225
5-3-78

LA-7198-MS, Vol. I
Informal Report

MASTER

LA. 28

UC-11

Issued: March 1978

Some Atmospheric Tracer Experiments in Complex Terrain at LASL

Experimental Design and Data

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LOS ALAMOS, NEW MEXICO 87545

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UNITED STATES
DEPARTMENT OF ENERGY
CONTRACT W-7408-ENG. 36

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ABSTRACT

Two series of atmospheric tracer experiments have been conducted in complex terrain situations in and around the Los Alamos Scientific Laboratory. Fluorescent particle tracers were used to investigate nighttime drainage flow in Los Alamos Canyon and daytime flow across the local canyon-mesa complex. This report describes the details of these experiments and presents a summary of the data collected. A subsequent report will discuss the analysis of these data.

I. INTRODUCTION

During the late summer and early fall of 1976 and the summer of 1977, two series of small-scale tracer experiments were conducted in an area of complex topographic structure at the Los Alamos Scientific Laboratory (LASL) in northern New Mexico. The general setting of the experimental site is within the Laboratory boundaries on the Pajarito Plateau on the eastern flank of the Jemez Mountains (Fig. 1). The plateau is cut by a series of east-west oriented erosion-produced canyons that originate in or near the base of the mountains and run eastward to the Rio Grande, a distance of about 10-20 km. The canyons are 50 to 100 m in depth and 200 to 400 m wide, and they separate a series of finger mesas which vary in width from a few hundred meters to more than a kilometer.

One series of tracer experiments was conducted under stable nocturnal conditions with a downslope drainage wind in Los Alamos Canyon, which has its origin well into the Jemez Mountains and is one of the major canyons in the Laboratory

area (Fig. 1). It contains a reactor facility which could pose a potential threat of airborne effluents in the event of an accident. The canyon runs approximately east-west sloping down to the east at a 4% grade and drains an area of 27.5 km². At the point where our investigations were made the canyon is 230 meters wide and 55 meters deep. Its cross section is fairly uniform in this area for several kilometers. Structurally, this canyon is representative of the others in which Laboratory operations are conducted. Finally, the canyon floor has a road that makes it accessible over much of its length. The objectives of this series were:

1. Determine dilution rates in a confined canyon under the light, steady drainage wind regime.
2. Determine the extent of material exchange between canyon and adjoining mesa top where most of the residential activity is located.

The other series of experiments was performed under moderate cross-mesa winds and daytime conditions. Tracer was released from the site of the LASL meteorological tower (TA-50) and traversed the corrugations of several mesa-canyon complexes (Fig. 1). This series simulated an inadvertent release from any one of several technical sites with subsequent wind transport toward the Los Alamos town site. The objectives of this series were:

1. Determine dilution rates under daytime cross-canyon wind conditions.
2. Determine exchange rates into the canyons.
3. Compare actual plume trajectories to estimates made from wind conditions near the release point.

II. EXPERIMENTAL DESIGN AND PROCEDURES

In both series of experiments, tracer was released at ground level from a single point and sampled at various downwind locations. Samplers were operated for a period longer than the estimated plume traversal time, thereby producing a ground-level integrated sample at each location. Appropriate meteorological data were collected prior to the release and during plume passage through the sampling array.

A. Tracer Material

The tracers used in these experiments were United States Radium Corporation fluorescent particles (FP). Three types were used with red, green, and yellow fluorescent color. All tracers used had a mean mass diameter in the order of 3 μ m and a particle density in the range of 10^{10} particles per gram.

Specifications of the particular tracer used in each experiment are given in data tables that will be discussed below.

B. Release Procedure

Metered quantities of FP tracer material were released using a Metronics Model 10 Aerosol Generator. The actual amount of tracer released was determined by pre- and postrelease mass determinations. Release rates were calculated from this value and the duration of the release. Release rates and amounts varied depending on the experimental situation and details for each experiment are given in data tables that will follow.

C. Sampling Procedure

Tracer samples were collected using Metronics Rotorod Sampler Model 60 A and Type H Rotorods. Metal fence posts were installed at each sampling location and a sampler was attached to each post at approximately one meter above the ground. The collection rods were installed and samplers turned on just prior to a release and collected as soon after plume passage as was practical. All samplers were operated on 12-volt d.c. battery systems.

The sampler motors used were measured to have a constant angular speed for supply voltage between 9.3 and 17 volts. To insure proper operation all batteries were checked before each experiment and none was used that measured less than 11.5 volts under a resistive load.

Figure 2 shows a sampler with a type H rotorod attached. The vertical rotorod arms are coated with a black silicone adhesive. When the sampler is energized the rotorod rotates and particles are imparted on the leading edge of the collection arms. For the particle size range (2-5 μm) used in these experiments this collection system has a 65% efficiency.

The sampling rate, the volume of air swept out by the rotorod per unit time, is determined as follows (refer to Fig. 3)

$$\text{Sampling Rate} = VW\omega, \quad (1)$$

where

$V = 2\pi dh$ = volume of a cylindrical shell formed by a rotating strip of H-type collector rod

d = diameter of rotating cylinder = 12 cm

h = length of one strip = 6 cm

W = width of strip = 0.048 cm

ω = angular speed = 2400 $\pm$ 50 rpm .

For the H-type collector rods and the rotorod motors used, the average sampling rate is 52.3 ± 1.1 liters per minute.

D. Sample Analysis

1. Particle Identification

In order to identify fluorescent particles from other airborne particles collected on sampling rods the criteria of color, intensity, and size were used. After each experiment collector rods were viewed through a microscope under a uv light where the FP particles emit their characteristic color and become visible. Since a particle when subjected to uv light fluoresces throughout its entire volume, the luminous intensity per particle is proportional to the cube of its diameter. Consequently, large-diameter particles appear much brighter than the smaller ones. Although most airborne particles fluoresce to some extent under uv light, their intensity as a function of diameter is much less than and their color is different from FPs. Therefore, on the basis of color, intensity, and size, airborne particles are identified and excluded from the total count.

2. Counting Procedure and Estimation of Total Number of Particles Per Rod

Figure 3 shows a diagram of H-type collector rods used in this experiment. The horizontal bar, with a microscope stage mounting slot, is 12 cm long and has two collector strips, each 6 cm long and 0.048 cm wide, attached to it. The exposed rods are mounted on a rod holder, attached to a mechanical microscope stage, and are viewed with a magnification of 100X (10X eyepiece and 10X objective). With this magnification the entire width of rod is visible in the field of view. Eyepieces are fitted with fixed cross-hair parallel lines (reticule) of various widths. The number of particles counted in each field of view are confined to the area formed by the reticule lines perpendicular to the rod and the edges of the rod as shown in Fig. 4.

The following counting procedure was used in determining the average number of particles per rod.

a. Low-Density (Particle Deposit) Rods.

For rods having fewer than 5-8 particles per counting area in a field of view (Fig. 4), the entire four arms of the rod are scanned and the total number of particles counted is recorded.

b. Medium-Density Rods.

For rods with 10-70 particles per counting area, one arm of the rod is examined with a given reticule width to obtain 8-15 particles per field

of view. Then, enough randomly selected fields of view are selected for this arm to yield a total of at least 80 particles counted. The same number of fields as examined on the first arm are then randomly selected on each of the remaining three arms and the number of particles counted per arm per field of view are recorded. Figure 5 shows a typical FP count record form where six fields per arm were counted.

In order to calculate the estimated FPs per rod, the following formulas were used:

total FP estimate = (area ratio factor) (average particles per field),

area ratio factor = $\frac{\text{combined lengths of the four arms}}{\text{apparent reticule width}}$, and

average particles per field = $\frac{\text{number of particles counted for a given rod}}{\text{number of fields examined}}$.

For example, for the FP count record form of Fig. 5,

area ratio factor = $\frac{12 \text{ cm}}{0.0719 \text{ cm}} = 167$,

average particles per field = $\frac{301}{24} = 12.54$, and

total FP estimate = $(12.54) (167) = 2094$.

Statistically, this number is reliable to better than $\pm 10\%$ with 90% confidence. Area ratio factors for the three microscope systems used on these analyses are given in Table I.

c. High-Density Rods.

For these rods the number of particles for the narrowest reticule exceeds 100, making counting difficult. An eyepiece with extremely narrow cross-hair lines along with a 20X objective was used to count the number of particles for these rods. The total FP estimated were calculated as described in Sec. II. D.2.b.

3. Determination of Average Counts Reported

As a quality control check each rod was examined by at least two individuals. If the total FP estimated for the two observers agreed to within 10%, these totals were recorded and the average particle count was calculated. Otherwise, rods were examined by other observers until the above agreement was reached. Estimated total counting time per rod is approximately 40 min (includes duplicate counting). The average value obtained in this way is reported for the total particles on a particular rod.

III. NIGHTTIME EXPERIMENTS IN LOS ALAMOS CANYON

A. Experimental Objectives

Since nighttime downslope drainage conditions present a stable thermal stratification with its associated weak turbulence levels, confined flows in canyons have the potential of carrying pollutants long distances with poor dilution. The objectives of these nighttime experiments were (1) to determine dilution rates in such a situation and (2) to investigate the extent of mixing between the canyon and adjacent mesa tops. A total of 7 of these experiments have been performed.

B. Experimental Specifics

Figure 6 shows the location of the study area in Los Alamos Canyon. The various sampling lines are labeled with their distances in kilometers from the release point. Figure 7 is a scaled drawing (except for the position of the rims at mesa levels) showing the positions of the samplers and Table II gives each sampler's distance from the southernmost sampler on each line in the canyon. Sampling lines B, C, and D were selected at 1, 1.8, and 4 km, respectively, from the release point R. In addition, single sampling locations were installed at 100 m, 200 m, and 6 kilometers distance from R in the center of the canyon. There are a total of 33 samplers installed in the canyon and on the rims at mesa levels as shown in Fig. 7. In order to investigate the vertical structure, diffusion, and the vertical mixing effect, a tower at 1 km from the release point was installed for positioning samplers at 6.5, 12, 17, 22, and 32 m above the canyon floor. The motors for each sampling line were connected in parallel to a 12-V battery and an electronic timer that kept each line energized for a preset time. The motor for each of the single sampling locations (A-10, A-20, and E-10) was operated by individual batteries.

A few hours prior to each experiment, collector rods were installed on each of the samplers. The actual release of fluorescent particles did not take place until a down-canyon drainage was well established, which for most cases was just before or after midnight local time. Because the average windspeed was, in general, less than 1 m s^{-1} , the samplers were kept running for a period of 5-6 hours to insure the passage of plume over the sampler at 6 km.

C. Data Summary

The type of tracer used, its physical characteristics, release data, and average drainage wind speed and direction are given in Table III for each of the nighttime experiments. Experiments 77-10 and 77-11 were performed back-to-back

on the same night using two differently colored tracers. Particles from both releases were collected on the same set of collector rods. Releases lasted from 2 to 4 minutes and totaled 100 to 300 grams of tracer. Wind speeds ranged from 0.5 to 1.0 ms^{-1} and directions were predominantly along the west to east drainage axis of the canyon but with a slight southerly component. Table IV gives the general meteorological conditions at mesa level as monitored at the Occupational Health Laboratory's (OHL) central meteorological station during each experiment. The reported values are averaged for the 4-hour period beginning at release time.

The total FP particles for each sampler location in this series of experiments are given in Table V. These values are the total number of particles collected on each sampler at a sampling efficiency of 65% and should be multiplied by 1.54 to obtain the actual number that should have been collected. The cross-canyon profiles of time-integrated concentration for each sampling line and for each experiment are shown in Figs. 8-14. The vertical profiles from the tower are shown in Figs. 15-21. Figures 22-28 are hand-drawn isopleths of integrated concentration for each of these experiments where rim samples have been included to help show their relationships to samples in the canyon.

Table VI gives the gross statistical analysis of each data set in this series of experiments. Values are given for the center of the distribution $\bar{y}$ (measured from B15, C20, and D15 on each line), the standard deviation σ , the moment coefficient of skewness γ_1 , and the moment coefficient of kurtosis γ_2 .

IV. DAYTIME CROSS-CANYON EXPERIMENTS

A. Experimental Objectives

Daytime southerly cross-canyon wind conditions produce a situation where effluents released on the laboratory site might reach the townsite very quickly. The daytime series of tracer experiments was run under these conditions to determine (1) what effect, if any, the canyon-mesa complex has on dilution rates under cross-wind conditions, (2) exchange rates into the canyons, and (3) a comparison of actual plume trajectories to estimates based on wind conditions near the release point. A series of 6 of these experiments was conducted during July and August 1977.

B. Experimental Specifics

Figure 29 shows the release point for this series of experiments and the 90° sampling sector employed. Sampling lines were established in Mortandad Canyon (M-line), on the mesa just north of Mortandad Canyon (P-line), on the

mesa just south of Los Alamos Canyon (J-line), in Los Alamos Canyon (L-line), and on the mesa top just north of Los Alamos Canyon (T-line). The relative locations of these sampling lines are shown in Fig. 30, which is a simplified terrain relief schematic from the release point north. The distance from the release point R to T-line ranges from 2-3 kilometers. Figure 31 shows the actual location of each sampler and Table VII gives its polar coordinates relative to the release point.

Fluorescent particles were released at about 1 m above ground level from point R during the periods of persistent southerly winds. Wind and temperature data were collected at the release point, on both rims and the floor of Los Alamos Canyon, as well as at the Central Meteorological Monitoring Station at OHL. Collector rods were installed approximately one hour before the release. Tracer was released between 1000 to 1100 MST after southerly wind was established. Since the average wind speed for each experiment was $3-4 \text{ ms}^{-1}$, the tracer cloud cleared the grid quickly and samples were retrieved one hour after the release.

C. Data Summary

The tracer used, its physical characteristics, release data, and the average wind conditions during the release are given in Table VIII for each of these six experiments. The general meteorological conditions as monitored at the central meteorological station at the Occupational Health Laboratory (approximately 1 km west of the release point) are given in Table IX. Data given are average values for the 1-hour period beginning at release time.

The total number of particles collected on each sampler for each experiment are given in Table X. As with the Los Alamos Canyon data, these values should be multiplied by 1.54 to obtain the number of particles that would have been collected if samplers were totally efficient. Figures 32 through 37 are graphic presentations of the results of each experiment in this series. Figures 38 through 43 are hand-drawn isopleths of total integrated concentrations for each experiment. Gross statistical parameters on each data set in these series are presented in Table XI.

V. DISCUSSION

The two series of atmospheric tracer experiments discussed above provide a data base for addressing transport and diffusion in two complex terrain meteorology situations: (1) nocturnal drainage flow in a confined canyon and (2) day-

time flow across a canyon-mesa complex. These problems are of interest both locally for operational needs and to the meteorology community at large to further the understanding of complex terrain meteorology. The latter is of particular importance in the consideration of the siting of new energy production facilities in the mountain west as outlined in a recent national workshop.¹

ACKNOWLEDGMENTS

The authors thank Frank Craven, Denby Auble, Walter Kubilius, Debra Martinez, and Bradley Woodworth for their assistance with these experiments.

REFERENCE

1. Workshop on Research Needs for Atmospheric Transport and Diffusion in Complex Terrain, S. Barr, R. E. Luna, W. E. Clements, and H. W. Church, Eds., Energy Research and Development Administration Conference 7609160, Albuquerque, NM, September 28-30, 1976.

TABLE I
AREA RATIO FACTORS FOR MICROSCOPES

Microscope 23

<u>Objective</u>	<u>Eyepiece</u>				
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
10 X	167	169	228	310	430
20 X	332	330	443	600	839

Microscope 24

<u>Objective</u>	<u>Eyepiece</u>				
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
10 X	167	166	222	303	412
20 X	326	327	444	609	828

Microscope 25

<u>Objective</u>	<u>Eyepiece</u>					
	<u>A*</u>	<u>A**</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
10 X	3750	284	169	220	308	414
20 X	7500	600	361	469	659	889

TABLE II
RELATIVE POSITIONS OF LOS ALAMOS CANYON SAMPLERS

<u>B-Line</u>		<u>C-Line</u>		<u>D-Line</u>	
<u>Sampler</u>	<u>Distance (m)</u>	<u>Sampler</u>	<u>Distance (m)</u>	<u>Sampler</u>	<u>Distance (m)</u>
B15	0	C20	0	D15	0
B20	23	C30	46	D20	61
B30	46	C40	92	D30	110
B40	69	C50	138	D40	156
B50	92	C60	184	D50	202
B60	115	C70	230	D60	248
B70	138				
B80	161				
B90	184				
B100	207				
B110	230				
B120	253				

TABLE III

BASIC DATA FOR THE LOS ALAMOS CANYON EXPERIMENTS

Experiment		Tracer Data			Release Data				Wind Data*		
Number	Date	Type	Particle Density (10^{10} g^{-1})	Mean Mass Diameter (μm)	Time (MST)	Duration (min)	Amount (g)	Rate (g min^{-1})	Speed (ms^{-1})	Direction (degrees)	σ_A (degrees)
FP76-1	10 Aug 76	3206 Green Lot 1202	1.27	3.34	19:05	3.5	207.10	59.2	0.6	210	34
FP76-2	10 Nov 76	3206 Green Lot 1202	1.27	3.34	17:49	4.0	232.27	58.1	0.8	255	10
FP77-1	27 Jun 77	3206 Green Lot 1713	1.27	3.34	20:55	2.3	295.10	131.2	0.9	260	9
FP77-2	28 Jun 77	318 Yellow Lot H511	2.15	2.81	23:36	4.0	241.60	60.4	0.5	255	14
FP77-3	29 Jun 77	2487 Red Lot 513	2.23	2.78	23:43	4.0	199.00	49.8	0.6	270	8
FP77-10	7 Sep 77	2443 Red Lot 513	2.23	2.78	21:32	2.8	95.25	33.8	0.5	260	8
FP77-11	7 Sep 77	3931 Green Lot 1320	2.21	2.79	21:20	2.8	133.70	47.7	0.6	255	8

*4-hour averages from Los Alamos Canyon mechanical weather station.

TABLE IV
METEOROLOGICAL CONDITIONS AT MESA LEVEL DURING THE LOS ALAMOS CANYON EXPERIMENTS

<u>Experiment</u>	<u>Average Winds (Release + 4 Hours)</u>			<u>General Meteorological Conditions for the Day</u>				
	<u>Direction (degrees)</u>	<u>Speed (ms⁻¹)</u>	<u>σ_A (degrees)</u>	<u>Mean Temp (°C)</u>	<u>Max Temp (°C)</u>	<u>Min Temp (°C)</u>	<u>Precip. (mm)</u>	<u>Relative Humidity at 2400 MST (%)</u>
FP76-1	247	4.0	49	18	23	9	0	68
FP76-2	260	2.5	11	10	17	0	0	41
FP77-1	282	3.2	15	19	31	11	0	48
FP77-2	230	5.7	16	18	30	13	0	60
FP77-3	227	5.5	16	16	27	13	0	63
FP77-10	265	7.0	9	14	29	11	0	54
FP77-11	265	7.0	9	14	29	11	0	54

TABLE V
FP COUNTS FOR THE LOS ALAMOS CANYON EXPERIMENTS

Location	Number of Particles Collected						
	FP76-1	FP76-2	FP77-1	FP77-2	FP77-3	FP77-10	FP77-11
A-10			4.15×10^5	7.68×10^5	5.92×10^5	2.19×10^5	1.91×10^5
A-20		1.40×10^5	1.47	5.73	0.311	0.358	0.227
B-10	$0.258 \times 10^4*$	2.90×10^1	0.050×10^2	0.130×10^2	1.00×10^1	2.50×10^1	4.80×10^1
B-15	1.09	2.70	0.270	0.380	0.023×10^5	2.10	0.10
B-20	1.56	2.00	2.43	0.400	0.197	3.10	6.30
B-30	1.78	3.30	4.62	5.91	0.244	0.018×10^5	0.11×10^5
B-40	1.80	0.028×10^5	0.016×10^5	0.531×10^5	0.619	0.079	0.49
B-50	1.39	0.137	0.092	1.48	1.20	0.20	0.817
B-60	3.07	0.361	0.789	3.66	2.89	0.72	1.32
B-70	10.8	2.17	2.41	3.17	3.14	1.09	1.58
B-80	5.51	1.77	2.45	4.43	3.82	1.58	2.12
B-90	16.0	1.47	3.83	3.99	5.12	3.48	3.32
B-100		0.586	4.37	2.63	2.86	3.23	2.46
B-110	12.7	0.256	2.62	0.712	1.23	1.54	1.18
B-120	6.72	0.175	1.30	0.546	7.56×10^4	1.18	0.966
B-130	0.604	0.10×10^2	0.30×10^1		0.003	0.004	0.005
C-10	0.038	0.120	1.10	0.004×10^4	0.004	0.70×10^1	0.40×10^1
C-20	0.633		0.103×10^5	0.407	1.40	0.011×10^5	0.022×10^5
C-30	0.439	4.79	0.036	2.10	2.08	0.018	0.014
C-40	0.218	0.285×10^5	0.382	13.6	13.0	0.278	0.317
C-50	0.187	2.01	1.41	30.1	22.3	1.07	1.36
C-60	0.397		1.93	25.3	19.9	1.97	1.69
C-70	0.763	1.10×10^1	0.37	3.07	4.84	0.148	0.203
C-80	0.153		0.30×10^1	0.006	0.70	7.10×10^1	3.70×10^1
D-10	4.10×10^1	0.40	0.029×10^4	0.032	0.074		
D-15	1.00		0.960	0.368	0.723		
D-20	1.00		2.10	1.90	1.31		
D-30	1.60	0.776×10^4	1.61	6.20	2.15		
D-40	0.70	0.964	1.18	5.33	4.44		
D-50	0.70	1.83	1.03	9.94	6.19		
D-60	0.40		1.59	10.1	0.268		
D-70	2.60	0.061	0.002	0.268			
E-10		0.337	0.582	0.568	0.80×10^1	0.107×10^5	0.104×10^5
T-5	1.14×10^5	45.9	39.6	42.7	4.27×10^5	1.70	3.61
T-10	1.05	52.2	17.7	15.6	3.28	2.48	4.07
T-15	0.884	3.63	10.7	7.80	2.78	2.03	1.76
T-20	0.766	2.45	5.82	6.60	1.90	1.58	1.31
T-30	0.892	8.86	3.14	3.49	0.623		

*Powers of 10 persist down a column until another is stated.

TABLE VI
GROSS STATISTICS FOR THE LOS ALAMOS CANYON EXPERIMENTS

<u>Experiment</u>	<u>$\bar{y}$ (m)^a</u>	<u>σ (m)^b</u>	<u>γ_1^c</u>	<u>γ_2^d</u>
<u>FP76-1</u>				
B-Line	171	61	-0.77	3.2
C-Line	119	93	-0.05	1.4
D-Line	109	74	0.15	2.2
<u>FP76-2</u>				
B-Line	163	33	0.46	3.4
C-Line	132	16	-2.37	7.3
D-Line	170	37	-0.58	1.8
<u>FP77-1</u>				
B-Line	190	42	-0.31	2.0
C-Line	159	45	-1.12	5.3
D-Line	129	81	0.09	1.8
<u>FP77-2</u>				
B-Line	157	42	0.05	2.5
C-Line	146	42	-0.40	3.2
D-Line	182	60	-0.65	2.6
<u>FP77-3</u>				
B-Line	181	58	-0.47	2.7
C-Line	144	49	-0.48	3.3
D-Line	154	57	-1.07	3.5
<u>FP77-10</u>				
B-Line	189	39	-0.50	3.2
C-Line	163	34	-0.93	4.5
<u>FP77-11</u>				
B-Line	171	47	-0.37	2.6
C-Line	159	37	-0.70	4.5

^a $\bar{y}$ = Center of distribution in coordinate system of Table II

^b σ = Standard deviation

^c γ_1 = Moment coefficient of skewness

^d γ_2 = Moment coefficient of kurtosis

TABLE VII

POLAR COORDINATES OF THE SAMPLERS USED IN THE CROSS-CANYON EXPERIMENTS

<u>Sampler</u>	<u>θ^a</u>	<u>R^b</u>	<u>Sampler</u>	<u>θ</u>	<u>R</u>	<u>Sampler</u>	<u>θ</u>	<u>R</u>	<u>Sampler</u>	<u>θ</u>	<u>R</u>	<u>Sampler</u>	<u>θ</u>	<u>R</u>
M-1	315	1.00	P-1	315	1.39	J-1	315	2.64	L-1	316	2.83	T-1	315	3.07
M-2	334	0.74	P-2	334	1.06	J-2	324	2.30	L-2	324	2.57	T-2	323	2.81
M-3	353	0.65	P-3	353	0.86	J-3	333	1.94	L-3	332	2.23	T-3	334	2.54
M-4	10	0.60	P-4	10	0.82	J-4	343	1.63	L-4	341	1.90	T-4	341	2.14
M-5	29	0.55	P-5	29	0.79	J-5	359	1.49	L-5	357	1.70	T-5	355	1.94
M-6	45	0.58	P-6	45	0.91	J-6	18	1.51	L-6	14	1.73	T-6	8	1.97
									L-7	28	1.87	T-7	22	2.06
									L-8	42	2.06	T-8	32	2.30
									L-9	52	2.38	T-9	43	2.47

^aTrue compass heading in degrees.

^bKilometers from release point.

TABLE VIII

BASIC DATA FOR THE CROSS-CANYON EXPERIMENTS

<u>Experiment</u>		<u>Tracer Data</u>			<u>Release Data</u>				<u>Wind Data*</u>		
<u>Number</u>	<u>Date</u>	<u>Type</u>	<u>Particle Density (10¹⁰ g⁻¹)</u>	<u>Mean Mass Diameter (μm)</u>	<u>Time (MST)</u>	<u>Duration (min)</u>	<u>Amount (g)</u>	<u>Rate (g min⁻¹)</u>	<u>Speed (ms⁻¹)</u>	<u>Direction (degrees)</u>	<u>σ_A (degrees)</u>
FP77-4	15 Jul 77	2487 Red Lot 513	2.23	2.78	11:43	8.0	564.42	70.6	2.8	180	25
FP77-5	21 Jul 77	3931 Green Lot 1320	2.21	2.79	13:42	5.0	922.60	184.5	4.2	180	30
FP77-6	26 Jul 77	2267 Yellow Lot 4511	2.15	2.81	11:30	~18.0	968.64	~53.8	2.3	200	20
FP77-7	29 Jul 77	2437 Red Lot 512	2.23	2.78	09:57	13.0	1161.65	89.4	2.9	165	30
FP77-8	24 Aug 77	3971 Green Lot 1320	2.21	2.79	10:14	15.5	1005.10	64.9	3.1	175	20
FP77-9	29 Aug 77	1772 Yellow Lot 1208	2.31	2.31	10:28	15.1	1012.20	67.3	3.4	180	25

*1-hour average from release point mechanical weather station.

TABLE IX
METEOROLOGICAL CONDITIONS AT MESA LEVEL DURING THE CROSS-CANYON EXPERIMENTS

<u>Experiment</u>	<u>Average Winds (Release + 1 Hour)</u>			<u>General Meteorological Conditions for the Day</u>				
	<u>Direction (degrees)</u>	<u>Speed (ms⁻¹)</u>	<u>σ_A (degrees)</u>	<u>Mean Temp (°C)</u>	<u>Max Temp (°C)</u>	<u>Min Temp (°C)</u>	<u>Precip. (mm)</u>	<u>Relative Humidity at 2400 MST (%)</u>
FP77-4	165	7.7	21	25	24	11	0	39
FP77-5	175	7.1	23	26	27	13	0	40
FP77-6	160	3.5	17	21	23	12	0	56
FP77-7	161	7.7	21	25	26	13	0	45
FP77-8	170	6.9	16	25	28	14	0	52
FP77-9	175	7.2	18	23	26	13	0	58

TABLE X
FP COUNTS FOR THE CROSS-CANYON EXPERIMENTS

<u>Location</u>	<u>FP77-4</u>	<u>FP77-5</u>	<u>FP77-6</u>	<u>FP77-7</u>	<u>FP77-8</u>	<u>FP77-9</u>
M-1	26	42	5	17	355	101
M-2	4 800	1 888	0	11 400	15 400	5 230
M-3	1 470	11 200	122	8 700	19 000	19 900
M-4	23	3 460	7 870	1 660	197	23 900
M-5	3	28	32 000	2	3	571
M-6	-	2	27 500	1	14	11
P-1	103	9	20	9	50	4
P-2	3 140	215	0	298	995	831
P-3	1 950	7 190	10	5 870	34 500	12 700
P-4	334	3 660	8 050	3 180	456	16 500
P-5	-	2	14 700	0	21	65
P-6	163	4	49 500	0	15	2
J-1	0	1	0	0	20	0
J-2	182	7	161	7	4	1
J-3	275	8	5	5	248	37
J-4	165	2 000	2	2 640	12 300	2 690
J-5	186	1 940	2 380	887	121	3 600
J-6	1	16	3 080	0	1	81
J-7	0	0	611	2	0	0
J-8	0	6	103	5	1	0
L-1	5	6	24	3	24	2
L-2	166	8	3	29	123	4
L-3	128	155	0	170	984	233
L-4	160	1 060	4	1 930	5 020	1 480
L-5	388	1 780	154	906	255	1 870
L-6	9	10	1 610	75	0	961
L-7	8	6	2 260	2	7	4
L-8	20	5	3 790	7	0	5
L-9	2	3	1 430	1	0	1
T-1	10	5	12	3	6	0
T-2	16	8	26	12	53	1
T-3	105	20	3	50	0	72
T-4	86	535	20	1 100	3 710	790
T-5	157	43	60	1 390	3 620	1 520
T-6	408	40	1 260	166	73	2 290
T-7	1	5	1 690	2	1	5 770
T-8	5	2	2 420	1	2	1
T-9	7	1	3 010	0	0	1

TABLE XI
GROSS STATISTICS FOR THE CROSS-CANYON EXPERIMENTS

Experiment	$\bar{y}$ (m) ^a	σ (m) ^b	γ_1 ^c	γ_2 ^d
<u>FP77-4</u>				
M-Line	392	108	1.08	3.7
P-Line	688	276	1.12	5.6
J-Line	1191	510	0.15	1.8
L-Line	1451	690	0.12	3.1
T-Line	2054	642	-0.95	3.6
<u>FP77-5</u>				
M-Line	588	123	-0.53	4.5
P-Line	944	142	-0.16	4.7
J-Line	1690	249	0.21	5.3
L-Line	1701	341	-0.46	6.5
T-Line	2120	327	-0.84	5.7
<u>FP77-6</u>				
M-Line	1017	115	-0.98	3.8
P-Line	1538	187	-1.32	4.1
J-Line	2551	460	-1.47	6.3
L-Line	3134	516	-0.84	5.7
T-Line	3195	517	-1.01	6.0
<u>FP77-7</u>				
M-Line	465	144	0.50	2.1
P-Line	941	150	-0.46	4.6
J-Line	1578	217	1.45	9.4
L-Line	1555	336	0.20	5.3
T-Line	1841	332	-0.44	4.5
<u>FP77-8</u>				
M-Line	466	130	-0.43	2.8
P-Line	857	77	-3.39	42.0
J-Line	1457	102	-5.33	89.7
L-Line	1337	268	-1.14	8.1
T-Line	1786	288	-0.62	5.4
<u>FP77-9</u>				
M-Line	213	316	0.91	2.0
P-Line	883	353	-1.70	4.7
J-Line	1564	476	-1.24	3.6
L-Line	1262	908	-0.39	1.6
T-Line	681	579	2.51	7.7

^a $\bar{y}$ = Center of distribution measured from west-most sampler

^b σ = Standard deviation

^c γ_1 = Moment coefficient of skewness

^d γ_2 = Moment coefficient of kurtosis

Fig. 1.
Location of tracer study sites on relief model of the
Los Alamos area.

Fig. 2.
Rotorod sampler with type H rotorod attached.

Fig. 3.
Dimensions of type h rotorod.

Fig. 4.
Schematic diagram of a portion of a rotorod arm in the microscope field of view. Only the particles in the shaded area are counted.

FP COUNT RECORD

TEST NO.	FP77-6	DATE COUNTED	8-3-77	OBSERVER	WK
MICROSCOPE	23	EYEPIECE	23A	OBJECTIVE	10X
	J-6	ROTOROD	03735		

1	11	21	31
2	11	22	11
3	12	23	10
4	20	24	16
5	13	25	6
6	22	26	15
7	9	27	11
8	87	28	69
9	18	29	
10	20	30	40

RESULTS SUMMARY

Number Fields Examined 24 Area Ratio Factor 167
 Number Particles Counted 301 Average Particles/Field 12.54
 Calculation: 12.54×167 -Total FP Estimate 2094
 Checked 16

Fig. 5.
Typical FP count record.

Fig. 6.
Location of study site in Los Alamos Canyon.
Sampling lines are labeled with the number of
kilometers from the release Point R.

Fig. 7.
Los Alamos Canyon sampling locations. Rim sites are not
to scale.

Fig. 8.
Cross-canyon FP profiles for FP76-1.

Fig. 9.
Cross-canyon FP profiles for FP76-2.

Fig. 10.
Cross-canyon FP profiles for FP77-1.

Fig. 11.
Cross-canyon FP profiles for FP77-2.

Fig. 12.
Cross-canyon FP profiles for FP77-3.

Fig. 13.
Cross-canyon FP profiles for FP77-10.

Fig. 14.
Cross-canyon FP profiles for FP77-11.

Fig. 15.
Vertical profile of FP from tower
for FP76-1.

Fig. 16.
Vertical profile of FP from tower
for FP76-2.

Fig. 17.
Vertical profile of FP from tower
for FP77-1.

Fig. 18.
Vertical profile of FP from tower
for FP77-2.

Fig. 19.
Vertical profile of FP from tower
for FP77-3.

Fig. 20.
Vertical profile of FP from tower
for FP77-10.

Fig. 21.
Vertical profile of FP from tower
for FP77-11.

Fig. 22.

FP isopleths for FP76-1. Down-canyon scale is ten times the cross-canyon scale.

Fig. 23.

FP isopleths for FP76-2.

Fig. 24.
FP isopleths for FP77-1.

Fig. 25.
FP isopleths for FP77-2.

Fig. 26.
FP isopleths for FP77-3.

Fig. 27.
FP isopleths for FP77-10.

Fig. 28.
FP isopleths for FP77-11.

Fig. 29.
Location of cross-canyon study site. Releases from R are sampled in the 90° sector shown.

North—

Fig. 30.

Simplified terrain relief from the release point north showing locations of the cross-canyon sampling lines. Vertical scale is somewhat exaggerated.

Fig. 31.

Sampler locations for the cross-canyon experiments. Line designation letters appear on the ends of each line.

Fig. 32.

Cross-wind FP profiles for FP77-4. The zero point is an axis running due north from the release point. Positive distances are toward the east.

Fig. 33.

Cross-wind FP profiles for FP77-5.

Fig. 34.
Cross-wind FP profiles for FP77-6.

Fig. 35.
Cross-wind FP profiles for FP77-7.

Fig. 36.
Cross-wind FP profiles for FP77-8.

Fig. 37.
Cross-wind FP profiles for FP77-9.

Fig. 38.

FP isopleths for FP77-4. Winds at release point are shown with a full flag being 5 ms^{-1} .

Fig. 39.

FP isopleths for FP77-5.

Fig. 40.
FP isopleths for FP77-6.

Fig. 41.
FP isopleths for FP77-7.

Fig. 42.
FP isopleths for FP77-8.

Fig. 43.
FP isopleths for FP77-9.