LA-UR -80-1824

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CONF-800489--1

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SUBMITTED TO: PROCEEDINGS PUBL ATION OF THE GETTYSBURG ASCOT MEETING OF ,PRIL 14, 1980

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UNITED STATES
ENERGY RESEARCH AND
DEVELOPMENT ADMINISTRATION
CONTRACT W-7405-ENG. 36

ANALYSIS OF FLUORESCENT PARTICLE TRACER DATA

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ABSTRACT

Four fluorsecent particle tracer experiments were conducted during the July 1979 ASCOT experiment in the Anderson Creek Valley of northern California. The purpose of the experiment was to examine the transport and elongation of a plume traveling in the Anderson Creek nocturnal drainage flow and investigate the interaction of the Anderson Creek and Putah Creek flow fields. Sequential samples of tracer material at three downwind locations in Anderson Creek gave effective transport velocities of 1 to 2 m/s and showed an approximately linear relationship between plume elongation and travel distance. Integrated samples taken in both the Anderson Creek and Putah Creek air sheds indicated considerable interaction between the two flow fields.

I. INTRODUCTION

In the July 1979 ASCOT intensive field study in Anderson Creek Valley, California fluorescent particle (FP) tracer experiments were conducted during drainage flow conditions on four of the experimental nights. The objectives of these were:

(1) To investigate the transport time and elongation of a plume of material carried down valley by the nocturnal drainage wind in both the Anderson Creek and Putah Creek air sheds.

(2) To investigate any possible interactions between the two air sheds.

This paper reports on the analysis of the tracer data collected. The unknown deposition properties of the FP material negates any quantitative calculation of absolute concentrations; however, for meeting the objectives of this study the FP tracer proved to be a good and simple one to use.

II. EXPERIMENTAL DESIGN

In each experiment tracer was released in the upper portion of each air shed and both sequential and integrated samples collected at downwind locations. The release sites and sampling locations are shown in Fig. 1. Detailed locations of each are given in the Appendix. In the first experiment (FP-1) the position of R1 was located slightly further below the ridge line than in the rest of the experiments in order to insure release in the drainage flow.

In the fourth experiment (FP-4) the Putah Creek release was made further north at location R3 near Whispering Pines (See Appendix and Fig. 2d) to examine the transport from that location. Yellow FP was released in Anderson Creek (R1) and green FP was released in Putah Creek (R2, R3) during each experiment. The FP material was obtained from Ted Brown Associates (Los Altos Hills, CA) and the characteristics of each are given in Table I. A total of 500 g was released over a period of approximately 20 min at each release site. Table II gives the actual start time and duration for each release. Releases were made with a standard FP aerosol generator (Metronics Associates, Palo Alto, CA; model 10) operated off of portable 110 VAC generators. All samples were collected on type H Rotorods using a Model 60A Rotorod Sampler (both Metronics Associates). The sampling rate with this configuration is 52 liters per minute with a collection efficiency of 65%.

The integrated sampler ran for sufficient time to allow for complete plume passage. The sequential sampling was begun as close to the time of release as possible and continued for 2 to 4 h depending on location with samples taken for 10 or 15 min intervals. Assay of the collection rods was done by visual counting or particles on random representative areas of each while illuminated with an ultra-violet light source. The total number of particles collected is then calculated based on the ratio of the area counted to the total collection area of the rod. Normally the assay was made by two individuals and the results averaged to produce the reported value.

III. RESULTS

A. Integrated Samples

The results of the integrated sampling network for the four experiments are shown in Figs. 2a-d. The total particles collected at each sampler are shown as a logarithmic bar graph near each sampling location. The shading of the bars are matched to the shading at the release point to identify the two tracers. The integrated values displayed at sampler 10 were derived from the sequential samples taken at that location.

There are several observations that can be made from the integrated data:

(1) The total particles collected at site 1 was remarkably constant in all four experiments with those collected during FP-1 being somewhat higher than the other three experiments.

(2) Tracer material released from R1 at the top of Anderson Creek was collected at every sampler in all four experiments.

(3) Tracer material released from R2 at the top of Putah Creek was collected in all samplers except at site 1 (it wouldn't be expected there) in all experiments except FP-2.

(4) In experiment FP-2 large amounts of R1 tracer were found in the Putah Creek samplers with comparatively low to no amounts of R2 tracer in all samplers.

(5) In all experiments site 8 collected more R2 tracer than the closer site 7, except in experiment FP-2 when site 8 collected no R2 tracer.

Based on these limited observations it would appear that:

(1) Drainage flow characteristics in the region from release point R1 to sampling site 1 were about the same each night due to the better defined Anderson Creek air shed in the region.

(2) In the lower area of Anderson Creek below sampling site 1 the drainage flow becomes more complex due to the interaction of other air sheds as evidenced by the different distributions of tracer in the integrated samplers in that region on different nights.

(3) The drainage flow characteristics of Putah Creek were not well defined by the R2 releases. This may be due to either a weaker drainage system or that the tracer was not released completely in the drainage flow regime.

(4) In three out of the four tracer experiments there was considerable transport interaction between the Anderson Creek and Putah Creek flow regimes.

(5) In experiment FP-2 there appears to have been a considerable transport of all tracer in an easterly direction as evidenced by high R1 tracer in Putah Creek and very low R2 tracer in all samplers.

It must be noted that the above are based upon the results of only four tracer experiments and, therefore, may not be representative. However, they do indicate quite well the complexity of interacting flows in the basin.

B. SEQUENTIAL SAMPLES

Sequential samples were collected at sampling sites 1, 9, and 10 (Fig. 1). These locations were selected primarily to look at plume transport from R1 down the Anderson Creek air shed. Although the sequential samplers at location 9 and 10 did collect some R2 tracer the counts were in general too low to interpret plume transport characteristics in Putah Creek. Therefore, the ensuing analysis is concerned only with the sequential sampling results for R1 released into Anderson Creek.

Figures 3a-d show the total particles collected in each sequential sampling interval as a function of time after start of release for each of the four experiments. Each curve is labeled with the distance of the sampler from the release point R1 and the duration of the release is shown by a horizontal bar in the upper left-hand corner of each figure. In the first experiment (July 18-19) sampling was terminated prematurely due to the unexpected elongation of the plume at sites 9 and 10.

The results of the sequential sampling for the first three experiments are fairly similar. They show a rather narrow plume (in time) at site 1 with considerable elongation (in time) at sites 9 and 10. The last experiment (July 26-27) shows a similar plume at site 1, but poorly defined ones at sites 9 and 10 indicating much different transport conditions in the lower part of Anderson Creek on that night than during the previous three experimental nights.

Plume arrival time at each sampler location was determined from Figs. 3a-d by determining the time at which the number of particles reached 10% of the peak value at that sampler. The 10% of peak value method was chosen as an objective method to treat each set of data. From the arrival time and the distance from the release point an effective transport velocity V-eff was computed in each case. In addition a plume elongation factor was determined by dividing the width (in time) of the plume at the 10% of peak point by the duration of the release. These effective transport velocities and elongation factors are given for each experiment at each sampler in Table III. Also listed is the elongation factor per kilometer of travel distance.

An inspection of this data reveals that:

(1) The effective transport velocity from R1 to sites 1 and 10 was fairly constant with values ranging from 1.0 to 1.4 m/s excluding the value of 0.6 at site 10 in the fourth experiment due to highly questionable data.

(2) In the first three experiments an effective transport velocity of 2.0 m/s was determined for transport from R1 to site 9 located between site 1 and 10. This would appear to be an anomaly. This result implies that the plume was transported faster between sites 1 and 9 and then slowed down again between sites 9 and 10. Another possible explanation is that part of the tracer plume was carried to site 9 by stronger upper level winds. Sites 1 and 10 were located in the creek bed while station 9 was located 80 meters above the bed of Anderson Creek.

(3) The plume elongated considerably in a relatively short travel distance. Elongation factors ranged from 1.8 at 2.5 km to 9.0 at 6.4 km. The elongation factor per kilometer of travel distance was more constant with values ranging from 0.7 to 1.5 indicating an almost linear relationship between the elongation and the travel distance.

One must be careful with the interpretation of the elongation factor since without good wind data at the sampling site one cannot distinguish between a long plume passing by at some speed and a short one passing by at a slower speed. This will be treated in future analysis of this data.

Each of Figures 4 - 6 show the plume passage profiles at a given site for all four experiments. At site 1 (Fig. 4) all profiles are relatively similar in shape. The profile for AC-1 has a larger peak value than the other three. At sites 9 and 10 (Figs. 5 and 6) the profile of AC-1 continues to have the largest peak value. The profiles for AC-2 and AC-3 are the most similar at these two sites, while that for AC-4 is fairly erratic and not well defined.

From this way of looking at the data, it is implied that at site 1 the transport characteristics of the drainage flow from R1 to site 1 were similar on all four nights. The higher concentration during the first experiment is probably due to the fact the release point R1 was further below the ridge line than in the other three experiments and more tracer was injected in the drainage flow. As stated in the section on integrated samples this result probably reflects the better defined air shed of Anderson Creek between R1 and site 1.

The results of Figures 4 - 6 also indicate that experiments 2 and 3 were conducted in very similar transport conditions in the drainage flow region from R1 to site 10. The first experiment is also very similar, but with higher concentrations, the reason for which have been speculated on above. Although experiment 4 looks similar to the others at site 1, the results at site 9 and 10 indicate a very erratic behavior and perhaps an absence of the drainage flow conditions in the lower part of the valley that existed on the three other nights.

IV. SUMMARY

Four fluorescent particle tracer experiments were performed during the 1979 ASCOT field experiment in Anderson Creek Valley. The results showed considerable interaction between the nocturnal drainage flow fields of Anderson and Putah Creek. Sequential samples taken at three locations in the Anderson Creek air shed measured effective transport velocities for the tracer material of 1 to 2 m/s. The same data also indicated a plume elongation in time that varies approximately linearly with travel distance measured in kilometers. The overall result of the tracer experiments reflects the complexity of the flow fields in the lower part of the Anderson Creek Valley due to various interacting drainage flows.

ACKNOWLEDGEMENTS

Dr. Teymoor Gedayloo and John Archuleta played a major role in data collection and processing. Environmental Systems and Services of Kelseyville, CA provided operational support for the execution of the experiments.

TABLE I

FP TRACER MATERIAL

Property	Yellow	Green
Type [1]	Lot 1208, #718	Lot 1320, #763
Mass Mean Diameter (μm)	2.74	2.79
Particles per gram	2.31×10^{10}	2.21×10^{10}

1 Ted Brown Associates, Los Altos Hills, CA.

TABLE II

RELEASE DATA FOR FP EXPERIMENTS

		Anderson Creek [1]		Putah Creek [2]	
Experiment	Date	Start	Duration (min)	Start	Duration (min)
FP -1	July 18	2300[3]	25	2300	27
FP -2	July 22	2215	23	2215	25
FP -3	July 24	2225	21	2225	25
FP -4	July 26	2310	21	2310	20

1 500 g of yellow FP, 2.3×10^{10} particles/g; mean mass dia. = 2.7 μm

2 500 g of green FP, 2.2×10^{10} particles/g; mean mass dia. = 2.8 μm

3 Pacific Standard Time.

TABLE III

Transport Characteristics for ACV Experiments

Experiment	Sampler[1]	V-eff(m/s)	Elongation Factor	Elongation Factor per Kilometer of Travel
ACV-1	1	1.2	1.8	0.7
ACV-1	9	2.0	1.7	0.7
ACV-1	10	1.0	- -	
ACV-2	1	1.4	1.8	0.7
ACV-2	9	2.0	4.6	0.9
ACV-2	10	1.4	7.0	1.1
ACV-3	1	1.1	1.8	0.7
ACV-3	9	2.0	7.3	1.5
ACV-3	10	1.4	9.0	1.4
ACV-4	1	1.2	2.6	1.0
ACV-4	9	0.7	- -	- -
ACV-4	10	0.6	- -	- -

1 Sampler 1 = 2.5 km from release
Sampler 9 = 4.9 km from release
Sampler 10 = 6.4 km from release

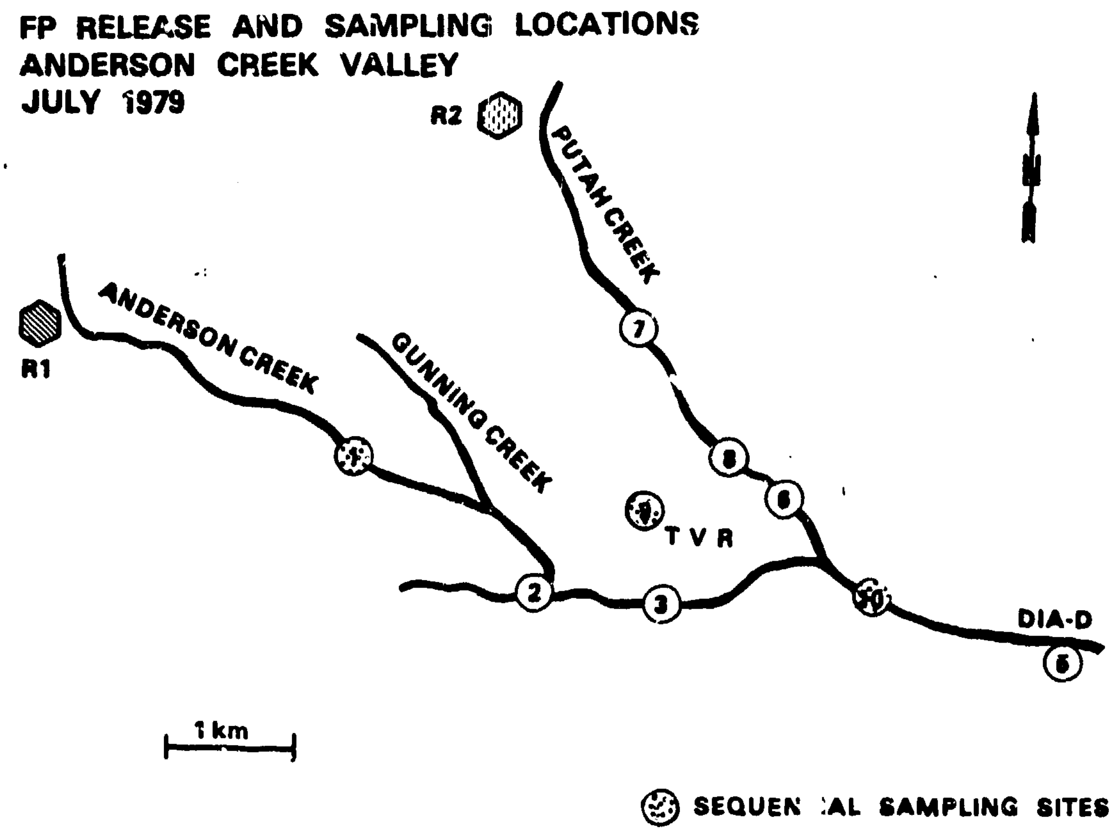

Fig. 1. Locations of release points and sampling sites for the FP tracer experiments.

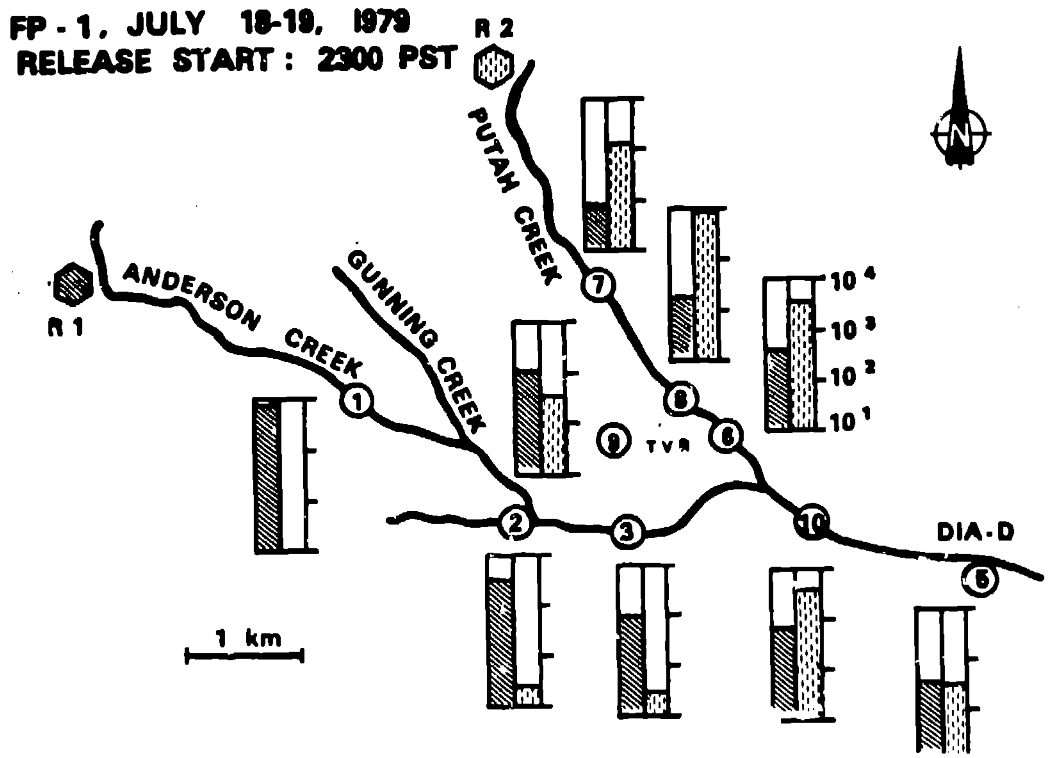

Fig. 2a. Integrated FP results for FP-1

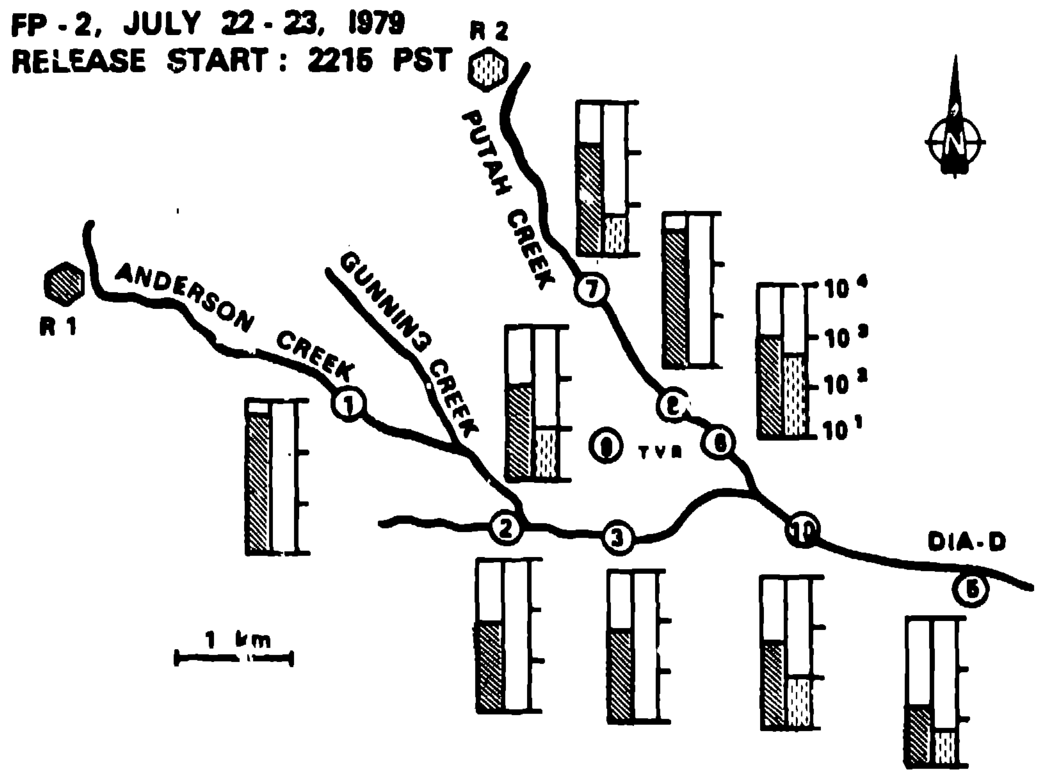

Fig. 2b. Integrated FP results for FP-2

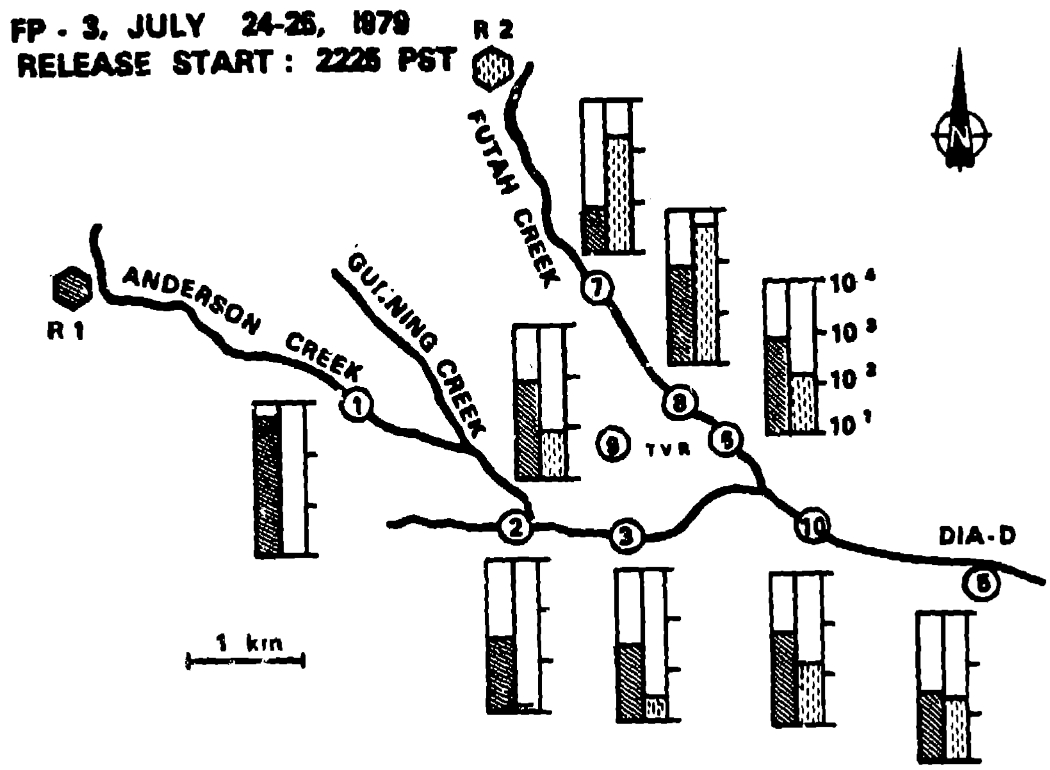

Fig. 2c. Integrated FP results for FP-3

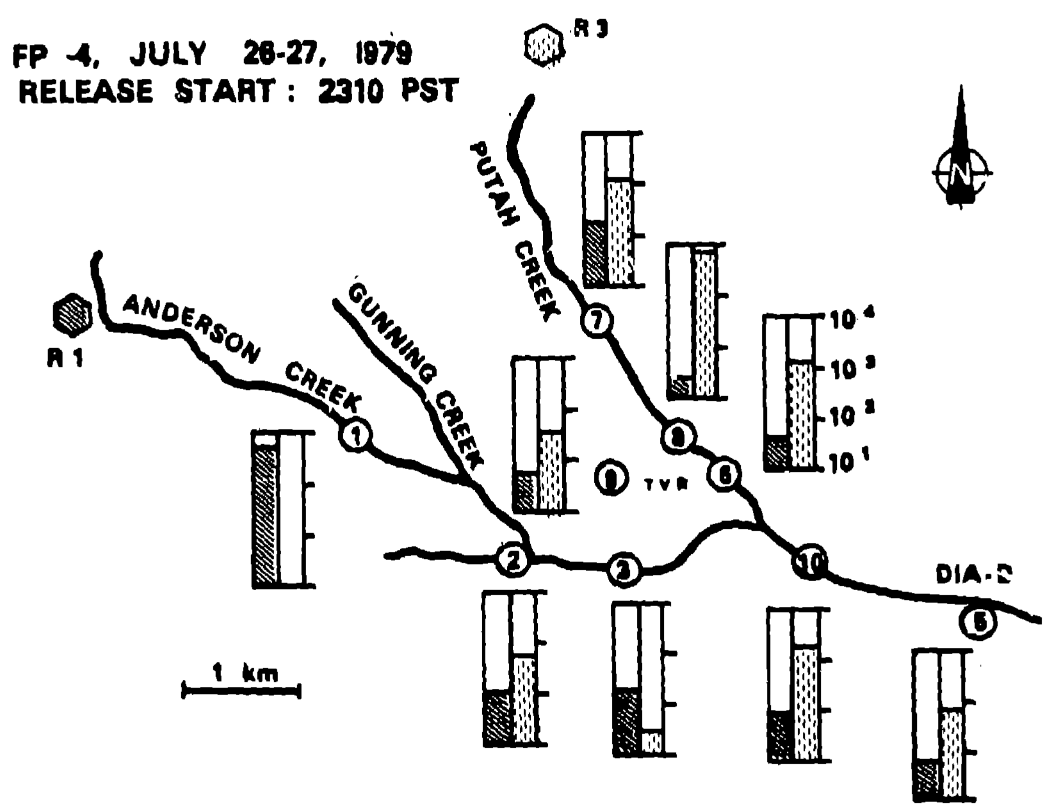

Fig. 2d. Integrated FP results for FP-4

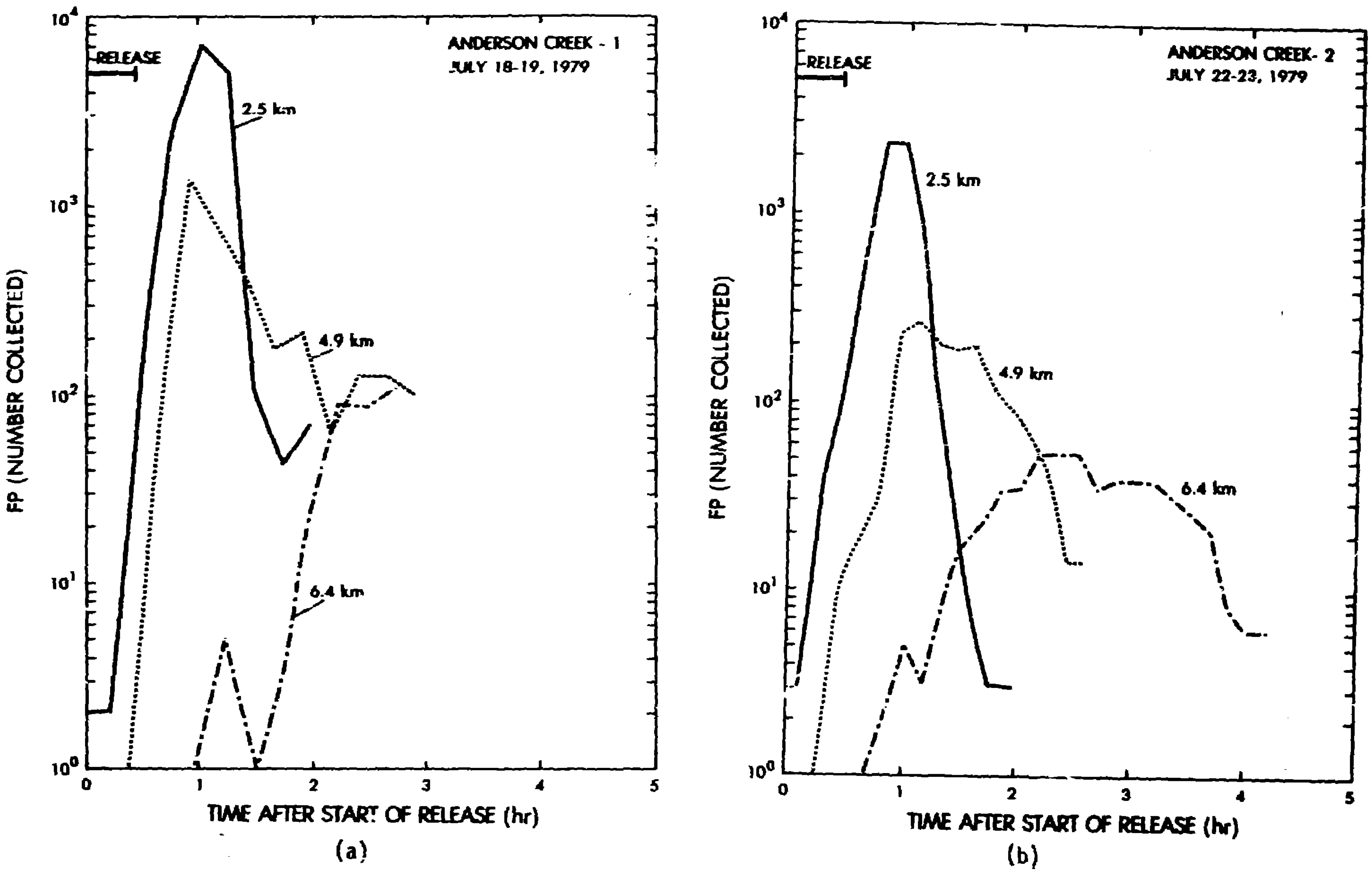

Fig. 3. Tracer Plume concentration as a function of time at three down valley locations. Curves are labeled with kilometers from the tracer release point.

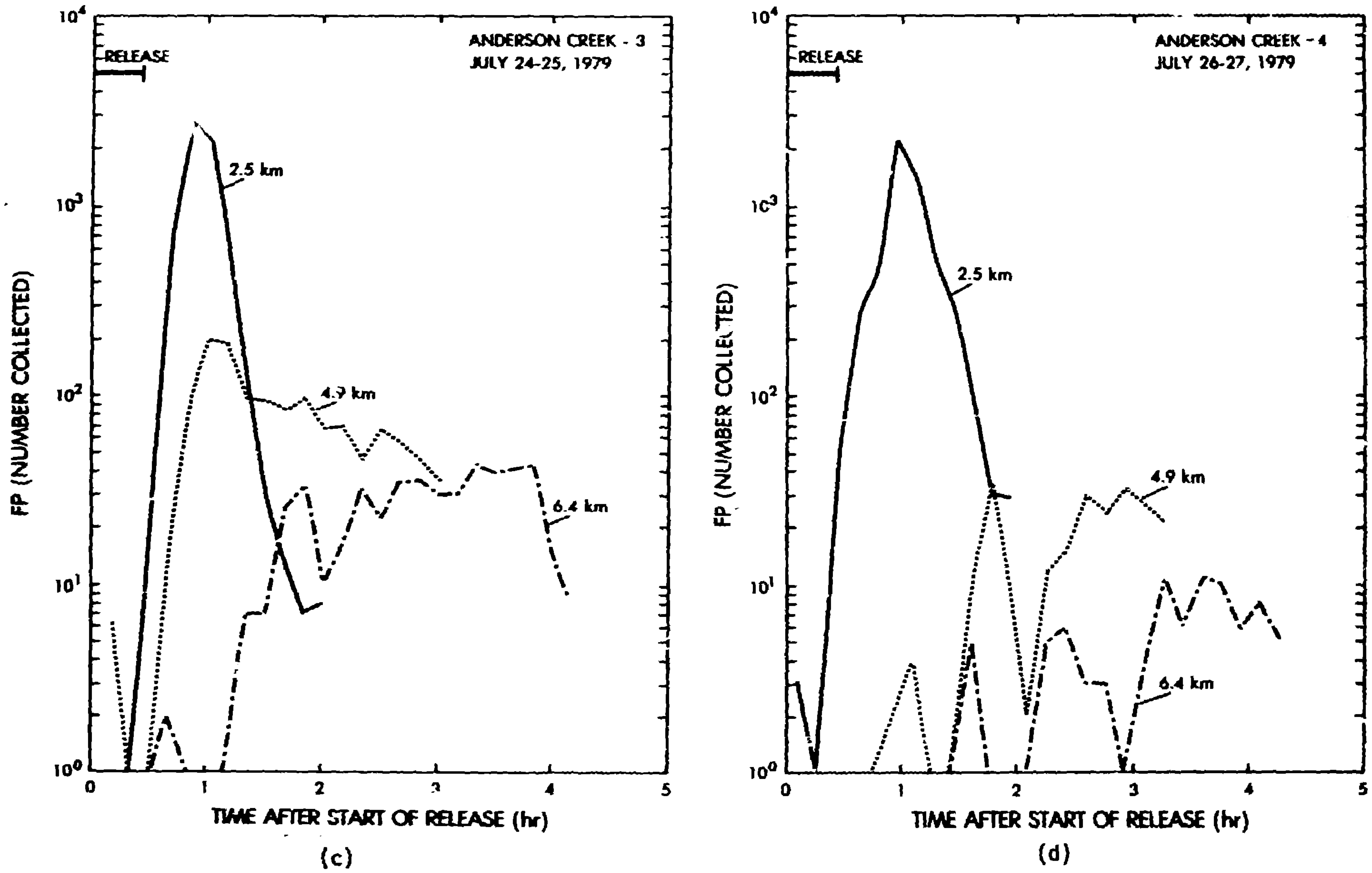

Fig. 3. Tracer plume concentration as a function of time at three down valley locations. Curves are labeled with kilometers from the tracer release point.

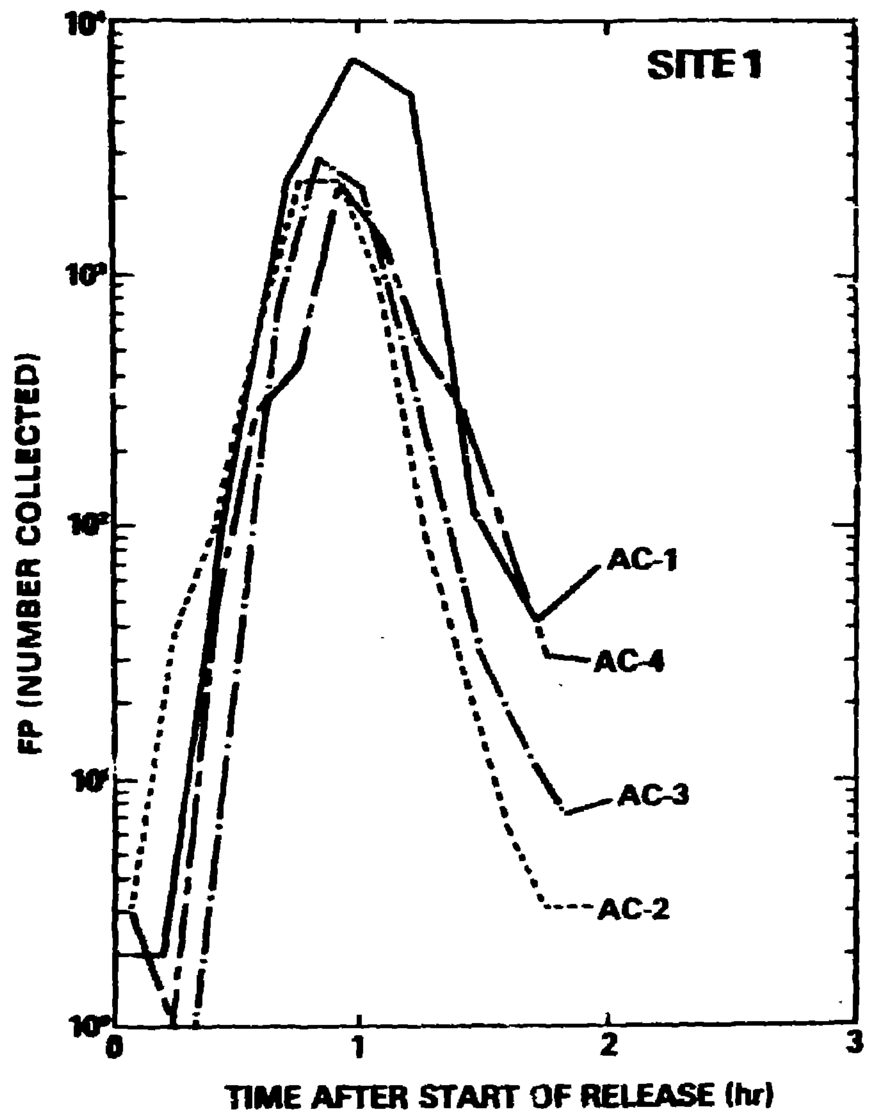

Fig. 4. Tracer plume concentration as a function of time at 2.5 km from the release point for all experiments.

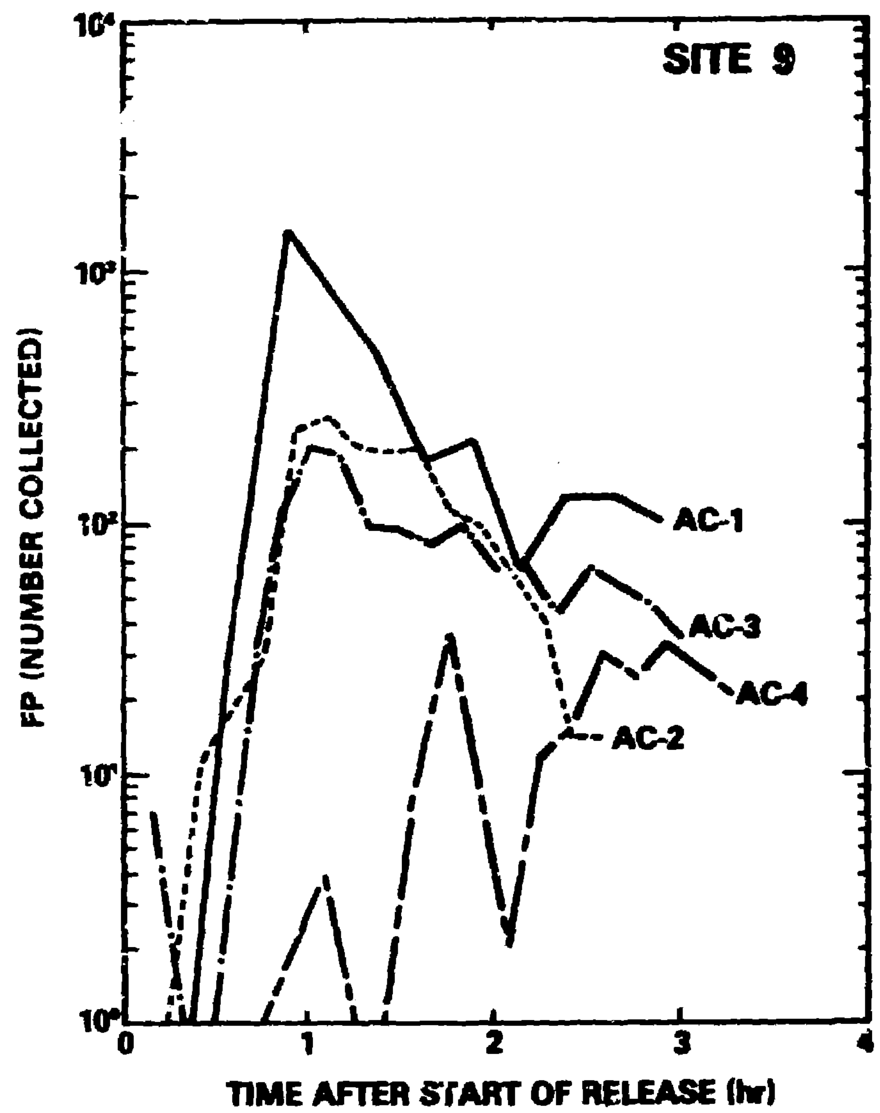

Fig. 5. Tracer plume concentration as a function of time at 4.9 km from the release point for all experiments.

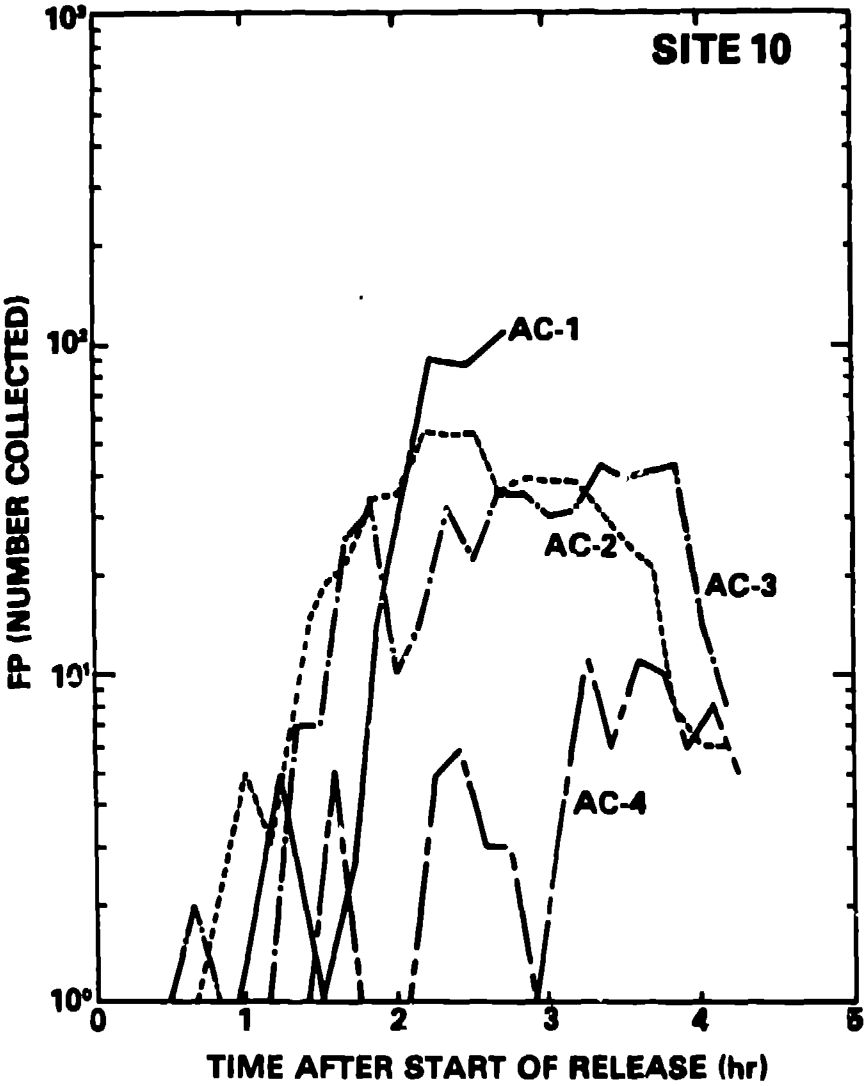

Fig. 6. Tracer plume concentration as a function of time at 6.4 km from the release point for all experiments.

APPENDIX

LOCATIONS OF FP RELEASE POINTS AND SAMPLERS

Identifier	UTM Coordinates (x,y)	Location
Release Points		
R1	(522.02, 4293.54)	Anderson Creek
R2	(525.70, 4295.01)	Putah Creek
R3	(525.45, 4296.11)	Whispering Pines
Samplers		
1 (I,S)[1]	(524.38, 4292.57)	Socrates Mine Road at Anderson Creek Crossing
2 (I)	(525.73, 4291.61)	Anderson Springs, 1.45 miles from junction of highway 175
3 (I)	(526.71, 4291.57)	Anderson Springs, 0.7 miles from junction of highway 175
4 (I)		Caltrans yard near ES&S-MRI tower
5 (I)	(529.70, 4291.12)	Diamond D Ranch near PNL tower
6 (I)	(527.56, 4292.28)	Highway 175, 0.1 mile south of junction with Socrates Mine Road
7 (I)	(526.45, 4293.52)	Highway 175, 1.3 miles south of Putah Creek release point R2
8 (I)	(527.19, 4292.61)	Highway 175, 0.15 mile north of junction with Socrates Mine Road, entrance to boys camp
9 (I,S)	(526.80, 4292.30)	TV Repeater Site
10 (S)	(528.23, 4291.73)	Highway 175, 0.3 mile south of south turnoff to Anderson Springs

1 - Type of Sampler: I - integrated, S - sequential

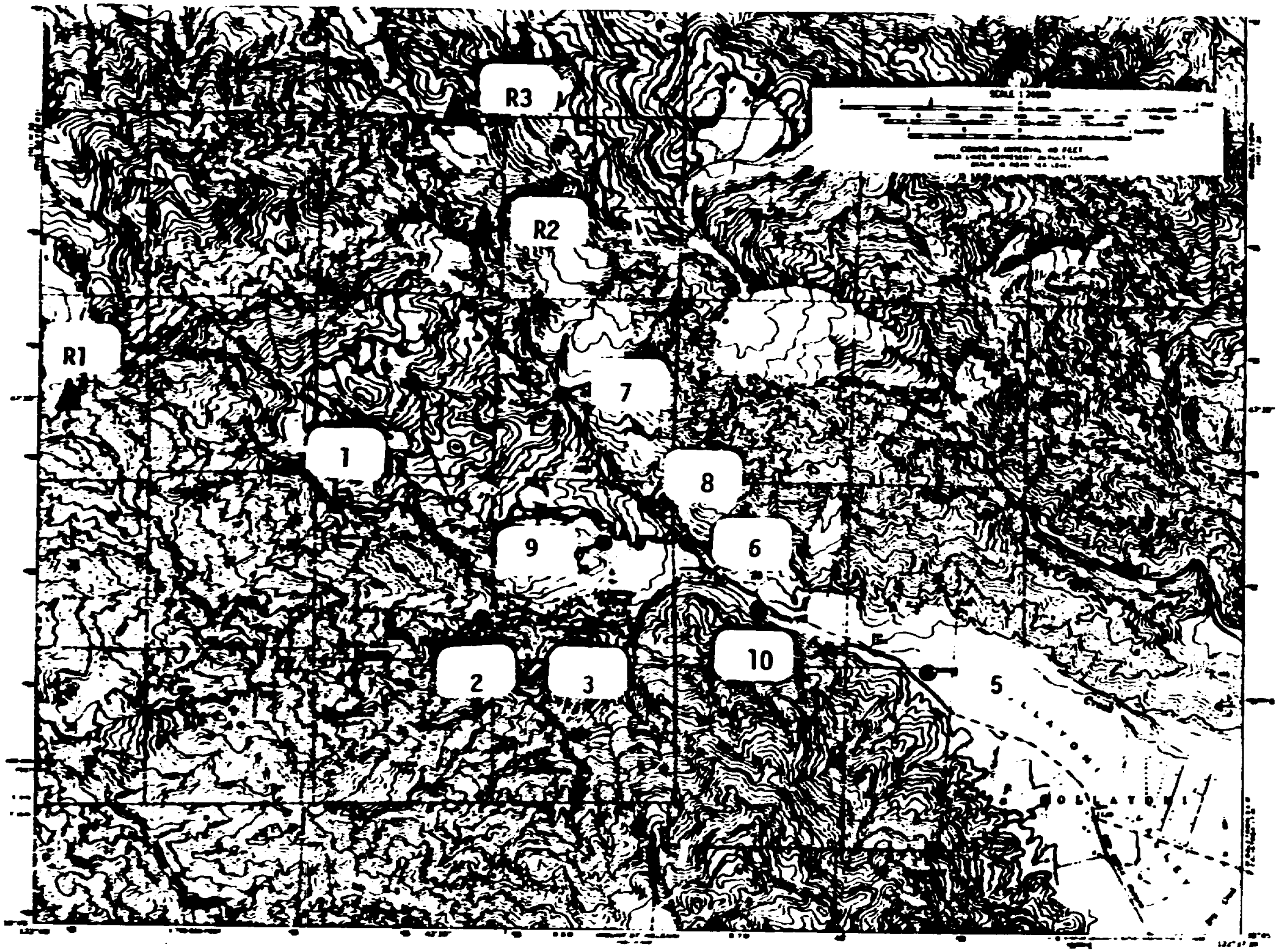

Fig. A-1 Locations of FP releases (R), integrated samples (I), and sequential samplers (S).