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Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory

January through June, 1971

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

UNITED STATES
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ENVIRONMENTAL MONITORING IN THE VICINITY OF THE LOS ALAMOS SCIENTIFIC LABORATORY

January through June 1971

ABSTRACT

A description is given of the environmental monitoring program in effect at the University of California Los Alamos Scientific Laboratory during the first half of calendar year 1971. 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.

Appendices describe the boundaries of the Laboratory site, the programs associated with various Laboratory technical areas, geologic, climatologic and economic characteristics of the Los Alamos area, and laboratory procedures used for the analysis of samples.

I. INTRODUCTION

This report describes the results of the environmental monitoring program in effect during the first half of calendar year 1971 at the Los Alamos Scientific Laboratory, administered by the University of California for the United States Atomic Energy Commission under Contract W-7405-ENG-36.

The Laboratory and Community at Los Alamos are located on the Pajarito Plateau, situated west of the Rio Grande on the eastern slopes of the Jemez Mountains in north-central New Mexico. This location was originally chosen for 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 of Los Alamos and White Rock. 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 which 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 geologic, climatologic and economic characteristics of the area given in Appendices C, D and E to this report.

The Laboratory Site comprises about 28,000 acres in and adjacent to Los Alamos County. A detailed description of the extent and boundaries of the land retained by the AEC for Laboratory use is given in Appendix A. The principle mission of the Laboratory is, as it has been since its

inception, the design and development of the 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 (Project Rover), controlled thermonuclear fusion (Sherwood Program), nuclear safeguards, biomedical research and space physics. These activities are located in 29 active Technical Areas widely spread over the AEC controlled lands. A description of these technical areas and the general types of activities carried out in each is given in Appendix B, and a map showing the location of these areas is given in Fig. 1.

During this period, a start was made on a critical review of the entire environmental monitoring program to make it more responsive to present day concerns about the environment and to provide for improved estimates of the very low levels of exposure to both radioactive and non-radioactive contaminants actually attributable to Laboratory operations. The air sampling network is being revised to provide wider coverage on circles about 3 and 10 km distant from a point near the center of AEC controlled land with less redundant coverage in the community of Los Alamos. Samplers were established in Santa Fe and Espanola to provide estimates of background radiation levels and concentrations of radionuclides. The water, sediment and soil monitoring programs were expanded to include a network for the sampling of regional surface waters, sediments and soils with stations located at approximately 45 degree intervals on a circle 40 to 50 km distant from the Laboratory. Analysis of many water samples for certain injurious metal ions such as mercury and cadmium was begun.

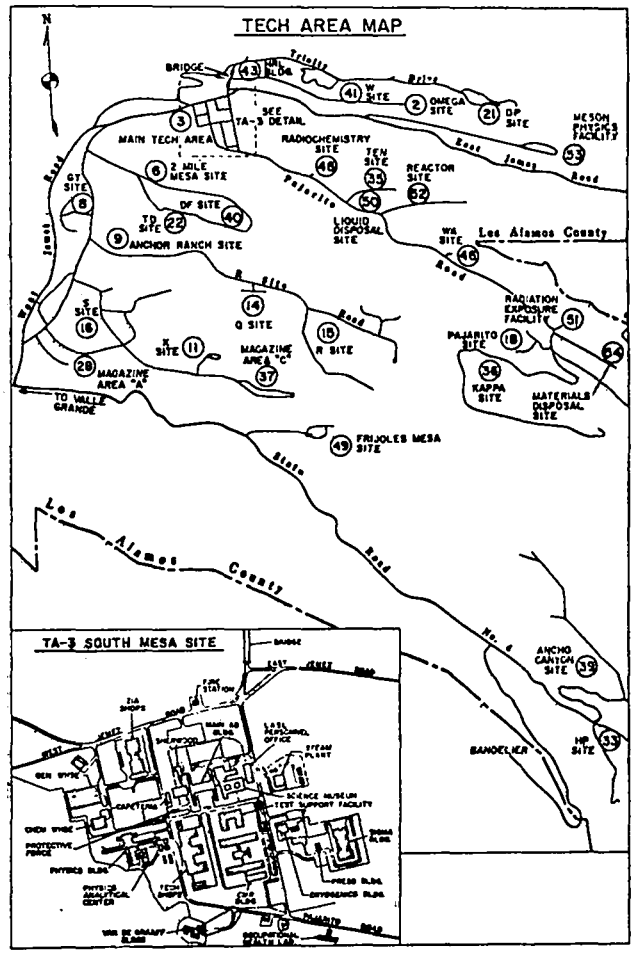

Fig. 1. Los Alamos Scientific Laboratory technical areas.

Additional changes are anticipated as the results from these and other programs become available for detailed analysis and assessment.

The appendices to this report contain details of many facets of the area which are of importance to the interpretation of the results. It is planned to use these appendices as basic references for future environmental monitoring reports. A given appendix will be repeated in a future report only if information collected or procedural changes implemented during that particular reporting period necessitates a revision of that appendix.

II. SUMMARY

Results of the Environmental Monitoring

Program at the Los Alamos Scientific Laboratory for the period January through June, 1971 are given. The program is in process of change in order to better satisfy the needs for environmental data at very low levels. Results for this period indicate no significant changes from those for previous periods. Concentrations of ^{238}Pu above that expected from worldwide fallout were measured at several stations including one off-site station. The 50 year dose commitment resulting from 6 months exposure at this station is estimated to be less than 0.04 mrem for the lungs or 2 mrem for the bone as compared to the annual radiation protection guide value given in AEC Manual Chapter 0524 of 1500 mrem for an individual or 500 mrem for a suitable sample of the population. Tritium concentrations in the atmosphere appear to be elevated in the Los Alamos area and may have contributed a whole-body dose of about 0.1 mrem dur- the report period as compared to the annual guide value of 500 mrem for an individual or 170 mrem for a suitable sample of the population.

Areas with trace contamination by plutonium and beta emitters are present in canyons now used or previously used for disposal of liquid effluents. These are unoccupied areas and present no problems in terms of radiation exposure. Small quantities of plutonium also appear in the soils around the plutonium fabrication facility (TA-21) as a result of past deposition from airborne effluents. Again, the quantities are small and there is no indication of an elevated air concentration which is the hazard of concern since inhalation is believed to be the main route of plutonium entry into the body.

III. ANCILLARY DATA

It is important for the design of an adequate environmental monitoring program and for the interpretation of the data to have current information on the quantities of materials released to the environs and on the vagaries of the atmosphere. summary of this information for this period is included in this section.

A. Gaseous Effluents

Since the Laboratory is a large, broadly diversified organization employing a few thousand personnel to engage in fundamental and applied research in the natural sciences with emphasis on nuclear materials, the facilities include literally hundreds of potential sources of airborne material. At present, processes which are known to have the potential for significant releases are controlled and monitored, but numerous laboratory hoods still exist where procedural controls are relied upon for proper utilization. However, it should be stressed that within this continually changing environment of research, the major potential sources of troublesome materials are confined to a few well known locations. The major sources of airborne contaminants at the Laboratory are summarized in Table I.

Certain tests with conventional explosives involve the dispersal into the atmosphere of kilogram quantities of depleted uranium and occasional small quantities of tritium and nonradioactive metals such as lead, copper, beryllium, aluminum and cadmium. Documentation of this source was begun at the end of the report period but is not reflected in the table.

B. Liquid Effluents

As is the case for sources of airborne contaminants noted above, the Laboratory facilities include a large number of sources of liquid effluent. Cooling water and sewage lagoons comprise by far the majority of these effluent streams. Again, processes which are known to have the potential for significant releases are controlled and monitored, but numerous drains exist where procedural controls are relied upon for proper utilization.

In general the effluents are released into canyons that contain intermittent streams. The effluents are depleted by evapotranspiration or

TABLE I

SUMMARY OF MAJOR AIRBORNE MATERIALS

January - June 1971

Technical Area	Gross Beta μCi	Pu μCi	^{235}U μCi	Depleted U μCi	^{131}I μCi	^{137}Cs μCi	^{41}Ar Ci	^{3}T Ci
3	600	5900	---	---	6100	---	---	5
21	---	970	350	---	---	---	---	2
2	---	---	---	---	---	560	710	---
33	---	---	---	---	---	---	---	3000
41	---	---	---	---	---	---	---	260
35	---	---	---	---	---	---	---	2700
Other	900	40	90	180	---	---	---	---

infiltration into the underlying rocks in the project area. None of these effluent streams reach the Rio Grande, and none recharge aquifers from which municipal, industrial, or irrigation water is drawn.

The primary sources of potentially contaminated liquid effluent from laboratory operations are from the industrial liquid waste treatment plant at TA-21 and from the central industrial liquidwaste treatment plant at TA-50. Effluents from the TA-21 plant are released into DP Canyon that is tributary to Los Alamos Canyon, and those effluents from TA-50 are released into Effluent Canyon which is 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.

Some chemical ions, primarily hexavalent chromate (Cr^{+6}), are released into Sandia Canyon from the Zia Company Power Plant as a result of the discharge of treated water from the cooling towers.

C. Solid Waste Disposal

Contaminated or potentially contaminated solid wastes, including sludges from the industrial waste treatment plants and trash from routine laboratory operations, are buried at TA-54 on the Mesita del Buey (a location chosen in cooperation with the U. S. Geological Survey to assure long time localization of radioactive materials) and in lined disposal shafts at TA-21. When appropriate, wastes are stabilized in concrete or other material prior to or during burial. The quantities of materials placed in storage during this period are given in Table III.

The quantity of radioactive material in the laboratory trash and equipment is not estimated because it is below the limits of detection for any device for the measurement of gross activity, however, it should be relatively low compared to that in the sludge. In addition, one batch of waste containing about 9 grams of plutonium was placed

TABLE II

SUMMARY OF MAJOR LIQUID EFFLUENTS

January - June 1971

	TA-21	TA-50
Gross α, mCi	0.43[a]	5.85
Gross β, mCi	--	768.51
^{238}Pu, ^{239}Pu, mCi	0.43[a]	3.81
^{89}Sr, ^{90}Sr, mCi[b]	--	28.02
Volume discharged, 10^6 liters	5.281	20.768

[a] All Alpha activity assumed to be due to Pu.

[b] Several spot analyses indicated a ratio of 52:48 for ^{89}Sr:^{90}Sr.

TABLE III

SOLID WASTE BURIAL

January-June 1971

Place	Waste	Container	Volume liter	Activity Ci
TA-54	^{239}Pu sludge from TA-50	55 gal steel barrels	84,800	2.6
TA-54	^{3}T	Metal containers filled with asphalt	80	6400
TA-54	Trash	--	1,260,000	Trace
TA-54	Equipment	--	885,000	Trace
TA-54	Fission products and activated metal	Disposal shafts	134	120
TA-21	^{239}Pu sludge from TA-21	201,690 liters cement paste in lined dis-	117,020	156
TA-21	Fission products	posal shafts	--	0.4

in a shaft at the burial site and embedded in concrete.

D. Meteorology

Selected meteorological statistics for this period are given in Table IV. These six months were characterized by extremes both in temperature and precipitation. All six months were below normal in precipitation with only about 40% of the normal amount received by the end of June. This lack of moisture, reinforced by persistent westerly winds, led to major forest fires in June. The period from January 3 to January 8 was one of the longest periods of extremely cold weather ever experienced in the area. From January 4 through January 8, the daily minimum temperature was -9 degrees F or below, with a minimum recorded temperature of -16 degrees F on January 6. This cold spell did major damage to the fruit trees in the Espanola region.

A wind rose for the period is given in Fig. 2. The presence of the strong and persistent westerly spring winds characteristic of the area is evident.

IV. ROUTINE MONITORING PROGRAMS

Several routine monitoring programs are carried out to provide information on the potential radiation doses to people in the environs and on the possible accumulations of radioactive or non-radioactive materials. The results of these

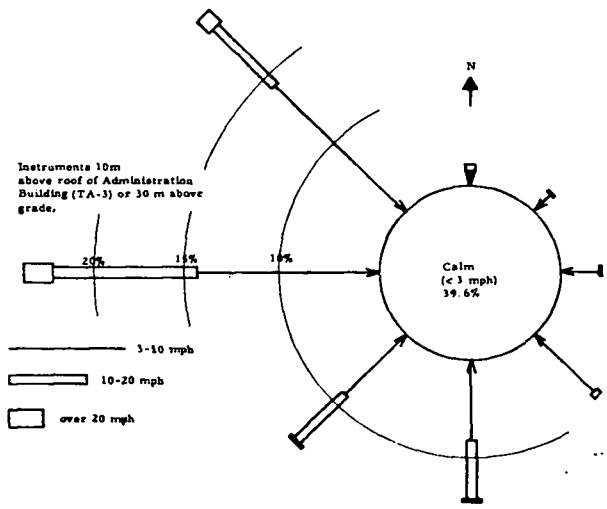

Fig. 2. Wind rose for the period January-June 1971.

TABLE IV

SELECTED METEOROLOGICAL STATISTICS

January-June 1971

	JAN	FEB	MAR	APR	MAY	JUN
Maximum Temperature:						
This month this year	62	56	71	73	76	85
Record for this month	64	66	71	80	89	93
Average Daily High Temperature:						
This month this year	41.1	42.0	52.5	57.1	65.8	78.1
Normal[a] for this month	39.0	42.8	48.9	58.4	67.8	77.6
Minimum Temperature:						
This month this year	-16	3	2	24	32	42
Record for this month	-18	-14	-3	5	24	28
Average Daily Low Temperature:						
This month this year	17.2	19.9	25.7	32.6	41.1	52.7
Normal[a] for this month	17.8	21.5	25.8	33.8	42.8	51.6
Precipitation:						
This month this year	0.82	0.25	0.32	0.48	0.21	0.40
Normal[a] for this month	0.84	0.70	0.96	1.01	1.29	1.37
Cumulative Precipitation:						
This month this year	0.82	1.07	1.39	1.87	2.08	2.48
Normal[a] for this month	0.84	1.54	2.50	3.51	4.80	6.17
Snow:						
This month this year	11.5	4.0	5.9	3.6	Trace	--
Normal[a] for this month	9.7	8.4	10.1	4.2	0.8	--
Cumulative Snow:						
This month this season	14.0	18.0	23.9	27.5	27.5	--
Normal[a] for this month	27.1	35.5	45.5	49.7	50.5	--

Last spring frost 19 May, Normal[a] 10 May

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.

programs are relayed immediately to the responsible operations so that any undesirable conditions may be immediately corrected.

Station locations are chosen to provide the geographic coverage desired for each type of measurement, with constraints imposed by physical accessibility and by availability of power. Similarly, collection dates are chosen to give a sampling frequency adequate for each type of measurement, with accessibility and distance from the Laboratory being the major constraining factors. Those stations which are within the Laboratory boundaries (as described in Appendix A) are listed in the tables as "on-site", and those which are outside of these boundaries are designated as "off-site".

A. Air

The air monitoring program is designed to provide for general surveillance of the gross radiation levels in the Los Alamos area; of the concentrations of those specific radionuclides directly associated with Laboratory operations; and of the concentrations of certain nonradioactive materials.

In order to provide a system of locating and describing the stations a radial grid centered on the site of the proposed new 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 90-2.7 would be directly east of the reference point at a distance of 2.7 km. The locations of all air sampling stations are shown in Fig. 3.

1. Radioactive Materials. A high volume air sampler drawing air through an MSA Type BM2133 filter cartridge and a charcoal canister at the rate of approximately 400 liters per minute is maintained on the roof of the Administration Building (TA-3). A second charcoal canister is operated on a similar high volume sampler at the waste treatment facility (TA-50). The filter and the canister are changed daily. The particulate material on the filters is measured for gross beta emission twice, immediately after and eight days after collection, on a Widebeta 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. This sampling system is maintained primarily to measure fallout from atmospheric testing in past years and to detect fresh fallout from foreign tests. The results in general are comparable with those samplers operated elsewhere in the country by the AEC and by the Public Health Service. The initial measurement of the gross beta is taken to give early warning of large changes which would be apparent above the natural radon-thoron background fluctuations. The primary record of the activity is established by the eight day measurement. These results are given in Fig. 4 for the six month period covered by this report. The increase in concentration over the early months of the year with a peaking in the spring is a normal trend. It is occasioned by a seasonal fluctuation in atmospheric mixing which brings the stratospheric storage of fission products from earlier tests to ground level in the spring. The results of the ^{131}I analysis on the two sets of charcoal cartridges are given in Table VII along with the results of the iodine analyses of the weekly air samples.

Deposition is measured on a daily basis using a precipitation collector 0.4 m^2 in area located at the waste treatment plant (TA-50). The collector is rinsed with water and the rinse water is combined with whatever precipitation may have been collected. The sample is filtered, the water is evaporated to dryness and the filter is wet ashed. The two resulting planchets are measured separately on the Widebeta counter for gross beta activity, and the total beta activity is obtained arithmetically. Again measurements are taken

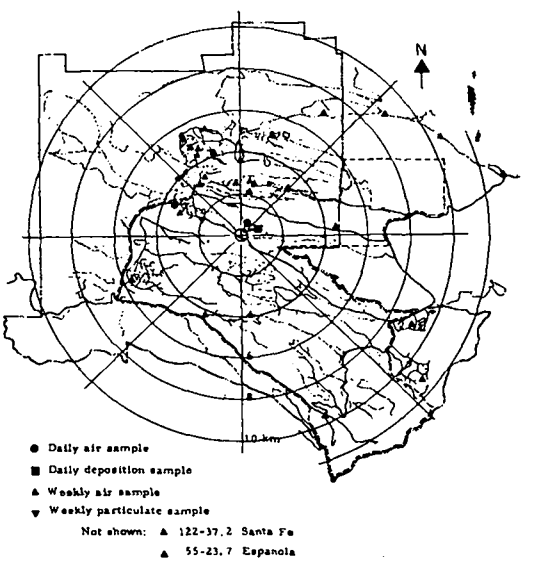

Fig. 3. Locations of air sampling stations.

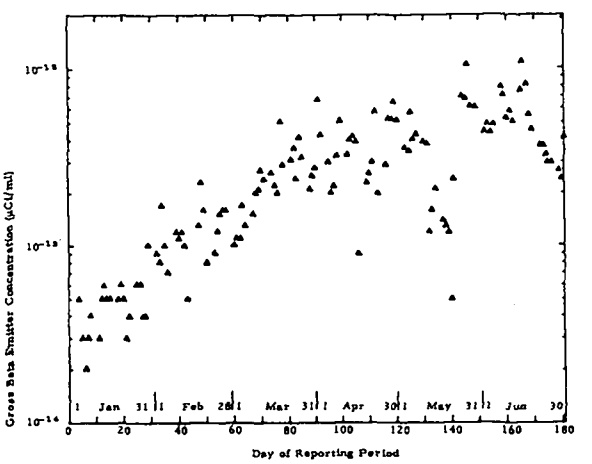

Fig. 4. Gross beta data from daily air sample.

immediately and after eight days with the eight day measurement considered to represent the gross emitters free of the interfering daughters of radon and thoron. The gross beta measurements are given in Fig. 5, along with the natural precipitation recorded during this period. Again, an increase in the earlier spring is noted although this trend is considerably obscured by fluctuations due to scavenging by natural precipitation.

The main air monitoring network consists of an array of air sampling stations which has grown over the years. During the period covered by this report several new stations were added to the past network expanding the total number in operation from 23 in January to 27 in April. The locations of these stations as of the end of the period are given in Fig. 3. Each station contains a pump which pulls air through a 50 mm membrane filter with a pore size of 1.2 μm at a rate of about 55 liters/minute. These filters are collected weekly and measured for gross alpha and gross beta emitters on a Widebeta proportional counter one day after collection and eight days after collection. The filters from each station are then pooled to form a monthly composite sample

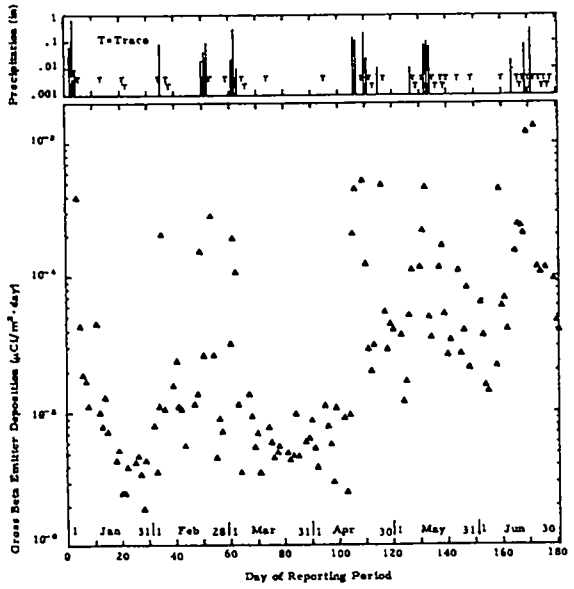

Fig. 5. Gross beta data from daily deposition sample.

which is analyzed radiochemically for plutonium. An alpha spectrometer is used to allow resolution of ^{238}Pu and ^{239}Pu. The general analytical scheme used for these samples is given in Appendix F. In addition, 12 of these samplers are fitted with charcoal cartridges to collect ^{131}I and seven are fitted to draw air through a tube of dessicant material at a flow of about 50 cm^3/min to permit collection of tritiated water vapor. The charcoal cartridges are analyzed for iodine on a gamma ray spectrometer while the tritium content of the water vapor is measured by liquid scintillation counting.

The gross alpha and gross beta activities are measured primarily for the purpose of screening the samples to insure against unexpectedly high concentrations of emitters which are not covered by the more specific analyses. A summary of the results of the measurements taken after eight days decay is given in Table V.

The gross alpha measurements have been corrected both for background of the counting chamber and for the approximately 0.1% of the beta counts which feed into the alpha channel of the Widebeta counter ("cross-talk"). Due to erratic behavior of the counter during this period, a detection limit could not be derived from considerations of the analytical procedure and the counting system. Instead, statistical analyses of the analytical results were used to estimate this detection limit. The entire group of samples (all stations and all times) were used to derive the detection limit for individual samples (maximum column), and only activities which lie more than 2.326 standard deviations above the mean (99% confidence level) were considered to be detectable. This procedure led to the value of 5×10^{-15} μCi/ml given in the table. A similar procedure, but considering the number of samples collected at each station, was used to arrive at the estimate of 2×10^{-15} μCi/ml for the detection limit for station averages.

TABLE V

SUMMARY RESULTS OF GROSS MEASUREMENTS ON WEEKLY AIR FILTERS

Station	Number Samples	Gross Alpha Average	Gross Alpha Maximum	Gross Beta Average	Gross Beta Maximum
		μCi/ml x 10^{-15}		μCi/ml x 10^{-15}	
Off-Site stations:					
332-3.3	11	<2	<5	5.2	11
333-4.7	23	<2	<5	6.1	18
334-4.3	22	<2	<5	5.1	14
337-4.4	23	<2	<5	6.4	21
340-4.2	22	<2	5.5	5.7	17
343-5.2	23	<2	<5	6.2	23
351-2.5	11	<2	<5	8.1	17
1-3.5	22	<2	<5	5.5	16
9-2.6	18	<2	<5	5.6	22
14-2.3	23	<2	<5	6.6	21
17-2.5	23	<2	<5	6.1	21
19-5.0	23	<2	6.7	5.8	13
37-7.0	23	<2	7.5	7.6	21
42-3.1	22	<2	<5	5.7	14
50-8.8	23	<2	5.0	5.7	14
55-23.7	11	<2	8.3	1.0	18
64-10.3	21	<2	<5	5.0	15
78-12.5	21	<2	<5	3.3	10
117-9.2	23	<2	<5	6.8	19
122-37.2	11	<2	12	8.7	14
130-11.1	12	<2	5.5	10.3	20
On-Site stations:					
87-4.7	22	<2	7.4	4.8	10
155-9.4	22	<2	<5	6.8	19
202-4.2	23	<2	<5	5.8	19
250-5.4	22	<2	<5	4.7	10
304-2.6	22	<2	<5	7.8	24
321-3.0	23	<2	<5	6.1	18
Detection Limit			See text		0.1

* The first entry under Gross Alpha is read <2 x 10^{-15} μCi/ml.

The gross beta emitters varied with time as expected from the seasonal variation of fallout with no real difference between the stations indicating that the activity was, within the error of the measurement, due to long term fallout from past weapons tests.

A summary of the results of the plutonium analyses performed on the monthly composites of the weekly air filters is given in Table VI. An analysis of variance performed on the logarithms of the ^{239}Pu values, on the assumption that these results are distributed according to a log-normal distribution as are many other air sampling results, indicates that there is no significant difference between the various sampling locations. There does appear to be a time variation pattern which may be similar to that of the gross beta emitters from worldwide fallout, but it is difficult to establish such a pattern or to provide any reasonable degree of correlation with only six individual sampling periods. This apparent increase over the sampling period can explain the higher values for those stations established in April where only three samples were obtained (including the remote stations of Santa Fe and Espanola). Since these stations were established about midway through the reporting period, they represent only the periods when the concentrations

TABLE VI

SUMMARY RESULTS FOR PLUTONIUM ANALYSES OF

MONTHLY COMPOSITED WEEKLY AIR FILTERS

Station	Number Samples	^{239}Pu Average	^{239}Pu Maximum	^{238}Pu Average	^{238}Pu Maximum
		μCi/ml x 10^{-17}[a]		μCi/ml x 10^{-17}	
Off-Site stations					
332-3.3	5	8.5	13	28	110
333-4.7	6	7.9	14	1.6	4.7
334-4.3	6	8.1	15	1.6	2.6
337-4.4	6	8.4	13	1.4	3.5
340-4.2	6	9.8	16	3.1	4.8
343-5.2	6	9.2	17	1.3	1.8
351-2.5	3	18	36	6.0	8.8
1-3.5	6	10	15	4.8	21
9-2.6	5	9.6	16	3.4	9.5
14-2.3	6	10	15	1.7	3.5
17-2.5	6	9.7	16	2.0	5.3
19-5.0	6	6.9	13	2.0	3.1
37-7.0	6	9.4	15	3.0	7.0
42-3.1	6	8.9	14	1.2	2.2
50-8.8	6	8.8	16	2.3	6.1
55-23.7	3	14	18	2.0	2.2
64-10.3	6	6.7	9.8	1.8	3.5
78-12.5	6	6.4	16	1.8	3.9
117-9.2	6	9.1	16	1.9	4.4
122-37.2	3	12	17	0.5	0.7
130-11.1	3	12	13	1.5	3.2
On-Site stations					
87-4.7	6	6.9	13	1.9	3.5
155-9.4	6	10	16	1.7	3.1
202-4.2	6	9.5	13	3.0	7.4
250-5.4	6	8.7	14	1.2	2.2
304-2.6	6	19	28	13	28
321-3.0	6	9.6	15	4.8	9.3
Detection Limit			1.0		1.0

[a] The first entry under ^{239}Pu is read 8.5 x 10^{-17} μCi/ml.

seem to be higher. However, even these values are not significantly different from the others because of the small number of samples. The average values given are generally in line with the concentrations of ^{239}Pu reported by the USPHS as occurring from worldwide fallout. For example, reported values for Denver are 5.5 x 10^{-17} μCi/ml for the first three months of 1970 and 1.3 x 10^{-16} μCi/ml for the second three month period.[1]* In view of this correspondence and the lack of difference between the individual sampling stations, it is concluded that ^{239}Pu concentrations listed are primarily due to fallout with no detectable contribution from the Laboratory.

The ^{238}Pu data, however, show a significant difference between several of the stations. Station 304-2.6, on the roof of the Administration Building, and station 321-3.0, at the Health Research Laboratory, both on-site stations, are significantly higher than the other stations. These high values are attributable to the emissions from the Chemistry and Metallurgy Building which is located several hundred meters west of the Administration Building. There is a routine emission of plutonium from this building (see Table I, under TA-3)

*Superscript numbers refer to the references, listed at the end of the report before the Appendices.

with the majority being ^{238}Pu. Measures are underway to install additional filtration on the exhaust from this building to further reduce these emissions. However, even the maximum concentration at the Administration Building, 28×10^{-17} μCi/ml, is only 0.014% of the concentration guide value of 2×10^{-12} μCi/ml for the soluble isotope as given in AEC Manual Chapter 0524 for occupational exposure applicable to on-site locations. Since the boundary of the Laboratory is near this station and since public traffic on adjacent roads is normally permitted, a comparison to the concentration guide for an individual in the general public of 7×10^{-14} μCi/ml is made which indicates that the maximum concentration is less than 0.4% of this guide. For the off-site stations, only station 351-2.5 showed a concentration significantly higher than the average. This station was operated for an abbreviated period so that only three samples were collected. Furthermore, this station is located in an area where there are many other samplers within a few kilometers which showed no apparent increase. Thus, although there are some reasons to consider this result an artifact, a close watch will be kept on this location. The average concentration at this location is less than 0.1% of the concentration guide prescribed by the AEC Manual Chapter 0524 for an individual in the general population. One other anomalously high monthly sample occurred at station 332-3.3, again in the town of Los Alamos. It was an order of magnitude higher than all other monthly samples from this period and no explanation can be given for this result.

A summary of the ^{131}I measurements is given on Table VII. Even the most positive values obtained from the counter were well within the limits of uncertainty due to the counting statistics, indicating that concentrations of ^{131}I at these stations were below the detection limits which were statistically estimated (as for the gross alpha data) to be 5.0×10^{-14} for individual samples and 1.0×10^{-14} for station averages. Therefore the average concentrations are less than 0.01% of the concentration guide of 1×10^{-10} μCi/ml for individuals in the population as given in AEC Manual Chapter 0524.

TABLE VII

SUMMARY RESULTS FOR ^{131}I ANALYSES OF WEEKLY AIR FILTERS

Location	Number Samples	Average μCi/ml x 10^{-14} [a]	Maximum μCi/ml x 10^{-14} [a]
Off Site Stations			
19-5.0	22	<1	<5
50-8.8	22	<1	<5
78-12.5	126	<1	<5
117-9.2	126	<1	<5
On Site Stations			
155-9.4	22	<1	<5
202-4.2	22	<1	<5
250-5.4	22	<1	<5
304-2.6 [b]	126	<1	<5
5-0.2 [b]	126	<1	<5
Detection Limit			See text.

[a] The first entry under average is read <1 x 10^{-14} μCi/ml.

[b] Daily samples with high volume samplers at Administration Building and at TA-50.

The measurements of tritium associated with atmospheric moisture are summarized in Table VIII. Analysis of the data indicates that the differences between sampling stations were much more significant than differences with respect to

TABLE VIII

SUMMARY RESULTS FOR ^{3}T ANALYSES OF WEEKLY AIR SAMPLES

Location	Number Samples	Average μCi/ml x 10^{-10} [a]	Maximum μCi/ml x 10^{-10} [a]
Off-Site Stations:			
1-3.5	20	1.0	4.2
14-2.3	20	1.6	4.5
37-7.0	20	0.7	2.0
42-3.1	20	1.4	4.0
55-23.7	11	0.5	1.4
78-12.5	20	1.1	6.0
117-9.2	20	1.1	2.4
122-37.2	11	0.6	1.4
On-Site Stations:			
155-9.4	20	7.5	34
202-4.2	20	2.2	22
304-2.6	20	3.3	16
5-0.2	20	6.3	22
Detection Limit			0.2

[a] The first entry under Average is read 1.0 x 10^{-10} μCi/ml.

time. The time behavior of the tritium was different than that of the plutonium, although the plutonium trend is difficult to assess because of the small number of plutonium samples. The on-site sampling stations, located closer to the areas where tritium releases occurred, indicated atmospheric concentrations higher than those measured by the samplers in the surrounding county, and these, in turn, showed levels above those in Santa Fe and Espanola. If the levels in Santa Fe and Espanola can be considered to be representative of the background tritium concentrations due to worldwide fallout, then the concentrations in the communities in Los Alamos County appear to be about twice background, and the concentrations at some of the on-site locations are about ten times background. The average off-site concentrations, including background, in the Los Alamos area are about 0.08% of the concentration guide of 2×10^{-7} μCi/ml as given in AEC Manual Chapter 0524 for individuals in the population or about 0.2% of the recommended guide for population groups. The average concentrations at the on-site stations are about 0.01% of the recommended guide for controlled areas of 5×10^{-8} μCi/ml.

2. Non Radioactive Materials. A sample of 24 hours 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 the rate of about 1500 liters per minute through an 8" x 10" 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. The results of these analyses for this period are given in Table IX.

At present the only air quality standards in effect are those for gross suspended particulate matter; the State of New Mexico has established a standard of 60 μg/m^3 for the annual geometric mean. The Los Alamos value of 17 μg/m^3 falls well below this standard, and is a value comparable to the lowest reported by the Public Health Service from the National Air Surveillance Network. However, since no laboratory activities discharge significant amounts of particulate matter to the atmosphere, the value merely reflects the relatively low levels of industrial activity and the relative isolation of the Laboratory and town in general. The average values of other contaminants reported are also comparable to non-urban levels reported by the USPHS from NASN stations.

B. External Gamma Radiation

An array of thermoluminescent dosimeters (TLD's) is maintained to monitor gamma and X-radiation at the levels of natural background to provide information on any possible contribution from the activities at the Laboratory. The present array uses two different TLD's at each station. One is the EG&G* Model TL-2B, consisting of a CaF:Mn powder chemically bonded to a heating coil and enclosed in an evacuated glass envelope; the other is the MBLE† consisting of CaF with an unknown activator bonded to a heating cylinder and enclosed in an evacuated glass envelope. The locations of these stations are given in Fig. 6. Two sets of each type of dosimeter are maintained for each station, and they are exchanged at intervals of approximately one month, so that a given dosimeter is out only every other month.

Both of the dosimeter systems used in the array have an inherent background, presumably due to naturally occurring isotopes, mostly ^{40}K, in the binding compounds and in the glass envelope. These materials contribute on the order of 0.7 mR/day with the natural background from external sources on the order of 0.1 to 0.2 mR/day.

* EG&G, Inc.
130 Robin Hill Road
Goleta, Calif.

† M.B.L.E.
80 Rue des Deux Gares
Brussels 7, Belgium

TABLE IX

ANALYTICAL RESULTS FOR THE WEEKLY PARTICULATE AIR SAMPLE

Constituent	Number Samples	Geometric Mean Concentration $\mu g/m^3$	Maximum Concentration $\mu g/m^3$	Detection Limit $\mu g/m^3$
Suspended Particulate	20	17	80	0.2
Benzene Soluble Organic	20	1.2	2.9	0.4
Beryllium	20	--	0.00022	0.0002
Cadmium	17	0.0013	0.0033	0.0009
Lead	20	0.062	0.14	0.0009
Uranium	17	--	0.00068	0.00009

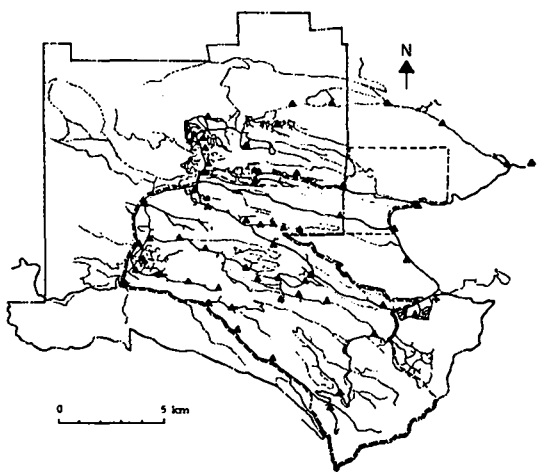

Fig. 6. Thermoluminescent dosimeter stations.

Correction for the dosimeter background has been made by subtracting 0.7 mR/day as based on the experience and data from other laboratories.[2,3] The two dosimeter systems are being phased out in favor of a system using LiF chips which do not suffer from this background.

A summary of the readings from these stations is given in Table X. Detailed comparison of the data from the two dosimeter systems indicated that there were no statistically significant deviations from average behavior for either system except at two locations during the month of June, where the EG&G dosimeters read significantly higher than the MBLE dosimeters. Both of these dosimeters read correctly on post-calibration. Since the MBLE dosimeters gave more normal readings it is concluded that there was no source of radiation at either station and that the over-response of the EG&G dosimeters was due to some artifact in the handling of the dosimeters. This type of sporadic behavior is not unusual for these TLD systems.

C. Water

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

1. General Techniques. Water samples are collected in new polyethylene bottles. For samples from wells other than supply 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 taken by the Zia Company the support contractor at Los Alamos, and are collected at the individual wells directly from the supply lines during pumping. 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 (see Appendix for gross alpha emitters, gross beta emitters, ^{3}T, U, ^{238}Pu and ^{239}Pu. Analyses for radium or strontium are performed if such analyses are indicated by the gross alpha

TABLE X

SUMMARY OF THERMOLUMINESCENT DOSIMETER READINGS

	EG & G Dosimeters				MBLE Dosimeters			
	Off-Site		On-Site		Off-Site		On-Site	
Month	N[a]	mR/Day	N	mR/Day	N	mR/Day	N	mR/Day
Jan	20	0.50±0.13[b]	37	0.53±0.13	20	0.20±0.12	37	0.21±0.12
Feb	22	0.44±0.11	37	0.52±0.11	22	0.20±0.10	37	0.21±0.09
Mar	21	0.29±0.11	36	0.31±0.09	21	0.20±0.10	37	0.21±0.12
Apr	21	0.20±0.09	37	0.28±0.12	21	0.18±0.10	37	0.21±0.13
May	22	0.26±0.10	35	0.31±0.09	22	0.26±0.12	37	0.31±0.15
Jun	21	0.24±0.14	34	0.31±0.12	20	0.22±0.11	36	0.24±0.09

[a] Number of stations included in the average.
[b] Standard deviation is given by the number following the ± sign.

or gross beta measurements. Standard chemical analyses are made for Ca, Mg, Na, Cl, F, NO_3, CO_3, HCO_3, Cr, total dissolved solids, hardness, pH and conductivity. Concentrations of Hg, Cd, Pb and Be or other metal ions are determined if deemed appropriate.

2. 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 the 16 deep supply wells completed into the main aquifer shown in Fig. 7. The wells range in depth from 870 to 2600 feet and supply over a billion gallons of water annually to the Los Alamos complex. Additional data was obtained from two test wells (also shown in Fig. 7) which are also completed into the main aquifer. The range and average of constituents in the water from the sixteen supply wells and the two test wells are shown in Table XI.

These results indicate no significant change in the water quality during this reporting period as compared to previous analyses. The maximum concentrations were all well below the limits defined by the U. S. Public Health Service standards for drinking water[4] and the concentration guides for radioactive materials as given in AEC Manual Chapter 0524.

3. Regional Surface Water. 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, 8 water samples were collected from rivers, the Rio Chama at Chamita and the Rio Grande at Embudo, Otowi and Cochiti (Fig. 8). In addition 8 samples were taken from the following bodies of water: the Caliente River, Santa Cruz Reservoir, Galisteo Reservoir, the Rio Grande at Bernalillo, Jemez Reservoir, Jemez Creek, Fenton Lake, Abiquiu Reservoir (Fig. 8). The range and average of constituents of water from these sampling stations is shown in Table XII.

The quality of this type of water may change drastically due to variations in discharge and in size and terrain of the drainage area. For example, Galisteo Reservoir (listed separately in Table XII) is used for flood control and is fed by an intermittent stream which drains an area underlain by red beds composed of shales and sandstones. The large mineral and metal ion concentrations in water from Galisteo Reservoir is directly attributable to leaching of these beds by storm runoff.

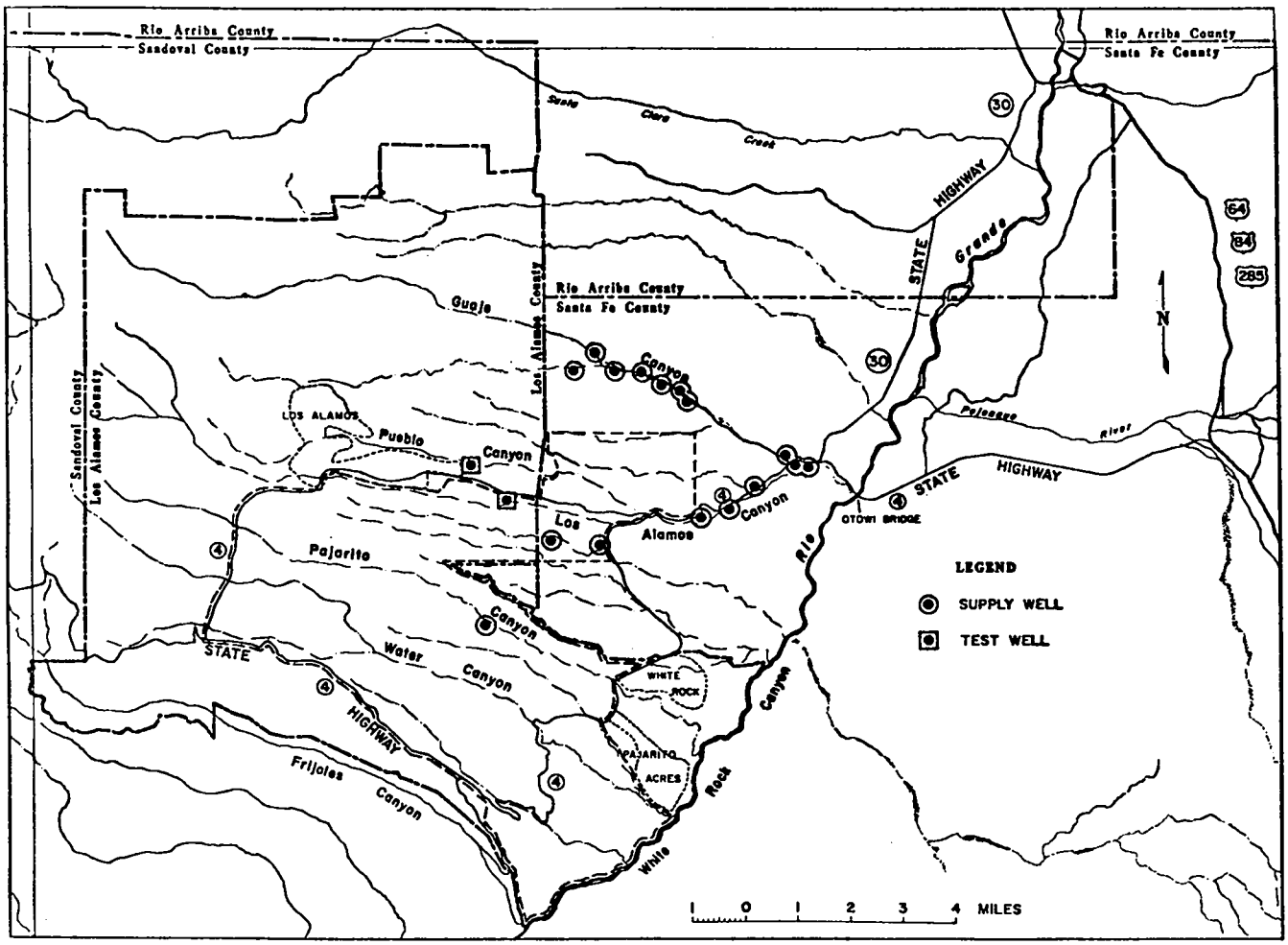

Fig. 7. Supply and test wells at Los Alamos.

TABLE XI

ANALYSIS OF WATER FROM SUPPLY AND TEST WELLS

Determination	Units	Number Samples	Range Min	Range Max	Range Av	Detection Limit
Gross Alpha	$\mu Ci/ml \times 10^{-9}$ [a]	18	<2.0	15	2.0	2.0
Gross Beta	$\mu Ci/ml \times 10^{-9}$	18	<2.0	7.2	3.0	2.0
Plutonium 238	$\mu Ci/ml \times 10^{-11}$	18	<5.0	<5.0	<5.0	5.0
Plutonium 239	$\mu Ci/ml \times 10^{-11}$	18	<5.0	<5.0	<5.0	5.0
Tritium	$\mu Ci/ml \times 10^{-6}$	18	<1.0	<1.0	<1.0	1.0
Natural Uranium	$\mu g/ml \times 10^{-4}$	18	<4.0	91	15	4.0
Chloride (Cl^-)	$\mu g/ml$	2	5.0	5.0	5.0	1.0
Fluoride (F^-)	$\mu g/ml$	2	0.6	0.8	0.7	0.1
Nitrate (NO_3^-)	$\mu g/ml$	2	<0.1	0.1	0.1	0.1
Dissolved Solids	$\mu g/ml$	2	86	106	96	--
Conductivity	$\mu mho/cm$	2	94	160	128	--

[a] The first entry under Range is read $<2.0 \times 10^{-9}$ $\mu Ci/ml$.

TABLE XII

ANALYSIS OF WATER FROM REGIONAL SAMPLING STATIONS

Determination	Units	Number Samples	Range Min	Range Max	Range Av	Galisteo Reservoir	Detection Limit
Gross Alpha	$\mu Ci/ml \times 10^{-9}$ [a]	15	<2.0	2.8	2.0	<2.0	2.0
Gross Beta	$\mu Ci/ml \times 10^{-9}$	15	<2.0	12	4.3	7.0	2.0
Plutonium-238	$\mu Ci/ml \times 10^{-11}$	15	<5.0	<5.0	<5.0	<5.0	5.0
Plutonium-239	$\mu Ci/ml \times 10^{-11}$	15	<5.0	<5.0	<5.0	<5.0	5.0
Tritium	$\mu Ci/ml \times 10^{-6}$	15	<1.0	<1.0	<1.0	<1.0	1.0
Natural Uranium	$\mu g/ml \times 10^{-4}$	15	<4.0	27	11	68	4.0
Chloride (Cl^-)	$\mu g/ml$	11	<1.0	95	12	30	1.0
Fluoride (F^-)	$\mu g/ml$	11	<0.1	1.0	0.4	1.5	0.1
Nitrate(NO_3^-)	$\mu g/ml$	11	<0.1	0.4	0.1	<0.1	0.1
Dissolved Solids	$\mu g/ml$	11	52	498	205	1812	--
Conductivity	$\mu mho/cm$	11	94	780	265	1800	--
Mercury (Solid)	$\mu g/ml \times 10^{-4}$	7	<0.6	<0.6	<0.6	<0.6	0.6
Mercury (Suspended)	$\mu g/ml \times 10^{-4}$	7	<1.0	<1.0	<1.0	<1.0	1.0
Beryllium	$\mu g/ml \times 10^{-4}$	7	<5.0	<5.0	<5.0	<5.0	5.
Lead	$\mu g/ml \times 10^{-4}$	7	<50	110	60	180	50
Cadmium	$\mu g/ml \times 10^{-4}$	7	<5.0	85	26	210	5.0

[a] The first entry under Range is read $<2.0 \times 10^{-9}$ $\mu Ci/ml$.

Furthermore, the sample was taken below the spillway from a pond which was being reduced in size by evaporation, thus concentrating the constituents in the remaining water.

4. General Surveillance. Samples of sewage effluent, surface water, shallow ground water and water from nearby reservoirs used for irrigation were collected and analyzed to help assess the overall impact of the Laboratory operations on the environment. Sampling locations are given in Fig. 9.

The range and average of constituents in sewage effluent from four off-site municipal sewage treatment ponds and lagoons is shown in Table XIII. The positive value of 7×10^{-11} $\mu Ci/ml$ for ^{239}Pu was detected in the sample from the Pueblo Treatment Plant. This is a very low value and is probably due to contamination in the handling of the sample prior to or during analysis. However, since this station had not been collected in the past,

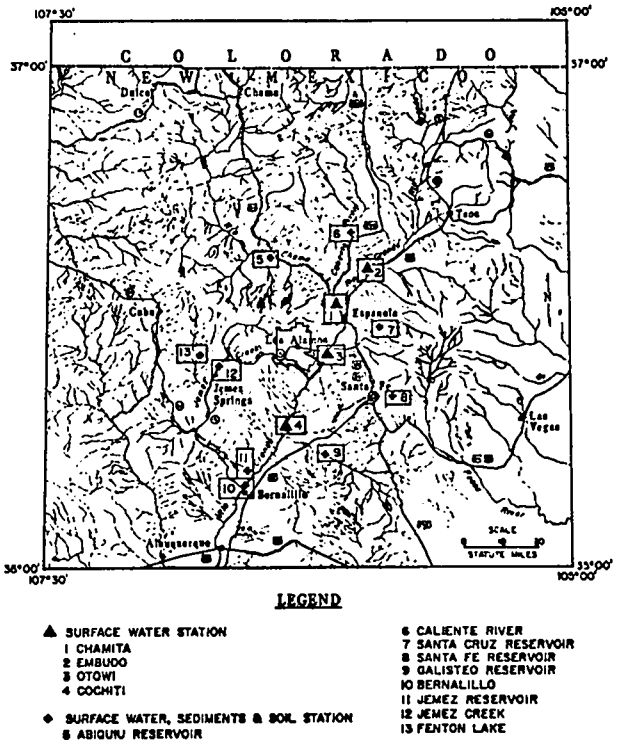

Fig. 8. Regional surface water, sediment and soil sampling stations.

TABLE XIII

ANALYSIS OF EFFLUENTS FROM SEWAGE TREATMENT PLANTS

Determination	Units	Number Samples	Range Min	Range Max	Range Av	Detection Limit
Gross Alpha	$\mu Ci/ml \times 10^{-9}$ [a]	4	<2.0	<2.0	<2.0	2.0
Gross Beta	$\mu Ci/ml \times 10^{-9}$	4	12	40	27	2.0
Plutonium-238	$\mu Ci/ml \times 10^{-11}$	4	<5.0	<5.0	<5.0	5.0
Plutonium-239	$\mu Ci/ml \times 10^{-11}$	4	<5.0	7.0	6.0	5.0
Tritium	$\mu Ci/ml \times 10^{-6}$	4	<1.0	<1.0	<1.0	1.0
Natural Uranium	$\mu g/ml \times 10^{-4}$	4	6.0	20	9.0	4.0
Chloride (Cl^-)	µg/ml	4	30	80	44	1.0
Fluoride (F^-)	µg/ml	4	0.4	1.0	0.7	0.1
Nitrate (NO_3^-)	µg/ml	4	0.4	13	5.2	0.1
Dissolved Solids	µg/ml	4	418	590	478	--
Conductivity	µmho/cm	4	520	640	570	--

[a] The first entry under Range is read $<2.0 \times 10^{-9}$ µCi/ml.

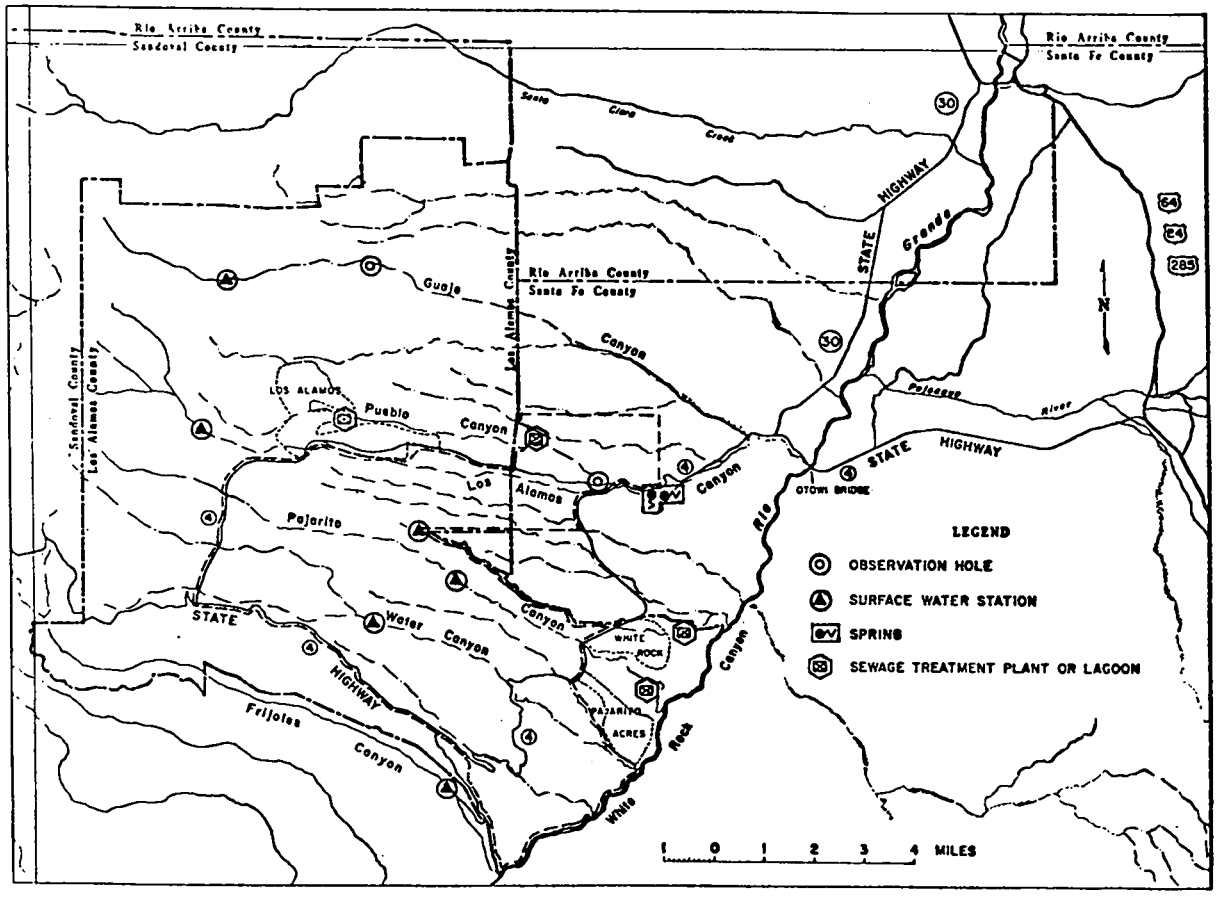

Fig. 9. Surveillance water sampling stations.

verification will have to wait until the next reporting period.

The range and average of the measurements on water samples from four streams, two reservoirs, two springs and two observation holes are given in Table XIV. The results indicate no anomalies. The observation holes are shallow penetrations into the alluvium underlying the canyons and the samples represent water which has seeped into the alluvium and is essentially static. Three of the intermittent flow stations and one observation hole are on-site.

D. Sediments

Sediments are those earthen materials which have been transported and reworked by surface water. Samples are collected at the 40-50 km distant stations from which regional surface water samples are taken. In addition, samples are taken for general surveillance from stream beds in the

TABLE XIV

ANALYSIS OF WATER FROM STREAM, RESERVOIR, SPRING AND OBSERVATION HOLE SURVEILLANCE STATIONS

Constituent	Units	Number Samples	Range Min	Range Max	Range Av	Detection Limit
Off-site stations:						
Gross alpha	$\mu Ci/ml \times 10^{-9}$ [a]	6	< 2.0	2.4	2.0	2.0
Gross beta	$\mu Ci/ml \times 10^{-9}$	6	< 2.0	2.3	2.1	2.0
Plutonium-238	$\mu Ci/ml \times 10^{-11}$	6	< 5.0	< 5.0	< 5.0	5.0
Plutonium-239	$\mu Ci/ml \times 10^{-11}$	6	< 5.0	< 5.0	< 5.0	5.0
Tritium	$\mu Ci/ml \times 10^{-6}$	6	< 1.0	< 1.0	< 1.0	1.0
Natural uranium	$\mu g/ml \times 10^{-4}$	6	< 4.0	14	7.0	4.0
Chloride (Cl^-)	$\mu g/ml$	5	< 1.0	25	7.6	1.0
Fluoride (F^-)	$\mu g/ml$	5	< 0.1	0.4	0.2	0.1
Nitrate (NO_3^-)	$\mu g/ml$	5	< 0.1	2.8	1.1	0.1
Dissolved Solids	$\mu g/ml$	5	110	364	203	---
Conductivity	$\mu mho/cm$	4	90	290	180	---
On-site stations:						
Gross alpha	$\mu Ci/ml \times 10^{-9}$	4	< 2.0	2.2	2.0	2.0
Gross beta	$\mu Ci/ml \times 10^{-9}$	4	2.3	6.8	3.6	2.0
Plutonium-238	$\mu Ci/ml \times 10^{-11}$	4	< 5.0	< 5.0	< 5.0	5.0
Plutonium-239	$\mu Ci/ml \times 10^{-11}$	4	< 5.0	< 5.0	< 5.0	5.0
Tritium	$\mu Ci/ml \times 10^{-6}$	4	< 1.0	4.0	1.8	1.0
Natural uranium	$\mu g/ml \times 10^{-4}$	4	< 4.0	7.0	4.8	4.0
Chloride (Cl^-)	$\mu g/ml$	4	5.0	45	19	1.0
Fluoride (F^-)	$\mu g/ml$	4	< 0.1	1.8	0.7	0.1
Nitrate (NO_3^-)	$\mu g/ml$	4	0.1	2.8	0.9	0.1
Dissolved Solids	$\mu g/ml$	4	160	262	198	---
Conductivity	$\mu mho/cm$	4	150	380	227	---

[a] The first entry under Range is read $< 2.0 \times 10^{-9}$ $\mu Ci/ml$.

canyons in the vicinity of the Laboratory. Some of these streams occur naturally and may flow intermittently only in the rainy season or continuously, and some are produced by effluents from laboratory or municipal facilities.

1. General Techniques. Sediment samples from perennial streams are taken from dunes built up in eddies behind boulders in the main channel. In still water the samples are dredged from the bottom with a bailer at some convenient point. From the intermittent streams, the samples are collected across the main channel to a depth of about one inch with a three inch scoop. The samples are placed in unused polyethylene containers for storage and transport to the laboratory. Analyses are made by leaching the samples with acids (see Appendix F) with determinations of gross alpha emitters, gross beta emitters, plutonium and uranium made on the acid leach. Strontium analyses are performed if the gross beta activity is high.

2. Sediments from Regional Surface Waters. Sediments were collected and analyzed from the regional surface water sampling stations shown in Fig. 8 to provide general data on the quantities of radioactive materials in the environment beyond the general Laboratory area. The locations of these stations are shown in Fig. 8, and the results of the analyses are given in Table XV.

3. Sediments for General Surveillance. Locations of these sediment sampling stations are shown in Fig. 10. The results of the analyses for on-site and off-site samples are given in Table XVI.

In general the results from this sampling program appear to be about as expected. Concentrations of plutonium lie in the range expected from fallout with the exception of the five samples taken from Pueblo, Los Alamos, and Mortandad Canyons.

The area from which the two Pueblo Canyon samples were taken is known to have trace amounts of plutonium as a result of earlier releases of industrial effluents into Acid Canyon, a tributary to Pueblo Canyon, a short distance above these sampling points. These effluents were released from 1949 through 1962, and the treatment plant has since been dismantled. The results of this program are in agreement with and confirm values reported earlier for this region.[5]

The two positive Los Alamos Canyon samples were also from an area known to contain small quantities of this material washed down the canyon from effluent disposal operations in DP Canyon which is tributary to Los Alamos Canyon several miles upgrade (see Section III. B.).

TABLE XV

ANALYSIS OF SEDIMENTS FROM REGIONAL SURFACE WATERS

Determination	Unit	Number Samples	Range Min	Range Max	Range Av	Detection Limit
Gross alpha	$\mu Ci/g \times 10^{-6}$ [a]	9	1.1	8.6	3.4	1.0
Gross beta	$\mu Ci/g \times 10^{-6}$	9	1.1	6.7	3.5	1.0
Plutonium-238	$\mu Ci/g \times 10^{-9}$	9	< 1.0	3.0	1.7	1.0
Plutonium-239	$\mu Ci/g \times 10^{-9}$	9	1.0	5.0	3.1	1.0
Natural uranium	$\mu g/g \times 10^{-6}$	9	< 1.0	13	5.2	1.0

[a] The first entry under Range is read 1.1×10^{-6} $\mu Ci/g$.

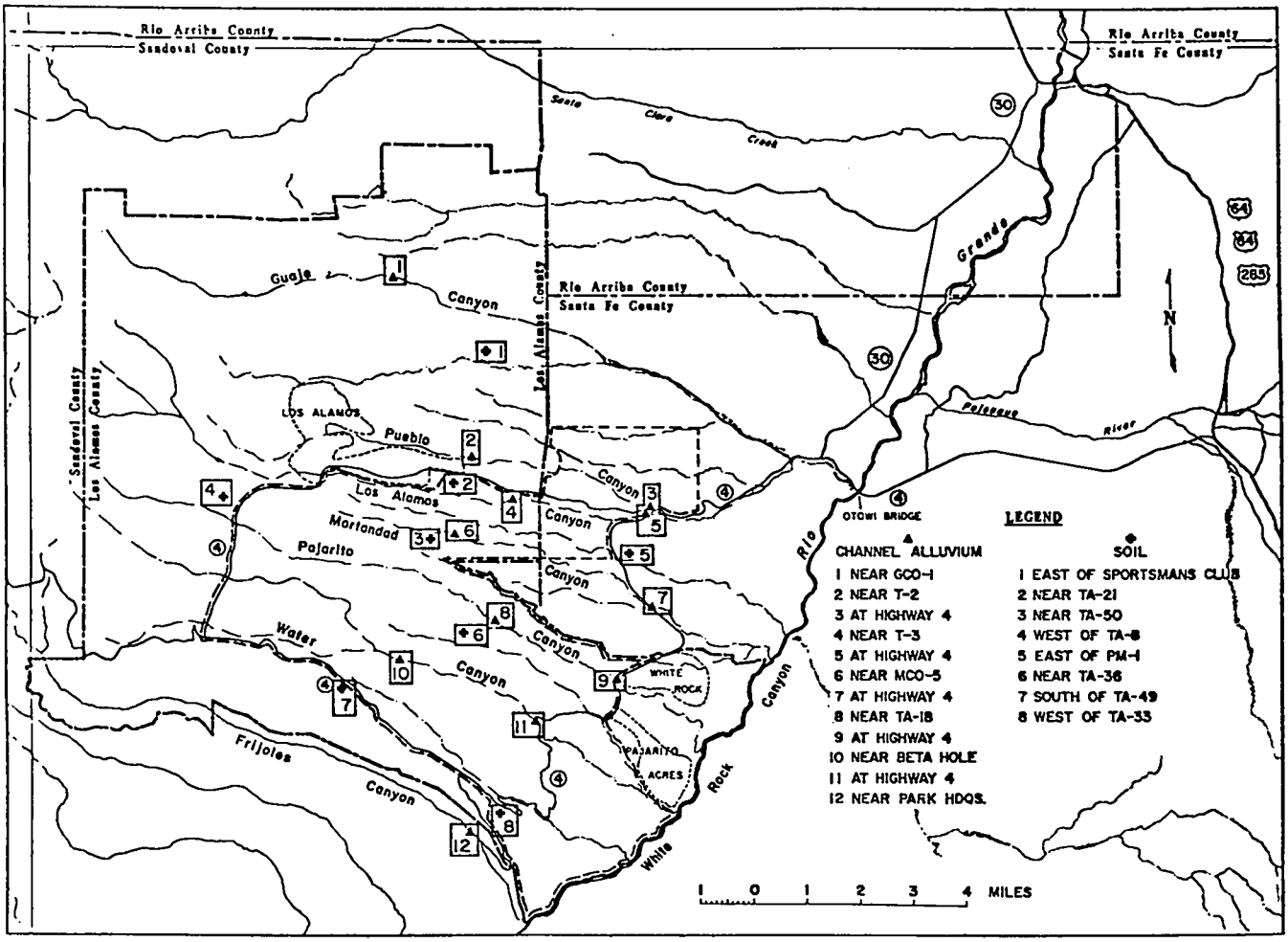

Fig. 10. Surveillance sampling stations for sediment and soil.

The concentrations measured are essentially the same as those reported earlier.[5]

The positive Mortandad Canyon sample reflects operations at the central liquid waste treatment plant at TA-50, which discharges liquid effluent into Effluent Canyon, a tributary to Mortandad Canyon a short distance upstream of the sample collection station (see Section III. B.). Again, the values reported here agree with those reported earlier.[5]

E. Soils

Soils are those earthen materials which are weathered in place. They are sampled primarily to indicate the possibility of deposition of contaminants from the atmosphere. Again, samples are taken at the regional surface water stations and at stations established for general surveillance in the vicinity of Los Alamos.

1. General Techniques. Samples are collected by taking five plugs, three inches in diameter and two inches deep, at the corners and center of a square ten meters on a side. The five plugs are composited into a single sample and analyzed for gross beta emitters, gross alpha emitters, plutonium and uranium by the methods outlined in Appendix F.

2. Soils in Vicinity of Regional Surface Waters. 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 XVII. The values are in line with those expected

TABLE XVI

ANALYSIS OF SEDIMENTS COLLECTED FOR GENERAL SURVEILLANCE

Determination	Units	Number Samples	Range Min	Range Max	Range Av	Detection Limit
Off-site samples:						
Gross alpha	$\mu Ci/gx10^{-6}$ [a]	5	1.2	7.4	3.2	1.0
Gross beta	$\mu Ci/gx10^{-8}$	5	1.9	3.7	2.6	1.0
Plutonium-238	$\mu Ci/gx10^{-9}$	5	1.0	16	4.8	1.0
Plutonium-239	$\mu Ci/gx10^{-9}$	4 [b]	2.0	9.0	4.8	1.0
Natural uranium	$\mu g/gx10^{-8}$	5	7.0	19	13	1.0
On-site samples:						
Gross alpha	$\mu Ci/gx10^{-6}$	7	1.1	6.3	2.5	1.0
Gross beta	$\mu Ci/gx10^{-8}$	7	< 1.0	31	5.9	1.0
Plutonium-238	$\mu Ci/gx10^{-9}$	6 [c]	< 1.0	7.0	4.3	1.0
Plutonium-239	$\mu Ci/gx10^{-9}$	3 [d]	< 1.0	6.0	2.6	1.0
Natural uranium	$\mu g/gx10^{-8}$	5	7.0	81	25	1.0

[a] The first entry under Range is read 1.2×10^{-6} $\mu Ci/g$.

[b] Does not include one sample from Pueblo Canyon which gave $2.9x10^{-6}$ $\mu Ci/gm$.

[c] Does not include one sample from Mortandad Canyon which gave $1.6x10^{-6}$ $\mu Ci/gm$.

[d] Does not include one sample from Pueblo Canyon which gave $0.8x10^{-6}$ $\mu Ci/gm$, two samples from Los Alamos Canyon which gave $1.0x10^{-8}$ and $0.1x10^{-8}$ $\mu Ci/gm$ and one sample from Mortandad Canyon which gave $1.1x10^{-6}$ $\mu Ci/gm$.

TABLE XVII

ANALYSIS OF SOILS IN VICINITY OF REGIONAL SURFACE WATERS

Determination	Units	Number Samples	Range Min	Range Max	Range Av	Detection Limit
Gross alpha	$\mu Ci/gx10^{-6}$ [a]	10	<1.0	6.3	3.3	1.0
Gross beta	$\mu Ci/gx10^{-6}$	10	3.1	9.2	5.2	1.0
Plutonium-238	$\mu Ci/gx10^{-9}$	10	< 1.0	11	2.7	1.0
Plutonium-239	$\mu Ci/gx10^{-9}$	10	3.0	25	10	1.0
Natural uranium	$\mu Ci/gx10^{-8}$	10	8.0	31	19	1.0

[a] The first entry under Range is read $<1.0 \times 10^{-6}$ $\mu Ci/g$.

TABLE XVIII

ANALYSIS OF SOILS TAKEN FOR GENERAL SURVEILLANCE

Determination	Units	Number Samples	Range Min	Range Max	Range Av	Detection Limit
Off-site stations:						
Gross alpha	$\mu Ci/g \times 10^{-6}$ [a]	4	3.9	4.6	4.1	1.0
Gross beta	$\mu Ci/g \times 10^{-6}$	4	4.8	5.7	5.1	1.0
Plutonium-238	$\mu Ci/g \times 10^{-9}$	4	< 1.0	2.0	1.5	1.0
Plutonium-239	$\mu Ci/g \times 10^{-9}$	4	7.0	15	12	1.0
Natural uranium	$\mu g/g \times 10^{-6}$	4	33	49	38	1.0
On-site stations:						
Gross alpha	$\mu Ci/g \times 10^{-6}$	4	2.8	5.0	3.8	1.0
Gross beta	$\mu Ci/g \times 10^{-6}$	4	4.5	7.0	5.6	1.0
Plutonium-238	$\mu Ci/g \times 10^{-9}$	4	< 1.0	3.0	1.8	1.0
Plutonium-239	$\mu Ci/g \times 10^{-9}$	2 [b]	12	18	15	1.0
Natural uranium	$\mu g/g \times 10^{-6}$	3	66	84	77	1.0

[a] The first entry under Range is read 3.9×10^{-6} $\mu Ci/g$.

[b] Does not include one sample from TA-21 which gave 2.2×10^{-7} $\mu Ci/g$ and one from near TA-50 which gave 1.1×10^{-7} $\mu Ci/g$.

from natural radioactivity and fallout from past weapons tests.[6]

3. Soils for General Surveillance. A summary of the results from the samples taken in the vicinity of Los Alamos County is given in Table XVIII.

The values found are again in general agreement with those expected from natural activity and fallout from past weapons tests with the exception of two samples. These two samples, which were high in plutonium, were taken from areas known to be contaminated from airborne effluents. There may be an indication that the amount of uranium increases in the on-site samples, particularly as compared to the values from the regional network, but the small number of samples taken during this period preclude a firm conclusion. This possible variation will be examined in more detail as the number of samples increases. Again, the results of these samples are in line with the previous samples taken in these areas.[7]

V. SPECIAL MONITORING PROGRAMS

In addition to the routine monitoring programs designed to provide continuing surveillance of the general area, special programs are undertaken to provide more intensive coverage of areas of particular interest or to study in detail individual possible sources of exposure. These programs may be single investigations or on-going studies designed to provide increased information on the ultimate fate of materials discharged to the environs.

A. Studies of Water in Effluent Discharge Areas

Routine monitoring of surface water and ground water in alluvium is conducted at on-site locations in areas where liquid effluent is released from waste treatment plants or other laboratory

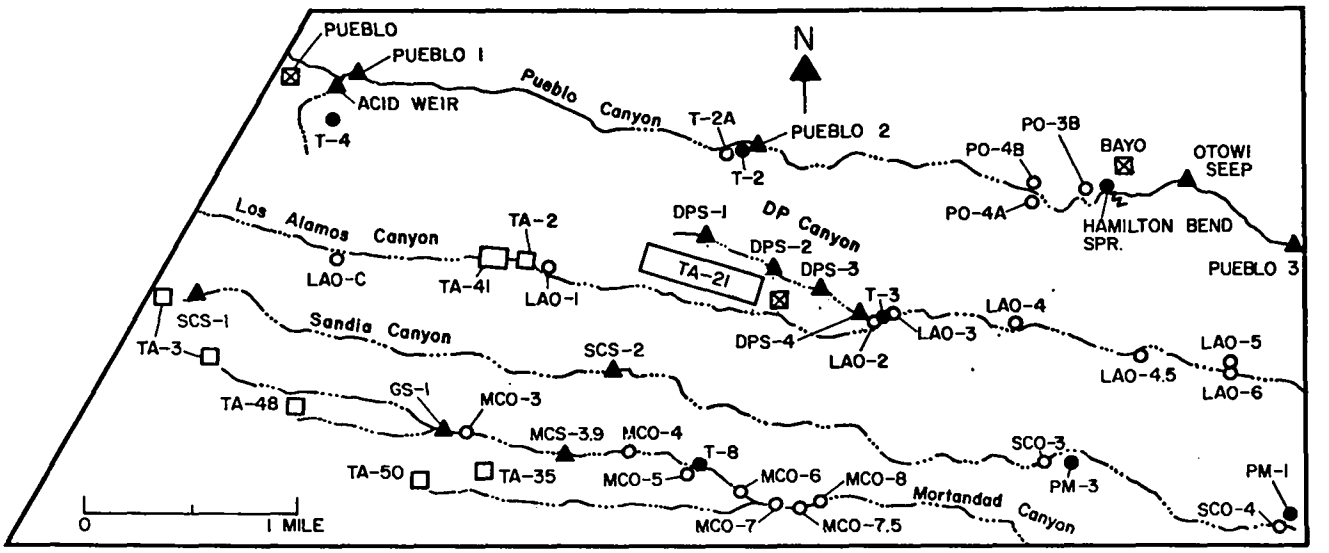

Fig. 11. Sampling stations for studies of water in effluent discharge areas.

facilities. Monitoring was accomplished in DP, Los Alamos, Sandia and Mortandad Canyons during this period at the stations shown in Fig. 11.

This program is a continuing one designed to study the movement and fate of the low levels of contamination in the effluents. As such, the significant feature is the long range trend rather than the concentration in any one sample or even a short term series of samples. It can be expected that the values obtained from single samples will vary with the character of the effluent discharged before the sample is taken, with the amount of rainfall in the immediately preceding period, and with the amount of water stored in the alluvium as effected by the rainfall in the drainage area over the preceding few months. In addition, one cannot characterize the overall results with a simple analysis such as the average or the maximum since there are wide variations in concentrations as one proceeds down canyon from the outfall. For these reasons, only a summary of the results of this monitoring effort is presented in this report.

A more detailed analysis will be discussed in separate documents.[8,9]

1. DP and Los Alamos Canyons. DP Canyon receives the effluent from the liquid waste treatment plant serving the TA-21 complex, which includes the main facilities for the processing of plutonium metal and for the developmental work on ^{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, together with effluent from a sewage treatment plant and from cooling towers, provides 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 the treatment plant outfall. The results from these samples are given in Table XIX.

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 as one progresses downstream is apparent.

TABLE XIX

ANALYSIS OF WATER FROM DP AND LOS ALAMOS CANYONS
DOWNSTREAM FROM THE TA-21 LIQUID WASTE TREATMENT PLANT

	Units	Station					
		DPS-1[a]	DPS-2	DPS-4	LAO-1	LAO-3	LAO-4.5
No. Samples		2	1	2	2	1	1
Gross alpha	$\mu Ci/ml \times 10^{-9}$ [b]	30	5	5	<2	<2	<2
Gross beta	$\mu Ci/ml \times 10^{-9}$	2000	640	590	110	190	7
Plutonium-238	$\mu Ci/ml \times 10^{-11}$	90	560	8	5	10	5
Plutonium-239	$\mu Ci/ml \times 10^{-11}$	2200	70	<5	5	5	<5
Americium-241	$\mu Ci/ml \times 10^{-11}$	240[c]	250	5	---	---	---
Cesium-137	$\mu Ci/ml \times 10^{-9}$	1700	500	<500	<500	<500	<500
Strontium-90	$\mu Ci/ml \times 10^{-9}$	300[c]	380	320[c]	80[c]	---	---
Uranium-234	$\mu Ci/ml \times 10^{-9}$	1	2	3[c]	---	---	---
Tritium	$\mu Ci/ml \times 10^{-6}$	160	200	110	50	20	30
Natural uranium	$\mu g/ml \times 10^{-4}$	---	---	---	12	<4	12
Chloride (CL^-)	µg/ml	110	15	55	25	50	40
Fluoride (F^-)	µg/ml	6	4	6	1	6	<1
Nitrate (NO_3^-)	µg/ml	21	8	10	2	5	1
Dissolved Solids	µg/ml	1200	640	570	410	430	310
Conductivity	µmho/cm	1420	330	700	460	520	260

[a] Effluent stream near TA-21 treatment plant outfall.

[b] The first activity entry under DPS-1 is used 30×10^{-9} µCi/ml.

[c] One sample.

2. Sandia Canyon. Sandia Canyon receives the effluent from the cooling towers at the power plant 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 XX.

Again averages for the two samples collected at each location are given. The presence of hexavalent chromium in this stream is due to the use of this material in the cooling tower water as a corrosion inhibitor. This material will be removed from effluent water by a processing plant which is now in the planning stage. The positive values for ^{238}Pu in the two samples analyzed for this material is unexpected and may be due to transfer of contamination in the Laboratory.

3. Mortandad Canyon. Mortandad Canyon receives the effluent from the central waste treatment plant at TA-50 which processes the industrial liquid wastes from the majority of the Laboratory technical areas. 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 use of established shallow observation holes. The results are given in Tables XXI and XXII, respectively.

The relatively rapid decrease in concentration as one progresses down canyon is apparent for most of the constituents. An exception is the increase in tritium which has been attributed to the down canyon progress of a slug of this material

TABLE XX

ANALYSIS OF WATER FROM SANDIA CANYON
DOWNSTREAM FROM THE POWER PLANT OUTFALL

	Units	SCS-1[a]	SCS-2
No. Samples	---	2	2
Gross alpha	$\mu Ci/ml \times 10^{-9}$[b]	< 2	< 2
Gross beta	$\mu Ci/ml \times 10^{-9}$	19	19
Plutonium-238	$\mu Ci/ml \times 10^{-11}$	6[c]	<5[c]
Plutonium-239	$\mu Ci/ml \times 10^{-11}$	< 5[c]	< 5[c]
Cesium-137	$\mu Ci/ml \times 10^{-9}$	< 500	< 500
Tritium	$\mu Ci/ml \times 10^{-6}$	6	10
Natural uranium	$\mu g/ml \times 10^{-4}$	< 4	< 4
Chloride (Cl^-)	µg/ml	50	70
Fluoride (F^-)	µg/ml	2	3
Nitrate (NO_3^-)	µg/ml	5	5
Chromate (Cr^{+6})	µg/ml	12[c]	9[c]
Dossolved Solids	µg/ml	650	830
Conductivity	µmho/cm	715	850

[a] Effluent stream near outfall from Power Plant.

[b] The first activity entry under SCS-1 is read $<2 \times 10^{-9}$ µCi/ml

[c] One sample.

released from the TA-50 treatment plant several years ago.

B. Environmental Studies at S-Site (TA-16)

A study[10] was conducted by Group GMX-3 to examine the extent to which activities at S-Site added certain contaminants to the environment. The materials investigated were the explosives TNT (2, 4, 6 - Trinitrotoluene), RDX (cyclotrimethylenetrinitramine) and HMX (cyclotetramethylenetetranitramine), and the elements boron and barium. The objective was to determine the levels of contamination in effluent water, the concentrations of these elements and compounds which might build up in soil, and the sources and distances of travel of these species throughout the S-Site drainage area.

It was shown that only very small quantities of the explosive compounds travel more than a mile or so from their sources. The highest concentrations of RDX-HMX (the two compounds were indistinguishable by the colorimetric analytical technique) in water samples were 1 ppm at one outfall and 1.5 ppm near another. The compounds were essentially undetectable a few hundred yards from either one. TNT was found at concentrations in water of 72 ppm and 3 ppm at these same two sampling stations and again, it was undetectable within a few hundred yards of the outfall. The maximum concentrations in soil samples were 11 ppm and 1 ppm for TNT and RDX-HMX respectively.

No sample exhibited the presence of boron. Barium appeared to travel farther than any of the other materials. Maximum water concentrations were 22 and 30 ppm near the outfalls noted above and was still detectable in a sample collected about 2 miles away after a heavy rainstorm. The

TABLE XXI

ANALYSIS OF WATER FROM EFFLUENT STREAM

IN MORTANDAD CANYON DOWNSTREAM FROM TA-50 OUTFALL

	Units	Station		
		GS-1[a]	MCS-3.9	Near MCO-4
No. Samples	---	3	2	1
Gross alpha	$\mu Ci/ml \times 10^{-9}$[b]	130	22	45
Gross beta	$\mu Ci/ml \times 10^{-9}$	1800	1100	300
Plutonium-238	$\mu Ci/ml \times 10^{-11}$	10000	420	10000
Plutonium-239	$\mu Ci/ml \times 10^{-11}$	780	40	500
Americium-241	$\mu Ci/ml \times 10^{-11}$	690	---	300
Cesium-137	$\mu Ci/ml \times 10^{-9}$	4700	<500	<500
Strontium-90	$\mu Ci/ml \times 10^{-9}$	300[c]	130[d]	90
Radium-226	$\mu Ci/ml \times 10^{-11}$	< 15[c]	---	< 15
Uranium-234	$\mu Ci/ml \times 10^{-9}$	3[c]	---	2
Tritium	$\mu Ci/ml \times 10^{-6}$	26	40	28
Natural uranium	$\mu g/ml \times 10^{-4}$	---	88	---
Chloride (Cl^-)	$\mu g/ml$	3[c]	30	---
Fluoride (F^-)	$\mu g/ml$	3[c]	2	---
Nitrate (NO_3^-)	$\mu g/ml$	12[c]	120	---
Dissolved Solids	$\mu g/ml$	620[c]	1200	---
Conductivity	$\mu mho/cm$	720[c]	1450	---

[a] Effluent stream near TA-50 outfall.

[b] The first activity entry under GS-1 is read 130×10^{-9}.

[c] Two samples.

[d] One sample.

maximum concentration in soil was 19 ppm.

No previous data are available for comparison. More studies will undoubtedly be carried out in the future so that an evaluation can be made regarding length of time required for buildup in soil and speed of movement down the canyons.

VI. DISCUSSION

The results of the monitoring program for this 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 somewhat above that expected from past weapons testing; and that the off-site concentrations of tritium appear to be about twice that encountered at locations distant from the

TABLE XXII

ANALYSIS OF WATER FROM OBSERVATION HOLES

IN MORTANDAD CANYON DOWNSTREAM FROM TA-50 OUTFALL

	Units	MCO-3	MCO-4	MCO-5	MCO-6	MCO-7	MCO-7.5
No. Samples		2	2	2	2	2	1
Gross alpha	$\mu Ci/ml \times 10^{-9}$ [a]	30	2	<2	<2	<2	<2
Gross beta	$\mu Ci/ml \times 10^{-9}$	2400	470	200	200	100	100
Plutonium-238	$\mu Ci/ml \times 10^{-11}$	2500	5	11	5	<5	10
Plutonium-239	$\mu Ci/ml \times 10^{-11}$	280	14	<5	<5	<5	<5
Cesium-137	$\mu Ci/ml \times 10^{-9}$	3900	<500	<500	<500	<500	<500
Strontium-90	$\mu Ci/ml \times 10^{-9}$	120[b]	75[b]	<9[b]	<9[b]	---	---
Tritium	$\mu Ci/ml \times 10^{-6}$	42	50	84	70	170	180
Natural uranium	$\mu g/ml \times 10^{-4}$	140	38	15	11	10	11
Chloride (Cl^-)	$\mu g/ml$	20	30	25	25	25	20
Fluoride (F^-)	$\mu g/ml$	3	1	1	1	1	1
Nitrate (NO_3^-)	$\mu g/ml$	100	130	120	120	85	68
Dissolved Solids	$\mu g/ml$	1140	1200	1100	1100	800	830
Conductivity	$\mu mho/cm$	1400	1400	1300	1300	920	920

[a] The first activity entry under MCO-3 is read 30×10^{-9} $\mu Ci/ml$.

[b] One sample.

Laboratory.

In the following discussion we will use the concept of "dose commitment" which may be defined as the total radiation dose resulting from procedures carried out during a given period of activity, i.e., the dose received during the given period and the dose received during a subsequent period of specified length resulting from events which occurred during the given period. This is clearly an integration of the dose from the beginning of the given period of activity to the end of the specified period of dose accumulation. For the purposes of this report, the period of accumulation has arbitrarily been chosen as 50 years. The period of activity is 6 months, the length of the reporting period. Therefore the 50 year dose commitment is the dose received over a 50 year period resulting from the intake of a radionuclide during the 6 month reporting period. For an element with an effective half-life considerably less than 50 years, by far the greatest part of the dose is contributed during the first few years, so that the length of the accumulation period is unimportant so long as it is more than several half-lives in length. We thus speak merely of a "dose commitment" rather than a "50 year dose commitment." Furthermore, for an element with an effective half-life much less than 50 years, the dose is received substantially instantaneously, and we speak merely of "dose" rather than "dose commitment."

Using the constants listed in the 1959 ICRP internal dose report,[11] the highest off-site ^{238}Pu concentration was sufficient to produce, during the report period, a dose commitment for the lungs, assuming all of the material to be insoluble, of about 0.04 mrem. Alternatively, assuming all of the material to be soluble (20% transferred to bone, a Quality Factor

of 10 and a "non-uniform distribution factor" of 5), the 50 year dose commitment to bone was about 1.3 mrem. The actual dose commitment would lie somewhere between these two. In comparison, the guide value from AEC Manual Chapter 0524 for the dose commitment for bone or lungs is 1500 mrem for an individual or 500 mrem for a suitable sample of the population. The ^{239}Pu results show no significant difference between stations indicating that the source is probably worldwide fallout. This source (averaged over all off-site stations) contributed an estimated dose commitment of about 0.06 mrem to the lungs or 2.4 mrem to bone.

During the reporting period the average off-site tritium concentration in the Los Alamos area was sufficient to produce a whole body dose to the standard man of about 0.1 mrem, using the Quality Factor of 1.7 which was used in the derivation of the 1960 ICRP-NCRP maximum permissible concentrations which apparently served as the bases for the AEC Manual Chapter 0524 concentration guides. If the Quality Factor now accepted by the ICRP and NCRP of 1.0 is used for these low energy beta radiations, this dose is about 0.06 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 a suitable sample of the population.

Small quantities of plutonium and some beta emitters are found in several off the off-site canyons as a result of past disposal operations. These locations, while accessible to the public, are reasonably well isolated so that occupancy is limited to an occasional hiker or hunter. While it is impossible to estimate a possible dose or dose commitment from these deposits, the low occupancy factor and the association of the material with large quantities of soil preclude the uptake of any significant quantities by either people or animals.

Because of the low emissions of most radioactive materials which 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 of flora and fauna of the region. It is known, for example, that the primary route of entry of plutonium into the body is by inhalation and that considerable discrimination against plutonium is operative in several steps of the human food chains. As a result, no samples of this type of environmental medium were analyzed during this period. Plans are in progress to amplify this part of the work with emphasis on certain of the areas where past disposals have resulted in measurable concentrations of plutonium and beta emitters in the soils and in assessing the possible uptake of tritium in these types of material. For the reasons given above, 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.

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APPENDIX A

LABORATORY BOUNDARIES

A general description is given of the extent and boundaries of the real estate controlled by the AEC and utilized by the Los Alamos Scientific Laboratory. This area lies mostly in Los Alamos County, with only a small segment in Santa Fe County, and totals approximately 28,000 acres. This parcel of AEC controlled land contains all of the Laboratory technical areas. For this reason we shall refer to it as "the Laboratory area" or simply as "the site" with the clear understanding that this land does not actually belong to but is merely used by the Laboratory. The technical areas are principally located on the mesa tops with the interspersed canyons serving as separation areas although a few have been located at the bottoms of steep, narrow canyons for isolation and safety purposes.

The boundary lines (Fig. A-1) of the Laboratory area follow an irregular pattern. Starting at the intersection of State Highway Loop No. 4 and State Highway No. 4 the boundary extends in a southeasterly direction following State Highway No. 4 to a point about halfway between the Bandelier National Monument entrance and TA-33. From that point the boundary extends southerly to the Los Alamos-Sandoval County line and follows this line to the Rio Grande. Bandelier National Monument occupies the land to the south and west. It then follows the county line along the Rio Grande in a northeasterly direction to the western edge of the Pajarito Acres residential area. The Ramon Vigil Grant extends along the other side of the river. The boundary swings away from the river in a northwesterly

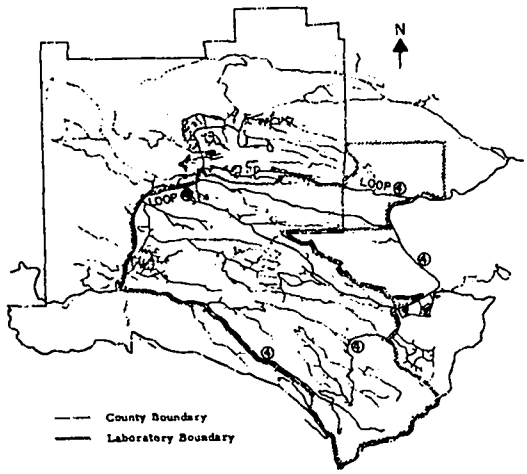

Fig. A-1. Los Alamos Scientific Laboratory site boundaries.

direction along the northeast edge of Potrillo Canyon to State Highway No. 4. It then continues in an easterly direction on the north side of State Highway No. 4 to the county line. The communities of Pajarito Acres, La Vista and White Rock lie to the south and east. The Laboratory boundary continues in a northwesterly direction along the Los Alamos-Santa Fe county line for about 14,000 feet and along the Los Alamos-Sandoval county line approximately 14,000 feet farther. At this point it turns to the east and continues in a straight line back to State Highway No. 4, initially following the county line for approximately 10,000 feet. The land lying outside of this easterly line and the previously described northwesterly line constitutes sacred areas of the San Ildefonso Indian Reservation. The Laboratory area boundary continues in a northerly and thence an easterly direction along the north side of State Highway No. 4 about 16,000 feet into Santa Fe County. A portion of Bandelier National Monument abuts this area. The Laboratory boundary then proceeds north about 8,000 feet, then west to the Los Alamos-Santa Fe county line and then south along this county line to the south side of State Highway Loop No. 4. The latter lines include the Otowi section tract. San Ildefonso Indian Reservation lies to the east, the Santa Fe National Forest lies to the north, and Los Alamos County property completes the contact along the west boundary. The Laboratory boundary continues in a westerly direction on the south side of State Highway No. 4 to a point adjacent to the west end of the Airport. It then swings to the south edge of the townsite mesa above Los Alamos Canyon and continues in a westerly direction with a northerly offset to include the Health Research Laboratory, TA-43. Continuing in a southwesterly direction on the northwestern side of State Highway Loop No. 4, the Laboratory boundary returns to our starting point at the intersection with State Highway No. 4. The Santa Fe National Forest lies on the other side of this boundary.

APPENDIX B

TECHNICAL AREAS AND ASSOCIATED PROGRAMS

The locations of the 29 active technical areas operated by the Laboratory are shown in Fig. 1 (Page 2), and the main programs conducted at each are listed below:

TA-2 - Omega Site: Two research reactors designed and built by LASL are located here. One is the "Water Boiler," the world's first homogeneous reactor, and the other is the Omega West Reactor, a swimming pool reactor. Each reactor serves as a research tool in providing a source of neutrons for fundamental studies in nuclear physics and associated fields.

TA-3 - South Mesa Site: This is the main technical area of the Laboratory. Situated here is the Administration Building which contains the office of the Director and the administrative offices and laboratories for several divisions. Other buildings house the Central Computing Facility, Personnel Department offices, Supply and Property, the science museum, Chemistry

and Metallurgy Division and Physics Division offices and laboratories, Occupational Health Laboratories, technical shops, cryogenics laboratories, Sherwood Program facilities, warehouses, the Van de Graaf accelerator, and the cafeteria.

TA-6 - Two Mile Mesa Site: This is one of three sites used in development of special detonators for initiation of high explosive systems. Fundamental and applied research in support of this activity includes investigation of phenomena associated with the initiation of high explosives and research in rapid shock-induced reactions with shock tubes and x-ray and electron densitometers. (Other two sites are TA-22 and TA-40)

TA-8 - GT Site (or Anchor Site West): This is a nondestructive testing site operated as a service facility for the entire Laboratory, maintaining capability in all modern nondestructive testing techniques for insuring quality of materials ranging from test weapon components to checking of high pressure dies and molds. Principal tools include radiographic techniques - x-ray machines to 1 million volts, 24-MeV betatron, radioactive isotopes, ultrasonic, penetrant, and electromagnetic methods.

TA-9 - Anchor Site East: This site is operated by Group GMX-2, the principal chemical research group in the GMX Division. It explores fabrication feasibility and physical properties, as well as basic evaluation, of explosives; and makes and evaluates novel organic compounds of possible interest as explosives. The group is also concerned with storage and stability problems of explosives.

TA-11 - K-Site: Facilities are located here for testing explosive components and systems under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely, and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested. Equipment includes a 160 foot high drop tower, a 100 foot long -24 inch bore air gun, a vibration tester for objects weighing up to 2,000 pounds, and controls and instrumentation for tests and testing equipment.

TA-14 - Q-Site: This is a firing site used for running various tests on relatively small explosive charges and for fragment impact tests.

TA-15 - R-Site: This is the home of PHERMEX - a multiple cavity electron accelerator capable of producing a very large flux of x-rays for certain weapons development problems and tests. This site is also used for the investigation of weapon functioning and weapon system behavior in non-nuclear tests, principally by electronic recording means.

TA-16 - This site is operated by Group GMX-3 whose activities are concerned with development, engineering design, pilot manufacture, environmental testing, and stockpile production liaison for nuclear weapon warhead systems. Development and testing of high explosives, plastics and adhesives, and process development for the manufacture of items using these and other materials are accomplished in extensive facilities.

TA-18 - Pajarito Laboratory Site: Experimental studies of the fundamental behavior of nuclear chain reactions with simple, low-power reactors called "critical assemblies" are conducted here. The experiments are operated by remote control and are observed by means of closed circuit television. The machines are housed in buildings known as "Kivas" and are used primarily to provide a controlled means of putting together a critical amount of fissionable material. This is done to study the effects of various shapes and sizes, and of adjacent materials. These machines are also used as sources of fission neutrons in large quantities for experimental purposes.

TA-21 - DP-Site: This site is divided into two primary research areas, DP West and DP East. DP West is concerned with plutonium research,

including production and fabrication of plutonium metal. DP East is the high temperature chemistry site where studies are conducted on the chemical stability and interaction of materials at temperatures up to and exceeding 6,000°F.

TA-22 - TD Site: See TA-6.

TA-28 - Magazine Area "A": Explosive storage area.

TA-33 - HP-Site: Design and development work on nuclear and other components of weapon systems are conducted here. A 175-mm self-propelled gun is part of the equipment used in the studies.

TA-35 - Ten Site: This is the headquarters of the Nuclear Safeguards research and development program at LASL which is concerned with techniques for non-destructive detection, identification, and analysis of fissionable isotopes. Research in the areas of electronics and heavy metals is also conducted here.

TA-36 - Kappa Site: Research on various explosive phenomena, such as detonation velocity, is conducted here.

TA-37 - Magazine Area "C": Explosive storage area.

TA-39 - Ancho Canyon Site: Non-nuclear weapon behavior is studied here, primarily by photographic techniques. Investigations into the various phenomenological aspects of the behavior of explosives and the interaction of explosives and explosions with other materials are also made.

TA-40 - DF-Site: See TA-6.

TA-41 - W-Site: This site is engaged primarily in engineering design and development of nuclear components including fabrication and evaluation of test materials for weapons. Also located here is an underground laboratory which was initially built to store nuclear material. Although this material is no longer stored here, the laboratory is still used for pure physics experiments.

TA-43 - Health Research Laboratory: The Biomedical Research Group does research here in the fields of cellular radiobiology, molecular radiobiology, biophysics, mammalian radiobiology and mammalian metabolism. A large medical library, special counters used to measure radioactivity in humans and animals, and animal quarters for dogs, mice and monkeys are also located in this building.

TA-46 - WA Site: This is where a large part of the nuclear rocket reactor work is conducted as part of the national program known as Project Rover. Here, studies of materials characteristics and design concepts are made.

TA-48 - Radiochemistry Site: LASL scientists and technicians at this site study the nuclear properties of radioactive materials by using the techniques of analytical and physical chemistry. Measurements of radioactive substances are made and "hot cells" are used for remote handling of radioactive materials.

TA-49 - Frijoles Mesa Site: Originally an explosives research area, this site has also been used for lightning studies in connection with the Vela Program.

TA-50 - Liquid Disposal Site: This site has the responsibility of treating and disposing of all contaminated liquid waste received from Laboratory technical areas and for development of improved methods of waste treatment and containment of radioactivity removed by treatment. Radioactive waste is piped to this site from nearly all tech areas.

TA-51 - Radiation Exposure Facility: Scientists at this site expose animals to a cobalt-60 radiation source to determine the biological effects of high and low dose rate gamma ray exposures.

TA-52 - Reactor Development Site: Home of UHTREX (Ultra High Temperature Reactor Experiment) now deactivated.

TA-53 - Meson Physics Site: This is where the Los Alamos Meson Physics Facility is being built. This is a $56 million proton linear

accelerator of energy more than 10 times higher than the highest-energy machine of this type now in operation. The facility will be utilized by scientists and physicians from throughout the country.

TA-54 - Materials Disposal Site (or Mesita del Buey): This is the principal LASL burial ground for radioactive materials.

APPENDIX C

GEOLOGY AND HYDROLOGY

The community and laboratories in Los Alamos County are located on the Pajarito Plateau, an apron 10 to 15 miles wide and 25 to 30 miles long around the eastern flanks of the Sierra de los Valles which forms the eastern mountain chain of the Jemez Caldera (Fig. C-1). The plateau slopes eastward from an altitude of about 7,800 ft along its western margin to about 6,200 ft. on the east where it terminates at the rim of the White Rock Canyon of the Rio Grande and on the northeast where it terminates at the Puye Escarpment. The surface of the plateau is cut into numerous narrow mesas by southeast trending intermittent streams.

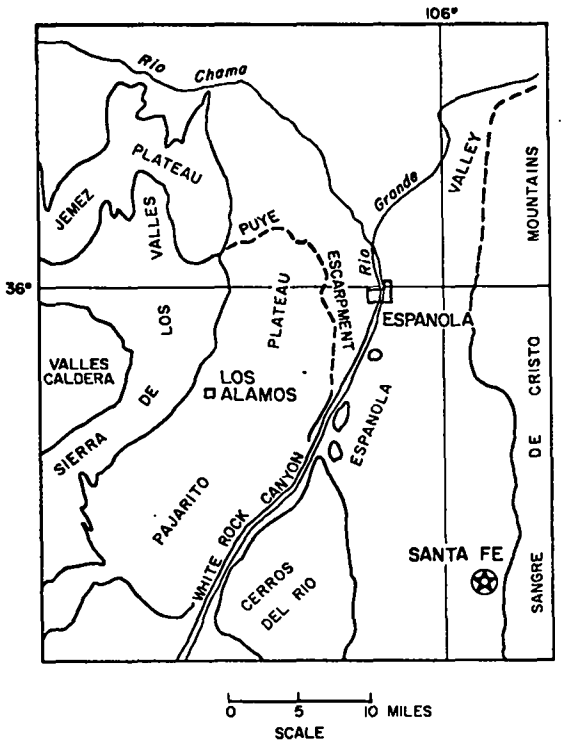

Fig. C-1. Topographic features in the Los Alamos area.

(Fig. C-2). The dissected eastern margin of the plateau stands 300 to 1,000 feet above the Rio Grande.

A brief description of the geology and hydrology of the area is included in this report as background material. The reader is referred to reports by Griggs,[1] Cushman,[2] and Purtymun and Cooper[3] for a more detailed discussion of the geology and hydrology of the Los Alamos Area.

The rock units and hydrologic characteristics described from oldest to youngest, are: the Tesuque Formation, Tschicoma Formation, Puye Formation, Bandelier Tuff and Alluvium.

The Tesuque Formation is a sequence of light-colored sediments laid down as coalescing alluvial fans and flood-plain deposits. The separate beds are composed of siltstone, sandstone and occasional lenses of clay and pebbly conglomerate. The zone of saturation is partly within the Tesuque Formation along the Rio Grande and within the Tesuque beneath the plateau.

The Tschicoma Formation is composed of volcanic flow rocks associated with the volcanic activity of the Jemez Caldera. They are undifferentiated latites and quartz latites and pyroclastic flow rocks that are highly jointed and fractured. These rocks form the mountains west of the plateau and are the recharge area for the zone of saturation. Some of the lower volcanic flow rocks are within the zone of saturation beneath the western part of the plateau.

The Puye Formation is a conglomerate composed of volcanic debris eroded from the Tschicoma Formation. The debris ranges from

Fig. C-2. Terrain model of Los Alamos, New Mexico, Area.

beds of ash to cobbles and boulders in an ash and gravel matrix. Basalt flow which originated from volcanic centers southeast of the area and flowed west and northwest are interbedded with the Puye Formation. The Puye Formation is above the zone of saturation along the Rio Grande while beneath the plateau the lower part lies within the zone of saturation. Basalt within the Puye contains perched water near the eastern edge of the plateau in Pueblo Los Alamos and Sandia Canyons.

The Bandelier Tuff is composed of a series of ashflows and ashfalls ranging from nonwelded to welded and forms the surface layer of the Pajarito Plateau. The tuff is above the zone of saturation and does not contain perched water beneath the plateau.

The recent alluvium in the canyons of the plateau consists of two types. Alluvium in canyons heading on the Sierra de los Valles crossing the plateau consists mainly of cobbles and boulders with sand and gravel derived from erosion of the Tschicoma Formation and some sand and gravel eroded from Bandelier Tuff. Alluvium in canyons heading on the Pajarito Plateau is composed mostly of sand and gravel with occasional cobbles and boulders of tuff. The alluvium contains water perched above the volcanic sediments or below rocks in some of the canyons of the plateau.

The Rio Grande, master stream of north-central New Mexico, flows along the eastern edge of the plateau. The upper reaches of Los Alamos and Guaje Canyons contain natural perennial flow from the flanks of the mountain. This flow is depleted by evaporation and infiltration into the underlying rock before it crosses the western third of the plateau. The perennial flow in the upper and mid reaches of Pueblo and Sandia Canyons on the plateau is from the release of treated sewage effluent. Intermittent flow in DP and the mid-reach of Mortandad Canyon is from

the release of treated industrial effluents. Generally only during periods of great precipitation (summer thunder showers) do the intermittent streams which cross the plateau carry surface runoff to the Rio Grande. Some of the canyons with small drainage area that head on the plateau never receive enough precipitation for storm runoff to reach the Rio Grande.

Ground water in the alluvium is found in places in Pueblo, Los Alamos, Sandia, and Mortandad Canyons and is probably found seasonally in the upper parts of other canyons which receive seasonal runoff from the mountains and plateaus. The water in alluvium is replenished from surface flow in the canyons either from storm runoff or from the release of sewage or industrial effluents.

As the water moves downgradient eastward in the alluvium, loss by evapotranspiration and by infiltration into the underlying volcanic sedimentsand volcanic rocks occurs so that the water in the alluvium is of limited extent existing as a thin narrow ribbon terminating on the plateau. Water in the alluvium does not move to the Rio Grande.

The evaporation of water in alluvium is high due to the fact that it is at shallow depths. Portions of canyons containing stream flow or water in alluvium are characterized by increased growth of grasses, plants, and trees which deplete a large percentage of the water by transpiration. Infiltration of water from alluvium into underlying volcanic sediments, such as in Pueblo and Los Alamos Canyons and be high. Water moving from alluvium in these canyons and possibly also in Sandia Canyon replenishes a perched body of ground water in the basalt. Water from this perched aquifer discharges from the base of the basalt and forms a series of falls in Los Alamos Canyon west of the Rio Grande.

The absence of perched water in the tuff or or volcanic sediments or basalt above the main aquifer indicates that infiltration of water from alluvium in stream channels into underlying tuff is small. This is due to the low permeability of the tuff.

DP, Los Alamos and Mortandad Canyons are examples of the relationship between surface water recharge and movement of ground water in the alluvium.

DP Canyon has a small drainage area on the plateau and receives treated effluent from the industrial waste treatment plant and from the sewage treatment plant at TA-21 (Fig. C-3). The channel is cut on bedrock tuff to a point about 1/4 mile west of the junction with Los Alamos Canyon. The surface flow infiltrates into the alluvium prior to reaching Los Alamos Canyon to replenish a small body of ground water in the alluvium which moves into the alluvium of Los Alamos Canyon.

Los Alamos Canyon heads on the flanks of the mountains west of the plateau and cuts across the plateau to the Rio Grande. It contains intermittent flow in the western part of the plateau and receives releases of sewage effluent and cooling water from TA-2 and TA-41. Only during heavy thunder showers does surface flow reach the Rio Grande. Flow in the canyon recharges the water in alluvium which ranges in thickness from 7 to about 20 feet. As the water moves eastward in the alluvium a part is lost to evapotranspiration while the rest is lost into the underlying volcanic sediments and basalts to recharge a body of water perched in the basalts near the junction with Pueblo Canyon.

Mortandad Canyon heads on the Pajarito Plateau and is tributary to the Rio Grande. The stream in the upper reach of the canyon is perennial due to cooling water from TA-48 and the release of treated low-level effluent from the waste treatment plant at TA-50. All storm runoff

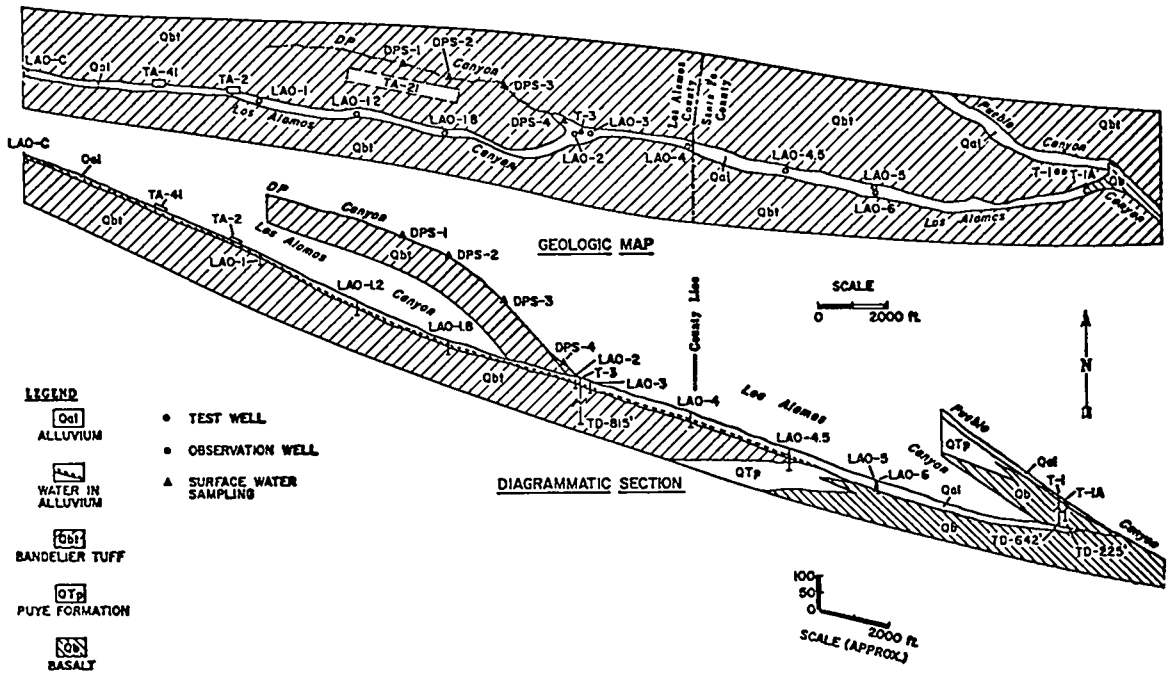

Fig. C-3. Planview and geologic section showing geology and hycrology of DP and Los Alamos Canyons.

infiltrated into the alluvium west of the Santa Fe-Los Alamos County line due to the small drainage area of the canyon and large volume of alluvium (Fig. C-4). Perennial flow and storm runoff recharges a body of water in the alluvium which is temporarily perched on the underlying tuff. As the water in the alluvium moves eastward steady loss to evapotranspiration with minor infiltration losses into the tuff occur so that the water in the alluvium is of limited extent.

The top of the main aquifer (ground water body capable of municipal and industrial water supply) in the Los Alamos Area rises from the Rio Grande westward through the Tesuque Formation into the lower part of the Puye Formation beneath the plateau. The depth of the main aquifer varies from about 1,200 feet along the western edge of the plateau to about 600 feet at the eastern margin. Water in the aquifer is moving eastward at about 1 foot per day toward the Rio Grande where some water is discharged through seeps and springs along the Rio Grande. The main aquifer, separated from the water in alluvium of streams and perched water in the basalts in lower Pueblo Canyon, is recharged through the precipitation on the banks and deep canyons cut into the flanks of the Sierra de los Valles.[2]

The Los Alamos area lies on the Rio Grande structural trough near large faults (Zone 2 on earthquake probability charts). The largest local fault, known as the Pajarito Fault, is located at the eastern edge of the Sierra de los Valles, just west of the Los Alamos area. Thus, earthquakes might occur at any time. There is no geologic or cultural evidence, however, to indicate that intensive earthquakes have occurred for hundreds and possibly thousands of years in this region.

A number of pinnacles 10 to 50 ft high, eroded from soft formations and capped with boulders 2 to 5 times the diameter of the supporting pinnacle, lie in Rendija Canyon, just north of Los Alamos. These formations are unstable and it is reasonable to think that they would topple

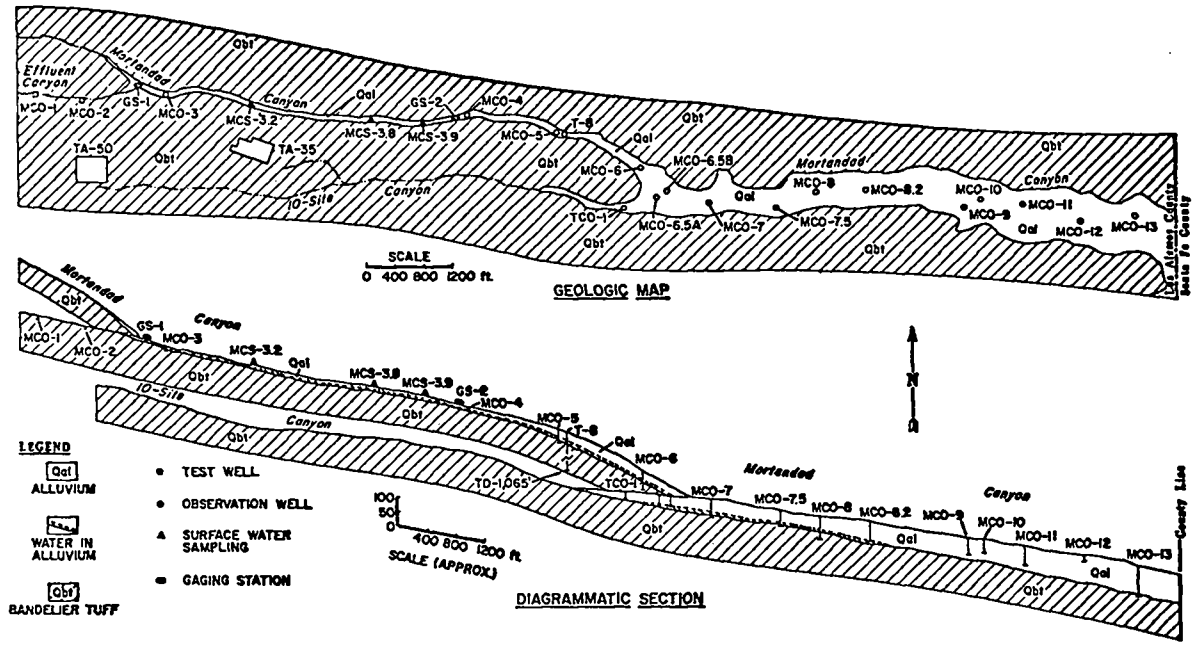

Fig. C-4. Planview and geologic section showing geology and hydrology of Mortandad Canyon.

under the influence of any sizable ground tremors. We note that a 60 foot pinnacle would require 75,000 to 120,000 years to develop with the erosion rate normal in the major canyons in the area.

Remains of Indian dwellings constructed with free standing walls with little lateral support indicate the absence of strong tremors for at least 500 years. Nearby pueblos that have been occupied continuously since the late sixteenth century, buildings in Santa Fe constructed by the Spanish in the early seventeenth century, and a lack of references to earthquakes in surviving records add support to this contention.

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2. Cushman, R. L., "An Evaluation of Aquifer and Well Characteristics of Municipal Well Fields in Los Alamos and Guaje Canyons, near Los Alamos, New Mexico," U. S. Geological Survey Water Supply Paper 1809-D, 1965.

3. Purtymun, W. D., and Cooper, J. B., "Development of Ground-Water Supplies on the Pajarito Plateau, Los Alamos County, New Mexico," U. S. Geological Survey Professional Paper 650-B, 1969.

APPENDIX D

CLIMATOLOGY AND METEOROLOGY

A. Climatology

The climatology described in this section is typically that of Los Alamos proper, where precipitation and temperature have been recorded since 1910 and 1918, respectively. Due to the tremendous irregularity of the terrain in the area, however, one can expect substantial inhomogeneities in weather patterns across the plateau. For instance, noticeably less precipitation falls in White Rock than in Los Alamos, although no data

exists to verify this quantitatively.

Los Alamos has a semiarid continental mountain climate. The average annual precipitation is slightly more than 18 inches, 75 per cent of it falling during the months of May through October. This rainfall, much of it released through thundershower activity, produces considerable natural vegetation. Shower activity reaches its peak in August, when rainfall of one-tenth inch or more can expected on one day out of four. These showers normally develop in the afternoon or early evening and are usually relatively brief. Most of the winter precipitation falls as snow, with 50 inches falling during an average winter and as much as six inches or more often falling in 24 hours. Snow may lie on the ground for several days to more than a week and in shady spots even longer. Although hail may accompany the more severe thunderstorms, serious hail damage from large hail stones is infrequent. Due to the amounts of rainfall and the nature of the terrain and soil, flooding does not occur except for very localized flash flooding in the canyons.

Summers are cool and pleasant. Maximum temperatures reach 90° on an average of only two days a year, with 95° the highest recorded. Summer nights are cool. In July, the hottest month, low readings average in the mid 50's, and it is rare for the temperature to fail to drop to the low 60's before morning. Freezes have been recorded in all months except July and August. Winters are rather cold, although, since this is the driest season, a great many winter days are clear and sunny and daytime warming under cloudless skies is rapid at this elevation. Even in January, the coldest month, daytime shade temperatures in the high 30's can be expected on most days, and an average winter includes only 18 days when the mercury fails to rise above freezing. During winter nights temperatures drop below freezing from November through mid-April, but below-zero readings can be expected only once a year.

The humidity at Los Alamos has a mean value of 41%. Lowest values near an average of 30% can be expected in late spring. Highest values near 50% occur during the wet months of July and August and during extended cold periods.

Although sunshine values are not available for Los Alamos, the value of 74% of possible sunshine that occurs at Santa Fe should be fairly representative of the area. Since the precipitation here is slightly higher than that at Santa Fe, a value of 70% of possible sunshine is probably more representative. At Santa Fe this value rises from a low average of 69% in February and July to a high of 80% in June and October.

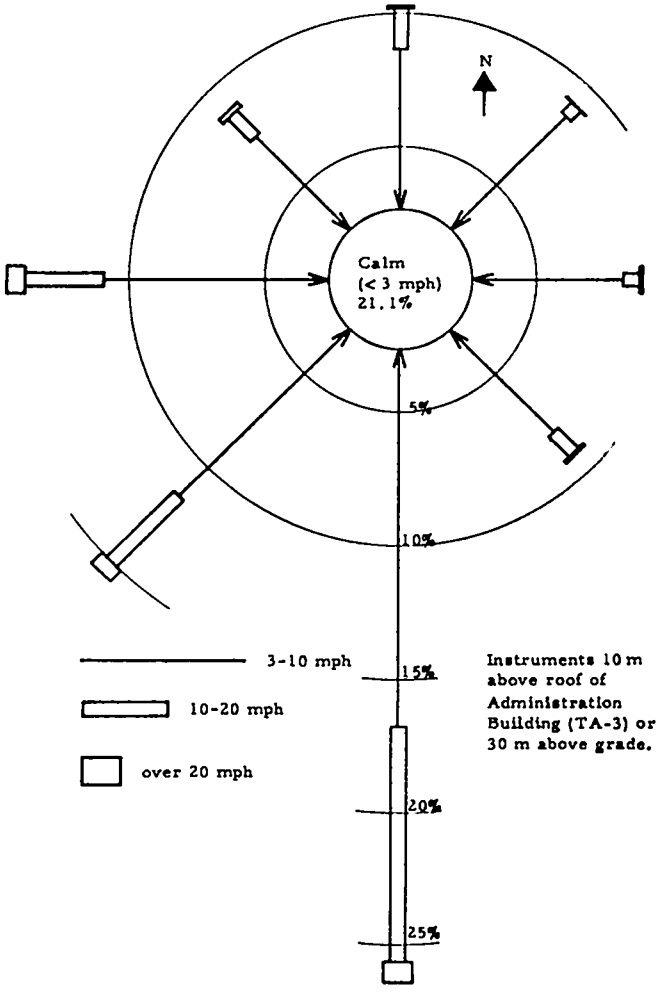

Fig. D-1. Wind rose for the period March, 1956-January 1964.

The prevailing winds at Los Alamos are out of the south and are 10 mph or less almost 80% of the time (Fig. D-1). The maximum ever recorded here is 93 mph in December 1949. Statistical analyses of wind data predict an approximate 50 year return period for 100 mph winds. A tornado has never been observed in Los Alamos County and only 2 have been observed in the 1° quadrangle of latitude and longitude centered on Los Alamos in 60 years of record. This yields a return period of over 100,000 years for a tornado strike on a given point in the quadrangle.

A climatological summary for the Los Alamos area is given in Table D-I. Precipitation records were begun in the area in November 1910, with the station known as Alamos Ranch until February 1942. Temperature records were not started until October 1918. Both are available to date.

B. LASL Meteorological Program

The meteorological program at Los Alamos at present is a very modest effort toward weather forecasting and climatological data collection. Climatological records include wind speed and direction, temperature, humidity, pressure, and precipitation. These are continually recorded at one central location, and several of these parameters are recorded at outlying sites and at temporary locations for special studies.

During this period, plans were formulated and funds expended to construct a 300 ft central meteorological tower with completely automated collection of wind speed and direction, temperature, and humidity data at four heights through computer control onto computer compatible magnetic tape. Data will be collected rapidly enough to not only provide typical climatological data, but also to provide extensive information concerning transient behavior and dispersion potential.

Instrumentation for collection of more data at more sites was acquired. Many years of old wind data records were placed onto punched cards for easier analysis, and a computer code was written to construct wind roses from available data under many different circumstances of time

TABLE D-I

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 - 1970

	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	8.4	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	3.79	2.26	1951	11.18	1952	0	0		0		8	12	0
Sep	72.5	48.1	60.3	94	1934	23	1936	1.93	2.21	1929	5.79	1941	0.2	6.0	1913	6.0	1914	5	5	0
Oct	62.2	37.9	50.0	82	1930	16	1970	1.56	3.48	1919	6.77	1957	0.9	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	5.5	14.0	1931	34.5	1957	2	0	2
Dec	40.9	19.9	30.4	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	18.36	3.48	1919	11.18	1952	50.7	18.0	**	41.3	1967	45	51	25

**1915 & 1916
Precipitation records are from November 1910
Temperature records are from October 1918

interval selection. A chart reading machine was designed and developed which greatly aids in transferring data from strip chart records to punched cards.

Special meteorological service was provided for two relatively short duration projects where wind dispersal features were important to the tests.

APPENDIX E

POPULATION AND ECONOMY

Approximately 400,000 people inhabit the circle of roughly 100 km radius centered on Los Alamos. Nearly 2/3 of this population is concentrated in Albuquerque, about 100 km to the south. Another 1/9 is located in Santa Fe, about 40 km to the southeast. Except for the 15,000 residents of Los Alamos, the remainder is distributed among small towns ranging in size from a few hundred to a few thousand people and Indian Pueblos of a few hundred people. The nearest community is Espanola, about 20 km to the northeast, which is a town of about 2000.

Of the Los Alamos population, about 11,000 live in the residential area of Los Alamos proper and the remaining 4000 reside in the developments of the White Rock community.

At any particular point in time, these people are scattered throughout the Los Alamos area at work, at school, at church, shopping, etc. Although it is impossible to predict the exact whereabouts of the entire population, it is meaningful to distinguish between a daytime population distribution and a nighttime distribution. Figures showing these distributions for angular sectors 45° wide and 1 km deep with respect to the meteorological tower are shown in Table E-I. Movements of people to work and to school and the influx of workers into the area have been approximately taken into account.

The economy of the Santa Fe-Los Alamos area is based largely on government (federal and state) operations, the large tourist trade, arts and crafts, agriculture, and some light and service industry, mostly associated with the tourist trade. The Los Alamos Scientific Laboratory accounts for much of the federal employment while the New Mexico state governmental offices, located in Santa Fe, provide the state jobs.

Agriculture is practiced to only a limited extent in the immediate vicinity, i.e., within 20-40 km of Los Alamos. In this area many people raise vegetables in home gardens, but very rarely depend on this activity for more than half of their subsistence. Outside this area agriculture is practiced by much of the rural population, some for subsistence and income augmentation and some on a strictly commercial basis. Limited truck farming has been made possible in the river valleys by irrigation. Tree fruits, chili peppers, beans, corn and alfalfa are the principle crops. Very little of this enters interstate commerce. Most of the unforested lands, although sparsely vegetated, is used for low-density grazing of beef cattle. Only small amounts of milk are produced in the Santa Fe area and none in the immediate vicinity of Los Alamos. A small dairy in Nambe, about 25 km east of Los Alamos, and another in Santa Fe use milk produced in the area. The only other agriculturally oriented activity in the area is logging, which is carried on in some of the highland forests.

TABLE E-1

POPULATION CONCENTRATIONS IN THE LOS ALAMOS, NEW MEXICO, AREA, FOR ANGULAR SECTORS 45° WIDE AND 1 KM DEEP, CENTERED ON NEW METEOROLOGY TOWER

Distance, km	Azimuth, degrees: 0-45	45-90	90-135	135-180	180-225	225-270	270-315	315-360	Total
0-1	26 /	37 /	/	/	/	/	55 /	/	118 /
1-2	100 /	/	165 /	/	84 /	/	136 /	127 / 300	612 / 300
2-3	737 / 1293	429 /	/	/	/	/	3061 /	375 / 736	4602 / 2029
3-4	635 /	/	47 /	23 /	/	102 /	/	3001 / 3266	3808 / 3266
4-5	1249 / 1779	/	/	/	/	29 /	/	2427 / 2290	3705 / 4069
5-6	/	/	/	/	/	292 /	/	1016 / 1646	1308 / 1646
6-7	/	/	/	/	/	/	/	/	/
7-8	/	/	/	/	/	/	/	/	/
8-9	/	/	/	/	/	/	/	/	/
9-10	/	/	2430 / 3404	69 / 27	/	/	/	/	2499 / 3431
10-11	/	/	194 / 457	/	/	/	/	/	194 / 457
Total	2747 / 3072	466 /	2836 / 3861	92 / 27	84 /	423 /	3252 /	6946 / 8238	16846 / 15198

x / y

x = daytime concentration
y = nighttime concentration

APPENDIX F

ANALYTICAL PROCEDURES

A. Sample Preparation

Preparation of samples for all analyses, except gross α and β determinations on membrane air filters and gross γ determination on charcoal cartridges, is accomplished by bringing the sample into solution. This liquid sample is then divided and aliquots are analyzed as described below in Section B-Specific Analyses. The membrane filters and charcoal cartridges require no chemical pretreatment for gross α, β and γ determinations.

1. Air. After gross α and β determinations are performed on the membrane filters, they are put into a flask and tracers and carriers are added as required. The filters are wet ashed with hydrogen peroxide and nitric acid. The residue is dissolved in acid and any remaining insolubles are filtered. The resulting filter papers are then destroyed by dry ashing in a furnace and treated with hydrofluoric acid to dissolve these insolubles. The fractions are recombined and this liquid is then aliquotted for the appropriate analyses.

2. Water. Water samples are divided into

three parts. Two of these are for chemical and metal ion analyses and require no pretreatment. The third part is filtered and aliquots are taken of the filtrate for the appropriate specific analyses. Each aliquot is treated to destroy organic materials and insoluble silica. [1,2] Insolubles which are removed by filtration are not analyzed.

3. Soil and sediments. Soil samples are manually blended and part is heated to 200-250°C to drive off unbound moisture which is collected for tritium analysis. The total sample is dried and sieved, and 100 grams are roasted and then leached with a mixture of hot concentrated acids.[1,3,4] Elements which are not readily removed by a leaching process are brought into solution through a complete dissolution technique. The resulting solution is aliquotted for required analyses.

4. Vegetation and tissue. Samples are handled substantially the same as soil samples. They are heated to drive off moisture which is collected for tritium analysis. The sample is then wet or dry ashed and the residue is brought into solution by treatment with acid.[5]

B. Specific Analyses

1. *Gross α and gross β.* These determinations are made by counting the membrane filters (for air samples) mounted on steel planchets and wrapped in mylar or aliquots evaporated on a 4 1/2" planchet (for liquids) on a Beckman-Wide-beta counting system.[1,2]

2. Gross γ and Cessium - 137. Gross γ determinations are made of the charcoal cartridges (for air samples) or aliquots in polyethylene bottles (for liquids) by counting on a γ spectrometer and summing the counts in all channels. Cesium-137 is calculated for each sample whose γ spectrum exhibits the Cesium-137 peak.

3. Plutonium, Americium and Uranium (radiometric). An appropriate tracer (^{236}Pu, ^{243}Am, or ^{232}U respectively) is added (if not already accomplished) and the required element is isolated by means of ion exchange resins.[3,6,7,8] Plutonium samples are treated with H_2O_2 to guarantee that the Pu in the sample is in the correct valence state.[9]

The element is removed from the resin, evaporated to dryness and redissolved in an appropriate electrolyte (nitrate for uranium and oxalate for plutonium and americium) which is used in an electrolytic cell to plate the element of interest onto a 3/4" stainless steel disc. This disc is counted on a spectrometer for the element in question and corrections for chemical recovery are made from analysis of the tracer peak.

4. Uranium (fluorometric). The uranium determination is made fluorometrically on liquid aliquots using a sodium fluoride-lithium fluoride fusion technique.[10,11] Uranium is removed from aliquots which originate from soil and similar types of samples which contain substantial amounts of iron by means of an ethyl acetate extraction.[12]

5. Strontium-90. Strontium-85 is added to the aliquot as a tracer, and the strontium is isolated by means of liquid ion exchange. A known amount of stable yttrium is added as a carrier and the strontium-90 is allowed to reach equilibrium with the yttrium-90 daughter by setting the sample aside for a minimum of 2 weeks. The yttrium-90 is separated from the parent strontium by liquid ion exchange and counted in the form of an oxalate precipitate on a Beckman Wide beta counting system. Chemical recoveries are accounted for by counting of the strontium-85 tracer and weighing of the stable yttrium carrier.[13]

6. Radium. Routine radium analyses are performed by selectively coprecipitating the radium with milligram quantities of barium sulfate.[8] The resulting precipitate is filtered and the filter is mounted and counted directly in an alpha spectrometer. The radium-226 content of the sample is calvulated either from the radium-226 peak or from its more energetic polonium-214 daughter. If this method yields results of more than, say,

5 pCi/l, these results are verified by a lengthier radom emanation technique.[14]

7. Tritium. Liquid scintillation counting[15] is used for tritium determinations of liquid aliquots which are dissolved in aromatic base counting cocktails.

8. Chemical. This category includes Ca^{+2}, Mg^{+2}, Na^{+1}, Cl^{-1}, Fl^{-1}, NO_3^{-1}, CO_3^{-2}, HCO_3^{-1}, total dissolved solids, hardness, pH and conductivity. These tests are performed according to the procedures outlined in Standard Methods.[16]

9. Metallic ion. This category includes the ions of mercury, cadmium, lead, beryllium and hexavalent chromate. These ions are either determined by absorption spectrophotometry[17] or by atomic absorption spectrometry.[17]

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