant Levels

Maximum hourly ozone concentrations throughout the valley on July 16 are shown in Figure 3.2.6. A number of exceedances were observed in the valley. The highest hourly average recorded was at Bakersfield (.14 ppm). On the following day, a maximum of .17 ppm was observed at Fresno and exceedances occurred at Whitaker's Forest and at Miracle Hot Springs, indicating the upslope transport of ozone and precursors from the valley floor.

Maximum hourly concentrations for CO, SO_2 and NO_x anywhere in the valley on July 16 are given in Table 3.2.3. Also shown are the maximum values recorded at the Rockwell International vans for the day.

Aircraft Sampling

Sampling was conducted late on the afternoon of the 16th (1650-2013 PDT) and again on the morning of the 17th (0540-0850 PDT) to determine the flux of pollutants into the San Joaquin Valley. The sampling pattern was

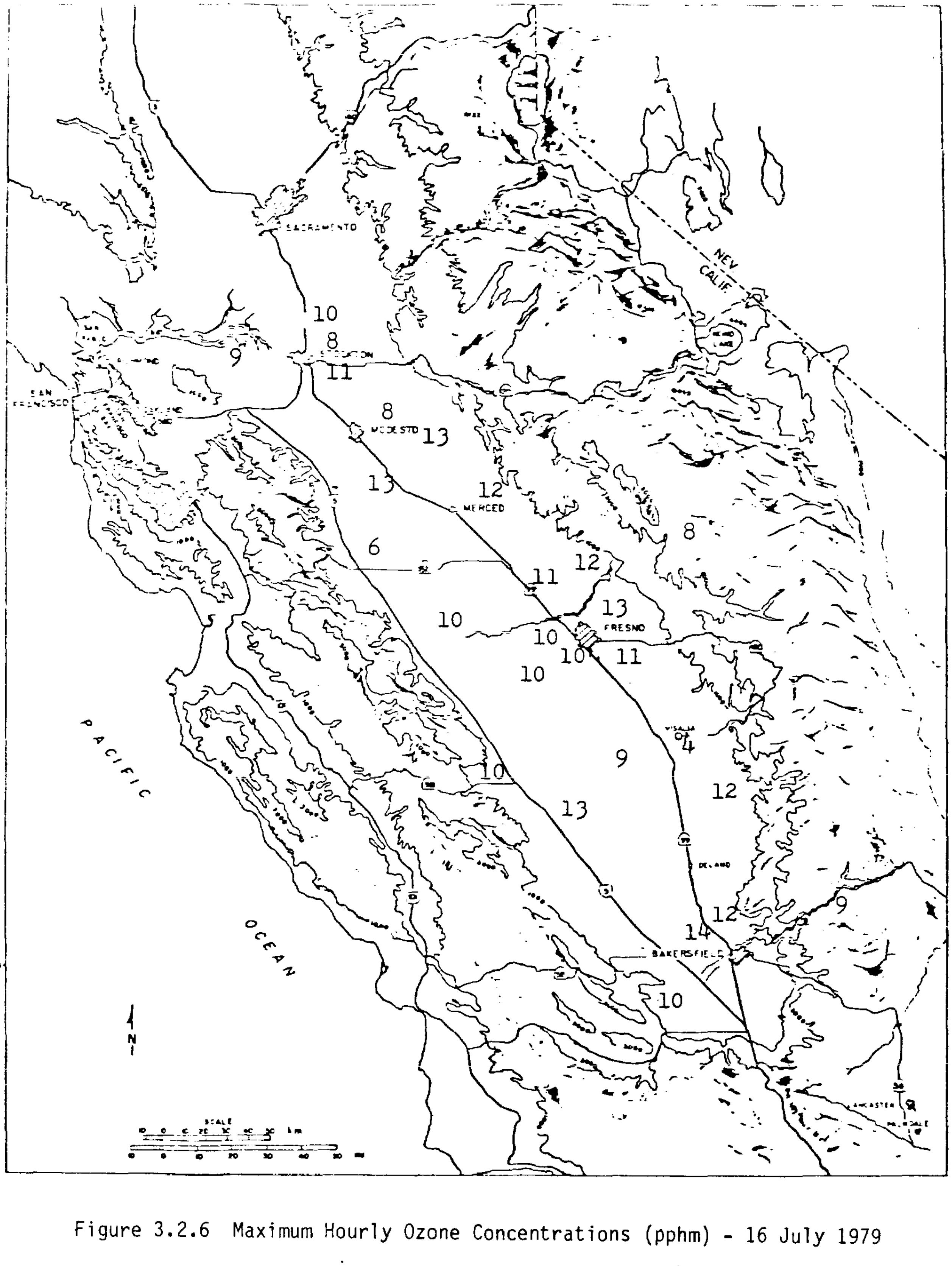


Figure 3.2.6 Maximum Hourly Ozone Concentrations (pphm) - 16 July 1979

Table 3.2.3

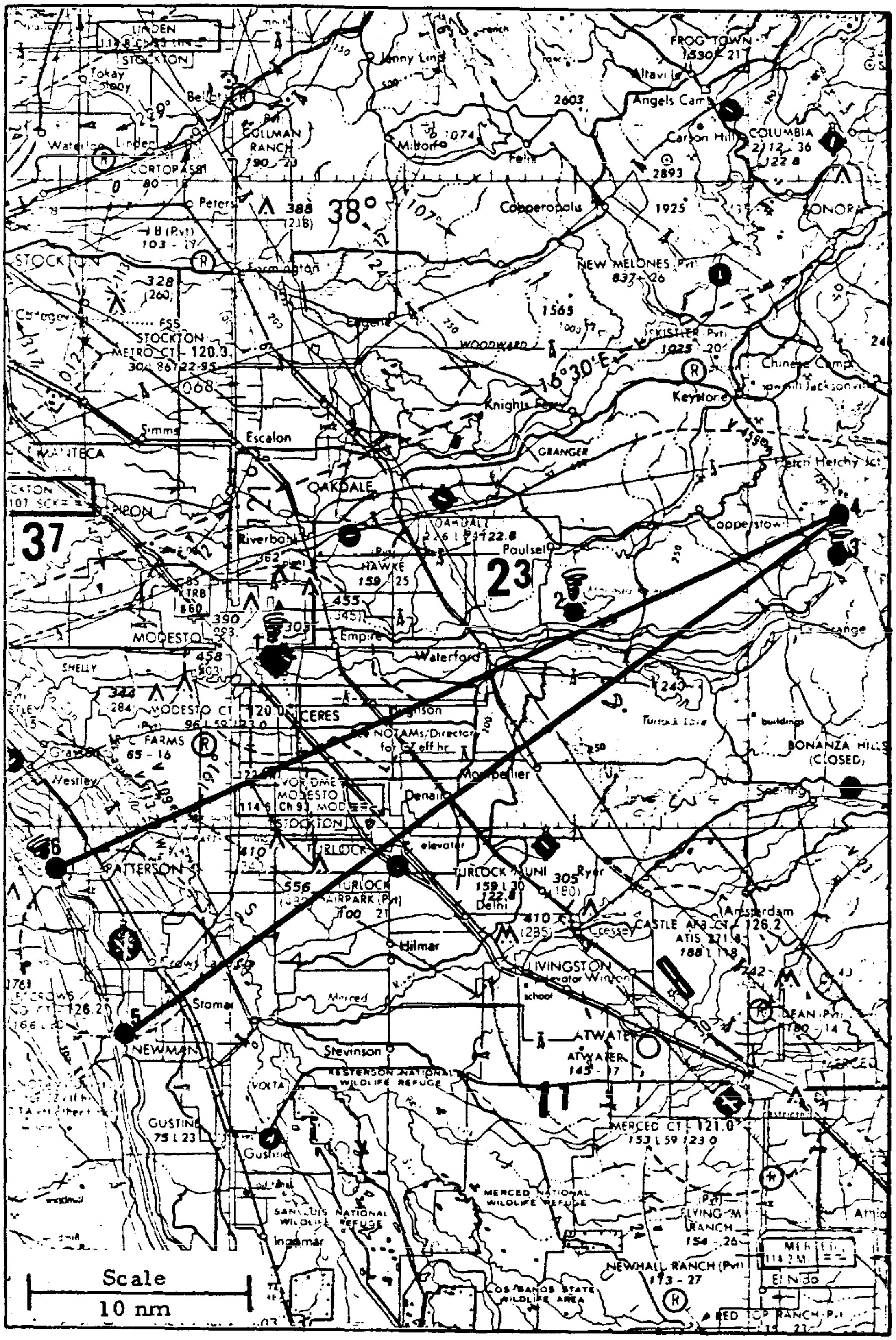
MAXIMUM HOURLY CONCENTRATIONS
JULY 16, 1979

Parameter	Location	Maximum Value (ppm)
SO_2	Bakersfield	.02
CO	Fresno-Olive	3.
CO	Bakersfield	3.
NO_x	Bakersfield	.19
SO_2	Modesto (RI)	< .01
SO_2	Merced (RI)	< .01
NO_x	Modesto (RI)	.01
NO_x	Merced (RI)	.01
NO_x	Madera (RI)	.02

similar on both days. The flight pattern consisted of a vertical cross section of the valley with two constant altitude traverses and a series of spirals on a line roughly perpendiclar to the valley axis between Modesto and Turlock. Spirals were flown over the Modesto Airport at the beginning and ending of sampling to document any temporal changes. Figure 3.2.7 shows the sampling routes carried out on July 16 and 17. Tables 3.2.4 and 3.2.5 give the general pollutant characteristics observed on the flights.

The horizontal distribution of ozone and b_{scat} was reversed from the sampling on the 13th. The greater pollution burden was found on the west side of the valley. At 4000 ft-msl (1919 PDT) ozone concentrations averaging over .10 ppm on the west side decreased to under .05 ppm on the east end of the traverse. Gradients were not as great on the 1500 ft-msl traverse, averaging .13 ppm on the west side as opposed to .11-.12 ppm on the east side. Maximum concentrations of ozone in excess of .18 ppm were measured over Patterson on the west side as opposed to less than .14 ppm on the east side.

Figures 3.2.8 to 3.2.12 show the aircraft soundings taken during the late afternoon of July 16. Figure 3.2.8 is a sounding over Modesto Airport. The mixed layer extends to about 610 m-msl but extensive ozone and b_{scat} exist



SAMPLING ROUTES 16 JULY 1979

Figure 3.2.7

Table 3.2.4

AIR QUALITY MEASUREMENTS CARB SAN JOAQUIN VALLEY PROJECT
JULY 16, 1979 SAMPLING

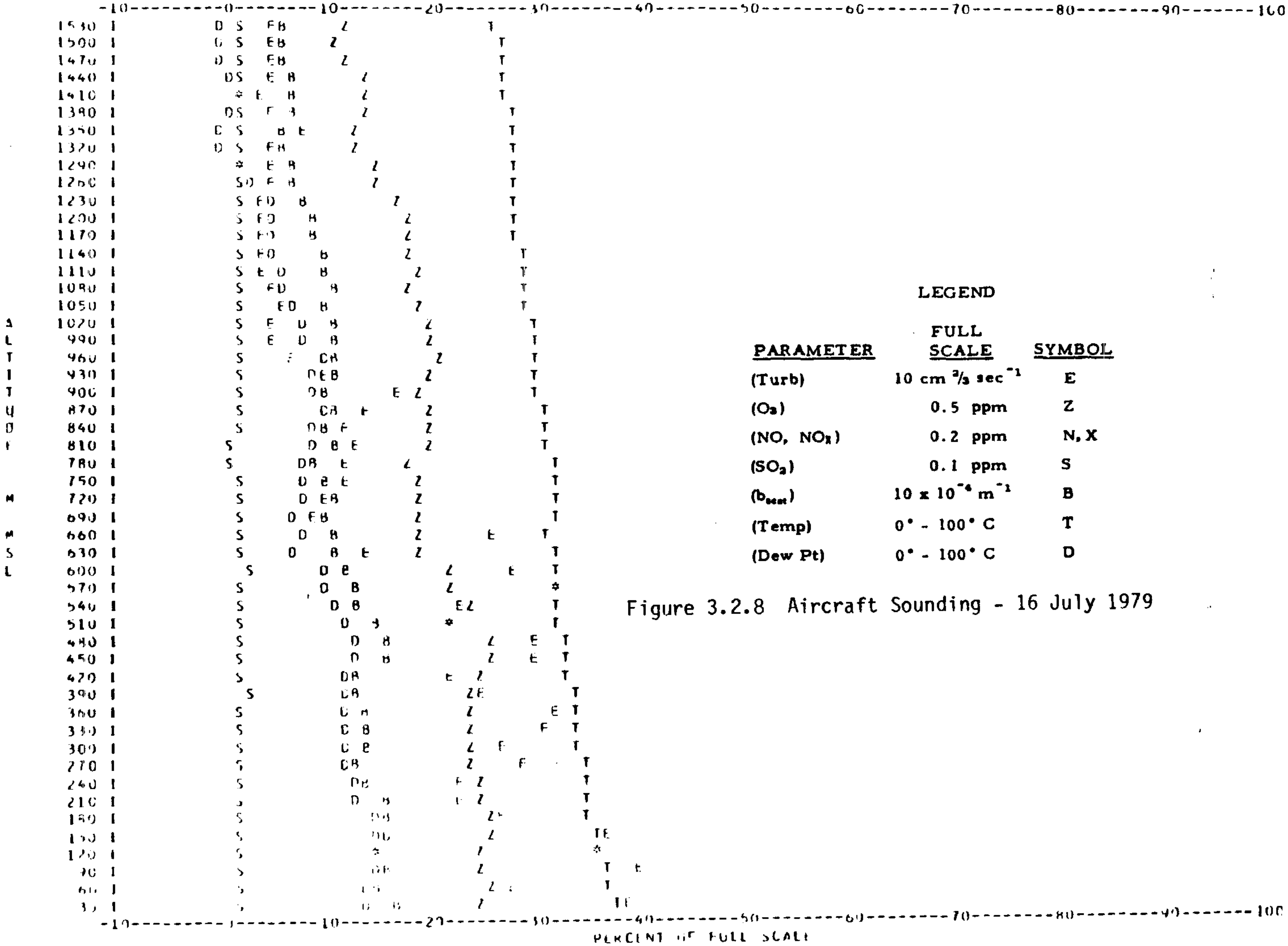
Start Time (PDT)	Location (Point)	O_3 Mean (ppb)	O_3 Max (ppb)	b_{scat} Mean ($x10^{-6}m^{-1}$)	b_{scat} Max ($x10^{-6}m^{-1}$)	SO_2 Mean (ppb)	SO_2 Max (ppb)	NO_x Mean (ppb)	NO_x Max (ppb)	NO Mean (ppb)	NO Max (ppb)
0653	1	79	130	80	210	1	2	-	-	-	-
1730	2	84	138	64	156	1	1	-	-	-	-
1755	3	99	143	76	158	0	1	-	-	-	-
1817	4-5	124	155	112	190	1	2	-	-	-	-
1851	6	124	185	93	184	1	3	-	-	-	-
1919	6-4	80	111	81	152	1	1	-	-	-	-
1959	1	103	168	109	192	1	1	-	-	-	-

Table 3.2.5

AIR QUALITY MEASUREMENTS CARB SAN JOAQUIN VALLEY PROJECT
JULY 17, 1979 SAMPLING

		O_3		b_{scat}		SO_2		NO_x		NO	
Start Time (PDT)	Location (Point)	Mean (ppb)	Max (ppb)	Mean ($x10^{-6}m^{-1}$)	Max ($x10^{-6}m^{-1}$)	Mean (ppb)	Max (ppb)	Mean (ppb)	Max (ppb)	Mean (ppb)	Max (ppb)
0541	1	63	120	76	186	1	2	-	-	-	-
0618	2	67	105	68	138	1	2	-	-	-	-
0642	3	63	105	64	136	1	3	-	-	-	-
0706	4-6	73	92	79	144	0	1	-	-	-	-
0733	6	52	119	56	188	1	11	-	-	-	-
0754	6-4	34	47	30	64	0	1	-	-	-	-
0822	4-6	79	108	75	138	1	1	-	-	-	-

DATE: 7/16/79   ROUTE: ... POINT 1
CARTRIDGE/PASS: 6757 1
TIME: 16:53:18 TO 17:12:43   MIN. GROUND ELEV.: 29 M(MSL)



LEGEND

PARAMETER	FULL SCALE	SYMBOL
(Turb)	10 cm $^{2/3}$ sec $^{-1}$	E
(O_3)	0.5 ppm	Z
(NO, NO_x)	0.2 ppm	N, X
(SO_2)	0.1 ppm	S
(b_{scat})	10 x 10^{-4} m^{-1}	B
(Temp)	0° - 100° C	T
(Dew Pt)	0° - 100° C	D

Figure 3.2.8 Aircraft Sounding - 16 July 1979

COMPLT VER 01 MOD 03   21-APR-80 54:22:11   PAGE 7

DATE: 7/16/79
CARTRIDGE/PASS: 6757 3
TIME: 17:30: 5 TO 17:48:49

ROUTE: OVER POINT 2
MIN. GROUND ELEV.: 67 M(MSL)

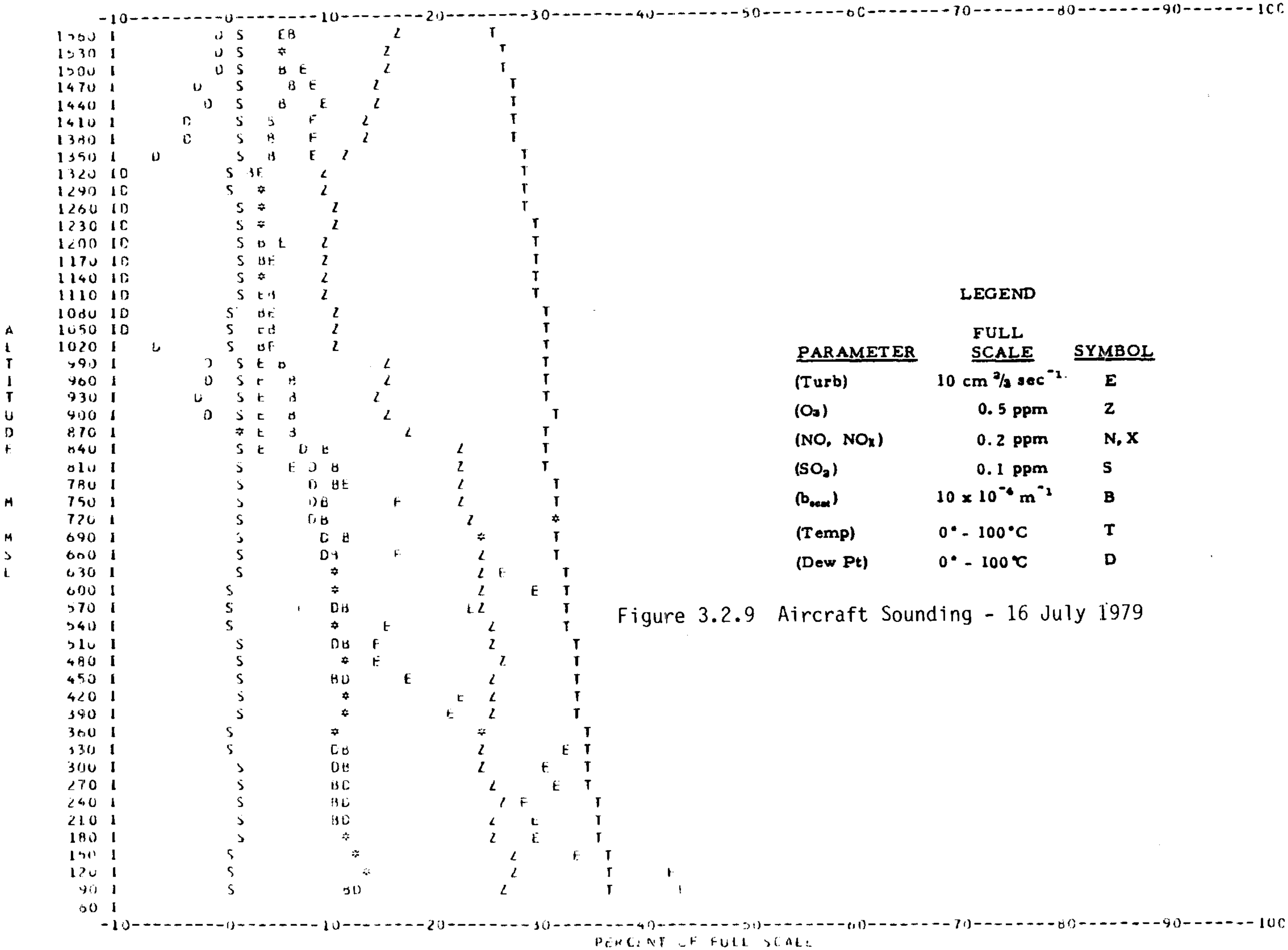
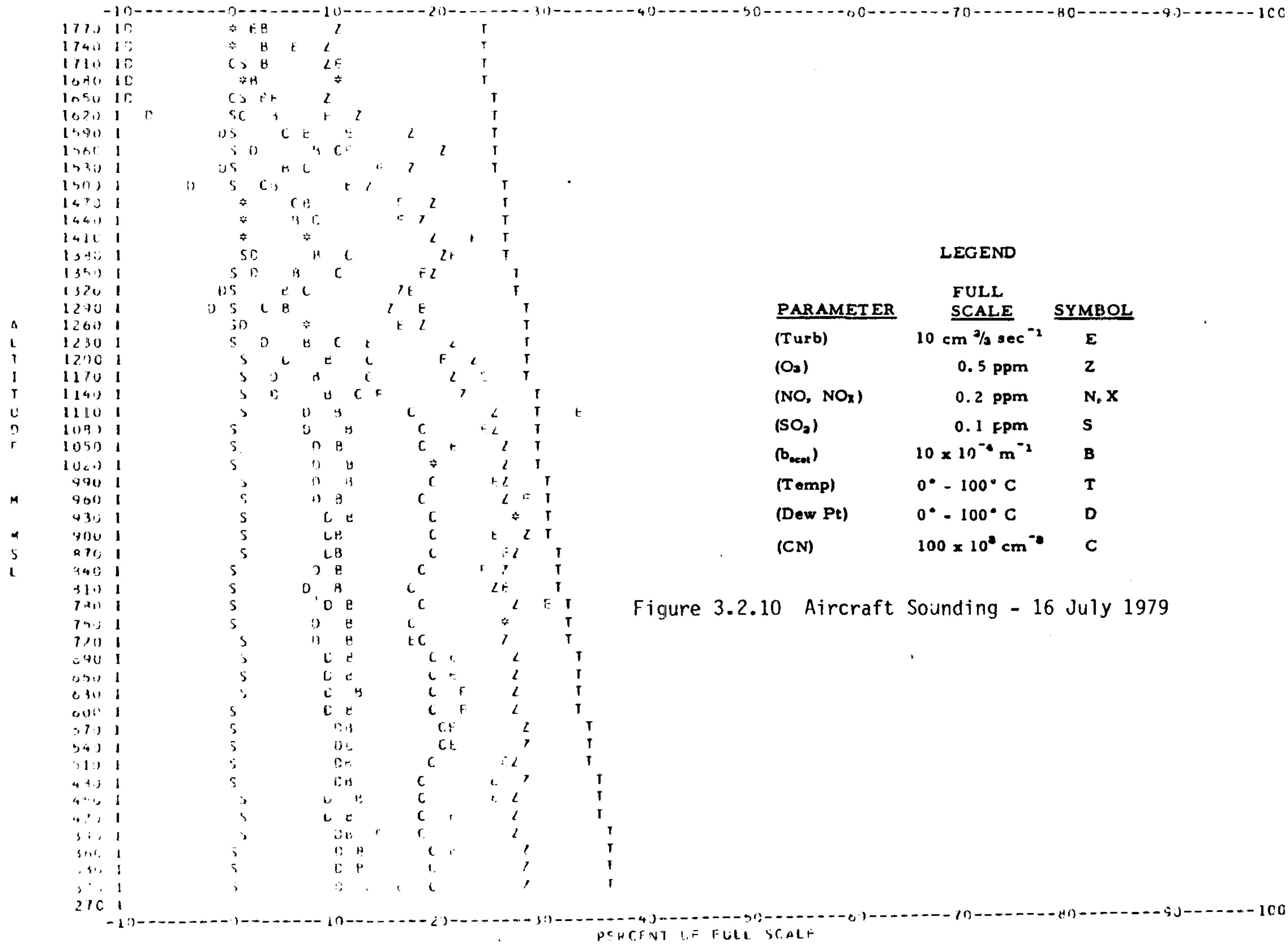


Figure 3.2.9 Aircraft Sounding - 16 July 1979

DATE: 7/16/79   ROUTE: IVER POINT 3
CARTRIDGE/PASS: 6757 4
TIME: 17:55:21 TO 18: 9:15   MIN. GROUND ELEV.: 274 M(MSL)



LEGEND

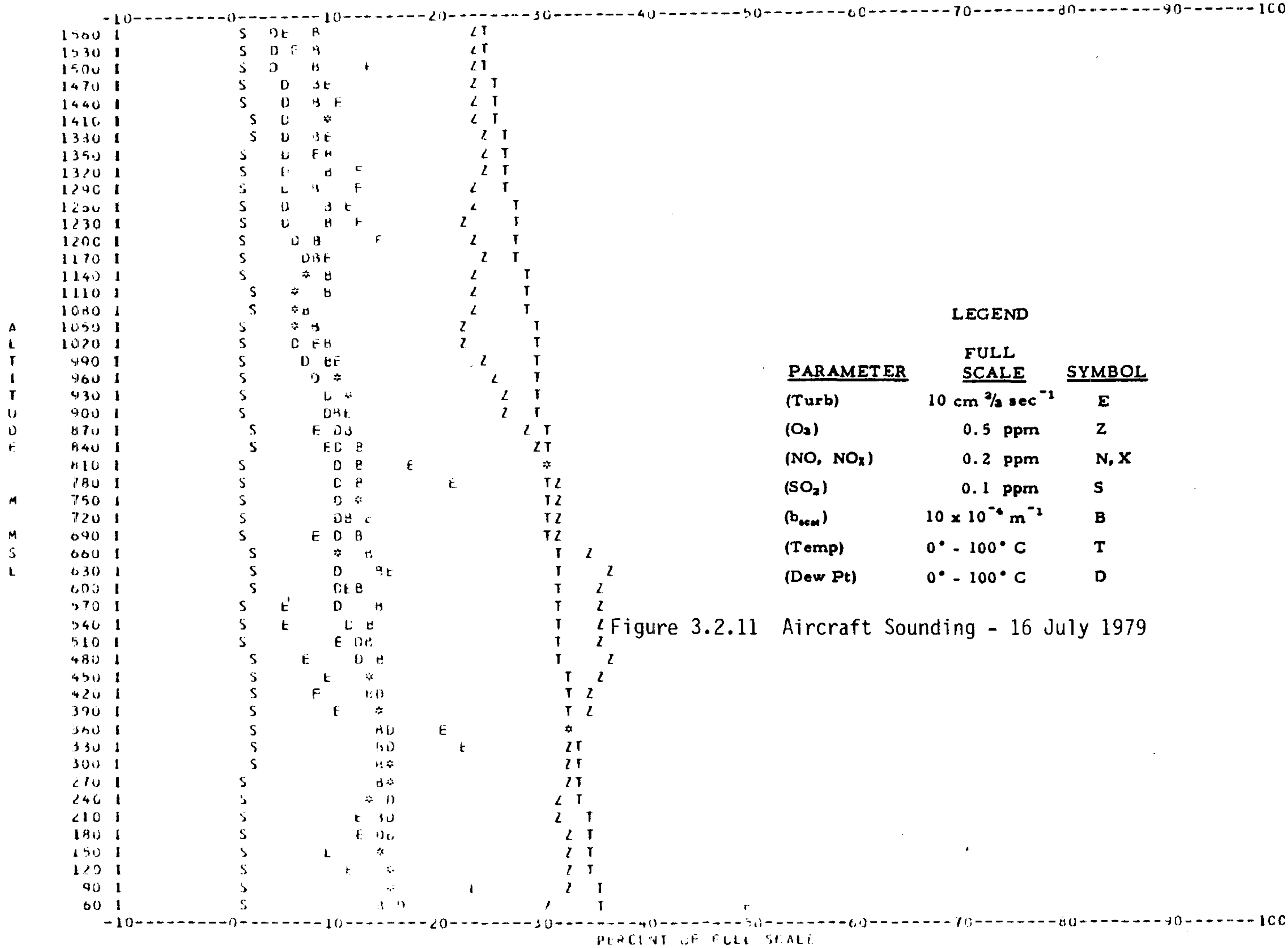
PARAMETER	FULL SCALE	SYMBOL
(Turb)	10 cm $^{2}/_{3}$ sec^{-1}	E
(O_3)	0.5 ppm	Z
(NO, NO_X)	0.2 ppm	N, X
(SO_2)	0.1 ppm	S
(b_{scat})	10 x 10^{-4} m^{-1}	B
(Temp)	0° - 100° C	T
(Dew Pt)	0° - 100° C	D
(CN)	100 x 10^{3} cm^{-3}	C

Figure 3.2.10 Aircraft Sounding - 16 July 1979

COFPLT VER 01 MOD 03   21-APR-80 14:22:11   PAGE 13

DATE: 7/16/79
CARTRIDGE/PASS: 6757 6
TIME: 18:51: 0 TO 19: 8:50

ROUTE: OVER POINT 6
MIN. GROUND ELEV.: 51 M(MSL)



LEGEND

PARAMETER	FULL SCALE	SYMBOL
(Turb)	10 cm $^{2/3}$ sec $^{-1}$	E
(O_3)	0.5 ppm	Z
(NO, NO_x)	0.2 ppm	N, X
(SO_2)	0.1 ppm	S
(b_{scat})	10 x 10^{-4} m^{-1}	B
(Temp)	0° - 100° C	T
(Dew Pt)	0° - 100° C	D

Figure 3.2.11 Aircraft Sounding - 16 July 1979

DATE: 7/16/79 ROUTE: OVER POINT 1
CARTRIDGE/PASS: 6757 8
TIME: 19:58:57 TO 20:12:19 MIN. GROUND ELEV.: 29 M(MSL)

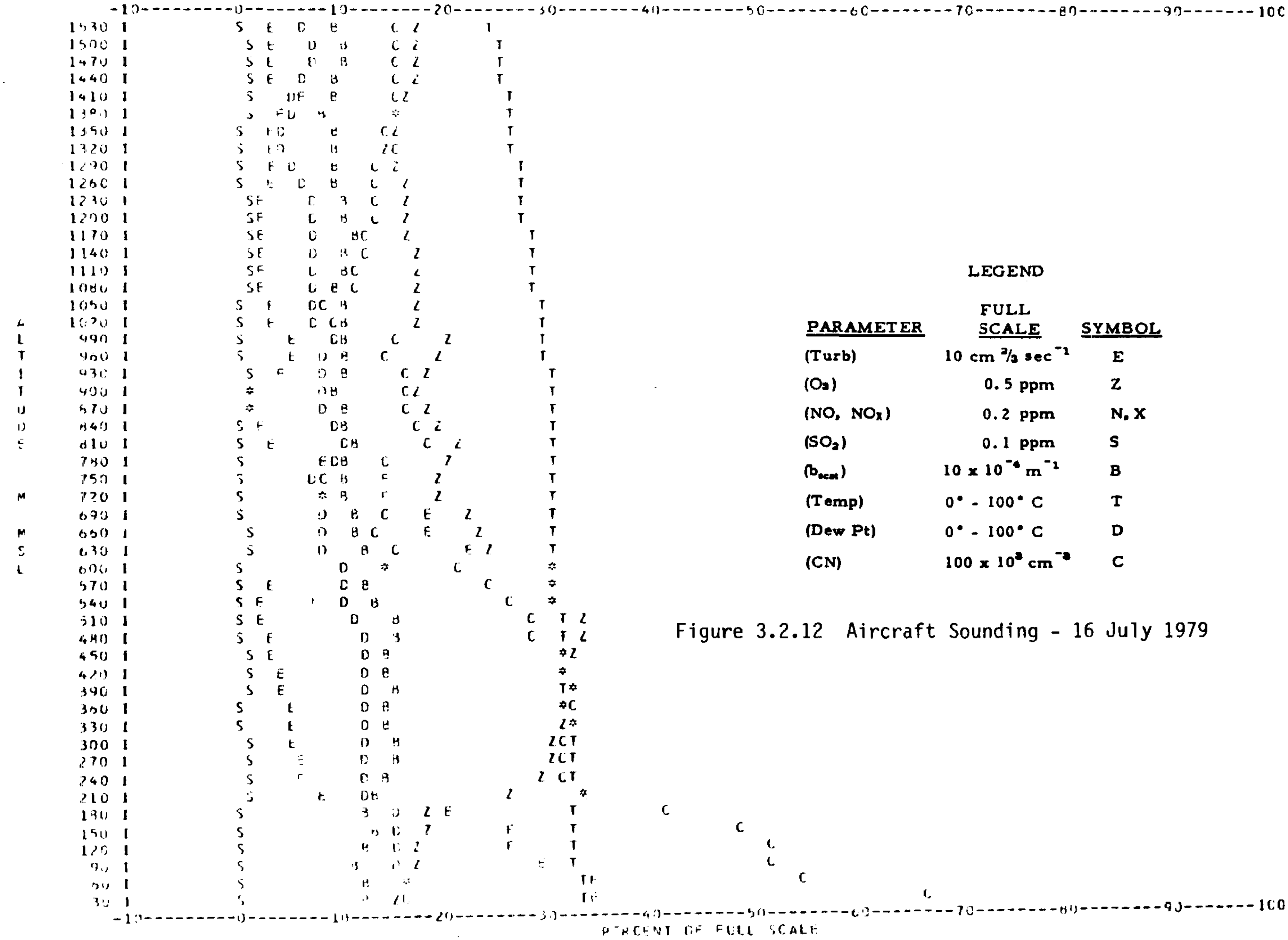


Figure 3.2.12 Aircraft Sounding - 16 July 1979

above this level. Figure 3.2.9 is a sounding made over Modesto Reservoir about one-half hour later. The mixed layer extends to 840 m-msl. Above this level is a very dry layer from 1050 to 1320 m. Another ozone-rich layer then extends from 1350 m to 1680 m.

Over the foothills to the east of Modesto Reservoir (Figure 3.2.10) the mixed layer was considerably deeper (1260 m-msl). Above that level, however, the ozone-rich layer was also found. The total ozone burden in the mixed layer was slightly larger than observed at Modesto Reservoir.

Figure 3.2.11 is a sounding made at Patterson on the far west side of the valley. The mixing layer is considered to extend to 1020 m-msl with high ozone levels (.18 ppm). Above the mixed layer was a deep and well-mixed layer characterized by ozone levels above .10 ppm. This layer extended to 1980 m-msl. Winds within the upper zone layer were from the south to southeast for all of the above soundings.

The aircraft completed its afternoon flight with another spiral sounding at Modesto Airport. Low level stability had developed by this time (1958 PDT) and surface layer mixing was confined to the lowest 180 m (msl). Considerable ozone remained aloft, however, isolated from the surface sources of NO. The total ozone burden above Modesto Airport was not substantially different from that observed at 1658 PDT.

The aircraft took off the following morning to repeat the flight pattern of the previous evening. Figure 3.2.13 was the first sounding made (0541 PDT). Surface depletion of ozone is readily apparent to a level of 330 m (msl), corresponding to the top of the temperature inversion. At higher levels substantial concentrations (.12 ppm) of ozone existed to 1320 m where a dry layer commenced.

Figure 3.2.14 shows the sounding made over Modesto Reservoir at 0618 PDT. The mixing layer and ozone depletion extends to a somewhat higher level but concentrations of .10 ppm exist aloft. Over the foothills at 0642 PDT (Figure 3.2.15) a similar pattern existed but with slightly lower ozone concentrations above the mixed layer.

At Patterson, on the west side of the valley (Figure 3.2.16) the surface mixed layer (and ozone depletion) extends to 330 m-msl. Aloft ozone concentrations of over .10 ppm exist but only to a level of 870 m-msl. Above this level the dry layer appears as indicated in the Modesto Airport sounding.

CCEPLT VER 01 MOD 03 21-APR-80 55:14:52 PAGE 3

DATE: 7/17/79
CARTRIDGE/PASS: 6767 1
TIME: 5:41:21 TO 5:58:33

ROUTE: OVER POINT 1
MIN. GROUND ELEV.: 29 M(MSL)

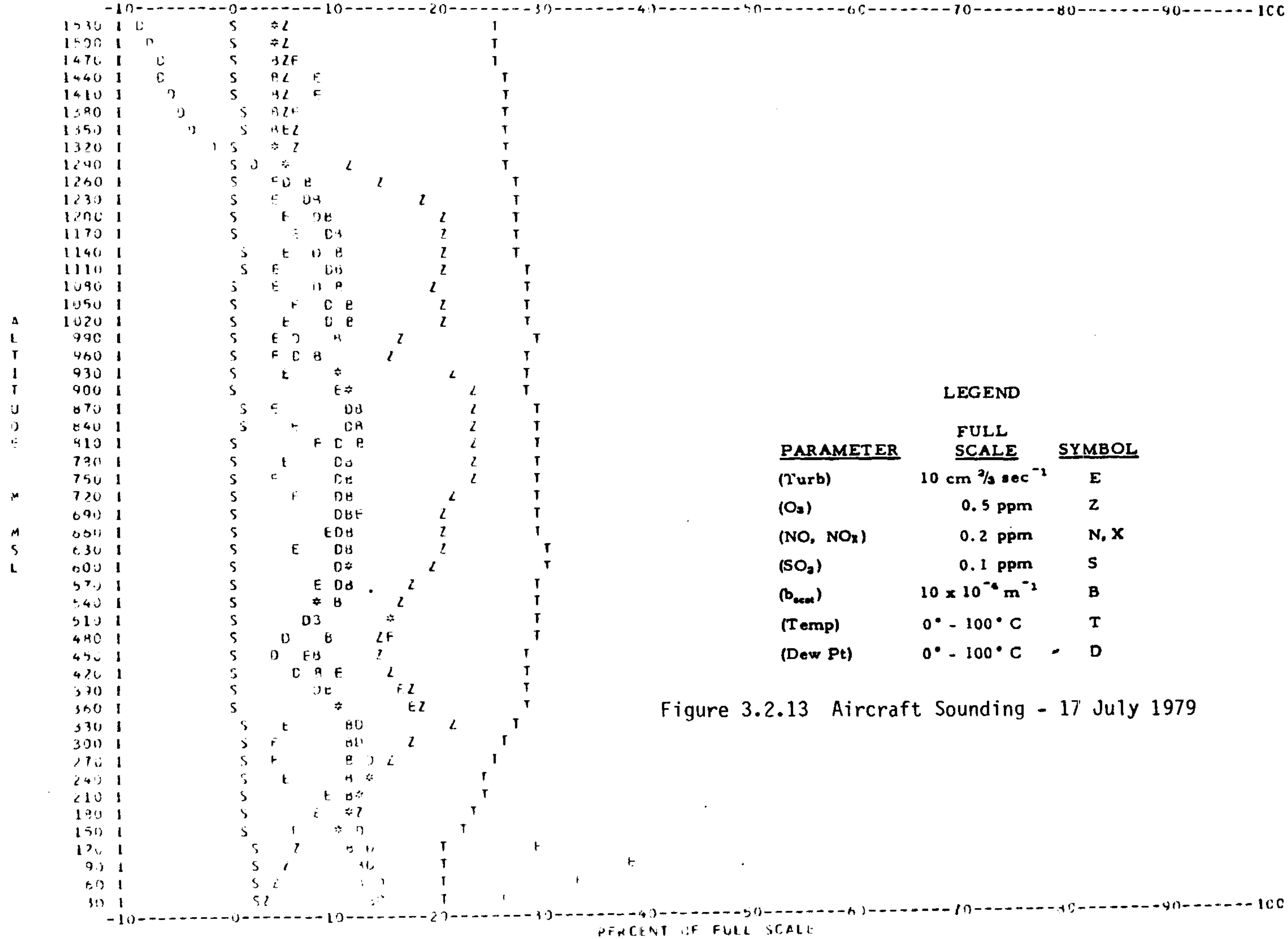


Figure 3.2.13 Aircraft Sounding - 17 July 1979

CLFPLT VER 01 MOD 03 21-APR-80 55:14:52 PAGE 7

DATE: 7/17/79
CARTRIDGE/PASS: 6767 3
TIME: 6:16:22 TO 6:34:18

ROUTE: OVER POINT 2
MIN. GROUND ELEV.: 75 M(MSL)

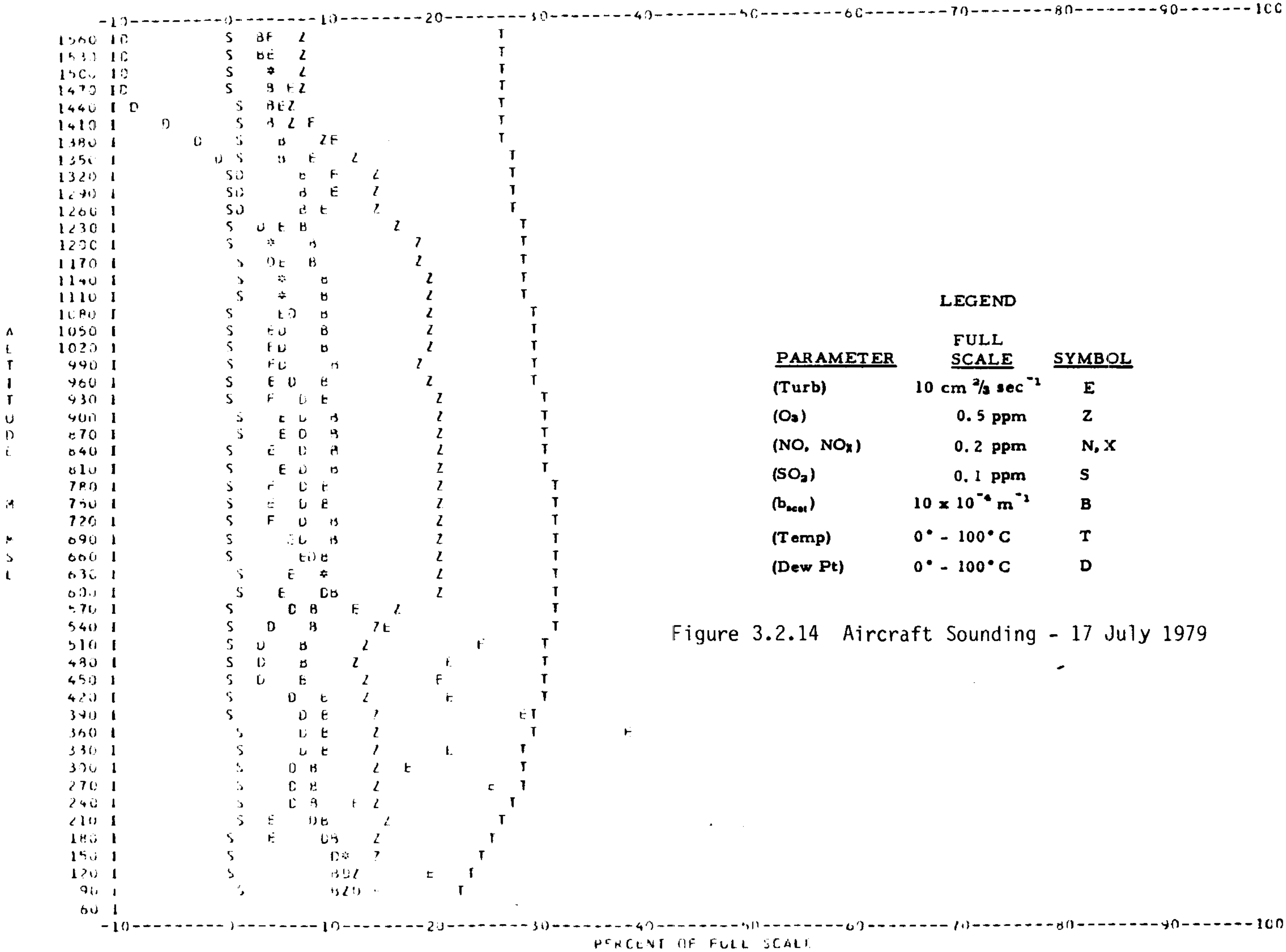
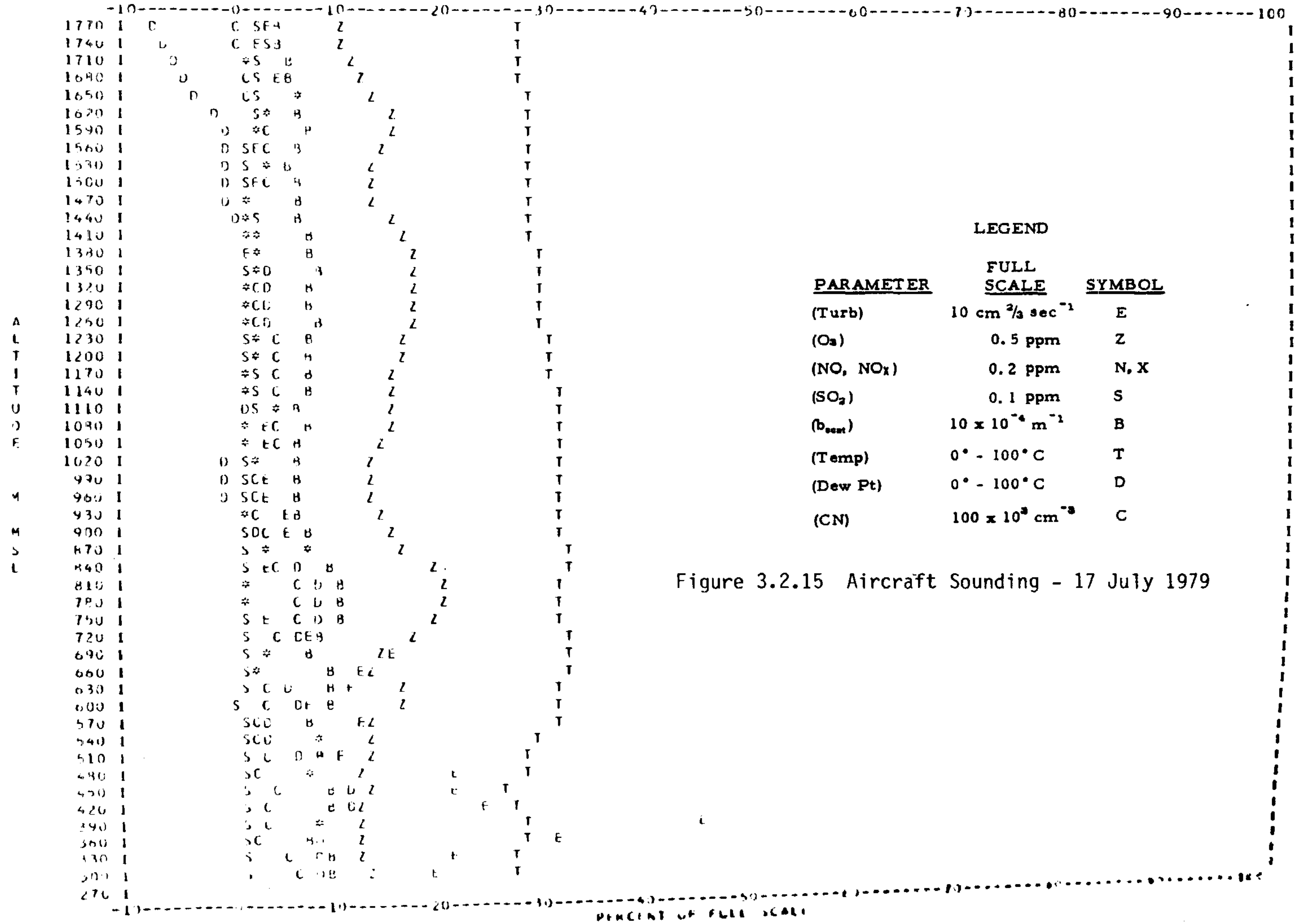


Figure 3.2.14 Aircraft Sounding - 17 July 1979

DATE: 7/17/79   ROUTE: [illegible] POINT 3
CARTRIDGE/PASS: 6/6/ 4
TIME: 6:42: 9 TO 6:59:44   MIN. GROUND ELEV.: 274 M(MSL)



LEGEND

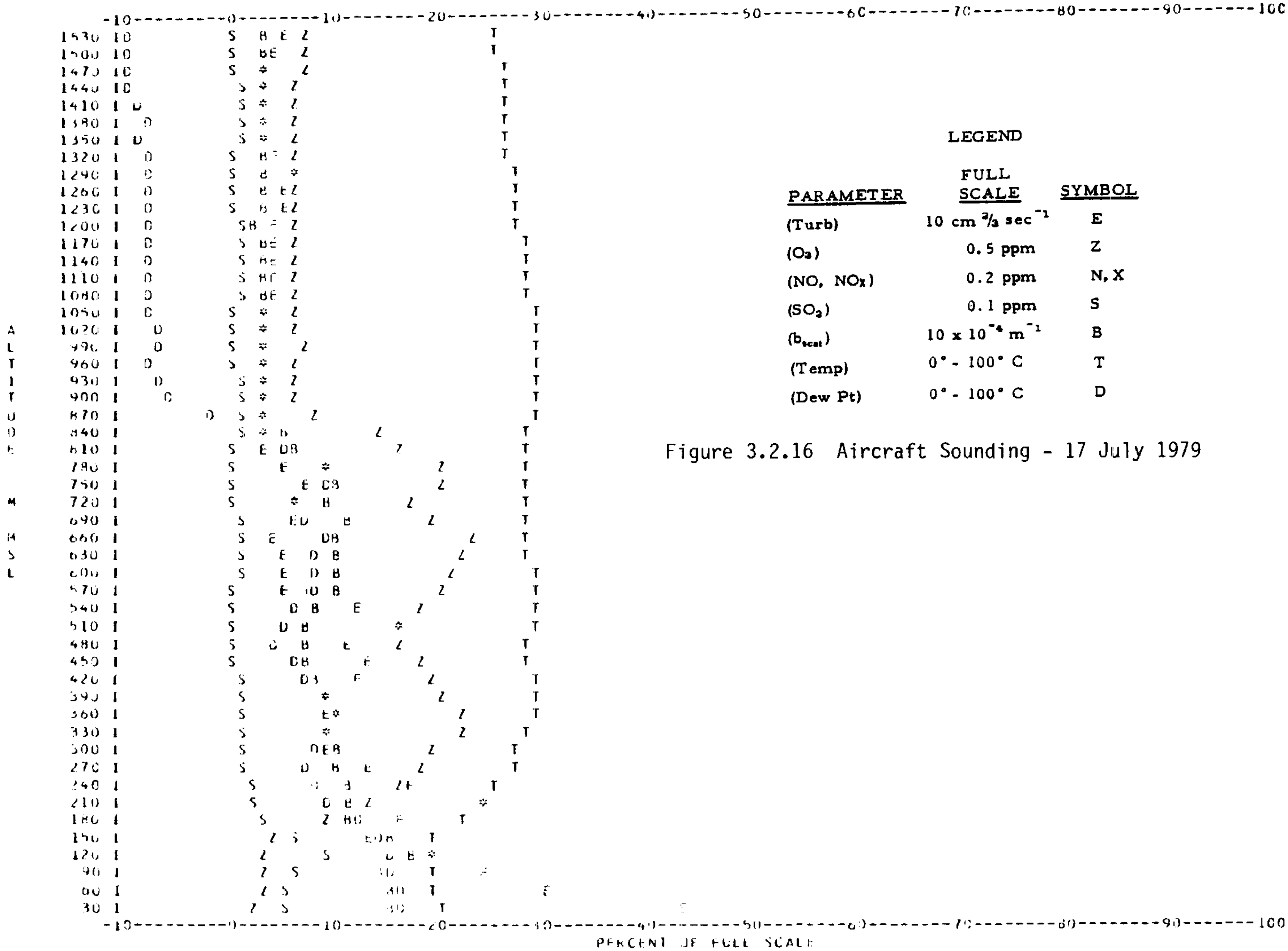
PARAMETER	FULL SCALE	SYMBOL
(Turb)	10 cm $^{2/3}$ sec $^{-1}$	E
(O_3)	0.5 ppm	Z
(NO, NO_X)	0.2 ppm	N, X
(SO_2)	0.1 ppm	S
(b_{scat})	10 x 10^{-4} m^{-1}	B
(Temp)	0° - 100° C	T
(Dew Pt)	0° - 100° C	D
(CN)	100 x 10^3 cm^{-3}	C

Figure 3.2.15 Aircraft Sounding - 17 July 1979

COFPLT VER 01 MOD 03   21-APR-80 55:14:52   PAGE 13

DATE: 7/17/79
CARTRIDGE/PASS: 5767 6
TIME: 7:32:57 TO 7:48: 5

ROUTE: OVER POINT 5
MIN. GROUND ELEV.: 30 M(MSL)



LEGEND

PARAMETER	FULL SCALE	SYMBOL
(Turb)	10 cm $^{2/3}$ sec $^{-1}$	E
(O_3)	0.5 ppm	Z
(NO, NO_X)	0.2 ppm	N, X
(SO_2)	0.1 ppm	S
(b_{scat})	10 x 10^{-4} m^{-1}	B
(Temp)	0° - 100° C	T
(Dew Pt)	0° - 100° C	D

Figure 3.2.16 Aircraft Sounding - 17 July 1979

Winds in the ozone layers aloft were from the south for all soundings made during the morning. Transport of ozone aloft from the southern part of the valley to the north is indicated in this series of soundings.

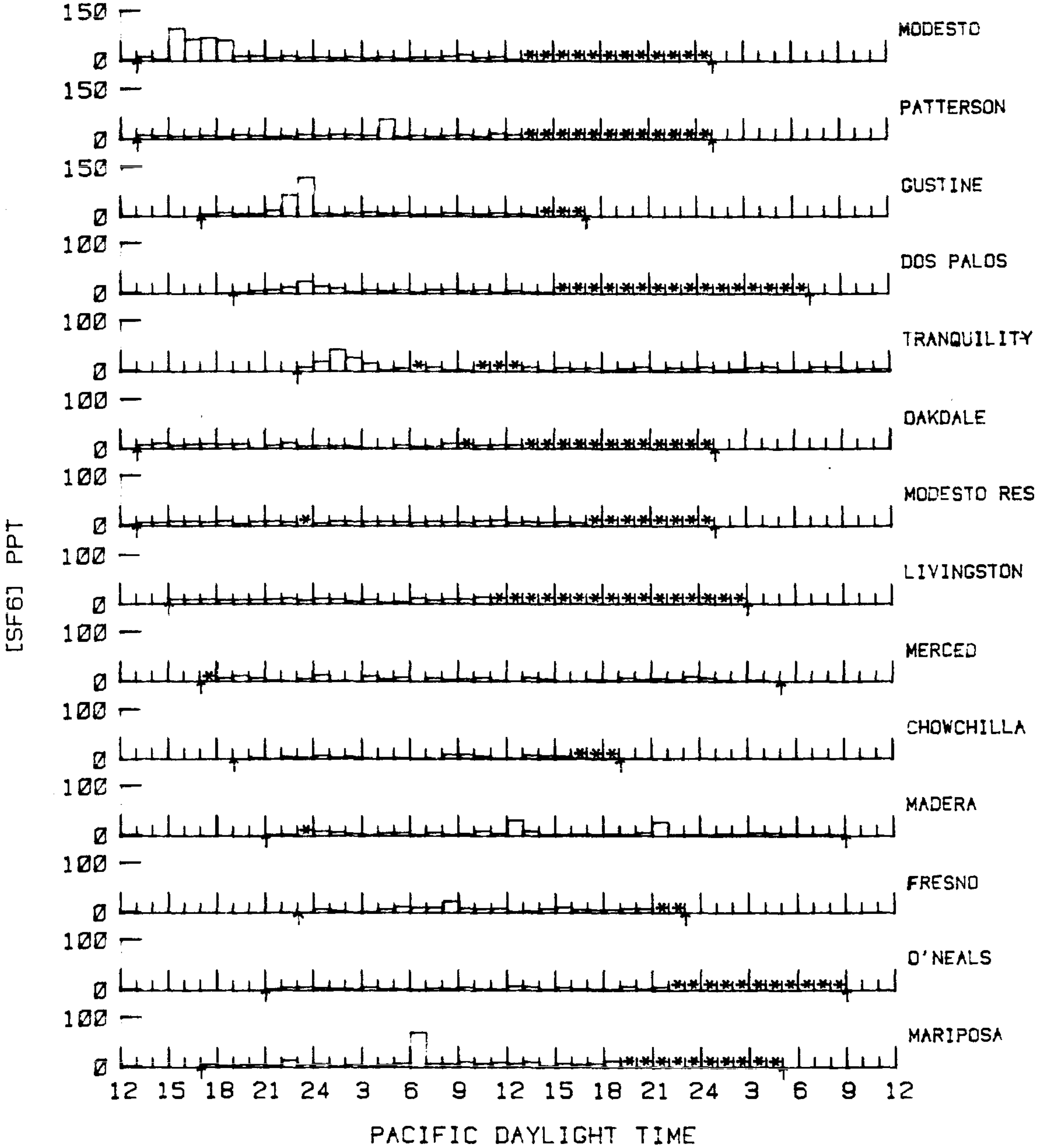
3.2.3 Tracer Test 2

Release Location: Manteca, San Joaquin County
Time and Date: 1300-1900 PDT, 7/16/79
Amount: 104 pounds of SF6 per hour
Release conducted during northwesterly winds of between 2 and 3 mps. A southerly flow on the eastern side of the valley (the Fresno Eddy) was replaced during the course of the release by northwesterly winds.

Initial transport southward

During Automobile Traverse 1-1, beginning about 1500 PDT, a peak SF6 concentration of about 630 PPT (880 PPT/lb-mole of SF6 released/hr) was detected near Modesto along Hwy 132. The peak concentration was detected slightly to the west of Modesto. 94 PPT of SF6 (132 PPT/lb-mole SF6 released/hr) was detected during the 1500-1600 PDT automatic hourly-averaged sample at Modesto (see Figure 3.2.17). At the Modesto hourly-averaged sampler, 70 +/- 15 PPT (about 100 PPT/lb-mole SF6 released/hr) was detected between 1500 and 1900 PDT. The timing between the start of the release and the detection of SF6 at Modesto was the same as during the first Manteca release. The concentration profile was centered farther to the west than during the first test and centerline concentrations detected along Hwy 132 during this experiment were about double the corresponding centerline concentrations detected during the previous test. The detection of higher concentrations during this experiment is surprising in that the release began during the early afternoon rather than during the typically more stable conditions persisting during early morning. The unusual meteorological conditions alluded to in the previous test were evidently the source of the enhanced instability detected during the first test. SF6 concentration profiles detected during Automobile Traverses 1-2, 1-4, 1-6 and 1-7 showed an SF6 peak near the same location as found during Traverse 1-1. The maximum concentration detected during the traverses, however, tended to increase throughout the afternoon. Maximum SF6 concentrations of 632 PPT, 643 PPT, 860 PPT and 1248 PPT (1753 PPT/lb-mole SF6 released/hr), were detected during Traverse 1-1, 1-2, 1-4 and 1-6,

SJV-2 7/16/79 - 7/18/79



RELEASE LOCATION: 621 LBS SF6 AT MANTECA
RELEASE TIME: 1300 PDT, 7/16/79

Figure 3.2.17

* INDICATES MISSING DATA

ARROWS INDICATE BOUNDS OF SAMPLING PERIOD

SJV

2

Figure 3.2.18

* INDICATES SAMPLER LOCATIONS

(R) IS THE RELEASE SITE

respectively. As mentioned previously, Traverse 1-1 began about 1500 PDT, while Traverse 1-6 began at the end of the release (1900 PDT). The increase in concentration detected during these traverses was probably due to a increasingly stable atmosphere as evening approached.

Continued southward transport during evening

As in the previous test, the tracer was detected west of Hwy 99 during traverses along Rd J17 (west of Turlock), Hwy 140 (west of Merced), Hwy 152 (west of Chowchila), Ave 7 and Hwy 180 (north and west of Fresno). Typical concentration profiles along these traverse routes are shown in Figure 3.2.19. The maximum concentrations detected along these traverse routes were 424 PPT (about 600 PPT/lb-mole of SF6 released/hr) along J17, 347 PPT (490 PPT/lb-mole SF6 released/hr) along Hwy 140, 112 PPT (158 PPT/lb-mole SF6 released/hr) along Hwy 152, 55 PPT (78 PPT/lb-mole SF6 released/hr) along Ave 7, and 56 PPT (79 PPT/lb-mole SF6 released/hr) along Hwy 180.

The hourly-averaged samplers also showed behavior similar to that of the first test. During this test, however, Gustine received high concentrations of SF6 (maximum of 116 PPT, 164 PPT/lb-mole SF6 released/hr) while Livingston did not. The tracer plume was thus detected farther west during this test than during the previous release. Dos Palos and Tranquillity were also impacted by the tracer plume. The arrival of SF6 at Dos Palos (2200 PDT) corresponded to a mean transport speed of just over 3 mps. Tranquillity was close to the centerline of the plume in that a maximum concentration of 41 PPT (58 PPT/lb-mole SF6 released/hr) was detected between 0200 and 0300 PDT, 7/17/79. The arrival of SF6 at Tranquility (0000 PDT, 7/17/79) corresponded to a mean transport speed of about 4 mps.

Gaussian plume model comparison

As in the previous test, the traverse data can be used to evaluate the dispersion parameters for the Gaussian plume model. As shown in Figure 3.2.19, the concentration profiles along the traverse routes were essentially Gaussian in shape. Figure 3.2.20 contains a summary of the horizontal and vertical dispersion parameters estimated from each of the traverses. The solid lines in

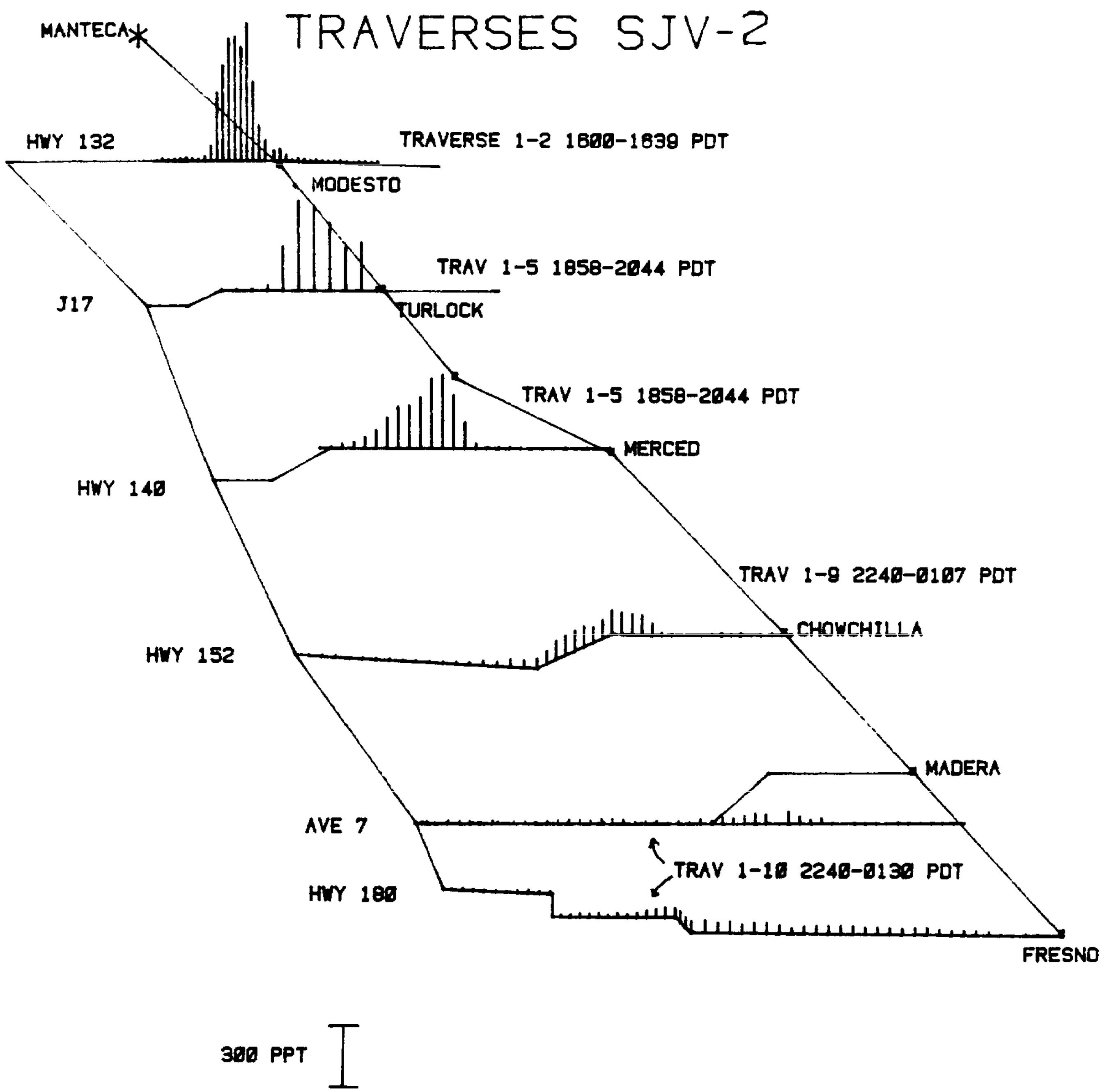


Figure 3.2.19

NORTHERN SJV SCALE - 1:208000

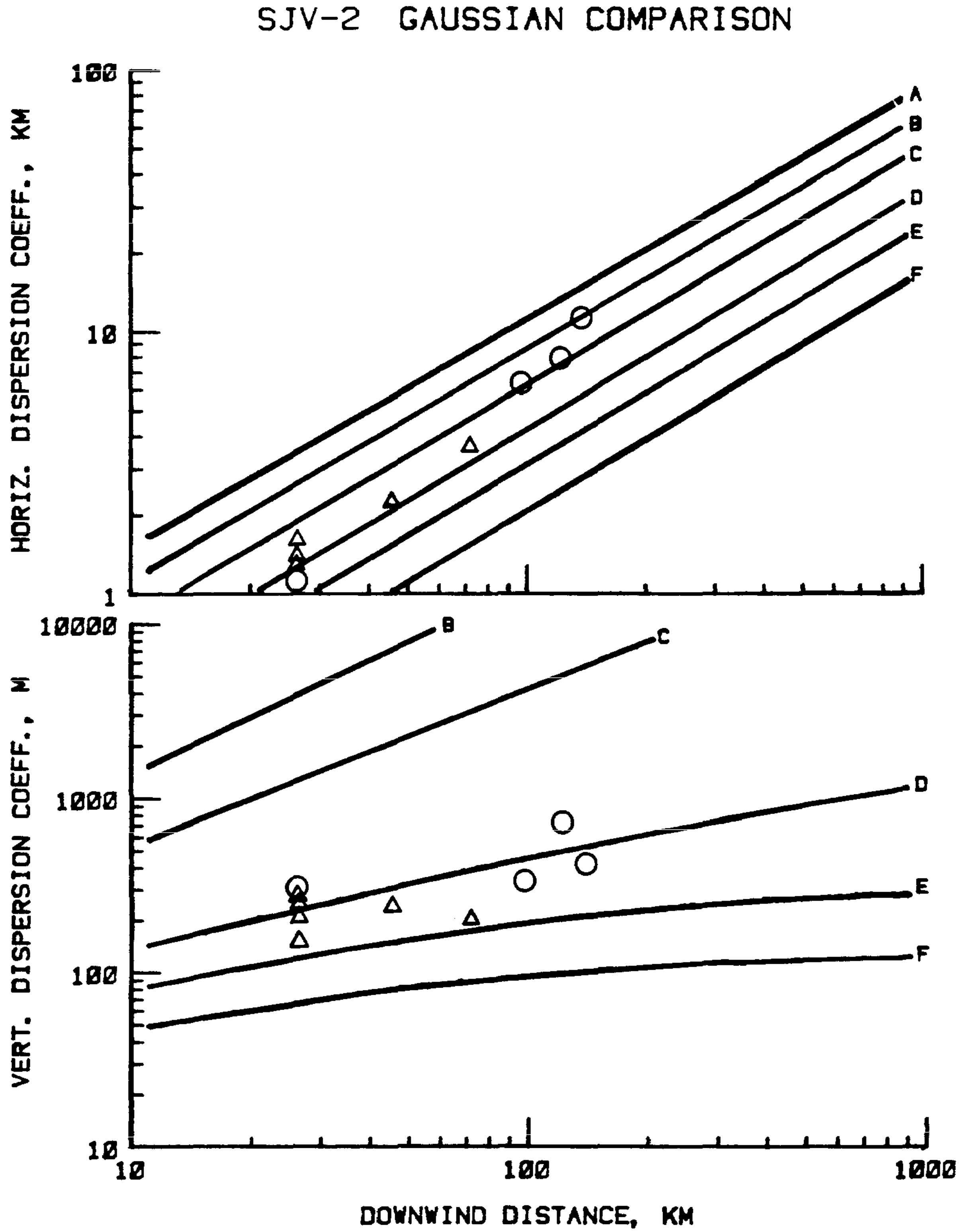


Figure 3.2.20

○ DATA TAKEN AFTER END OF RELEASE

the figure correspond to the predicted coefficients for each Pasquill-Gifford Stability Class based on extrapolations of the curves presented by Turner (1970). The vertical dispersion parameter was again back-calculated from the horizontal dispersion coefficient by mass balance considerations. As noted in the figure, the horizontal dispersion coefficients slowly increased with distance downwind but were generally consistent with Pasquill-Gifford Stability Class C or D. The apparently decreasing stability with increasing distance downwind is surprising in that the shorter distances correspond to mid-afternoon while the larger distances correspond to the presumably more stable evening conditions. The calculated vertical dispersion coefficients for each traverse corresponded to Pasquill-Gifford Stability Class D. The calculated vertical dispersion coefficients are also consistent with a more unstable atmosphere (than stability class D) with a constant or slowly varying mixing height. An average transport speed of 3 mps was assumed in the calculation of the vertical dispersion coefficient. Due to the uncertainties associated with the vertical dispersion coefficient calculation it is not possible to determine whether the tracer slowly mixed upward continuously or quickly mixed within a well-defined mixing layer. The estimated mixing height in the valley, based on pibal data, was 2-3000 ft. If the tracer was well-mixed vertically, the vertical dispersion coefficient calculation suggests a mixing height of about 400 m or about 1300 ft.

Carryover of tracer

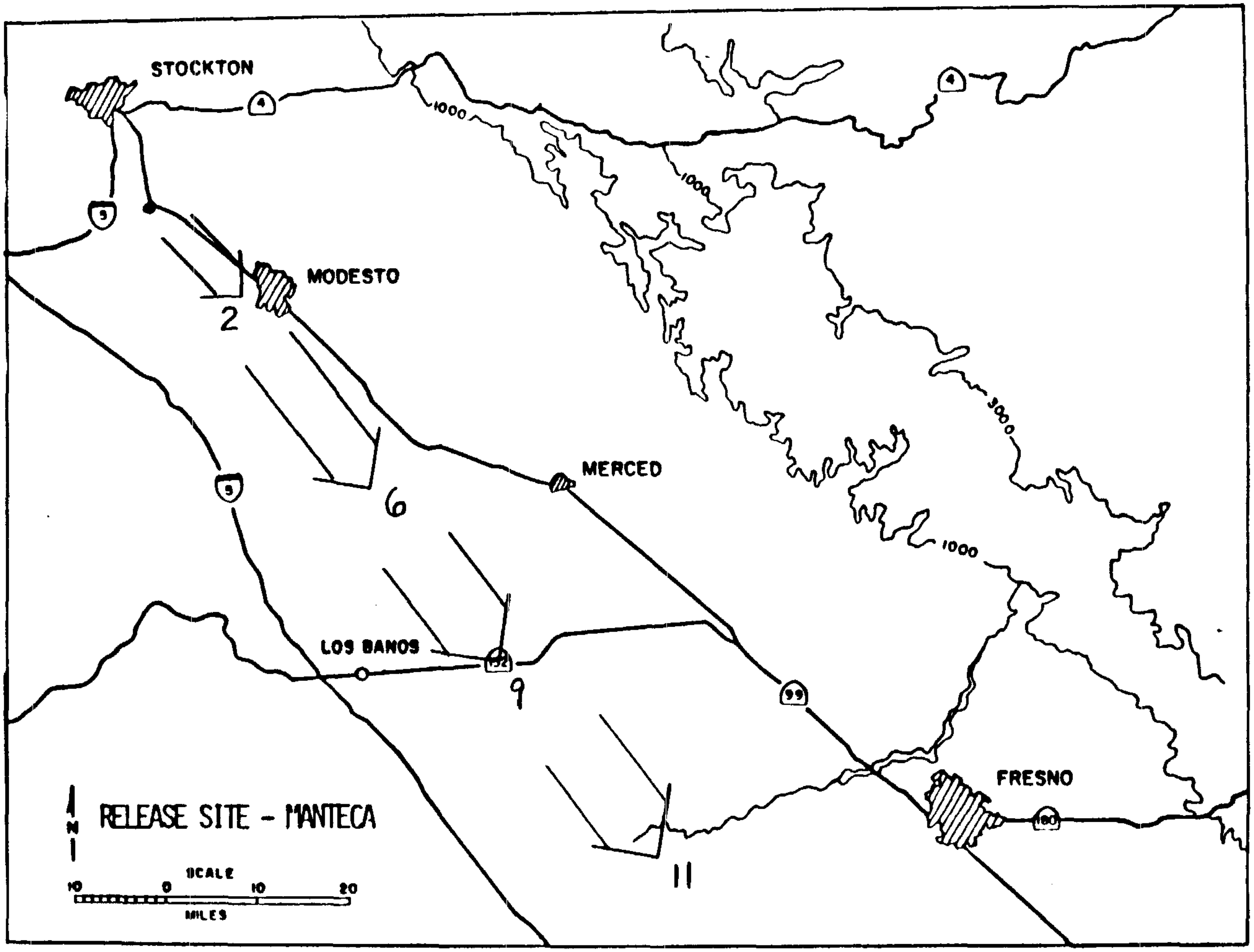
As in the previous test, low concentrations of the tracer (5-10 PPT) were detected over a wide area north and west of Fresno on the day after the release. Again, the night and early morning winds apparently redistributed the tracer throughout the northern valley any tracer not transported out of the valley.

Summary

Many characteristics of the first release from Manteca were repeated during this experiment. An overview of the transport path of the tracer is shown in Figure 3.2.21. The tracer was again preferentially transported down the central and western sides of the valley. Since higher pollutant concentrations were detected on the east side of the valley, San Francisco Bay Area or California Delta pollutants transported into the valley apparently had little effect on valley air quality.

It was possible to interpret the dispersion of the tracer in terms of the Gaussian plume model. The horizontal dispersion corresponded to that expected under mildly unstable atmospheric conditions, Pasquill-Gifford Stability Class C or D. The vertical dispersion corresponded to that expected in neutral stability, Pasquill-Gifford Stability Class D. The vertical dispersion was also consistent with a well-mixed layer with a height of 1300 ft.

As in the previous experiment, low but non-zero concentrations of the tracer, were detected on the day after the release. It was not possible to quantify the amount of carryover from the release day.



ARROW POINT INDICATES OBSERVED TRACER LOCATIONS
NUMBERS REFER TO HOURS AFTER RELEASE START (1300 PDT., 7/16/79)

Figure 3.2.21

3.3 Test 3 18-19 July 1979, Livermore Release (1510-2030 PDT)

3.3.1 Meteorology

General

The synoptic meteorology of 18 July, depicted in Figure 3.3.1 was characterized by intense ridging aloft on the west coast, extending well up into northern Canada. Warming of the temperatures aloft due to subsidence is reflected in the plots of 850 mb temperatures at Oakland and Vandenberg in Figure 2.2.1. At the surface, thermal troughing due to heating of the interior resulted in onshore pressure gradients. A high pressure area located near Four Corners reinforced the summer monsoon flow over the southwest desert, allowing moisture to penetrate into central California at middle levels and causing widespread shower activity in the central and southern Sierras. Skies in the valley remained clear and visibilities were generally good except in the northern portion. Stockton reported visibility restricted to 4 miles by smoke. Temperatures were several degrees above normal with Fresno reporting a high of 108°F.

Transport Winds

As shown in Table 3.3.1, the surface flow at the release site was directed towards Altamont Pass during the afternoon of the 18th and until early morning on the following day. Wind speeds averaged about 6 m/s in the afternoon and increased to a maximum of over 8 m/s in the late evening. By 0300 PDT on the 19th, the winds were no longer directed through the pass and speeds decreased. From the pibal data taken at a location 4 miles east of Altamont Pass summit, a time-height cross section of the wind component representing flow into the San Joaquin Valley axis was developed and is shown on Figure 3.3.2. A main point to be noted from the cross section is the persistence of a significant component of the wind directed ino the valley at low levels (18 hours duration or more). The flow maxima occurred between 2100 and 2300 PDT on the evening of the 18th. Depth of the flow was about 500 m.

WEDNESDAY, JULY 18, 1979

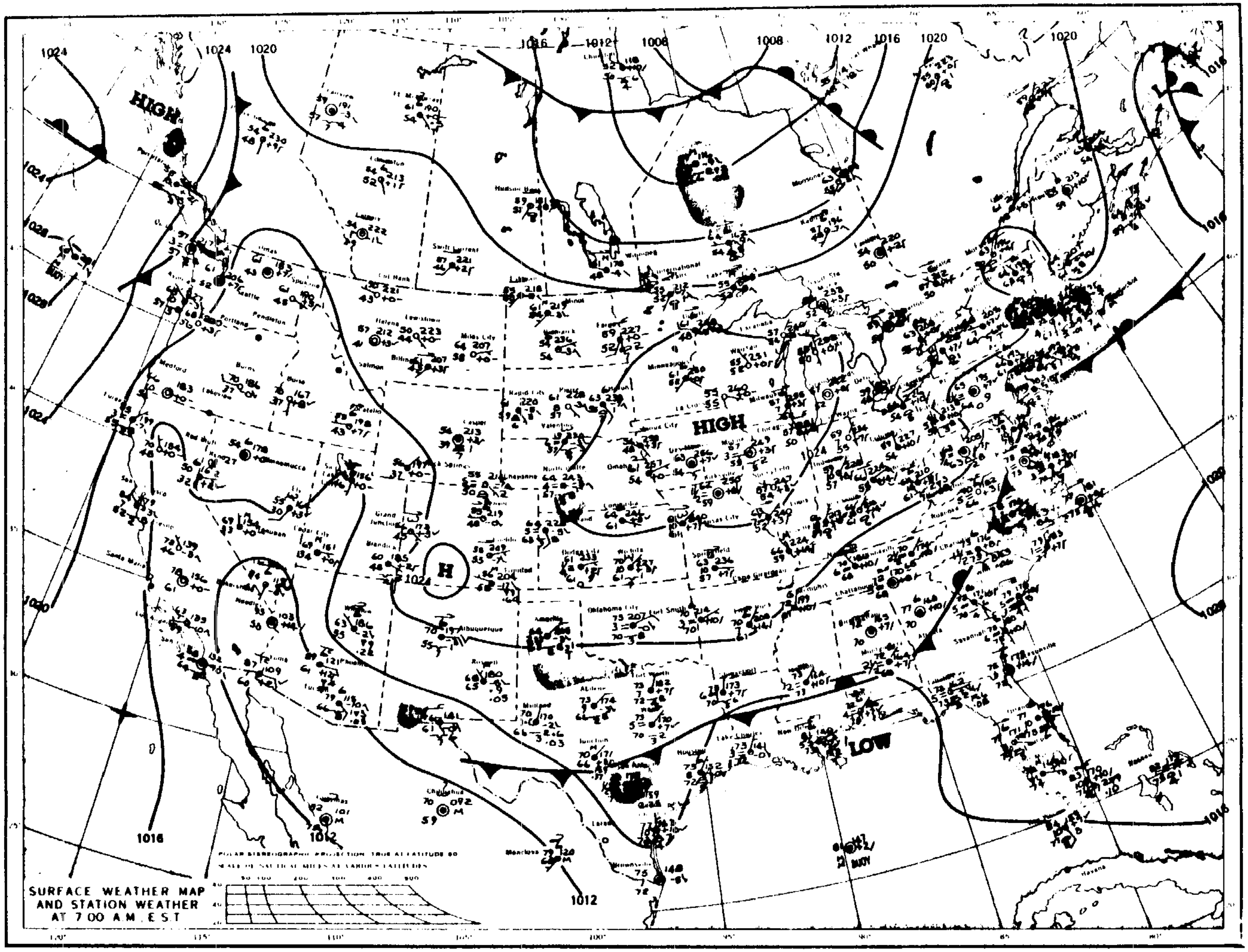


Figure 3.3.1 Surface Weather Charts - 18 July 1979 (05 PDT)

Table 3.3.1

SURFACE WINDS AT LIVERMORE
18-19 JULY 1979

Time (PDT)	Wind (m/s)
July 18	
1600	255/5.4
1700	245/6.0
1800	250/6.6
1900	250/6.8
2000	250/6.0
2100	245/6.5
2200	245/7.9
2300	240/8.4
July 19	
0000	240/7.4
0100	240/6.3
0200	250/4.7
0300	190/1.3
0400	120/1.2
0500	250/5.4
0600	095/2.7
0700	150/1.6
0800	155/1.7

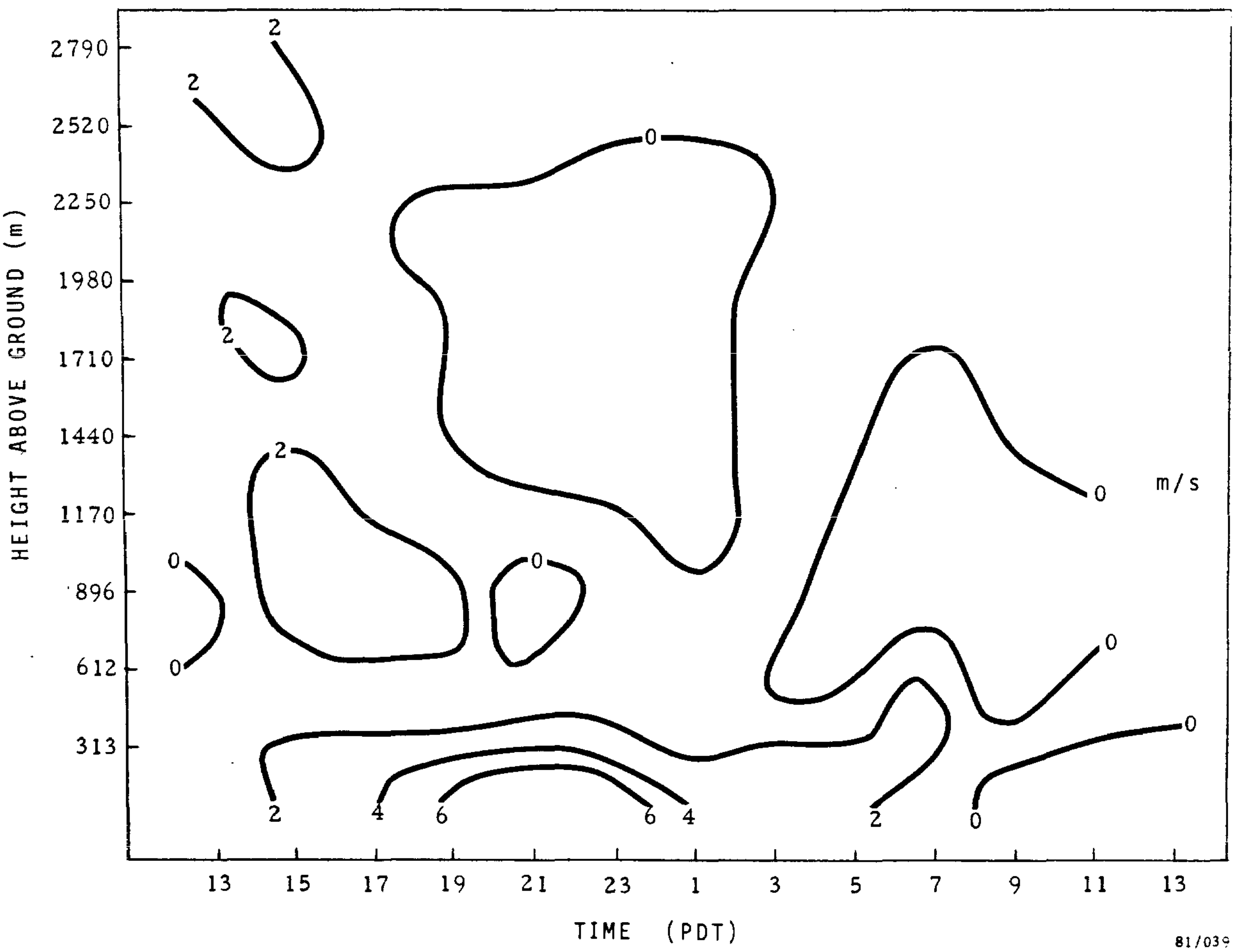


Figure 3.3.2 Time-Height Cross Section Component Winds (m/s) From Altamont Pass 18-19 July 1979 (Positive Component Represents Flow Into Valley)

Flows within the valley during the test can be described by the streamlines constructed from the 1000 foot measured winds from the pibal network. The 1500 PDT flow is shown in Figure 3.3.3. From the streamlines it can be seen that northwest winds were predominant in the northern and central portions of the valley. By 1900 PDT (Figure 3.3.4) the northwest flow extended throughout the valley and persisted until the following morning. Maximum speeds ranging from 8-9 m/s were observed between 2100 PDT on the evening of the 18th and 0100 PDT the following morning. By 0500 PDT the Fresno eddy was established (Figure 3.3.5) in the central and southern portions of the valley. Subsequently, winds dominated the flow in the southern half of the valley through 1100 PDT.

Mixing Heights

Mixing heights were measured by the aircraft during the afternoon flight on July 16. Heights were determined primarily from the characteristics of the observed ozone and b_{scat} vertical profiles. Measured mixing layer heights are given in Table 3.3.2. In two of the soundings, there were two principal layers. Heights of both layer tops are given in the table.

Table 3.3.2

AIRCRAFT MIXING HEIGHT
JULY 18, 1979

Time (PDT)	Location *	Mixing Height (m [above ground level])
July 18		
1645	Modesto Airport	210 (690)
1747	Brentwood	620 (1250)
1830	Livermore	560

(* Distances in miles)

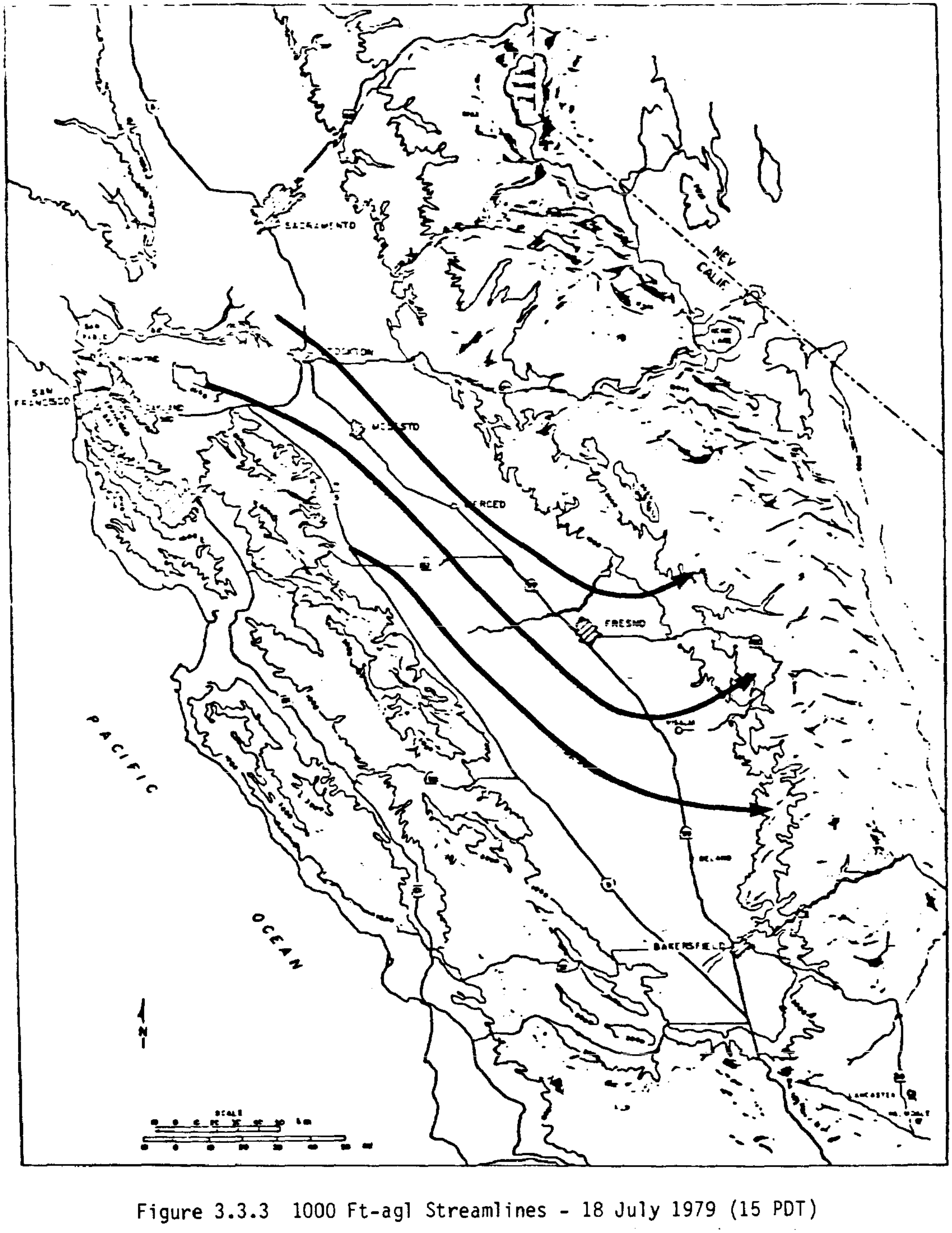


Figure 3.3.3 1000 Ft-agl Streamlines - 18 July 1979 (15 PDT)

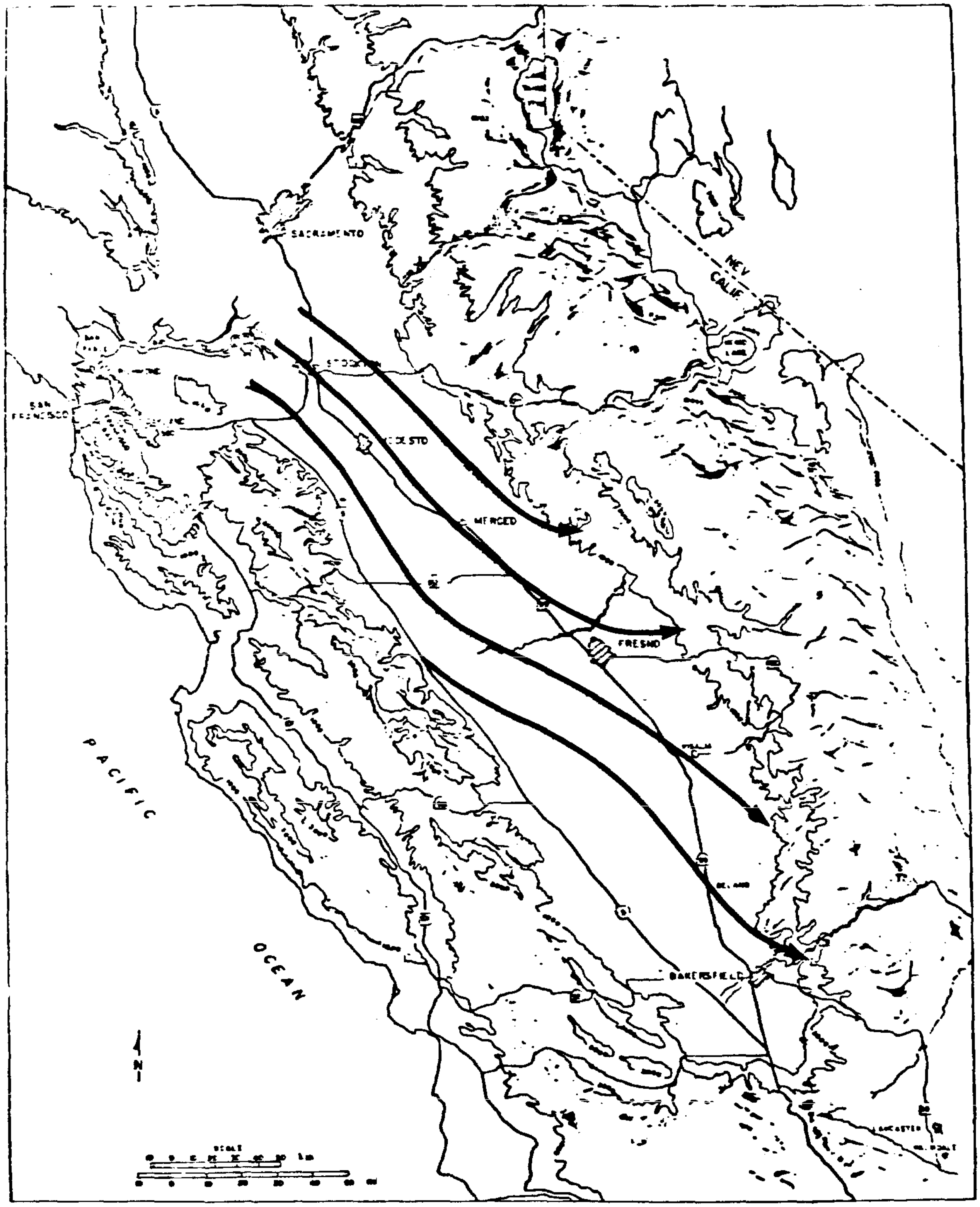


Figure 3.3.4 1000 Ft-agl Streamlines - 18 July 1979 (19 PDT)

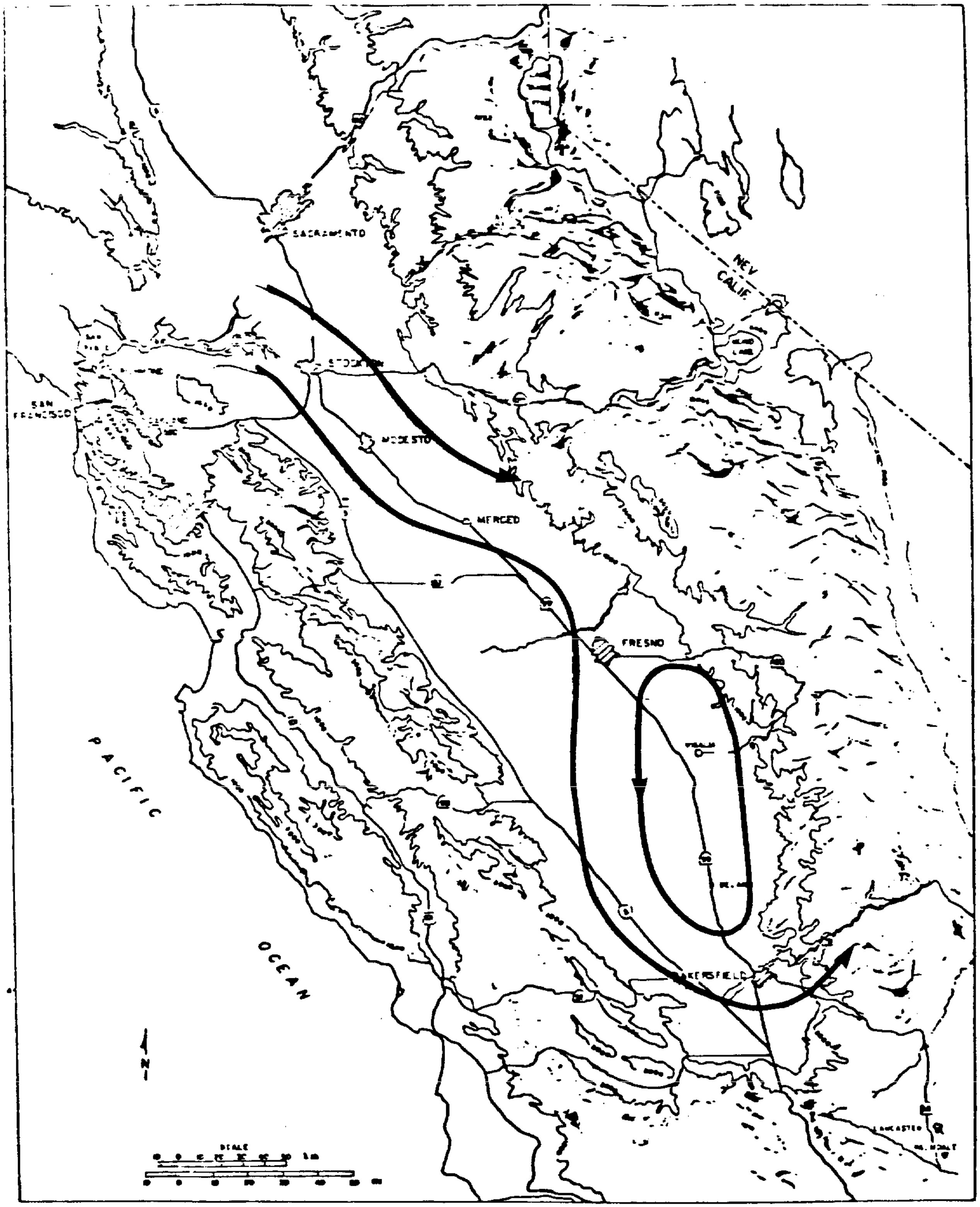


Figure 3.3.5 1000 Ft-agl Streamlines - 19 July 1979 (05 PDT)

3.3.2 Air Quality

Regional Pollutant Levels

Maximum hourly average ozone concentrations throughout the valley on July 18 are shown in Figure 3.3.6. Exceedances of the .10 ppm standard were frequent within the valley. Highest observed hourly concentration was .17 ppm at Fresno. Locations within the Sierra National Forest recorded values of .11 ppm.

Maximum hourly concentrations of SO_2, CO and NO_x throughout the valley on July 25 are given in Table 3.3.3 together with the maximum values recorded at the Rockwell International vans on the same day.

Table 3.3.3

MAXIMUM HOURLY CONCENTRATIONS
JULY 18, 1979

Parameter	Location	Maximum Value (ppm)
SO_2	Bakersfield	.02
CO	Bakersfield	2.
CO	Fresno-Olive	2.
CO	Stockton	2.
CO	Modesto	2.
NO_x	Bakersfield	.19
NO_x	Modesto (RI)	.01
NO_x	Merced (RI)	.05
NO_x	Madera (RI)	< .01
SO_2	Modesto (RI)	< .01
SO_2	Merced (RI)	< .01

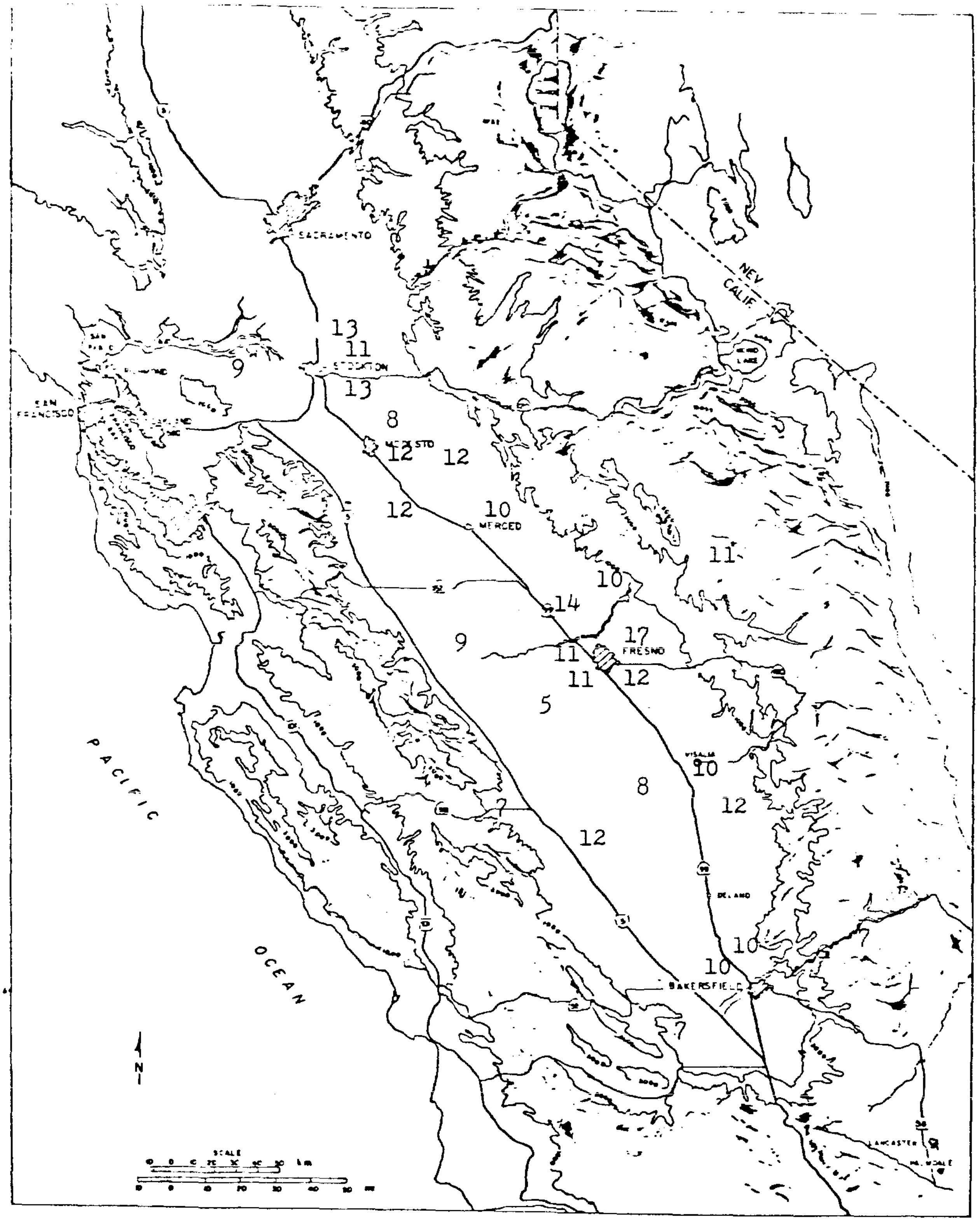


Figure 3.3.6 Maximum Hourly Ozone Concentrations (pphm) - 18 July 1979

Aircraft Sampling

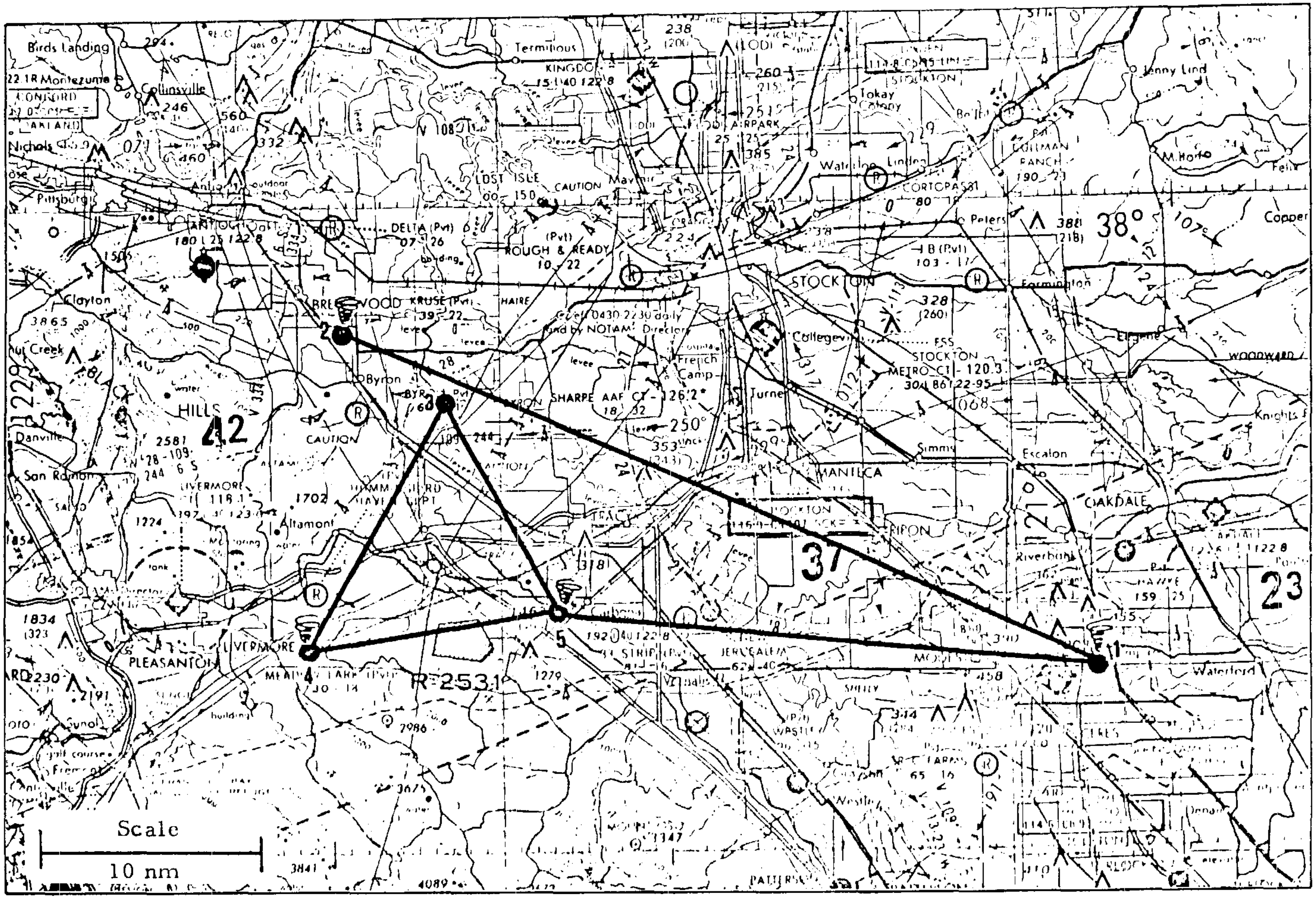
In conjunction with the tracer release from Altamont Pass, the airplane sampled in the late afternoon (1645-2000 PDT); concentrating on a triangular route between Tracy, Brentwood, and Livermore. Two altitudes were traversed between Brentwood and Tracy, east of Altamont Pass, and at an altitude within the surface mixing layer on the other two legs. Sampling was also conducted within the mixing layer in the valley to and from Modesto. Spirals were flown at Livermore, Brentwood, Tracy and Modesto.

Figure 3.3.7 shows the flight pattern followed on July 18. Table 3.3.4 gives the overall air quality characteristics observed during the flight. Sounding profiles for Modesto, Brentwood and Livermore appear in Figures 3.3.8 to 3.3.10.

The sounding at Modesto (Figure 3.3.8) shows several layers of pollutants. A lower layer (to 240 m-msl) was capped by a high b_{scat} layer between 270 and 510 m-msl. A very dry layer is indicated between 750 and 1080 m-msl containing relatively high b_{scat} values. The wind flow in the upper layer was from the northwest.

At Brentwood (Figure 3.3.9) there were two main layers, both characterized by high ozone values (maximum .22 ppm). Above 1260 m a very dry and clear layer is shown.

The sounding at Livermore (Figure 3.3.10) shows a well-mixed layer to 750 m-msl with values of ozone to .10 ppm. Above this layer the dry, clear air was again found but a second ozone layer was centered at 1050 m. The wind direction at the height of the second layer was from the west.



SAMPLING ROUTES 18 July 1979

Figure 3.3.7

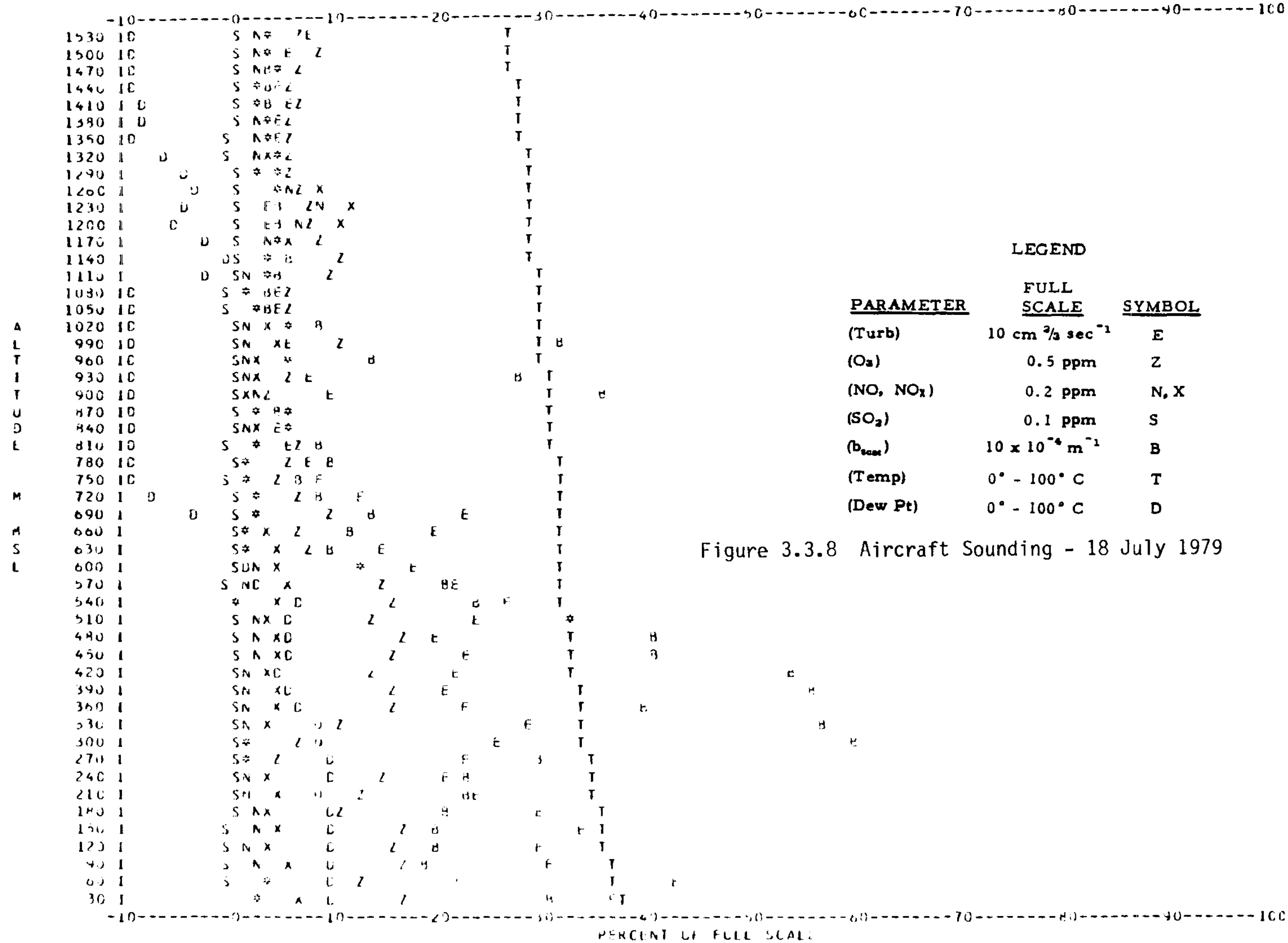
Table 3.3.4

AIR QUALITY MEASUREMENTS CARB SAN JOAQUIN VALLEY PROJECT
JULY 18, 1979 SAMPLING

Start Time (PDT)	Location (Point)	O_3 Mean (ppb)	O_3 Max (ppb)	b_{scat} Mean ($x10^{-6}m^{-1}$)	b_{scat} Max ($x10^{-6}m^{-1}$)	SO_2 Mean (ppb)	SO_2 Max (ppb)	NO_x Mean (ppb)	NO_x Max (ppb)	NO Mean (ppb)	NO Max (ppb)
0646	1	37	152	145	1108	0	33	6	44	4	34
1719	1-2	147	241	163	1196	1	4	14	32	4	13
1747	2	132	223	82	196	0	21	17	36	6	18
1812	3-4	117	179	86	144	0	0	20	36	5	13
1830	4	71	145	51	130	0	0	17	44	7	15
1844	4-5	94	165	82	200	-1	0	23	41	10	28
1855	5	66	76	37	68	0	0	8	15	8	15
1916	5-3	71	82	35	70	0	0	19	27	12	20
1929	3-5	161	176	109	156	0	0	24	36	7	15
1943	5-1	158	192	131	266	1	4	23	40	7	15

COFPLT VER 01 MOD 03   00--00 13:36:19   PAGE 3

DATE: 7/18/79   ROUTE: OVER POINT 1
CARTRIDGE/PASS: 677/ 1
TIME: 16:45:34 TO 16:53:19   MIN. GROUND ELEV.: 29 M(MSL)

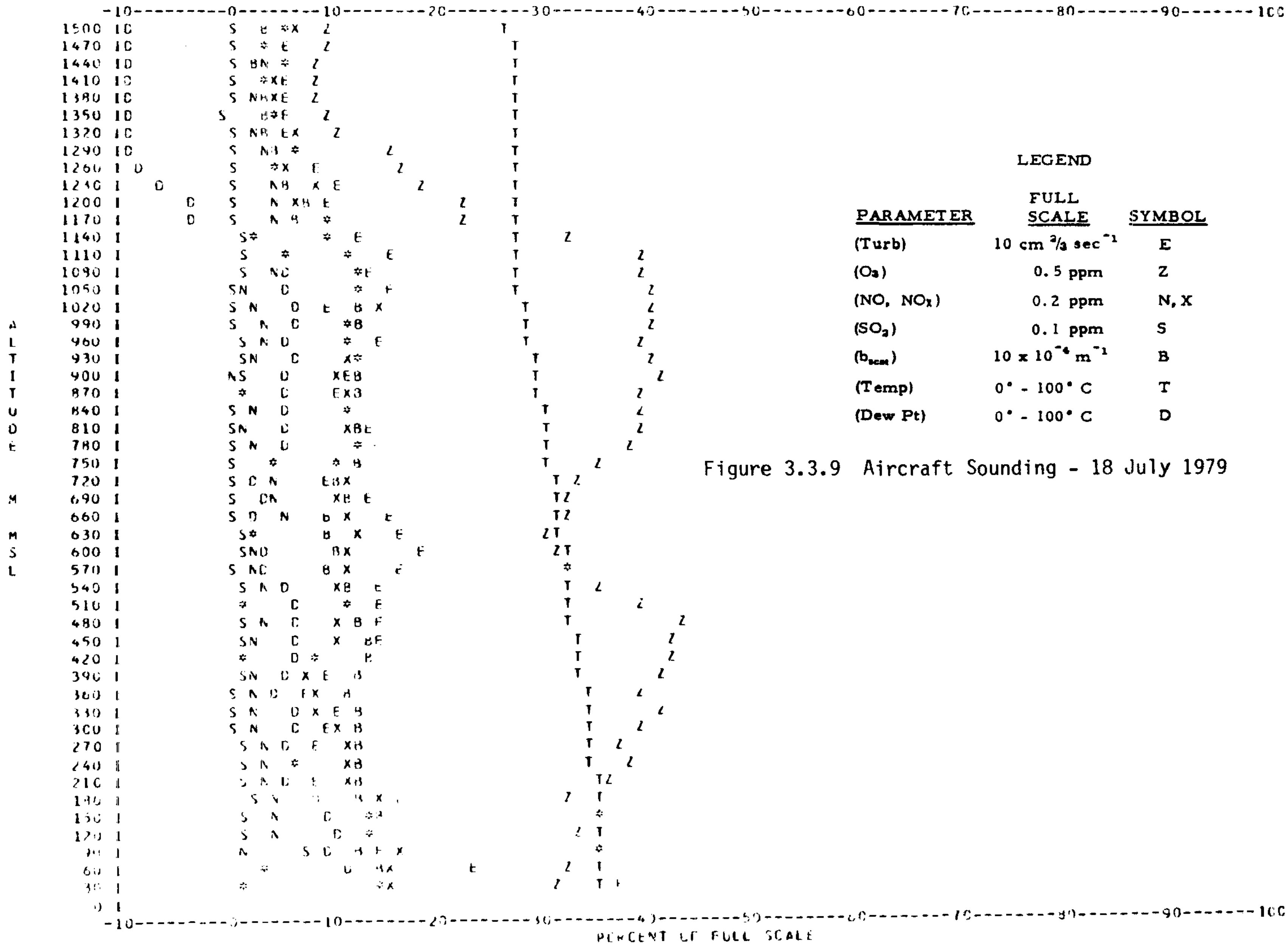


LEGEND

PARAMETER	FULL SCALE	SYMBOL
(Turb)	10 cm $^{2/3}$ sec $^{-1}$	E
(O_3)	0.5 ppm	Z
(NO, NO_x)	0.2 ppm	N, X
(SO_2)	0.1 ppm	S
(b_{scat})	10 x 10^{-4} m^{-1}	B
(Temp)	0° - 100° C	T
(Dew Pt)	0° - 100° C	D

Figure 3.3.8 Aircraft Sounding - 18 July 1979

DATE: 7/18/79 ROUTE: OVER POINT ?
CARTRIDGE/PASS: 677/ 4
TIME: 0:20:38 TO 0:34:43 MIN. GROUND ELEV.: 11 M(MSL)



LEGEND

PARAMETER	FULL SCALE	SYMBOL
(Turb)	10 cm $^{2/3}$ sec $^{-1}$	E
(O_3)	0.5 ppm	Z
(NO, NO_x)	0.2 ppm	N, X
(SO_2)	0.1 ppm	S
(b_{scat})	10 x 10^{-4} m^{-1}	B
(Temp)	0° - 100° C	T
(Dew Pt)	0° - 100° C	D

Figure 3.3.9 Aircraft Sounding - 18 July 1979

COFPLT VER 01 MOD 03   00--00 13:36:19   PAGE 12

DATE: 7/18/79   ROUTE: ... POINT 4
CARTRIDGE/PASS: 677/ 7
TIME: 0:55:54 TO 1: 2:36   MIN. GROUND ELEV.: 222 M(MSL)

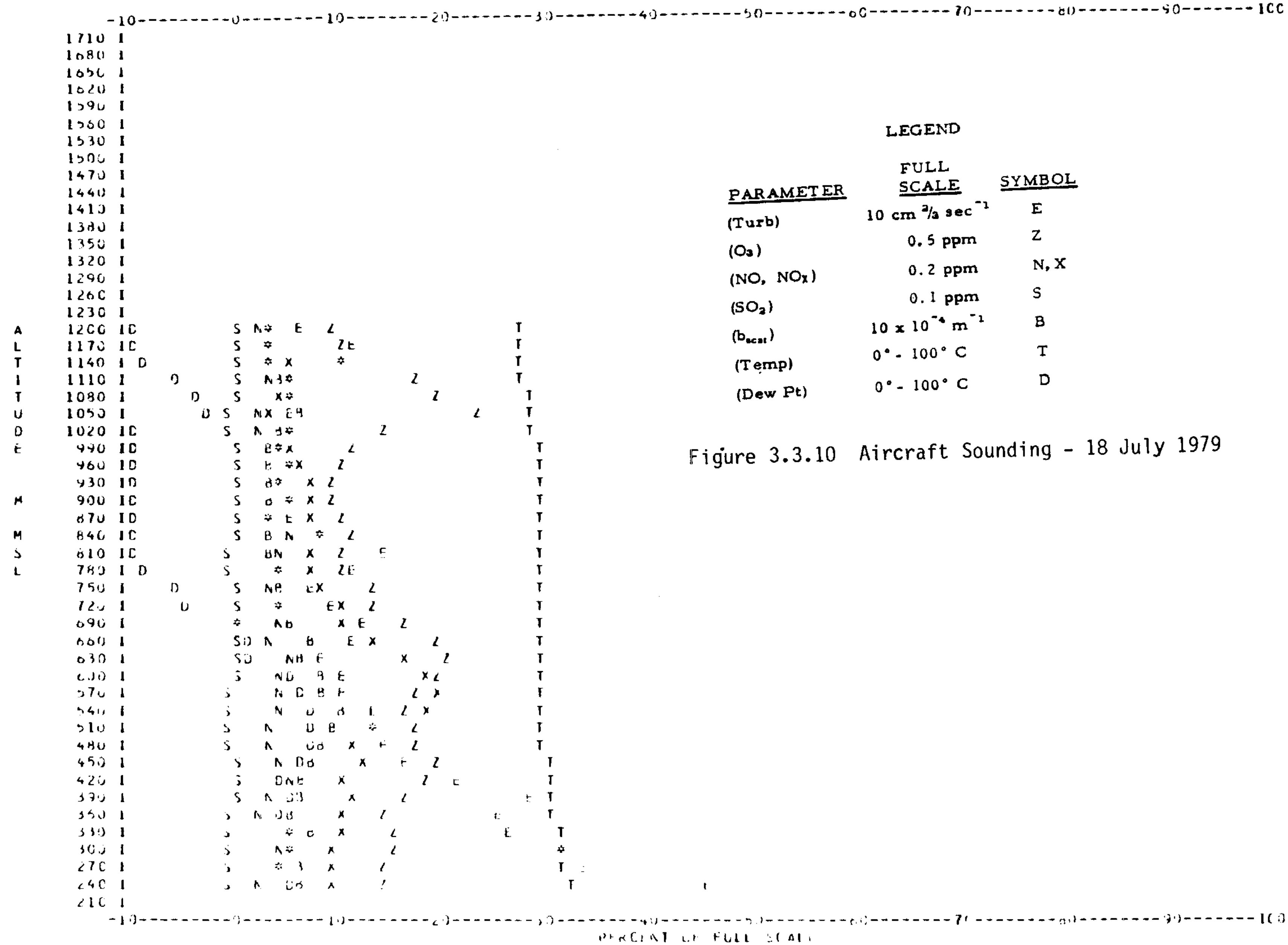


Figure 3.3.10 Aircraft Sounding - 18 July 1979

3.3.3 Tracer Test 3

Release Location: Livermore, Alameda County
Time and Date: 1510-2030 PDT, 7/18/79
Amount: 101 pounds of SF6 per hour
Release conducted during west-southwesterly winds (directed toward Altamont Pass) of between 5 and 7 mps. Winds within the San Joaquin Valley were similar to previous test

Initial transport into the San Joaquin Valley

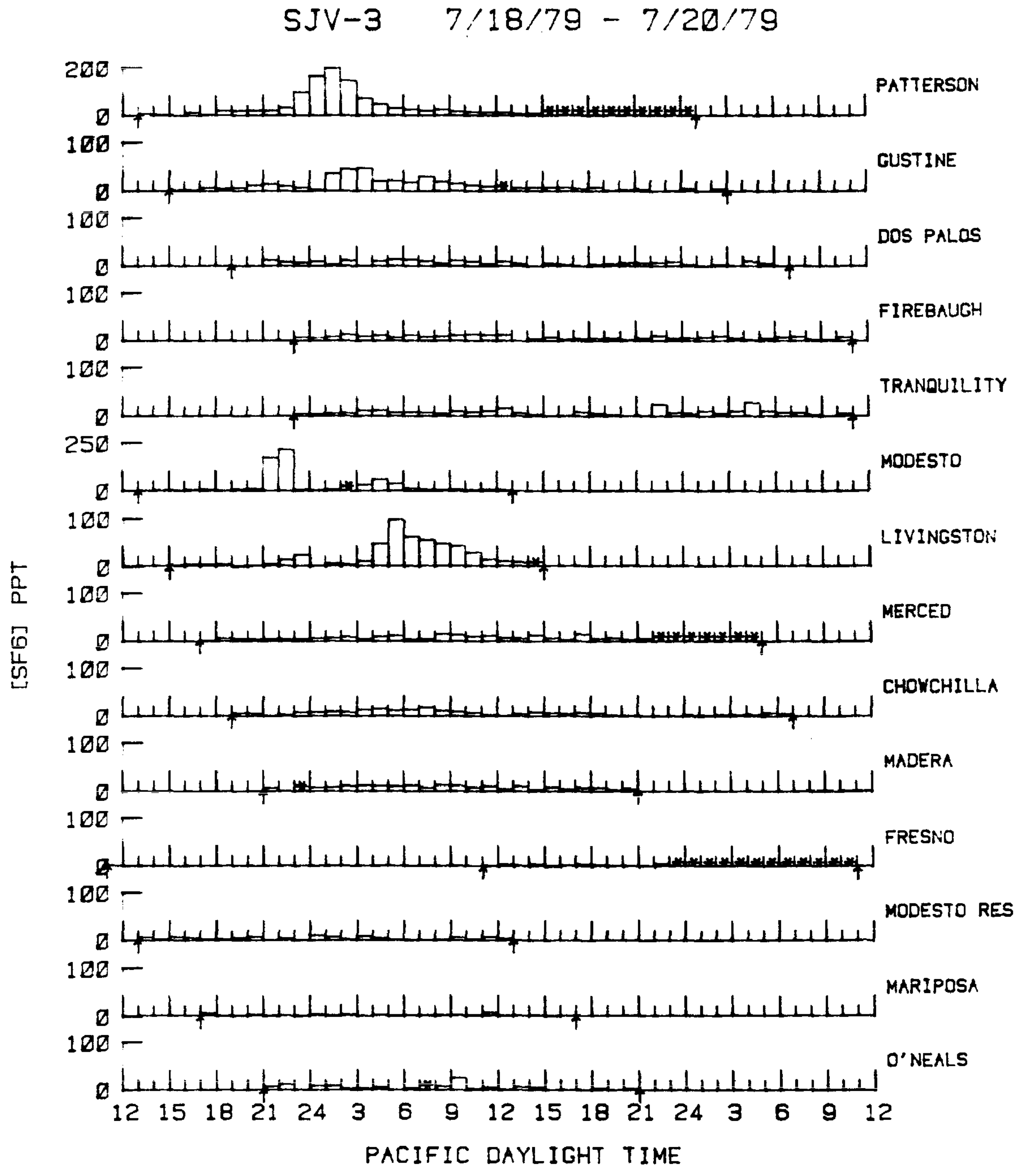
The tracer was transported by the generally westerly winds at the release site through Altamont Pass and into the San Joaquin Valley. The tracer was first detected in concentrations as high as 103 PPT along Coral Hollow Rd in the San Joaquin Valley during Traverse 1-1, conducted between 1658 and 1725 PDT. During Traverse 1-6, an essentially Gaussian plume with a peak of about 900 PPT (1300 PPT/lb-mole SF6 released/hr) was detected at about 1930 PDT along Corral Hollow Rd. Corral Hollow Rd. lies directly east of Altamont Pass. During Traverse 1-4 conducted between 1919 and 2045 PDT, SF6 was detected along Interstate 5 between Gustine and Altamont Pass. The tracer was spread quite uniformly (peak concentration of 83 PPT) over the entire distance of about 45 miles. The route probably traversed the western edge of the tracer plume. The first evidence of a clear plume within the San Joaquin Valley was found during Traverse 1-5 in which concentrations as high as about 440 PPT (640 PPT/lb-mole of SF6 released/hr) were found along Hwy 132 between I-5 and Hwy 99. The tracer concentration profile along Hwy 132 was broader than that detected during the previous tests from Manteca due not only to the greater distance traveled but also to the turning and divergence of the Altamont Pass flow as it entered the San Joaquin Valley. Also during Traverse 1-5, which ended shortly after midnight 7/19/79, SF6 was detected at about 20 PPT as far south as Hwy 140, west of Merced.

SF6 was detected at the Modesto hourly-averaged sampling site beginning at 2100 PDT, 7/18/79. A maximum concentration of 215 PPT (310 PPT/lb-mole SF6 released/hr) was detected in Modesto between 2200 and 2300 PDT. As shown in

Figure 3.3.11, SF6 was also detected at the west San Joaquin Valley sites of Patterson and Gustine. A maximum of 198 PPT (290 PPT/lb-mole SF6 released/hr) was detected at Patterson between 0100 and 0200 PDT, 7/19/79. Low but non-zero SF6 concentrations (about 20 PPT) were first detected at Patterson between 1800 and 1900 PDT. Between 2000 and 2300 PDT, low but non-zero levels of SF6 (10-15 PPT) were detected at Gustine.

Tracer detection during the night following the release

During the night of 7/18/79, SF6 was detected at 10-40 PPT over a wide area on the northwest side of the San Joaquin Valley. There was a concentration gradient between that portion of the San Joaquin Valley closest to the Altamont Pass (as high as 458 PPT) to that region of the San Joaquin Valley west of Merced and Chowchilla (10-80 PPT). Due to the complexities of the wind flow patterns between Livermore and that region of the San Joaquin Valley west of Merced and Chowchilla, the tracer concentration profile was highly irregular. Due to the timing of the release, the tracer was probably limited to a shallow layer of air close to the surface. During the night , the surface winds in the northern end of the San Joaquin Valley were quite low. At Stockton, the winds in the lower 1000 ft were less than 2 mps during the 0100 PDT pibal and essentially calm during the 0300 PDT pibal. As would be expected from the low wind speeds at Stockton, the hourly averaged sampling sites in the northern end of the San Joaquin Valley detected SF6 throughout the night of 7/19/79. SF6 was detected continuously at Livingston between 0300 PDT and and the conclusion of sampling at 1400 PDT on 7/19/79. 98 PPT was detected between 0500 and 0600 PDT. SF6 was also detected throughout the night at Gustine and Patterson. Some SF6 (as high as 59 PPT) was detected as far north as Modesto between 0300 and 0700 PDT. During the evening of the release, SF6 was detected at low levels (<10 PPT) as far south as Fresno. A number of hourly-averaged samplers and automobile traverses showed these levels. This may have been due to carryover from the tests conducted 7/13/79 and 7/16/79. It was not possible to estimate the amount of the carryover.



RELEASE LOCATION: 541 LBS AT LIVERMORE
RELEASE TIME: 1510 PDT, 7/18/79

Figure 3.3.11

* INDICATES MISSING DATA
ARROWS INDICATE BOUNDS OF SAMPLING PERIOD

Figure 3.3.12

* INDICATES SAMPLER LOCATIONS

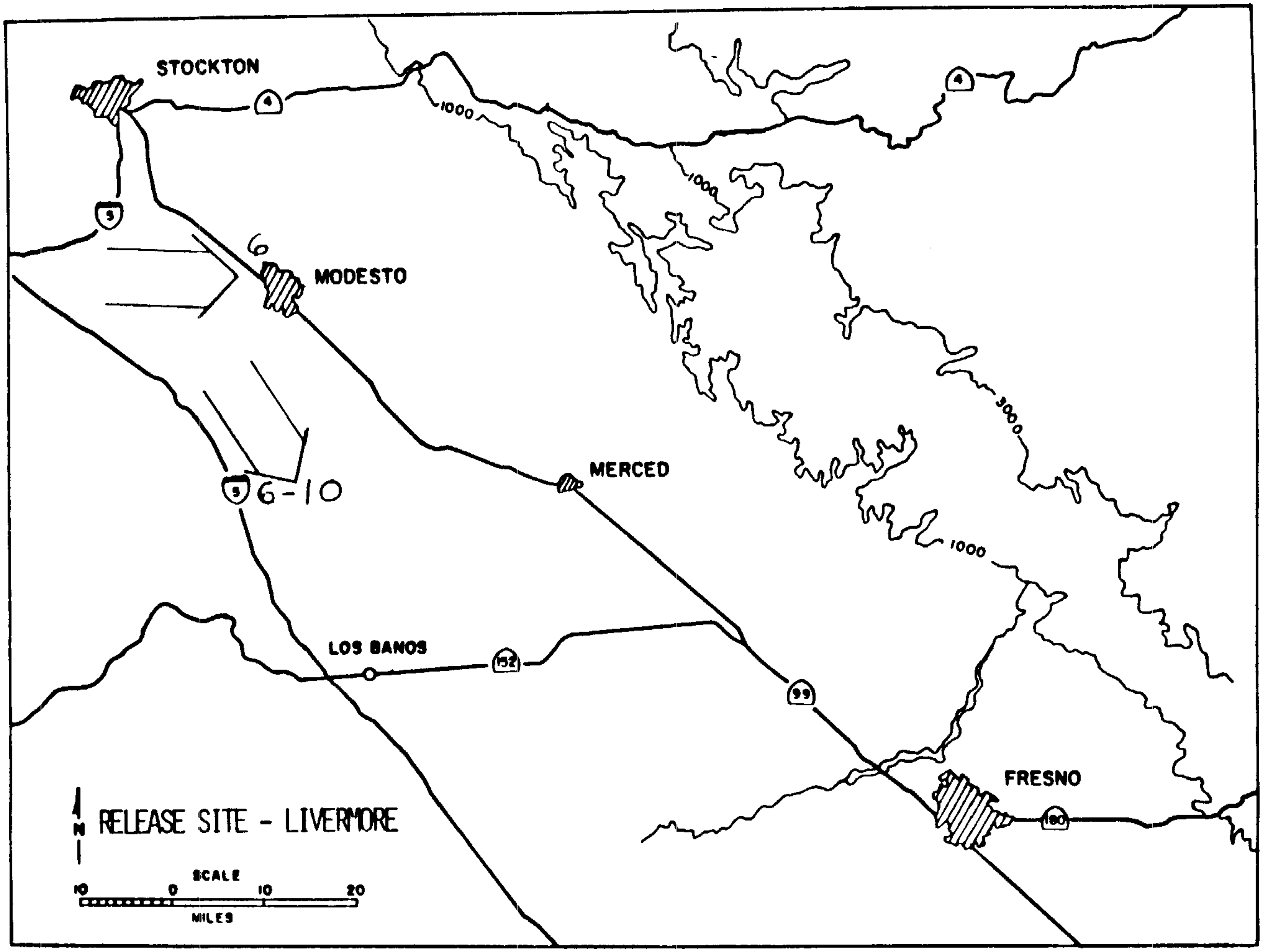
R IS THE RELEASE SITE

Tracer carryover into day following the release

Automobile traverses on the day following the release showed that the SF6 was spread over most of the San Joaquin Valley north of Fresno. During the morning of 7/19/79, concentrations of 10-20 PPT were detected while during the afternoon SF6 concentrations were generally below 10 PPT. The concentrations detected during the day after the release were higher than those found after the previous releases from Manteca. This was probably due to the late hour of the release which reduced the loss and dispersion of the tracer during unstable afternoon conditions and to carryover from the previous releases. Nighttime wind speeds, at least in the extreme northern end of the valley, were also lower than during the previous two tests. A mass balance estimate indicated that about 600 lbs of SF6 could be accounted for in a rectangular area bounded on the east by Hwy 99, on the west by I-5, on the north by Manteca and in the South by Hwy 180. This estimate was made using an average concentration of 17 PPT (+/-10 PPT) detected during Traverses 2-2, 2-3, 2-4 and 2-5 and by assuming a 2000 ft mixing height. Due to the uncertainties inherent in this calculation, the mass balance merely indicates that a majority of the SF6 released was detected within the San Joaquin Valley during the day after the release.

Summary

During this experiment, the tracer was released from the Livermore Valley during mid and late afternoon. High levels of ozone and other pollutants are typically found in the Livermore Valley, possibly due to transport from the San Francisco Bay Area. This experiment was designed to determine if these pollutants represent a significant flux into the San Joaquin Valley. The tracer was transported into the valley and, as might be expected from the previous tests, was preferentially transported along the western side of the valley. An overview of the tracer transport path is shown in Figure 3.3.13. Due to the late release time (1510 PDT-2030 PDT), the tracer was detected only as far south as the region west of Chowchilla and Merced on the night after the release. The late release time also increased the amount of carryover into the subsequent day, as compared to the two previous tests. An amount equal to



ARROW POINT INDICATES OBSERVED TRACER LOCATIONS
NUMBERS REFER TO HOURS AFTER RELEASE START (1510 PDT., 7/18/79)

Figure 3.3.13

essentially all of the SF6 released could be accounted for within the northern San Joaquin Valley on the day after this release. The majority of the tracer detected on this day must have been due to the release made during this experiment but it is also possible that a small amount of tracer remained from either or both of the first two tests.

3.4 Test 4 25 July 1979, Reedley Release (1200-1700 PDT)

3.4.1 Meteorology

General

The synoptic meteorology of 25 July was again characterized by ridging aloft over the southwestern states (Figure 3.4.1). Maximum heights at 500 mb were located over southern California with consequent warming aloft and atmospheric stabilization as reflected by the 850 mb temperature trends shown on Figure 2.2.1. At the surface a thermal trough was established over the Central Valley resulting in an onshore pressure gradient. The skies were generally clear throughout the San Joaquin Valley. Visibilities during the test ranged from 15 miles in the northern portions of the valley to 10 miles in the south. In the Fresno vicinity, visibilities ranged from 10-15 miles. Surface temperatures were above normal for the time of the year. Maximum temperature reported was 107°F at Bakersfield.

Transport Winds

Low-level winds during and after the release are given in Table 3.4.1. Early in the release period the low-level winds were southwest, shifting to west or west-northwest by the middle of the release. Wind speeds remained relatively high during the night until the early morning hours.

The 1000-foot streamlines (Figures 3.4.2 to 3.4.4) reflect the moderately strong northwest flow throughout the valley during the night. The wind speed at 1000 ft at Fresno was 11.7 m/s at 23 PDT from the northwest. By 05 PDT, an eddy had formed in the southern part of the valley as shown in Figure 3.4.4.

Pibal winds from Cherry Gap (in the mountains east of Reedley) were resolved into components parallel and perpendicular to the valley axis. The time variations in the perpendicular component (Figure 3.4.5) can be used to delineate the diurnal variations in the upslope-downslope flow. As shown in the figure, a strong upslope flow developed after 11 PDT and lasted through 19 PDT. Maximum depth of the flow was about 800 m. During the balance of the observational period the flow had a component toward the valley at all levels which masked any drainage flow that might have been present.

WEDNESDAY, JULY 25, 1979

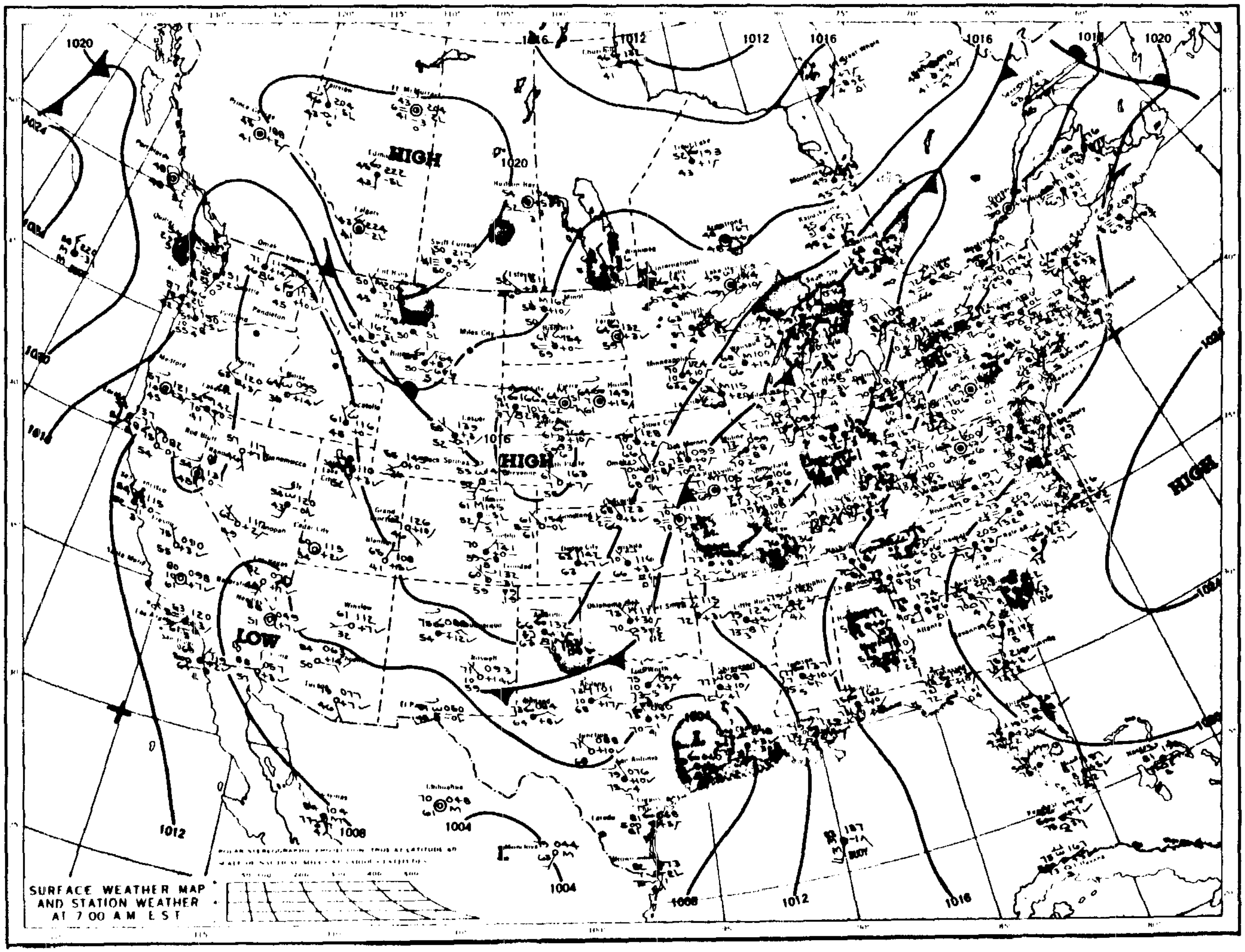


Figure 3.4.1 Surface Weather Charts - 25 July 1979 (05 PDT)

Table 3.4.1

LOW-LEVEL WINDS
25-26 JULY 1979

Time (PDT)	Reedley (Surface-100 m)	Fresno (Surface)
25 July		
09	144°/3.7 m/s	Calm
11	191 /4.3	-
13	217 /2.2	240°/2.1 m/s
15	260 /4.5	240 /3.6
17	275 /2.0	290 /3.1
19	254 /1.4	300 /3.1
21	270 /3.9	280 /4.1
23	330 /4.2	290 /4.6
26 July		
01	320 /3.7	290 /4.1
03	300 /1.0	290 /3.6
05	305 /0.9	Calm
07	087 /1.4	160 /1.5
09	152 /1.8	220 /2.1

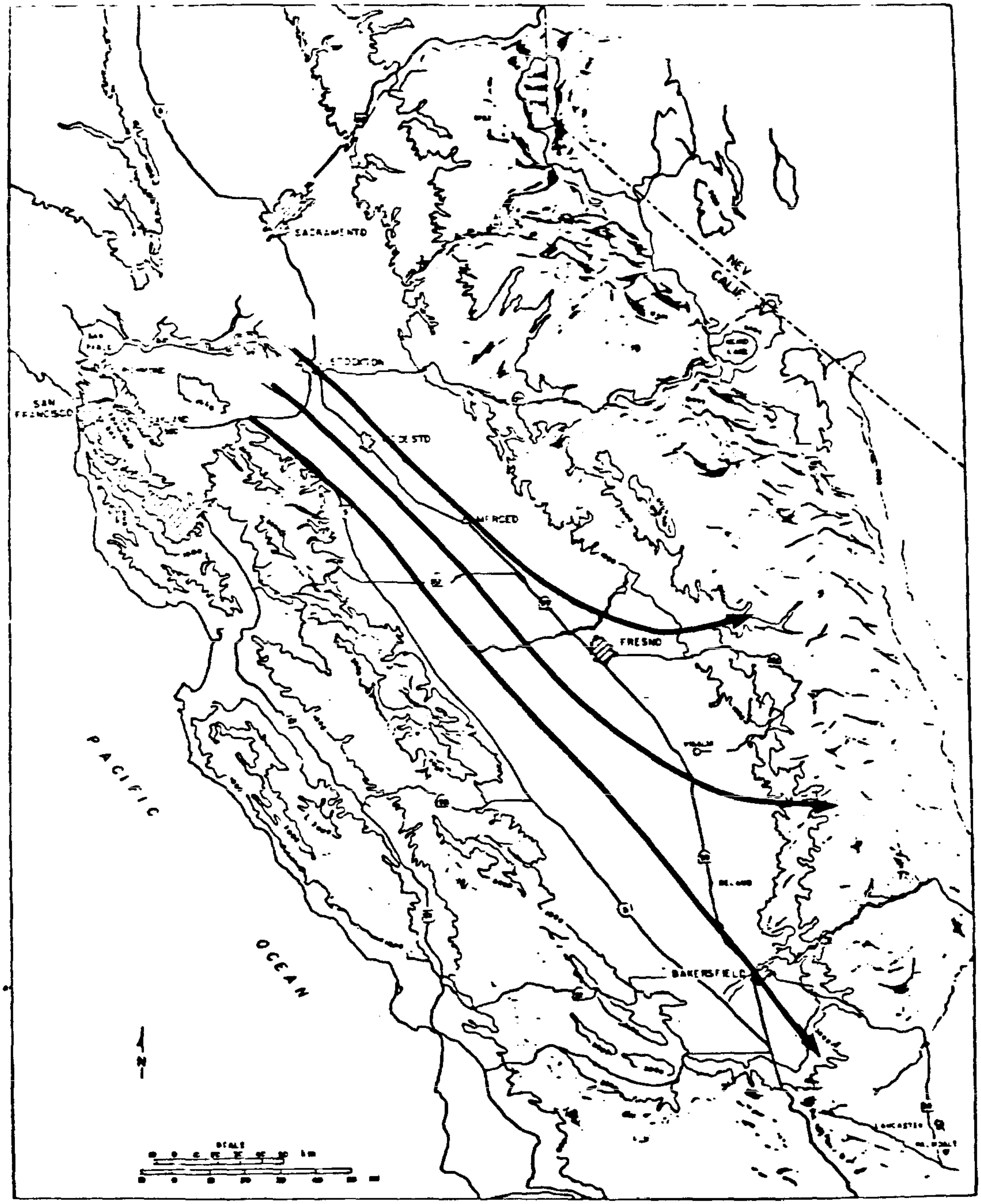


Figure 3.4.2 1000 Ft-agl Streamlines - 25 July 1979 (15 PDT)

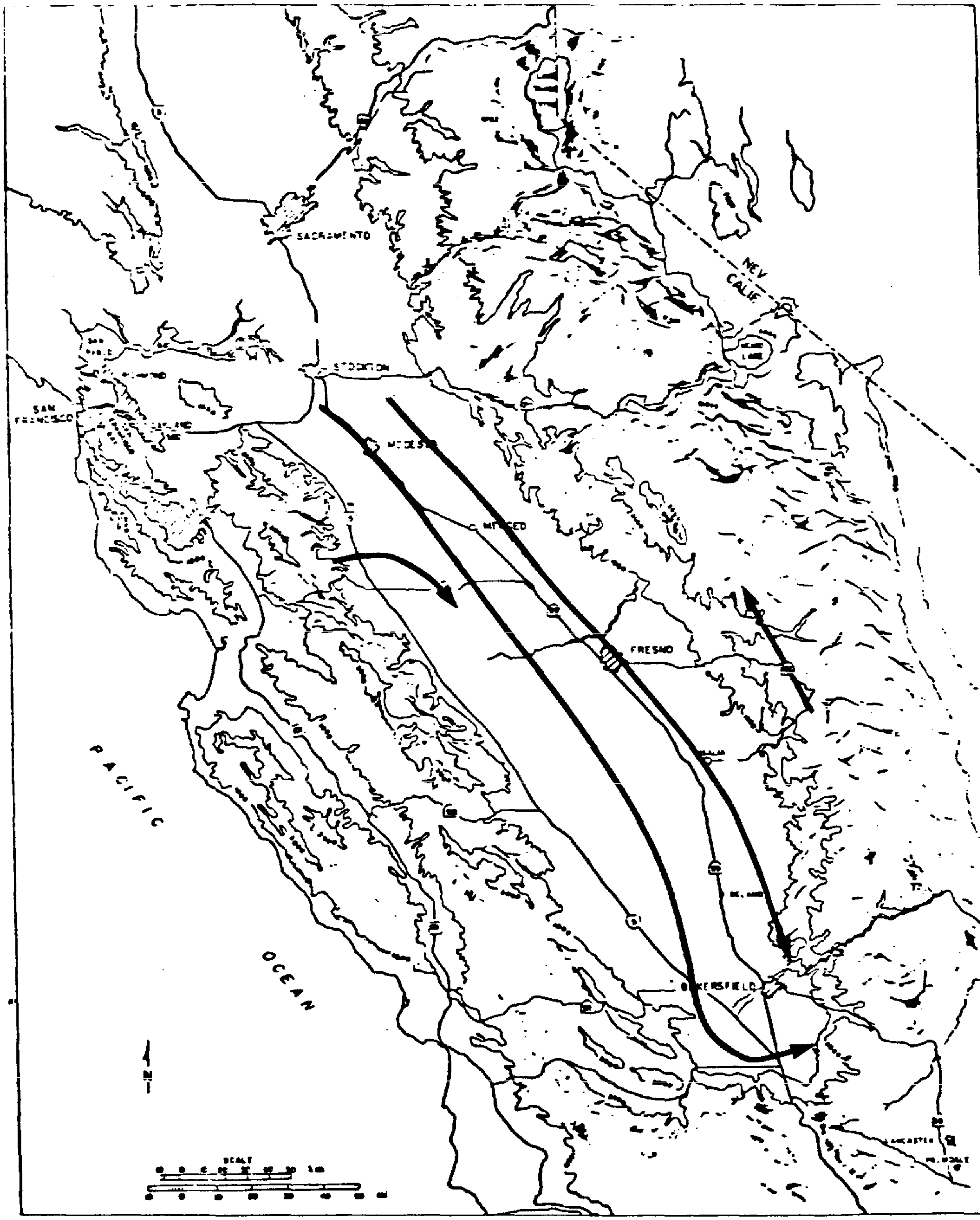


Figure 3.4.3 1000 Ft-agl Streamlines - 25 July 1979 (23 PDT)

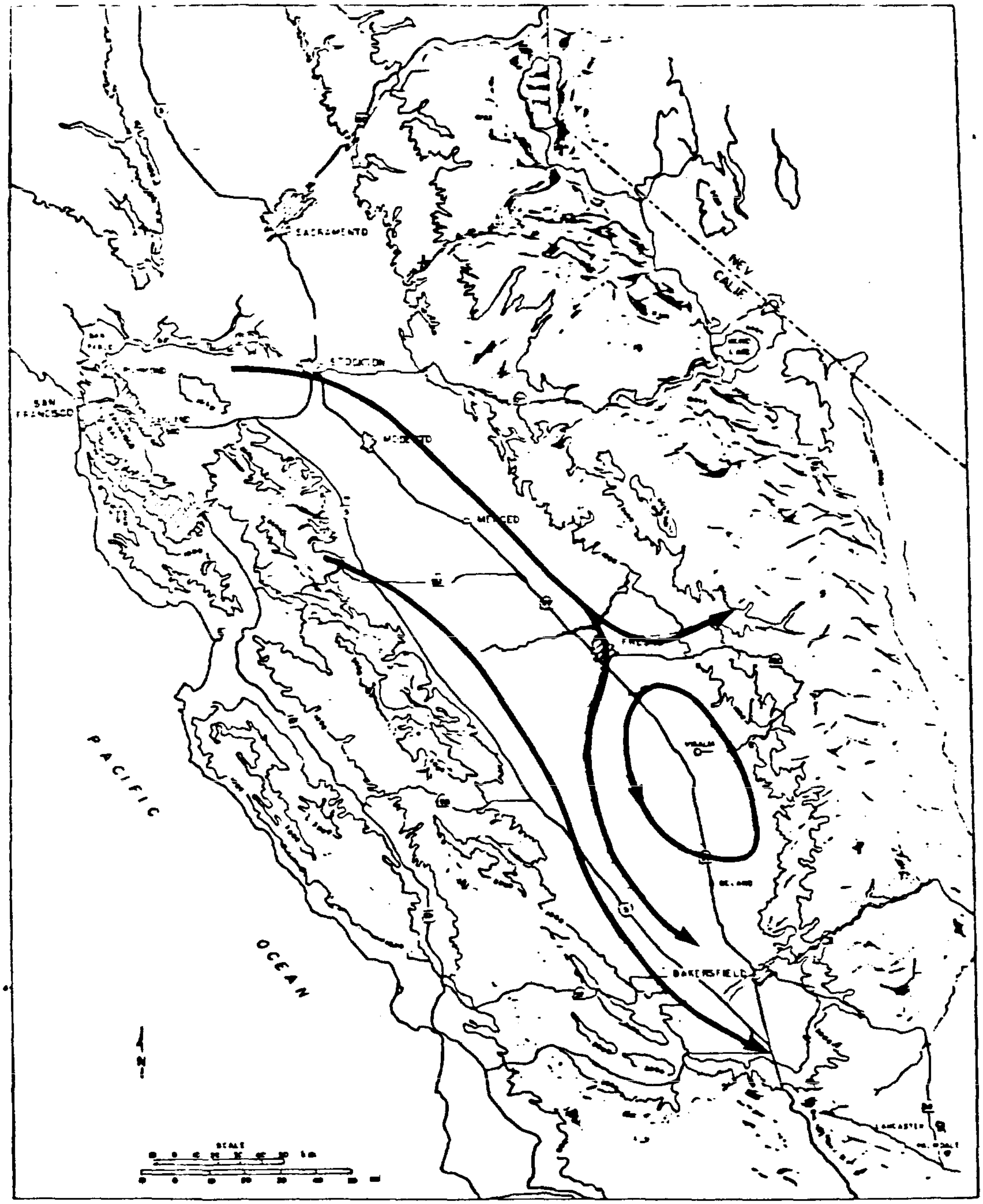


Figure 3.4.4 1000 Ft-agl Streamlines - 26 July 1979 (05 PDT)

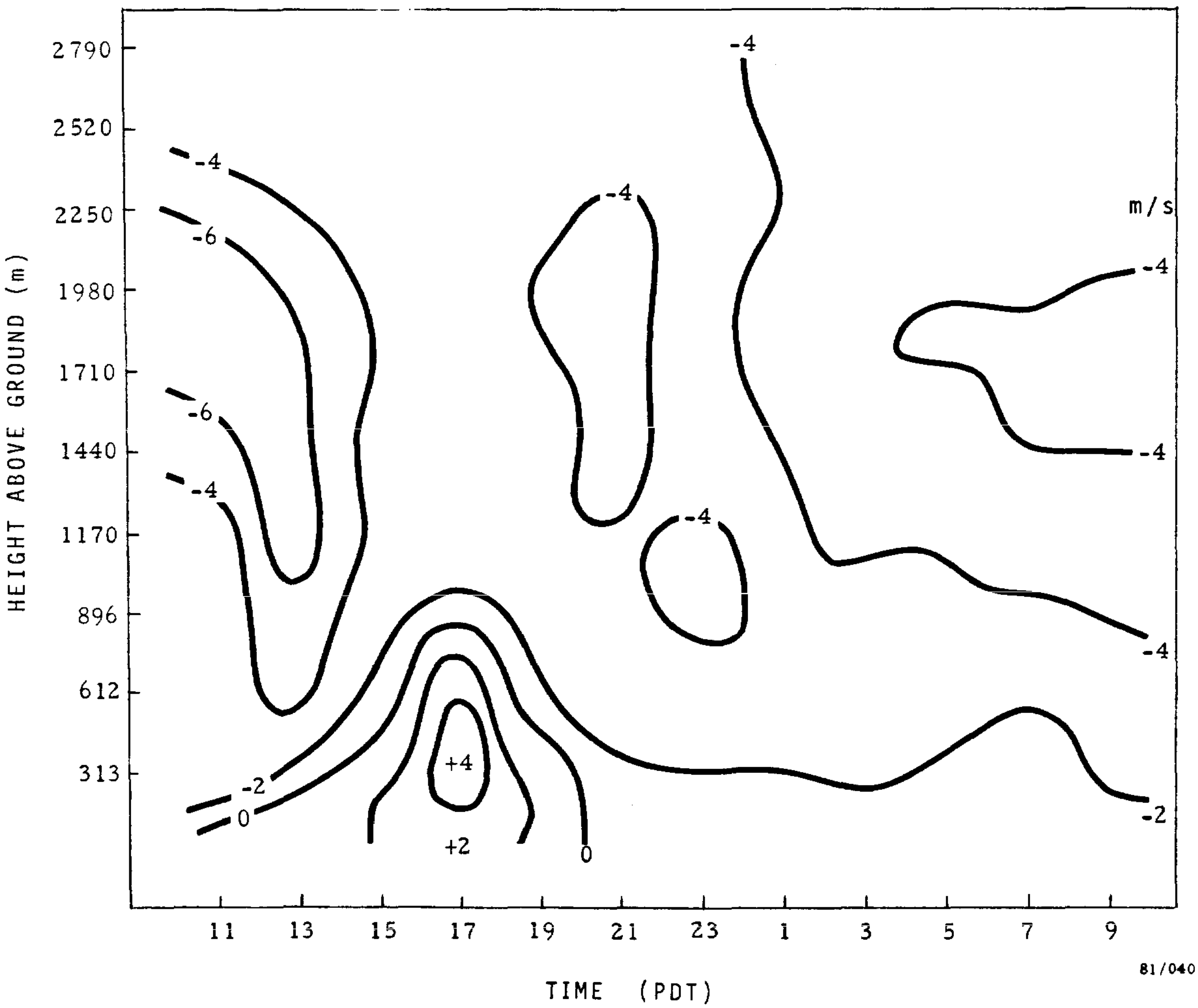


Figure 3.4.5 Time-Height Cross Section Component Winds (m/s) From Cherry Gap 25 July 1979 (Positive Component Represents Upslope Flow)

Mixing Heights

Aircraft mixing heights were measured on July 25 and are shown in Table 3.4.2. As noted in earlier tests, the mixing height over the slopes tends to be somewhat greater (relative to the terrain) than over the valley itself.

Table 3.4.2

AIRCRAFT MIXING HEIGHTS
JULY 25, 1979

Time (PDT)	Location *	Mixing Height (m [above ground level])
1529	5 N Reedley	785
1603	23 E Reedley	645 (1370)
1735	6 NNE Grant Grove	1060

(* Distances in miles)

3.4.2 Air Quality

Regional Pollutant Levels

Maximum hourly concentrations of ozone are given in Figure 3.4.6. Numerous exceedances of the .10 ppm standard were observed in the north and east portions of the San Joaquin Valley. Concentrations of .15 ppm were measured at Modesto, Fresno and Bakersfield. All three monitoring sites along the Sierra Nevada slopes reported concentrations in excess of .10 ppm.

Maximum hourly concentrations for CO, SO_2 and NO_x anywhere in the valley are listed in Table 3.4.3 together with the maximum hourly values recorded at the Rockwell International vans.

All hourly concentrations were relatively low with the exception of NO_x at Modesto. Another unusually high value (.39 ppm) was recorded on July 24 at Modesto. Otherwise, no comparable values were observed during the month. The unusually high values suggest that the measurements may not be representative of a wide area around Modesto.

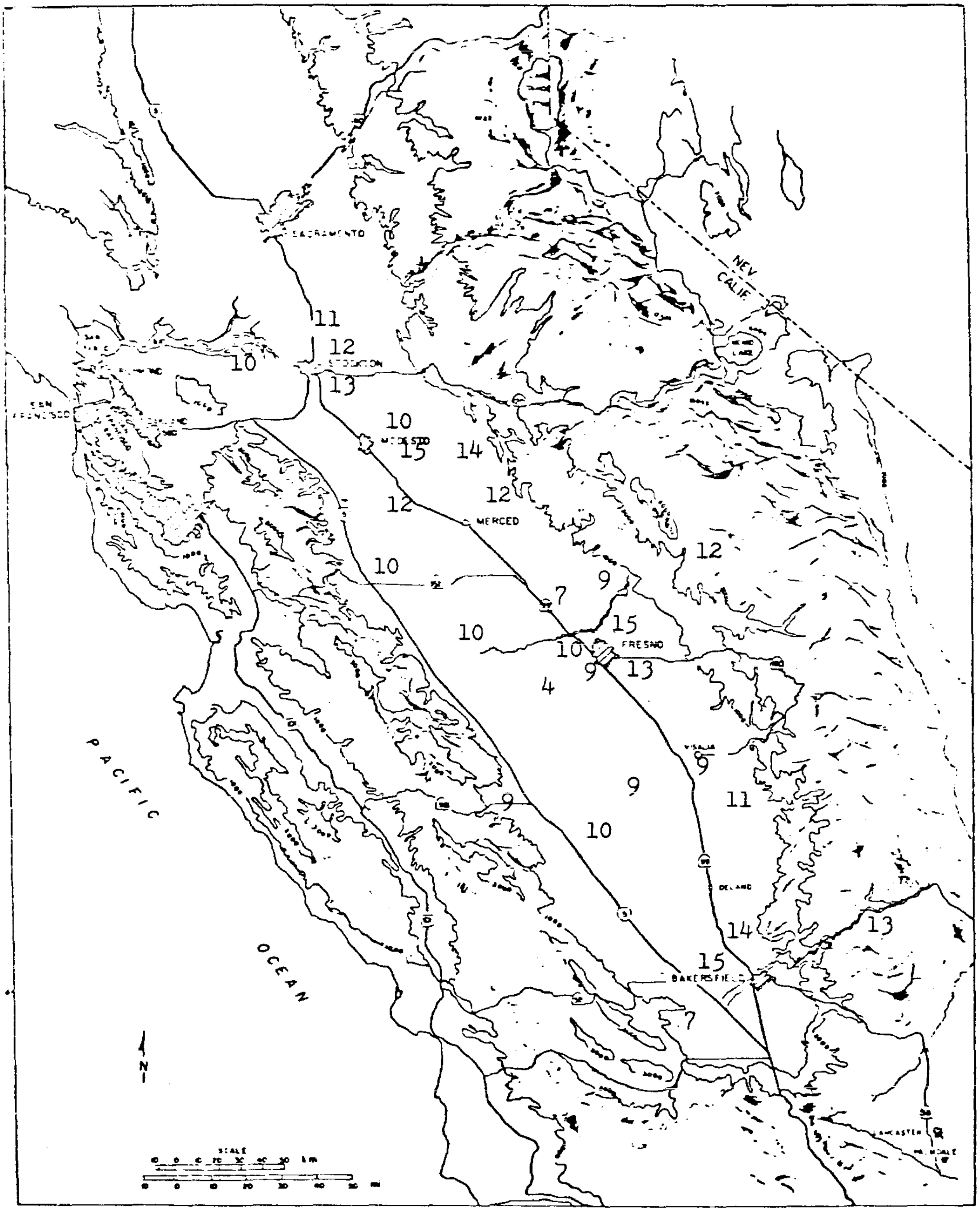


Figure 3.4.6 Maximum Hourly Ozone Concentrations (pphm) - 25 July 1979

Table 3.4.3

MAXIMUM HOURLY CONCENTRATIONS
JULY 25, 1979

Parameter	Location	Maximum Value (ppm)
SO_2	Bakersfield	.02
CO	Fresno-Olive	3.
NO_x	Modesto	.32
SO_2	Modesto (RI)	< .01
SO_2	Merced (RI)	< .01
NO_x	Modesto (RI)	.01
NO_x	Merced (RI)	.02
NO_x	Mad ra (RI)	.01

Aircraft Sampling

In conjunction with the tracer release near Reedley, the airplane sampled in the afternoon (1529-1920 PDT) downwind in the Sierra Nevadas. The sampling route consisted of the following key elements:

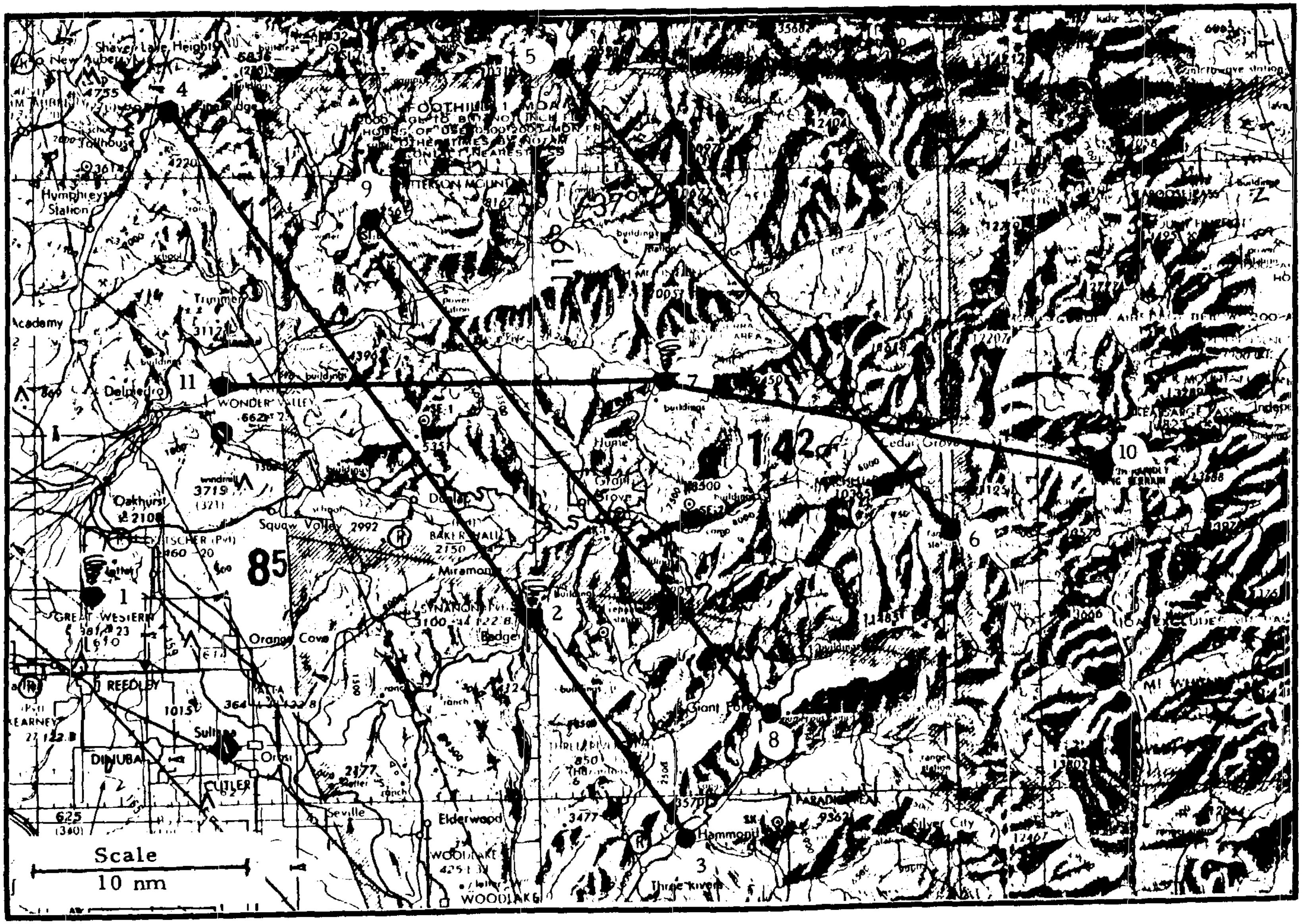
- Three spirals; one in the valley near the tracer release location, one in the Sierra Nevada foothills, and another in the High Sierra region at the convergence of the South and Middle Forks of the Kings River.
- Three constant altitude downwind traverses parallel to the Sierra crest at as low an altitude as safety would permit and,
- A traverse from the Sierra crest down the South and Main Forks of the Kings River to the valley, descending with the terrain at as low an altitude as safety would permit.

Table 3.4.4 gives the overall pollutant characteristics measured on the flight. Figure 3.4.7 shows the map of the flight patterns employed on July 25.

Table 3.4.4

AIR QUALITY MEASUREMENTS CARB SAN JOAQUIN VALLEY PROJECT
JULY 25, 1979 SAMPLING

Start Time (PDT)	Location (Point)	O_3 Mean (ppb)	O_3 Max (ppb)	b_{scat} Mean ($x10^{-6}m^{-1}$)	b_{scat} Max ($x10^{-6}m^{-1}$)	SO_2 Mean (ppb)	SO_2 Max (ppb)	NO_x Mean (ppb)	NO_x Max (ppb)	NO Mean (ppb)	NO Max (ppb)
1529	1	71	124	97	204	5	7	-	-	-	-
1603	2	85	112	140	218	4	6	-	-	-	-
1629	3-4	110	154	155	236	0	2	-	-	-	-
1711	5-6	102	127	137	234	0	2	-	-	-	-
1735	7	123	141	154	236	4	6	-	-	-	-
1810	8-9	144	183	159	230	0	3	-	-	-	-
1851	10-11	130	171	143	216	3	5	-	-	-	-



SAMPLING ROUTES 25 July 1979

Figure 3.4.7

Aircraft soundings made during the afternoon of July 25 are shown in Figures 3.4.8 to 3.4.10. The sounding over the valley north of Reedley (Figure 3.4.7) shows a relatively well-mixed layer to 870 m-msl. Ozone concentrations reached a maximum of .11 ppm in this layer. Another pollutant layer with much lower concentrations existed above 1230 m.

The sounding over the foothills east of Reedley (Figure 3.4.8) showed a well-mixed layer to 1620 m-msl but with a higher, mixed layer extending to 2300 m. The break between these two layers corresponded to a shift in wind direction from the upslope flow to an easterly direction.

In the Kings Canyon (Figure 3.4.9) uniform mixing was evident from the bottom of the canyon at 975 m-msl to 2800 m-msl or roughly to the mean terrain height at that point. Within the mixing layer, ozone averaged about .13 ppm. Thus, the deep river canyons seem to be able to provide a major ventilating mechanism for valley air. The traverses parallel to the crest would seem to support this conclusion as ozone bulges are evident over the canyons of the various forks of the Kings River. The maximum mean ozone concentrations encountered during sampling were found on the 1680 m-msl traverse some 30 miles downwind from Reedley. Peak ozone levels were in excess of .18 ppm on that traverse. Over the High Sierra traverse between points 5 and 6, some 42 miles east of Reedley, mean ozone concentrations were still in excess of .10 ppb. The extent of the intrusion of polluted valley air into the mountains is well-defined by the east-west traverse down the Kings Canyon. Ozone concentrations rose to over .10 ppm within a couple of miles from the Sierra crest and increased to a maximum about 5 miles east of the convergence of the South and Middle Forks of the Kings River (point 7), where levels as high as .17 ppm were measured. Thus, the maximum impacted area from the valley sources can be at substantial downwind distances.

COFPLT VER 01 MOD 03   00--00 12:47:04   PAGE   3

DATE: 7/25/79   ROUTE: OVER POINT 1
CARTRIDGE/PASS: 680/ 1
TIME: 15:28:53 TO 15:49: 2   MIN. GROUND ELEV.: 116 M(MSL)

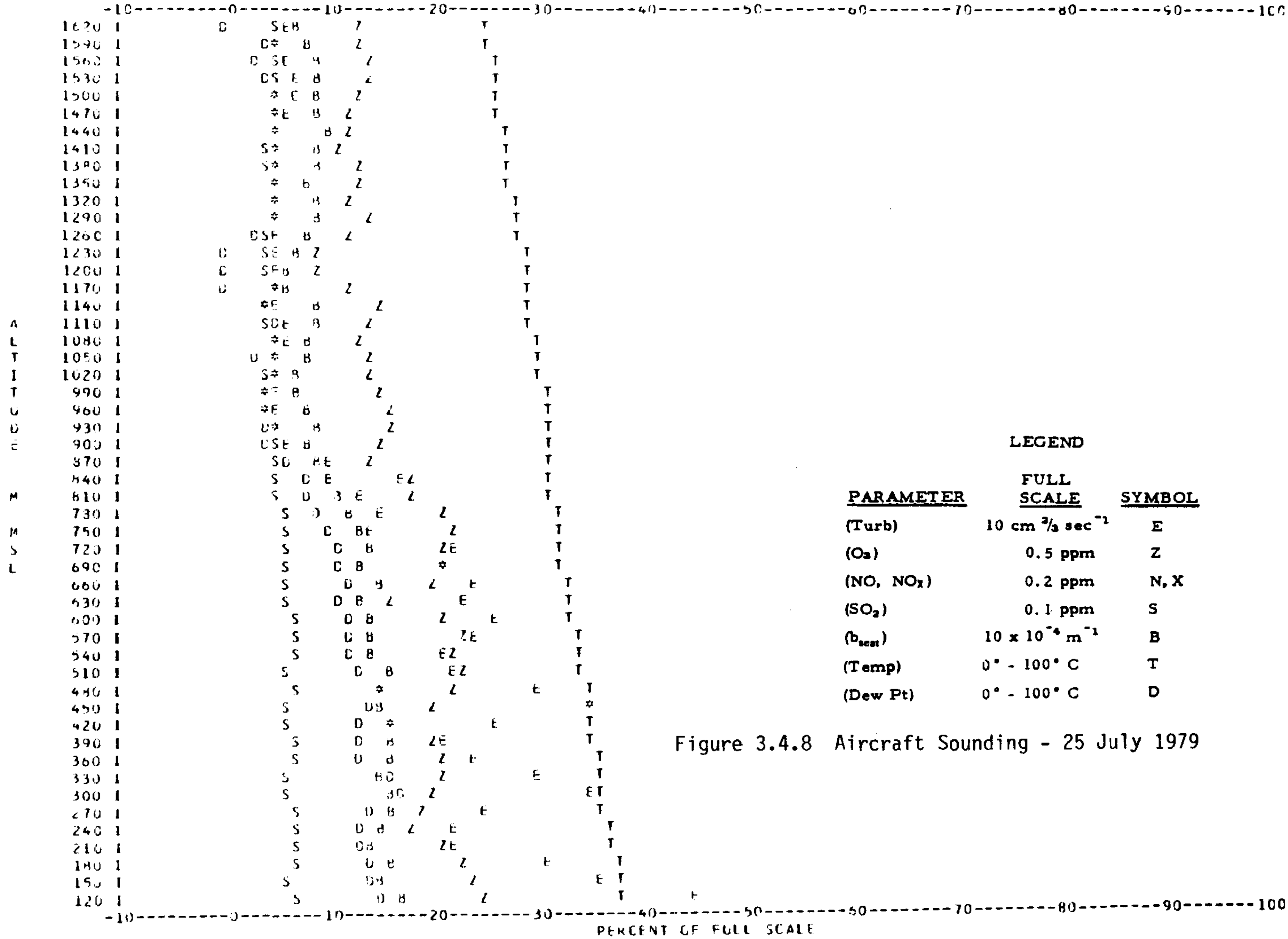


Figure 3.4.8 Aircraft Sounding - 25 July 1979

CUFPLT VER 01 MOD 03   00--00 12:47:04   PAGE 5

DAT : 7/25/79
CARTRIDGE/PASS: 5807 2
TIME: 16: 3:26 TO 16:18: 7

ROUTE: V K POINT Z
MIN. GROUND ELEV.: 944 M(MSL)

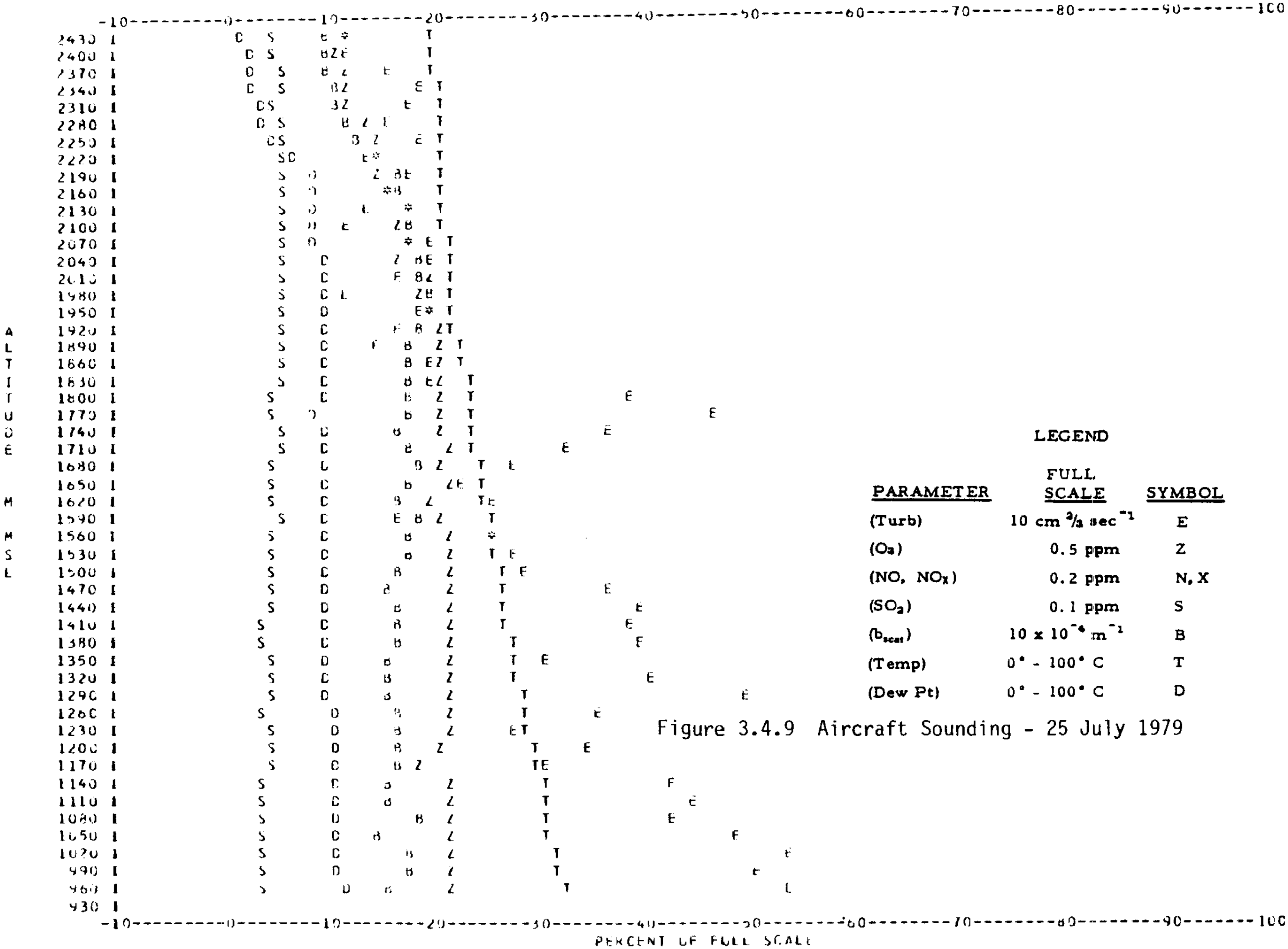


Figure 3.4.9 Aircraft Sounding - 25 July 1979

DATE: 7/25/79
CARTRIDGE/PASS: 680/ 5
TIME: 17:34:48 TO 17:50: 0

ROUTE: OVER POINT 7
MIN. GROUND ELEV.: 975 M(MSL)

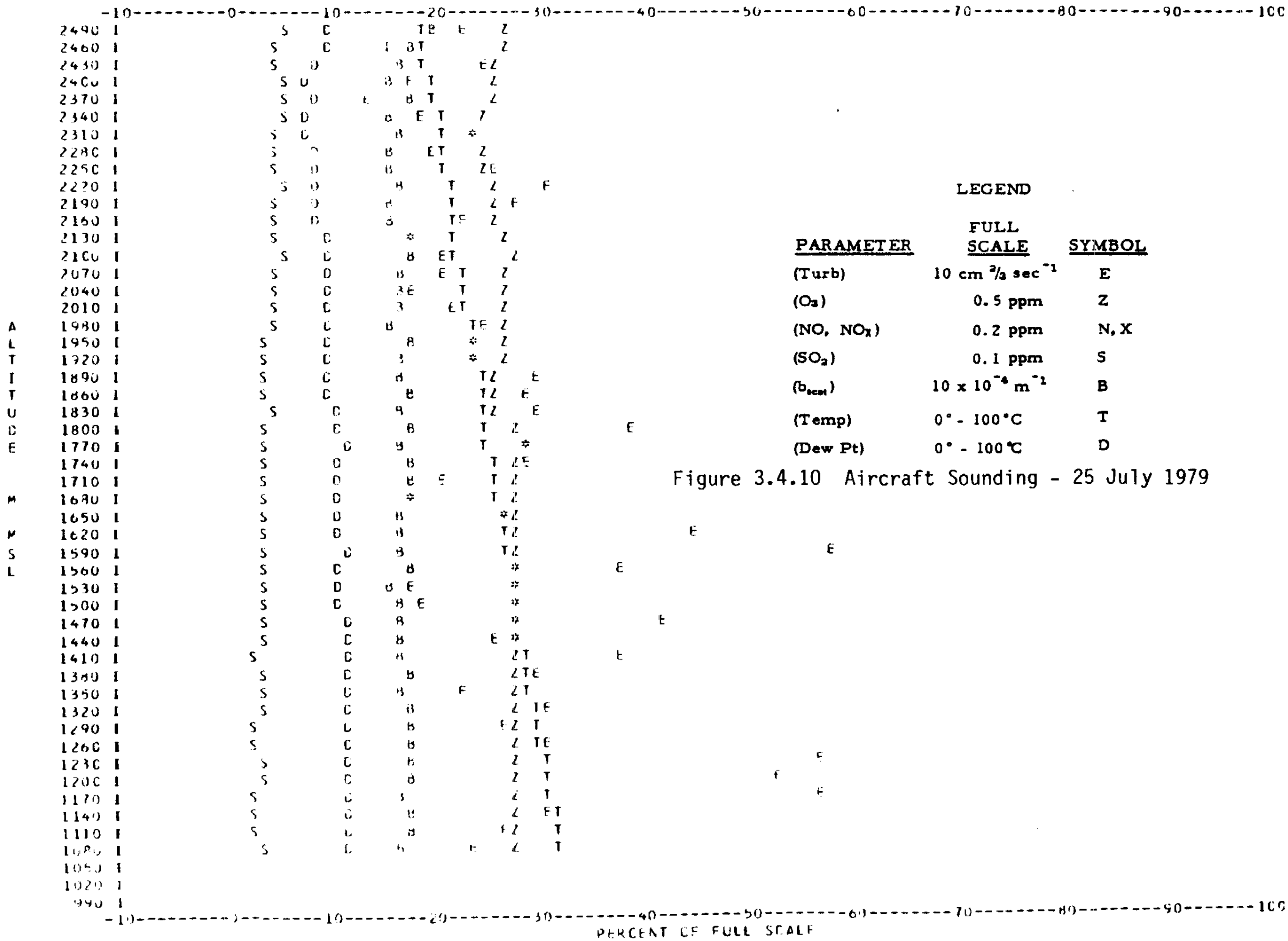


Figure 3.4.10 Aircraft Sounding - 25 July 1979

3.4.3 Tracer Test 4

Release Location: Reedley, Fresno County

Time and Date: 1200-1700 PDT, 7/25/79

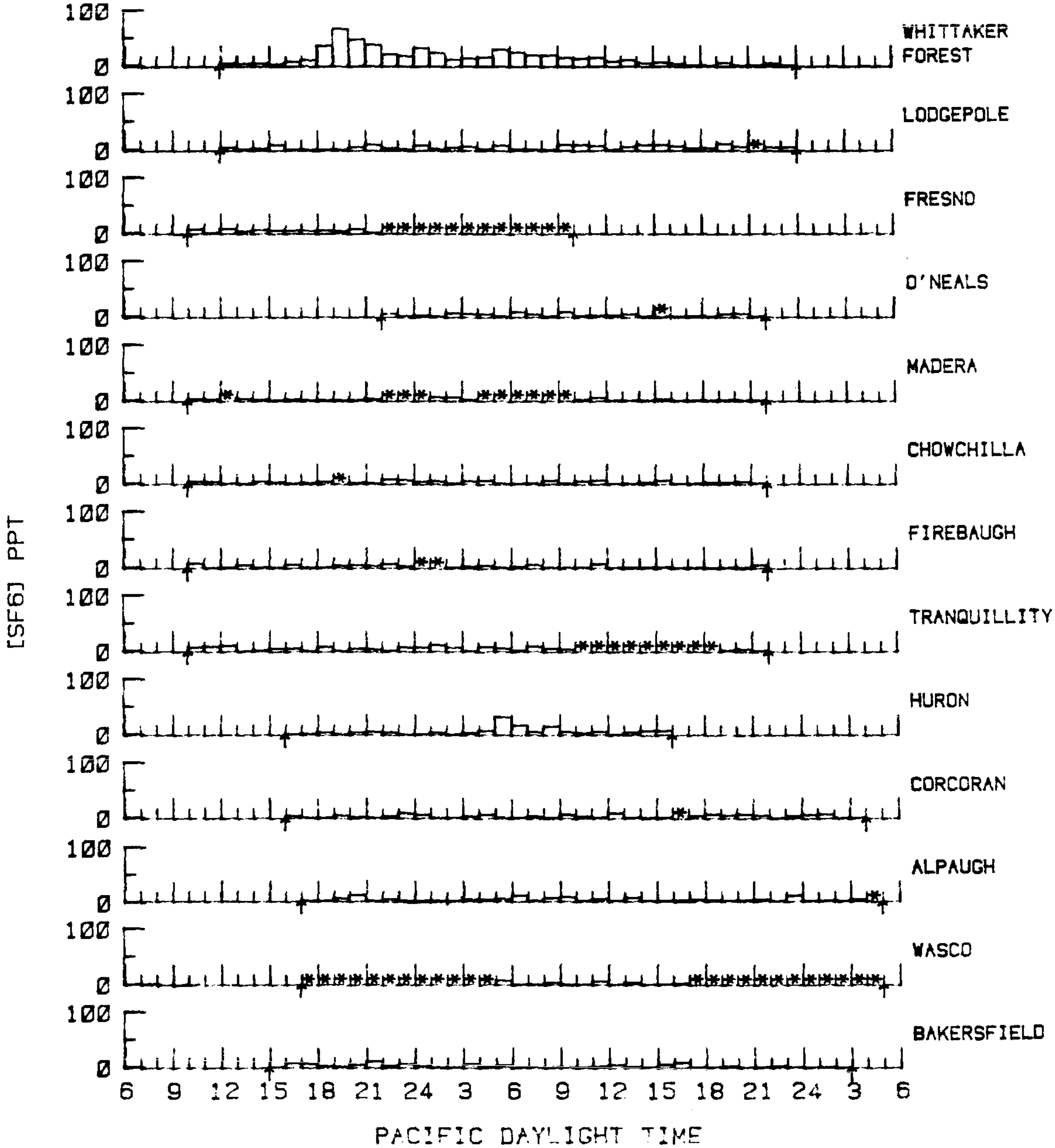
Release Amount: 97 lbs SF6/hr

Release conducted during afternoon westerly upslope winds. Surface winds at the release site varied between about 2 and 5 mps during the release.

Initial upslope transport

During Traverse 1-1, conducted between 1430 and 1558 PDT, SF6 was detected in two locations along Hwy 63. About 8 miles east of Reedley, concentrations as high as about 1100 PPT (1660 PPT/lb-mole SF6 released/hr) were detected. A separate SF6 plume with concentrations as high as about 260 PPT were detected northeast of Reedley. The release began at the onset of the afternoon upslope flow, and the existence of two separate SF6 plumes was the result of the wind direction variation as the flow developed. The plume detected directly east of the release point was transported by the fully developed upslope flow that persisted until between 2100 and 2300 PDT. SF6 was detected in the National Forest and Park areas (Whittaker Forest and Grant Grove) beginning about 1730 PDT-1800 PDT. This corresponded to a mean transport wind speed of about 5 miles per hour. A maximum hourly-averaged sample concentration of 65 PPT (98 PPT/lb-mole SF6 released/hr) was detected at Whittaker Forest between 1900 and 2000 PDT. No other fixed sampling site showed a significant SF6 concentration during the evening of the release (see Figure 3.4.11). By 1830 PDT, during Traverse 1-5, a distinct tracer plume was detected along Generals Hwy between Grant Grove and Lodgepole. The concentration profile detected during this traverse is displayed in Figure 3.4.13. Also included in the figure is the concentration profile detected by an airplane traverse through the same area. Excellent agreement can be seen between the tracer concentrations detected by the airplane and automobile traverses. It is difficult to assess the crosswind width of the tracer plume due to the tortuous nature of the traverse routes. Based upon the airplane traverse data, the crosswind standard deviation in concentration was between 3 and 4 miles (5-6 km). Grant Grove lies about 30 miles (48 km) downwind of Reedley suggesting that the horizontal dispersion of

SJV-4 7/25/79 - 7/27/79



RELEASE LOCATION: 484 LBS SF6 AT REEDLEY
RELEASE TIME: 1200-1700 PDT, 7/25/79

Figure 3.4.11

* INDICATES MISSING DATA
ARROWS INDICATE BOUNDS OF SAMPLING PERIOD

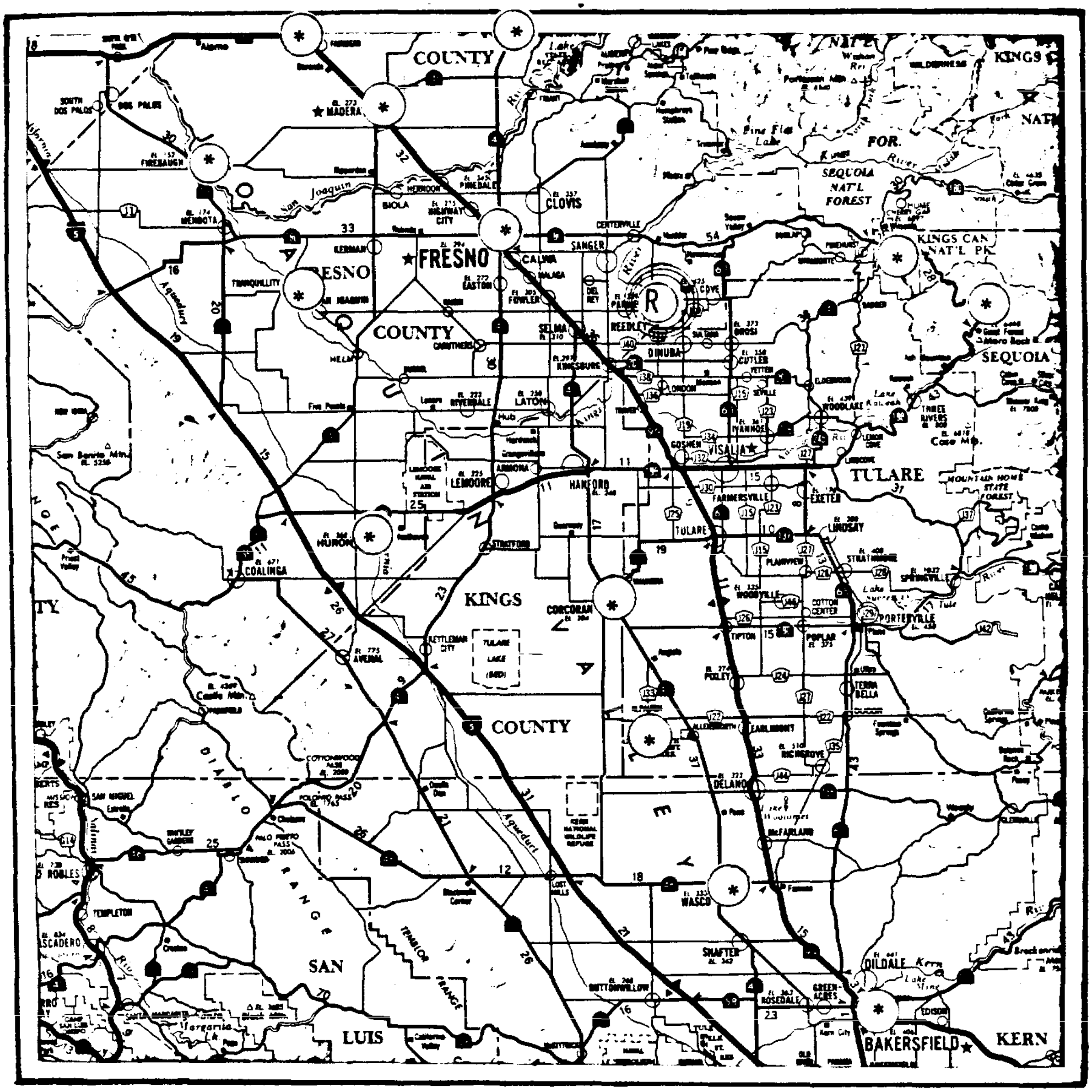


Figure 3.4.12

* INDICATES SAMPLER LOCATIONS

(R) IS THE RELEASE SITE

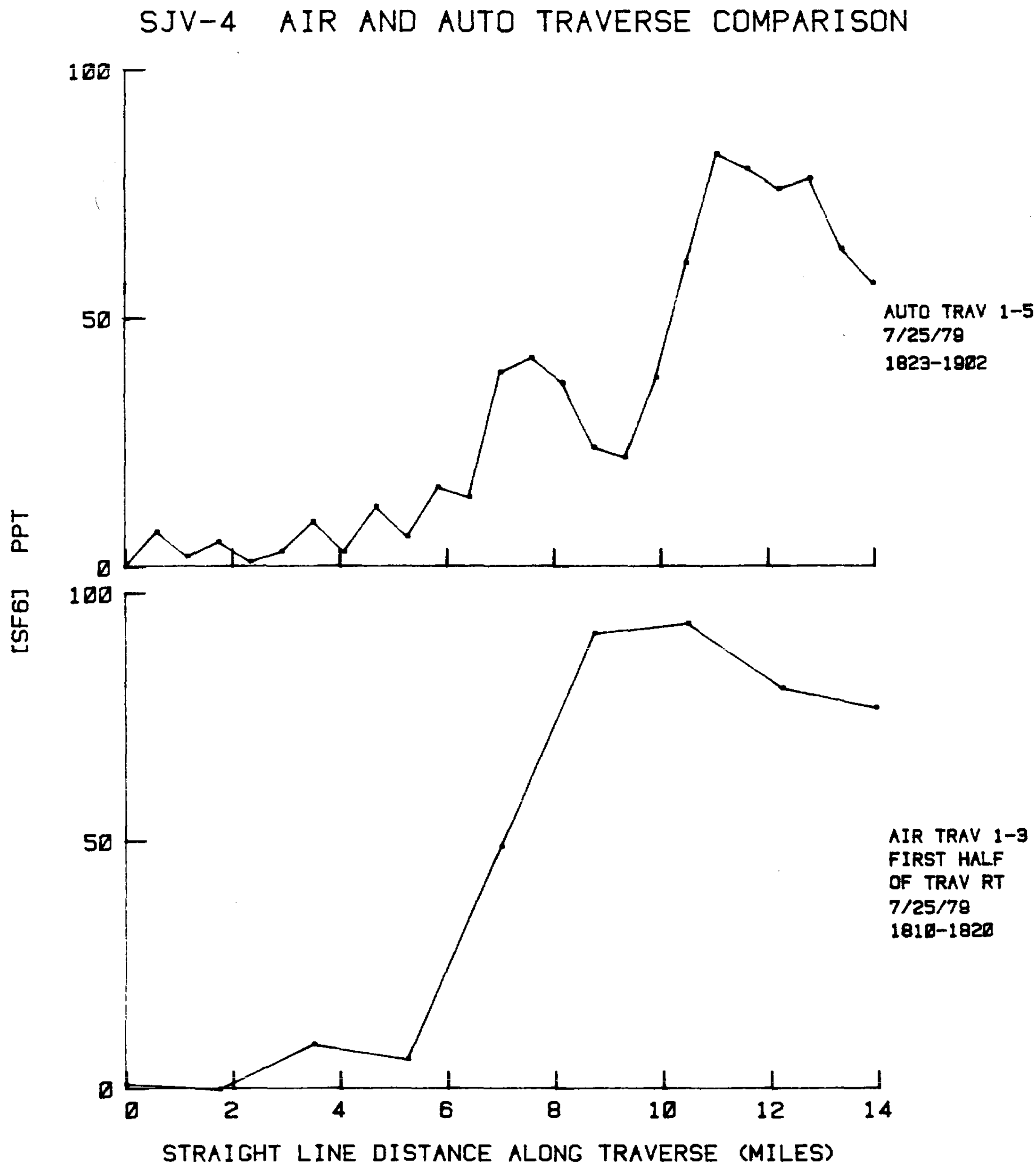

SJV-4 AIR AND AUTO TRAVERSE COMPARISON
100
50
0
[SF6] PPT
AUTO TRAV 1-5
7/25/79
1823-1902
100
50
0
AIR TRAV 1-3
FIRST HALF
OF TRAV RT
7/25/79
1810-1820
0
2
4
6
8
10
12
14
STRAIGHT LINE DISTANCE ALONG TRAVERSE (MILES)

Figure 3.4.13

the tracer corresponded to highly unstable conditions (Pasquill-Gifford Stability Class A or B). The rapid horizontal dispersion of the tracer was probably due in large part to mechanical turbulence generated by the rough terrain. In order to account for all of the tracer released, the SF6 must have been well-mixed over a height of about 600 m (about 2000 ft).

Transport during nightime drainage flow

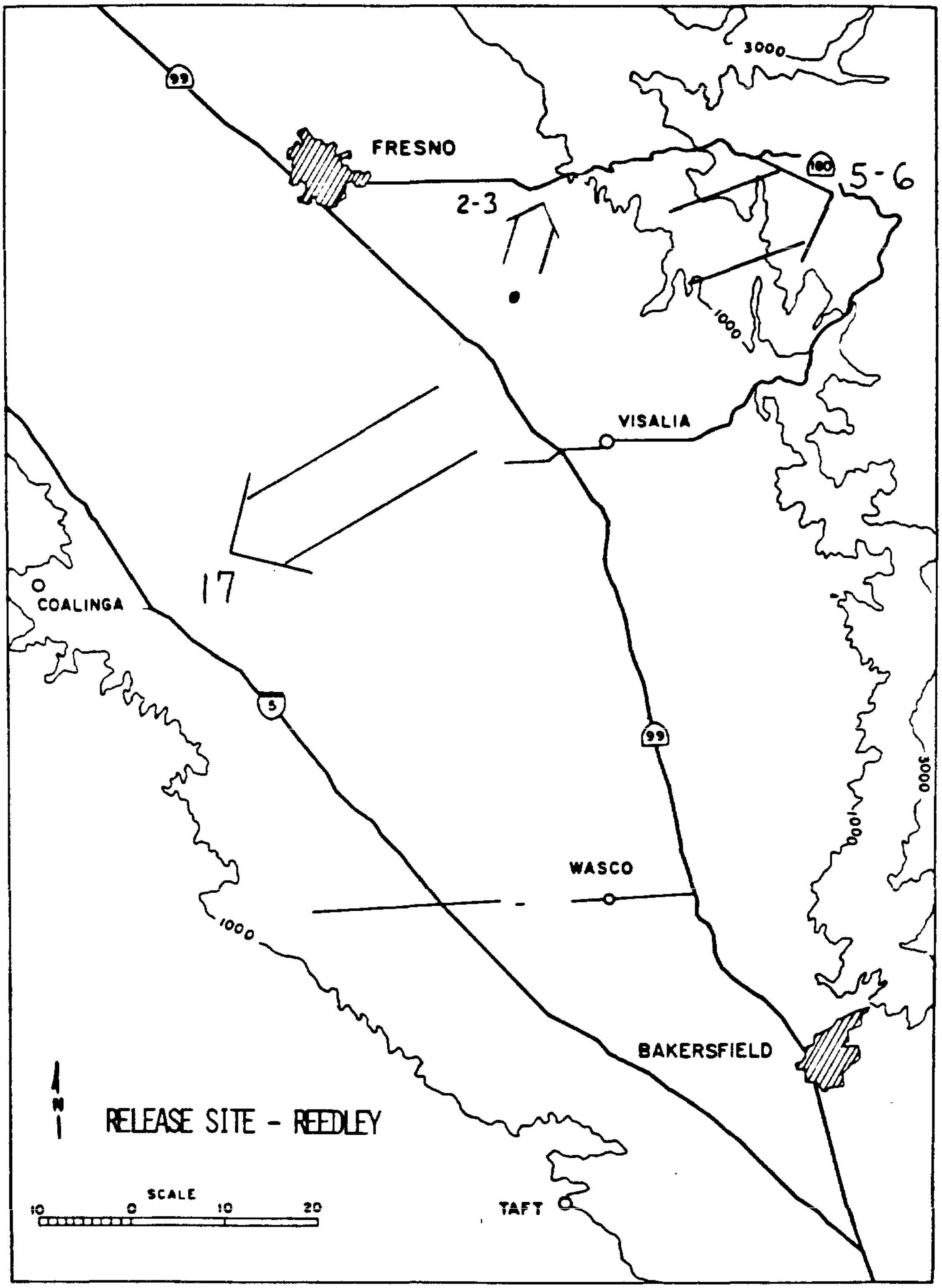
After nightfall, preferential cooling of the mountain slopes led to drainage flows oriented towards the valley. The upslope motion of the tracer was halted. At Whittaker Forest, the tracer was detected throughout the night. Due to the flow reversal, a 5 hour tracer release led to an 18 hr impact at Whittaker Forest. The concentration data collected at the hourly-averaged sampler at Whittaker Forest is shown in Figure 3.4.11. Note that the tracer concentrations detected at Whittaker Forest dropped to zero during the subsequent afternoon upslope flow, presumably transporting the tracer out of the San Joaquin Valley. Also included in the figure is the hourly-averaged data collected at the other fixed sampling sites employed during the test. At most sites within the valley, little or no SF6 was detected. Note however, that tracer concentrations as high as 31 PPT were detected between 0500 and 0900 PDT at Huron on the western side of the valley. The tracer detected at this location was apparently transported across the entire width of the valley by the combination of nighttime drainage winds on the mountain slopes and the valley floor eddy structure referred to in the meteorological discussion. Clearly, the nighttime drainage winds reduce the effectiveness of the daytime upslope flow as a mechanism for ventilation of the valley. Since the afternoon upslope flow is typically stronger and deeper than the nighttime drainage flow, at least during the summer, the diurnal mountain-valley wind cycle does account for a net flow out of the valley. As shown during this experiment, however, little, if any, of the tracer released into the upslope flow during the afternoon was transported out of the valley by nightfall. After midday on the day after the release, only low levels of tracer were detected in the San Joaquin Valley. Either the second day of upslope flows were sufficient to transport the bulk of the tracer out of the San Joaquin Valley or the tracer was effectively dispersed throughout the valley.

Summary

During this experiment, the tracer was released from Reedley, a location southeast of Fresno, during the afternoon. This test was designed to evaluate the importance of the afternoon upslope flow on the overall ventilation budget of the San Joaquin Valley and to quantify the impact of valley pollutant sources on air quality on the western slope of the Sierra Nevada Mountains. The tracer was initially transported upslope at an average speed of about 5 miles/hr. Good agreement between automobile and airplane traverse samples was noted along and above Generals Hwy along the western slope of the Sierra Nevada Mountains. The tracer concentrations detected during these traverses suggested that the tracer was well-mixed to a height of about 600 m or 2000 ft. The width of the tracer plume during these traverses was consistent with Pasquill-Gifford Stability Class A or B (highly unstable conditions) over flat terrain. The enhanced horizontal dispersion of the tracer was probably due to mechanically induced turbulence over the rough terrain.

As the afternoon upslope flow weakened and reversed during the evening and nighttime hours, the upslope movement of the tracer was arrested. The 5 hour release led to a measurable impact 18 hours in length at Whittaker Forest. The tracer was also detected in the San Joaquin Valley during the night after the release, indicating that at least some of the tracer was returned to the valley by nighttime drainage flows. The tracer was detected as far west as Huron, about 45 miles southwest of the release site. An overview of the tracer transport path is shown in Figure 3.4.14.

It was not possible to estimate the amount of tracer remaining in the valley on the day after the end of the release. Low concentrations of tracer were detected over a wide area. As will be made clear in the discussion of Test 5, however, there is reason to believe that at least 25% of the tracer released during this test remained within the valley during the night of 7/27/79, 2 days after this release. By considering the San Joaquin Valley as a well-mixed tank, this loss rate corresponds to a mean residence time of the tracer within the valley of just over 2 days.



ARROW POINT INDICATES OBSERVED TRACER LOCATIONS
NUMBERS REFER TO HOURS AFTER RELEASE START (1200 PDT., 7/25/79)

Figure 3.4.14

3.5 Test 5 27-28 July 1979, Airborne Herndon-Chowchilla Release (2300-0215 PDT)

3.5.1 Meteorology

General

The major synoptic features of the meteorology on the morning of the 28th are shown on Figure 3.5.1. At 500 mb a weak short wave trough was moving across the northern half of California, but not significantly influencing the meteorology in the San Joaquin Valley. Temperatures aloft over central California remained warm as shown by the isotherms at 500 mb and also by the 850 mb temperatures at Vandenberg and Oakland plotted in Figure 2.2.1. At the surface a thermal trough again developed in the interior of California. Sky conditions on the 28th were clear and visibilities were generally good. Maximum surface temperatures were near normal with both Fresno and Bakersfield reporting a maximum of 100°F.

Transport Winds

The tracer release on 27-28 July was made by aircraft at a level of 400 m above ground. The aircraft track was parallel to the wind, flying back and forth between Herndon and Chowchilla.

The pibal winds from Madera were resolved into components parallel and perpendicular to the valley axis. The parallel component was used to examine the transport up-valley and is shown on the time-height cross section in Figure 3.5.2. From the cross section it can be seen that the night jet was established at the time of the start of the elevated tracer release and that the jet continued for the release duration. Wind speeds averaged over 12 m/s during this period.

As shown by the 1000 ft streamlines at 2300 PDT (Figure 3.5.3), flows were northwesterly and roughly parallel to the valley axis through the length of the San Joaquin Valley. The flow remained similar throughout the night. The streamlines developed from the 0700 PDT data on the following morning show cyclonic curvature developing at the southern extreme of the valley, signaling the formation of the eddy which was fully developed by the next observation time at 0900 PDT (Figure 3.5.4). By the 1100 PDT observation time (Figure 3.5.5), the "Fresno" eddy had moved north allowing the northwest flow on the west side of the valley, which had persisted throughout the test, to diverge in the southern end.

SATURDAY, JULY 28, 1979

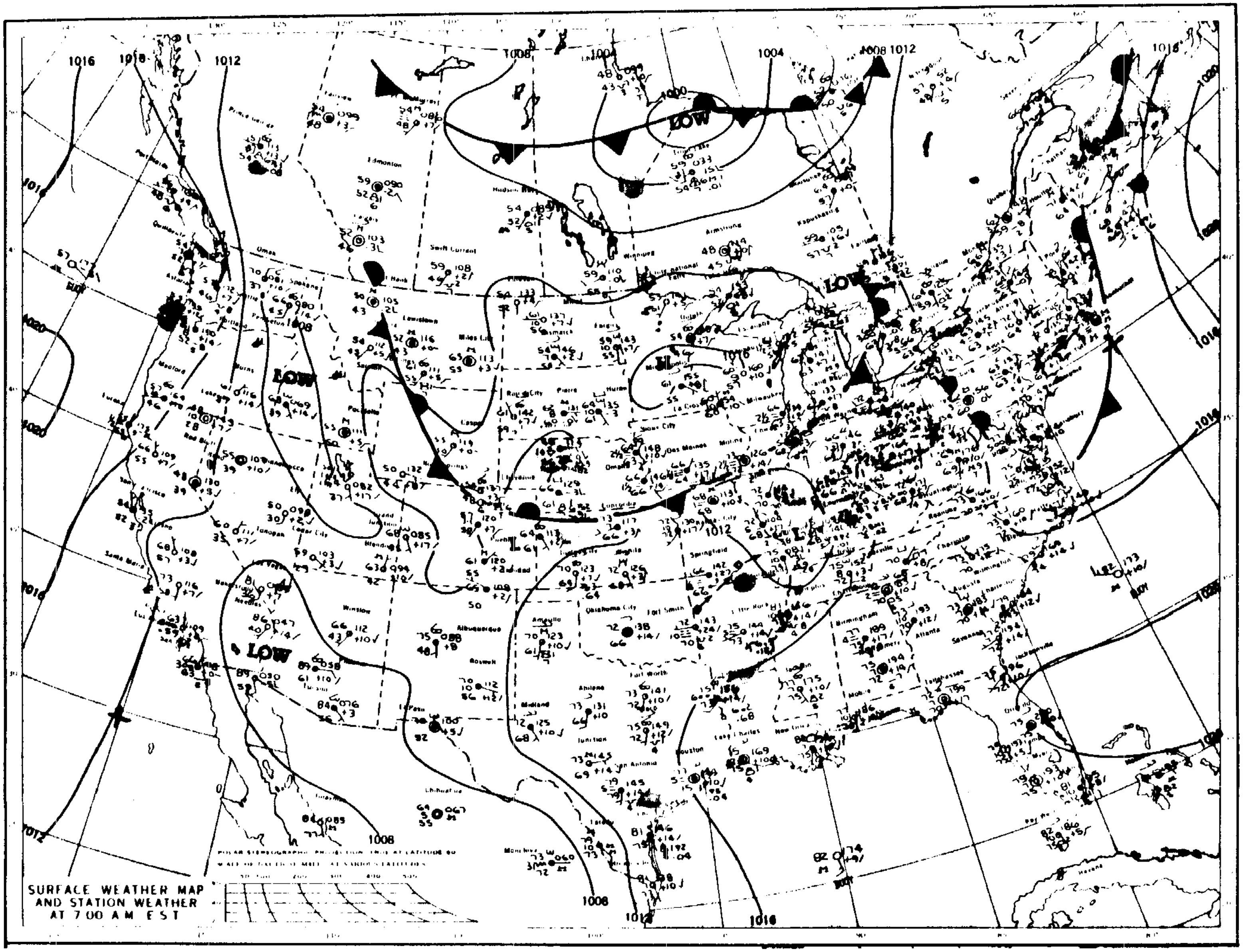


Figure 3.5.1 Surface Weather Charts - 28 July 1979 (05 PDT)

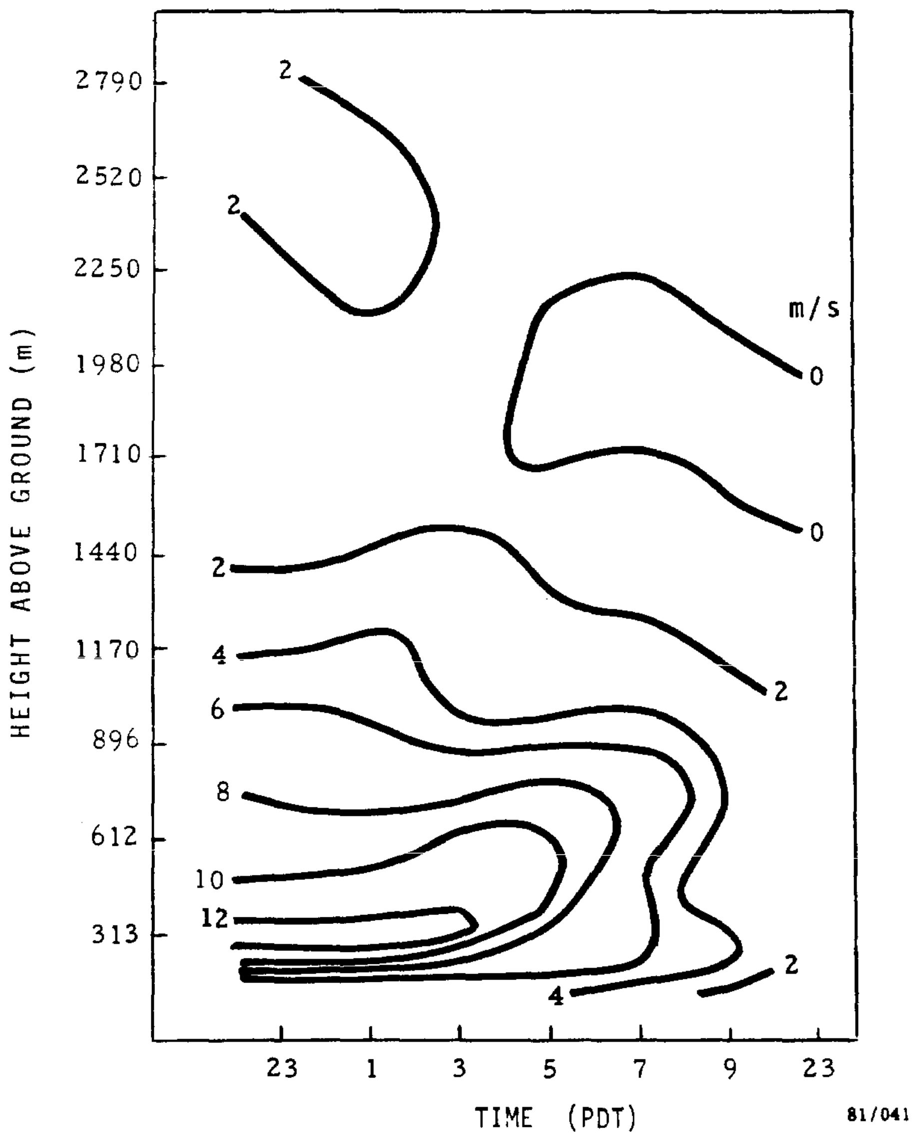


Figure 3.5.2 Time-Height Cross Section Component Winds (m/s) From Madera 27-28 July 1979 (Positive Component Refers to Northwesterly Winds)

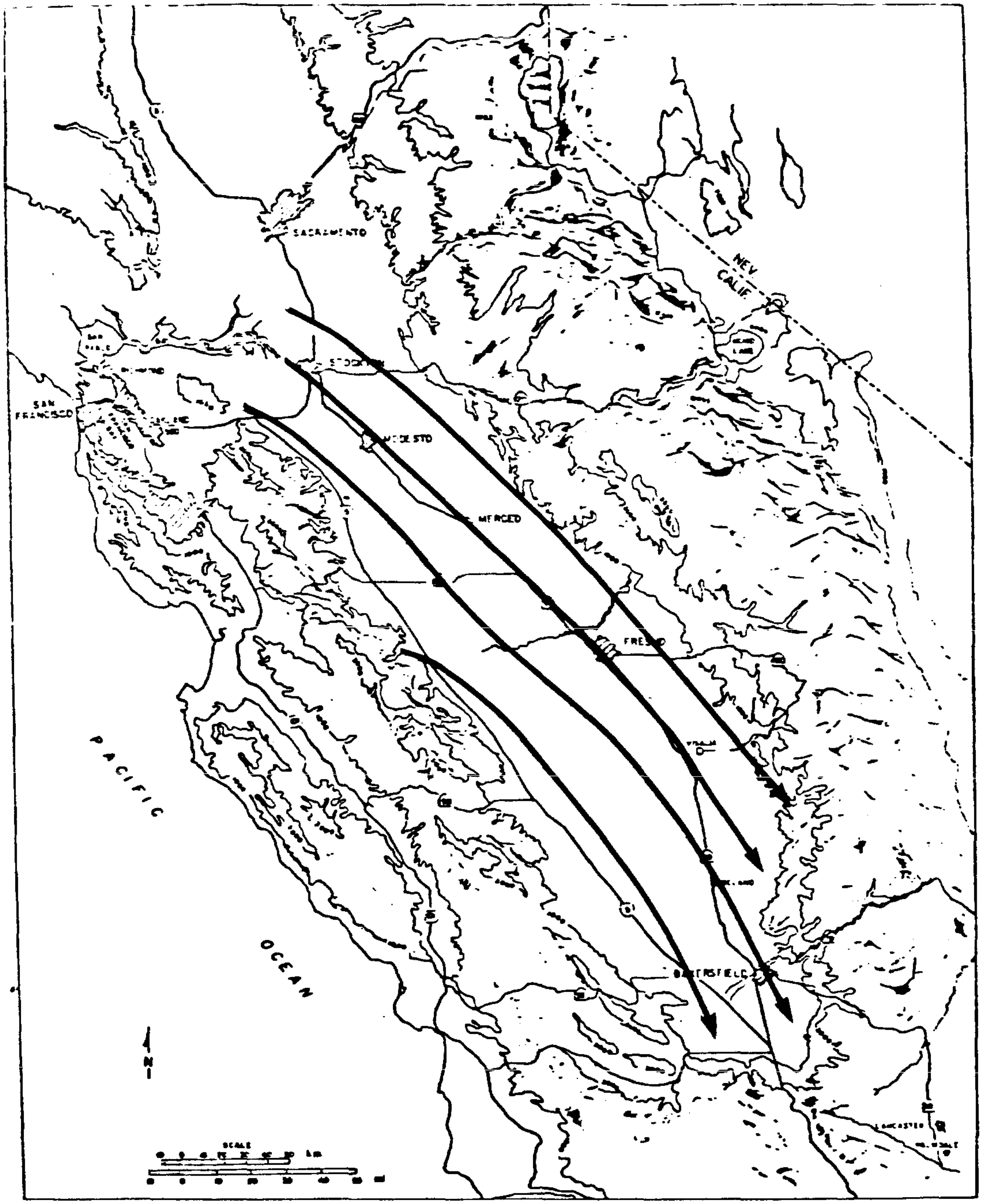


Figure 3.5.3 1000 Ft-agl Streamlines - 27 July 1979 (23 PDT)

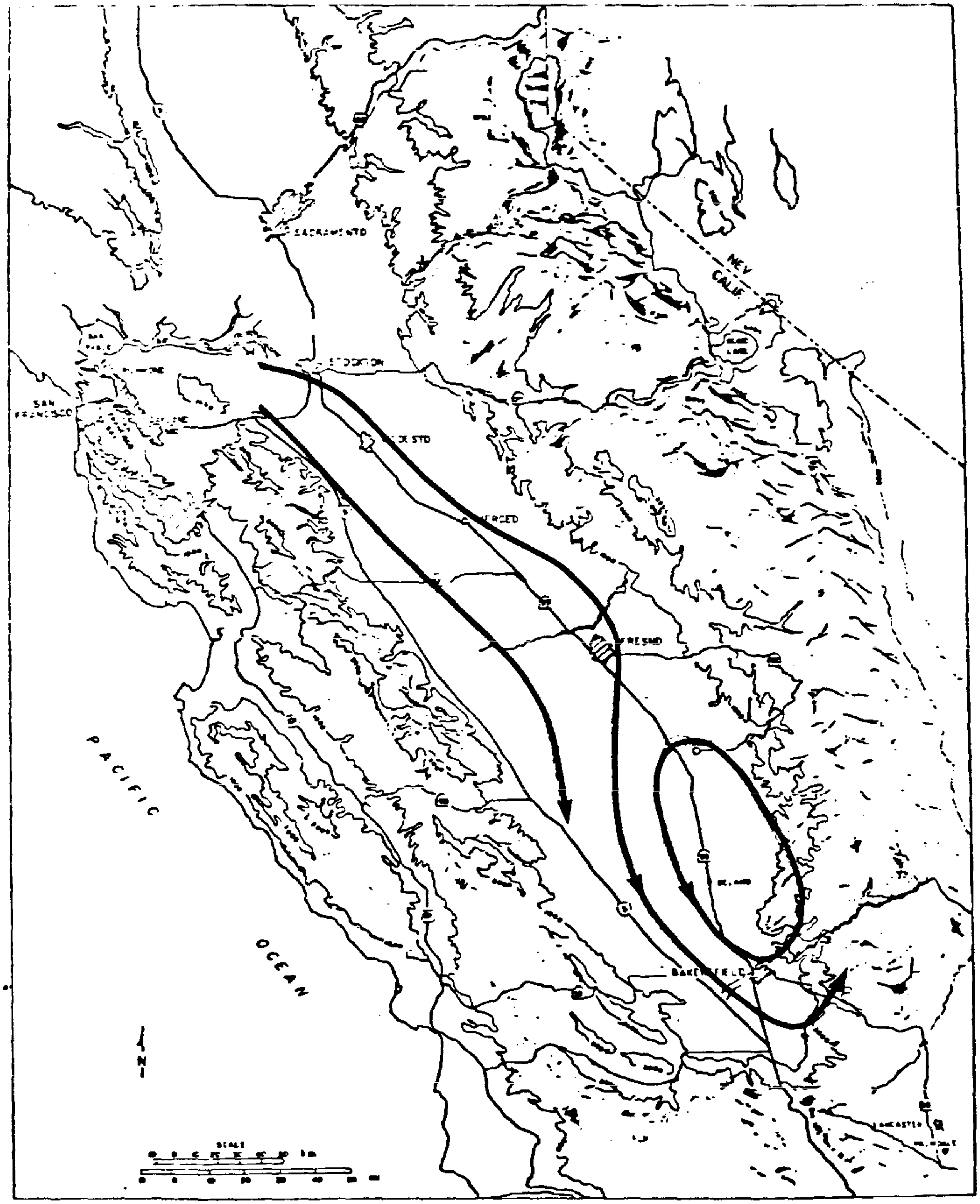


Figure 3.5.4 1000 Ft-agl Streamlines - 28 July 1979 (09 PDT)

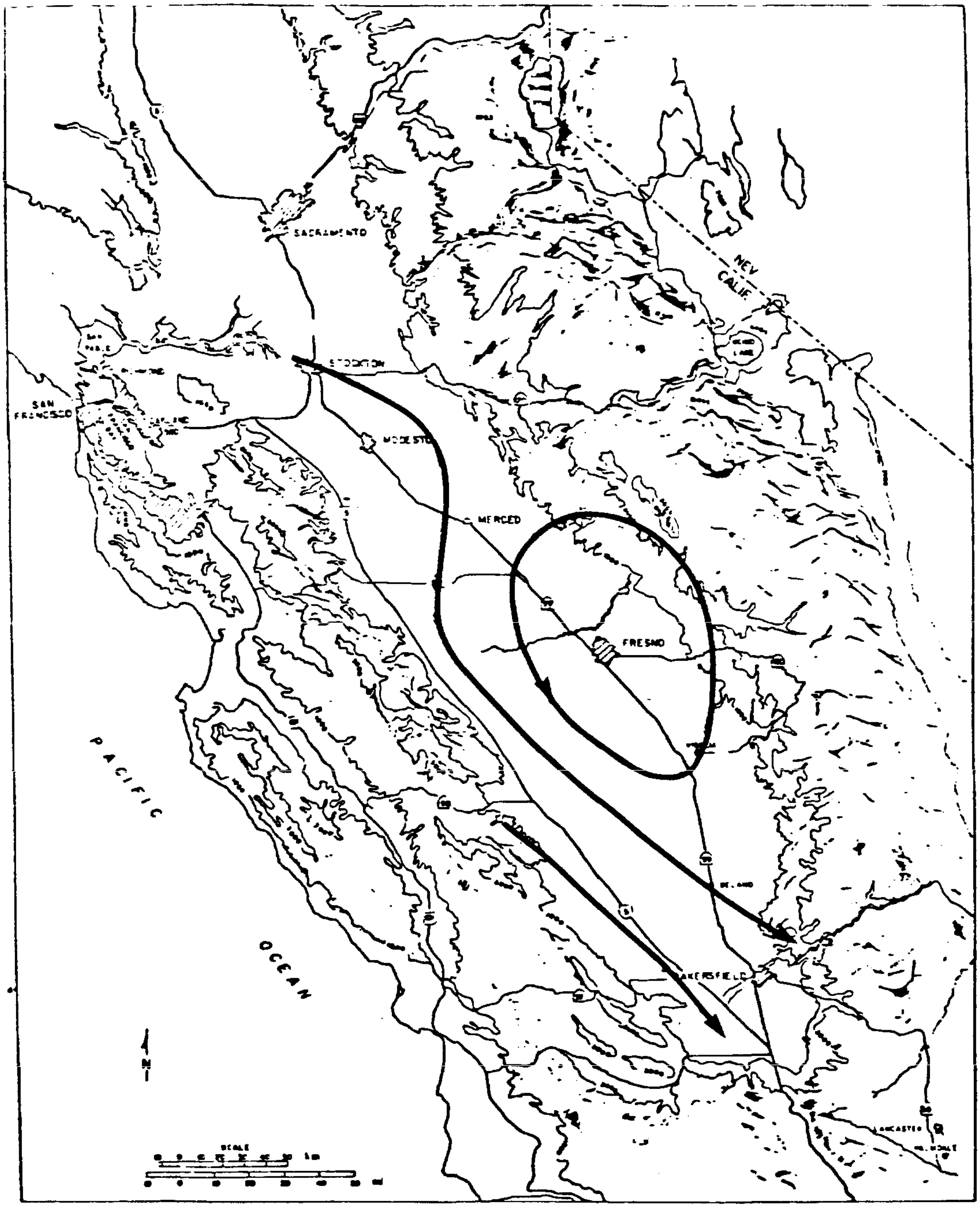


Figure 3.5.5 1000 Ft-agl Streamlines - 28 July 1979 (11 PDT)

Mixing Heights

No sounding data were obtained from the aircraft flights. Maximum mixing heights derived from the pibal wind data ranged between 1200 m and 1500 m at Fresno on July 27 and 28.

3.5.2 Air Quality

Regional Pollutant Levels

Maximum ozone concentrations throughout the valley on July 27 are given in Figure 3.5.6. Highest observed concentration was .11 ppm, measured at the Rockwell International van near Modesto. .10 ppm was the highest value recorded at any of the CARB sites.

Maximum hourly concentrations of other pollutants in the valley on July 27 are given in Table 3.5.1. All values were rather low, indicating a relatively clear day in the valley.

Table 3.5.1

MAXIMUM HOURLY CONCENTRATIONS
JULY 27, 1979

Parameter	Location	Maximum Value (ppm)
SO_2	Bakersfield	.04
CO	Bakersfield	2.
NO_x	Bakersfield	.27
SO_2	Merced (RI)	< .01
NO_x	Modesto (RI)	.03
NO_x	Merced (RI)	.02

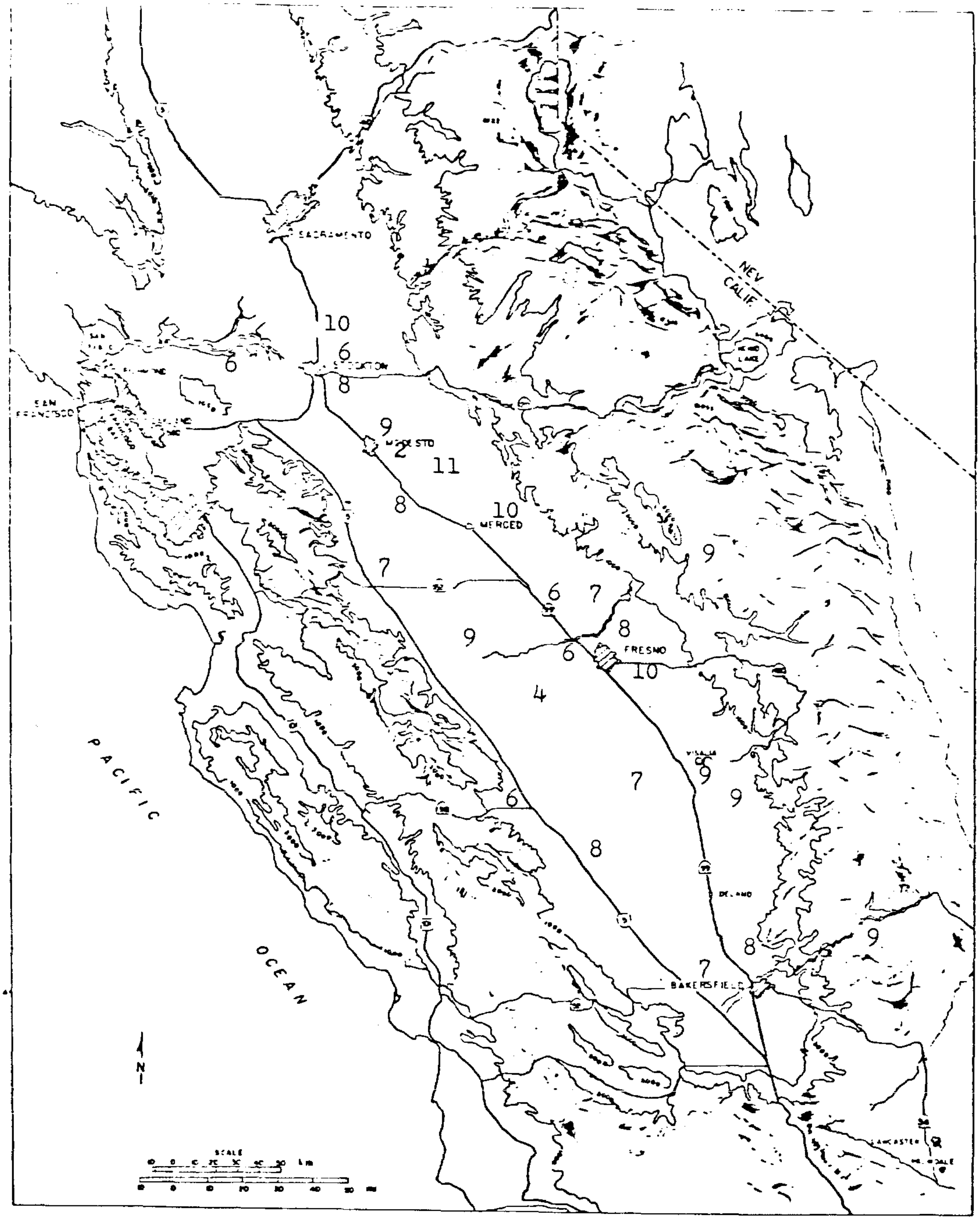


Figure 3.5.6 Maximum Hourly Ozone Concentrations (pphm) - 27 July 1979

3.5.3 Tracer Test 5

Release Location: Airborne - from Herndon to Chowchilla, Madera County
Time and Date: 2300, 7/27/79- 0215, 7/28/79
Release Amount: 67 lbs SF_6/hr
Release made into low-level nocturnal jet. Winds were northwesterly at about 12 mps in the jet.

Nocturnal Jet chracteristics

The nocturnal jet,which occurs frequently during the summer in the San Joaquin Valley, is formed due to the decoupling of the stable surface layer from the air aloft. The lack of surface shear stress allows the air above a few hundred meters in altitude to accelerate to velocities in excess of 10 mps. The velocity profile typically goes through a maximum about a thousand feet above the ground. The velocity profiles measured at Fresno by pilot balloons are shown in Figure 3.5.7. Note that the 2300 PDT, 7/27/79, and 0100 and 0300 PDT, 7/28/79, velocity profiles are very similar. Note also that the velocity decays exponentially with altitude throughout the night (Figure 3.5.8). Only the slope (or exponential decay rate) varies between the velocity profiles. The later velocity profiles fall off more rapidly than the first three. If the atmosphere could be characterized by a constant eddy diffusivity, the velocity profiles might be expected to fall as the square of the altitude. This prediction is based on the analogy of flow in the nocturnal jet to the steady-state problem of shear flow in a channel with parallel boundaries with a no shear stress condition at the lower boundary and a constant velocity layer at the upper boundary. The deviation from the height squared law for the velocity decay with altitude may be a reflection of the variation of eddy diffusivity with height.

The presence of a high velocity jet just above the surface layer can lead to a significant redistribution of pollutants within the valley during the night. Pollutants that mixed upward during the afternoon could be efficiently transported towards the southern end of the valley and detected at ground level as the mixing height increased on the following day. This tracer release was

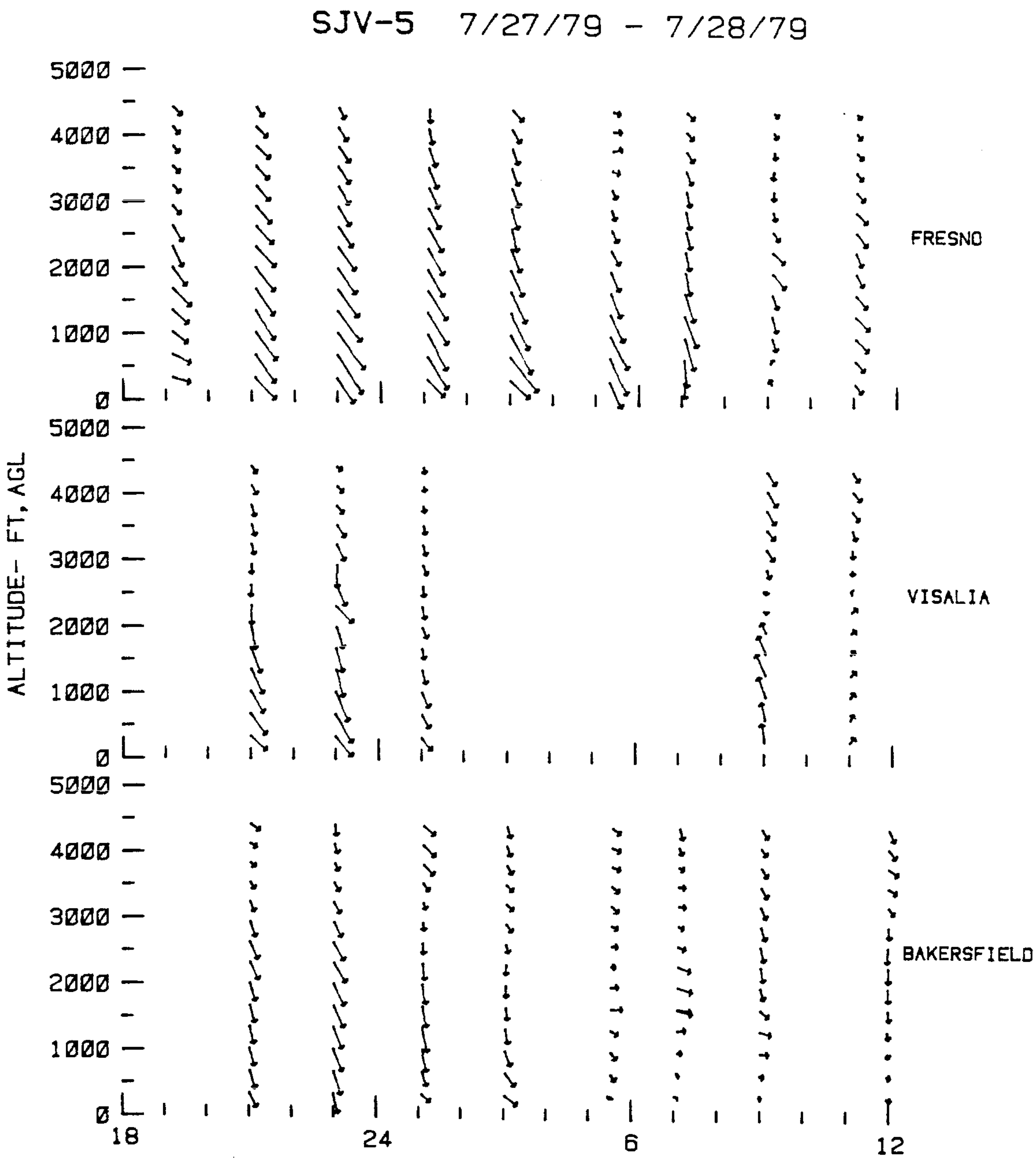


Figure 3.5.7

WIND VECTOR LENGTH SCALE - 1 CM = 15 M/S
WIND VECTOR ALIGNED WITH WIND DIRECTION

NOCTURNAL JET VELOCITY PROFILES

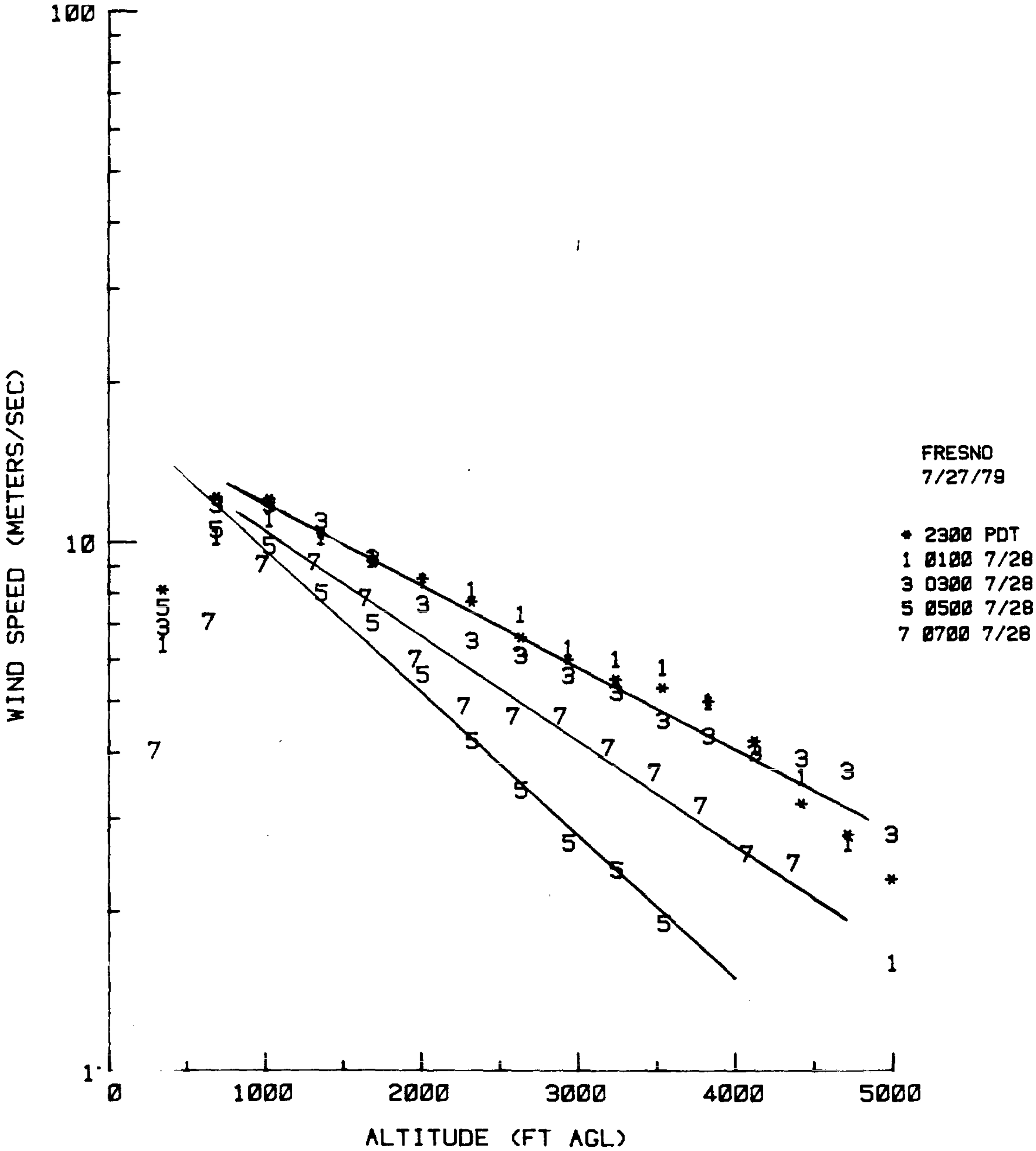


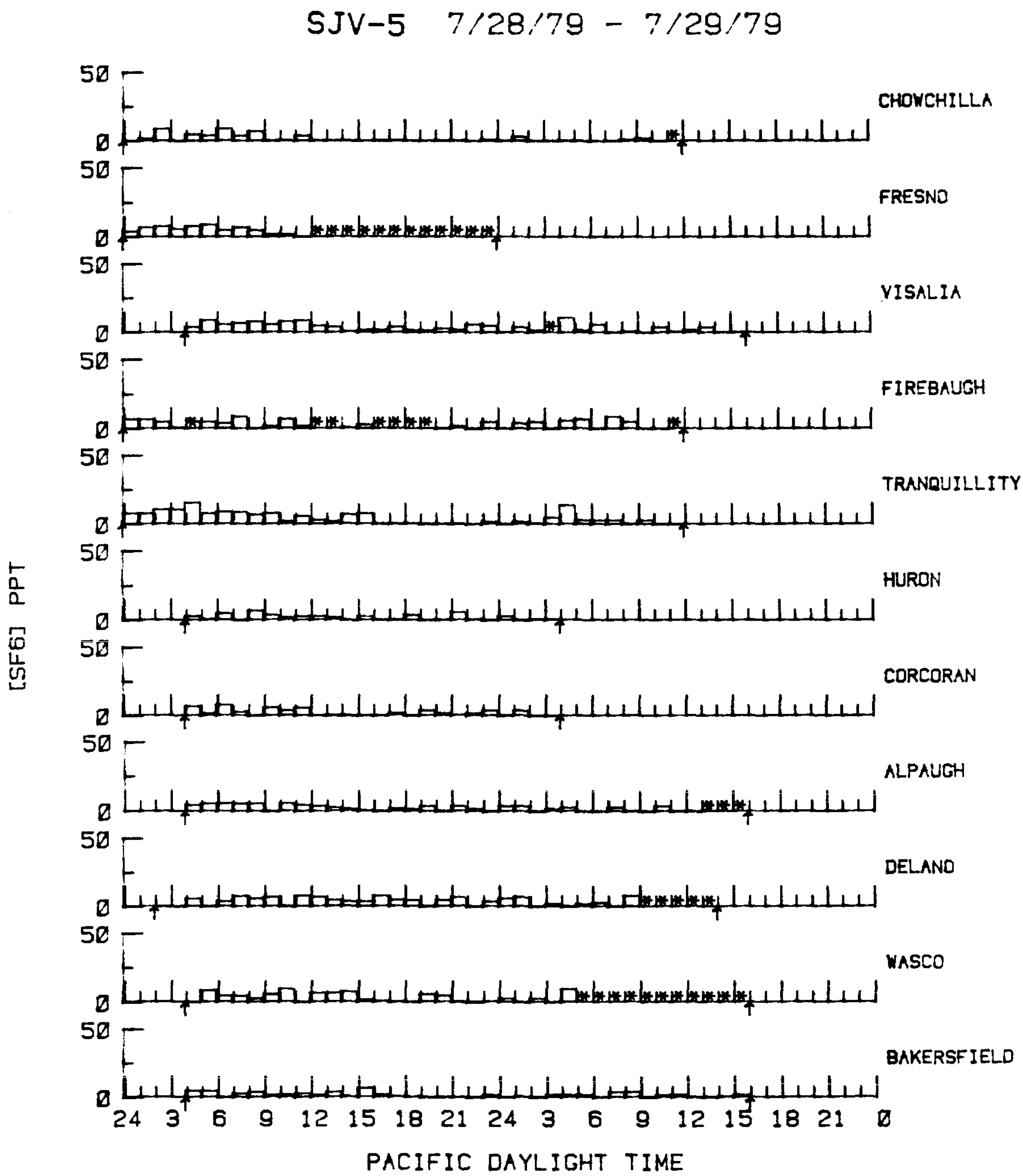
Figure 3.5.8

designed to evaluate the effectiveness of this transport mechanism. The tracer was released from an airplane flying in the high velocity portion of the nocturnal jet. The airplane flew between Chowchilla and Herndon throughout the release. The tracer source could thus be approximately characterized as an elevated, line source.

Transport towards southern end of valley

Automobile traverses detected 10-15 PPT of the tracer over a zone about 20 miles wide in the center of the valley. SF6 was detected at ground level along both Hwy 180, west of Fresno and Hwy 198, west of Visalia. SF6 was also detected at these same low levels at Tranquility as shown in Figure 3.5.9. It appears unlikely, however, that most of the SF6 detected in these samples was from the tracer released into the nocturnal jet. The tracer was spread over a length of at least 40 miles. 10 PPT SF6 in a volume measuring 20 miles in width, 40 miles in length and 1500 ft deep accounts for a majority of the released tracer (about 120 lbs). Yet during airplane traverses conducted on the day after the release, concentrations as high as 75 PPT were detected aloft at the extreme southern end of the San Joaquin Valley (see Figure 3.5.11). Presumably, a majority of the tracer was transported into this zone. It is also unlikely that such a large fraction of the tracer was transported rapidly through the stable surface layer of air. A much more likely source of the tracer detected in the center of the San Joaquin Valley is the release begun at Reedley less than 60 hours previously. The tracer was apparently transported back and forth across the center of the valley by the diurnally varying wind flows. Due to the nighttime drainage condition, the carryover was detected in the center of the valley. The estimate of the total mass of tracer detected during the mid-valley traverses is about 25% of the tracer released during the previous test. If all of this tracer was from the previous test, which appears likely, this loss rate corresponds to an characteristic time for exponential decay (a mean residence time assuming good mixing within the valley) of just over 2 days for the meteorological conditions that prevailed prior to this experiment.

As mentioned in the previous paragraph, the highest concentrations of tracer (except for a few isolated samples) were detected on the day after the



RELEASE LOCATION: 219 LBS SF6 AIRBORNE
RELEASE TIME: 2300-0215 PDT, 7/27/79

Figure 3.5.9

* INDICATES MISSING DATA
ARROWS INDICATE BOUNDS OF SAMPLING PERIOD

SJV

5

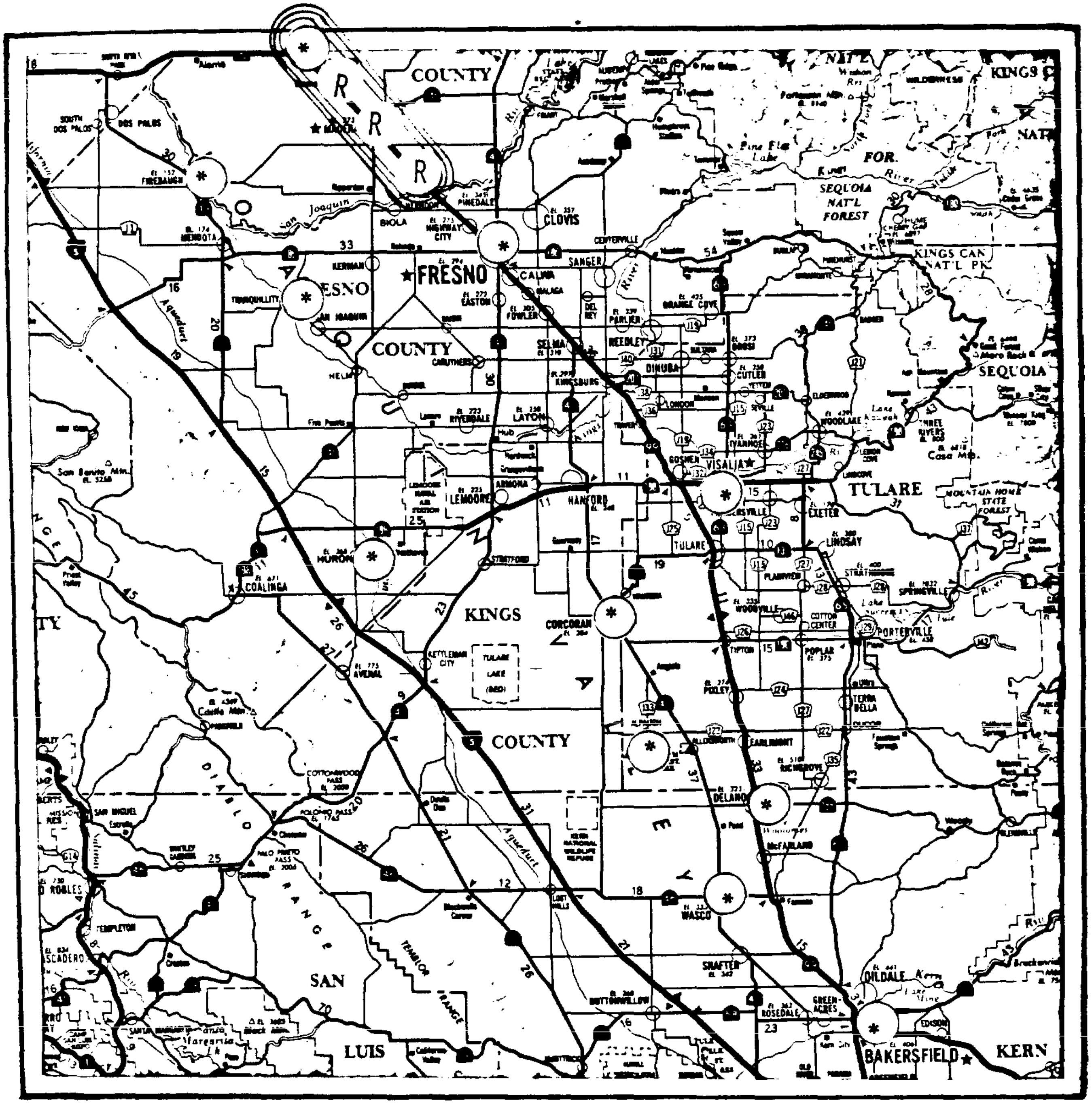


Figure 3.5.10

* INDICATES SAMPLER LOCATIONS

R IS THE RELEASE SITE

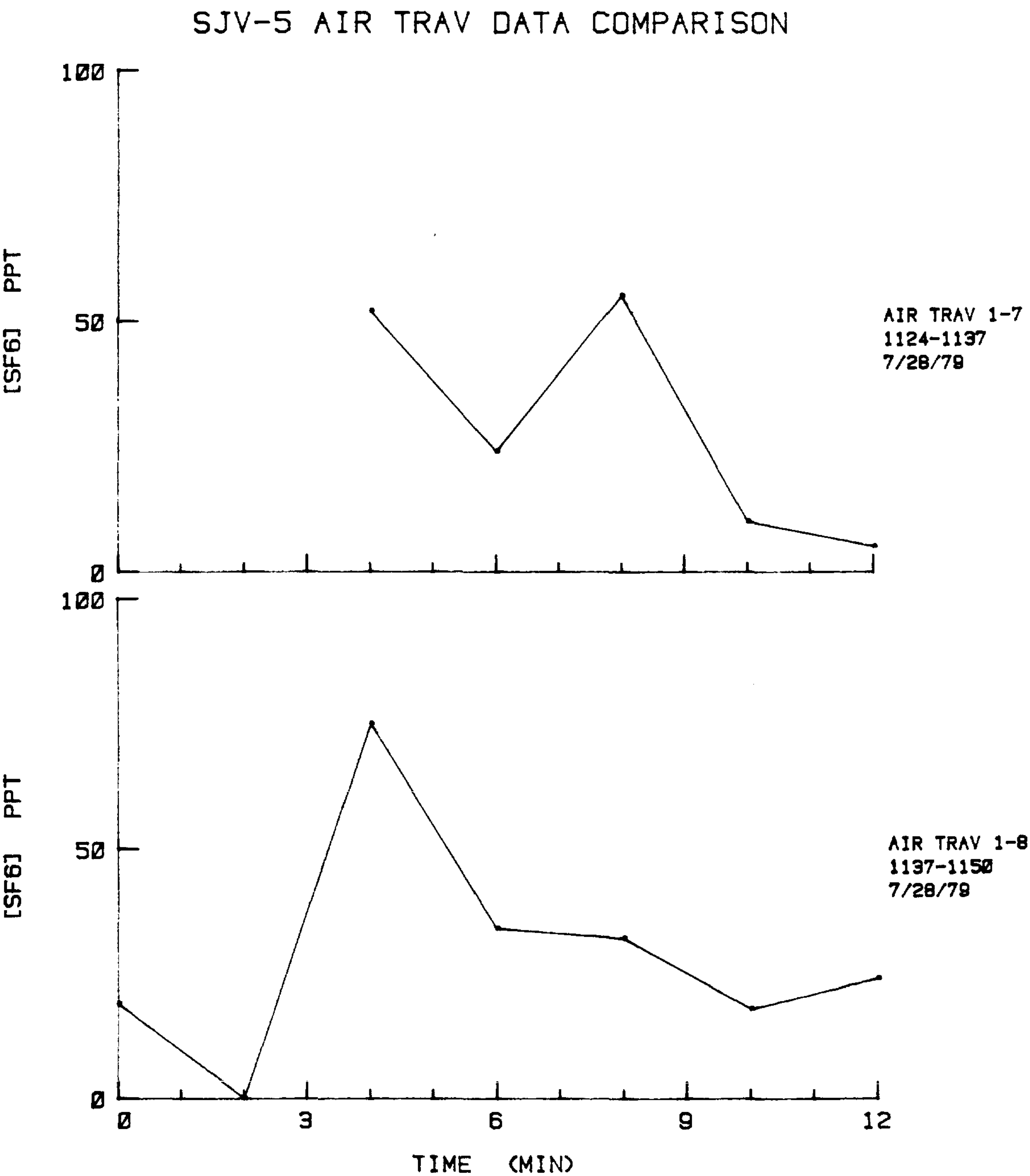

SJV-5 AIR TRAV DATA COMPARISON
100
50
0
[SF6] PPT
AIR TRAV 1-7
1124-1137
7/28/79
100
50
0
[SF6] PPT
AIR TRAV 1-8
1137-1150
7/28/79
0
3
6
9
12
TIME (MIN)

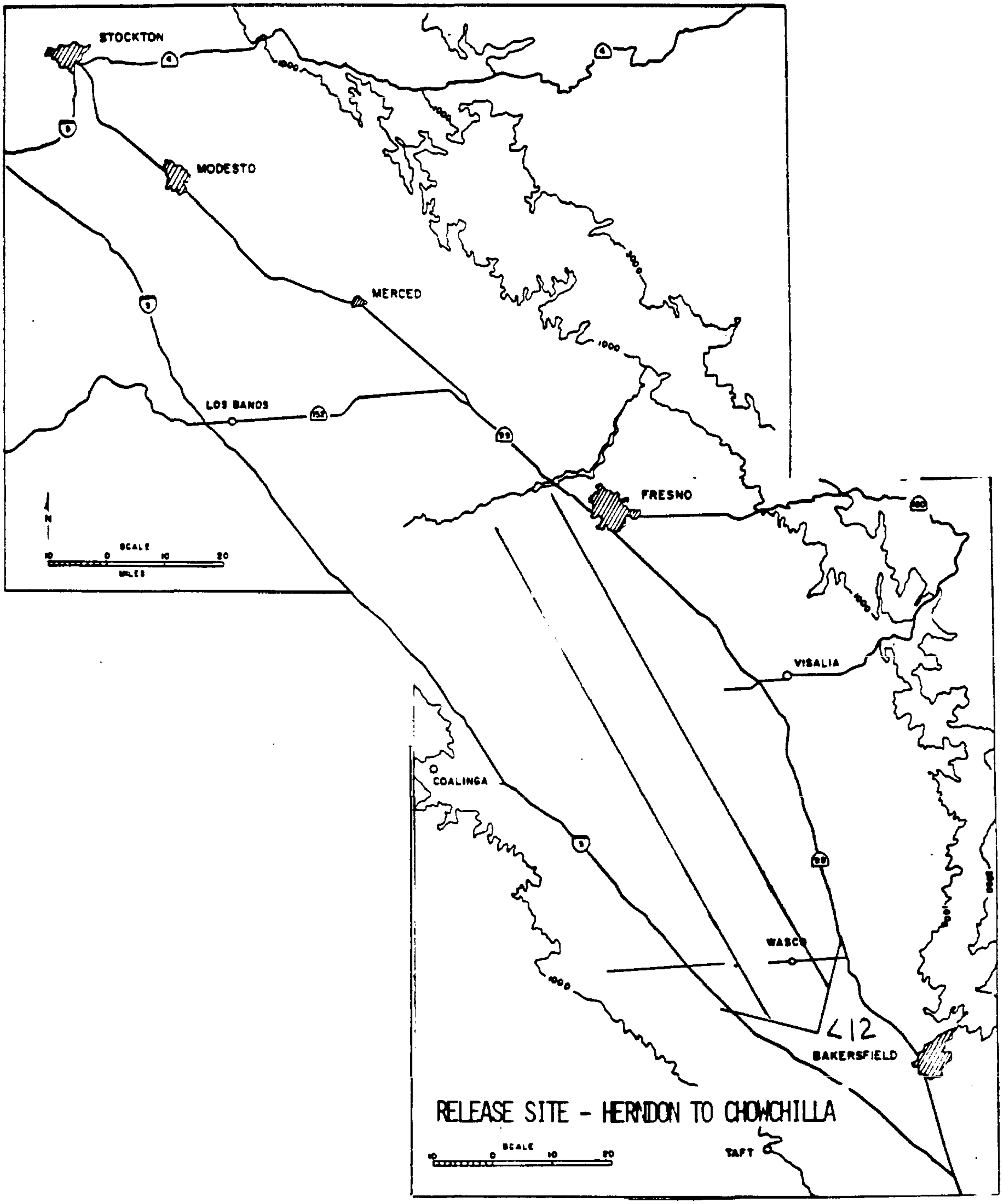
Figure 3.5.11

release at the southern end of the valley. An average concentration of 29 PPT was detected over the entire southern boundary of the San Joaquin Valley at an altitude of 1000 ft during Airplane Traverses 1-7 and 1-8 (Figure 3.5.11). The tracer was apparently transported to the southern end of the valley by the nocturnal jet, but there appears to be no evidence of mixing downward by midday of the day after the release. As the mixing height grows during the afternoon, however, the tracer transported from the northern end of the valley will have a chance to mix downward. No automobile or airplane traverses were conducted during the afternoon to verify this.

Summary

During this experiment, the tracer was released into the nocturnal jet which frequently develops above the San Joaquin Valley in the summertime. The nocturnal jet refers to a region of air with maximum velocities in excess of 10 mps. The velocity maximum typically occurs about 1000 ft above the surface of the San Joaquin Valley. The jet apparently forms due to the decoupling of the air aloft from the surface layer. The lack of shear stress at the surface can lead to acceleration of the air aloft. This test was designed to evaluate the nocturnal jet as a mechanism for transport of airborne pollutants from the northern half of the valley to its southern end.

SF6 was detected at ground level west and southwest of Fresno. The amount of SF6 detected within this zone was a majority of the amount released. Yet the concentrations detected in this zone (about 10 PPT) were an order of magnitude less than the concentrations detected at the southern end of the valley on the day after the release. Also, the winds in the nocturnal jet were directed along the eastern side of the valley. The tracer detected southwest of Fresno on the night of the release was apparently not from this release but carryover from the previous experiment. The tracer released during this experiment was apparently not detected at ground level on the night of the release. As mentioned previously, tracer from this experiment was detected aloft at the southern end of the valley on the morning after the release. A crude picture of the apparent tracer transport path is shown in Figure 3.5.12. The tracer was apparently still confined to a shallow layer about 1000 ft off the ground. The tracer was probably detected at ground level only after the



ARROW POINT INDICATES OBSERVED TRACER LOCATIONS
NUMBERS REFER TO HOURS AFTER RELEASE START (2300 PDT., 7/27/79)

Figure 3.5.12

mixing height increased to above the level of the tracer allowing fumigation of the tracer to ground level.

3.6 Test 6 30 July 1979, Pacheco Pass Release (1200-1725 PDT)

3.6.1 Meteorology

General

The synoptic meteorology (Figure 3.6.1) during Test 6 was characterized by a region of high pressure aloft at 500 mb centered offshore of the central-southern California coast. As reflected in the 850 mb temperature trend shown on Figure 2.2.1, the air mass residing over California remained warm and stable. At the surface, a thermal trough was established over the interior of California. A weak weather front off the Washington-Oregon coast was not affecting conditions in the San Joaquin Valley. Skies remained clear throughout the test. Afternoon visibilities in the valley ranged from 10-12 miles, although smoke was observed in the distance at both Stockton and Bakersfield. Surface temperatures were above normal for the date. Both Fresno and Bakersfield reported maximum temperatures of 104°F.

Transport Winds

During the tracer release, pibal winds were taken on both the west and east sides of Pacheco Pass on alternating hours. The measured winds were resolved into wind components roughly parallel and perpendicular to the orientation of the pass. The parallel component was used to define the flux through the pass and is shown on the time-height cross sections in Figures 3.6.2 (a and b). The major feature of the cross sections is the low level convergence of the flow at the pass, i.e., the flow was directed toward the summit on both sides. This would imply that the tracer material would be carried aloft in the convergence zone. Within the valley, the afternoon flow at 1000 ft-agl is described by the streamlines on Figure 3.6.3. Northwest flow predominated throughout the valley with winds generally on the order of 3-5 m/s.

Mixing Heights

No aircraft sounding data were available during the release period. Maximum mixing depths in the San Joaquin Valley as determined from the pibal data ranged from 1000-1300 m at Los Banos and Fresno.

MONDAY, JULY 30, 1979

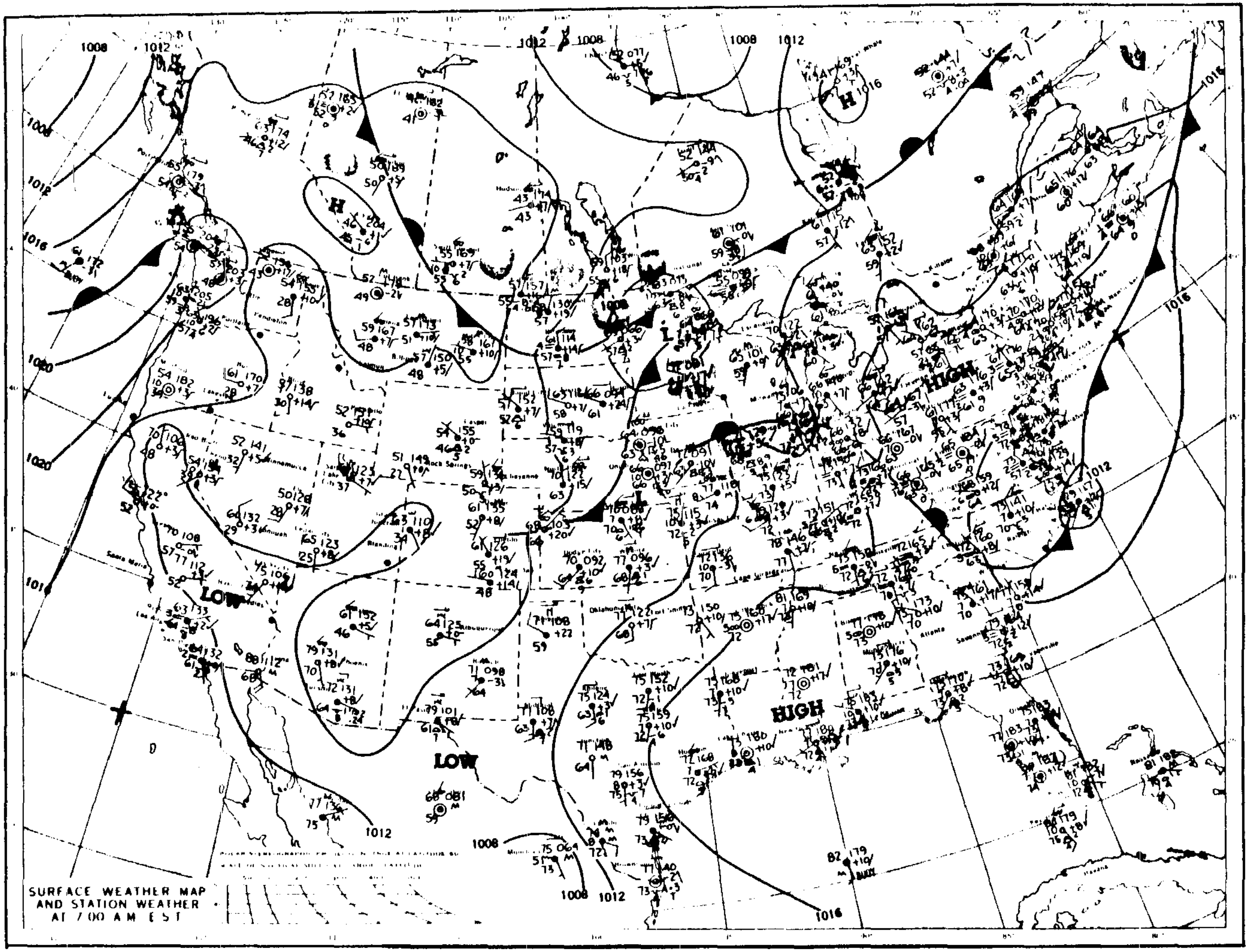


Figure 3.6.1 Surface Weather Chart - 30 July 1979 (05 PDT)

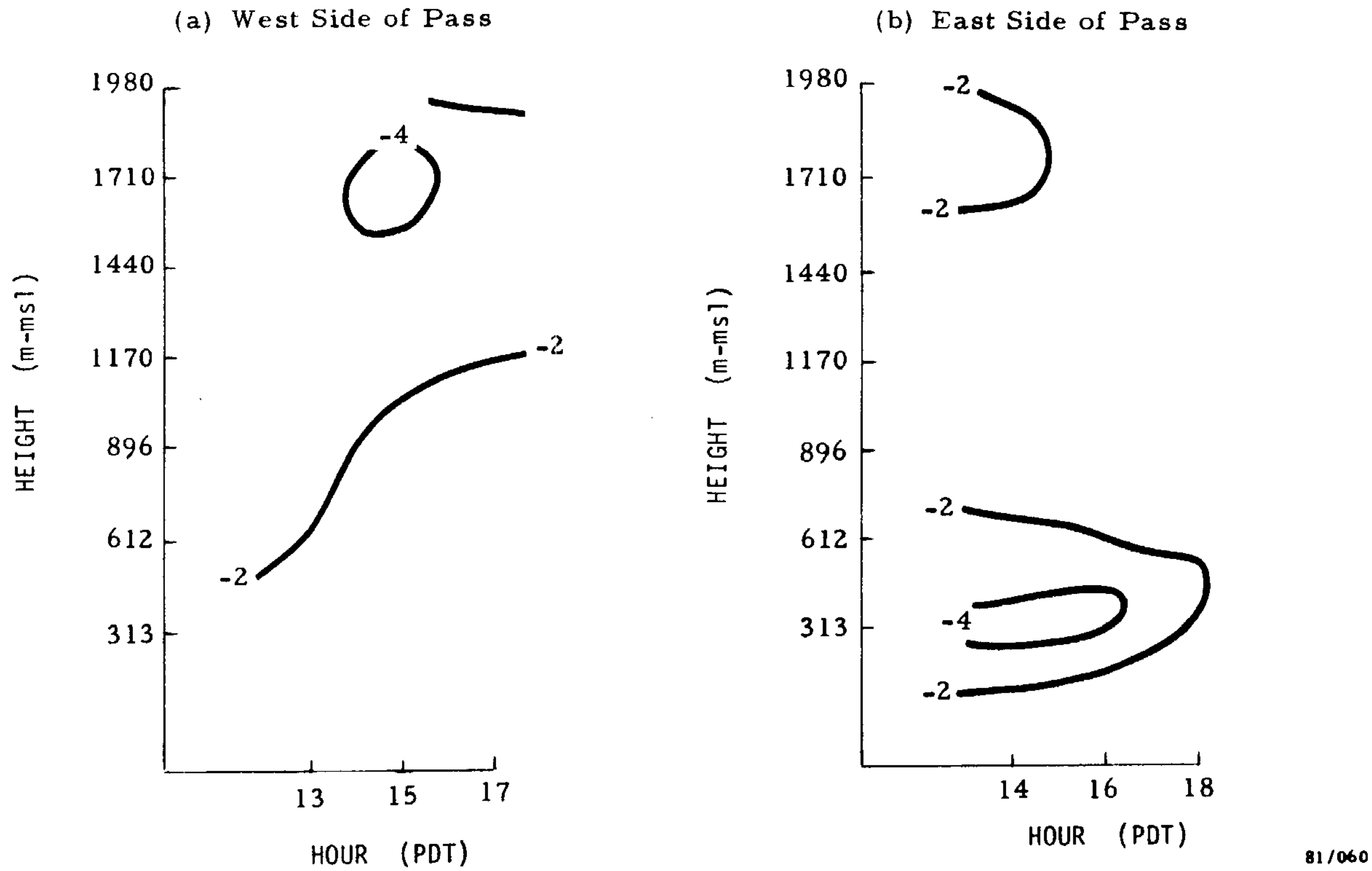


Figure 3.6.2 Time-Height Cross Section of Through Pass Component of Wind (m/s) at Pacheco Pass - 30 July 1979

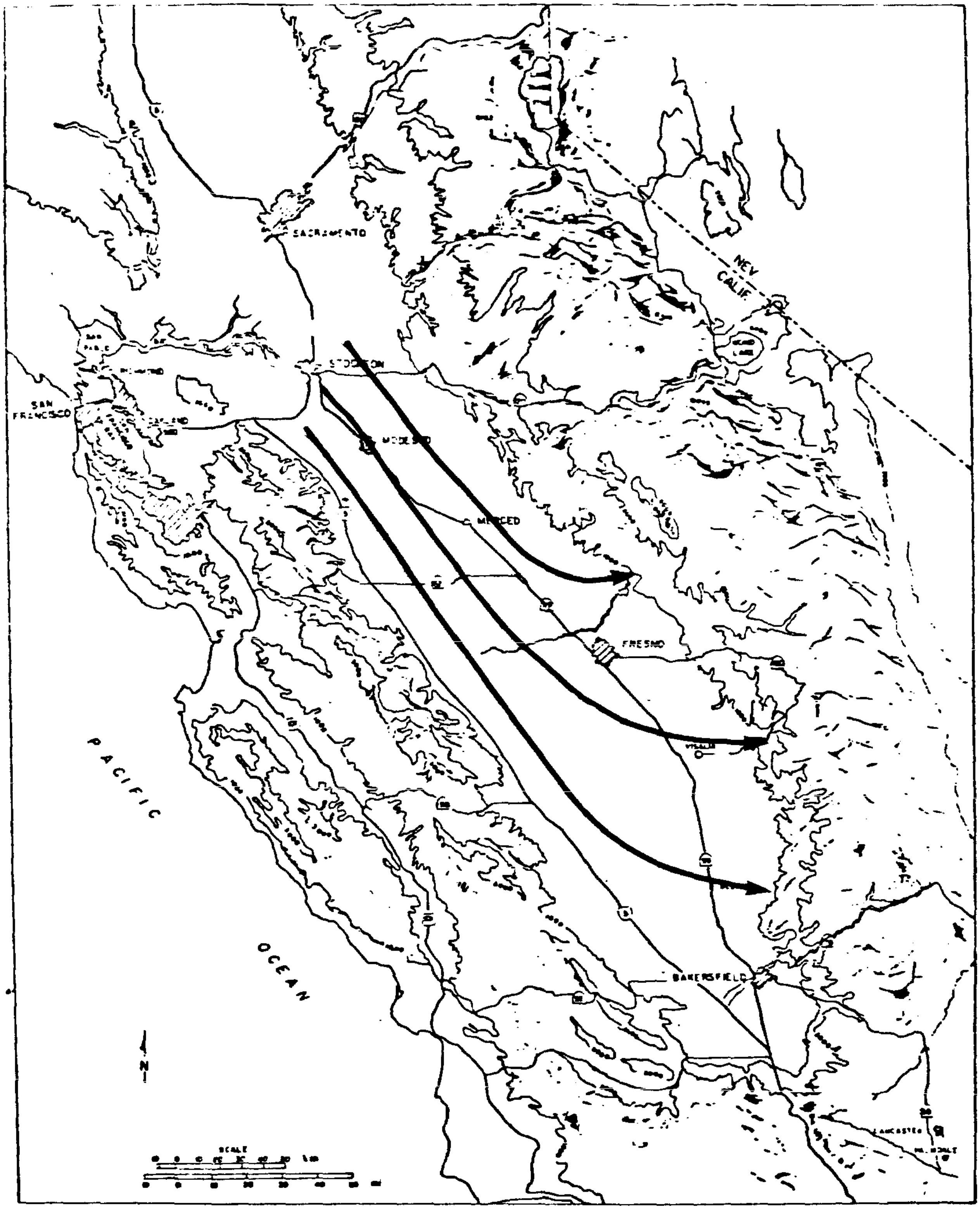


Figure 3.6.3 1000 Ft-agl Streamlines - 30 July 1979 (15 PDT)

3.6.2 Air Quality

Regional Pollutant Levels

Maximum hourly average ozone concentrations for 30 July 1979 are shown on Figure 3.6.4. Numerous exceedances of California's ambient air quality standard for oxidant were experienced throughout the valley. Maximum concentrations (.14 ppm) were measured in the Fresno urban area. Levels as great as .12 ppm were experienced at Whitaker's Forest in the Sierra Nevadas.

Maximum hourly values of other pollutants in the valley on July 30 are shown in Table 3.6.1 together with maximum hourly concentrations observed at the Rockwell International vans. Relatively low levels of all pollutants were observed during the day.

Table 3.6.1

MAXIMUM HOURLY CONCENTRATIONS
JULY 30, 1979

Parameter	Location	Maximum Value (ppm)
SO_2	Oildale	.07
CO	Fresno-Olive	5.
NO_x	Fresno-Olive	.18
SO_2	Modesto (RI)	.01
SO_2	Merced (RI)	$<$ .01
NO_x	Modesto (RI)	.02
NO_x	Merced (RI)	.02
NO_x	Madera (RI)	$<$ .01

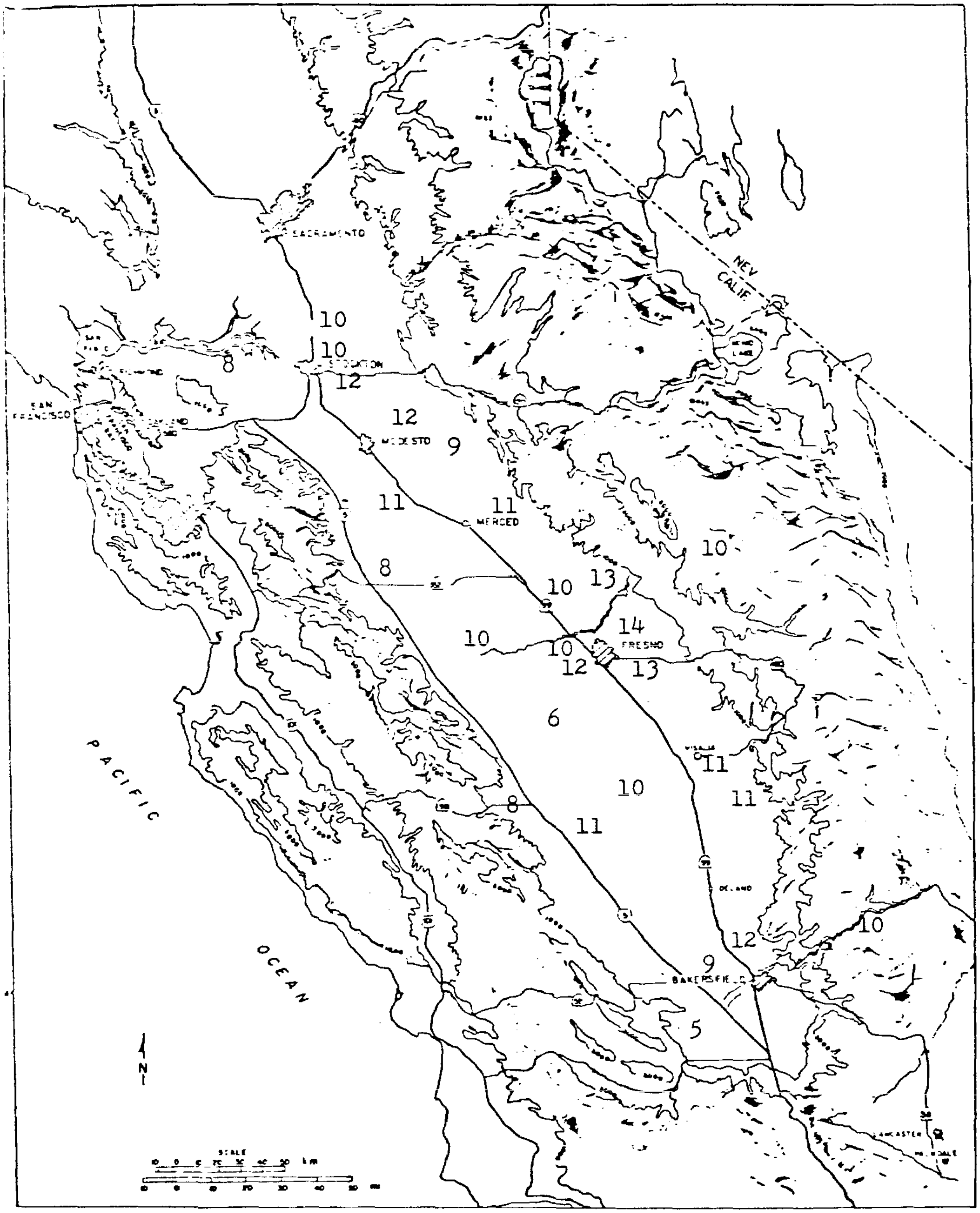


Figure 3.6.4 Maximum Hourly Ozone Concentrations (pphm) - 30 July 1979

Aircraft Sampling

The aircraft sampled in the late afternoon (1551-1911 PDT) on July 30 to provide (1) aerial coverage of the tracer plume and (2) to measure the flux of pollutants from the Santa Clara/San Benito Valleys into the San Joaquin Valley. To this end, traverses were flown within the mixing layer in the San Joaquin Valley, over Pacheco Pass, in the Santa Clara and San Benito Valley and across the Diablo Range from Hollister to Mendota. Spirals were flown on the east side and west side of the pass and over Fresno.

Although the data system failed to record the meteorological and air quality data, from observations and the strip chart recorder the following comments are offered:

- The top of mixing at Santa Nella Airport was 2700 ft-msl.
- Some mixing was observed to 6000 ft-msl in the Santa Clara Valley.
- On the east-west traverse across the pass, ozone sharply increased just east of Bell Station (near the summit) suggesting vertical transport and little exchange through the pass.
- Ozone levels in excess of .30 ppm were observed at 2500 ft-msl over the South County Airport in the Santa Clara Valley.
- Ozone levels dropped off sharply after leaving Hollister Airport heading east over the Diablo Range suggesting no transport into the San Joaquin Valley at that time.

3.6.3 Tracer Test 6

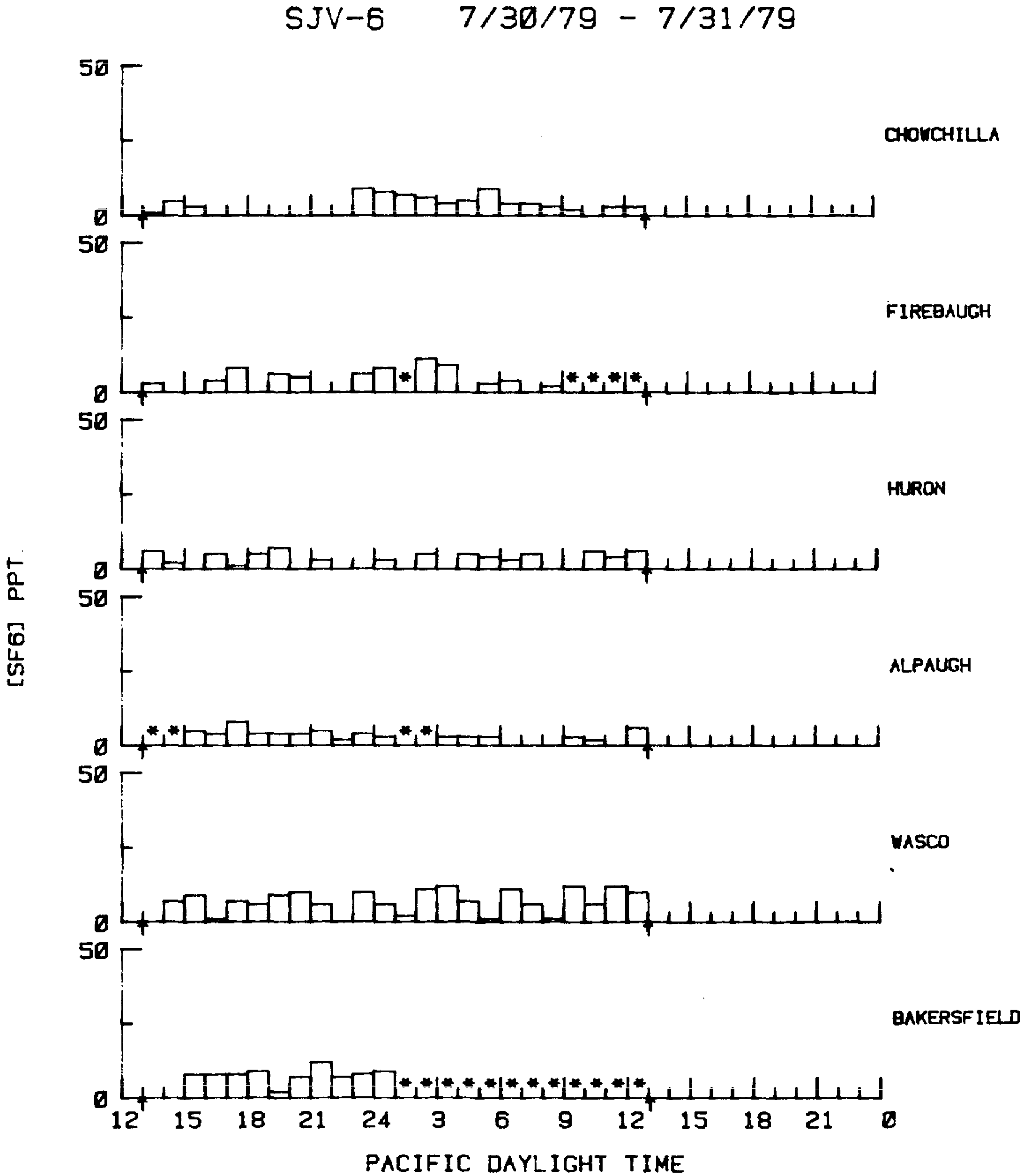
Release Location: Pacheco Pass above Los Banos, Merced County
Time and Date: 1200-1725 PDT, 7/30/79
Release Amount: 99 lbs SF6/hr
Release was made into a convergence zone between a easterly flow from the San Joaquin Valley and a westerly flow from the coastal side of the pass.

The majority of the tracer was not detected at ground level during the day of the release. High concentrations of the tracer were detected only during Traverse 1-1 which passed through Pacheco Pass and the release area. Low levels of tracer were detected during other automobile traverses, notably Traverse 1-2 and 1-3, but the levels detected during these traverses could not account for more than a small fraction of the SF6 originally released. Automobile traverses were conducted on both the east and west sides of Pacheco Pass. During Airplane Traverse 1-3 tracer concentrations as high as 253 PPT were detected. The tracer plume detected during this traverse extended for about 8 miles with concentrations above 30 PPT. This traverse was about 600 ft above the release height. This suggests that the tracer was carried aloft by the flow convergence near the release site. The convergence of air at the release site is consistent with afternoon upslope flows on both sides of the coastal mountains that form the western boundary of the San Joaquin Valley.

At fixed sampling sites within the San Joaquin Valley, most sites showed low, essentially background levels of tracer. The concentration data collected at each of the fixed sampling sites is included in Figure 3.6.5. The concentrations detected at these sites may be a small amount of carryover from previous tests. Approximately 1240 lbs of SF6 was released in the San Joaquin Valley between 7/25/79 and 7/30/79.

Summary

The tracer was released from a pass through the coastal mountain range on the west side of the San Joaquin Valley. The surface layer flow on both the east and west sides of the pass were converging, indicating that the tracer was carried aloft. Significant tracer concentrations were detected only during an



RELEASE LOCATION: 536 LBS SF6 AT LOS BANOS
RELEASE TIME: 1200-1725 PDT, 7/30/79

Figure 3.6.5

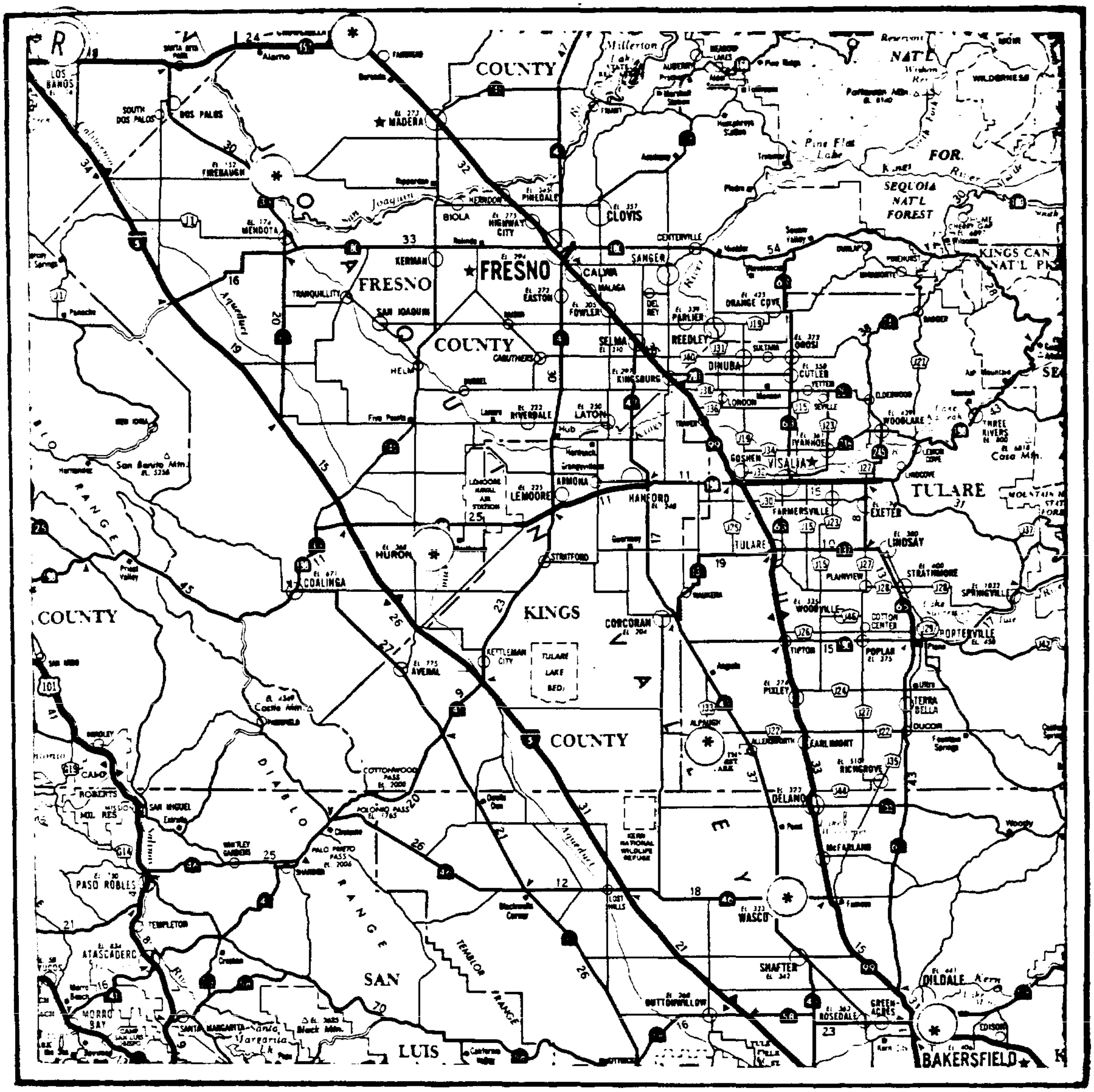


Figure 3.6.6

* INDICATES SAMPLER LOCATIONS

(R) IS THE RELEASE SITE

airplane traverse conducted about 600 ft above the release site. It was not possible to determine the transport path of the tracer after being carried aloft. The tracer concentrations within the San Joaquin Valley were indistinguishable from background levels.

4. Conclusions

1. The July 1979 field program was characterized by relatively warm temperatures at 850 mb compared to average. All tracer tests were carried out under above average temperature conditions.
2. Average wind flow into the valley at Stockton and Los Banos during July is directed from Stockton to Bakersfield at all hours of the day. The principal driving force for this flow is the thermal low pressure area to the east of the Sierras.
3. Average wind direction in the low levels at Visalia and Fresno for the July program was southeasterly during the early morning hours but northwesterly for the balance of the day. The duration of the southeasterly winds was longer at Visalia, associated with northward spreading of the Fresno Eddy.
4. The Fresno Eddy develops during the night as a result of stable conditions in the southern end of the valley. The absence of the eddy is associated with the passage of weak, cool troughs through the area.
5. As the eddy develops, the flow above Bakersfield and Visalia (from 1000 to 2000 m, agl) increases compared to the value at Fresno, indicating that some of the northwest flow is displaced upward and over the eddy.
6. The nocturnal wind jet formed to a significant degree during about half of the July 1979 data sample. Peak wind speed occurred at about 300-400 m (agl) at 2100-2300 PDT.
7. Mixing layer depths were observed to range from 600 to 1200 m during the afternoons when tracer tests were conducted.
8. Maximum ozone concentrations ranged between .11 and .17 ppm on the days when tracer releases were carried out.
9. Maximum CO values on tracer days were 2 to 5 ppm while NO_x observations ranged between .18 and .32 ppm.
10. NMHC concentrations taken near Stockton averaged less than .2 ppm with low concentrations attributable to automobile sources.

11. The major components of the total particle composition were silicon, sulfate and carbon. Crustal-like materials accounted for the largest fraction of the mass.

12. Tracer released between 0700 and 1300 PDT on July 13, 1979 at Manteca was transported by northwesterly winds along Hwy 99. Approximately 40 miles south of the release site, the tracer trajectory shifted westward and followed the San Joaquin River, the lowest portion of the valley. Pollutants transported into the San Joaquin Valley from the California Delta and San Francisco Bay area would also have been transported along the western side of the valley on this day, minimizing the impact of these plumes on the urban east side of the valley. Based on a comparison to the Gaussian plume model, the dispersion of the tracer plume was consistent with neutral or slightly unstable atmospheric conditions and a mixing depth of about 1650 ft.

13. Tracer released between 1300 and 1900 PDT on July 16, 1979 at Manteca was transported by northwesterly winds along the San Joaquin River. As in the previous test, pollutants transported into the San Joaquin Valley from the San Francisco Bay area would have had a minimal impact on pollutant levels on the urban east side of the valley. Based on a comparison to the Gaussian plume model, both the horizontal and vertical dispersion of the tracer was consistent with neutral or slightly unstable atmospheric conditions.

14. Tracer released between 1510 and 2030 PDT on July 18, 1979 at Livermore was transported by westerly winds over Altamont Pass and into the San Joaquin Valley. The intrusion of tracer into the San Joaquin Valley was limited due to stabilization (and comparative stagnation) of the atmosphere after nightfall. On the day following the release, the tracer "cloud" was transported down the western side of the valley in a manner similar to that found during the previous two tests.

15. Tracer released between 1200 and 1700 PDT on July 25, 1979 at Reedley was transported upslope by the westerly afternoon winds, impacting sites in the National Forest and Park areas in the Sierra Nevada Mountains. The upslope movement of the tracer plume was arrested by the nighttime reverse flow. Some of the tracer carried downslope by the nighttime flow was was transported by flow across the valley floor to Huron on the western side of the valley. The afternoon upslope flow appears to be a mechanism for valley ventilation but its effectiveness is reduced by the corresponding downslope flow at night.

16. Tracer released between 2300, July 27, 1979 and 0215, July 28, 1979 aloft into the nocturnal jet northwest of Fresno was transported to the extreme southern end of the San Joaquin Valley by late morning on the day following the release. Essentially none of the tracer was transported to the ground level during the night of the release. Tracer detected at ground level west of Fresno on the night of the release was apparently carryover from the experiment conducted two days previously. The nocturnal jet appears to be an efficient mechanism for transport to the southern end of the valley, but minimal ground level impacts occur until the surface mixing layer deepens during the following day.

17. Tracer released between 1200 and 1725 PDT, July 30, 1979 at Pacheco Pass west of Los Banos was carried aloft due to the convergence of a westerly coastal flow and an easterly valley uplsope flow. Essentially none of the tracer was detected at ground level within the valley.