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Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory

July through December 1971

los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87544

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Compiled by

Joseph E. Herceg

*This is the last issue of the semiannual environmental monitoring reports. In the future, this report will be published annually.

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ENVIRONMENTAL MONITORING IN THE VICINITY OF THE LOS ALAMOS SCIENTIFIC LABORATORY

July through December 1971

ABSTRACT

The environmental monitoring program in effect at the Los Alamos Scientific Laboratory of the University of California for the last half of calendar year 1971 is described. Results of programs designed to monitor radiation levels in the Laboratory environs, including the atmosphere, local surface and ground waters, sediments and soils are presented. These measurements are used to make estimates of the dose commitments due to plutonium and tritium concentrations in air.

I. Introduction

This report describes the results of the environmental monitoring programs conducted by Group H-8 (Environmental and Field Programs) during the last half of calendar year 1971 at the Los Alamos Scientific Laboratory (LASL). This facility is administered by the University of California for the United States Atomic Energy Commission under Contract W-7405-ENG-36.

The Laboratory and the Los Alamos Community are located in north-central New Mexico (Fig. 1) on the Pajarito Plateau, situated west of the Rio Grande on the eastern slopes of the Jemez Mountains (Fig. 2). This location was originally chosen for the atomic weapons laboratory during World War II because of its relative isolation. Thus the area surrounding Los Alamos, including all of Los Alamos County and large portions of Sandoval and Santa Fe Counties, is largely undeveloped except for those areas occupied by the Laboratory facilities and the associated communities. Large tracts of land in the Jemez Mountains to the north, west, and south of the Laboratory site are held by the Forest Service. This land is largely covered by fir and aspen forests that support the usual variety of western mountain wildlife. Agriculture is limited to home gardens with some grazing of beef cattle. In the river valleys to the east, agriculture is restricted to relatively small plots supported by irrigation. Primary crops are chili peppers, beans, and tree fruits. Milk is not produced in commercial quantities in the immediate vicinity of Los Alamos. More detailed descriptions of the geology, climatology, and economy of the area are given in the appendixes of the January-June 1971 environmental monitoring report.[1]

The Laboratory site covers about 28,000 acres in and adjacent to Los Alamos County. The principle mission of the Laboratory is, as it has been since its inception in 1943, the design and development of weapons for the nation's nuclear arsenal. This program is supported by extensive research programs in nuclear physics, hydrodynamics, conventional explosives, chemistry, metallurgy, radiochemistry, and biology. In addition to this program, considerable effort is directed toward the peaceful uses of nuclear energy including medium-energy physics (Los Alamos Meson Physics Facility), space nuclear propulsion, controlled thermonuclear fusion (Sherwood Program), nuclear safeguards, biomedical research, and space physics. These activities are located in 29 active Technical Areas (TA) widely spread over the AEC-controlled lands. The locations of these areas are shown in Fig. 3, the basic map to which all others in this

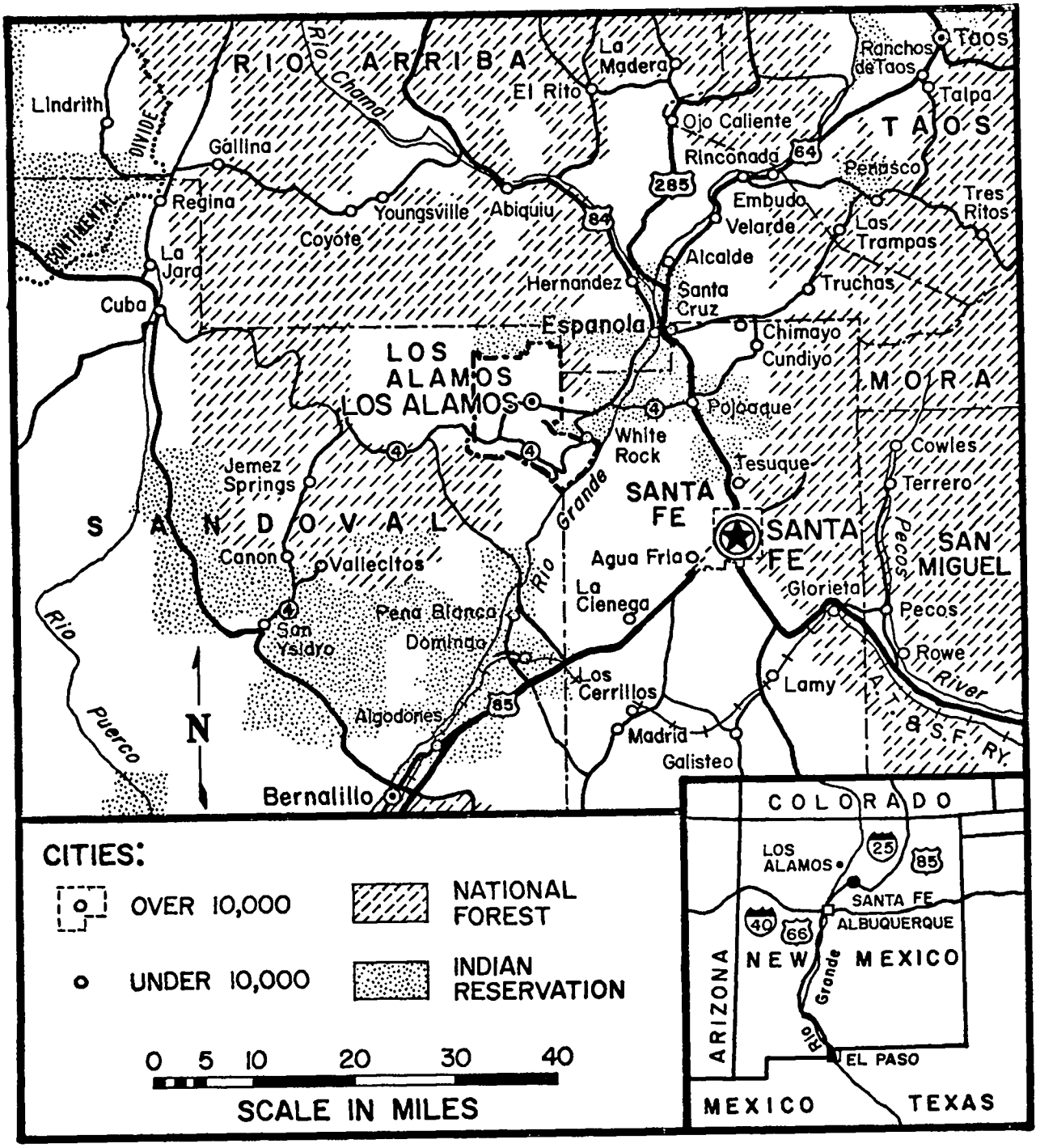


Fig. 1.
North-central New Mexico

report are keyed. Appendix B in Ref. 1 contains descriptions of the programs being undertaken at each of the Technical Areas.

The reevaluation and revision of the various monitoring programs begun during the last reporting period were continued. The weekly air sampling program evolved into an array of 35 samplers at the end of this period. This represents an increase of six stations from the array reported in the January-June report. Placement of the stations provides more uniform coverage of the

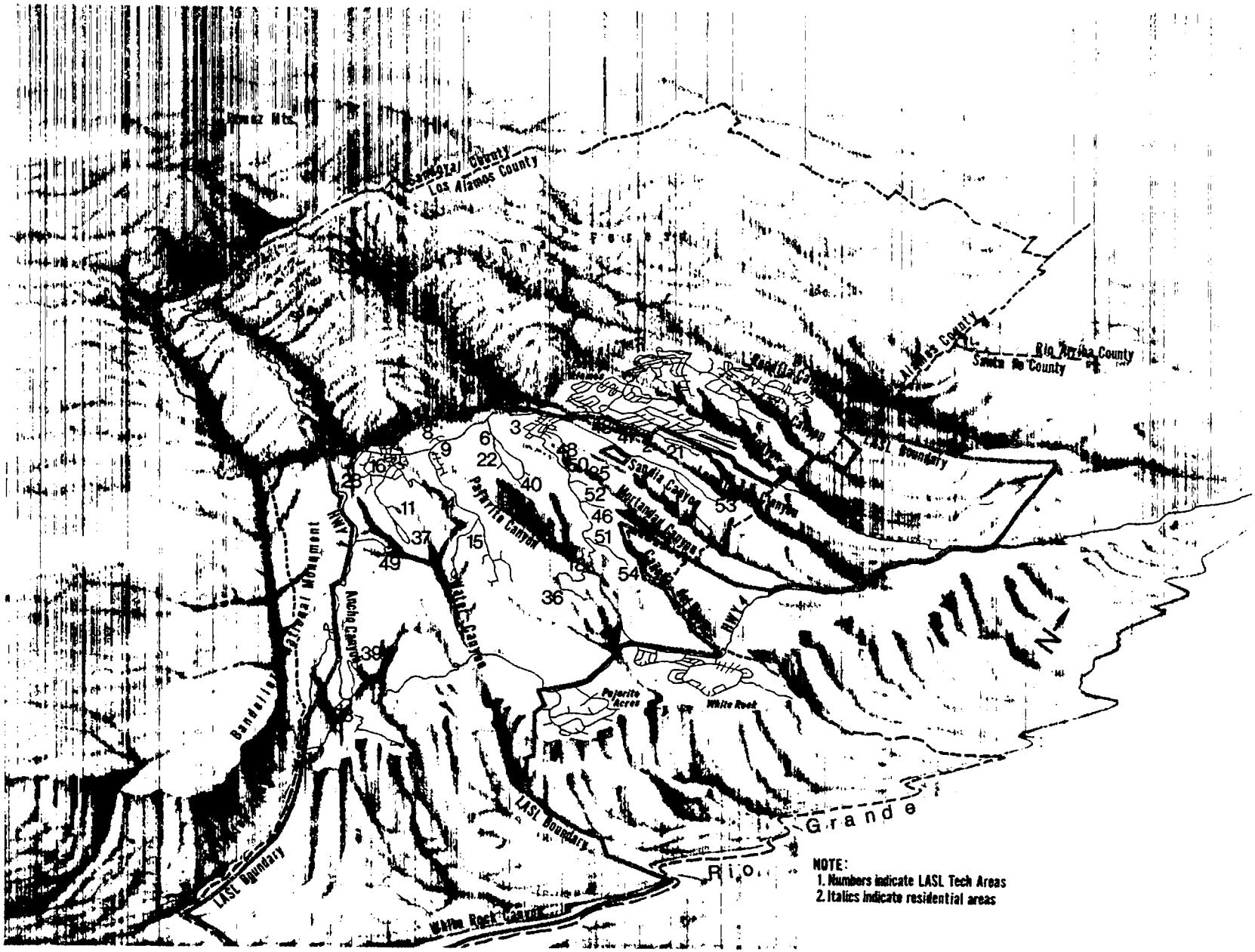


Fig. 2.
Topography of the Los Alamos, N.M., area.

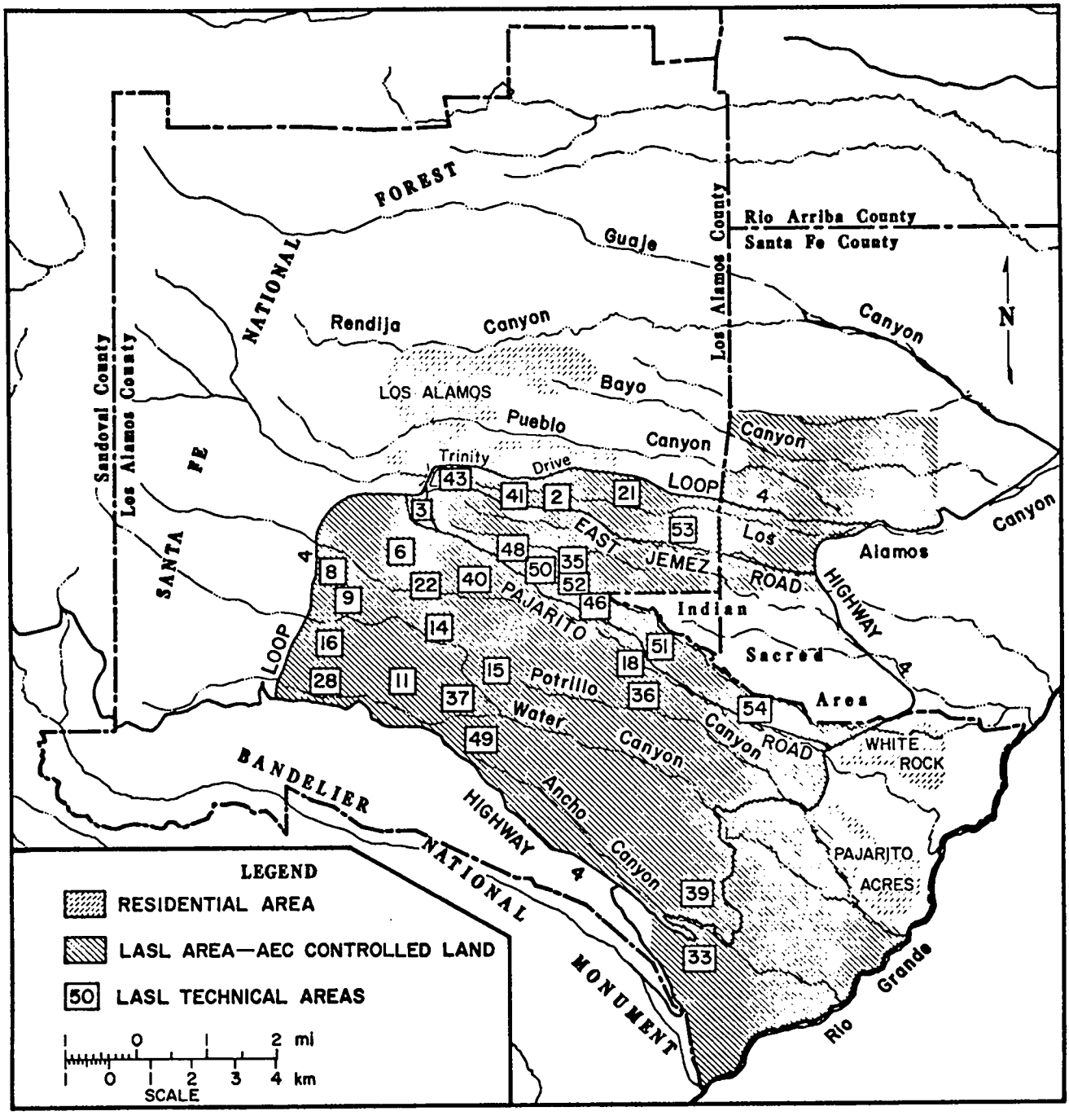


Fig. 3.
Los Alamos County and LASL Technical Areas.

Laboratory areas (16 stations) as well as of the residential communities and other off-site areas (19 stations). A new filter media was introduced [see Technical Notes (Fultyn)], and fluorometric analysis of the monthly composited weekly air samples for uranium was initiated.

During June through August fauna were studied in two areas where Laboratory effluents are released, and although this was a one-time effort, plans are being formulated to initiate a routine monitoring program of this type. The revised external radiation monitoring program

consists of an array of 58 thermoluminescent dosimeters, 22 of which are at off-site locations. A new type thermoluminescent dosimeter with negligible internal background radiation is now being used.

II. Effluents Associated with Laboratory Activities

Because the Laboratory is a large, broadly diversified organization employing several thousand people engaged in fundamental and applied research in the natural sciences, with emphasis on nuclear materials, the facilities include hundreds of potential sources of effluents and wastes. Processes known to have the potential for significant releases are confined to a few well-known locations and are rigorously controlled and monitored. Numerous laboratory hoods, drains, and waste receptacles exist, however, where procedural controls are relied upon for proper utilization. Information concerning gaseous and liquid effluents and solid waste disposal is summarized in this section.

A. Airborne Effluents. The major sources of airborne contaminants at LASL and the amounts of effluent from each source are summarized in Table I. The "other" category accounts for certain conventional explosive tests conducted by GMX Division at the various explosives test areas. In addition to the radioactive materials listed in the table, the following quantities of nonradioactive materials were also used.

High explosive (various compositions)	6500 kg
Lead	63 kg
Beryllium	15 kg
Mercury	68 kg
Barium	6 kg
Copper	21 kg
Aluminum	34 kg

The amounts of materials given for these tests are not the amounts actually dispersed into the atmosphere; significant fractions remain in the immediate vicinity of the test

TABLE I

SUMMARY OF MAJOR AIRBORNE EFFLUENTS
JULY-DECEMBER 1971

Tech Area	Gross β μCi	^{238}Pu ^{239}Pu μCi	^{235}U μCi	U[a] μCi	^{131}I μCi	^{88}Rb ^{138}Cs mCi	^{41}Ar Ci	^{3}H Ci
2	—	—	—	—	—	26	860	—
3	880	3000	370	210	850	—	—	84
21	—	570	830	—	—	—	—	3
33	—	—	—	—	—	—	—	1100
35	—	4	—	—	—	—	—	430
41	—	5	—	—	—	—	—	60
46	—	—	4	—	—	—	—	—
48	990	14	—	—	—	—	—	—
50	51	5	—	—	—	—	—	—
Other	—	—	—	890[b]	—	—	—	1100

[a] Natural and depleted uranium. Does not include those amounts listed under ^{235}U.

[b] Kilograms of depleted uranium. Mass spectrometer analysis of a typical sample indicates the composition to be (weight percent)

^{234}U	0.0006%
^{235}U	0.1925%
^{236}U	0.0036%
^{238}U	99.803%

An estimate of the uranium activity only (excluding daughters) for 890 kg is 0.33 Ci.

site. The magnitudes of these fractions will be studied later.

The increase in ^{88}Rb - ^{138}Cs from the TA-2 reactor site over that reported last period was almost entirely due to a single release in December when a valve in the stack discharge line failed. To document the environmental consequences of this release, filters from selected downwind weekly air samplers were collected and analyzed. No activity attributable to this release was found on any of the weekly filters or on the filter from the daily air sampler collected that day. The excess tritium released from TA-3 was due to the rupture of several targets at the tandem Van de Graaff accelerator facility.

B. Liquid Effluents. Cooling water and sanitary sewage comprise the majority of the liquid effluent streams at the Laboratory. The effluents are released into canyons that contain intermittent streams. The effluents recharge water in the alluvium that is depleted by evaporation and transpiration and do not reach the Rio Grande. None of the effluent streams recharge aquifers from which municipal, industrial, or irrigation waters are drawn.

The primary sources of potentially contaminated liquid effluent from LASL operations are from the industrial liquid waste treatment plant at TA-21 and from the central industrial liquid waste treatment plant at TA-50. Effluents from the TA-21 plant are released into DP Canyon, a tributary to Los Alamos Canyon, and the effluents from TA-50 are released into Effluent Canyon, a tributary to Mortandad Canyon. Water is released with concentrations lower than those listed in Table II, AEC Manual Chapter 0524, but evaporation and adsorption tends to concentrate the contamination in the channel alluvium. The amounts of radionuclides released from these two sources are shown in Table II.

TABLE II

SUMMARY OF MAJOR LIQUID EFFLUENTS JULY-DECEMBER 1971

Contaminant	TA-21 mCi	TA-50 mCi
Gross alpha	0.28[a]	5.0
Gross beta	—	320
Plutonium-238	0.10	2.6
Plutonium-239	0.18	0.47
Strontium-89	4.6	0.08
Strontium-90	12	0.11

[a]All alpha activity discharged at TA-21 is assumed to be due to plutonium, although as much as 10% of this may be due to ^{241}Am for individual discharges.

Some chemical ions, primarily hexavalent chromate (Cr^{+6}), are released into Sandia Canyon from the Zia Company Power Plant in TA-3 and into Los Alamos Canyon from TA-2 as a result of the discharge of treated water from cooling towers. Corrective action; chromate reduction treatment or substitute water treatment chemicals, is being studied by Zia and LASL.

C. Solid Waste. Solid wastes, consisting mostly of contaminated sludges from the industrial waste treatment plants and potentially contaminated trash from routine Laboratory operations, are buried in pits at TA-54 on the Mesita del Buey and in lined shafts at TA-21. The TA-54 location was chosen in cooperation with the United States Geological Survey to assure long-time localization of radioactivity. Large pits are 100 ft wide by 600 ft long by 30 ft deep, and smaller ones are 50 by 300 by 30 ft. The shafts at TA-21 are nominally 6 ft in diameter and 15 to 64 ft deep. They are asphalt lined and do not penetrate to the depth of the water table.

The quantities of materials placed in storage during this period are given in Table III. The total quantity of radioactive material in the Laboratory trash is not estimated. Individual consignments are below the limits of detection for any device to measure gross activity, but the large volume of such wastes would make any overall estimate meaningless.

III. Atmospheric Monitoring Program

The air monitoring program is designed to provide for general surveillance of the levels of gross alpha and beta radioactivity in air, the concentrations of those specific radionuclides directly associated with Laboratory operations, and the concentrations of certain nonradioactive materials.

To provide a system for locating and describing the stations, a polar grid centered on the site of the Laboratory meteorology tower has been established. The station designation is related to this grid by two numbers: the first denotes the azimuth in degrees clockwise from north, and the second denotes the distance from the center in kilometers. Thus, a station numbered 90-22.7 would be 22.7 km directly east of the meteorology tower. The locations of all air sampling stations are shown in Fig. 4. For clarity, station locations are indicated on the map by serial numbers and the correspondence between these numbers and the radial grid designations is given in Table IV. The common name associated with each station is also given.

TABLE III

SUMMARY OF SOLID WASTE DISPOSAL
JULY-DECEMBER 1971

Burial Site	Nature of Waste	Container or Stabilizer	Estimated Volume (liters)	Estimated Activity (Ci)
TA-54	Classified	Steel drums, 30 and 55 gal	71,000	Not estimated
TA-54	Hot cell wastes, activated metal, wastes containing fission products	Metal containers	175	120
TA-54	Contaminated sludge from TA-50 liquid waste treatment plant	Steel drums, 55 gal	42,000	1.9
TA-54	Air exhaust filters	Wooden boxes	18,100	0.6
TA-54	Laboratory trash and scrap	Bags, boxes, crates, drums	2,300,000	Not estimated
TA-54	Wastes containing ^{238}Pu	Steel drums, 55 gal	42,000	180
TA-21	Contaminated sludge from TA-21 liquid waste treatment plant	Cement paste	25,000	180

A. Radioactive Materials.

1. Daily Air and Deposition Sampling. A high-volume air sampler, drawing air through an MSA No. BM2133 filter cartridge and a charcoal canister at approximately 400 liters/min, is maintained on the roof of the Occupational Health Laboratory (OHL, TA-3). The filter and the canister are changed daily. The particulate material on the filters is measured for gross beta emission twice, immediately and 8 days after collection, on an alpha-beta gas flow proportional counter. The activity collected by the canister is measured by gamma-ray spectrometry with emphasis on the ^{131}I determination. The initial measurement of the gross beta will give early warning of large changes that would be apparent above the natural radon-thoron background fluctuations. The primary record of the activity, however, is established by the 8-day measurement. These measurements are shown in Fig. 5 for the 6 months covered by this report and they are comparable with measurements from samplers operated elsewhere in the country by the Environmental Protection Agency (EPA).[2] The decrease in concentration for the final 6 months of the year compensated for the gradual increase observed during the spring months.[1] This observed cyclic trend is occasioned by a seasonal fluctuation in atmospheric mixing that brings part of the stratospheric storage of fission products produced by past atmospheric testing activities to ground level in the spring. The peak at the end of July is associated with the July 4 French atmospheric test, and the peak near the end of November is possibly associated with the November 18 Chinese test. None of the charcoal cartridges contained ^{131}I at a level of more than 10^{-14} μCi/ml, the estimated minimum detection level (MDL) of the system.

Deposition is measured at the OHL building on a daily basis using a 0.4 m^2 precipitation collector. The collector is rinsed with water and the rinse water is combined with whatever precipitation may have been collected. This water is filtered and evaporated to dryness, and the filter is wet ashed. The two resulting planchets are measured separately on the proportional counter for gross beta activity, and the total beta activity is obtained by summing these values for the soluble and insoluble components. Measurements are taken immediately and after 8 days with the 8-day measurement considered to represent

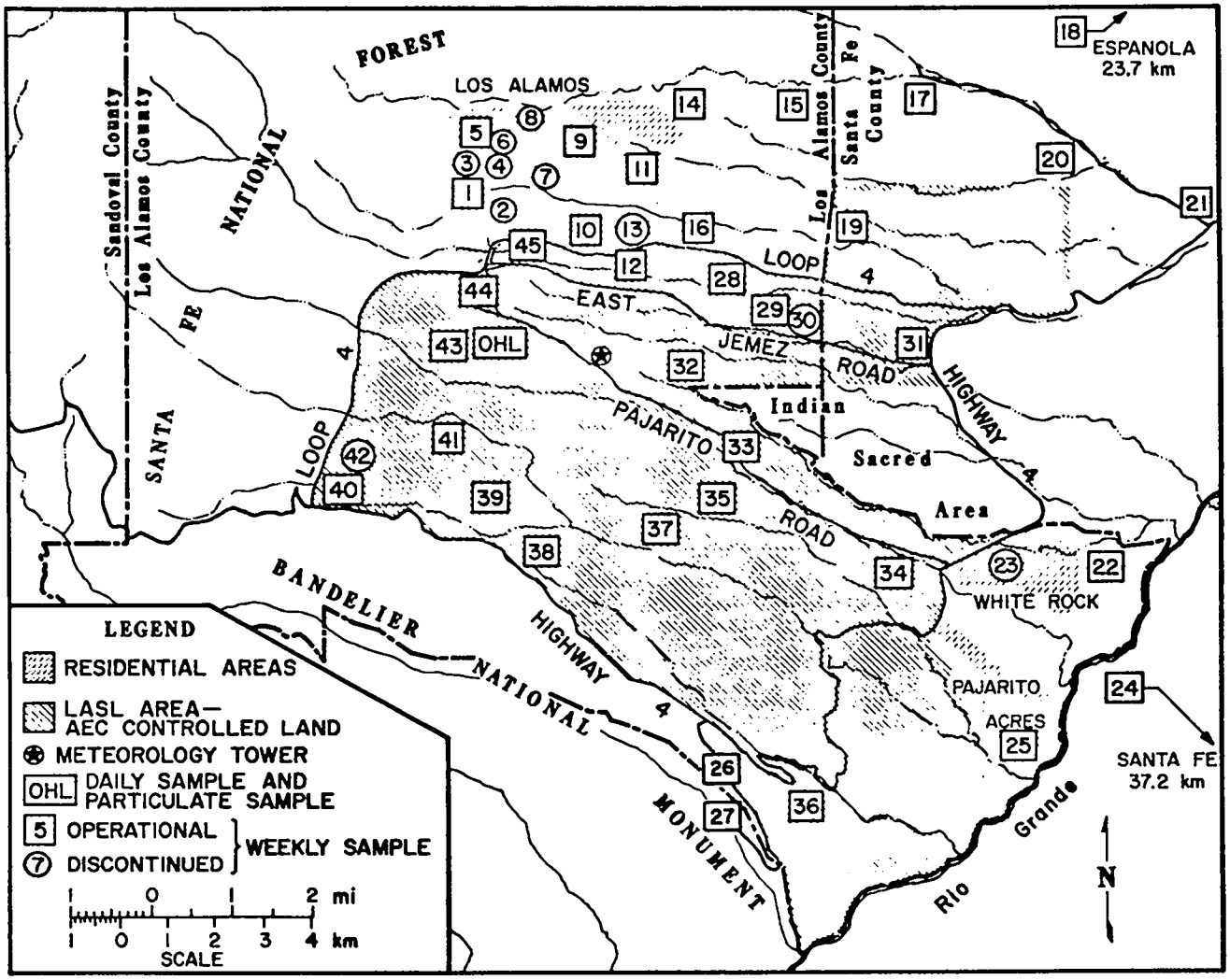


Fig. 4.
Locations of atmospheric monitoring stations.

the gross activity free of the interfering daughters of radon and thoron. The gross beta measurements and the natural precipitation recorded during this period are given in Fig. 6. The decrease in the fall and winter is noted although this trend is considerably obscured by fluctuations due to scavenging by precipitation.

2. Weekly Air Sampling. The main air monitoring network consists of an array of air sampling stations whose samples are collected weekly. During the period covered by this report, several new stations were added to and several were deleted from the past network, expanding the total from 29 in July to 35 in December. Forty-five different stations were operated at one time or another during this reporting period.

Each station consists of a pump that pulls air through a 78-mm Microsorban filter having an efficiency of about 99.8% for 0.3-μm di-octylpthalate (DOP) particles (a standard test aerosol for determining filter efficiency) and an 80-mm Welsh charcoal respirator cartridge. The flow, as measured by rotameters, averages about 75 liters/min. The filters are collected weekly and are measured on the first and eighth day after collection for gross alpha and beta activities by simultaneous counting on a gas-flow proportional counter. Each set of samples is counted repeatedly to minimize the effects of any short-term (daily) drifts that might occur in the counting system. For the 1-day measurement, a 10-min count is repeated 1 to 3 times and for the 8-day measurement, a 10-min count is repeated 7 to 10 times. The filters from

TABLE IV

GROSS ALPHA AND GROSS BETA MEASUREMENT OF WEEKLY AIR SAMPLES

Station				Gross Alpha Concentration		Gross Beta Concentration		
Map No.	Array Designation	Status[b]	No. of Samples	Max 10^{-15} μCi/ml	Av[a] 10^{-15} μCi/ml	Max 10^{-13} μCi/ml	Av[a] 10^{-13} μCi/ml	Remarks
Off-Site Stations:								
1	330-3.8	N	24	7.3	1.3 ± 0.7	4.0	1.3 ± 0.4	Diamond Drive
2	332-3.3	D	2	1.4	1.0 ± 5.0	1.4	1.2 ± 2.0	High School
3	333-4.7	D	13	7.0	1.4 ± 1.1	3.6	1.9 ± 0.6	Mountain School
4	334-4.3	D	2	1.7	1.2 ± 6.2	3.0	2.4 ± 7.8	Pueblo Jr. High
5	335-4.9	N	14	1.2	0.6 ± 0.2	2.3	1.0 ± 0.3	Arkansas Avenue
6	337-4.4	D	2	1.7	1.6 ± 1.9	3.1	3.1 ± 0.1	Little Forest School
7	340-4.2	D	2	2.1	1.7 ± 4.9	3.8	3.0 ± 1.0	Aspen School
8	343-5.2	D	13	5.0	1.3 ± 0.8	4.2	2.2 ± 0.8	Pajarito School
9	350-4.3	N	24	5.2	1.0 ± 0.5	4.1	1.3 ± 0.4	Golf Course
10	351-2.4	C	27	9.4	1.1 ± 0.7	3.7	1.4 ± 0.4	Museum
11	3-3.7	C	27	5.2	1.1 ± 0.4	3.6	1.4 ± 0.4	Cumbres Jr. High
12	15-2.0	C	27	10	1.1 ± 0.7	4.0	1.4 ± 0.4	Acorn Street
13	17-2.5	D	2	2.3	1.9 ± 5.6	3.6	3.4 ± 3.4	Canyon School
14	18-4.9	C	27	3.5	1.1 ± 0.3	4.5	1.4 ± 0.4	Barranca School
15	36-7.0	C	27	8.5	1.2 ± 0.6	4.4	1.7 ± 0.5	Guaje Booster 2
16	42-3.1	C	27	9.1	1.2 ± 0.7	4.0	1.4 ± 0.4	Airport
17	50-8.6	C	27	5.5	1.1 ± 0.4	4.1	1.5 ± 0.4	Guaje Booster 1
18	55-23.7	C	27	6.9	1.4 ± 0.5	5.5	1.7 ± 0.5	Espanola
19	64-5.8	N	16	31	2.6 ± 4.0	2.2	0.9 ± 0.2	Bayo STP
20	64-10.2	C	27	5.7	1.1 ± 0.4	3.9	1.5 ± 0.4	Well G-1
21	78-12.4	C	27	1.9	0.7 ± 0.2	2.7	1.0 ± 0.2	Well LA-3
22	111-10.6	N	14	2.0	0.7 ± 0.3	2.3	1.1 ± 0.3	White Rock STP
23	117-9.2	D	13	5.9	1.5 ± 0.9	4.3	2.0 ± 0.7	Piñon School
24	122-37.2	C	25[c]	4.0	1.6 ± 0.4	3.5	1.6 ± 0.4	Santa Fe
25	132-11.1	C	27	6.0	1.1 ± 0.5	4.0	1.5 ± 0.5	Pajarito Acres
26	164-8.5	N	8	0.9	0.3 ± 0.2	2.2	0.9 ± 0.5	Bandelier Entrance
27	164-9.4	N	8	2.9	0.6 ± 0.8	2.4	0.9 ± 0.5	Bandelier HQ
On-Site Stations:								
28	58-3.1	N	17	1.5	0.5 ± 0.2	2.1	0.7 ± 0.2	TA-21
29	73-3.0	N	9	14	2.1 ± 3.5	2.2	1.0 ± 0.5	TA-53
30	87-4.7	D	10	5.4	1.6 ± 1.1	4.4	1.7 ± 1.0	Sandia Canyon
31	92-6.7	N	17	1.1	0.5 ± 0.2	2.2	0.9 ± 0.2	E. Jemez Road
32	99-2.0	N	8	1.0	0.3 ± 0.3	3.6	1.2 ± 1.0	Beta Site
33	122-3.7	N	17	2.0	0.7 ± 0.3	1.8	0.9 ± 0.2	Pajarito Booster 2
34	123-7.0	N	17	1.4	0.5 ± 0.2	1.2	0.7 ± 0.1	Pajarito Booster 1
35	141-3.3	N	18	2.3	0.8 ± 0.3	2.2	0.8 ± 0.2	TA-36
36	156-9.4	C	27	3.2	0.8 ± 0.3	3.9	1.2 ± 0.4	TA-33
37	189-2.8	N	16	1.5	0.6 ± 0.3	2.2	1.0 ± 0.2	TA-15
38	204-4.2	C	27	5.2	1.1 ± 0.5	4.3	1.6 ± 0.5	TA-49
39	224-3.5	N	16	5.1	1.0 ± 0.7	2.3	1.0 ± 0.2	TA-11
40	242-6.3	N	15	2.1	0.8 ± 0.4	2.6	1.0 ± 0.3	W. Jemez Road

TABLE IV (cont)

Station				Gross Alpha Concentration		Gross Beta Concentration		
Map No.	Array Designation	Status[b]	No. Samples	Max 10^{-15} μCi/ml	Av[a] 10^{-15} μCi/ml	Max 10^{-13} μCi/ml	Av[a] 10^{-13} μCi/ml	Remarks
41	245-3.3	N	16	1.4	0.5 ± 0.2	2.2	0.9 ± 0.2	TA-16
42	250-5.4	D	12	3.4	1.3 ± 0.6	3.3	2.1 ± 0.7	TA-16
43	277-3.3	N	8	0.9	0.4 ± 0.3	2.5	1.0 ± 0.5	TA-6
44	304-2.6	C	27	11	1.7 ± 0.9	4.4	1.6 ± 0.4	TA-3
45	319-3.1	C	27	8.1	1.1 ± 0.6	2.9	1.3 ± 0.3	TA-43

[a]Average and 95% confidence limits for the average.

[b]Status: N - New station initiated this report period.
D - Old station discontinued this report period.
C - Old station continuing in operation.

[c]Includes two 2-week samples.

each station are then pooled to form a monthly composite sample that is analyzed radiochemically for plutonium and fluorometrically for uranium. An alpha spectrometer is used to allow resolution of ^{238}Pu and ^{239}Pu. The charcoal cartridges are collected weekly and are analyzed for iodine on a gamma-ray spectrometer. In addition, the stations collect a separate weekly sample by drawing air through a tube of silica gel dessicant at an average flow of about 50 ml/min. This arrangement permits water vapor collection at about 95% efficiency. Water samples are obtained by heating the dessicant and condensing the resulting vapor. A standard aliquot of this water is measured for tritium content by liquid scintillation counting. This measurement is combined with the average humidity for the week to obtain an estimate of the average tritium concentration in air.

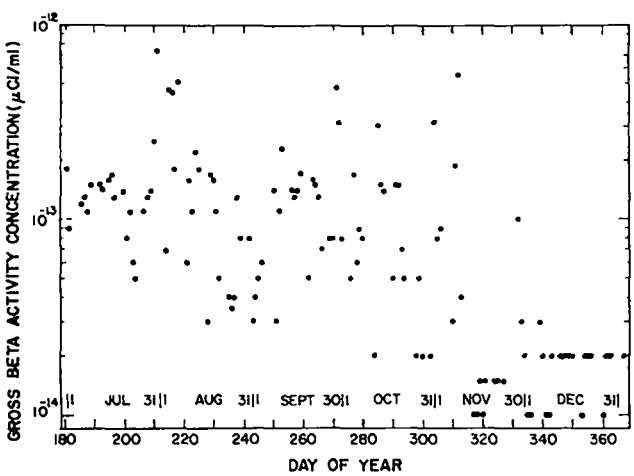


Fig. 5.
Daily air sample measurements.

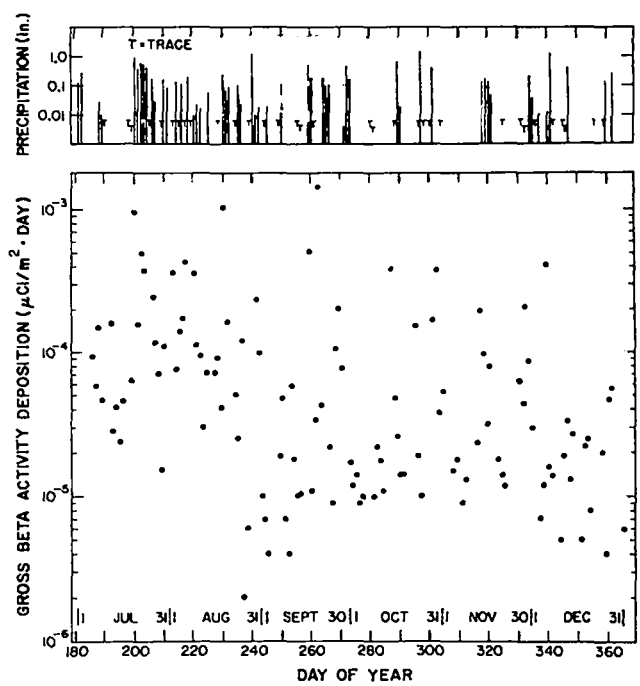


Fig. 6.
Daily deposition sample measurements.

The gross alpha and gross beta activities are measured primarily for the purpose of screening the samples to detect unexpectedly high concentrations of radionuclides not covered by the more specific analyses. The results of the measurements taken after 8 days of decay are summarized in Table IV.

The gross alpha measurements have been corrected both for background of the counting chamber and for the approximately 0.1% of beta counts that feed into the alpha channel of the counter (cross-talk). Background, i.e., count of an unused filter (blank), normally runs 0.2 counts/min. A filter from the sampling array can thus be distinguished from the blank if it contains a total activity of more than 0.3 counts/min. Consideration of total flow through the filter yields an MDL of about 2×10^{-16} μCi/ml for the total collection and analysis procedure. This value is subject to variation due to fluctuations in sampling rate.

The gross alpha measurements were of about the same magnitude as those reported previously. The decrease with time noted in the daily air measurements was also evident from inspection of the weekly gross alpha results. Stations operated during the first part of this period tended to exhibit high averages, whereas those in operation at the end of this period exhibited low averages. Those stations operated during the entire period, characterized by 27 samples, gave imtermediate values. Except for three stations, 304-2.6 (Map No. 44), 73-3.0 (Map No. 29), and 64-5.8 (Map No. 19), differences in gross alpha concentration with respect to time were much more significant than differences between stations. This fact tends to indicate that the samplers measured alpha activity from a widespread source, probably fallout from atmospheric weapons testing, rather than from a local source. Station 304-2.6 is located at the Administration Building in TA-3, just north of the Chemistry and Metallurgy Research (CMR) Building, where effluents are known to contain alpha emitters. For two different weeks, measurements from the other two stations were much higher than from all other stations for the same period. The high value at station 64-5.8 is associated with an exceptionally high value for ^{238}Pu concentration. The exact reason for these high measurements is not known. The French test of July 4 was noticeable in the weekly data. The highest averages for stations operating for the entire period occurred at the most distant stations, [55-23.7 (Map No. 18, Espanola) and 122-37.2 (Map No. 24, Santa Fe)], which indicates that LASL activities have very little effect on regional levels of gross alpha activity.

The gross beta measurements of the weekly air filters (Table IV) were corrected for counter background only because the cross talk from the alpha channel is negligible. Background is about 9 counts/min yielding an estimate of 10^{-15} μCi/ml for the MDL of the system. The decrease in concentration with time observed in the gross beta activity in the daily air sample and in the gross alpha activity in the weekly sample was also seen here. The effects of the French and Chinese tests mentioned earlier were also seen in the data. No significant station effects were noted.

Analysis of the charcoal cartridges indicated that ^{131}I could not have been present at concentrations above 10^{-14} μCi/ml, the estimated MDL of the system.

Measurements of tritiated water vapor in air are summarized in Table V and are shown graphically in Fig. 7. The concentrations given are for unit volume of air The MDL is approximately 10^{-11} μCi/ml. Although there was an overall tendency for concentration to decrease with time, there were significant differences between stations. Figure 7 shows that stations to the north and east of locations where tritium releases occurred (TA-33, TA-35, and the explosives test areas, see Table I) exhibited concentrations generally higher than those measured at the distant stations in Santa Fe and Espanola. This is consistent with the prevailing southerly and easterly winds for the 6-month period (see Appendix).

The highest average off-site air concentration, including background due to past atmospheric weapons testing, occurred at station 42-3.1 (Map No. 16, Los Alamos Airport). This concentration was about 0.06% of the concentration guide value of 2×10^{-7} μCi/ml, as given in AEC Manual Chapter 0524 for individuals in uncontrolled areas or about 0.2% of the recommended guide for the most restrictive population group. The average air concentration at the highest on-site station, 156-9.4 (Map No. 36, TA-33), was about 0.005% of the recommended guide for controlled areas of 5×10^{-6} μCi/ml.

Plutonium concentrations in air, as determined by the monthly composited weekly air samples, are summarized in Table VI. The ^{238}Pu data are also shown in Fig. 8. The MDL for the system is about 10^{-17} μCi/ml for both plutonium isotopes.

The ^{238}Pu measurements indicated a slight decrease in concentration over the 6-month period, but significant differences between stations were also observed. Stations to the north and east of the locations where ^{238}Pu releases occurred (TA-21 and the CMR Building in TA-3, see Table I) exhibited concentrations generally higher than the average of all other stations to the south and the distant stations in Santa Fe and Espanola (Fig. 8). This result is again consistent with the wind patterns in Los Alamos over the 6-month period.

The maximum observed on-site concentration, 14×10^{-17} μCi/ml at station 304-2.6 (Map No. 44,

TABLE V

TRITIATED MOISTURE CONCENTRATIONS IN AIR

Station				Concentration	
Map No.	Array Designation	Status[b]	No. of Samples	Max 10^{-11} μCi/ml	Av[a]
Off-Site Stations:					
1	330-3.8	N	23	11	3.4 ± 1.0
5	335-4.9	N	13	8.0	2.6 ± 1.1
9	350-4.3	N	23	8.2	3.7 ± 0.9
10	351-2.4	N	21	8.3	3.7 ± 0.9
11	3-3.7	C	27	19	5.0 ± 1.8
12	15-2 0	C	27	24	7.4 ± 2.1
14	18-4.9	N	22	40	5.9 ± 4.0
15	36-7.0	C	27	11	3.3 ± 0.8
16	42-3.1	C	27	74	12 ± 6.0
17	50-8.6	N	19	6.7	2.2 ± 0.6
18	55-23.7	C	27	10	3.3 ± 1.0
19	64-5.8	N	16	20	3.6 ± 2.5
20	64-10.2	N	19	9.4	2.7 ± 1.0
21	78-12.4	C	27	15	4.3 ± 1.3
22	111-10.6	N	14	5.5	2.0 ± 0.6
23	117-9.2	D	13	14	7.6 ± 2.4
24	122-37.2	C	27	8.0	3.1 ± 0.7
25	132-11.1	N	14	22	3.2 ± 3.1
26	164-8.5	N	8	5.3	3.0 ± 1.2
27	164-9.4	N	8	8.9	3.0 ± 2.5
On-Site Stations:					
28	58-3.1	N	17	32	8.5 ± 4.7
29	73-3.0	N	8	46	7.9 ± 13
31	92.6.7	N	17	93	9.8 ± 11
32	99-2.0	N	8	14	6.2 ± 3.9
33	122-3.7	N	17	31	5.9 ± 3.9
34	123-7.0	N	17	30	5.4 ± 3.7
35	141-3.3	N	18	12	3.8 ± 1.6
36	156-9.4	C	27	180	24 ± 14
37	189-2.8	N	16	76	8.2 ± 9.9
38	204-4.2	C	27	92	7.4 ± 6.7
39	224-3.5	N	16	19	4.2 ± 2.3
40	242-6.3	N	15	3.3	1.9 ± 0.4
41	245-3.3	N	16	10	4.5 ± 1.4
43	277-3.3	N	8	7.3	3.6 ± 2.1
44	304-2.6	C	27	23	7.6 ± 2.1
45	319-3.1	N	21	12	4.3 ± 1.3

[a]Average and 95% confidence limits for the average.

[b]Status: N - New station or old station fitted with moisture collector this report period.
D - Old station discontinued this report period.
C - Old station continuing in operation.

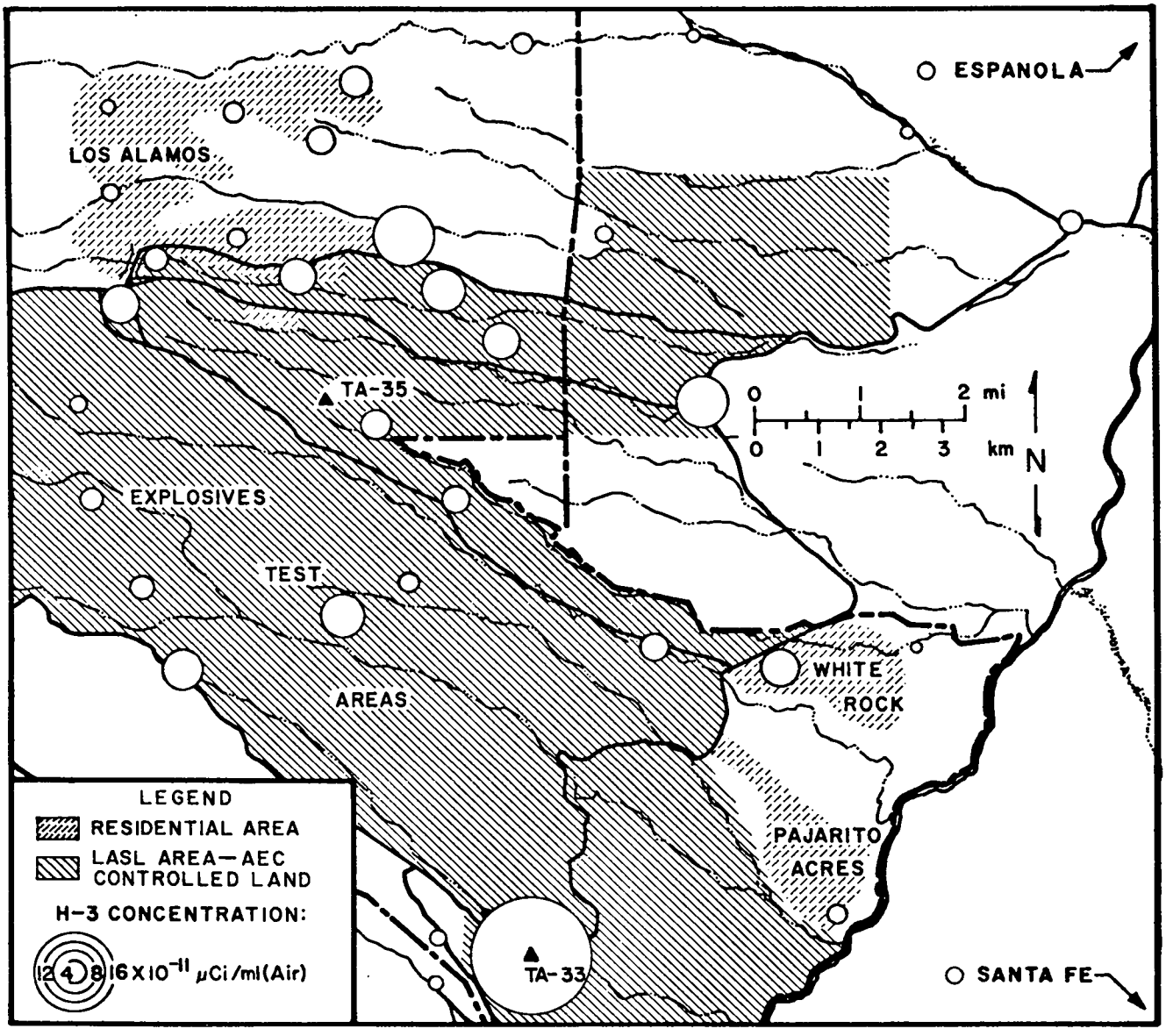


Fig. 7.
Tritiated moisture concentrations in air.

Administration Building), was only 0.007% of the 2×10^{-12} μCi/ml concentration guide value for the soluble form of the isotope as given in AEC Manual Chapter 0524 for occupational exposure. Public traffic on adjacent roads is normally permitted, and the boundary of the Laboratory is near this station. A comparison to the 7×10^{-14} μCi/ml concentration guide for an individual in the general public indicates that the maximum concentration is less than 0.2% of this guide. The maximum off-site concentration 8.5×10^{-17} μCi/ml at station 15-2.0 (Map No. 12, Museum) was approximately 0.1% of this same guide value. The unusually high concentration of 590×10^{-17} μCi/ml recorded at station 64-5.8 (Map No. 19, Bayo Canyon Sewage Treatment Plant) is nearly two orders of magnitude higher than all other measurements made during the 6-month period and is not completely understood. It appears that one of these anomalously high values occurs about every 6 months at one of the weekly air sampling stations.

The only significant station effect in the ^{239}Pu concentrations occurred at station 304-2.6 (Map No. 44, Administration Building). Because the ^{238}Pu concentration was also high at this station, both high measurements are attributed to the CMR Building airborne effluents. All

TABLE VI

PLUTONIUM CONCENTRATIONS IN AIR

Station				^{238}Pu Concentration		^{239}Pu Concentration	
Map No.	Array Designation	Status[b]	No. of Samples	Max	Av[a]	Max	Av[a]
				10^{-17} μCi/ml		10^{-17} μCi/ml	
Off-Site Station:							
1	330-3.8	N	6	1.0	0.5 ± 0.3	5.5	3.0 ± 2.0
3	333-4.7	D	3	4.0	2.3 ± 3.6	7.0	4.8 ± 4.7
5	335-4.9	N	4	1.3	0.6 ± 0.8	2.5	1.5 ± 1.2
8	343-5.2	D	1	3.5	— —	1.5	— —
9	350-4.3	N	6	2.5	1.2 ± 0.8	8.0	3.7 ± 2.7
10	351-2.4	C	7	5.5	2.5 ± 1.8	6.5	4.2 ± 1.6
11	3-3.7	C	7	4.5	1.8 ± 1.6	4.0	2.1 ± 1.4
12	15-2.0	C	7	8.5	2.9 ± 2.7	4.5	2.8 ± 1.1
14	18-4.9	C	7	3.0	1.3 ± 1.9	8.0	4.1 ± 1.8
15	36-7.0	C	7	4.0	1.8 ± 1.2	6.5	3.7 ± 1.9
16	42-3.1	C	7	4.0	1.5 ± 1.3	6.5	3.5 ± 1.3
17	50-8.6	C	7	1.5	0.7 ± 0.4	5.5	3.0 ± 1.9
18	55-23.7	C	7	3.2	1.0 ± 0.9	3.2	2.0 ± 0.9
19	64-5.8	N	5	590	2.6 ± 5.8[c]	20	2.3 ± 3.6[c]
20	64-10.2	C	7	4.5	1.5 ± 1.5	9.0	4.0 ± 2.5
21	78-12.4	C	7	5.5	1.7 ± 1.7	3.6	2.4 ± 0.9
22	111-10.6	N	4	2.3	1.1 ± 1.4	3.2	2.5 ± 1.2
23	117-9.2	D	3	2.0	1.2 ± 2.0	4.5	3.0 ± 3.7
24	122-37.2	C	7	4.0	1.3 ± 1.2	6.0	4.0 ± 1.0
25	132-11.1	C	7	2.7	1.4 ± 0.9	10	3.7 ± 2.7
26	164-8.5	N	3	5.1	1.9 ± 6.8	2.6	2.1 ± 2.3
27	164-9.4	N	3	2.4	1.3 ± 2.6	4.8	3.2 ± 3.5
On-Site Stations:							
28	58-3.1	N	5	1.9	1.1 ± 0.8	2.8	1.8 ± 1.2
29	73-3.0	N	3	1.9	0.9 ± 2.2	13	5.7 ± 15
30	87-4.7	D	2	2.0	1.3 ± 9.5	4.0	2.8 ± 16
31	92-6.7	N	5	2.5	1.2 ± 1.1	4.6	2.8 ± 1.8
32	99-2.0	N	3	2.5	1.4 ± 2.6	4.3	2.5 ± 4.0
33	122-3.7	N	5	3.4	1.7 ± 1.6	2.9	2.1 ± 1.1
34	123-7.0	N	5	3.0	1.1 ± 1.4	5.5	1.8 ± 2.6
35	141-3.3	N	5	2.0	1.0 ± 0.8	2.4	1.7 ± 0.7
36	156-9.4	C	7	3.8	1.6 ± 1.2	7.5	3.3 ± 2.3
37	189-2.8	N	5	2.0	1.1 ± 0.8	4.0	3.1 ± 1.3
38	204-4.2	C	7	2.5	1.6 ± 0.8	5.0	2.6 ± 1.4
39	224-3.5	N	5	1.5	0.8 ± 0.6	9.5	3.9 ± 4.7
40	242-6.3	N	4	2.4	1.0 ± 1.5	3.3	2.3 ± 1.6
41	245-3.3	N	5	1.5	0.8 ± 0.7	12	3.9 ± 5.8
42	250-5.4	D	3	2.0	1.0 ± 2.2	5.5	2.7 ± 6.1
43	277-3.3	N	3	2.0	1.2 ± 2.0	3.4	2.9 ± 1.2

TABLE VI (cont)

Station				^{238}Pu Concentration		^{239}Pu Concentration	
Map No.	Array Designation	Status[b]	No. of Samples	Max	Av[a]	Max	Av[a]
				10^{-17} μCi/ml		10^{-17} μCi/ml	
44	304-2.6	C	7	14	6.5 ± 5.2	33	17 ± 10
45	319-3.1	C	7	10	3.2 ± 3.2	18	4.5 ± 5.8

[a]Average and 95% confidence limits for the average.

[b]Status: N - New station initiated this report period.
D - Old station discontinued this report period.
C - Old station continuing in operation.

[c]Average and confidence interval do not include the high value.

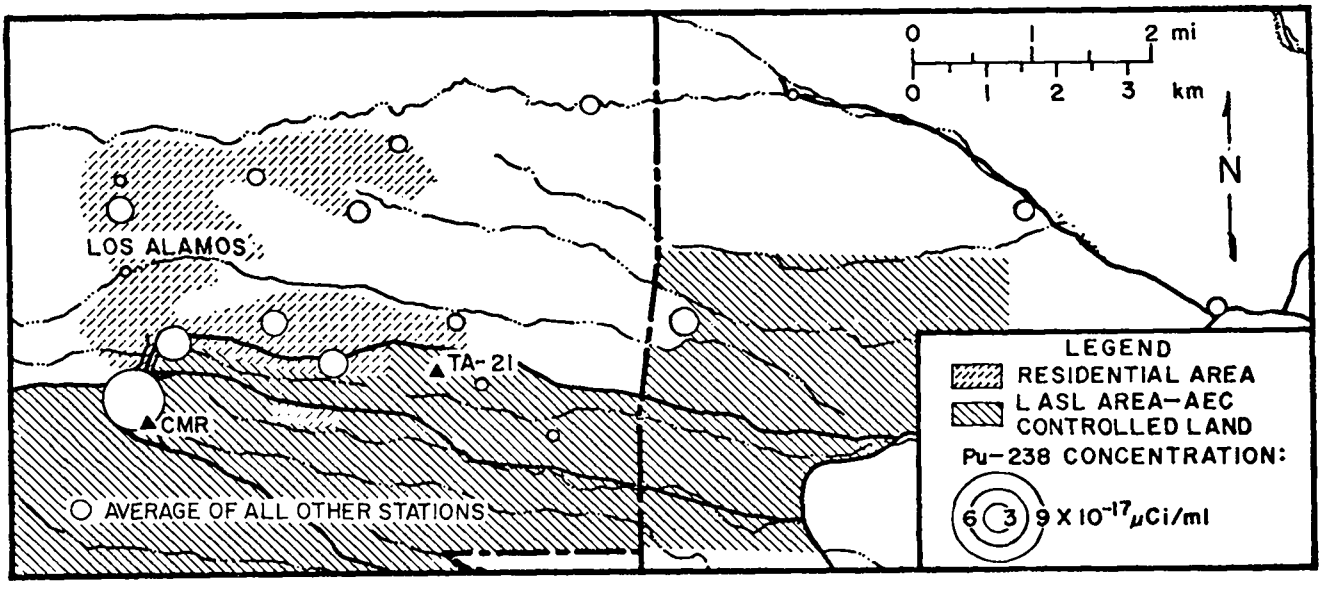


Fig. 8.
Plutonium-238 concentrations in air.

other ^{239}Pu concentrations fall within the range of values attributable to worldwide fallout[3] and exhibit the same decrease with time as did the gross alpha and gross beta concentrations.

All future plutonium effluents will be decreased. Measures are underway to improve the filtration of the exhaust from the CMR Building. This work should reduce the effluents by several orders of magnitude and is expected to be completed by mid-1973. A new and improved plutonium processing facility to replace the one at TA-21 is in the conceptual design stage.

The uranium analysis of the composited samples is done by a fluorometric technique and is therefore incapable of determining the various isotopes separately. The MDL is about 0.5×10^{-10} μg/ml. Table VII summarizes the results of the uranium determinations on these samples. The two stations with the largest deviations from the Los Alamos area average, stations 141-3.3 (Map No. 35, TA-36) and 189-2.8 (Map No. 37, TA-15), are located in on-site areas where depleted uranium involved in explosive tests could be expected to be dispersed into the atmosphere (see Table I). Several other stations in this

TABLE VII

URANIUM CONCENTRATIONS IN AIR

Station				Concentration	
Map No.	Array Designation	Status[b]	No. of Samples	Max	Av[a]
				10^{-10} µg/ml	
Off-Site Stations:					
1	330-3.8	N	6	3.0	1.7 ± 1.0
3	333-4.7	D	3	2.5	2.0 ± 1.2
5	335-4.9	N	4	2.3	1.8 ± 0.8
8	343-5.2	D	1	2.0	— —
9	350-4.3	N	6	2.5	1.5 ± 0.8
10	351-2.4	C	7	2.8	1.0 ± 0.9
11	3-3.7	C	7	2.0	1.1 ± 0.5
12	15-2.0	C	7	6.0	2.0 ± 1.8
14	18-4.9	C	7	3.0	1.5 ± 0.8
15	36-7.0	C	7	2.1	1.4 ± 0.5
16	42-3.1	C	7	3.0	1.5 ± 0.8
17	50-8.6	C	7	3.0	1.6 ± 0.9
18	55-23.7	C	7	3.5	1.3 ± 1.0
19	64-5.8	N	5	2.0	1.4 ± 0.5
20	64-10.2	C	7	3.5	1.2 ± 1.0
21	78-12.4	C	7	2.0	1.1 ± 0.5
22	111-10.6	N	4	1.3	1.0 ± 0.3
23	117-9.2	D	3	1.5	1.5 —
24	122-37.2	C	7	4.0	1.5 ± 1.0
25	132-11.1	C	7	2.5	1.2 ± 0.6
26	164-8.5	N	3	2.6	1.4 ± 2.7
27	164-9.4	N	3	5.9	2.9 ± 6.9
On-Site Stations:					
28	58-3.1	N	5	1.5	0.8 ± 0.5
29	73-3.0	N	3	1.9	1.6 ± 1.0
30	87-4.7	D	2	1.0	1.0 —
31	92-6.7	N	5	2.4	1.4 ± 1.0
32	99-2.0	N	3	2.5	1.4 ± 2.6
33	122-3.7	N	5	2.0	1.2 ± 0.7
34	123-7.0	N	5	4.0	2.1 ± 2.2
35	141-3.3	N	5	15	5.7 ± 8.6
36	156-9.4	C	7	1.1	0.8 ± 0.3
37	189-2.8	N	5	16	4.5 ± 8.0
38	204-4.2	C	7	6.9	2.4 ± 2.0
39	224-3.5	N	5	2.0	0.9 ± 0.8
40	242-6.3	N	4	3.0	1.1 ± 2.0
41	245-3.3	N	5	4.0	1.8 ± 1.6
42	250-5.4	D	3	4.0	2.3 ± 3.8
43	277-3.3	N	3	3.7	2.4 ± 3.4
44	304-2.6	C	7	4.5	1.7 ± 1.2
45	319-3.1	C	7	3.0	1.4 ± 0.9

[a] Average and 95% confidence limits for the average.

[b] Status: N - New station initiated this report period.
D - Old station discontinued this report period.
C - Old station continuing in operation.

area, but a little farther from those particular firing sites, exhibited slightly elevated uranium concentrations due to these experiments. None of the off-site sampling stations showed higher-than-average uranium concentrations.

B. Nonradioactive Materials. A sample of 24-h duration is taken once per week on the roof of the Occupational Health Laboratory (TA-3) and is analyzed by Group H-5 (Industrial Hygiene) for particulates. The sample is taken on a different day each week by drawing air at about 1500 liters/min through an 8- by 10-in. glass fiber filter provided by the Environmental Protection Agency. These filters are then analyzed for suspended particulate material, for benzene soluble organic material, and for selected metals. A similar sampling arrangement is used with a Whatman 41 filter for airborne beryllium measurements. The results of these analyses for this period are given in Table VIII.

The state of New Mexico has established ambient air quality standards,[4] and comparisons are made to these standards. The Los Alamos 6-month geometric mean was about 25% of the established standard of 60 $\mu g/m^3$ for the annual geometric mean for total suspended particulates. The maximum beryllium concentration was 0.4% of the allowed 30-day average of 0.01 $\mu g/m^3$. The total heavy metals (atomic number greater than 21) concentration standard is 10 $\mu g/m^3$, again based on a 30-day average. The Los Alamos total of maximum lead and cadmium concentrations was less than 2% of this value. These low levels of nonradioactive atmospheric contaminants tend to reflect the low level of industrial activity in the Los Alamos vicinity.

IV. External Radiation Monitoring Program

A thermoluminescent dosimeter (TLD) array is maintained to monitor gamma and X radiation at natural background levels to provide information on any possible contribution due to Laboratory activities. To improve the quality of the data from this array, substantial changes in equipment, location, and procedure were effected this reporting period.

The previous array utilized two TLDs at each station. One was the EGG Model TL-2B consisting of a CaF_2:Mn powder chemically bonded to a heating coil and enclosed in an evacuated glass envelope; the other was the MBLE consisting of CaF_2:(unknown activator) bonded to a heating cylinder and enclosed in an evacuated glass envelope. Two sets of each were maintained and swapped for reading at approximately 30-day intervals. Both types suffered from an inherent natural dosimeter background, presumably due to naturally occurring radioisotopes in the binder and glass envelope. This source normally contributed 3 to 5 times the external dose intended to be measured and made interpretation and evaluation of the measurements very difficult. In addition, unexplainable discrepancies in readings from the two dosimeters at each station occasionally occurred. Sporadic behavior has been reported elsewhere.[5]

We therefore decided to replace both types of TLD with Harshaw TLD-100 LiF chips (natural lithium). This system was chosen because LiF exhibits negligible dosimeter background and fading characteristics, tissue equivalence, and uniform energy response. Although this system lacks the sensitivity of the CaF_2:Dy system, its fading and

TABLE VIII

PARTICULATE CONCENTRATIONS IN AIR

Contaminant	No. of Samples	Geometric Mean Concentration $\mu g/m^3$	Maximum Concentration $\mu g/m^3$	MDL $\mu g/m^3$
Suspended particulate	17	15.4	24.2	0.2
Benzene soluble organic	11	0.87	1.7	0.4
Cadmium	12	—	0.0023	0.0004
Lead	12	0.084	0.16	0.0009
Beryllium	8	—	0.00006	0.00004

energy response characteristics are better. Increasing the high voltage on an Eberline TLR-5 reader produces approximately 60 net counts above a 20 to 25-count background for a 10-mR dose to the TLDs. This is approximately the dose received at a typical station in the TLD array.

Due to delays in acquisition, the TLD-100 chips were not available for placement in July. The operational necessity to field a set of TLDs to maintain continuity led to the placement of 55 Harshaw TLD-700 chips that were available for other purposes. Both TLD-700 and TLD-100 chips are LiF chips, but in this case the lithium is depleted in ^{6}Li. For comparison, 39 EGG and 41 MBLE TLDs were placed with the TLD-700 chips, and the results of this placement are given in Table IX. Continued acquisition delays led to further complications in August. Not enough TLD-700 chips were available to allow for placement of fresh TLDs while reading those that had been in the field. Therefore MBLE and EGG TLDs were again fielded in August, and the results of this placement are also given in Table IX.

The Harshaw TLD-100 TLDs were finally put into service on August 25, 1971. The configuration of the station array was revised slightly to provide more uniform coverage. Stations have been assigned polar grid designations according to the same scheme used for the atmospheric monitoring program discussed in Sec. III. The locations are shown in Fig. 9, again using serial numbering on the map for clarity. Note that No. 1 on this map is not coincident with No. 1 on the map for weekly air sampling stations. Each station consists of three TLD chips in a single container. The TLDs are exchanged for fresh ones and read at 28-day intervals, and the average of the three readings for each station is taken to be the dose at that station for that period.

A summary of these measurements is given in Table X. There were five measurement invervals during the last part of the report period. Occasionally, a TLD package was missing at collection time causing the number of measurements to be less than five. Station 138-3.4 (Map No. 35) was discontinued during the report period but will be reinstated.

In general, the TLD measured dose decreased over the 6-month period. The average for all off-site stations was 10.8 mR per 28-day interval, and the corresponding number for all on-site stations was 11.6 mR, neglecting station 129-3.9 (Map No. 33, TA-18) whose response was due to the programmed operation of a fast burst reactor at TA-18. The readings for two off-site stations, 42-3.1 (Map No. 11, Los Alamos Airport) and 164-9.4 (Map No. 22, Bandelier Headquarters), and one on-site station, 152-9.2 (Map No. 38, TA-39), were slightly higher than the on-site and off-site averages. For comparison purposes, TLD-measured dose at Colorado Springs (6170-ft elevation) for an equivalent period was about 11.3 mR and points closer to sea level (<1000-ft elevation) were reported as 2 to 6 mR.[6] The Los Alamos averages seem to be consistent with doses expected from solar radiation at this elevation.

TABLE IX

THERMOLUMINESCENT DOSIMETER READINGS FOR JULY AND AUGUST 1971

	July (31 days)		August (30 days)	
	No. of Stations	Reading[a] (mR/day)	No. of Stations	Reading[a] (mR/day)
Off-Site Stations:				
EG&G	12	0.47 ± 0.07	23	0.18 ± 0.05
MBLE	13	0.14 ± 0.07	23	0.20 ± 0.04
Harshaw	22	0.12 ± 0.03	—	—
On-Site Stations:				
EG&G	27	0.47 ± 0.05	31	0.26 ± 0.07
MBLE	28	0.12 ± 0.04	31	0.18 ± 0.03
Harshaw	33	0.14 ± 0.01	—	—

[a]Average and 95% confidence limits for the average.

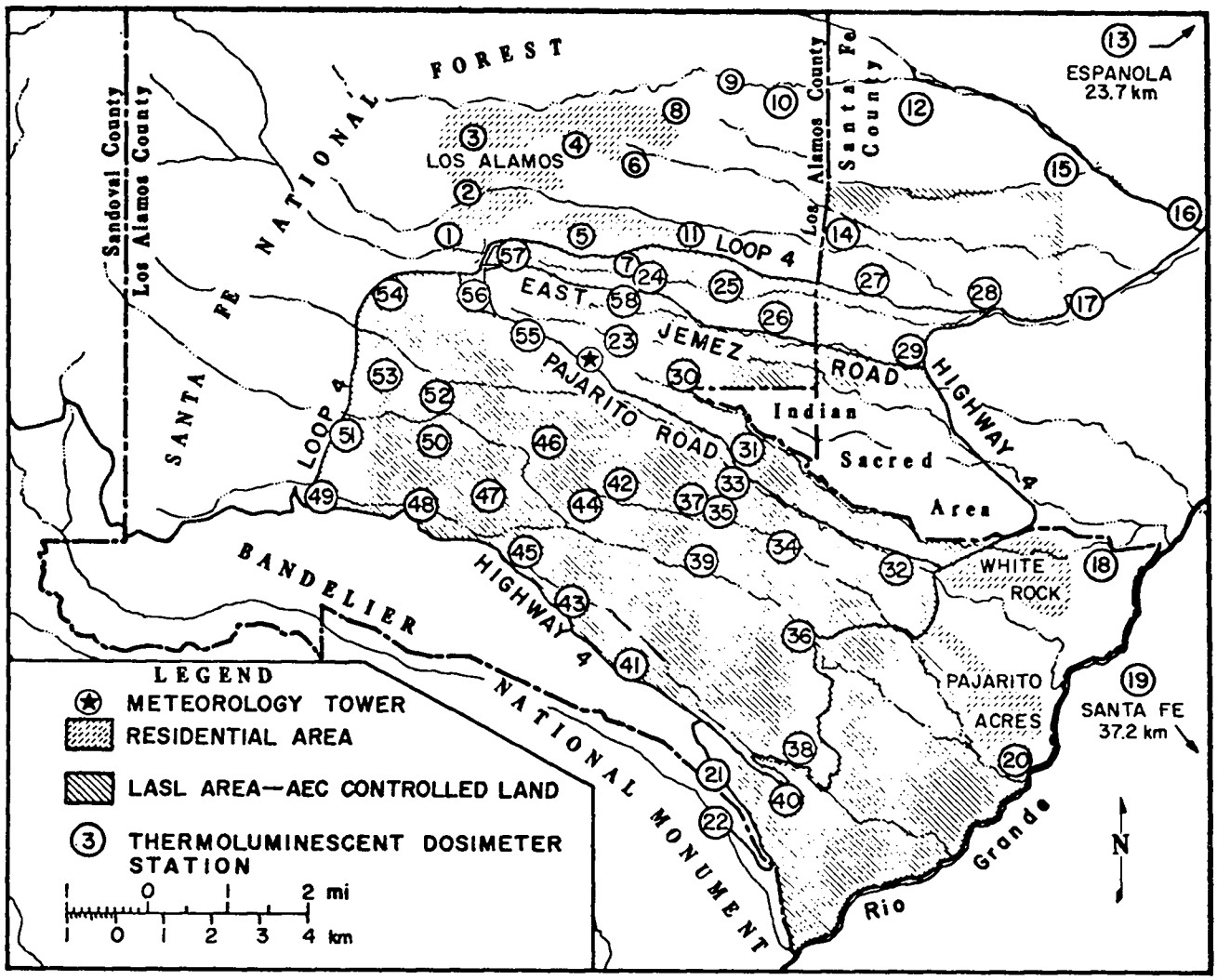


Fig. 9.
Locations of thermoluminescent dosimeter stations.

TABLE X

SUMMARY OF THERMOLUMINESCENT DOSIMETER READINGS

Station			Dose	
Map No.	Array Designation	No. of Readings	Max	Av[a]
			mR	
Off-Site Stations:				
1	315-3.6	5	12.1	10.1 ± 2.1
2	330-3.8	5	13.2	10.6 ± 2.7
3	335-4.9	5	13.1	10.2 ± 2.2
4	350-4.3	5	11.8	10.7 ± 1.8
5	351-2.4	5	12.0	10.8 ± 0.9

TABLE X (cont)

Station			Dose	
Map No.	Array Designation	No. of Readings	Max	Av[a]
			mR	
6	3-3.7	5	15.4	13.6 ± 2.5
7	15-2.0	5	10.9	9.8 ± 1.1
8	18-4.9	5	11.4	9.7 ± 1.5
9	20-5.8	5	15.6	11.4 ± 3.2
10	36-7.0	5	11.5	10.7 ± 0.8
11	42-3.1	5	17.2	14.2 ± 3.1
12	50-8.6	5	10.7	10.0 ± 0.6
13	55-23.7	4	10.3	8.5 ± 2.1
14	64-5.8	5	16.6	13.5 ± 2.6
15	64-10.2	5	11.6	10.3 ± 1.6
16	78-12.4	5	11.2	10.0 ± 1.2
17	83-10.7	5	11.9	10.4 ± 1.1
18	111-10.6	5	11.3	9.3 ± 1.6
19	122-37.2	4	11.4	8.8 ± 3.6
20	132-11.1	4	10.2	8.9 ± 2.1
21	164-8.5	5	11.6	10.5 ± 1.3
22	164-9.4	5	19.1	14.8 ± 3.5
On-Site Stations:				
23	18-0.2	5	11.3	10.2 ± 1.0
24	23-1.9	5	16.5	13.6 ± 2.4
25	58-3.1	5	14.0	10.8 ± 3.5
26	73-3.0	5	12.7	11.0 ± 1.2
27	75-5.3	5	13.0	10.7 ± 2.0
28	83-8.1	3	12.9	11.4 ± 5.2
29	92-6.7	5	14.0	12.8 ± 1.6
30	99-2.0	5	12.2	10.5 ± 1.2
31	122-3.7	5	15.8	12.9 ± 2.3
32	123-7.0	5	13.7	12.5 ± 1.6
33	129-3.9	5	34.1	21.8 ± 10.1
34	134-5.5	5	13.4	12.1 ± 1.6
35	138-3.4	1	15.9	— —
36	140-7.3	5	14.9	12.9 ± 2.0
37	141-3.3	4	12.4	11.9 ± 0.5
38	152-9.2	5	16.2	15.0 ± 1.3
39	156-4.2	5	15.1	12.9 ± 2.9
40	156-9.4	5	12.5	10.9 ± 1.9
41	174-6.4	5	11.5	10.2 ± 2.2
42	184-2.0	5	12.0	10.9 ± 1.3
43	184-5.1	5	12.7	11.1 ± 2.1
44	189-2.8	5	16.5	13.6 ± 2.6
45	204-4.2	5	12.1	9.9 ± 2.6
46	225-1.9	5	12.9	11.4 ± 1.3
47	224-3.5	5	12.1	11.0 ± 1.6
48	228-4.7	5	13.7	11.2 ± 3.3
49	242-6.3	5	14.4	11.2 ± 3.4
50	245-3.3	4	11.2	10.1 ± 2.1

TABLE X (cont)

Station			Dose	
Map No.	Array Designation	No. of Readings	Max	Av[a]
			mR	
51	251-5.0	5	12.3	10.4 ± 1.5
52	254-2.8	5	11.9	11.0 ± 1.6
53	261-4.3	4	13.1	10.7 ± 3.3
54	286-4.5	5	15.5	12.5 ± 3.1
55	296-1.8	5	12.4	11.8 ± 1.2
56	309-2.9	5	12.3	10.8 ± 1.3
57	319-3.1	5	10.6	9.1 ± 2.0
58	346-3.2	5	13.3	10.7 ± 2.2

[a]Average and 95% confidence limits for the average.

V. Water Monitoring Program

The water monitoring program is designed to provide for surveillance of the Los Alamos municipal water supply drawn from the deep aquifer underlying the Laboratory area, as well as for general surveillance of the ground and surface waters in the vicinity.

Water samples are collected in new polyethylene bottles. For samples from observation holes and test wells, a sufficient quantity of water is drawn and discarded so that the sample is representative of the ground water at the time of sampling. Samples from supply wells are collected at the individual well heads during pumping, and samples of surface water are bailed from a convenient pool or allowed to flow directly into the sample container. All samples are analyzed by radiochemical methods for gross alpha, beta, and gamma activities and for tritium, plutonium, and cesium (^{137}Cs). Analyses for radium or strontium are performed if the gross alpha or beta activity is greater than 10^{-8} μCi/ml or 2×10^{-7} μCi/ml, respectively. A fluorometric technique is used to measure uranium concentration. Standard chemical analyses are made for calcium, magnesium, sodium, fluorides, chlorides, nitrates, carbonates, bicarbonates, chromates, total dissolved solids, hardness, pH, and conductivity. Concentrations of mercury, cadmium, lead, and beryllium are determined to establish background levels for these contaminants and to assure that no hazardous concentrations remain undetected. Analyses for other constituents may be run in addition to, or instead of, the above if there is evidence that such analyses are necessary.

The plutonium determinations performed on these water samples deserve special mention since tenuous identifications of trace amounts of this material were made on several occasions. These identifications are believed to be due to cross-contamination in the analytical laboratory or to fluctuations of the MDL, both very real problems at the low concentrations being investigated here. Thus, those samples in which traces of plutonium were found are reported with the understanding that they are probably not indicative of actual plutonium contamination of the water from which they were taken. Verification will depend upon patterns established by analyses of future sample collections.

A. Los Alamos Water Supply. Samples of water were collected and analyzed in a continuing program to monitor the chemical and radiochemical quality of the municipal water supply at Los Alamos. This water is pumped from 16 deep supply wells (Fig. 10) completed into the main aquifer and ranging in depth from 870 to 2600 ft. One spring on the eastern flanks of the Jemez Mountains has been developed and also contributes to the water supply. About 5 billion gallons of water were supplied to the Los Alamos complex during 1971.

The range and average of constituents in the water from the 16 supply wells and the spring are shown in Table XI. Range rather than confidence interval is given for water sample analyses because the large number of results falling below the detection limits preclude the definition of the statistical distribution of these results.

These results indicate no significant change in the water quality during this reporting period as compared to previous analyses.[1] The maximum concentrations were all well below the limits defined by the U.S. Public Health Service standards for drinking water[7] and the concentration guides for radioactive materials as given in AEC Manual Chapter 0524, Table II (uncontrolled areas).

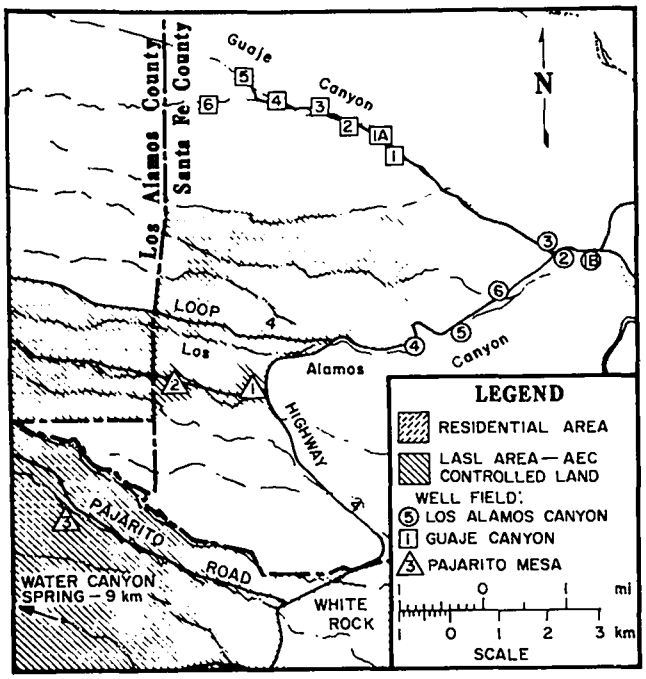


Fig. 10.
Locations of Los Alamos water supply system wells.

B. Regional Surface Waters. Off-site rivers and reservoirs in and adjacent to the Los Alamos area are sampled and analyzed on a routine basis to provide information on general water quality in the area and to serve as background for other measurements. During this period, eight water samples were collected at four river stations: the Rio Chama at Chamita and the Rio Grande at Embudo, Otowi, and Cochiti (Fig. 11). Eight water samples, one each, were taken from the Caliente River, Santa Cruz Reservoir, Galisteo Reservoir, the Rio Grande at Bernalillo, Jemez Reservoir, Jemez Creek, Fenton Lake, and Abiquiu Reservoir (Fig. 11).

The range and average of constituents of water from these sampling stations are shown in Table XII. It should be noted that the quality of water from those sources is subject to drastic fluctuations due to variations in discharge and in size and terrain of the drainage area. The analysis of the water taken from the Rio Grande at Embudo indicated a trace of ^{239}Pu.

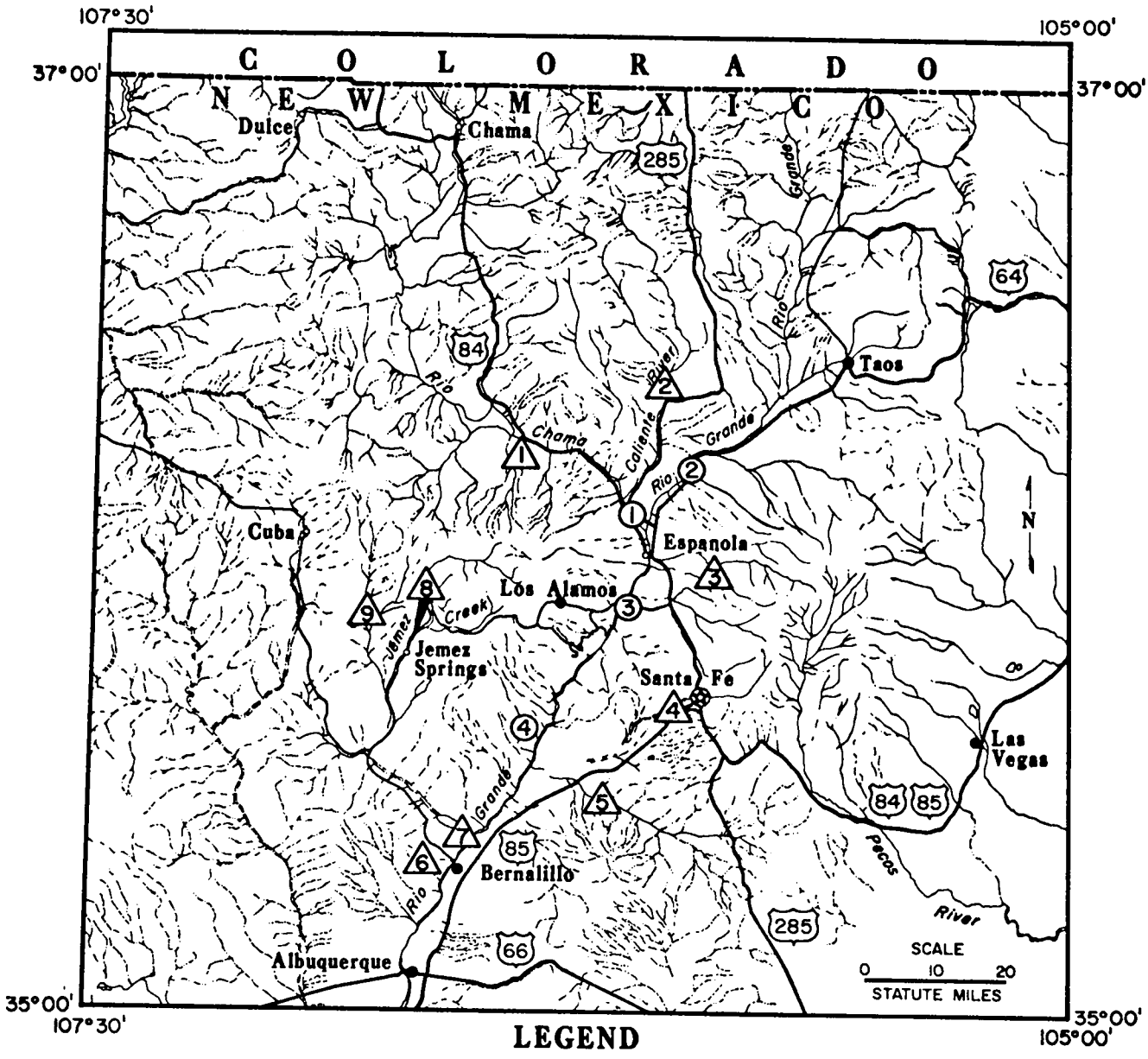
C. Surveillance Water Sampling. Samples of sewage effluent, surface water, and ground water were collected

TABLE XI

ANALYSES OF LOS ALAMOS WATER SUPPLY SYSTEM SAMPLES

Determination	Unit	No. of Samples	Range		Av	MDL
			Min	Max		
Gross alpha	10^{-9} μCi/ml	17	<1.0	4.0	<1.3	1.0
Gross beta	10^{-9} μCi/ml	17	<1.0	<1.0	<1.0	1.0
Plutonium-238	10^{-11} μCi/ml	17	<5.0	<5.0	<5.0	5.0
Plutonium-239	10^{-11} μCi/ml	17	<5.0	<5.0	<5.0	5.0
Cesium-137	10^{-7} μCi/ml	17	<3.5	<3.5	<3.5	3.5
Tritium	10^{-6} μCi/ml	17	<1.0	<1.0	<1.0	1.0
Total uranium	10^{-4} μg/ml	17	<4.0	27	<7.7	4.0
Chloride	μg/ml	17	<1.0	14	<4.0	1.0
Fluoride	μg/ml	17	0.1	2.2	0.5	0.1
Nitrate	μg/ml	17	0.2	0.4	0.3	0.1
Dissolved solids	μg/ml	17	98	420	180	—
Conductivity	μmho/cm	17	64	500	160	—
Cadmium	10^{-4} μg/ml	17	4.0	27	12	2.5
Lead	10^{-3} μg/ml	17	<1.0	2.5	<1.2	1.0
Beryllium	10^{-4} μg/ml	17	<2.5	<2.5	<2.5	2.5
Mercury	10^{-5} μg/ml	17	<2.0	<2.0	<2.0	2.0
Cadmium[a]	10^{-4} μg/ml	17	<2.5	3.9	<2.6	2.5
Lead[a]	10^{-3} μg/ml	17	<1.0	<1.0	<1.0	1.0
Beryllium[a]	10^{-4} μg/ml	17	<2.5	<2.5	<2.5	2.5
Mercury[a]	10^{-5} μg/ml	17	<2.0	67	<10	2.0

[a] Particulates



LEGEND

② SURFACE WATER STATIONS:

1 CHAMITA
2 EMBUDO
3 OTOWI
4 COCHITI

⑥ SURFACE WATER, SEDIMENT & SOIL STATIONS:

1 ABIQUIU RESERVOIR
2 CALIENTE RIVER
3 SANTA CRUZ RESERVOIR
4 SANTA FE
5 GALISTEO RESERVOIR
6 BERNALILLO
7 JEMEZ RESERVOIR
8 JEMEZ CREEK
9 FENTON LAKE

Fig. 11.
Locations of regional surface water, sediment, and soil sampling stations.

TABLE XII

ANALYSES OF REGIONAL SURFACE WATER SAMPLES

Determination	Units	No. of Samples	Range Min	Range Max	Av	MDL
Gross alpha	10^{-9} μCi/ml	16	<1.0	6.0	<1.6	1.0
Gross beta	10^{-9} μCi/ml	16	<1.0	6.0	<3.1	1.0
Plutonium-238	10^{-11} μCi/ml	16	<5.0	<5.0	<5.0	5.0
Plutonium-239	10^{-11} μCi/ml	16	<5.0	6.0	<5.1	5.0
Cesium-137	10^{-7} μCi/ml	16	<3.5	<3.5	<3.5	3.5
Tritium	10^{-6} μCi/ml	16	<1.0	<1.0	<1.0	1.0
Total uranium	10^{-4} μg/ml	16	<4.0	95	<25	4.0
Chloride	μg/ml	15	2	26	14	1.0
Fluoride	μg/ml	15	<0.1	0.6	<0.2	0.1
Nitrate	μg/ml	15	<0.1	0.2	<0.1	0.1
Dissolved solids	μg/ml	15	82	1400	370	—
Conductivity	μmho/cm	15	110	1400	410	—
Cadmium	10^{-4} μg/ml	16	35	80	50	2.5
Lead	10^{-3} μg/ml	16	<1.0	2.0	<1.1	1.0
Beryllium	10^{-4} μg/ml	16	<2.5	<2.5	<2.5	2.5
Mercury	10^{-5} μg/ml	16	<2.0	<2.0	<2.0	2.0
Cadmium[a]	10^{-4} μg/ml	16	<2.5	50	<9.4	2.5
Lead[a]	10^{-3} μg/ml	16	<1.0	11	<2.9	1.0
Beryllium[a]	10^{-4} μg/ml	16	<2.5	29	<6.1	2.5
Mercury[a]	10^{-5} μg/ml	16	<2.0	<2.0	<2.0	2.0

[a]Particulates.

and analyzed to help assess the overall impact of the Laboratory operations on the environment. Sampling locations are given in Fig. 12.

The range and average of constituents in sewage effluent from four off-site municipal sewage treatment ponds and lagoons are given in Table XIII. Trace amounts of ^{238}Pu were reported in one sample each from the White Rock Sewage Treatment Plant and the Bayo Sewage Treatment Plant, 6×10^{-11} and 8×10^{-11} μCi/ml, respectively.

Samples from all but two surveillance surface and ground water stations are collected on an annual basis. The requirement that the sampling schedule should provide an approximately uniform flow of samples through the laboratory necessitates that the collections be staggered. For this reason, only the two semiannually collected stations were collected during this period, Los Alamos Spring and Basalt Spring (Fig. 12). The results of the analyses of these samples are given in Table XIV. No results were abnormal for these stations.

A group of samples collected only on a biennial basis is included in this report. This group consists of water samples collected from 24 spring and 3 stream stations in the White Rock Canyon of the Rio Grande (Fig. 12). These springs and streams are perennial with most of the water discharging from the main aquifer from which the municipal water supply is drawn. Most of these stations are inaccessible from the rim of the canyon, and the only practical way of collecting the samples is by making a trip along the river by raft. The Otowi bridge (where Highway 4 crosses the Rio Grande) is a convenient embarkation point and Cochiti, about 40 km downstream, is the termination point. The trip normally takes three men three days to complete.

The range and average of constituents in water from off-site stations at 17 springs and 2 streams in the White Rock Canyon are shown in Table XV. Spring 3B, a highly mineralized spring issuing from a fault line on the east bank of the river, is responsible for several of the reported maximum values. Its natural uranium and cadmium

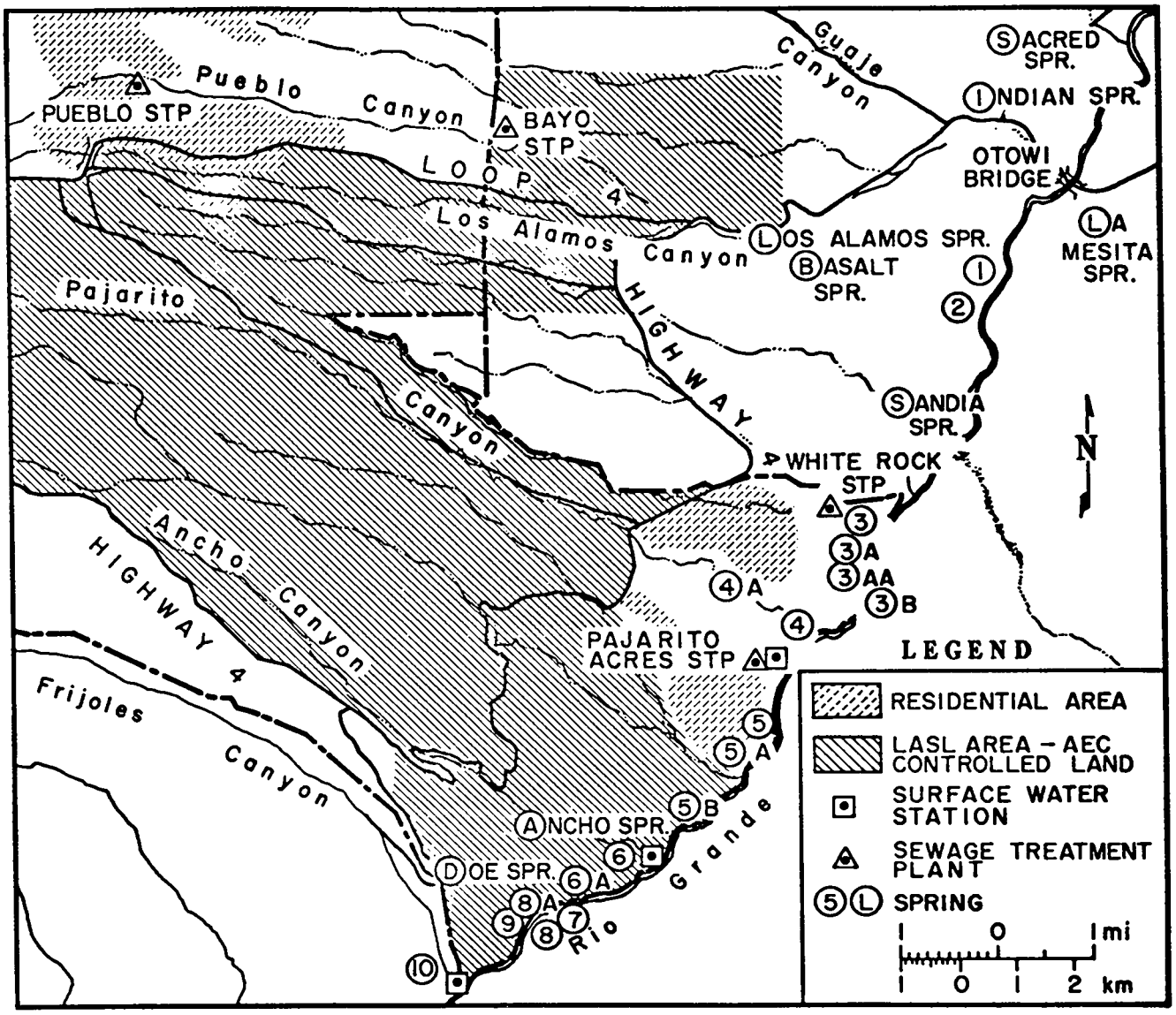


Fig. 12.
Locations of surveillance water sampling stations.

concentrations are much higher than in water from the other stations as are conductivity and dissolved solids. Spring 1 is a seep area more than an acre in extent and the sample was collected near its discharge into the river. Traces of ^{238}Pu and ^{239}Pu were found for the first time in water from this source.

The range and average of constituents in water from on-site stations at seven springs and one stream in the White Rock Canyon (Fig. 12) are shown in Table XVI. Nothing unusual was found in any of these samples.

The chemical and radiochemical quality of water from the White Rock Canyon water samples has not changed from previous analyses except as noted for Spring 1. Metal ion analyses were conducted for the first time, thus establishing background levels of naturally occurring concentrations of these materials.

VI. Sediment Monitoring Program

Sediments are those earthen materials that have been transported and reworked by surface water. Samples were collected at the 40- to 50-km distant stations from which regional surface water samples were obtained (Fig. 11). In addition, samples were taken for surveillance from canyon stream beds in the vicinity of the

TABLE XIII

ANALYSES OF SEWAGE TREATMENT PLANT EFFLUENT WATER

Determination	Unit	No. of Samples	Range Min	Range Max	Av	MDL
Gross alpha	10^{-9} μCi/ml	8	<1.0	2	<1.0	1.0
Gross beta	10^{-9} μCi/ml	8	2	37	12	1.0
Plutonium-238	10^{-11} μCi/ml	8	<5.0	8.0	<5.5	5.0
Plutonium-239	10^{-11} μCi/ml	8	<5.0	<5.0	<5.0	5.0
Cesium-137	10^{-7} μCi/ml	4	<3.5	<3.5	<3.5	3.5
Tritium	10^{-6} μCi/ml	8	<1.0	13	<2.5	1.0
Total uranium	10^{-4} μg/ml	8	<4	18	<11	4.0
Chloride	μg/ml	4	30	42	36	1.0
Fluoride	μg/ml	4	0.3	0.7	0.5	0.1
Nitrate	μg/ml	4	0.2	18	2	0.1
Dissolved Solids	μg/ml	4	330	550	430	—
Conductivity	μmho/cm	4	460	660	570	—

TABLE XIV

ANALYSES OF OFF-SITE GROUND WATER

Determination	Unit	Los Alamos Spring	Basalt Spring	MDL
Gross alpha	10^{-9} μCi/ml	<1.0	<1.0	1.0
Gross beta	10^{-9} μCi/ml	<1.0	<1.0	1.0
Plutonium-238	10^{-11} μCi/ml	<5.0	<5.0	5.0
Plutonium-239	10^{-11} μCi/ml	<5.0	<5.0	5.0
Cesium-137	10^{-7} μCi/ml	<3.5	<3.5	3.5
Tritium	10^{-6} μCi/ml	<1.0	<1.0	1.0
Total uranium	10^{-4} μg/ml	6.0	18	4.0
Chloride	μg/ml	20	12	1.0
Fluoride	μg/ml	0.9	0.9	0.1
Nitrate	μg/ml	2.5	2.6	0.1
Dissolved solids	μg/ml	250	230	—
Conductivity	μmho/cm	290	230	—
Cadmium	10^{-4} μg/ml	3.5	3.3	2.5
Lead	10^{-3} μg/ml	<1.0	<1.0	1.0
Beryllium	10^{-4} μg/ml	<2.5	<2.5	2.5
Mercury	10^{-5} μg/ml	<2.0	<2.0	2.0
Cadmium[a]	10^{-4} μg/ml	<2.5	<2.5	2.5
Lead[a]	10^{-3} μg/ml	<1.0	<1.0	1.0
Beryllium[a]	10^{-4} μg/ml	<2.5	<2.5	2.5
Mercury[a]	10^{-5} μg/ml	<2.0	<2.0	2.0

[a]Particulates.

TABLE XV

ANALYSES OF OFF-SITE SURFACE AND GROUND WATER FROM THE WHITE ROCK CANYON

Determination	Unit	No. of Samples	Range Min	Range Max	Av	MDL
Gross alpha	10^{-9} μCi/ml	19	<1.0	6.0	<1.5	1.0
Gross beta	10^{-9} μCi/ml	19	<1.0	2.5	<1.1	1.0
Plutonium-238	10^{-11} μCi/ml	19	<5.0	7.0	<5.1	5.0
Plutonium-239	10^{-11} μCi/ml	19	<5.0	5.0	<5.0	5.0
Cesium-137	10^{-7} μCi/ml	19	<3.5	<3.5	<3.5	3.5
Tritium	10^{-6} μCi/ml	19	<1.0	<1.0	<1.0	1.0
Total uranium	10^{-4} μg/ml	19	<4.0	130	<18	4.0
Chloride	μg/ml	19	<1.0	11	<4.4	1.0
Fluoride	μg/ml	19	<0.1	1.4	<0.5	0.1
Nitrate	μg/ml	19	<0.1	2.4	<0.4	0.1
Dissolved solids	μg/ml	19	150	530	240	—
Conductivity	μmho/cm	19	110	680	230	—
Cadmium	10^{-4} μg/ml	18	12	240	39	2.5
Lead	10^{-3} μg/ml	18	<1.0	<1.0	<1.0	1.0
Beryllium	10^{-4} μg/ml	18	<2.5	<2.5	<2.5	2.5
Mercury	10^{-5} μg/ml	18	<2.0	<2.0	<2.0	2.0
Cadmium[a]	10^{-4} μg/ml	18	<2.5	72	<7.2	2.5
Lead[a]	10^{-3} μg/ml	18	<1.0	4.4	<2.4	1.0
Beryllium[a]	10^{-4} μg/ml	18	<2.5	<2.5	<2.5	2.5
Mercury[a]	10^{-5} μg/ml	18	<2.0	11	<2.0	2.0

[a]Particulates

Laboratory at the stations shown in Fig. 13. Some of these sources are natural streams, flowing either perennially or intermittently during the rainy season, and some are streams produced by effluents from laboratory or municipal facilities. Sediment samples from perennial streams are taken from dunes built up in eddies behind boulders in the main channel. From the intermittent streams, the samples are collected across the main channel to a 1-in. depth with a 3-in. scoop. In still water the samples are dredged from the bottom with a bailer at some convenient point. The samples are placed in unused polyethylene containers for storage and are transported to the laboratory. Samples are leached with acids, and determinations of gross alpha and beta activities, plutonium, cesium, and uranium are made on the acid leach. Strontium analyses are performed if desirable.

A. Regional Sediments. Sediments were collected and analyzed from the regional surface water sampling stations shown in Fig. 11 to provide general data on the quantities of radioactive material in the environment beyond the general Laboratory area. The results of the analyses are given in Table XVII.

B. Surveillance Sediment Sampling. Locations of these sediment sampling stations are shown in Fig. 13. The results of the anlyses for on-site and off-site samples are given in Table XVIII. In general, the results from this sampling program appear to be about as expected.[8] Concentrations of plutonium lie in the range expected from fallout. One on-site sample exhibited an unusually high uranium concentration, even considering the fact that it was collected in an area where explosive tests could be expected to disperse uranium.

TABLE XVI

ANALYSES OF ON-SITE SURFACE AND GROUND WATER FROM THE WHITE ROCK CANYON

Determination	Unit	No. of Samples	Range Min	Range Max	Av	MDL
Gross alpha	10^{-9} μCi/ml	8	<1.0	<1.0	<1.0	1.0
Gross beta	10^{-9} μCi/ml	8	<1.0	<1.0	<1.0	1.0
Plutonium-238	10^{-11} μCi/ml	8	<5.0	<5.0	<5.0	5.0
Plutonium-239	10^{-11} μCi/ml	8	<5.0	<5.0	<5.0	5.0
Cesium-137	10^{-7} μCi/ml	8	<3.5	<3.5	<3.5	3.5
Tritium	10^{-6} μCi/ml	8	<1.0	<1.0	<1.0	1.0
Total uranium	10^{-4} μg/ml	8	<4.0	6.0	<4.4	4.0
Chloride	μg/ml	8	<1.0	6.0	<3.3	1.0
Fluoride	μg/ml	8	<0.1	0.7	<0.4	0.1
Nitrate	μg/ml	8	0.1	0.4	0.2	0.1
Dissolved solids	μg/ml	8	160	230	200	—
Conductivity	μmho/cm	8	120	160	140	—
Cadmium	10^{-4} μg/ml	6	15	24	18	2.5
Lead	10^{-3} μg/ml	6	<1.0	3.8	<1.7	1.0
Beryllium	10^{-4} μg/ml	6	<2.5	<2.5	<2.5	2.5
Mercury	10^{-5} μg/ml	6	<2.0	<2.0	<2.0	2.0
Cadmium[a]	10^{-4} μg/ml	6	<2.5	7.5	<3.3	2.5
Lead[a]	10^{-3} μg/ml	6	<1.0	2.6	<1.3	1.0
Beryllium[a]	10^{-4} μg/ml	6	<2.5	<2.5	<2.5	2.5
Mercury[a]	10^{-5} μg/ml	6	<2.0	<2.0	<2.0	2.0

[a]Particulates.

VII. Soil Monitoring Program

Soils are those earthen materials that are weathered in place. They are sampled primarily to indicate the possibility of deposition of contaminants from the atmosphere. Samples are collected by taking five plugs, 3 in. in diameter and 2 in. deep, at the corners and center of a square 10 m on a side. The five plugs are composited into a single sample and analyzed for gross alpha and beta activities, plutonium, cesium, tritium, and uranium using basically the same techniques as for sediment samples. Samples were taken at the regional surface water stations (Fig. 11) and at stations established for general surveillance in the vicinity of Los Alamos (Fig. 13).

A. Regional Soils. A summary of the results from the samples taken at distances of 40- to 50-km from the center of the Laboratory area is given in Table XIX. The values are in line with those expected from natural radioactivity and fallout from past weapons tests.[9]

B. Surveillance Soil Sampling. A summary of the results from the samples taken in the vicinity of Los Alamos County (Fig. 13) is given in Table XX. The values found are again in general agreement with those expected from natural activity and fallout from past weapons tests.

VIII. Special Studies

In addition to the routine monitoring programs designed to provide information on background radiation levels in northern New Mexico and to provide continuing surveillance of the Los Alamos vicinity, special programs are undertaken to provide more intensive coverage of areas of particular interest or to study in detail individual possible sources of contamination. These programs may be single investigations or continuing studies designed to provide increased information on the ultimate fate of materials discharged to the environs.

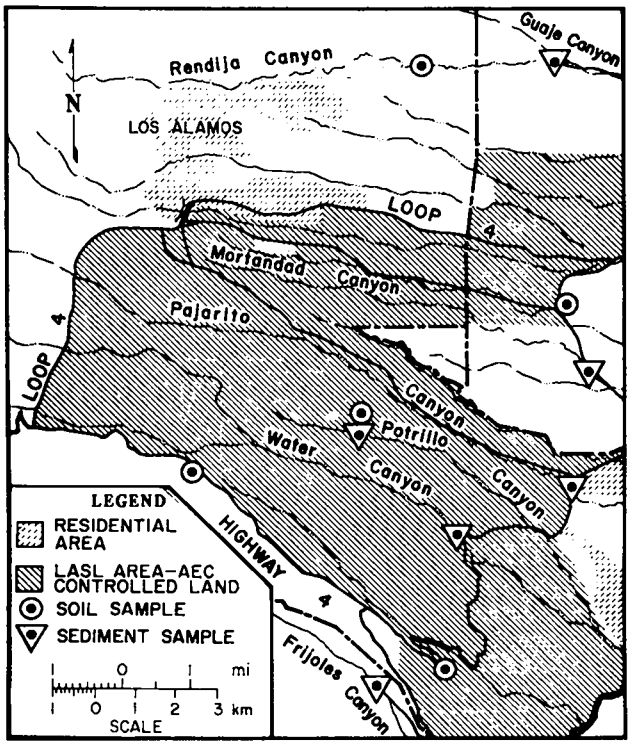


Fig. 13.
Locations of surveillance sediment and soil sampling stations.

A. Monitoring in Effluent Discharge Areas. Monitoring surface water, ground water in alluvium, sediment, and soil is conducted at three on-site and one off-site (previously on-site) locations in areas where effluent is or has been released to the environment. The on-site locations are TA-21 and DP-Los Alamos Canyons, TA-3 and Sandia Canyon, and TA-50 and Mortandad Canyon; the off-site location is TA-45 (dismantled) and Acid-Pueblo Canyons. The stations at which samples were collected are shown in Fig. 14.

1. TA-45 (Dismantled) and Acid-Pueblo Canyons. Acid and Pueblo Canyons received treated industrial effluents from the Industrial Liquid Waste Treatment Plant at TA-45 from 1951 until 1964 when the operations were transferred to the new plant at TA-50. Sediments and the quality of surface water and shallow ground water in alluvium are monitored in a continuing study to determine the environmental distributions of contaminants resulting from the past release of these effluents. The results of analyses on these water samples are shown in Table XXI. The traces of plutonium found in the water were probably released from the sediments that captured the plutonium when TA-45 was active. Analyses of sediments taken in the stream channel are shown in Table XXII. The concentrations in the sediments are about the same as reported earlier.[9]

2. TA-21 and DP-Los Alamos Canyons. DP Canyon receives the effluent from the industrial liquid waste treatment plant serving the TA-21 complex, which includes the main facilities for processing plutonium metal and developing ^{238}Pu heat sources. This canyon joins Los Alamos Canyon about 1.5 km below the outfall from the waste treatment plant. The discharge from this plant, the effluents from a sewage treatment plant, and the effluents from cooling towers provide a volume of water sufficient to maintain flow in the DP Canyon channel a relatively large percentage of the time. This liquid soaks into the alluvium upstream of the confluence with Los Alamos Canyon, however, and the stream in that canyon flows only during periods of heavy runoff from precipitation. Samples were taken from the stream in DP Canyon and from shallow observation holes in the alluvium in Los Alamos Canyon at various distances below

TABLE XVII

ANALYSES OF REGIONAL SEDIMENT SAMPLES

Determination	Unit	No. of Samples	Range Min	Range Max	Av	MDL
Gross alpha	10^{-6} μCi/g	8	2.0	5.0	3.0	1.0
Gross beta	10^{-6} μCi/g	8	1.0	3.0	2.0	1.0
Plutonium-238	10^{-9} μCi/g	8	1.0	3.0	2.0	1.0
Plutonium-239	10^{-9} μCi/g	8	2.0	4.0	3.0	1.0
Cesium-137	10^{-7} μCi/g	8	2.0	2.0	2.0	2.0
Total uranium	10^{-2} μg/g	8	7.0	31	19	1.0

TABLE XVIII

ANALYSES OF SURVEILLANCE SEDIMENT SAMPLES

Determination	Unit	No. of Samples	Range Min	Range Max	Av	MDL
Off-Site Stations:						
Gross alpha	10^{-6} μCi/g	4	2.0	5.0	3.0	1.0
Gross beta	10^{-6} μCi/g	4	1.0	18.0	6.0	1.0
Plutonium-238	10^{-9} μCi/g	4	<1.0	1.0	<1.0	1.0
Plutonium-239	10^{-9} μCi/g	4	1.0	4.0	4.0	1.0
Cesium-137	10^{-7} μCi/g	4	<2.0	<2.0	<2.0	2.0
Total uranium	10^{-2} μg/g	4	2.0	8.0	5.0	1.0
On-Site Stations:						
Gross alpha	10^{-6} μCi/g	2	5.0	11	8.0	1.0
Gross beta	10^{-6} μCi/g	2	4.0	8.0	6.0	1.0
Plutonium-238	10^{-9} μCi/g	2	<1.0	5.0	<3.0	1.0
Plutonium-239	10^{-9} μCi/g	2	1.0	7.0	4.0	1.0
Cesium-137	10^{-7} μCi/g	2	<2.0	<2.0	<2.0	2.0
Total uranium	10^{-2} μg/g	2	15	279	147	1.0

TABLE XIX

ANALYSES OF REGIONAL SOIL SAMPLES

Determination	Unit	No. of Samples	Range Min	Range Max	Av	MDL
Gross alpha	10^{-6} μCi/g	9	2.0	10	5.0	1.0
Gross beta	10^{-6} μCi/g	9	4.0	10	6.0	1.0
Plutonium-238	10^{-9} μCi/g	9	1.0	5.0	3.0	1.0
Plutonium-239	10^{-9} μCi/g	9	3.0	20	10	1.0
Cesium-137	10^{-7} μCi/g	9	<2.0	3.0	<2.0	2.0
Tritium[a]	10^{-6} μCi/ml	9	<2.0	9.0	<4.0	2.0
Total uranium	10^{-2} μg/g	9	4.0	50	23	1.0

[a]Soil moisture distilled from sample.

the treatment plant outfall. The analyses of these samples are given in Table XXIII.

The values given in the table are averages when more than one sample was taken at a given station, even though there were variations in some of the measurements. The decrease in quantities of both radioactive and nonradioactive constituents is apparent as one progresses downstream.

One sample of soil taken at soil station 1 (near TA-21) and two sediment samples taken downgradient in the stream channel from the plant are shown in Table XXIV. Plutonium-238 and tritium in the soil measured slightly above what is expected from worldwide fallout and were probably the results of airborne material from the plant. The sample collected at sediment station 3 exhibited an above-normal concentration of gross

TABLE XX

ANALYSES OF SURVEILLANCE SOIL SAMPLES

Determination	Unit	No. of Samples	Range Min	Range Max	Av	MDL
Off-Site Stations:						
Gross alpha	10^{-6} μCi/g	3	6.0	8.0	7.0	1.0
Gross beta	10^{-6} μCi/g	3	5.0	6.0	6.0	1.0
Plutonium-238	10^{-9} μCi/g	3	2.0	5.0	4.0	1.0
Plutonium-239	10^{-9} μCi/g	3	7.0	36	19	1.0
Cesium-137	10^{-7} μCi/g	3	<2.0	<2.0	<2.0	2.0
Tritium[a]	10^{-6} μCi/ml	3	13	14	3	2.0
Total uranium	10^{-2} μg/g	3	22	33	26	1.0
On-Site Stations:						
Gross alpha	10^{-6} μCi/g	2	6.0	6.0	6.0	1.0
Gross beta	10^{-6} μCi/g	2	6.0	7.0	6.0	1.0
Plutonium-238	10^{-9} μCi/g	2	1.0	10	5.0	1.0
Plutonium-239	10^{-9} μCi/g	2	20	25	22	1.0
Cesium-137	10^{-7} μCi/g	2	<2.0	<2.0	<2.0	2.0
Tritium[a]	10^{-6} μCi/ml	2	14	15	14	2.0
Total uranium	10^{-2} μg/g	2	20	50	35	1.0

[a]Soil moisture distilled from soil sample.

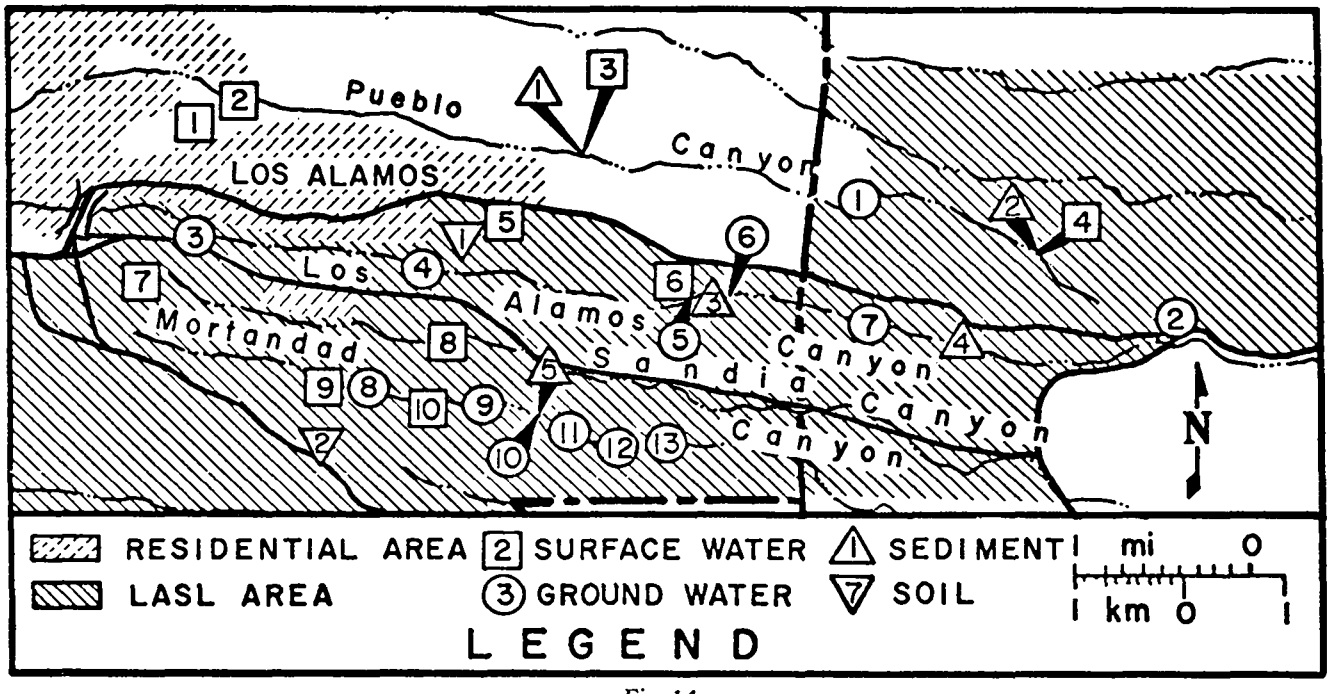


Fig. 14.
Locations of sampling stations for monitoring in effluent discharge areas.

TABLE XXI

ANALYSES OF WATER SAMPLES FROM ACID AND PUEBLO CANYONS

Determination	Unit	Surface water Station 1	2	3	4	Ground Water Station 1	2
Number of samples		1	1	1	1	1	1
Gross alpha	10^{-9} μCi/ml	6	<1	<1	<1	<1	<1
Gross beta	10^{-9} μCi/ml	52	7	9	6	6	<1
Plutonium-238	10^{-11} μCi/ml	18	7	7	6	5	<5
Plutonium-239	10^{-11} μCi/ml	800	8	100	<5	<5	<5
Americum-241	10^{-11} μCi/ml	—	—	—	—	—	—
Cesium-137	10^{-7} μCi/ml	<4	<4	<4	<4	<4	<4
Strontium-90	10^{-8} μCi/ml	—	—	—	—	—	—
Radium-226	10^{-11} μCi/ml	—	—	—	—	—	—
Uranium-234	10^{-9} μCi/ml	—	—	—	—	—	—
Tritium	10^{-6} μCi/ml	1	<1	<1	<1	<1	<1
Total uranium	10^{-4} μg/ml	21	<4	<4	<4	<4	<4
Chloride	μg/ml	52	28	28	26	34	30
Fluoride	μg/ml	<1	6	5	5	<1	2
Nitrate	μg/ml	1	13	6	15	3	13
Chromate	10^{-2} μg/ml	—	—	—	—	—	<1
Dissolved solids	μg/ml	280	480	330	420	260	370
Conductivity	μmho/cm	220	400	360	380	240	240
Cadium	10^{-4} μg/ml	56	72	74	61	190	55
Lead	10^{-3} μg/ml	3	<1	3	3	<1	1
Beryllium	10^{-4} μg/ml	<3	<3	<3	<3	<3	<3
Mercury	10^{-5} μg/ml	<2	8	<2	27	47	<2
Cadium[a]	10^{-4} μg/ml	<3	140	<3	10	102	3
Lead[a]	10^{-3} μg/ml	2	2	<1	16	25	55
Beryllium[a]	10^{-4} μg/	<3	<3	<3	<3	<3	<3
Mercury[a]	10^{-5} μg/ml	20	<2	<2	<2	<4	<2

[a]Particulates.

alpha activity, gross beta activity, ^{238}Pu, ^{239}Pu, and ^{137}Cs; however, the sample taken at station 4 about 2.5 km farther downstream did not show high radionuclide levels, indicating that concentrations decrease with downstream distance. Only trace amounts of radionuclides are contained in the industrial effluents released into the canyon, but these trace amounts have been retained by the sediments for years, giving higher concentrations.

3. TA-3 and Sandia Canyon. Sandia Canyon receives the effluent from the cooling towers at the power plant and from a sewage treatment plant in TA-3, both operated by the Zia Company. A summary of the results of the analyses performed on samples taken from the stream produced by these effluents is given in Table XXV. Averages for the two samples collected at each location are given. the hexavalent chromium in this stream is due to its use in the cooling tower water as a corrosion inhibitor. A new processing plant is being planned that will reduce chromium to the trivalent state. The presence of the plutonium isotopes could be due to the sewage treatment plant that receives wastes from the CMR Building.

TABLE XXII

ANALYSES OF SEDIMENTS FROM PUEBLO CANYON

Determination	Unit	Sediment Station 1	Sediment Station 2
Number of samples		1	1
Gross alpha	10^{-6} μCi/g	10	4
Gross beta	10^{-6} μCi/g	2	2
Plutonium-238	10^{-9} μCi/g	7	1
Plutonium-239	10^{-9} μCi/g	2200	390
Cesium-137	10^{-7} μCi/g	<2	<2
Total uranium	10^{-2} μg/g	22	2

4. TA-50 and Mortandad Canyon. Mortandad Canyon receives the effluent from the central industrial waste treatment plant at TA-50 where the industrial liquid wastes from the majority of the Laboratory technical areas are processed. The effluent produces a flowing stream for only a relatively short distance below the outfall. The surface water in this stream was sampled at several locations, and the ground water in alluvium at greater distances was sampled by using established shallow observatios holes. The results are given in Table XXVI.

The rapid decrease in concentration as one progresses down canyon is apparent for most of the constituents. An exception is the increase in tritium attributed to the down-canyon progress of a slug of this material released from the TA-50 treatment plant several years ago.

One soil sample from near TA-50 and one sediment sample from Mortandad Canyon are summarized in Table XXVII. The constituents in the soil sample were about what may be expected from worldwide fallout. The gross beta activity, ^{238}Pu, ^{239}Pu, and ^{137}Cs found in the sediment sample were the result of adsorption or attachment of these radionuclides to material in the sediments.

B. Fauna in Liquid Effluent Discharge Areas. During the summer of 1971, the quantities of certain radioactive and nonradioactive materials were studied in the fauna from the immediate vicinities of liquid effluent discharges. The work was conducted by the New Mexico Health and Social Services Department (under contract to the U.S. Army) and three Health Division groups, H-4 (Biomedical Research), H-5, and H-8. Trap lines were established near the outfalls at TA-50 and TA-21 and, to collect control samples, in Guaje Canyon far from the active technical areas. Due to a severe laboratory backlog, the analyses of these samples are not yet complete. It is intended, however, that the following analyses will be performed on animal tissue: kidneys for mercury; liver and soft tissue for tritium, lead, cadmium, and plutonium; and bone for plutonium and strontium.

IX. Discussion

The results of the monitoring program for this report period confirm the generally low radiation levels in the Los Alamos environs as noted in previous periods. Measurements of the gross activities in air and precipitation indicate concentrations similar to those measured at other locations in the northern hemisphere where activity is entirely attributable to the presence of worldwide fallout. Isotopic measurements of iodine, plutonium, and tritium in the atmosphere show that the iodine concentrations are below the detection limit; that there are places where the plutonium concentrations may be above that expected from past weapons testing; and that some of the off-site concentrations of tritium appear to be about twice that encountered at locations distant from the Laboratory.

In the following discussion we will use the concept of "dose commitment," the total radiation dose received by an individual during his remaining lifetime due to operations during this report period. For radionuclides with long effective half-lives (physical and biological) the length of the remaining lifetime must be considered. This length has arbitrarily been set at 50 yr for the purposes of this report. For an element with an effective half-life considerably less than 50 yr, by far the greatest part of the dose is contributed during the first few years so that the length of the remaining lifetime is unimportant

TABLE XXIII

ANALYSES OF WATER SAMPLES FROM DP AND LOS ALAMOS CANYON

Determination	Unit	Surface Water Station		Ground Water Station				
		5	6	3	4	5	6	7
Number of samples		2	2	2	2	2	2	2
Gross alpha	10^{-9} μCi/ml	13	2	<1	1	1	2	2
Gross beta	10^{-9} μCi/ml	860	150	2	74	100	47	3
Plutonium-238	10^{-11} μCi/ml	140	14	<5	5	10	5	7
Plutonium-239	10^{-11} μCi/ml	190	22	<5	47	38	10	15
Americium-241	10^{-11} μCi/ml	46	7	—	—	—	—	—
Cesium-137	10^{-7} μCi/ml	8	<4	<4	<4	<4	4	<4
Strontium-90	10^{-8} μCi/ml	92	31	—	—	—	—	—
Radium-226	10^{-11} μCi/ml	<15	—	—	—	—	—	—
Uranium-234	10^{-9} μCi/ml	18	1	—	—	—	—	—
Tritium	10^{-6} μCi/ml	550	100	<1	21	100	46	—
Total uranium	10^{-4} μg/ml	23[a]	6[a]	<4	<4	9	16	<4
Chloride	μg/ml	45	35	45	28	32	35	25
Fluoride	μg/ml	4	4	<1	<1	6	5	<1
Nitrate	μg/ml	9	5	<1	1	4	3	1
Chromate	10^{-2} μg/ml	3	2	<1	55	6	4	2
Dissolved solids	μg/ml	630	490	250	420	430	420	270
Conductivity	μho/cm	800	580	290	460	490	490	300
Cadmium	10^{-4} μg/ml	120	72	40	70	65	52	53
Lead	10^{-3} μg/ml	<1	<1	9	1	7	1	<1
Beryllium	10^{-4} μg/ml	<3	<3	<3	<3	<3	<3	<3
Mercury	10^{-5} μg/ml	9	<2	<2	<2	<2	6	<2
Cadmium[b]	10^{-4} μg/ml	4	<3	41	<3	69	10	11[a]
Lead[b]	10^{-3} μg/ml	2	3	32	6	9	9	14[a]
Beryllium[b]	10^{-4} μg/ml	<3	<3	32	<3	11	12	<3
Mercury[b]	10^{-5} μg/ml	6	<2	16	5	7	5	<2

[a]One sample analyzed.

[b]Particulates.

provided it is longer than several half-lives. Furthermore, for an element with an effective half-life very short compared to 50 yr, the dose is received substantially instantaneously, and it is sufficient to use the more familiar concept of dose rather than dose commitment.

During this reporting period the highest average off-site tritium concentration in the Los Alamos area was sufficient to produce a whole-body dose of about 0.12 mrem, using the Quality Factor of 1.7 used in the derivation of the 1960 ICRP-NCRP maximum permissible concentrations that apparently served as the bases for the AEC Manual Chapter 0514 concentration guides. If the Quality Factor of 1.0 now accepted by the ICRP and NCRP is used for these low-energy beta radiations, this dose is about 0.07 mrem. This may be compared with the radiation protection guide for annual dose to the whole body given in AEC Manual Chapter 0524 of 500 mrem for an individual or 170 mrem for the most restrictive segment of the population.

Using the constants listed in the 1959 ICRP internal dose report,[10] the highest average off-site ^{238}Pu concentration was sufficient to produce, for 6 months, a dose

TABLE XXIV

ANALYSES OF SOIL AND SEDIMENT SAMPLES FROM NEAR TA-21 AND IN LOS ALAMOS CANYON

Determination	Unit	Soil Station	Sediment Station	
		1	3	4
Number of samples		1	1	1
Gross alpha	10^{-6} μCi/g	8	18	<1
Gross beta	10^{-6} μCi/g	7	73	<1
Plutonium-238	10^{-9} μCi/g	26	2500	3
Plutonium-239	10^{-9} μCi/g	14	1400	53
Cesium-137	10^{-7} μCi/g	3	100	3
Tritium[a]	10^{-6} μCi/ml	270	—	—
Total uranium	10^{-2} μg/g	39	16	2

[a]Soil moisture distilled from soil sample.

commitment for the lungs of about 0.02 mrem, assuming all of the material to be insoluble. Alternatively, assuming all of the material to be soluble (20% transferred to bone, a Quality Factor of 10 and a "nonuniform distribution factor" of 5), the 50-yr dose commitment to bone was about 0.6 mrem. The actual dose commitment would lie somewhere between these two. In comparison, the guide value from AEC Manual Chapter 0524 for the annual dose commitment for bone or lungs is 1500 mrem for an individual or 500 mrem for the most restrictive segment of the population. The ^{239}Pu results show no significant difference between stations, which indicates that the source is probably worldwide fallout. The highest average off-site concentration contributed, over the 6 months, an estimated dose commitment of about 0.03 mrem to the lungs or 1.0 mrem to bone.

External gamma and X-radiation levels, as measured by thermoluminescent dosimeters, were comparable to those measured elsewhere at approximately the same elevation. This suggests that the predominent contribution to external dose is from solar radiation.

The Los Alamos water supply remained uninfluenced by Laboratory operations. Traces of plutonium have been tenuously identified in off-site samples collected from bodies of surface water, sewage effluent, and, in one instance, ground water. These identifications are believed to be due to cross-contamination in the laboratory, a very real problem when dealing with such low levels.

Small quantities of plutonium and some beta emitters were found in sediment collected at two locations in an off-site canyon, a result of past disposal operations. These locations, although accessible to the public, are reasonably isolated so that occupancy is limited to an occasional hiker or hunter. It is impossible to estimate a possible dose or dose commitment from these deposits, but the low occupancy factor and the association of the material with large quantities of sediment sould preclude the uptake of any significant quantities by people, animals, or plants. The effects of this type of contamination are being investigated.

A study of fauna in two Laboratory liquid effluent discharge areas was conducted, but analysis and interpretation are not yet complete. Plans are in progress to amplify this part of the work to permit assessment of the possible uptake and dispersal into the environment of Laboratory-generated contaminants such as plutonium and tritium, using these on-site discharge areas as study sites.

Because of the low emissions of most radioactive materials that could enter the food chains and the lack of significant use of the surrounding area for food production, little attention has been paid to sampling the food supply at Los Alamos. This is not believed to be a serious lack in documenting the exposures in the environs, but future studies will permit assessment of this possible contribution.

TABLE XXV

ANALYSES OF WATER SAMPLES FROM SANDIA CANYON

Determination	Unit	Surface Water Station 7	Surface Water Station 8
Number of samples		2	<2
Gross alpha	10^{-9} μCi/Ml[a]	2	<1
Gross beta	10^{-9} μCi/ml	13	8
Plutonium-238	10^{-11} μCi/ml	8	<5
Plutonium-239	10^{-11} μCi/ml	6	<5
Americium-241	10^{-11} μCi/ml	—	—
Cesium-137	10^{-7} μCi/ml	<4	<4
Strontium-90	10^{-8} μCi/ml	—	—
Radium-226	10^{-11} μCi/ml	—	—
Uranium-234	10^{-9} μCi/ml	—	—
Tritium	10^{-6} μCi/ml	3	6
Total uranium	10^{-4} μg/ml	16	<4
Chloride	μg/ml	49	79
Fluoride	μg/ml	2	2
Nitrate	μg/ml	5	5
Chromate	10^{-2} μg/ml	710	560
Dissolved solids	μg/ml	2400	760
Conductivity	μmho/cm	3800	750
Cadmium	10^{-4} μg/ml	120	24[a]
Lead	10^{-3} μg/ml	13	<3[a]
Beryllium	10^{-4} μg/ml	<3	<3[a]
Mercury	10^{-5} μg/ml	<2	<2[a]
Cadmium[b]	10^{-4} μg/ml	12	<3[a]
Lead[b]	10^{-3} μg/ml	11	<1[a]
Beryllium[b]	10^{-4} μg/ml	<3	<3[a]
Mercury[b]	10^{-5} μg/ml	17	43[a]

[a]One sample analyzed.

[b]Particulates.

TABLE XXVI

ANALYSES OF WATER SAMPLES FROM MORTANDAD CANYON

Determination	Unit	Surface Water Station		Ground Water Station					
		9	10	8	9	10	11	12	13
Number of samples		2	2	2	2	2	2	2	2
Gross alpha	10^{-9} μCi/ml	9	8	11	3	1	2	<1	<1
Gross beta	10^{-9} μCi/ml	1300	500	540	370	170	140	100	55
Plutonium-238	10^{-11} μCi/ml	680	210	320	32	6	<5	12	5
Plutonium-239	10^{-11} μCi/ml	100	26	44	9	<5	<5	<5	<5
Americum-241	10^{-11} μCi/ml	89	—	—	—	--	—	—	—
Cesium-137	10^{-7} μCi/ml	18	4	4	<4	<4	<4	<4	<4
Strontium-90	10^{-8} μCi/ml	16	17	31	18	18[a]	—	—	—
Radium-226	10^{-11} μCi/ml	<15[a]	<15[a]	<15[a]	—	—	—	—	—
Uranium-234	10^{-9} μCi/ml	6	—	—	—	—	—	—	—
Tritium	10^{-6} μCi/ml	38	50	65	49	64	52	84	120
Total uranium	10^{-4} μg/ml	—	73	61	36	13	18	<4	5
Chloride	μg/ml	42	140	120	130	67	66	34	27
Fluoride	μg/ml	2	2	2	<1	<1	<1	<1	<1
Nitrate	μg/ml	3	35	19	46	48	66	86	95
Chromate	10^{-2} μg/ml	3[a]	—	—	—	—	—	—	—
Dissolved solids	μg/ml	420	980	790	1000	740	890	940	920
Conductivity	μmho/cm	530	1200	1000	1200	900	1100	1000	1000
Cadmium	10^{-4} μg/ml	8[a]	12[a]	62	18[a]	39[a]	8[a]	66	5[a]
Lead	10^{-3} μg/ml	<1[a]	18[a]	24	29[a]	<1[a]	<1[a]	4	<1[a]
Beryllium	10^{-4} μg/ml	<3[a]	<3[a]	<3	<3[a]	<3[a]	<3[a]	<3	<3[a]
Mercury	10^{-5} μg/ml	<2[a]	<2[a]	<2	<2[a]	<2[a]	<2[a]	<2	<2[a]
Cadmium[b]	10^{-4} μg/ml	<3[a]	6[a]	8	4[a]	12[a]	18[a]	3	7[a]
Lead[b]	10^{-3} μg/ml	1[a]	<1[a]	20	30[a]	30[a]	25[a]	49	15[a]
Beryllium[b]	10^{-4} μg/ml	<3[a]	<3[a]	<3	<3[a]	<3[a]	22[a]	5	11[a]
Mercury[b]	10^{-5} μg/ml	21[a]	<2[a]	10	<2[a]	<2[a]	<2[a]	<2	<2[a]

[a]One sample analyzed.

[b]Particulates.

TABLE XXVII

ANALYSES OF SOIL AND SEDIMENT SAMPLES FROM NEAR TA-50 AND IN MORTANDAD CANYON

Determination	Unit	Soil Station 2	Sediment Station 5
Number of samples		1	1
Gross alpha	10^{-6} μCi/g	4	4
Gross beta	10^{-6} μCi/g	6	20
Plutonium-238	10^{-9} μCi/g	8	44
Plutonium-239	10^{-9} μCi/g	12	380
Cesium-137	10^{-7} μCi/g	<2	21
Tritium[a]	10^{-6} μg/g	21	—
Total uranium	10^{-2} μg/g	14	7

[a]Soil moisture distilled from soil sample.

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APPENDIX

METEOROLOGY

Selected meteorological statistics and a wind rose for this period are given in Table A-I and Fig. A-1, respectively. An up-to-date climatological summary and wind rose are presented in Table A-II and Fig. A-2.

The dryness of the first half of 1971 was offset by the wetness of the second half. All months except August produced higher-than-normal amounts of precipitation. Whereas precipitation for the January-June period amounted to only 40% of normal, that for the July-December period amounted to 137%, giving 1971 105% of the normal amount of precipitation. The earliest measurable snow fall (1.5 in.) and earliest frost on record occurred on September 18. In December, 35.8 in. of snow were recorded. This corresponded to 2.80 in. of precipitation, over three times normal.

The July-December period was also colder than normal. Daily high temperatures were below normal in all months, and daily low temperatures averaged below normal in all months except July. The average temperature of 46.9° for the year was 1.1° below the normal yearly average of 48.0°.

October and November were fairly windy; October had 4 and November had 3 days with gusts over 40 mph. Overall, however, the winds were calm 52.4% of the time for the period and 46.0% for the year, more than twice the 21.1% average.

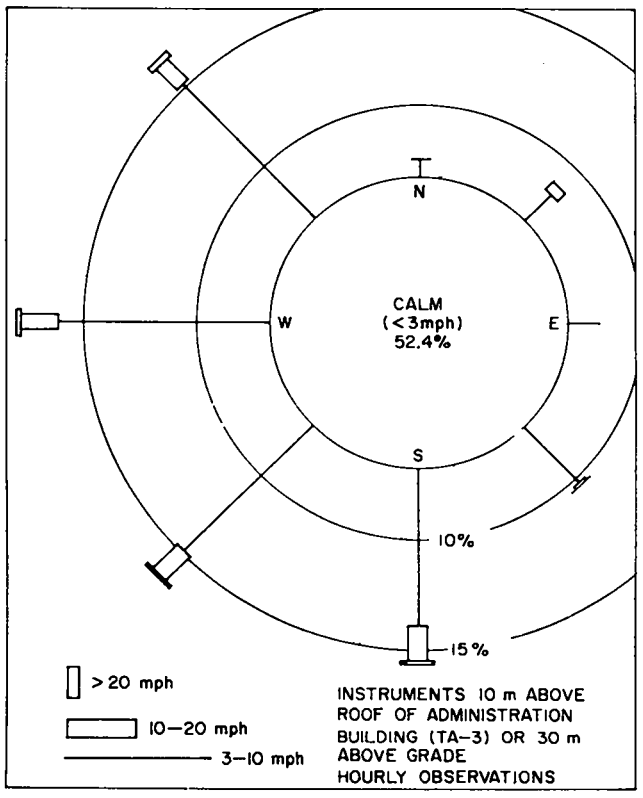

Fig. A-1.
Wind rose, July-December 1971.

TABLE A-I

SELECTED METEOROLOGICAL STATISTICS
JULY-DECEMBER 1971

	JUL	AUG	SEP	OCT	NOV	DEC
Maximum Temperature:						
This month this year	91	81	82	72	64	54
Record for this month	95	92	94	82	69	62
Average Daily High Temperature:						
This month this year	79.5	76.0	69.1	57.1	47.8	37.3
Normal[a] for this month	80.4	77.9	72.4	62.1	49.1	40.8
Minimum Temperature:						
This month this year	47	45	26	18	12	4
Record for this month	37	40	23	16	-4	-10
Average Daily Low Temperature:						
This month this year	55.6	52.3	45.2	35.1	26.4	17.1
Normal[a] for this month	55.2	54.0	48.1	37.8	26.6	19.8

TABLE A-I (cont)

	JUL	AUG	SEP	OCT	NOV	DEC
Precipitation:						
This month this year	4.83	2.89	2.48	3.02	0.79	2.80
Normal[a] for this month	3.29	3.78	1.94	1.59	0.70	0.92
Culmulative Precipitation:						
This month this year	7.31	10.20	12.68	15.70	16.49	19.29
Normal[a] for this month	9.46	13.24	15.18	16.77	17.47	18.39
Snow:						
This month this year	—	—	1.5	0.7	4.9	35.8
Normal[a] for this month	—	—	0.2	1.4	4.9	10.9
Cumulative Snow:						
This month this season	—	—	1.5	2.2	7.1	42.9
Normal[a] for this month	—	—	0.2	1.6	6.5	17.4

First fall frost September 19, Normal[a] October 12

Temperature - degrees Fahrenheit
Precipitation and snow - inches

[a]Normal denotes what is to be expected based on past experience, i.e., it is the average of all past values. These averages are kept up-to-date, therefore they include measurements from the current year, 1971.

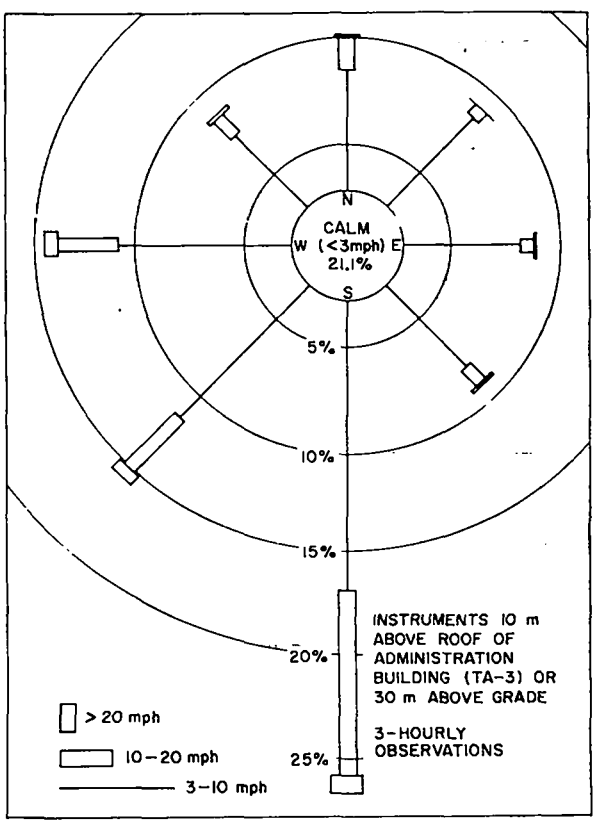

Fig. A-2.
Wind rose of record.

TABLE A-II

CLIMATOLOGICAL SUMMARY

Latitude 35° 32′ North
Longitude 106° 19′ West
Elevation 7410 feet

Los Alamos, New Mexico

Means and Extremes for Period of Record: 1910 - 1971

	Temperature (°F)							Precipitation Totals (Inches)										Mean Number of Days		
	Means			Extremes				Rain					Snow or Frozen Precipitation							
Month	Daily Maximum	Daily Minimum	Monthly	Highest	Year	Lowest	Year	Mean	Daily Maximum	Year	Monthly Maximum	Year	Mean	Daily Maximum	Year	Monthly Maximum	Year	Precipitation 0.10 inches or more	Maximum temperature 80° or above	Minimum temperature 15° or below
Jan	39.0	17.8	28.4	64	1963	-18	1963	0.84	2.45	1916	6.75	1916	9.7	15.0	1913	39.3	1949	2	0	8
Feb	42.8	21.5	32.1	66	1936	-14	1951	0.70	1.05	1915	2.44	1948	8.3	13.0	1915	23.8	1948	2	0	6
Mar	48.9	25.8	37.4	71	1971	-3	1948	0.96	2.25	1916	3.27	1919	10.1	18.0	1916	35.5	1958	3	0	3
Apr	58.4	33.8	46.1	80	1950	5	1925	1.01	1.45	1969	4.64	1916	4.2	12.0	1958	33.6	1958	3	0	0
May	67.8	42.8	55.3	89	1935	24	1938	1.29	1.80	1929	4.47	1929	0.8	9	1917	17.0	1917	3	1	0
Jun	77.6	51.6	64.6	93	1954	28	1919	1.37	2.51	1913	5.57	1913	0	0		0		3	14	0
Jul	80.4	55.2	67.8	95	1935	37	1924	3.29	2.78	1968	7.98	1919	0	0		0		8	19	0
Aug	77.9	54.1	66.0	92	1937	40	1947	3.78	2.26	1951	11.18	1952	0	0		0		8	12	0
Sep	72.4	48.0	60.2	94	1934	23	1936	1.94	2.21	1929	5.79	1941	0.2	6.0	1913	6.0	1914	5	5	0
Oct	62.1	37.8	49.9	82	1930	16	1970	1.59	3.48	1919	6.77	1957	1.4	7.5	1929	9.0	1959	3	0	0
Nov	49.1	26.6	37.9	69	1937	-4	1957	0.70	1.46	1931	3.30	1957	4.9	14.0	1931	34.5	1957	2	0	2
Dec	40.8	19.8	30.3	62	1933	-10	1924	0.92	1.35	1965	2.85	1965	10.9	18.0	1915	41.3	1967	3	0	6
Year	59.8	36.3	48.0	95	1935	-18	1963	18.39	3.48	1919	11.18	1952	50.5	18.0	**	41.3	1967	45	51	25

**1915 and 1916

Precipitation records are from November 1910.

Temperature records are from October 1918.

AIR SAMPLING SYSTEM COMPARISON TESTS

by

Robert V. Fultyn

During November and December 1971, comparisons were made to evaluate the relative performance of three types of air sampling systems. Two new systems utilized respirator components, and the third system was identical to that used for years in the LASL environmental monitoring program. Each week during the 2-month period, two samples of each system were placed side by side on a common manifold in the same equipment enclosure on the roof of the OHL building, and operated to sample air for approximately 7 days. The concentration of air-borne radioactivity was determined by each system, and the results were compared. The results indicated that one of the new systems performed better than the other and that both performed better than the old system.

The first system combined Delbag Microsorban 99/98 filter media with a Welsh Mfg. Co. No. 7500-8 charcoal respirator cartridge. A Welsh No. 7500-38 respirator prefilter pad was used between the Microsorban filter and the cartridge to provide support for the Microsorban filter, and also to effect a tighter seal of the components. A Welsh No. 7500-14 louvered cover held the filters in front of the cartridge, which is typical of the Welsh respirator system. The sampling head was connected to the pump system by screwing the cartridge outlet onto a 3/4-in. NPT bushing suitably fitted with a stop and an O-ring seal. The second system was identical to the first except that Whatman 41 filter paper was used instead of Delbag Microsorban. The third system consisted of a 2-in. Gelman Metracel GA-3 membrane filter in a typical aluminum 2-in. open-face filter holder, followed by an MSA No. 44135 charcoal cartridge housed in an MSA in-line cartridge holder. The filter holder outlet screwed directly into the cartridge holder inlet. The cartridge holder outlet was fitted with a pipe union used to connect the sampling head to the pump system. This third sampling system was identical to those used for many years in the LASL Environmental Monitoring Program.

Two examples of each air sampling system were connected to a Dwyer No. RMA-10 rotameter, and thence to a manifold on a Roots-Conorsville No. AF-24 positive displacement pump. A vacuum gauge was connected to the manifold to measure the negative pressure in the system. The pump was belt driven at approximately 1400 RPM, which was sufficient to pull 120 cfh (2 cfm) through each of the six sampling assemblies when the filters were fresh. The negative pressure in the manifold was never sufficient to cause the vacuum gauge (an inexpensive bourdon tube-type gauge) to register, and could therefore be assumed to be less than about 1-1/2 in. of mercury (gauge). Experience revealed that the flow rate through the Microsorban and Whatman assemblies remained essentially constant for a week's sampling duration. The flow rate through the membrane filter assembly continually decreased with time, however, so that by the end of the week's sample period the flow rate was down to perhaps 25 to 30% of initial, and the average flow rate was as low as 50% of initial. Flow rates were read and recorded daily during the experiment.

The entire sampling apparatus was housed in an aluminum enclosure typical of those now used in the air sampling program, and the housing was placed on the sampling deck on the roof of the OHL building. The filters were inside the housing, and pump exhaust was directed downward a few feet below the cabinet. The Welsh systems were placed with the filter planes vertical and facing the rear of the cabinet; the membrane filters faced downward. This orientation was necessitated by considerations of space and component structure at the time of the experiment.

The first set of samples was started on Friday, November 5, 1971. The samples were run for 1 wk and then changed. On November 29, 1971, the sample change day was moved to Monday to make count scheduling more convenient. Upon removal from the system, the filter samples were mounted on aluminum planchets and covered with a Mylar sheet, the typical procedure used for preparing regular environmental air filter samples for counting. The filter samples were then counted for gross

alpha and gross beta activity, usually for 10 min per sample, on a cyclic basis beginning a few hours after collection. Continuation of the counting for up to 2 days produced a sufficient quantity of early time filter-decay data. One week after collection, the filters were again counted repeatedly for 10-min periods, and the results of these counts were averaged to give an "8-day" activity. After two weekly sample periods, counting of the charcoal cartridges was abandoned because no activity was found on any of them. Although this study was conducted for 2 months, only 6 weeks' data were usable. One week, incorrect filter media were mounted, and count data were unsuitable from two other weeks' samples because of scheduling difficulties. Each week, a blank of each type of filter media was also prepared and counted with the samples. The counts from each respective blank for each count cycle were used as a background for the respective filter type. It was found that at early times blanks gave rather high counts. These decayed rapidly, but the source of this activity was never ascertained. During the period of this experiment, atmospheric radioactivity was at its lowest point for the year, and thus count rates were not appreciable. In fact, at 8 days, the standard deviation of the alpha concentration was typically of the same order of magnitude as the average concentration. Compounding this problem was an idiopathic variability in the counter that produced about double the variability expected from count statistics.

The difference in concentrations determined by two samples of the same media occasionally was as much as 50%, with 15 to 20% not uncommon. These differences were not usually consistent from one counting to the next, and are therefore more strongly suspected to result from counter fluctuations than from other causes. Occasionally, the differences did tend to remain consistent, indicating that two samples of the same system type would give different results. Consistent differences occurred with the membrane filter systems more often than with the other systems.

Differences in concentration as determined by different systems did remain consistent, however. The concentrations of both alpha and beta activities as determined by Microsorban systems were clearly higher than concentrations determined by the other two systems. This was somewhat surprising in a number of aspects. A widely held belief is that a soft, deep-filter media like Microsorban, though highly efficient as a collection media, might be a poor filter to use because the collected material would be dispersed throughout a heavy bed, thus resulting in radioactive particle self-absorption with low counting efficiency. A Whatman 41 filter, although of modest collection efficiency, should have a high count efficiency because material should tend to be collected on the hard filter surface. It is generally thought that membrane filters have high collection efficiency and no particle penetration, and therefore they should yield good count efficiency as well as good collection efficiency. The interpretation of the data collected here is that, in spite of its depth, Microsorban collects such a large fraction of atmospheric material near its surface that the effects of penetration and count self-absorption are minimal. In addition to its lower collection efficiency, Whatman 41 appears to exhibit much more dispersion through the media with resultant count self-absorption, and these combined effects are appreciable. The poor performance of the membrane system can only be attributed to large leakage of the systems (an existent design deficiency) or possibly to a poorer than imagined collection efficiency for particles smaller than the characteristic pore size of the media. This aspect will be studied in greater detail as time permits.

Table T-I attempts to summarize relatively the data collected during this experiment. Because concentrations of airborne radioactivity as determined by the Microsorban system were higher than for the other two systems, the table presents fractions or ratios of concentration as determined by Whatman or membrane to concentrations as determined by Microsorban. The confidence intervals include normal count statistics but not the bad behavior of the counter. These ratios are given for both alpha and beta activity, at three times of determination. One day and 8 days are standard count times; 200 to 500 min are early times for which counting is not normally done, and the measurements were included simply because the count statistics were best for these early counts. Examination of Table T-I reveals that the performance of the Welsh systems, relative to each other, was much more consistent than performance of the membrane system relative to the Welsh systems. This variability tends to confirm the conjecture that membrane systems tended to leak in field situations.

TABLE T-I

RATIOS OF AIR CONCENTRATIONS DETERMINED BY DIFFERENT SAMPLING SYSTEMS AND 95% CONFIDENCE LIMITS OF THOSE RATIOS

Date Collected	Gross Alpha Concentration Ratios		Gross Beta Concentration Ratios	
	Whatman 41/ Microsorban	Membrane/ Microsorban	Whatman 41/ Microsorban	Membrane/ Microsorban
	Concentrations Determined 200-500 Minutes after Sampling			
11/12	0.42 ± 0.03	0.37 ± 0.03	0.72 ± 0.02	0.39 ± 0.02
11/19	0.49 ± 0.11	0.32 ± 0.11	0.80 ± 0.05	0.45 ± 0.06
11/29	0.57 ± 0.06	0.34 ± 0.06	0.80 ± 0.02	0.37 ± 0.02
12/6	0.43 ± 0.06	0.40 ± 0.07	0.72 ± 0.04	0.48 ± 0.03
12/20	0.52 ± 0.16	0.60 ± 0.22	0.80 ± 0.08	0.65 ± 0.10
12/27	0.58 ± 0.11	0.89 ± 0.15	0.91 ± 0.07	0.94 ± 0.08
Av	0.50	0.49	0.79	0.55
	Concentrations Determined 1 Day after Sampling			
11/12	0.41 ± 0.06	0.34 ± 0.07	0.72 ± 0.04	0.44 ± 0.03
11/19	0.61 ± 0.16	0.28 ± 0.15	0.81 ± 0.05	0.58 ± 0.06
11/29	0.56 ± 0.20	0.26 ± 0.29	0.83 ± 0.02	0.41 ± 0.02
12/6	0.35 ± 0.11	0.54 ± 0.16	0.78 ± 0.04	0.61 ± 0.04
12/20	0.42 ± 0.19	0.49 ± 0.28	0.81 ± 0.07	0.92 ± 0.10
12/27	0.55 ± 0.17	1.05 ± 0.27	0.91 ± 0.09	1.00 ± 0.11
Av	0.48	0.49	0.81	0.66
	Concentrations Determined 8 Days after Sampling			
11/12	0.40 ± 0.21	0.12 ± 0.30	0.76 ± 0.03	0.53 ± 0.03
11/19	0.62 ± 0.90	2.35 ± 2.23	0.80 ± 0.05	0.74 ± 0.06
11/29	0.23 ± 0.29	1.26 ± 0.63	0.82 ± 0.01	0.44 ± 0.01
12/6	0.49 ± 0.56	0.52 ± 0.80	0.83 ± 0.03	0.66 ± 0.03
12/20	0.89 ± 1.17	1.19 ± 1.76	0.87 ± 0.07	0.94 ± 0.09
Av	0.53	1.09	0.82	0.66

TORNADO STRIKE FREQUENCIES

by

Joseph E. Herceg

Siting and design considerations for a new plutonium processing facility at LASL required an investigation by Group H-8 into the likelihood of a tornado strike in the Los Alamos area. It was discovered that most authors take the tornado strike frequency for a structure as being equal to the point strike frequency on the basis that the area of the structure is small compared with the destructive area of the tornado. That is,

$$f = IA_t \qquad (1)$$

where f is the number of tornado strikes per unit time, I is the tornado incidence (the number of tornadoes per unit area per unit time), and A_t is the destructive area of the tornado. As will be shown, this may not always be correct even though the area of the structure is indeed much smaller than the area covered by the tornado.

Case 1: Circular Area of Destruction and Circular Area of Risk. We first make the (unwarranted) assumption that the area of destruction of the tornado and the area of risk (the structure) are both circular with radii R_t and R_r, respectively. Then, referring to Fig. T-1a, we note that if the center of the tornado lies at a distance from the center of the structure which is less than $R_t + R_r$, then the structure will be struck. (Note that we have made the assumption that a strike is constituted by any part of the structure's falling within the destructive area of the tornado.) In other words, a tornado strike will have occurred if the center of the structure lies within the circular area A_e (effective area). This area, A_e is then the area that should be used in the frequency formula

$$f = IA_e \quad . \qquad (2)$$

Geometric considerations reveal that

$$A_e = \pi (R_t + R_r)^2 \quad ,$$

$$= A_t + A_r + 2 (\pi R_t R_r) \quad , \qquad (3)$$

and

$$f = I[A_t + A_r + 2(\pi R_t R_r)] \quad . \qquad (4)$$

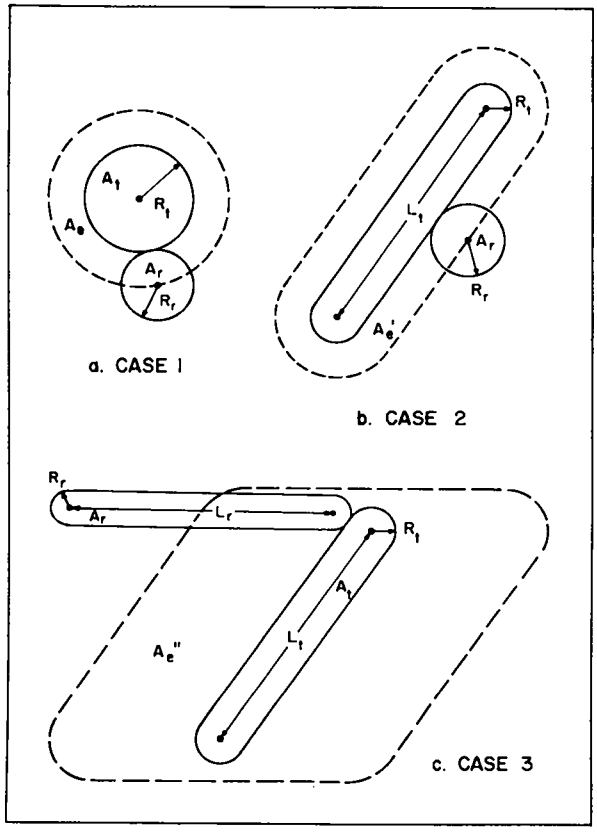

Fig. T-1.
Encounter possibilities for various tornado and risk area shapes.

Inspection reveals that if $A_t \gg A_r$, that is, if $R_t \gg R_r$, A_t makes the predominant contribution to the term in brackets and that Eq. (4) reduces to Eq. (1).

The only time a tornado presents a circular destruction area, however, is if it merely touches down and immediately breaks contact with the surface of the earth. In this event, the area of destruction will indeed be circular, but will only be on the order of 100 yd in diameter, the same size as a moderately large structure.

Case 2: Elongated Area of Destruction and Circular Area of Risk. The destruction area of most tornadoes is a long,

narrow strip perhaps 100 yd wide and several miles long. We shall retain the circular concept for the area at risk for convenience (many irregular shapes can be approximated fairly well by a circle), but we now adopt the shape just described for the destructive area. The physical situation is shown in Fig. T-1b. We note that R_t is half the width of the destruction strip and L_t is the distance between the points where the tornado touches down and breaks contact. If the structure defined by A_r lies within the area A_e', it will be hit. Now

$$A_e' = \pi (R_t + R_r)^2 + 2L_t (R_t + R_r) \quad ,$$

$$= A_t + A_r + 2(\pi R_t R_r + L_t R_r) \quad , \qquad (5)$$

and

$$f = I[A_t + A_r + 2(\pi R_t R_r + L_t R_r)] \quad . \qquad (6)$$

We note that the expressions for A_e and A_e' are similar and differ only by the terms in parentheses and that if $R_r = 0$ (the condition that $R_t \gg R_r$ is no longer sufficient), then $A_e' = A_t$ and we may again speak of point frequencies.

Case 3: Elongated Area of Destruction and Elongated Area of Risk. We turn to the more general case where we wish to calculate the strike frequency of, perhaps, a bridge much longer than it is wide. The situation is that shown in Fig. T-1c. The tornado path, A_t, is oriented at angle θ to the risk area, A_r, and L_t and R_t are as in Case 2. The risk area has been approximated by a rectangle of length L_r and width $2R_r$ with rounded ends of radius R_r. If the center of the tornado's path falls within the rounded parallelogram A_e'', then the structure will be struck. This area is

$$A_e'' = \pi(R_t + R_r)^2 + 2(L_t + L_r)(R_t + R_r) + L_t L_r \sin\theta \quad ,$$

$$= A_t + A_r + 2(\pi R_t R_r + L_t R_r + L_r R_t) + L_t L_r \sin\theta \quad , \qquad (7)$$

and

$$f = I[A_t + A_r + 2(\pi R_t R_r + L_t R_r + L_r R_t) + L_t L_r \sin\theta]. \qquad (8)$$

We have added two terms here, and both L_r and R_r must be zero for Eq. (8) to reduce to Eq. (1).

Example: Consider a railroad trestle 0.5 mi long and 5.0 yd wide ($A_r = 0.0014$ mi^2). Given 1 tornado per mi^2 per year having an average path width of 100 yd and an average path length of 10.0 mi ($A_t = 0.57$ mi^2), what is the frequency with which the bridge will be struck by a tornado? Results of computations are shown in Table T-II. (Case 0 corresponds to $f = IA_t$). It is emphasized that the areas have been kept constant throughout the example and that the various radii and lengths have been calculated to satisfy the assumptions of the various models. As shown in Table T-II, the strike frequency increases as the model becomes more complex (except for Case 3 with $\theta \cong 0$, parallel or nearly parallel orientations). If the tornado tracks in a given area fall predominantly along southwest-northeast lines (not unusual for the midwest) and the trestle is oriented in the northwest-southeast direction, the strike frequency is an order of magnitude higher than what is predicted from the simple point model. This is clearly a problem where oversimplification gives a grossly erroneous result.

TABLE T-II

TORNADO STRIKE FREQUENCIES CALCULATED FROM VARIOUS MODELS

Case	θ deg	R_t mi	L_t mi	R_r mi	L_r mi	f strikes/yr	f/f_0
0	—	—	—	—	—	0.57	1.0
1	—	0.425	—	0.021	—	0.63	1.1
2	—	0.028	10.0	0.021	—	1.00	1.8
3	0	0.028	10.0	0.0014	0.5	0.63	1.1
3	15	0.028	10.0	0.0014	0.5	1.92	3.4
3	45	0.028	10.0	0.0014	0.5	4.16	7.3
3	90	0.028	10.0	0.0014	0.5	5.63	9.9

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