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LOS ALAMOS SCIENTIFIC LABORATORY
of the
University of California
LOS ALAMOS • NEW MEXICO

Plutonium in Stream Channel Alluvium in the Los Alamos Area, New Mexico

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by

William D. Purtymun

Work done by Jack W. Aeby, William D. Purtymun, Pablo O. Romero, and Patricio E. Trujillo.

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PLUTONIUM IN STREAM CHANNEL ALLUVIUM IN THE LOS ALAMOS AREA, NEW MEXICO

by

William D. Purtymun

ABSTRACT

A survey of plutonium isotopes ^{238}Pu and ^{239}Pu in the alluvium of major canyons in the Los Alamos Area was made to determine concentrations and movement of soil-bound plutonium. Trace concentrations of plutonium were found in alluvium in those canyons which have received or are receiving treated effluents from operations of the Laboratory. The concentrations of plutonium in the alluvium of the remainder of the canyons was no greater than those concentrations attributed to world-wide fallout from atmospheric tests.

I. INTRODUCTION

A survey was made of the plutonium isotopes ^{238}Pu and ^{239}Pu in stream channel alluvium in the major canyons of the Pajarito Plateau and along the Rio Grande in the Los Alamos area to determine concentrations of plutonium in the canyons and to delineate areas of movement of soil-bound plutonium.

The Pajarito Plateau forms an apron 7 to 10 miles wide and about 12 miles long around the eastern flanks of the Jemez Mountains. The surface of the plateau slopes eastward from the mountains to the Rio Grande where it terminates along the canyon cut by the river. Southeastward trending canyons have cut the surface of the plateau into a number of finger-like mesas. The stream flow in the canyons is intermittent. The stream flow only reaches the Rio Grande during storm runoff from summer thunder showers.

Stack emissions are filtered to remove particulates while liquids and gases are processed to remove waste chemicals and radioactive isotopes before release into canyon disposal areas. Stack emissions after filtration and liquids after treatment may contain trace amounts of plutonium.

Particulate fallout from stack emissions is subject to transport from the mesas into the canyons by storm runoff. Treated liquid effluents are released into the canyons. The soil on the mesas and the alluvium in the canyons have a high ion exchange capacity for the plutonium isotopes. Therefore, such isotopes are bound to the finer materials in the alluvium of the stream channels and are subject to physical transport by storm runoff.

The survey was made by collecting 63 samples of alluvium in the major canyons of the plateau (Fig. 1). The samples were collected with a 3-in. scoop across the main channel to a depth of about 1 in. Six samples of alluvium were collected along the Rio Grande south from Otowi Bridge. The river samples were taken from a sediment dune build-up in the eddy behind

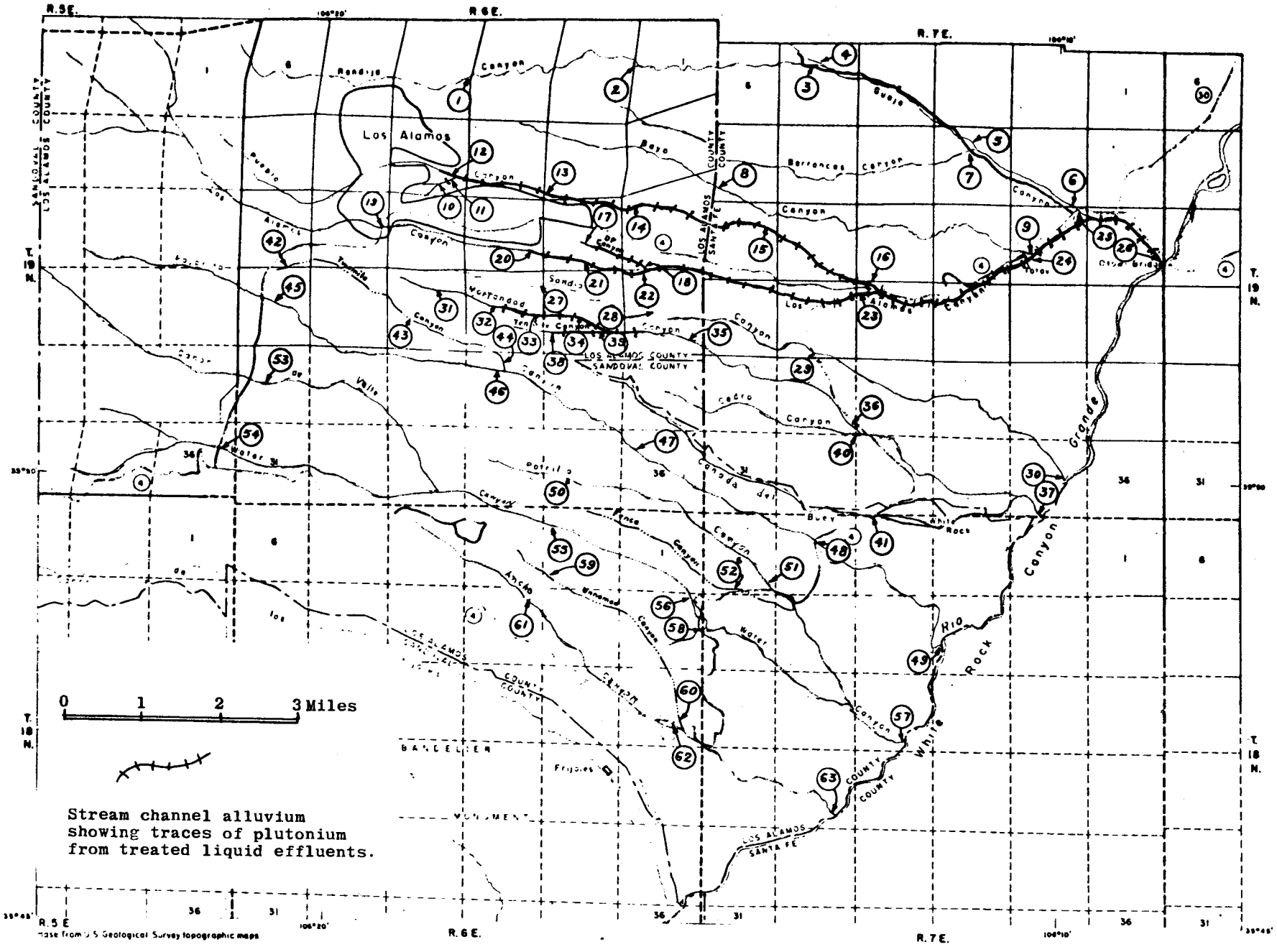
R.5E.
R.6E.
R.7E.
Los Alamos
Pueblo Canyon
Rendija Canyon
Barranca Canyon
Guaje Canyon
Los Alamos Canyon
Sandia Canyon
Mortandad Canyon
Ten Site Canyon
DP Canyon
Cañada del Buey
Pajarito Canyon
Water Canyon
Cañon de Valle
Potrillo Canyon
Fence Canyon
Ancho Canyon
Threemile Canyon
Twomile Canyon
Rio Grande
White Rock Canyon
Rio Grande
White Rock
SANDOVAL COUNTY
LOS ALAMOS COUNTY
LOS ALAMOS SANTA FE
BANDELIER NATIONAL MONUMENT
T. 19 N.
T. 18 N.
0 1 2 3 Miles
Stream channel alluvium showing traces of plutonium from treated liquid effluents.
Base from U.S. Geological Survey topographic maps

Fig. 1. Stream channel alluvium showing traces of plutonium from treated liquid effluents.

Sample No.	Location
1	Rendija Canyon at Cemetary Road
2	Rendija Canyon near Rifle Range
3	Rendija Canyon near confluence with Guaje Canyon
4	Guaje Canyon near confluence with Rendija Canyon
5	Guaje Canyon near confluence with Barrancas Canyon
6	Guaje Canyon near confluence with Los Alamos Canyon
7	Barrancas Canyon near confluence with Guaje Canyon
8	Bayo Canyon at County Road
9	Bayo Canyon near confluence with Los Alamos Canyon
10	Acid Canyon near AC-4
11	Acid Canyon near Acid Weir
12	Pueblo Canyon at PC-1
13	Pueblo Canyon at PC-5
14	Pueblo Canyon at PC-7
15	Pueblo Canyon at PC-9
16	Pueblo Canyon at Highway 4
17	DP Canyon near TA-21
18	DP Canyon near TW-3
19	Los Alamos Canyon at bridge (town)
20	Los Alamos Canyon at TA-2
21	Los Alamos Canyon 0.7 mile west of TW-3
22	Los Alamos Canyon at TW-3
23	Los Alamos Canyon at Highway 4
24	Los Alamos Canyon near confluence with Bayo Canyon
25	Los Alamos Canyon near confluence with Guaje Canyon
26	Los Alamos Canyon near confluence with Rio Grande
27	Sandia Canyon 3.5 miles west of Highway 4
28	Sandia Canyon 2.2 miles west of Highway 4
29	Sandia Canyon at Highway 4
30	Sandia Canyon near Rio Grande
31	Mortandad Canyon near New Sigma
32	Mortandad Canyon at Gaging Station 1
33	Mortandad Canyon at MCS-3.8
34	Mortandad Canyon at MCO-5
35	Mortandad Canyon at MCO-12
36	Mortandad Canyon at Highway 4
37	Mortandad Canyon at Rio Grande
38	Ten-Site Canyon near TA-35
39	Ten-Site Canyon near MCO-6.5A
40	Cedro Canyon at Highway 4
41	Canada del Buey at Highway 4
42	Twomile Canyon at Jemez Road
43	Twomile Canyon at new H-1 Building
44	Twomile Canyon near confluence with Pajarito Canyon
45	Pajarito Canyon at Jemez Road
46	Pajarito Canyon near confluence with Twomile Canyon
47	Pajarito Canyon near TA-18
48	Pajarito Canyon near Highway 4
49	Pajarito Canyon at Rio Grande
50	Potrillo Canyon near TA-36
51	Potrillo Canyon at Highway 4
52	Fence Canyon at Highway 4
53	Valles Canyon at Jemez Road
54	Water Canyon at Jemez Road
55	Water Canyon 2 miles west of Highway 4
56	Water Canyon at Highway 4
57	Water Canyon at Rio Grande
58	Indio Canyon at Highway 4
59	Unnamed Canyon near DT-9
60	Unnamed Canyon at TA-33
61	Ancho Canyon near DT-9
62	Ancho Canyon at Highway 4
63	Ancho Canyon at Rio Grande

some large rocks in the main channel.

The procedures used for sample preparation and analyses are outlined by Trujillo (1970).[1] Plutonium was assayed by using an alpha spectrometer after concentration and purification by ion exchange chemistry with internal tracers added for recovery corrections.

Previous studies of plutonium in soil, due to world-wide fallout from atmospheric testing, in the Los Alamos and adjacent area indicated the following ranges for plutonium isotopes.

Isotope	Range in Concentrations dpm/g of soil (Top 2 in.)
^{238}Pu	0.001 - 0.008
^{239}Pu	0.001 - 0.051

Plutonium concentrations found in the alluvium near or within these ranges are attributed to world-wide fallout and not activities of the Los Alamos Scientific Laboratory (LASL).

II. LITHOLOGY AND PARTICLE-SIZE DISTRIBUTION OF THE ALLUVIUM

The particles constituting the alluvium in the canyons of the plateau are derived from the chemical and mechanical weathering of acid volcanic rocks. The granules are composed principally of tuff, pumice, latite, and rhyolite rock fragments with minor amounts of quartz and sanidine crystals. The fractions of fine-to-coarse sand consist mainly of quartz and sanidine crystals and crystal fragments with minor amounts of rock fragments. The silt and clay fraction is composed mainly of clay minerals montmorillonite and illite.

The 63 samples were separated mechanically into seven fractions ranging in partial size from silt and clay to granules. The average particle-size distribution is shown in percent by weight.

Classification	Particle Diam(mm)	Distribution (wt %)
Silt and Clay	<0.062	5
Very Fine Sand	0.062-0.125	4
Fine Sand	0.125-0.250	9
Medium Sand	0.250-0.500	16
Coarse Sand	0.500-1.00	35
Very Coarse Sand	1.00 -2.00	24
Very Fine Gravel	2.00 -4.00	7

The silt and clay size fraction makes up about 5% of the channel alluvium and is subject to suspended transport by storm runoff, which leaves the coarse materials behind to move at a slower rate as bed material.

III. PAJARITO PLATEAU

Plutonium was found in concentrations in excess of world-wide fallout in Acid, Pueblo, DP, Los Alamos, Ten-Site, and Mortandad Canyons (Table I). The plutonium is released from the industrial waste treatment plants in the treated liquid effluents and is attached or absorbed on alluvium particles.

Acid and Pueblo Canyons received effluents from a treatment plant from 1949 through 1962. The plant, now dismantled, released effluents into the canyon 300 yd southwest of where Sample 10 was collected (Fig. 1). The trace of plutonium in the alluvium of the two canyons is residual and is from previously released effluent.

DP Canyon receives treated liquid effluents from the treatment plant at LASL Technical Area TA-21. The wastes have been released into the canyon since 1950. The canyon is tributary to Los Alamos Canyon near the center of the plateau.

Traces of plutonium were found in sediments in Los Alamos Canyon downgradient from TA-2 (Sample 20, Fig. 1). Below the junction of DP and Los Alamos Canyons, the concentration of plutonium increased due to transport of sediments from DP Canyon with bound plutonium from the plant effluents. The concentrations show no consistent trends downgradient in the canyon.

Initial build-up of plutonium occurs below effluent out-falls from the waste treatment plants. The build-up in the alluvium is dispersed by periodic flushing of the alluvium down the canyon by storm runoff. The radionuclides attached to the silt and clays are carried out of the canyon as suspended sediments with the runoff. The radionuclides attached to the larger sediments are transported as bed material. The bed material lags behind and moves down the canyon a short distance with each runoff event.

Mortandad Canyon received treated effluents from the plant at TA-50. The canyon has a small drainage area and a thick section of unsaturated alluvium. Since hydrologic observation began in 1960, storm runoff has infiltrated into the alluvium west of the Santa Fe-Los Alamos County line. In general, the concentrations of plutonium decrease downgradient from the plant outfall.

Ten-Site Canyon is tributary to Mortandad. Traces of plutonium in the canyon could be from early release of waste from Ten-Site or overflow from holding tanks at TA-50. The storm runoff from the drainage area of Ten-Site Canyon is lost into the thick section alluvium in Mortandad Canyon. There has been no storm runoff to the Rio Grande through Mortandad or Ten-Site Canyons from west of the Los Alamos County line.

Sample 44 from Twomile Canyon and Sample 55 from Water Canyon contained amountsof plutonium that were borderline, probably from world-wide fallout. The remainder of the samples contained low concentrations of plutonium in the range of what would be expected from world-wide fallout.

IV. RIO GRANDE

Samples of alluvium were collected from the stream channel of the Rio Grande and canyon tributary to the river south of the Los Alamos area (Fig. 2). The sediments contained low concentrations of plutonium in the range of what is expected from world-wide fallout (Table II).

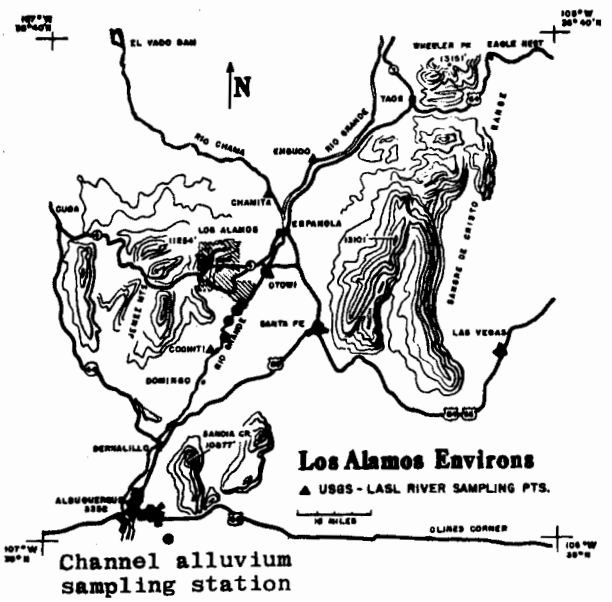

Fig. 2. Channel alluvium sampling stations along the Rio Grande.

V. CONCLUSIONS

Trace concentrations of plutonium in stream channel alluvium attributed to operations of LASL were found in Acid, Pueblo, Los Alamos, DP, Mortandad, and Ten-Site Canyons. These canyons received, or are now receiving, treated low-level liquid effluents. Plutonium in the liquids is adsorbed or exchanged with clay minerals in the alluvium. The fine sediments are being carried out of the canyons as suspended sediments with storm runoff, whereas the larger sediments are being transported as bed material. The bed material lags behind moving only short distances with each succeeding runoff event.

Storm runoff reaches the Rio Grande from Acid, Pueblo, Los Alamos, and DP Canyons. The amount of storm runoff in Mortandad and Ten-Site Canyons is small due to a small drainage area. The thick section of unsaturated alluvium in the canyons has absorbed all runoff within the project boundaries since 1960.

Concentrations of plutonium slightly above world-wide atmospheric test values were found in short reaches of Twomile and Water Canyons. The source of the plutonium

is probably world-wide fallout.

Samples of alluvium from the Rio Grande and canyons tributary to the Rio Grande south of the Los Alamos area did not contain plutonium in excess of world-wide fallout levels.

REFERENCE

1. P. E. Trujillo, Jr., "Standard Analytical Procedure for Soils," manuscript in preparation by LASL Group H-6, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

TABLE I

ANALYTICAL RESULTS OF PLUTONIUM IN ALLUVIUM FROM MAJOR CANYONS ON THE PAJARITO PLATEAU

Sample No.	Date Collected	Concentrations dpm/g ^{238}Pu	Concentrations dpm/g ^{239}Pu	Remarks
1	2-5-70	0.010 ± 0.003	0.007 ± 0.003	
2	2-5-70	0.003 ± 0.003	0.003 ± 0.003	
3	2-5-70	0.003 ± 0.003	0.007 ± 0.002	
4	2-5-70	0.003 ± 0.003	0.003 ± 0.003	
5	2-5-70	0.003 ± 0.003	0.003 ± 0.003	
6	2-5-70	0.003 ± 0.003	0.003 ± 0.003	
7	2-5-70	0.003 ± 0.003	0.015 ± 0.004	
8	2-10-70	0.003 ± 0.003	0.008 ± 0.003	
9	2-5-70	0.003 ± 0.003	0.010 ± 0.004	
10	4-16-70	0.422 ± 0.036	64.1 ± 5.5	Acid Canyon
11	4-16-70	0.471 ± 0.042	54.7 ± 4.8	Acid Canyon
12	4-16-70	0.004 ± 0.001	0.081 ± 0.012	Pueblo Canyon
13	4-16-70	0.025 ± 0.008	10.3 ± 1.4	Pueblo Canyon
14	2-10-70	0.003 ± 0.003	2.54 ± 0.24	Pueblo Canyon
15	2-10-70	0.003 ± 0.003	0.883 ± 0.053	Pueblo Canyon
16	2-10-70	0.012 ± 0.002	2.39 ± 0.15	Pueblo Canyon
17	3-19-70	5.98 ± 0.54	34.97 ± 3.14	DP Canyon
18	3-19-70	0.46 ± 0.04	3.10 ± 0.24	DP Canyon
19	3-19-70	0.005 ± 0.002	0.022 ± 0.006	
20	3-19-70	0.058 ± 0.009	0.224 ± 0.021	Los Alamos Canyon
21	3-19-70	0.002 ± 0.002	0.258 ± 0.015	Los Alamos Canyon
22	3-19-70	0.022 ± 0.006	0.395 ± 0.042	Los Alamos Canyon
23	2-10-70	0.007 ± 0.002	1.876 ± 0.115	Los Alamos Canyon
24	2-5-70	0.002 ± 0.002	0.861 ± 0.048	Los Alamos Canyon
25	2-5-70	0.023 ± 0.003	1.311 ± 0.074	Los Alamos Canyon
26	2-5-70	0.005 ± 0.002	0.809 ± 0.043	Los Alamos Canyon
27	2-24-70	0.005 ± 0.002	0.009 ± 0.003	
28	2-24-70	0.002 ± 0.002	0.002 ± 0.002	
29	2-10-70	0.004 ± 0.002	0.007 ± 0.002	
30	9-16-69	0.003 ± 0.003	0.010 ± 0.004	
31	4-15-70	0.002 ± 0.002	0.002 ± 0.002	
32	3-17-70	92.1 ± 8.9	103.1 ±10.0	Mortandad Canyon
33	2-16-70	2.95 ± 0.36	5.41 ± 0.66	Mortandad Canyon
34	2-16-70	1.55 ± 0.21	4.75 ± 0.65	Mortandad Canyon
35	2-16-70	0.007 ± 0.002	0.036 ± 0.011	Mortandad Canyon
36	2-10-70	0.002 ± 0.002	0.009 ± 0.003	

TABLE I (cont)

Sample No.	Date Collected	Concentrations dpm/g ^{238}Pu	Concentrations dpm/g ^{239}Pu	Remarks
37	9-16-70	0.006 ± 0.002	0.008 ± 0.003	
38	2-16-70	0.139 ± 0.026	0.250 ± 0.041	Ten-Site Canyon
39	2-16-70	0.099 ± 0.015	0.819 ± 0.091	Ten-Site Canyon
40	2-10-70	0.003 ± 0.003	0.004 ± 0.004	
41	2-10-70	0.003 ± 0.003	0.004 ± 0.004	
42	2-12-70	0.003 ± 0.003	0.005 ± 0.004	
43	4-15-70	0.010 ± 0.003	0.004 ± 0.004	
44	4-15-70	0.027 ± 0.005	0.056 ± 0.010	Twomile Canyon
45	2-12-70	0.004 ± 0.004	0.008 ± 0.005	
46	4-15-70	0.002 ± 0.002	0.019 ± 0.004	
47	2-12-70	0.002 ± 0.002	0.005 ± 0.002	
48	2-10-70	0.002 ± 0.002	0.017 ± 0.003	
49	9-17-69	0.007 ± 0.003	0.002 ± 0.003	
50	2-24-70	0.002 ± 0.002	0.013 ± 0.003	
51	2-12-70	0.002 ± 0.002	0.005 ± 0.002	
52	2-12-70	0.002 ± 0.002	0.008 ± 0.002	
53	4-23-70	0.002 ± 0.002	0.024 ± 0.006	
54	2-12-70	0.002 ± 0.002	0.050 ± 0.007	
55	4-23-70	0.002 ± 0.002	0.110 ± 0.009	Water Canyon
56	2-12-70	0.002 ± 0.002	0.006 ± 0.002	
57	9-17-69	0.006 ± 0.003	0.004 ± 0.002	
58	2-12-70	0.002 ± 0.002	0.002 ± 0.002	
59	2-12-70	0.002 ± 0.002	0.004 ± 0.002	
60	2-12-70	0.002 ± 0.002	0.005 ± 0.002	
61	2-12-70	0.002 ± 0.002	0.014 ± 0.003	
62	2-12-70	0.002 ± 0.002	0.004 ± 0.001	
63	9-17-69	0.002 ± 0.002	0.007 ± 0.005	

TABLE II

ANALYTICAL RESULTS OF PLUTONIUM IN ALLUVIUM ALONG THE RIO GRANDE

Location	Miles Below Otowi	Date Collected	Concentrations dpm/g ^{238}Pu	Concentrations dpm/g ^{239}Pu
Rio Grande at Sandia Canyon	3.2	9-16-69	0.003 ± 0.003	0.001 ± 0.003
Chaquehui at the Rio Grande	8.4	9-17-69	0.006 ± 0.002	0.005 ± 0.002
Rio Grande at Frijoles Canyon	10.3	9-17-69	0.011 ± 0.004	0.002 ± 0.002
Frijoles Canyon at Rio Grande	10.3	9-17-69	0.006 ± 0.001	0.007 ± 0.002
Alamo Canyon at Rio Grande	13.6	9-17-69	0.002 ± 0.001	0.007 ± 0.002
Rio Grande above Cochiti	19.9	9-13-69	0.009 ± 0.004	0.002 ± 0.002

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