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OZONE TRANSPORT IN THE NORTH CENTRAL COAST AIR BASIN

Final Report

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ABSTRACT

SRI conducted an experimental study during the period 17 September to 8 October 1980 to examine the transport of air pollutants (principally ozone) into and within the North Central Coast Air Basin (NCCAB). Ozone conditions during the study were the highest ever recorded in the NCCAB. The study employed two inert, nontoxic gaseous tracers (sulfur hexafluoride and bromotrifluoromethane) released at different locations or times on each of eight test days. Up to 1000 measurements of each tracer were made on each test day using aircraft, vehicle, and stationary sampling. Aerometric measurements were made by the airplane and two surface monitoring stations. In addition to the tracer tests, two airborne ozone mapping tests were conducted off the coast from Monterey to San Francisco. The measurements documented significant ozone transport from San Francisco to the NCCAB over the coastal waters and onshore in Monterey Bay. Transport was also documented from San Jose to Hollister through the Santa Clara Valley, although less dramatic than the offshore transport. The Santa Clara Valley transport pattern is impeded and complicated by the complex terrain and meteorology. Significant ozone transport was not observed over the Santa Cruz Mountains between Los Gatos and Scotts Valley although transport of the tracer did occur. The strong marine inversion over the coast on the two relevant test days inhibited elevated emissions from Moss Landing from dispersing to the surface within the NCCAB. Other prevailing meteorological regimes may result in different impacts than those observed during the eight tests. Recommendations are provided for more quantitative and more detailed analyses of the data.

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GLOSSARY

ppt	concentration, parts per trillion
ppb	concentration, parts per billion
SF_6	sulfur hexafluoride
F13B1	bromotrifluoromethane
O_3	ozone
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides (sum of NO and NO_2)
T	temperature
b_{scat}	optical scattering coefficient
PDT	Pacific Daylight Time
msl	mean sea level
agl	above ground level
m	meter
km	kilometer
ADIZ	Air Defense Intercept Zone
kg	kilogram
h	hour
nmi	nautical mile

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I INTRODUCTION

The basic objective of the study was to collect atmospheric data to resolve and quantify the origin and fate of the high surface oxidant concentrations occasionally monitored within the North Central Coast Air Basin (NCCAB). An experimental program was conducted during the period 17 September through 8 October 1980 to measure ambient aerometric parameters as well as the dispersion of two inert tracer gases released at various locations both within and outside the basin.

The NCCAB comprises Santa Cruz, Monterey, and San Benito counties. Four mountain ranges influence atmospheric transport and residence patterns throughout the basin. The northwest sector of the basin is dominated by the Santa Cruz Mountains, which provide a barrier between the northern end of the Monterey Bay region and the southwestern corner of the upper Santa Clara Valley. The Diablo Range marks the northeastern boundary of the NCCAB. Together with the southern extent of the Santa Cruz Mountains, the Diablo Range forms the Santa Clara Valley, which extends into the northeastern tip of the NCCAB. Farther south, the Santa Clara Valley evolves into the San Benito Valley, which runs NW-SE and has the Gabilan Range as its western boundary. To the west of the Gabilan Range is the Salinas Valley, which extends from Salinas at the NW end to King City at the SE end. The western side of the Salinas Valley is formed by the Sierra de Salinas, which also forms the eastern side of the smaller Carmel Valley; the coastal Santa Lucia Range defines the western side of the valley.

Figure 1 illustrates the general location of the NCCAB, while Figure 2 shows the location of the mountain ranges and valleys within the air basin.

Prior to this study, three principal routes had been postulated for atmospheric transport from the San Francisco Bay Area into the NCCAB; these are shown in Figure 3. An additional three transport routes that had been identified within the basin are illustrated in Figure 4. The most frequently discussed interbasin transport route is through the Santa Clara Valley (Number 1 in Figure 3). The northern end of the route is known to be an effective funnel of oxidant and oxidant-precursors into the Morgan Hill area, although a convergence zone in the Gilroy-Hollister area has been postulated to impede or retard the southward transport in that region. The mountain pass that parallels Highway 17 between Los Gatos and Santa Cruz has been identified as another, though less effective, transport route (Number 2). Lastly, there has also been speculation that occasionally high oxidant concentrations along the Monterey Bay from Scotts Valley and Santa Cruz to Monterey and Carmel have been the result of over-water transport down the coast from the San Francisco Area (Number 3).

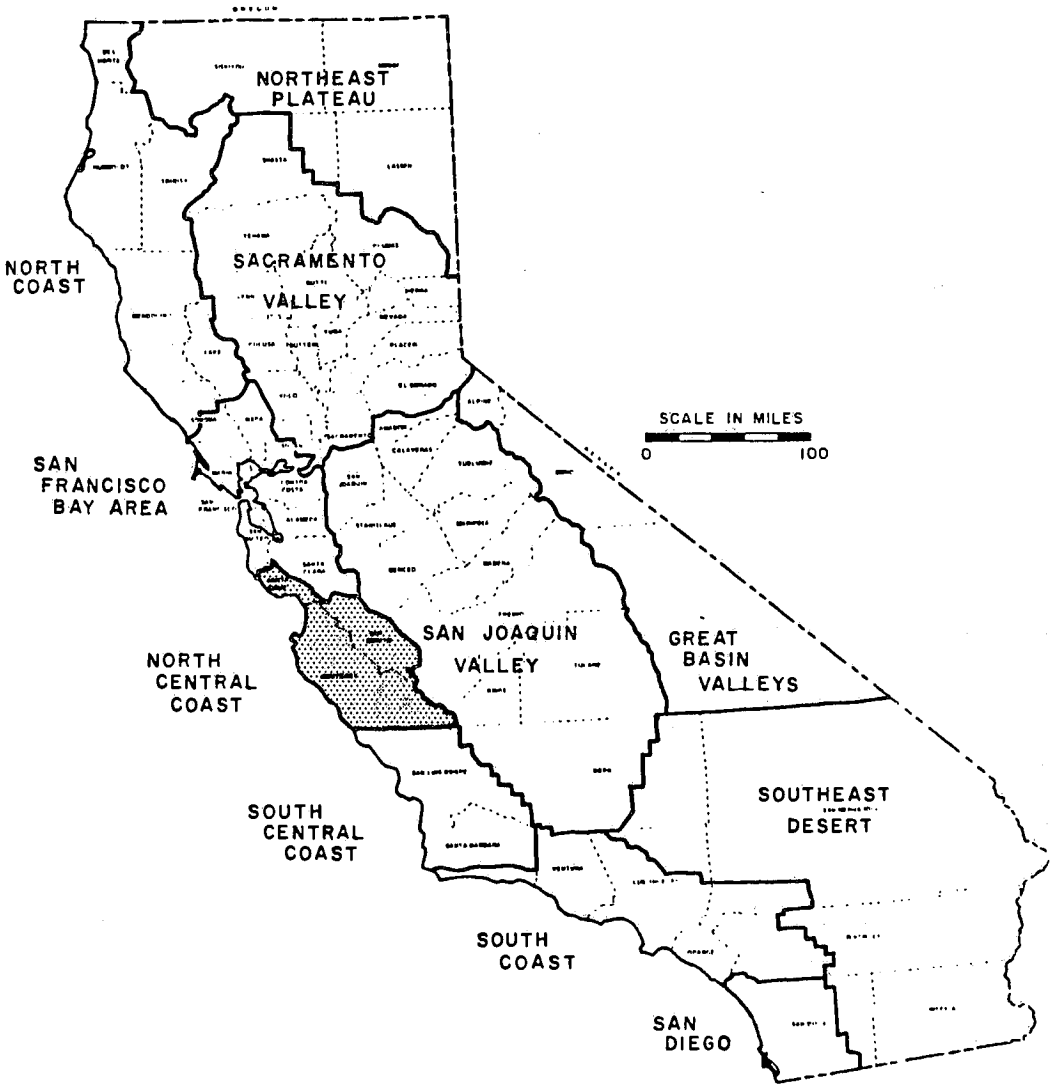
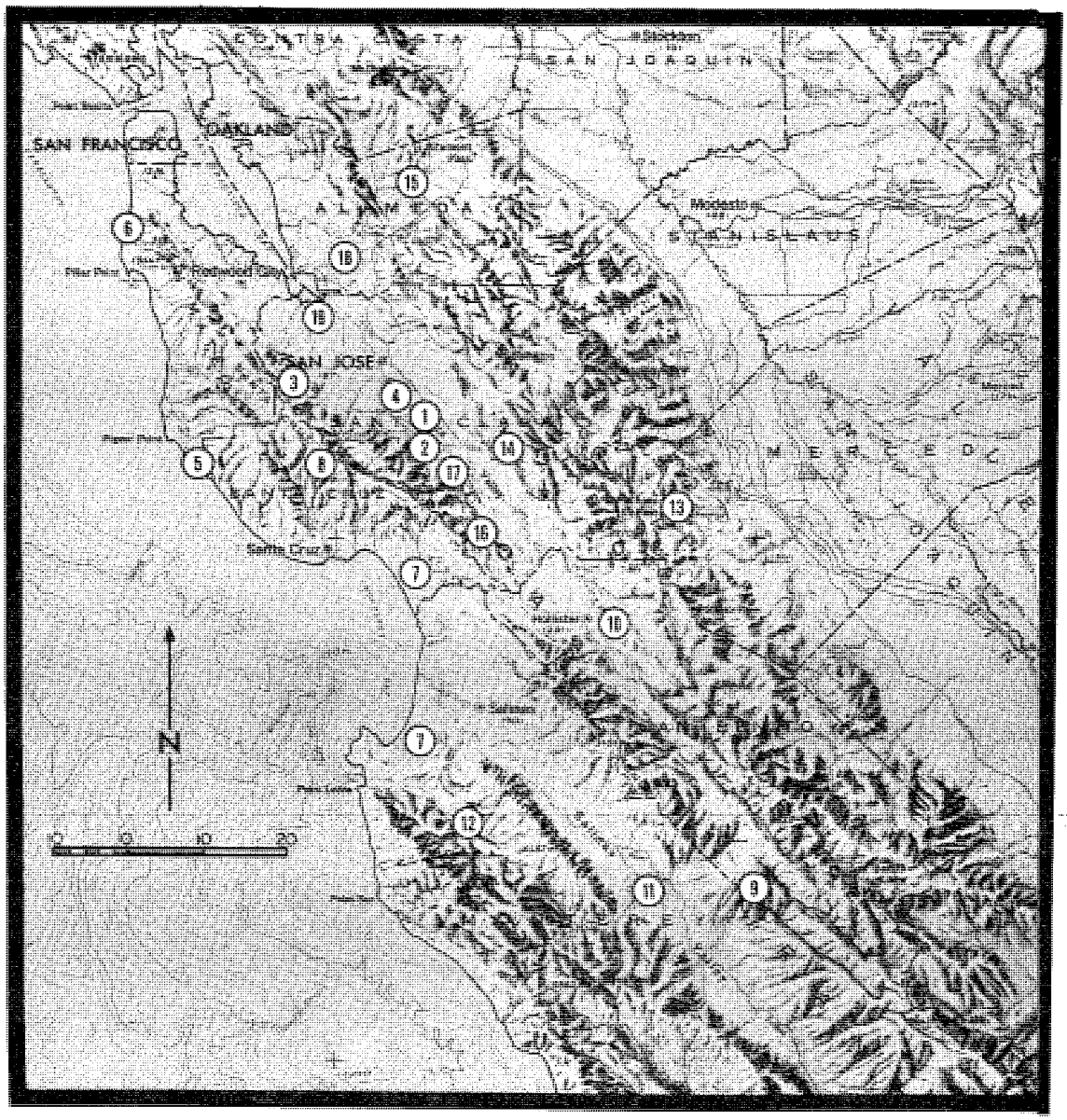


FIGURE 1 LOCATION OF THE NORTH CENTRAL COAST AIR BASIN

GENERALIZED TOPOGRAPHY

NORTH CENTRAL COAST
AIR BASIN



1. SANTA TERESA HILLS
2. CALERO RESERVOIR
3. LEXINGTON RESERVOIR
4. ALMADEN
5. ANO NUEVO RESERVE
6. SAN PEDRO POINT
7. PAJARO COASTAL PLAIN
8. SANTA CRUZ MOUNTAINS
9. SAN LORENZO VALLEY
10. SAN BENITO VALLEY
11. SALINAS VALLEY
12. CARMEL VALLEY
13. PACHECO PASS
14. ANDERSON RESERVOIR
15. LIVERMORE VALLEY
16. HECKER PASS
17. UVAS RESERVOIR
18. MISSION SAN JOSE
19. MOFFETT FIELD

FIGURE 2 TOPOGRAPHY OF THE NORTH CENTRAL COAST AIR BASIN
(see Appendix B for area/road maps)

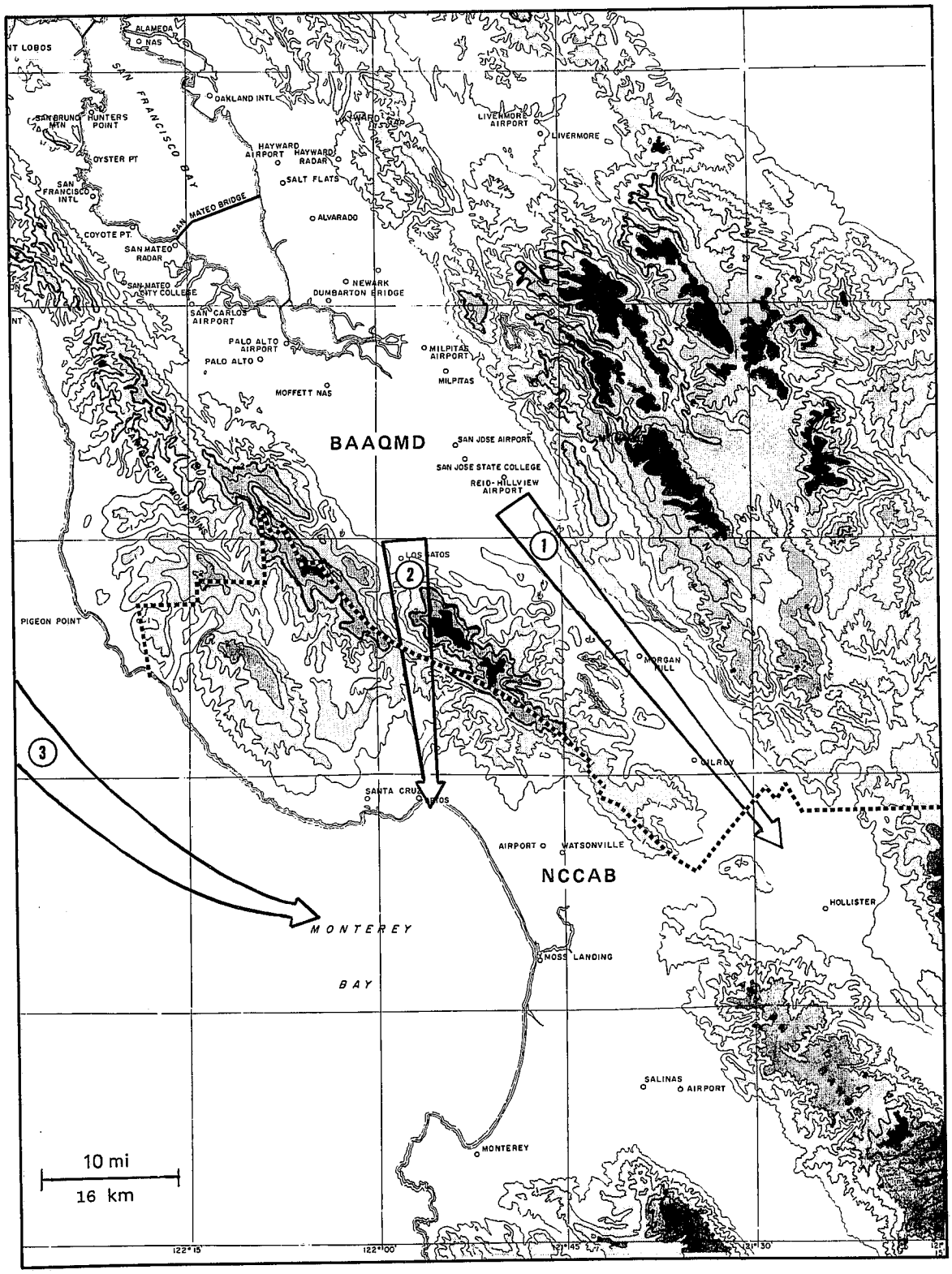


FIGURE 3 POSTULATED TRANSPORT ROUTES FROM SAN FRANCISCO BAY AREA INTO THE NORTH CENTRAL COAST AIR BASIN

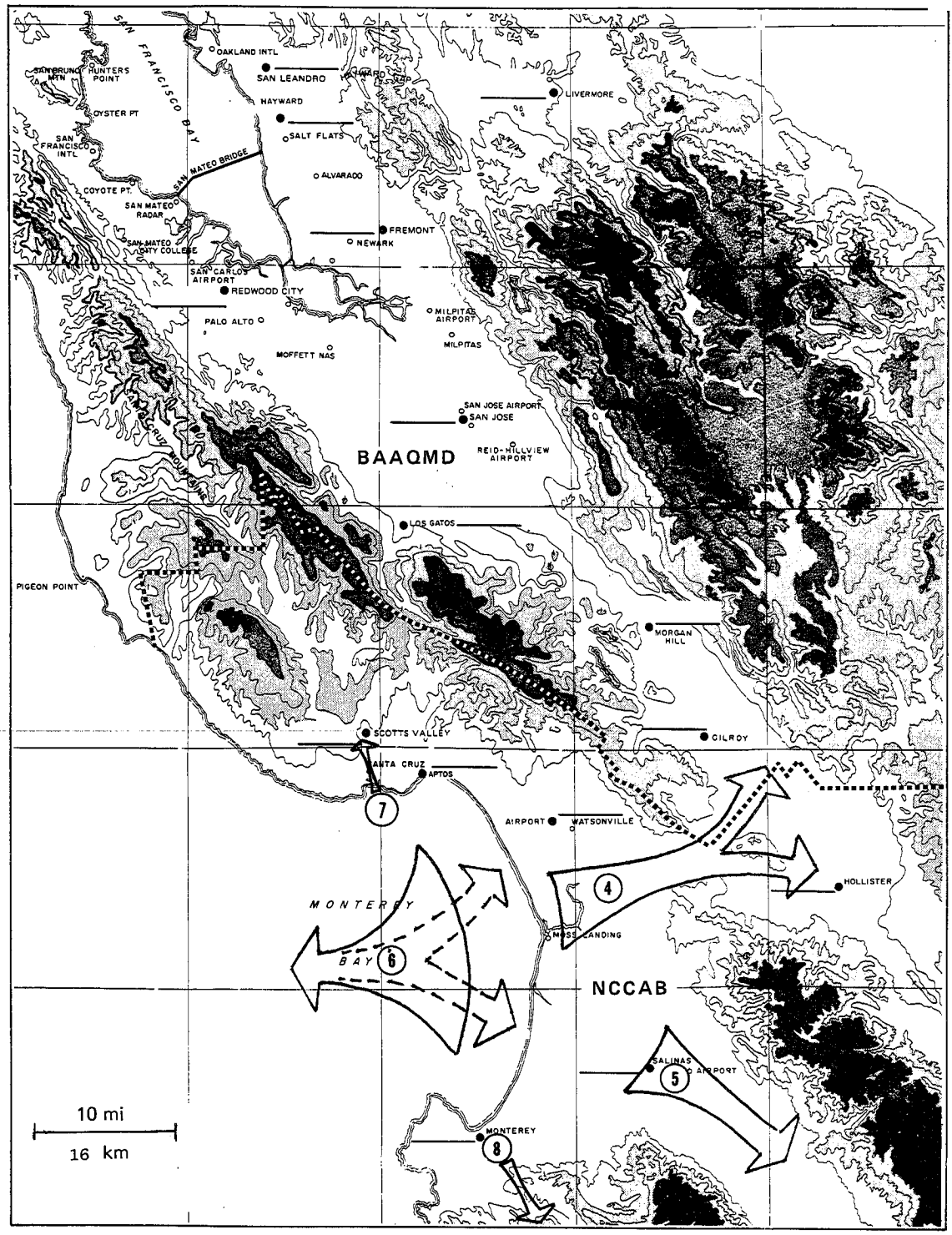


FIGURE 4 POSTULATED TRANSPORT ROUTES WITHIN THE NORTH CENTRAL COAST AIR BASIN

Five routes had also been postulated as significant to oxidant advection within the NCCAB. First, there is transport from Moss Landing to Hollister and Gilroy (Number 4 in Figure 4); this route can converge with the Santa Clara Valley transport route to produce the convergence zone referenced earlier. Second, there is ozone transport down the Salinas Valley toward King City (Number 5). Third, the on- and offshore transport between Monterey Bay and the adjacent coastal plain (Number 6) is in response to the combined effects of the diurnal land and sea breezes and the prevailing synoptic flow. The fourth route (Number 7) is from the Santa Cruz area inland to Scotts Valley, and last, the postulated route (Number 8) inland from Monterey to Carmel Valley.

Prior to this study, the highest oxidant levels on record in the NCCAB occurred during September and October 1976. Peak concentrations in Hollister and Aptos were 14 pphm, while Scotts Valley had the all-time maximum of 21 pphm on 9 September 1976. Synoptic weather patterns showed some similarity on the high-ozone days, and were distinct from the adjacent low-ozone days. Temperatures were warm, but not hot, being generally in the low-to-mid 80s during the peak hours. Winds were light--generally less than 5 knots, although sometimes up to 10 knots. Skies were usually clear in the morning, although some high-ozone days had morning stratus in the coastal regions. The most pronounced similarity was in the surface pressure pattern. Figure 5 shows surface conditions at 0500 PDT, 8 October 1976. The isobars in California reflect the thermal low in the southwest; this pattern was present regularly on all days when Hollister or Aptos experienced ozone levels equal to or greater than 10 pphm. Although the total number of days available for study admittedly was small, the consistency of the correspondence between isobaric pattern and ozone suggests the possibility of determining what synoptic meteorological regimes lead to high ozone in the NCCAB and of identifying the significant transport routes.

A total of eight dual-tracer atmospheric tests were conducted over the period 17 September through 8 October 1980. Table 1 summarizes the characteristics of the tracer release times and locations for the various tests.

Meteorological conditions were ideal for the study insofar as they helped to create perhaps the severest ozone concentrations recorded up to that time within the NCCAB. Four of the test days had ozone concentrations equal to or exceeding the national ambient standard;* four different stations within the basin had these high readings on at least one of the four days. The Watsonville station had high readings on three of the four days and was inoperative on the afternoon of the fourth day. Additionally, five neighboring BAAQMD stations recorded above-standard ozone levels on all four of these days plus two additional days. For

*The national ambient air quality standard for ozone requires the daily peak-hour average concentration not to exceed 12 pphm (240 $\mu g\ m^{-3}$) more than once per year.

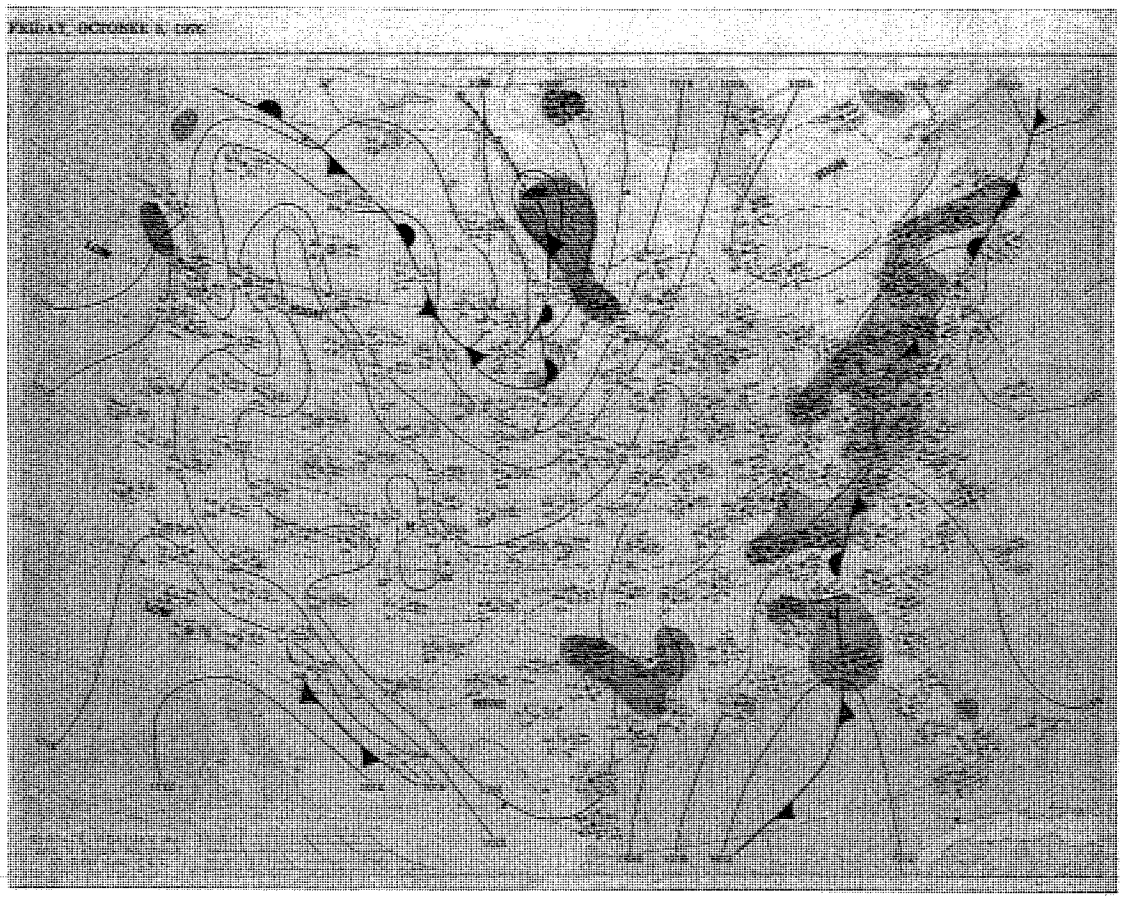


FIGURE 5 SURFACE WEATHER MAP, 0500 PDT, 8 OCTOBER 1976

Table 1

SUMMARY OF TRACER TESTS

Date (1980)	Type of Test	Tracer Release Points*	
		SF_6 †	F13B1 ‡
17 September	Simultaneous, surface, dual-tracer release	Newark (0931-1131)	Cupertino (0936-1136)
22 September	Simultaneous, surface, dual-tracer release	Newark (0900-1100)	Cupertino (0900-1100)
24 September	Simultaneous, surface, dual-tracer release	Fairgrounds, San Jose (0900	Vasona Park, Los Gatos (0900
25 September	Carryover study--surface and aircraft measurements	—	—
26 September	Simultaneous, surface, dual-tracer release	Coyote Park, San Jose (1000-1200)	Vasona Park, Los Gatos (1000-1200)
30 September	Sequential, surface, dual-tracer release	San Jose City College (0900-1100)	San Jose City College (1030-1230)
1 October	Coastal air quality mapping with aircraft	—	—
2 October	Simultaneous, surface, dual-tracer release	Santa Cruz (1030-1230)	Monterey (1015-1215)
6 October	Simultaneous surface and elevated dual-tracer release	Moss Landing, PG&E stack (1049-1249)	Moss Landing, surface (1030-1230)
7 October	Carryover study--surface and aircraft measurements	—	—
8 October	Simultaneous surface and elevated dual-tracer release	Moss Landing, PG&E stack (1100-1300)	Moss Landing, surface (1100-1300)

*Release period (PDT) shown in parentheses

†SF_6 release rate: 26 kg h^{-1} for surface releases
52 kg h^{-1} for elevated releases

‡F13B1 release rate: 34 kg h^{-1} for all tests

orientation purposes, peak-hour concentrations are summarized in Table 2 for each of the test days for all stations in the NCCAB and those that are nearby but within the BAAQMD.

In summary, the study was undertaken at an optimum time for providing data with which to address the principal objectives of the study.

Table 2

PEAK-HOUR OZONE CONCENTRATION (pphm)

Underscores indicate concentrations ≥ ambient standard

Station	Date (1980)										
	17 Sep	22 Sep	24 Sep	25 Sep	26 Sep	30 Sep	1 Oct	2 Oct	6 Oct	7 Oct	8 Oct
Scotts Valley[a]	5	*	8	7	4	*	*	10	7	9	10
Aptos[a]	5	5	8	4	4	11	11	9	6	10	7
Carmel Valley[a]	5	6	6	5	4	10	10	14	7	6	5
Hollister[a]	7	7	8	8	3	14	10	11	10	12	8
Monterey[a]	*	*	*	*	*	*	*	*	6	5	4
Salinas[a]	5	5	7	5	4	9	9	12	6	6	4
Gilroy[b]	8	9	9	10	5	18	20	19	14	13	11
Los Gatos[b]	7	6	11	9	6	16	16	>15†	11	*	12
San Jose (4th Street)[b]	5	7	8	8	5	15	16	17	8	9	5
San Jose (Piedmont Road)[b]	5	9	11	10	6	19	19	19	9	10	7
Watsonville[c]	7	8	10	6	6	12	15	17	9	*	10
Morgan Hill[c]	6	7	9†	*	*	18	20	19	13	*	12

*Missing.

†Some missing afternoon hours.

[a]NCCAB station.

[b]BAAQMD station.

[c]Special, study station.

II CONTINUOUS AEROMETRIC MONITORING

A. Existing Stations

Data from 14 existing air quality monitoring stations were obtained and analyzed for each test day. Six of the stations are located in the NCCAB:

- Scotts Valley
- Aptos
- Salinas
- Monterey
- Carmel Valley
- Hollister.

The remaining eight are in the BAAQMD:

- Gilroy
- Los Gatos
- San Jose
- Redwood City
- Fremont
- Hayward
- Livermore
- San Leandro.

All 14 stations use the ultraviolet photometric principle for measuring ozone. The 14 stations are identified on the base map used in Figures 3 and 4.

B. Special Supplemental Stations

Two special air quality monitoring stations were established for this study: one in Morgan Hill* to fill the gap between Gilroy and San Jose; the other in Watsonville* to fill the void between Aptos, Hollister, and Salinas. The station locations are shown on Figures 3 and 4.* The following measurements were made at both stations:

- Ozone
- Oxides of nitrogen
- Wind speed and direction (10-m height)
- Ambient temperature
- Solar radiation (Watsonville only).

Table 3 lists the instrumentation specifications, while Figure 6 illustrates the 10-m meteorological mast at the Watsonville station. Figure 7 is an illustration of the daily hour-by-hour data summaries prepared for each station (see Volume II).

*The Watsonville station was located about 0.4 km south of the airport and about 1.5 km east of Highway 1. The Morgan Hill station was on the eastern portion of the State Department of Forestry facility, near the intersection of Watsonville Road and Highway (Business) 101.

Table 3

AEROMETRIC INSTRUMENTATION AT THE MORGAN HILL AND WATSONVILLE STATIONS

Parameter	Instrument	Range	Accuracy	Method
O_3	Dasibi Model 1003AH	0-1 ppm 0-2000 $\mu g\ m^{-3}$	±0.005 ppm ±10 $\mu g\ m^{-3}$	UV photometry
NO/NO_x	Monitor Labs Model 8440E	0-0.5 ppm 0-600 $\mu g\ m^{-3}$	±0.005 ppm ±6 $\mu g\ m^{-3}$	Chemiluminescence
Air temperature	YSI linear thermistor in R.M. Young radiation shield (aspirated)	0-100°C	±0.5°C	
Wind speed	R.M. Young Model 35002 propeller vane	0-30 m s^{-1}	±0.2 m s^{-1}	
Wind direction and standard deviation*	R.M. Young Model 35002 propeller vane	0-360°	±5°	
Solar radiation flux	Eppley solar radiometer	0-2 ly min^{-1}	±1 mly min^{-1}	Black and white thermopile
Digital data recorder	Memodyne Corp. cassette recorder			
Analog data recorder (backup)	Esterline Angus Model E1124E Multipoint recorder			

*$\sigma(\theta)$ derived continuously with electronic sigma card.

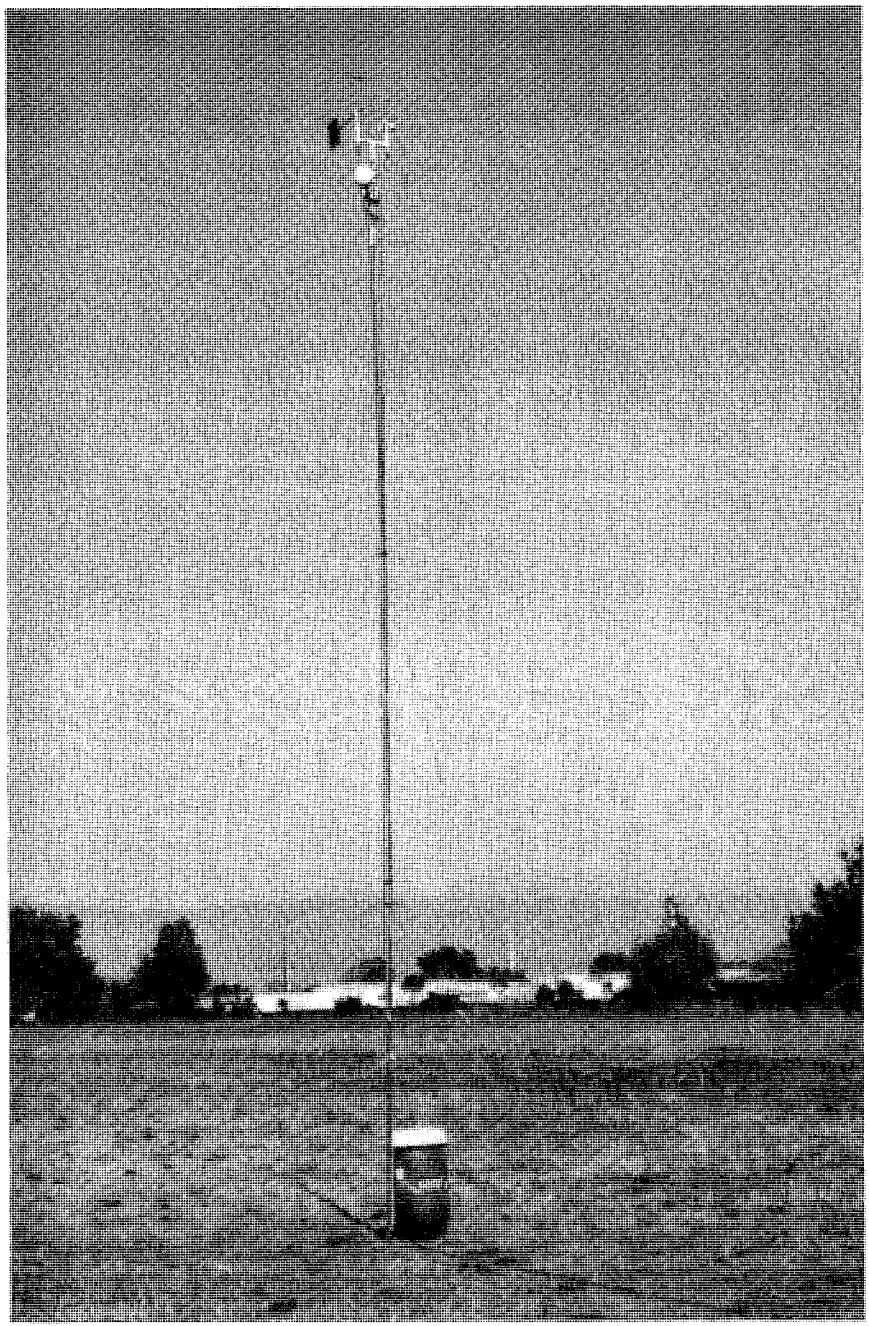


FIGURE 6 10-METEOROLOGICAL MAST AT WATSONVILLE AIR QUALITY AND BASE STATION

HOURLY SUMMARIES FOR WATSONVILLE, CALIF.

DATE (y/m/d)	TIME (PDT)	WIND SPEED (m/s)	WIND DIRECTION (deg)	SOLAR IRRADIANCE (ly/min)	TEMP. (deg C)	NO (ppb)	NO_x (ppb)	NO_2 (ppb)	O_3 (ppb)
801006	0000	.5	223.	0.00	12.9	2.	7.	5.	76.
801006	0100	.6	238.	0.00	12.8	1.	5.	4.	75.
801006	0200	.8	276.	0.00	12.7	1.	5.	4.	74.
801006	0300	.6	254.	0.00	12.6	1.	5.	4.	73.
801006	0400	.8	143.	0.00	12.5	2.	6.	4.	70.
801006	0500	.8	142.	0.00	12.5	1.	6.	5.	72.
801006	0600	.5	151.	0.00	12.3	1.	7.	6.	70.
801006	0700	.6	109.	.00	12.3	2.	16.	13.	55.
801006	0800	.7	210.	.02	12.5	4.	23.	19.	35.
801006	0900	.5	203.	.06	13.3	4.	24.	19.	32.
801006	1000	.7	182.	.14	15.0	6.	27.	20.	33.
801006	1100	1.0	241.	.35	18.4	9.	31.	22.	44.
801006	1200	1.6	174.	.46	22.0	7.	28.	21.	55.
801006	1300	4.8	255.	.45	17.7	4.	16.	12.	68.
801006	1400	4.3	252.	.42	17.1	3.	12.	9.	80.
801006	1500	3.5	229.	.34	17.5	3.	11.	9.	85.
801006	1600	2.6	223.	.17	16.7	2.	13.	11.	84.
801006	1700	2.5	220.	.04	14.1	2.	13.	11.	91.
801006	1800	1.3	172.	.00	13.2	2.	11.	9.	89.
801006	1900	1.0	166.	0.00	12.6	2.	11.	9.	84.
801006	2000	1.0	161.	0.00	12.2	2.	9.	8.	81.
801006	2100	.8	139.	0.00	12.1	2.	17.	16.	61.
801006	2200	.7	147.	0.00	12.1	1.	31.	29.	37.
801006	2300	.8	164.	0.00	12.0	2.	44.	42.	22.

FIGURE 7 SAMPLE DAILY AEROMETRIC DATA SUMMARY FROM WATSONVILLE AND MORGAN HILL STATIONS

III INTENSIVE MONITORING PROGRAM

A. Objectives and Scope

As discussed earlier, the principal objective of this study has been to quantify the origin and fate of ozone and its precursors into and within the North Central Coast Air Basin. To meet this objective, a quasi-controlled atmospheric sampling program was conducted, including

- Controlled release of two gas tracers: sulfur hexafloride (SF_6) and bromotrifluoromethane (F13B1).
- Concurrent release of constant density-altitude balloons.
- Mobile (both aircraft and vehicular) and fixed site sampling for the tracer gases.
- Aircraft aerometric measurements.
- Surface aerometric measurements (described in Section II-B).

The daily schedule was summarized earlier in Table 1; the individual components of the program are described in the following subsections.

B. Gas Tracer and Tetroon Releases

Sulfur hexafluoride (SF_6) and bromotrifluoromethane (F13B1) were released at different locations or times early on each of the eight tracer test days. The gases were released at a constant rate over a two-hour period. The release system is illustrated in Figure 8. Basically, the tracer was emitted from the cylinder in the liquid state and vaporized in a heat-exchange circuit. Flow rates were monitored and controlled with a dry test meter and a metering valve. The cylinder and supporting bracket were mounted on a precision balance; the weight of the cylinder, tracer, and bracket were recorded at 5-min intervals together with gas volume, temperature, and pressure readings from the flowmeter. Figure 9 is an example of the operator's release log from one of the tests.

In all, 10 different tracer release points were used; these are summarized in Table 4 and illustrated on two maps in Figures 10(a) and (b). Release rates were nominally controlled at 26 kg h^{-1} for the SF_6 and 34 kg h^{-1} for the F13B1 for each of the surface releases. Two elevated releases of SF_6 were made through one of the stacks at the PG&E

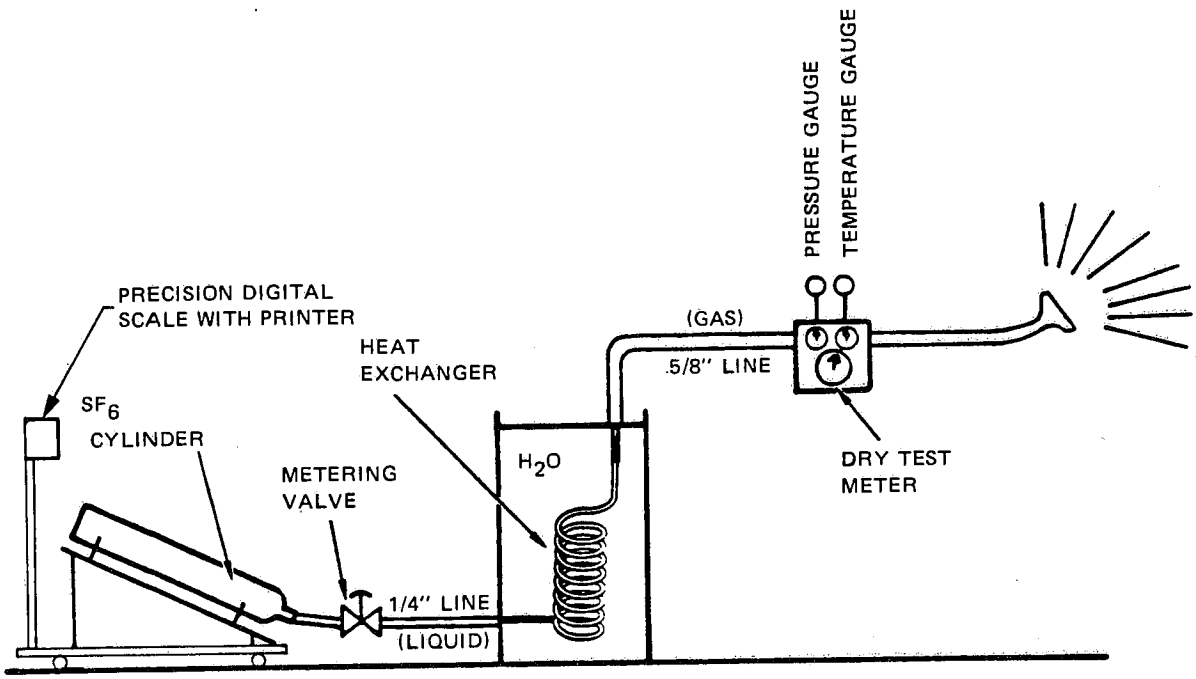


FIGURE 8 TRACER RELEASE SYSTEM

Moss Landing Power Plant, and the nominal release rate was doubled while the release period remained unchanged. The surface release rates were precalculated on the basis of the following assumptions:

- Wind speed of 5 m s^{-1}.
- Maximum afternoon inversion of 750 m.
- Gas chromatograph (GC) detection sensitivity of 2 ppt SF_6 and 6 ppt F13B1.
- Diffusion calculations for a downwind distance of 100 km, assuming a surface-based receptor located two standard deviations from the centerline of a Gaussian plume and a Turner Type-B stability.

Tetroons were launched at each tracer release location midway through the gas release period. The tetrahedral-shaped balloons are 1.5 m on a side and are made of 2-mil mylar; see Figure 11. The very low elasticity and high strength of the mylar maintains nearly constant density of the helium-nitrogen-filled tetroons. The altitude selected was about one-half the height of the marine inversion as determined from the early morning airplane soundings (see Section IV-A); these soundings provided the atmospheric float-level temperature used to obtain the required free lift and superpressure of the tetroon. Although the tetroons are designed to float at a uniform density altitude, their

TRACER RELEASE LOG

LOCATION: Moss Landing

DATE: 10-8-80

OPERATOR: Bruner

TRACER GAS: F13B1

PROJECT: 1898

WEIGHTS: START: 92.5

(Kg) END: 30.6

CHANGE: 61.9

CLOCK TIME (PDT)	VOLUME ( )	VOLUME CHANGE ( )	PRESSURE ( )	VALVE POSITION	TEMPERATURE ( )	REMARKS
1100	92.2	—	28.5 oz	180°	15.5°	Pressure Gauge offset of 18 oz
1105	110.3	17.9	28.0 oz	180°	15.8°	
1110	129.3	19.0	27.0 oz	180°	15.3°	
1115	144.3	15.0	27.0 oz	160°	15.7°	
1120	161.8	17.5	27.0 oz	170°	15.0°	
1125	177.8	16.0	26.5 oz	170°	15.7°	
1130	193.5	15.7	26.5 oz	175°	15.2°	Visit by Chuck Unger
1135	210.0	16.5	27.0 oz	180°	15.0°	
1140	226.5	16.5	27.0 oz	185°	15.0°	
1145	248.8	17.3	28.5 oz	195°	15.0°	
1150	261.0	17.2	28.5 oz	195°	15.3°	
1155	278.1	17.1	28.0 oz	195°	15.7°	
1200	295.3	17.2	28.5 oz	200°	16.0°	
1205	323.4	17.1	28.0 oz	200°	16.0°	
1210	339.4	17.0	27.5 oz	200°	14.5°	
1215	296.0	16.6	27.5 oz	220°	14.5°	
1220	263.1	17.1	27.7 oz	230°	14.3°	
1225	279.6	16.5	27.0 oz	230°	14.3°	end of liquid
1230	284.0	14.4	24.0 oz	-	14.5°	
1235	307.2	13.2	21.5 oz	-	14.5	
1240	313.4	6.2	19.0 oz	-	14.8	Valve opened full
1245	314.9	1.5	18.5 oz	-	15.0	
1250	315.8	0.9	18.5 oz	-	15.2	
1255	316.5	0.7	18.5 oz	-	15.2	end of Release
1300						

FIGURE 9 ACTUAL TRACER RELEASE LOG

Table 4

TRACER RELEASE POINTS

Release Point*	Location
1	Newark; east of Dumbarton Bridge
2	Cupertino; De Anza College
3	Santa Clara County Fairgrounds
4	Los Gatos; Vasona Park
5	San Jose; Coyote Creek Park
6	San Jose; San Jose City College
7	Santa Cruz; Coast Guard Station/lighthouse
8	Monterey; Fisherman's Wharf
9	Moss Landing; PG&E stack
10	Moss Landing; west of Highway 1

*See Figure 10.

height can vary rapidly and greatly--particularly during unstable conditions, when the restoring force of the balloon is exceeded by strong up- and downdrafts.

The position of the tetroons was determined in two ways: visual observation by light aircraft (Cessna 152) of one tetroon, and visual tracking plus radar fixes from SRI's Beechcraft Queen Air aircraft (used primarily for aerometric and tracer sampling). Each balloon was marked to visually designate its origin, while the tetroon tracked by the Queen Air was equipped with a 403-MHz transponder as shown in Figure 12.

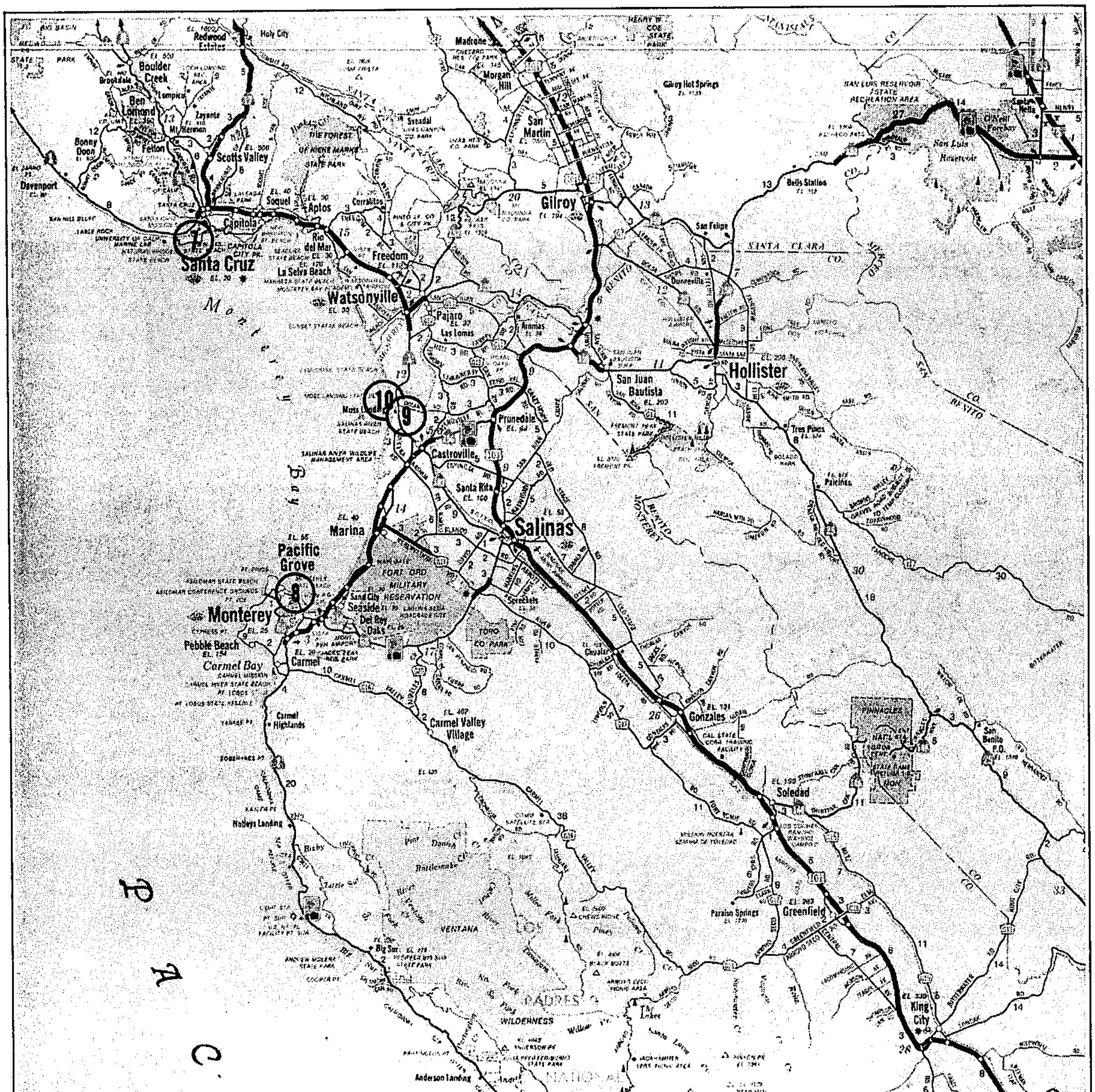
C. Surface Tracer Sampling

Tracer concentrations at ground level were determined by collecting air samples in the field and subsequently analyzing them in a laboratory set up for this purpose adjacent to the Watsonville Airport. Two types of samples were collected:

- Hourly samples collected automatically in 5-liter Tedlar bags at 25 locations by portable, programmable samplers.
- Instantaneous grab samples collected manually in 20-cm^3 disposable syringes by up to four automobiles that traversed the region.

Figure 13 illustrates the 44 sampler locations that were used for one or more of the eight tests. Each sampler collected 12 one-hour samples in sequence, commencing within an hour or so of the end of the two-hour

FIGURE 10a LOCATION OF TRACER RELEASE POINT (see Table 4)



BASE MAP REPRODUCED WITH PERMISSION OF THE CALIFORNIA STATE AUTOMOBILE ASSOCIATION, COPYRIGHT OWNER.

FIGURE 10b (CONCLUDED)

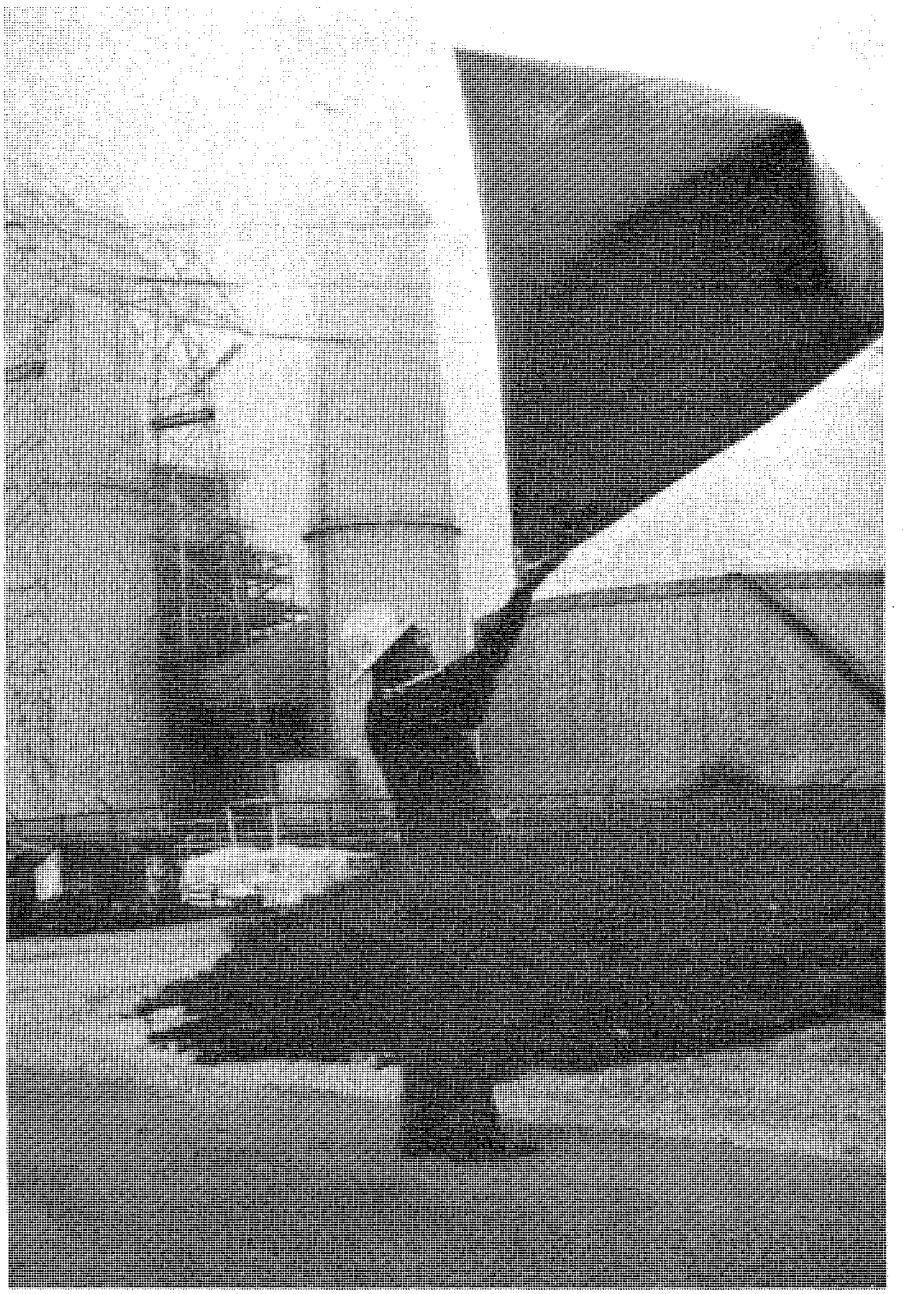


FIGURE 11 TETROON LAUNCHING AT PG&E MOSS LANDING POWER PLANT

Test 1006, 1140 PDT; note upper portion of stacks obscured by fog.

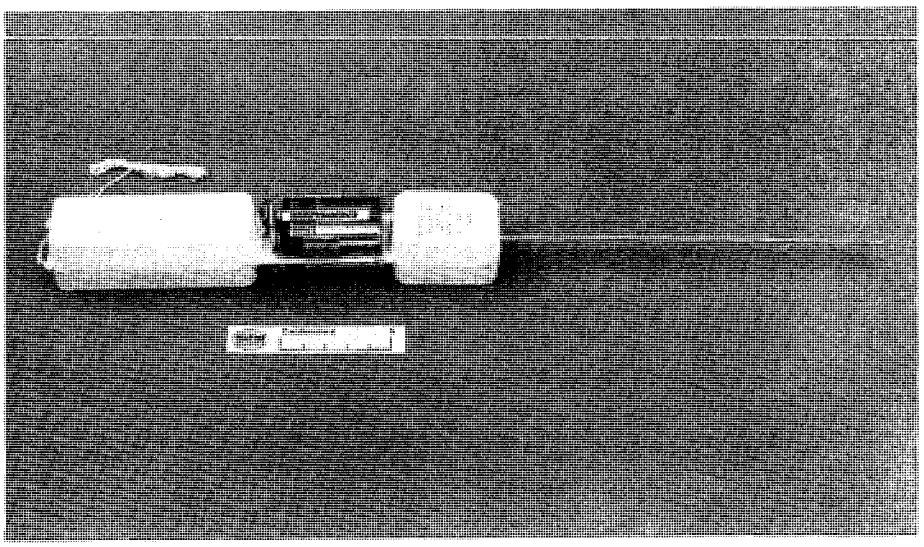
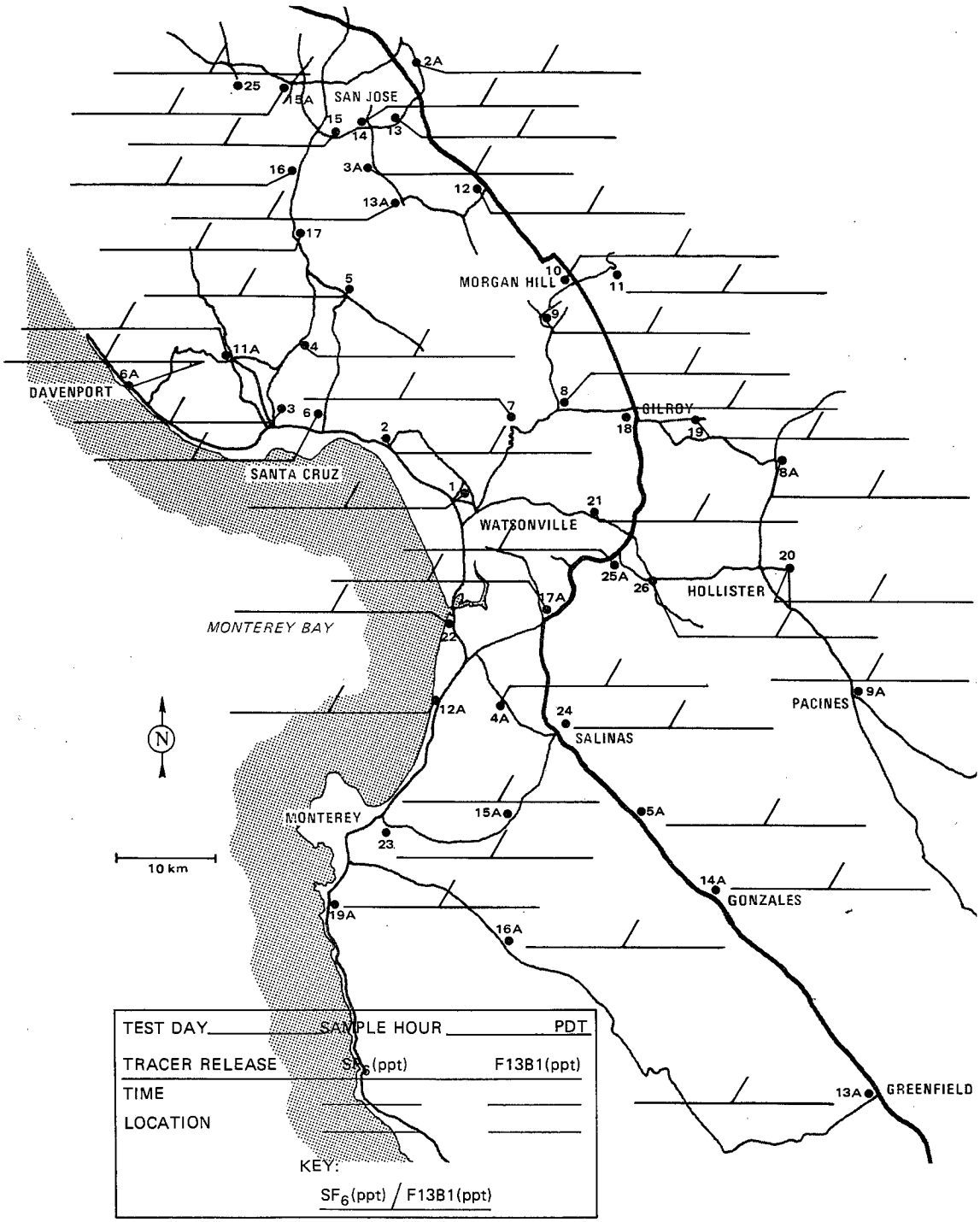


FIGURE 12 403-MHz TETROON-BORNE TRANSPONDER

tracer release period. Figures 14 and 15 illustrate the log sheets used during the deployment and retrieval of the samplers, respectively. Additional details of the construction of the samplers and bags are provided in Appendix A, "Gas Tracer and Analysis Methods."

Instantaneous grab samples were collected in 20-cm^3 disposable syringes by each of up to four sampling crews traversing the area in automobiles. The procedure used to direct and coordinate the sampling is summarized below:

- Air-to-ground radio communication with the two aircraft provided updated information on the two tetroons used in an attempt to physically tag the tracer-laden air parcels.
- Current surface wind conditions throughout the region were transcribed from NOAA weather radio broadcasts.
- With the tetroon and wind data, a projection was made of the likely transport routes for periods of six to eight hours after release of the gas tracers.
- Written instructions were provided each sampling crew, describing the time and route for sampling and the sampling frequency (usually one sample every one or two miles).
- Each sampling crew communicated by telephone with the base in Watsonville so that routes could be modified as necessary.
- All syringes were prenumbered and systematic logs were maintained, indicating the time and location of each sample; Figure 16 illustrates an actual log sheet.



(a) MAP DISPLAY OF SITE NUMBERS

FIGURE 13 LOCATION OF STATIONARY TRACER SAMPLERS (CONTINUED)

NO.	LOCATION	TEST DAYS* 1	2	3	4	5	6	7	8
1	Watsonville Base, Airport Boulevard at Hangar Way	x	x	x	x	x	x	x	x
2	Freedom Boulevard and Highway 1, Aptos	x	x	x			x	x	x
2A	Capitol Expressway (G21) at Cunningham, San Jose				x	x			
3	Highway 17 at Pasatiempo Drive, Santa Cruz	x	x	x		x	x	x	x
3A	Almaden Expressway at Redmond, San Jose				x	x			
4	Santa's Village at Highway 17, Scotts Valley	x	x	x	x	x	x	x	
4A	Cooper Road at Watsonville Highway (183), between Salinas and Castroville								x
5	Summit Road, 1 mile NW of Soquel-San Jose Road, Laurel	x	x	x	x	x	x	x	
5A	101 at Somavia Road, between Salinas and Gonzales								x
6	Soquel-San Jose Road, north of Soquel	x	x	x	x	x			
6A	Highway 1 at Lone Star Industries, Davenport							x	x
7	Mount Madonna	x	x	x	x		x	x	x
8	Highway 152 at G8 (Watsonville Road)	x	x	x	x	x			
8A	Highway 156 at Highway 152						x	x	x
9	Edmundson at Glen Avenue, Morgan Hill	x	x	x	x	x			
9A	Highway 25 at Panoche Road, Pacines						x	x	x
10	Dunne Avenue at Highway 101, Morgan Hill	x	x	x	x	x	x	x	x
11	Dunne Avenue at Anderson Reservoir, Morgan Hill	x	x	x	x	x			
11A	Felton Empire Road at Highway 9, Felton						x	x	
12	Bailey Avenue at Monterey Road, San Jose	x	x	x	x	x			
12A	Reservation Road at Highway 1, Marina						x	x	x
13	Highway 82 at Capitol Expressway, San Jose	x	x	x	x				
13A	McKean Road at Almaden Road, San Jose					x			
13A	Highway 101 at Thorne Avenue, Greenfield						x	x	x
14	Capitol Expressway at Almaden Expressway, San Jose	x	x	x	x	x			
14A	Highway 101 at Johnson, Gonzales						x	x	x
15	Camden at Union, San Jose	x	x						
15A	Highway 280 at Saratoga Avenue, Cupertino			x	x	x			
15A	Highway 68 at Toro Park Estates, between Salinas and Monterey						x	x	x
16	Blossom Hill Road at Vasona Park, Los Gatos	x	x	x	x	x			
16A	Carmel Valley Road at Ford Road, Carmel Valley						x	x	x
17	Highway 17 at Fire Station near Lexington Reservoir	x	x	x	x	x	x	x	
17A	Highway 101 at G12 (San Miguel Canyon Road), Prunedale								x
18	Monterey Road at Highway 152 (Hecker Pass Road), Gilroy	x	x	x	x	x	x	x	x
19	Canada Road east of Highway 152, Gilroy	x	x	x	x	x			
19A	Point Lobos, SW of Entrance to Highway 1						x	x	x
20	Fairview at Sunnyslope, Hollister	x	x	x	x	x	x	x	x
21	Highway 129 at Soda Lake (Riverside Drive)	x	x	x	x	x	x	x	x
22	Moss Landing	x	x	x	x	x	x	x	x
23	Highway 68 just east of Highway 1, Monterey	x	x	x	x	x	x	x	x
24	Natividad Road near East Laurel, Salinas	x	x	x	x	x	x	x	x
25	DeAnza College at Stevens Creek Boulevard, Cupertino				x	x			
25A	Highway 101 at Highway 156, near San Juan Bautista							x	x
26	San Juan Road at Highway 156, San Juan Bautista							x	x

*Test Day	Date (1980)
1	9/17
2	9/22
3	9/24
4	9/26
5	9/30
6	10/2
7	10/6
8	10/8

FIGURE 13 (concluded)
(b) LOCATIONS BY TEST DAY

PAGE _____ OF _____

SAMPLER DEPLOYMENT CHECKOFF LOG

RUN DATE: _____ OPERATOR: _____

SITE	ACTUAL LOCAL TIME (PDT)	INDICATED SAMPLER TIME	ALARM TIME	PUSH START BUTTON (YES?)	CHECK BATTERY (YES?)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					

FIGURE 14 SAMPLE OF SAMPLER DEPLOYMENT LOG

SAMPLER PICK UP LOG

RUN DATE: _____ OPERATOR: _____

SITE	ACTUAL LOCAL TIME (PDT)	INDICATED SAMPLER TIME	ALARM TIME	BAG/SYRINGE CONDITION											
				1	2	3	4	5	6	7	8	9	10	11	12
33															
34															
35															
36															
37															
38															
39															
40															
41															
42															
43															
44															
45															
46															
47															
48															
49															
50															
51															
52															
53															

√ = Bag OK F = Bag Flat O = Bag Over

NOTE: Record Local, Sampler, and Alarm times when each sampler is picked up. Then turn each sampler off. On SRI samplers, close clips (DO NOT remove bags). Record bag/syringe condition when back at base. Hang bags in sampler order and time order.

FIGURE 15 SAMPLE OF SAMPLER PICKUP LOG

VEHICLE SAMPLING LOG

DATE Oct. 8, 1980 PROJECT 1898

OPERATOR Patti

CHECK POINT odometer DIRECTION OF TRAVEL circle (CW)

TIME (PDT)	SYRINGE # ( )	MILES FROM CHECK POINT ( )	TRACER COUNTS SF_6	F_{131B}	COMMENTS
3:00	V817	620			17 North
3:02	V818	622			Santa's Village
3:05	V819	624			
3:08	V820	626			
3:10	V821	628			17 near Summit Rd.
3:13	V822	630			Summit Road east
3:15	V823	632			
3:18	V824	634			Soquel - San Jose Road South
3:21	V825	636			
3:26	V826	638			
3:28	V827	640			
3:31	V828	642			
3:37	V829	644			HW 1 North
3:40	V830	646			
3:43	V831	648			near Mission & HW 1
3:46	V832	650			Safeway on Mission

FIGURE 16 ACTUAL AUTOMOBILE SYRINGE LOG

- Before taking a sample, the syringe was expunged of air two or three times; the syringe was capped immediately after taking the sample to eliminate dilution (through diffusion) and contamination. Syringes were not reused.

D. Tracer Analysis

A building was rented adjacent to the Watsonville Airport for use as a field tracer analysis laboratory; it also served as a staging area, communication center, and air quality monitoring station. The bag and syringe samples were analyzed using two Perkin-Elmer Model 3920 dual-channel gas chromatographs equipped with variable-pulse electron capture detectors and 120-mesh 5A molecular sieves. The outputs were recorded on strip charts and automatically integrated. Multipoint calibrations for both tracers were made before and after each test series. Details of the procedures used are given in Appendix A. Figure 17 shows the analysis setup in the field.

E. Airborne Aerometric and Tracer Sampling

1. Instrumentation

The airborne sampling platform used was SRI's twin-engine Beechcraft A-80/8800 Queen Air. It provided three general types of measurements:

- Meteorological--temperature, dewpoint, turbulence, altitude.
- Air quality--ozone, nitric oxide, oxides of nitrogen, light-scattering aerosols, and cannister samples for hydrocarbon speciation.
- Tracer--20-cm^3 syringe grab samples for SF_6 and F13B1 analysis.

The aircraft has a payload capacity of 820 kg (1825 lb) and provides power for the monitoring instrumentation through 2000-W inverters in addition to 40 A of 24-V aircraft systems power. The inlet for the sampling manifold is located in the nose of the aircraft and protrudes into the free airstream. Air is ducted straight back from the nose to the cabin of the aircraft where the aerometric instrumentation is located along the floor of the aircraft. Figure 18 shows the exterior of the aircraft and the interior instrumentation.

The instruments aboard the aircraft included aerometric instrumentation, weather radar used for tracking of the transponder-equipped tetroons, and communication equipment that linked the aircraft directly with the base station near the Watsonville Airport.

Table 5 summarizes the aerometric measurements. Included are aircraft auxilliary and meteorological measurements, atmospheric gas-concentration measurements, and the aerosol and special measurements

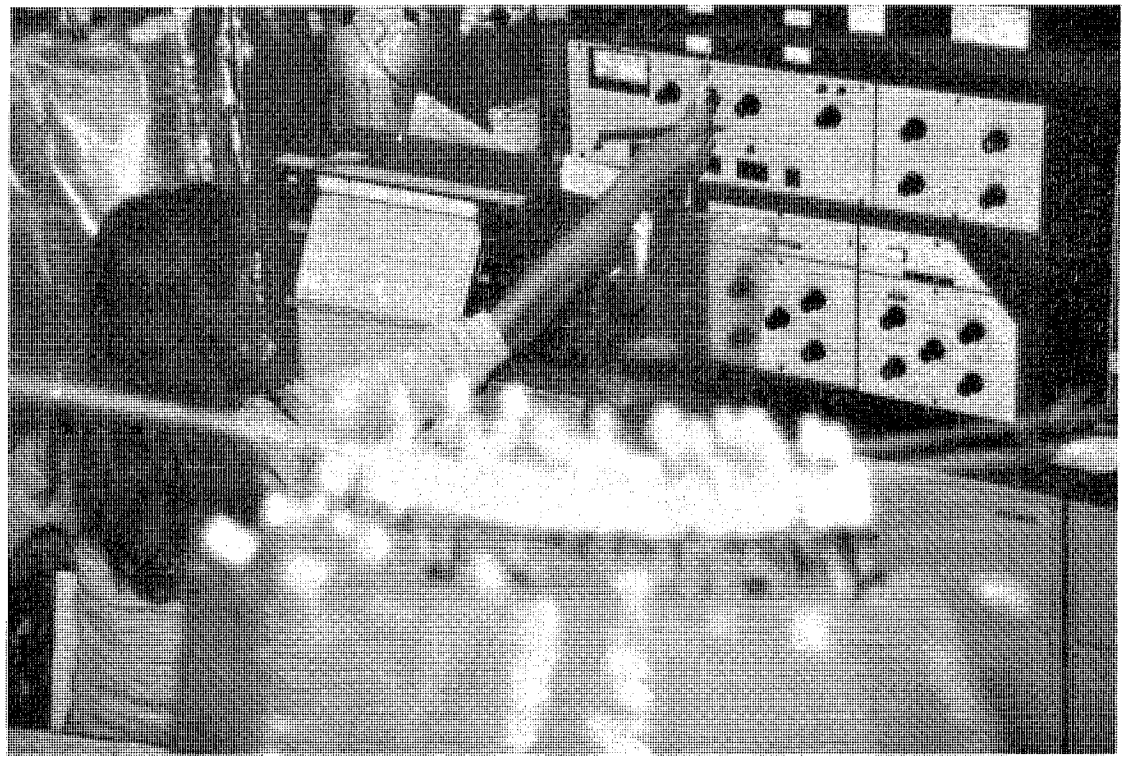


FIGURE 17 GAS TRACER ANALYSIS INSTRUMENTATION IN WATSONVILLE FIELD LABORATORY

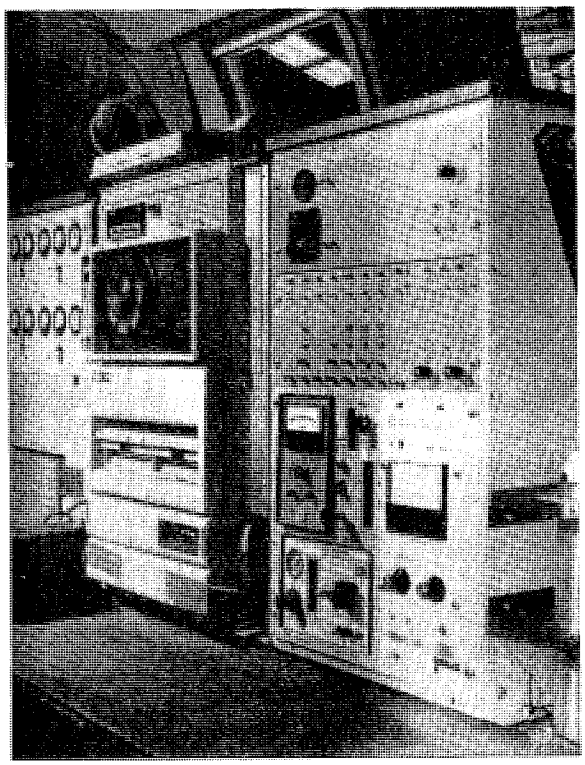


FIGURE 18 SRI QUEEN AIR A-80/8800 AND AEROMETRIC/RECORDING INSTRUMENTATION

Table 5

AEROMETRIC MEASUREMENTS ABOARD SRI QUEEN AIR

Variable	Instrument
Aircraft auxilliary and meteorology	
Horizontal position (x,y)	Two VORS; one DME
Air speed	Aircraft systems
Pressure/altitude (z)	Validyne pressure transducer
Turbulence	MRI turbulence indicator
Air temperature	Rosemont resistence wire probe
Air humidity (dew point)	General Eastern Model 1011 dewpoint hygrometer
Atmospheric gas concentration	
O_3 (ozone) baseline monitor	Dasibi Model 1003 AH
NO/NO_x	Monitor Labs Model 8440 E
Atmospheric aerosol concentration	
Aerosol light scattering	MRI Model 1592 nephelometer
Special measurements	
Tracer gas	Syringe sampler
Background hydrocarbon	Pressurized container

(i.e. tracer gases and background hydrocarbons). Turbulence measurements were made using a pitot tube mounted on the wing. The air temperature and humidity sensors were mounted in the nose of the aircraft. The atmospheric gas monitors were mounted in the rear cabin of the aircraft and sampled air from the manifold connected to the nose inlet. A nephelometer sampled air from the sampling manifold just before it exited the aircraft through a port in the tail of the aircraft. Between the gas instrumentation and the nephelometer, a syringe-sampling board was mounted to enable the instrument operator to take up 12 samples sequentially from the air flowing through the manifold. This was facilitated using a modular sampling board containing 12 syringes and a section of manifold that slid into a bracket mounted on the aircraft floor. With the sampling board in place, it became a portion of the aircraft-sampling manifold. A schematic diagram of this unit is presented in Figure 19, which also shows the sample timer. This simple electronic timing device operates a buzzer at selectable time intervals so that the instrument operator can space the syringe samples evenly as the aircraft passes through the volume of the air to be sampled.

The analog signals produced by the aerometric and meteorological equipment aboard the aircraft were digitized and recorded both on nine-track magnetic tape and on analog strip chart. The data were digitized once each second and were subsequently averaged over 11-s periods. A sample of data reduced from a typical flight is presented in Table 6.

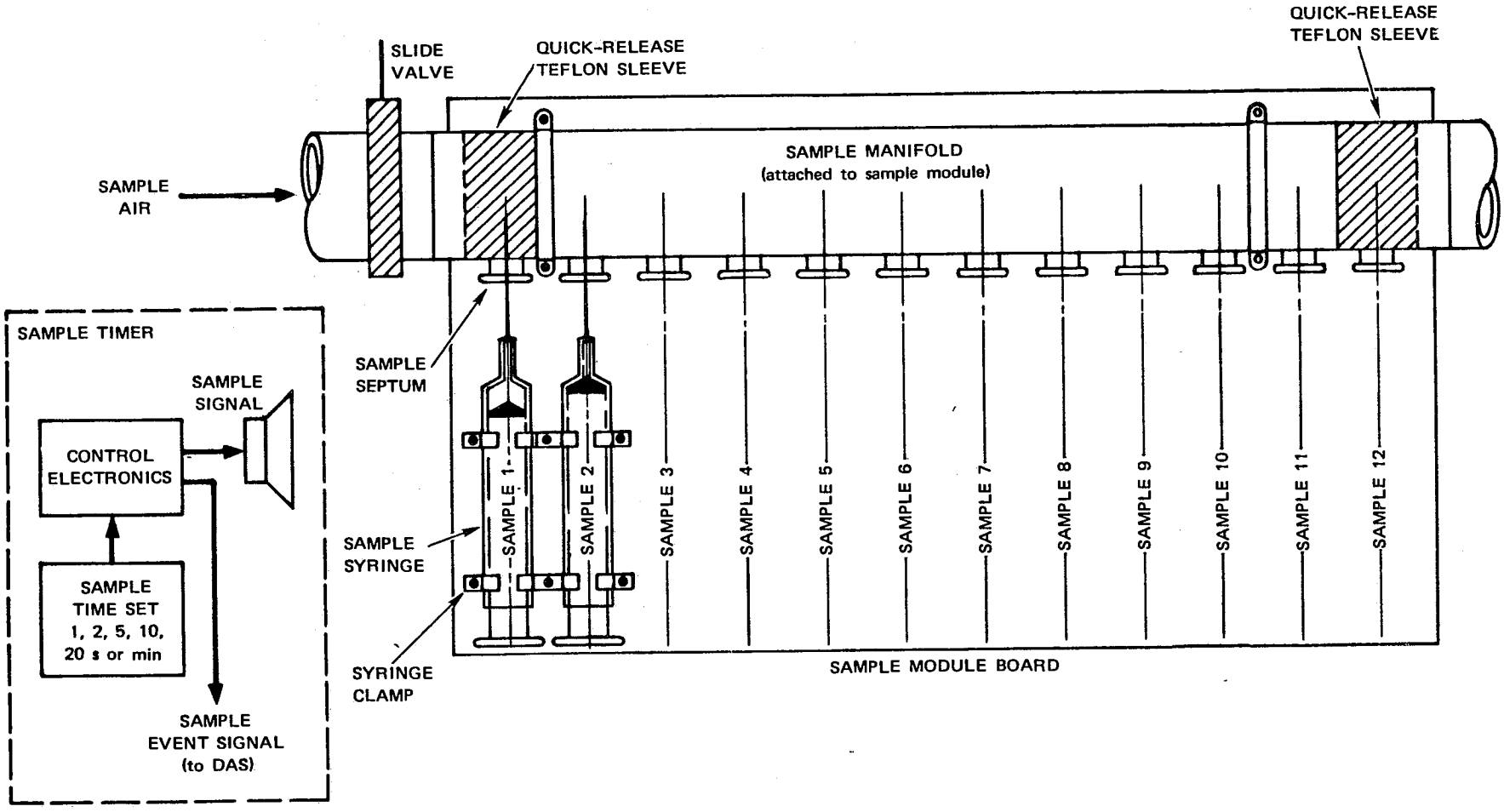


FIGURE 19 MANUAL TRACER SAMPLE MODULE

Table 6

EXAMPLE OF AEROMETRIC DATA COLLECTED BY SRI QUEEN AIR

DATE: 06-OCT-80
LOCATION: HOLLISTER
PASS NUMBER: 2 PASS TYPE: SPIRAL

START TIME: 73200 PDT STOP TIME: 74100 PDT

PARAMETER AVERAGE LIST: -999.9 = INVALID DATA

TIME (PDT)	O3 PPB	NO PPB	NOX PPB	TEMP DEG C	TURB R UNITS	AS KM/HR	BSCAT 10-4/M	ALT M
7:32:22	78.0	5.2	3.3	25.47	0.1	393.5	0.20	1583.8
7:32:33	75.6	5.4	2.3	25.47	0.2	399.6	0.21	1572.9
7:32:44	75.3	5.3	3.3	25.90	0.1	423.9	0.22	1537.3
7:32:55	75.1	5.3	3.8	26.30	0.1	425.4	0.21	1516.5
7:33: 6	75.1	4.7	4.6	26.20	0.1	410.1	0.22	1513.0
7:33:17	74.8	5.4	3.2	26.53	0.1	429.3	0.21	1486.1
7:33:28	74.5	5.2	4.0	27.00	0.1	448.0	0.21	1442.3
7:33:39	74.3	5.1	4.5	27.32	0.1	448.4	0.22	1420.2
7:33:50	75.6	4.0	2.9	27.28	0.1	436.2	0.22	1405.0
7:34: 1	84.9	5.4	3.0	27.17	0.1	422.8	0.23	1378.6
7:34:12	85.9	3.6	2.8	27.51	0.1	425.4	0.23	1333.0
7:34:23	85.6	3.3	4.6	27.97	0.1	427.3	0.24	1284.8
7:34:34	85.3	4.5	4.6	28.02	0.1	421.2	0.24	1250.3
7:34:45	84.8	2.5	4.6	28.34	0.2	421.9	0.24	1208.0
7:34:56	84.2	3.8	3.9	28.73	0.3	412.8	0.23	1167.3
7:35: 7	82.1	4.7	3.5	28.94	0.1	407.1	0.23	1131.3
7:35:18	83.7	4.9	4.3	29.23	0.2	408.2	0.23	1092.2
7:35:29	86.9	2.6	4.6	29.45	0.5	407.5	0.25	1044.1
7:35:40	88.9	2.6	4.6	29.50	0.4	396.9	0.25	1005.9
7:35:51	88.5	3.2	4.2	29.52	0.2	398.4	0.25	970.7
7:36: 2	89.5	4.8	4.1	29.46	0.1	406.1	0.25	938.6
7:36:13	92.2	3.0	3.6	29.30	0.1	395.7	0.22	921.7
7:36:24	93.8	3.2	2.4	29.03	0.2	381.9	0.22	899.6
7:36:35	76.0	3.0	2.5	28.63	0.8	393.9	0.22	864.9
7:36:46	76.0	4.9	3.2	28.93	0.9	400.5	0.19	839.7
7:36:57	72.2	4.9	2.9	29.28	0.5	395.4	0.17	808.0
7:37: 8	50.6	3.1	2.3	29.57	0.2	394.5	0.16	772.9
7:37:19	50.4	3.2	1.7	29.61	0.1	400.3	0.17	737.8
7:37:30	54.9	5.1	2.3	29.54	0.2	409.0	0.19	701.3
7:37:41	67.5	3.5	2.3	29.48	0.2	416.7	0.20	666.2
7:37:52	67.3	4.0	3.3	29.01	0.1	420.6	0.24	642.6
7:38: 3	73.8	2.6	4.6	28.30	0.2	425.9	0.24	615.4
7:38:14	84.3	3.0	4.0	26.68	0.3	429.7	0.21	582.9
7:38:25	83.9	2.5	2.4	24.19	0.2	430.8	0.22	551.2
7:38:36	74.5	2.5	3.2	22.35	0.1	411.4	0.26	540.8
7:38:47	66.1	3.0	5.8	19.61	0.2	416.0	0.31	509.1
7:38:58	66.0	1.9	6.9	18.14	0.2	402.1	0.34	494.4
7:39: 9	69.3	2.5	8.3	15.16	0.4	401.4	0.37	470.1
7:39:20	71.0	3.1	7.3	13.00	0.7	376.0	0.36	460.1
7:39:31	71.5	3.5	7.3	13.56	0.7	346.2	0.37	464.4

Approximately three cannisters were filled on each test day while flying over the San Jose portion of the San Francisco Bay Area; the cannisters were subsequently turned over to the Bay Area Air Quality Management District for analysis by Washington State University. The samples were taken as a courtesy to the District for use in their hydrocarbon speciation study.

Figure 20 illustrates the aircraft check sheet that was filled out for each flight, while Figures 21 and 22 are samples of the log sheets used to identify the time and location of the syringe samples taken during spirals and traverses, respectively.

The sample air for the hydrocarbon canister samples was extracted from the sampling manifold using a Teflon probe. The sample air was then passed via Teflon tubing to the inlet side of a stainless steel bellows pump (Metal Bellows Pump Model MB-158 equipped with a 24-V motor). Sample air passed from the outlet of the bellows pump to the inlet of a 6-liter canister through a Teflon tube and stainless steel valve. An outlet on the canister enabled sample air to be passed through the canister. This canister outlet was equipped with another stainless steel valve that vented to the atmosphere. Sampling was initiated by connecting the tubing from the outlet of the metal bellows pump to the inlet valve of the canister, opening the inlet and outlet valves and starting the pump. Air was then flushed through the canister long enough to guarantee at least five exchanges of air in the canister at the nominal sampling rate of 30 liters per minute. This required approximately 1 minute, although air was usually permitted to flow through the canister for up to 10 minutes for some samples. Sample flows for the canister samples were measured with a Kurz Model 543 portable mass flow meter.

2. Sampling Procedures

Two basic sampling procedures were used by the sampling aircraft:

- Horizontal traverses through the plume at multiple levels
- Spirals through the planetary boundary layer.

Typically, each test day began with a series (usually three) of spirals at area airports; ascent rates were about 150 m min^{-1} to/from a maximum altitude of 1500 m. The lower height of the spiral was restricted on several flights because of early-morning stratus. These flights generally were conducted between 0630 and 0800 PDT, and served two purposes:

- To define ambient background meteorological and air quality conditions prior to the onset of the daytime photochemistry.
- To provide temperature structure information with which to determine the height at which the tetroons would be flown, and to specify the required free lift and superpressure.

Field Q.C. ____ _____

SYSTEMS CHECK SHEET

Date _____ Tape Start Time _____ Preflight ☐

Tape _____ Visibility _____ In-flight ☐

Project _____ Ceiling _____ SF_6 Samples Start # _____ Stop # _____

Location _____ Wind _____ Takeoff Time _____

A/C Crew _____ Temp. _____ Landing Time _____

Time Zone _____ Alt. Setting _____ Tape Stop Time _____

CH#	D.L.	SRI	Check	CH#	D.L.	SRI	Check	CH#	D.L.	SRI	Check	
01			Altitude:	08			Dew Point:	15			NO Meter: NO Range	Span: Zero:
02			Air Speed:	09			Solar Up:	16			NO_x Meter: NO_x Range:	Span: Zero:
03			Turbulence:	10			Solar Down:	17			O_3(1):	Span: Zero:
04			VOR1 Freq: VOR:	11			UV Up:	18			O_3(2):	Span: Zero:
05			VOR2 Freq: VOR:	12			O_3(1) Flag:	19			SO_2: SO_2 Range:	Span: Zero:
06			DME Freq: Distance:	13			O_3(2) Flag:	20				
07			Temperature	14			SF_6 Flag:	TAPE RUNNING: ☐ PREFLIGHT ☐ PRIOR TO TAKEOFF ☐ OTHER				

CH#	D.L.	SRI	Check	CH#	D.L.	SRI	Check	CH#	D.L.	SRI	Check	
21			Neph/Cal: Range:	28				35				
22			CNC: Range:	29				36				
23			CNC Range:	30				37			< 3 μ	
24				31				38			> 3 μ	
25				32				39			TOTAL	
26				33			Event:	40				
27				34			Tape #:	PRESSURE _____ PSI N_2 PRESSURE _____ PSI AMOUNT OF DRIERITE REMAINING _____ o/o				

FIGURE 20 SAMPLE OF QUEEN AIR SYSTEMS CHECK SHEET

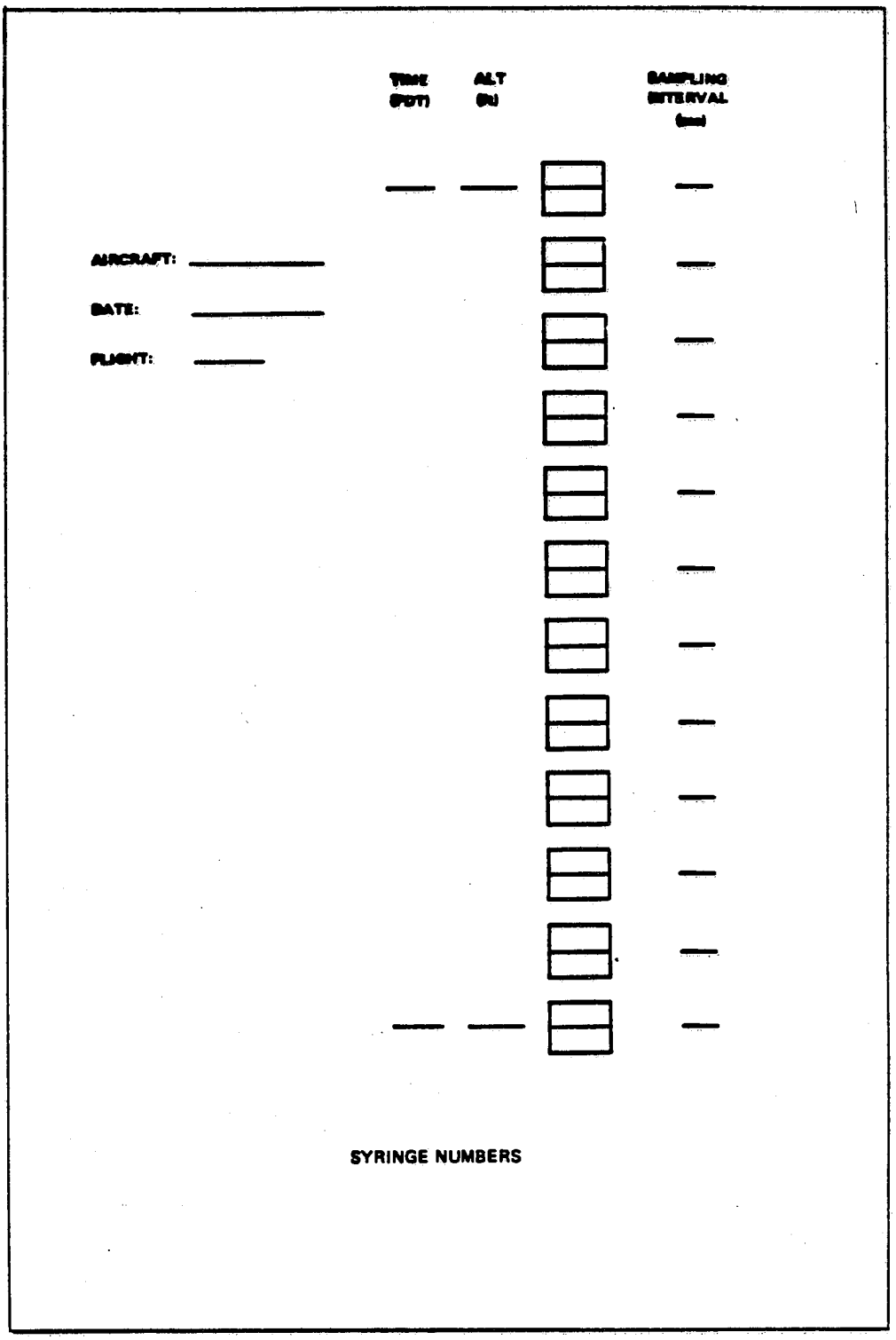


FIGURE 21 SAMPLE AIRCRAFT SYRINGE LOG SHEET FOR SPIRALS

AIRCRAFT: _____ DATE: _____ FLIGHT: _____

TIME (PDT)	ALT (ft)	END POINT A											END POINT B	SAMPLING INTERVAL (sec)	TIME (PDT)
—	—													—	—
—	—													—	—
—	—													—	—
—	—													—	—
—	—													—	—

SYRINGE NUMBER

FIGURE 22 SAMPLE AIRCRAFT SYRINGE LOG SHEET FOR TRAVERSES

Spirals were also flown around midday at two or three locations and again in the late afternoon. The primary purpose of these spirals was to document meteorological and air quality conditions, although syringe samples were taken when the spiral location was within the area of the tracer plume(s).

Horizontal traverses were (usually) made at up to three heights, at roughly equidistant height intervals up to the marine inversion. The traverses consisted of the collection of 12 syringe samples at equal time (and distance) intervals perpendicular to the plume's transport direction when it could be determined. Additional samples were taken when longer traverses were made. When the plume transport was ill-defined, traverses were made along routes perpendicular to each other.

Flight maps were prepared for each day, indicating the location of traverses and spirals made on that day. Corresponding tables (as illustrated in Figures 21 and 22) indicated the time, altitude, and number of syringe samples for each maneuver.

F. Mobile Surface Ozone Sampling

Members of the CARB staff* operated a Dasibi ozone monitor in a vehicle on most test days. The data were recorded on a stripchart recorder. Two persons operated the system: While one drove, the other annotated the chart and collected syringe samples for subsequent tracer analysis. Only data collected on very lightly traveled roads were processed to avoid unrepresentative data resulting from ozone scavenging by nitric oxide. These mobile "grab" data have been included on the hourly surface ozone maps along with measurements from the routine air quality monitoring stations; the grab measurements are indicated by the asterisk that accompanies each datum.

*Both the Research Division in Sacramento and the Planning Division in Berkeley.

IV SUMMARY OF THE INTENSIVE TEST-DAYS

A. Introduction

The sequence of activities on each test day is illustrated schematically in Figure 23. Daily weather and air pollution forecasts were prepared with the help of the Bay Area Air Quality Management District staff in San Francisco and the CARB staff in Sacramento. Weather maps, pollution summaries and outlooks, and teletype forecast information were transmitted daily to the Watsonville base station via telephone facsimile recorder. A tentative commitment was made late afternoon on the day before a test, and preliminary preparations were made that evening. In the early morning, aircraft spirals were made while the updated weather/pollution forecast was reviewed. Air samplers were then programmed and deployed. At the same time, the tracer releases were initiated; midway through the releases, tetroons were launched from each tracer release site. Shortly after completion of the tracer release, sampler deployment was completed while the midday sequence of aircraft ambient aerometric mapping spirals began. Air sample collection at the

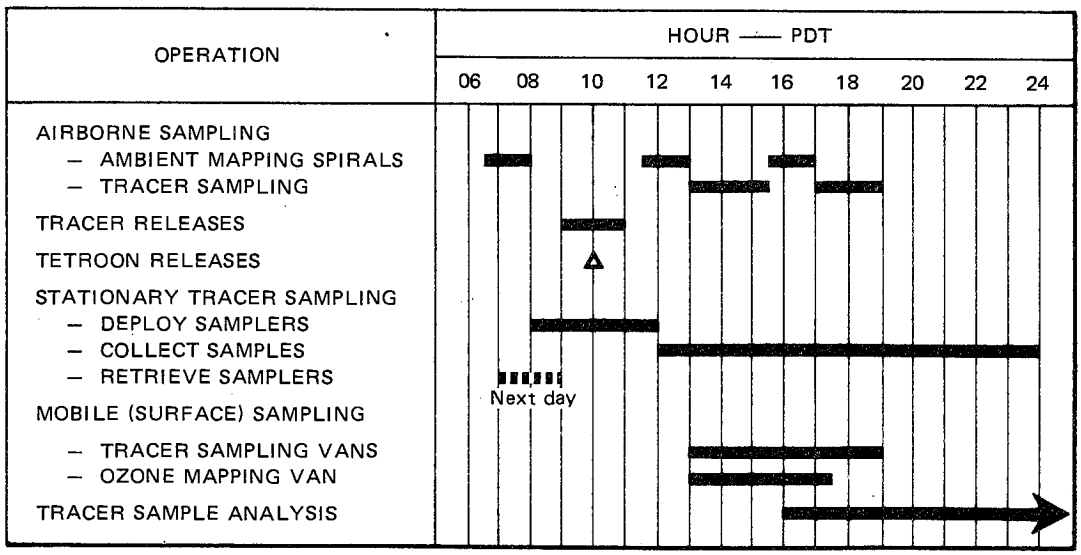


FIGURE 23 NOMINAL TEST-DAY ACTIVITY SCHEDULE

fixed array started about one hour after the end of the tracer release. About two to three hours after the end of tracer release, the mobile syringe-sampling and ozone-mapping crews began their sampling program. The aircraft, syringe and ozone mapping continued until about 1800 to 1900 PDT, while the fixed-point tracer sampling continued until the end of the 12-hour sampling period (usually about midnight).

Meteorological conditions varied widely over the nearly one-month period of testing. Figure 24 illustrates the day-to-day variation of several key meteorological and air quality parameters throughout the period. The ozone concentration in the illustration is the peak hourly value at Gilroy, which is representative of maximum concentrations in the study region (see Table 2). Temperature is the 12Z (05 PDT), 850-mb value on the Oakland RAOB, and winds are the 850-mb winds from the 00Z Oakland sounding (i.e., 17 PDT); westerly and southerly wind components are denoted as positive values. Surface pressure differences (12Z) between San Francisco (SFO) and Reno (RNO), Las Vegas and Los Angeles were evaluated to determine which station-pair best represented the presence and intensity of the thermal trough historically associated with episodes of high ozone concentration; the SFO-RNO difference was selected and is plotted in Figure 24(a).

Ozone varied throughout the period from generally low concentrations during the first 14 days to very high values during the last 10 days, when 7 days equalled or exceeded the peak-hour standard of 12 pphm. Both temperature and pressure difference are highly correlated with the ozone variations. During the 10-day high-ozone episode, 850-mb temperature was consistently more than one standard deviation above the climatic mean of 15.3°C for the period mid-September to mid-October. Temperatures on October 1, 2, 3, and 4 exceeded the monthly maximum reported in the 1957 "Upper Air Climatology of the United States." The linear correlation coefficient (r) between ozone and temperature is 0.78 for the 24-day experimental period, and the ozone-pressure difference has r of -0.77; the corresponding linear regression equations are:

$$O_3 \text{ (pphm)} = 3.73(\pm 1.26) - 0.665(\pm 0.116)\ \Delta P_{SFO-RNO} \quad , \qquad (1a)$$

and

$$O_3 \text{ (pphm)} = 8.77(\pm 1.93) + 0.969(\pm 0.175)\ T_{850\ mb,OAK} \quad , \qquad (1b)$$

where the numbers in parentheses are the one-sigma values of the coefficients as determined from the least-squares fit to the data.

Figure 24(b) is the temporal distribution of ozone and the north-south (v) and east-west (u) 850-mb wind components. The correlation of the wind components with ozone is poor (both are about 0.2), although qualitatively there appears to be a weak inverse relationship with the absolute value of the zonal wind speed.

The meteorology of the individual test days is given in more detail in the following discussions of the test results.

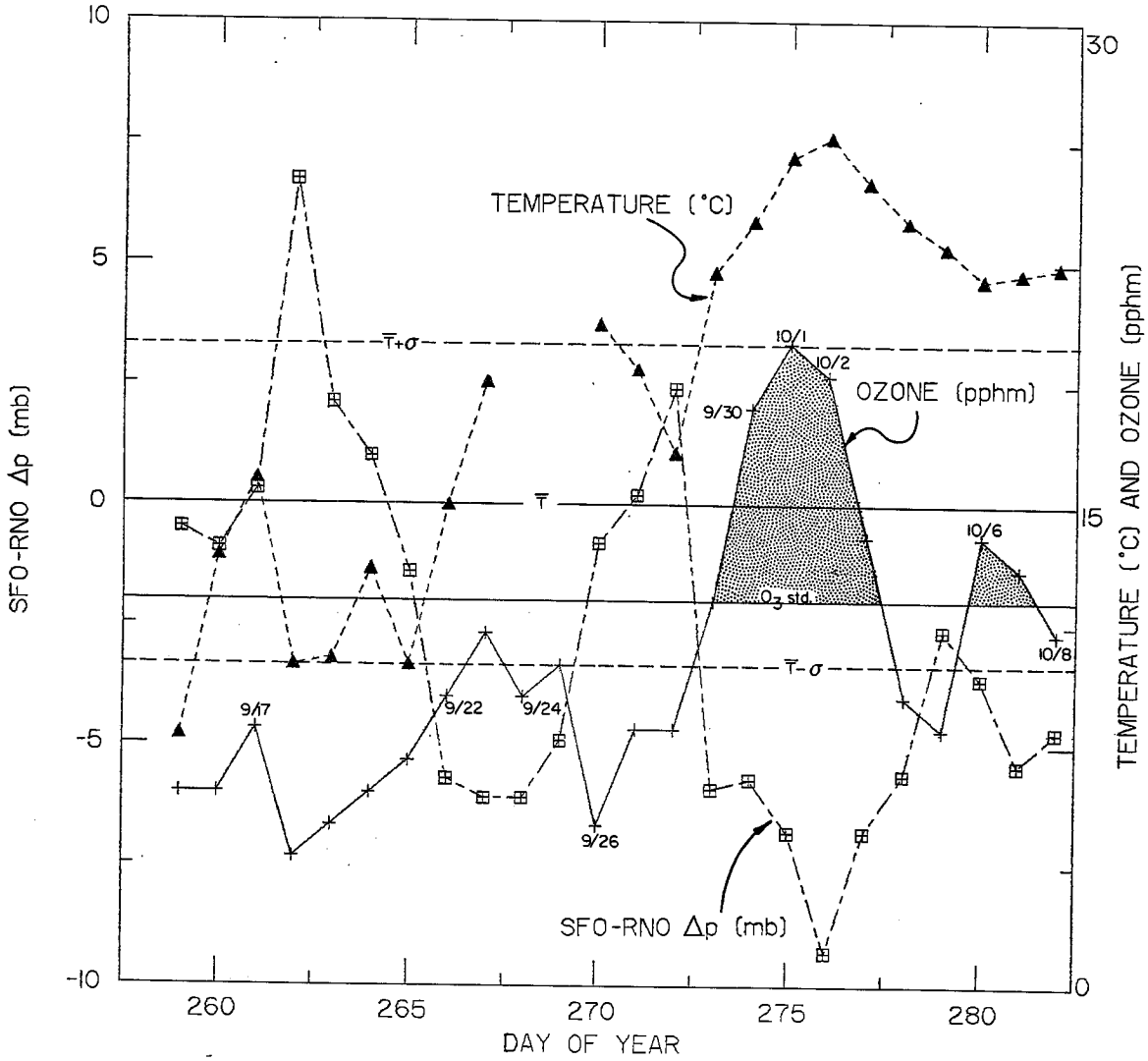


FIGURE 24a. SYNOPTIC AEROMETRIC SUMMARY: TEMPERATURE, OZONE, AND PRESSURE DIFFERENCE (continued)

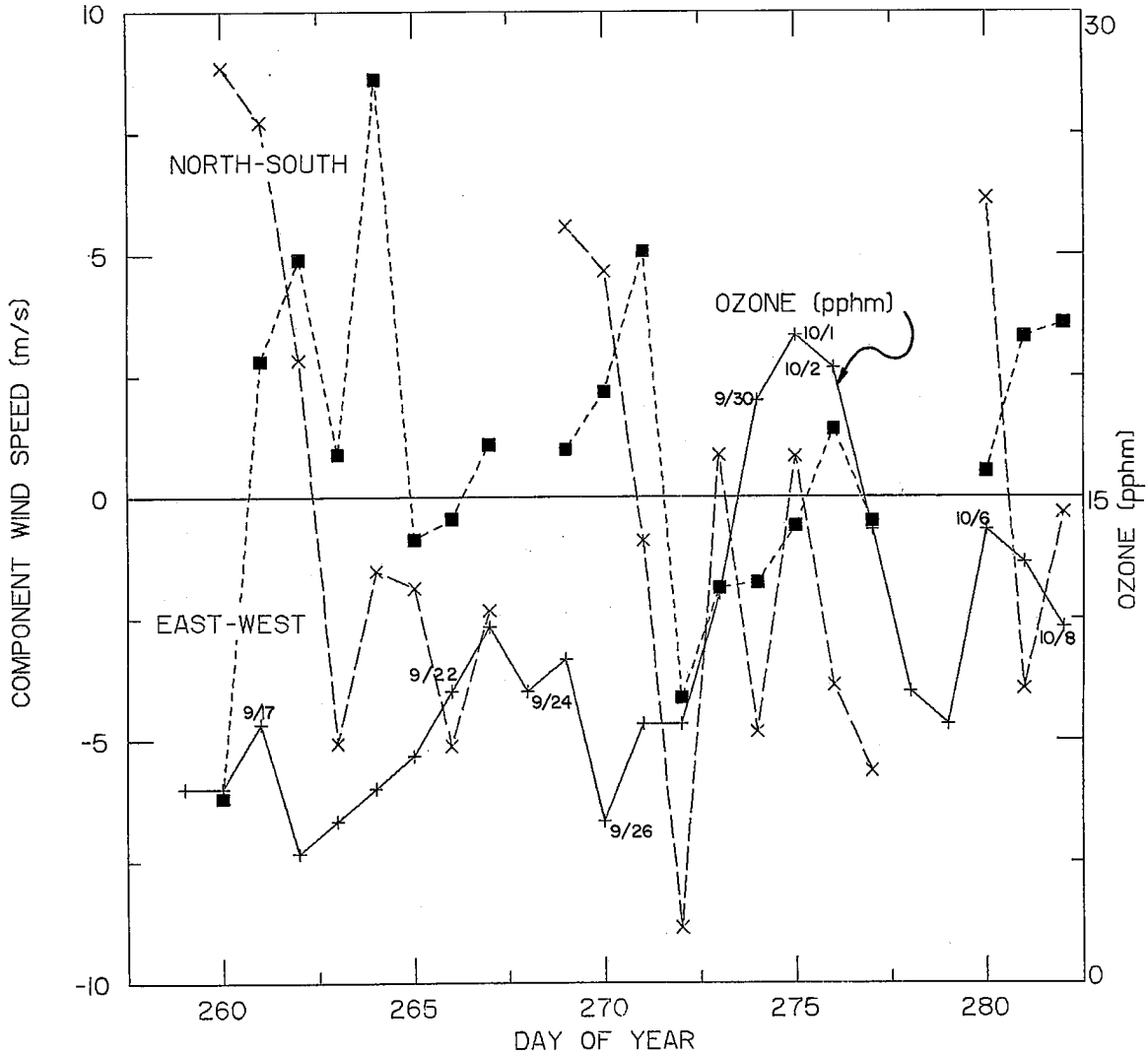


FIGURE 24b. SYNOPTIC AEROMETRIC SUMMARY:
OZONE AND COMPONENT - WINDS (concluded)

B. Summaries

1. Test 0917: 17 September 1980

The 0500-PDT surface weather for the day is shown in Figure 25. The western states were dominated by a broad, flat high-pressure region; a weak thermal trough was centered in extreme southwestern Arizona, but was restricted to southern California on its northern end. At the 850-mb level, winds in the test area were strong (8 m s^{-1}) from the SSW and the temperature (16°C) was nearly equal to the climatic norm for the period (15.3°C). The peak hourly ozone concentrations occurred during the hour 13-1400 PDT, with the maximum value of 80 ppb recorded at the Gilroy station (see Figure 26). Hourly ozone contour plots for the other hours are given in Volume II; note that all ozone plots have a minimum contour value of 60 ppb and the contour interval is 20 ppb.

The release of SF_6 was from 0931-1126 PDT in Newark, about 1.5 km east of the Dumbarton Bridge, and the F13B1 was released from 0936-1129 PDT at DeAnza College in Cupertino. Figure 27(a-l) illustrates the hourly distribution of the two tracers as measured by the fixed surface network. Figure 28 shows the tetroon launches and sightings, while Figure 29 and Table 7 document the location and time of the aircraft flight segments. Table 8 lists the hourly surface wind observations from 08-09 PDT through 20-21 PDT at three locations in the Santa Clara-San Benito Valley: (1) the BAAQMD station on 4th Street in downtown San Jose, (2) the Morgan Hill aerometric station, and (3) the BAAQMD station in Hollister. The Morgan Hill site recorded only wind direction because of a malfunction of the anemometer; however, these data are still very useful in evaluating transport in the valley. (For orientation purposes, Figure 2 and Appendix B identify the towns and features referenced in the following discussions.)

The first three hours of tracer sampling by the surface network (i.e., 12-1500 PDT) indicate low SF_6 concentrations only in the Los Gatos-Lexington Reservoir area except for a 5-ppt measurement at 14-1500 PDT west of Gilroy. Higher F13B1 levels are generally found in the same areas in addition to some low-level concentrations in the Almaden-Morgan Hill region. Starting with the 14-1500 sample hour, there is some evidence of SF_6 transport into south San Jose and subsequently into Almaden (16-1700) and later, east Morgan Hill (18-1900). However, SF_6 observations account for only a small portion of the total release. F13B1 concentrations were uniformly high (~20 ppt) in the Los Gatos-Lexington Reservoir area until 1700 when they abruptly went to zero. F13B1 transport continued southward as far as Watsonville where low concentrations ($\ll$10 ppt) were observed until 1800 when they abruptly increased to the 20-ppt level and then generally persisted throughout the end of the sampling period (23-2400). Surprisingly, however, none of the fixed sampling stations immediately upwind of Watsonville detected any F13B1 throughout the day. Except for isolated F13B1 concentrations measured at various times, there is no indication of F13B1 transport to other parts of the study area until the last sampling hour when modest

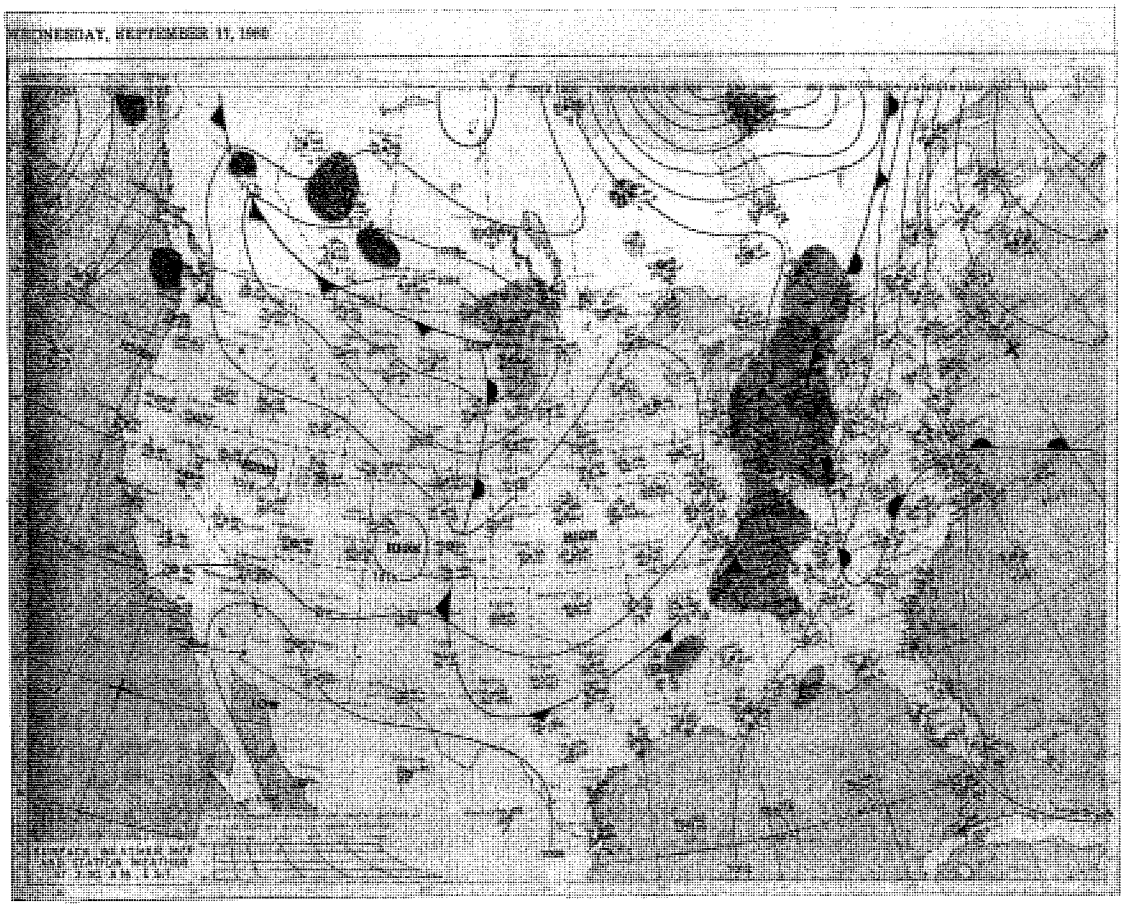


FIGURE 25 SURFACE WEATHER MAP, 0500 PDT, TEST 0917

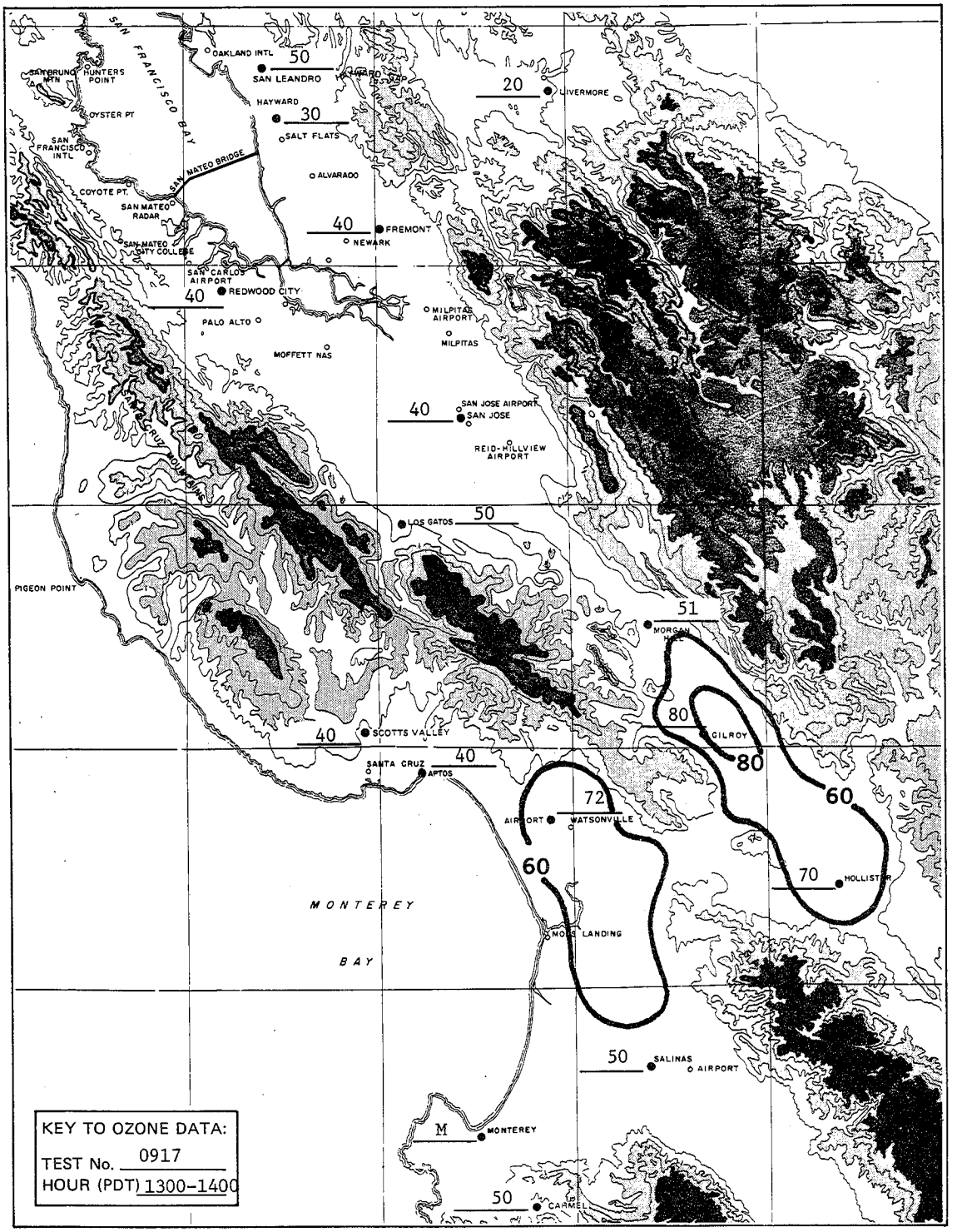


FIGURE 26 DISTRIBUTION OF SURFACE OZONE (ppb),PEAK HOUR, TEST 0917

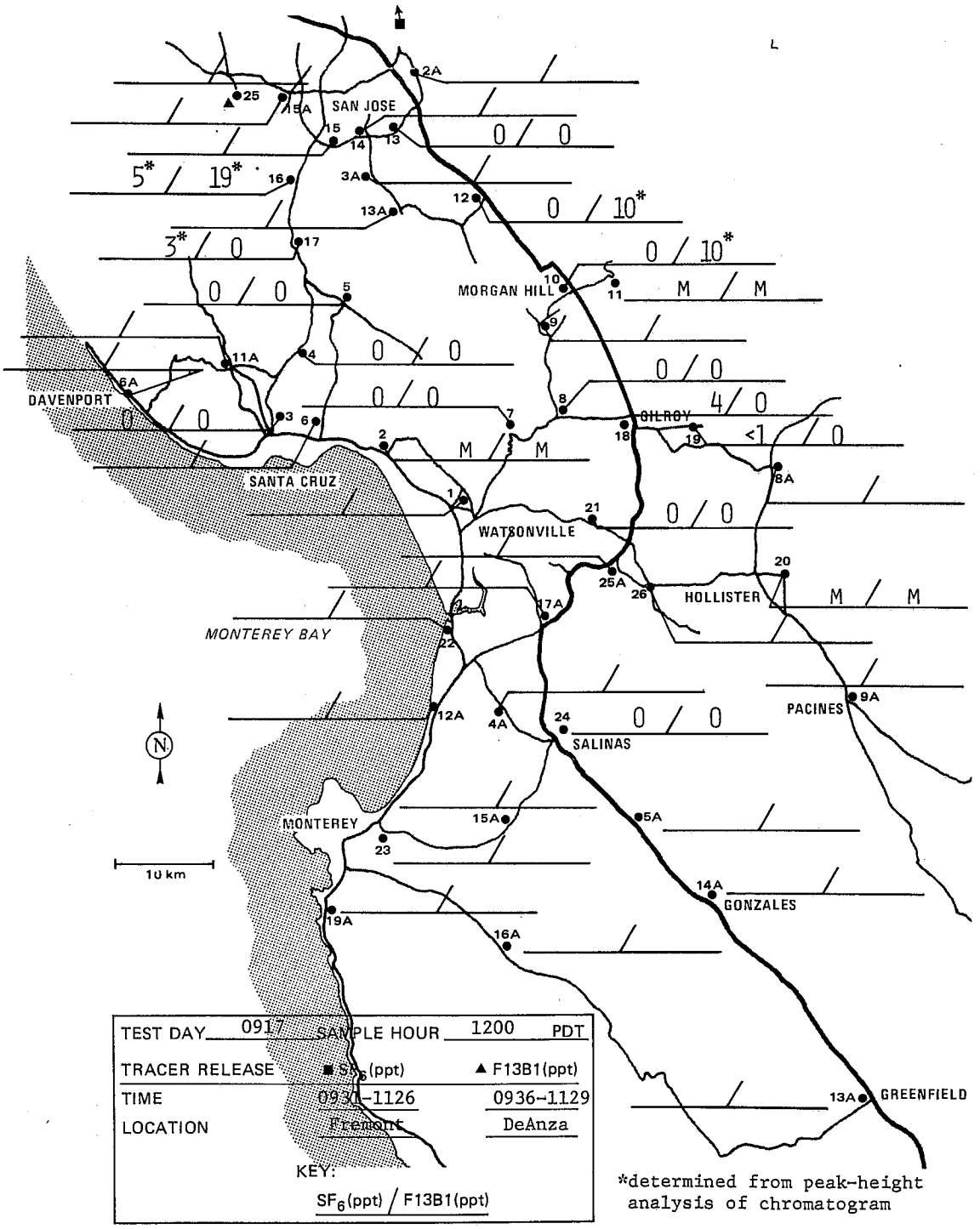


FIGURE 27a HOURLY SURFACE TRACER MEASUREMENTS, TEST 0917

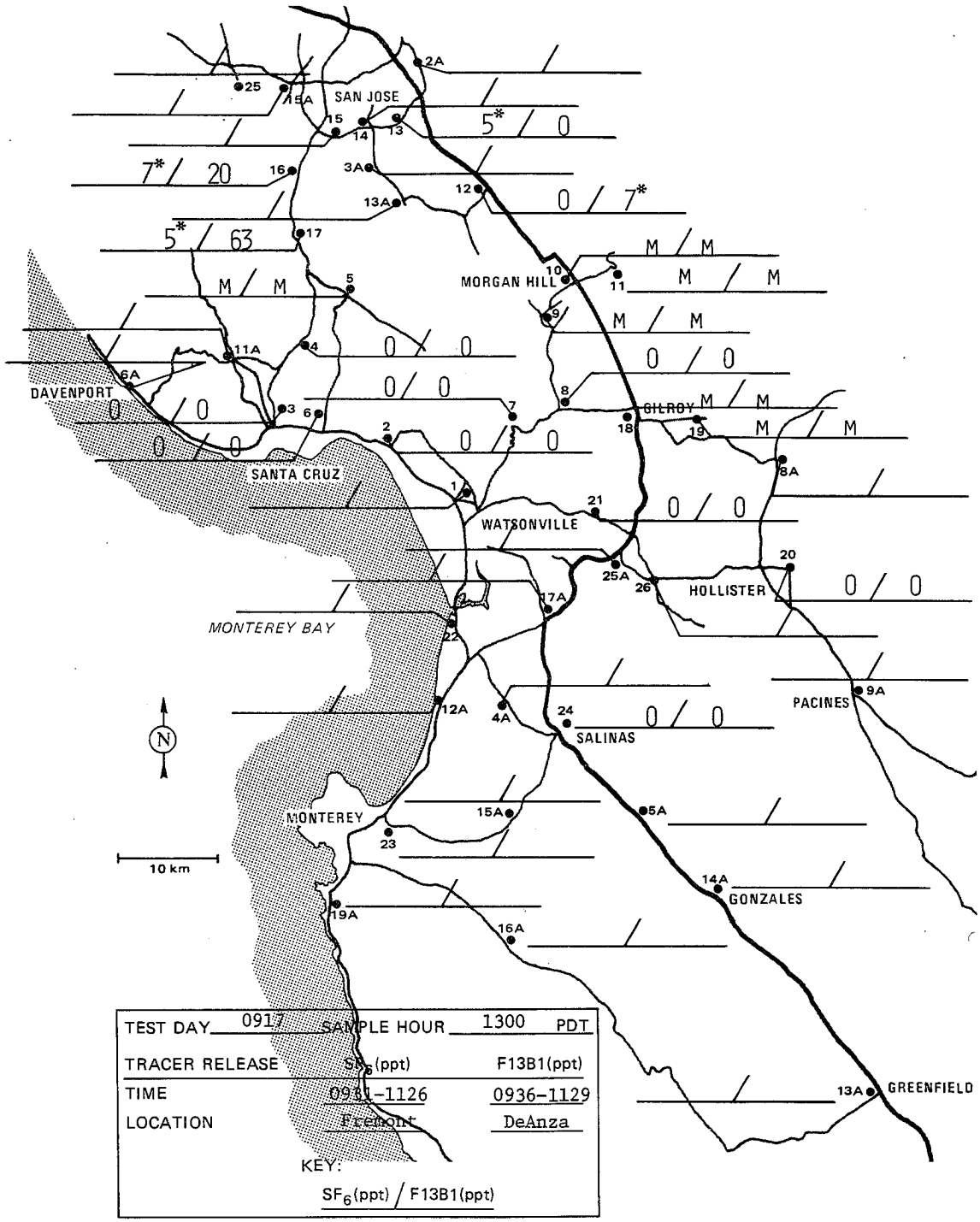


FIGURE 27b (CONTINUED)

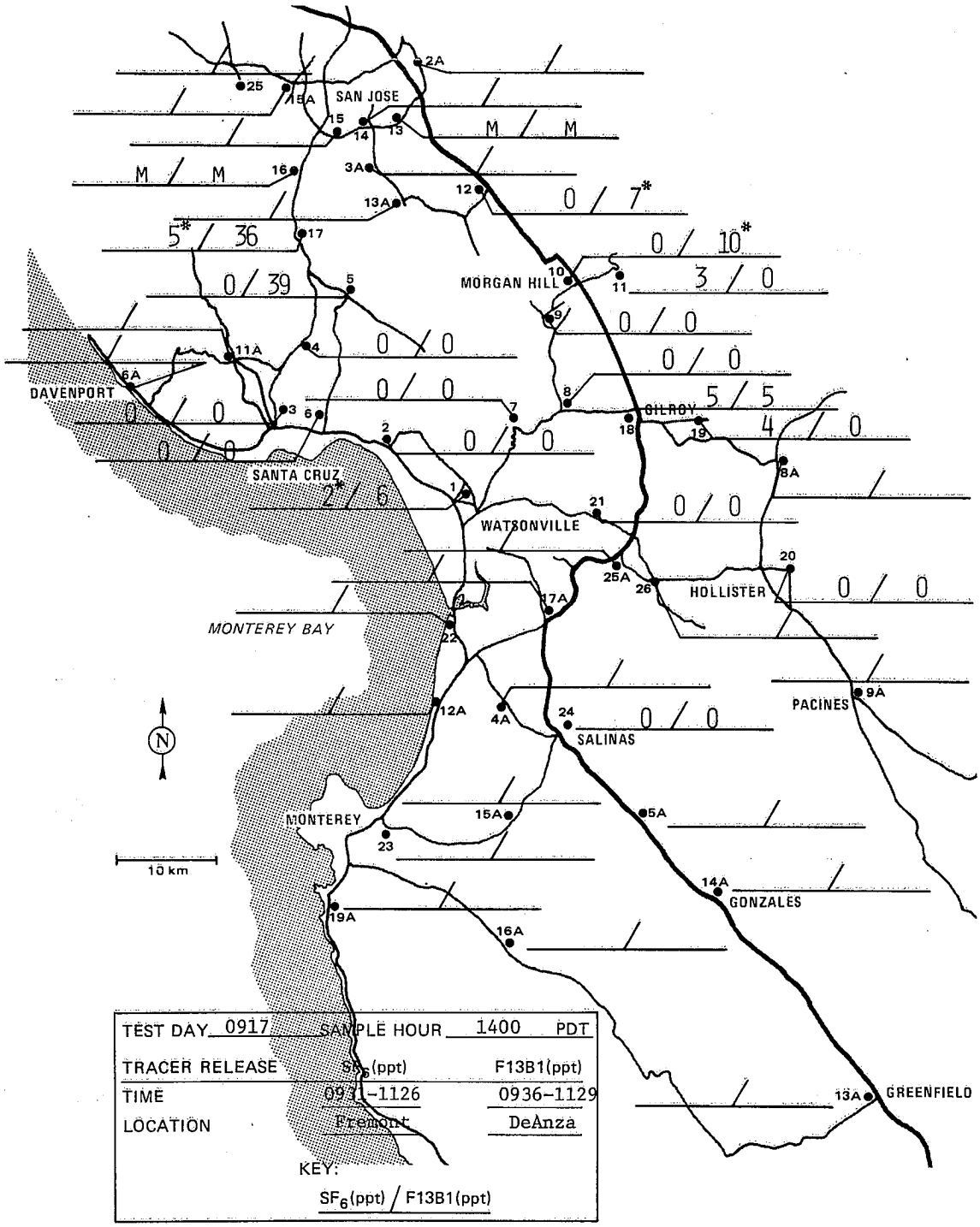


FIGURE 27c (CONTINUED)

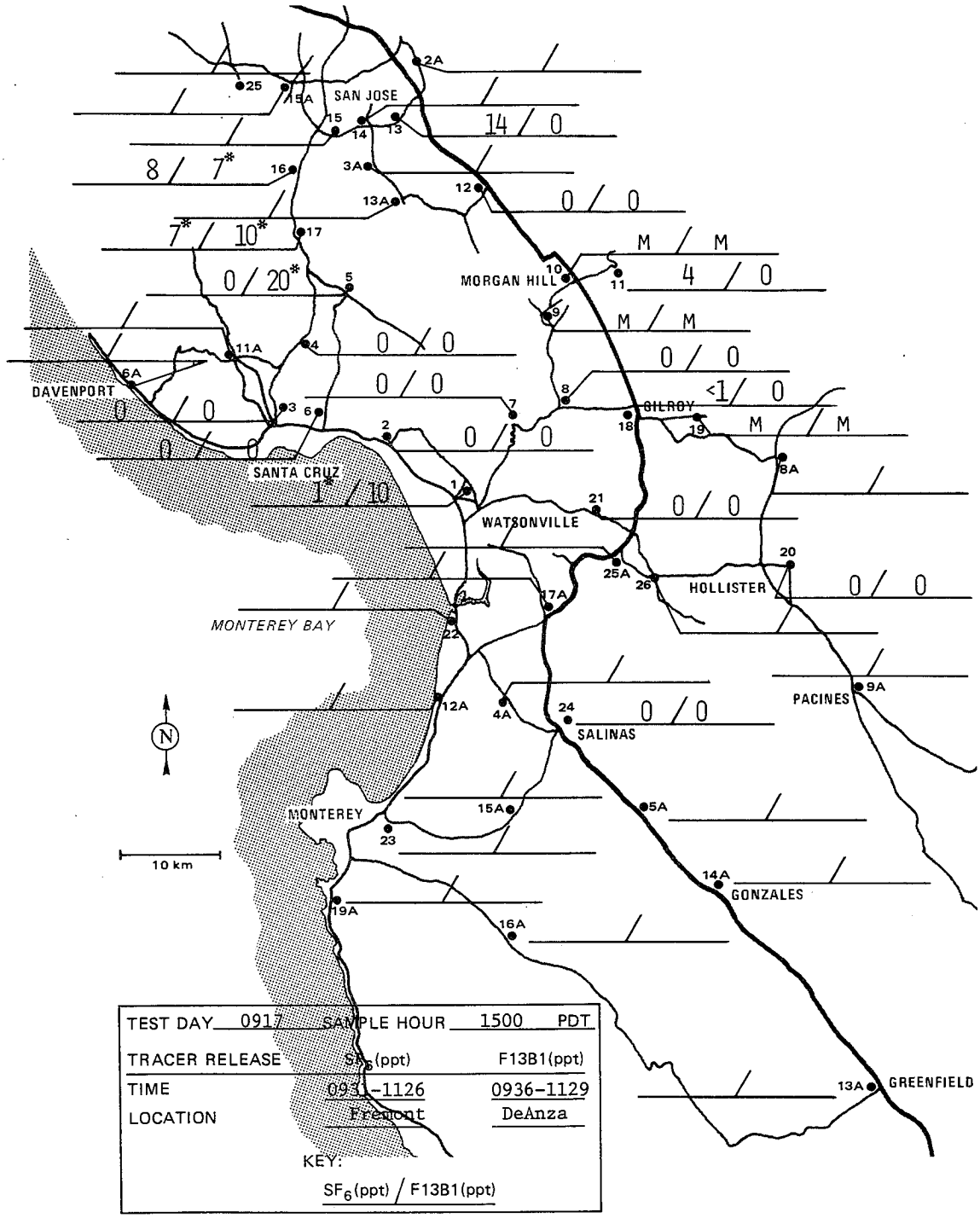


FIGURE 27d (CONTINUED)

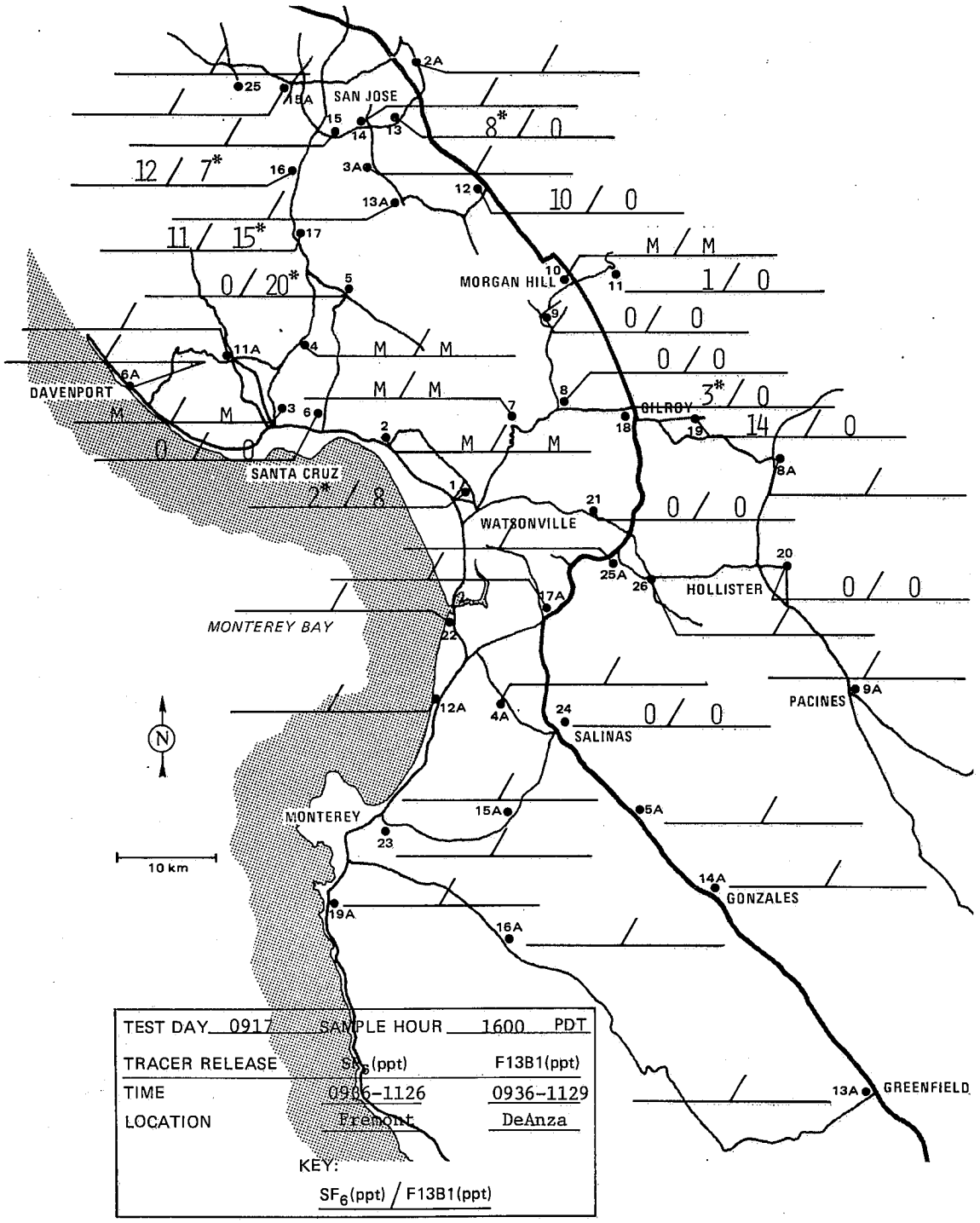


FIGURE 27e (CONTINUED)

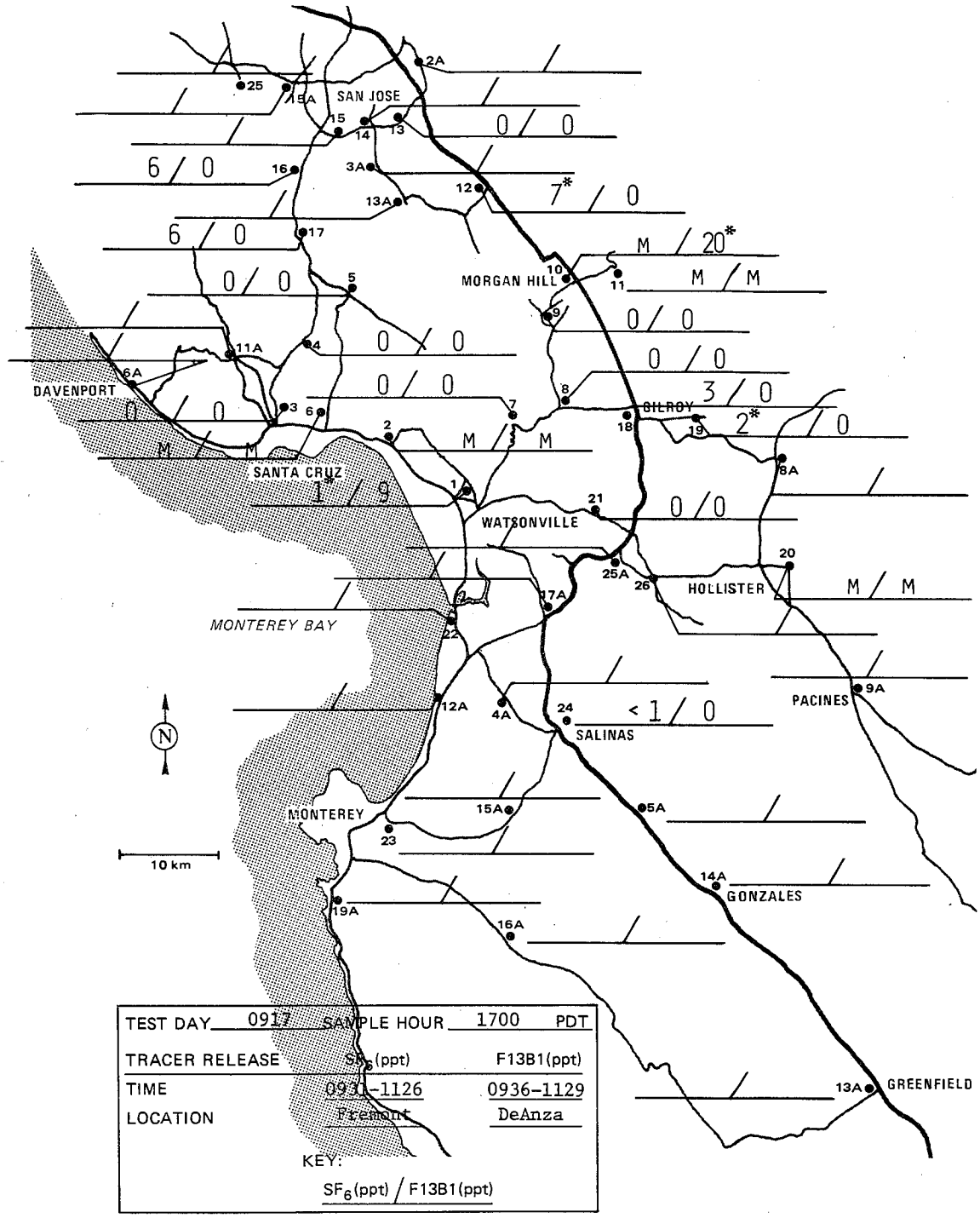


FIGURE 27f (CONTINUED)

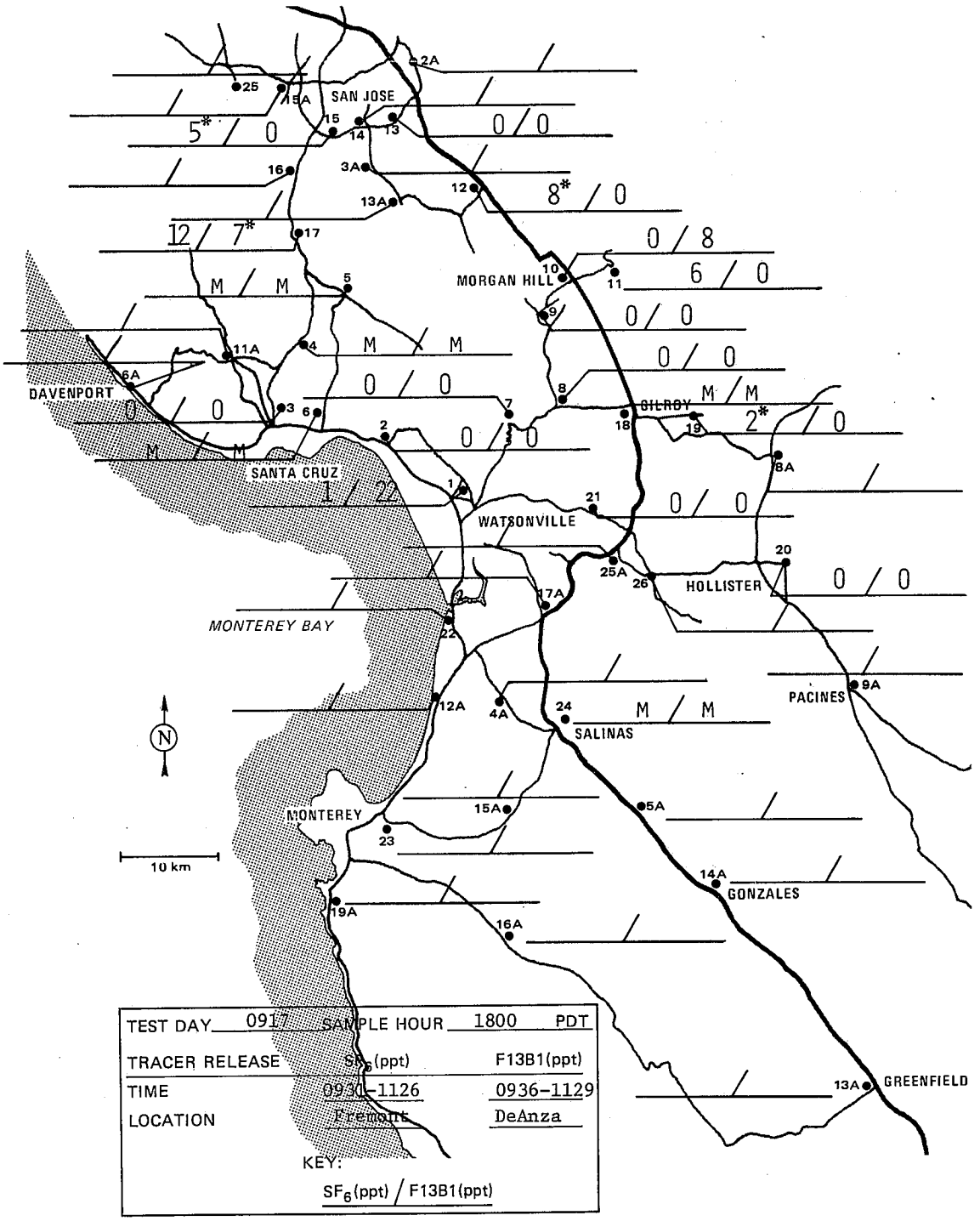


FIGURE 27g (CONTINUED)

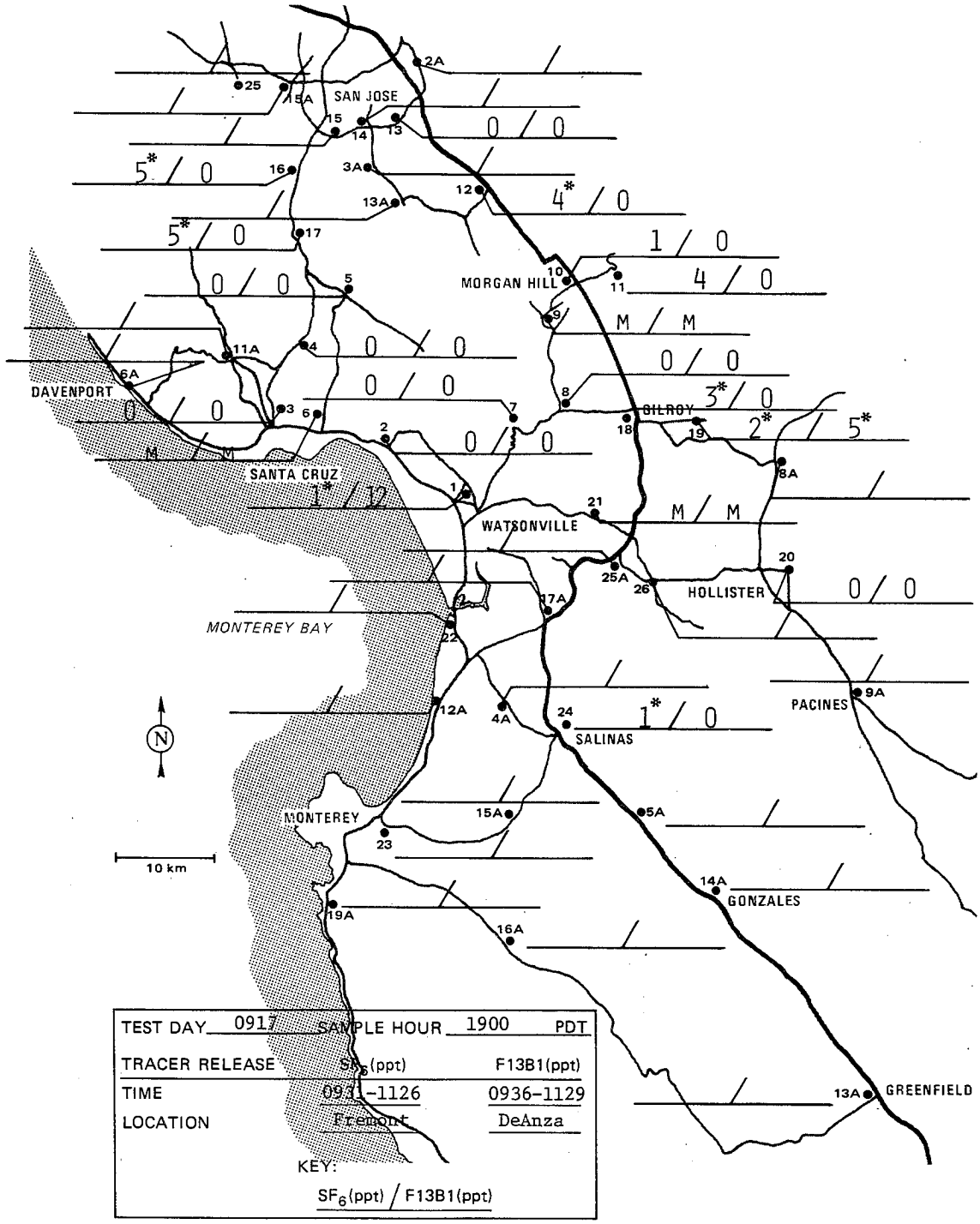


FIGURE 27h (CONTINUED)

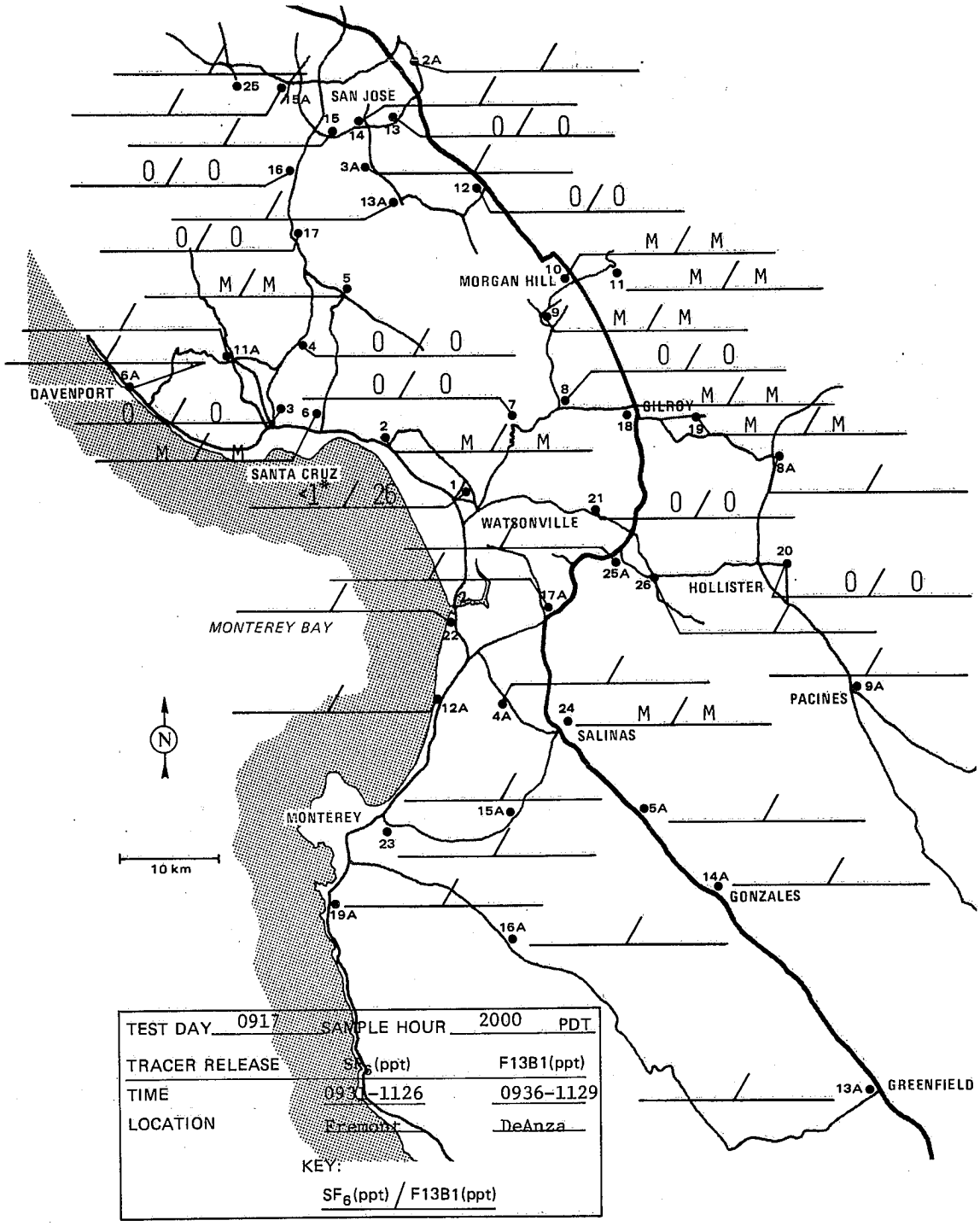


FIGURE 27i (CONTINUED)

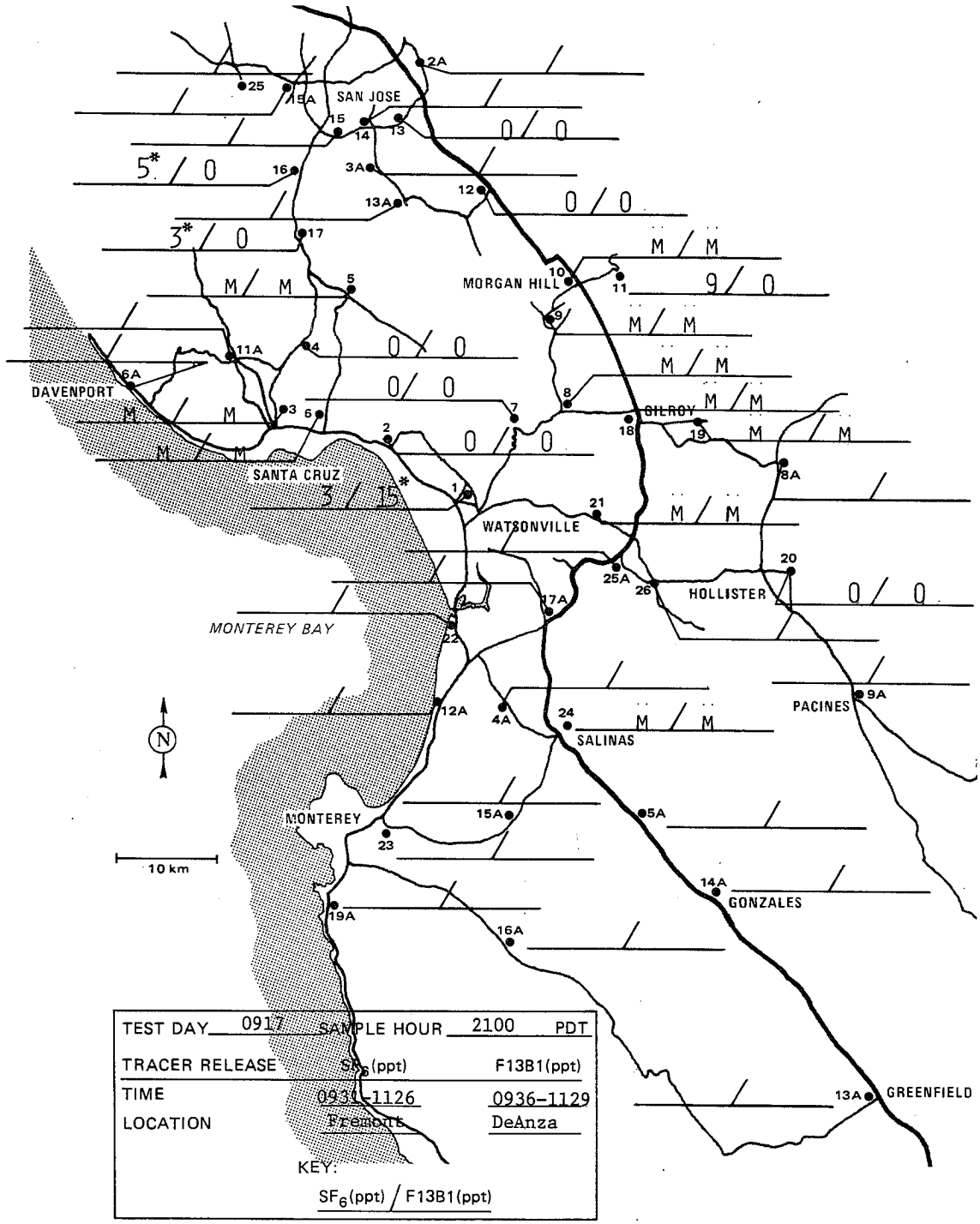


FIGURE 27j (CONTINUED)

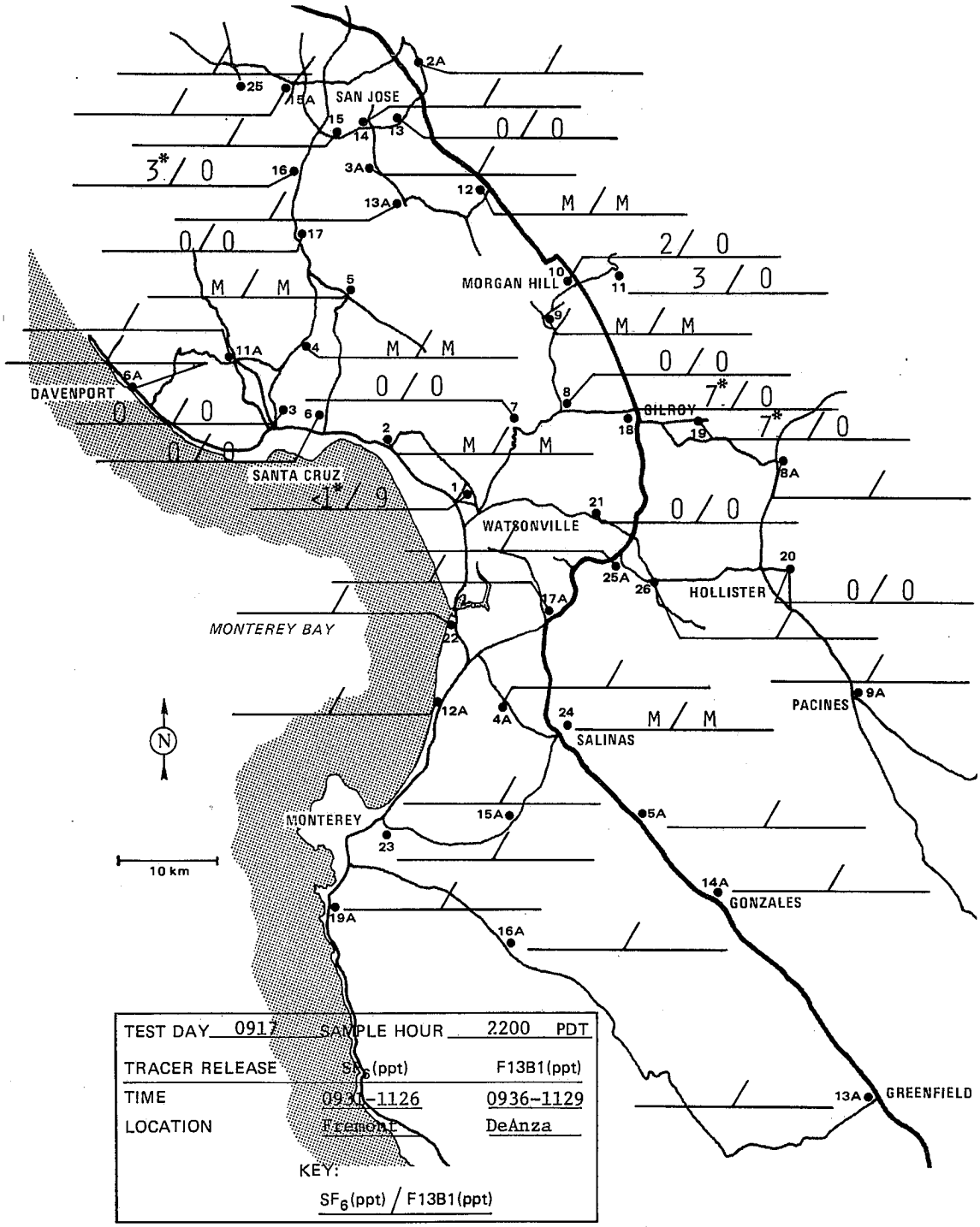


FIGURE 27k (CONTINUED)

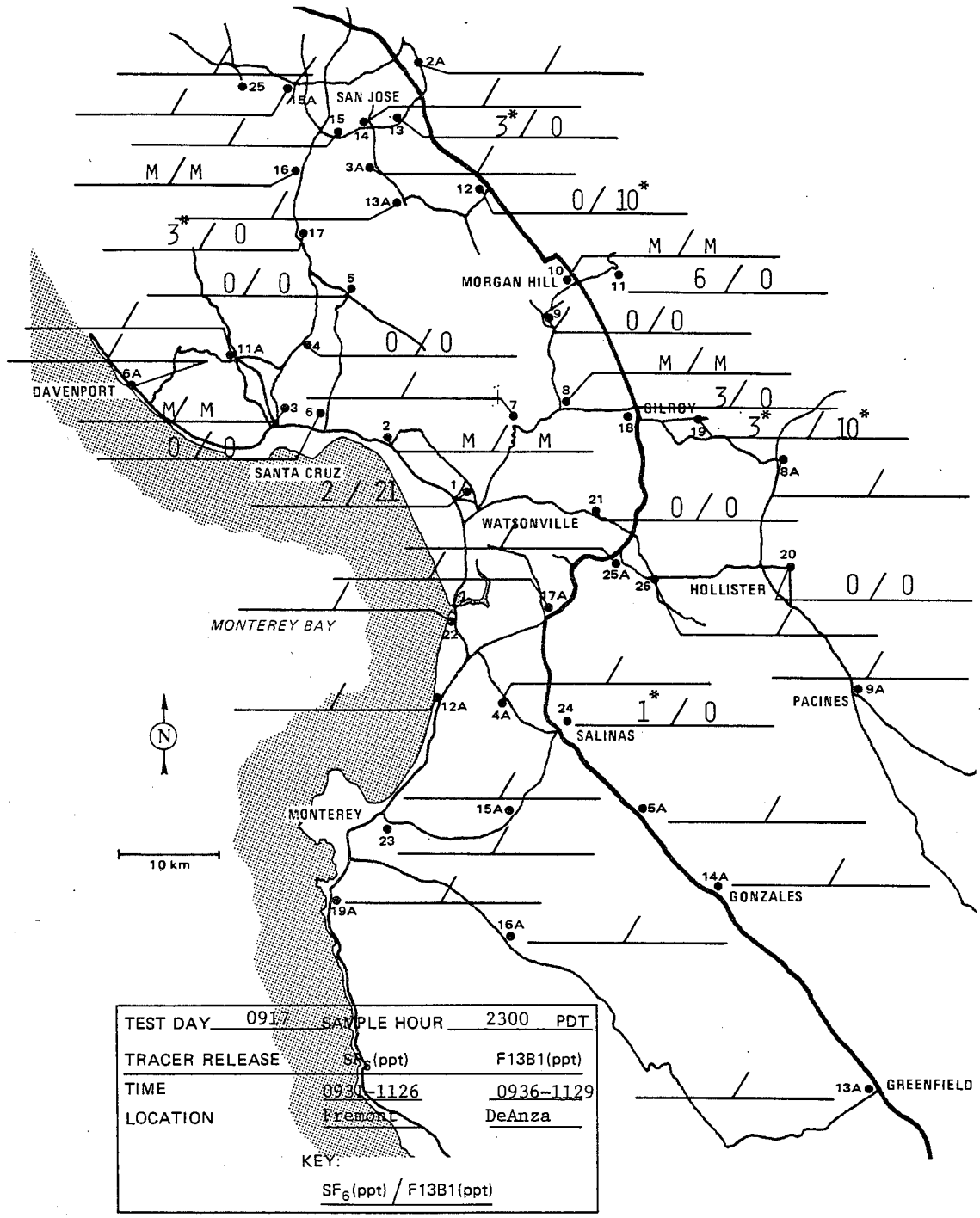


FIGURE 271 (CONCLUDED)

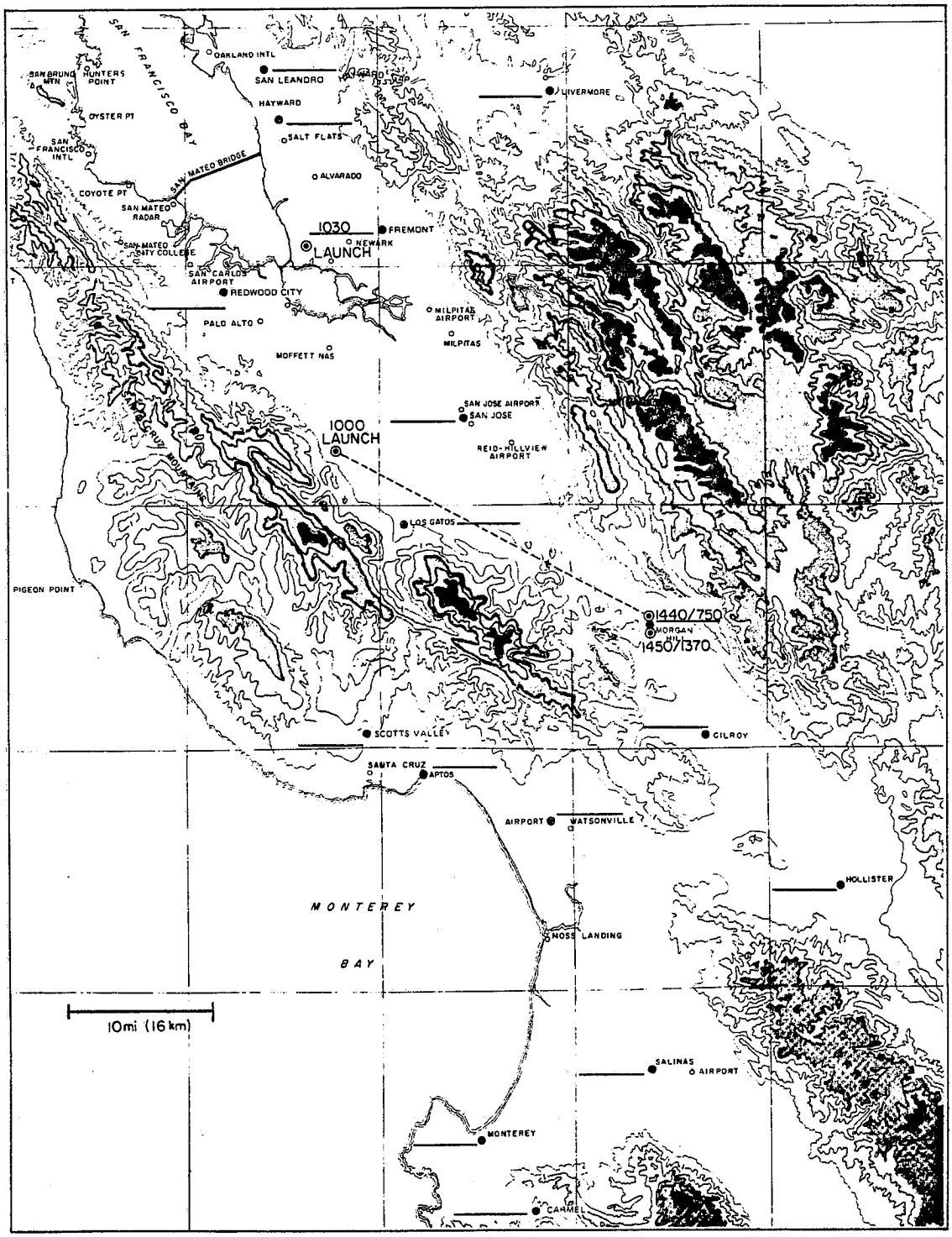


FIGURE 28 TETROON OBSERVATIONS, TEST 0917
[Time (PDT)/Altitude (m, agl)]

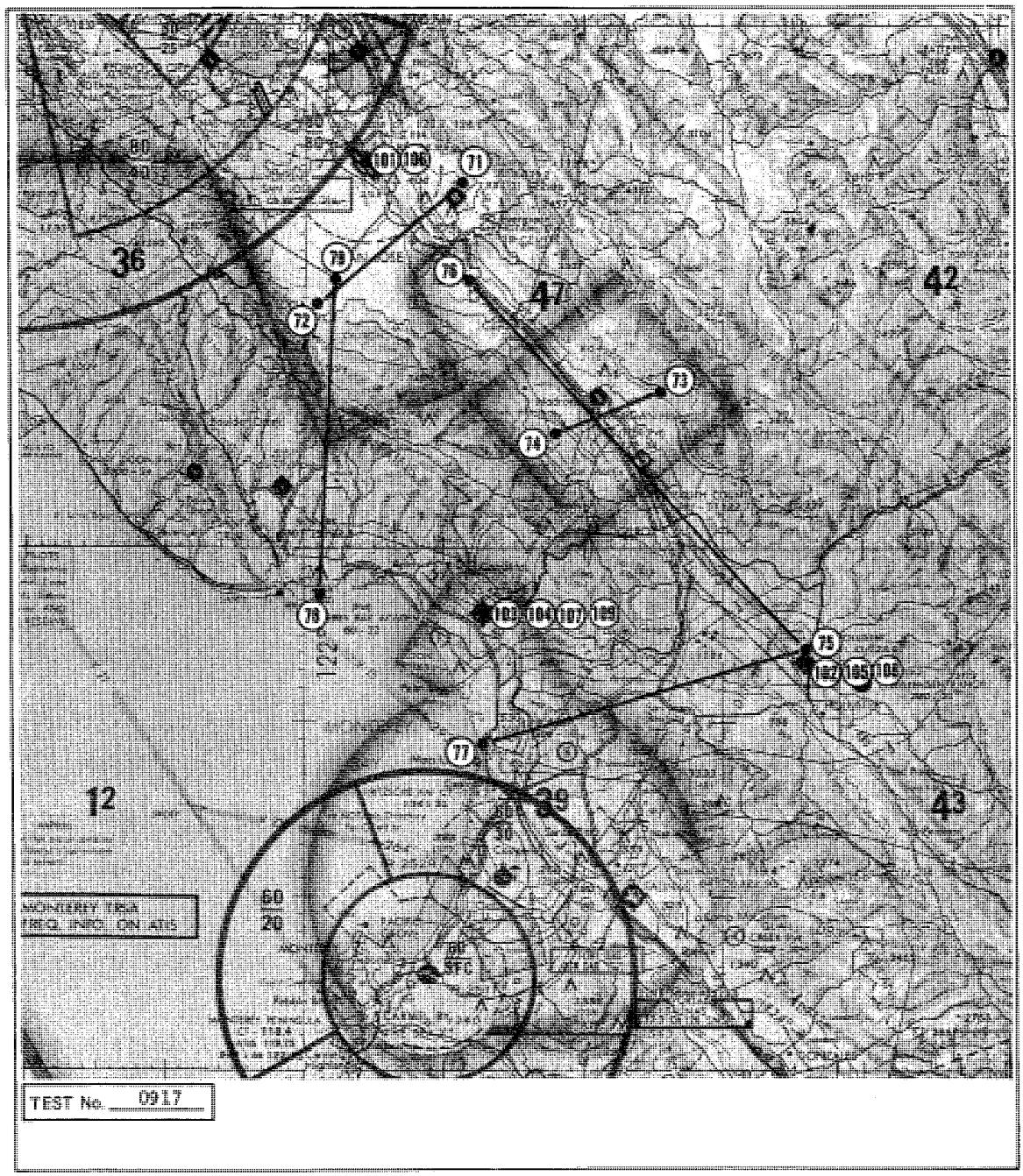


FIGURE 29 AIRCRAFT FLIGHT PATTERN, TEST 0917

Table 7

AIRCRAFT WAY POINTS, TEST 0917

Way Point	Geographic Location	Altitude (m)	Nominal Time (PDT)
Traverses			
71	Reid Hillview Airport	600	1402
72	Los Gatos	600	1402
71	Reid Hillview Airport	450	1412
72	Los Gatos	450	1412
71	Reid Hillview Airport	300	1417
72	Los Gatos	300	1417
73	Anderson Dam	600	1431
74	Chesbro Reservoir	600	1431
73	Anderson Dam	450	1438
74	Chesbro Reservoir	450	1438
73	Anderson Dam	300	1441
74	Chesbro Reservoir	300	1447
75	Hollister Airport	600	1513
76	IBM, San Jose	600	1513
75	Hollister Airport	360	1536
76	IBM, San Jose	360	1536
77	Moss Landing	600	1547
78	Santa Cruz	630	1600
79	Los Gatos	630	1600
78	Santa Cruz	600	1612
79	Los Gatos	600	1612
Spirals			
101	San Jose		0646
102	Hollister		0703
103	Watsonville		0719
104	Watsonville		1037
105	Hollister		1039
106	San Jose		1115
107	Watsonville		1135
108	Hollister		1828
109	Watsonville		1848

Table 8

SANTA CLARA-SAN BENITO VALLEY WIND VARIATIONS,
SEPTEMBER 17, 1980

Time (PDT)	Wind Direction/Speed* Downtown San Jose	Morgan Hill	Hollister
08-09	023/02	272	var/02
09-10	(1) 315/02	293	(2) 293/04
10-11	315/03	303	293/08
11-12	293/03	305	293/06
12-13	338/03	299	292/07
13-14	338/04	301	293/06
14-15	338/05	298	270/10
15-16	338/04	296	270/13
16-17	338/04	297	270/15
17-18	338/05	296	270/14
18-19	338/05	296	var/09
19-20	338/04	298	338/08
20-21	338/04	(2) 285	338/07

*deg(true)/mph

(1) = Upvalley flow (San Jose to Hollister)
(2) = Cross-valley flow
(3) = Downvalley flow (Hollister to San Jose)

concentrations were detected in east Gilroy and Almaden. The mobile (grab-type) tracer measurements confirm the limited amount of SF_6 detected at the surface, but indicate a broader distribution of the F13B1 than was seen by the fixed network. The mobile tracer samples are tabulated in Volume II; these data indicate widespread F13B1 concentrations at the surface in the 20-50 ppt range throughout the Santa Clara Valley, along the ridge line from Los Gatos to Watsonville, and into the Pajaro Plain around Watsonville. A portion of the F13B1 plume was observed in late afternoon (1745-1800) as far south as Moss Landing. Going southward along Highway 1 from Watsonville to Moss Landing, concentrations systematically increased from near zero to a peak of 143 ppt at Moss Landing; there were no samples taken further south. North of Watsonville at about the same time, intermittent peaks and nulls in the F13B1 concentrations were observed along the coast to Soquel.

Throughout the Santa Clara Valley, pockets of high and low F13B1 concentrations were observed during the afternoon by the vehicles sampling in that area. Figure 29 illustrates the location of three sets of aircraft sampling traverses made during mid-afternoon in the valley; two sets of three-altitude traverses were flown across the valley, and one two-altitude traverse was flown along the axis of the valley. The flights across the northern end of the valley detected no F13B1 at 300 m agl and only one nominal trace of SF_6 (at the eastern end of the traverse). The mid-level flight (450 m) detected F13B1 toward the eastern end and an isolated SF_6 peak (95 ppt) on the western end. At 600 m, both SF_6 and F13B1 were measured on the eastern end and again in the center of the traverse, with some F13B1 also to the west. The cross-valley traverses at Morgan Hill detected F13B1 across the valley at 300 m, but only sporadic traces at the 450 and 600-m altitudes. Flying along the valley at 360 m, no F13B1 was observed south of Gilroy, but concentrations were observed to be generally uniform to the northern end of the flight in south San Jose. At 600 m, however, F13B1 was distributed uniformly from San Jose to Hollister; concentrations were about equal to those at the lower level. No traces of SF_6 were detected at either altitude. The southern extent of the F13B1 corresponds to the sighting of the DeAnza tetroon at 1450 PDT at 750-1370 m agl over Morgan Hill.

The surface wind data in Table 8 confirm a steady transport up the valley from San Jose toward Hollister that began at 0900 PDT and persisted all day both at San Jose and in Morgan Hill. The tetroon sighting at 1450 in Morgan Hill indicated a transport speed of 6.5 m s^{-1}. Hollister, on the other hand, was not subject to significant up-valley transport until 1900 PDT. For most of the day, Hollister was under the influence of moderate to strong W and WNW winds.

Summarizing, 17 September 1980, was characterized by low surface ozone concentrations throughout the day and the region. F13B1 tracer gas was released in the morning and was transported: (1) through the Santa Clara Valley, and (2) along and over the ridge line between Los Gatos and Watsonville and into the Pajaro coastal plain. Transport to Moss Landing was observed on the surface around 1800 PDT, while the

leading edge of the F13B1 at 300 m agl was detected around 1530 PDT in the vicinity of Gilroy. Significant F13B1 concentrations persisted at the Watsonville sampling site until midnight when sampling ceased. Very little of the SF_6 tracer released from Newark was present in the air samples. Aircraft traverses indicated some SF_6 aloft on the eastern side of the northern end of the Santa Clara Valley (near Alum Rock). Although the transport pattern was not detected from the tracer measurements, the mid-morning streamline analysis suggests the possibility of transport into the Livermore Valley.

2. Test 0922: 22 September 1980

Ozone concentrations at Gilroy peaked at 90 ppb during the hour 16-1700 PDT, the highest this day throughout the study area; see Figure 30. The 850-mb temperature reached the period norm, and was up 5°C from the previous calendar day, while the Gilroy peak-hour ozone also increased (20 ppb) above the September 21 peak. As shown in Figure 24, the SFO-RNO pressure difference decreased significantly from -1.4 mb on September 21 to -5.7 mb on this day. The drop was in response to the thermal troughing over California that was illustrated by the isobar patterns on the surface weather map in Figure 31. Except for a wet frontal system in northwestern Washington State and British Columbia, the synoptic map was devoid of weather in the western states.

Similar to the previous test, SF_6 was released from 0900-1100 PDT in Newark and F13B1 from 0900-1053 in Cupertino. Figure 32(a-l) illustrates the hourly distribution of both tracers as measured by the 25-station fixed sampling network. Both tetroons were launched at 1000 PDT (Figure 33). The Newark tetroon remained in sight of the tracer release point for 40 min, first drifting slowly east, then north and west. It is reported to have been sighted late in the morning passing over the San Carlos Airport; it was not possible to locate or track the tetroon during the test. The DeAnza tetroon initially drifted steadily SE at an estimated altitude of 300 m agl, remaining in view from the launch site for 30-40 min. The tetroon was located at 1204 PDT south of Highway 17 in Los Gatos; it was not sighted again (visually nor by radar) and is presumed to have grounded on the hills near Los Gatos. The location and altitude of the aircraft aerometric and tracer sampling flights are given in Figure 34 and Table 9, while Table 10 tabulates the hourly winds at San Jose, Morgan Hill and Hollister. The early-morning aircraft spiral from San Jose Municipal Airport (see Volume II) indicates a surface-based temperature inversion of 8°C extending to 560 m, with a nearly constant lapse rate of about 0.6°C/100 m from 560 to 1500 m. Ozone concentrations are low ($\ll$50 ppb) throughout the entire spiral with levels near zero in the lowest 150 m. By late-afternoon (1625 PDT), the vertical structure as measured at South County Airport in Gilroy indicated a dry adiabatic lapse rate from the surface to 950 m, capped by an inversion; ozone ranged from 75 ppb near the surface to a 107-ppb reservoir from 400 to 550 m. In the early evening (1900 PDT), a sounding at Hollister indicated a monotonic increase in ozone from 40 ppb at the surface to nearly 150 ppb at 1100 m where concentrations peaked

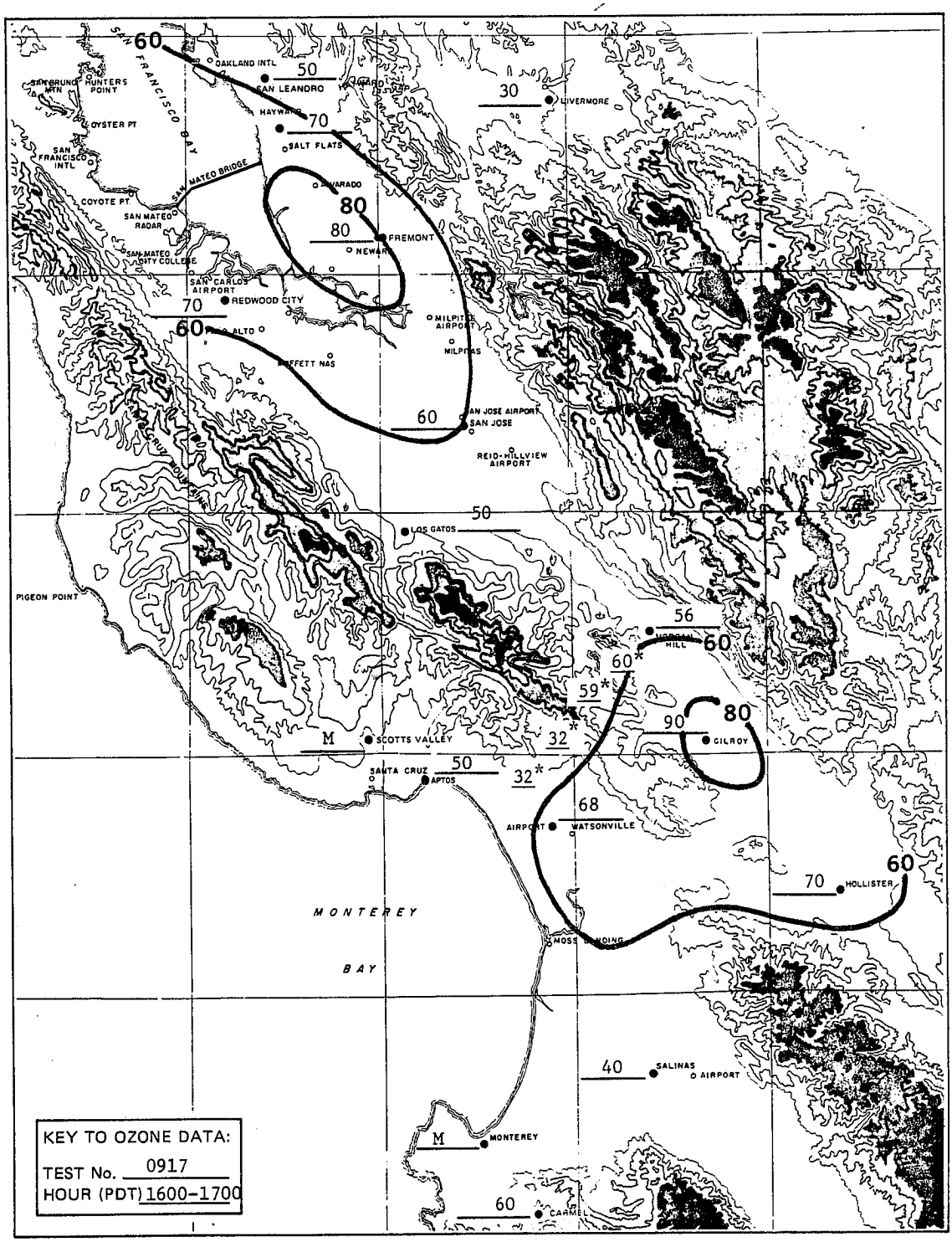


FIGURE 30 DISTRIBUTION OF SURFACE OZONE (ppb), PEAK HOUR, TEST 0922

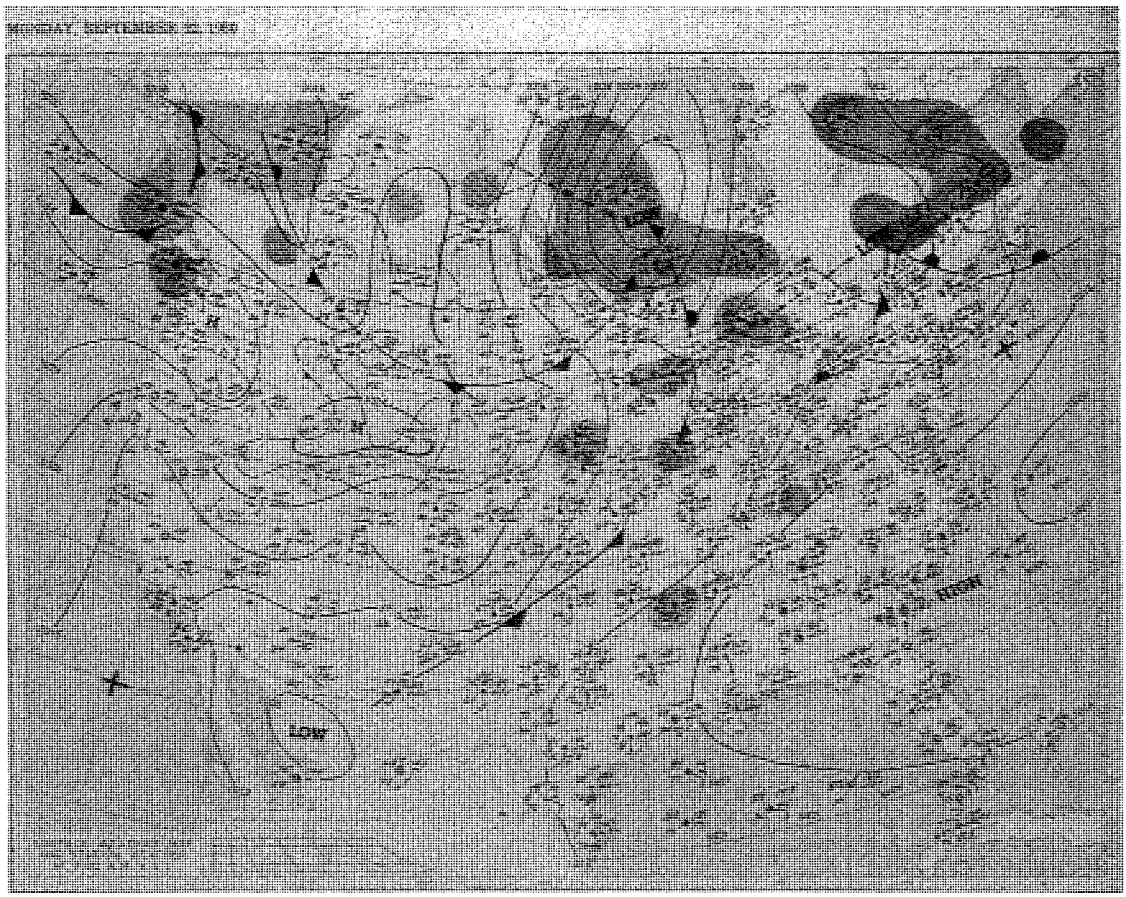


FIGURE 31 SURFACE WEATHER MAP, 0500 PDT, TEST 0922

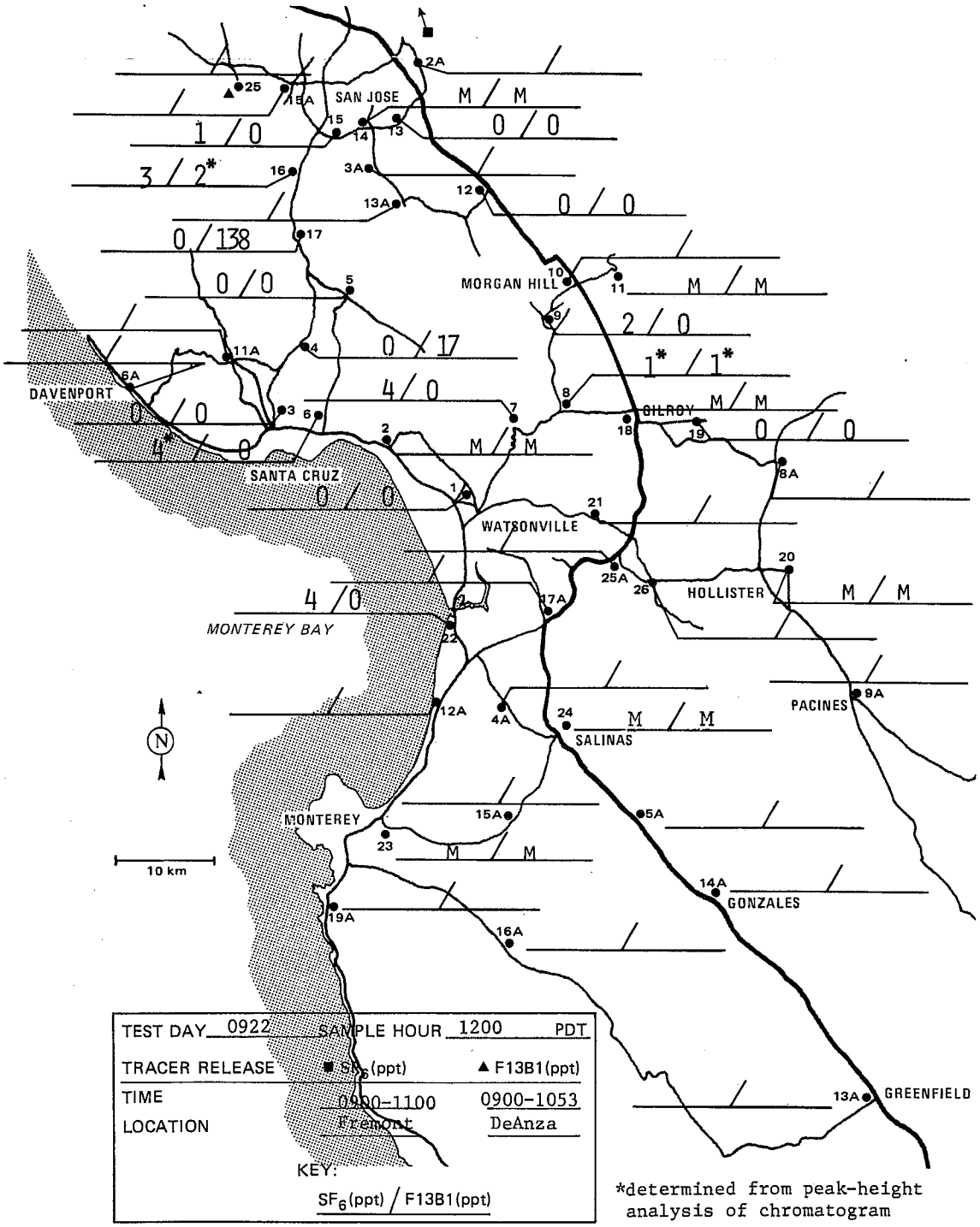


FIGURE 32a HOURLY SURFACE TRACER MEASUREMENTS, TEST 0922

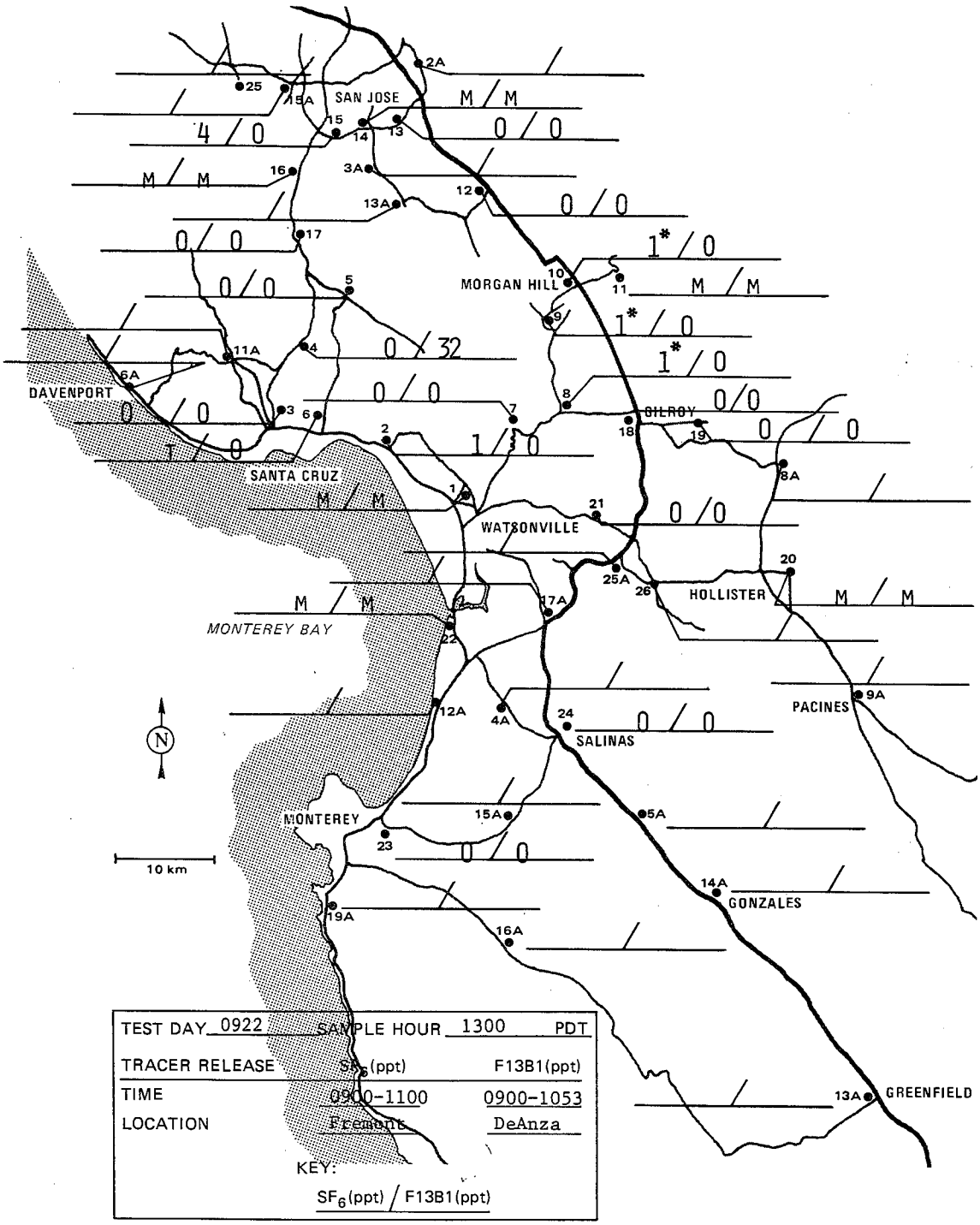


FIGURE 32b (CONTINUED)

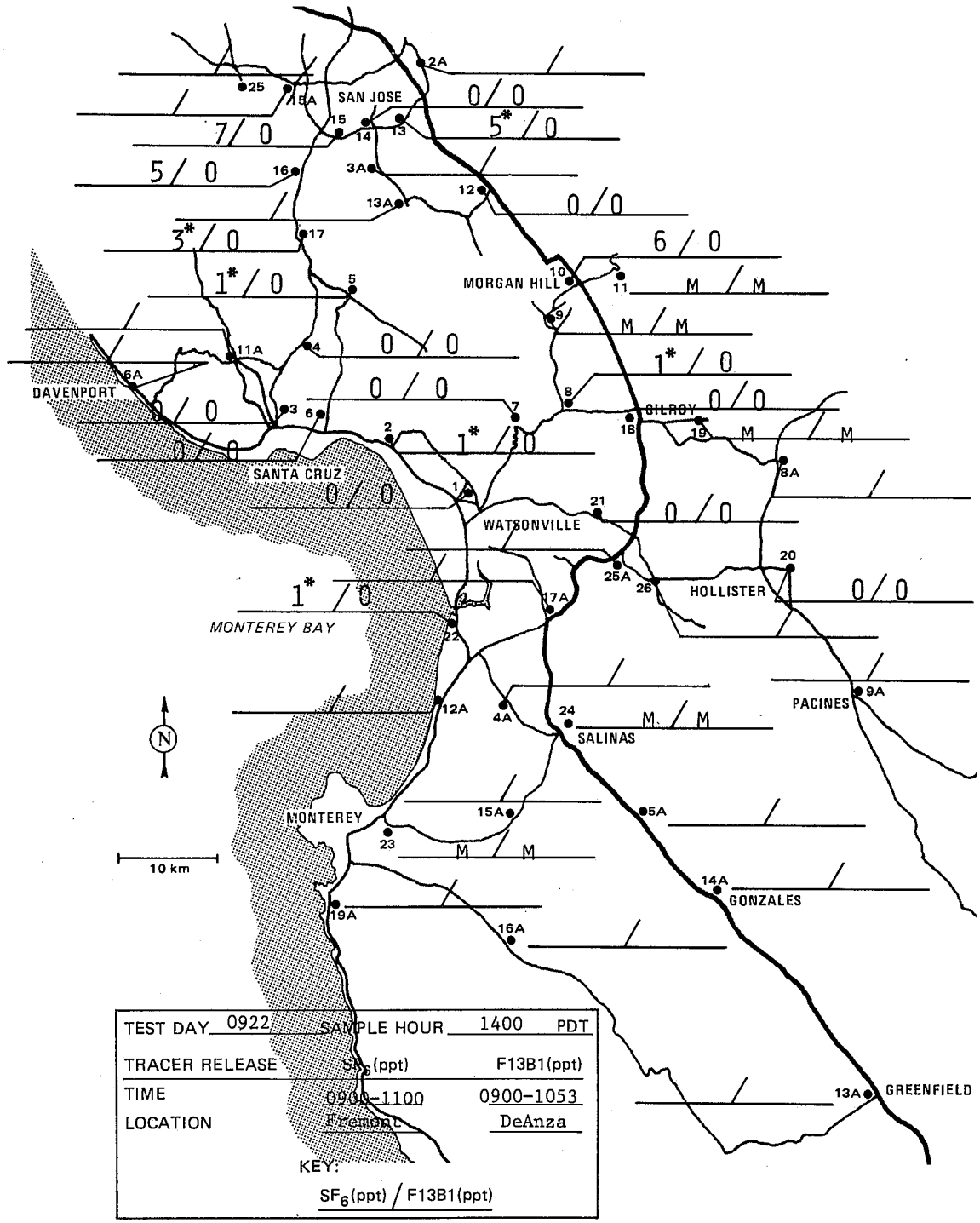


FIGURE 32c (CONTINUED)

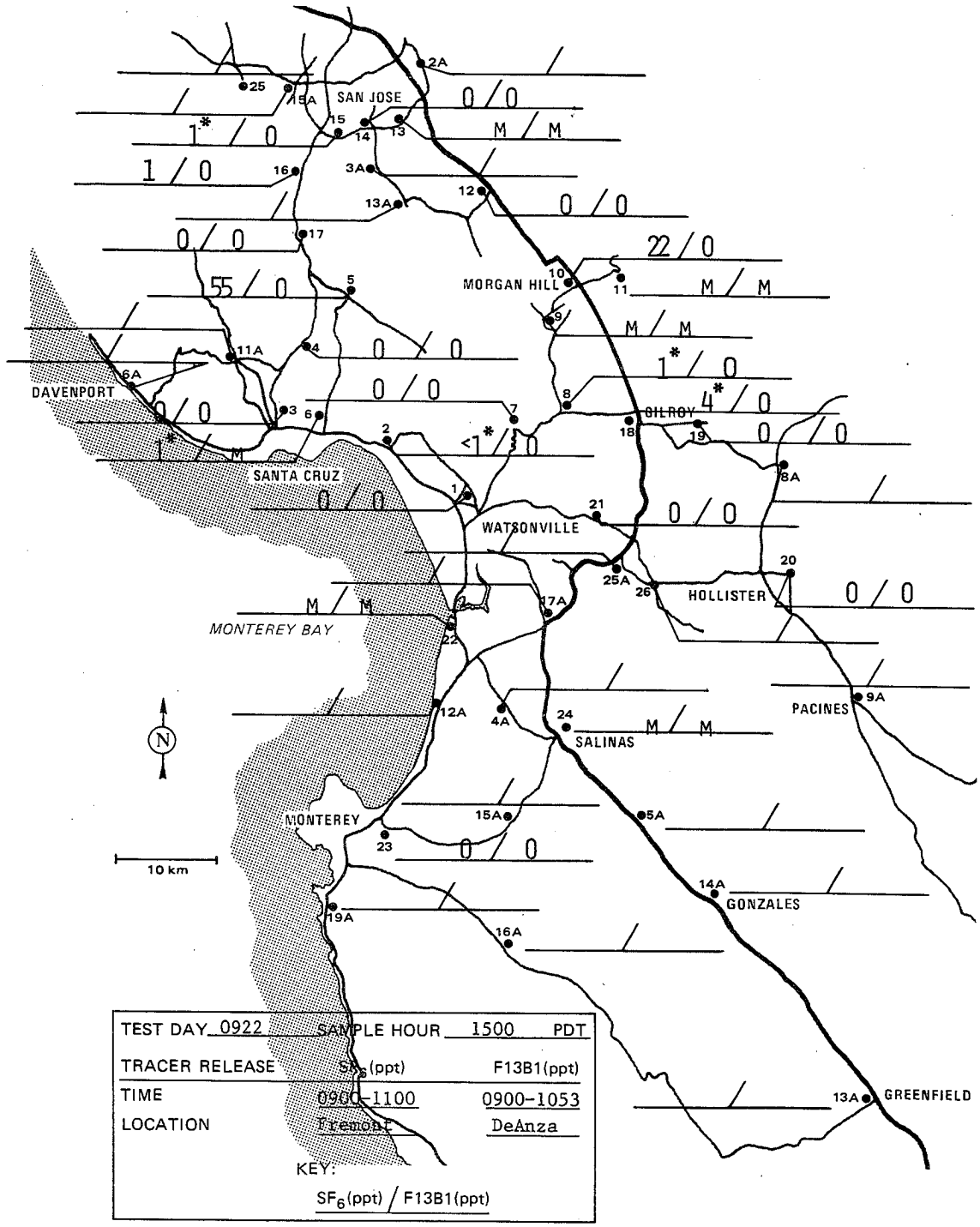


FIGURE 32d (CONTINUED)

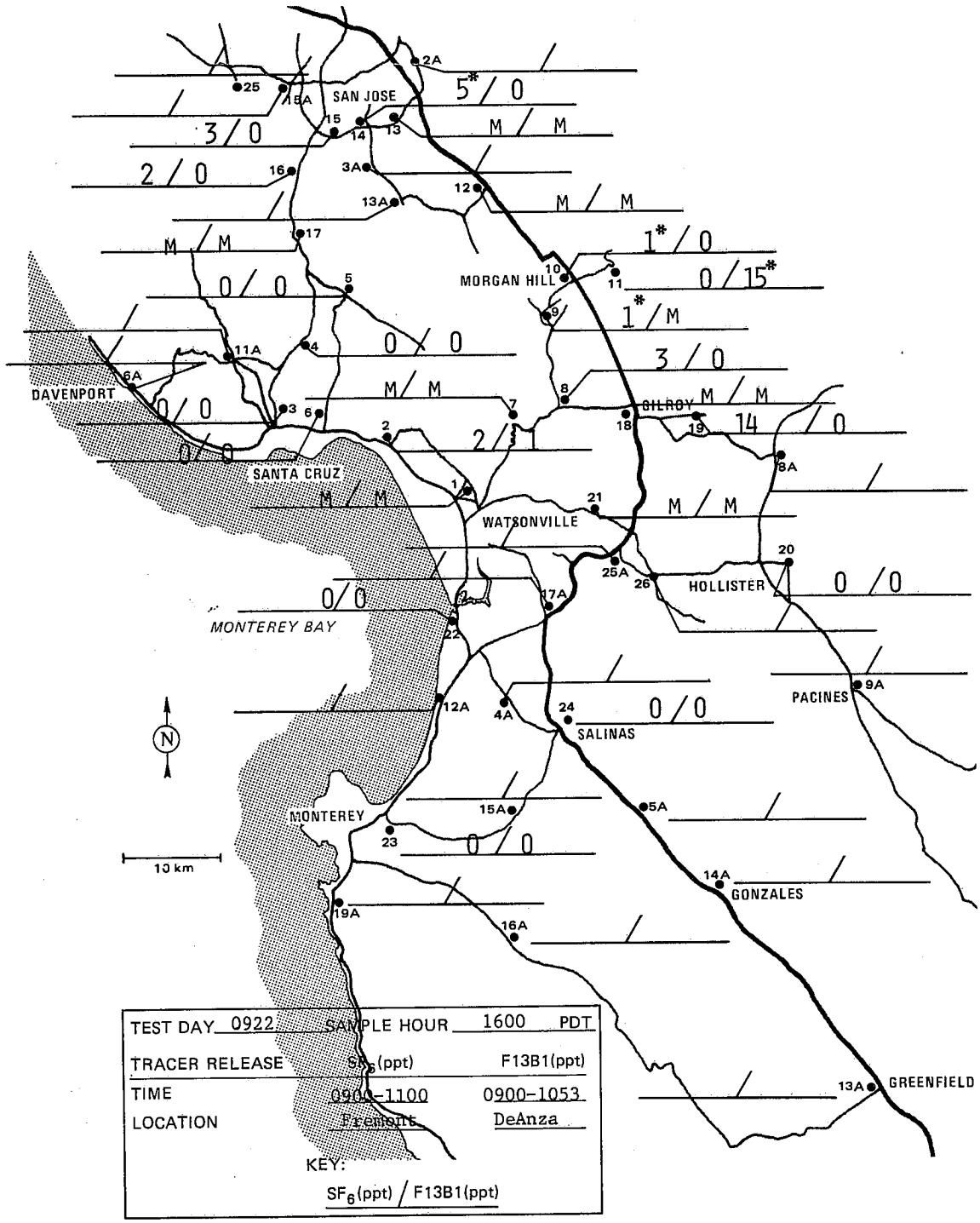


FIGURE 32e (CONTINUED)

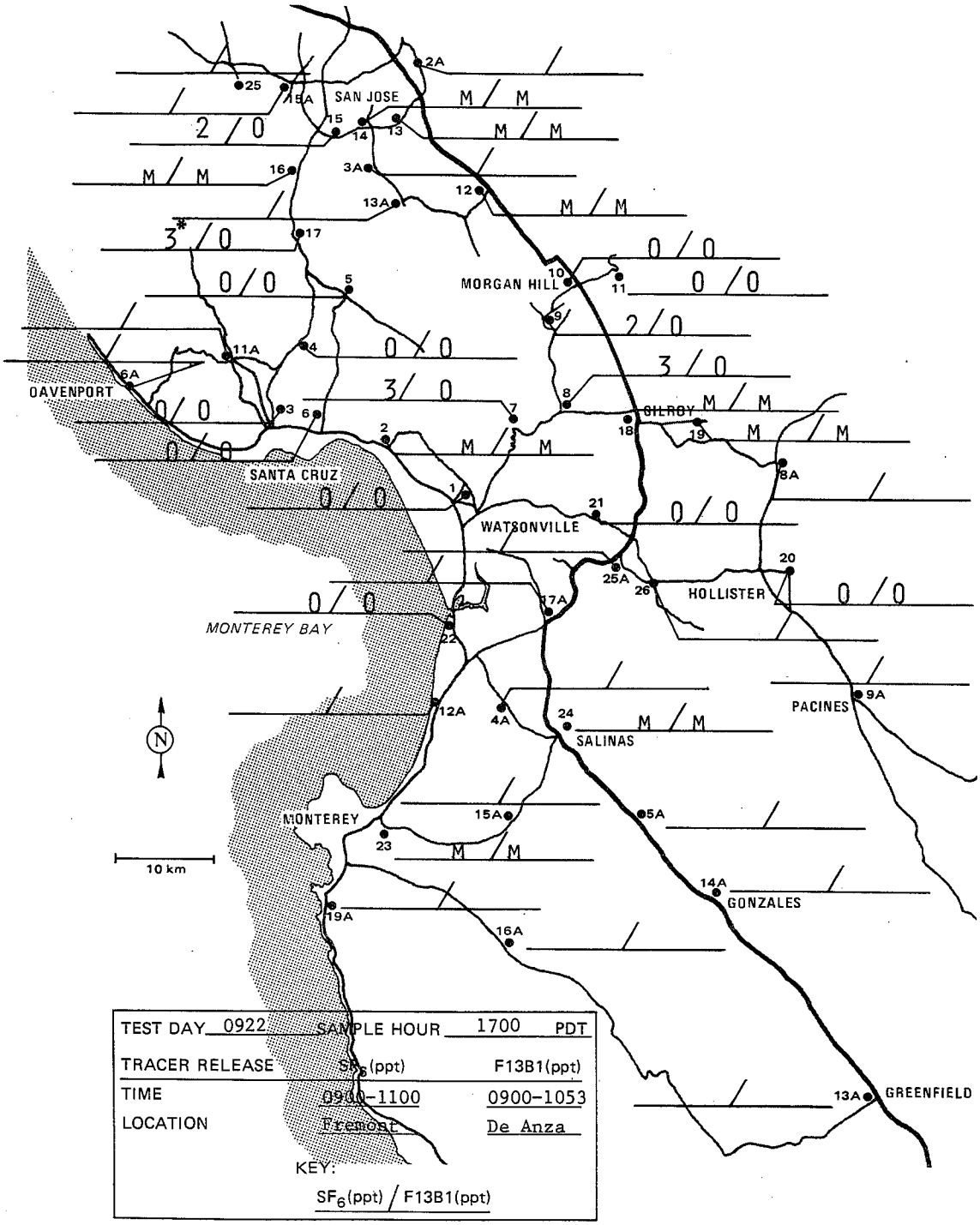


FIGURE 32f (CONTINUED)

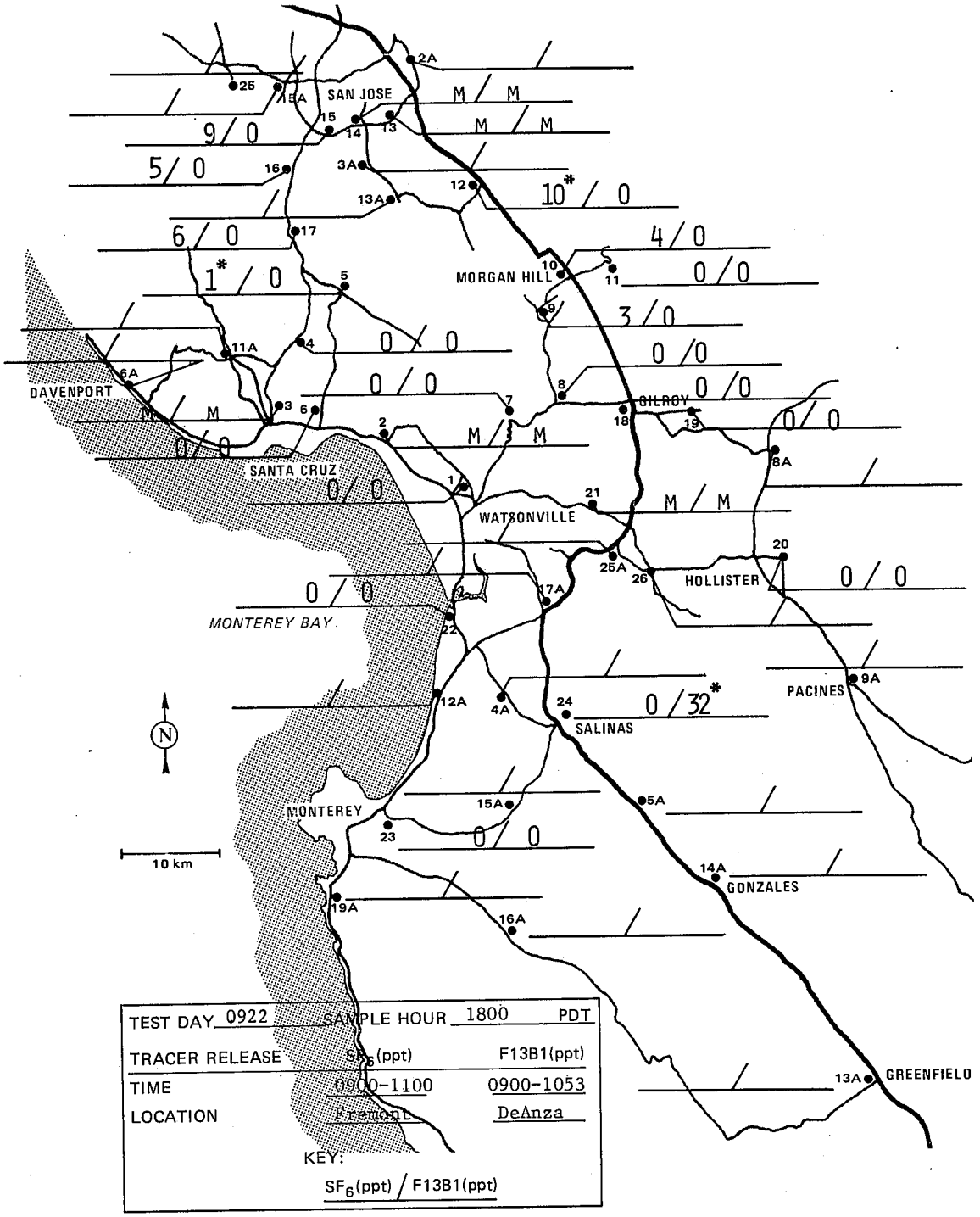


FIGURE 32g (CONTINUED)

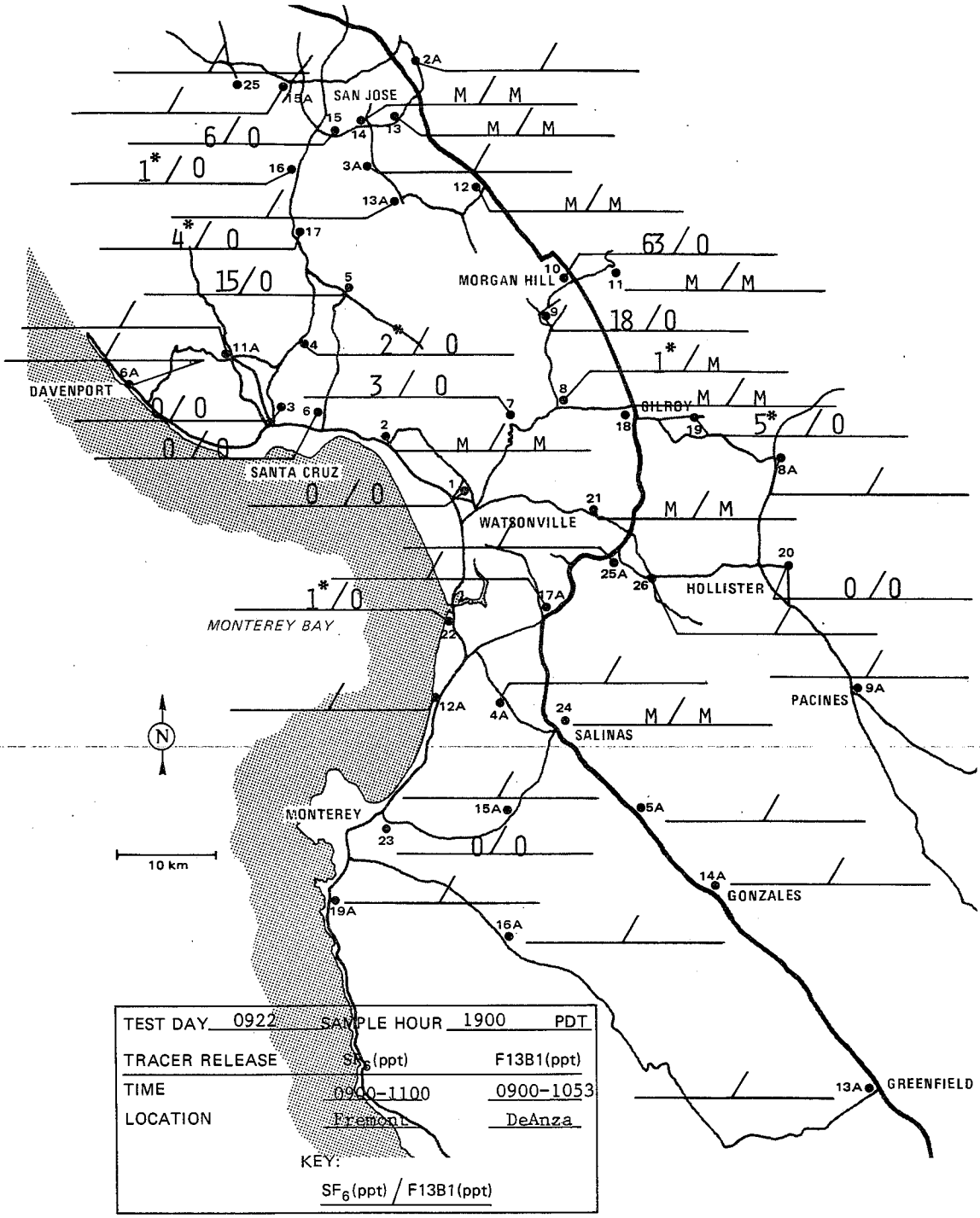


FIGURE 32h (CONTINUED)

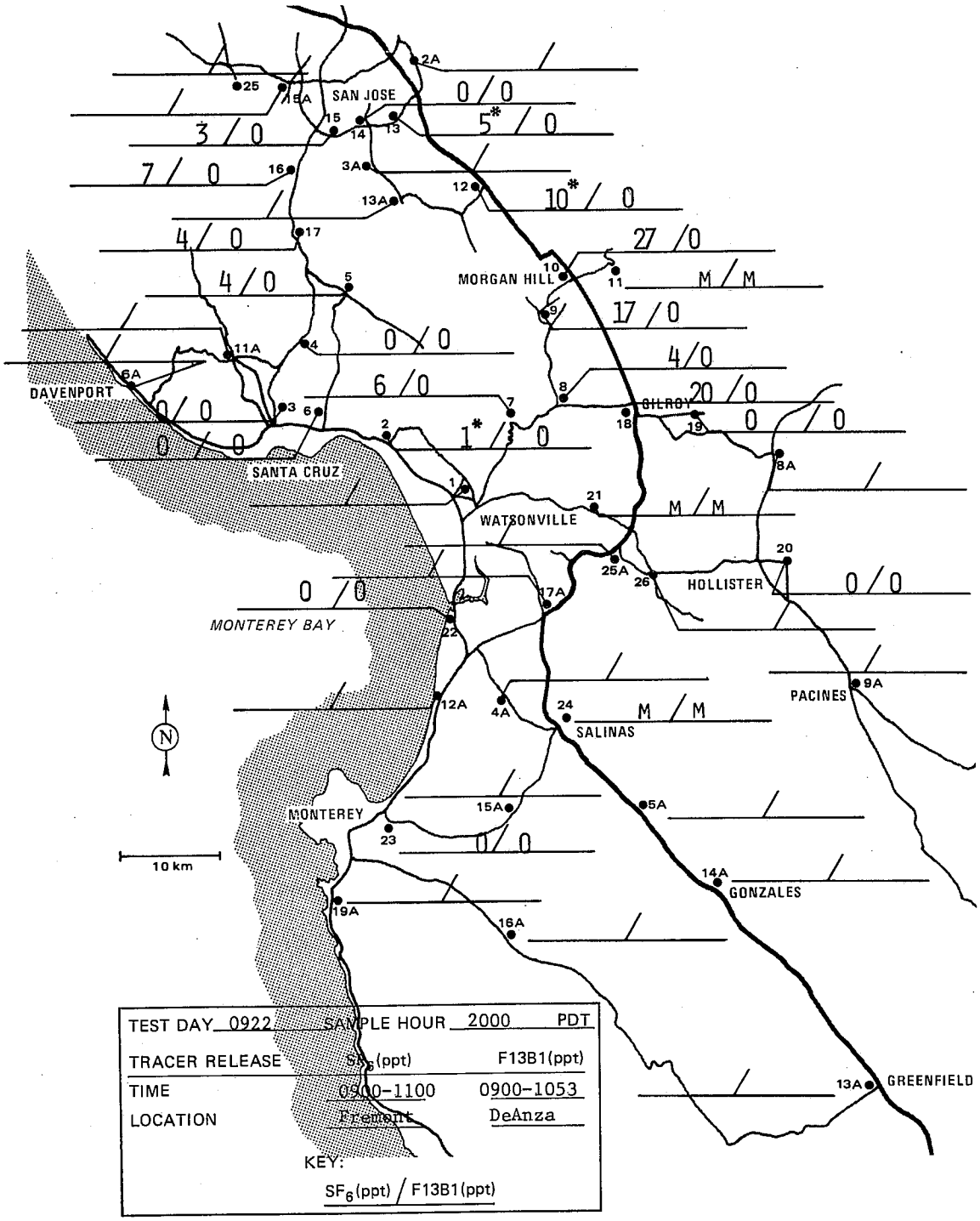


FIGURE 32i (CONTINUED)

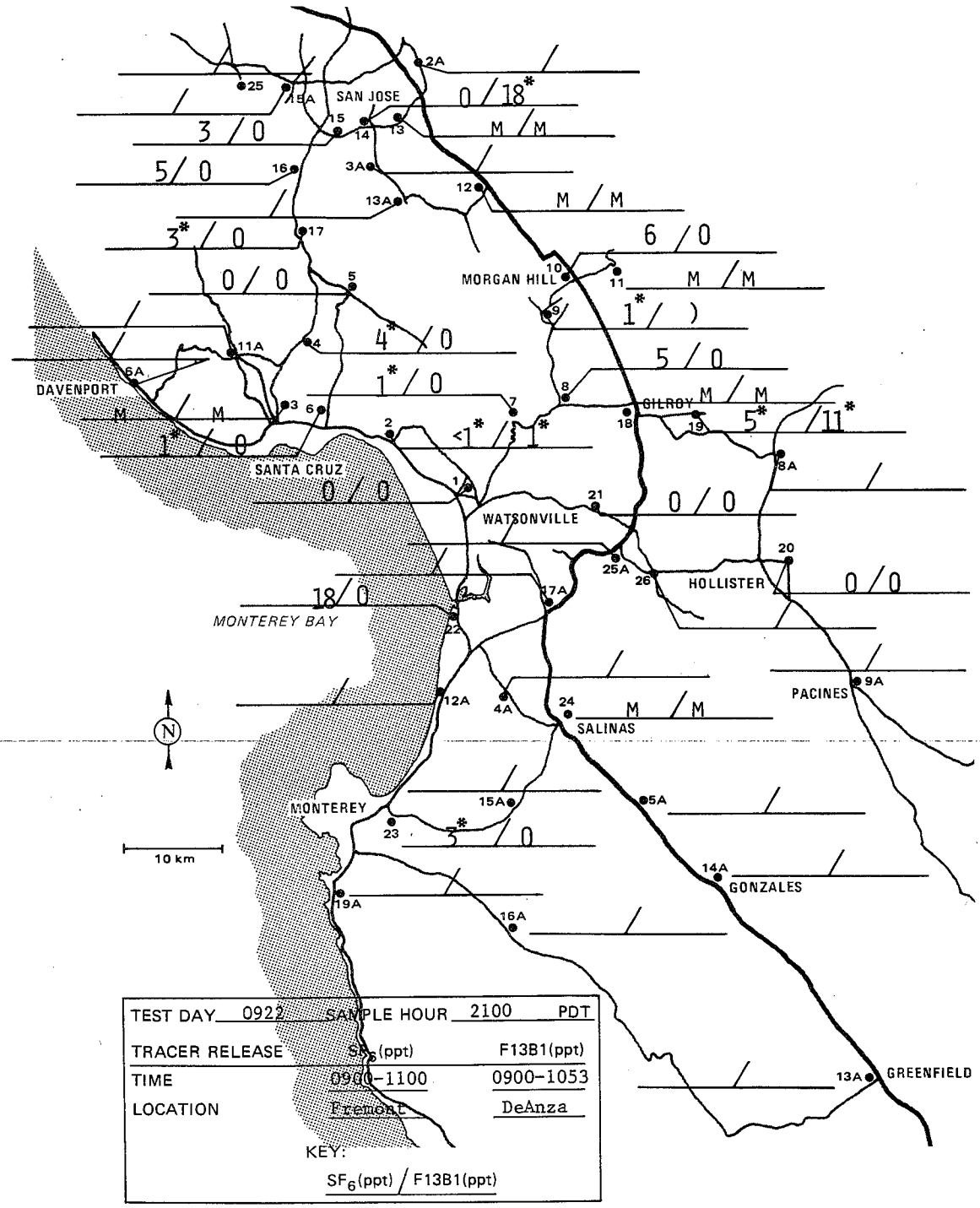


FIGURE 32j (CONTINUED)

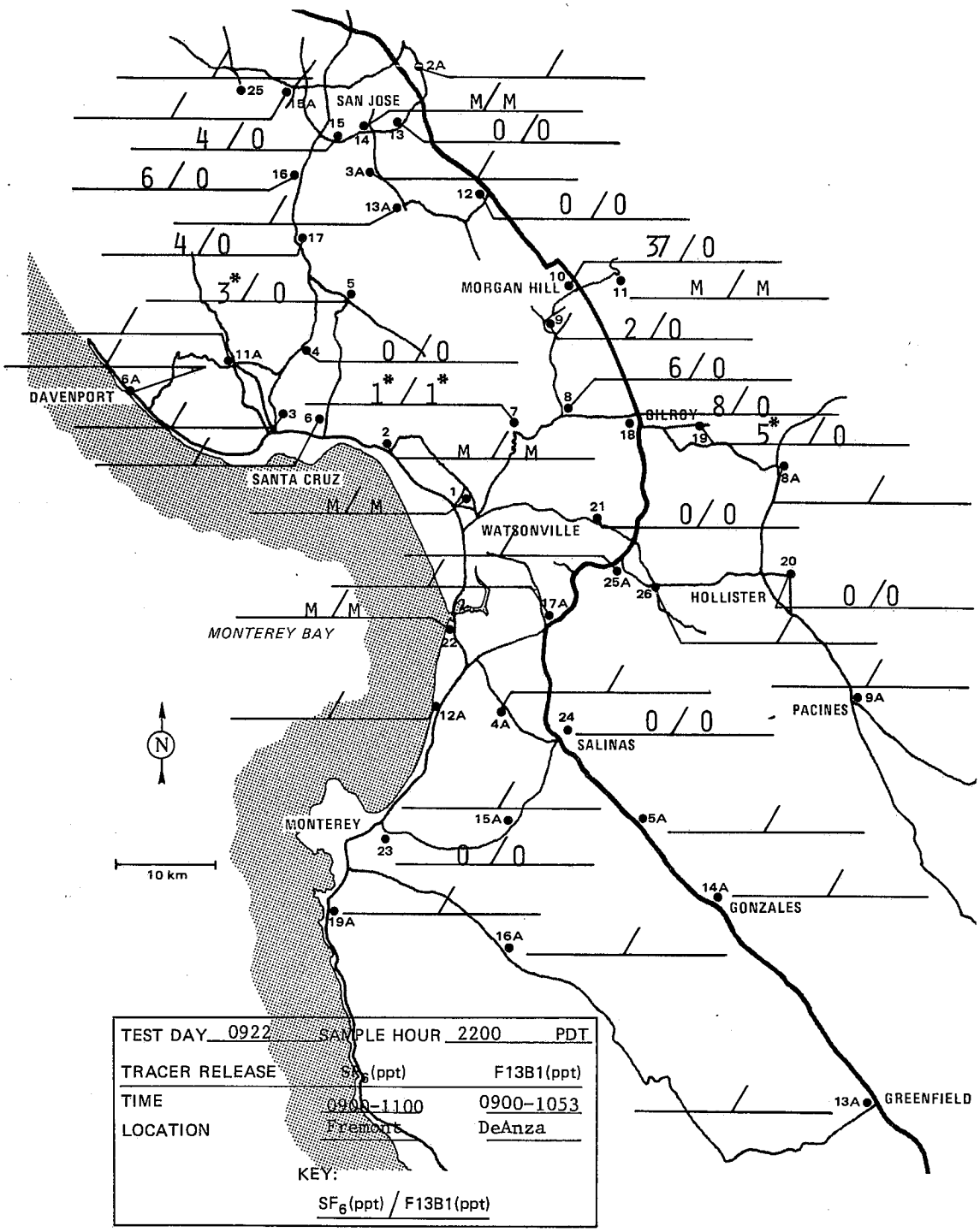


FIGURE 32k (CONTINUED)

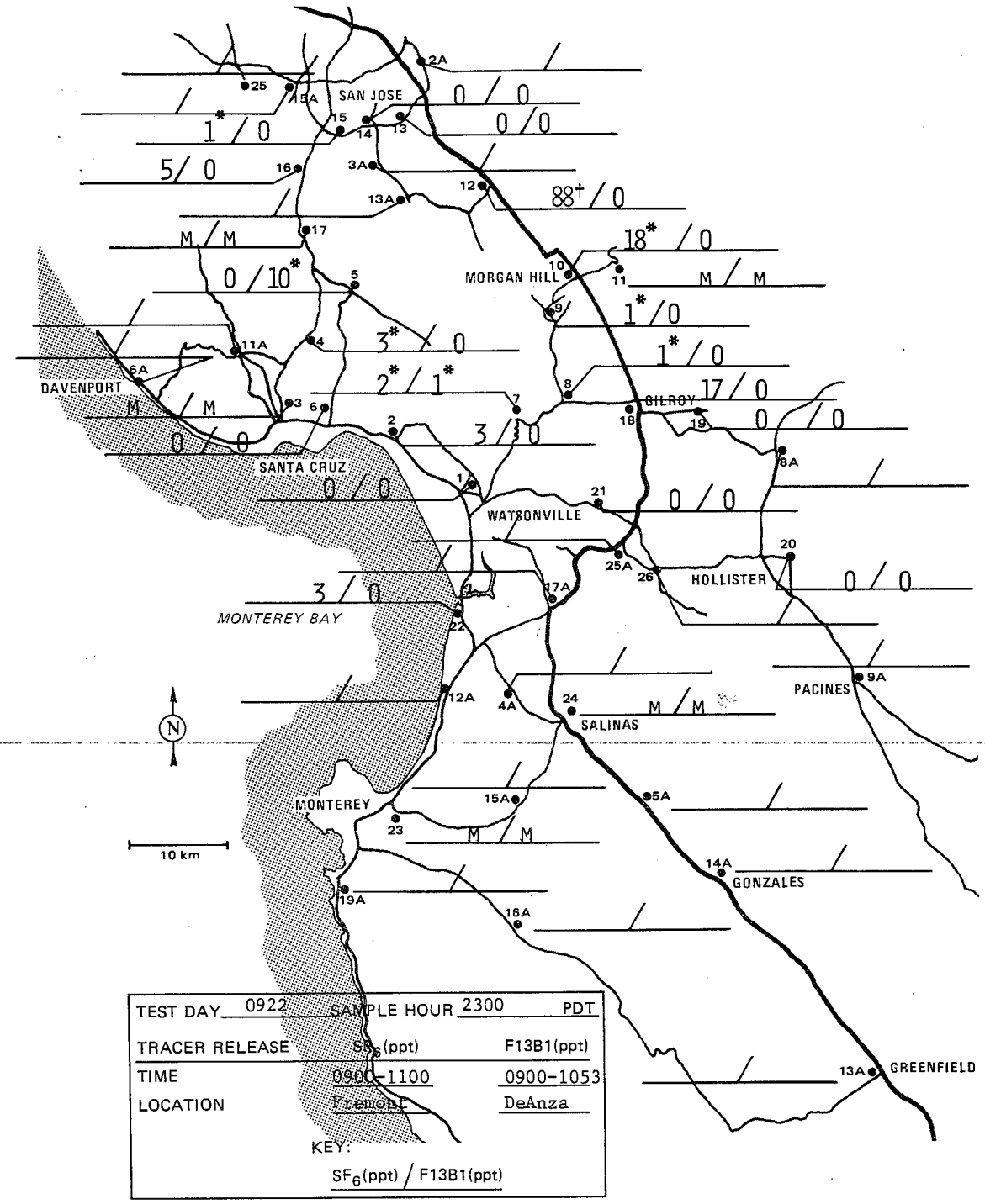


FIGURE 321 (CONCLUDED)

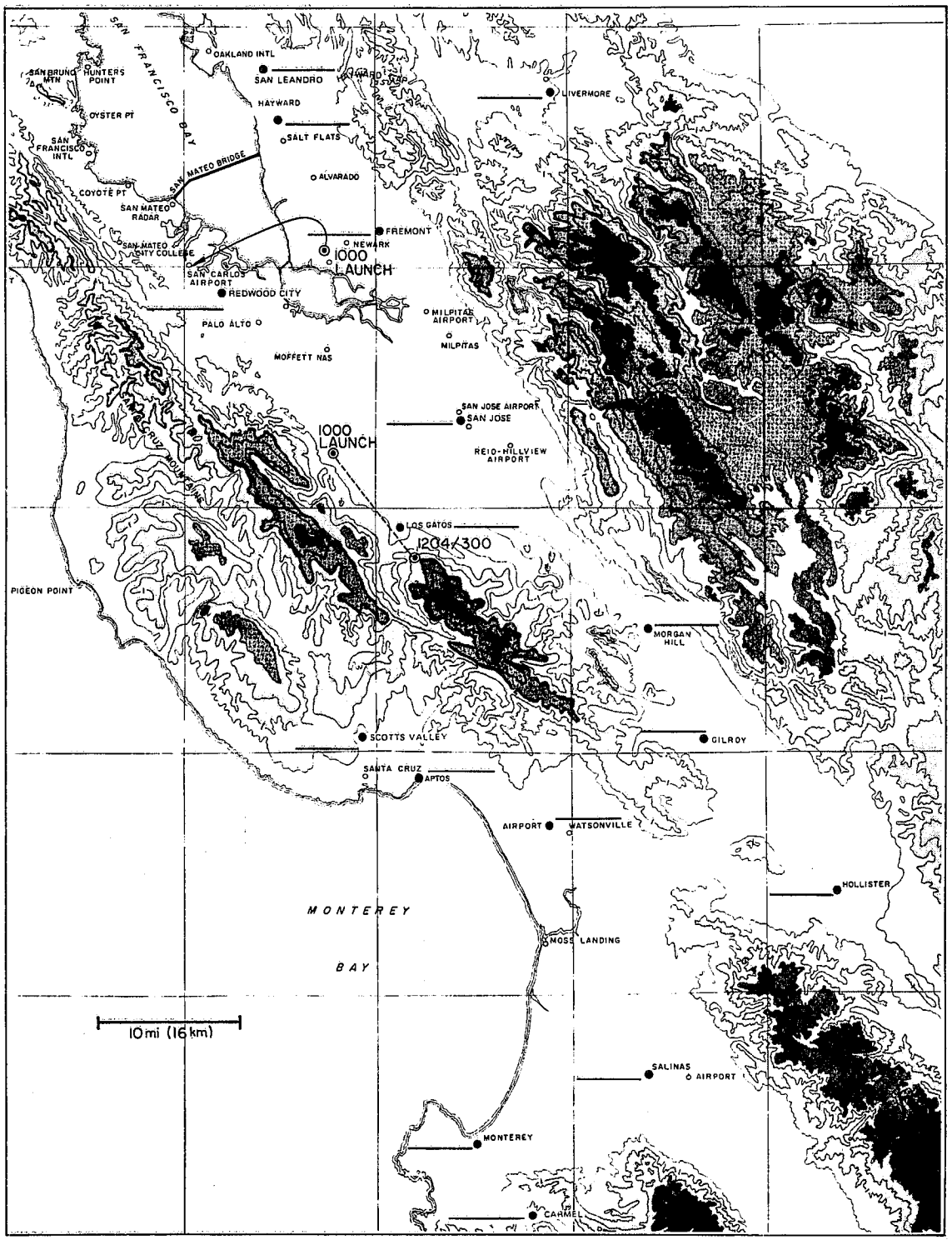


FIGURE 33 TETROON OBSERVATIONS, TEST 0922
[Time (PDT)/Altitude (m, agl)]

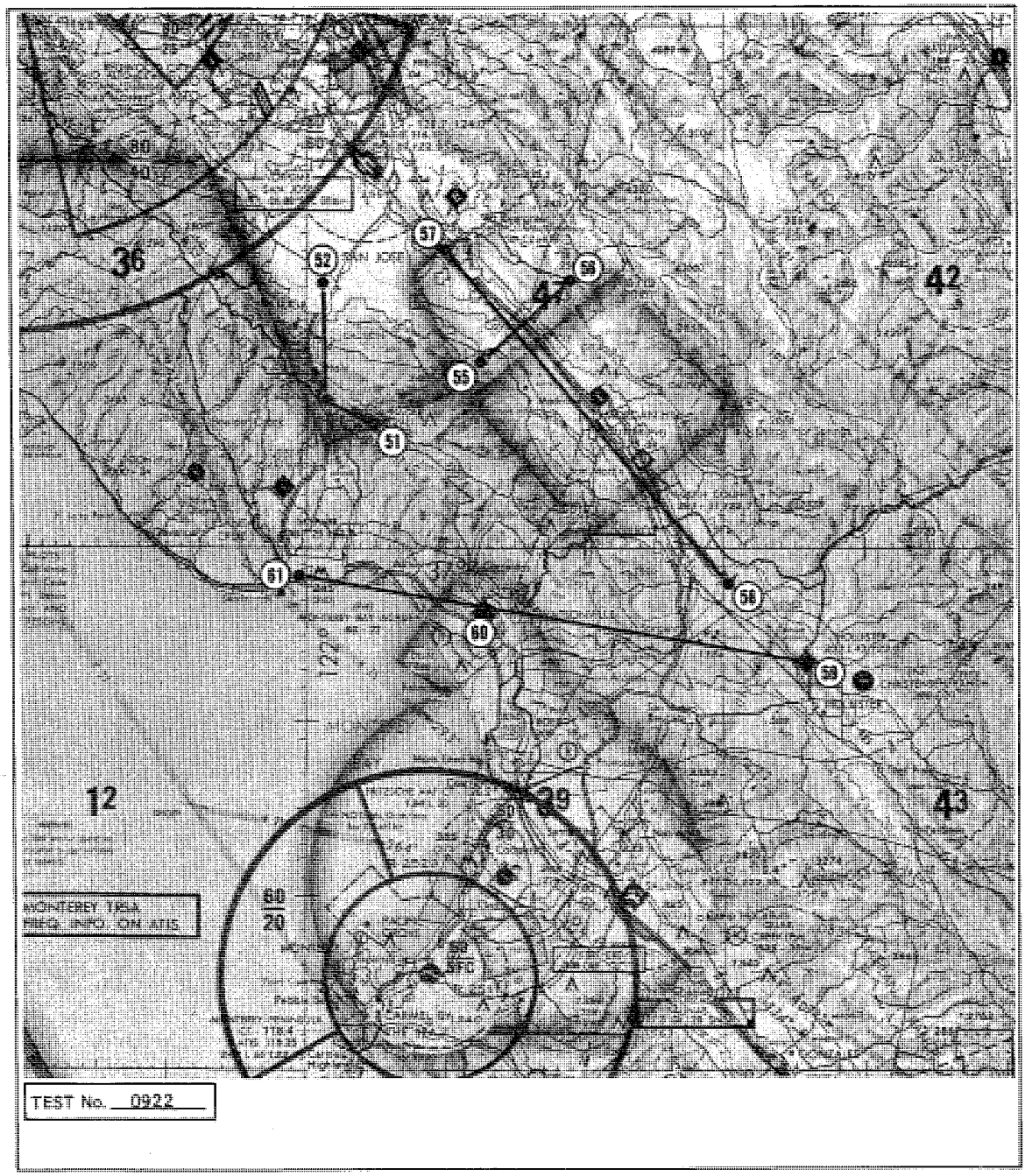


FIGURE 34a AIRCRAFT FLIGHT PATTERN, TEST 0922

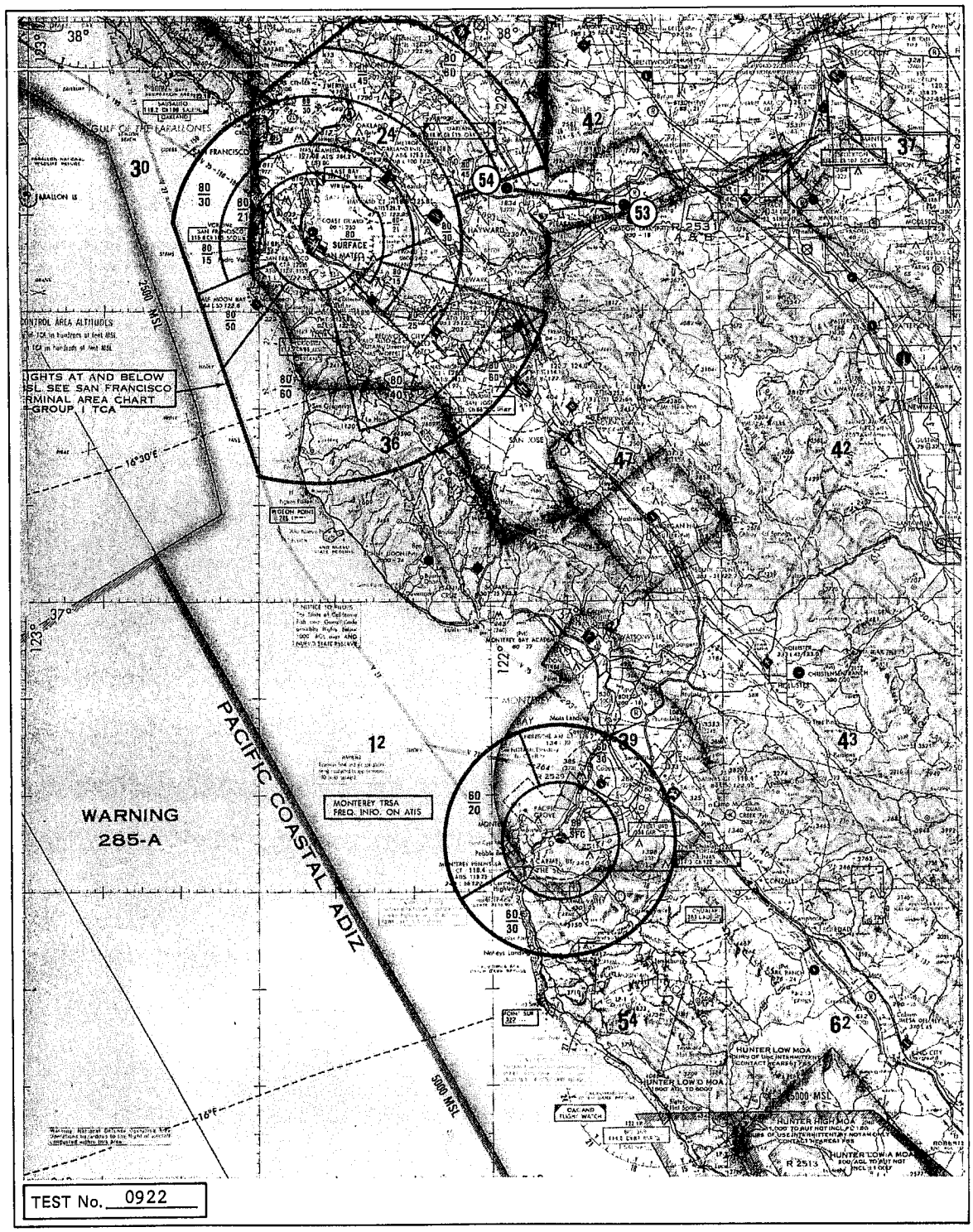


FIGURE 34b (CONTINUED)

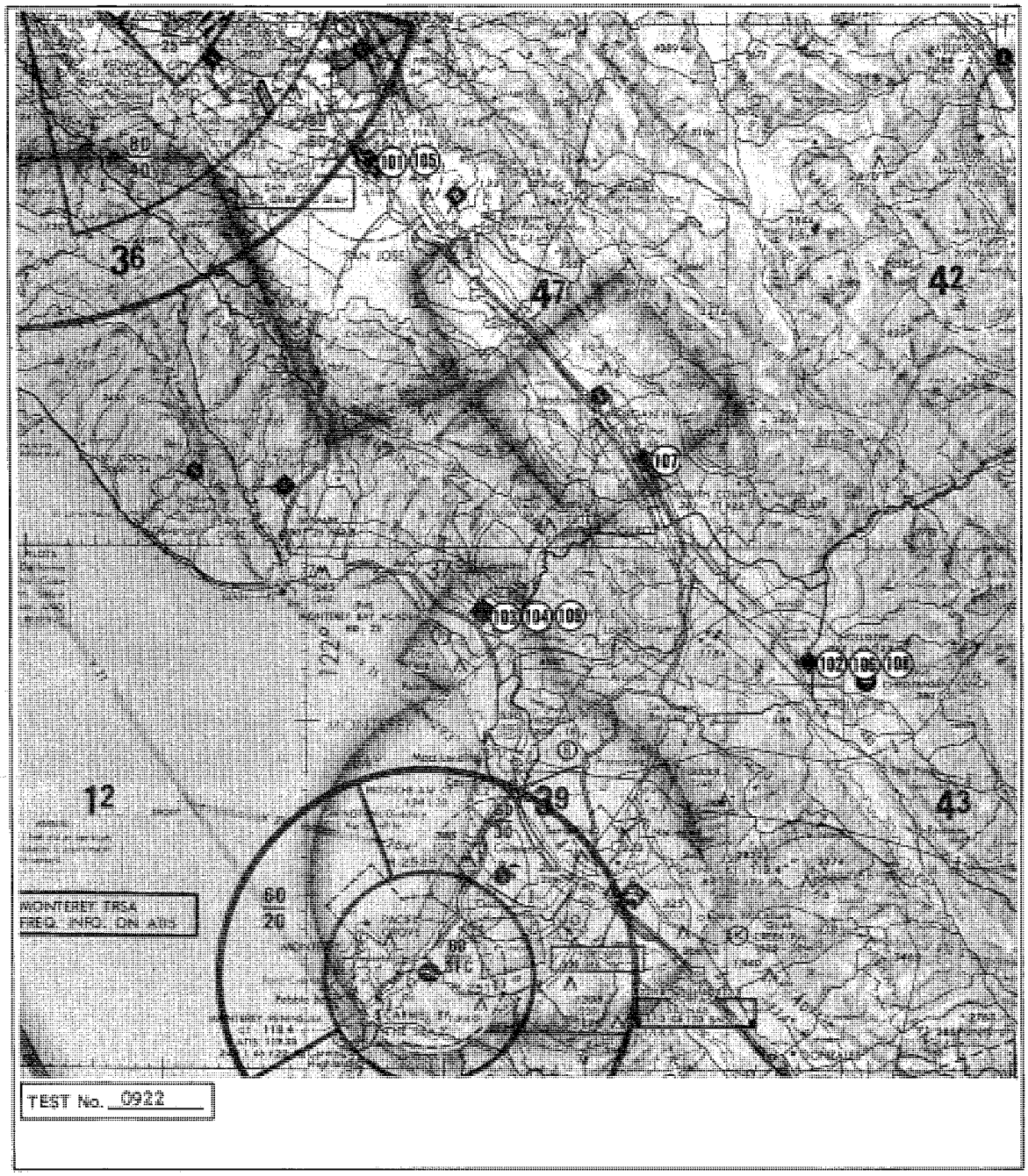


FIGURE 34c (CONCLUDED)

Table 9

AIRCRAFT WAY POINTS, TEST 0922

Way Point	Geographic Location	Altitude (m,msl)	Nominal Time (PDT)
Traverses			
51	Summit (sampler site 5)	150*	1342
52	Los Gatos	150	1342
53	Livermore	425	1424
54	San Ramon	425	1424
55	Calero Reservoir	760	1510
56	Las Animas Creek	760	1517
55	Calero Reservoir	150*	1522
57	Santa Clara County Fairgrounds	400	1542
57	Santa Clara County Fairgrounds	550	1542
58	South Gilroy	400	1555
58	South Gilroy	550	1555
59	Hollister	550	1635
60	Watsonville	550	1645
61	Santa Cruz	550	1645
Spirals			
101	San Jose Airport		0655
102	Hollister Airport		0720
103	Watsonville Airport		0740
104	Watsonville Airport		1033
105	San Jose Airport		1053
106	Hollister Airport		1116
107	South County Airport		1621
108	Hollister Airport		1852
109	Watsonville Airport		1911

*agl

Table 10

SANTA CLARA-SAN BENITO VALLEY WIND VARIATIONS,
SEPTEMBER 22, 1980

Time (PDT)	Wind Direction/Speed* Downtown San Jose	Morgan Hill	Hollister
08-09	113/02 (3)	109	var/03
09-10	135/02	081	315/05
10-11	248/02 (2)	096	315/04
11-12	315/03 (1)	299	315/06
12-13	315/04	300	(2) 293/08
13-14	315/04	302	293/07
14-15	315/05	298	293/09
15-16	315/06	296	293/09
16-17	338/05	295	270/10
17-18	338/04	302	270/15
18-19	338/05	295	270/10
19-20	338/03	303	var/03
20-21	315/03	315	(3) 135/04

*deg(true)/mph

(1) = Upvalley flow (San Jose to Hollister)
(2) = Cross-valley flow
(3) = Downvalley flow (Hollister to San Jose)

before leveling off; the temperature profile revealed an inversion extending from about 280 to 350 m with a nearly isothermal layer from the surface to 280 m. The temperature structure of the lower layers appeared to reflect the inland penetration of marine air from Monterey Bay. This is reinforced by the Hollister surface winds (Table 10), which indicated strong westerly flow throughout the entire afternoon. Higher up, the 850-mb (ca. 1500 m) winds were from the north at 10 m s^{-1}. Together, the surface and upper-air winds indicated that starting at 1100 PDT the Santa Clara Valley was under the influence of N and NW flow through the entire planetary boundary layer, while the northern San Benito Valley (i.e., Hollister) had N winds aloft but W and WNW in the lowest 350 m. These would indicate that the high early-evening ozone values aloft at Hollister may be the result of ozone and precursor transport from the San Francisco Bay Area, while the low afternoon ozone values at the surface in Hollister were the result of the clean marine air. Note that the peak-hour surface ozone concentration at Watsonville (WNW of Hollister) was equal to the Hollister peak, again suggesting transport to Hollister from WNW rather than from the north. If, on the other hand, there had been transport during the afternoon from the north out of the Santa Clara Valley, then the ozone peak at Hollister would likely have equalled or exceeded the 90-ppb peak at Gilroy.

The fixed-sampling network indicated a large F13B1 concentration at the Lexington Reservoir near Los Gatos at 12-1300 PDT and a moderate concentration at the same time in Scotts Valley, to the west of the ridge line. The Scotts Valley F13B1 level doubled during the next hour and then dropped to zero for the remainder of the day. At 1600 there was a pocket that appeared in east Morgan Hill, although no F13B1 concentrations were observed the next hour throughout the network. For the 1800-hour, a significant concentration (32 ppt) was detected in Salinas. Later in the evening, isolated pockets were seen sporadically, but they did not depict any systematic transport. The ground and airborne tracer measurements are a useful supplement to the fixed network by providing detail for understanding the F13B1 transport patterns. In the early afternoon (ca. 1300 PDT), tracer sampling vehicle number one encountered a 15-km segment of F13B1 between Los Gatos and the ridge line to the south and west. Later in the afternoon (1717-25 PDT), the same vehicle detected a 10-km segment along Highway 101 in the Gilroy area. Around 1300 PDT, vehicle two measured a broad F13B1 segment along Highway 17 from Lexington Reservoir to Milpitas and then east on Highway 237 to Highway 680. Scattered peaks of F13B1 were detected along portions of Highways 580 and 680 in the east bay region up to 1400 PDT. Vehicle three observed a 7-km F13B1 segment around 1725 PDT along Highway 152 between Watsonville and Hecker Pass. Other isolated pockets were seen by vehicles three and four during the late afternoon between Watsonville and Gilroy.

No significant traces of SF_6 were measured by the fixed network until 14-1500 PDT when a broad low-level area was observed from Lexington Reservoir (near Los Gatos) along Highway 17 and the Capitol Expressway to south San Jose near Highway 280; see Figure 32(c). During the

following hour (15-1600), one significant peak (55 ppt) was measured on the ridge line above Lexington Reservoir and a second (22 ppt) in Morgan Hill. The broad low-level band seen the previous hour was no longer present, nor were there other similar patterns elsewhere. Some indications of a limited SF_6 band were seen at 16-1700 between Morgan Hill and Gilroy, with scattered low-level observations in various sectors. Starting at 18-1900 PDT, SF_6 concentrations began to increase in the Campbell-Los Gatos-Lexington Reservoir ("western") corridor. By 19-2000, the SF_6 in the western corridor had advanced to the ridge-line station (Number 5), and there were traces in Scotts Valley, Watsonville, and Hecker Pass as well. An hour later (20-2100), SF_6 in the western corridor had increased at Hecker Pass but decreased elsewhere in this corridor. At 2100 PDT, Moss Landing observed its first SF_6 concentration (18 ppt), and Monterey detected a trace (3 ppt). During the last sample hour, 23-2400 PDT, there were still remnants of SF_6 throughout the western corridor, ranging from 5 ppt in Los Gatos to 3 ppt in Moss Landing.

SF_6 concentrations in the so-called southern corridor show an unusual and dramatic evolution. No systematic detection of SF_6 was apparent in the Santa Clara Valley until early evening (18-1900), when concentrations of 3-10 ppt were observed between Morgan Hill and south San Jose. At 1900, Morgan Hill concentrations increased dramatically to 63 ppt and 18 ppt (the south San Jose observation was missing). The pattern continued evolving throughout the evening: at 2000, the southern SF_6 corridor extended up the Santa Clara Valley from San Jose to Gilroy with concentrations in the 17-27 ppt range between Morgan Hill and Gilroy; Hollister, however, reported no SF_6 (nor F13B1). Concentrations at 21-2200 PDT were distributed in much the same way although values were generally reduced by a factor of four. The last two hours (22-2300 and 23-2400 PDT) continued to indicate a broad band of SF_6 between Gilroy and south San Jose, except that concentrations increased again, reaching 37 ppt at 22-2300 in Morgan Hill (but 0 in south San Jose) and 88 ppt at 23-2400 in south San Jose (and 17 ppt in Morgan Hill).

Summarizing the transport patterns as depicted by the tracer measurements, there are different patterns for each of the two tracers. The SF_6, released in late-morning from Newark, is detected along two "corridors" in the afternoon and evening. (Because of the topography, sampling was done along geographic corridors. In reality, it is not possible from the data to determine the lateral extent of these corridors or if they are indeed separate transport routes rather than a larger, contiguous transport pattern.) One corridor extends along Highway 17 from Los Gatos to the summit and then generally southward along and over the ridge line to Scotts Valley and Watsonville. Movement along this western corridor results in transport to Moss Landing at 21-2200 PDT, about 12 hours after initiation of the tracer release in Newark--a net transport rate of 2.9 m s^{-1}. The southern corridor extends through the Santa Clara Valley. SF_6 transport was first observed around 1300 near San Jose Municipal Airport by one of the mobile sampling vehicles; the next significant observation was for the hour 15-1600 PDT at Morgan Hill. Both the mobile and fixed-network samples indicated a relatively

compact plume. By early evening, a broad plume was observed in the Morgan Hill-Gilroy area with higher concentrations. The plume persisted, varying in size and intensity, throughout the evening. This sudden onset of high concentrations over a broad area of the Valley suggests that more than one trajectory transported SF_6 from Newark to the upper Santa Clara Valley. Several alternative trajectories are possible for the evening transport; for example, horizontal transport through the Bay Area and vertical transport to the mountain ridges during daytime and return flow to the valley floor with evening drainage winds. No SF_6 was observed beyond (i.e., south of) Gilroy,* indicating transport into the NCCAB did not occur on this day through the Santa Clara Valley.

The F13B1 observations indicate transport occurred primarily along the western corridor. By mid-afternoon, concentrations measured by the fixed network were near zero throughout the region, although the mobile sampling vehicles continued to detect isolated and widely scattered F13B1 pockets. However, a significant F13B1 sample (32 ppt) was observed for the hour 18-1900 PDT in Salinas. Mobile samples taken around 1900 PDT in this area did not detect F13B1 in Salinas, but similar concentrations were detected between Castroville and Moss Landing.

3. Test 0924: 24 September 1980

The surface synoptic weather pattern (Figure 35) for virtually all of California and Arizona was dominated by a well-established thermal trough centered in northwestern Mexico. The SFO-RNO pressure difference (Figure 24) decreased an additional 0.4 mb from September 22 to a value of -6.1 mb. The Gilroy peak-hour ozone reached 90 ppb at 15-1600 PDT; Watsonville had a corresponding ozone level of only 63 ppb. However, during the preceding hour (14-1500 PDT), Watsonville recorded a daily maximum hourly concentration of 101 ppb; see Figure 36. The area-wide maxima for the day were observed at Los Gatos (110 ppb at 13-1400 PDT) and Fremont (130 ppb at 16-1700 PDT). By comparison, Hollister peaked for the day at 80-ppb ozone during the hour 15-1600 PDT.

The F13B1 tracer was released from 0900-1100 in Vasona Park in Los Gatos to study the effectiveness of Transport Route 2 (Figure 3), also denoted here as the western corridor. SF_6 was released simultaneously from the Santa Clara County Fairgrounds in south San Jose. Tetroons were launched at 1000 PDT from both locations (Figure 37a-n). On release, the Vasona Park tetroon become entangled in a tree and was unable to work itself free; the Fairgrounds tetroon headed north over downtown San Jose but could not be located visually or by radar. Figure 38 provides hourly maps of tracer concentrations measured at the fixed

*A single syringe sample (33 ppt) containing SF_6 was collected at 1833 PDT in Hollister; however, the isolated nature of the SF_6 sample suggests it is not indicative of a broad transport pattern.

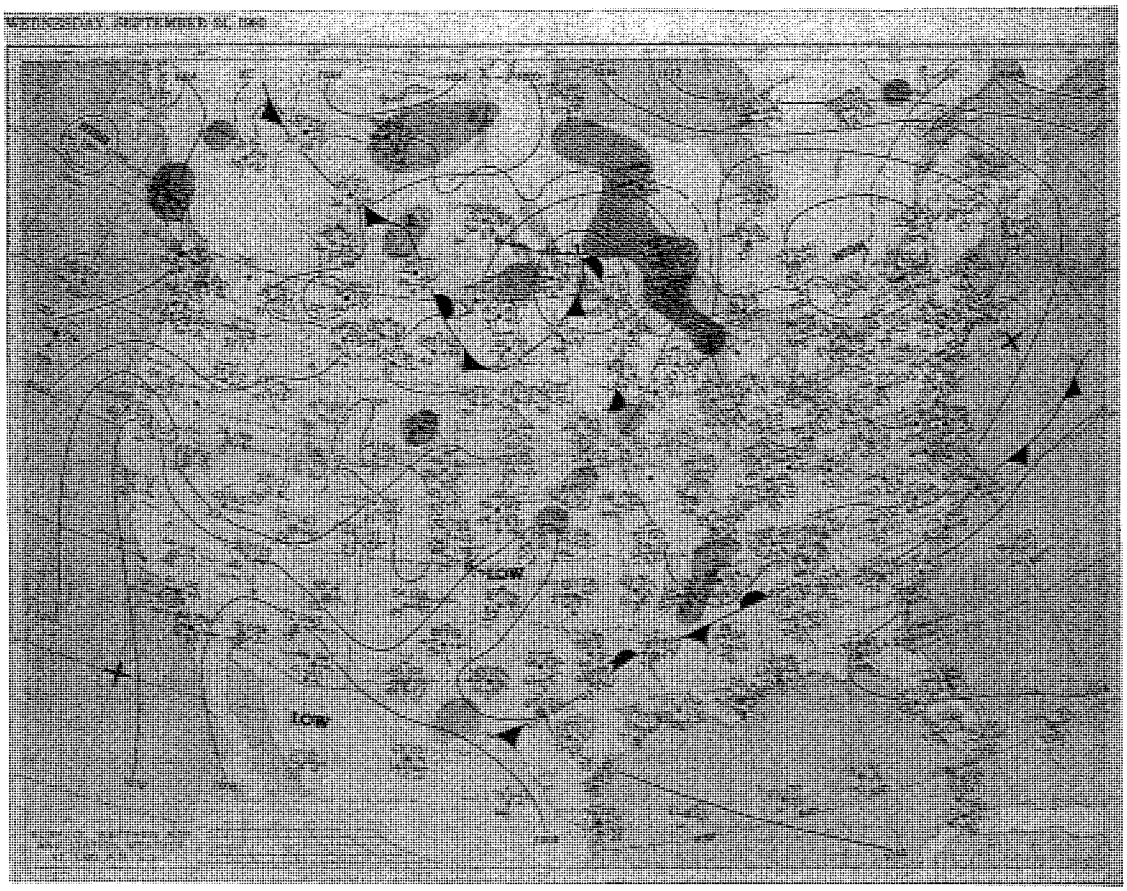


FIGURE 35 SURFACE WEATHER MAP, 0500 PDT, TEST 0924

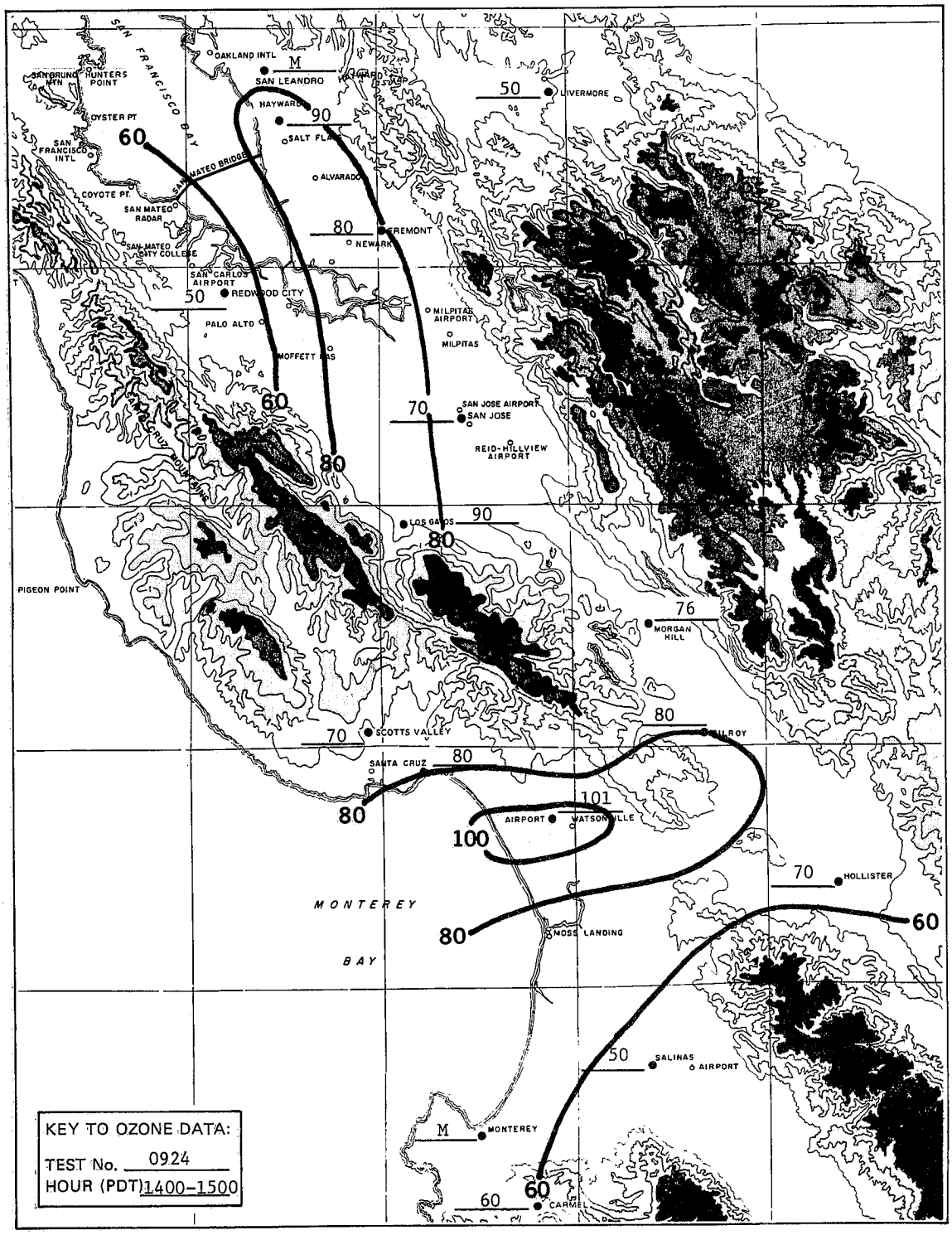


FIGURE 36 DISTRIBUTION OF SURFACE OZONE (ppb), PEAK HOUR, TEST 0924

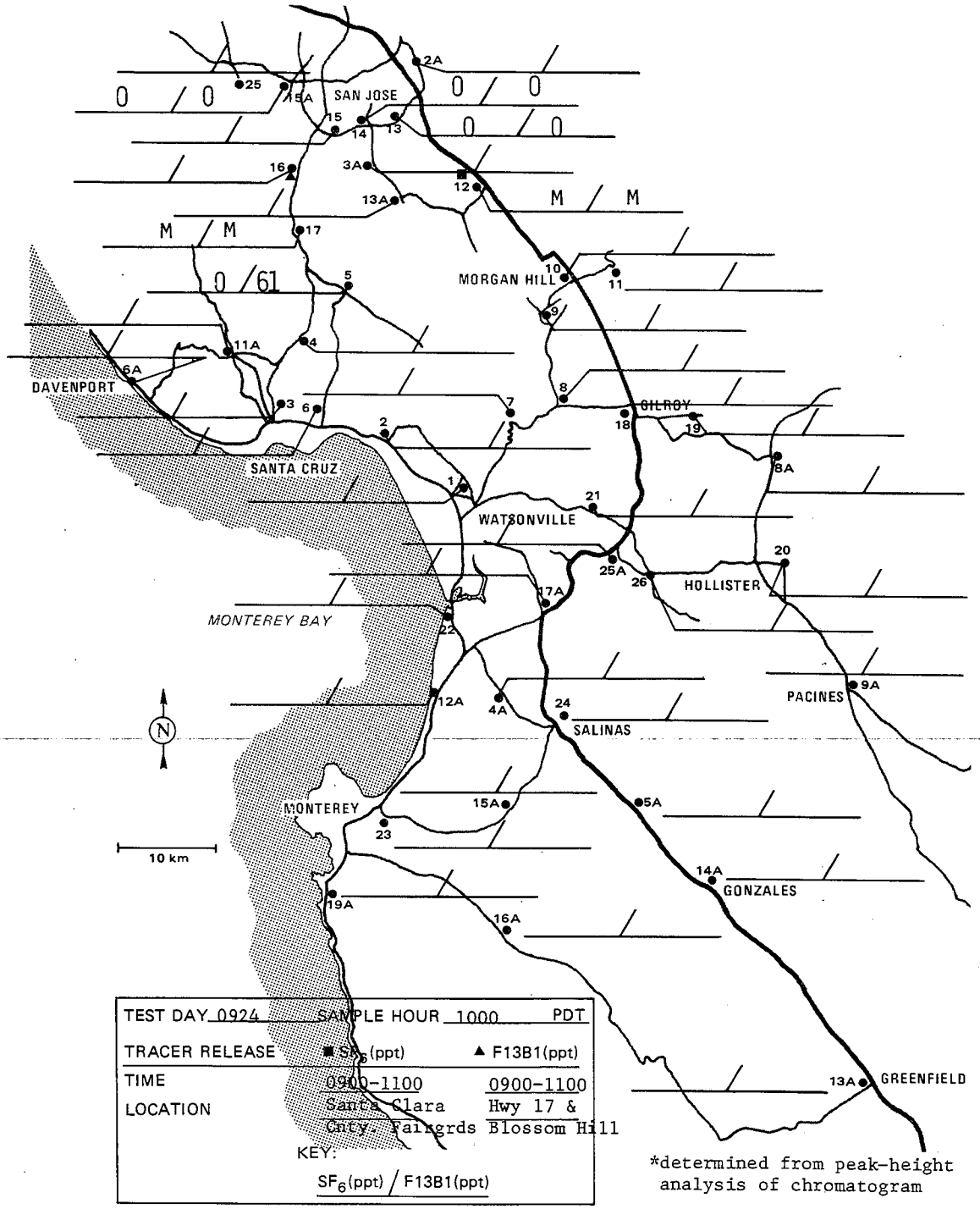


FIGURE 37a HOURLY SURFACE TRACER MEASUREMENTS, TEST 0924

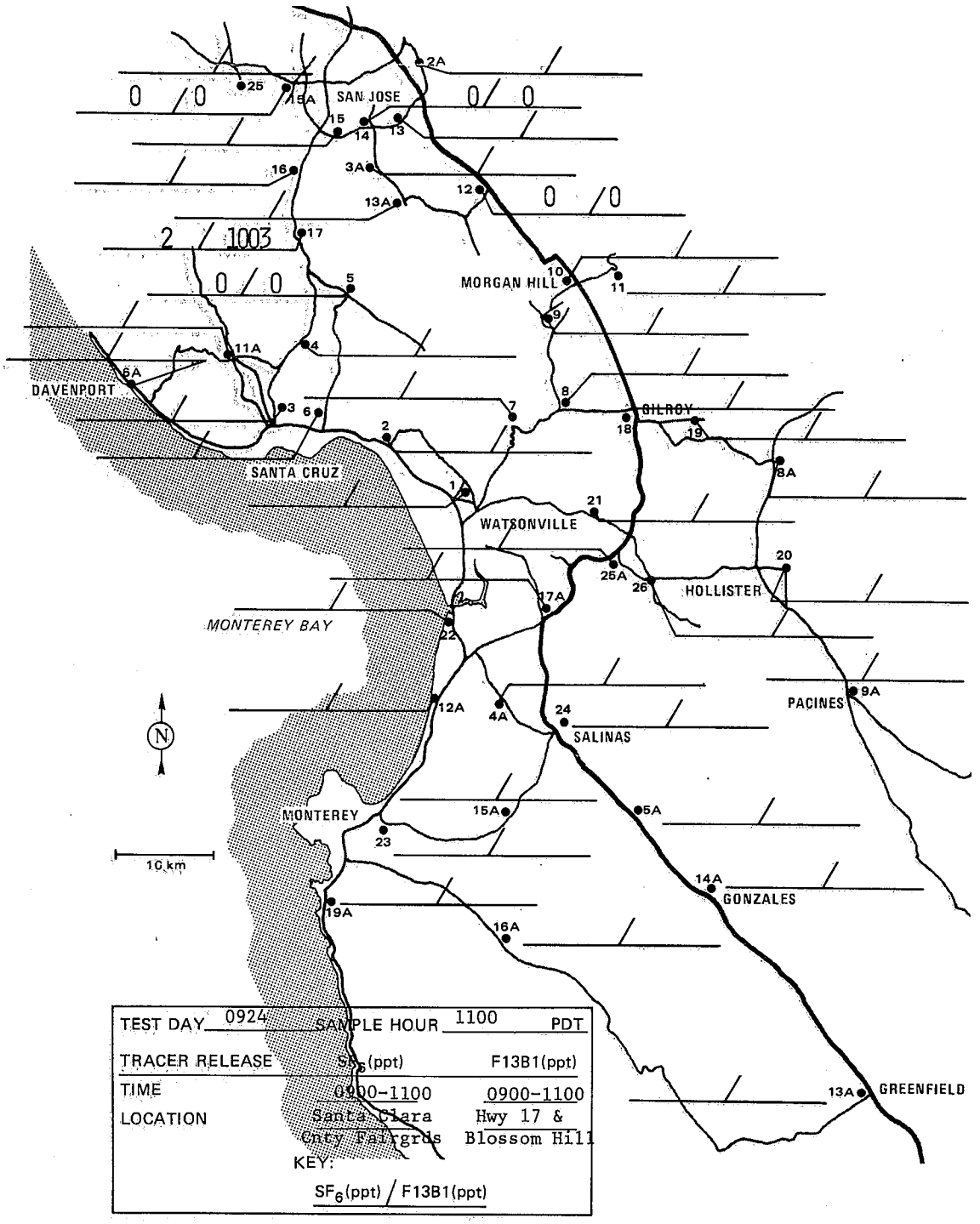


FIGURE 37b (CONTINUED)

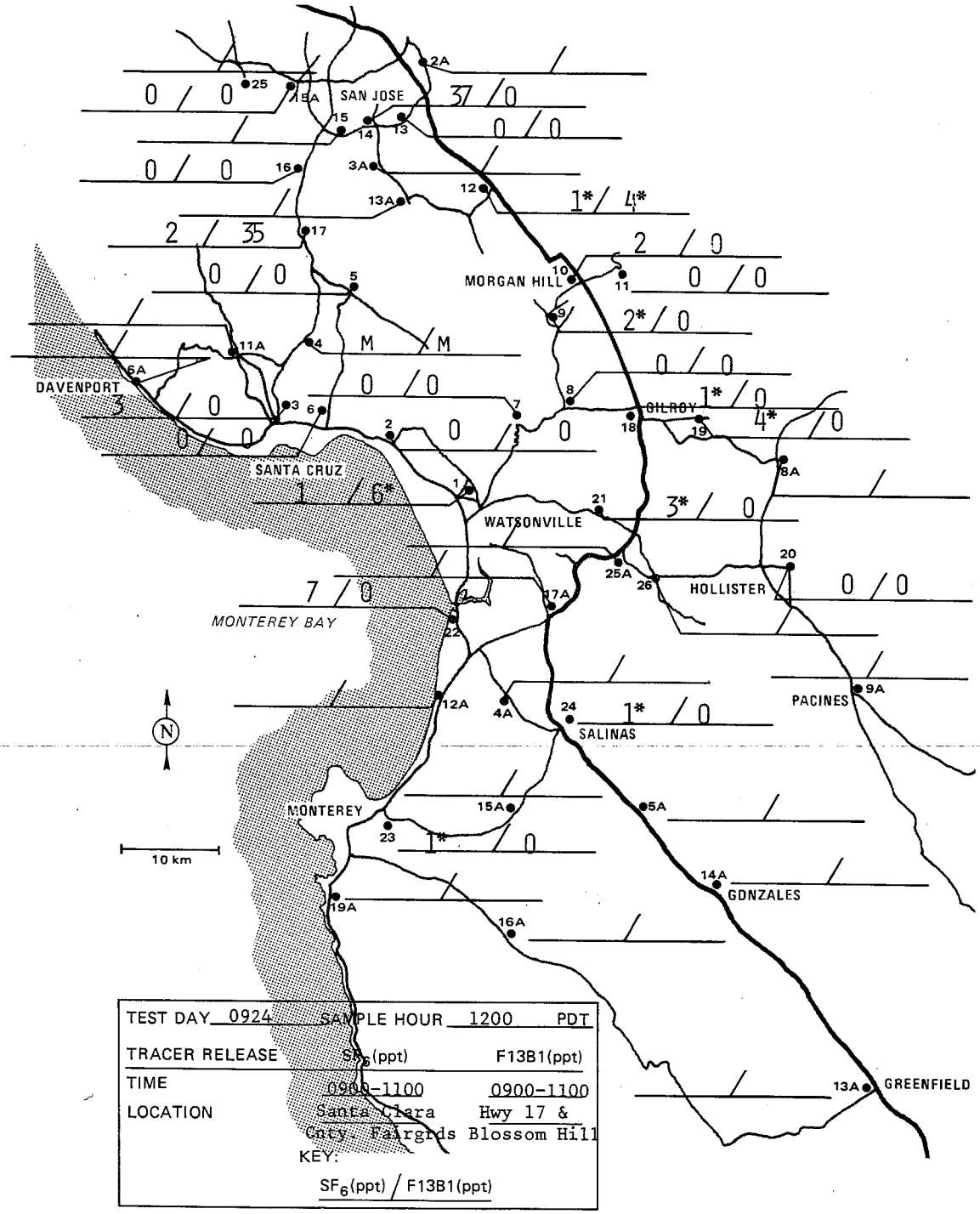


FIGURE 37c (CONTINUED)

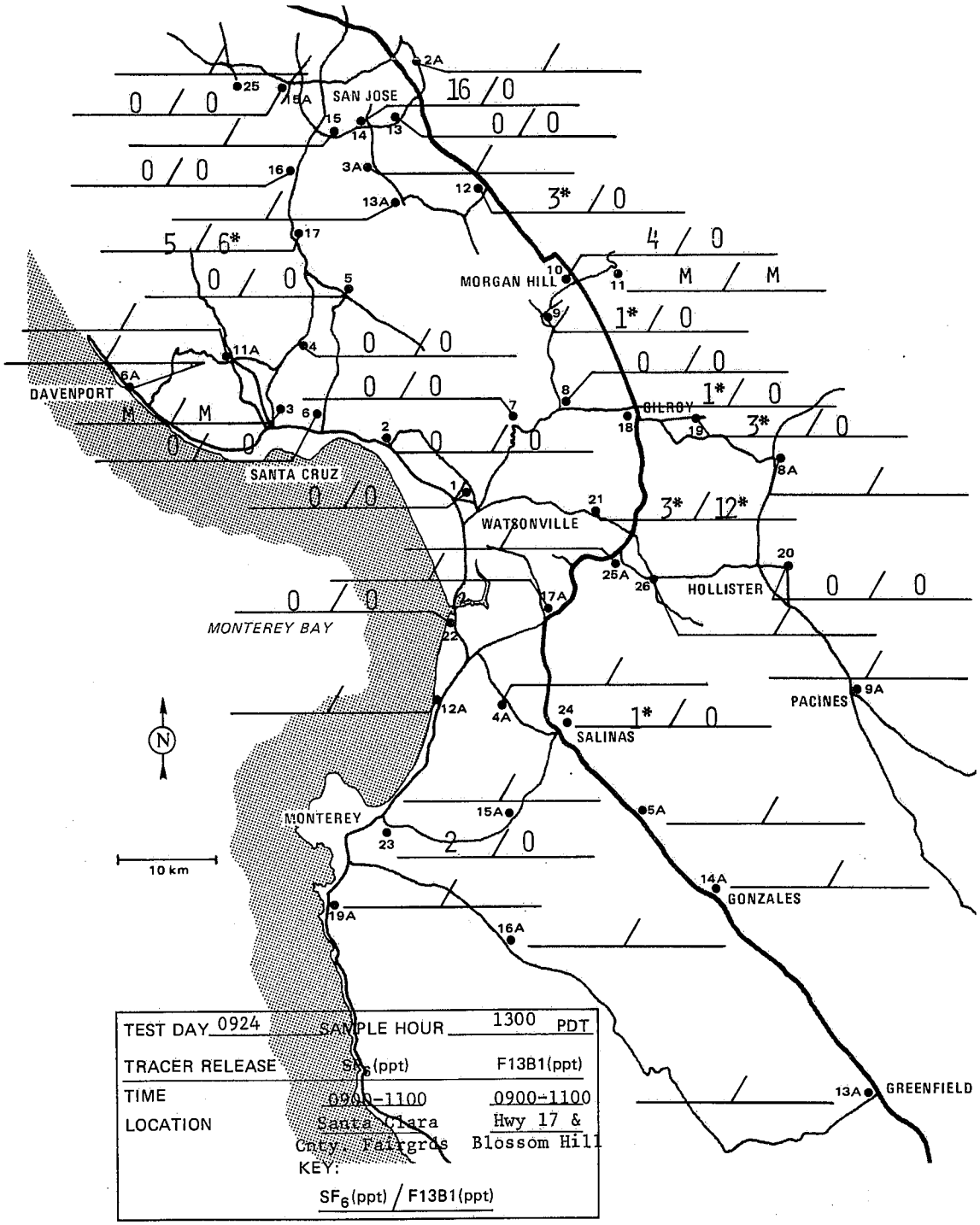


FIGURE 37d (CONTINUED)

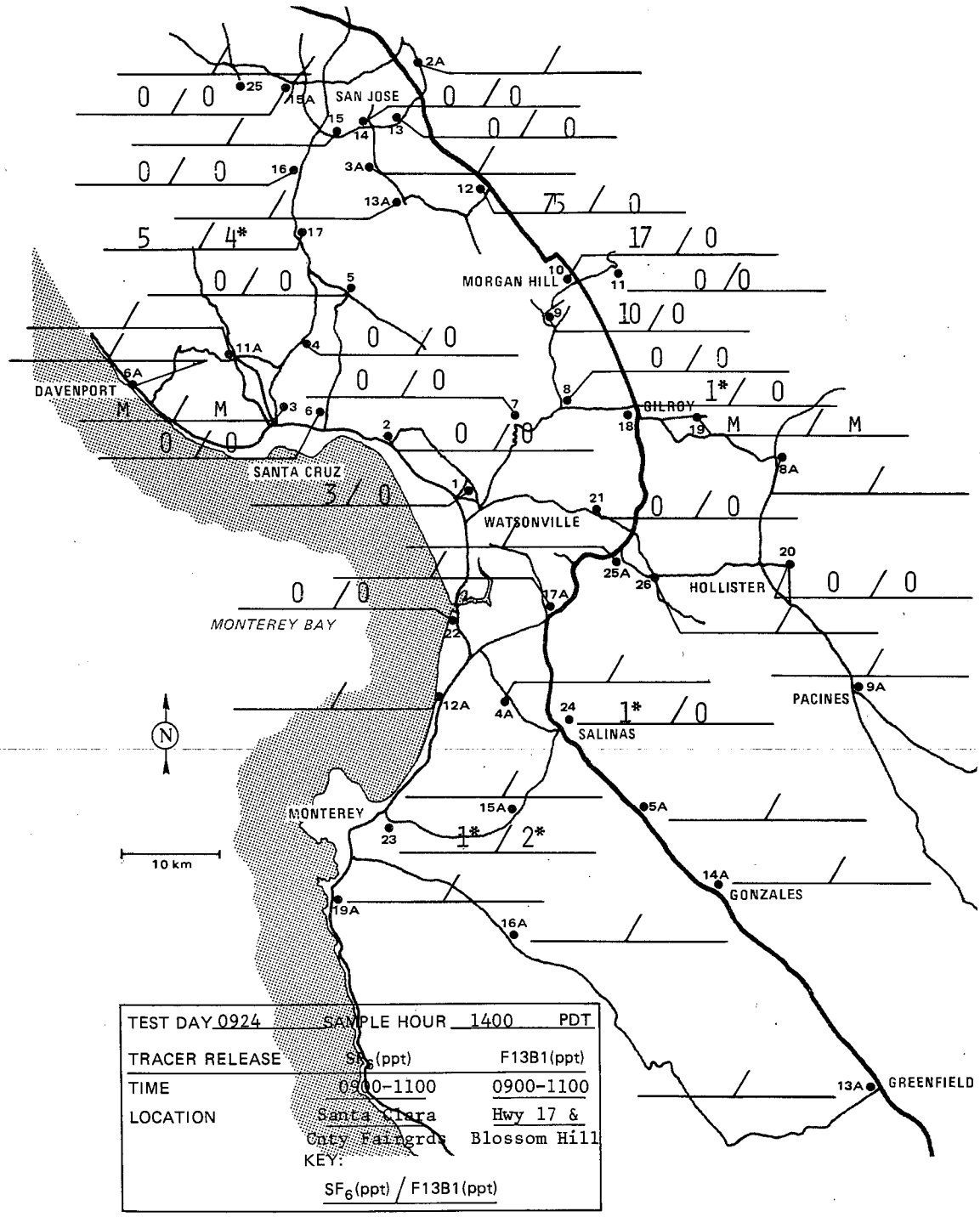


FIGURE 37e (CONTINUED)

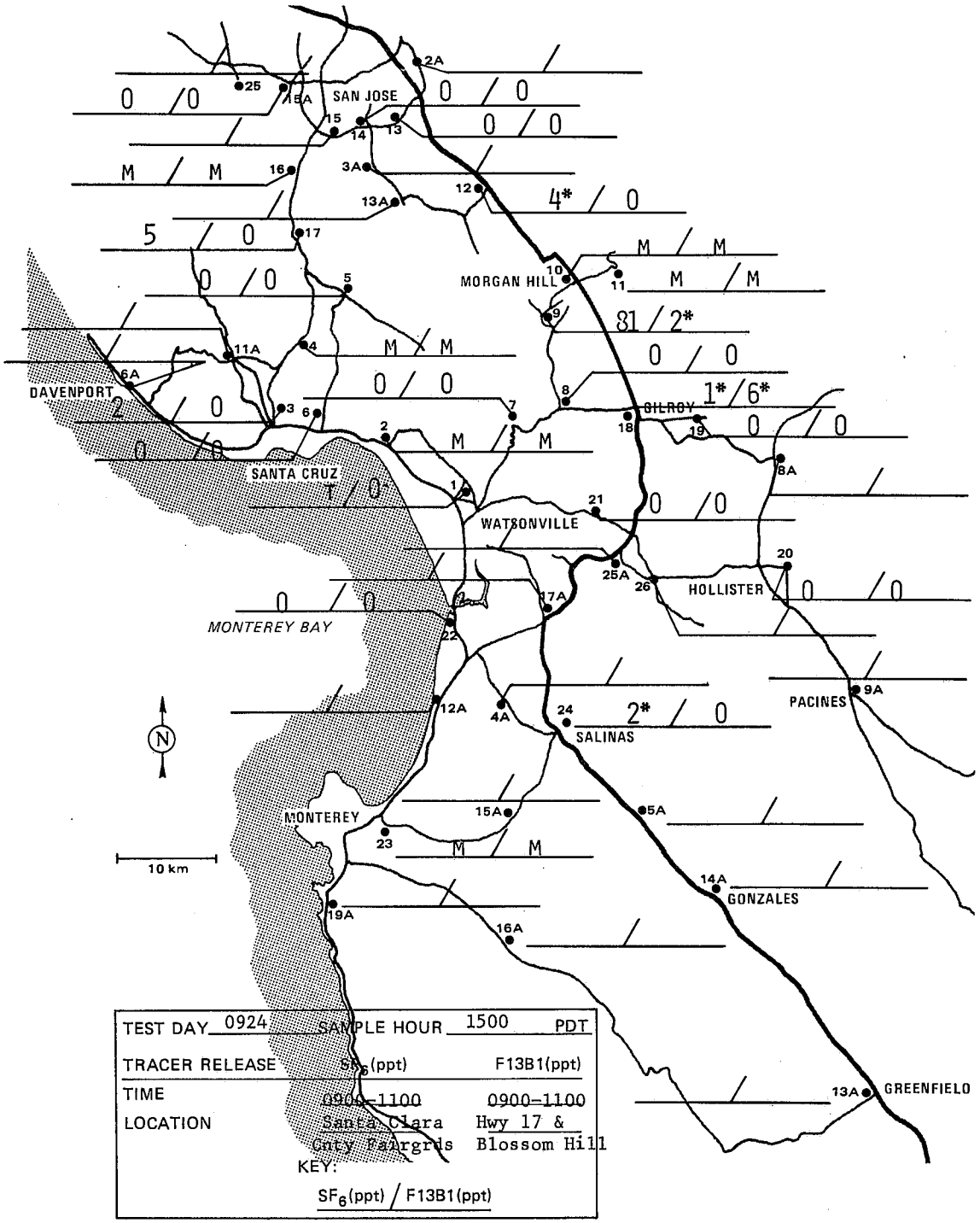


FIGURE 37f (CONTINUED)

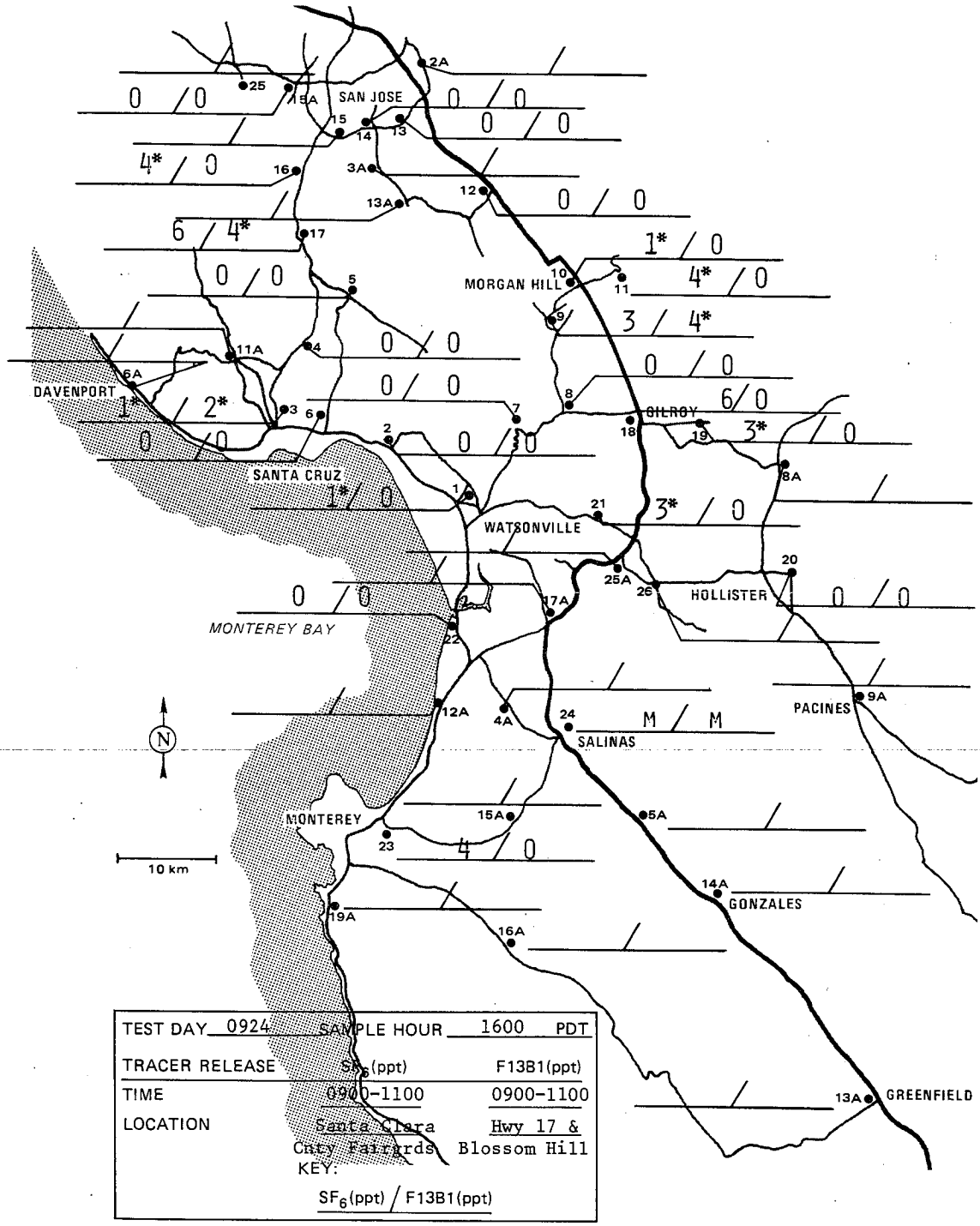


FIGURE 37g (CONTINUED)

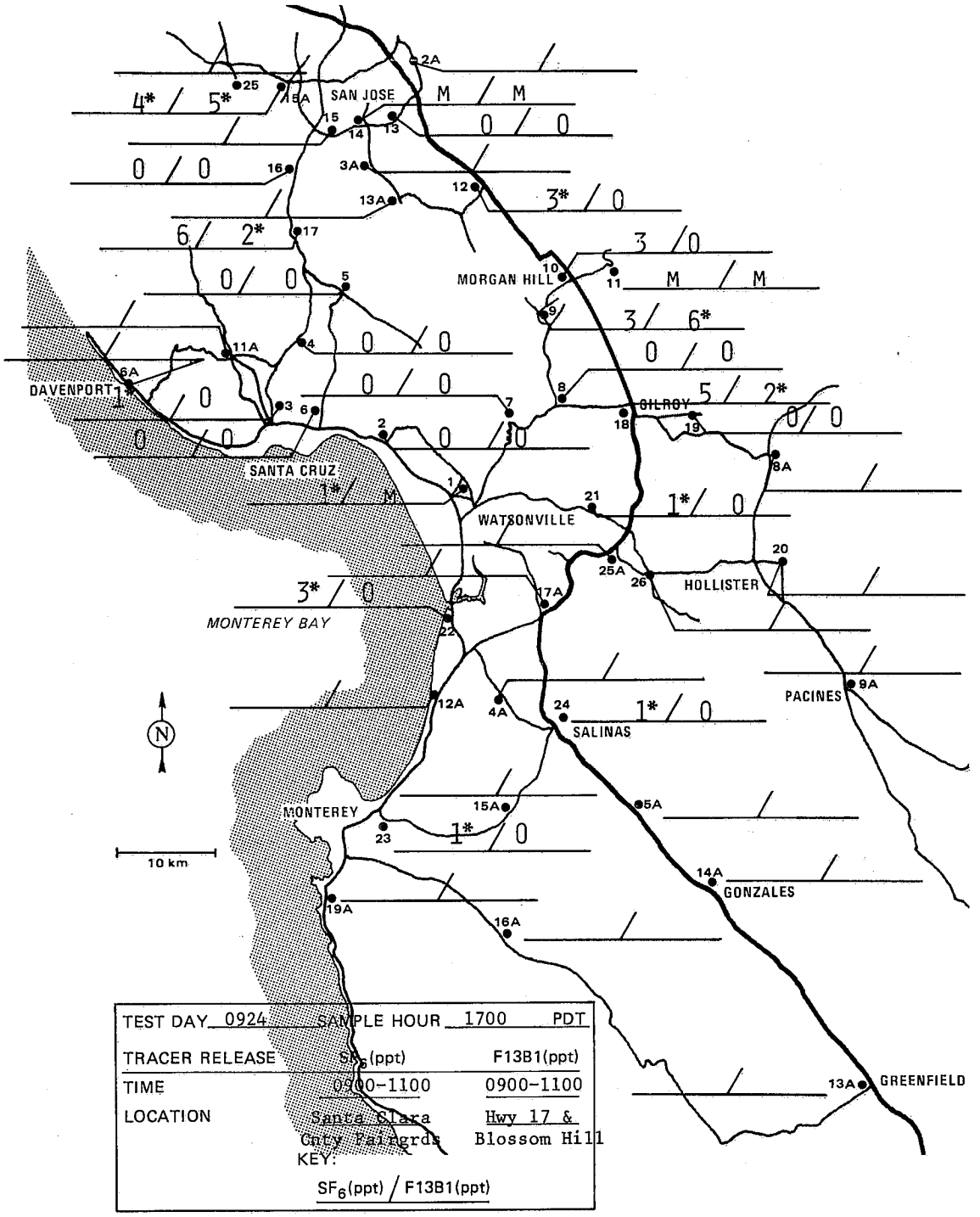


FIGURE 37h (CONTINUED)

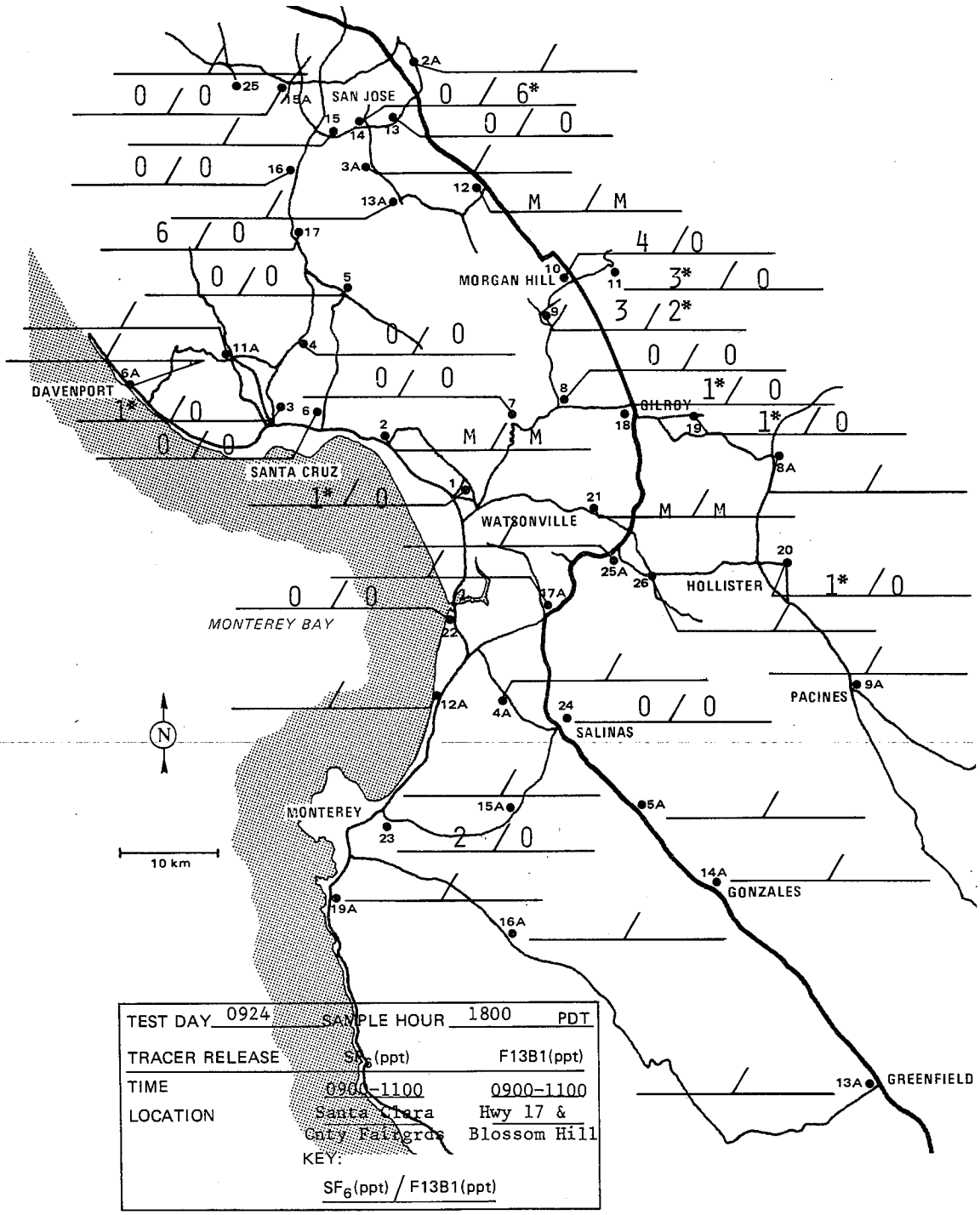


FIGURE 37i (CONTINUED)

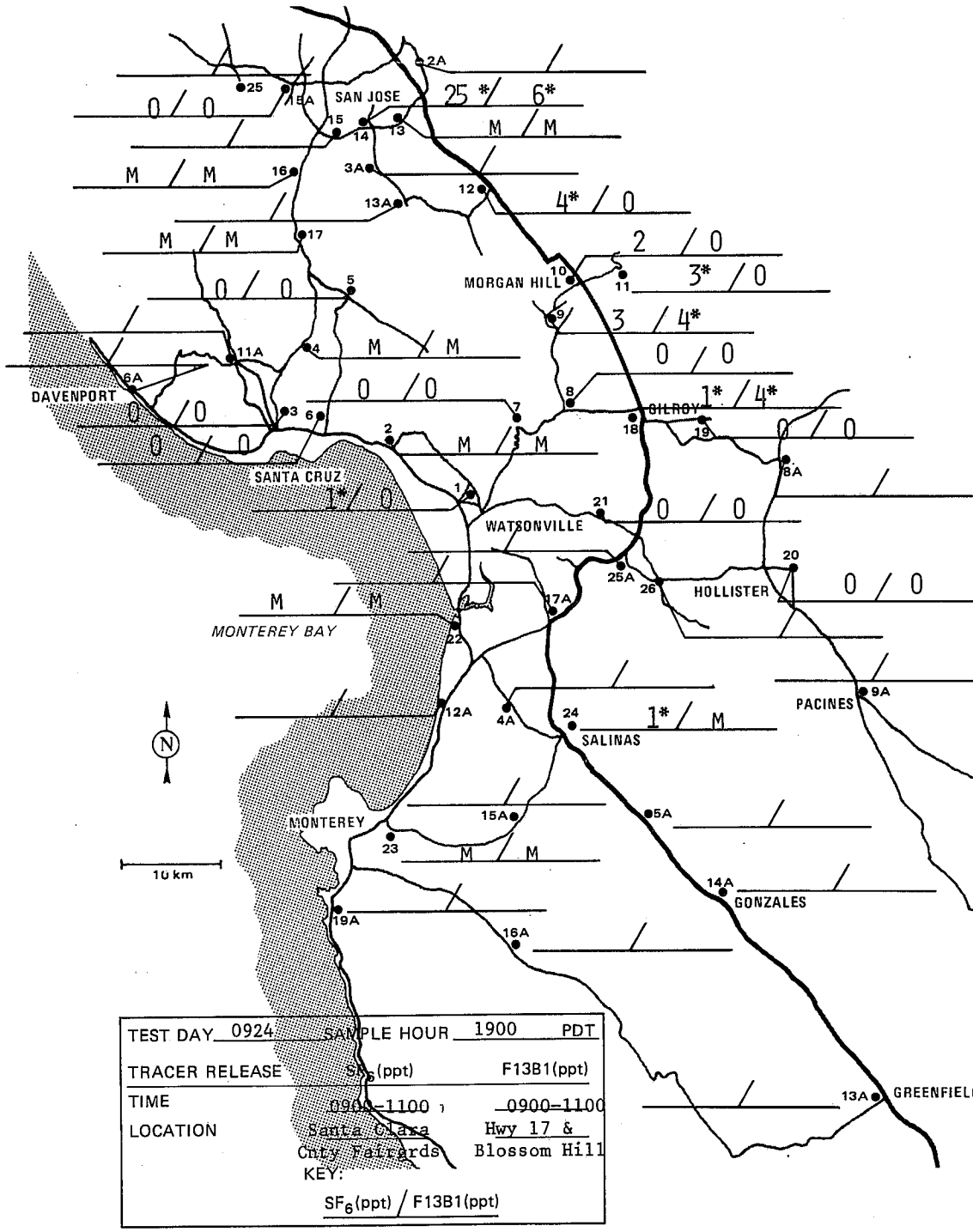


FIGURE 37j (CONTINUED)

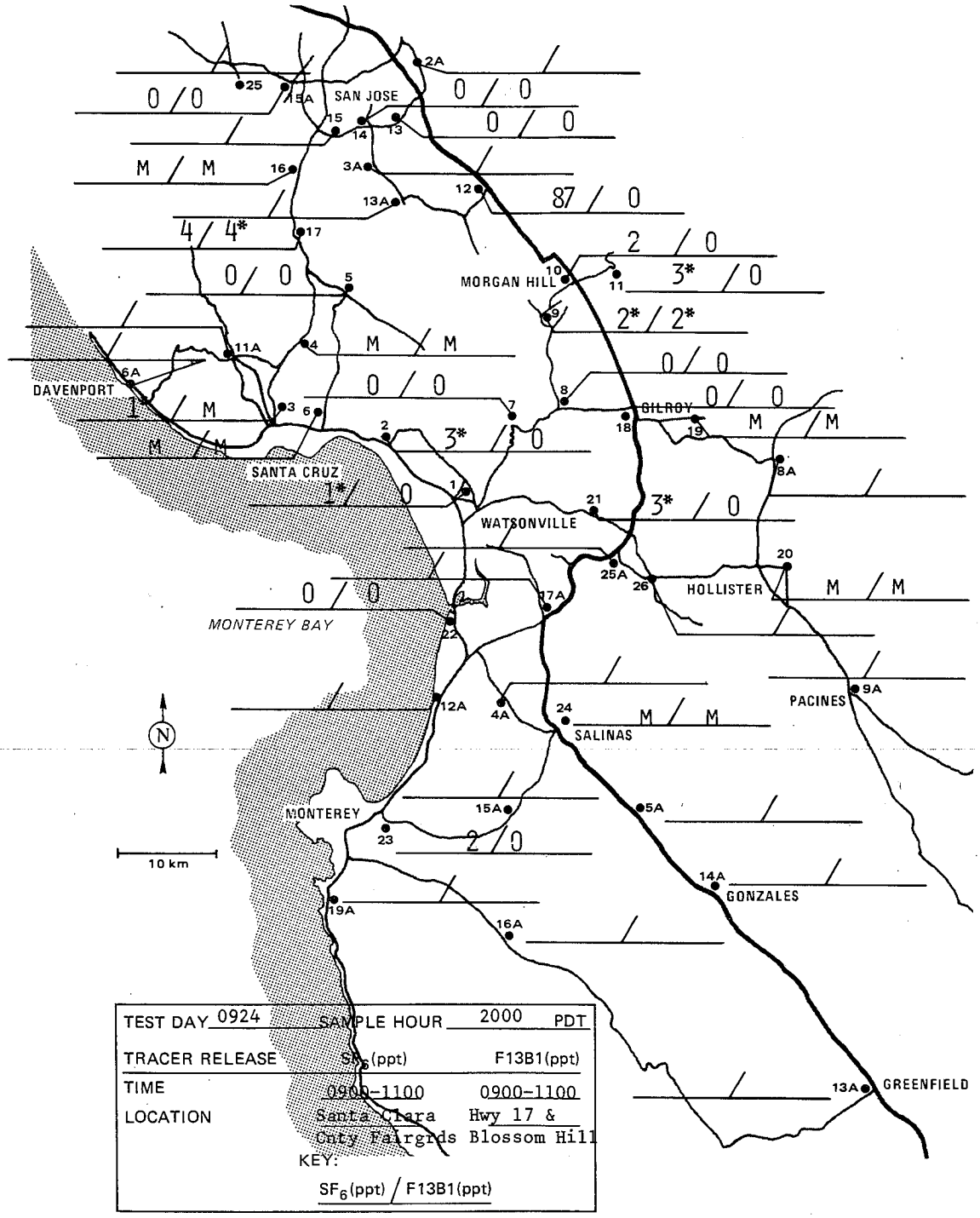


FIGURE 37k (CONTINUED)

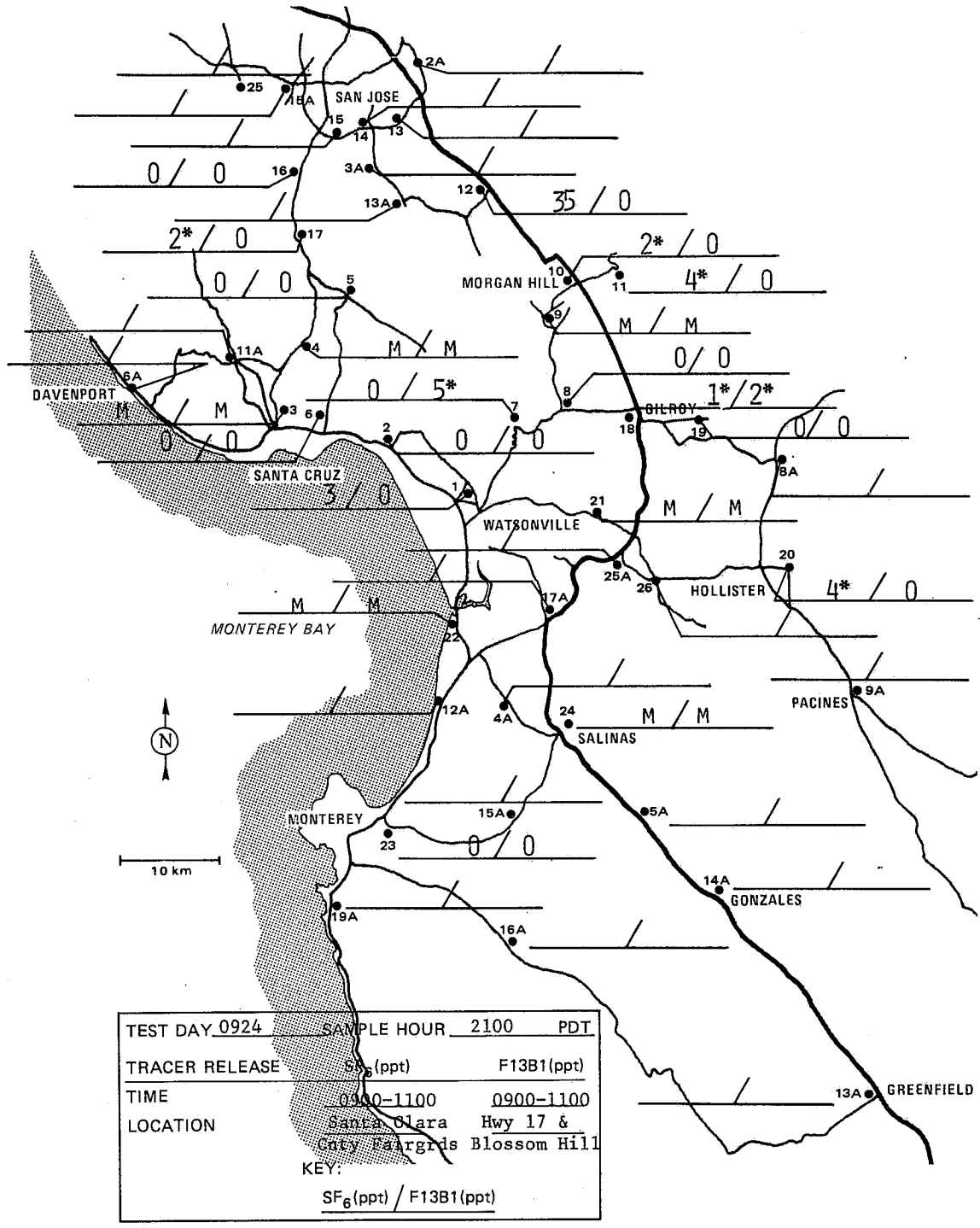


FIGURE 371 (CONTINUED)

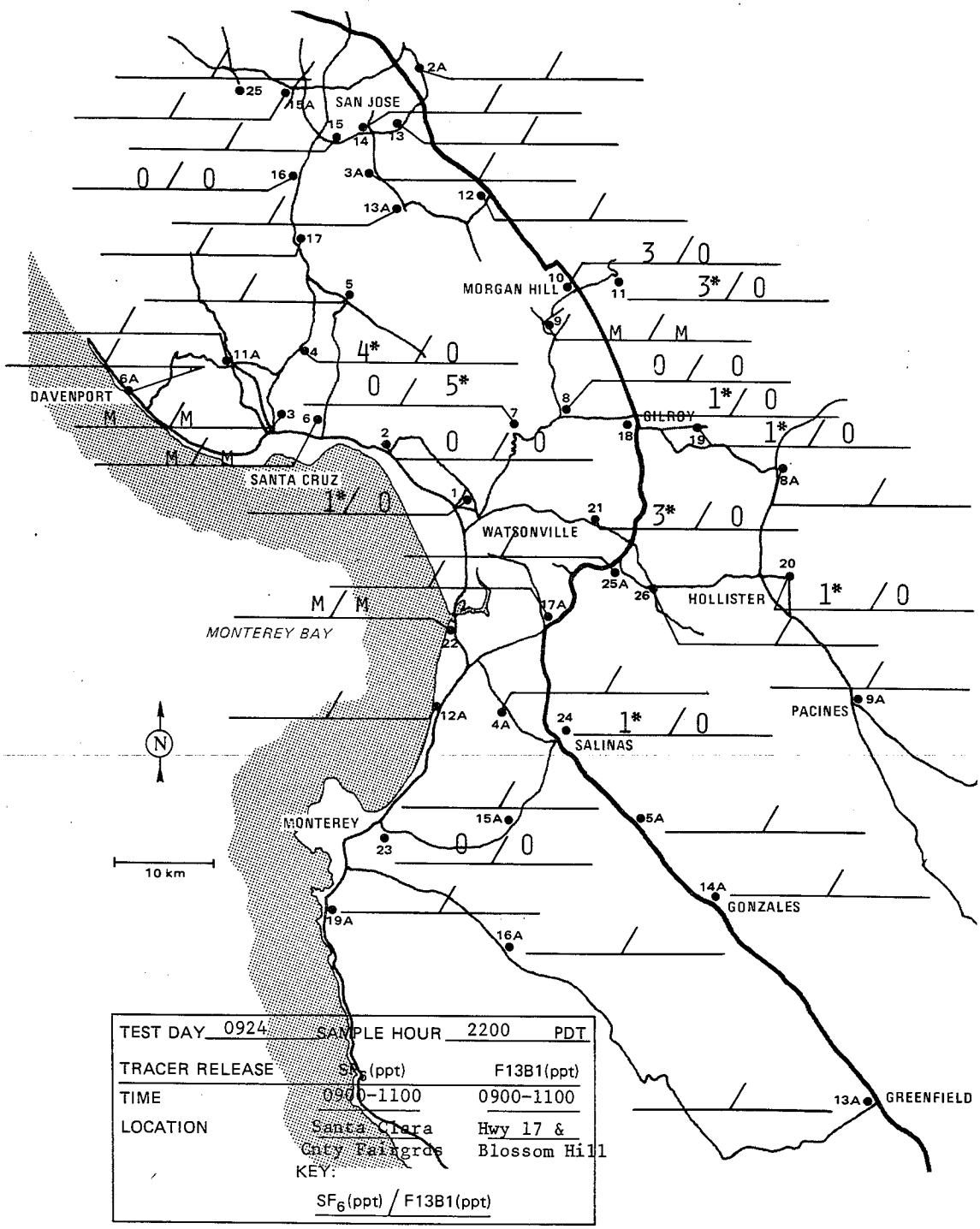


FIGURE 37m (CONTINUED)

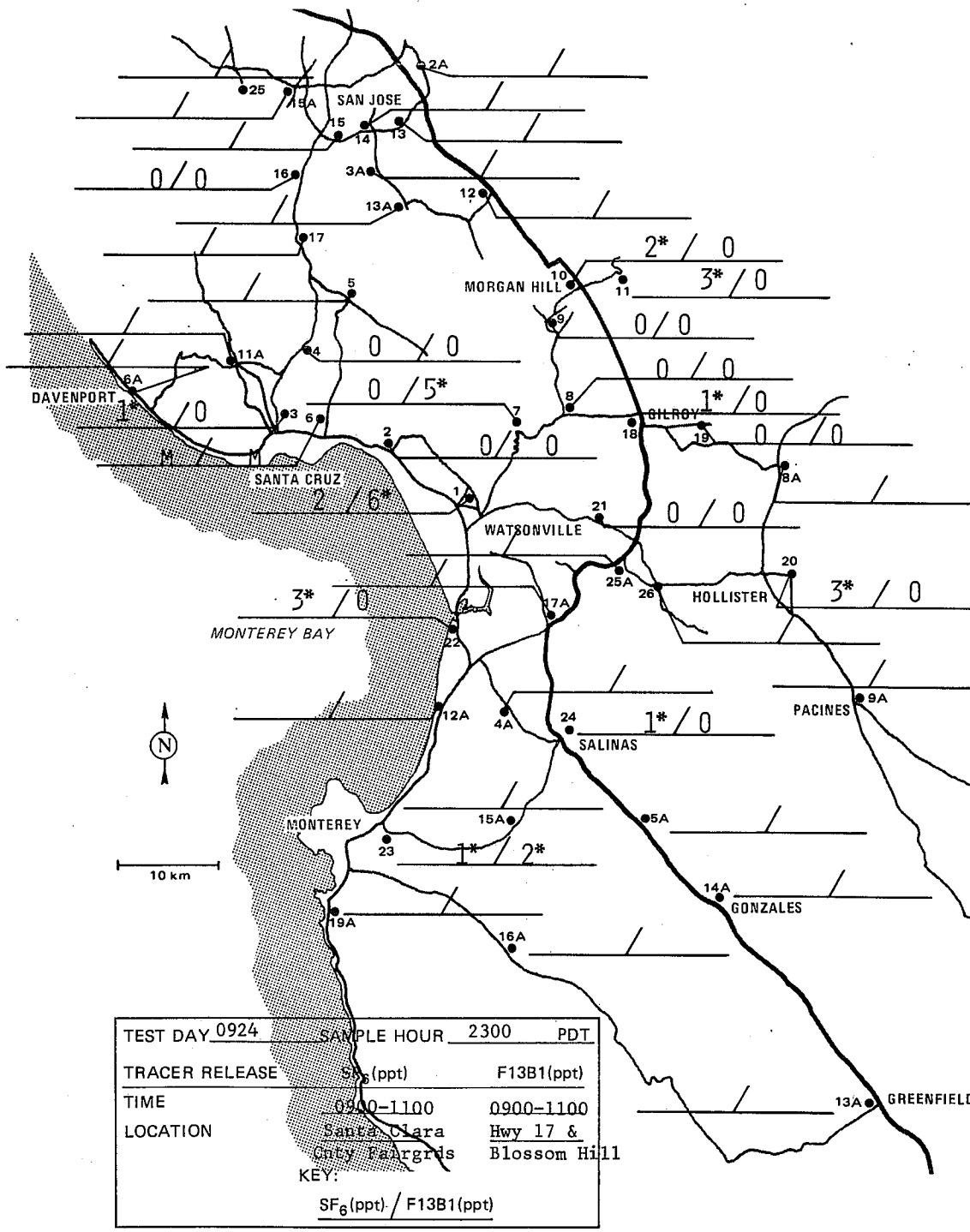


FIGURE 37n (CONCLUDED)

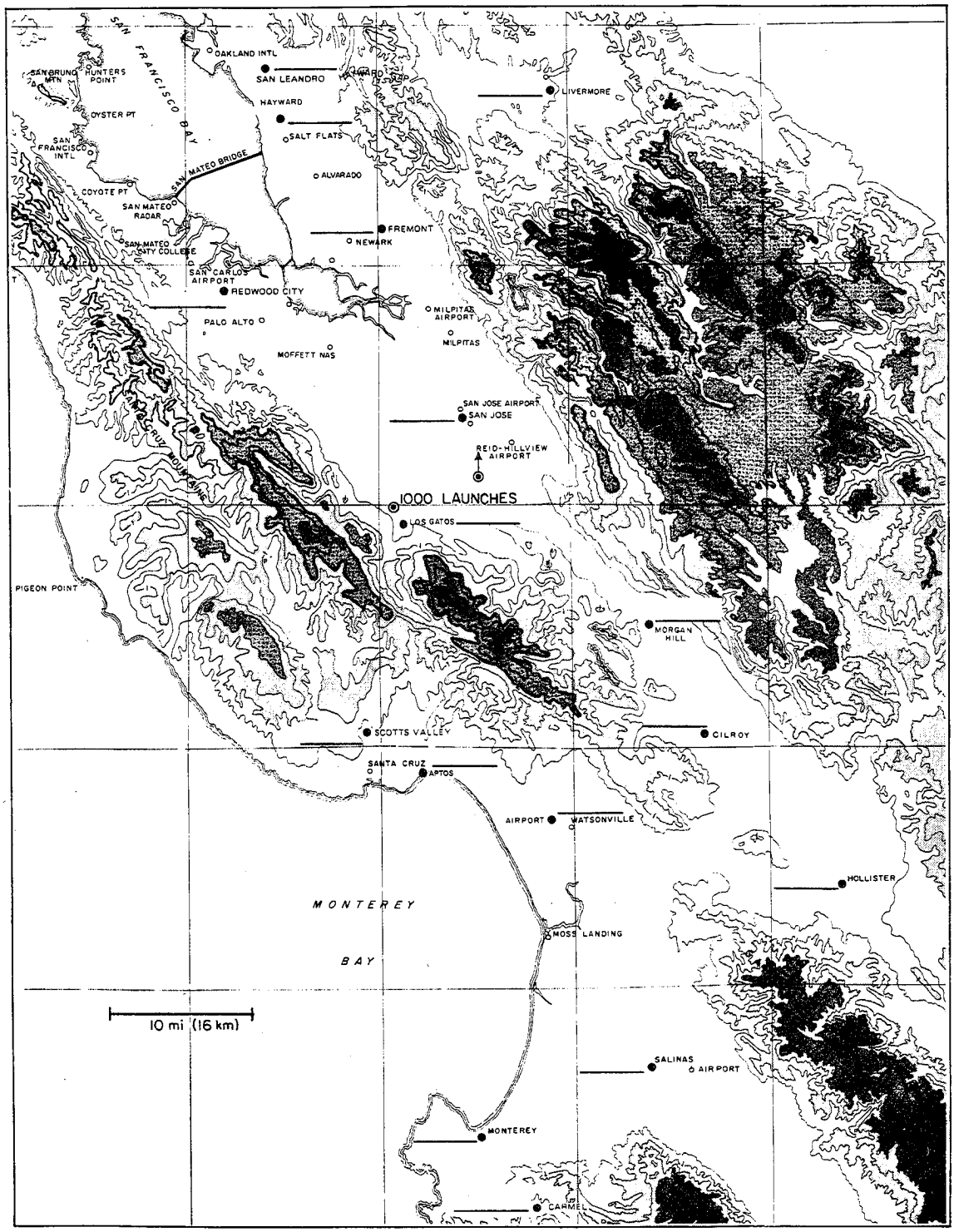


FIGURE 38 TETROON OBSERVATIONS, TEST 0924
[Time (PDT)/Altitude (m, agl)]

sampling sites, while Figure 39 and Table 11 provide the time, location and altitude of the aircraft-sampling traverses and spirals. Table 12 presents an analysis of the hourly wind data from San Jose, Morgan Hill and Hollister. The San Jose surface winds indicate light downvalley flow from the SE and SSE throughout most of the morning with a reversal during 11-1200 PDT and NW-NNW until 1900 PDT. At Morgan Hill, the winds are crossvalley out of the east until mid-afternoon when there is an apparent shift to an upvalley flow (several missing values in the afternoon preclude a definitive analysis). In Hollister the winds are also variable, blowing from the NW from 1000 to 1400 PDT and then increasing in speed out of the west from 1400 to 1700 PDT; during the period 17-2100, the winds vary between northwest, west and variable. Summarizing, the surface winds in the Santa Clara and San Benito Valleys do not reflect either a strong or consistent transport pattern; instead, they suggest a situation dominated by local effects that strengthen and weaken as they vary throughout the day.

The boundary-layer structure in the morning at San Jose (see Volume II aircraft spirals) contained a strong surface-based inversion that extended to 500 m and which was capped by a 350-m deep isothermal layer with a near-adiabatic layer above it. Ozone was low (about 25 ppt) and constant up to 300 m and then generally increased to a poorly defined peak of 85 ppb at 1100 m. In the late afternoon, Watsonville had an unstable layer from the surface to 140 m that was capped by a strong inversion to 450 m. Ozone was low in the unstable layer, but increased rapidly to a peak of 150 ppb at 300 m; above the peak, ozone varied about an average value of 85 ppb. The corresponding Hollister profile shows a surface-based inversion to 230 m msl and near-adiabatic conditions aloft. Again, ozone was low in the lowest layer, peaking at 105 ppb at the top of the inversion and gradually decreasing higher up.

The fixed sampling network detected F13B1 dispersion from Vasona Park, Los Gatos, into and over the Santa Cruz Mountains. The first sampling hour, 10-1100 PDT, corresponded with the second hour of the tracer release and indicated 61 ppt at the ridge-line station (Number 5). However, the next hour's measurement at that location showed a zero value of F13B1, but a 1003-ppt concentration above Lexington Reservoir (Station 17). Beginning at 1200 PDT, all fixed samples were operating and F13B1 continued to be observed at Lexington Reservoir (35 ppt) with hour-average concentrations of 6 ppt in Watsonville and 4 ppt in south San Jose. The 13-1400 PDT tracer map indicates F13B1 transport to Soda Lake (Station 21, midway between Hollister and Watsonville), while a trace was measured at 14-1500 in Monterey. Later in the afternoon, F13B1 traces were observed at various locations throughout the study region, including Morgan Hill, Gilroy, and Santa Cruz. In the evening, the F13B1 continued to be observed a low levels in various isolated locations. Carry-over measurements (Volume II) the following morning (06-0900 PDT) continued to show concentrations in the 5-ppt range at Lexington Reservoir and the ridge line station, Santa Cruz, Morgan Hill, and south San Jose.

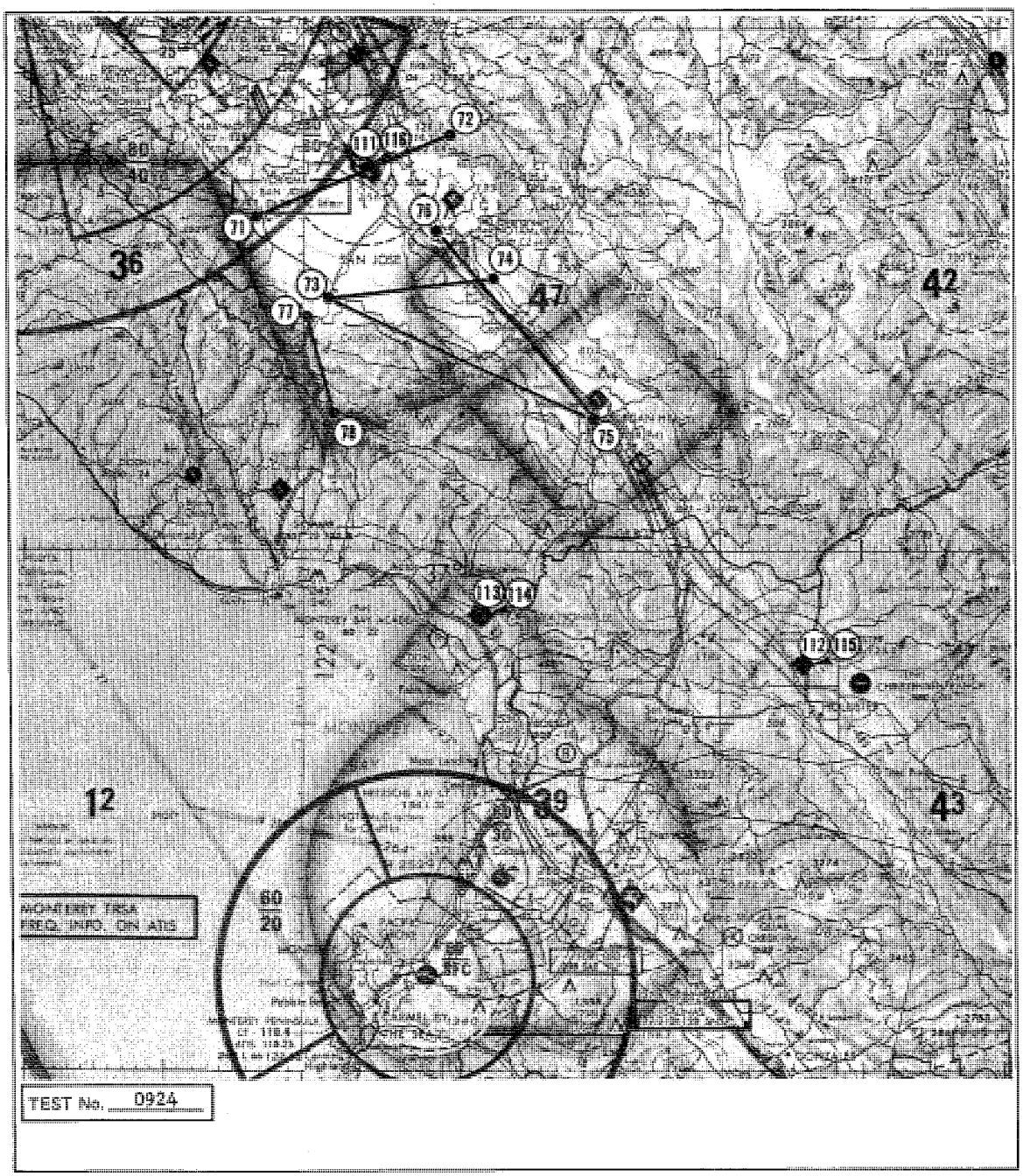


FIGURE 39a AIRCRAFT FLIGHT PATTERN, TEST 0924

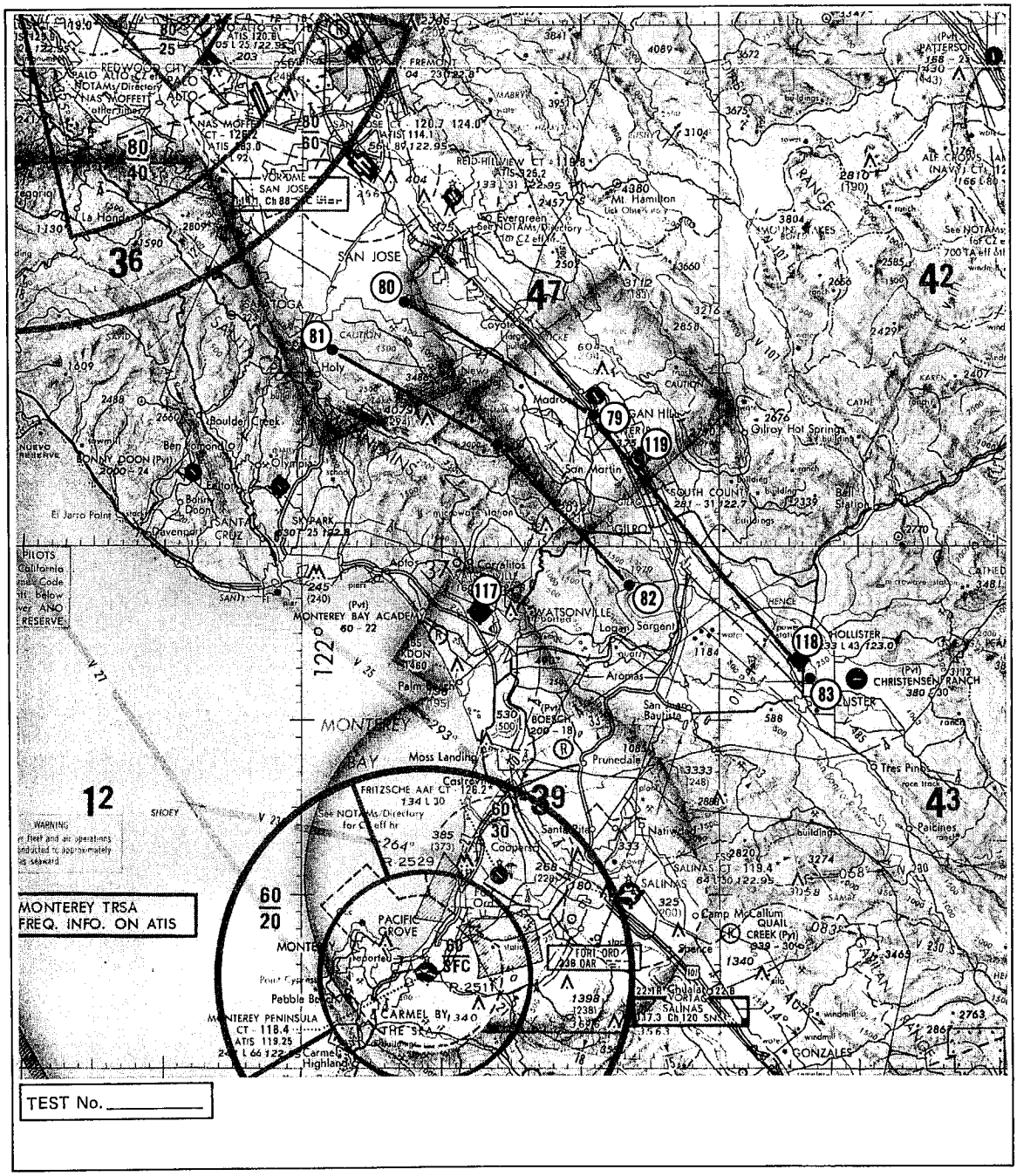


FIGURE 39b (CONCLUDED)

Table 11

AIRCRAFT WAY POINTS, TEST 0924

Way Point	Geographic Location	Altitude (m,msl)	Nominal Time (PDT)
Traverses			
71	Cupertino	490	1337
72	Alum Rock	490	1337
71	Cupertino	300	1344
72	Alum Rock	300	1344
73	Los Gatos	490	1352
74	South San Jose	490	1352
73	Los Gatos	335	1359
74	South San Jose	335	1359
73	Los Gatos	300*	1420
75	Morgan Hill	300*	1420
75	Morgan Hill	400	1430
76	Santa Clara County Fairgrounds	400	1430
78	Summit	300*	1444
79	Morgan Hill	400	1701
80	Almaden	400	1701
81	Lexington Reservoir	150*	1722
82	Pajaro Gap	150*	1722
83	Hollister	400	1737
79	Morgan Hill	400	1737
Spirals			
111	San Jose Airport		0643
112	Hollister Airport		0705
113	Watsonville Airport		0725
114	Watsonville Airport		1015
115	Hollister Airport		1029
116	San Jose Airport		1052
117	Watsonville Airport		1625
118	Hollister Airport		1638
119	South County Airport		1650

*agl.

Table 12

SANTA CLARA-SAN BENITO VALLEY WIND VARIATIONS,
SEPTEMBER 24, 1980

Time (PDT)	Wind Direction/Speed* Downtown San Jose	Morgan Hill	Hollister
08-09	(3) 135/02	(2) 113	var/02
09-10	158/02	103	var/03
10-11	158/02	098	(1) 315/03
11-12	var/02	078	315/04
12-13	(1) 315/03	054	315/04
13-14	315/04	102	315/07
14-15	338/05	074	270/13
15-16	338/04	m	270/15
16-17	338/04	m	270/15
17-18	338/05	298	315/10
18-19	315/03	m	(2) 270/08
19-20	(2) 270/02	m	var/02
20-21	270/02	m	var/02

*deg(true)/mph

(1) = Upvalley flow (San Jose to Hollister)
(2) = Cross-valley flow
(3) = Downvalley flow (Hollister to San Jose)

Mobile sampling provides a more detailed indication of the F13B1 transport throughout the region. From 1300-1530 PDT, F13B1 concentrations $\leq$35 ppt were observed over a broad triangular portion of the northern reaches of the study region, ranging from Soquel and the ridge station on the southwest to Santa Clara and Milpitas on the north, and Almaden and south San Jose on the southeast. Between 1530 and 1700 PDT, near-zero levels were measured near Morgan Hill and Gilroy and farther north toward Campbell, as well as in the Santa Cruz-Watsonville-ridge station area. During this period when near-zero amounts were detected in the central part of the Santa Clara Valley near Morgan Hill and Gilroy, there were simultaneous indications of tracer on the western slope up to Hecker Pass and also on the eastern slope from east Morgan Hill to Anderson Reservoir. These likely are indications of upslope flow due to daytime heating. The lack of any broad transport up the Santa Clara Valley during the afternoon is consistent with the Morgan Hill wind data, which indicate crossvalley flow at that time. From 1636-1709 PDT, samples were taken up the valley from Morgan Hill, southeastward to Gilroy, and then eastward to San Felipe with no indication of any F13B1. Subsequent samples taken from 1745-1810 PDT from Hollister northwest to Gilroy did locate a broad band of F13B1 in the 10-15 ppt range, suggesting transport along the western slope of the Santa Clara Valley. Sampling from 18-2000 PDT in the Pajaro Plain detected no tracer along the coast from Watsonville to Monterey, but did locate scattered pockets and traces between Salinas and Watsonville. In summary, F13B1 on this day was complex and poorly defined. Initially, there was dispersion both over the Santa Cruz Mountains and also into the northern Santa Clara Valley. Afternoon transport was generally southward, apparently along the mountains with subsequent dispersion by late afternoon into Hollister and Salinas. The effects of local circulations on this low-wind day complicated the transport pattern.

The SF_6 released from 09-1100 PDT at the County Fairgrounds in San Jose exhibited a more systematic transport pattern than did the F13B1 (released in Los Gatos). The first trace detected by the fixed network was 11-1200 at Lexington Reservoir; trace-values ($\leq$6 ppt) were subsequently observed throughout the day at this and surrounding stations. This suggests either a continuous transport into the area throughout the day or an initial transport from the release point with long-term residence in the small air basin that partially envelopes Los Gatos and the immediate areas to the west and south. Of the two, the latter mechanism is more likely in view of the relatively short duration of the release. The more significant transport feature is movement down and up the Santa Clara Valley. The release point is located about 3 km NW of the south San Jose tracer-sampling site, Number 12. Through 1100 PDT, winds in downtown San Jose were from the SSW at 2 kt (1 m s^{-1}). The 11-1200 hour had variable winds which then shifted to the NW at 1.5 m s^{-1}. Winds remained NW and NNW at $\leq$2.5 m s^{-1} throughout the afternoon; at 1900 PDT, they shifted to the west. Although the tetroon was not tracked, its initial movement at 1000 PDT was to the north. The first SF_6 observations occurred at 12-1300 and included traces (1-4 ppt) along the southern corridor from south San Jose to Soda Lake and low-level pockets ($\leq$7 ppt) in Santa Cruz, Watsonville, and Moss Landing. The main

feature of the 12-1300 SF_6 pattern is a 37-ppt concentration at Site 14, about 10 km NW of the release point. Since the previous hour had zero SF_6 in this area, the indicated transport vector at the surface is about 1 m s^{-1}, or equal to the morning San Jose winds. During 13-1400 the concentration at Site 14 decreased to 16 ppt while values in the southern corridor remained essentially unchanged; traces were no longer observed along Monterey Bay. By 14-1500, the tracer cloud had moved SE with a peak concentration of 75 ppt at south San Jose and 10-17 ppt values in Morgan Hill. Transport continued SE during 15-1600; the 81-ppt peak in Morgan Hill indicates movement to the SSE at a speed of about 3.7 m s^{-1}. The mobile data for this hour indicated the plume had an 8-km length along Highway 101, centered just north of San Martin. However, there continued to be no significant SF_6 levels farther south until the next two hours when Gilroy recorded 5-6-ppt levels; the central portion of the cloud was not detected at this time by either the fixed or mobile samples. The 19-2000 tracer map indicates that a second cloud entered the northern end of the Santa Clara Valley where 25 ppt SF_6 was measured at site 14. The cloud moved SE at 2-4 m s^{-1} for the next 1-2 hours, but did not progress beyond the south San Jose Site 12, which had concentrations of 87 and 35 ppt for the hours 20-2100 and 21-2200, respectively. Site 12 did not sample beyond 2200 PDT, although Morgan Hill measurements the next two hours were unchanged at 3 ppt. The precise mechanism that produced the second SF_6 cloud is unknown, but it appears likely that a bifurcation accompanied the wind reversal during the morning hours.

4. Test 0926: 26 September 1980

The thermal trough that had persisted over California the previous two test days was present only in the extreme southern portion of the state; see Figure 40. A weak, surface low-pressure area can be seen off the Washington coast and the eastern edge of the Pacific high extends into south-central California. The SFO-RNO surface pressure difference had all but disappeared (-0.8 mb), although the 850-mb temperature exceeded the climatic average by more than one standard deviation. Winds at 850 mb were SSW at 10 m s^{-1}. The maximum hourly surface ozone concentration at Gilroy was very low (50 ppb), and the maximum at any of the fixed monitors in the basin was similarly low (60 ppb) (see Figure 41). The mobile ozone-sampling vehicle, however, did measure a short-term peak of 113 ppb in the foothills near Uvas Reservoir, west of Morgan Hill.

Both tracers were released during the two-hour period 10-1200 PDT, SF_6 from Coyote Park (10 km NNW of Morgan Hill and 2.5 km SSE of sampling Site 12) and F13B1 from Vasona Park in Los Gatos. Figure 42 illustrates the hourly tracer measurements for 12-1300 through 23-2400 from the fixed sampling network. Tetroons were launched at 1000 PDT from both sites. The trajectory of the Vasona Park tetroon (Figure 43) indicated a slow movement (1 m s^{-1}) nearly due south into the mountain pass surrounding the Lexington Reservoir; the tetroon became entangled in trees as it attempted to rise over the 600-m western edge of the pass opposite the reservoir. The Coyote Park tetroon drifted erratically for

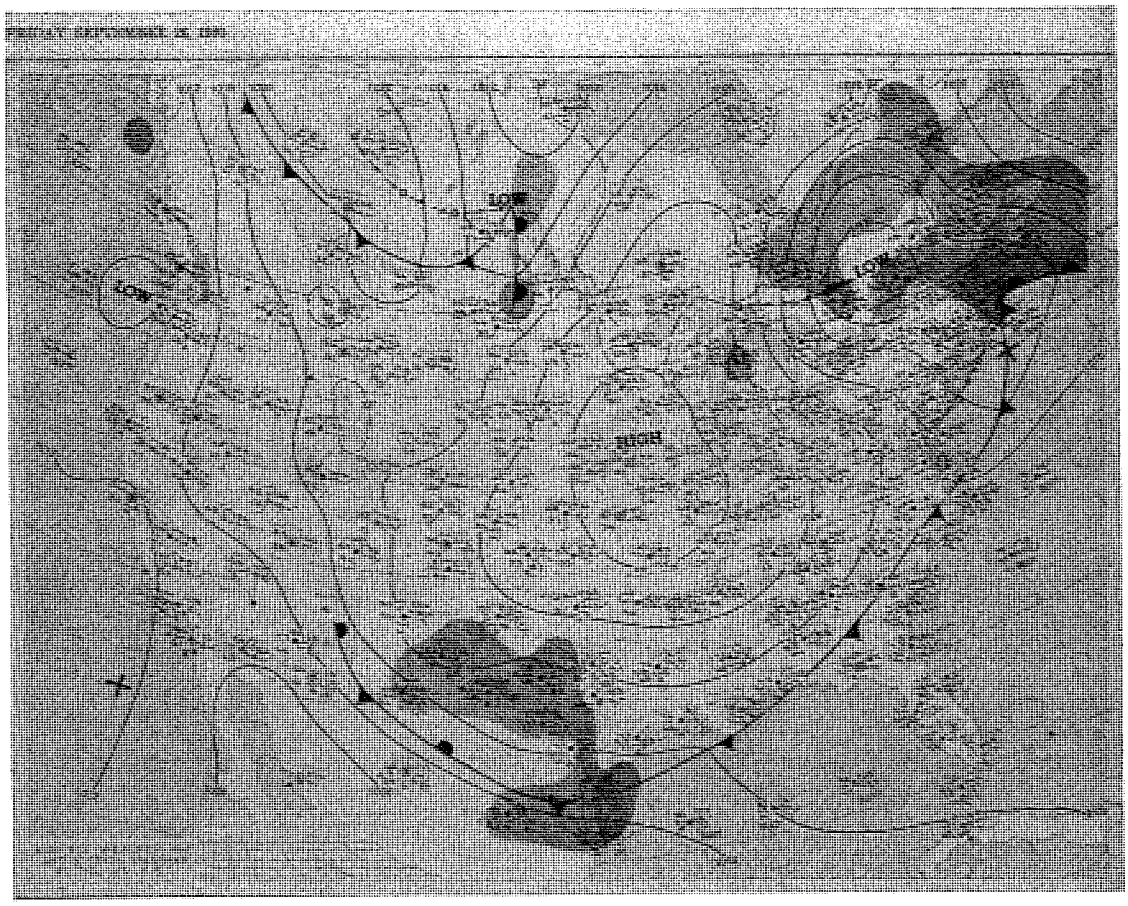


FIGURE 40 SURFACE WEATHER MAP, 0500 PDT, TEST 0926

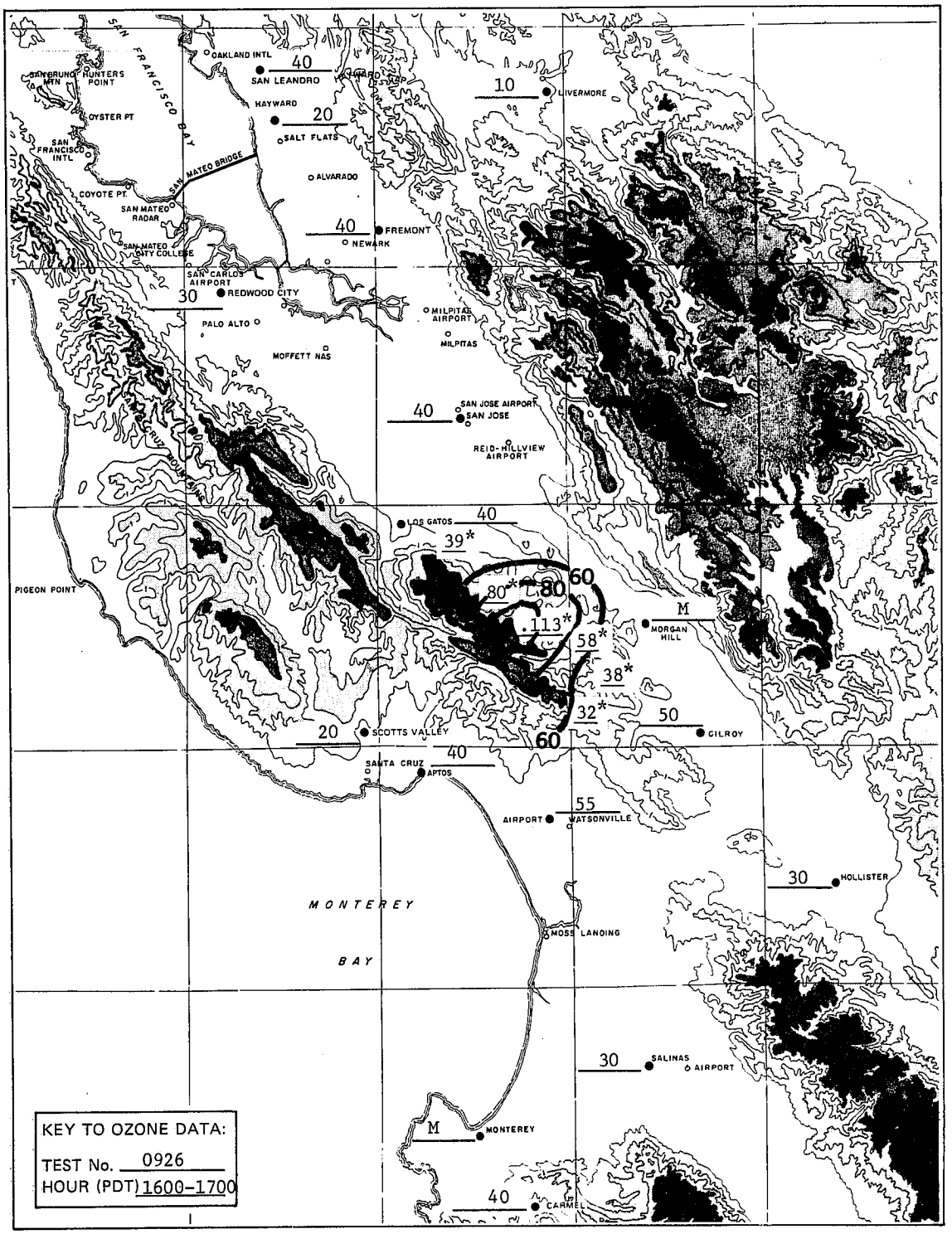


FIGURE 41 SURFACE OZONE CONCENTRATION (ppb), PEAK HOUR, TEST 0926

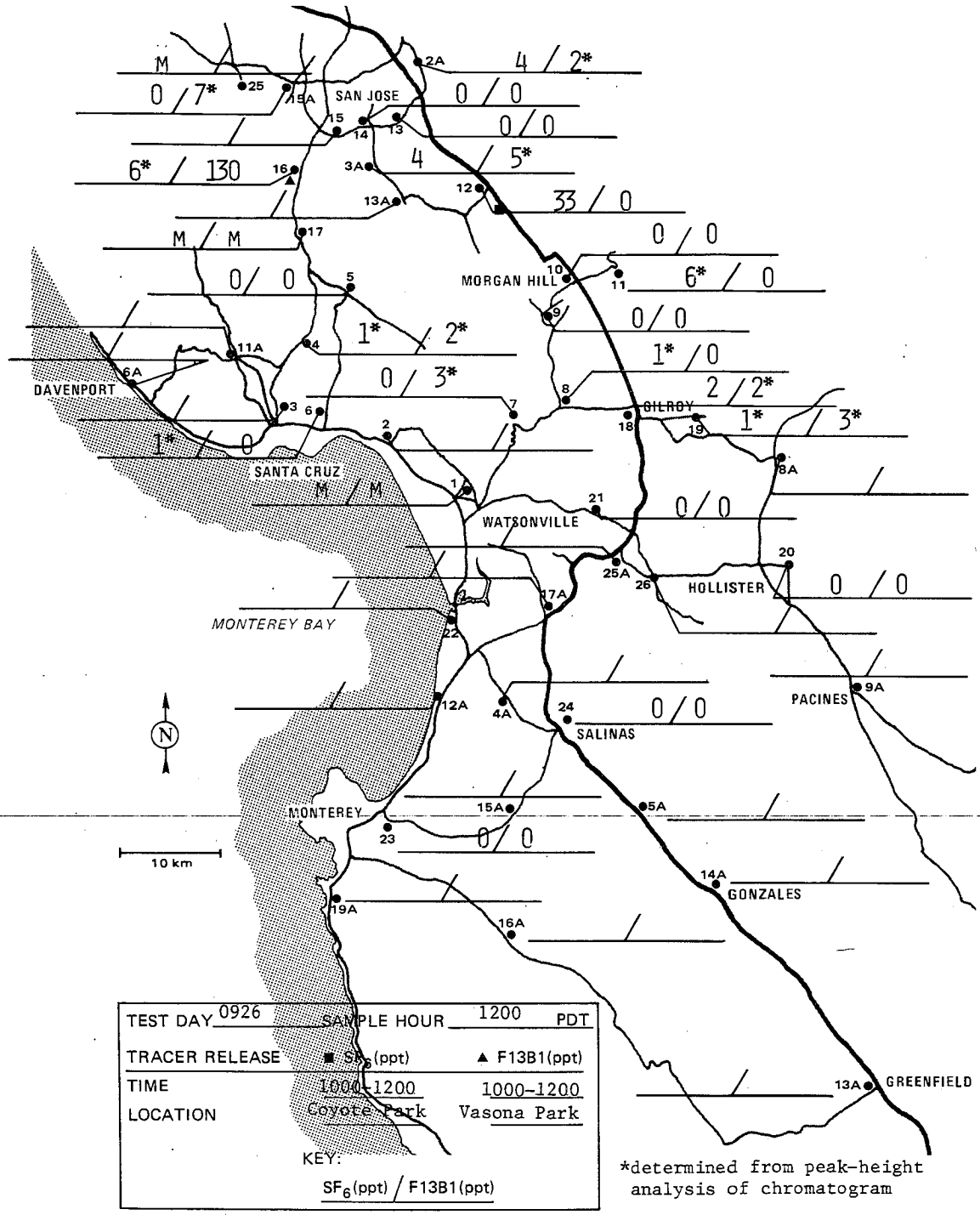


FIGURE 42a HOURLY SURFACE TRACER MEASUREMENTS, TEST 0926

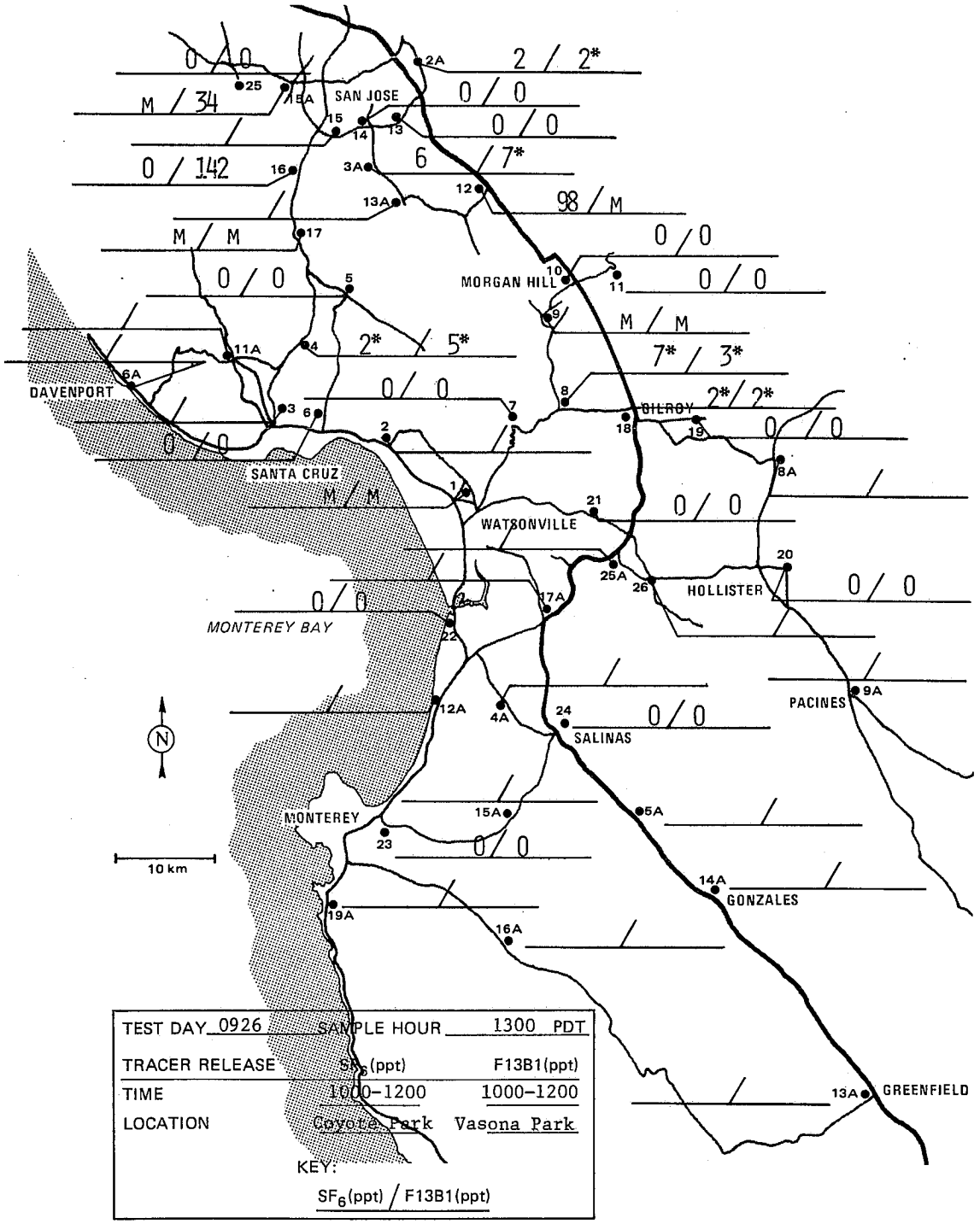


FIGURE 42b (CONTINUED)

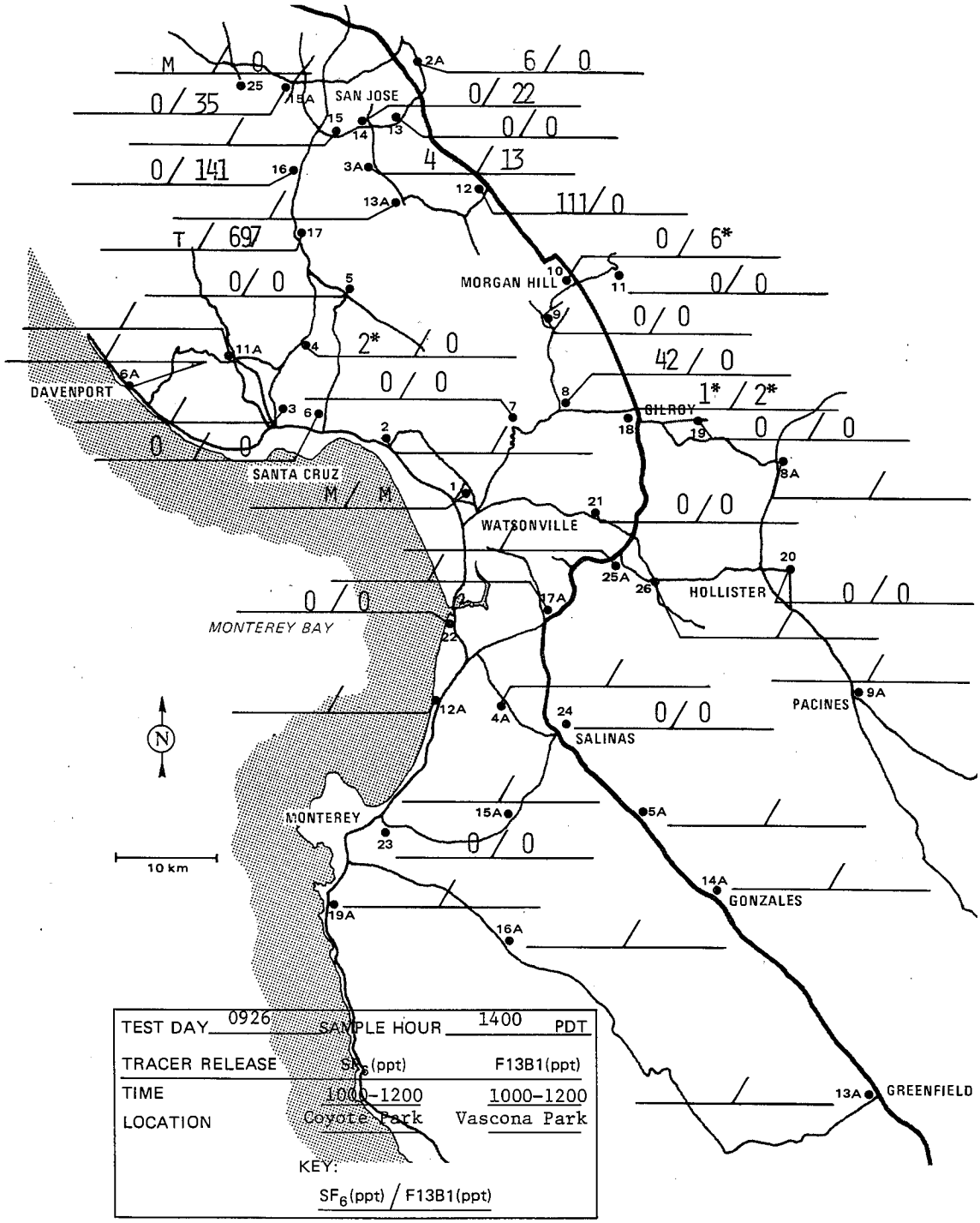


FIGURE 42c (CONTINUED)

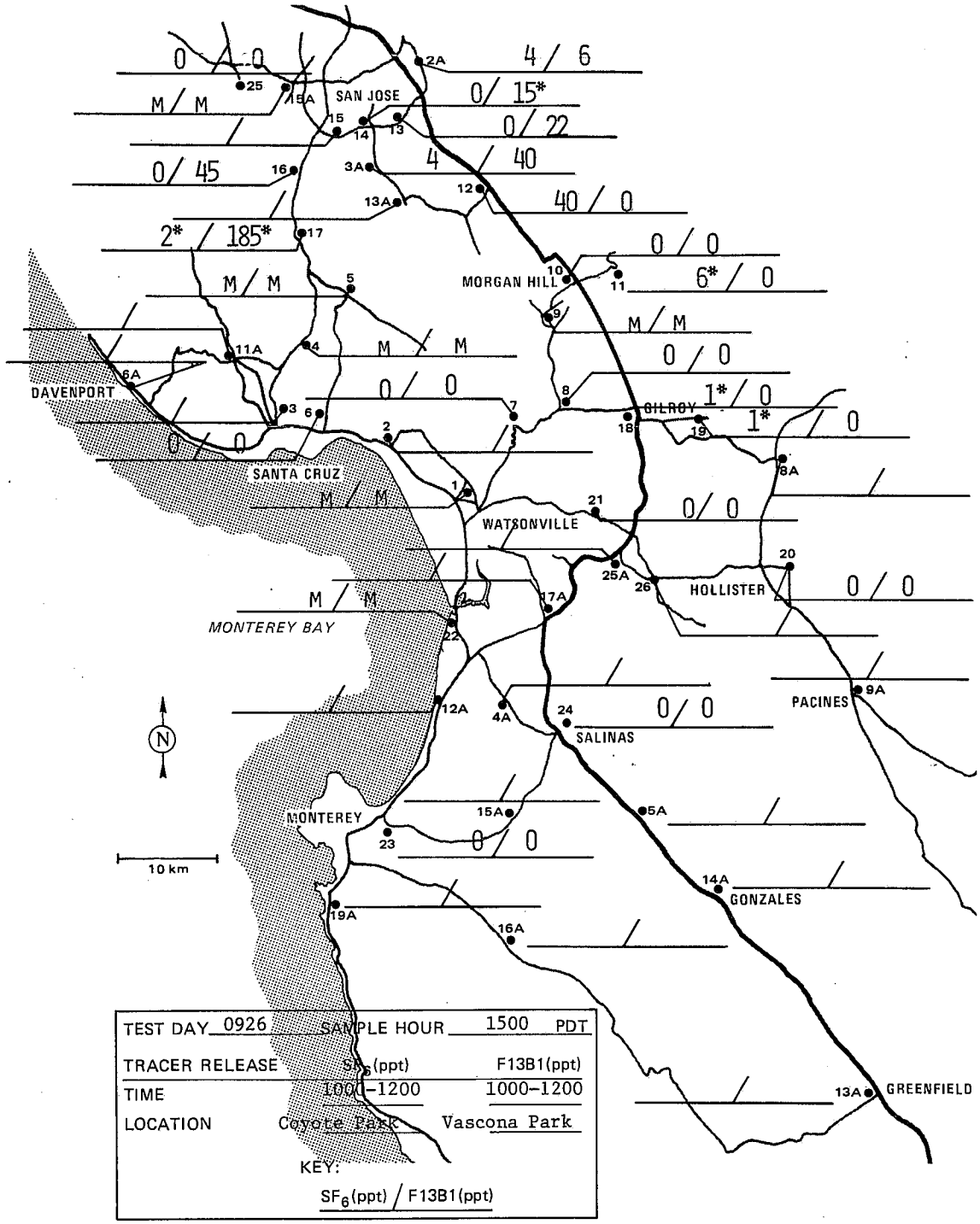


FIGURE 42d (CONTINUED)

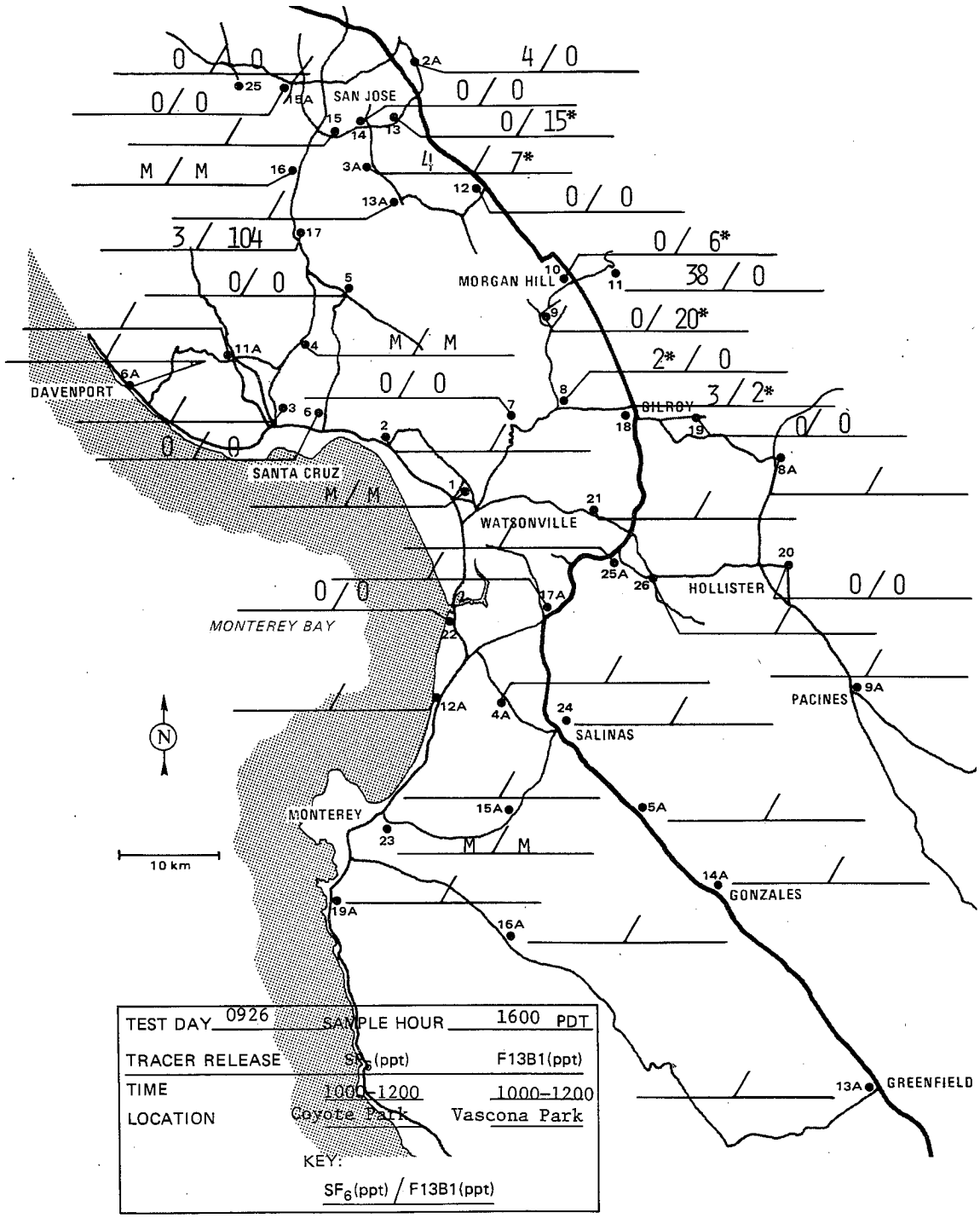


FIGURE 42e (CONTINUED)

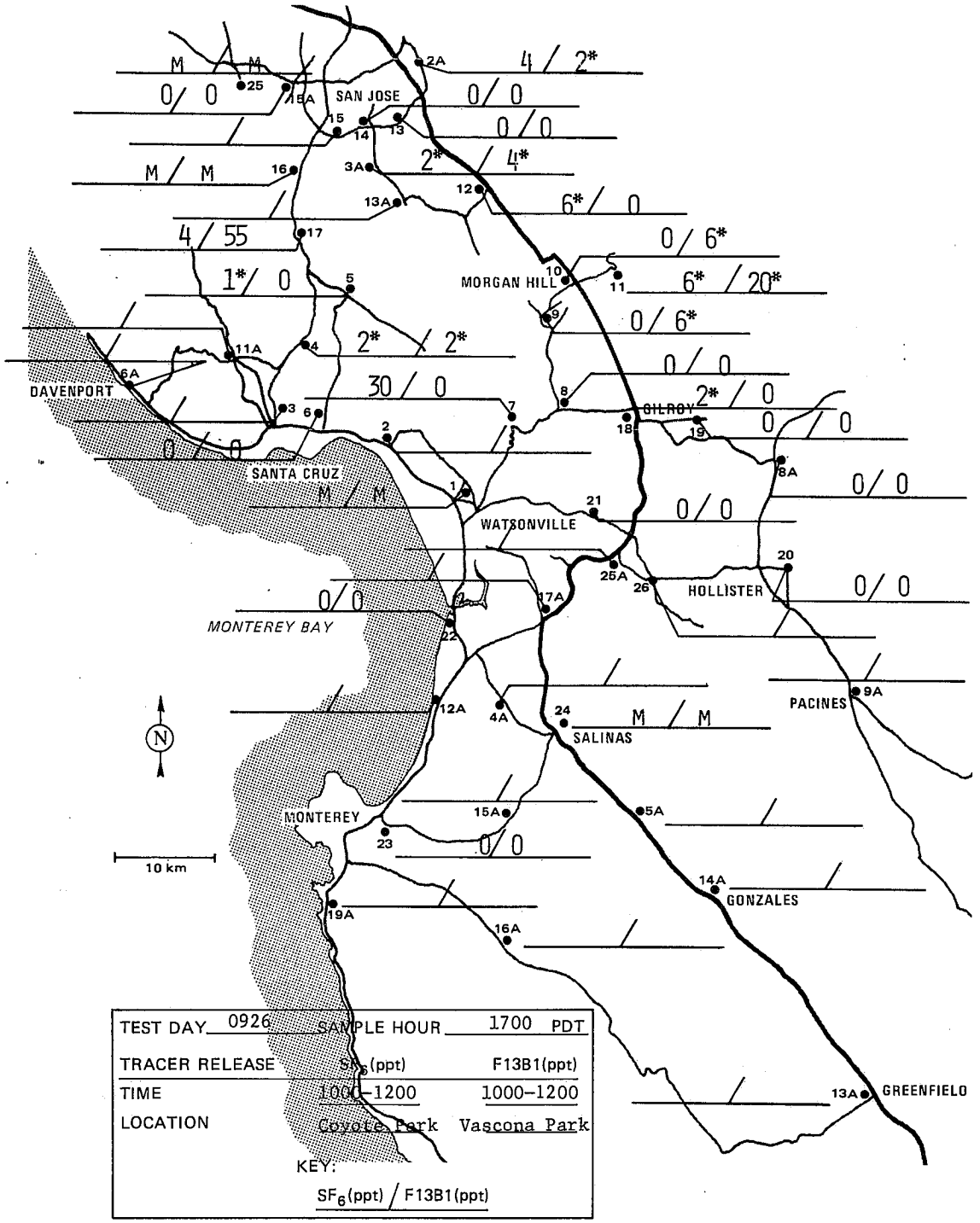


FIGURE 42f (CONTINUED)

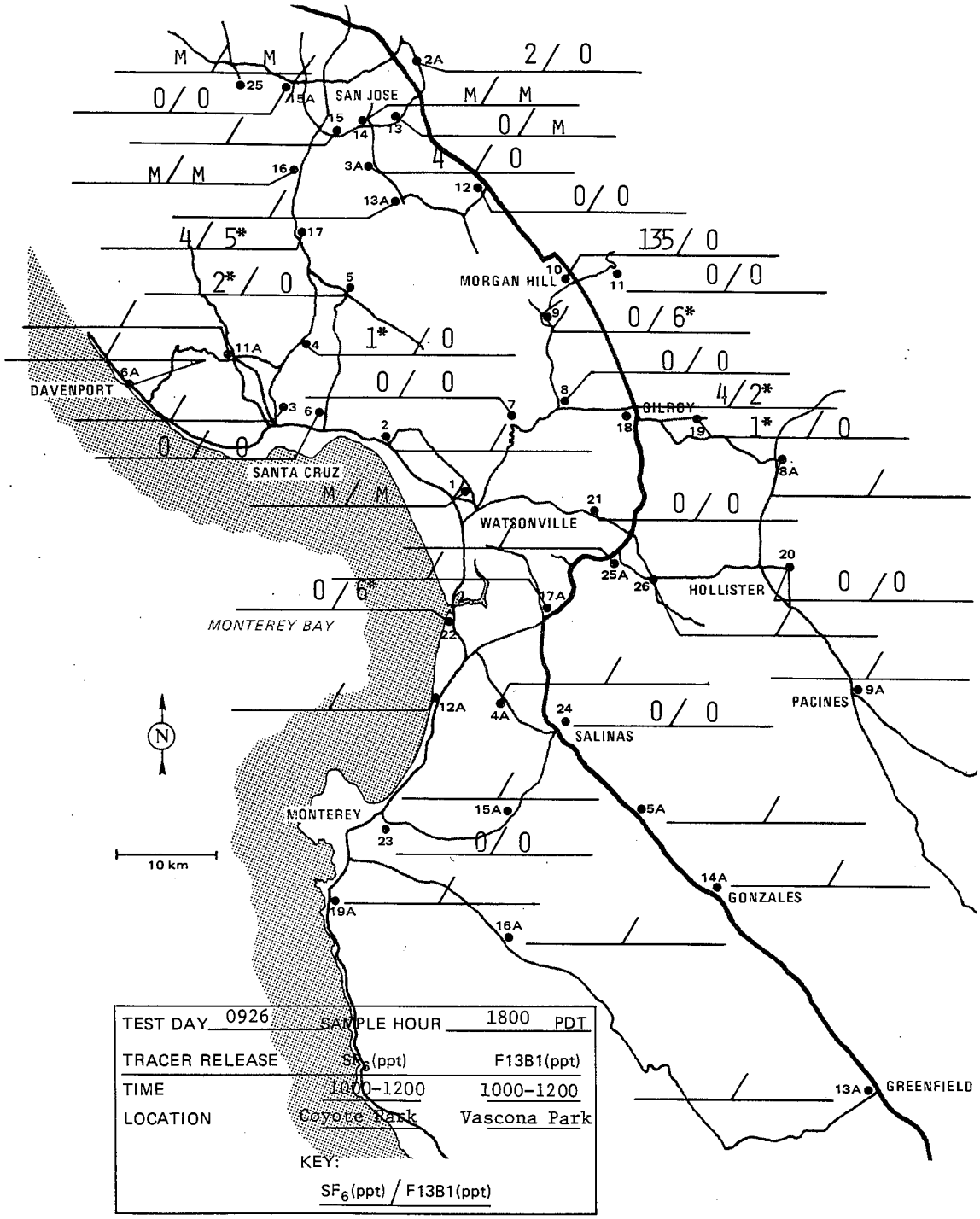


FIGURE 42g (CONTINUED)

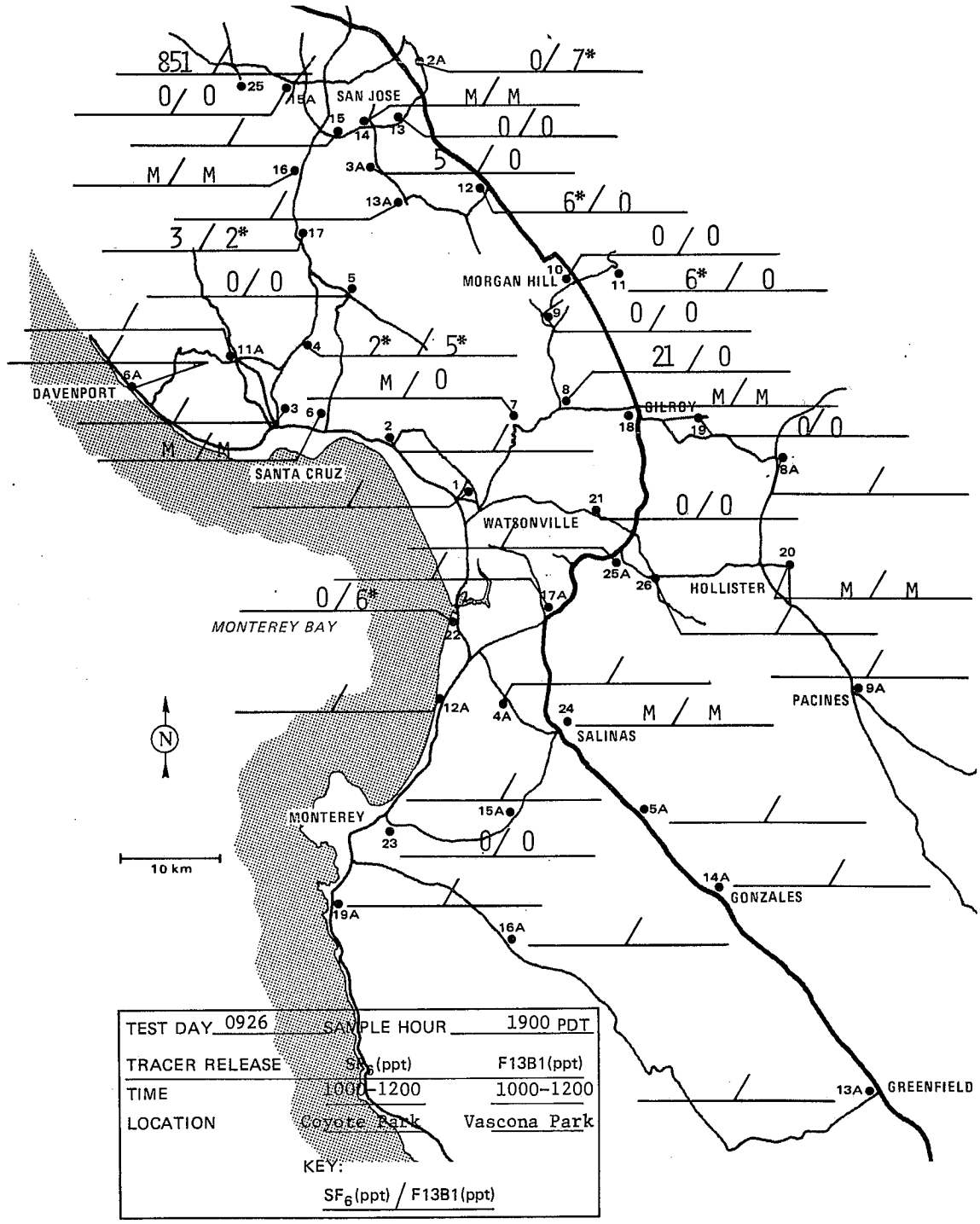


FIGURE 42h (CONTINUED)

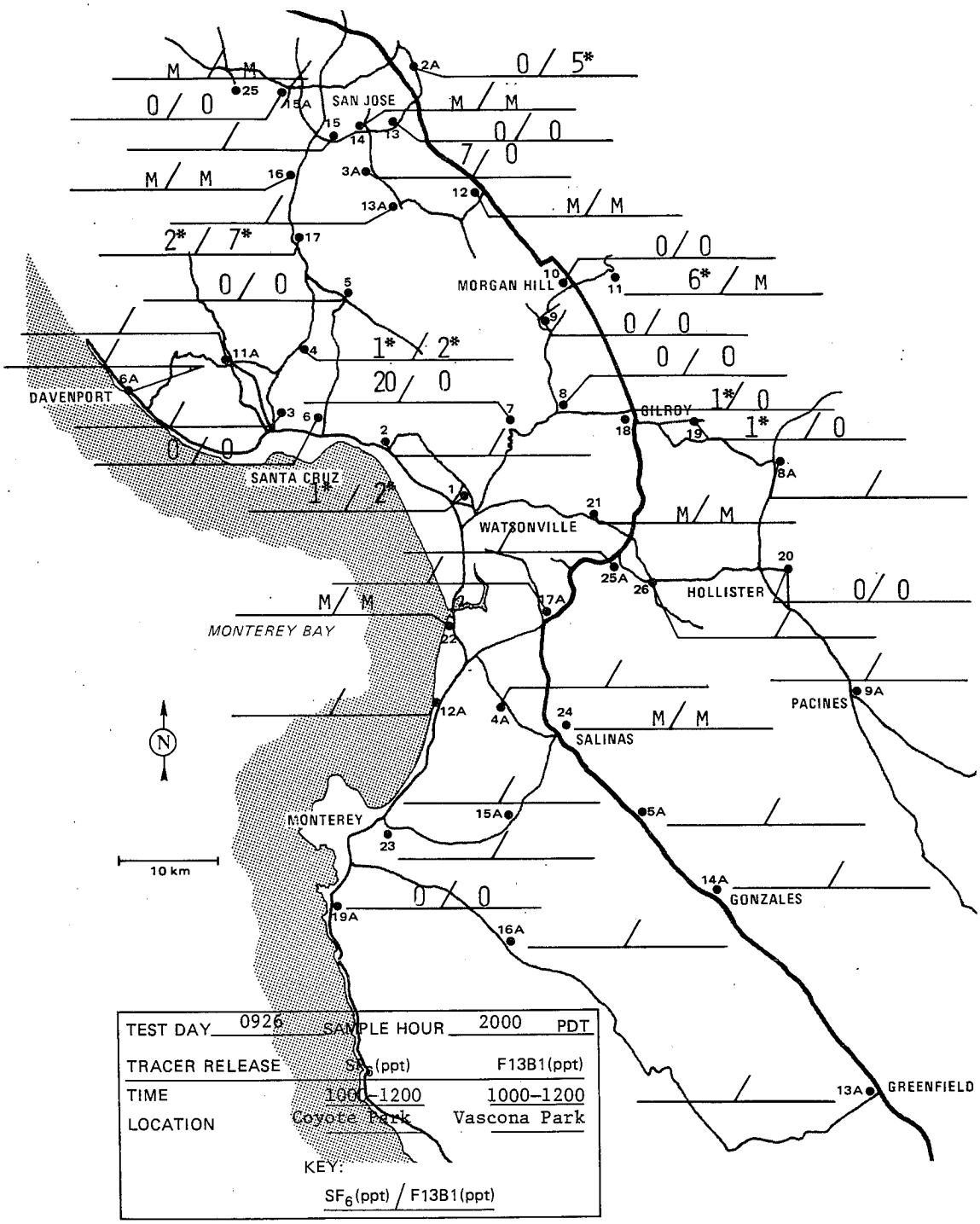


FIGURE 42i (CONTINUED)

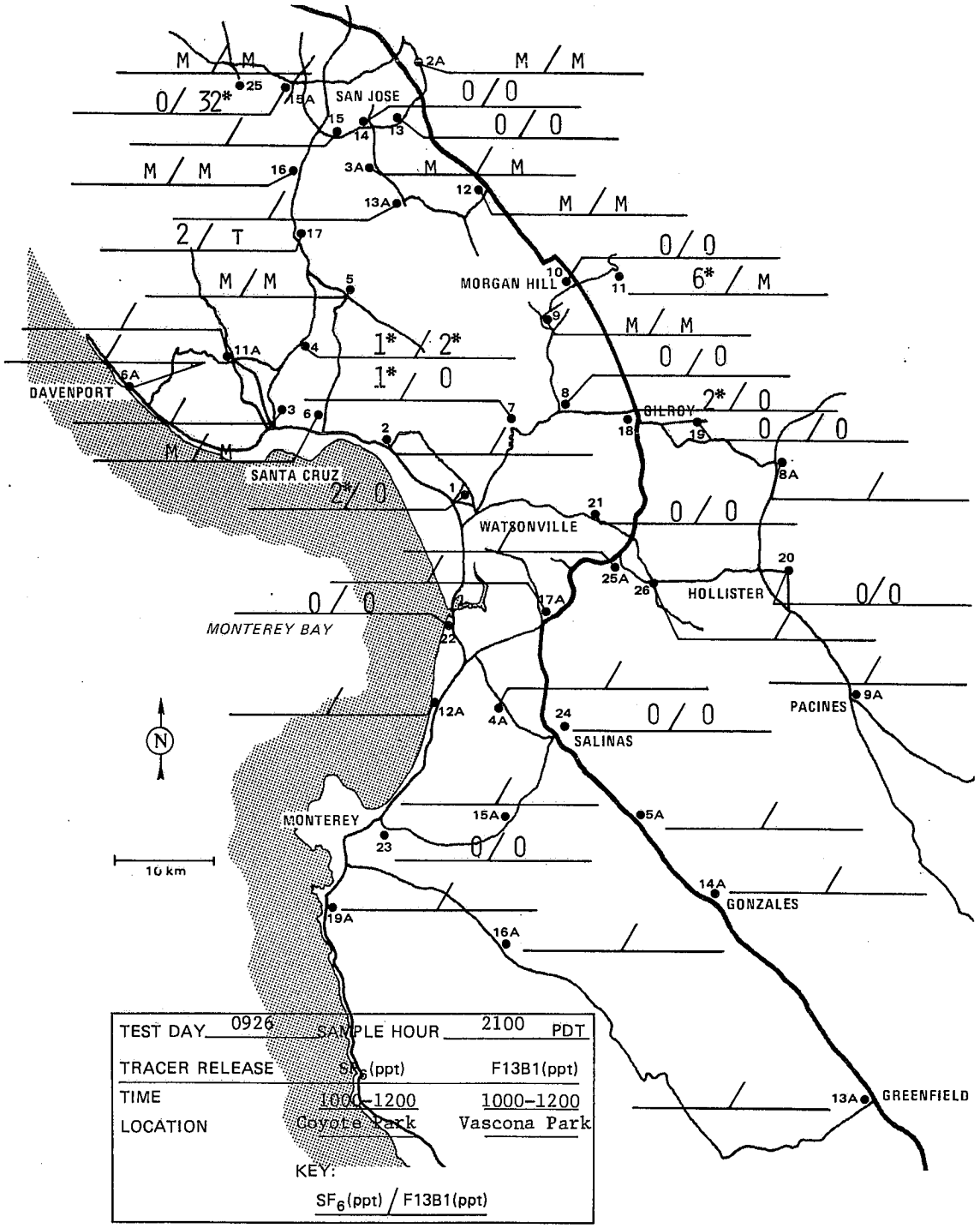


FIGURE 42j (CONTINUED)

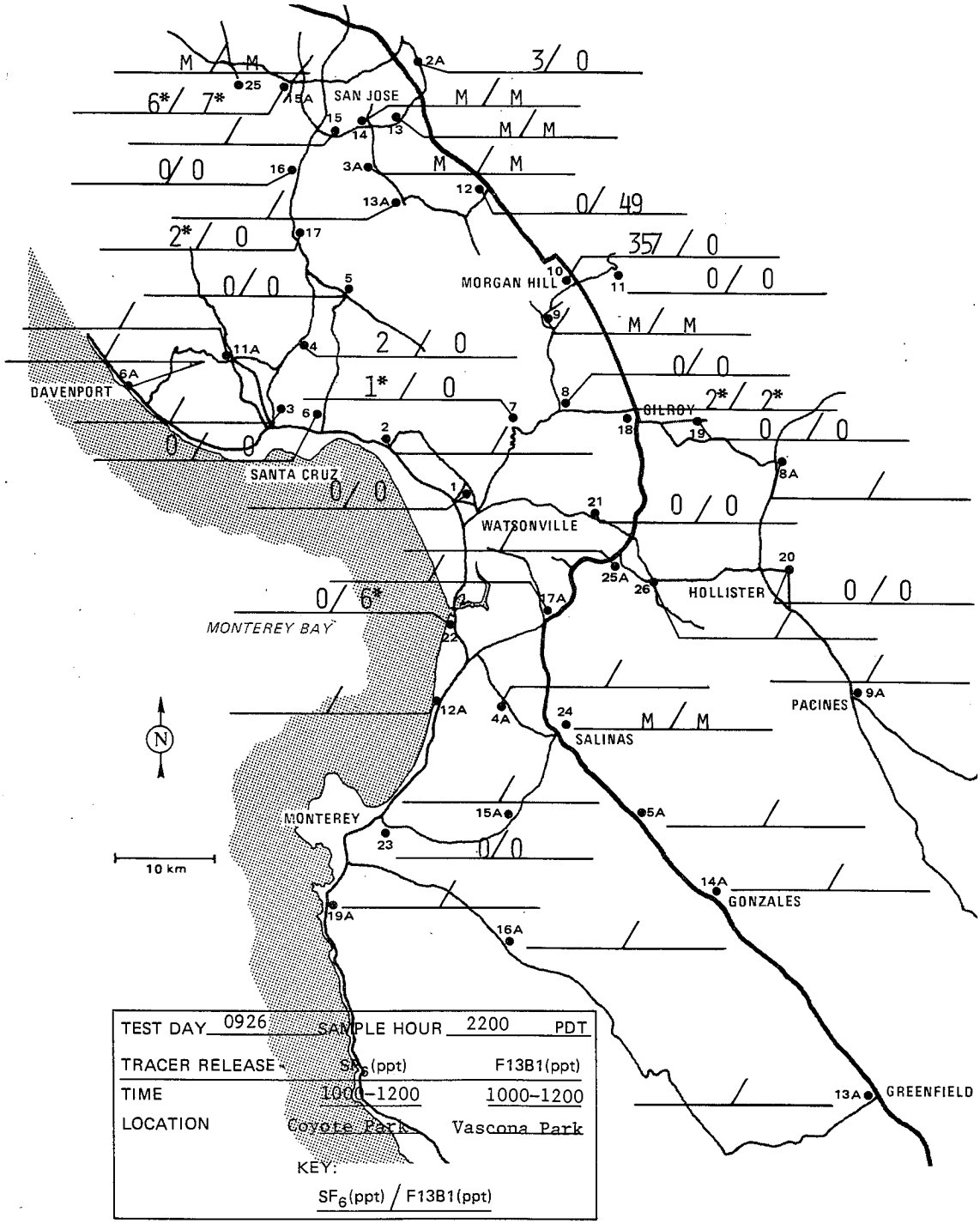


FIGURE 42k (CONTINUED)

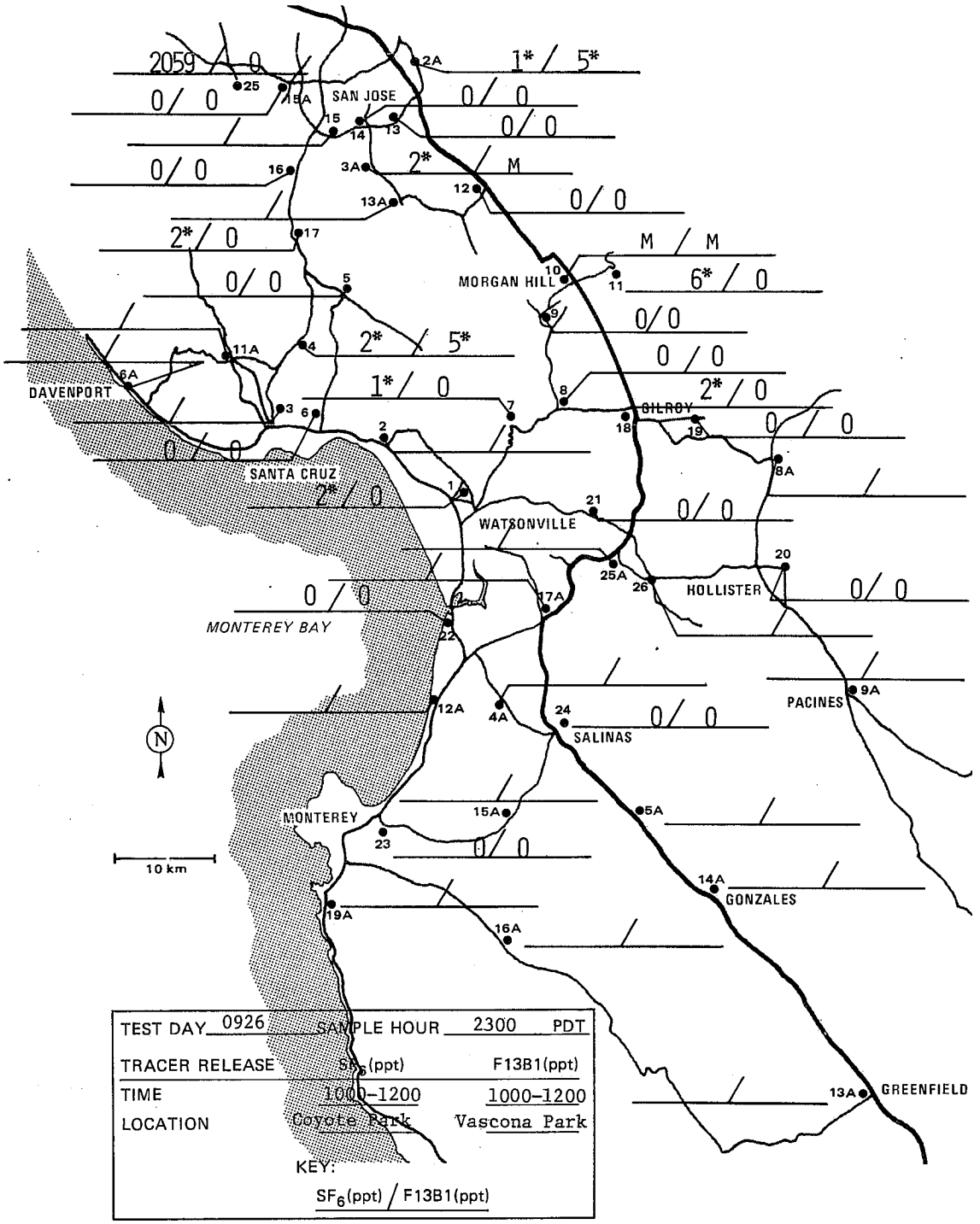


FIGURE 4211 (CONCLUDED)

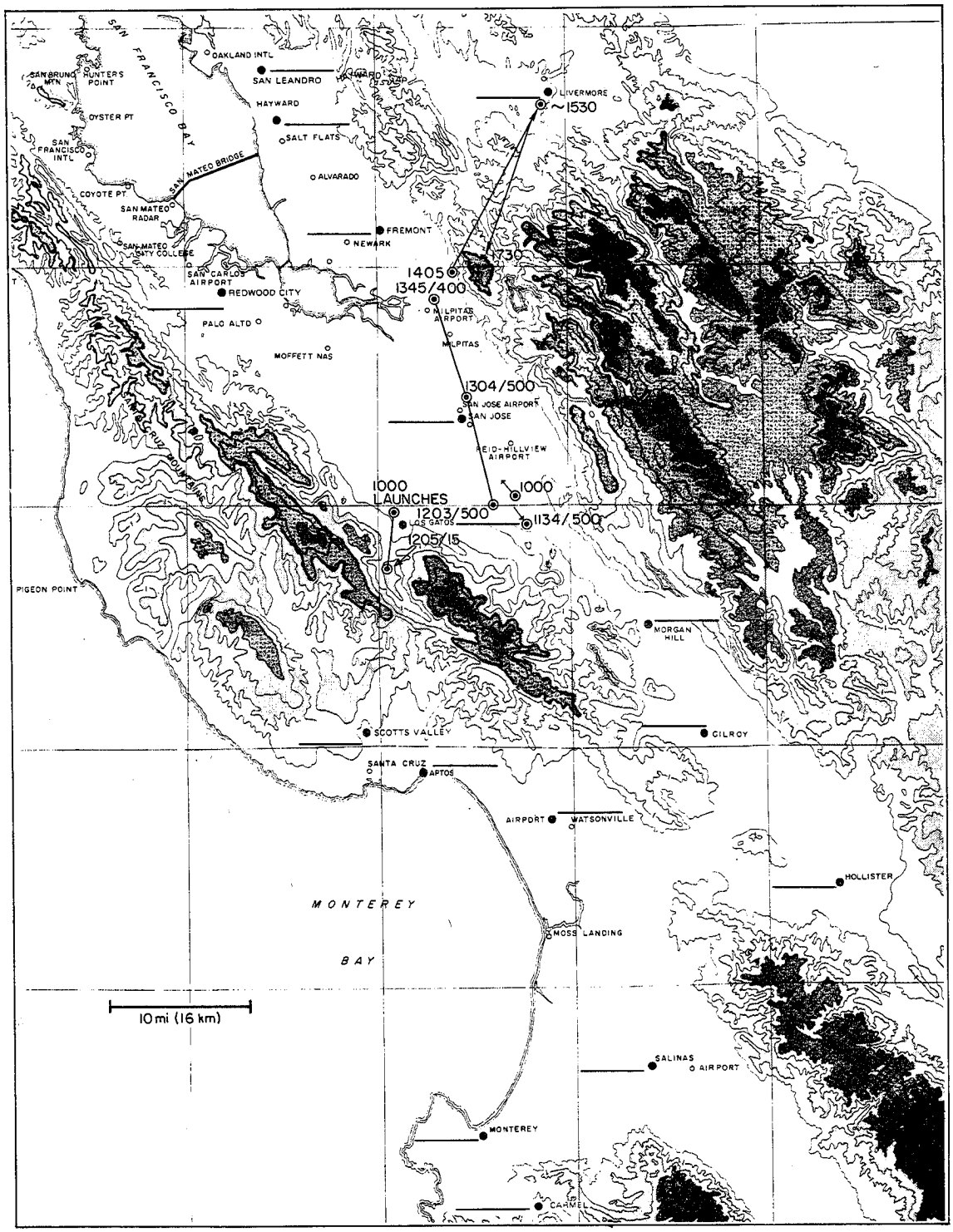


FIGURE 43 TETROON OBSERVATIONS, TEST 0926
[time (PDT)/altitude (m, agl)]

about two hours, first north and then south, within 2 km of the launch site maintaining an altitude of 500 m. At 1203 PDT, it was about 1 km WSW of the launch site and began a systematic movement past San Jose Municipal Airport (1304 PDT), Milpitas Airport (1345), and into the Livermore Valley; about 1530 PDT it reversed direction to the SSW and was last observed at 1730 PDT near Mission Peak (4 km NE of Milpitas Airport).

The aircraft-sampling pattern is given in Figure 44 and Table 13, while the San Jose and Hollister winds are tabulated in Table 14. The 0700-PDT aircraft sounding at San Jose (see Volume II) indicated a slightly stable layer (-0.65°C/100 m) from the surface to 420 m, capped by a very stable layer (+5.3°C/100 m) to 650 m with isothermal and slightly stable layers above. Ozone was uniformly low (25 ppb) in the near-surface layer and peaked at 110 ppb in the isothermal layer at 900 m. Fog and low clouds at Hollister extended to 600 m at 0730 PDT; between 600 and 1500 m, ozone was nearly uniform around 80 ppb except for a narrow 150-ppb peak at 900 m.

San Jose winds varied considerably throughout the day. From 0800-1300 PDT, the successive hourly directions backed systematically: SE, E, NE, NNW, NW, and variable; speeds were light, varying from 0.5 to 2 m s^{-1}. Afternoon San Jose winds, however, were steadily from NNW and NW at 2-3 m s^{-1}. Morgan Hill winds were missing this day while Hollister winds fluctuated similar to San Jose, varying from NW and WNW until 1400 PDT when they remained out of the west at 3.5-7 m s^{-1} until evening.

The tracer transport pattern is diverse and complex, reflecting the morning variability of the surface winds. The 12-1300 F13B1 measurements from the fixed network indicate a high concentration (130 ppb) remained in the Los Gatos release area. Otherwise, traces were measured in various locations: Scotts Valley, Cupertino-San Jose, Gilroy, and Hecker Pass. The next hour had a similar pattern except that levels in Cupertino increased to 34 ppt and remained there for the following hour as well. At this time (14-1500), Lexington Reservoir had the highest recorded value (697 ppt) indicating dispersion had proceeded both to the north and south; see Figure 42(c). Concentrations both at Los Gatos and Lexington Reservoir decreased by a factor of 3-4 during 15-1600, while southeastward transport was observed into San Jose. The next two hours had F13B1 transport up the Santa Clara Valley as far south as Morgan Hill. Then, F13B1 levels decreased abruptly at 18-1900 and remained low at scattered locations throughout the evening.

The instantaneous samples from the five vehicles sampling this day further clarify the F13B1 transport pattern. During the period 1305-1433 PDT, a broad region of low concentrations ($\leq$20 ppt) was observed along the western edge of the Santa Clara Valley from Campbell to Uvas Reservoir and west of San Martin. About the same time (1339-1412), high levels up to 215 ppt were measured from the summit of Highway 17 north to Los Gatos and west to Saratoga and midway up the slope to the ridge line. Returning eastward, moderate concentrations up to 30 ppt were seen to Cupertino. Perhaps the most significant measurements were made

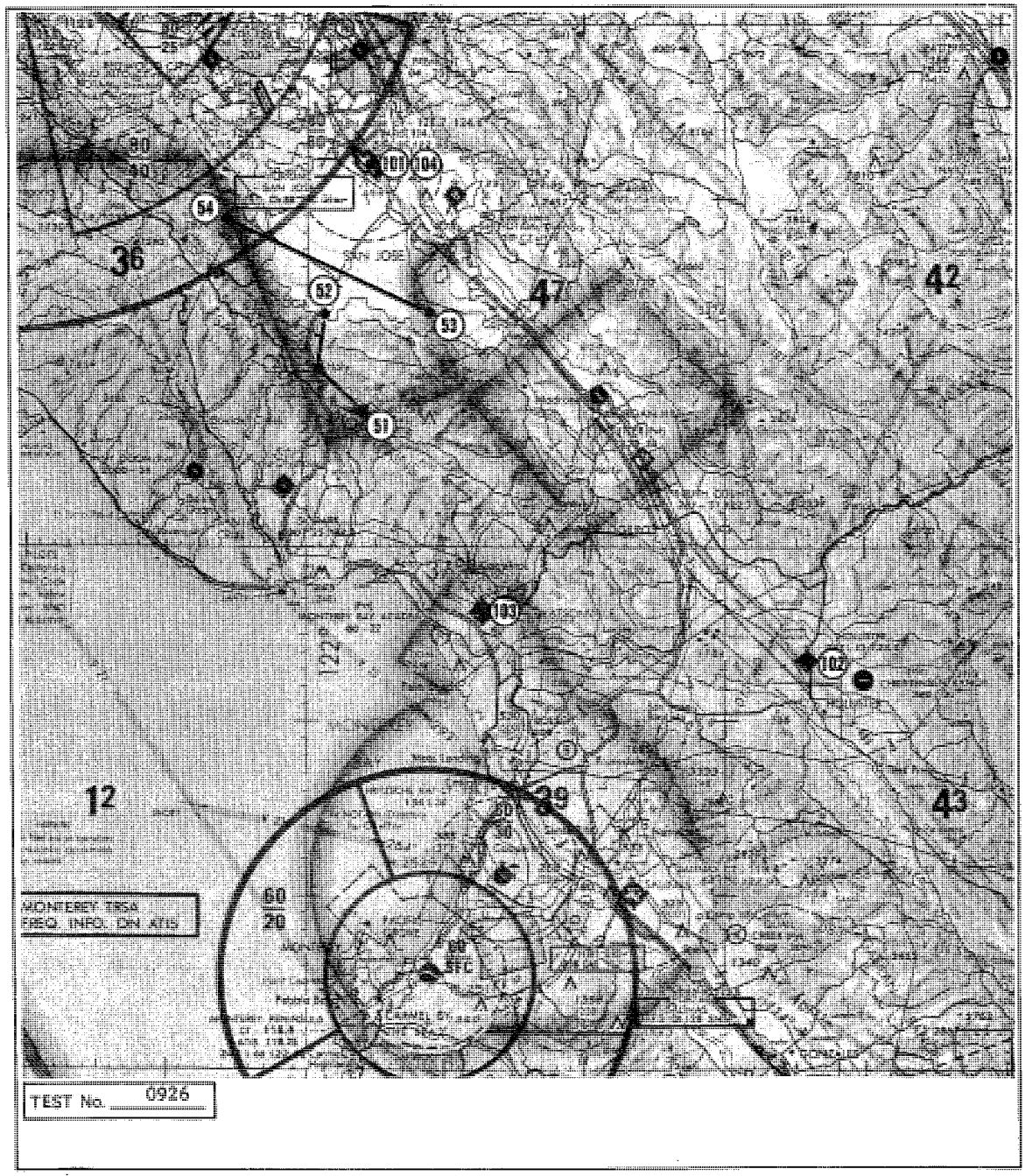


FIGURE 44a AIRCRAFT FLIGHT PATTERN, TEST 0926

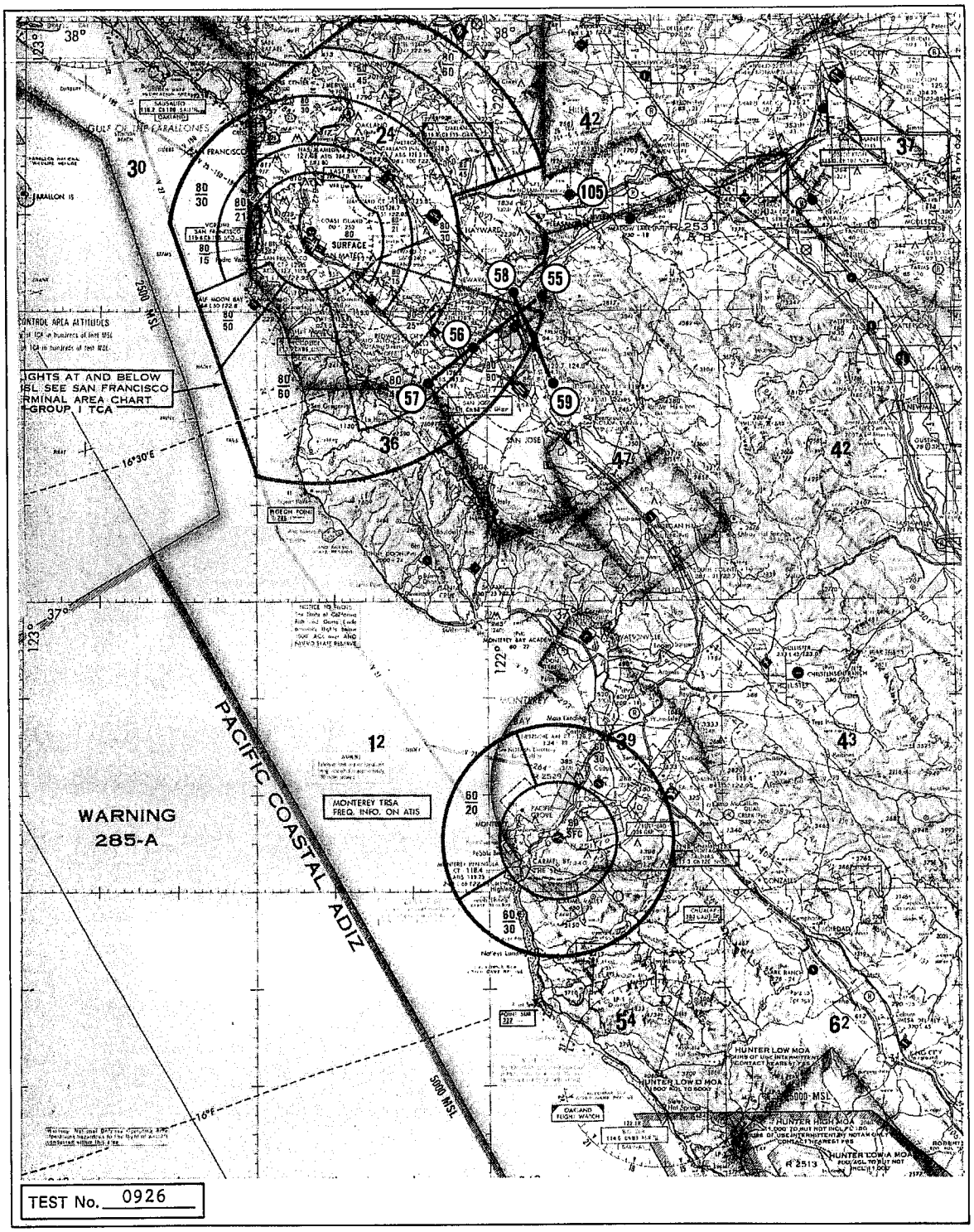


FIGURE 44b (CONTINUED)

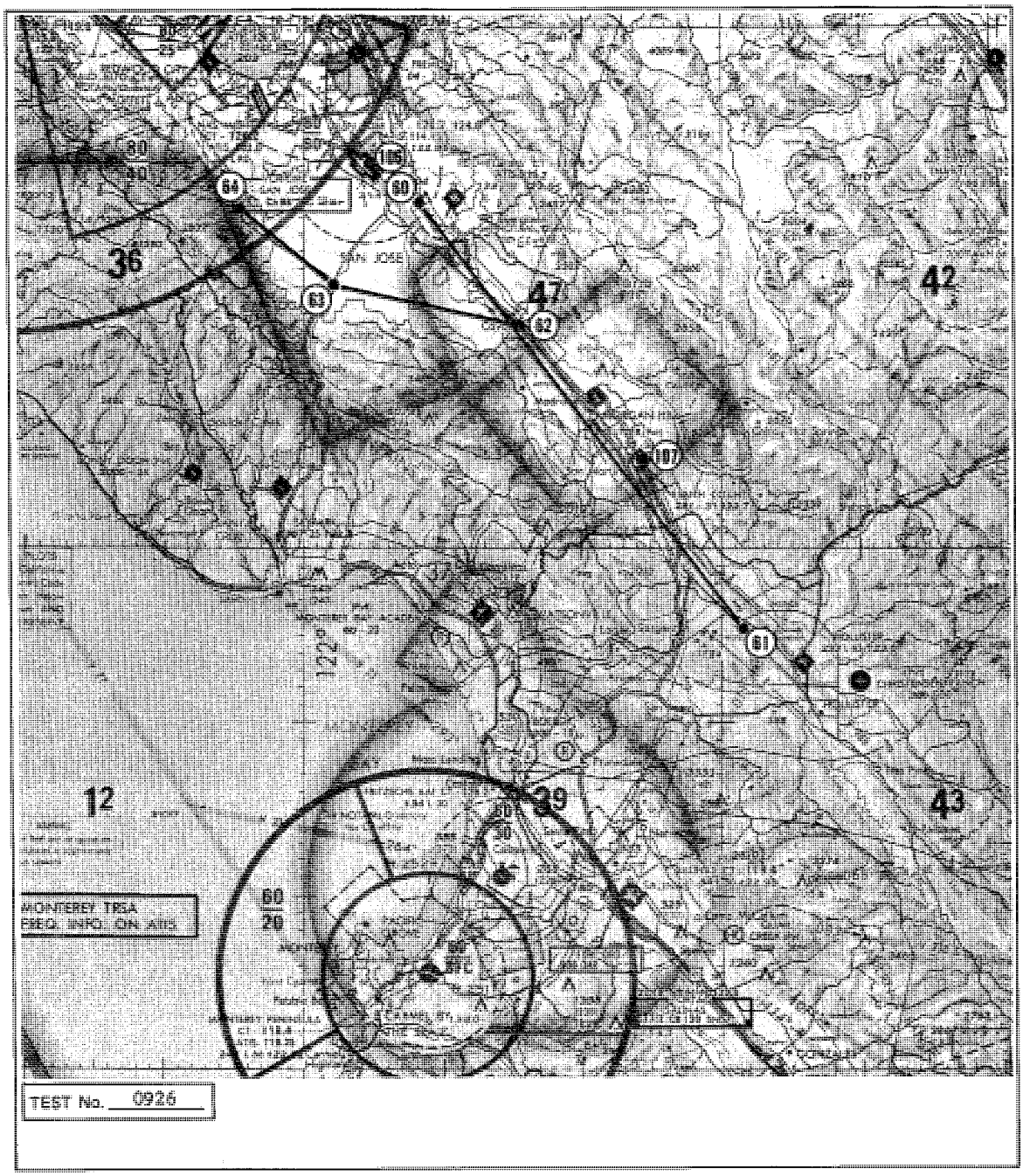


FIGURE 44c (CONCLUDED)

Table 13

AIRCRAFT WAY POINTS, TEST 0926

Way Point	Geographic Location	Altitude (m,msl)	Nominal Time (PDT)
Traverses			
51	Lake Elsman	300*	1311
52	Los Gatos	300*	1311
53	Almaden	300*	1320
54	Cupertino (Permanente)	300*	1320
53	Almaden	550	1331
54	Cupertino (Permanente)	550	1331
55	Mission San Jose	300*	1351
56	Moffett Field	300*	1351
55	Mission San Jose	450	1359
56	Moffett Field	450	1359
55	Mission San Jose	600	1407
57	Los Altos	600	1407
55	Mission San Jose	300*	1627
56	Moffett Field	300*	1627
58	Newark	300*	1634
59	Evergreen	300*	1634
60	Santa Clara County Fairgrounds	300*	1643
61	Hollister	300*	1643
62	Coyote Park	300*	1703
63	Vasona Park	300*	1703
63	Vasona Park	300*	1711
64	Cupertino (Permanente)	300*	1711
Spirals			
101	San Jose Airport		0703
102	Hollister Airport		0726
103	Watsonville Airport		0752
104	San Jose Airport		0821
105	Livermore Airport		1614
106	San Jose Airport		1829
107	South County Airport		1851

*agl.

Table 14

SANTA CLARA-SAN BENITO VALLEY WIND VARIATIONS,
SEPTEMBER 26, 1980

Time (PDT)	Wind Direction/Speed* Downtown San Jose	Morgan Hill	Hollister
08-09	(3) 135/04	m	var/02
09-10	(2) 090/02	m	(1) 315/04
10-11	045/01	m	315/08
11-12	(1) 338/03	m	(2) 293/09
12-13	315/03	m	var/04
13-14	var/02	m	(1) 315/07
14-15	(1) 315/04	m	(2) 270/09
15-16	338/06	m	270/13
16-17	338/06	m	270/14
17-18	315/05	m	270/12
18-19	338/04	m	270/10
19-20	338/03	m	270/07
20-21	338/03	m	293/03

*deg(true)/mph

(1) = Upvalley flow (San Jose to Hollister)
(2) = Cross-valley flow
(3) = Downvalley flow (Hollister to San Jose)

between Portola Valley and San Jose along Highway 280; Portola Valley is 25 km NW of Vasona Park. Concentrations of F13B1 were observed continuously along this route at an average value of about 70 ppt. These data indicate that most of the F13B1 was transported NW up the peninsula and a lesser fraction south and southeast along the southern and western corridors (transport Routes 1 and 2, respectively; see Figure 3). Further evidence of some transport along the western corridor is seen in mobile samples taken during the interval 1510-1539 PDT, indicating concentrations averaging about 40 ppt from just south of the Highway 17 summit to Santa Cruz and Watsonville. The aircraft tracer samples reconfirm many of the surface observations and add new information. Traverses at 1320-1337 PDT detected F13B1 concentrations of 30-70 ppt at 550 m between Almaden and Saratoga; concentrations at 300 m are slightly greater and are shifted about 3 km to the north. Measurements from 1407-1414 PDT found F13B1 at 600 m from Mission San Jose in Fremont to Moffett Field; similar traverses at 300 and 450 m located only scattered, low-level values.

The SF_6 released from Coyote Park was first detected at 12-1300 PDT sampling Site 12, about 2 km NNW in south San Jose. The 33-ppt is very low considering the proximity to the release point, the low air movement during the late morning, and the short transport time from release; the implication is that only the edge of the tracer cloud passed over the site during the hour. Other locations detected only very low-level SF_6 traces during the hour. Conditions were relatively unchanged the following hour (13-1400) except the concentration at Site 12 increased by a factor of three. The trend continued from 14-1500 with SF_6 at Site 12 up to 111 pt; the only other significant measurement was west of Gilroy where a 42 ppt was observed. The 15-1600 pattern again showed the maximum concentration (40 ppt) in south San Jose, but no other significant values at any of the fixed sampling sites. The following hour (16-1700), east Morgan Hill had the only significant concentration (38 ppt) and from 17-1800 there was no measurement greater than 6 ppt. The samples obtained up to this time account for only a very small fraction of the total SF_6 mass released. Recalling the tetroon trajectory, it appears likely that the main SF_6 cloud was transported northward out of the sampling grid, and the measurements from south San Jose, west Gilroy and east Morgan Hill are indications of one or more secondary plumes that bifurcated away from the main cloud. There is some evidence to support the hypothesis in the evening tracer measurements. At 19-2000 PDT, the Cupertino sampling Site 25 measured an SF_6 concentration of 851 ppt while west Gilroy measured 21 ppt for the hour. Site 25 missed the next 3 hours; however, west Gilroy decreased to zero while Hecker Pass increased to 20 ppt during 20-2100 PDT. The following hour had no measurements above a trace, but during 22-2300 Morgan Hill (Site 10) registered 357 ppt; the origin of this very high concentration 10 hours after cessation of the tracer release is unknown. Even more unusual are some of the 23-2400 observations: one, Site 10 was missing, yet none of the adjacent stations registered any concentrations greater than a trace; and two, Site 25 in Cupertino recorded a daily high of 2059 ppt for the hour.

As before, the mobile data help clarify some features of the transport pattern. The midday SF_6 distribution is clarified by the 1500-1700 surface-sampling pattern, which originated in Los Gatos. The first half of the sampling pattern was a broad triangle extending first ESE to south San Jose, then north to central San Jose, and SW back to Los Gatos; no SF_6 was detected along any part of this route. Similarly, there was no SF_6 detected along the second half of the pattern which progressed from Los Gatos to the summit on Highway 17 and then SSE along the ridge line adjacent to the Forest of Nicene Marks and into Watsonville. Another sampling traverse during mid-afternoon (1511-1547) did detect low concentrations (10 ppt) from south San Jose north to Milpitas and west to Sunnyvale. About the same time (1433-1519), a third sampling vehicle observed moderate-to-high concentrations (17-93 ppt) from west Morgan Hill to southeast San Jose (8 km NE of Anderson Reservoir). A fourth vehicle sampling in the same general area about one hour later detected only a short segment (10 km long) that extended north of central Morgan Hill; concentrations had decreased to the 20-ppt range. These observations generally confirm the inferences from the fixed network: the presence of a 10- to 15-km-long tracer cloud in the Morgan Hill area during mid- and late-afternoon characterized by moderate concentrations that can account for only a small percentage of the total SF_6 release; and the suggestion of a second SF_6 cloud transported farther north. The latter is corroborated by other surface and aerial tracer samples. A fifth vehicle sampling from 1437 to 1502 PDT observed a continuous band of SF_6 along Highway 280 from Portola Valley in the north to San Jose in the south; concentrations ranged from 25-55 ppt. About two hours later,the aircraft detected a very localized SF_6 peak of 1181 ppt at 300 m in the vicinity of Stevens Creek Reservoir, about 2-3 km SW of DeAnza College in Cupertino. The college is also the location of Site 25, which measured an hourly concentration of 851 ppt at 19-2000 and 2059 ppt at 23-2400 PDT.*

In summary, it appears that a large percentage of the two tracers were initially transported northward out of the sampling grid and were subsequently transported southward later in the afternoon and evening. Some of the tracer did, however, move southward throughout the day although none was transported into the NCCAB.

5. Test 0930: 30 September 1980

Test 0930 (30 September) was the first test day where ambient ozone concentrations in the study region exceeded the one-hourly standard of 120 ppb; Watsonville peaked at 120 ppb (hour average) and Hollister at 140, while San Jose, Los Gatos, Gilroy, and Morgan Hill recorded maxima ranging from 150 to 190 ppb. Peak hourly readings were up from 40 to 80

*Site 25 measured 0 ppt SF_6 16-1700 PDT, and had no data for the hours 17-, 18-, 20-, 21-, and 22-2300 PDT.

ppb over peak values measured the preceding day. Early (0500 PDT) on 28 September, a weak cold front was situated 350 km to the east, oriented north-south from southeastern California through central Nevada and Idaho and into Canada. On 29 September, the front was oriented approximately southwest-northeast with its trailing edge located in south-central Nevada. Meanwhile a closed surface high was centered at the Idaho-Oregon-Nevada junction, while at 500 mb it was centered over the study region (although no longer closed). Maximum surface temperatures along the central California coast rose about 6°C from 28 to 29 September, in response to light airflow out of the Central Valley; a thermal trough centered in Baja California began to develop in the western half of the state. On 30 September (see Figure 45) the trough persisted, with the pressure pattern in Northern and North-Central California appearing very similar to the previous day's. The SFO-RNO pressure difference decreased markedly from the previous test (26 September) to -5.7 mb. The maximum surface temperature at San Francisco International Airport increased 9°C from the preceding calendar day to 30°C (87°F). At 850 mb, the temperature of 23.8°C was 8.5°C (or 1.7 standard deviations) above the climatic norm for the period. Afternoon 850-mb winds were from the NNE at 10 m s^{-1}.

Winds on 30 September were very light at the surface in the interior portions of the study region. Both tracer/tetroon releases (Figure 46) were made at the San Jose City College; SF_6 was released from 0900 to 1100 PDT and F13B1 from 1030 to 1230. The 1000 tetroon drifted slowly to the ESE at a speed of about 1.1 m s^{-1} for approximately two hours when it grounded on a hill near the County Fairgrounds. The 1130 tetroon drifted SE at about 2 m s^{-1} before grounding in the Santa Teresa Hills northwest of the Calero Reservoir on the western edge of the Santa Clara Valley. Morning surface winds in downtown San Jose (Table 15) were light (1 m s^{-1}) and variable from SSE to SE to WNW. At noon they shifted to NNW, where they remained until 2000 PDT, ranging in speed from 0.5 to 2 m s^{-1}. At 20-2100 PDT, the wind reversed direction to SE and decreased in speed to 0.5 m s^{-1}. Morgan Hill varied directionally through 1300 PDT, although in a narrower arc than San Jose. Afternoon and evening winds indicated consistent upvalley flow at Morgan Hill. Hollister, however, shifted from upvalley to crossvalley flow at 1100 PDT and winds were steady from the WNW at 2-7 m s^{-1} until 1900 PDT when they changed, shifting to SSE at 20-2100 PDT.

Figure 47 shows the hourly averaged SF_6 and F13B1 tracer data from 1000-1100 through 2300-2400 PDT, respectively, for each of the 25 fixed air sampling sites. The SF_6 tracer measurements indicate there was organized transport both along the southern corridor (Route 1) and the western corridor (Route 2) in addition to some poorly organized dispersion of secondary elements of the main tracer plume. At 12-1300 PDT, the principle SF_6 measurement was a 136-ppt concentration in south-central San Jose at Site 14. However, there were also trace measurements (5-10 ppt) from Morgan Hill to Hollister. The SF_6 core moved southward during the next hour with 228- and 375-ppt concentrations observed in the Almaden-Santa Teresa Hills region indicating slow transport at 1-2 m s^{-1}; trace values continued along the southern corridor

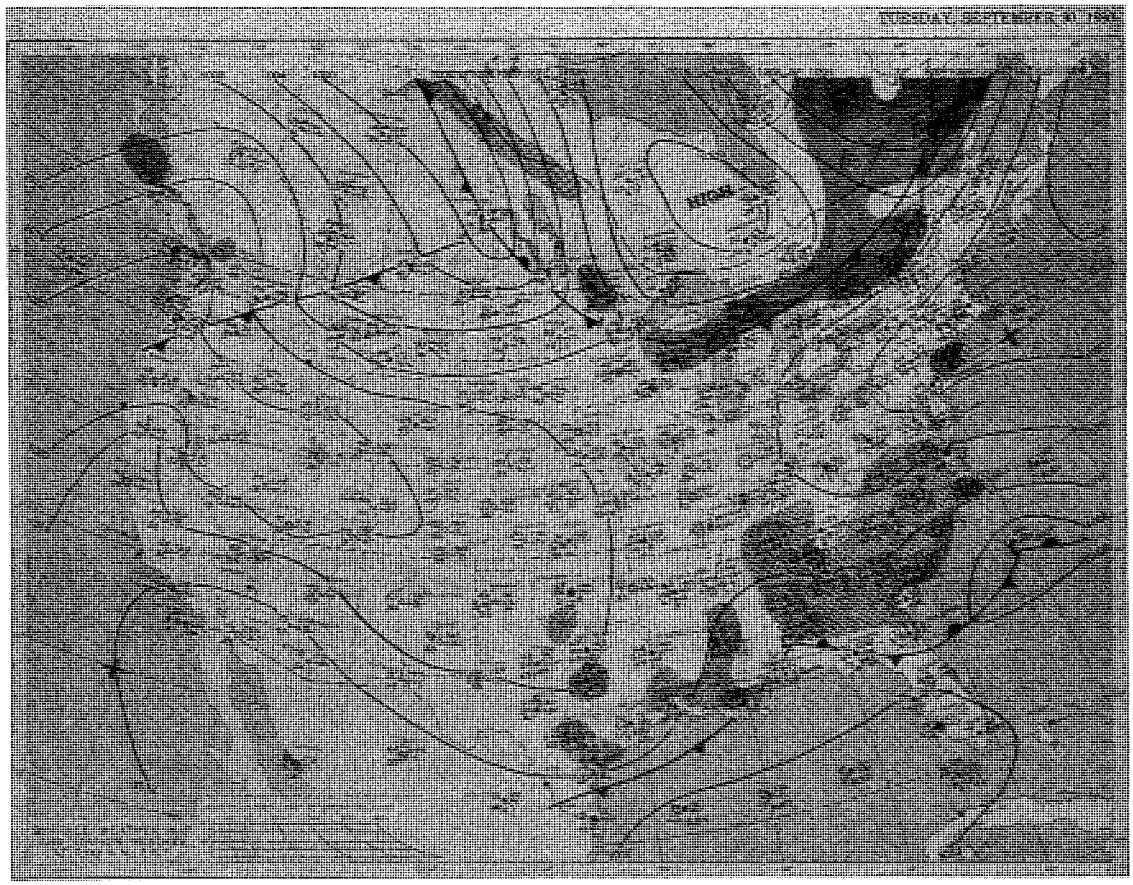


FIGURE 45 SURFACE WEATHER MAP 0500 PDT, Test 0930

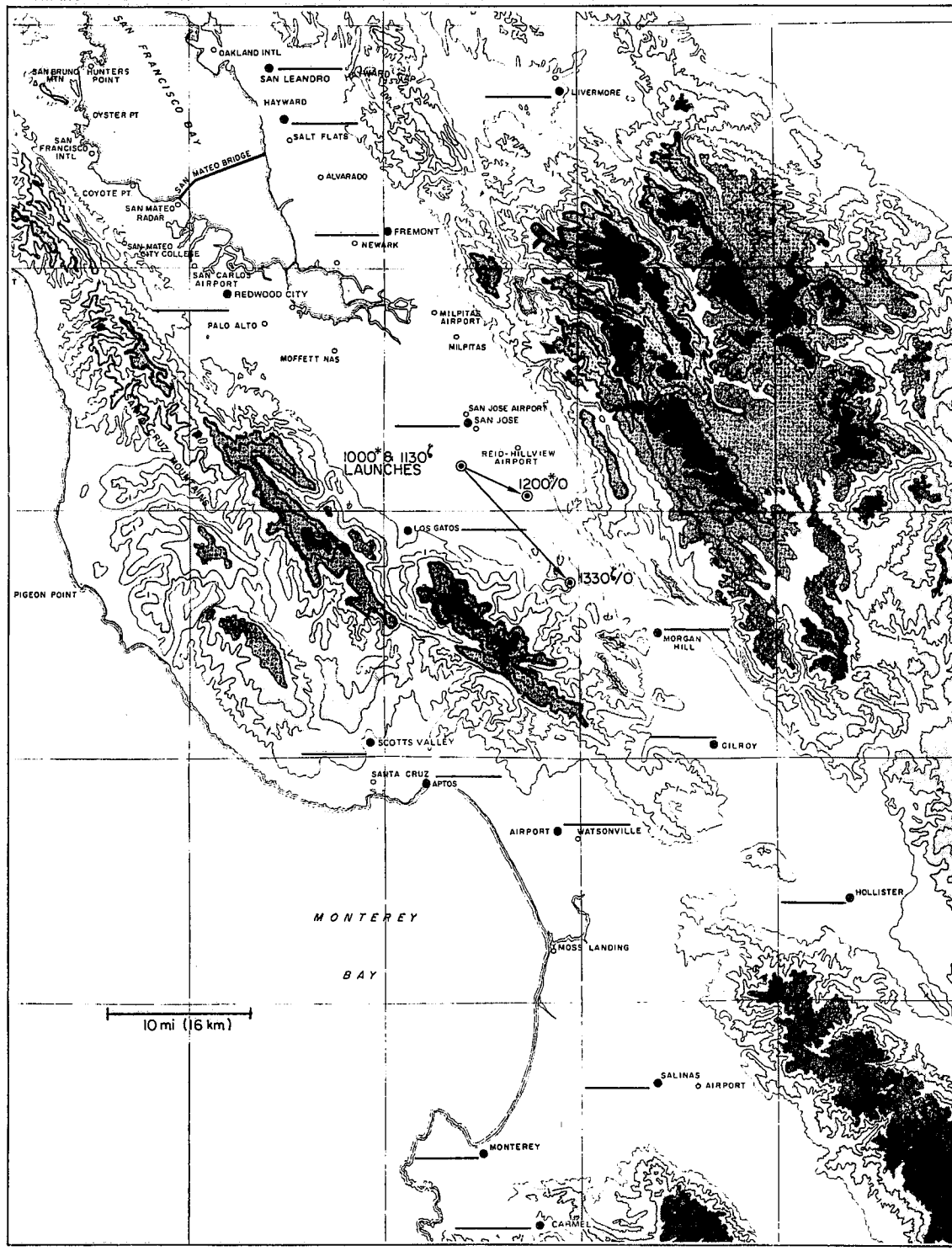


FIGURE 46 TETROON OBSERVATIONS, TEST 0930
[Time (PDT)/Altitude (m, agl)]

Table 15

SANTA CLARA-SAN BENITO VALLEY WIND VARIATIONS, SEPTEMBER 30, 1980

Time (PDT)	Wind Direction/Speed* Downtown San Jose	Morgan Hill	Hollister
80-09	(3) 158/02	(1) 297	var/03
09-10	135/02	(2) 283	(1) 315/03
10-11	(2) 293/02	277	315/03
11-12	293/02	(1) 294	(2) 293/04
12-13	338/03	265	293/05
13-14	338/04 (1)	295	293/05
14-15	315/04	304	293/07
15-16	338/04	299	293/10
16-17	338/04	299	293/13
17-18	338/03	302	293/15
18-19	338/01	295	293/09
19-20	338/02	337	var/04
20-21	135/01 (3)	298	(3) 158/06

*deg(true)/mph

(1) = Upvalley flow (San Jose to Hollister)

(2) = Cross-valley flow

(3) = Downvalley flow (Hollister to San Jose)

as well as in Santa Cruz. Transport accelerated from 14-1500 along the southern corridor: the peak hourly average of 149 ppt was located in Morgan Hill, equivalent to SSE transport at 5-6 m s^{-1}. Also, the first significant indication of transport into the western corridor was the 82-ppt SF_6 concentration in Los Gatos. During the ensuing hours, some transport continued along the western corridor although the concentrations were small and erratic, and the rate of movement could not be estimated. The principal trace cloud continued movement down the southern corridor, and was detected in the Hecker Pass-Gilroy area by the 15-1600 measurements; the inferred transport speed for the hour was about 3 m s^{-1}. Beginning with the 16-1700 hour and continuing throughout the evening, there were no further SF_6 measurements above

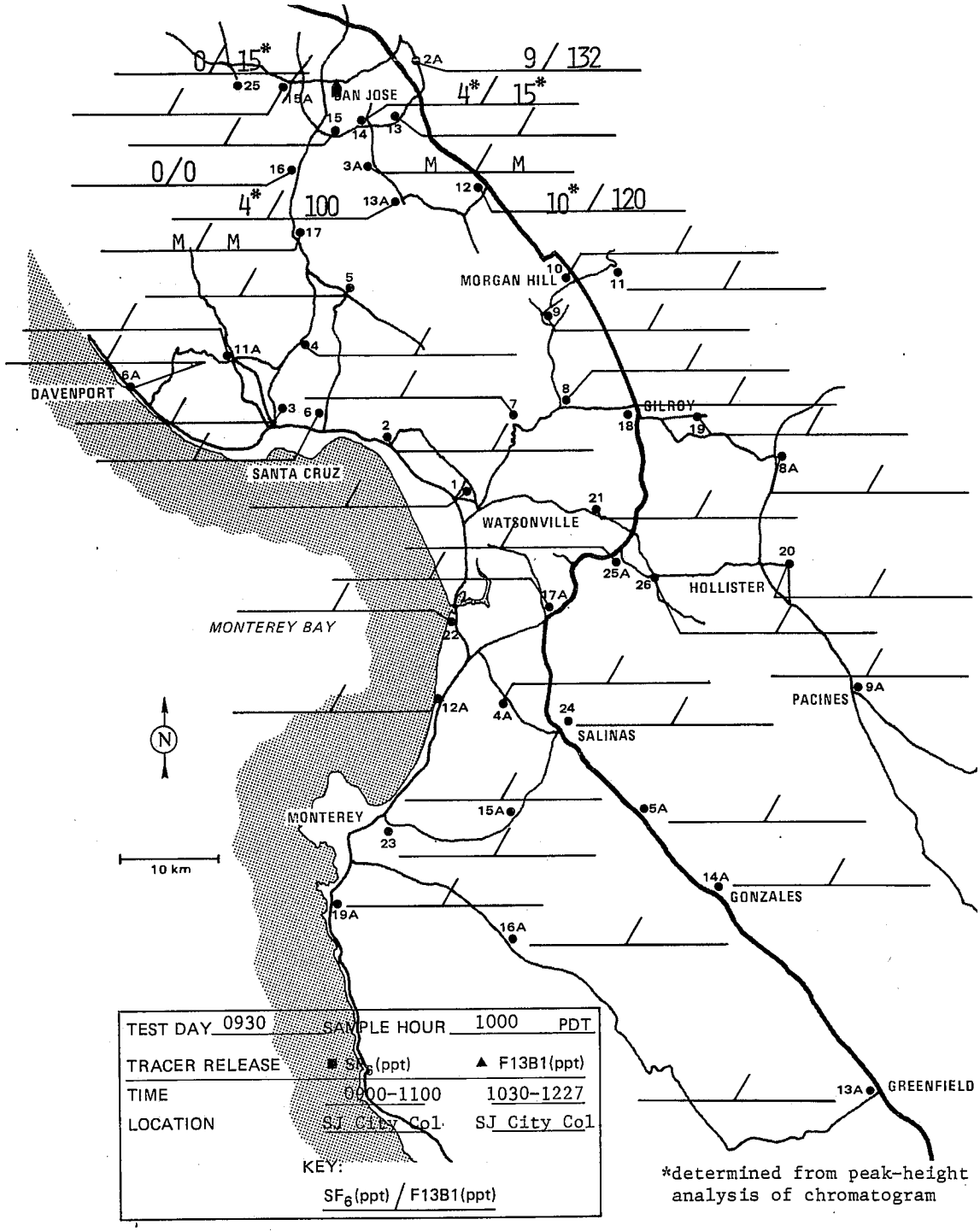


FIGURE 47a HOURLY SURFACE TRACER MEASUREMENTS, TEST 0930

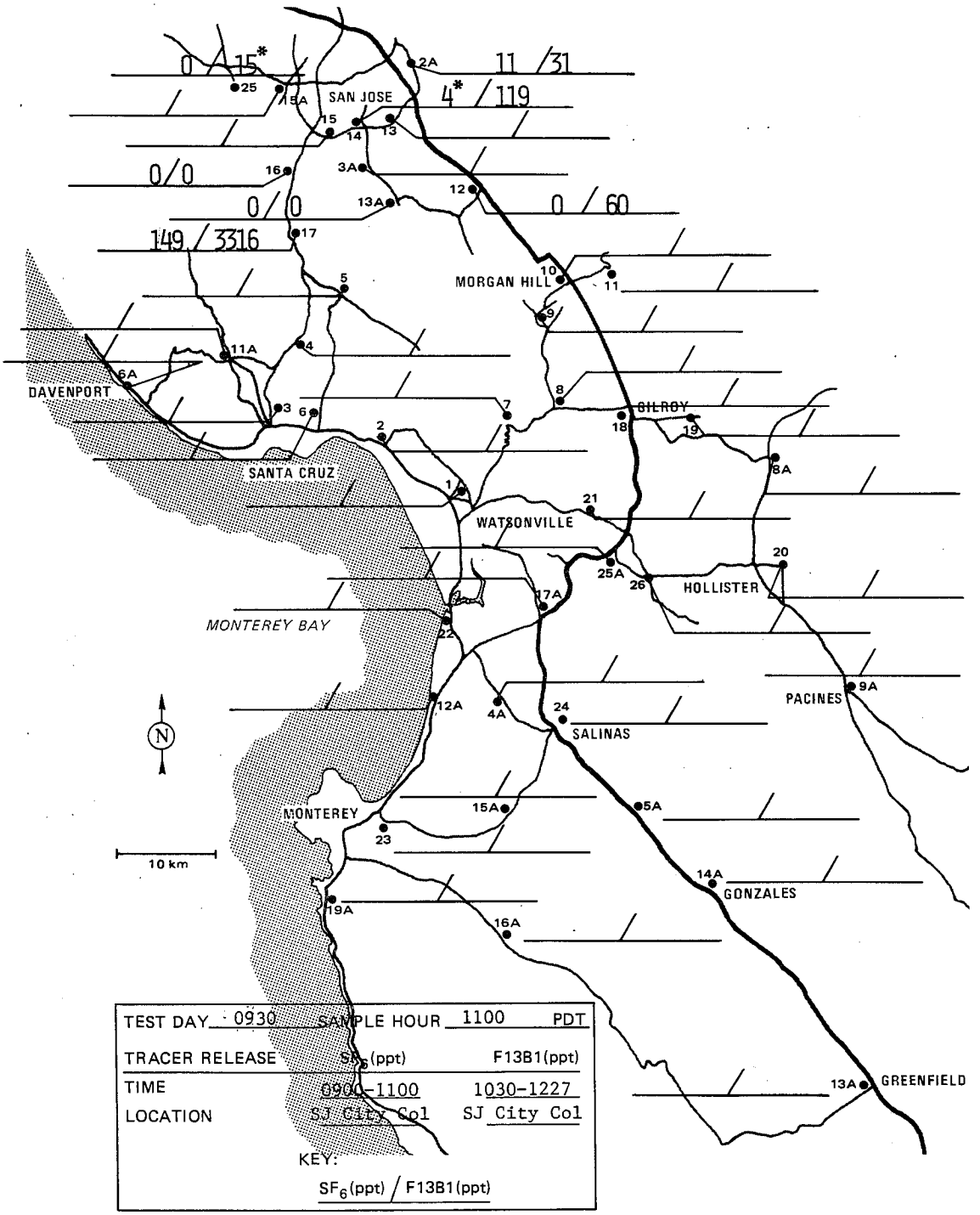


FIGURE 47b (CONTINUED)

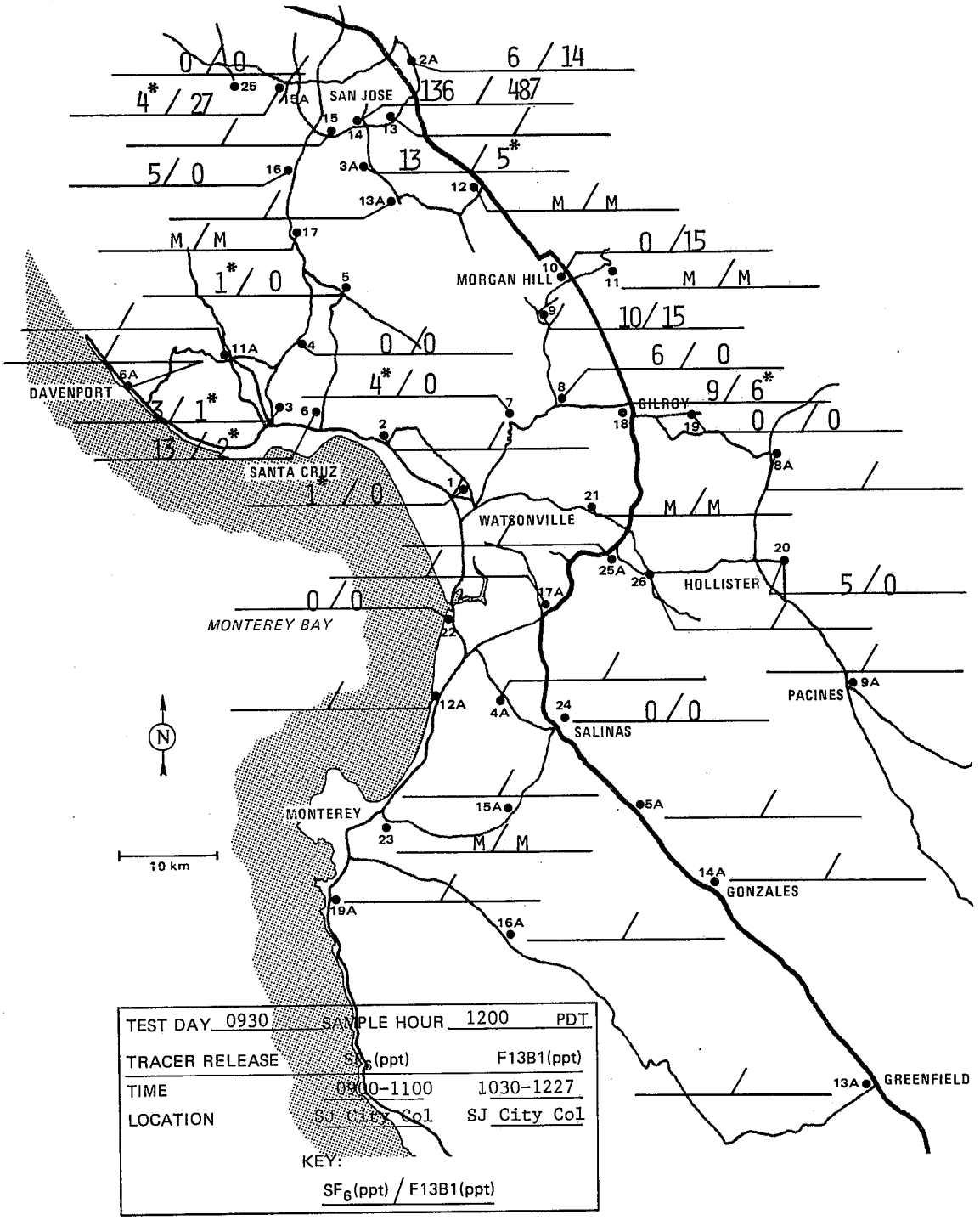


FIGURE 47c (CONTINUED)

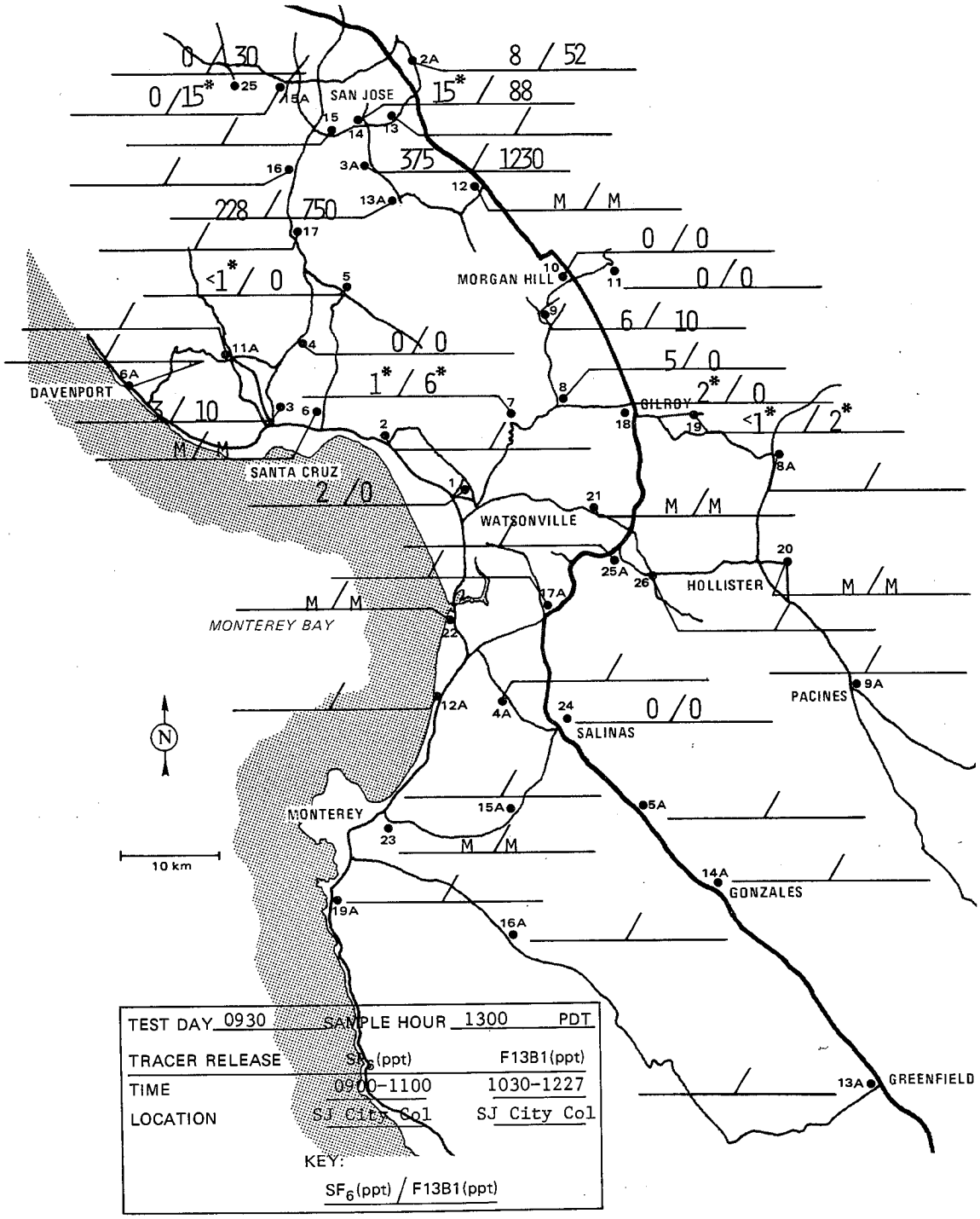


FIGURE 47d (CONTINUED)

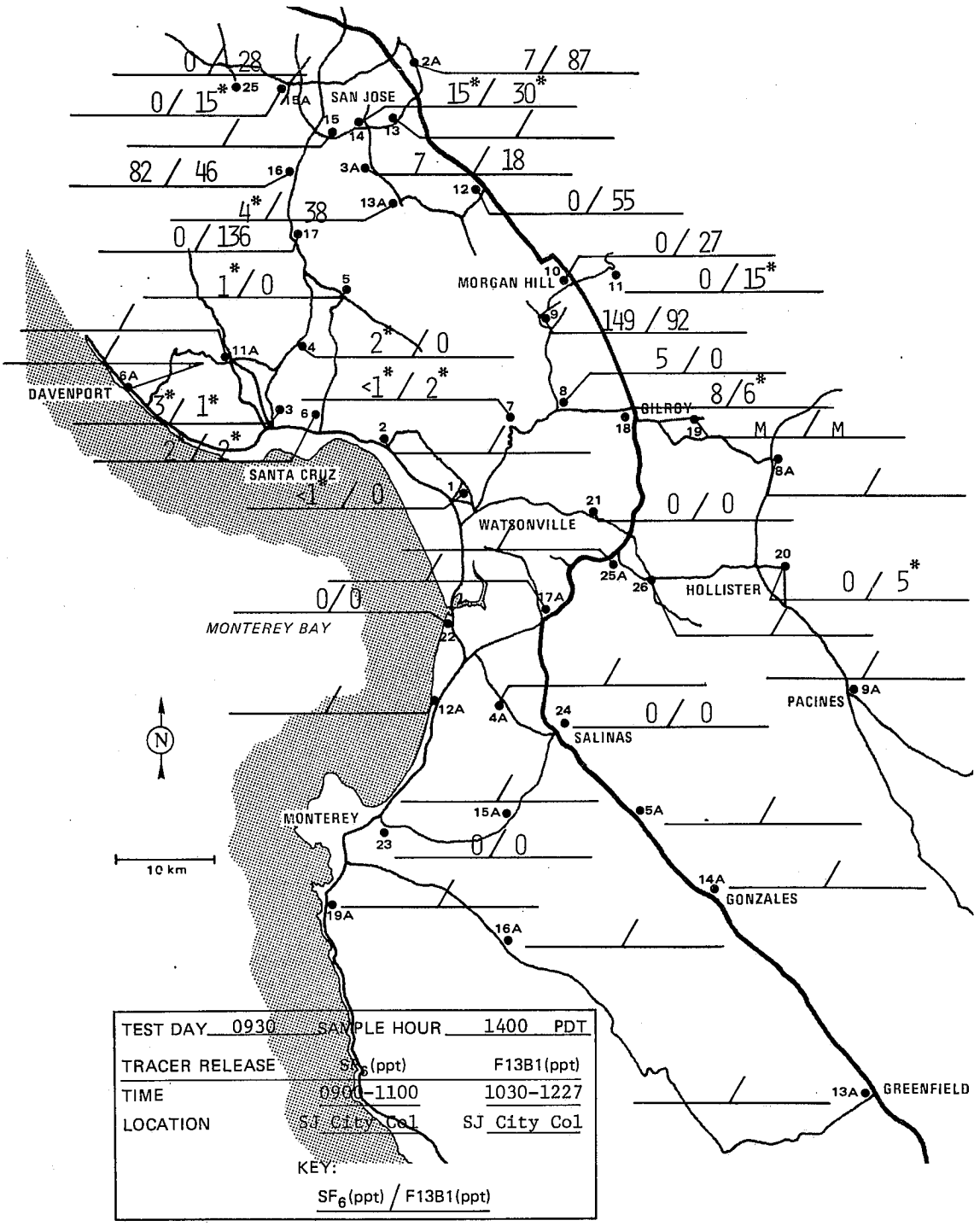


FIGURE 47e (CONTINUED)

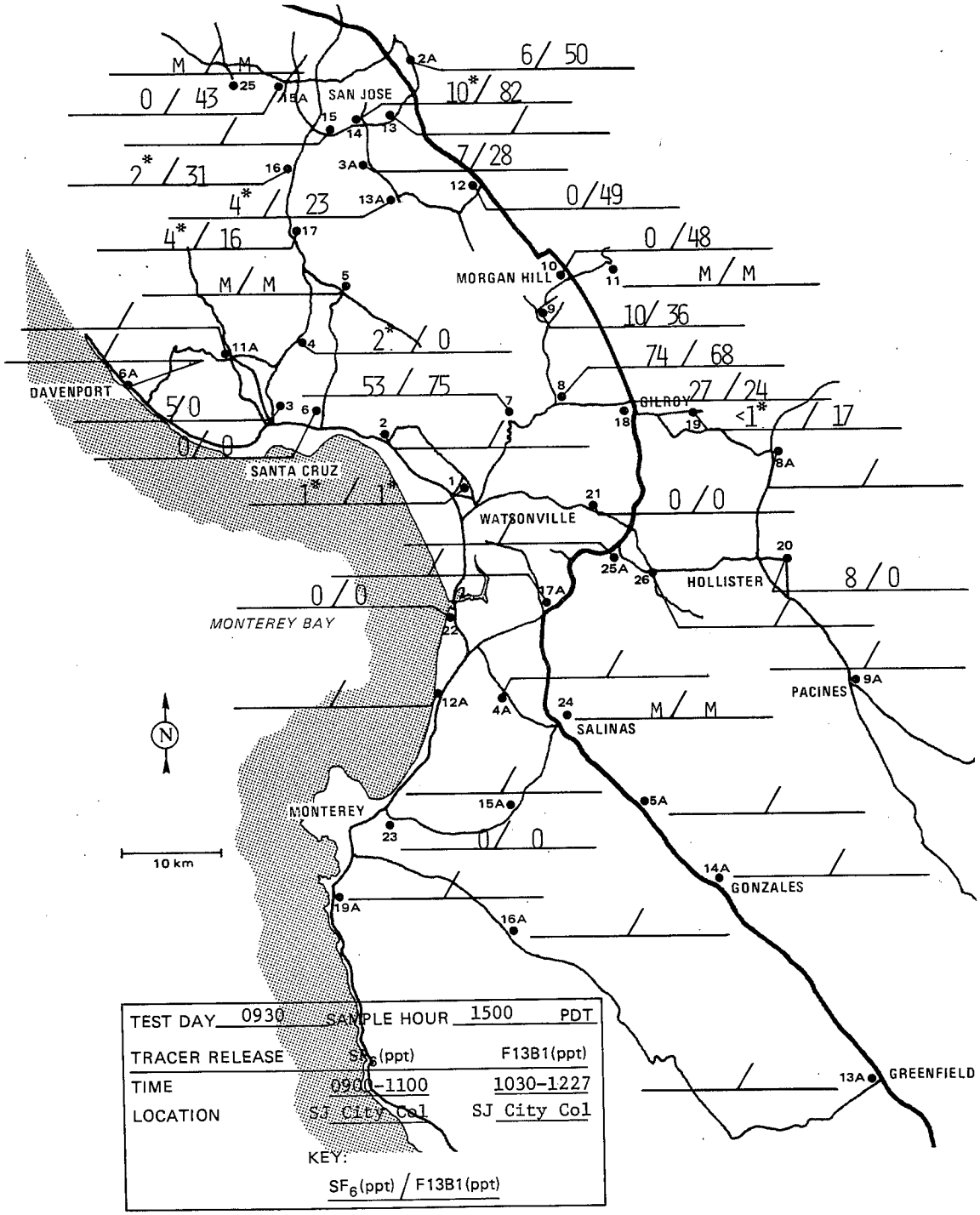


FIGURE 47f (CONTINUED)

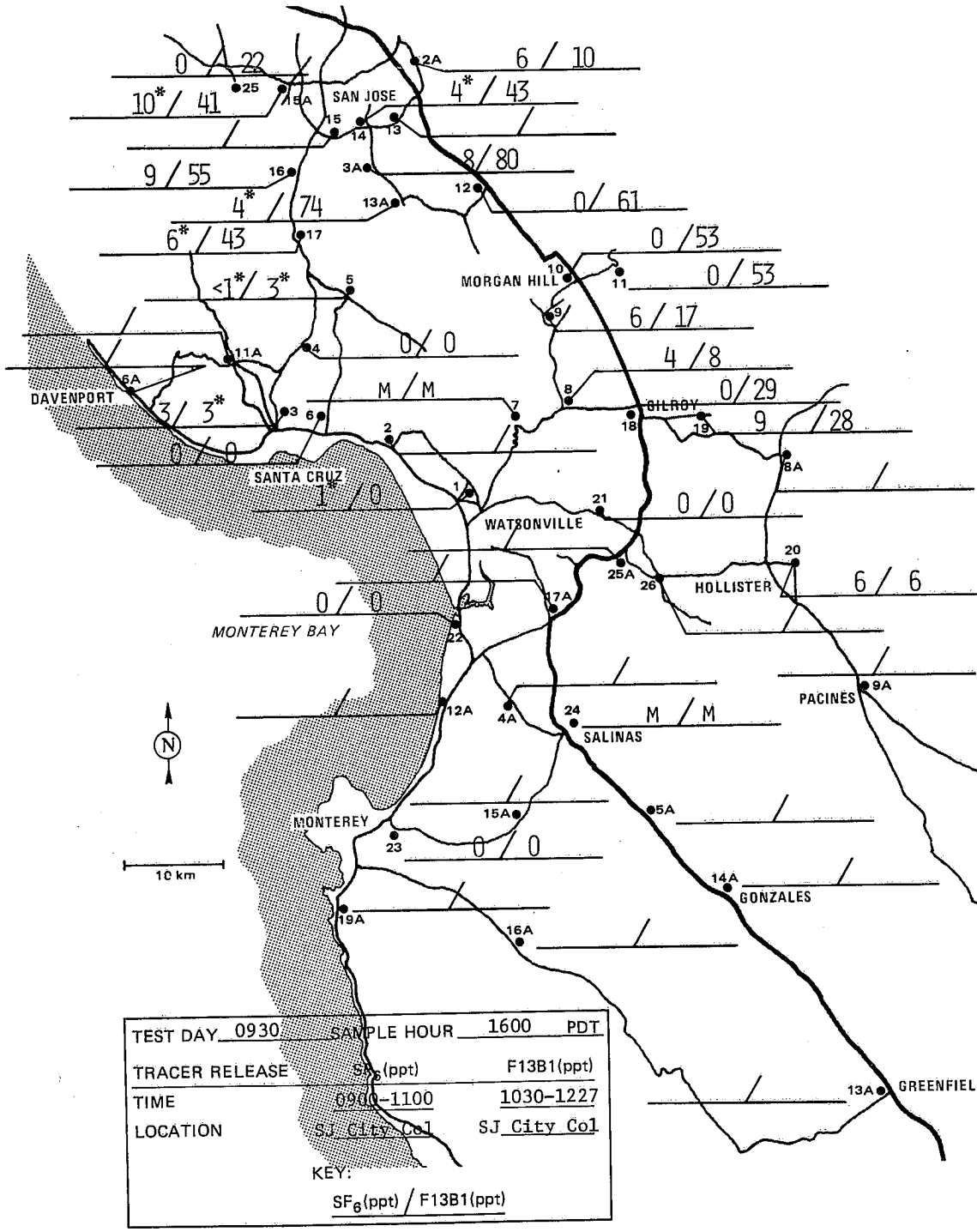


FIGURE 47g (CONTINUED)

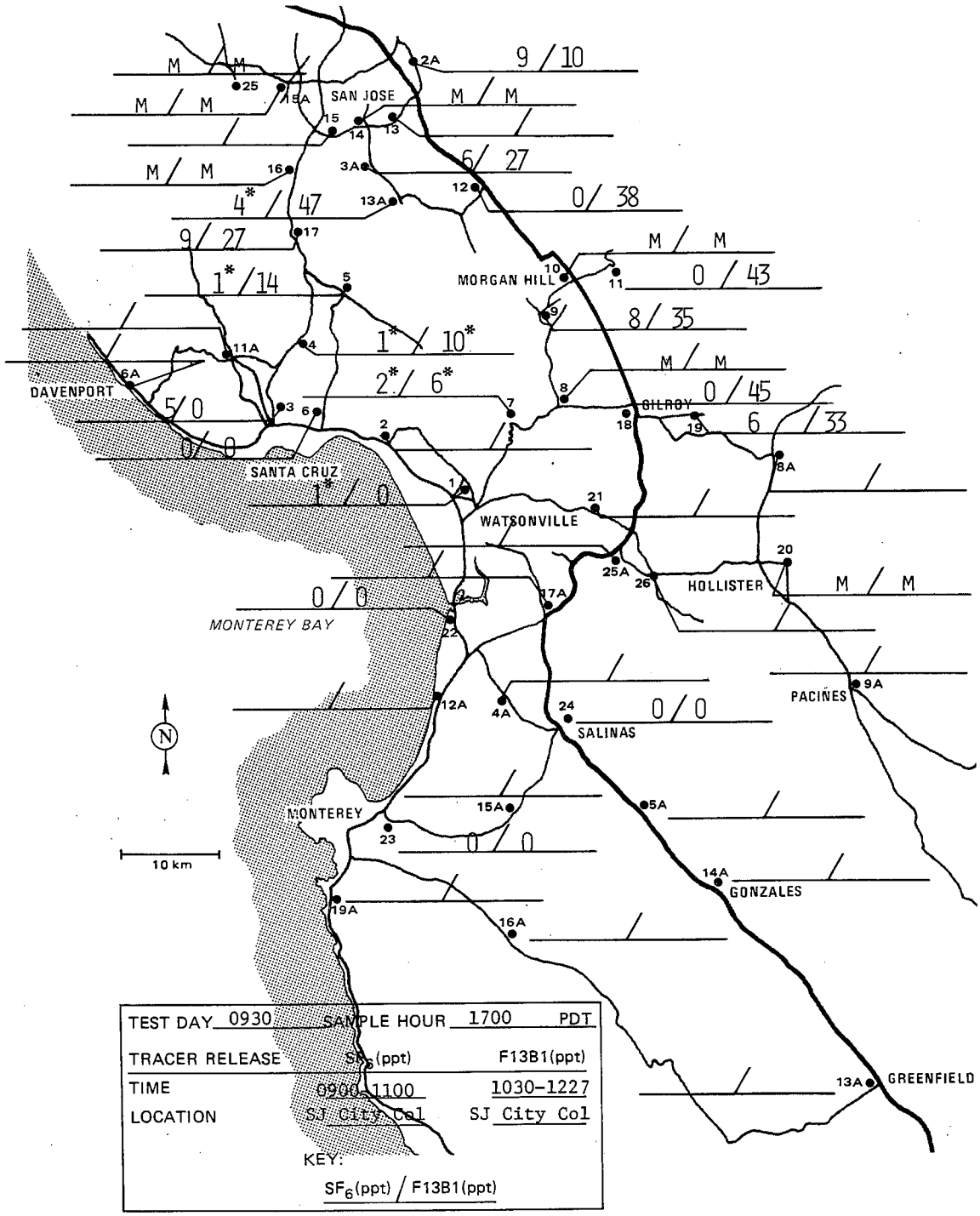


FIGURE 47h (CONTINUED)

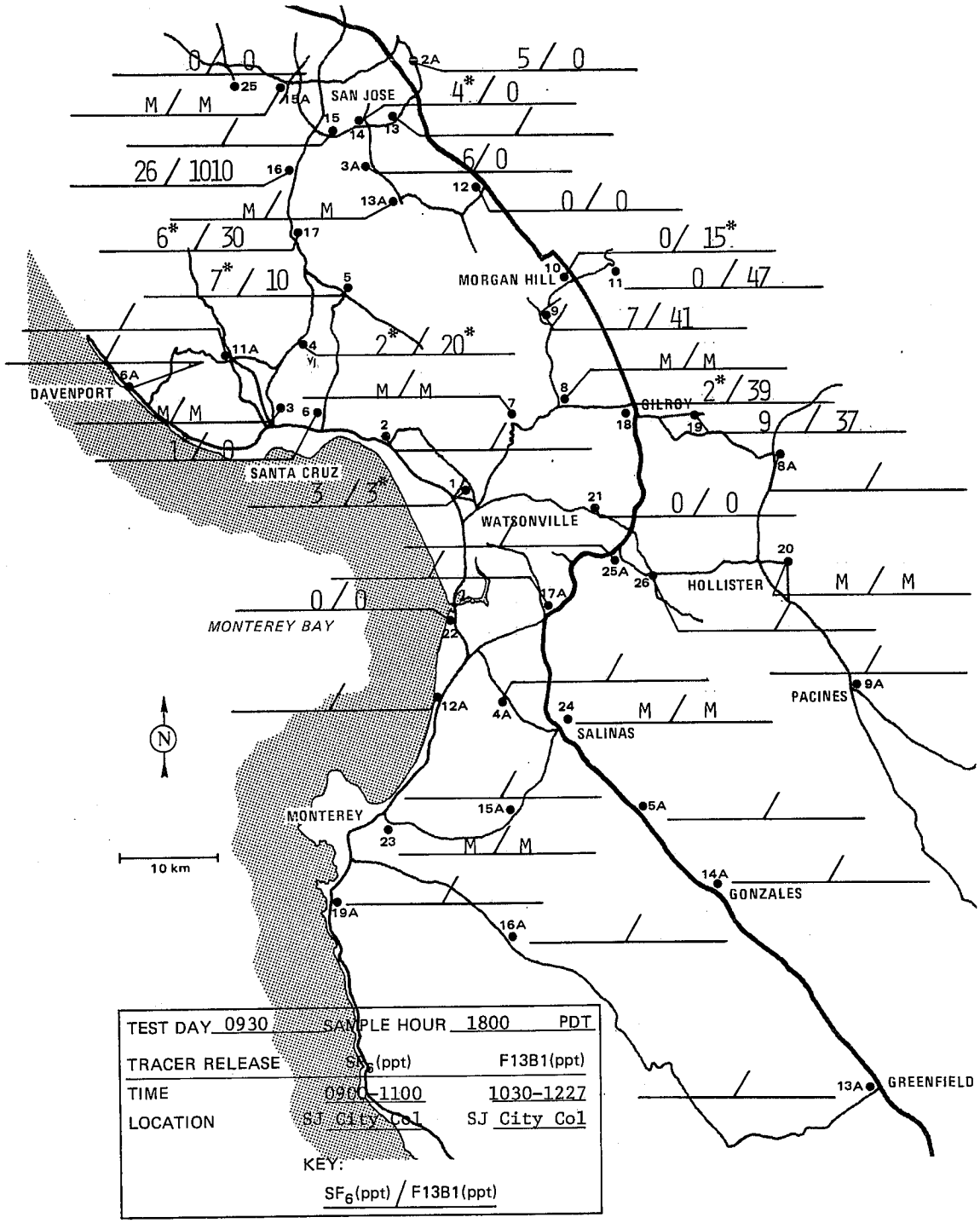


FIGURE 47i (CONTINUED)

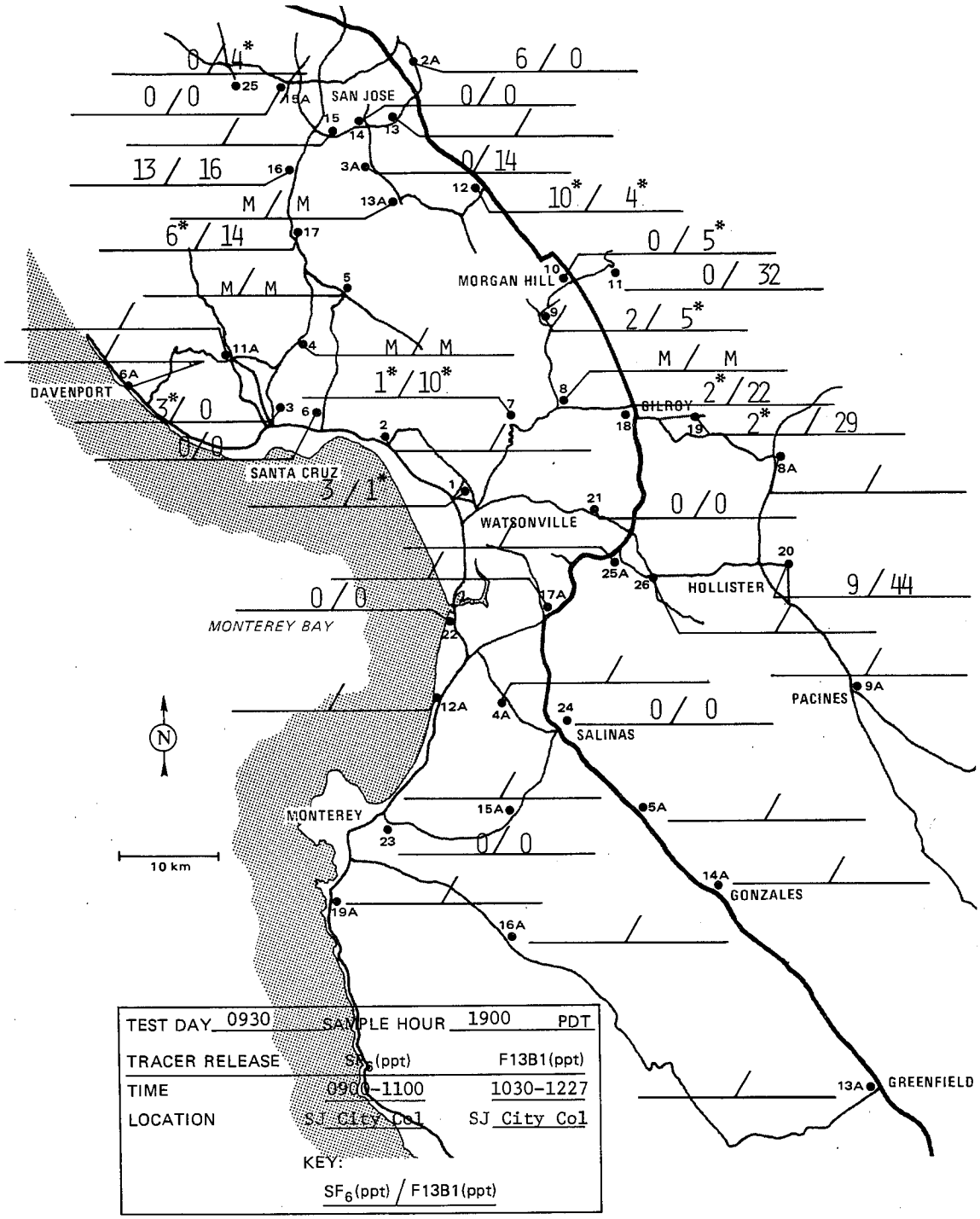


FIGURE 47j (CONTINUED)

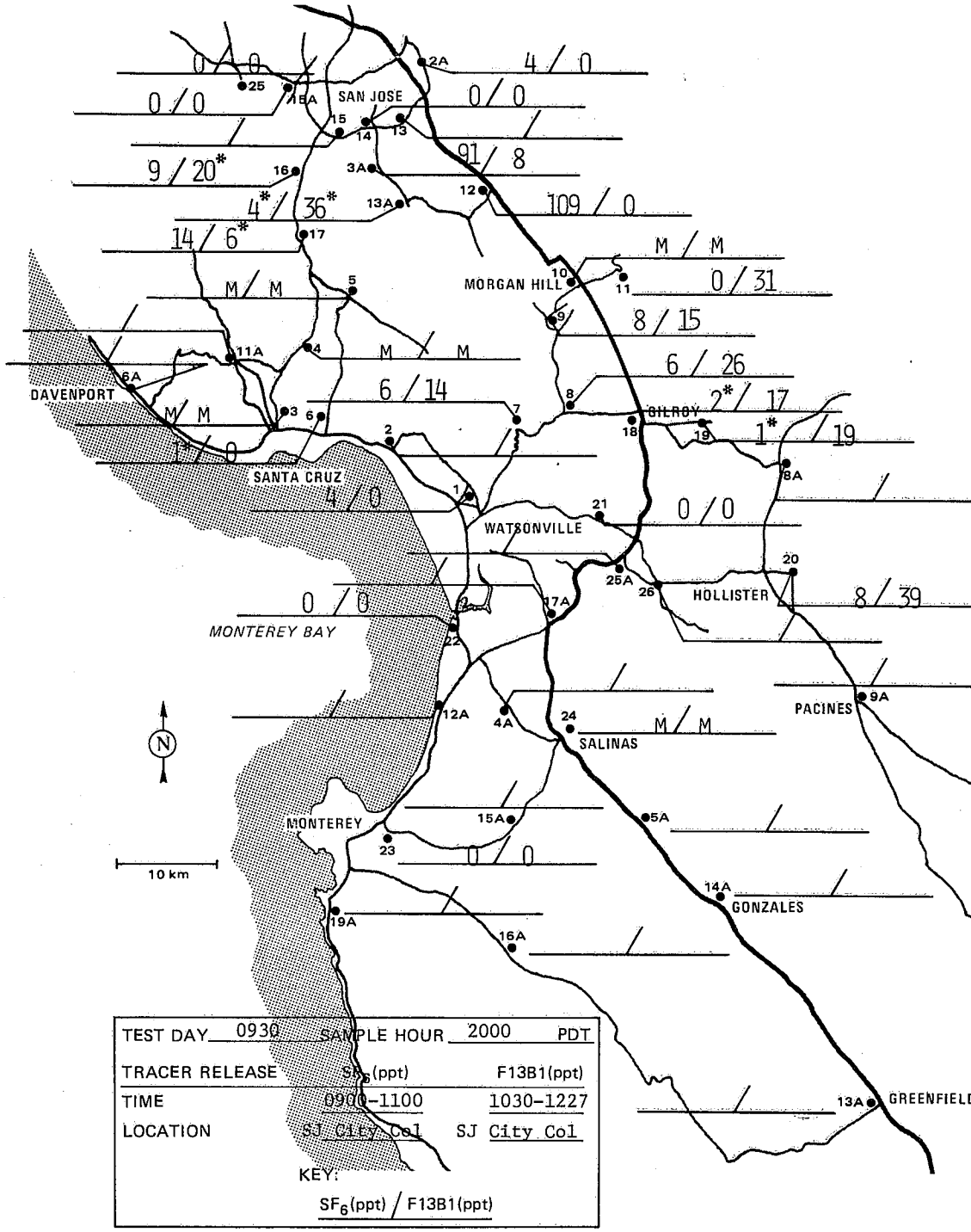


FIGURE 47k (CONTINUED)

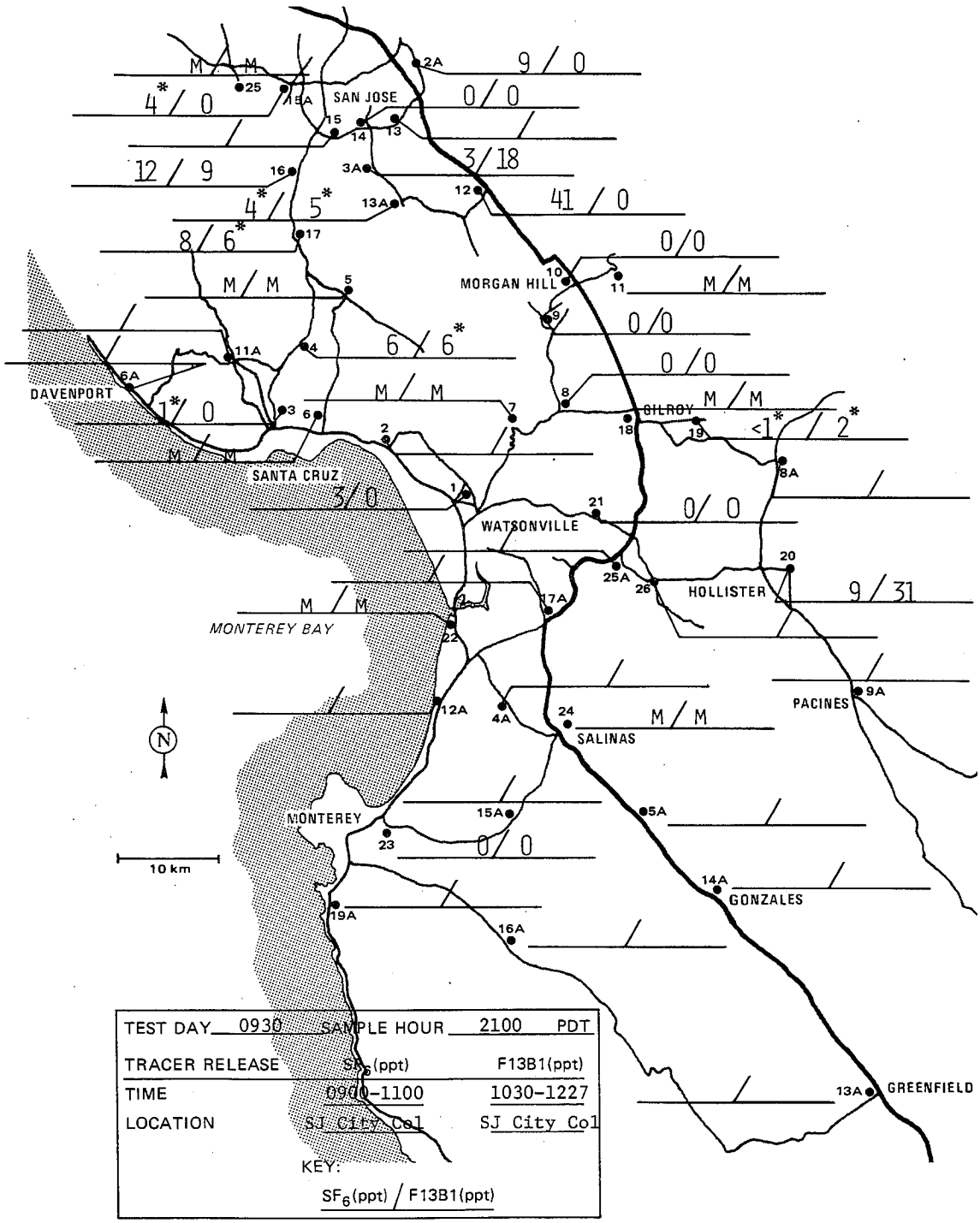


FIGURE 471 (CONTINUED)

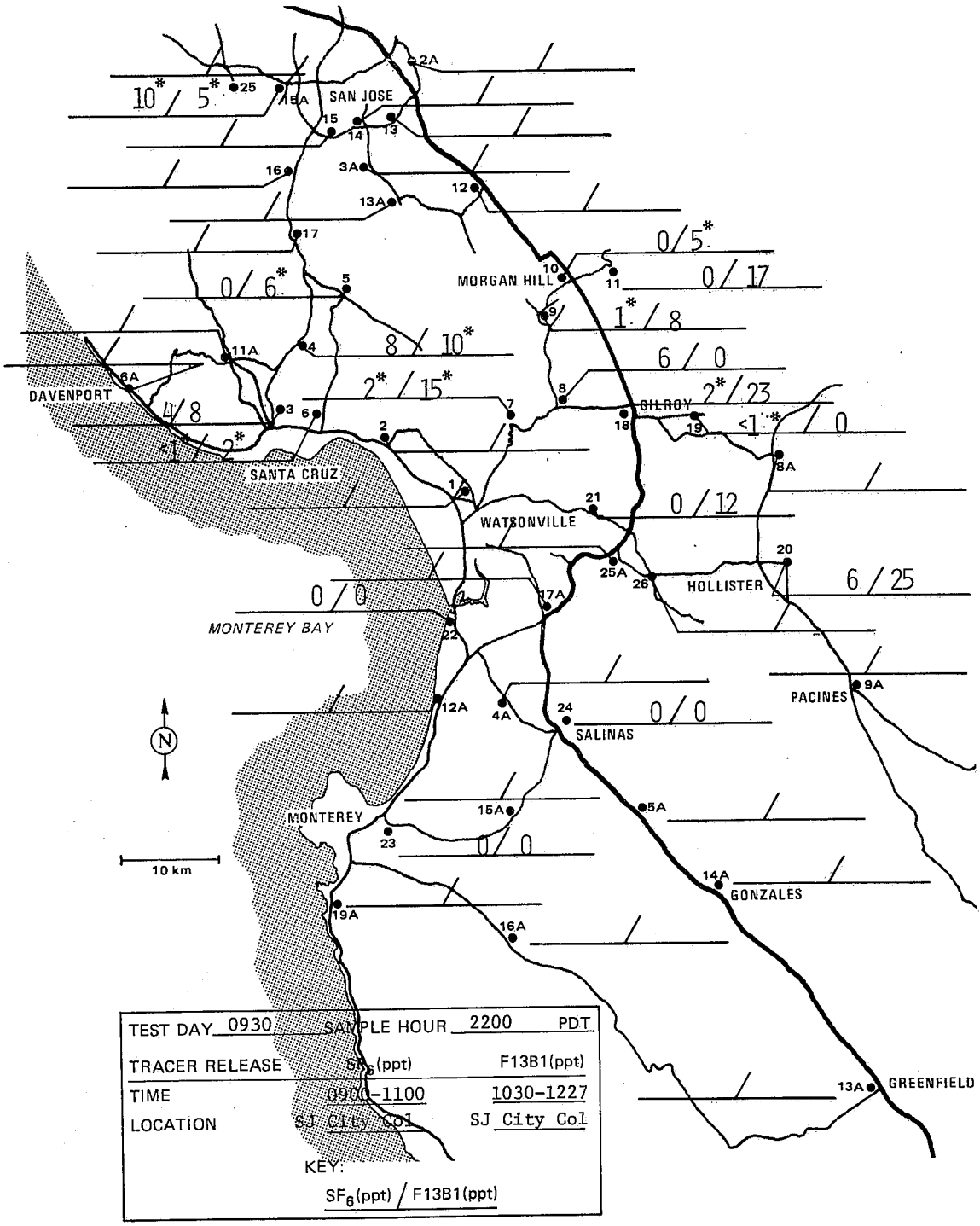


FIGURE 47m (CONTINUED)

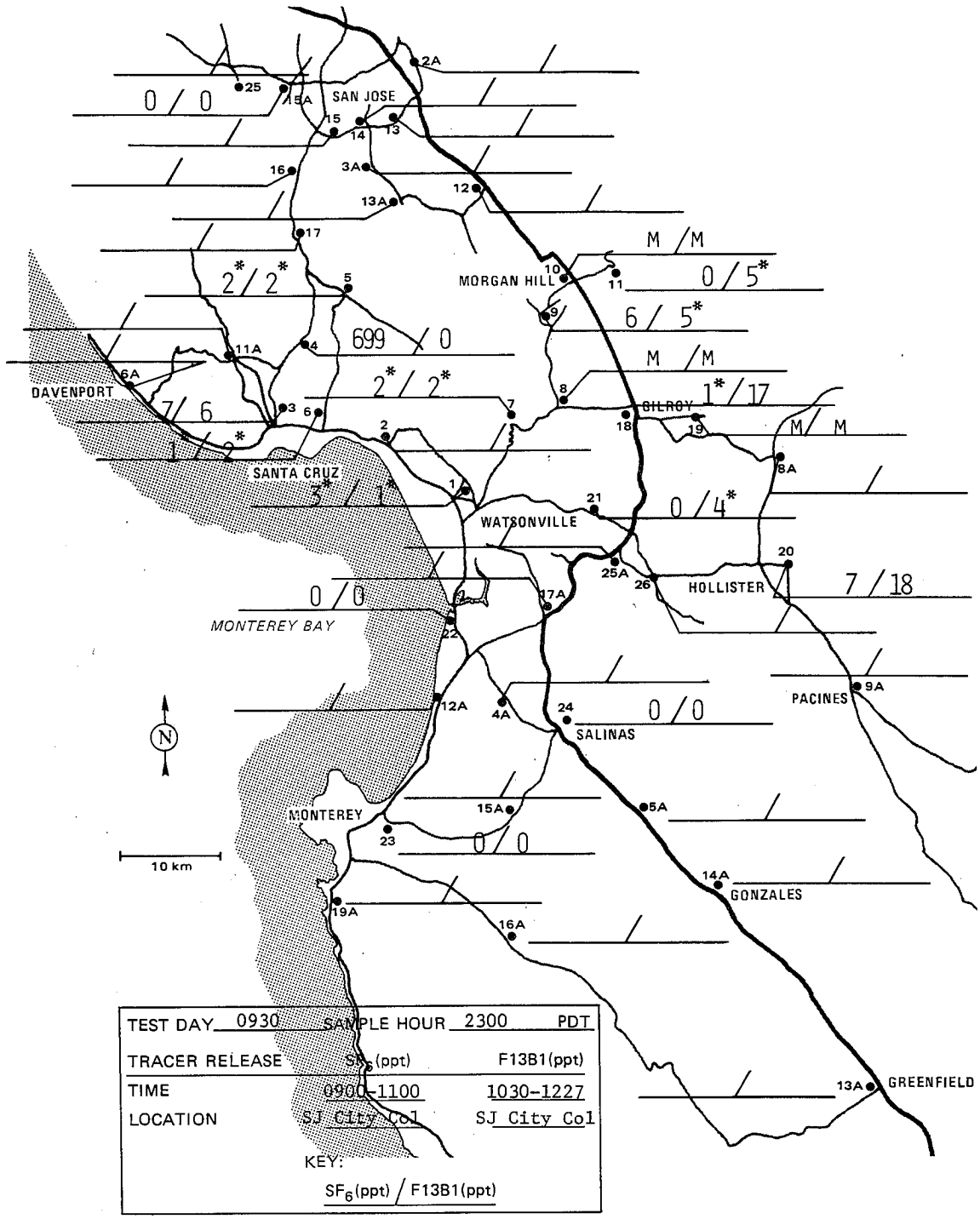


FIGURE 47n (CONCLUDED)

trace level. In view of the strong late-afternoon WNW winds at Hollister (Table 15), it may be assumed that the plume was diluted by the 5-7 m s^{-1} winds and transported in the general direction of Pacheco Pass. SF_6 concentrations in Hollister persisted throughout the remainder of the sampling period at 6-9 ppt.

Whereas the 0900-1100 SF_6 release was made during varying SE and WNW winds, the F13B1 release period was characterized by steady WNW winds that shifted to NNW immediately afterwards. These conditions should favor transport up the Santa Clara Valley. (The SE flow during the first half of the SF_6 release actually resulted in some portion of the tracer being transported away from the NCCAB; one of the mobile sampling vehicles confirmed this NW transport when it measured 10-15 ppt SF_6 levels on the ridge line above Cupertino.)

The 12-1300 F13B1 samples located the tracer core in south-central San Jose and low-to-moderate traces ($\leq$27 ppt) in east and west San Jose and up the Santa Clara Valley to Gilroy. A broader pattern is reflected by the 13-1400 PDT samples (nominally, two hours after the release). The F13B1 plume had spread throughout most of San Jose; the peak value of 1230 ppt occurred in the Almaden section. Traces continued to be found in the Santa Clara Valley as well as in Santa Cruz. By 15-1600, the plume had spread throughout virtually all of the Santa Clara Valley south of the release point; concentrations ranged from 17-82 ppt as far south as Gilroy. However, neither the San Benito Valley nor the Pajaro Coastal Plain measured any of the tracer. There was some evidence of transport into the western corridor with 31- and 16-ppt samples in Los Gatos and Lexington Reservoir, respectively. During the next hour, 16-1700, moderate-to-high concentrations persisted throughout the Santa Clara Valley, and a small concentration was first observed in Hollister. In contrast to some of the other tests, there was no discernible core of F13B1 that dispersed up the valley. Instead, the tracer was well mixed throughout the entire 50-km length of the Santa Clara Valley. Concentrations in the western corridor essentially doubled from the previous hour, although only low-level traces were observed at the summit and farther south. Transport into Scotts Valley occurred during the 17-1800 hour and persisted through 22-2300. Santa Cruz and Soquel did not measure tracer until 22-2300.

Significant tracer concentrations first occurred in Hollister during the hour 1900-2000 PDT, although the two preceding hours at that station had missing data. Referring to the mobile tracer measurements (see Volume II), similar F13B1 concentrations (about 50 ppt) were observed around 1715 PDT along Highway 101 as far south as AQS station location 25A; further south and west on 101, no tracer was detected. These measurements indicate a slow dispersion of tracer from San Jose down the Santa Clara Valley at an effective transport speed of about 11 km h^{-1} or 3 m s^{-1}. Although the morning release in San Jose was a two-hour puff (and if we assume, on the basis of the van measurements, that the puff first arrived in Hollister around 1700 PDT), there appears to be little transport out of the Hollister area or dilution within the area from the time the tracer first arrived until cessation of sampling

at 2300-2400. For the 1700-1800 hour, the effective dilution (XU/Q) to Hollister is $1.0 \times 10^{-7}\ m^{-2}$, equivalent to A-stability dispersion over the 65-km transport fetch for a theoretical 500-m mixing height, using Turner's (1970) algorithms. The 1918 PDT aircraft sounding at Hollister indicated an actual inversion height about 175 m agl while a weak elevated inversion was present between 350 and 400 m agl.

The slow dilution after 1700 PDT can be seen by examining the hourly F13B1 concentrations in Hollister for each of the available evening hours. The dilution was evaluated as an exponential decay proportional (1) to time, and (2) time squared; time is measured from the hour when a high F13B1 concentration was observed first in Hollister (i.e., 17-1800 PDT). Table 15a indicates the evening dilution is approximated very well by the nonlinear time dependence, where

$$\chi = \chi_o \exp(-bt^2) \quad , \tag{3}$$

and

$$b = 0.029\ h^{-2} \quad .$$

The implication is that morning air of San Jose origin was transported into the Hollister area in late afternoon and that this transport either

- Continued through the evening hours at a constant rate.
- Was cut off soon after 1800 PDT, whereafter the tracer-laden air mass diffused within the area.
- Continued while the tracer simultaneously diffused at an equivalently uniform rate.

However, the sharp dropoff of tracer levels in Morgan Hill after 2000 PDT gives some support to the second mechanism.

Table 15a

ANALYSIS OF HOLLISTER F13B1 TRACER MEASUREMENTS, TEST 0930

Parameter	Hour (PDT)						
	1700	1800	1900	2000	2100	2200	2300
F13B1 concentration (ppt):	50	m	44	39	31	25	18
t (hours):	0	1	2	3	4	5	6
$a\ (h^{-1}) = \frac{-1}{t} \ln \frac{\chi}{\chi_o}$:	-	-	-0.064	-0.083	-0.120	-0.139	-0.170
$b\ (h^{-2}) = \frac{-1}{t^2} \ln \frac{\chi}{\chi_o}$:	-	-	-0.032	-0.028	-0.030	-0.028	-0.028

The hourly distribution of ozone throughout the study region is given in Figure 48 and presents an unusual situation. Contrary to expectation, the highest surface ozone concentrations in the region during the late morning hours were centered in the NCCAB between Moss Landing and Hollister. This high-ozone zone expanded throughout the afternoon, linking up with rising concentrations in San Jose. However, the core of the afternoon ozone maximum shifted only slightly northward into Gilroy and Morgan Hill, where O_3 values were higher than those in San Jose, Los Gatos, and Fremont every hour. The afternoon SE transport indicated by the tracer data are reflected in the ozone pattern. From 1400-1500 PDT onward, there is first a stagnant situation, followed by a slow progression of the high-ozone core toward Hollister. Some indications of upvalley pollutant transport are also apparent in the diurnal variation of NO_x and O_3 at the Morgan Hill station. Starting at 1400 PDT, NO_x concentrations increased steadily until 21-2200 when they decreased abruptly. The mid-afternoon NO_x increase followed by one hour the Morgan Hill wind shift from crossvalley to upvalley; conversely, the evening NO_x decrease coincided with an 80-deg shift from upvalley to crossvalley flow. The mid-afternoon period of increasing NO_x and high ozone at Morgan Hill is further documented by the 1425-1430 PDT aircraft traverse at 300 m-altitude from Madrone (north Morgan Hill) to the Santa Clara County Fairgrounds; see Figure 49a and Table 16. At Madrone, O_3 is about 175 ppb, and NO_x, 90 ppb. About 6 km NNE of Madrone, O_3 rapidly increased about 25 ppb and NO_x increased about 30 ppb. Ozone gradually increased farther northward, but NO_x increased abruptly (40 ppb) after another 4 km. Both NO_x and O_3 decreased again over south San Jose. With wind flow at the surface and aloft having a significant northerly component, the implication of the measurements is a significant transport of ozone and precursors during mid-afternoon from San Jose to Morgan Hill. Hollister and Gilroy concentrations are still above the 120-ppb ozone standard at 1900-2000 PDT, while Hollister still measured 110 ppb at 2100-2200. At the same time, San Jose measured 0, Los Gatos and Morgan Hill 40, but Carmel Valley remained at 70 ppb.

The high ozone readings at the Watsonville base station continued with the arrival there of the sea breeze around 1300 PDT. This suggested either a local pollution reservoir over the Monterey Bay (perhaps due to nocturnal offshore transport) or the occurrence of long-range transport. To evaluate these hypotheses, the aircraft broke off its inland tracer sampling in mid-afternoon and initiated an aerometric mapping survey at 150 m altitude over the Monterey Bay and up the coast to San Francisco, before returning along the coast to Watsonville. The flight pattern is illustrated in Figure 49; Table 16 provides a key to time, location, and altitude for the day's flights. The flight route has been annotated with near-instantaneous ozone concentrations (ppb) at periodic intervals; detailed graphics between each pair of waypoints are provided in Volume II and include time plots of ozone, temperature, nitrogen oxides, and the light-scattering coefficient as well as the mean flight altitude for the traverse segment plotted. At the conclusion of the mapping survey in the early evening, aircraft soundings were made at the Watsonville, South County, and Hollister airports; these are illustrated in Figure 50.

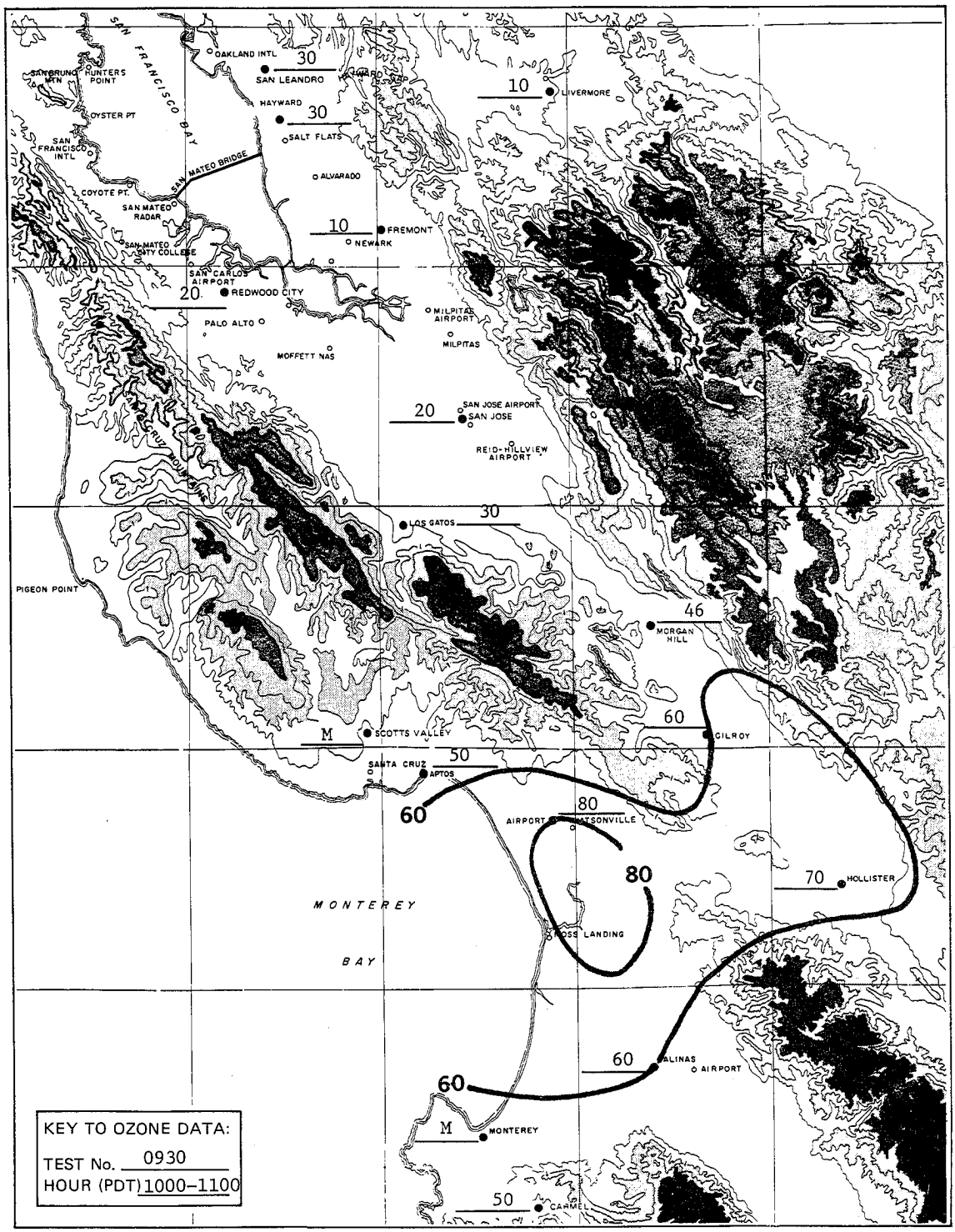


FIGURE 48a HOURLY DISTRIBUTION OF SURFACE OZONE (ppb), TEST 0930

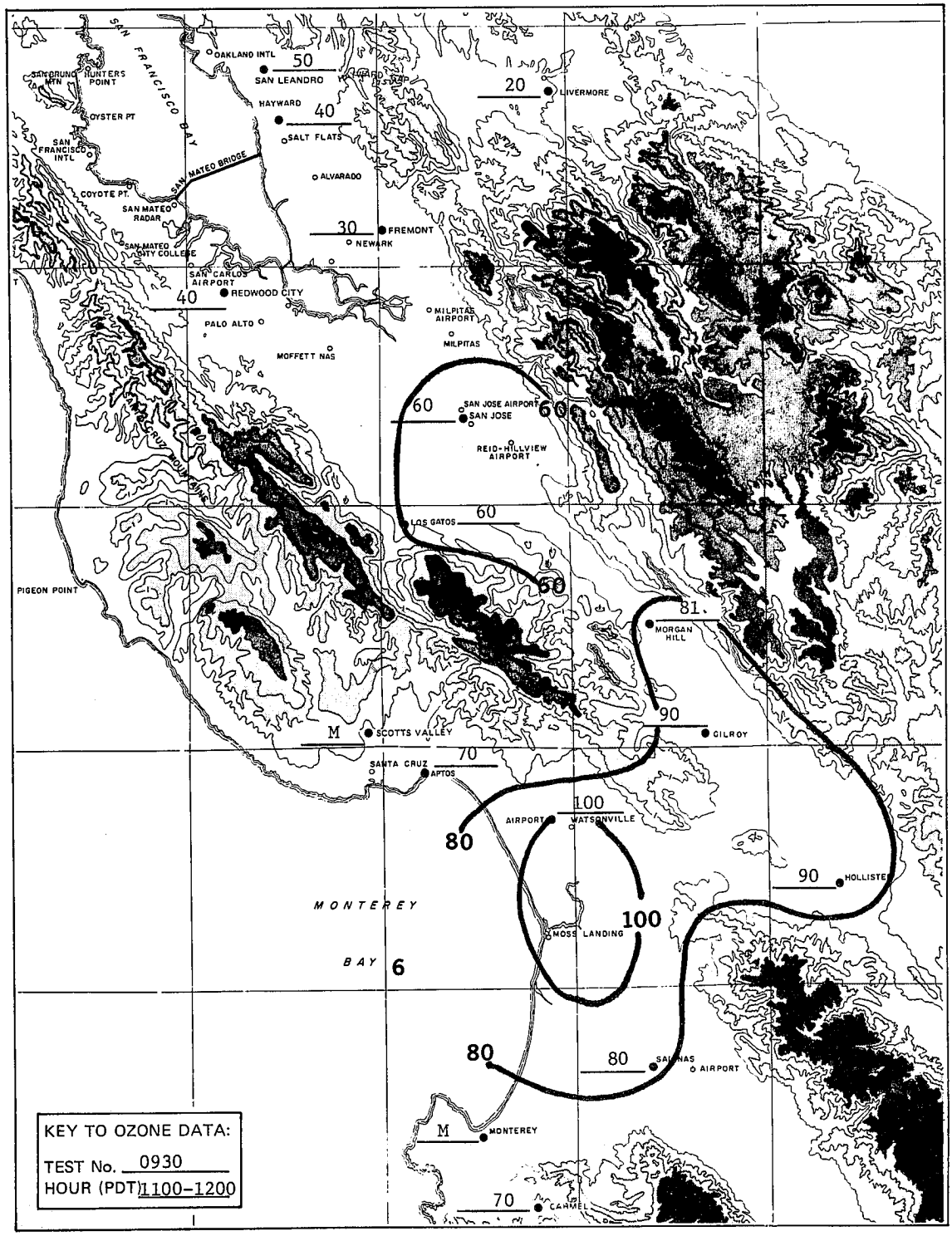


FIGURE 48b (CONTINUED)

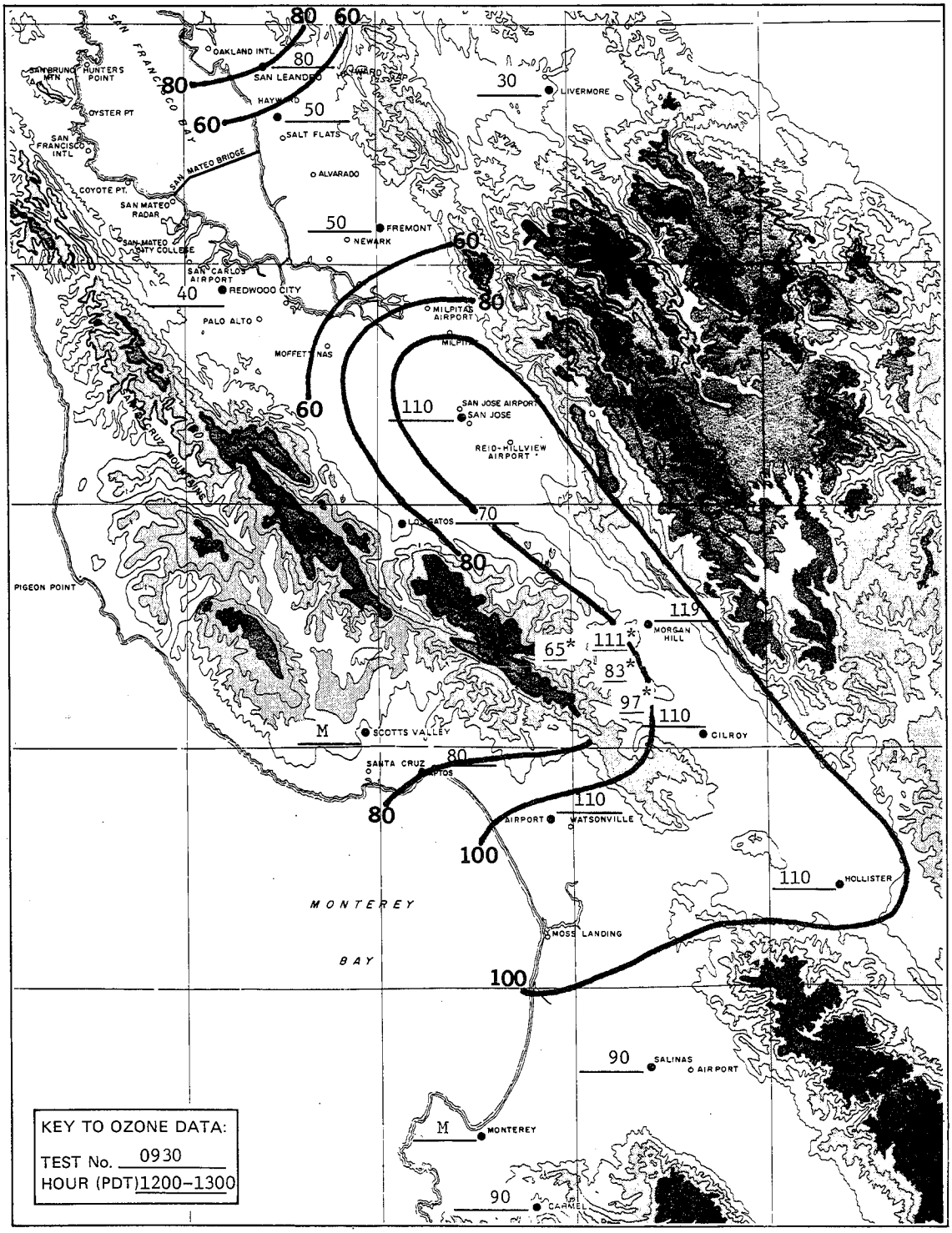


FIGURE 48c (CONTINUED)

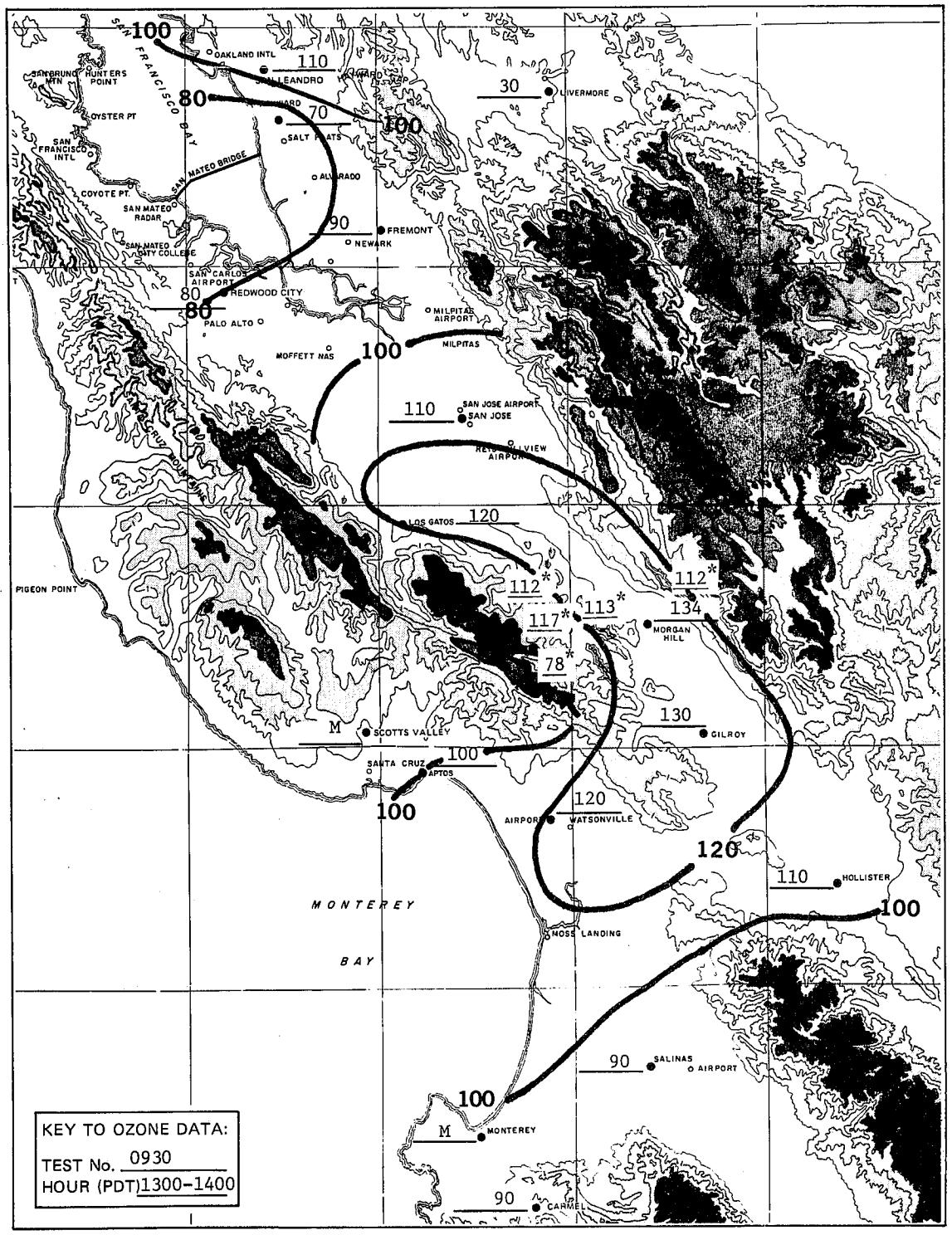


FIGURE 48d (CONTINUED)

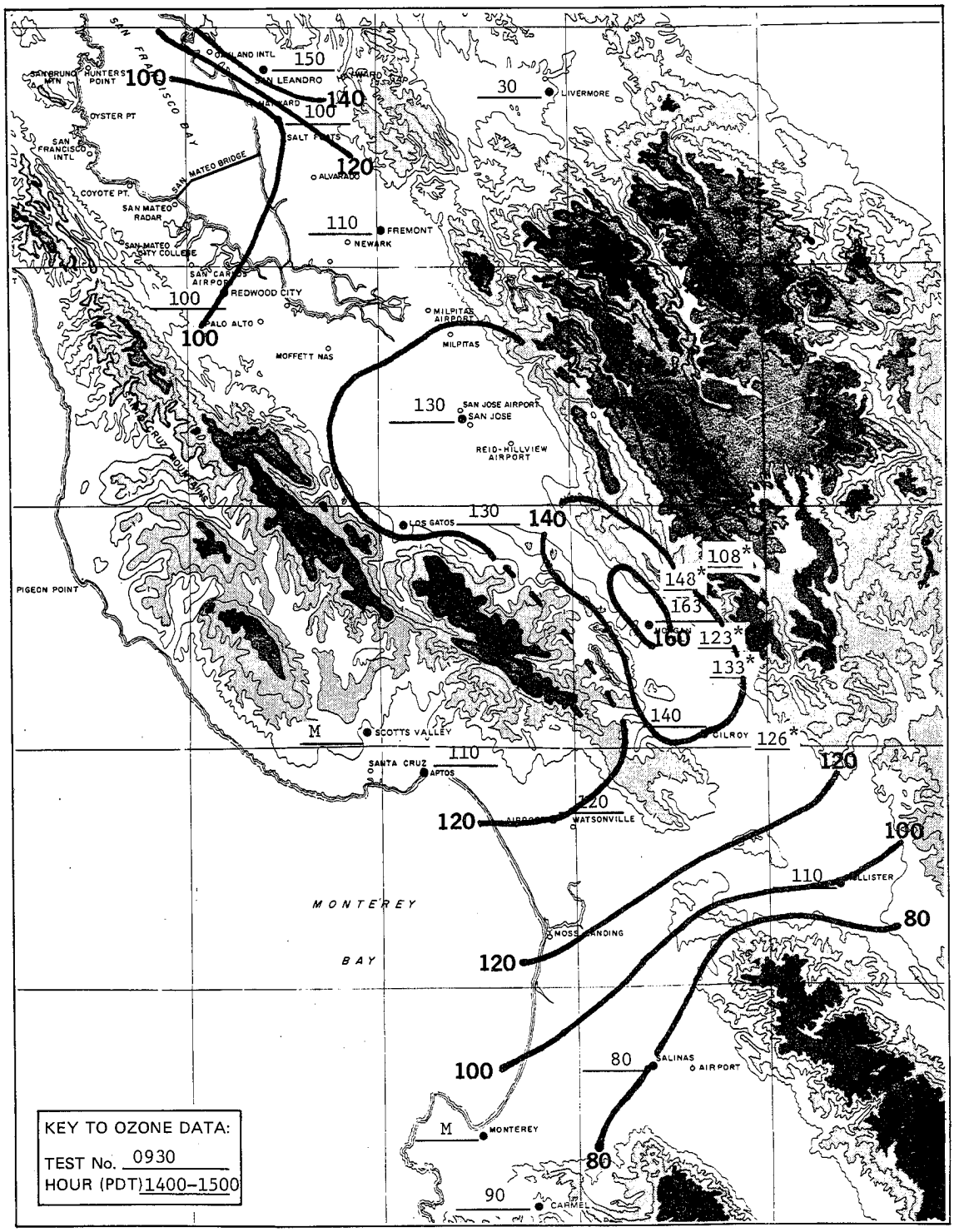


FIGURE 48e (CONTINUED)

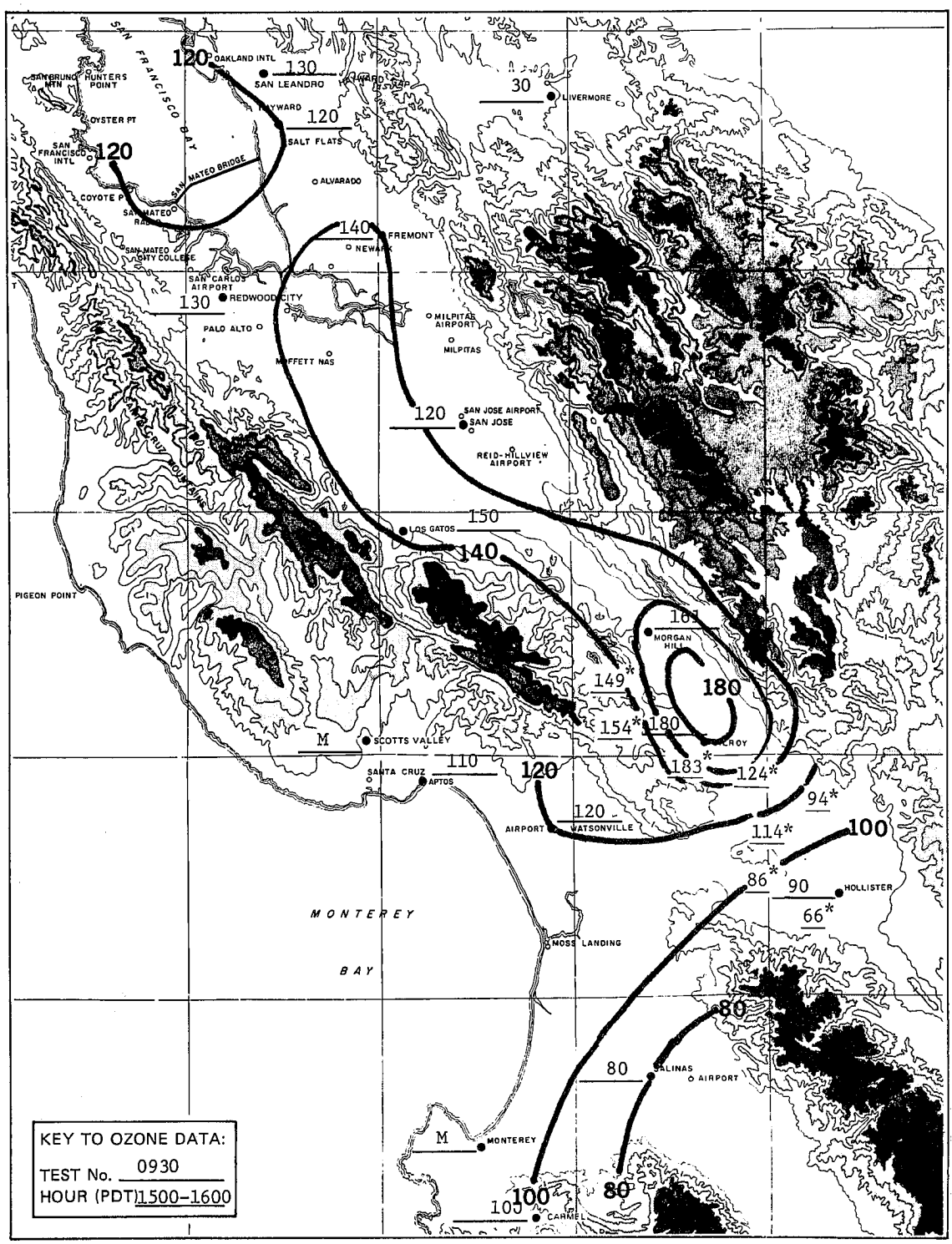


FIGURE 48f (CONTINUED)

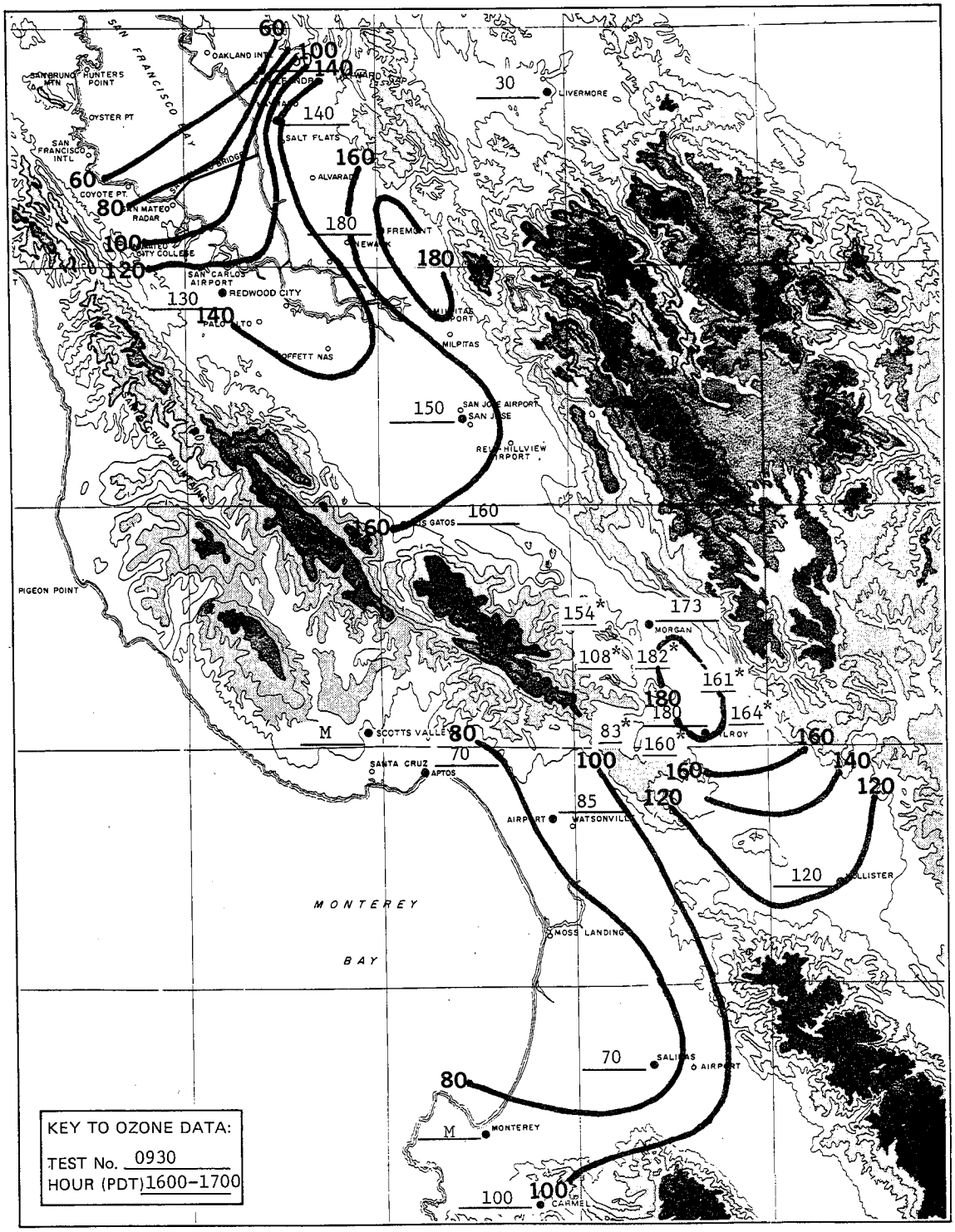


FIGURE 48g (CONTINUED)

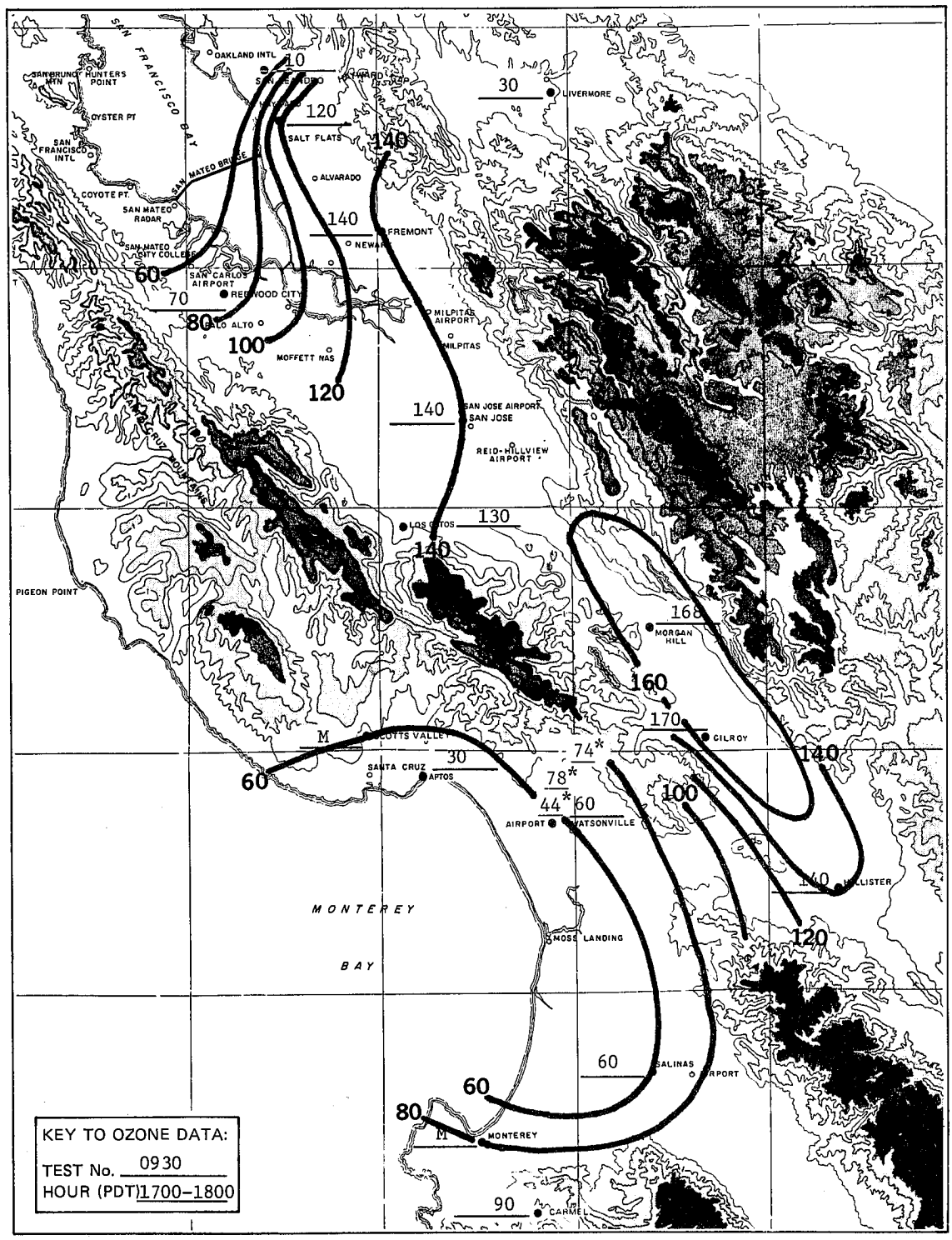


FIGURE 48h (CONTINUED)

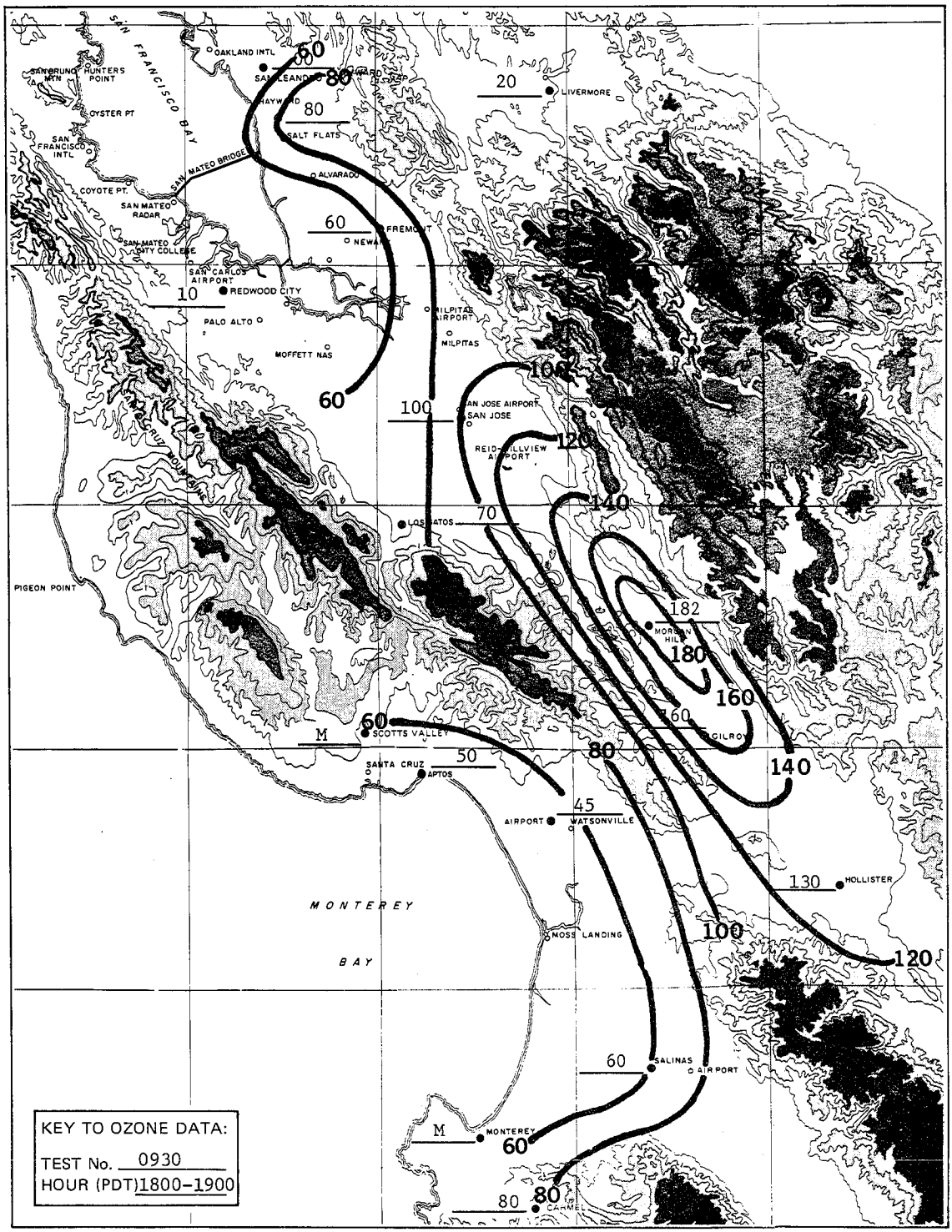


FIGURE 48i (CONTINUED)

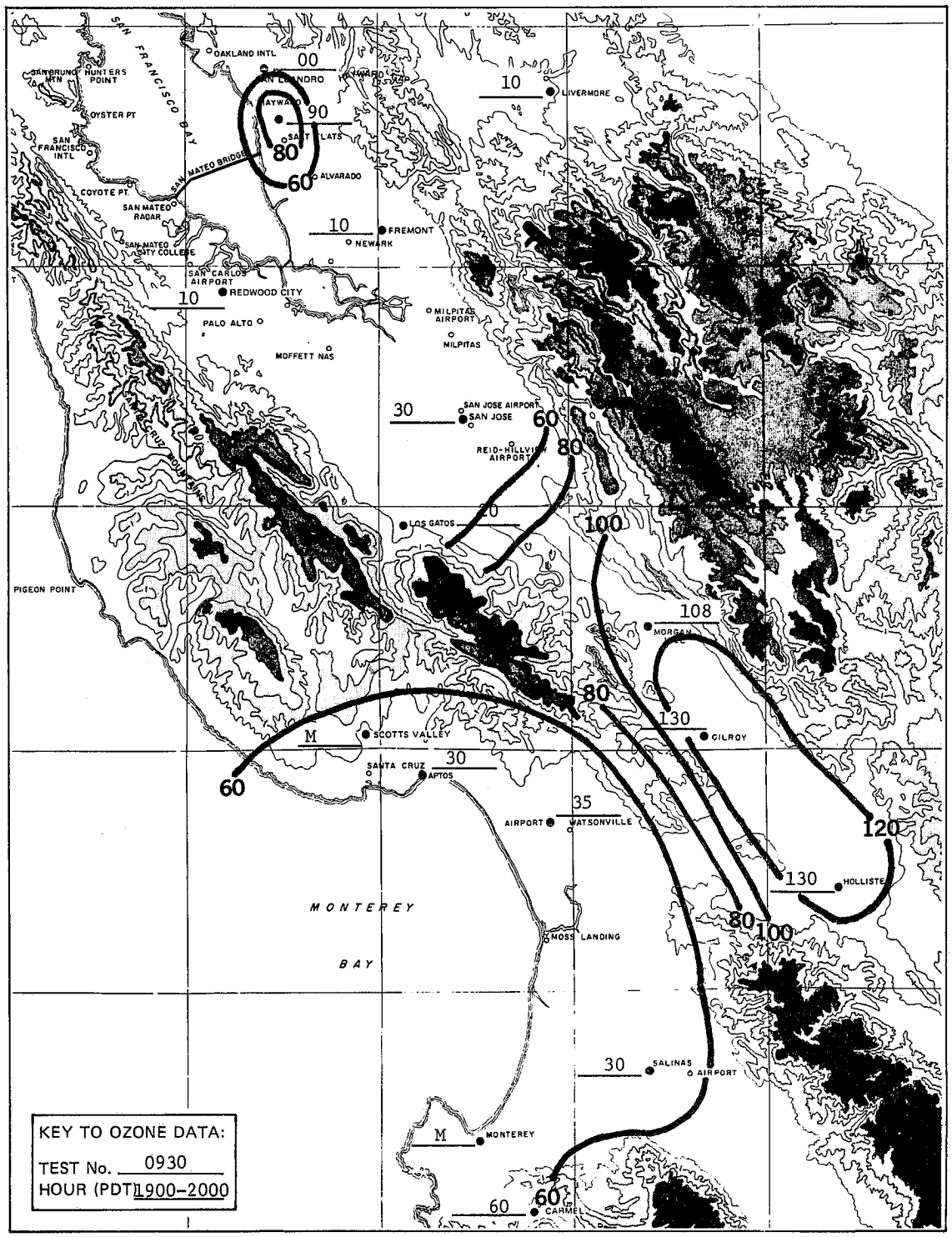


FIGURE 48j (CONTINUED)

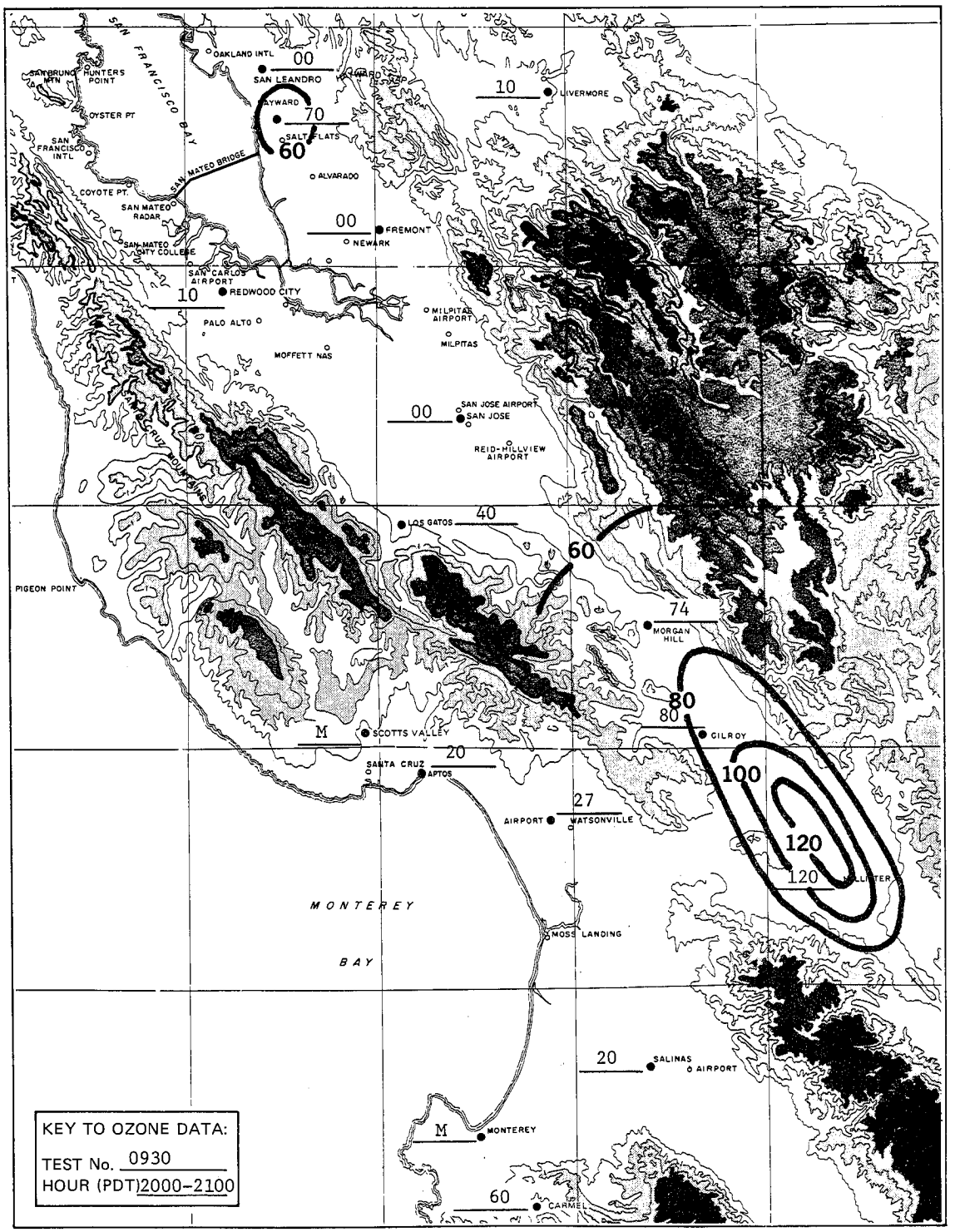


FIGURE 48k (CONTINUED)

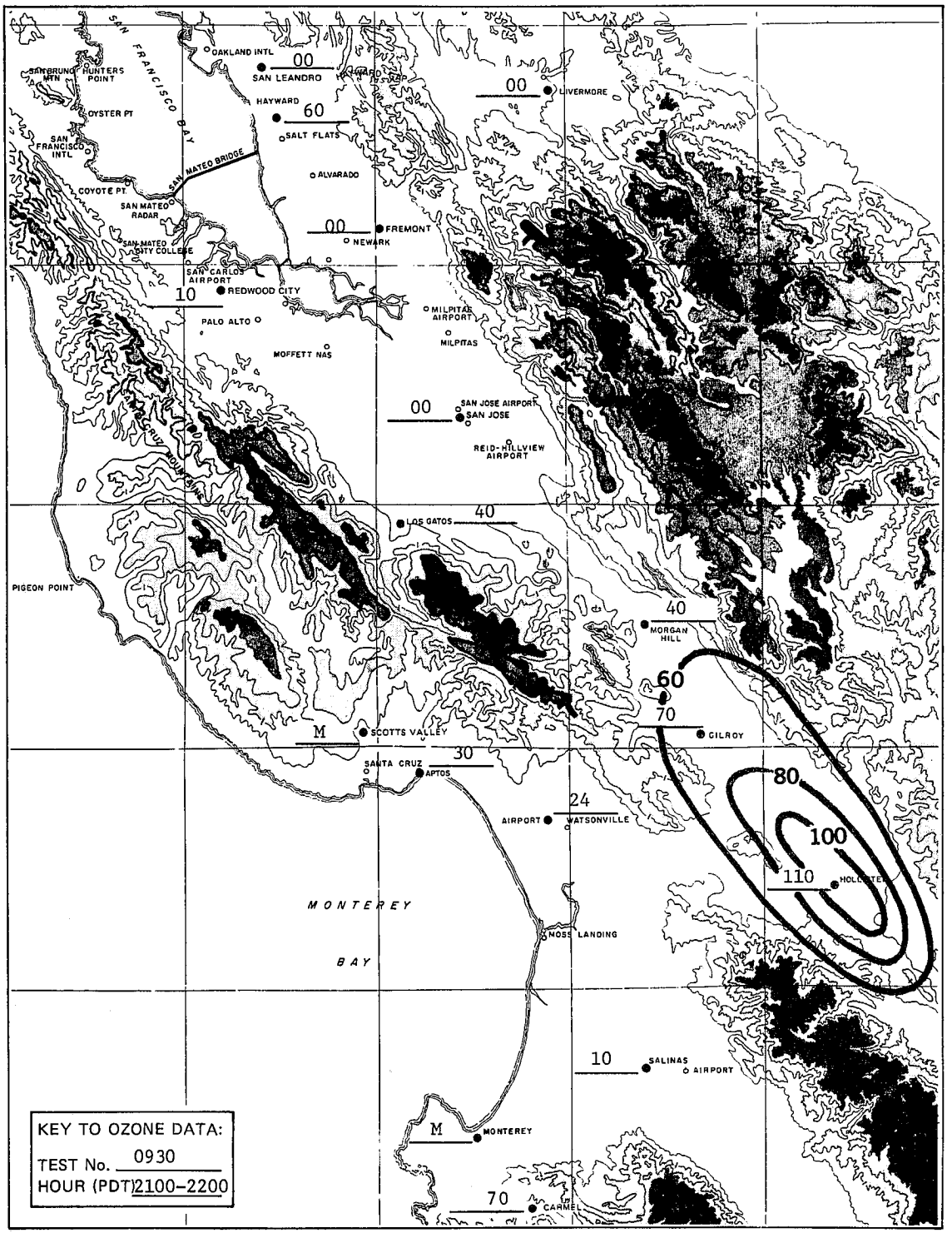


FIGURE 481 (CONCLUDED)

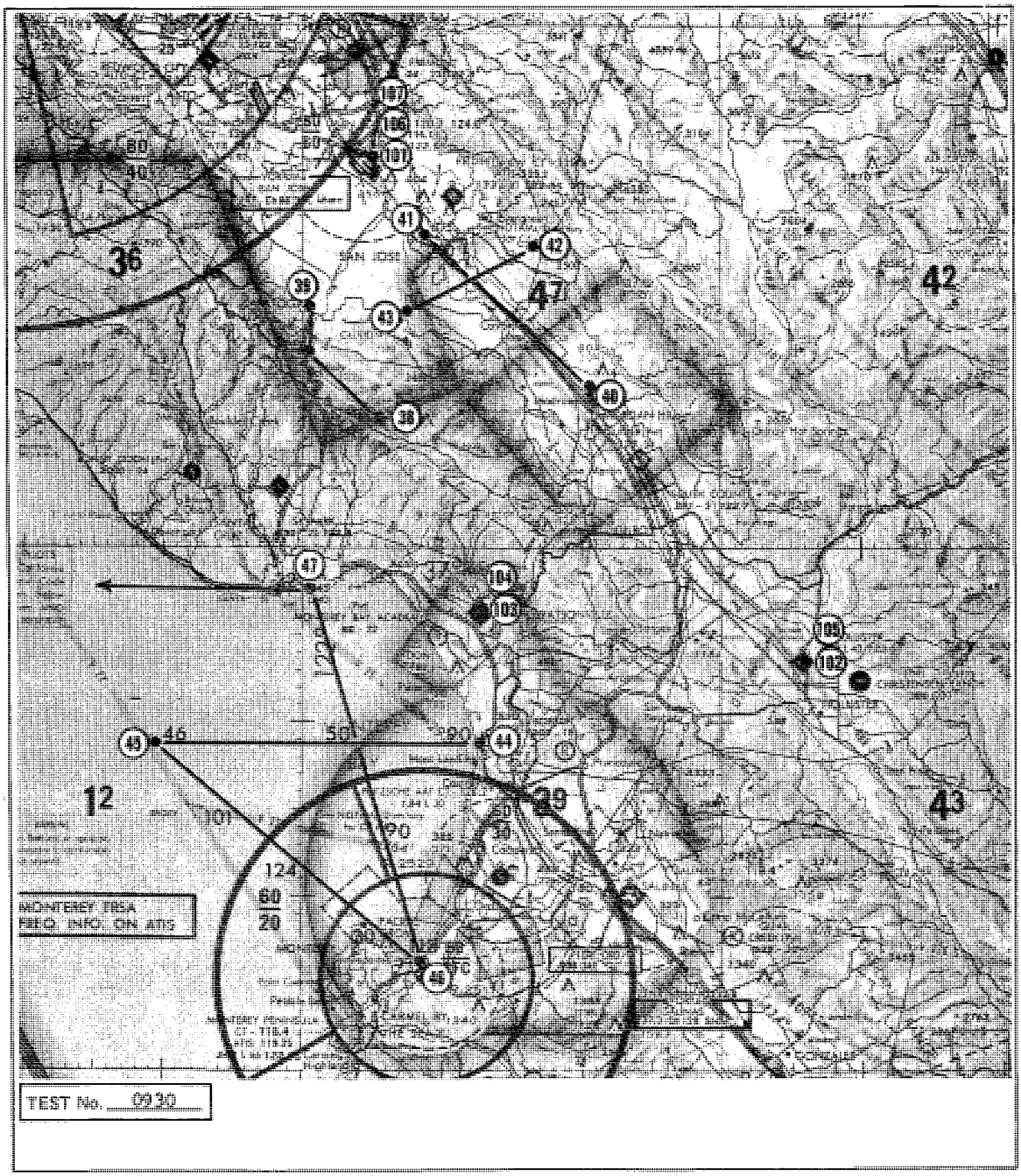


FIGURE 49a AIRCRAFT FLIGHT PATTERN, TEST 0930
WITH OZONE CONCENTRATIONS (ppb)

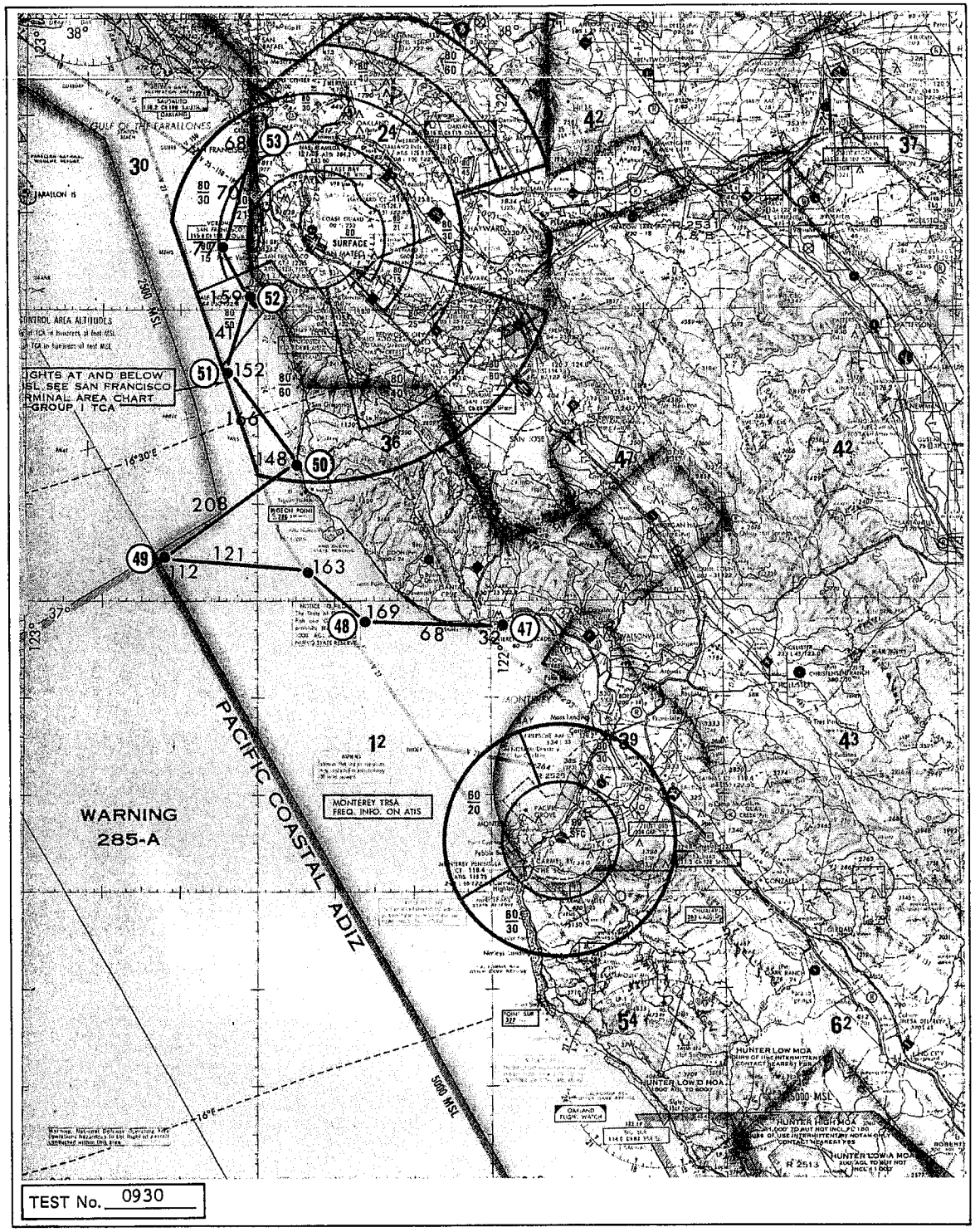


FIGURE 49b (CONTINUED)

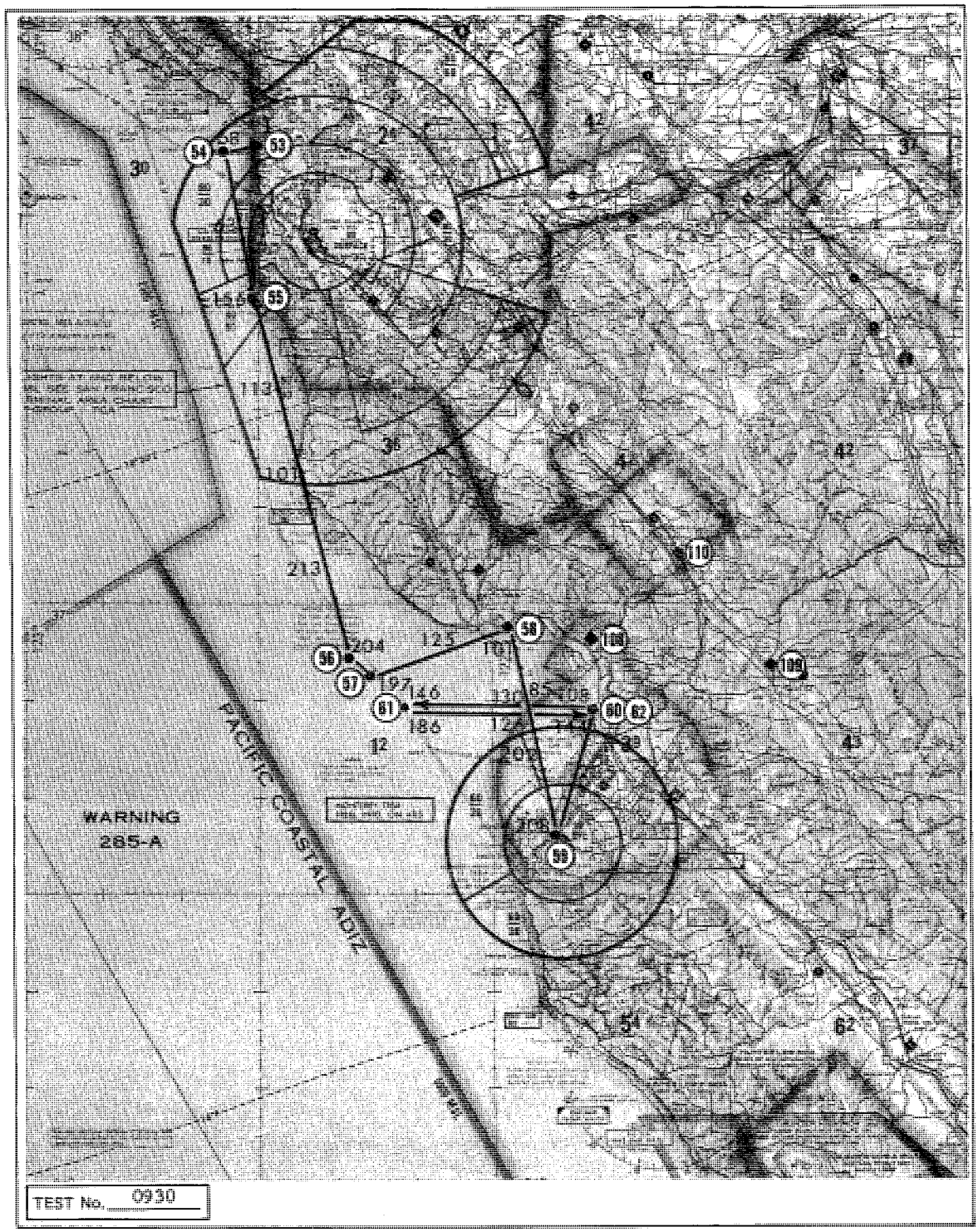
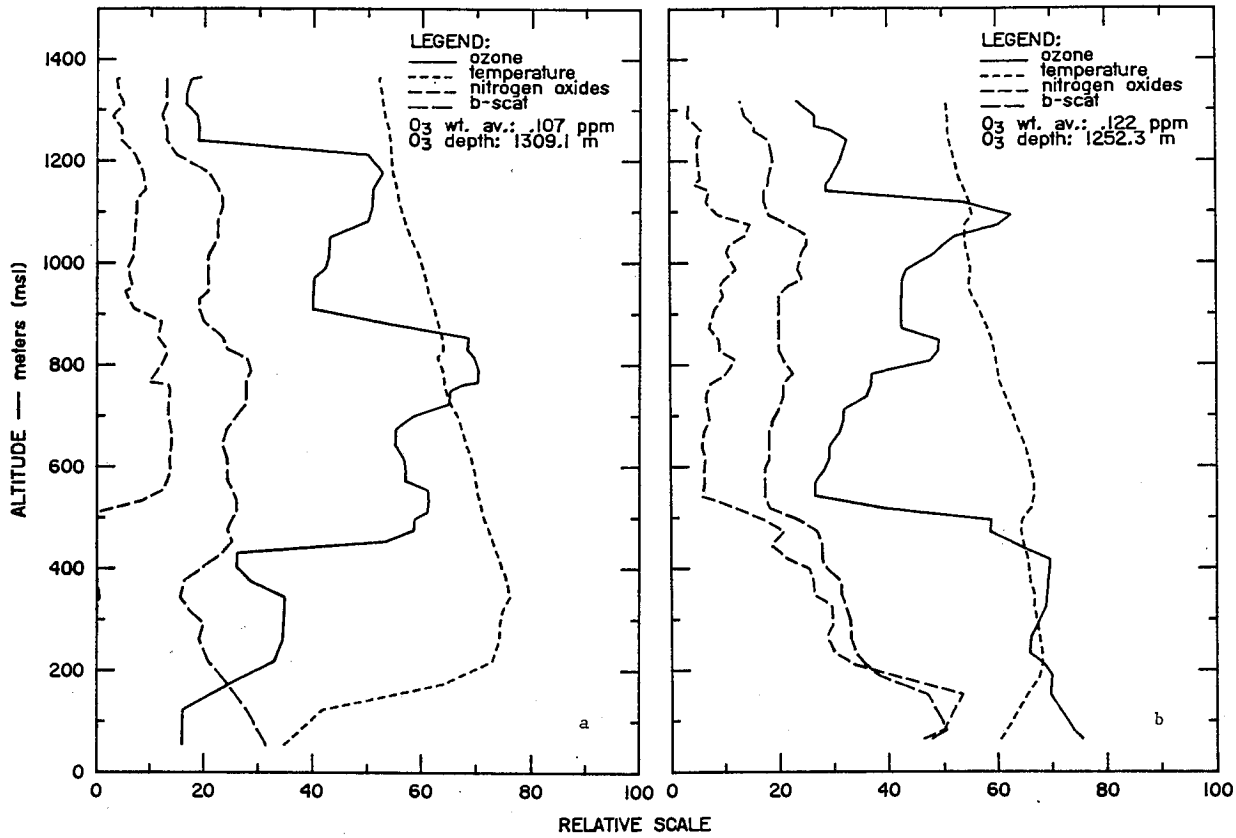


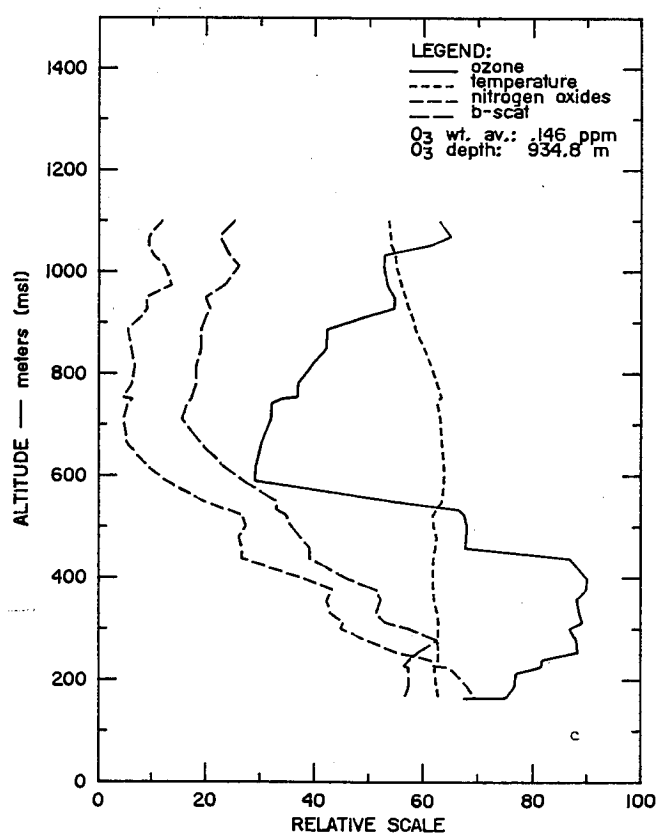
FIGURE 49c (CONCLUDED)

Table 16

AIRCRAFT WAY POINTS, TEST 0930

Way Point	Geographic Location	Altitude (m)	Nominal Time (PDT)
Traverses			
38	Summit at Old San Jose Road	400	1411
39	Vasona Park	290	1414
40	Madrone	270	1425
41	Santa Clara County County Fairgrounds	300	1430
42	Southeast San Jose	350	1433
43	Almaden	490	1437
44	Moss Landing	150	1510
45	50 km west of Moss Landing	150	1520
46	Monterey	150	1529
47	Santa Cruz	150	1540
48	Offshore	150	1546
49	Offshore	150	1556
50	Pescadero Point	150	1604
51	Offshore	150	1604
52	Half Moon Bay	150	1617
53	San Francisco	150	1628
54	Offshore	150	1630
55	Half Moon Bay	150	1635
56-57	Offshore	150	1650
58	Santa Cruz	150	1700
59	Monterey	150	1712
60	Moss Landing	150	1717
60	Moss Landing	150	1844
61	Coastal ADIZ, 30 miles	150	1856
	west of Moss Landing	220	1857
62	Moss Landing	220	1907
Spirals			
101	San Jose		0704-0711
102	Hollister		0723-0732
103	Watsonville		0740-0751
104	Watsonville		1050-1100
106	Hollister		1112-1124
106	San Jose		1153-1203
107	San Jose		1439-1442
108	Watsonville		1827-1837
109	Hollister		1918-1928
110	South County Airport		1935-1942





RELATIVE SCALE (n.d.)	ACTUAL VALUES O_3 (ppb)	NO_x (ppb)	T (°C)	b_{scat} ($10^{-4}m^{-1}$)
0	0	0	5	0.
20	50	35	12	0.23
40	100	70	19	0.46
60	150	105	26	0.69
80	200	140	33	0.92
100	250	175	40	1.15

FIGURE 50 AIRCRAFT SOUNDINGS, TEST 0930

a) Watsonville Airport (1827-1837 PDT)
b) Hollister Airport (1918-1928 PDT
c) South County Airport (1935-1943 PDT)

The offshore mapping flight provided the following observations of ozone structure over Monterey Bay and along the coast from Monterey to San Francisco:

- Flying at 150 m msl from Moss Landing due west 24 nmi (39 km) toward the coastal Air Defense Intercept Zone (ADIZ), ozone concentrations oscillated for the first 24 km between about 40 and 120 ppb with an effective wavelength about 4 km; oscillations continued to the west end of the traverse but with lower peaks (approximately 60 ppb). A similar oscillatory pattern was observed between the ADIZ and Monterey waypoints and again between Monterey and Santa Cruz. No similar variations occurred in the NO_x records, which remained nearly uniform around 10 ppb; no consistent correlation of NO_x or NO with corresponding ozone concentrations was apparent.
- Fifteen kilometers due west of Santa Cruz, ozone concentrations rose steeply to about 175 ppb and remained at this magnitude to a point about 22 km WxS of the Año Nuevo State Reserve, where they decreased to the 80- to 110-ppb range. Heading northeast to Pescadero, ozone levels again increased to above 200 ppb. Along the ensuing northwesterly leg (Waypoints 50 and 51), ozone varied from 50 ppb to 200 ppb. The subsequent NNE leg (51 to 52) had near-uniform ozone around 140 ppb.
- From the Half Moon Bay waypoint (52) northward to San Francisco, ozone concentrations were uniformly low--70 ppb.
- The return flight from San Francisco to Santa Cruz (same 150-m altitude) displayed a similar spatial variation of ozone, except the areas of high ozone had increased concentrations.
- Areas marked by high ozone showed similar increases in air temperature, oxides of nitrogen, and particulates. NO_x concentrations were around 20 ppb in these regions with $NO:NO_x$ ratios in the 15- to 20-percent range.
- The 1830 PDT aircraft sounding at Watsonville showed an inversion from the surface to 350 m msl. Ozone in this layer varied from 40 ppb near the surface to about 90 ppb at the top of the inversion layer. Immediately above, ozone decreased slightly and then increased markedly to an average value near 150 ppb. This ozone reservoir consisted of two parts:
  - A primary layer from 400 to 900 m msl
  - A secondary layer of lower concentration from 900 to 1200 m msl.

Above 1200 m, concentrations dropped rapidly from 125 ppb in the upper layer to 50 ppb above it; 50 ppb is typical of ambient background concentrations above clean environments.

- The evening's two-level flight pattern over Monterey Bay from Moss Landing (Waypoint 61) to a point 24 nmi due west (62) verified the continued presence of moderate ozone levels over the bay. The westbound traverse at 150 m msl from 1844 to 1856 PDT showed ozone fluctuations from 50 to 175 ppb with an average around 125 ppb; NO_x varied from 7 to 15 ppb. Ozone concentrations were more uniform along the eastbound return leg at 220 m msl, averaging about 140 ppb; NO_x was also less variable, ranging mainly from 8 to 12 ppb.
- The evening spiral at Hollister differed from the earlier Watsonville sounding in the lower portions. The surface-based inversion extended to 200 m, with a second inversion from 500 to 550 m msl. Ozone from the surface to 500 m msl was more or less uniform around 175 ppb with a slight increase to 185 ppb toward the surface. The shape of the NO_x and particulate profiles generally paralleled the ozone profile over Hollister; the near-surface NO_x concentrations of 50 ppb were at least a factor of three larger than those over the water.

The observations suggest a transport down the coast of ozone and ozone precursors (i.e., NO_x) from the San Francisco Bay Area (south of Half Moon Bay) to the Monterey Bay, where the secondary wind circulation over the bay and the afternoon sea breeze transport the air into the interior valleys (e.g., Hollister). However, the tracer and ambient pollution measurements also indicate a SE transport down the Santa Clara Valley from the greater San Jose area to Hollister. There is some qualitative evidence to suggest (at least) a late convergence in the Hollister-Gilroy area: On ascending from the Watsonville airport, the aircraft observer noted in his log that haze was visible to 1000 m agl above Hollister, but that the depth of the layer was appreciably less over Morgan Hill. However, a comparison of the later Hollister and South County Airport soundings [Figures 29(b) and (c)] indicates the vertical structure of O_3, NO_x, b_{scat}, and T is virtually identical at the two locations, except that the near-surface contaminant values are moderately greater at South County.

6. Test 1001; 1 October 1980

Ozone peak-hourly concentrations (Table 2) were very nearly identical to the previous day's; Hollister decreased slightly (4 pphm, from 14 to 10), while Gilroy, Morgan Hill, and Watsonville increased 2 to 3 pphm. The 0500 PDT surface weather map (Figure 51) is a near replica of the previous morning's map with pressure changes less than 2 mb throughout the state. The SFO-RNO pressure difference decreased further to -6.8 mb and the 850-mb temperature increased 2°C to 25.8°C (2 standard deviations above the climatic norm). No tracer releases were made this day; however, extensive aerometric mapping over the coastal waters was undertaken to identify more accurately the extent and magnitude of the ozone reservoir off the coast between San Francisco and Monterey.

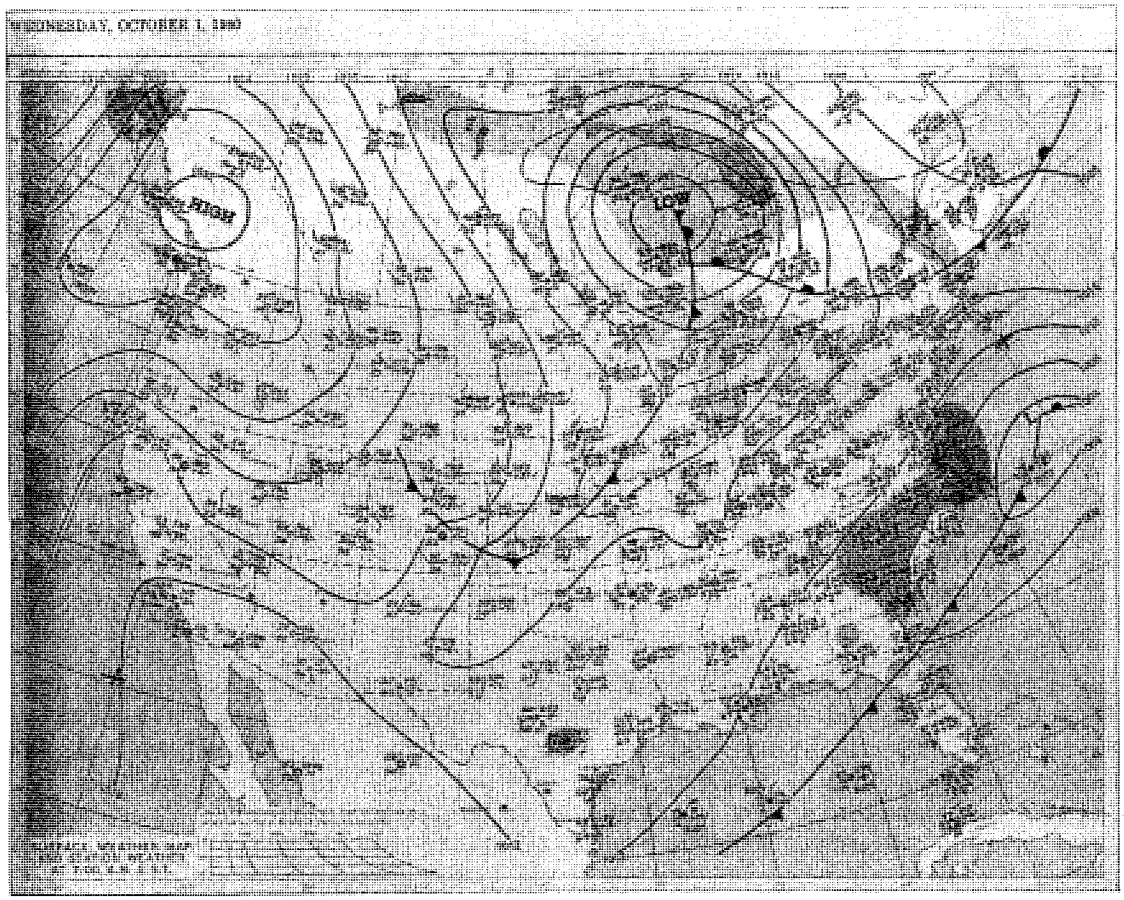


FIGURE 51 SURFACE WEATHER MAP 0500 PDT, TEST 1001

To better understand the coastal ozone measurements, the inland hourly ozone data are given in Figure 52 and include the period from 1000-1100 PDT through 2100-2200 PDT. The day began much like Test 0930: A late-morning ozone maximum around 100 ppb was seen at Watsonville, while a secondary maximum extended from Morgan Hill to Hollister but with lower concentrations (60 to 70 ppb); at this hour, the San Jose area was still reporting very low concentrations around 30 ppb. The sea breeze was observed to penetrate to the Watsonville base station at 1410 PDT; ozone concentrations increased nearly 30 pphm from the previous hour (in fact, ozone was nearly constant at 100 to 115 ppb for the previous four hours). With the persistence of the sea breeze, concentrations remained high for the next few hours, peaking at 150 ppb in Watsonville at 1500-1600 PDT. With the retreat of the sea breeze, concentrations dropped 40 ppb in one hour and decreased erratically into the evening. At 2100-2200 PDT, Watsonville ozone was only 36 ppb.

In contrast to the previous day, Hollister exceeded 100 ppb only one hour (1300-1400 PDT, 110 ppb). However, Morgan Hill and Gilroy exceeded 100 ppb seven and five hours, respectively, and they peaked around 200 ppb, as did Fremont further north. The ozone contours indicate a buildup within the vicinity of Morgan Hill without significant transport of ozone out of San Jose. (Of course, precursors could have been transported and might explain at least part of the ozone maximum.) In mid-afternoon, there is an apparent transport from Morgan Hill to Gilroy that results in a 190-ppb ozone peak in Gilroy at 1700 PDT, while Morgan Hill has dropped to 163 ppb. In the next hour, Gilroy ozone decreases 100 ppb to 90 ppb while Morgan Hill is virtually unchanged. Thereafter, Morgan Hill also records a rapid decline in ozone until at 2100 PDT all stations in the region are equal to or below 60 ppb. In contrast to the morning hours that suggest the significance of ozone transport from offshore, the late evening hours suggest no such influence. This is consistent with the surface wind flow at Watsonville in the evening when a persistent land breeze was observed.

Transport conditions in the Santa Clara and San Benito Valleys are summarized in Table 17. Central San Jose winds varied in the early morning from the south and east and then varied for the next three hours (11-1400 PDT); the 14-1900 winds were primarily NNW. Farther up the valley in Morgan Hill, crossvalley winds persisted through 1300 PDT, when they veered to upvalley flow that held until 2000 PDT. Hollister winds varied throughout the day in 2- to 3-hour increments from upvalley to crossvalley, upvalley, crossvalley and variable. Table 17 suggests a two-hour period from 14-1600 when upvalley flow occurred from San Jose to Hollister. The daily aerometric variation of temperature, ozone and nitrogen oxides at Morgan Hill is illustrated in Figure 53. There is an abrupt increase at 14-1500 PDT both in NO_x and O_3; the apparent cause is transport up the Santa Clara Valley, considering the wind pattern discussed above and the lack of significant local emission sources.

Table 17

SANTA CLARA-SAN BENITO VALLEY WIND VARIATIONS,
OCTOBER 1, 1980

Time (PDT)	Wind Direction/Speed* Downtown San Jose	Morgan Hill	Hollister
08-09	(3) 113/01	(2) 258	var/03
09-10	135/01	247	(1) 360/04
10-11	180/02	099	338/05
11-12	var/02	268	315/05
12-13	(1) 315/03	277	293/06
13-14	(2) 293/03	304	293/07
14-15	(1) 338/03	307	315/08
15-16	338/04	306	315/09
16-17	338/03	298	(2) 270/12
17-18	338/02	294	270/11
18-19	315/01	301	var/05
19-20	var/01	318	var/02
20-21	calm	288 (2)	(3) 113/09

*deg(true)/mph

(1) = Upvalley flow (San Jose to Hollister)
(2) = Cross-valley flow
(3) = Downvalley flow (Hollister to San Jose)

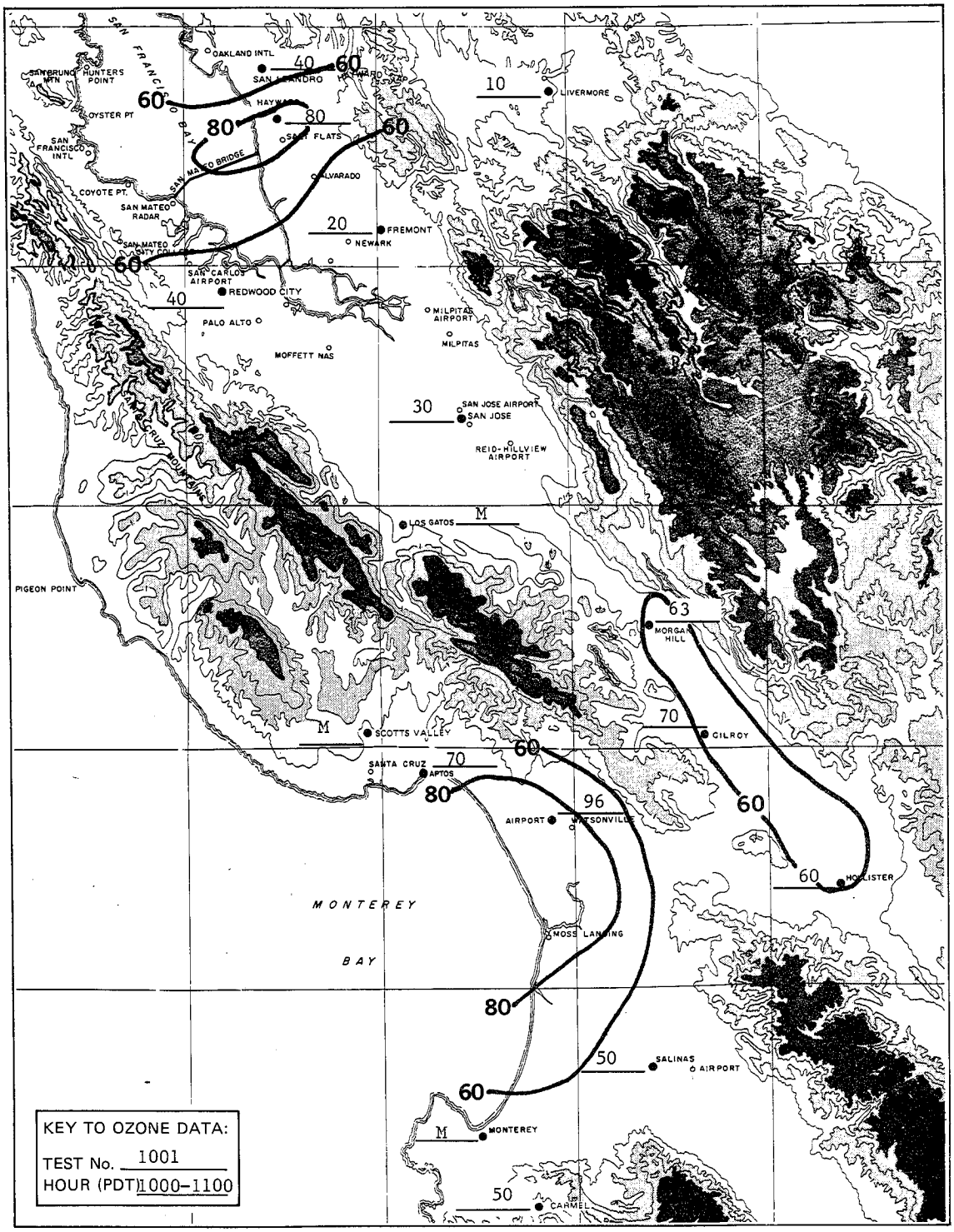


FIGURE 52a HOURLY DISTRIBUTION OF SURFACE OZONE (ppb), TEST 1001

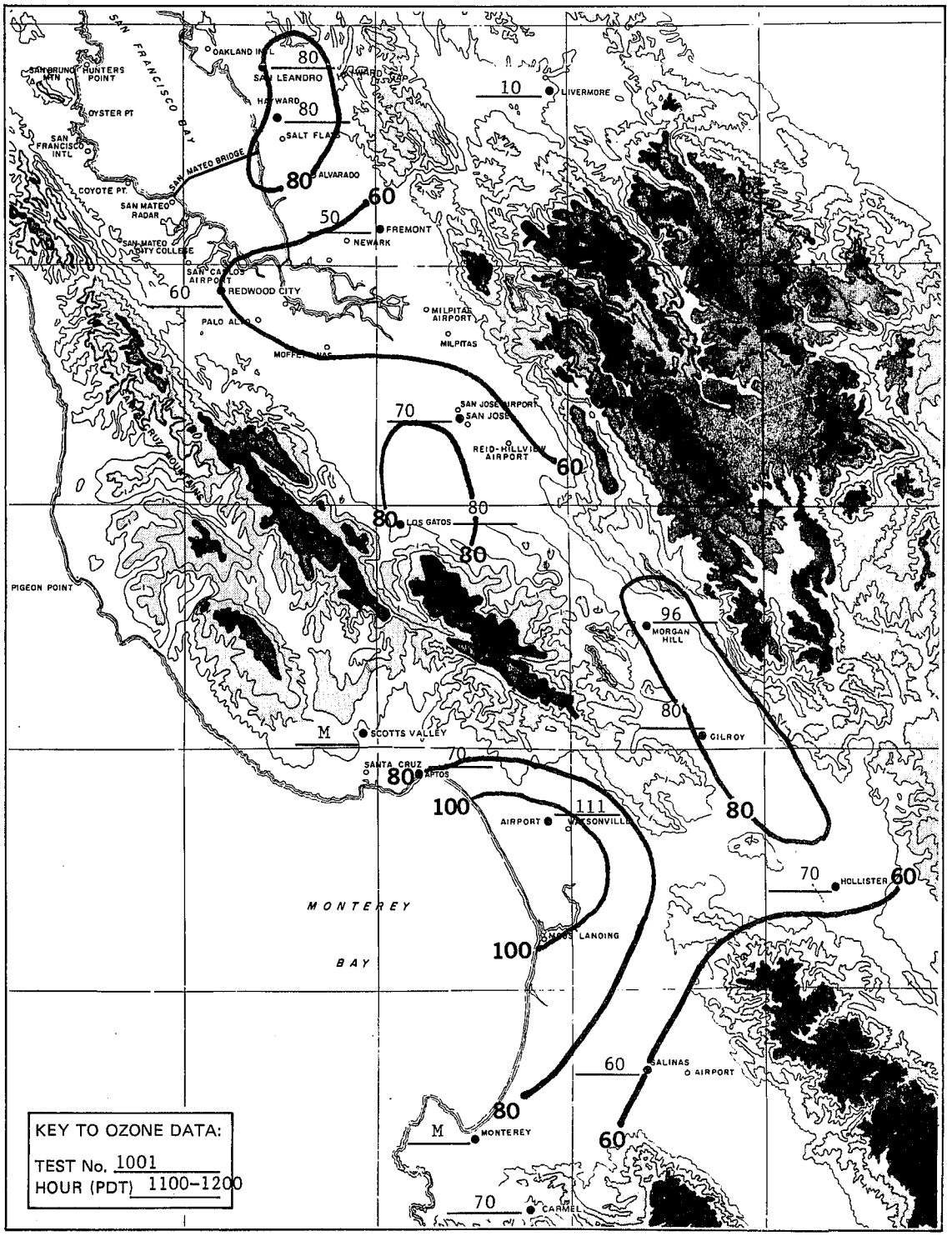


FIGURE 52b (CONTINUED)

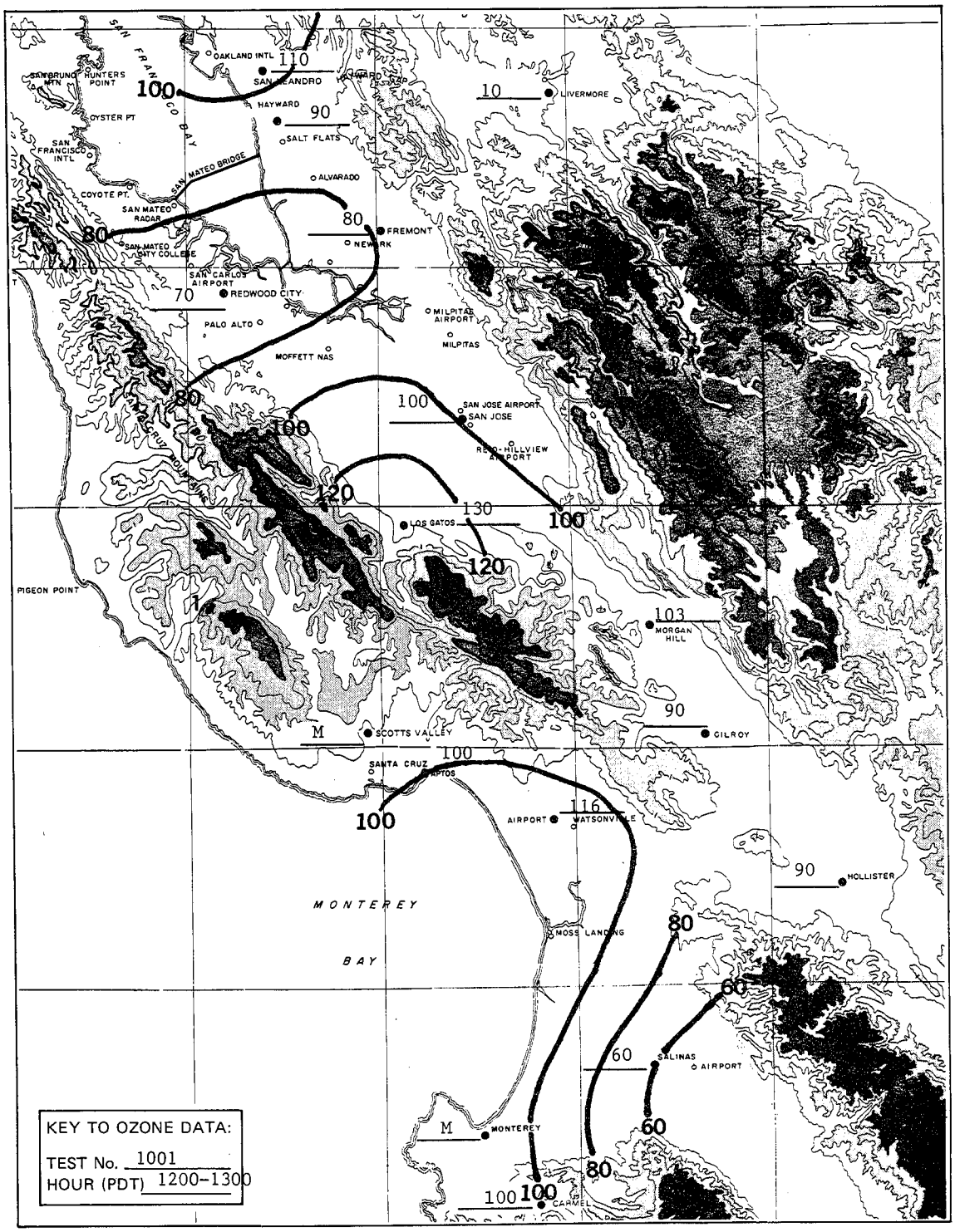


FIGURE 52c (CONTINUED)

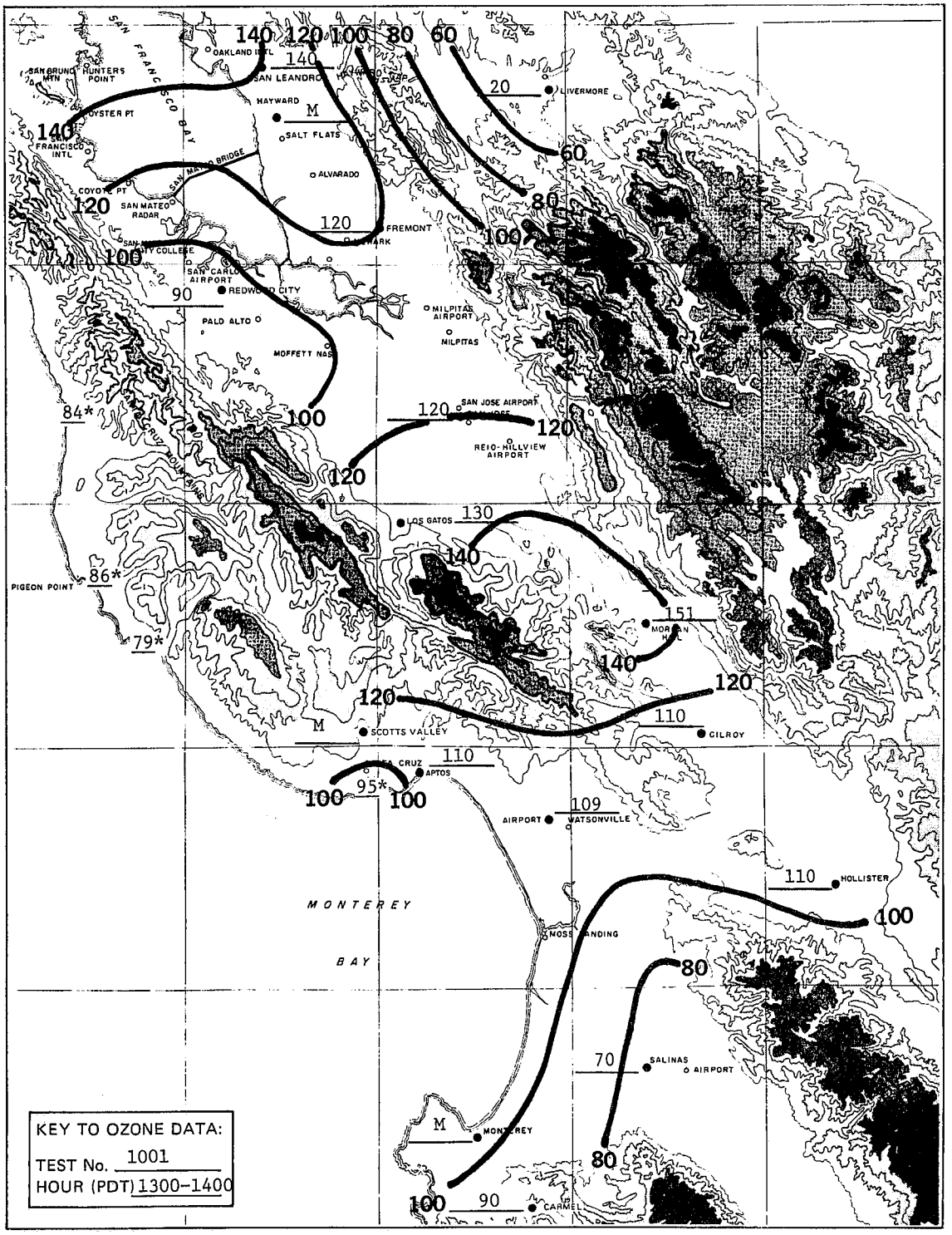


FIGURE 52d (CONTINUED)

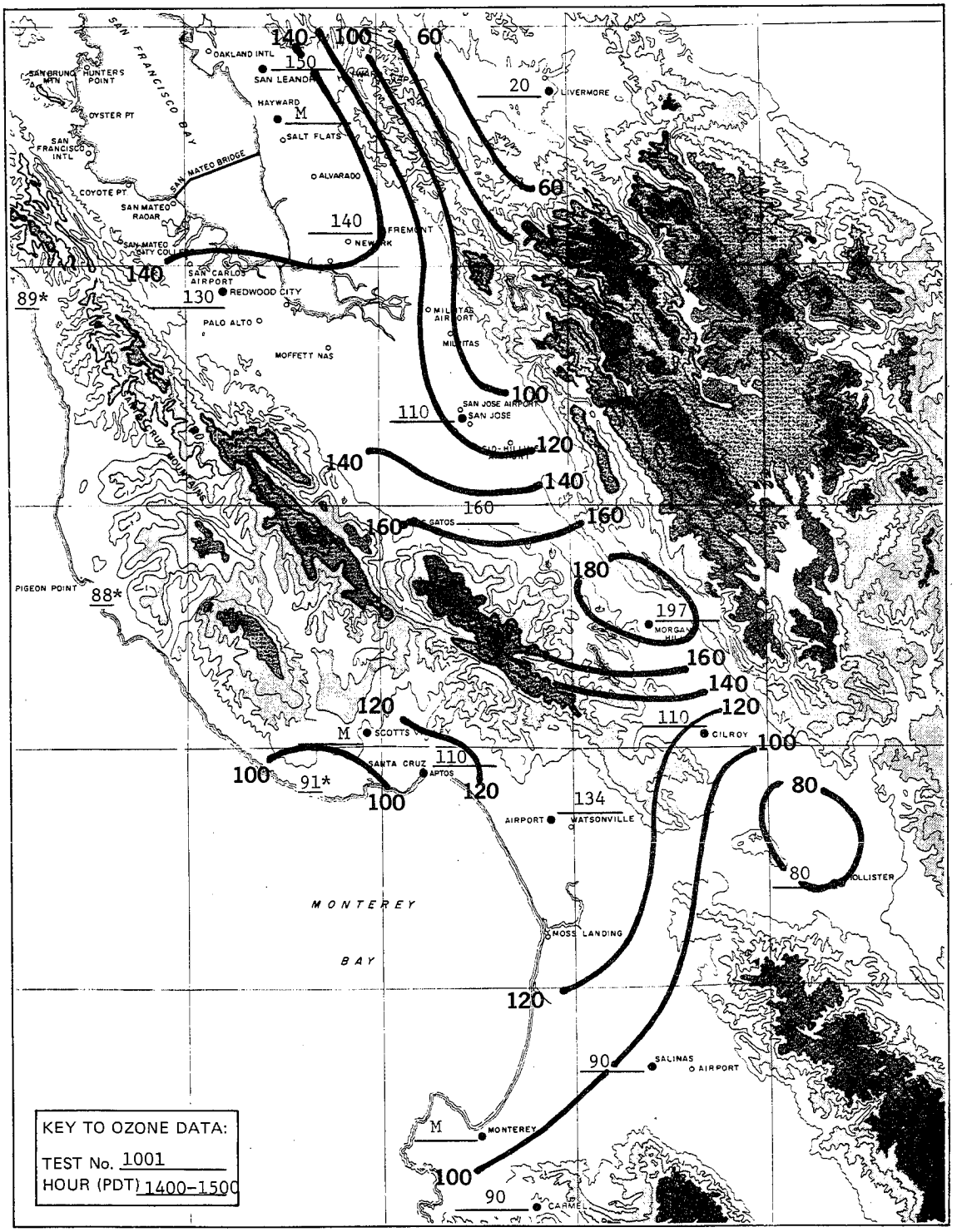


FIGURE 52e (CONTINUED)

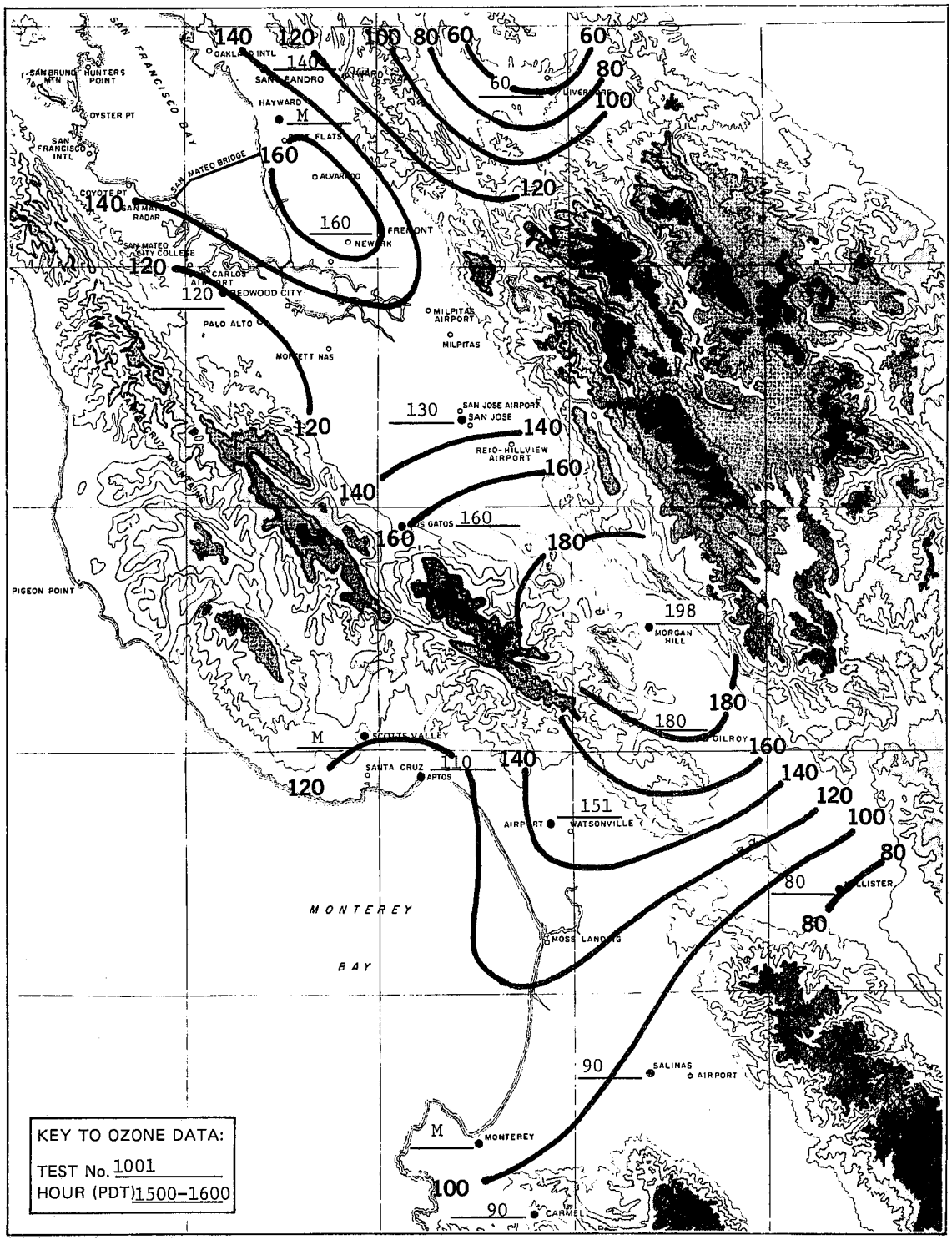


FIGURE 52f (CONTINUED)

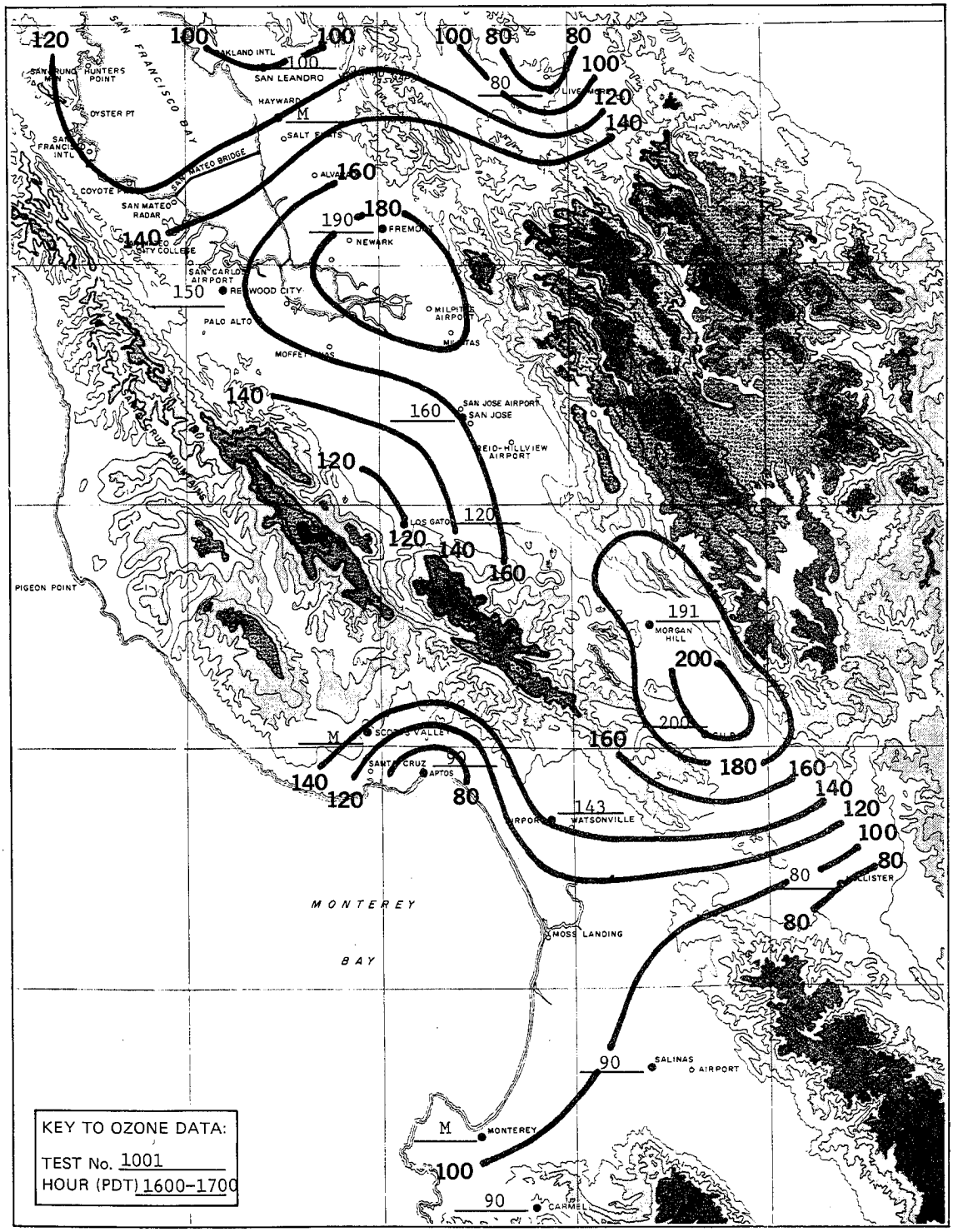


FIGURE 52g (CONTINUED)

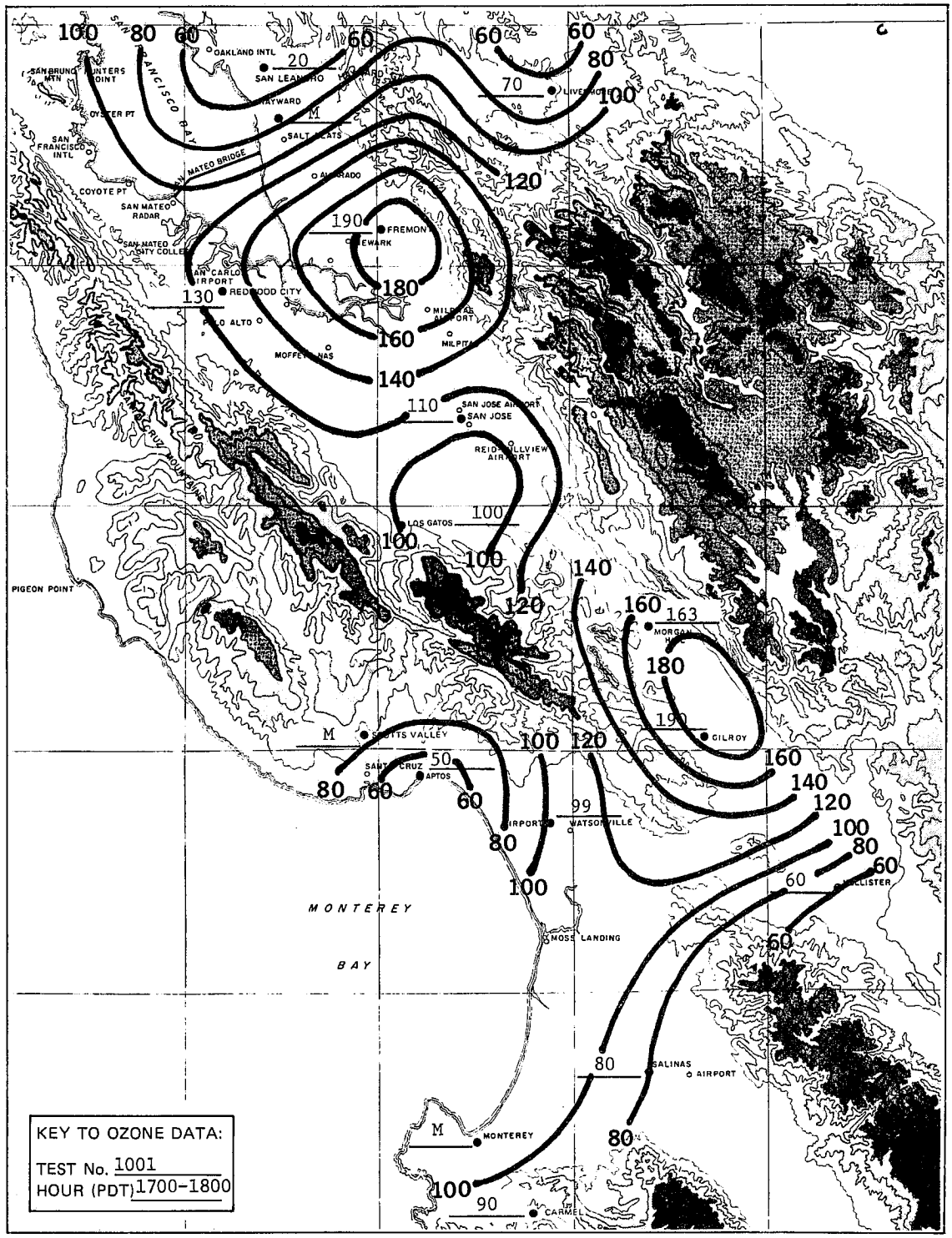


FIGURE 52h (CONTINUED)

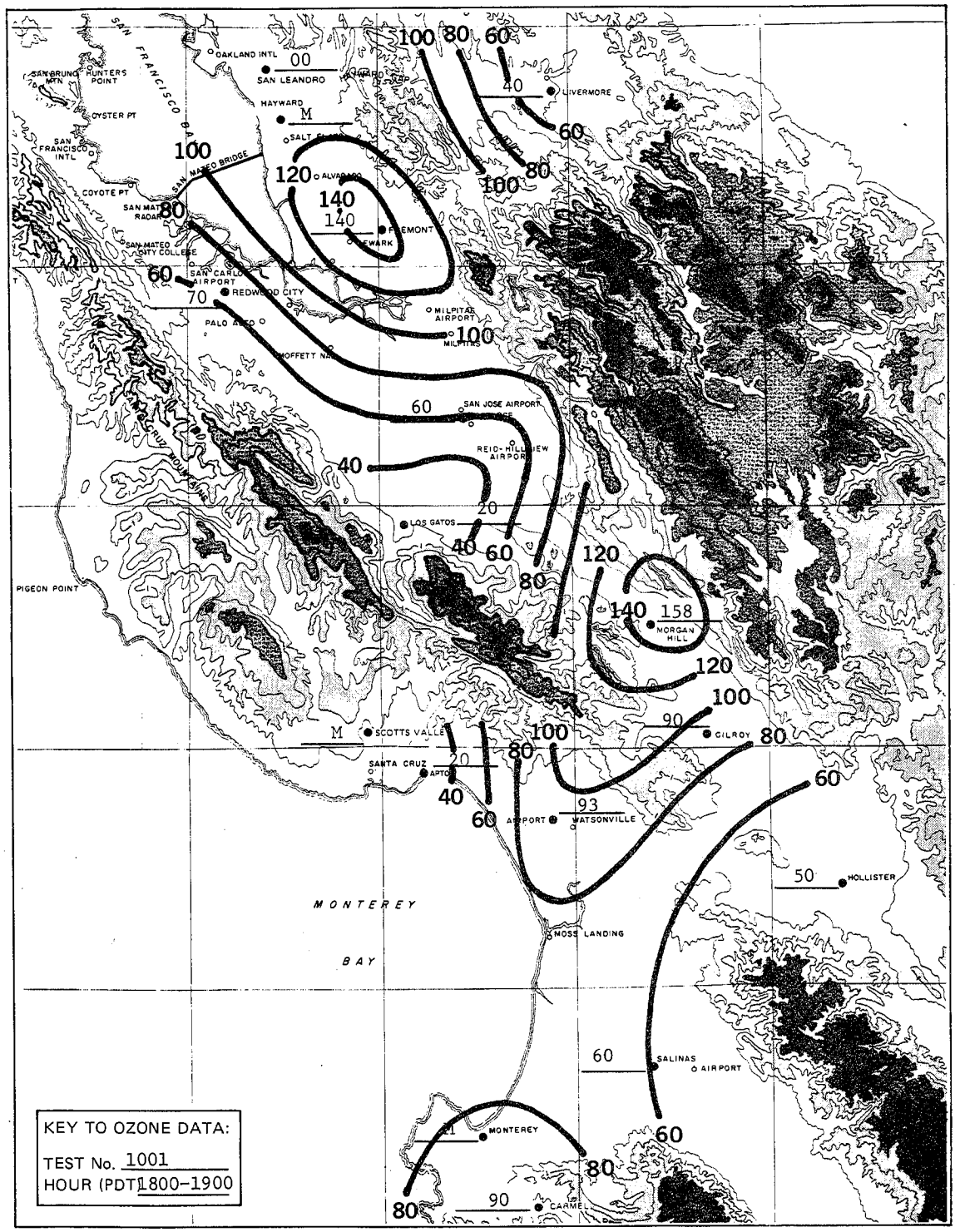


FIGURE 52i (CONTINUED)

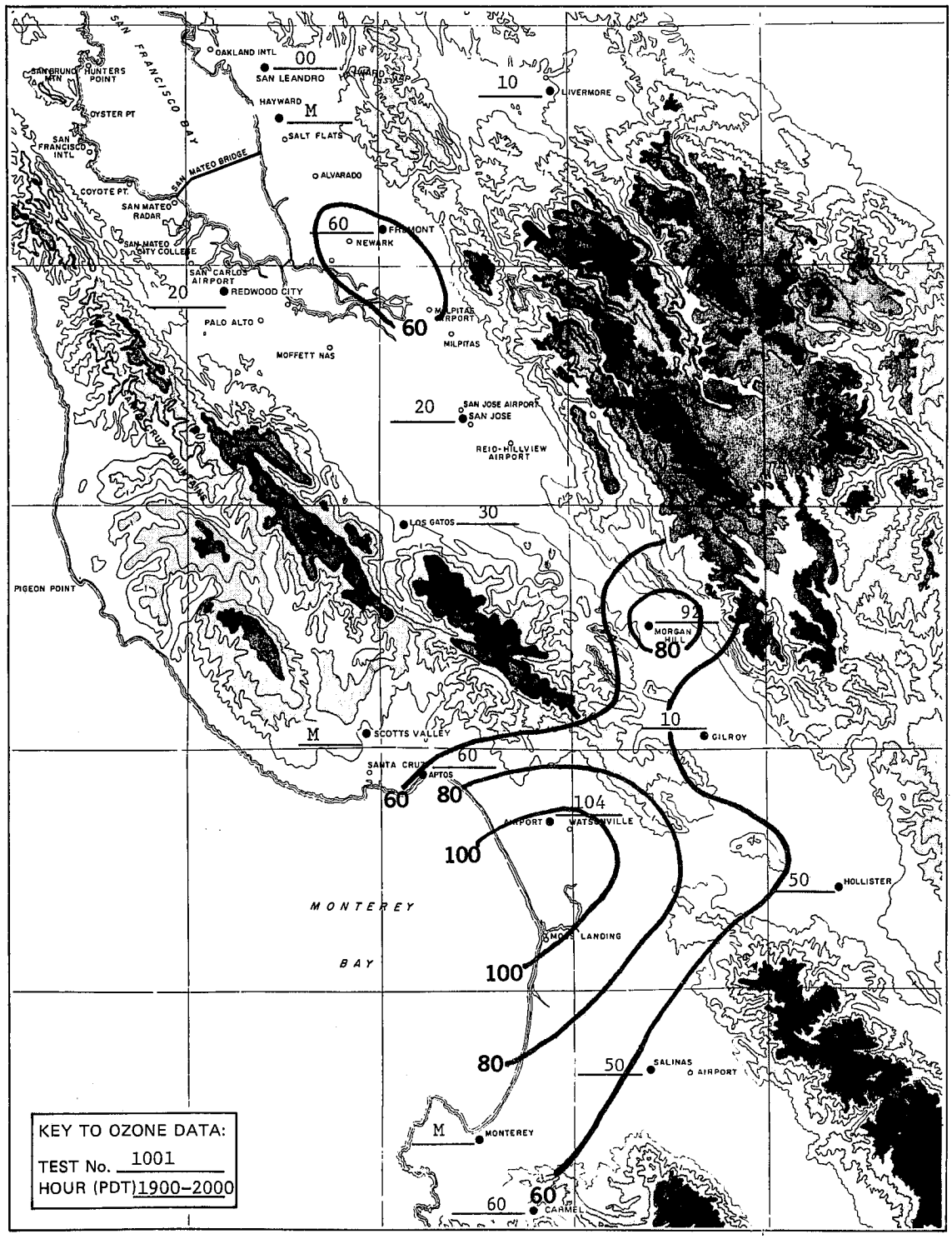


FIGURE 52j (CONTINUED)

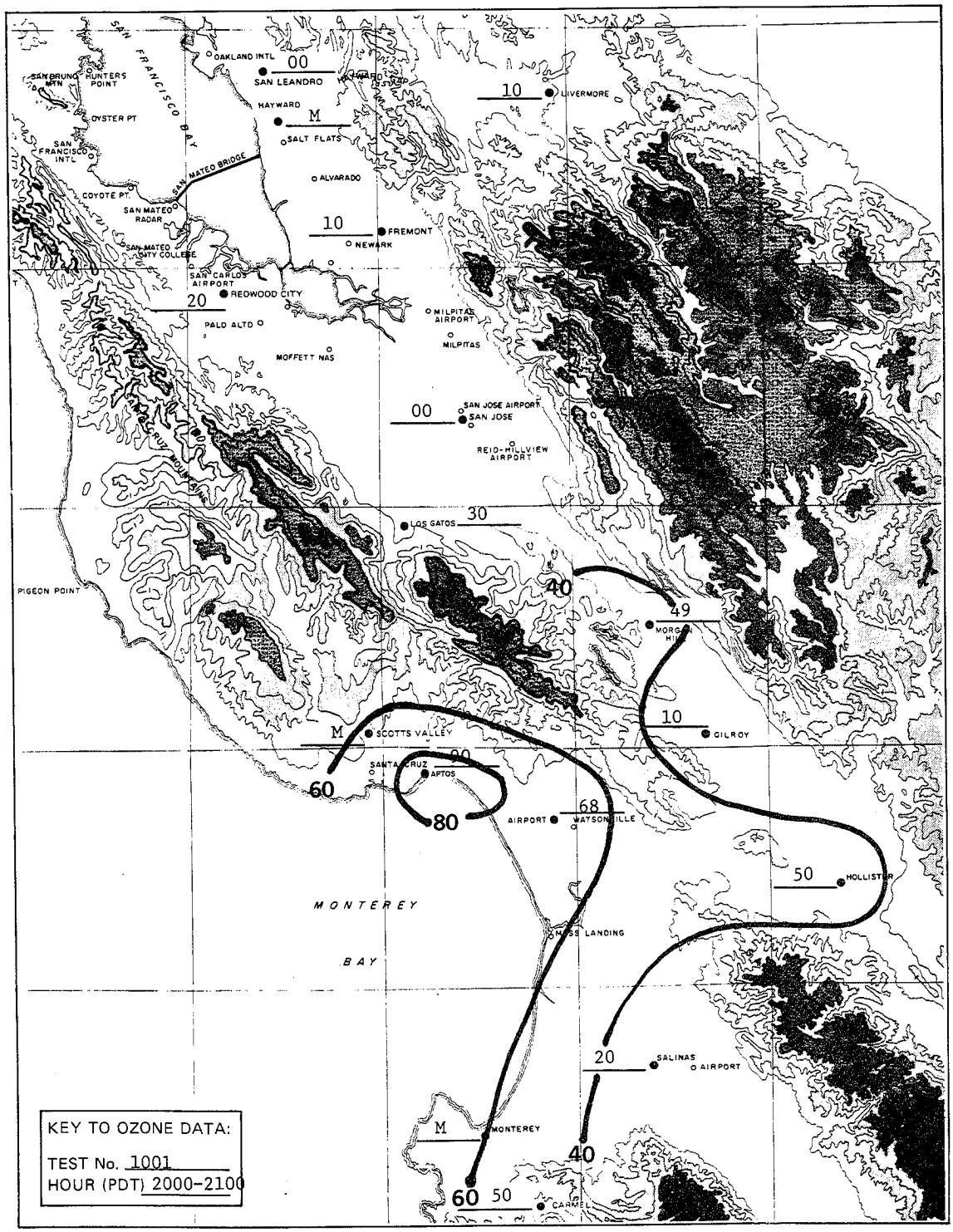


FIGURE 52k (CONTINUED)

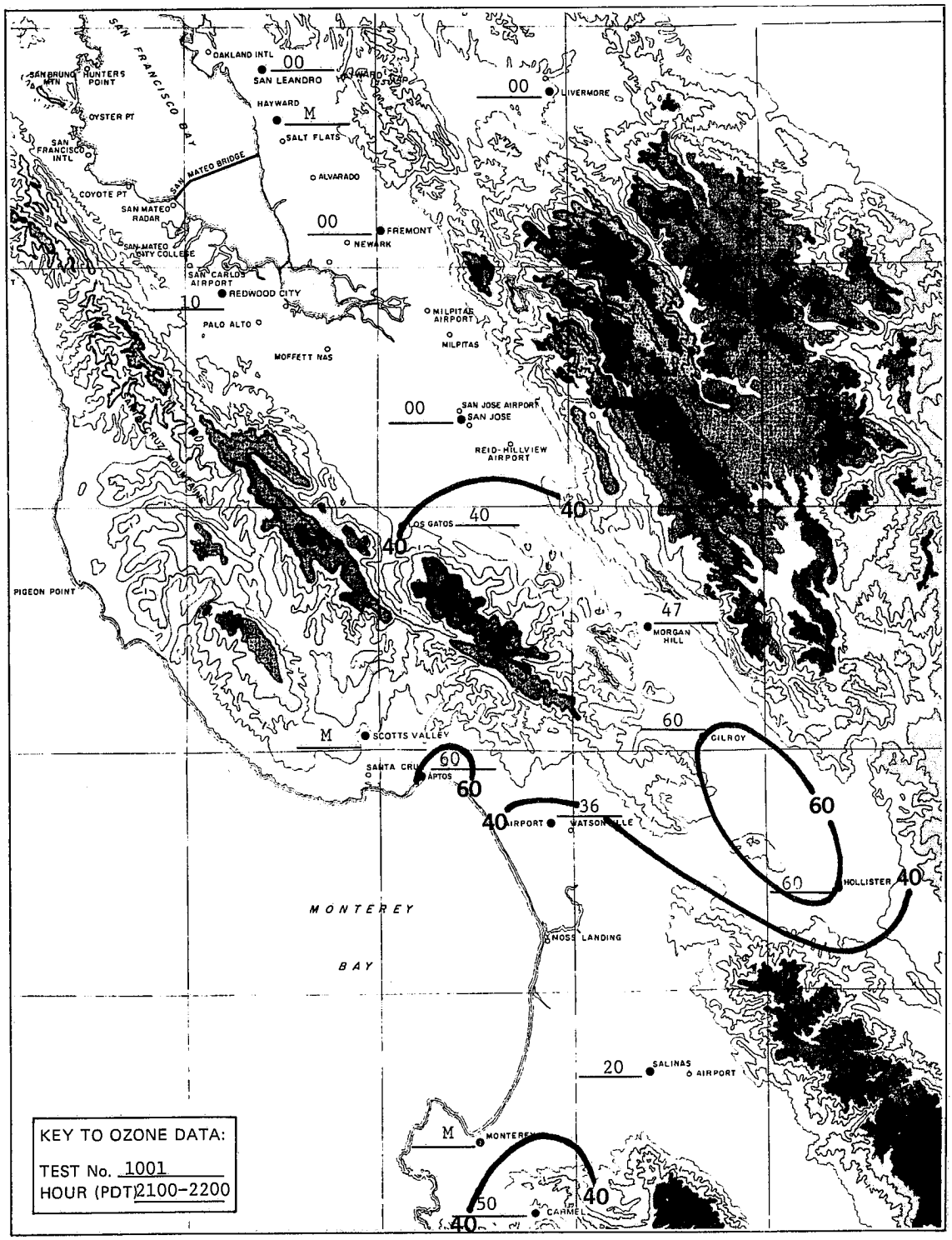


FIGURE 521 (CONCLUDED)

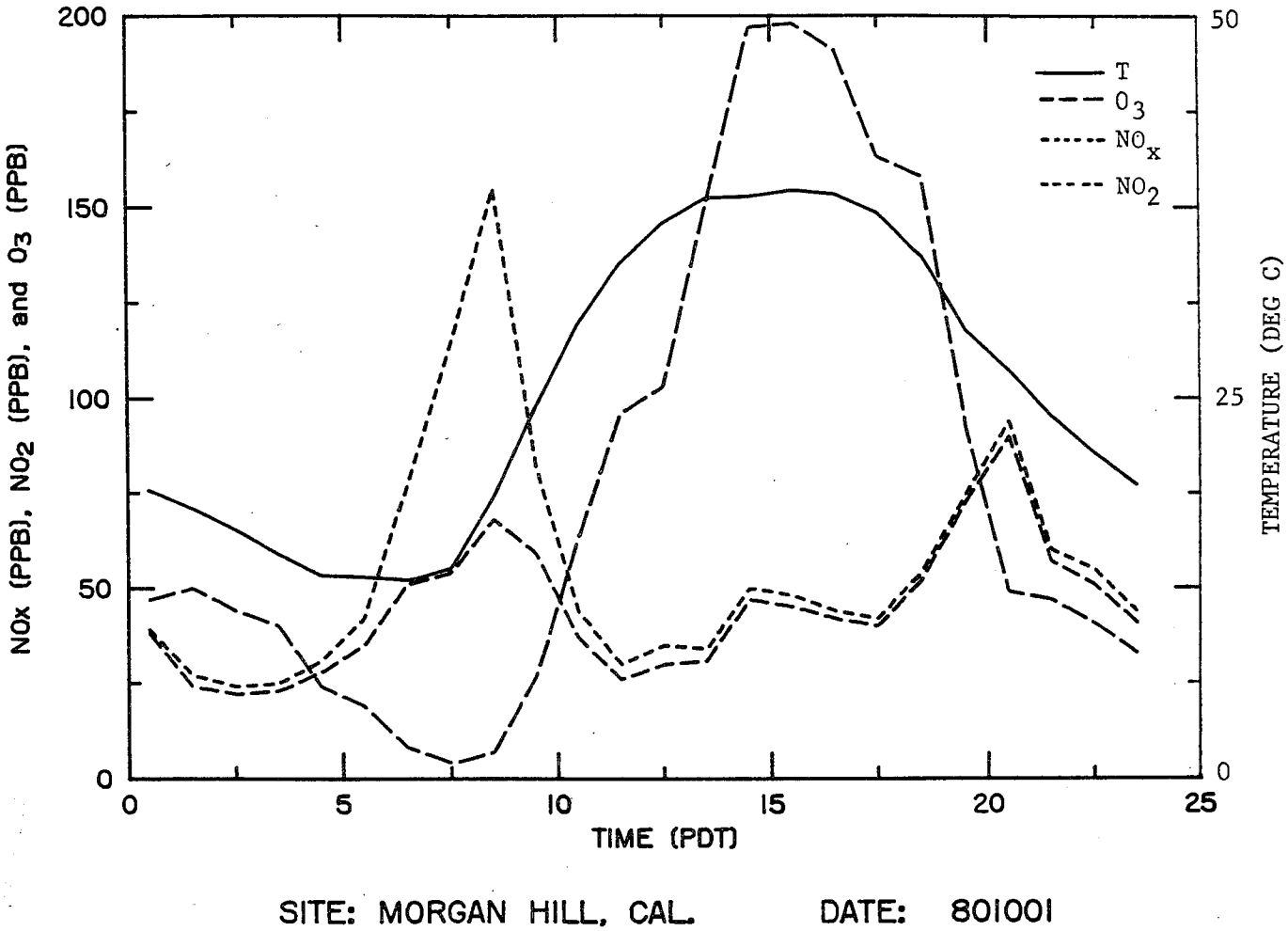


FIGURE 53 HOURLY AEROMETRIC VARIATION, 1 OCTOBER 1980, AT MORGAN HILL

The aircraft flight pattern is shown in Figure 54, while the corresponding key to waypoint locations, time, and altitude is provided in Table 18. The following features are noted:

- A significant ozone reservoir persisted offshore. Over Monterey Bay, concentrations were about 90 ppb over the eastern portions while the western portions reached 125 ppb and did not decrease out to the 30-nmi waypoint (52). Further south and east, there was a steady decrease to the 85-ppb levels in Monterey.
- A marked increase in ozone concentration was observed offshore (both on the outgoing and return traverses) in the vicinity of the Año Nuevo Reserve. Concentrations increased rapidly from 110 to 125 ppb south of this boundary to 175 ppb and higher to the north. Near-uniform concentrations up to 200 ppb were observed from just offshore to a point about 18 nmi offshore; further west, measured concentrations remained above 100 ppb.
- Elevated concentrations 175 ppb and higher were present as far north as San Pedro Point. Farther north, there was a gradual decrease to 125 ppb at the Marin headlands west of the Golden Gate (i.e., Point Diablo).
- On the southerly return traverse, the north-south ozone distribution was observed again except that concentrations were about 5 to 10 percent lower. However, this may reflect ozone destruction by the land surface in that the return flight paralleled the coastline at a distance of 3 to 4 nmi.
- A significant NO_x plume was encountered around 1406 PDT, 5.9 km due west of Moss Landing at an altitude of 175 m; the length of the plume was about 12 km along the westerly aircraft heading. NO_x concentrations increased from 20 ppb before and after the plume to a maximum value of 150 ppb in the plume; ozone decreased about 50 ppb within the plume from an average of about 100 ppb outside the plume. Starting at 1400 PDT, surface winds at Watsonville were WSW after coming from the E through SE the previous six hours; 850-mb winds were 145° at 10 m s^{-1}. While the source, orientation, and extent of the plume cannot be ascertained from the limited observations, it is significant that these anomalies exist offshore and that they can be transported onshore. Their impact on air quality within the NCCAB cannot be determined a priori, but would appear to warrant future study.

Early-afternoon soundings at Watsonville and Hollister are shown in Figure 55. A significant reduction in ozone aloft is seen in comparison with Test 0930 [Figures 50(a) and (b)]. Both the vertical extent and absolute concentrations have decreased markedly. The vertical extent decreased from 1200 m to 650 m, peak concentration from 175 ppb to 95 ppb, and the profile average concentration from 197 to 71 ppb; assuming a 50-ppb background, the ozone "excess" decreased from about 6.84×10^4 ppb-m to about 2.60×10^4 ppb-m, a factor of 2.6 reduction.

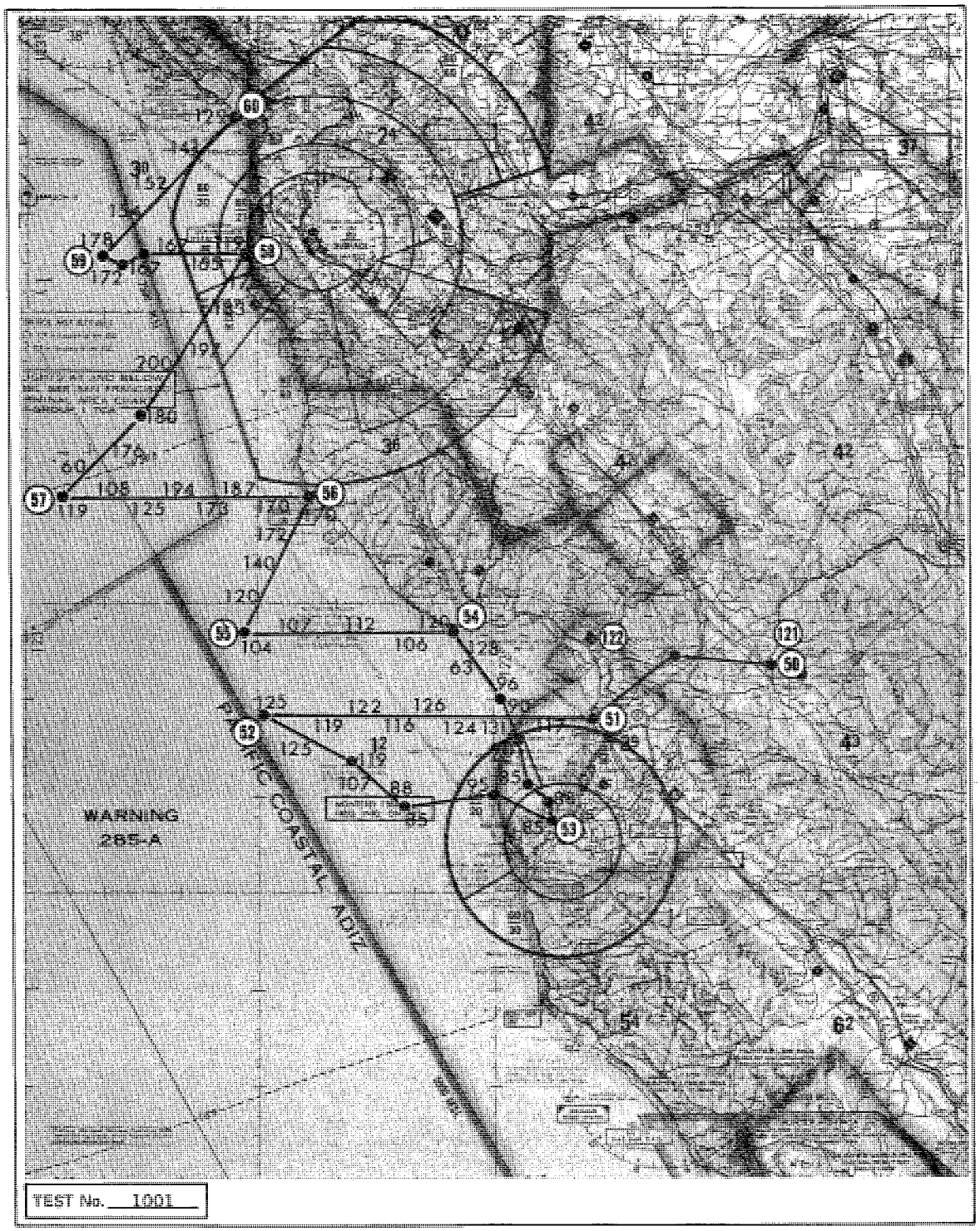
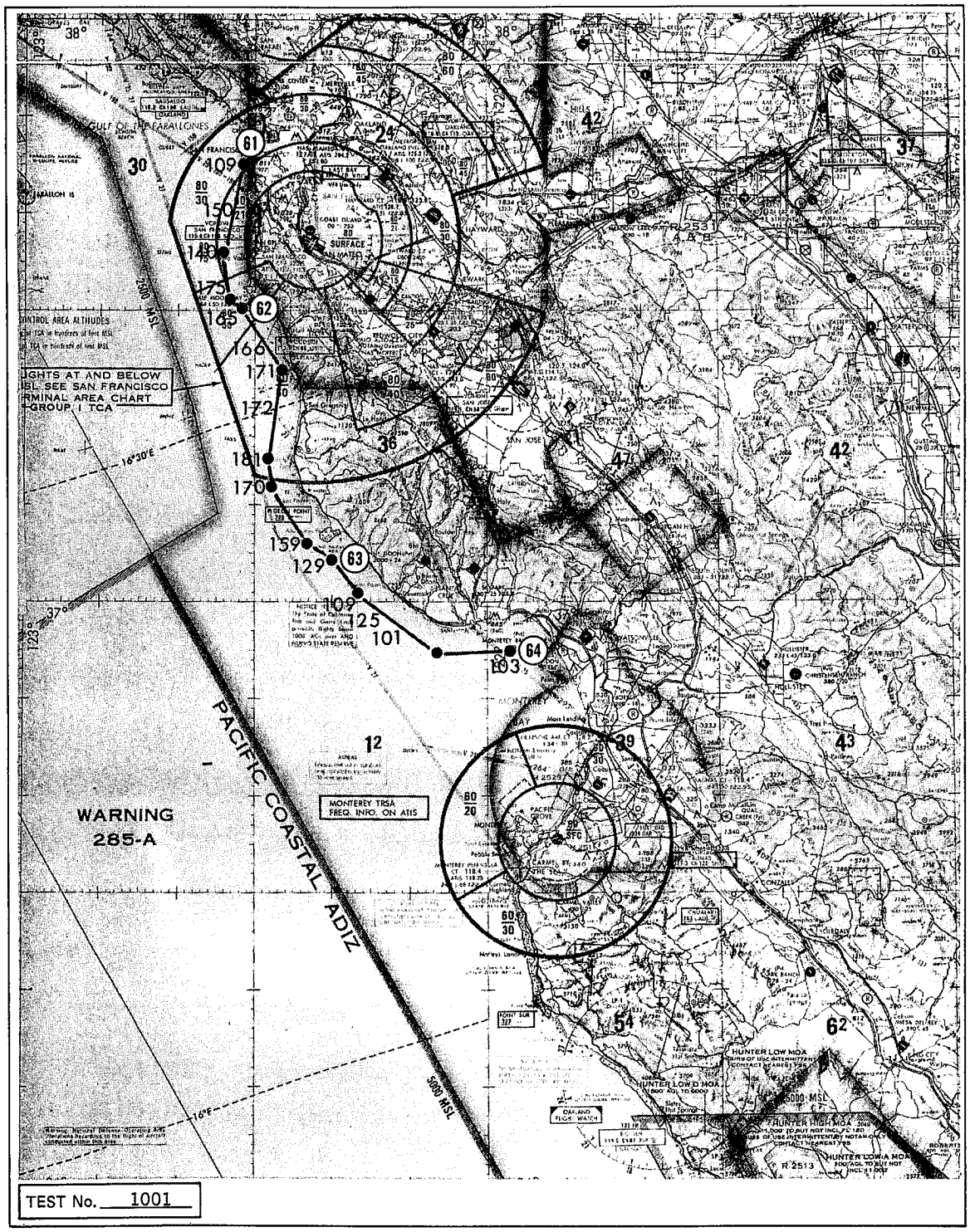


FIGURE 54a AIRCRAFT FLIGHT PATTERN, TEST 1001, WITH OZONE CONCENTRATIONS (ppb)



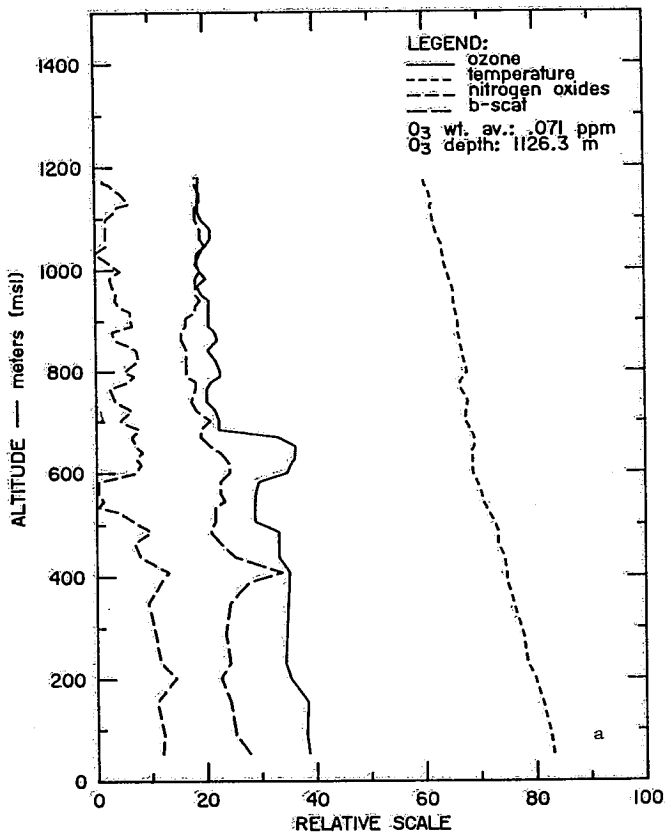
TEST No. 1001

FIGURE 54b (CONCLUDED)

Table 18

AIRCRAFT WAY POINTS, TEST 1001

Way Point	Geographic Location	Altitude (m)	Nominal Time (PDT)
Traverses			
50	Hollister	300	1356
51	Moss Landing	175	1405
52	Coastal ADIZ 30 nmi W of Moss Landing	150	1421
53	Monterey	150	1436
54	Santa Cruz	150	1447
55	24 nmi west	150	1457
56	Pigeon Point	150	1505
57	25 nmi west	150	1517
58	Pedro Valley	150	1532
59	17 nmi west	150	1539
60	Marin headlands	150	1546
61	San Francisco	150	1552
62	Half Moon Bay	150	1558
63	Año Nuevo	150	1610
64	Soquel	150	1618
Spirals			
121	Hollister		1344
122	Watsonville		1326



RELATIVE SCALE (n.d.)	ACTUAL VALUES			
	O_3 (ppb)	NO_x (ppb)	T (°C)	b_{scat} ($10^{-4}m^{-1}$)
0	0	0	5	0.
20	50	35	12	0.23
40	100	70	19	0.46
60	150	105	26	0.69
80	200	140	33	0.92
100	250	175	40	1.15

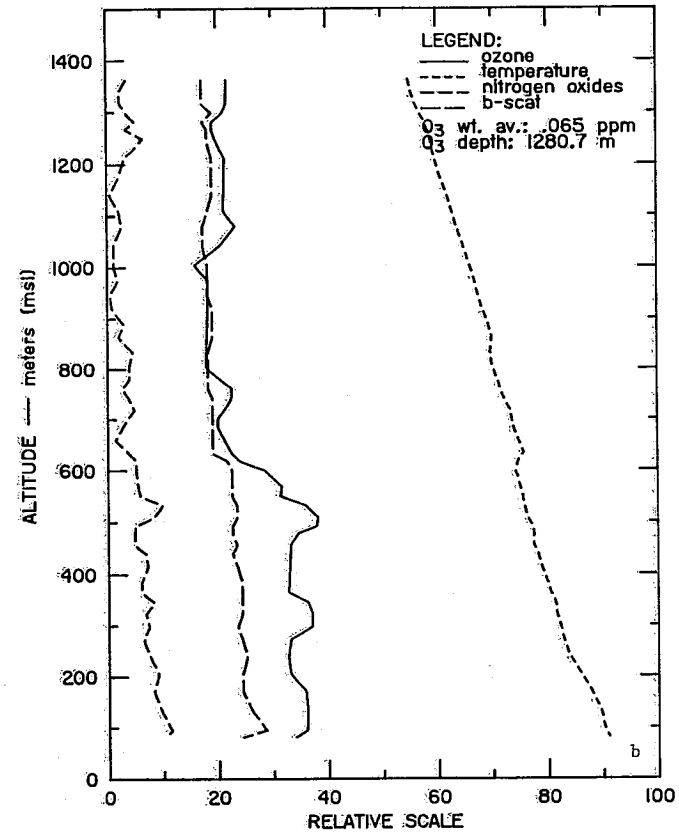


FIGURE 55 AIRCRAFT SOUNDINGS, TEST 1001

a) Watsonville Airport (1326-1337 PDT)
b) Hollister Airport (1344-1354 PDT)

The distribution of ozone offshore and the diurnal cycle of surface concentrations inland provide the basis for postulating the importance of the southerly transport of ozone and its precursors during high-ozone episodes in the NCCAB. The apparent origin of this ozone-rich air is likely the San Francisco urban area, although the dynamics that lead to its transport from the interior out over the coastal waters are not understood at this time. Indeed, Test 0930 and 1001 may provide an excellent case study and data base for understanding this phenomenon.

From a purely subjective analysis, the data imply that the polluted interior air is transported from the San Francisco Bay area to the coast in the Half Moon Bay to Pacifica Region, and is then transported down the coast during the daytime when surface winds are strongest.

7. Test 1002: 2 October 1980

The weather pattern of the preceding two days presisted through 2 October; the surface weather map is shown as Figure 56. The thermal trough through California was elongated and the 1012-mb core moved off the coast. The SFO-RNO pressure difference decreased substantially to -9.3 mb, while the 850-mb temperature reached 26.4°C, or 2.4°C above the climatic maximum for October. Hourly ozone peaks throughout the region are comparable to Tests 0930 and 1001, except that Salinas and Carmel Valley recorded peaks of 120 and 140 ppb, respectively, while Watsonville recorded 170 ppb. Unfortunately, the Monterey station did not come back on line until the next day. Scotts Valley reached a peak of 100 ppb, and was oriented downwind of the Santa Cruz Lighthouse tracer (SF_6) release point. The other release point, Fisherman's Wharf in Monterey, was upwind of the Carmel Valley station on this day. Because of the southeasterly transport along the Pacific coast of significant concentrations of ozone, the two tracer release points were ideally located to help understand onshore transport and its impact on coastal and interior ozone levels on a day when the ambient standard was exceeded both in the NCCAB and the BAAQMD.

Hourly plots of surface ozone are illustrated in Figure 57 from 1000-1100 PDT through 2100-2200 PDT. Late morning (1000-1100 PDT) ozone levels are highest at Watsonville (108 ppb) and Carmel Valley and Gilroy (80 ppb) while Morgan Hill, Los Gatos, and San Jose are in the 30- to 40-ppb range. From the shape of the ozone contours, there is an indication of onshore transport from the Monterey Bay to the Pajaro coastal plain. The following hour shows dramatic increases in interior ozone concentrations at Los Gatos (40 to 100 ppb) and San Leandro (50 to 100 ppb) while Watsonville increased to 125 ppb and most other stations are in the 60- to 90-ppb range. The ozone pattern and concentrations do not change much in the NCCAB for the next few hours, except that there is a general increase on the order of 10 ppb h^{-1}. The peak hour in the NCCAB is 1600-1700 PDT with Watsonville at 167 ppb, Carmel 130 ppb, Salinas 120 ppb, Scotts Valley 100 ppb, and Hollister 110 ppb. Throughout the day, the distribution of ozone in the NCCAB appears to be independent of conditions in the Santa Clara Valley where Morgan Hill and Gilroy peaked

FIGURE 56 SURFACE WEATHER MAP, 0500 PDT, TEST 1002

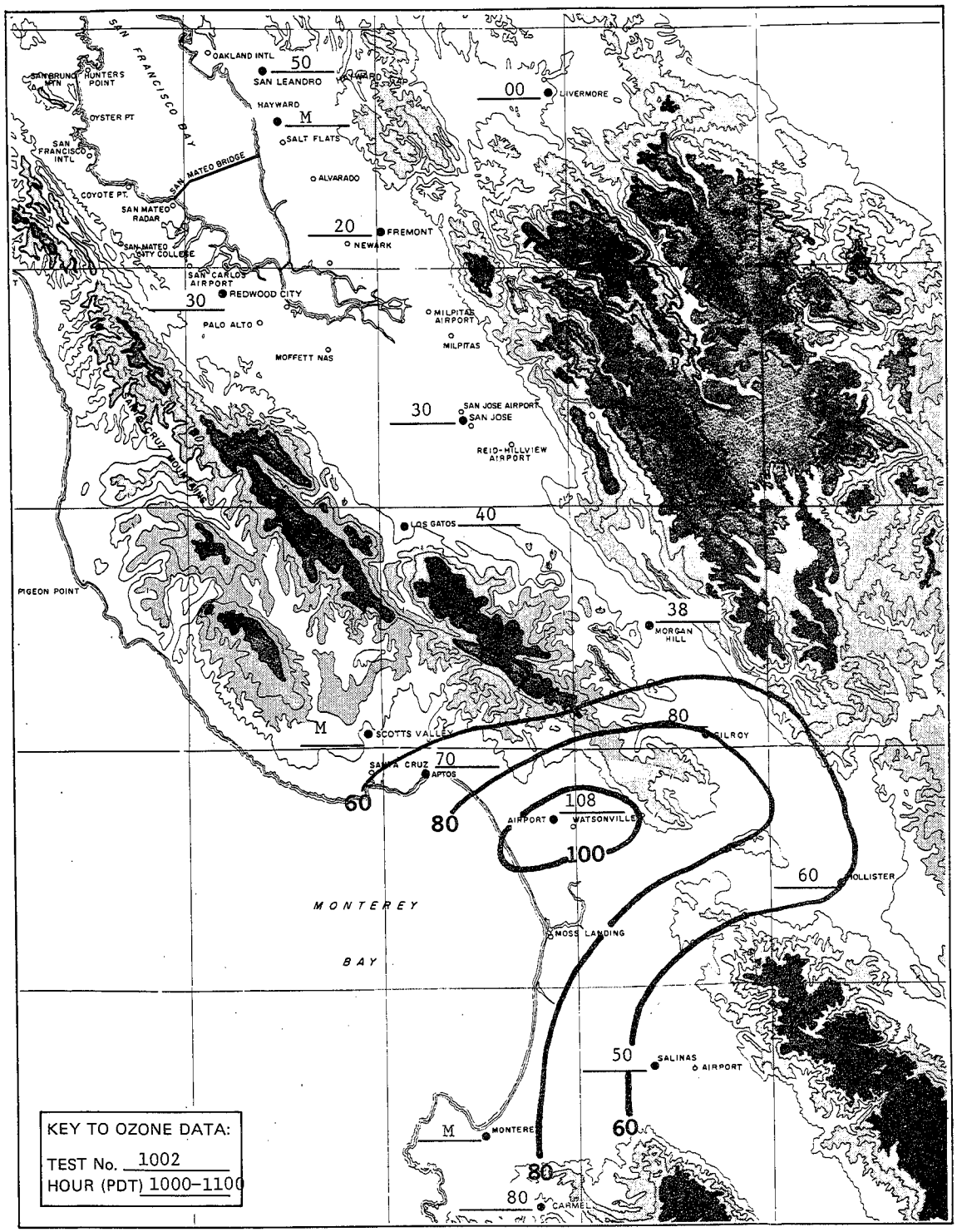


FIGURE 57a HOURLY DISTRIBUTION OF SURFACE OZONE (ppb), TEST 1002

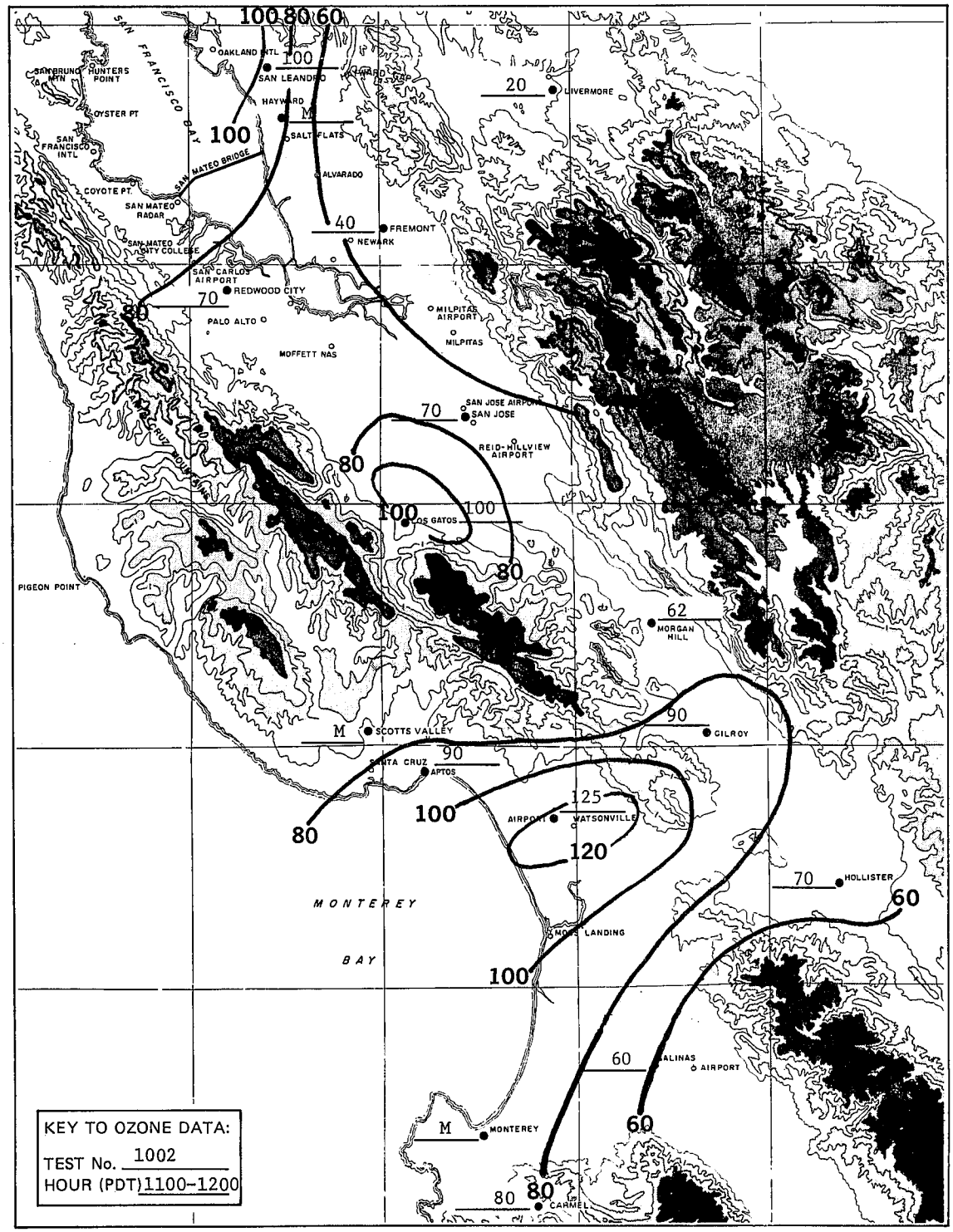


FIGURE 57b (CONTINUED)

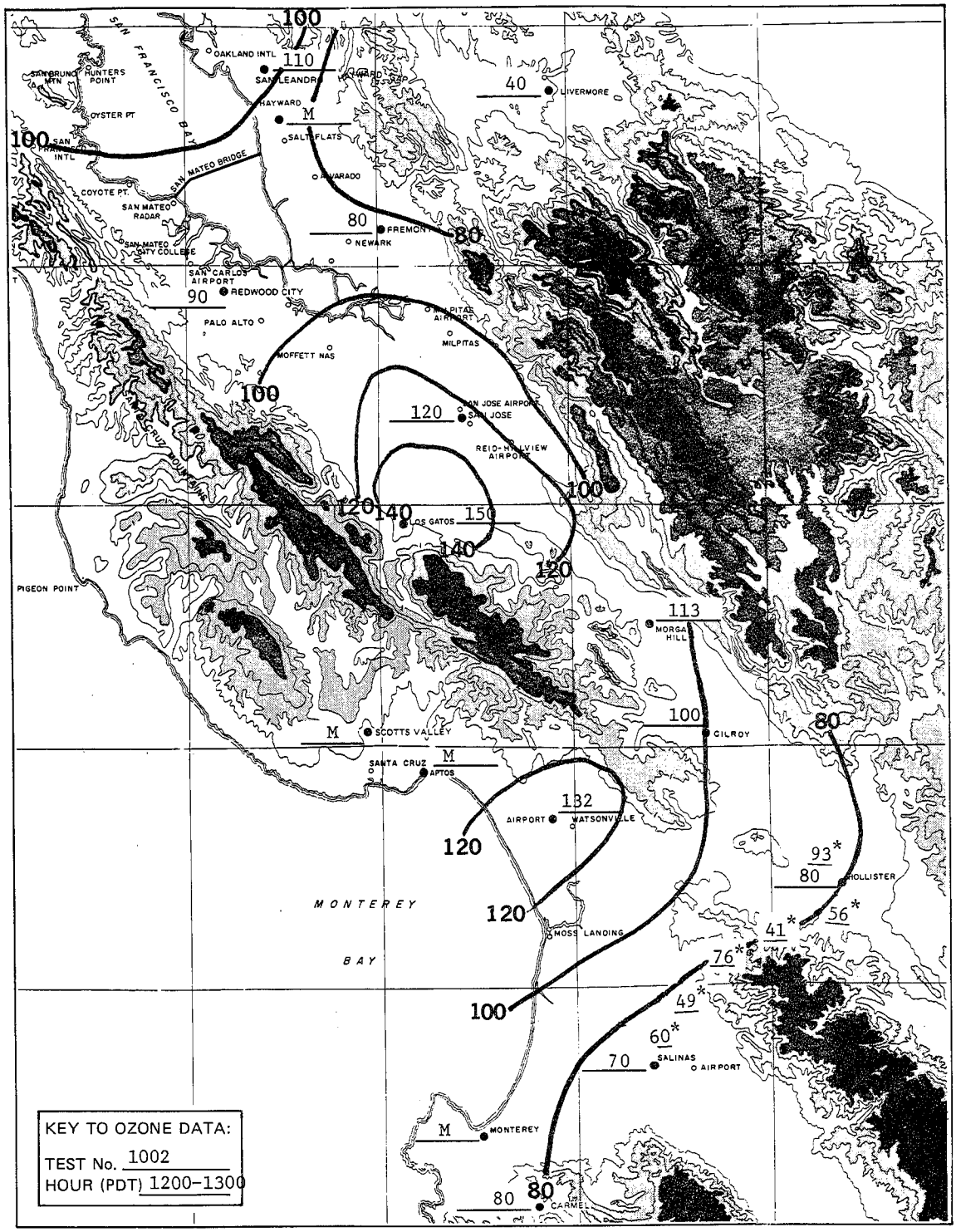


FIGURE 57c (CONTINUED)

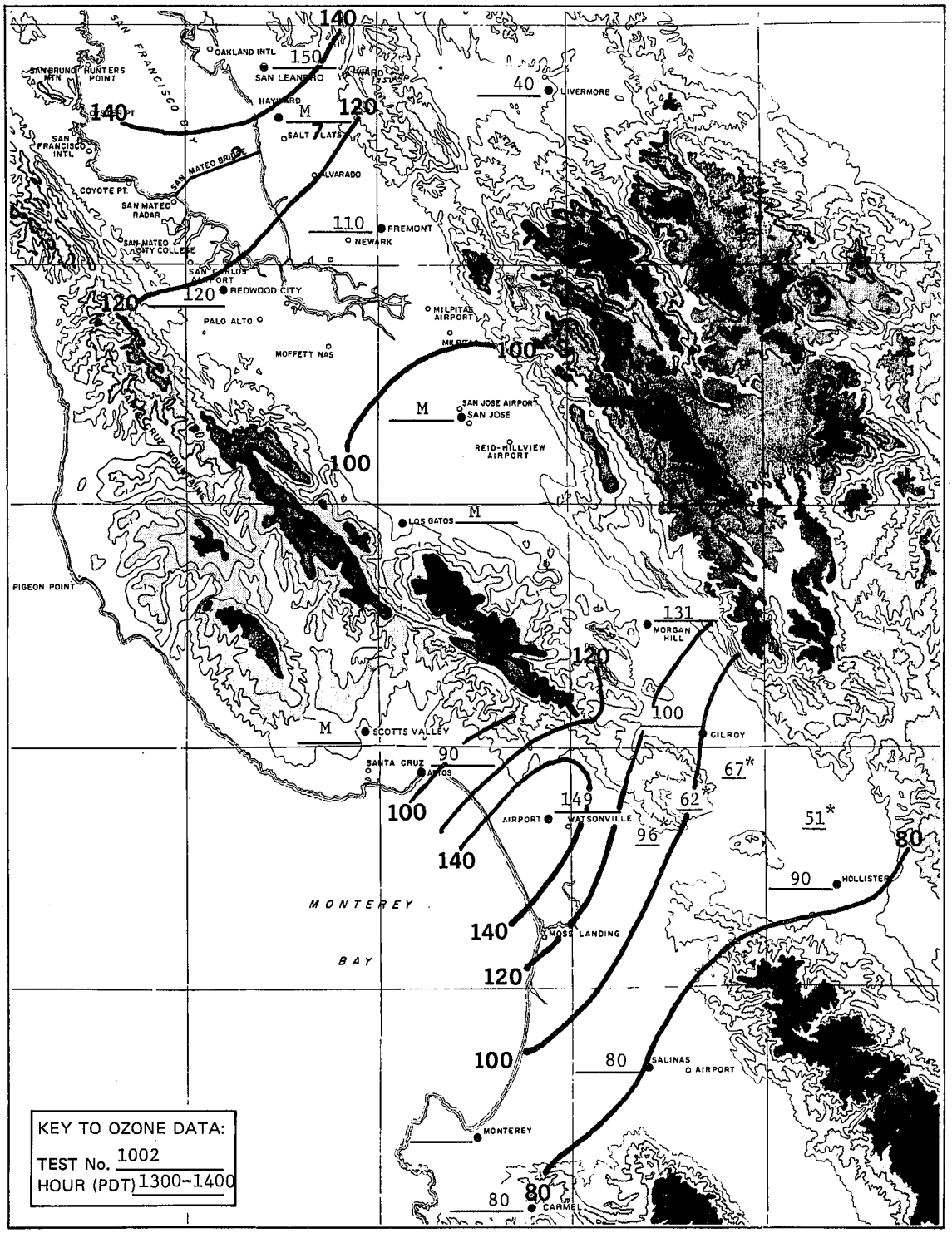


FIGURE 57d (CONTINUED)

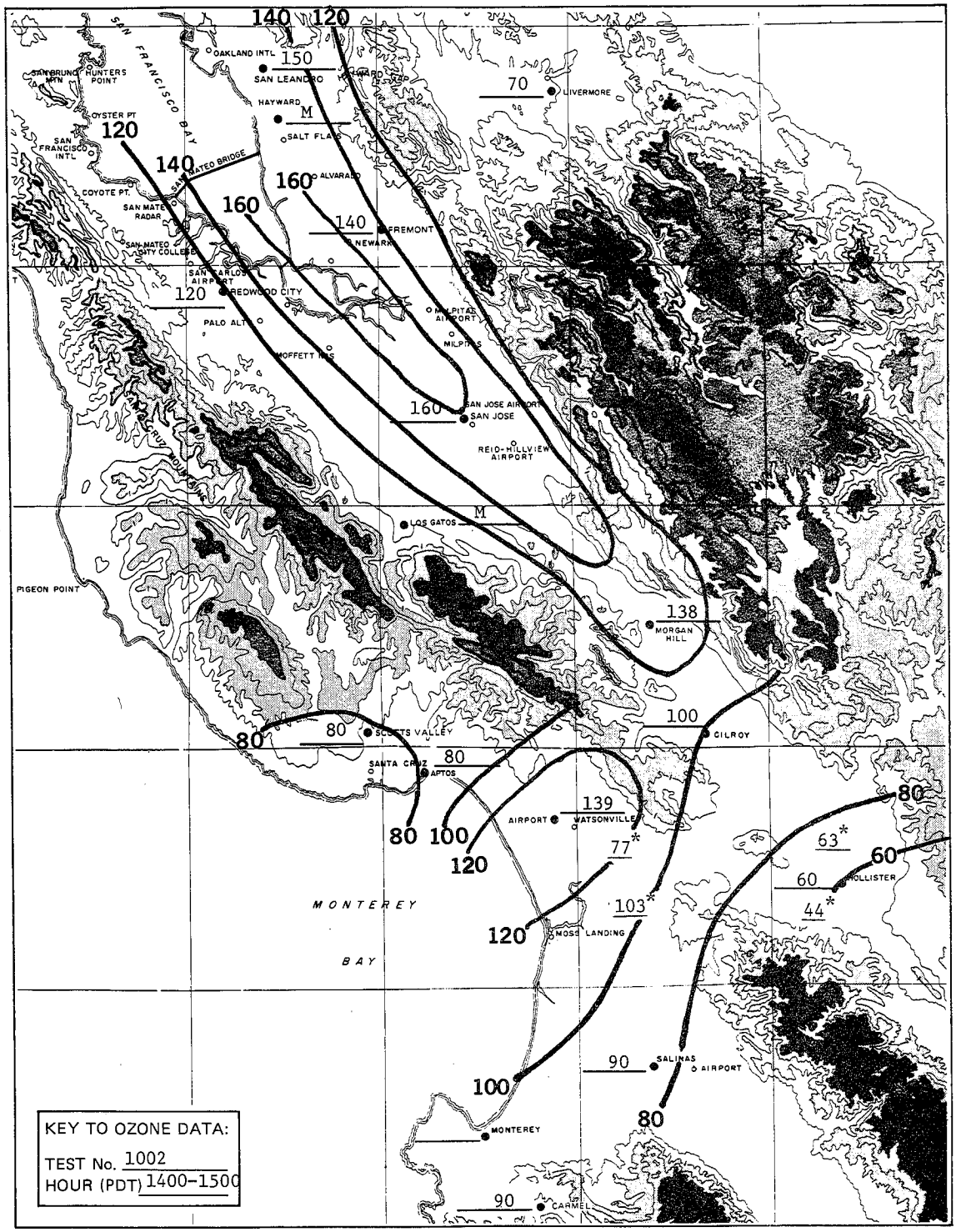


FIGURE 57e (CONTINUED)

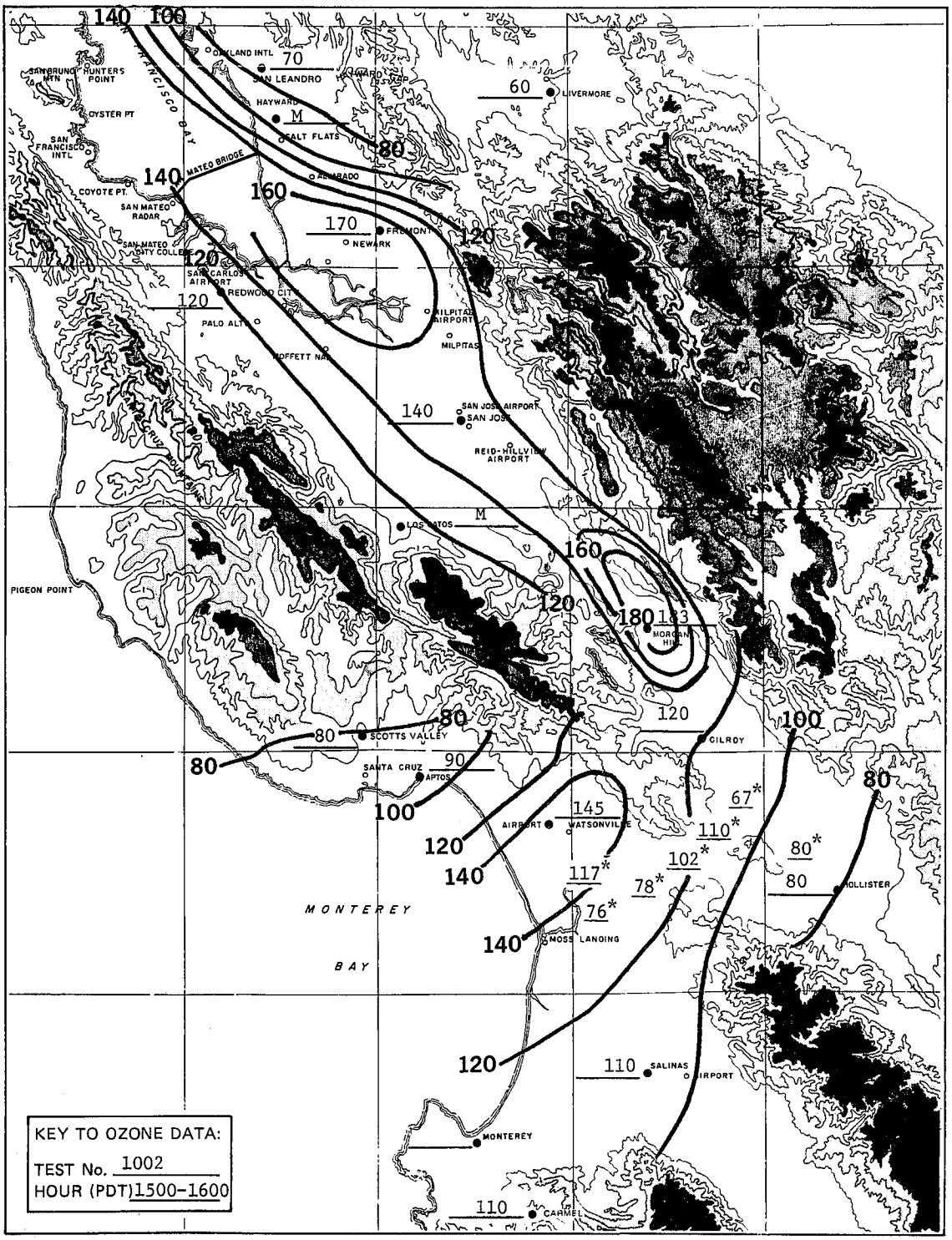


FIGURE 57f (CONTINUED)

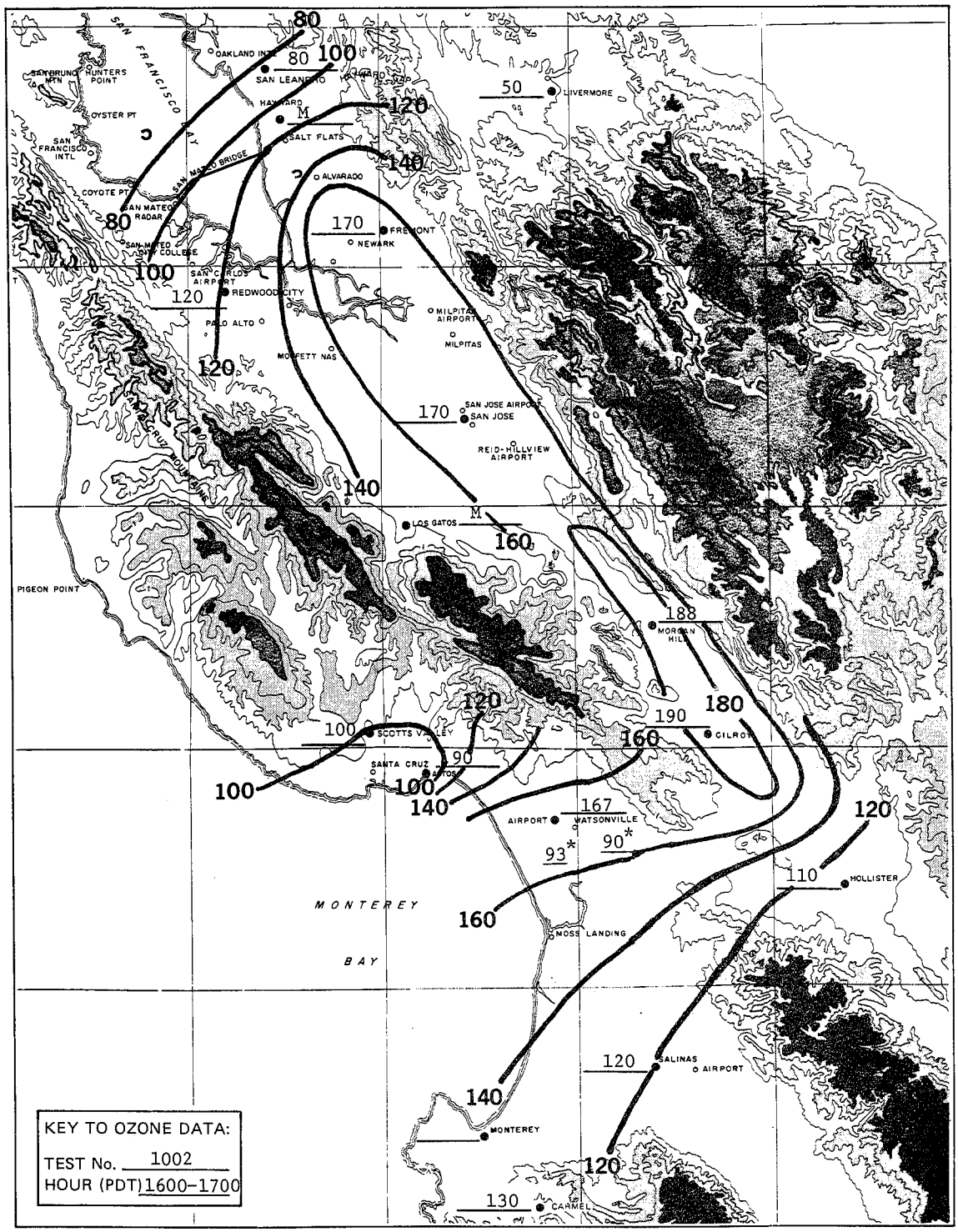


FIGURE 57g (CONTINUED)

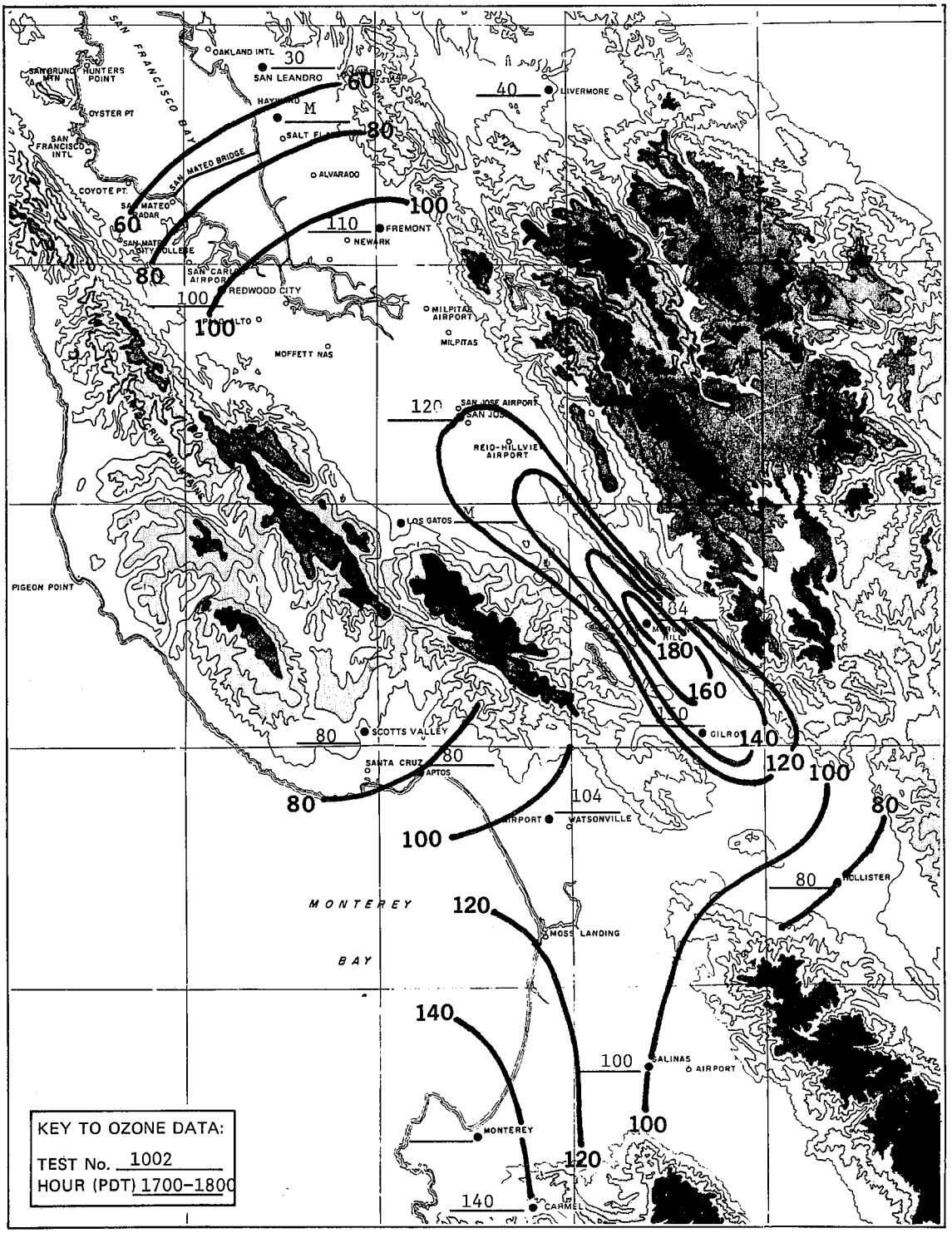


FIGURE 57h (CONTINUED)

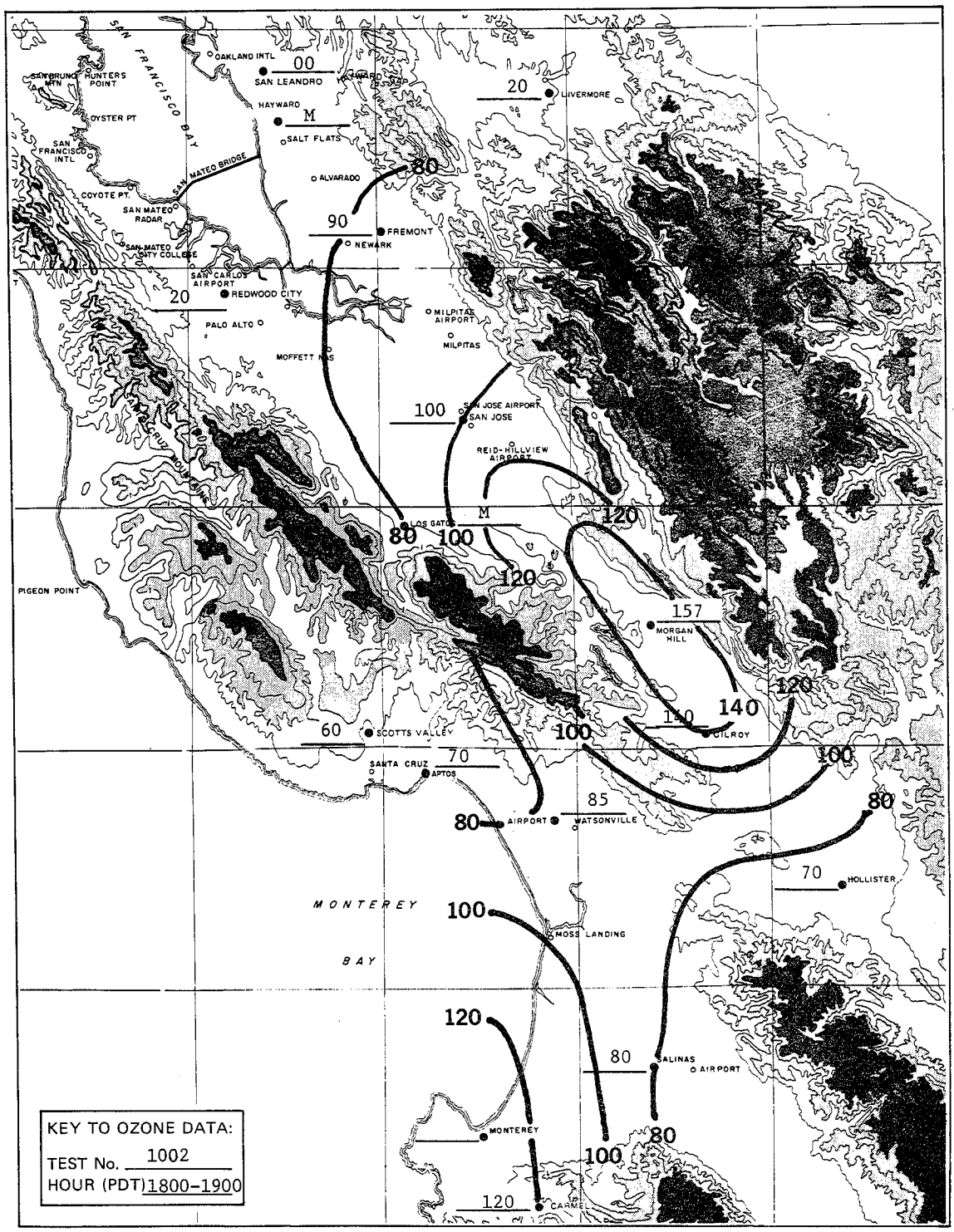


FIGURE 57i (CONTINUED)

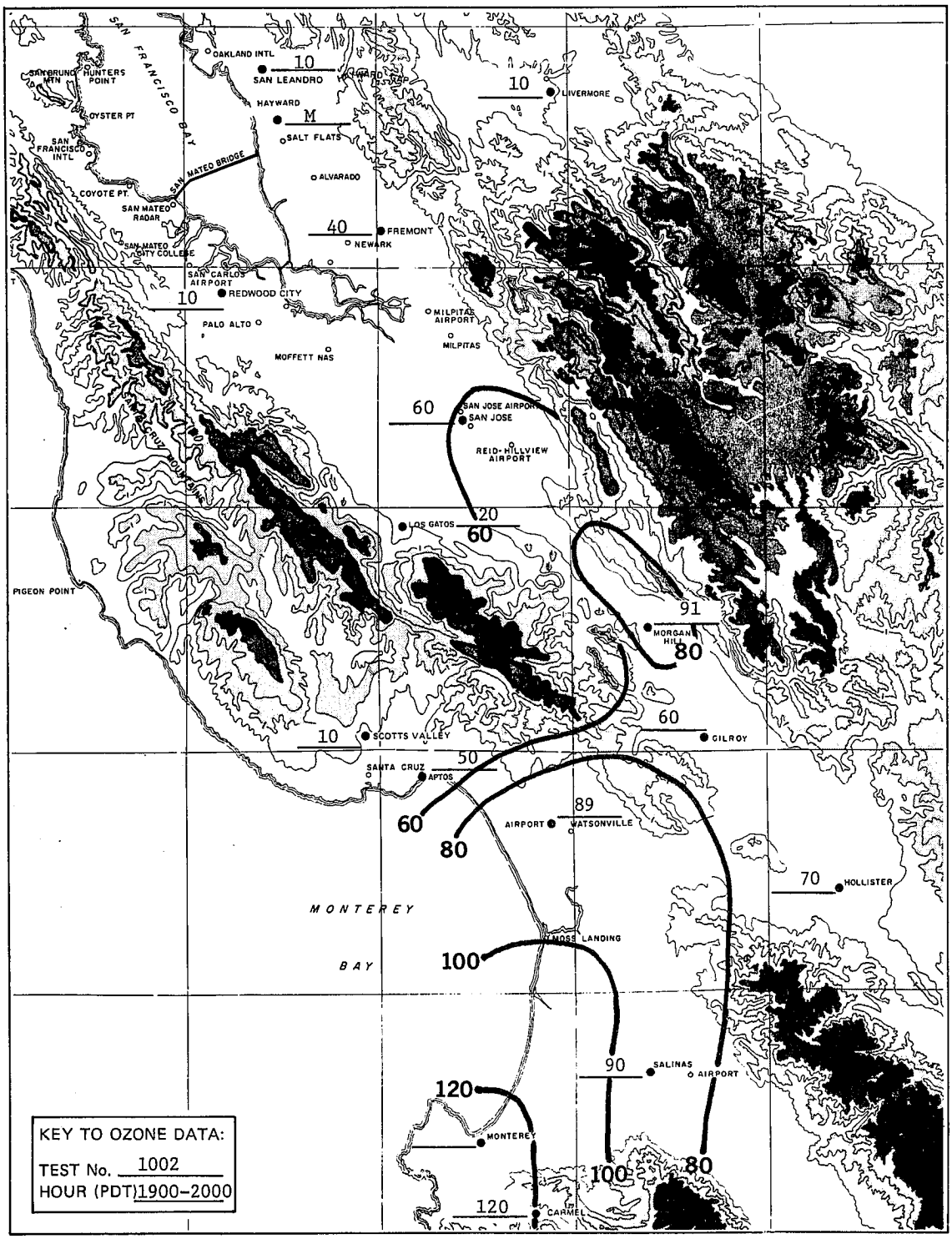


FIGURE 57j (CONTINUED)

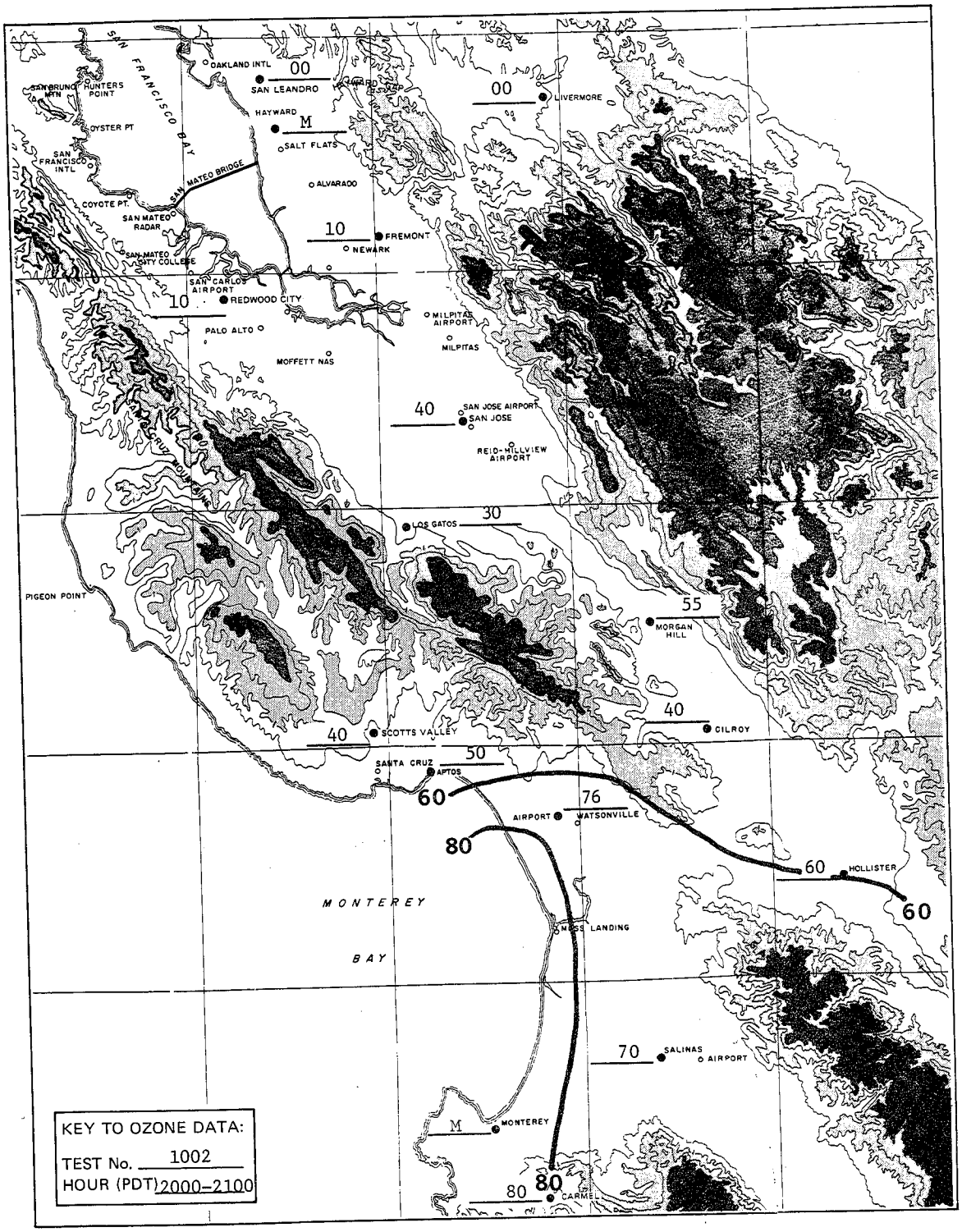


FIGURE 57k (CONTINUED)

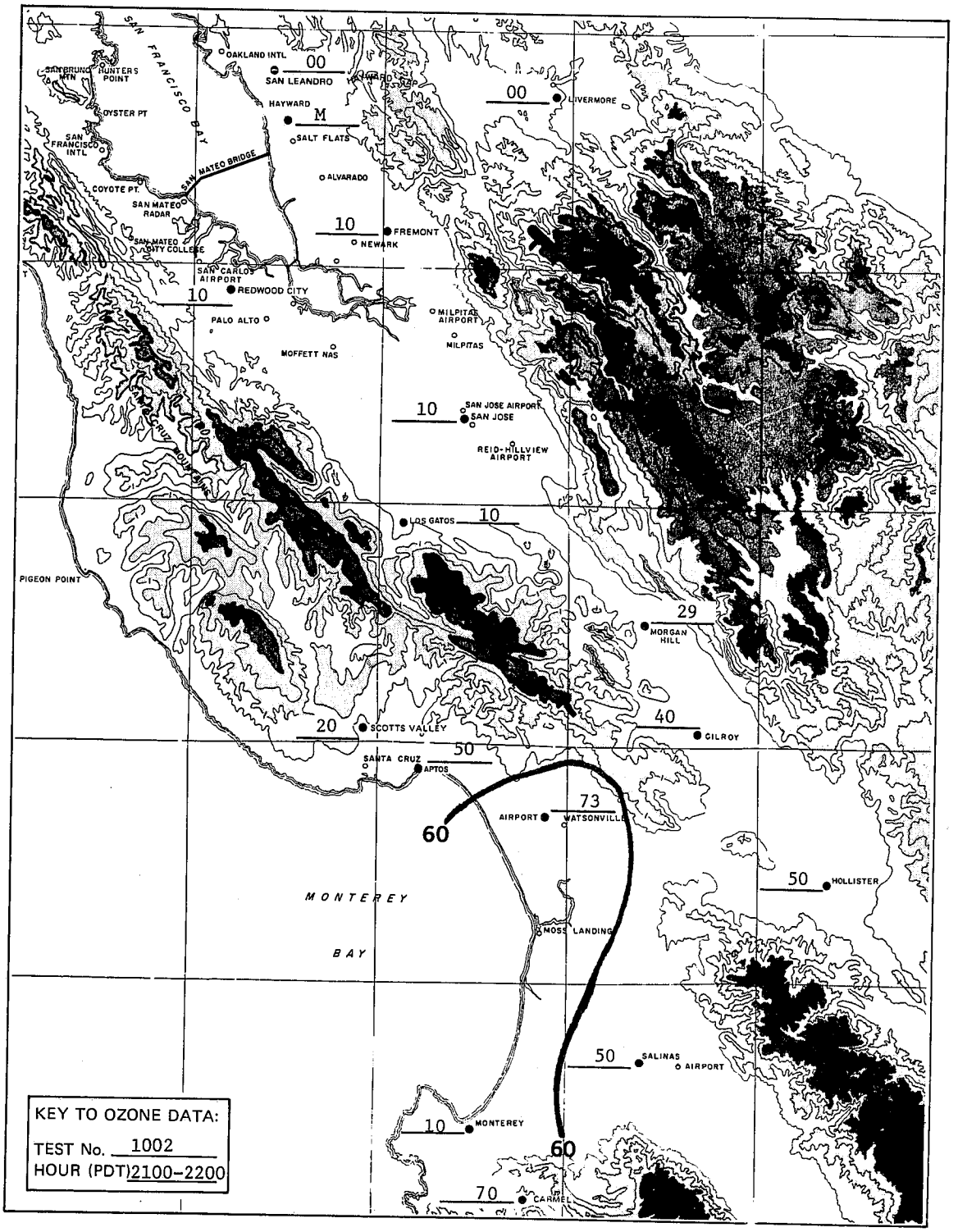


FIGURE 571 (CONCLUDED)

at 190 ppb, while Los Gatos registered 150 ppb at 1200-1300 PDT before going off-line for the remainder of the day. Moreover, ozone levels in the NCCAB appear to be augmented or dominated by transport down the coast from the San Francisco urban area to Monterey Bay and environs. In addition to the offshore measurements of the two preceding days and the shape of the surface (interior) ozone contours, there are also three other independent sets of measurements that support this hypothesis:

- Tetroon trajectories from Santa Cruz and Monterey
- Offshore ozone mapping from Monterey to Big Sur
- Vertical ozone profiles in the NCCAB.

Table 19 and Figure 58 illustrate the aircraft flights during Test 1002; Figure 59 illustrates the tetroon trajectories. Aircraft soundings at Watsonville, Hollister, Salinas, and King City are given in Figure 60, while the aircraft traverse from Monterey (Waypoint 59) to Big Sur (60) is provided as Figure 61.

The midday trajectories originating in Santa Cruz and Monterey confirm the general northerly flow along the coastline and the onshore transport in the Monterey Bay resulting from the so-called Santa Cruz hook in the prevailing flow pattern. The "hook" refers to the cyclonic curvature induced by the shape of the coastline relative to the normal northwesterly flow; the phenomenon is most apparent in the presence of coastal stratus, where this local circulation often results in a hook-shaped cloud-free area in the northern half of the bay. Under high-ozone conditions as were observed 30 September through 2 October, the circulation is an effective mechanism for transporting coastal, ozone-rich air onshore; the effect is enhanced by the sea breeze under clear-sky conditions. Further south, the Monterey trajectory substantiates the downcoast transport, particularly when the offshore aircraft measurements of ozone are considered. Referring to Figure 61, ozone concentrations at 180 m msl and about 1 km offshore range from 225 ppb at Monterey to 175 ppb some 28 km down the coast; at that point, the ozone drops sharply to 100 ppb, where it remains for the remaining 12 km of the traverse.

The midday Salinas ozone profile [Figure 60(c)] shows concentrations not far above background except for a layer between 250 and 400 m that peaks at 100 ppb; the profile-average ozone is only 57 ppb. Seven hours later, however, the profile-average concentration has increased to 104 ppb with multiple peaks of 160, 175, and 195 ppb through a layer that extends from the surface to 1150 m msl. It is unlikely that such a large and rapid increase in ozone could result from local production. Transport is more reasonable, and the likely transport route is from the coastal waters under the influence of the sea breeze and prevailing flow. Hollister [Figures 60(e) and (f)] shows a similarly dramatic increase of ozone aloft from 1300 to 1900 PDT, although the transport route(s) cannot be implied easily (i.e., down the Santa Clara Valley or inland from the coast, or both).

Table 19

AIRCRAFT WAY POINTS, TEST 1002

Way Point	Geographic Location	Altitude (m)	Nominal Time (PDT)
Traverses			
51	Capitola	300	1435
52	Summit	300	1437
53	Skyline Road at Hwy 9	215	1445
54	Santa Cruz	215	1454
55	East-west at Scotts Valley	300	1501-1504
56	West-east at Scotts Valley	600	1506-1510
57	Aptos	300	1514
58	Watsonville	300	1519
59	Monterey	150	1531
60	Big Sur	150	1542
61	Northwest Carmel Valley	250	1603
62	Southeast Carmel Valley	250	1610
63	Gonzales	300	1621
64	Moss Landing	300	1632
65	East of Scotts Valley	300	1647
66	West of Scotts Valley	300	1650
Spirals			
111	Watsonville		1831
112	Salinas		1143
113	Hollister		1256
114	Salinas		1845
115	King City		1226
116	Hollister		1900

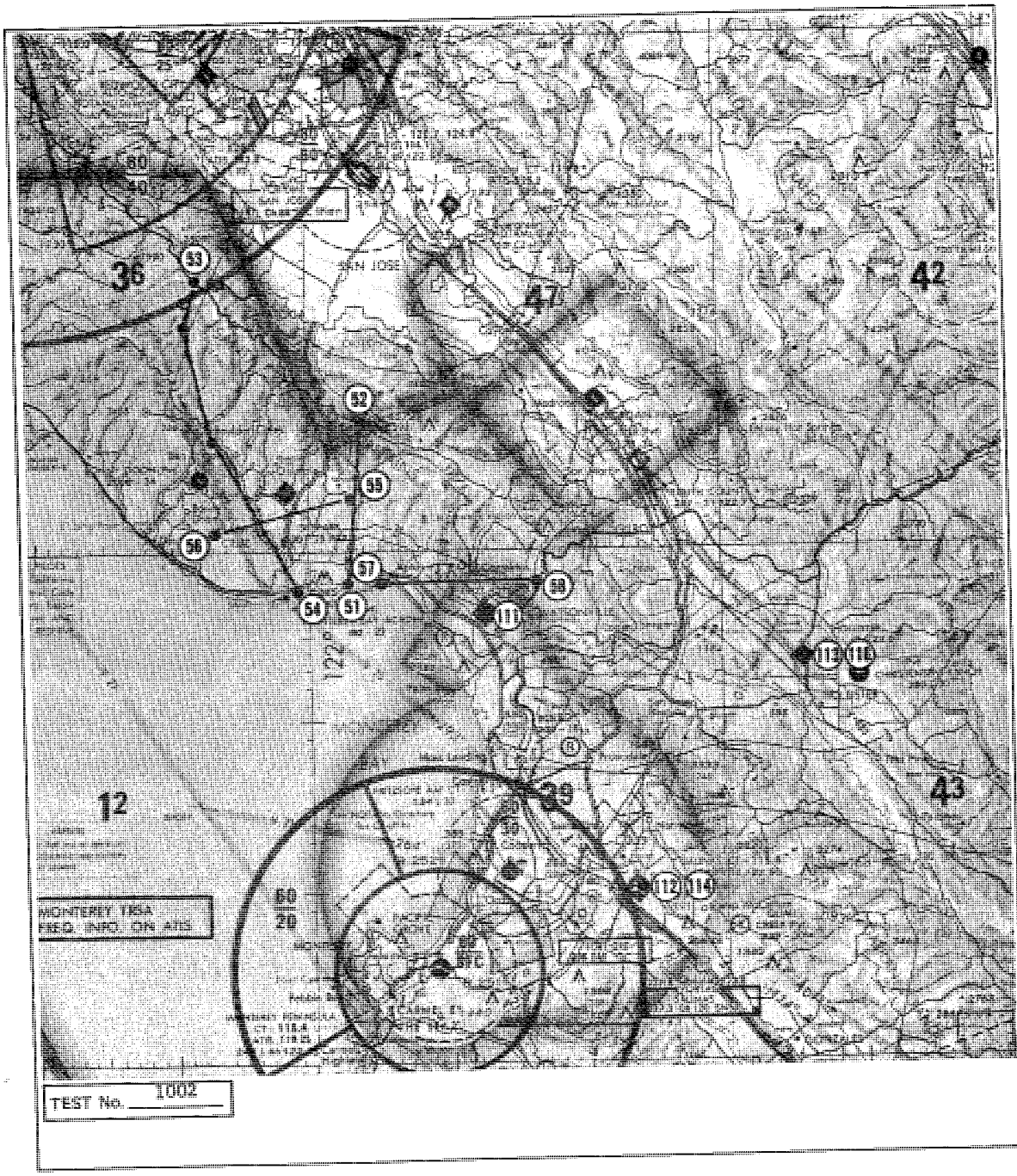


FIGURE 58a AIRCRAFT FLIGHT PATTERN, TEST 1002

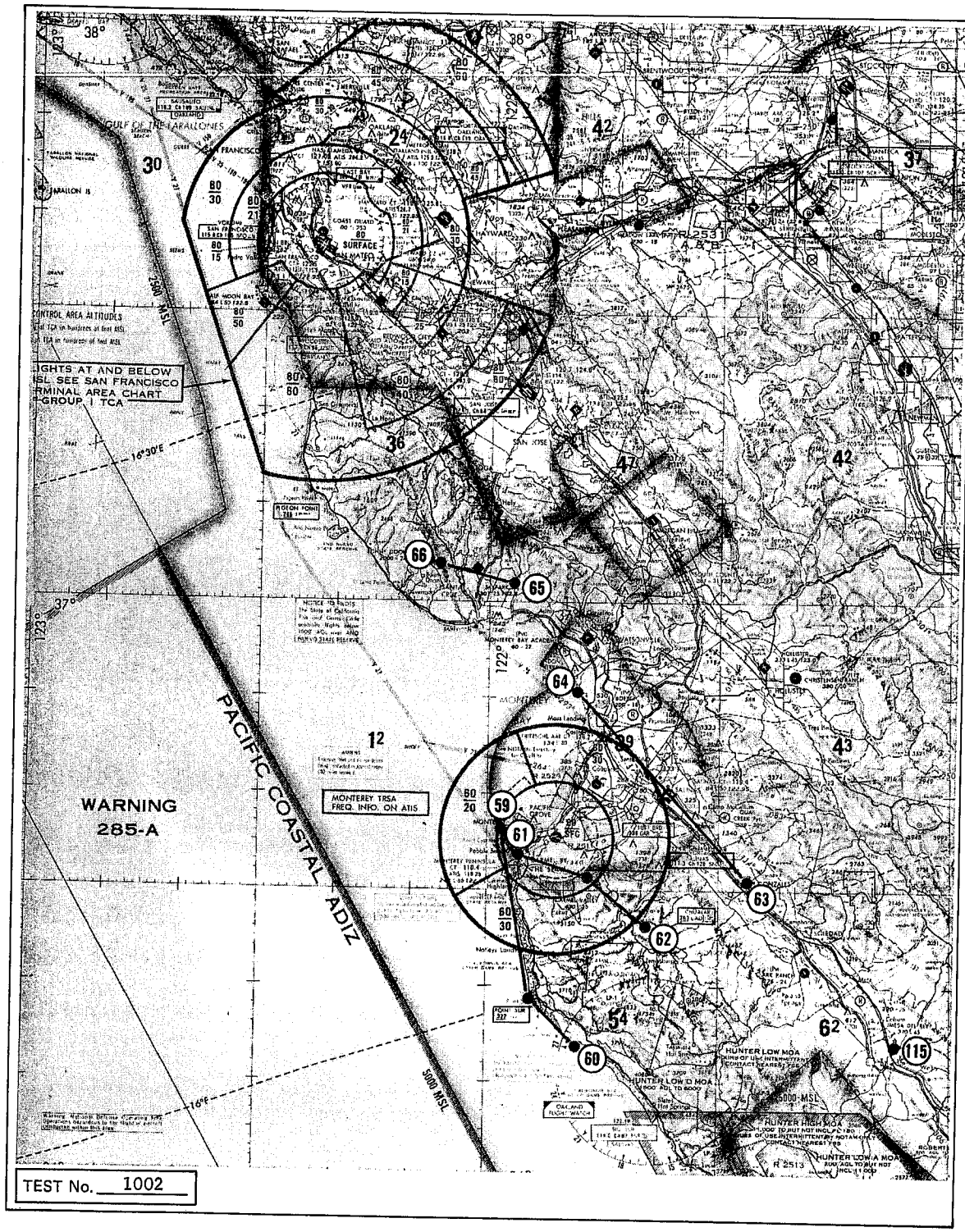


FIGURE 58b (CONCLUDED)

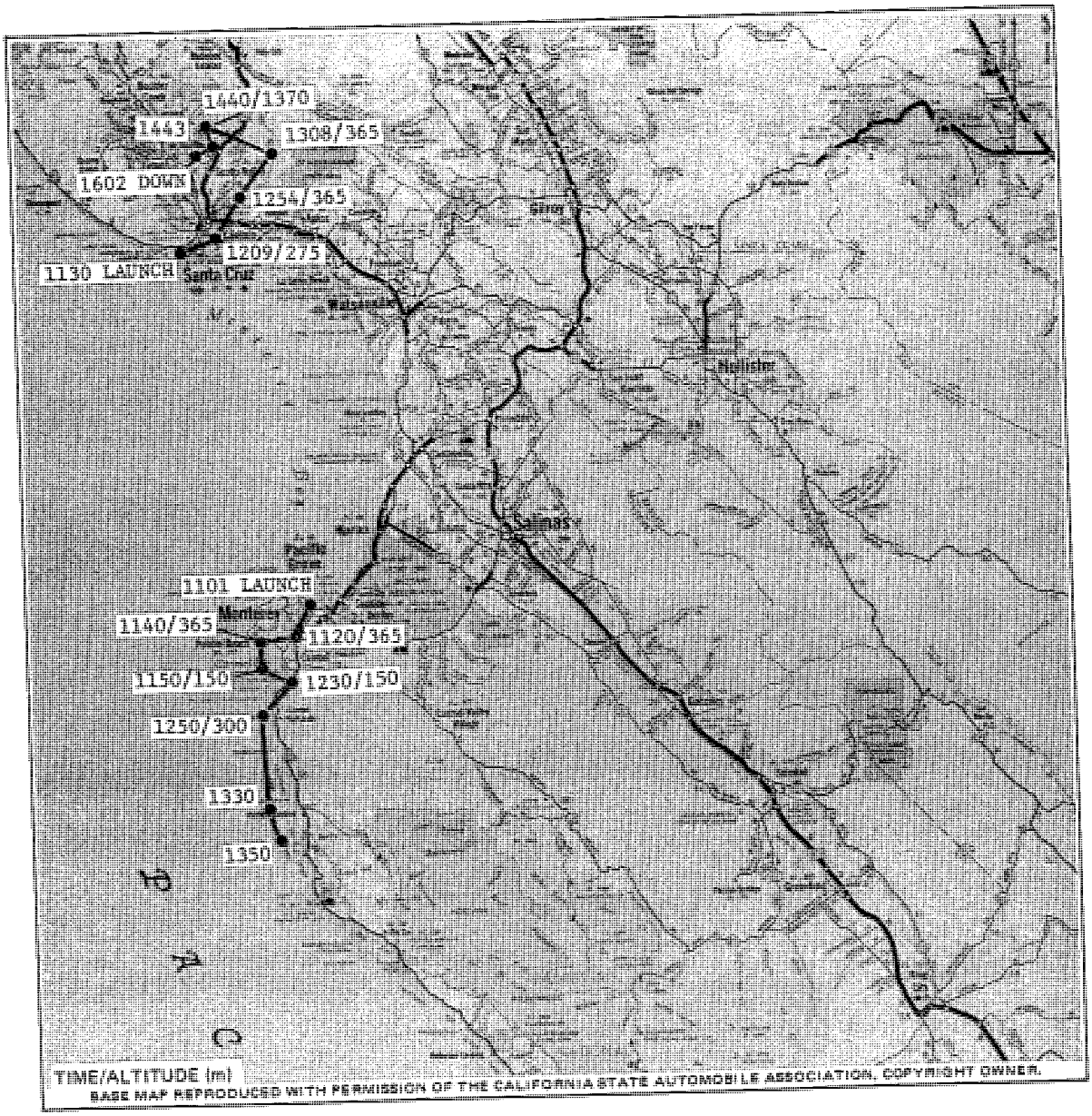
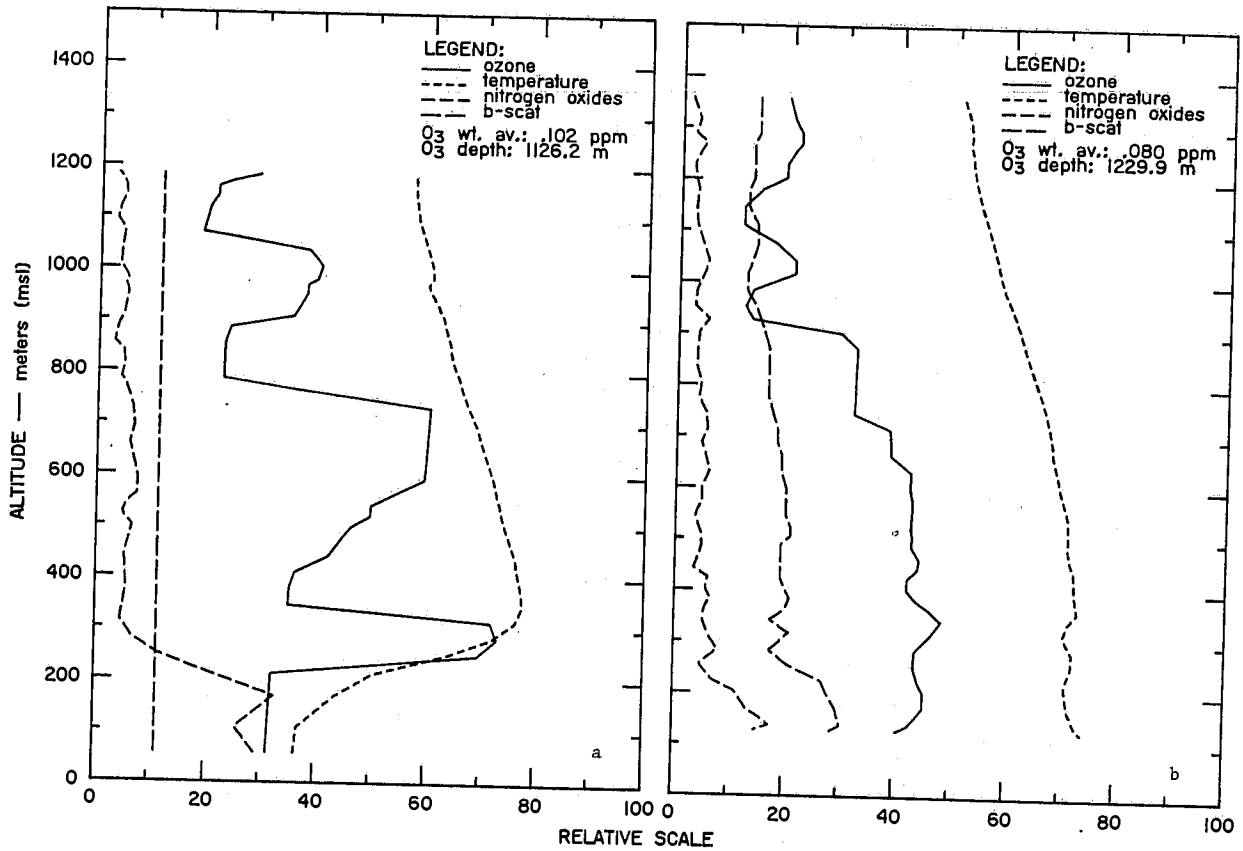
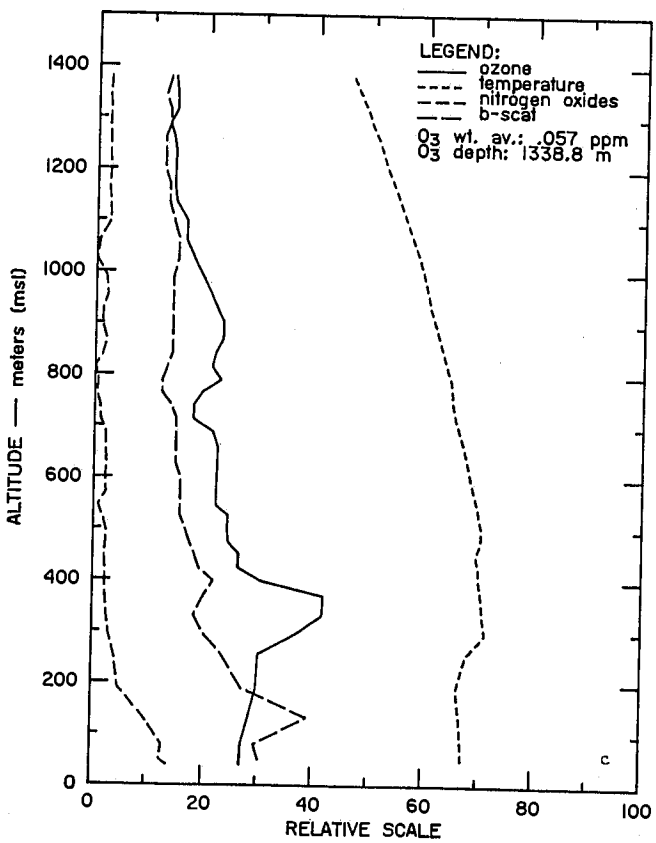


FIGURE 59 TETROON-DERIVED TRAJECTORIES, TEST 1002

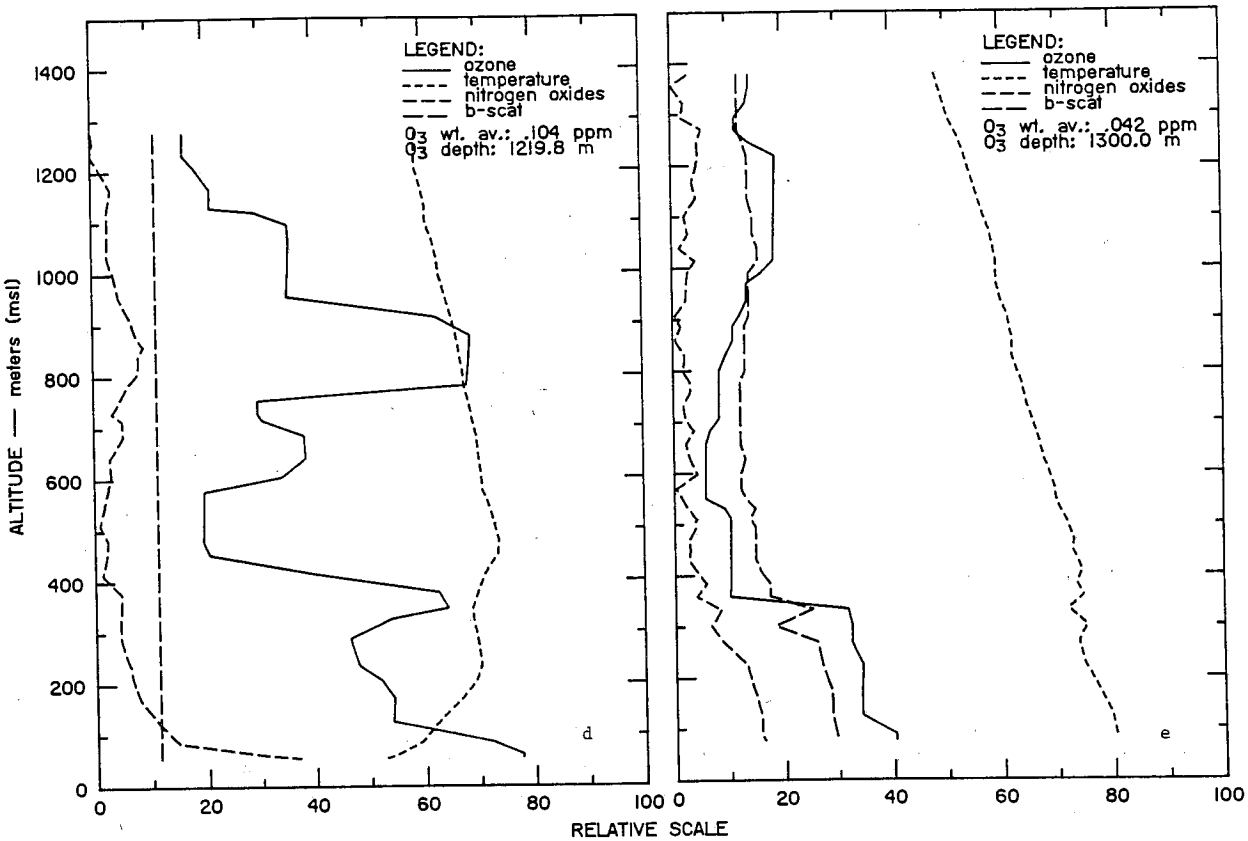


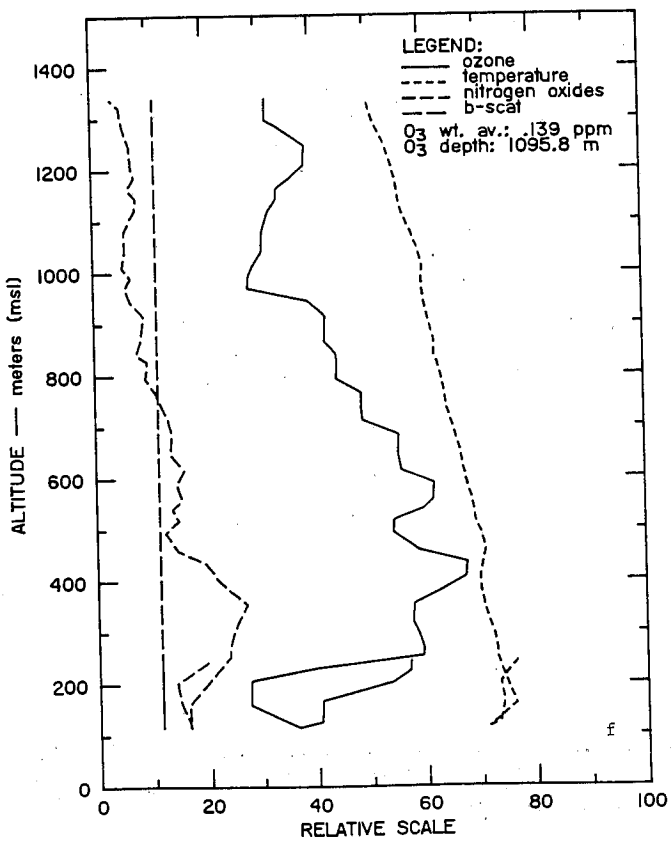


RELATIVE SCALE (n.d.)	ACTUAL VALUES			
	O_3 (ppb)	NO_x (ppb)	T (°C)	b_{scat} ($10^{-4}m^{-1}$)
0	0	0	5	0.
20	50	35	12	0.23
40	100	70	19	0.46
60	150	105	26	0.69
80	200	140	33	0.92
100	250	175	40	1.15

FIGURE 60 AIRCRAFT SOUNDINGS, TEST 1002

a) Watsonville Airport (1831-1839 PDT)
b) King City Airport (1226-1235 PDT)
c) Salinas Airport (1143-1151 PDT)

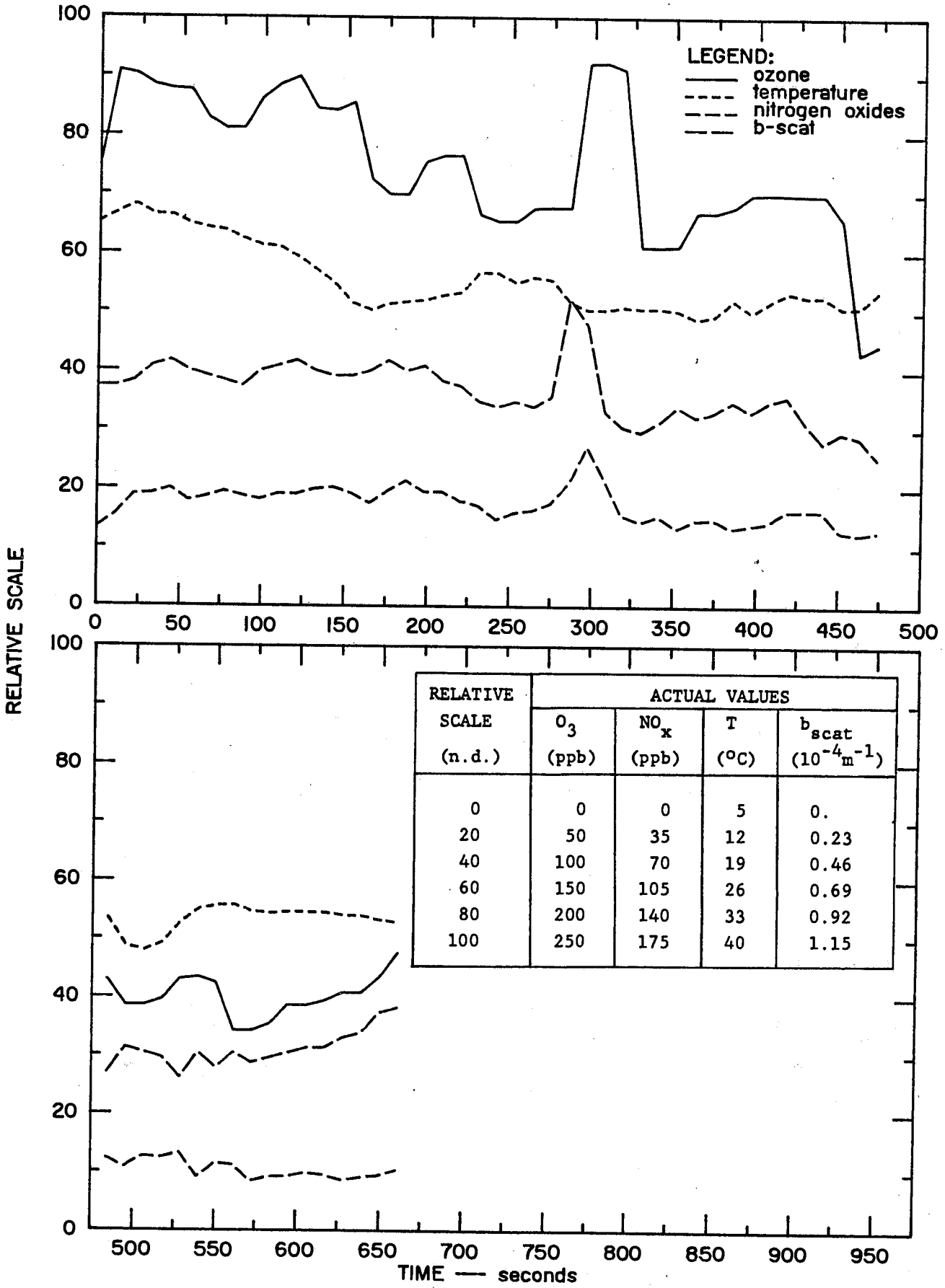




RELATIVE SCALE (n.d.)	ACTUAL VALUES O_3 (ppb)	NO_x (ppb)	T (°C)	b_{scat} ($10^{-4}m^{-1}$)
0	0	0	5	0.
20	50	35	12	0.23
40	100	70	19	0.46
60	150	105	26	0.69
80	200	140	33	0.92
100	250	175	40	1.15

FIGURE 60 (CONCLUDED)

d) Salinas Airport (1845-1853 PDT)
e) Hollister Airport (1256-1305 PDT)
f) Hollister Airport (1900-1909 PDT)



RELATIVE SCALE (n.d.)	ACTUAL VALUES O_3 (ppb)	NO_x (ppb)	T (°C)	b_{scat} ($10^{-4}m^{-1}$)
0	0	0	5	0.
20	50	35	12	0.23
40	100	70	19	0.46
60	150	105	26	0.69
80	200	140	33	0.92
100	250	175	40	1.15

FIGURE 61 AIRCRAFT TRAVERSE FROM MONTEREY (WAY-POINT 59) TO BIG SUR (WAY-POINT 60), TEST 1002

SF_6 was released from 1030 to 1230 PDT at the Santa Cruz Lighthouse, while F13B1 was released from 1015 to 1215 PDT at the Fisherman's Wharf parking lot in Monterey. Data from the surface-sampling network are given in Figure 62. The SF_6 tracer data confirm the representivity of the tetroon trajectory. From 1200-1300 PDT, Felton and Scotts Valley (Santa's Village) registered peaks of 354 and 177 ppt, respectively, while Gilroy and Morgan Hill were at 7 and 6 ppt. The following hour, Felton had decreased to 72 ppt and Scotts Valley to 54 ppt. Santa Cruz (Site 3, Highways 1 and 17), which did not sample the first hour, had an SF_6 concentration of 328 ppt for the hour (1300-1400 PDT). The near-stationary location of the tetroon near Scotts Valley after 1300 PDT is reflected in the surface SF_6 values. Santa Cruz (Site 3) continued at 252 ppt and Scotts Valley at 66 ppt. Felton was missing from 1400-1500 PDT, although Lexington Reservoir (Site 17) measured 10 ppt. (The 8-ppt value at Gonzales appears to be an anomaly, either a bifurcated puff or a contaminated sample.) Between 1433 and 1519 PDT, the Queen Air made five passes in the area where high surface values of SF_6 were recorded; see Table 20. Between Capitola and the summit (due north) at 300 m agl, SF_6 concentrations up to 115 ppt were encountered along the northern half of the traverse. Two east-west traverses centered over Scotts Valley were made; one at 300 m agl, the other 600 m agl. No SF_6 was detected at 300 m--consistent with the Capitola-summit flight. However, concentrations ranging from 20 to 37 ppt were detected along most of the 600-m traverse. The 1445-1454 PDT (215 m agl) flight from the summit to Santa Cruz above Highway 9 detected no traces of SF_6, nor did the 1514-1519 PDT flight at 300 m agl from Aptos to Watsonville.

From 1500-1600 PDT onward, Scotts Valley and Felton showed a steady decline in tracer concentration. However, there is an indication of transport into the Santa Clara Valley as a result of an increase in SF_6 seen during the evening, starting with 2100-2200 PDT and persisting until the last sampling hour (2300-2400 PDT). The 1603-1610 PDT aircraft flight at 250 m agl over the Carmel Valley detected SF_6 in the 5-ppt range along virtually the entire track. Similarly, the 1621-1632 PDT flight at 300 m agl encountered equivalent SF_6 levels along the northern half of the traverse (approximately from Salinas to Moss Landing). A late-afternoon traverse (1647-1650 PDT) over Scotts Valley at 300 m also detected SF_6 in the 5-ppt range. The 1900 PDT sounding at Hollister detected traces of SF_6 (and F13B1), but all lower than 5 ppt.

The major features of the transport away from Santa Cruz are further substantiated by the instantaneous tracer samples collected in the three vans. Perhaps most intersting are the 10-ppt surface SF_6 concentrations detected around 1430 PDT between Salinas and Chualar along Highway 101--a distance of 15 km. Similar concentrations were detected later (1611 to 1741 PDT) from Gonzales to King City--30 km. In contrast, the afternoon (1430-1800 PDT) sampling route that surveyed the area between Santa Cruz, Watsonville, Hollister, Morgan Hill, and Redwood Estates detected no traces of SF_6 (see Volume II for data tabulation).

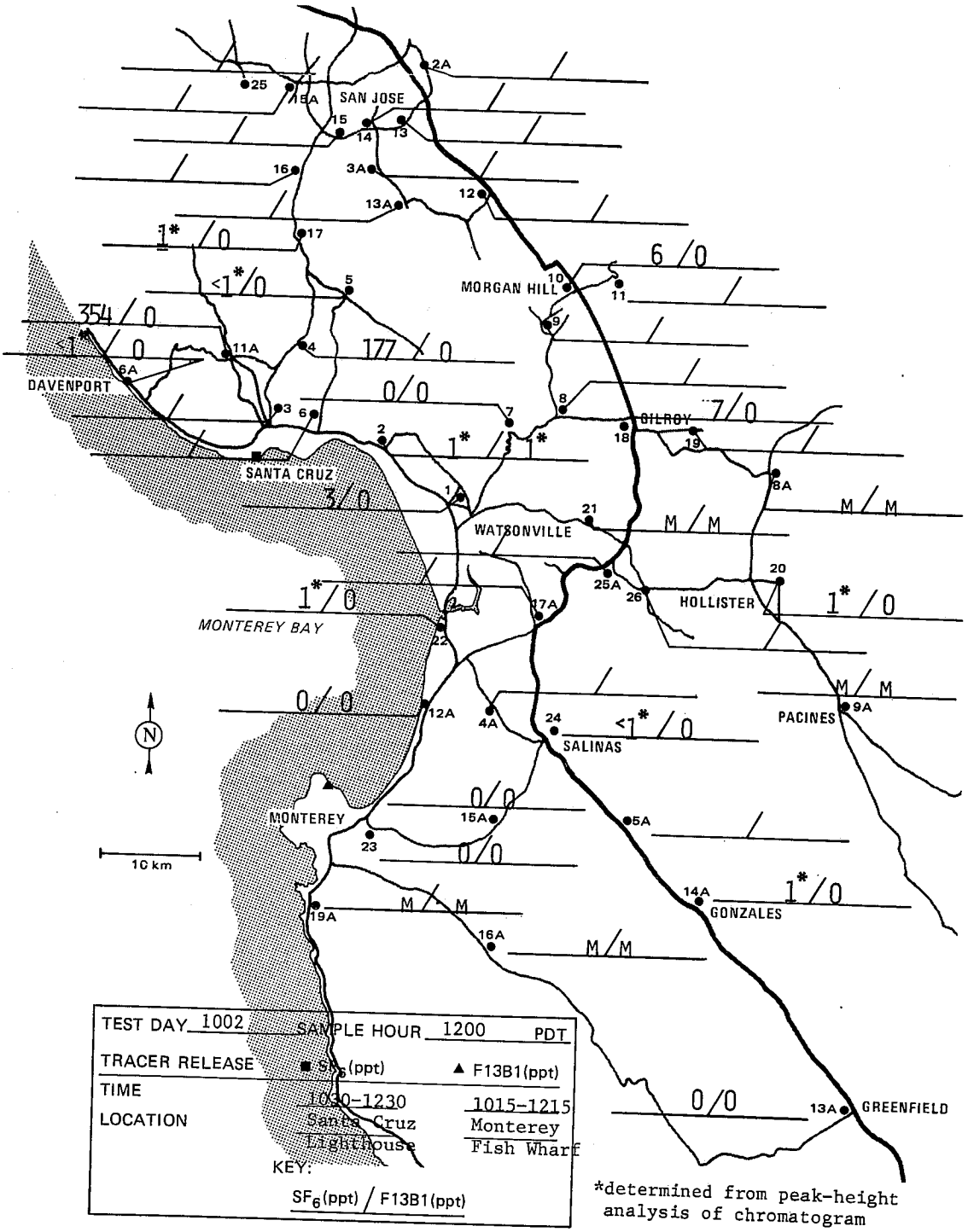


FIGURE 62a HOURLY SURFACE TRACER MEASUREMENTS, TEST 1002

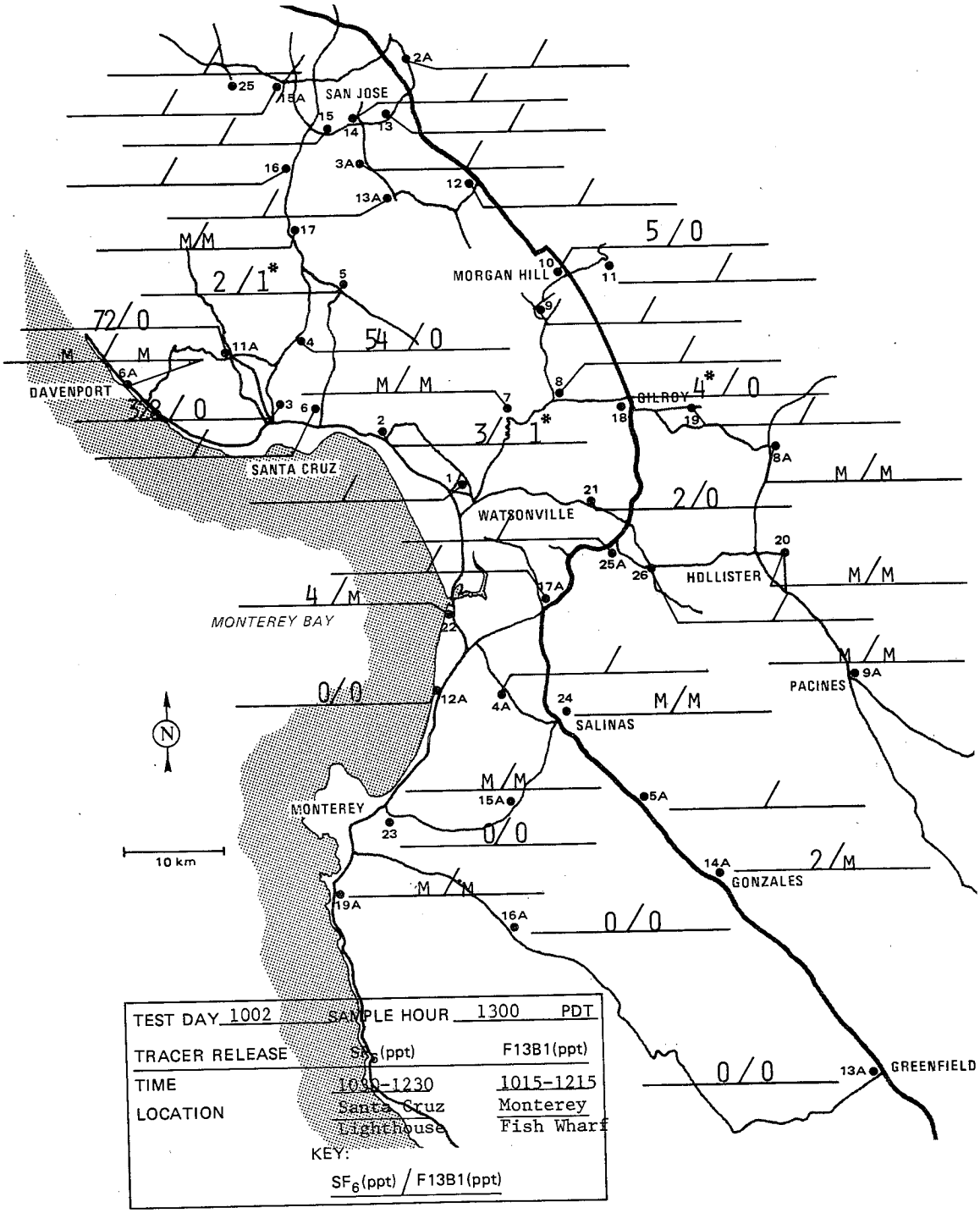


FIGURE 62b (CONTINUED)

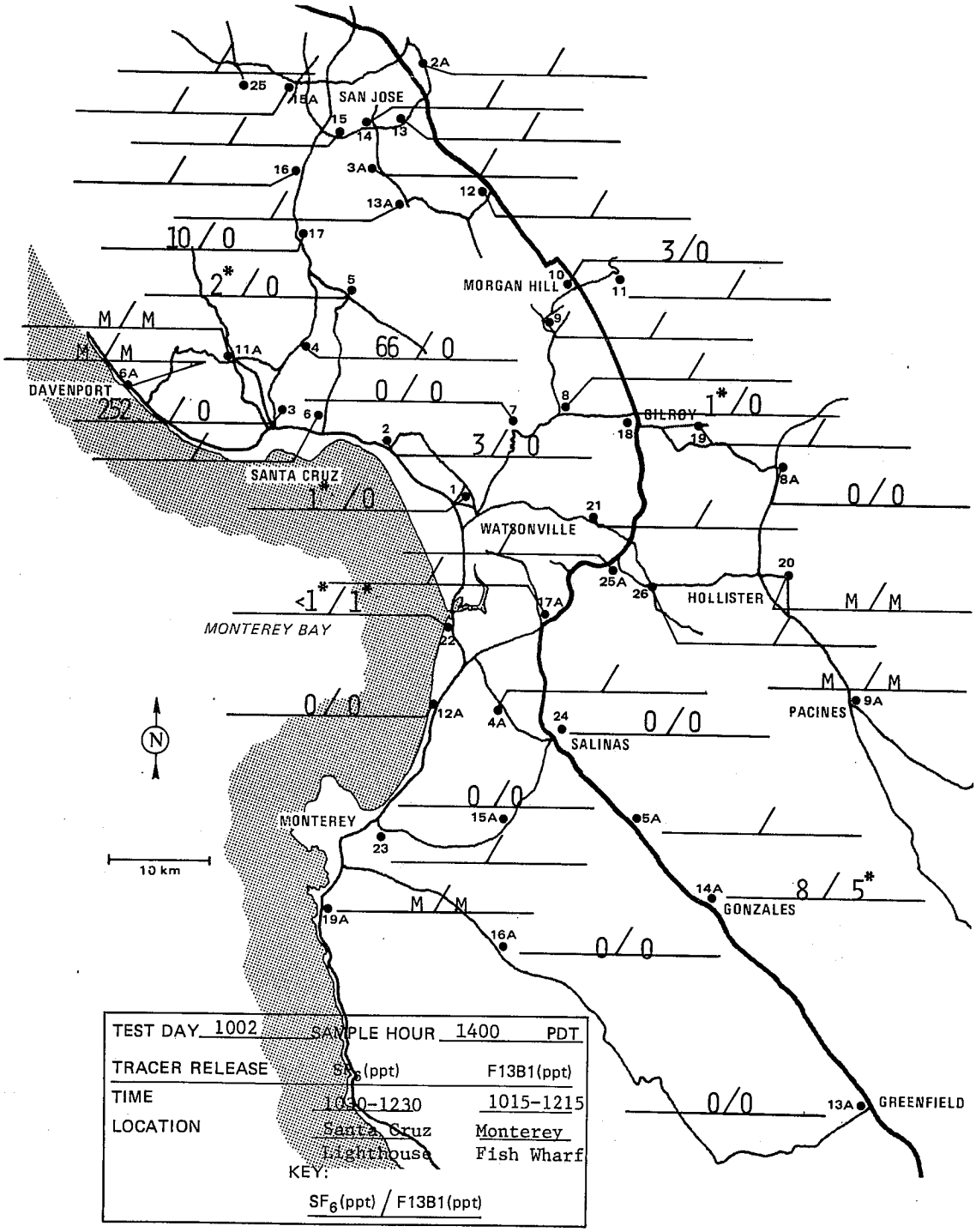


FIGURE 62c (CONTINUED)

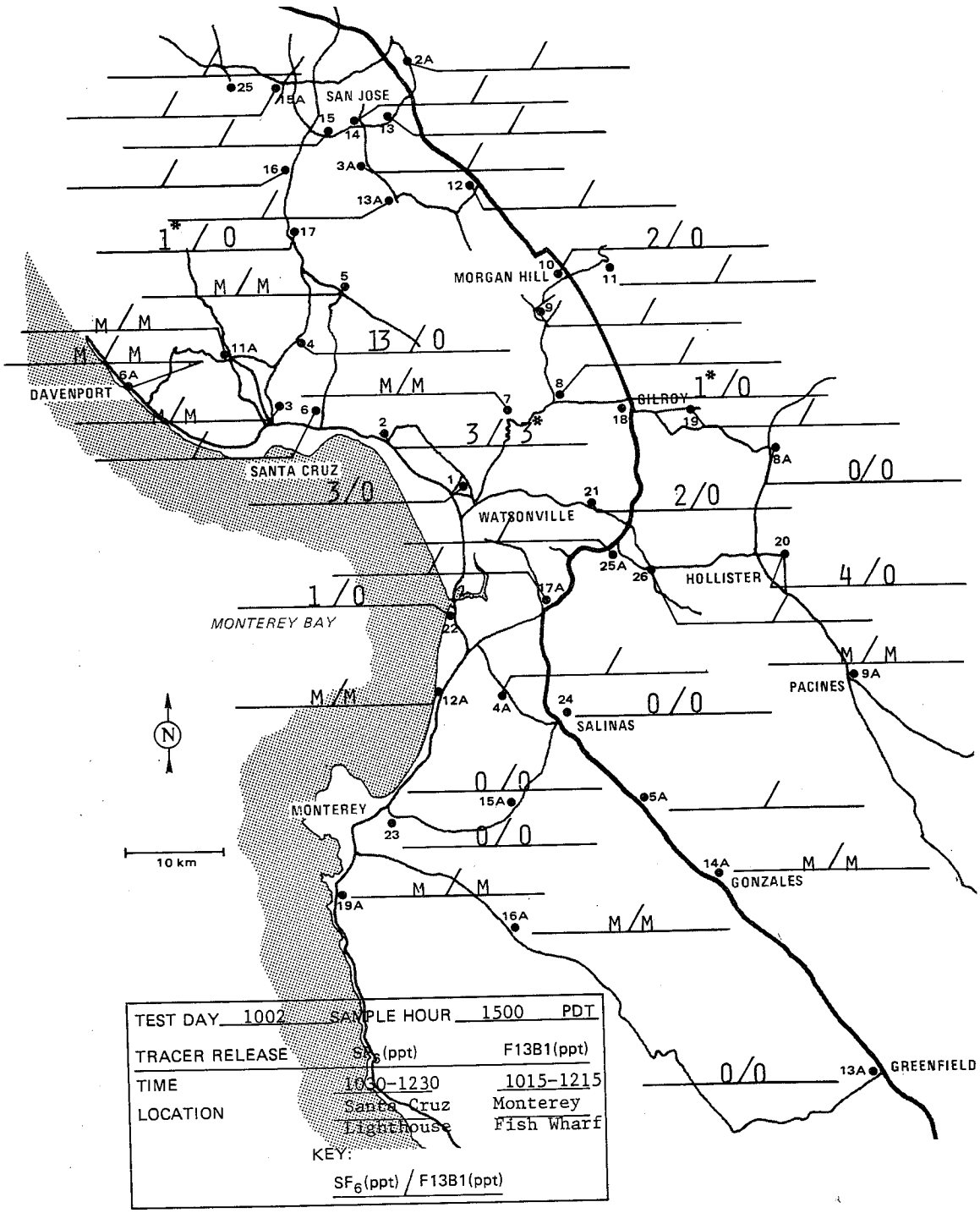


FIGURE 62d (CONTINUED)

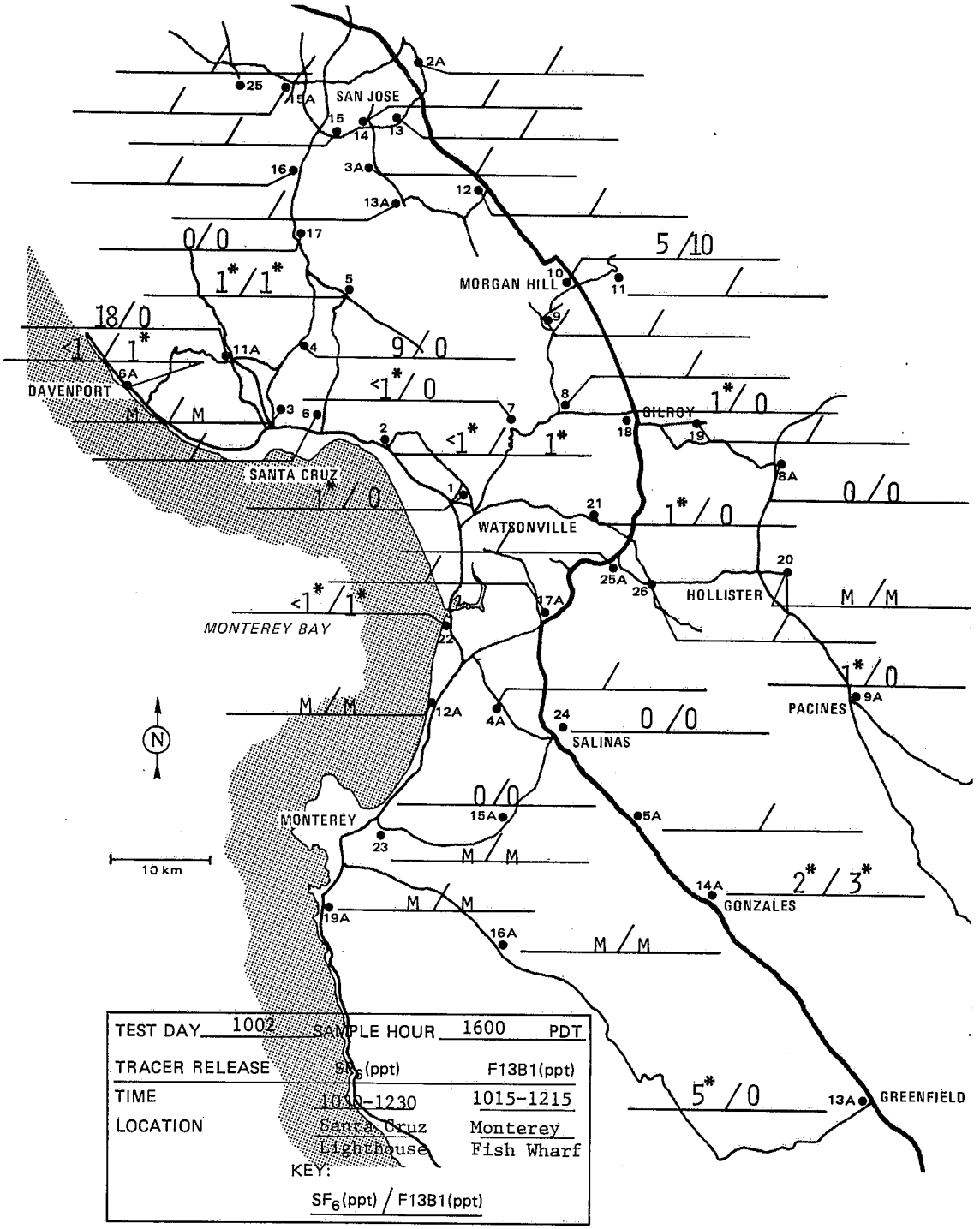


FIGURE 62e (CONTINUED)

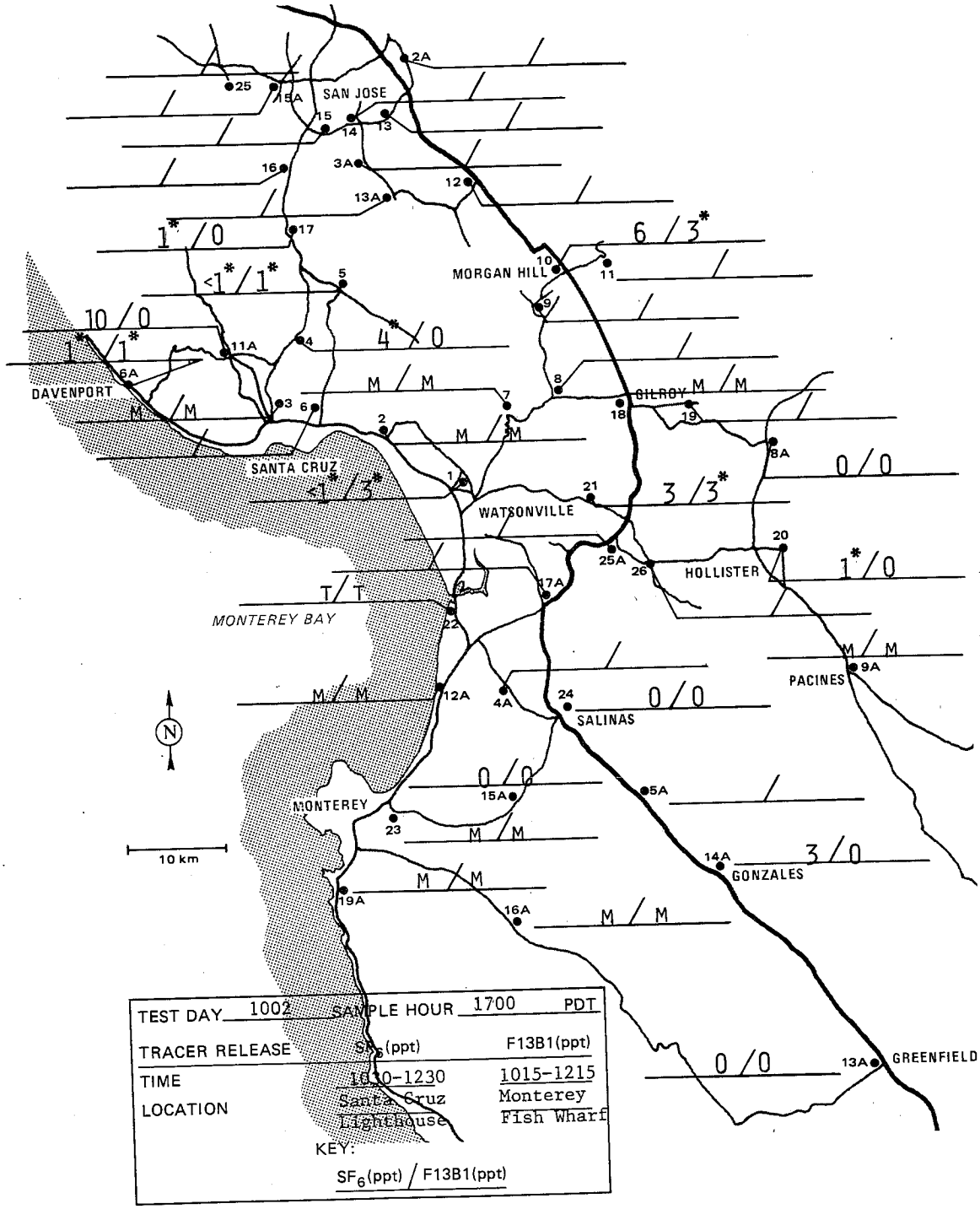


FIGURE 62f (CONTINUED)

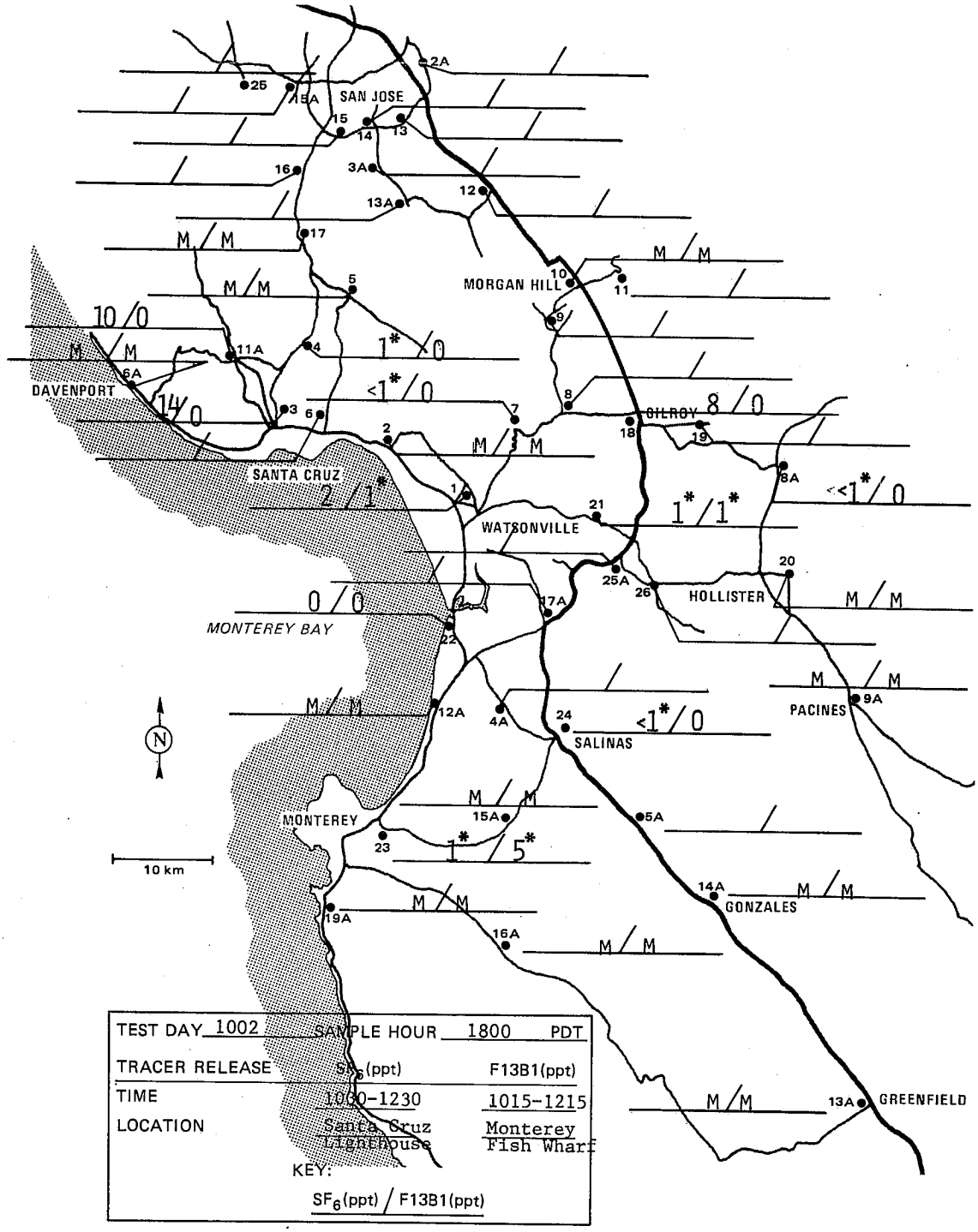


FIGURE 62g (CONTINUED)

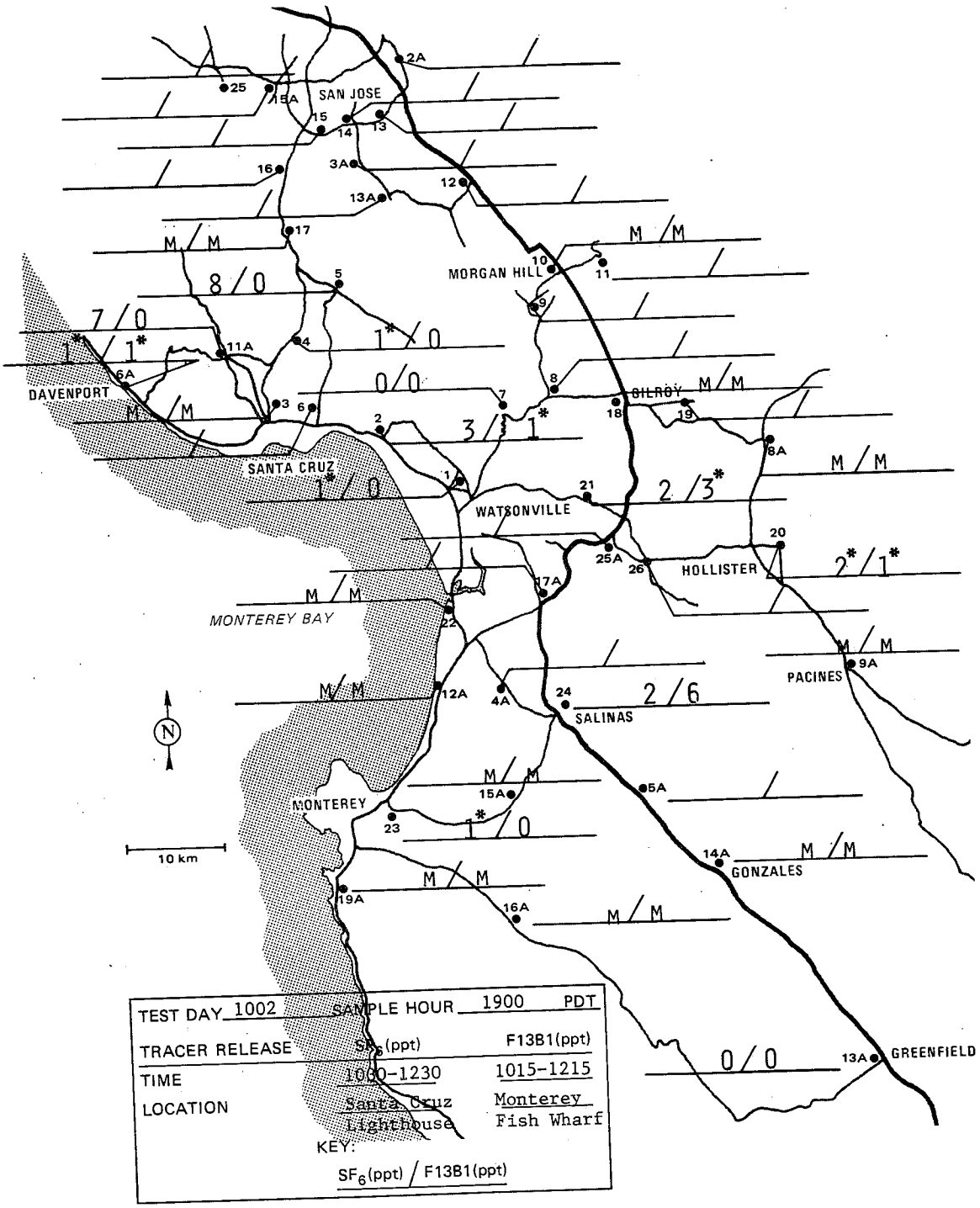


FIGURE 62h (CONTINUED)

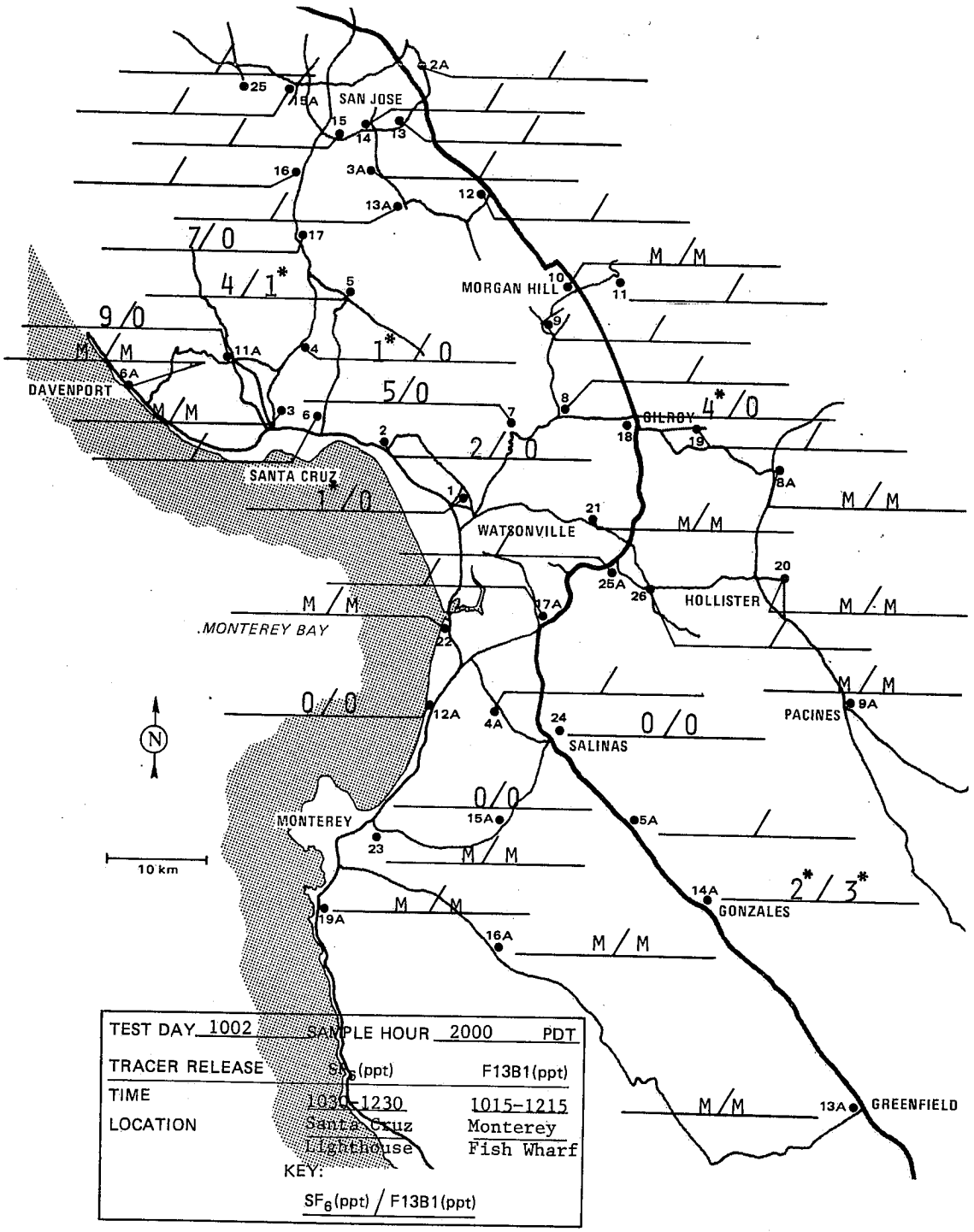


FIGURE 62i (CONTINUED)

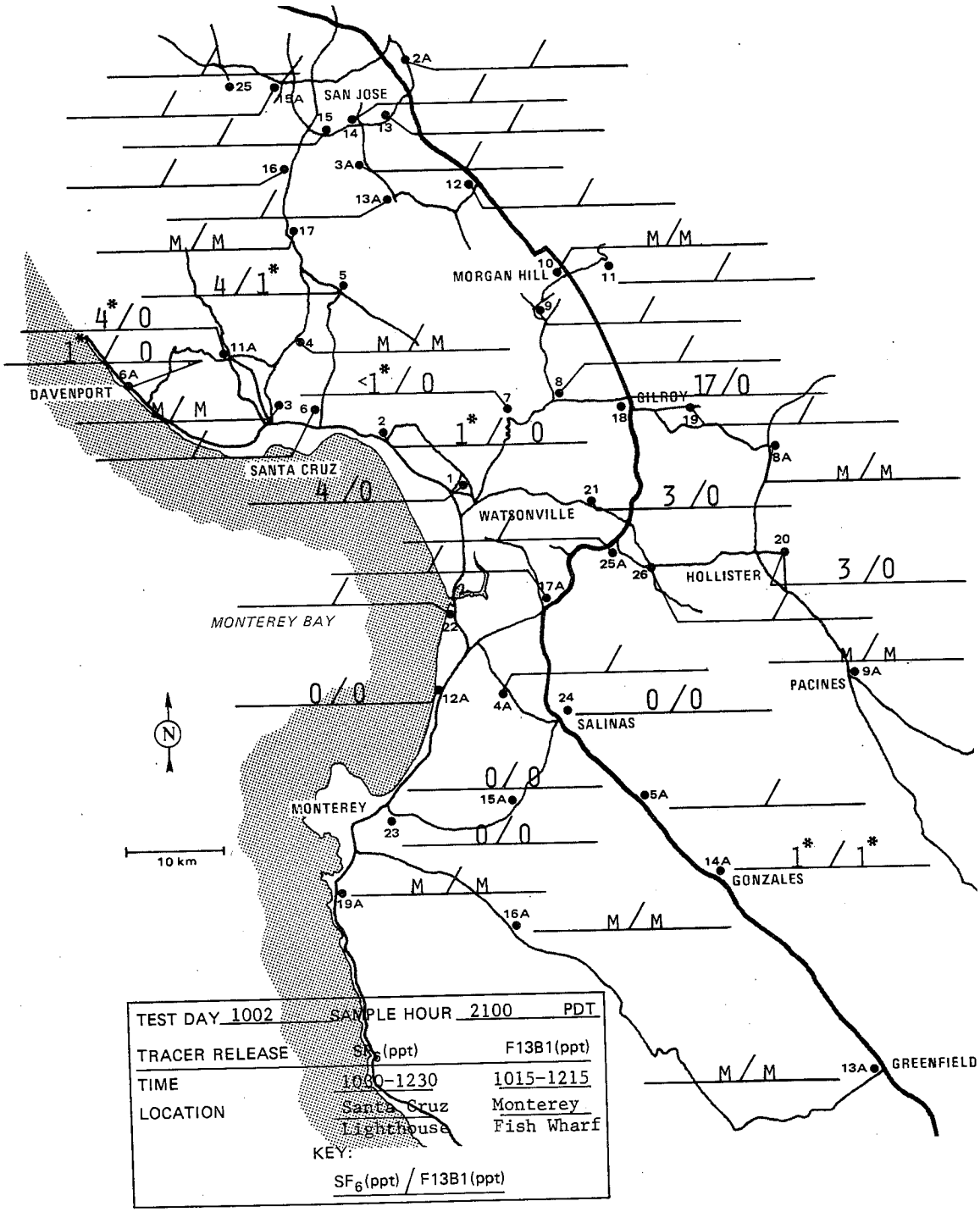


FIGURE 62j (CONTINUED)

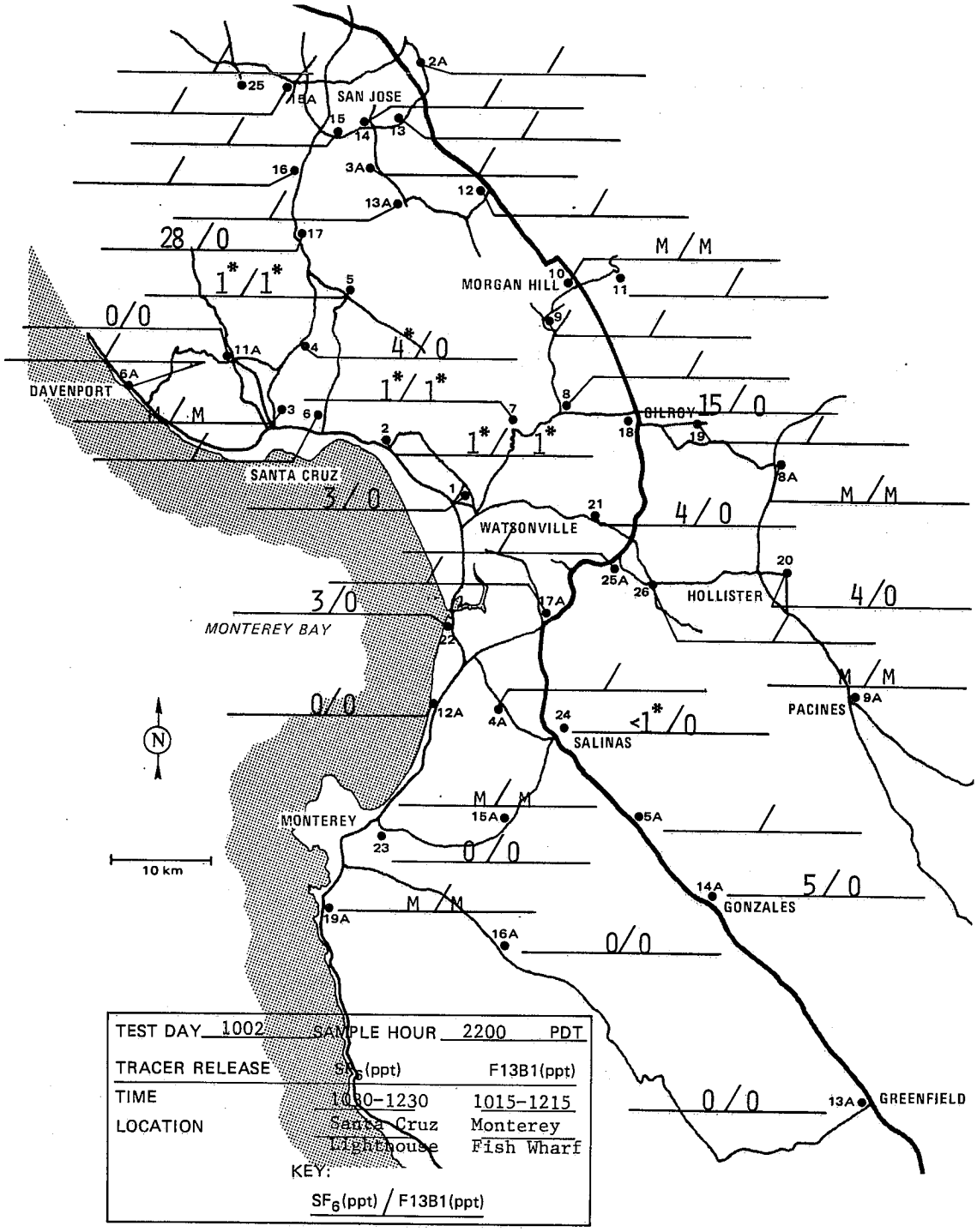


FIGURE 62k (CONTINUED)

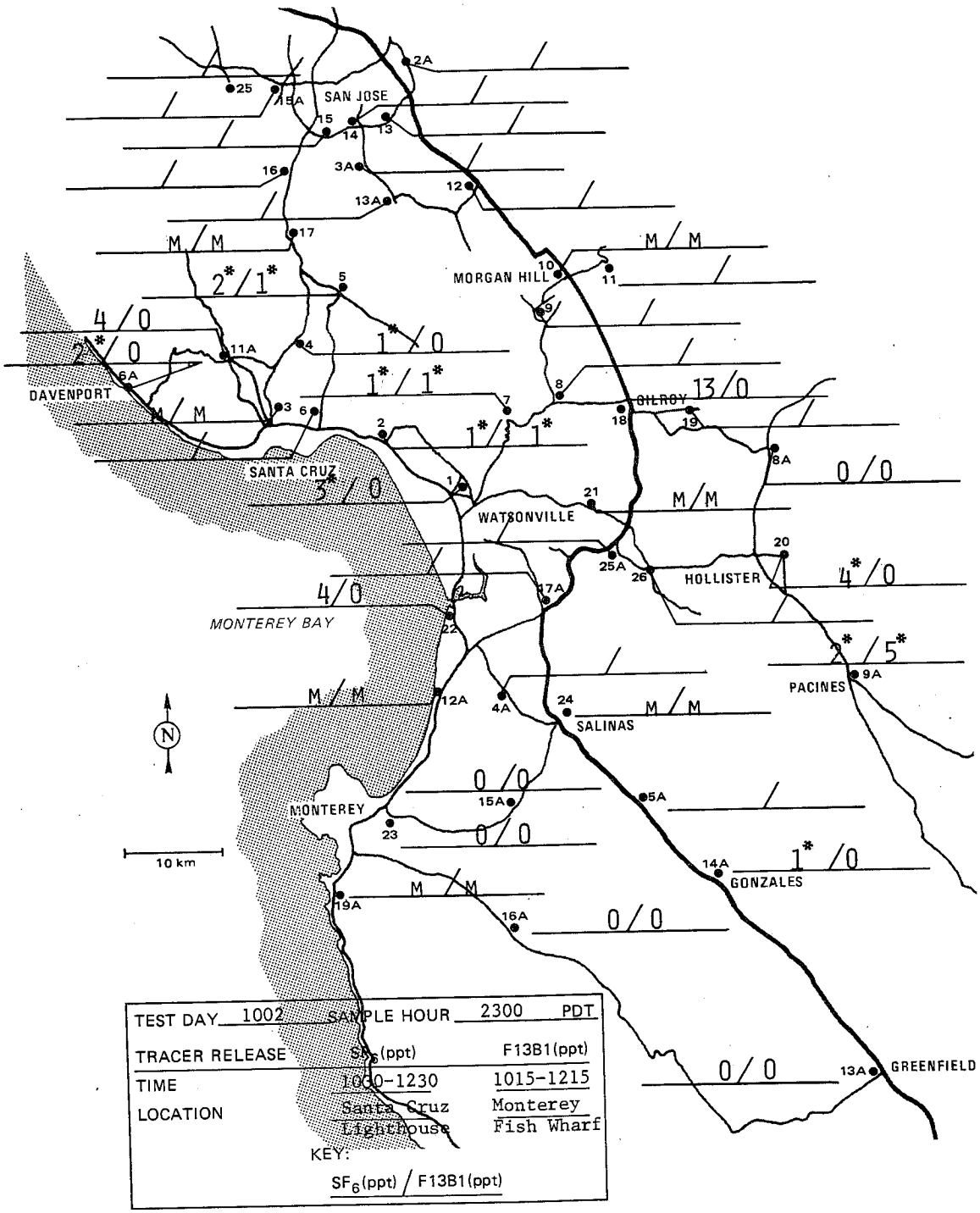


FIGURE 621 (CONCLUDED)

Table 20

AERIAL TRACER GAS CONCENTRATIONS (ppt)

AIRCRAFT: Queen Air DATE: 10-2-80 FLIGHT: ____

	TIME (PDT)	ALT (ft)														SAMPLING INTERVAL (sec)	TIME (PDT)	
51	1433 CAPITOLA	1000agl	0	0	0	0	0	72	31	115	32	t(8)	0	0	SF_6	20	1437 SUMMIT	52
			0	0	0	t(10)	0	t(7)	0	0	0	0	0	0	F13B1			
55	1501 SCOTTS	1000agl VALLEY	0	0	0	0	0	0	0	0	0	0	0	0	SF_6	18	1504 WEST	56
			0	0	0	0	0	0	0	0	0	0	0	0	F13B1			
55	1510 SCOTTS	2000agl VALLEY	0	0	t(2)	19	26	t(12)	35	37	31	27	38	20	SF_6	18	1506 WEST	56
			0	0	0	0	0	0	0	0	0	0	0	0	F13B1			
	—	—													SF_6	—	—	
															F13B1			
	—	—													SF_6	—	—	
															F13B1			

Very little of the F13B1 released at midday in Monterey was detected by either the surface network, airplane, or vehicles. Referring to Figure 62, there are sporadic traces (1 to 3 ppt) at Moss Landing, Aptos, Hecker Pass, Hollister, and Salinas; these were observed starting at 1400 PDT. The 5-ppt level concentrations observed at Gonzales may suggest some organized transport to the southeast, although the adjacent stations detected no F13B1 at or near those hours. However, the only aircraft measurements of F13B1 above a trace are from the 1621-1632 PDT flight at 300 m agl above Salinas. Grab samples from the vans indicate a discontinuous plume of F13B1 between Castroville and Gonzales; the measurements, which peak at 25 ppt, were taken between 1338 and 1500 PDT. Later in the day (1700-1840 PDT) F13B1 concentrations around 10 ppt were observed from Salinas to King City. The tracer sampling vans also detected isolated traces of F13B1 in the midafternoon in the 5- to 10-ppt range between Santa Cruz, Watsonville, Hollister, and Morgan Hill; they do not appear to indicate any organized transport. No F13B1 was detected by the airplane in its sampling run down the coastline from Monterey to Big Sur.

In summary, it appears that transport away from Santa Cruz is a complicated phenomenon, while little was learned of transport out of Monterey. Two transport routes can be identified for Santa Cruz: one to the north into the mountain valleys of Scotts Valley and the San Lorenzo Valley; the other to the southeast down the Salinas Valley. The initial structure of the Salinas route is not known, though it may entail transport over Monterey Bay. The northerly route with the moderate tracer concentrations aloft at 600 m agl (although not at 300 m) is probably complicated by terrain effects. However, the lack of tracer found in the Watsonville-Aptos area does suggest some bifurcation of the puff over the two-hour period of the release.

8. Test 1006: 6 October 1980

The early-morning surface weather map (Figure 63) indicates the presence of a thermal trough aligned NW-SE through central California. The SFO-RNO surface pressure difference increased from Test 1002 to -3.6 mb. The 850-mb temperature (22°C) was 1.4 standard deviations above the period norm, while the 850-mb wind was from the south at 12 m s^{-1}. Surface winds at Watsonville varied considerably throughout the test period: from 09-1300 PDT, winds were SE-SSE at 1-2 m s^{-1}; 13-1600 winds generally were WSW at about 4 m s^{-1}; then SSW at 1.5-3 m s^{-1} from 16-1900; and approximately SW at 0.5-1 m s^{-1} until 2100 PDT when they began veering to the NW while staying light. Stratus was widespread in the morning; Hollister and Watsonville had tops of 400 m msl in the early morning. Insolation dissipated the stratus around noon at the coastline, and earlier inland. The hourly ozone peak for the day (Figure 64) occurred at 15-1600 PDT at Gilroy with a value of 140 ppb. However, the peak was rather isolated and short-lived, particularly in contrast with the preceding week's ozone episode. Peaks within the NCCAB included 100 ppb at Hollister, 90 ppb at Watsonville, and 60 ppb at Salinas and Gilroy. The Hollister peak-value occurred abruptly at

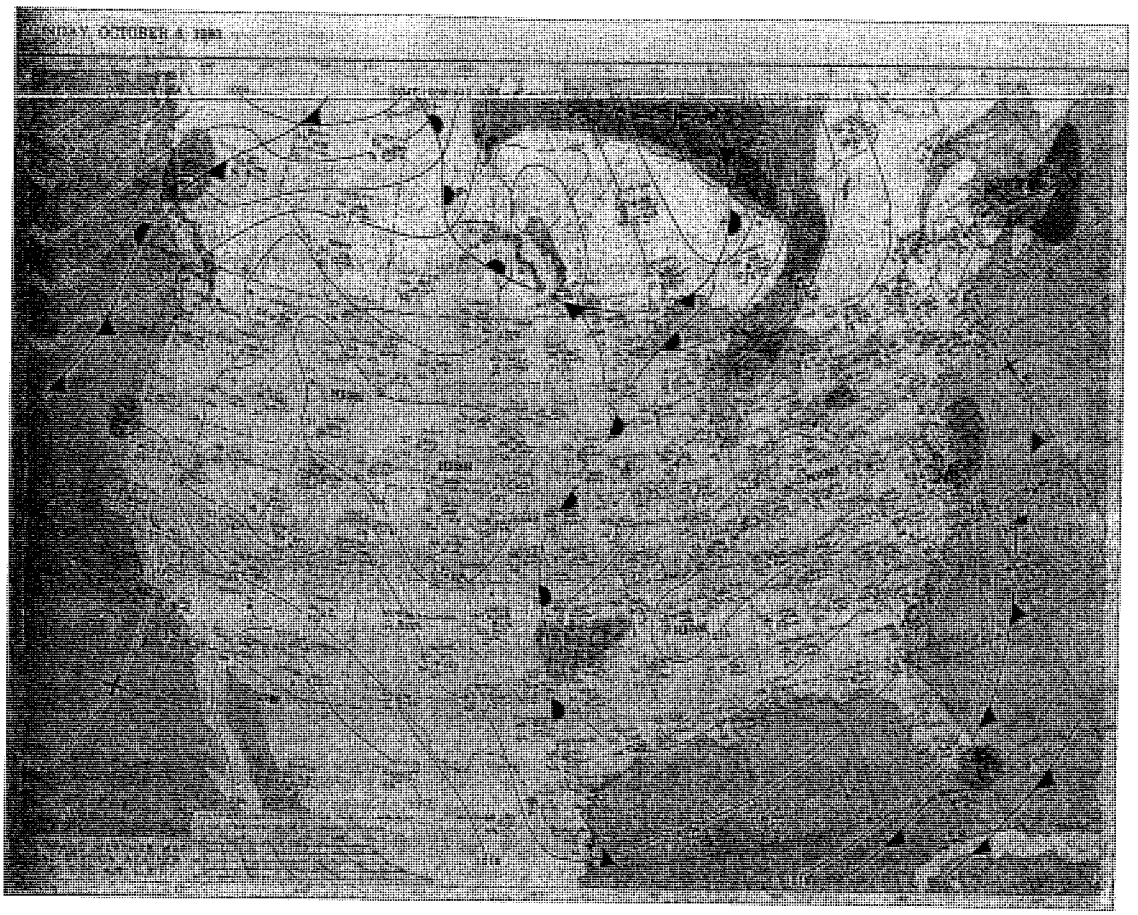


FIGURE 63 SURFACE WEATHER MAP, 0500 PDT, TEST 1006

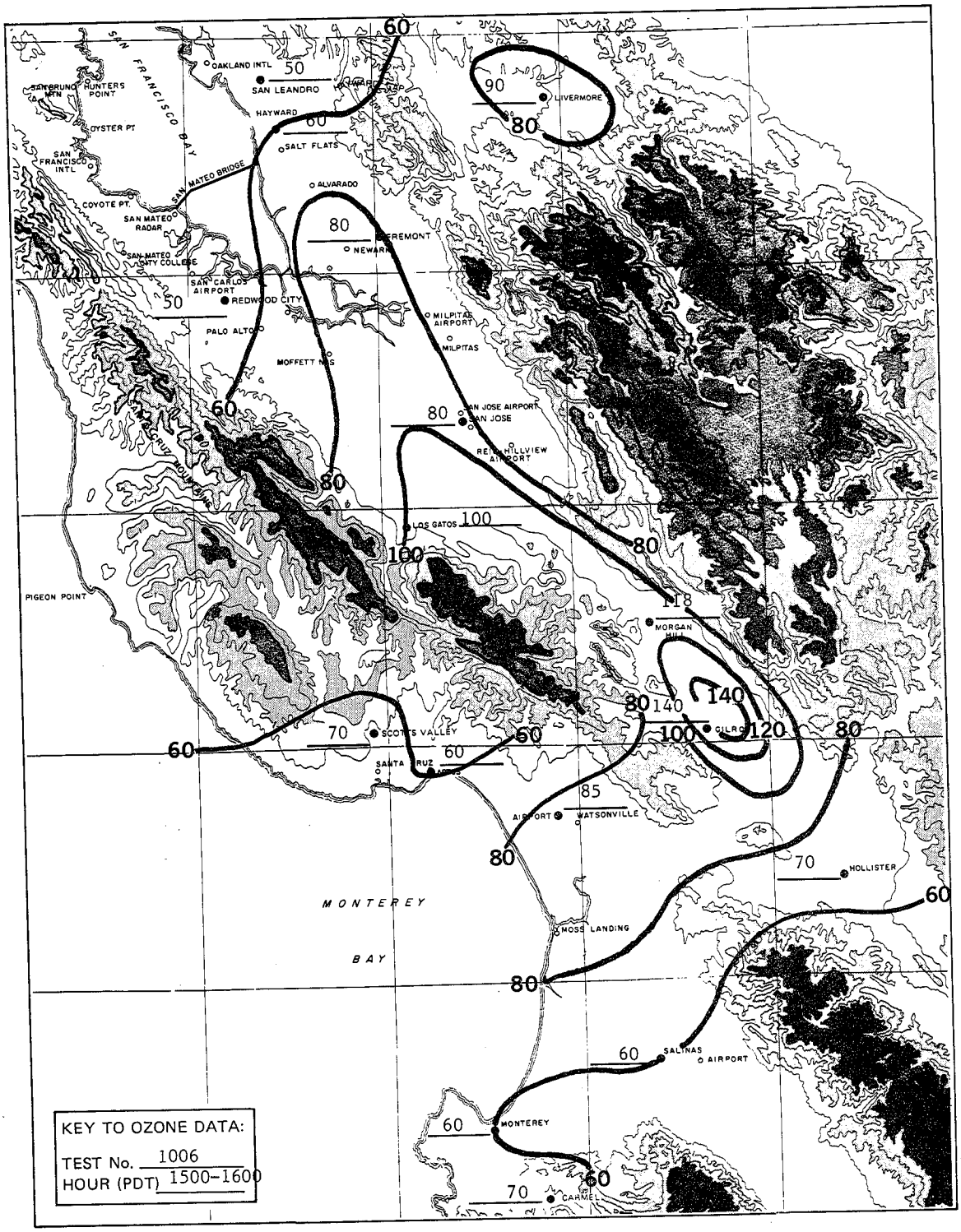


FIGURE 64 DISTRIBUTION OF SURFACE OZONE (ppb), PEAK HOUR, TEST 1006

13-1400 PDT; the preceding hour had only 50 ppb ozone and the following hour, 60 ppb. The explanation for the short-lived peak is in the Santa Clara-San Benito Valley transport pattern, see Table 21. For the four-hourly interval 10-1400 PDT, winds at Hollister supported transport up the Santa Clara Valley into the San Benito Valley at an average speed of about 2 m s^{-1}. During the peak hour at Hollister, Gilroy had a corresponding ozone value of 130 ppb. However, the wind backed abruptly to WSW at Hollister beginning at 14-1500 PDT. With the transport pattern altered, Hollister ozone concentrations decreased 40 ppb in the hour following the peak; Gilroy remained in WNW flow throughout the afternoon and early evening and ozone concentrations first continued to increase and then decreased gradually during late afternoon.

Both tracers were released during late morning at Moss Landing. SF_6 was emitted from 1030-1230 PDT at a rate of 54 kg h^{-1} from one of the 150-m stacks at the PG&E Moss Landing Power Plant. F13B1 was released at the surface at 35 kg h^{-1} from 1049-1245 PDT at a location about 400 m NW of the SF_6 release. The tetroon was launched at 1140 PDT from the PG&E yard; Figure 65 illustrates its trajectory through the afternoon. At 1215 PDT it was only 50 m offshore at an altitude of 400 m southwest of the launch. At 1254 PDT, the tetroon was at 660 m, 1.5 km due south-southwest of the launch site. An hour later (1347 PDT), the tetroon was up to 945 m, 2.5 km north-northeast of the power plant. The tetroon continued its erratic movement throughout the afternoon. At 1516 PDT, it was 3 km southwest of the town of Aromas near Pajaro Gap; at 1554 PDT it was still heading north-northeast (altitude, 840 m). However, around 1800 PDT the tetroon was still at 760 m, but was now 0.8 km west of Fremont Peak (essentially midway between Hollister and Salinas).

The fixed tracer-sampling network data for the hours 12-1300 through 23-2400 PDT are illustrated in Figure 66a-l. The F13B1 measurements indicate the plume was initially transported to the ENE: the 12-1300 PDT data show a single large peak (2094 ppt) at site 25A (on Highway 101, west of San Juan Bautista). Mobile surface sampling (see data Volume II) at the same time indicated concentrations from 451 to 948 ppt along Highway 156 between Castroville and Prunedale, and 138 to 861 ppt on Highway 101 from Santa Rita northward for 11 km (just north of Prunedale). About one hour later (1341-1344 PDT), F13B1 concentrations of 16-262 ppt were observed along the same segment of Highway 101. Starting at 14-1500, F13B1 had been transported up the Salinas Valley to Gonzales where the hourly concentration was 18 ppt. Mobile samples during the same hour indicated a broader extent of F13B1 (25-50 ppt) in the Valley extending from a few km south of Salinas to Greenfield, about 40 km to the SE. Both the fixed stations at Greenfield and Gonzales detected moderate concentrations (7-36 ppt) the next two hours (15-1700 PDT), followed by zero levels the remainder of the evening. A mobile traverse on the ground through the San Benito Valley around 1600 PDT indicated 10- to 20-ppt levels in the Tres Pinos-Paicines area; this was followed by a 22-ppt hourly value at the fixed site in Hollister at

Table 21

SANTA CLARA-SAN BENITO VALLEY WIND VARIATIONS,
OCTOBER 6, 1980

Time (PDT)	Wind Direction/Speed* Downtown San Jose	Morgan Hill	Hollister
08-09	360/02	279	var/02
09-10	045/01	286	var/02
10-11	360/03	276	315/03
11-12	315/02	255	315/03
12-13	315/03	251	315/05
13-14	338/04	294	315/05
14-15	315/04	300	248/09
15-16	338/04	299	248/10
16-17	338/03	300	270/07
17-18	338/04	297	270/07
18-19	338/02	296	var/03
19-20	338/03	290	var/03
20-21	315/02	104	var/02

*deg(true)/mph

(1) = Upvalley flow (San Jose to Hollister)

(2) = Cross-valley flow

(3) = Downvalley flow (Hollister to San Jose)

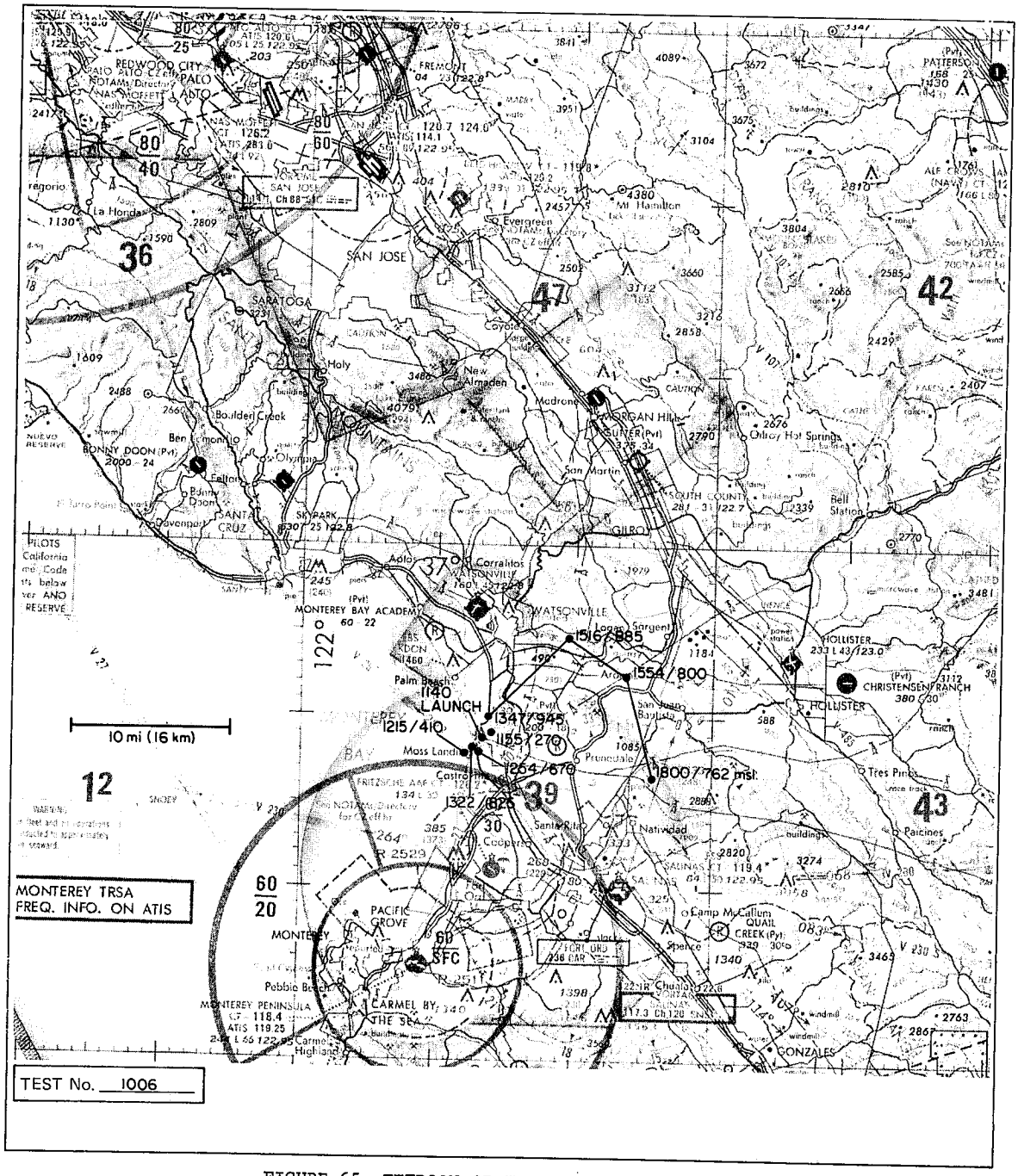


FIGURE 65 TETROON OBSERVATIONS, TEST 1006
[time (PDT)/altitude (m, agl)]

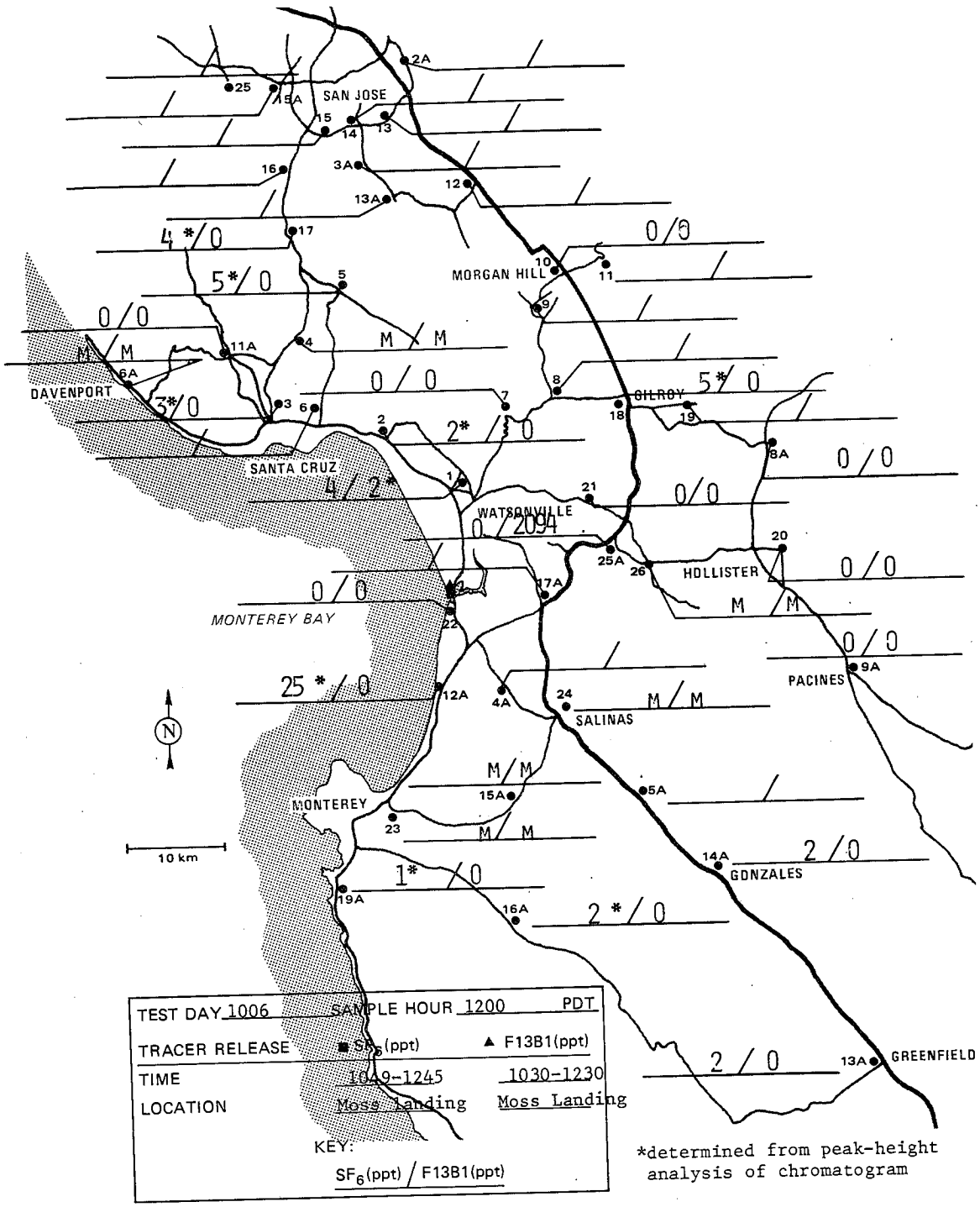


FIGURE 66a HOURLY SURFACE TRACER MEASUREMENTS, TEST 1006

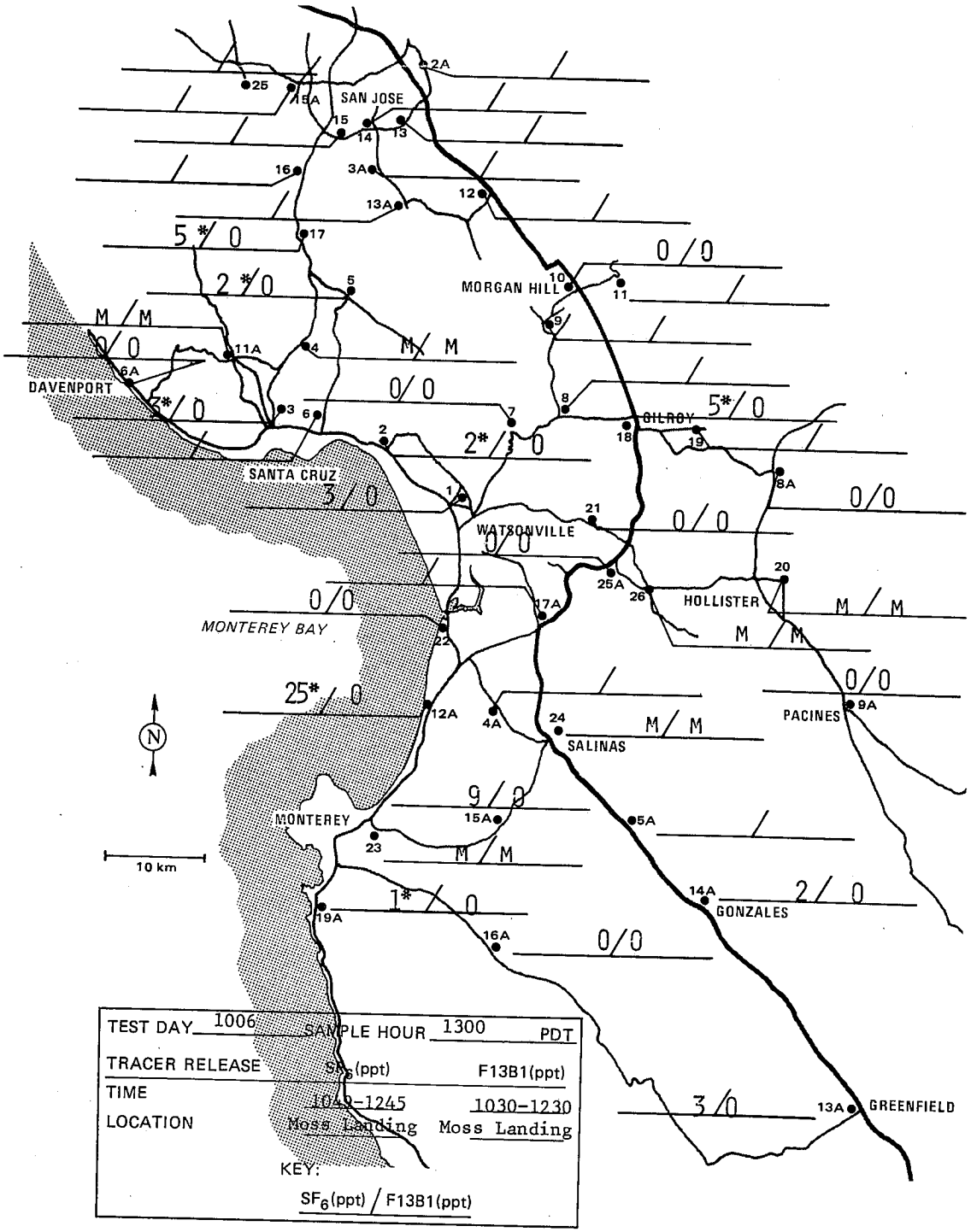


FIGURE 66b (CONTINUED)

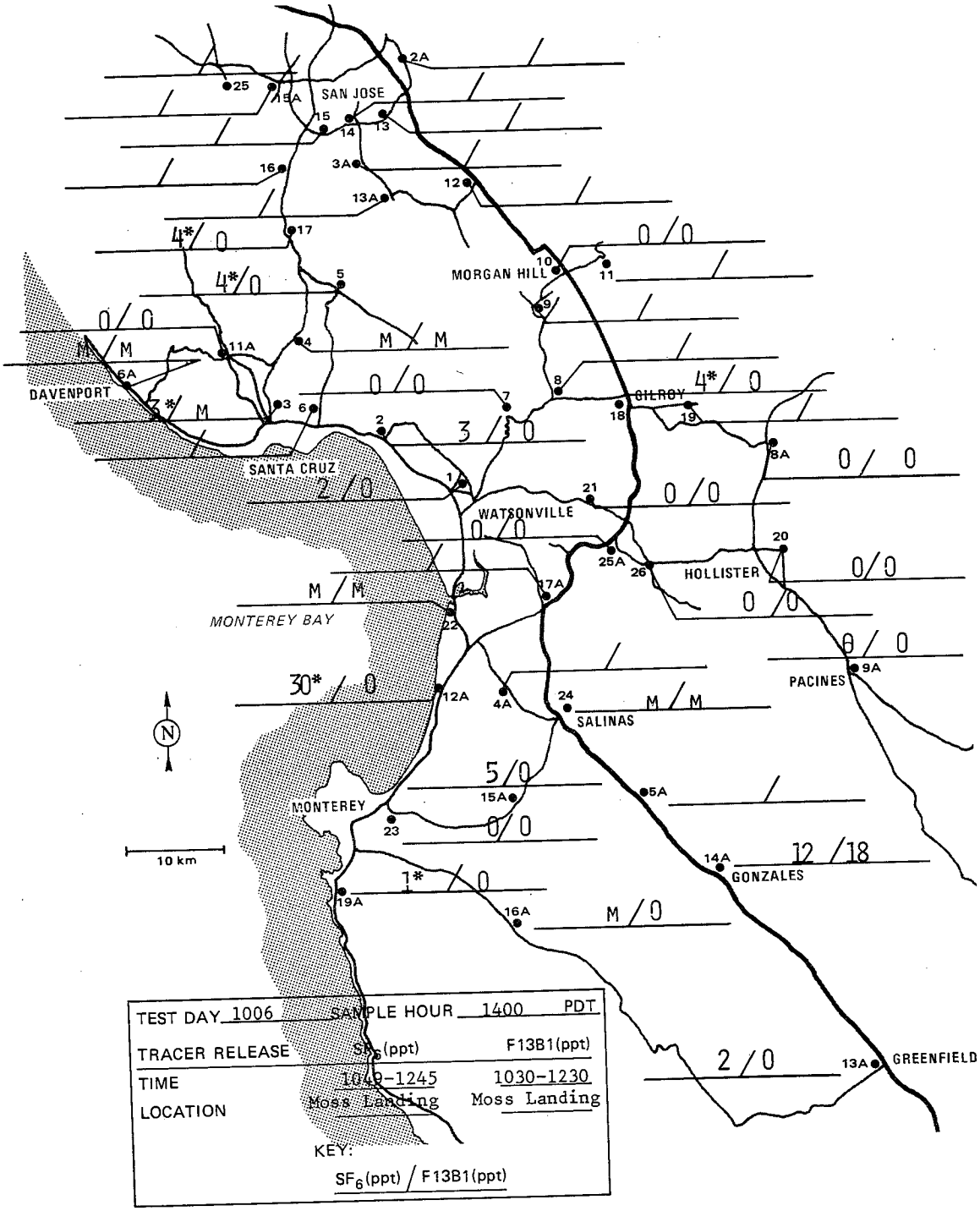


FIGURE 66c (CONTINUED)

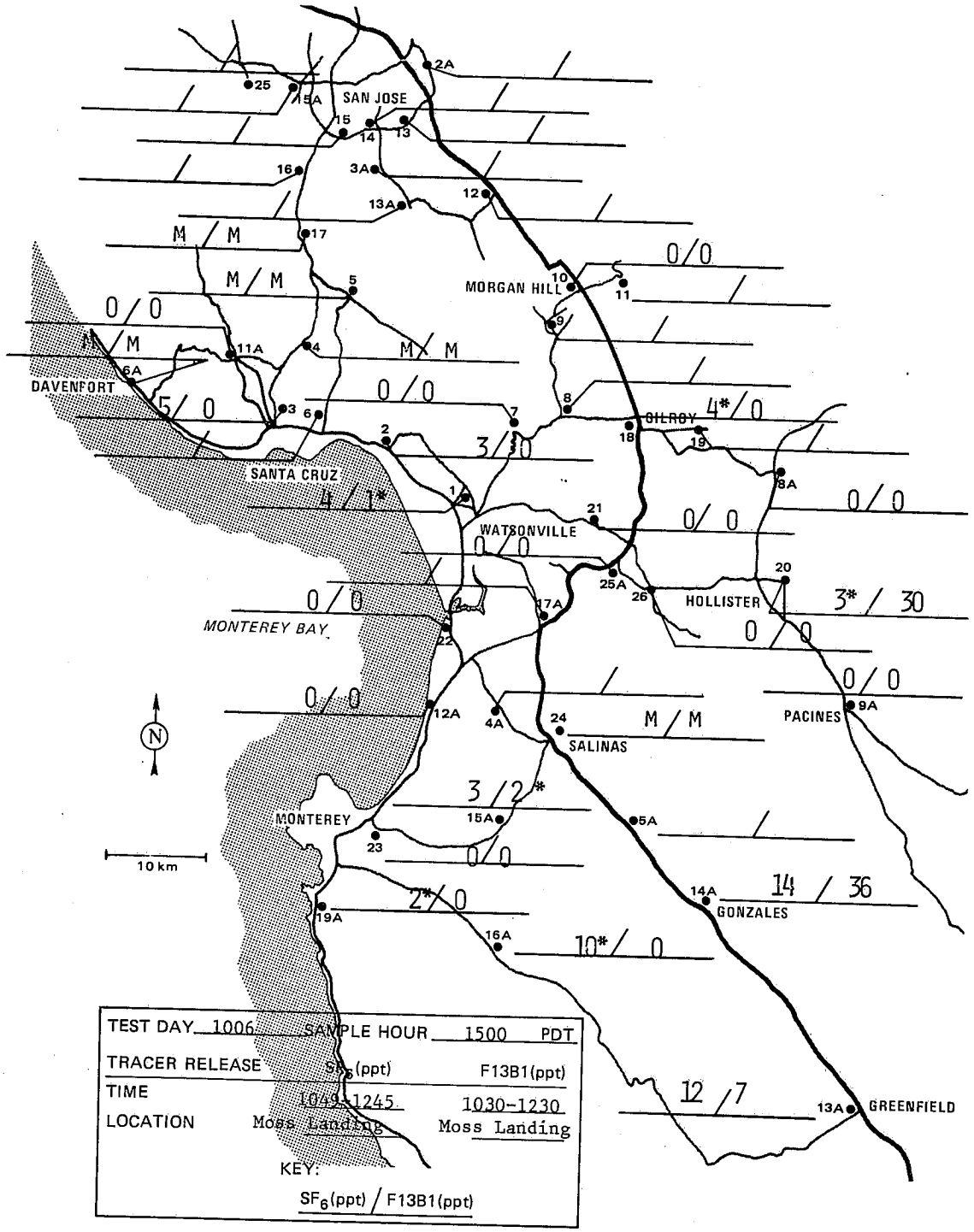


FIGURE 66d (CONTINUED)

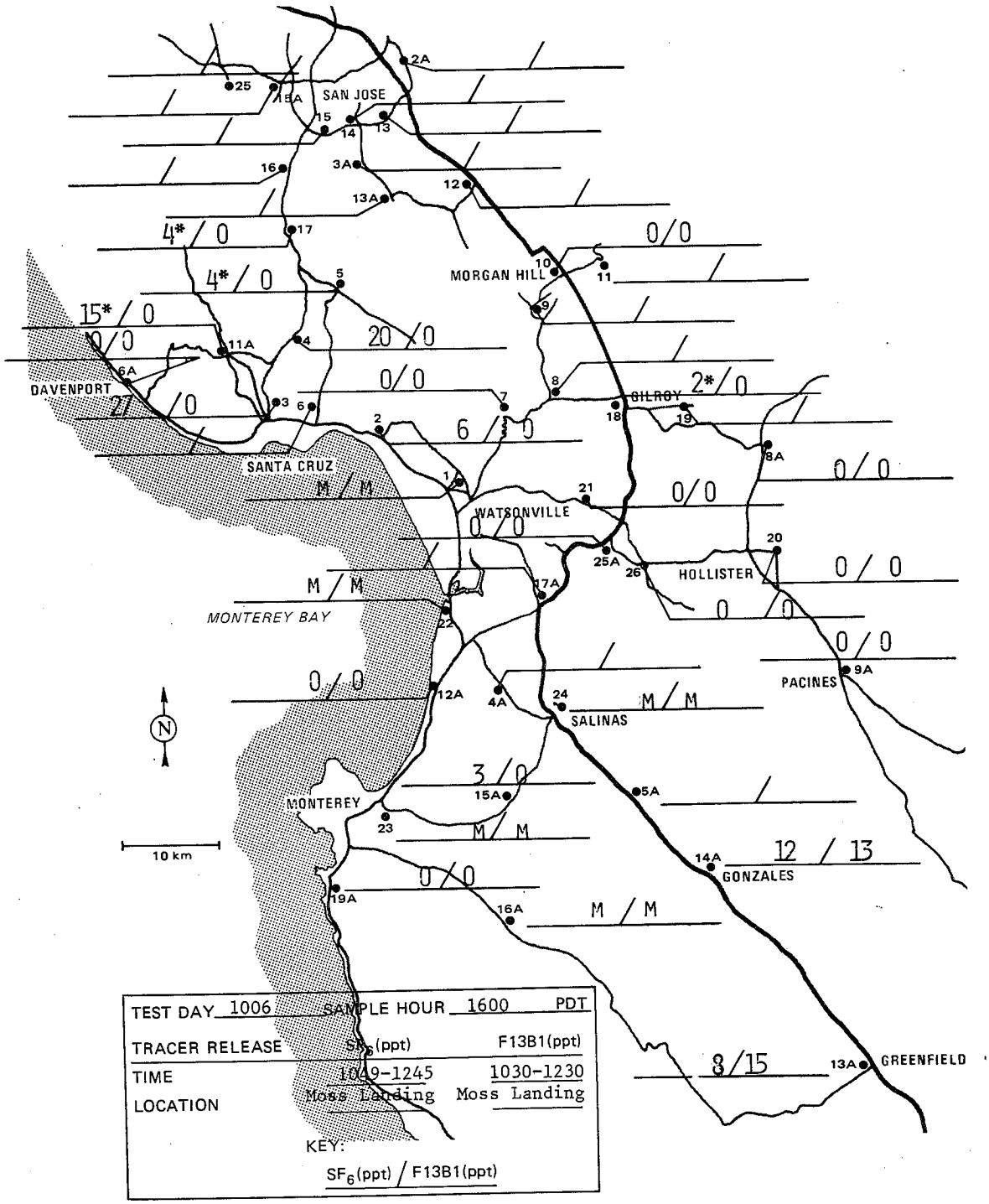


FIGURE 66e (CONTINUED)

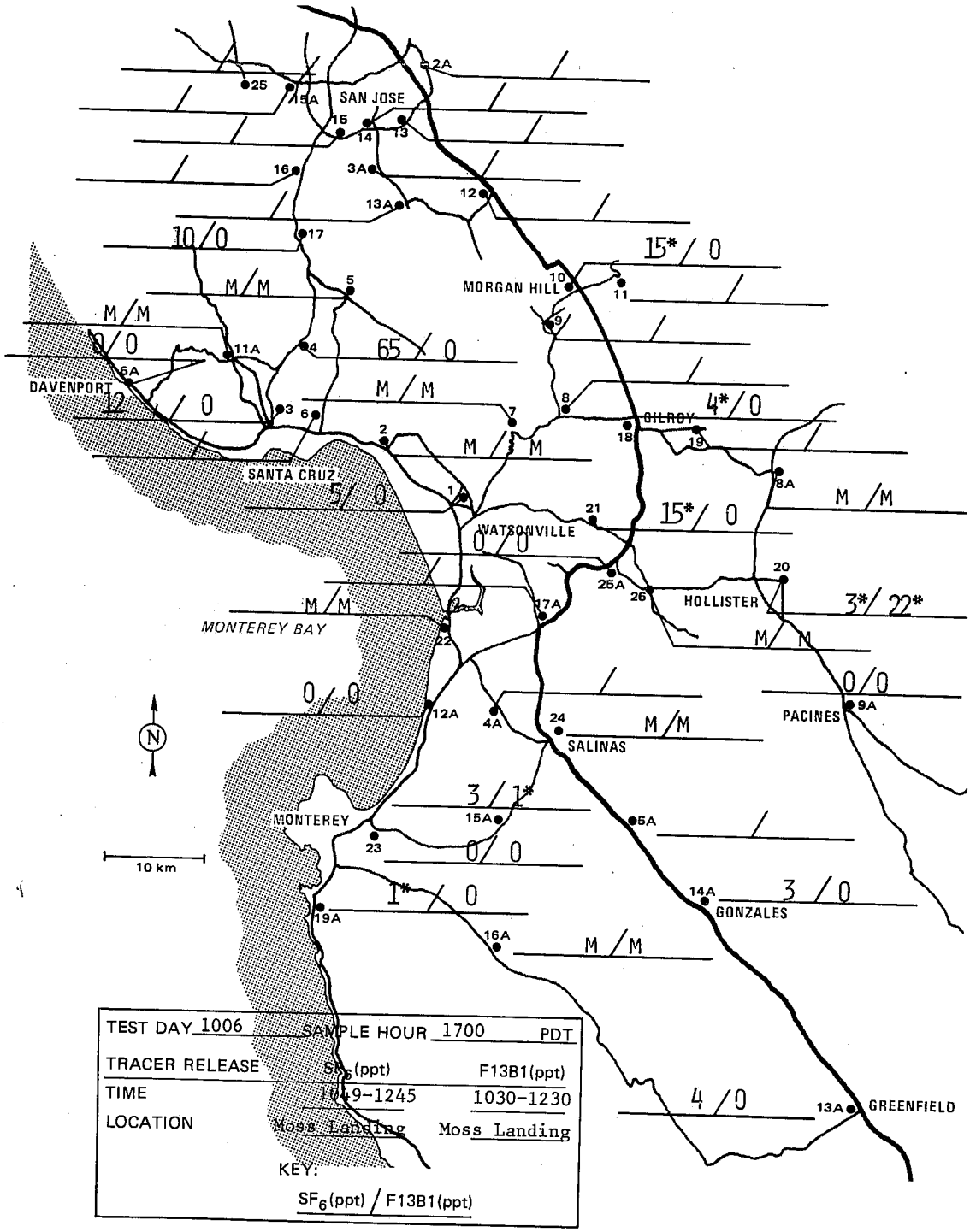


FIGURE 66f (CONTINUED)

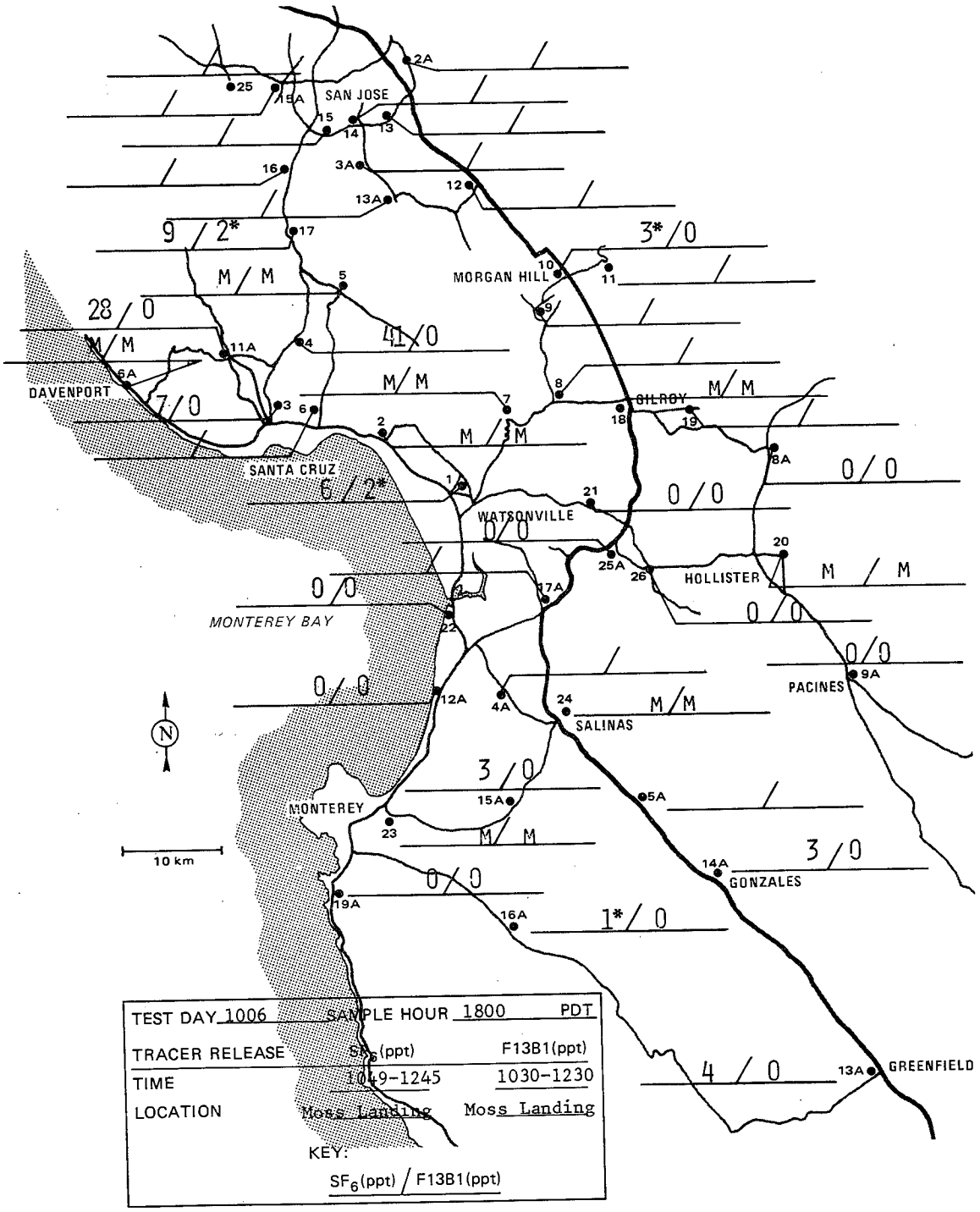


FIGURE 66g (CONTINUED)

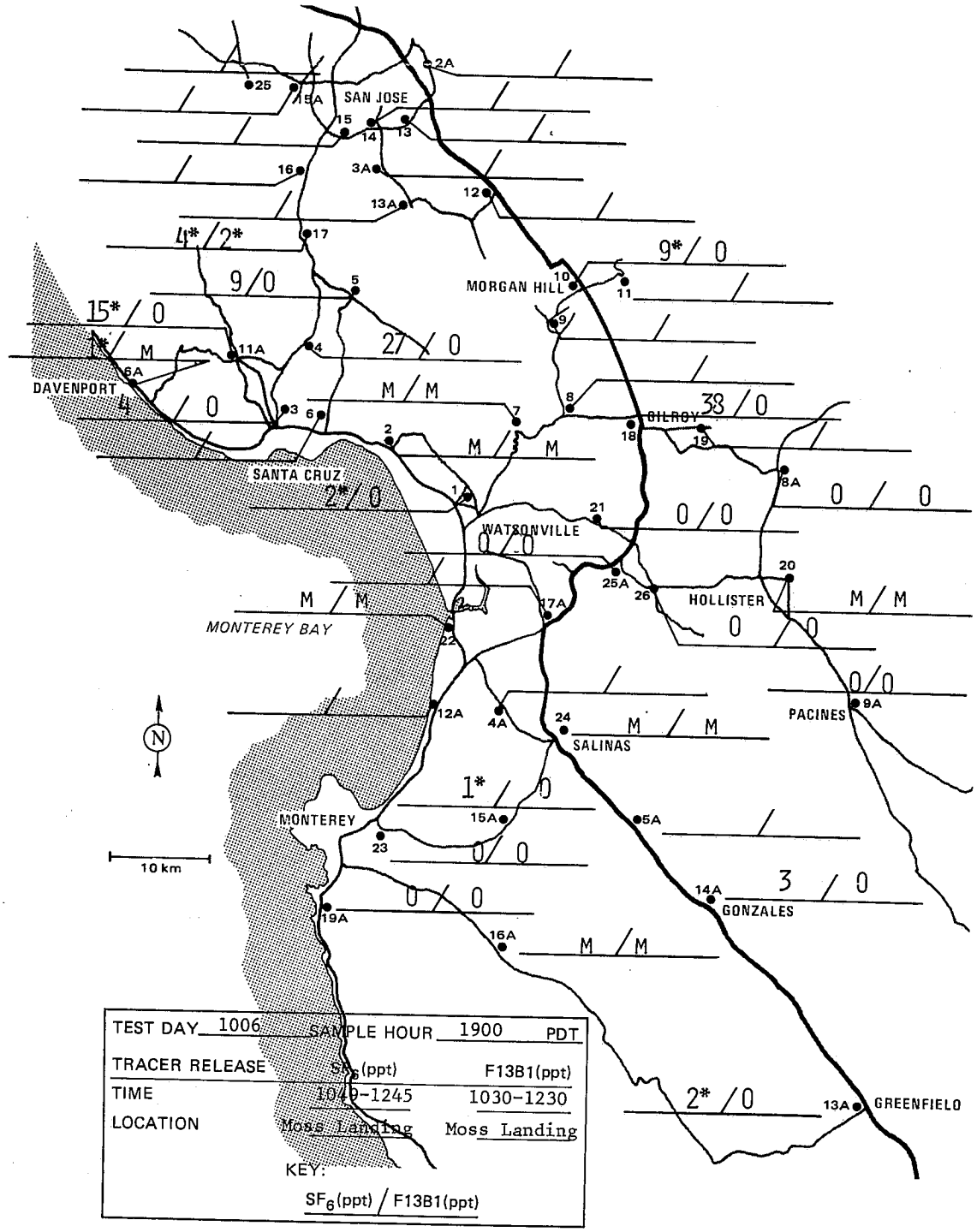


FIGURE 66h (CONTINUED)

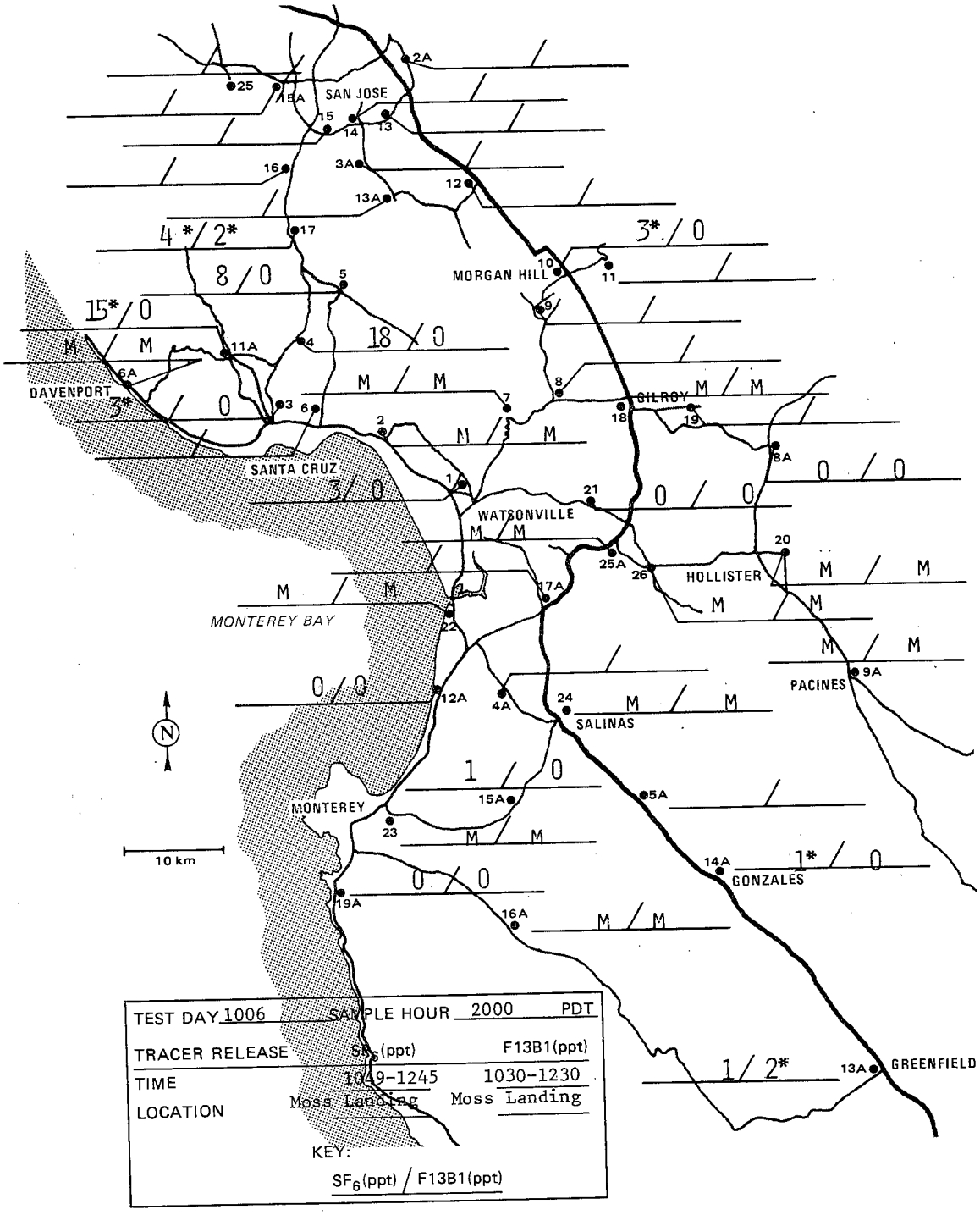


FIGURE 66i (CONTINUED)

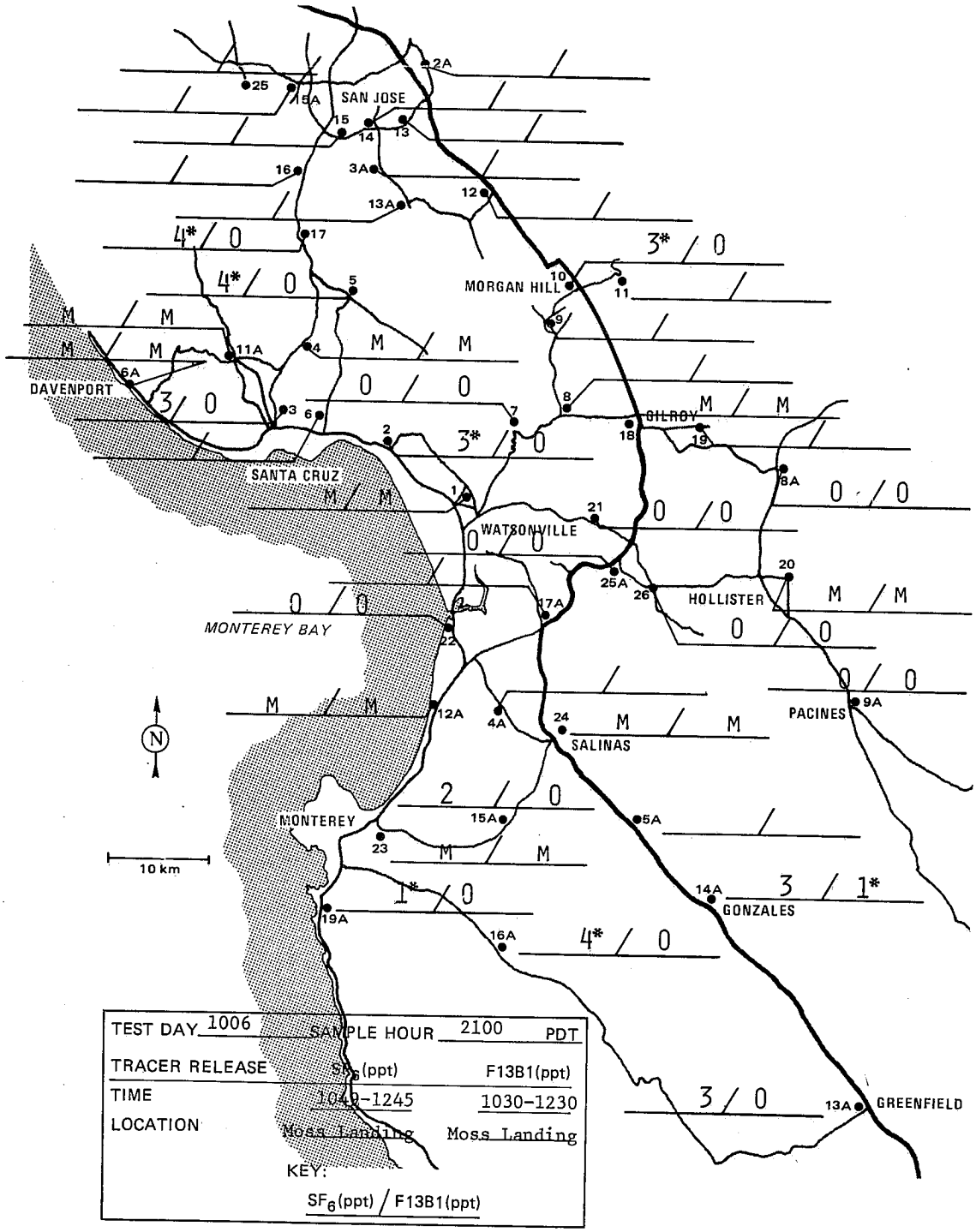


FIGURE 66j (CONTINUED)

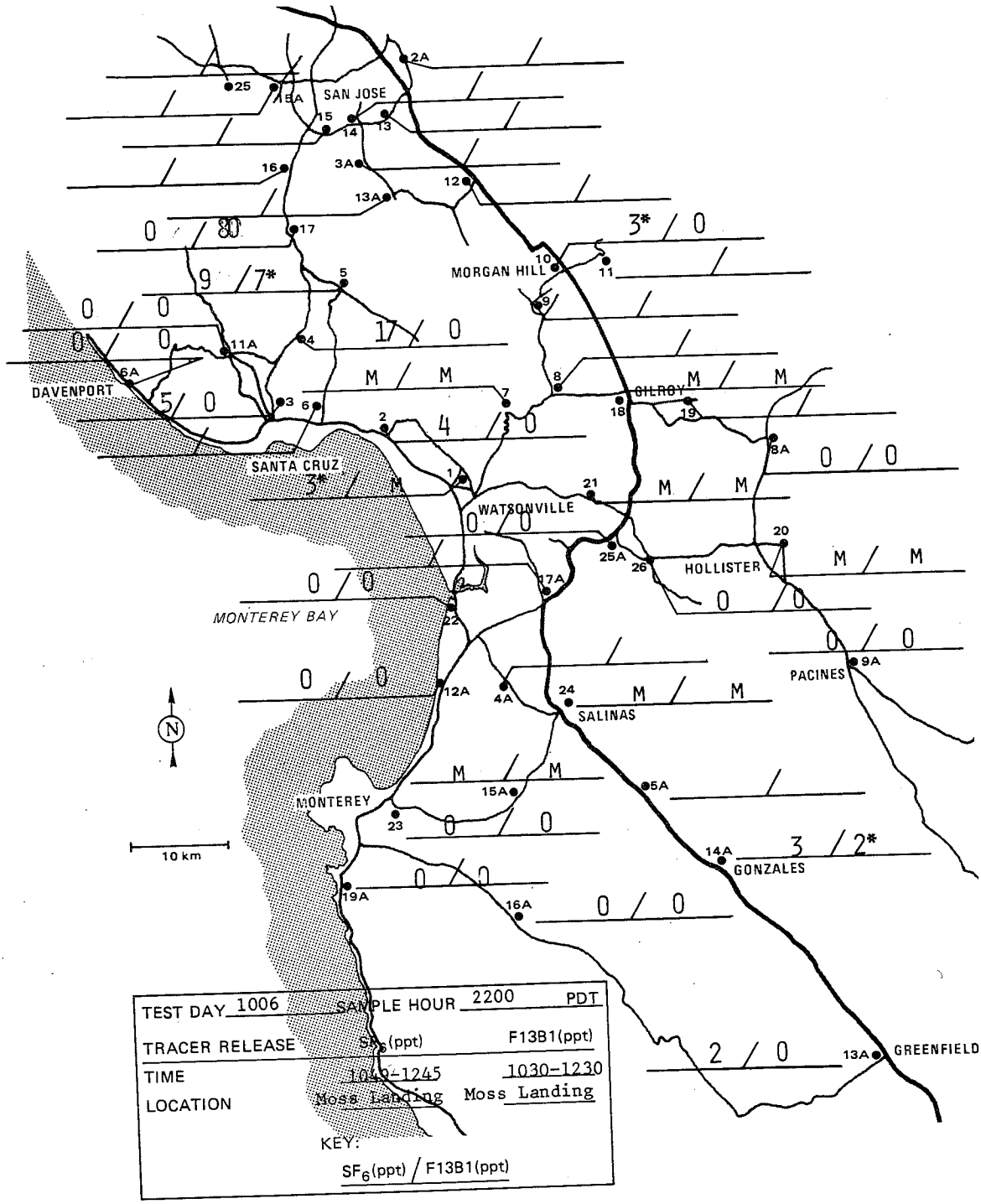


FIGURE 66k (CONTINUED)

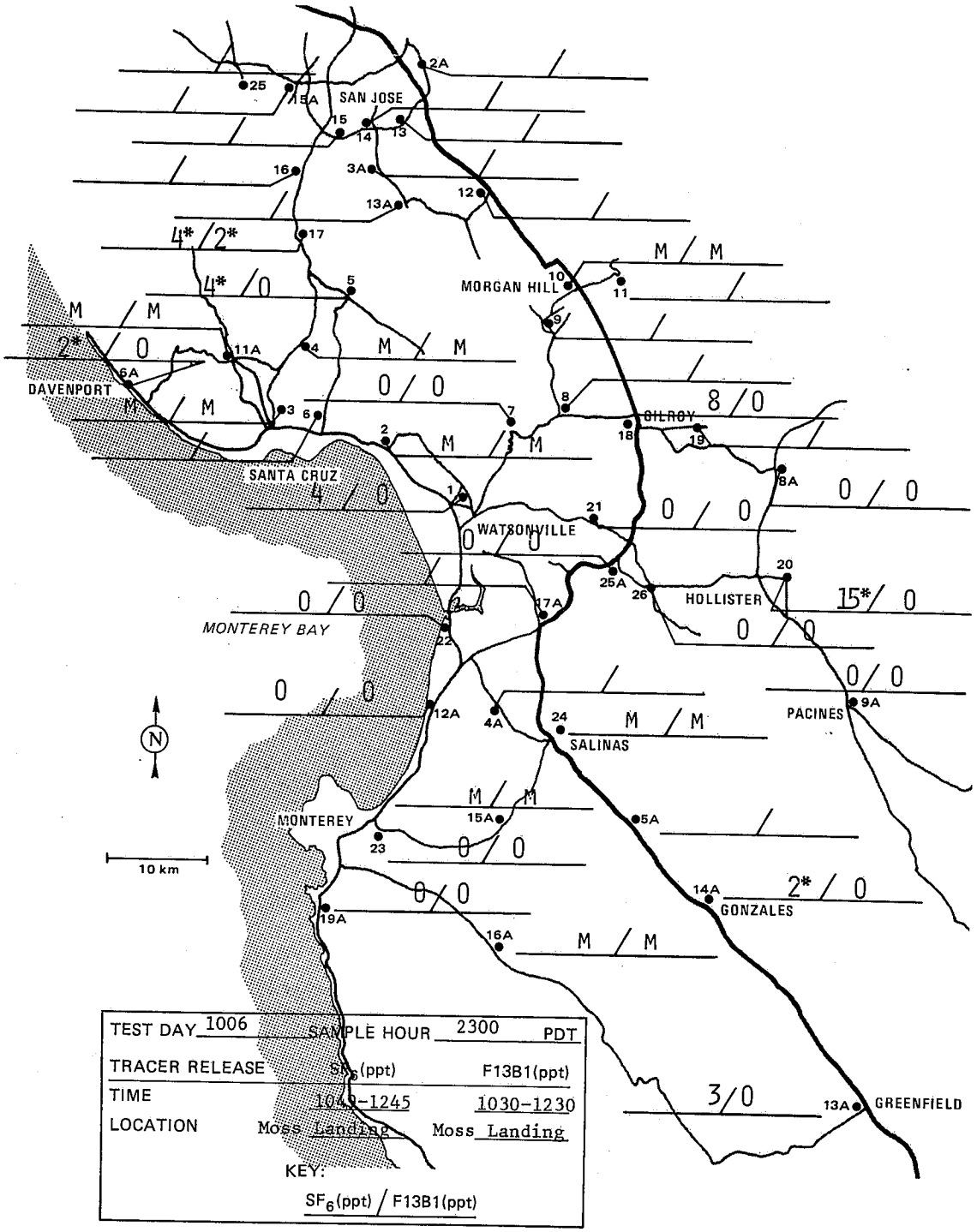


FIGURE 661 (CONCLUDED)

17-1800 PDT. The 1900 PDT aircraft sounding in Hollister showed 20- to 30-ppt concentrations uniformly distributed from the surface to 670 m, the top of the sounding. Thereafter, none of the fixed sites measured any significant amounts of F13B1 for the remainder of the test.

The F13B1 data indicate either a bifurcation or spread of the plume into the Salinas and San Benito Valleys. Transport occurred into the Hollister-Paicines area by late afternoon, reflecting a net transport rate of 5.5 km h^{-1} (1.5 m s^{-1}). However, the fixed Hollister site measured F13B1 during only one hour, inferring that the measurement reflected either transport of a secondary fragment of the plume or a measurement along the edge of a broad plume. Transport up the Salinas Valley was more systematic: The plume was transported at a rate of about 2.8 m s^{-1}, and after 4-5 hours had diffused in the longtitudinal direction to 40-km in length.

The SF_6 tracer data reflect an equally complex transport pattern. First, a 25- to 30-ppt pocket persisted at the Marina site (12A) for the first three hours of sampling (12-1500 PDT), but did not appear on any subsequent measurements at that site. Transport occurred into the Salinas Valley with the 13-1400 hour: the Toro Park Estates fixed site (Number 15A, midway between Salinas and Carmel Valley) registered 9 ppt while numerous sites detected 2- to 3-ppt trace levels. Transport to Gonzales was first observed at 14-1500 and SF_6 continued to be observed there the next three hours. At 15-1600, the plume extended to Greenfield on the south and Carmel Valley to the west of the Valley. The plume passed south of Greenfield during 17-1800 when only a trace was measured. However, transport up the surface of the Pajaro Coastal Plain began at 16-1700 with 6- to 20-ppt measurements in Aptos, Santa Cruz, Felton, and Scotts Valley. Transport continued during the next hour northward to Lexington Reservoir and eastward to Morgan Hill and Soda Lake. SF_6 persisted in the Santa Clara Valley until 2000 PDT and in the Santa Cruz-Scotts Valley area until 2100 PDT. Only trace-values were detected at 21-2200 PDT, but scattered hourly measurements up to 17 ppt were observed from 22-2400 in Scotts Valley, Felton, Gilroy, and Hollister.

The aircraft SF_6 samples confirm many of the ground-level features described above. Early-afternoon (1345 PDT) constant-level traverses at 330 m msl detected a very high and localized SF_6 peak (1923 ppt) about 6 km west of Moss Landing. A 250-ppt peak was recorded at 1830 PDT, midway between Salinas and King City at an altitude of 300 m agl. The 1837 PDT sounding at King City detected a 115-ppt peak at 180 m agl. And a 723-ppt SF_6-spike was seen at 300 m in the early evening (1855 PDT) about midway between Paicines and Hollister.

It is reasonable to conclude that backing of the wind during the release period resulted in multiple "puffs" being transported in several directions. This is further confirmed by the broad area covered by the surface tracer measurements and is reconfirmed by the tracer samples

collected by the vehicles, particularly for F13B1. The low-to-moderate hourly tracer concentrations at the surface are again the result of a strong elevated temperature inversion that dominated the region.

The aircraft flight pattern is illustrated in Figure 67 and Table 22; the tracer and aerometric data are tabulated in Volume II. Figure 68(a) and (b) are the late-afternoon soundings at Salinas and King City (70 km to the SE). The Salinas temperature profile (Figure 68a) reflects the intrusion of cool Pacific air in the lower levels and the warmer air aloft. A very strong inversion (6.1°C/100 m) is present from 280 m msl to the top at 600 m; above, the temperature gradient (-0.7°C/100 m) is only slightly stable. The intrusion of coastal stratus prevented the aircraft from sampling below 280 m. Ozone increases rapidly toward the top of the inversion, peaking around 170 ppb in a 60-m deep layer centered around 500 m; above the inversion lid the ozone is nearly constant at about 40 ppb. Nitrogen oxides are very low (~15 ppb) within the inversion and near zero above; there is no peak in the NO_x profile to coincide with the ozone peak. However, the late-afternoon sounding at King City (Figure 68b) and the morning Salinas sounding (Volume II) indicate a slightly unstable mixed layer from the surface to 300-400 m, capped by a strong inversion (5.1°C/100 m) to 550 m. The layer apparently was deep enough to disperse at least a portion of the elevated SF_6 plume to the surface. (By comparison, Test 1008 had a deeper elevated inversion layer that prevented nearly all dispersion to the surface.) Ozone peaks weakly at 92 ppb near 450 m; again, NO_x is 400 and 500 m. F13B1 ranged from 17 to 28 ppt over the depth of the sounding (60-730 m agl), except for a 166-ppt F13B1 peak at 180 m (the same height as the 115-ppt SF_6 peak cited earlier).

The temperature structure this day was typical of onshore flow conditions where cool marine air is capped by a subsidence inversion at 500-1000 m. During clear, daytime conditions, surface heating creates a thermal internal boundary layer (TIBL) that grows during the day and in proportion to the fetch from the coastline. Pollutants emitted aloft do not mix the surface until the TIBL has extended to the effective height of their release. In this respect, Test 1006 is quite typical of summertime coastal conditions.

2. Test 1008: 8 October 1980

Test 1006 and 1008 were designed to study transport of surface and elevated sources at Moss Landing. During Test 1008, F13B1 was released from 1100-1300 PDT from the same ground-level location; the release rate was maintained at the earlier value of 35 kg h^{-1}. SF_6 was released over the same period at a rate of 54 kg h^{-1} through one of the 150-m PG&E stacks. A single tetroon was launched at 1200 PDT from the power plant site.

Figure 69 is the 0500 PDT surface weather map. The thermal trough over California that was so pronounced the previous week was still present but was less intense in the northern half of the state. The

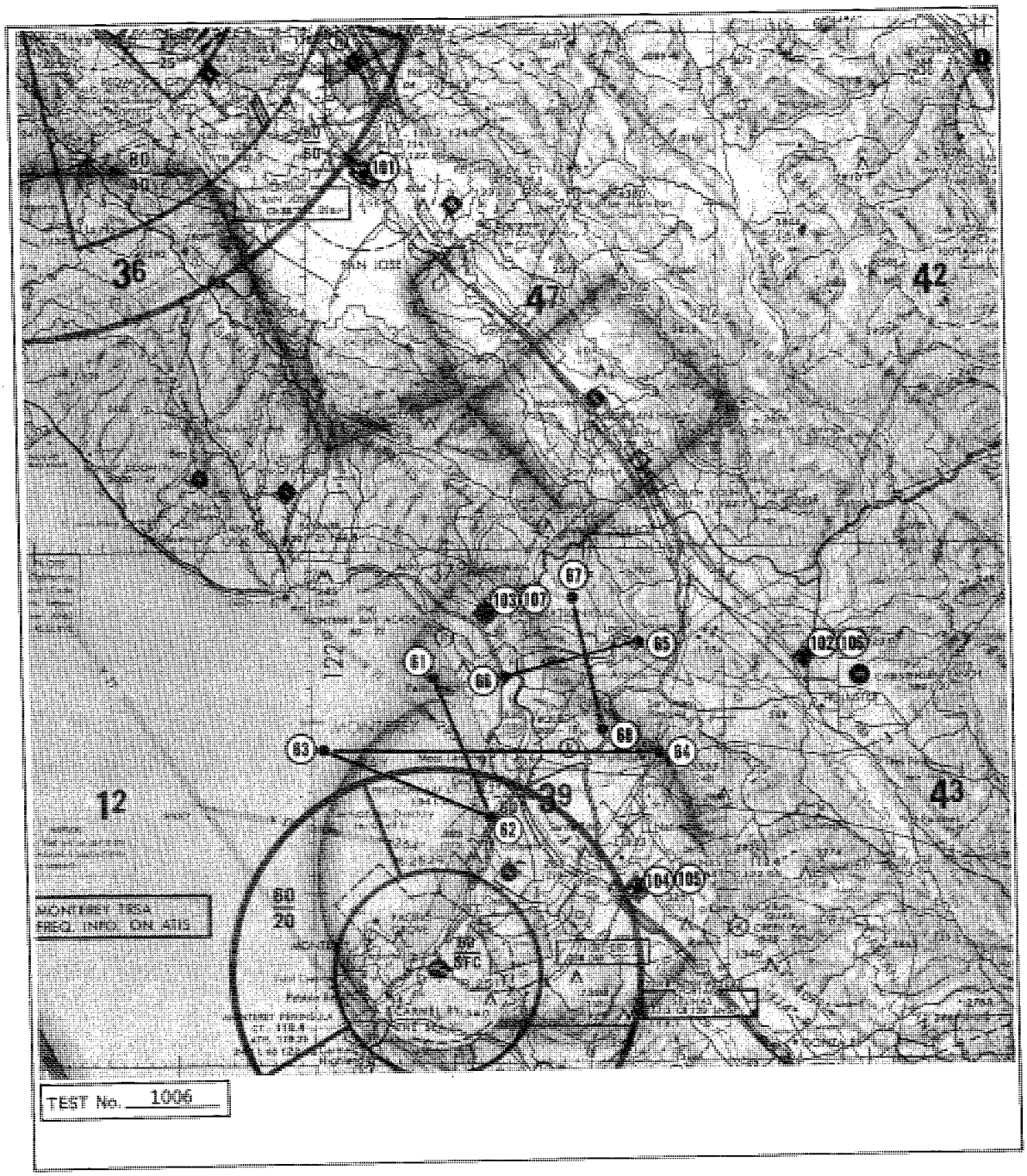


FIGURE 67a AIRCRAFT FLIGHT PATTERN, TEST 1006

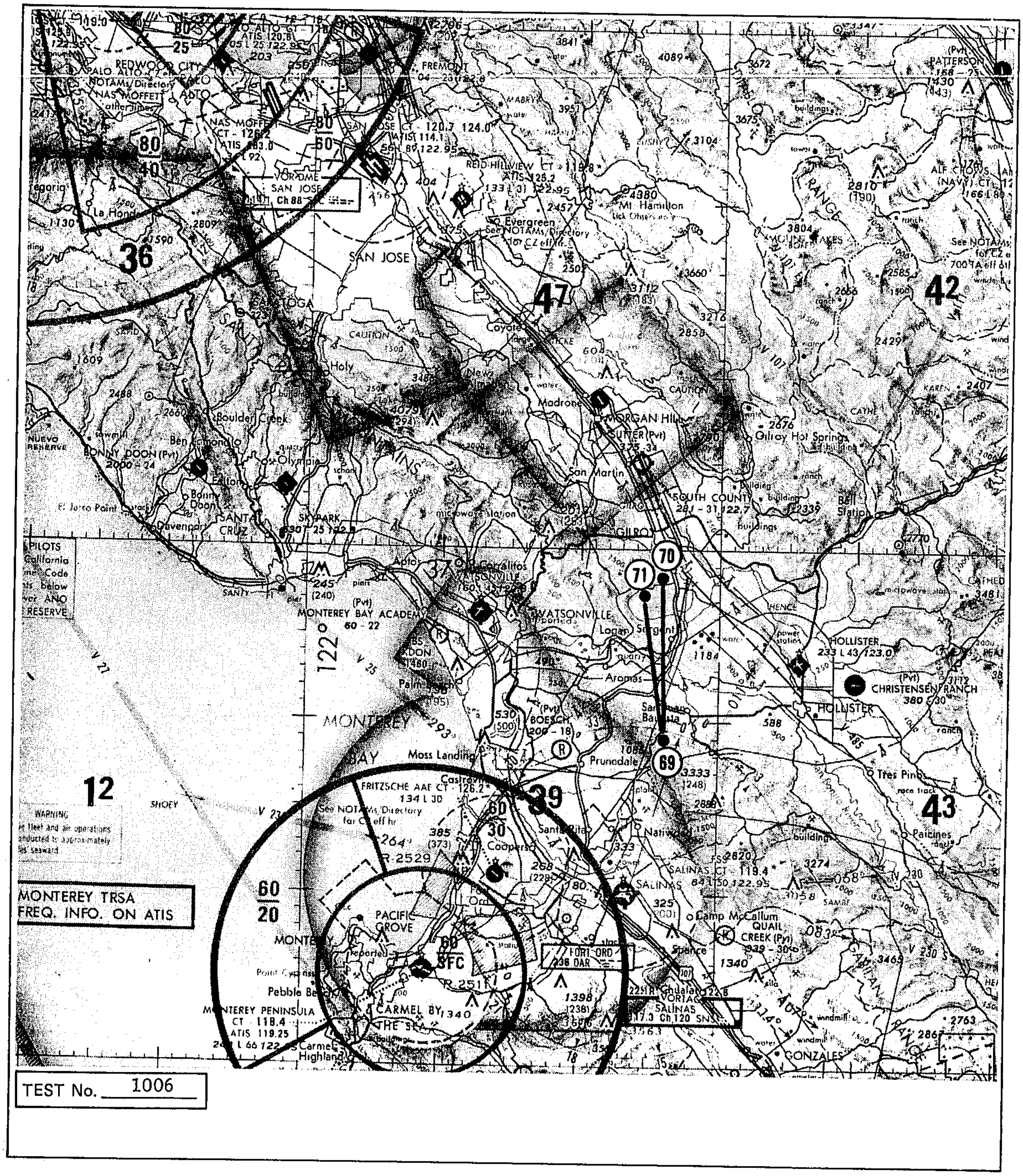


FIGURE 67b (CONTINUED)

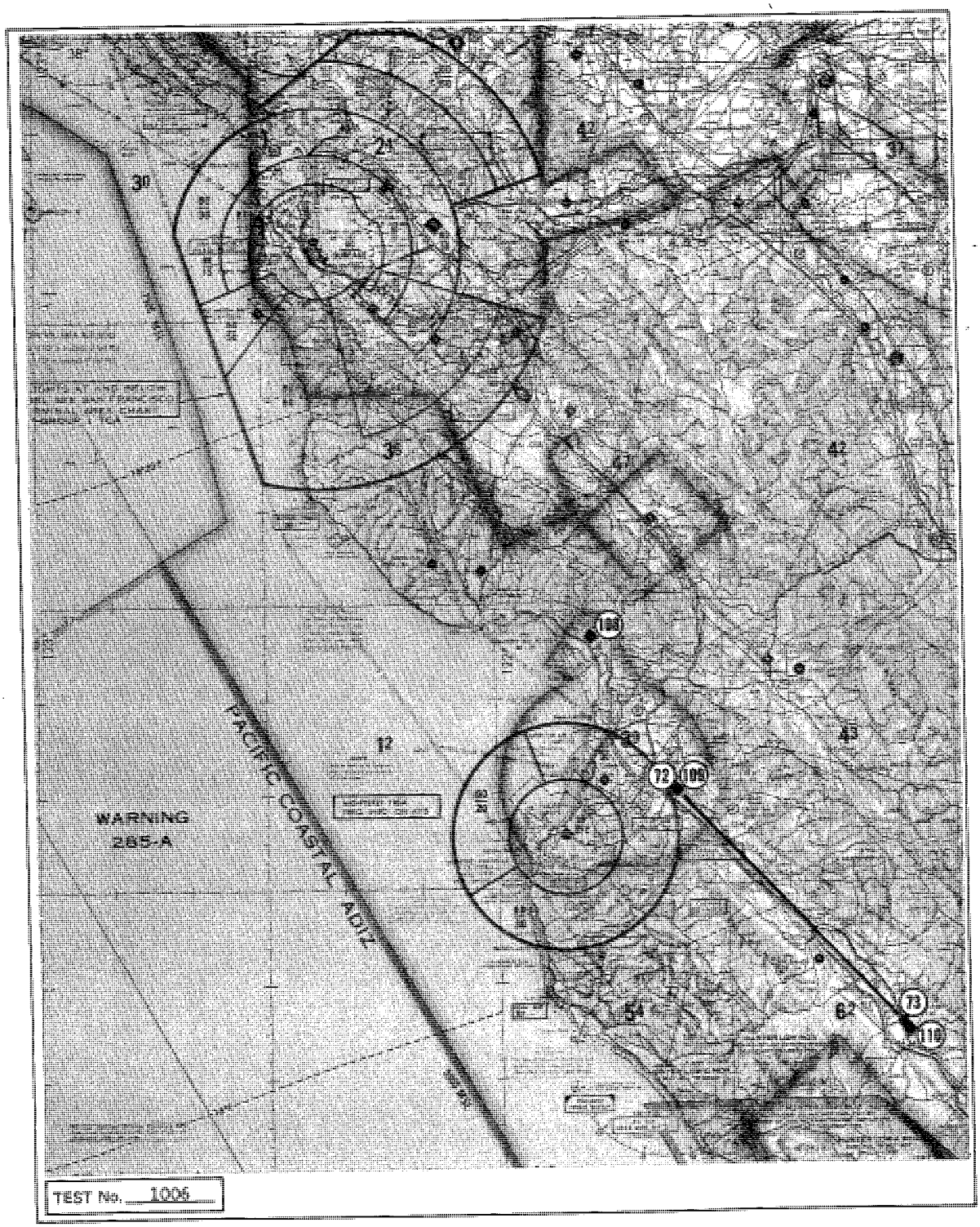


FIGURE 67c (CONTINUED)

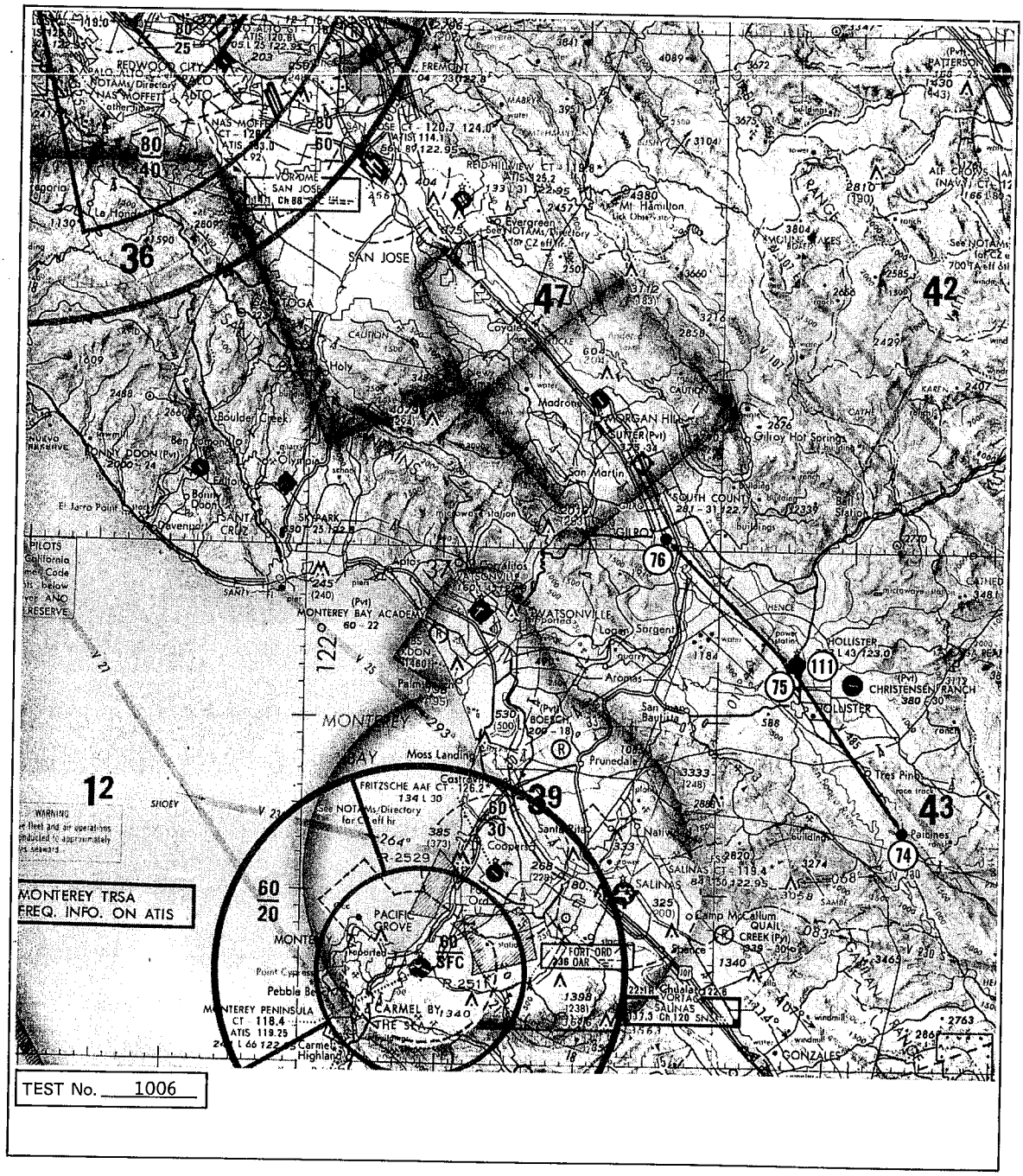


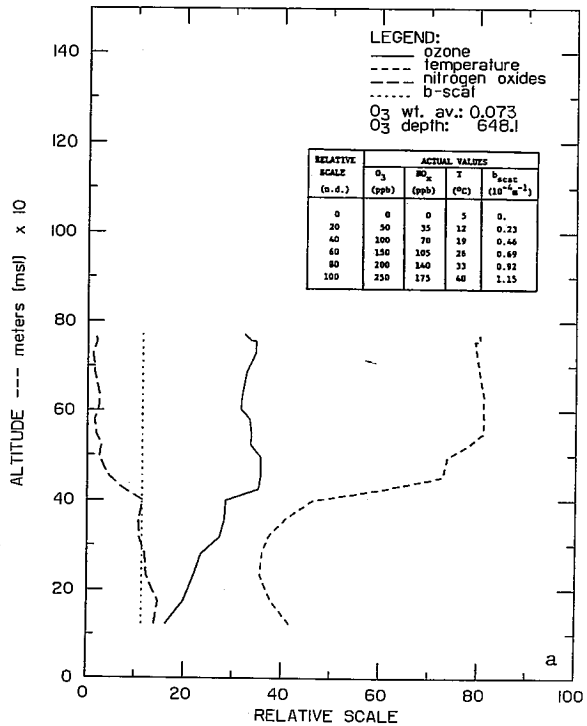
FIGURE 67d (CONCLUDED)

Table 22

AIRCRAFT WAY POINTS, TEST 1006

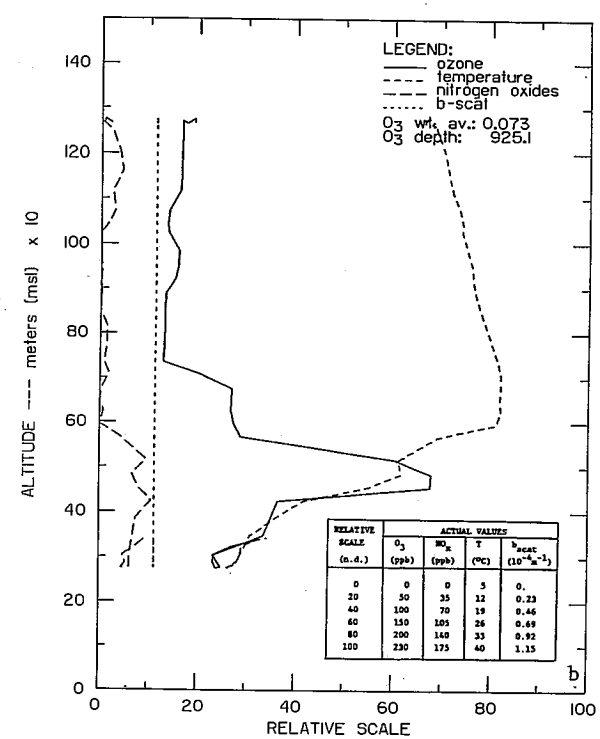
Way Point	Geographic Location	Altitude (m,msl)	Nominal Time (PDT)
Traverses			
61	Palm Beach	600	1306
62	Salinas River	600	1306
61	Palm Beach	365	1313
62	Salinas River	365	1313
61	Palm Beach	245	1318
62	Salinas River	245	1318
62	Salinas River	335	1328
63	Center Monterey Bay	335	1328
63	Center Monterey Bay	335	1344
64	Prunedale	335	1344
65	Quarry, Sargent	600	1506
66	Palm Beach	600	1506
65	Quarry, Sargent	300	1518
66	Palm Beach	300	1518
67	Watsonville	600	1513
68	Prunedale	600	1513
67	Watsonville	300	1525
68	Prunedale	300	1525
69	Prunedale	300*	1602
70	Gilroy	300*	1602
71	Gilroy	450*	1607
69	Prunedale	450*	1607
72	Salinas	300*	1823
73	King City	300*	1823
74	Paicines	300*	1853
75	Hollister	300*	1853
75	Hollister	300*	1905
76	Gilroy	300*	1905
Spirals			
101	San Jose Airport		0713
102	Hollister Airport		0732
103	Watsonville Airport		0748
104	Salinas Airport		0813
105	Salinas Airport		1101
106	Hollister Airport		1112
107	Watsonville Airport		1128
108	Watsonville Airport		1751
109	Salinas Airport		1813
110	King City Airport		1837
111	Hollister Airport		1900

*agl.



RELATIVE SCALE (n.d.)	ACTUAL VALUES O_3 (ppb)	NO_x (ppb)	T (°C)	b_{scat} ($10^{-4}m^{-1}$)
0	0	0	5	0.
20	50	35	12	0.23
40	100	70	19	0.46
60	150	105	26	0.69
80	200	140	33	0.92
100	250	175	40	1.15

NORTH CENTRAL COASTAL STUDY DATE: 801006 TIMES: 18.37.55 TO 18.41.24
site: SALINAS



RELATIVE SCALE (n.d.)	ACTUAL VALUES O_3 (ppb)	NO_x (ppb)	T (°C)	b_{scat} ($10^{-4}m^{-1}$)
0	0	0	5	0.
20	50	35	12	0.23
40	100	70	19	0.46
60	150	105	26	0.69
80	200	140	33	0.92
100	230	175	40	1.15

NORTH CENTRAL COASTAL STUDY DATE: 801006 TIMES: 18.12.00 TO 18.18.58
site: KING CITY

FIGURE 68 AIRCRAFT SOUNDINGS, TEST 1006

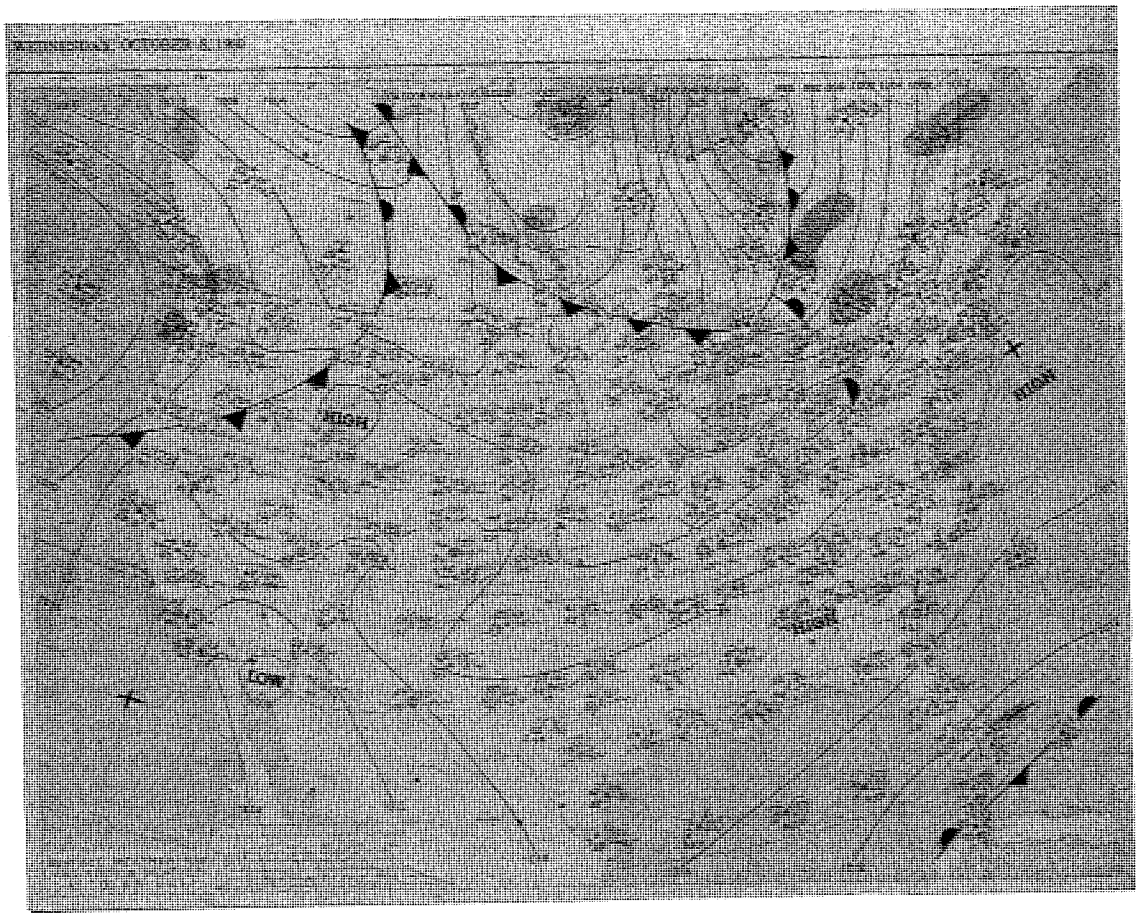


FIGURE 69 SURFACE WEATHER MAP, 0500 PDT, TEST 1008

SFO-RNO pressure difference was still -4.7 mb and the 850-mb temperature remained a very warm 22.4°C. A dry cold front ran from the northern tip of California through west-central Montana. Coastal stratus were present through noon in Moss Landing, though slightly inland (0.5 km) skies were clear and temperatures warm. The highest hourly ozone concentrations in the NCCAB were 100 ppb in Watsonville and Scotts Valley, while Salinas peaked at 40 ppb, Hollister at 80 ppb, and Monterey at 40 ppb. Figure 70 is the peak hourly distribution of ozone at the surface. The location of the aircraft spirals and traverses is plotted in Figure 71, while Table 23 is the corresponding key. The tetroon trajectory is plotted on Figure 72, and Figure 73 gives the hourly distribution of tracer concentration at the surface from 1200-1300 PDT and ending 2300-2400 PDT on 8 October. Figure 74 shows plots of ozone, temperature, oxides of nitrogen, and particulates (b_{scat}) for each of the 11 soundings made on Test 1008 at Hollister, Salinas, Watsonville, Moss Landing, and Clark Ranch. The soundings were made from midmorning (0857 PDT) through early evening (1813 PDT), and all show the presence of a strong inversion based at or near the surface and extending to an altitude on the order of 0.5 km. The gross features of each sounding are summarized in Table 24.

The height of release from the PG&E stacks, plus the nominal plume rise in view of the strong inversion at and well above the top of the stack, would have placed the initial height of the tracer at 300 m or less, well within the 500-m inversion top measured at Moss Landing during the tracer release period. None of the afternoon soundings show the presence of a neutral or unstable layer from plume height to the surface. Therefore, it is consistent that no significant SF_6 concentrations were detected either by the sampler network (Figure 73) or the grab-sampling vans (Volume II). For example, Table 25 gives tracer data from an early afternoon (1338-1343 PDT) sounding conducted at the location of the tetroon from a minimum altitude of 150 m agl to a maximum of 825 m agl. The dominant feature is the intense and spatially limited SF_6 core (498 ppt) seen at 275 m; concentrations above range from 37 to 93 ppt while the 150- and 215-m observations are about 45 ppt. From the surface measurements at the time, it appears the fringes of the plume did not extend to the surface or if they did, then not with significant concentrations. Later in the day, however, the plume did reach to the surface as indicated by the 1705 PDT spiral, again done at the location of the tetroon (now near Tres Pinos). SF_6 was detected from near the surface to a height of 245 m agl, and showed a monotonic decrease with height.

The F13B1 plume was transported through Prunedale and San Juan Bautista in the early afternoon and Paicines down the San Benito Valley in the middle afternoon. No concentrations were detected aloft except for sporadic trace measurements ($\leq$5 ppt). The five vehicles collecting grab samples on this day provided details of the surface transport pattern. Around 1315 PDT again at 1400 PDT, large concentrations (100 to 870 ppt) were detected by vehicle one along a 13-km segment of Highway 101 between Prunedale and the San Juan Bautista exit. Lower concentrations (around 10 ppt) were observed along the coast highway from

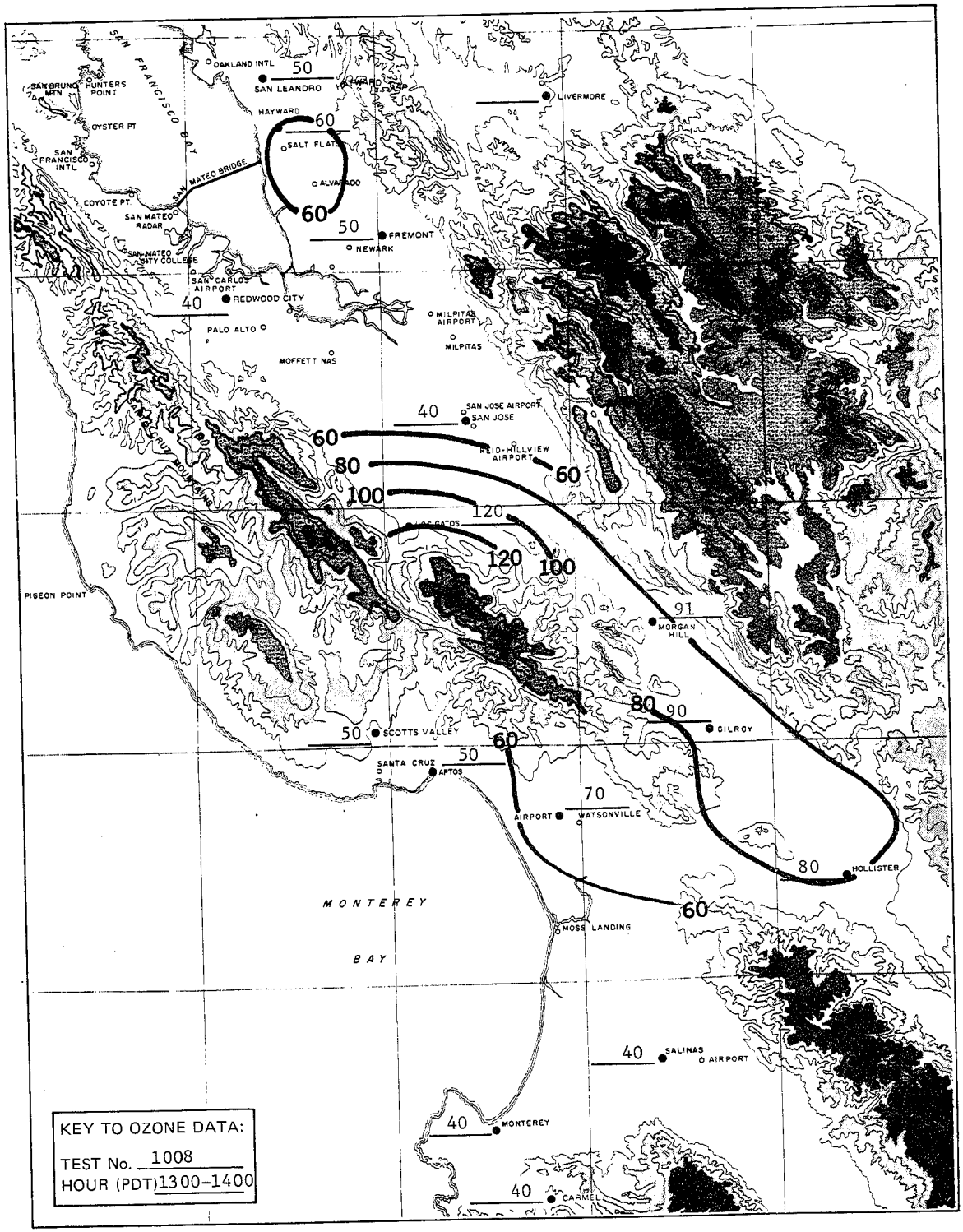


FIGURE 70 DISTRIBUTION OF SURFACE OZONE (ppb), PEAK HOUR, TEST 1008

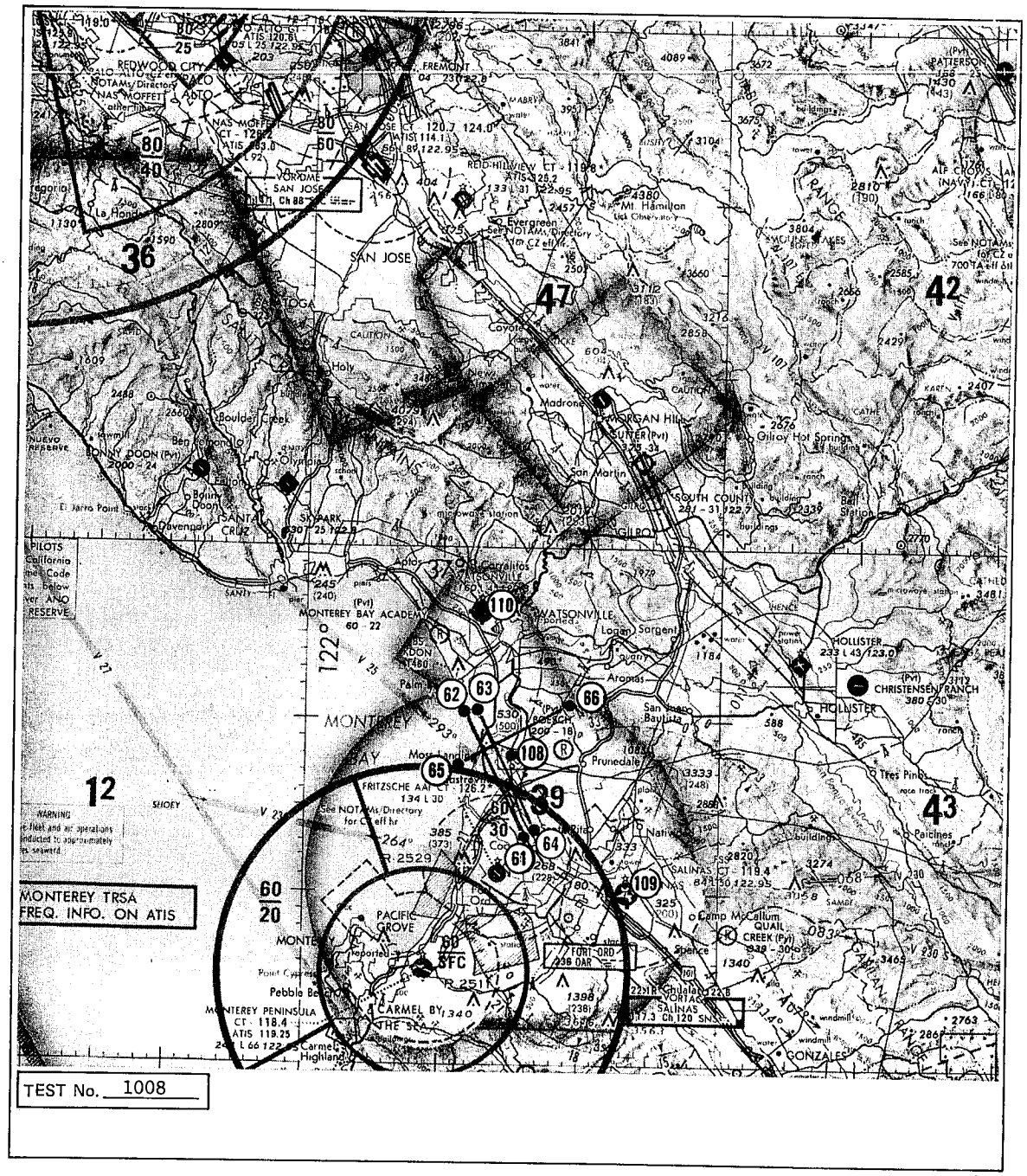


FIGURE 71a AIRCRAFT FLIGHT PATTERN, TEST 1008

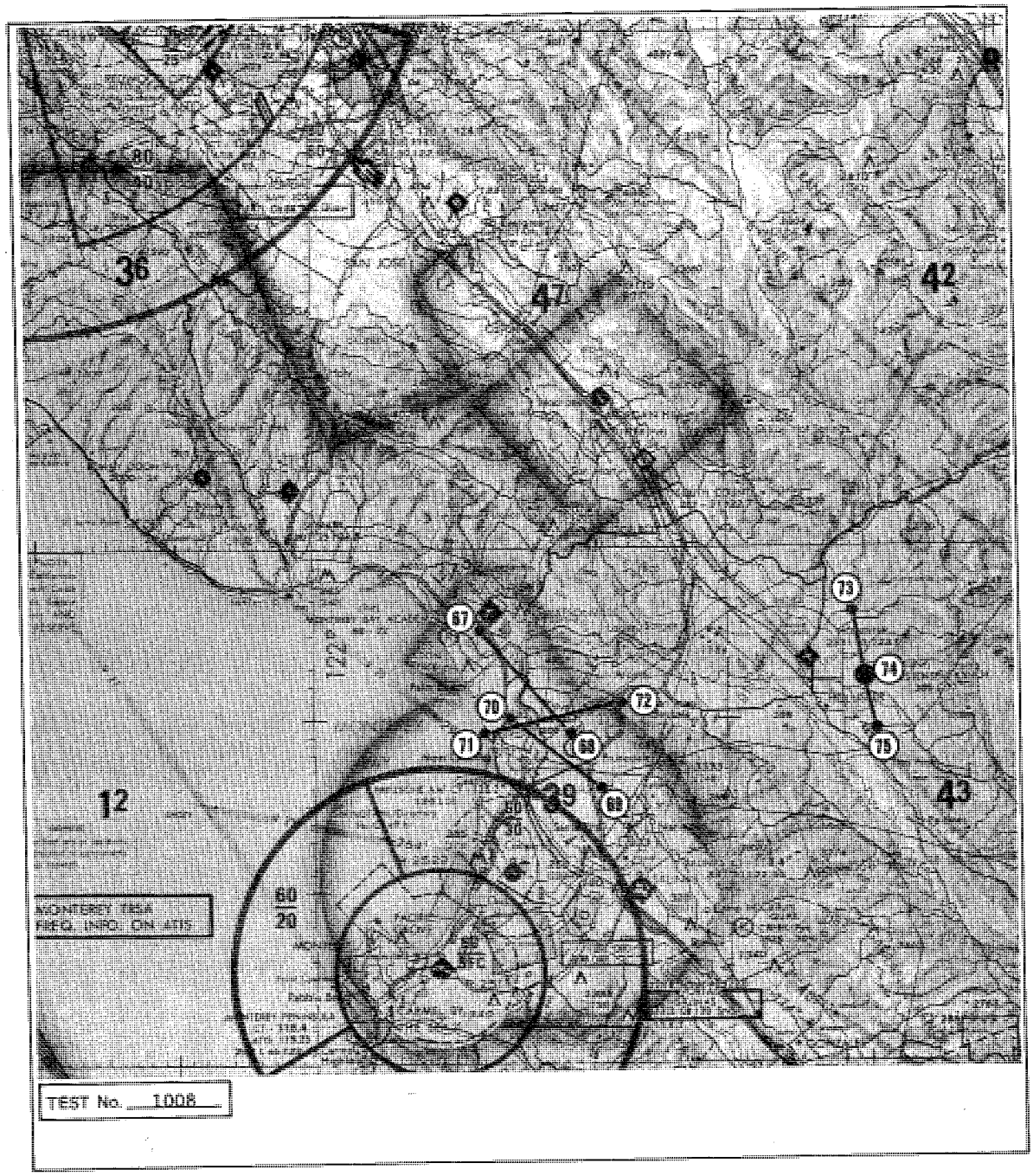


FIGURE 71b (CONTINUED)

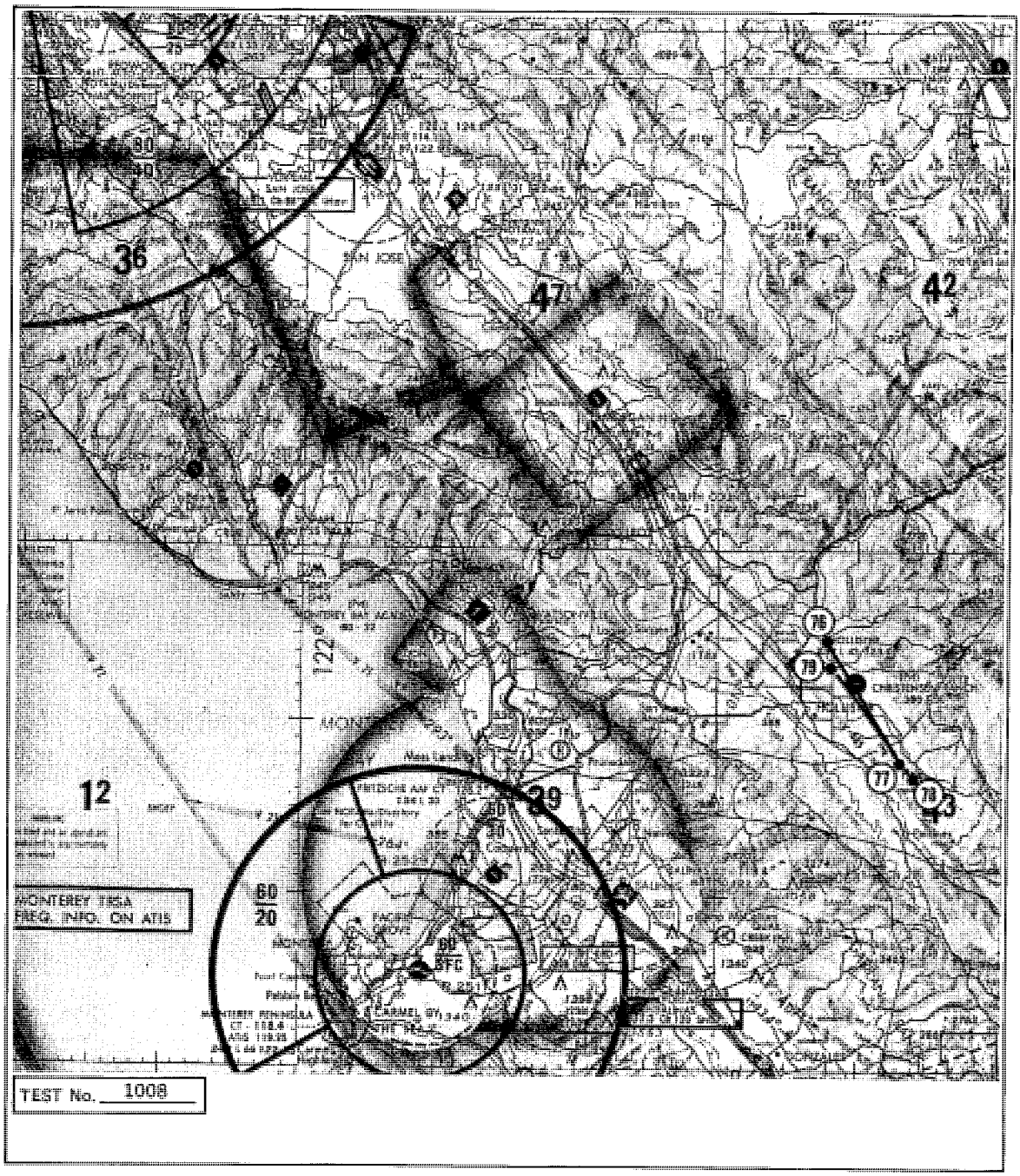


FIGURE 71c (CONTINUED)

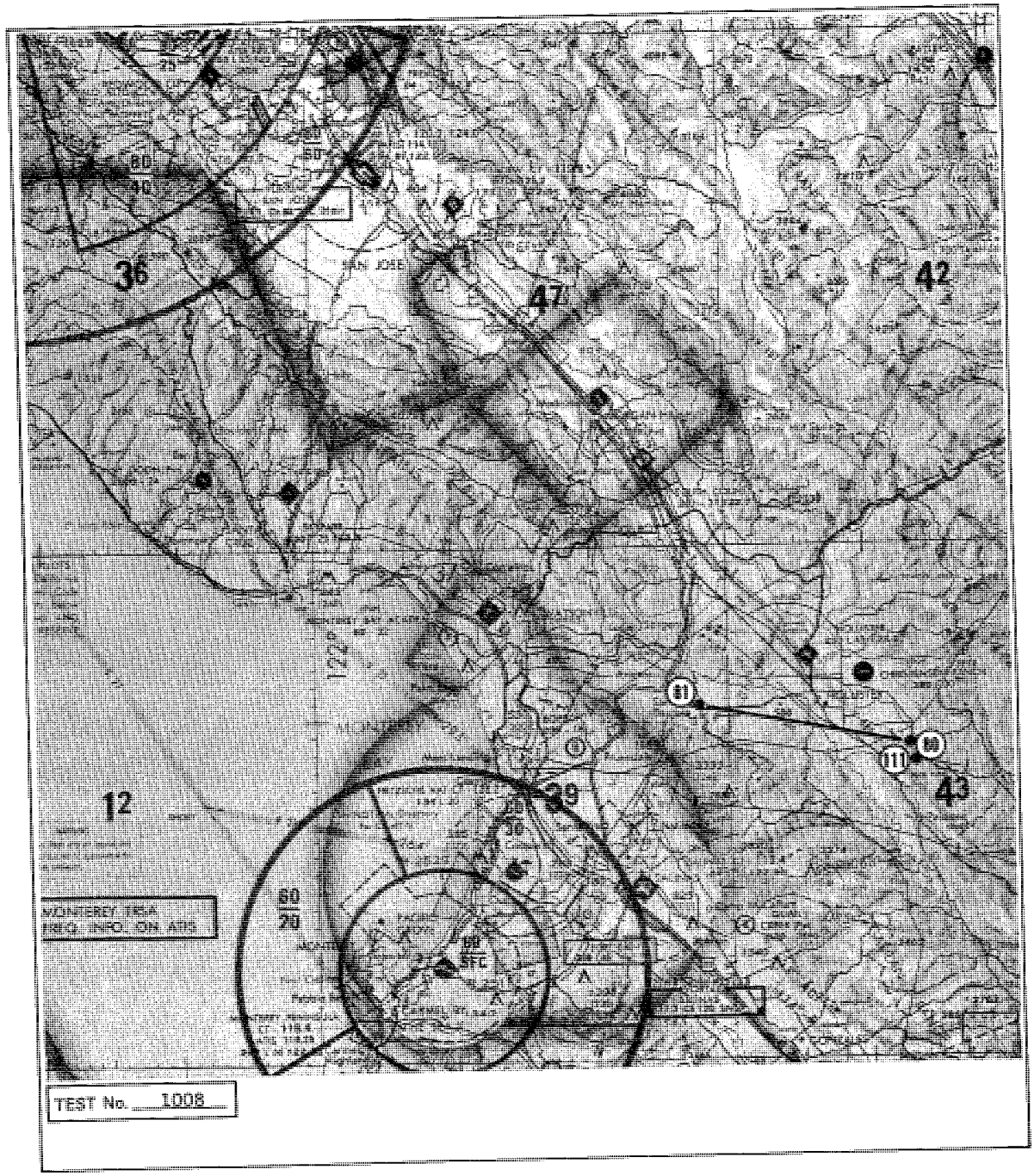


FIGURE 71d (CONTINUED)

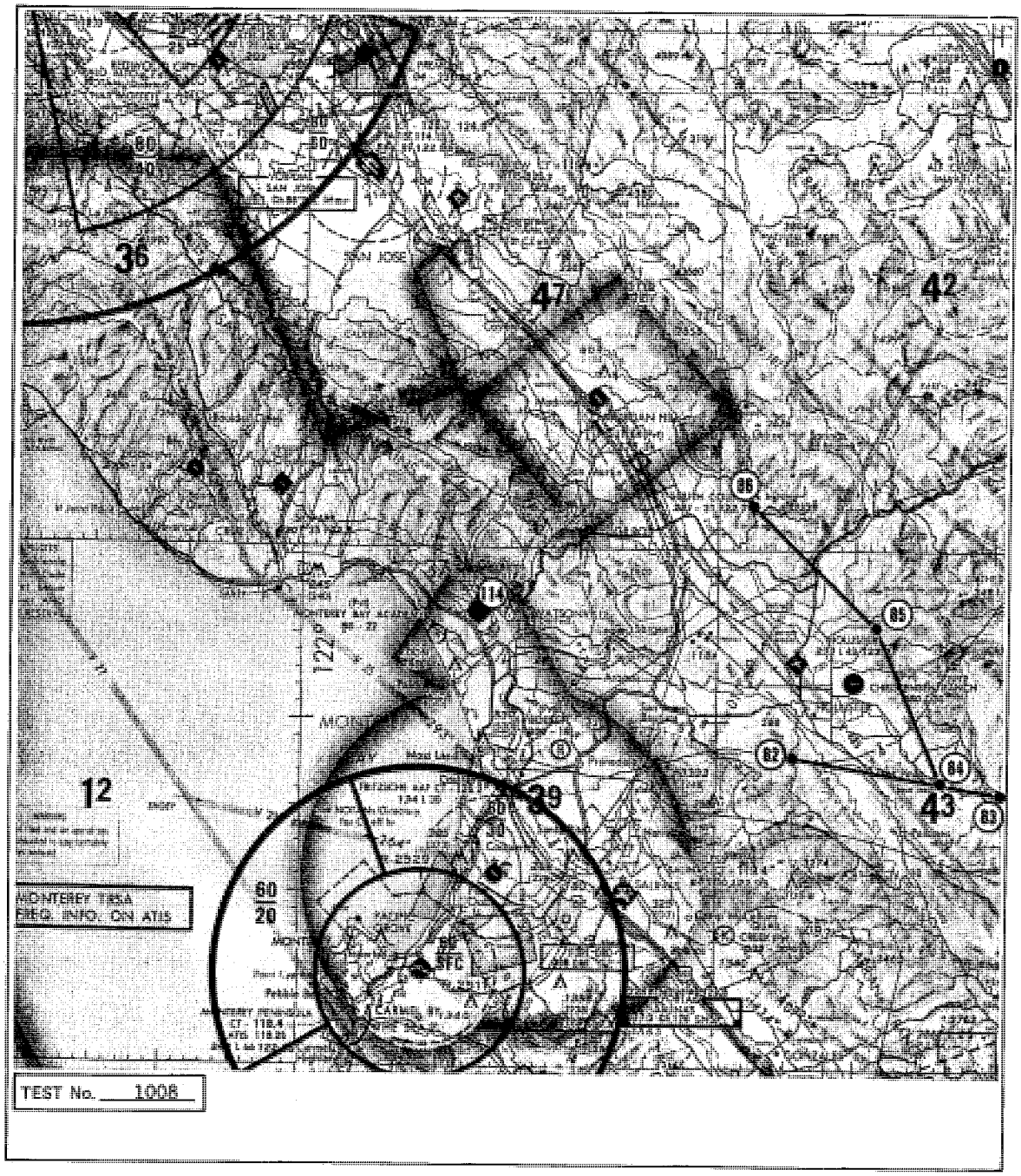


FIGURE 71e (CONTINUED)

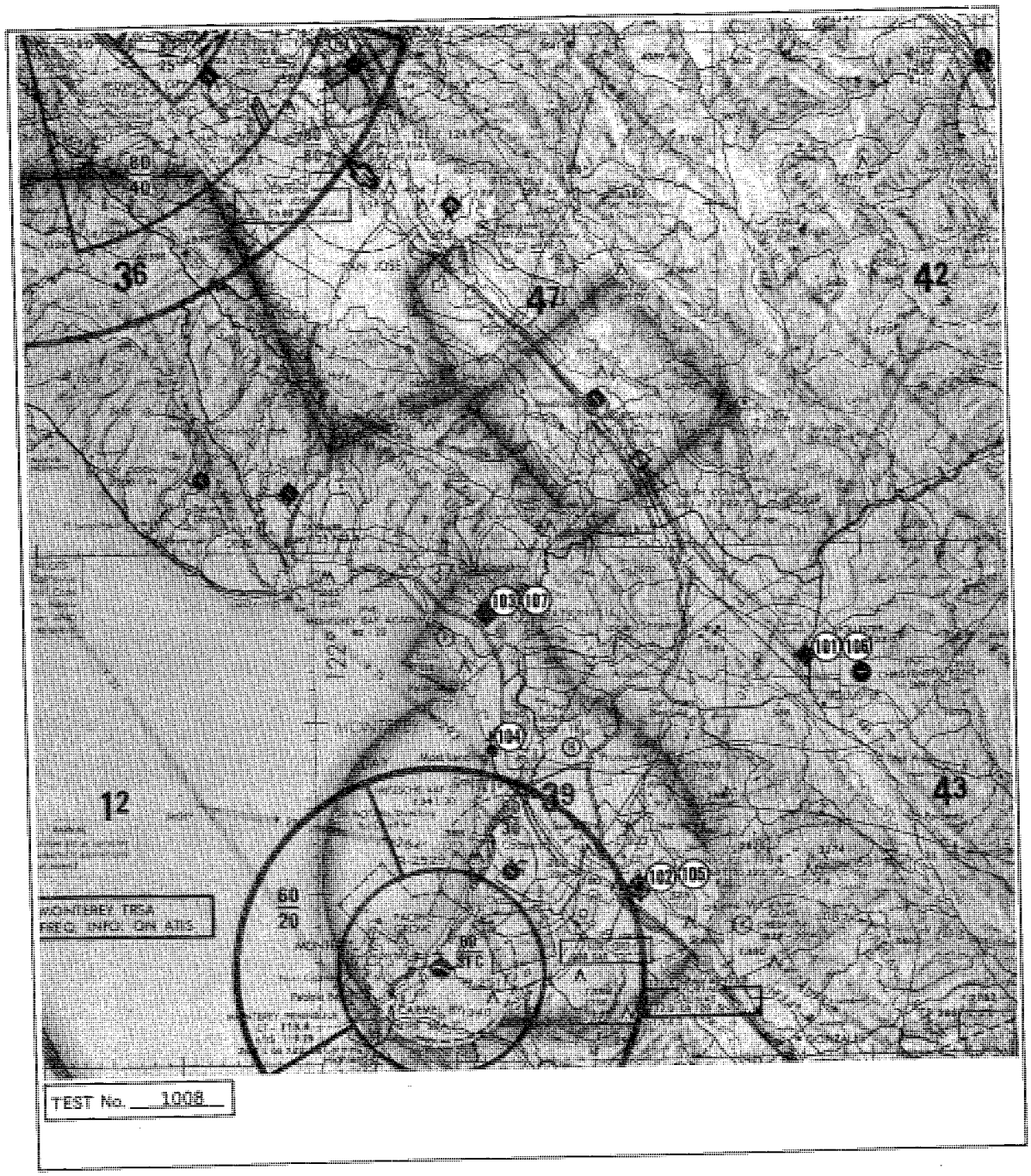


FIGURE 71f (CONTINUED)

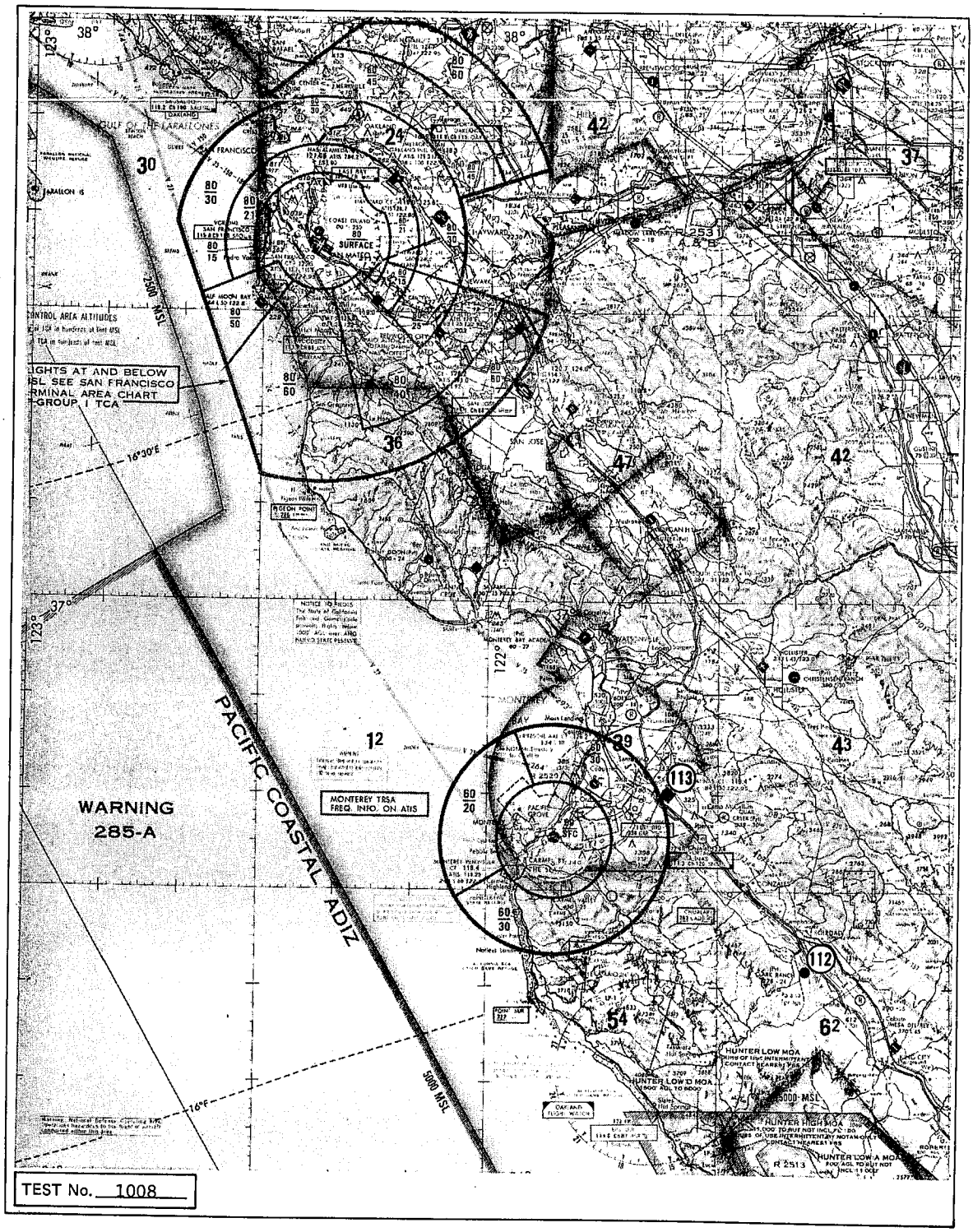


FIGURE 71g (CONCLUDED)

Table 23

AIRCRAFT WAY POINTS, TEST 1008

Way Point	Geographic Location	Altitude (m,msl)	Nominal Time (PDT)
Traverses			
61	Coopers	245	1313
62	Palm Beach	245	1316
63	Palm Beach	335	1317
64	Coopers	335	1321
64	Coopers	450	1323
63	Palm Beach	450	1326
65	Monterey Bay and Moss Landing	335	1329
66	5 nmi NE of Moss Landing	335	1332
67	Watsonville	300	1415
68	Boesch private airfield	300	1419
69	2 nmi south of Prunedale	400	1422
70	1.5 nmi NE of Moss Landing	400	1425
71	Moss Landing	365	1428
72	Hwy 101 west San Juan Bautista	365	1433
73	Hollister	335	1612
74	Christensen Ranch airfield	335	1613
75	Tres Pinos	450	1631
74	Christensen Ranch airfield	450	1633
76	Hollister	600	1636
77	Tres Pinos	600	1639
78	Tres Pinos	245	1641
79	Hollister	245	1644
80	Tres Pinos	450	1650
81	San Juan Bautista	450	1655
81	San Juan Bautista	300	1659
80	Tres Pinos	300	1704
82	South of Hollister	670	1752
83	ESE of Tres Pinos	670	1758
84	ESE of Tres Pinos	600	1802
85	Hollister	600	1895
86	Gilroy	600	1809
Spirals			
101	Hollister		0900
102	Salinas		0915
103	Watsonville		0933
104	Moss Landing		1046
105	Salinas		1115
106	Hollister		1133
107	Watsonville		1152
108	2 nmi ESE of Moss Landing		1338
109	Salinas		1351
110	Watsonville		1408
111	Tres Pinos		1704
112	Clark Ranch		1724
113	Salinas		1741
114	Watsonville		1817

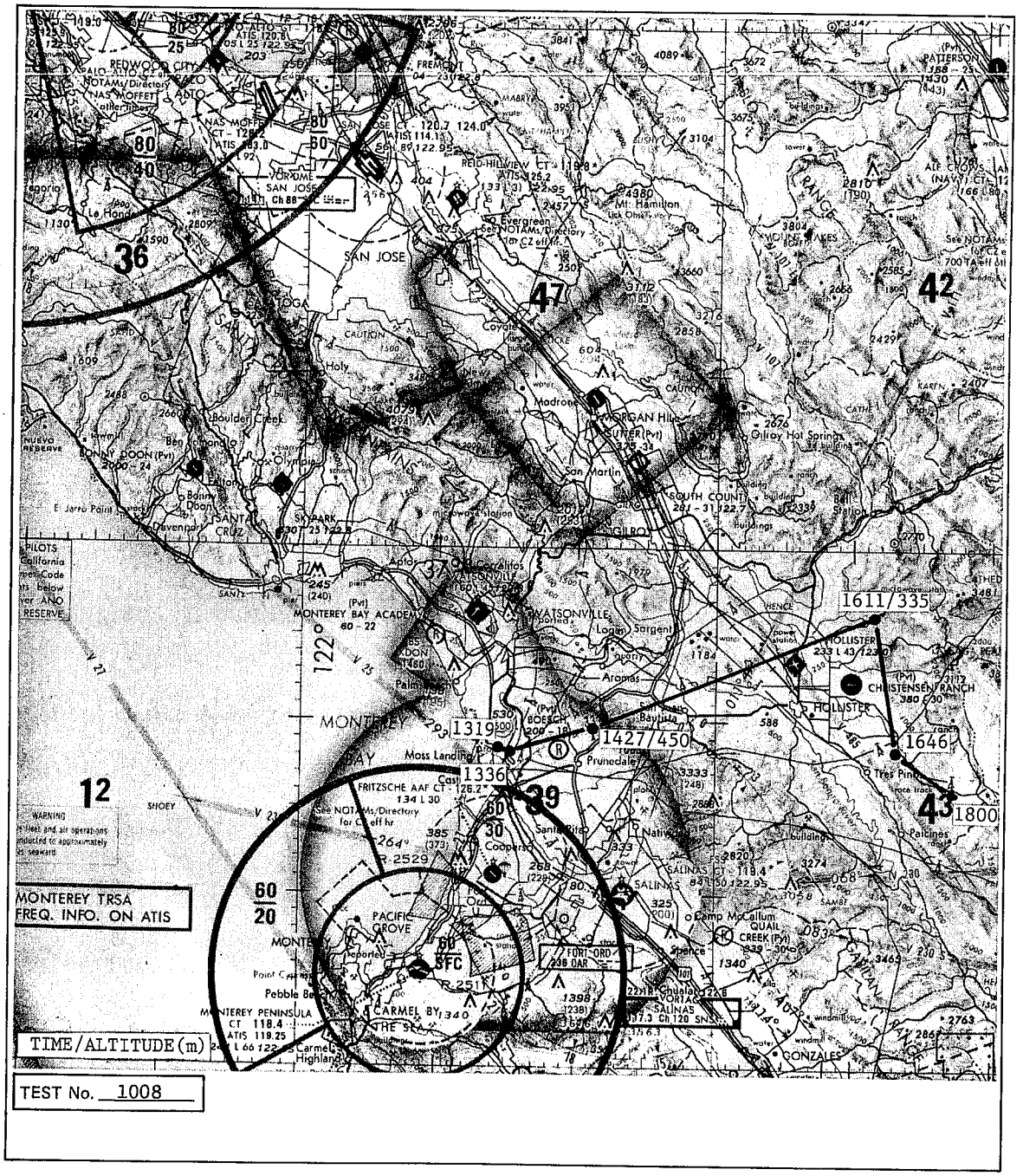


FIGURE 72 TETROON-DERIVED TRAJECTORY, TEST 1008