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The hydrology and the chemical and radiochemical quality of surface and ground water at Los Alamos, New Mexico, 1949-55

By

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Contents

	Page
Abstract	1
Introduction	4
Geology	7
Hydrology	8
Aquifer tests	10
Velocity of ground-water movement	11
Relation of surface and ground water in the Los Alamos area	12
Acid-Pueblo Canyon disposal system	16
Quality of water	19
Radioactivity of the alluvium	23
Test wells	24
Quality of water	27
DP laundry and DP west disposal system	31
Springs and seeps in Los Alamos area	33
Supply wells, rivers, and reservoirs in the Los Alamos area	35
Summary	36
References cited	40

Illustrations

(All illustrations are in pocket)

		Reference page
Figure 1.	Index map of New Mexico showing Los Alamos County -----	4
2.	Map showing locations of weirs and stations for streamflow measurements in Acid and Pueblo Canyons, waste and sewage disposal sites, and sampling points, Los Alamos and Santa Fe Counties, N. Mex. ----------	4
3.	Diagrammatic cross section showing generalized stratigraphic relations of the Santa Fe Group, Tschicoma Formation, and Bandelier Tuff in the Los Alamos area ----------	7
4.	Map of river-sampling sites on the Rio Chama and Rio Grande ----------	15
5.	Deleted.	
6.	Discharge of West Fork and South Fork weirs correlated with that of acid weir to show gains and losses in flow in Acid Canyon ----------	17
7.	Nonpumping water levels in test wells 1A and 2A -------	24
8.	Nonpumping water levels in test wells 1, 2, 3, and 4 --	24

Illustrations - Continued

		Reference page in text
Figure 9.	Monthly precipitation at Los Alamos, 1950 through 1955	24
10.	Chemical quality of water from test wells, January 7, 1953	27

Tables

Page

Table 1. Generalized stratigraphic section of the eastern slopes of the Sierra de los Valles, the Pajarito Plateau, and along the Rio Grande near Los Alamos, N. Mex. ---------- 7a

2. Geologic and hydraulic characteristics of aquifers of test wells 1, 1A, 2, 2A, 3, and 4 near Los Alamos, N. Mex. ---------- 10a

3. Permeability of the Bandelier Tuff ---------- 17a

4. Average weekly volume of sewage discharged into Pueblo Canyon and volume of waste discharged into Acid Canyon, July 1951 through December 1955, in gallons ---------- 17b

5. Streamflow measurements in Acid and Pueblo Canyons on June 10, 1952 ---------- 17c

6. Streamflow at Pueblo Canyon stations and discharge from Hamilton Bend Springs and Otowi Seep, 1951 through 1954 ---------- 18a

7. Summary of chemical quality of water collected from Acid and Pueblo Canyon wells ---------- 19a

8. Chemical quality of water from Acid and Pueblo Canyon wells ---------- 19b

9. Chemical quality of surface flow in Acid and Pueblo Canyons ---------- 20a

Tables - Continued

Page

Table 10. Chemical quality of surface flow from Acid Weir, and near wells Pueblo 1, and Pueblo 2 ---------- 20b

10a. Radiological analyses of stream-bed alluvium in Acid and Pueblo Canyons ---------- 23a

11. Chemical quality of water from test wells---------- 27a

12. Range and average of the concentrations of plutonium and uranium samples from test wells --- 29a

13. Ion-exchange capacity and mineral constituents of four samples of the Tshirege Member of the Bandelier Tuff ---------- 32a

14. Chemical quality of water from springs and seeps near Los Alamos, N. Mex. ---------- 33a

15. Range of chemical and radiological quality of water from Guaje and Los Alamos Canyon well fields, Rio Grande, Rio Chama, Rito de los Frijoles, and Los Alamos, Guaje, and Water Canyon reservoirs ---------- 35a

The hydrology and the chemical and radiological quality of surface and ground water at Los Alamos, New Mexico, 1949-55

By

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Abstract

Treated liquid wastes and sewage from the Los Alamos Scientific Laboratories at Los Alamos are discharged into canyons eroded in the volcanic rocks and sediments of the Pajarito Plateau. Liquids containing waste and sewage constitute the perennial flow of the upper reaches of Acid and Pueblo Canyons.

Four deep and two shallow test wells were drilled to determine the transmissibility of the perched aquifers and to monitor the chemical and radiological quality of ground water. Values of transmissibility range from 200 to 7,800 gallons per day per foot for the deep perched aquifer, and 50 to 8,300 gallons per day per foot for the shallow perched aquifers. The velocities of ground water in these aquifers range, from about 150 feet per year to about 4,500 feet per year.

Shallow wells 2 to 10 feet in depth were constructed in Acid and Pueblo Canyons in order that data could be collected on the chemical and radiological nature of water in the alluvium. They consisted of four wells cased with corrugated culvert pipe in Acid Canyon and 10 drivepoint wells in Pueblo Canyon.

Surface flow in Acid and Pueblo Canyons was observed to determine seepage losses or gains. Seepage losses are high during high flow in Acid Canyon, and seepage gain may occur at low flow. In Pueblo Canyon, streamflow diminishes downstream from the confluence with Acid Canyon, except for a gain in flow at the outfall of the Central Sewage Plant, and disappears into the pumiceous material of the Bandelier Tuff which underlies the upper part of the middle reach of the stream. Stormflow may carry some waste and sewage effluent into the lower reaches of the canyon or to the Rio Grande. Precipitation and streamflow in Pueblo Canyon may correlate with water levels in some of the test wells.

Radioactive contaminants probably are retained in Acid Canyon. Plutonium concentrations in Acid Canyon were sometimes equal to about one-tenth the limits for off-site tolerance, but in Pueblo Canyon were considerably below this limit. Uranium concentrations were not significantly high except in a few samples from Acid Canyon. Nitrate, chloride, and fluoride concentrations in samples from shallow test wells suggest a possible hydraulic connection between perched aquifers and the contaminated streamflow in Pueblo Canyon. Analyses of samples from the Rio Grande and Rio Chama show no significant amounts of contaminants.

Introduction

Los Alamos County is in north-central New Mexico about 25 miles northwest of Santa Fe (fig. 1). Nuclear research was bugun

Figure 1.--Index map of New Mexico showing Los Alamos County.

at Los Alamos about 1943 and continued beyond December 1955, the cutoff date of this report. Most liquid radioactive and industrial wastes from technical areas in the Los Alamos area and most of the sewage wastes of the city of Los Alamos were discharged into Acid and Pueblo Canyons near Los Alamos. Liquid wastes of undetermined radioactive content were discharged until about 1950, but since then have been treated to below tolerance levels of radioactivity before discharge. Several other areas have been used for the disposal of both liquid and solid radioactive wastes. The locations of the liquid disposal sites are shown on figure 2, and brief

Figure 2.--Map showing locations of weirs and stations for streamflow measurements in Acid and Pueblo Canyons, waste and sewage disposal sites, and sampling points, Los Alamos and Santa Fe Counties, N. Mex.

descriptions of the sites and the waste discharged are given by Abrahams (1962). In this report, radioactive wastes will be referred to as "waste", and the discharge from the sewage treatment plants will be referred to as "sewage".

A joint study including the Ground Water, Surface Water, and Quality of Water Branches of the U.S. Geological Survey, and the Los Alamos Scientific Laboratory (formerly the Industrial Waste Section of the Atomic Energy Commission) was begun in 1949 to investigate the movement of waste and sewage waters because of the possibility of movement of the waste and sewage into the ground-water body that supplies the wells of the city of Los Alamos and into the Rio Grande. The drilling of six test wells to sample parts of the aquifer(s) that would most likely receive wastes and sewage discharged from the research laboratories and from the sewage treatment plants was started in May 1949. This report is intended primarily to summarize and record data and results obtained from the investigation through 1955, although the study of the contamination problem is being continued.

The principal area of the investigation includes Los Alamos, Acid, and Pueblo Canyons and the intercanyon mesa surfaces (fig. 2). Los Alamos, Acid, and Pueblo Canyons are cut deeply into the Pajarito Plateau, which lies on the eastern flank of the Sierra de los Valles. The canyons are part of the west-to-east drainage net that carries runoff from the mountains and plateau to the Rio Grande. The altitudes in the area range from about 7,300 feet on the mesas to 6,500 feet in the bottoms of the canyons, and about 5,500 feet at the Rio Grande.

Gratitude is due the Engineering and Construction Division of the Atomic Energy Commission, Los Alamos Scientific Laboratory, and the Utilities Division of the Zia Company for their close cooperation and assistance in the work.

Geology

Los Alamos is on the Pajarito Plateau, which is underlain by the Bandelier Tuff of Pleistocene age. Rocks of the Santa Fe Group of middle(?) Miocene to Pleistocene(?) age beneath the Bandelier Tuff are exposed along the eastern edge of the plateau. The western edge of the plateau laps onto the Sierra de los Valles which is formed by the Tschicoma Formation of Pliocene and Pleistocene(?) age (fig. 3).

Figure 3.--Diagrammatic cross section showing generalized stratigraphic relations of the Santa Fe Group, Tschicoma Formation, and Bandelier Tuff in the Los Alamos area.

A generalized stratigraphic section of the geologic formations, their ages, thickness, and water-bearing characteristics is shown on table 1.

Table 1.—Generalized stratigraphic section of the eastern slopes of the Sierra de los Valles, the Pajarito Plateau, and along the Rio Grande near Los Alamos, N. Mex.

System	Series	Subdivision			Physical characteristics	Estimated thickness (feet)	Water-bearing characteristics
QUATERNARY	Recent	Alluvium			Gravel, sand, and silt	0 - 50	Yields small quantities of water to wells and springs.
	Pleistocene	Tewa Group	Bandelier Tuff	Tshirege Member	Rhyolite tuff, light gray to buff, composed of quartz, sanidine, mafic minerals, xenoliths of pumice, rhyolite, and latite in a fine ash matrix.	Varies up to 1,000	Yields small quantities of perched water to a few springs along Sierra de los Valles.
				Otowi Member	Rhyolite tuff, light gray, pumiceous, friable, quartz, glass shards, minor amounts mafic minerals, xenoliths of rhyolite, latite, and pumice in fine ash matrix.	0 - 215	Yields small quantities of perched water to springs in upper Guaje Canyon.
				Guaje Member	Lapilli tuff, light grey, glass shards, quartz, and sanidine in a cellular structure of pumice. Pumice fragments as much as 2 inches in length at base, smaller near top.	0 - 90	May contain perched water locally.
		Santa Fe Group	Unit 5 of the basaltic rocks of Chino Mesa		Cinder cone, local basalt flows, and a dome of basalt.	Variable	Not known to yield water.
			Unit 4 of the basaltic rocks of Chino Mesa		Black basalt and associated tuff.	0 - 240	Not known to yield water.
			Old Alluvium	Unit 3 of the basaltic rocks of Chino Mesa of the Santa Fe Group.	The Old alluvium consists of gravel, sand, silt, and clay. Unit 3 of the basaltic rocks of Chino Mesa consists of thick steep sided masses of basalt and breccias.	The Old alluvium is as much as 2,600. 0 - 500	The old alluvium is as much as 2,600. Yields water. Yields small quantities of water to springs and seeps.
QUATERNARY or TERTIARY	Pliocene to Pleistocene	Tschicoma Formation		Unit 2 of the basaltic rocks of Chino Mesa of the Santa Fe Group.	The Tschicoma Formation consists of undifferentiated thick flows of latite, quartz latite, pyroxene andesite, and some older flows of rhyolite. Unit 2 of the basaltic rocks of Chino Mesa consists of andesite basalt, commonly in thick flows.	The Tschicoma Formation varies locally in thickness, may be more than 2,600. 0 - 850	The Tschicoma Formation forms part of the main aquifer in the eastern part of the Pajarito Plateau, yields water to springs and wells. May contain small quantities of perched water locally.
				Unit 1 of the basaltic rocks of Chino Mesa of the Santa Fe Group.	Unit 1 of the basaltic rocks of Chino Mesa consists of basalts and basaltic tuff with interbedded thick sediments locally.	0 - 360	May contain small quantities of perched water locally.
				Fanglomerate member of the Puye Conglomerate of the Santa Fe Group.	The fanglomerate member is a conglomerate consisting of interbedded silt, sand, and pebble-to-boulder size material derived from the Tschicoma Formation. Units 1 and 2 of the basaltic rock of Chino Mesa are interbedded with the fanglomerate member beneath the central and eastern part of the Pajarito Plateau. Flow rock of the Tschicoma Formation are interbedded with the lower part of the fanglomerate member. The bulk of the fanglomerate is derived from the Tschicoma Formation that forms the Sierra de los Valles west of the Pajarito Plateau.	0 - 640	Contains small quantities of perched water locally along the eastern part of the Pajarito Plateau and is within the main aquifer along the central and western part of Pajarito Plateau.
				Totavi Lentil of the Puye Conglomerate of the Santa Fe Group.	The Totavi Lentil is of conglomerate, silt, sand, and pebble-to-boulder size material consisting of fragments of quartz, quartzite, gneiss schist, granite, and limestone.	0 - 75	Forms part of the main aquifer in the central and western part of the Pajarito Plateau, yields water to springs and wells.
TERTIARY	Middle(?) Miocene to Pliocene	Santa Fe Group	Tesuque Formation		Silty sandstones, sandy siltstones, and occasional bed of pebbly conglomerate.	2,450+	Forms part of the main aquifer, yields water to municipal wells and springs.

Hydrology

Six test wells were drilled and equipped with pumps during June 1949 to June 1950. Detailed information on the dates of drilling, original water levels, casing schedules, geologic logs, and original pumping installation on the six wells is given by Black and Veatch (1950). The six wells were used to sample the ground water of the area for possible contamination and to determine the aquifer characteristics in order to estimate the velocity of ground-water flow in the aquifers tapped by the wells.

The aquifers in test wells 1A and 2A are perched zones above and separate from the main aquifer. Test wells 1, 2, 3, and 4 may penetrate the top of the main aquifer. However, the information is inconclusive and it is possible that these wells tap perched water above the main aquifer. The supply wells in Los Alamos and Guaje Canyon tap the main aquifer. The main aquifer in the Los Alamos area is the saturated zone in the Santa Fe Group and the Tschicoma Formation. The water in the main aquifer is under artesian pressure. The piezometric surface rises from the Rio Grande westward through the Tesuque Formation into the upper units of the Santa Fe Group and into the upper part of the Tschicoma Formation (fig. 5). The Tschicoma Formation and the upper part of the Santa Fe Group also may contain perched aquifers.

Movement of water in the main aquifer is from the Sierra de los Valles eastward toward the Rio Grande where there is some discharge from springs into the river. The gradient on the piezometric surface of the main aquifer between wells G-1 and G-5 in the Guaje Canyon well field was about 85 feet per mile in 1952. A difference in head between test wells 1 and 2 indicates a hydraulic gradient of about 40 feet per mile.

Aquifer tests

Aquifer tests on the six test wells to determine the aquifer characteristics were conducted during 1951 and 1952. The tests ranged in length from 4 hours and 15 minutes to 47 days. The important characteristic of the aquifer determined by aquifer tests, is the coefficient of transmissibility. The coefficient of transmissibility is expressed as the rate of flow of water at prevailing water temperature, in gallons per day, through a vertical strip of the aquifer 1 foot wide extending the full saturated height of the aquifer under a hydraulic gradient of 100 percent.

Another important aquifer characteristic is the coefficient of permeability, which is the rate of flow of water in gallons per day, through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent at the prevailing temperature. This is obtained by dividing the transmissibility by the thickness of the aquifer yielding water to the well.

The specific capacity of a well can also be determined by aquifer tests. It is the discharge expressed as rate of yield per unit drawdown, in gallons per minute per foot of drawdown.

The locations of the test wells are shown on figure 2, and the geologic and hydraulic characteristics of the aquifers as determined from pumping tests in the test wells are shown in table 2.

Table 2.--Geologic and hydraulic characteristics of aquifers of test wells 1, 1A, 2, 2A, 3, and 4 near Los Alamos, N. Mex.

Well	Aquifer	Duration of test (hours)	Pumping rate (gallons per minute)	Water level prior to pumping (feet below land surface)	Total drawdown (feet)	Specific capacity		Transmissibility (gpd/ft)	Permeability (gpd/ft)	Thickness of aquifer (feet)
						First 4 hrs.	Entire test			
1	Totavi Lentil of the Puye Conglomerate	246	2.4	591.7	38.9	0.5	0.06	200	11	19
1A	Unit 3 of the basaltic rocks of Chino Mesa	1,128	3.4	182.73	4.72	10.0	.75	8,300	2,800	3
2	Totavi Lentil of Puye Conglomerate	760	6.7	760.60	7.48	1.1	1.0	7,000	290	24
2A	Fanglomerate member of the Puye Conglomerate (small in areal extent)	4.5	.3	116.2	10.24	.03	.03	50	10	5
3	Totavi Lentil of Puye Conglomerate	720	6.6	751.14	15.0	.5	.5	7,800	310	25
4	Tschicoma Formation	720	2.8	1,166.6	4.85	1.2	.6	750	36	21

Velocity of ground-water movement

The aquifer with the highest permeability contained perched water and was found in test well 1A. This aquifer which is an interflow zone in basalt ~~which~~ may connect with joints and fractures in the basalt. The other aquifers, with the exception of the one penetrated by test well 4, are in alluvial sediments and are possibly the upper part of the main saturated section at Los Alamos. The permeability of the upper part of the saturated section ranges between 111 and 310 gpd (gallons per day) per square foot. This is high compared with permeability of the Bandelier Tuff which is less than 1 to about 12 gpd per square foot (table 3).

The velocity of ground water in the lower part of the Puye Conglomerate is about 150 feet per year based on an average permeability of 100 gpd per square foot, and average gradient of the piezometric surface of 40 feet per mile, and an average porosity of 25 percent. On the same basis the velocity of the perched water in the interflow zone penetrated by test well 1A, locally, may be nearly 30 times this or about 4,500 feet per year.

Relationship of surface and ground water in the Los Alamos area

The major part of this study is to determine the relationship between surface and ground water. Wastes discharged into the canyons adjacent to Los Alamos travel as surface flow until they infiltrate the volcanic rock and the sediments of the canyon bottoms or are evaporated to the atmosphere. Some of the percolating water probably recharges the ground water.

The investigation of the chemical and radiological quality of surface and ground water was designed to monitor all water that may have become contaminated. Samples were collected from springs, seeps, surface flow, and underflow in Acid and Pueblo Canyons; streams, springs, and seeps in other areas; the test wells and supply wells; and the Rio Chama and Rio Grande Rivers. All chemical and radiological analyses made by the Los Alamos Scientific Laboratory during the period of this investigation are on file at the Health Division of the Laboratory. These records were evaluated and are in part summarized in this report. Chemical analyses made by the Geological Survey are also included in this report.

Shallow wells were installed in Acid and Pueblo Canyons during 1954 so that information on the chemical and radiological nature of the water in the alluvium could be obtained. Four shallow wells, cased with corrugated culvert pipe, were constructed in Acid Canyon, and 10 drivepoint wells were constructed in Pueblo Canyon (fig. 2). The wells ranged in depth from about 2 feet in upper Acid Canyon to about 10 feet in lower Pueblo Canyon. These wells will be referred to as Acid Canyon wells or Pueblo Canyon wells. Samples were collected with a small hand pump or with a small bailer if the well could not be pumped. Whenever possible, the wells were pumped for about 5 minutes to bring formational water into ~~clean~~ the wells.

Streamflow measurements in Acid and Pueblo Canyons and water-level measurements in the test wells were made to aid in correlating changes in the quality of water and to study or determine areas of recharge. Changes in surface flow were used to determine the losses in streamflow by seepage into the sediments and rocks of the floors of the canyons, or the gain in flow by return of subsurface water to the stream. Changes in water levels in the shallow and deep ground-water bodies may indicate a hydraulic connection with surface waters.

Locations of samples of streamflow collected in Acid and Pueblo Canyons ~~(tables 9 and 10)~~ are shown on figure 2. Samples in the vicinity of the Central Sewage Plant were collected during 1952 at selected times. The quality of samples collected from the test wells is shown in tables 11 and 12, and the quality of samples collected from the supply wells, rivers, and reservoirs is shown in table 15.

The locations of springs and seeps in Pueblo, Los Alamos, and Ancho Canyons ~~(table 14)~~ are shown on figure 2. Hamilton Bend and Indian Springs were sampled at random. The samples at Hamilton Bend Spring were collected at the end of a discharge pipe driven into the bank of the stream, and the samples from Indian Spring were collected from a concrete trough.

Sample collection since June 1952, from the Rio Chama and Rio Grande, Rivers were to obtain background data and to determine if any contaminants from Los Alamos reached the Rio Grande, ~~started in June 1952.~~ Samples were collected from the Rio Chama at Chamita; the Rio Grande at Embudo, the point farthest upstream in the sampling net; at Otowi; and at Cochiti, the point farthest downstream (fig. 4). Samples

Figure 4.--Map of river-sampling sites on the Rio Chama and Rio Grande.

collected daily at the Chamita, Embudo, and Otowi stations were composited into monthly samples for each station and sent to the Los Alamos Scientific Laboratory where they were further composited into 3-month samples for each station. The river at Cochiti was sampled weekly, composited into a 1-month sample, and then composited into a 3-month sample ~~(table 15)~~.

Acid-Pueblo Canyon disposal system

Waste waters have been discharged into Acid Canyon by a waste treatment plant since about 1951, and sewage has been discharged in Pueblo Canyon by the Pueblo and Central sewage plants since 1944.

Three weirs, recording streamflow in Acid Canyon, were operated from October 1, 1950 to July 1, 1952 (fig. 5) on the West Fork,

Figure 5.--Location of weirs and stations for streamflow measurements in Acid and Pueblo Canyons, Los Alamos and Santa Fe Counties, N. Mex.

South Fork, and at the mouth of Acid Canyon. The West Fork weir measured mainly storm runoff; the South Fork weir measured, primarily, waste from the treatment plant, plus some incidental waste from vehicle washing near the laboratory, and storm runoff; the weir at the mouth of Acid Canyon (Acid weir) measured the combined flow of the two upper weirs and storm runoff. The distance from the two upper weirs to the lower weir is about a quarter of a mile. Flow is in a narrow steep-walled canyon cut in the Tshirege Member of the Bandelier Tuff.

Data of losses and gains of flow at the weirs (fig. 6) indicate

Figure 6.--Hydrograph of streamflow in Acid Canyon, October 1950 through June 1952, showing loss or gain between upstream stations and the mouth of Acid Canyon.

that about 25 to 50 percent of the streamflow at the two upstream weirs was lost from the stream by seepage or evaporation before it reached the lower weir. Streamflow lost to bank storage during periods of high flow returned to the stream during periods of low flow (fig. 6). A large part of the loss from the stream was in the numerous joints and fractures in the tuff, as the tuff itself has low permeability (table 3).

The average weekly discharge of waste and sewage (table 4) is indicative of flow in upper Pueblo Canyon, except for that lost by seepage into the alluvium and underlying rock, evaporation, and transpiration. During the warmer months of the year much of the sewage discharge was used for irrigation water and did not reach Pueblo Canyon.

Spot measurements of surface flow made in Acid and Pueblo Canyons on June 10, 1952 (table 5 and fig. 2) show that the streamflow varied between 31.0 and 58.8 gpm above the Central Sewage Plant. The large increase in flow at station 5 reflects discharge from the Central Sewage Plant.

Table 3.--Permeability of the Bandelier Tuff

(Analyses by the U.S. Geological Survey

Hydrologic Laboratory)

Core number	Bandelier Tuff	Porosity (percent)	Coefficient of permeability (Meinzer's units)1/
5	Tshirege Member	46.3	1
6	do.	35.8	1
7	do.	38.0	0.5
8	do.	37.2	2
9	do.	47.3	6 2/
1	Otowi Member	46.9	8
2	do.	50.2	0.08 3/
3	Guaje(?) Member	39.3	12
4	Guaje Member	40.0	5

1/ Meinzer's units are defined in Water-Supply Paper 887 as the flow in gallons per day per square foot of cross-sectional area under a 100 percent gradient at 60° F.

2/ Sample cored from near the surface and thus considerably weathered.

3/ Not representative of the gross permeability of the member. Probably represents the minimum.

Table 4.--Average weekly volume of sewage discharged into Pueblo Canyon and volume of waste discharged into Acid Canyon, July 1951 through December 1955, in gallons

Period	Sewage plants		Waste plant
	Pueblo	Central	Acid Canyon
July 1951 through October 1951	142,020	2,292,900	154,878
November 1951 through March 1952	1,806,750	2,568,845	94,108
April 1952 through October 1952	143,901	1,354,747	145,985
November 1952 through March 1953	2,225,328	1,151,220	210,446
April 1953 through October 1953	120,950	805,963	165,732
November 1953 through March 1954	2,266,212	1,027,570	233,957
April 1954 through October 1954	244,646	236,150	215,014
November 1954 through March 1955	2,302,373	685,109	197,151
April 1955 through October 1955	207,000	151,765	203,985
November-December 1955	2,070,700	235,565	189,529

Table 5.--Streamflow measurments in Acid and Pueblo Canyons on June 10, 1952

Station	Discharge
West Fork Weir	0.6 gpm
South Fork Weir	1.9 gpm
Total flow (sum of above 2).	2.5 gpm
At a point 20 yards below junction South Fork and West Fork of Acid Canyon.	No flow
Streambed at a point about midway between upper Weirs and Acid Weir.	No water 1 foot below streambed.
Point 80 yards above Acid Weir, where the streambed drops about 20 feet over rocks.	Water flowing out of rocks about the same rate as that seeping into the pool above the gaging station.
Acid Weir	15.0 gpm
Station 1, Pueblo Canyon, 50 yards above mouth of Acid Canyon.	38.6 gpm
Junction of Acid Canyon and Pueblo Canyon (sum of above 2).	53.6 gpm
Station 2, Pueblo Canyon, 150 to 200 yards below Acid Canyon.	58.8 gpm
Station 3, Pueblo Canyon, 300 to 400 yards below Acid Canyon	31.0 gpm
Station 4, Pueblo Canyon, 70 yards above Central Sewage Plant infall.	44.9 gpm
Station 5, Pueblo Canyon, 200 yards below Central Sewage Plant infall.	123.0 gpm

Periodic estimates of streamflow were made between December 1951 and October 195[illegible] (table 6 and fig. 5) at six stations in the middle and lower reaches of Pueblo Canyon to study the infiltration of water downstream from test well 2 where the canyon widens. Flow at station 6 correlates roughly with total discharge into Pueblo Canyon, except during periods when the stream is affected by runoff from precipitation. A general decrease in discharge from the Central Sewage Plant ~~since~~ after early 1952 caused a considerable reduction of stream flow at station 6 and ~~provided~~ only intermittent flow at station 7. Flow at station 7 does not appear to correlate directly with discharge from the Central Sewage Plant, about one-half mile upstream.

The stream flows mainly on the Otowi Member of the Bandelier Tuff and partially ~~over~~ on Puye Conglomerate between stations 6 and 8, and on a compacted silt layer between stations 8 and 9. Most of the infiltration takes place upstream from station 8 (Hamilton Bend), because the pumiceous tuff and conglomerate is more permeable than the silt layer. The streamflow loss between stations 6 through 9 is high, except for floodflow as occurred on April 9, and July 15, 1952 (table 6).

Flow was reported at station 10 on fewer than half the dates. No flow was reported at station 11, opposite test well 1. It can be assumed that no waste waters reach the Rio Grande as streamflow except during floodflow.

9-880

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Table 6.--Discharge at Pueblo Canyon stations and from Hamilton Bend Spring and Otowi Seep, 1951 through 1954
(Discharge in gallons per minute)

Sta. / Date		Station 6	Station 7	Station 8	Hamilton Bend Spr.	Otowi Seep	Station 9	Station 10	Station 11			
1951 Dec.		28	20	7	-	6	F	F	0			
1952 Jan.11		70	48	25	-	4	20	F	-			
Jan.25		105	80	65	-	4	50	10	0			
Feb.12		200	150	105	-	8	80	14	0			
Feb.21		215	175	125	-	14	80	23	0			
Mar. 7		350	200	95	-	13	60	18	0			
Mar.26		300	165	100	-	15	85	12	0			
Apr. 9		500	425	425	-	17	400	13	0			
May 7		275	200	50	-	13	40	10	0			
May 21		80	45	15	-	7	12	6	0			
June 5		115	70	23	-	13	15	0	0			
June 25		100	35	0	8	10	0	0	0			
July 15		400	300	275	2	10	150	0	0			
Aug. 7		90	0	0	4	11	0	-	0			
Aug.22		125	60	10	5	5	0	-	0			
Sept.8		75	0	15	10	0	15	-	0			
Sept25		300	0	0	12	5	10	-	0			
Oct. 9		60	0	0	12	10	0	-	0			
Nov. 6		150	40	0	10	10	0	-	0			
Dec.10		F	F	0	10	10	0	-	0			
1953 Jan.		F	F	F	-	-	-	-	-			
Feb. 3		300	250	25	10	10	15	0	0			
Mar. 3		300	200	15	10	10	10	0	0			
Apr. 7		250	150	10	10	8	10	0	0			
May 5		100	60	0	10	3	0	0	0			
June 9		0	0	0	5	2	.5	0	0			
July 14		10	0	0	5	1	3	0	0			
Aug.19		150	90	0	5	1	3	0	0			
Sept 22		0	0	0	1	2	0	0	0			
Oct.27		60	45	0	8	2	2	0	0			
Nov.25		100	100	0	8	-	0	-	-			

Table 6.--Discharge at Pueblo Canyon stations - Continued

Sta. / Date		Station 6	Station 7	Station 8	Hamilton Bend Spring	Otowi Seep	Station 9	Station 10	Station 11			
1953 Dec.		F	F	F	8	-	-	-	0			
1954 Jan.		F	F	F	8	-	-	-	0			
Feb.26		200	150	50	8	-	50	0	0			
Apr.21		50	20	0	5	2	5	0	0			
May 26		40	10	0	-	-	-	-	-			
Aug.24		50	50	0	8	2	2	0	0			
Sept22		0	0	0	8	1	2	0	0			
Oct.27		30	30	0	5	1	5	0	0			

F Frozen

Quality of water

Samples collected from 1 to 4 sampling points on 5 dates in the Acid Canyon wells and from 2 to 5 sampling points on 8 dates in the Pueblo Canyon wells were analyzed by the Los Alamos Scientific Laboratory. The only apparent trend of chemical constituents in samples from either canyon was a downstream decrease in the pH values in water from wells in Acid Canyon; however, some gross effects were noted (table 7). The range and average of most of the constituents in samples collected from Pueblo Canyon wells was substantially less than in samples from Acid Canyon, due largely to dilution by sewage in Pueblo Canyon. The averages of the fluoride ion and total solids in water from Pueblo Canyon were slightly below municipal tolerances, although several individual samples collected from wells in lower Pueblo Canyon contained fluoride and total solids above these tolerances. The concentration of nitrates was high in samples throughout most of Pueblo Canyon.

Data from one set of samples collected in Acid Canyon and analyzed by the Geological Survey (table 8) shows only that the average concentrations of the fluoride, nitrate, and phosphate ions decreased downstream.

Table 7.--Summary of chemical quality of water collected from Acid and Pueblo Canyon wells

(Analyses by the Los Alamos Scientific Laboratory, in parts per million)

Analyses	Acid Canyon		Pueblo Canyon		Accepted standard tolerances for municipal supplies[c]
	Range	Average	Range	Average	
pH	7.0 - 10.8	7.8[a] 9.3[d]	7.8 - 8.0	7.9	-
Calcium	18 - 61	-	9 - 51 [a]	-	-
Magnesium	1 - 13	-	5 - 18 [a]	-	-
Chloride	16 - 67	36	19 - 36	28	250
Fluoride	1.6 - 10.0	3.1	0.4 - 4.0[b]	1.4	1.5[e]
Total solids	334 - 2,201	960	285 - 1,024	466	500
Nitrates (NO_3)	12 - 447	194	4 - 106	53	20

[a] 1954.

[b] One surface sample 9.0 ppm.

[c] Public Health Service figures, 1946.

[d] 1955.

[e] 53.8-58.3°F.

Table 8.--Chemical quality of water from Acid and Pueblo Canyon wells

(Analyses by the U.S. Geological Survey, in parts per million except as indicated)

Well	Date of collection	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	pH	Specific conductance (micromhos at 25° C)
				Acid Canyon				
AC-2	10- 8-54	80	5	2.4	2.6	1.0	-	179
AC-3	10- 8-54	200	57	7	108	0	-	887
AC-4	10- 8-54	164	48	7	161	.1	-	860
AC-5	10- 8-54	167	39	-	119	.2	-	750
Do.	4-21-55	156	32	5.0	170	1.9	-	900
				Pueblo Canyon				
PC-1	8- 9-54	119	21	1.4	18	23	-	360
Do.	10- 8-54	130	33	1.6	13	.5	-	413
Do.	4-15-55	135	33	1.8	65	39	-	541

Table 8.--Chemical quality of water - Continued

Well	Date of collection	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	pH	Specific conductance (micromhos at 25° C)
			Pueblo Canyon - Continued					
PC-2	8- 9-54	109	19	2.2	30	17	-	361
Do.	10- 8-54	119	31	2.4	54	.5	-	477
Do.	4-15-55	160	38	2.2	66	20	-	598
Do.	6-23-55	172	29	3.2	133	2.8	7.2	759
PC-3	8-11-54	97	27	1.8	53	27	-	426
Do.	10- 8-54	94	33	2.4	71	.5	-	491
Do.	4-15-55	80	36	2.2	117	45	-	601
Do.	6-23-55	159	28	4.8	190	7.7	-	866
PC-4	8-11-54	104	24	2.0	44	26	-	406
Do.	10-14-54	88	35	1.8	74	6.1	-	501
Do.	4-15-55	91	38	2.2	115	46	-	600

19c

Table 8.--Chemical quality of water - Continued

Well	Date of collection	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	pH	Specific conductance (micromhos at 25° C)
			Pueblo Canyon - Continued					
PC-5	8-11-54	111	24	1.8	35	22	-	390
Do.	10-14-54	97	35	1.8	66	33	-	486
Do.	4-14-55	104	39	2.2	106	44	-	600
Do.	6-23-55	209	34	1.8	-	10	7.2	527
PC-6	8-16-54	123	23	1.8	18	16	-	372
Do.	10-14-54	101	30	1.0	52	23	-	425
Do.	4-14-55	151	34	2.2	51	35	-	556
PC-7	8-16-54	121	28	1.6	44	12	-	449
Do.	10-14-54	131	30	1.0	27	11	-	428
Do.	4-14-55	146	36	1.8	65	31	-	583

Table 8.--Chemical quality of water - Continued

Well	Date of collection	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	pH	Specific conductance (micromhos at 25° C)
			Pueblo Canyon - Continued					
PC-8	8-17-54	120	31	0.4	41	0.6	-	440
Do.	10-14-54	119	31	.4	45	.5	-	432
Do.	4-14-55	111	32	.8	47	1.4	-	438
Do.	6-22-55	115	41	.6	46	.2	7.0	478
PC-9	8-17-54	187	25	1.2	2.3	5.5	-	435
Do.	10-14-54	133	22	1.2	.9	6.3	-	330
Do.	6-23-55	162	35	1.0	.3	.3	-	473
PC-10	10-13-54	181	23	.8	2.4	.8	-	486

Samples of surface flow in Pueblo Canyon above and below the confluence with Acid Canyon and above and below the outlet from the Central Sewage Plant (table 9) show that the daily changes in quality of water from the three sources of discharge caused sufficient variations to make significant trends difficult to recognize. Samples collected at Acid Weir and surface flow samples collected from near stations 1 and 2 in Pueblo Canyon (table 10) also show that the concentrations of the chloride, fluoride, and nitrate ions generally were higher in waters in Acid Canyon, but that the concentration of the phosphate ions from the sewage plants generally was higher, commonly 30 to 40 ppm (parts per million), than in Acid Canyon. The specific conductance ranged between 500 and 1,080 micromhos (at 25° C) and averaged about 830 micromhos in Acid Canyon. In Pueblo Canyon the specific conductance ranged from 370 to 600 micromhos and decreased irregularly downstream from an average of 580 in the upper part of the canyon to an average of 485 in the lower part.

The daily average concentration of plutonium in waste water discharged from the waste treatment plant in Acid Canyon during 1954 and 1955 was about 110 d/m/l (disintegration per minute per liter), but the concentration in slug discharges may have been as high as 500 to 800 d/m/l or as low as 10 to 20 d/m/l. Plutonium concentrations above 300 d/m/l were rare. Nothing is known of the concentrations of contaminates in the discharge from the contaminated-vehicle washing area at the site.

Table 9.—Chemical quality of surface flow in Acid and Pueblo Canyons

(Analyses by the U.S. Geological Survey

Results in parts per million except as indicated)

Point of collection	Date of Collection	Discharge (gallons per minute)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C) Parts per million	Dissolved solids (residue at 180°C) Tons per acre-foot	Hardness as $CaCO_3$ Calcium, magnesium	Per cent sodium	Specific conductance (micromhos at 25° C)	pH	Remarks
150 ft above flow from Central Sewage Plant	1-3-52	80	22	0.06	18	5.6	86		154	26	28	1.6	71	334	0.45	68	73	545	7.1	Flow in Pueblo Canyon
50 ft below flow from Central Sewage Plant	1-3-52	110	23	.07	15	4.2	92		192	26	27	1.6	35	319	.43	55	78	553	7.3	Do.
200 ft above flow from Central Sewage Plant	2-4-52	10	21	.04	16	5.7	90		138	27	34	1.8	81	345	.47	64	75	578	7.2	Do.
Outfall from Central Sewage Plant	2-4-52	-	-	-	-	-	-		210	-	30	1.6	35	-	-	-	-	568	-	Sewage
Central Sewage Plant effluent, just above confluence with Pueblo Canyon	2-4-52	-	-	-	-	-	-		176	-	32	1.6	40	-	-	-	-	540	-	Do.
100 ft below flow from Central Sewage Plant	2-4-52	250	24	.09	12	2.0	109		223	26	34	1.6	41	335	.46	38	86	578	7.5	Flow in Pueblo Canyon
100 yds. above Test Hole 2 and 2A	2-4-52	-	-	-	-	-	-		196	-	32	1.6	30	-	-	-	-	551	-	Do.
0.5 mi. above Test Hole 1 and 1A	2-4-52	-	-	-	-	-	-		242	-	30	1.6	-	-	-	-	-	516	-	Do.

Table 9.--Chemical quality of surface flow in Acid and Pueblo Canyons--Continued

Point of collection	Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C) Parts per million	Dissolved solids (residue at 180°C) Tons per acre-foot	Hardness as $CaCO_3$ Calcium, magnesium	Hardness as $CaCO_3$ Per cent sodium	Specific conductance (micromhos at 25° C)	pH	Remarks
200 ft above flow from Central Sewage Plant	3-6-52	43	-	18	5.3	84		139	25	33	1.6	74	352	0.48	67	73	541	7.3	Flow in Pueblo Canyon
Outfall from Central Sewage Plant	3-6-52	64	-	18	3.1	78		150	29	34	.8	31	332	.45	58	75	508	7.2	Sewage
Central Sewage Plant effluent, just above confluence with Pueblo Canyon	3-6-52	64	-	18	4.2	61		98	35	34	1.2	35	300	.41	62	68	476	7.2	Do.
100 ft below flow from Central Sewage Plant	3-6-52	59	-	17	3.5	83		137	33	34	1.4	47	345	.47	57	76	514	7.[illegible]	Flow in Pueblo Canyon
Pueblo Sewage Plant effluent	4-3-52	-	-	-	-	-		201	-	32	2.0	32	-	-	-	-	595	7.3	Sewage
Acid Weir	4-3-52	-	-	-	-	-		60	-	22	8.0	450	-	-	-	-	1,120	6.6	Flow in Acid Canyon
200 yds. below confluence with Acid Canyon	4-3-52	-	-	-	-	-		218	-	32	1.8	26	-	-	-	-	590	7.2	Flow in Pueblo Canyon
150 yds. above flow from Central Sewage Plant	4-3-52	-	-	-	-	-		187	-	32	1.8	28	-	-	-	-	563	7.1	Do.

Table 9.--Chemical quality of surface flow in Acid and Pueblo Canyons--Continued

Point of collection	Date of Collection	Discharge (gallons per minute)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C) Parts per million	Dissolved solids (residue at 180°C) Tons per acre-foot	Hardness as $CaCO_3$ Calcium, magnesium	Per cent sodium	Specific conductance (micromhos at 25° C)	pH	Remarks
150 ft above flow from Central Sewage Plant	4-10-52	1,000	40	-	14	5.7	38		116	13	8.0	0.7	24	200	0.27	58	59	274	7.3	Flow in Pueblo Canyon
Outfall from Central Sewage Plant	4-10-52	500	-	-	-	-	-		247	-	34	1.4	1.8	-	-	-	-	609	7.2	Sewage
Central Sewage Plant effluent, just above confluence with Pueblo Canyon	4-10-52	500	-	-	-	-	-		226	-	35	2.0	.7	-	-	-	-	561	7.3	Do.
100 ft below flow from Central Sewage Plant	4-10-52	1,500	40	-	14	4.7	46		117	15	12	1.0	28	219	.30	54	64	293	7.2	Flow in Pueblo Canyon
Acid Weir	6-10-52	38.6	-	-	-	-	-		80	-	21	9.0	238	-	-	-	-	714	-	Flow in Acid Canyon
150 yds. below confluence of Acid and Pueblo Canyons	6-10-52	58.8	-	-	-	-	-		100	-	27	2.4	17	-	-	-	-	540	-	Flow in Pueblo Canyon
400 yds. below confluence of Acid and Pueblo Canyons	6-10-52	30.97	-	-	-	-	-		106	-	27	1.6	72	-	-	-	-	481	-	Do.
70 yds. above flow from Central Sewage Plant	6-10-52	44.88	-	-	-	-	-		113	-	27	1.6	66	-	-	-	-	463	-	Do.

Table 9.--Chemical quality of surface flow in Acid and Pueblo Canyons--Continued

Point of collection	Date of collection	Discharge (gallons per minute)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C) Parts per million	Dissolved solids (residue at 180°C) Tons per acre-foot	Hardness as $CaCO_3$ Calcium, magnesium	Per cent sodium	Specific conductance (micromhos at 25° C)	pH	Remarks
Outfall from Central Sewage Plant	8-26-52	100	-	-	-	-	-		139	-	30	1.1	18	-	-	-	-	456	-	Sewage
South Fork Weir	10-22-52	51	-	-	-	-	-		151	-	8	4.8	79	-	-	-	-	467	-	Flow in Acid Canyon
Acid Weir	10-22-52	51	-	-	-	-	-		66	-	30	7	589	-	-	-	-	1,290	-	Do.
Below confluence with Acid Canyon	10-22-52	-	-	-	-	-	-		95	-	30	2.0	120	-	-	-	-	568	-	Flow in Pueblo Canyon
½ mi. below confluence with Acid Canyon	10-22-52	30	-	-	-	-	-		99	-	31	2.2	116	-	-	-	-	558	-	Do.
Above flow from Central Sewage Plant	10-22-52	35	-	-	-	-	-		107	-	28	2.0	59	-	-	-	-	460	-	Flow in Pueblo Canyon
Outfall from Central Sewage Plant	10-22-52	150	-	-	-	-	-		172	-	29	1.8	31	-	-	-	-	521	-	Sewage
Central Sewage Plant effluent, just above confluence with Pueblo Canyon	10-22-52	0.05	-	-	-	-	-		96	-	28	1.0	32	-	-	-	-	409	-	Do.
Below flow from Central Sewage Plant	10-22-52	25	-	-	-	-	-		105	-	30	2.0	59	-	-	-	-	460	-	Flow in Pueblo Canyon
150 ft above Test Hole 2 and 2A	10-22-52	20	-	-	-	-	-		104	-	30	2.0	64	-	-	-	-	474	-	Do.

Table 10.--Chemical quality of water from Acid Weir, ~~Pueblo 1, and Pueblo 2~~ and Pueblo Stations 1 and 2.

(Analyses by the U.S. Geological Survey. ~~Quality of Water Branch~~, Results in parts per million, except as indicated)

Source	Date of collection	Discharge (gallons per minute)	Silica (SiO_2)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	pH	Specific conductance (micromhos at 25°C)
Acid Weir	4- 7-53	8	13	110	22	7.0	213	0.4	-	739
Do.	5- 4-53	10	22	133	25	7.0	164	.4	-	661
Do.	6- 9-53	3	24	146	26	7.0	115	1.4	-	661
Do.	7-13-53	25	39	141	29	3.0	85	6.6	-	532
Do.	8-19-53	10	28	114	23	7.0	93	1.0	-	497
Do.	9-22-53	5	26	115	31	5.0	141	.0	-	630
Do.	10-27-53	10	-	0 a/(25)	30	4.4	87	.1	-	559
Do.	11-23-53	50	-	76 a/(8)	25	3.6	284	.3	-	881
Do.	12-29-53	10	-	12 a/(50)	50	3.6	230	.1	-	833
Do.	1-28-54	15	-	107	40	4.4	366	.6	-	1,080
Do.	2-26-54	20	-	144	47	4.4	240	1.1	-	932
Do.	3-31-54	10	-	129	42	4.8	294	.5	-	965
Do.	4-21-54	15	-	133	39	5.2	274	.7	-	960

Table 10.--Chemical quality of water - Continued

Source	Date of collection	Discharge (gallons per minute)	Silica (SiO_2)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	ph	Specific conductance (micromhos at 25°C)
Acid Weir	5-26-54	20	-	140	29	7.0	198	1.3	-	486
Do.	6-30-54	20	-	140	34	5.0	151	1.7	-	703
Do.	7-26-54	20	-	116	28	5.0	218	1.2	-	725
Do.	9-22-54	0	-	105	31	5.0	252	.9	-	838
Do.	10-27-54	2	-	157	36	5.6	193	3.3	-	813
Do.	11-24-54	2	-	124	44	6.0	231	1.2	-	885
Do.	1-12-55	15	-	110	42	5.6	272	1.2	-	955
Do.	3- 1-55	5	-	98	45	4.8	333	.8	-	1,020
Do.	3-31-55	15	-	98	44	4.8	377	1.0	-	1,050
Do.	4-28-55	15	-	116	35	4.8	284	1.1	-	1,010
Do.	6- 3-55	10	-	121	27	4.8	335	1.0	-	981
Do.	6-23-55	1[illegible]	-	162	25	6.4	225	1.6	-	864

20c

Table 10.--Chemical quality of water - Continued

Source	Date of collection	Discharge (gallons per minute)	Silica (SiO_2)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	pH	Specific conductance (micromhos at 25°C)
Pueblo 1	4- 7-53	200	58	184	29	1.0	29	43.0	-	552
Do.	5- 4-53	125	58	157	38	1.6	44	3.8	-	590
Do.	6- 9-53	15	22	137	26	4.0	90	9.9	-	572
Do.	7-13-53	150	47	102	30	1.5	84	32.0	-	501
Do.	8-19-53	150	51	90	34	1.3	42	3.8	-	436
Do.	9-22-53	15	33	114	29	5.0	120	6.3	-	588
Do.	10-27-53	50	-	140 a/(70)	30	1.0	32	.7		446
Do.	11-23-53	100	-	121	31	2.2	76	.9	-	558
Do.	12-29-53	60	-	156	29	1.8	30	.2		576
Do.	1-27-54	100	-	94	34	1.6	28	.2	-	526
Do.	1-26-54	1	-	109 a/(5)	36	1.3	68	.9	-	525
Do.	2-26-54	100	-	132	20	1.2	32	.6	-	591
Do.	3-31-54	75	-	230	30	2.4	56	.3	-	694

Table 10.--Chemical quality of water - Continued

Source	Date of collection	Discharge (gallons per minute)	Silica (SiO_2)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	pH	Specific conductance (micromhos at 25°C)
Pueblo 1	4-21-54	100	-	70	29	2.4	86	1.5	-	462
Do.	5-26-54	100	-	91	30	1.5	54	3.3	-	476
Do.	7-30-54	50	-	128	23	2.2	56	16.0	-	448
Do.	8-26-54	50	-	111	25	2.4	73	2.9	-	460
Do.	9-22-54	20	-	110	29	4.0	196	.6	-	732
Do.	10-27-54	50	-	126	37	4.4	149	2.3	-	684
Do.	11-24-54	100	-	132	33	3.0	54	67.0	-	551
Do.	1-21-55	100	-	194	37	2.8	52	2.3	-	649
Do.	3- 1-55	25	-	200	34	2.6	164	1.6	-	690
Do.	3-31-55	40	-	112	38	2.6	120	49.0	-	690
Do.	4-28-55	25	-	106	31	2.8	147	1.1	-	729
Do.	6- 3-55	20	-	121	23	3.2	213	4.3	9.5	706
Do.	6-23-55	15	-	177	28	6.0	226	4.4	7.2	881

Table 10.--Chemical quality of water - Continued

Source	Date of collection	Discharge (gallons per minute)	Silica (SiO_2)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	pH	Specific conductance (micromhos at 25°C)
Pueblo 2	4- 7-53	250	56	122	36	1.3	40	31.0	-	516
Do.	5- 5-53	100	58	90	30	1.3	69	32.0	-	495
Do.	6- 9-53	.5	47	130	34	1.3	21	33.0	-	466
Do.	7-14-53	10	48	117	30	.3	52	22.0	-	481
Do.	8-19-53	150	46	96	28	1.1	34	24.0	-	401
Do.	9-22-53	.1	44	186	36	2.0	46	11.0	-	506
Do.	10-27-53	60	-	62 a/(23)	30	1.4	46	.8	-	447
Do.	11-25-53	100	-	0 a/(27)	29	1.0	31	.2	-	445
Do.	12-29-53	Frozen	-	121	34	1.8	72	1.0	-	562
Do.	2-26-54	200	-	122	25	1.6	38	.8	-	428
Do.	3-31-54	30	-	95	32	2.4	84	3.5	-	508
Do.	4-21-54	50	-	83	32	2.8	97	.9	-	511
Do.	5-26-54	40	-	100	34	2.0	51	36.0	-	478
Do.	7-30-54	5	-	123	28	1.8	21	25.0	-	417

Table 10.--Chemical quality of water - Continued

Source	Date of collection	Discharge (gallons per minute)	Silica (SiO_2)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	pH	Specific conductance (micromhos at 25°C)
Pueblo 2	8-26-54	35	-	102	24	2.4	41	2.7	-	386
Do.	9-22-54	0	-	114	39	2.2	48	.6	-	494
Do.	10-27-54	100	-	134	38	2.4	76	25.0	-	526
Do.	11-27-54	30	-	84	34	2.8	87	44.0	-	528
Do.	3-31-55	120	-	121	36	2.6	69	49.0	-	592
Do.	4-29-55	15	-	112	31	2.4	60	35	-	522

[a] Carbonates.

The average and range of the concentrations of plutonium and uranium in samples collected in Acid and Pueblo Canyons are shown below:

	Acid Canyon		Pueblo Canyon	
	Plutonium Disintegrations per minute per liter	Uranium micrograms per liter	Plutonium Disintegrations per minute per liter	Uranium micrograms per liter
Average, 1954	1,131	79	18.5	1.1
Average, 1955	726	32	7.1	1.1
Range	6 to 2,818	8 to 162	0 to 56.0	.3 to 4.0

The maxium concentration of plutonium in samples collected in Acid Canyon was almost equal to about one-tenth the tolerance limit (Dummer, J. E., 1958, p. 42) and almost 30 times the average discharge concentrations. The high concentration of plutonium (max. 1,570 d/m/l; ave. 930 d/m/l) in samples from well AC-2, upstream from the waste treatment plant, was from processed wastes discharged into the canyon before the plant was in operation. Samples from well AC-3, a short distance downstream from the treatment plant and vehicle-washing area, contained the highest concentrations (max. 2,818 d/m/l; ave. 1,360 d/m/l). A significant decreasing trend between wells AC-3 and AC-4 was evident; the data between wells AC-4 and AC-5 was inconclusive. No significant trends of the concentration of uranium in Acid Canyon were noted.

Table 11.--Chemical quality of water from test wells

(Analyses by the U.S. Geological Survey, Quality of Water Branch, parts per million, except as indicated)

Well number	Date of collection	Temp. (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C)		Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
														Parts per million	Tons per acre-foot	Calcium, magnesium			
	5- 9-52	-	37	0.4	17	0.7	22		92	5.7	3.8	0.9	3.9	136	0.18	46	51	176	8.0
	5-21-52	58	-	-	-	-	-		96	-	4.0	1.0	5.6	-	-	-	-	185	-
	5-26-52	60	-	-	-	-	-		92	-	3.8	1.0	8.0	-	-	-	-	187	-
	5-31-52	60	-	-	-	-	-		98	-	12	1.0	7.5	-	-	-	-	207	-
	6- 5-52	74	-	-	-	-	-		92	-	5.5	1.0	8.6	-	-	-	-	190	-
	6- 5-52	73	49	.02	20	1.4	21		94	6.0	6.0	1.0	8.7	159	.22	56	45	190	7.6
	8- 7-52	69	36	.69	15	.8	17		79	4.2	3.8	1.1	.5	118	.16	41	47	151	7.8
	8-15-52	73.5	-	-	-	-	-		91	-	3.5	1.0	8.3	-	-	-	-	189	-
	9- 8-52	72	49	.44	17	2.1	16		83	3.9	3.8	1.0	6.2	140	.19	51	40	169	8.0
	9-12-52	73	-	-	-	-	-		94	-	3.5	1.0	8.5	-	-	-	-	187	-
	9-19-52	73	-	-	-	-	-		94	-	3.5	1.0	8.3	-	-	-	-	188	-
1	9-26-52	73	-	-	-	-	-		90	-	3.5	1.0	8.1	-	-	-	-	188	-
	10- 2-52	72	-	-	-	-	-		92	-	3.5	1.0	7.5	-	-	-	-	188	-
	10-10-52	-	-	-	-	-	-		94	-	3.8	1.0	7.6	-	-	-	-	194	-
	10-17-52	-	56	.01	20	1.0	20		94	4.9	3.8	1.1	8.8	161	.22	54	44	191	7.4
	12- 3-52	70	56	.01	20	1.2	19		92	5.3	4.0	1.1	7.8	159	.22	55	42	185	7.6
	1- 7-53	70	56	.04	20	1.2	19		92	5.1	4.2	1.1	7.8	159	.22	55	43	183	7.8
	2- 3-53	70	56	.01	20	.8	a/19		81	4.5	2.5	1.1	6.0	157	.21	54	43	183	8.2
	3- 3-53	70	57	.02	20	.9	19		92	4.8	4.0	1.1	6.6	158	.21	54	43	182	8.0
	4- 8-53	-	62	.02	19	1.4	17		88	4.1	4.0	1.1	6.8	158	.21	54	41	180	7.5
	5- 5-53	70	55	.02	20	1.3	17		90	4.7	2.8	1.1	7.3	153	.21	56	39	184	7.3
	6-10-53	70	55	.02	20	1.2	18		90	4.8	4.2	1.1	7.8	156	.21	55	41	184	7.6
	8-19-53	74	43	.14	17	1.1	18		85	5.2	4.0	1.0	6.0	b/136	.18	47	46	171	7.3
	9-23-53	-	54	.02	20	1.1	17		90	4.2	4.0	1.0	6.4	152	.21	55	40	188	7.4

Table 11.--Chemical quality of water - Continued

Well number	Date of collection	Temp. (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C) Parts per million	Dissolved solids (residue at 180° C) Tons per acre-foot	Hardness as $CaCO_3$ Calcium, magnesium	Percent sodium	Specific conductance (micromhos at 25° C)	pH
	8- 7-51	55	-	-	-	-	-	-	17[illegible]	-	28	0.5	14	-	-	-	-	443	-
	8- 8-51	55	-	-	-	-	-	-	17[illegible]	-	28	.5	14	-	-	-	-	444	-
	8- 9-51	55	48	0.02	29	9.1	48	7.8	16[illegible]	29	28	.5	15	297	0.40	110	47	442	7.2
	8-17-51	-	-	-	-	-	-	-	17[illegible]	-	27	.5	17	-	-	-	-	452	-
	8-20-51	-	-	-	-	-	-	-	17[illegible]	-	28	.4	18	-	-	-	-	456	-
	8-23-51	-	-	-	-	-	-	-	17[illegible]	-	27	.4	18	-	-	-	-	456	-
	8-26-51	-	-	-	-	-	-	-	17[illegible]	-	26	.5	19	-	-	-	-	458	-
	8-28-51	55	49	.02	30	9.1	49	7.2	17[illegible]	30	27	.5	22	309	.42	112	47	457	7.2
	9- 1-51	55	-	-	-	-	-	-	168	-	26	.4	26	-	-	-	-	452	-
	11-14-51	54	50	.03	28	13		42	15[illegible]	27	21	.6	37	295	.40	124	43	429	6.9
	11-19-51	54.3	-	-	-	-		-	160	-	22	.5	37	-	-	-	-	439	-
	11-24-51	56	-	-	-	-		-	16[illegible]	-	22	.6	37	-	-	-	-	448	-
	11-29-51	-	-	-	-	-		-	15[illegible]	-	25	.6	37	-	-	-	-	438	-
	12- 4-51	-	-	-	-	-		-	15[illegible]	-	22	.6	37	-	-	-	-	436	-
	12- 9-51	-	-	-	-	-		-	15[illegible]	-	21	.6	33	-	-	-	-	420	-
	12-10-51	55.3	51	.02	25	7.3		53	151	25	22	.6	33	291	.40	92	56	419	7.1
	9- 9-52	56	45	.04	23	7.7		46	119	27	25	.5	32	265	.36	89	53	385	7.4
	9-12-52	56	-	-	-	-		-	129	-	20	.5	35	-	-	-	-	385	-
	9-13-52	55.5	-	-	-	-		-	128	-	20	.5	34	-	-	-	-	384	-
1A	9-14-52	56	-	-	-	-		-	130	-	22	.5	32	-	-	-	-	384	-
	9-15-52	56	-	-	-	-		-	130	-	20	.5	35	-	-	-	-	384	-
	9-16-52	56	-	-	-	-		-	134	-	20	.5	34	-	-	-	-	384	-
	9-17-52	56	-	-	-	-		-	130	-	20	.5	35	-	-	-	-	387	-
	9-22-52	56	-	-	-	-		-	132	-	21	.5	32	-	-	-	-	382	-
	9-26-52	56	-	-	-	-		-	134	-	19	.5	34	-	-	-	-	377	-
	10- 2-52	56	-	-	-	-		-	128	-	18	.5	35	-	-	-	-	366	-
	10-10-52	-	-	-	-	-		-	126	-	35	.6	22	-	-	-	-	351	-
	10-17-52	-	-	-	-	-		-	127	-	15	.6	22	-	-	-	-	343	-
	10-23-52	-	-	-	-	-		-	106	-	12	.6	20	-	-	-	-	338	-
	10-28-52	-	46	.28	19	7.9		41	130	20	17	.5	21	237	.32	80	53	328	7.2
	12- 3-52	55	53	.09	17	8.1		37	122	19	15	.5	17	227	.31	76	51	321	7.4
	1- 7-53	53	49	.09	17	7.8		38	125	19	14	.5	17	223	.30	74	53	321	7.2
	2- 3-53	53	40	.13	19	6.2		39	131	22	11	.6	12	214	.29	73	54	305	7.9
	3- 3-53	55	42	.05	21	6.4		35	136	22	9.2	.6	8.4	212	.29	79	49	294	7.7
	3- 3-53	56	41	.05	21	6.3		32	131	20	9.0	.6	7.9	208	.27	78	47	289	7.7
	4- 8-53	51	37	.01	25	7.3		26	131	22	7.8	.5	c/ 7.9	198	.27	92	38	292	7.7
	5- 5-53	56	36	.02	26	7.2		25	131	21	7.8	.5	d/ 8.2	196	.27	94	36	292	7.7
	6-10-53	56	45	.03	22	7.6		36	132	19	13	.5	e/ 17	227	.31	86	48	324	7.1
	8-19-53	56	42	.11	19	7.3		39	118	20	16	.5	f/ 23	227	.31	78	52	330	7.4
	9-23-53	56	46	.17	19	7.5		40	114	21	16	.6	g/ 27	236	.32	78	53	336	7.3

Table 11.--Chemical quality of water - Continued

Well number	Date of collection	Temp. (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C) Parts per million	Dissolved solids (residue at 180° C) Tons per acre-foot	Hardness as $CaCO_3$ Calcium, magnesium	Percent sodium	Specific conductance (micromhos at 25° C)	pH
	9-26-51	71	66	0.84	12	4.1	11		75	3.1	3.5	0.5	0.8	139	0.19	47	34	133	7.5
	9-26-51	71	-	-	-	-	-		75	-	3.0	.5	.6	-	-	-	-	134	-
	9-27-51	-	-	-	-	-	-		80	-	3.0	.4	.5	-	-	-	-	139	-
	10- 2-51	70	-	-	-	-	-		80	-	2.8	.4	.4	-	-	-	-	140	-
	10- 3-51	71.5	-	-	-	-	-		80	-	2.8	.4	.4	-	-	-	-	141	-
	10- 4-51	71	-	-	-	-	-		80	-	2.5	.4	.5	-	-	-	-	139	-
	10- 5-51	71	-	-	-	-	-		80	-	3.0	.4	.4	-	-	-	-	143	-
	10- 6-51	71	-	-	-	-	-		79	-	2.8	.4	.4	-	-	-	-	144	-
	10- 7-51	71	-	-	-	-	-		81	-	2.5	.4	.3	-	-	-	-	141	-
	10- 8-51	-	-	-	-	-	-		80	-	2.8	.4	.4	-	-	-	-	139	-
	10- 9-51	71	-	-	-	-	-		82	-	2.8	.4	.4	-	-	-	-	141	-
	10-10-51	71	-	-	-	-	-		80	-	2.5	.4	.5	-	-	-	-	140	-
	10-11-51	71	-	-	-	-	-		82	-	2.8	.4	.4	-	-	-	-	143	-
	10-16-51	72	-	-	-	-	-		80	-	2.8	.4	.4	-	-	-	-	139	-
	10-21-51	72	-	-	-	-	-		80	-	2.8	.4	.6	-	-	-	-	139	-
	10-25-51	70	68	.29	14	3.7	11		80	2.7	2.5	.4	.6	142	.19	50	32	138	7.5
	11- 1-51	70.1	-	-	-	-	-		79	-	2.5	.4	.6	-	-	-	-	140	-
	11- 5-51	71	-	-	-	-	-		80	-	2.8	.4	.6	-	-	-	-	140	-
	11- 9-51	71.2	-	-	-	-	-		80	-	2.5	.4	.5	-	-	-	-	140	-
2	11-14-51	71	-	-	-	-	-		80	-	2.5	.4	.6	-	-	-	-	140	-
	11-19-51	71.2	-	-	-	-	-		80	-	2.5	.4	.7	-	-	-	-	141	-
	11-24-51	71.2	-	-	-	-	-		80	-	2.5	.4	.4	-	-	-	-	142	-
	11-29-51	-	-	-	-	-	-		80	-	2.5	.4	.6	-	-	-	-	140	-
	12- 1-51	71.5	68	.02	14	3.7	11		79	2.6	3.2	.4	.5	142	.19	50	32	139	7.6
	4-10-52	70	-	-	-	-	-		80	-	3.2	.5	.8	-	-	49	-	138	7.6
	4-21-52	66	-	-	-	-	-		83	-	2.5	.4	.9	-	-	-	-	139	7.9
	4-26-52	68	-	-	-	-	-		81	-	3.2	.4	.9	-	-	-	-	141	7.9
	5- 1-52	68	-	-	-	-	-		80	-	3.0	.4	1.2	-	-	-	-	140	8.0
	5- 6-52	66	-	-	-	-	-		83	-	2.8	.4	.9	-	-	-	-	144	8.1
	5-12-52	69	-	-	-	-	-		83	-	3.0	.5	.5	-	-	-	-	144	-
	5-16-52	-	-	-	-	-	b/		79	-	3.8	.5	.5	-	-	-	-	156	-
	5-23-52	58	64	.05	15	4.7	9.9		84	3.4	3.0	.5	.5	142	.19	57	27	142	7.7
	9-17-52	71.5	75	.03	14	4.8	9.0		82	2.5	2.5	.3	.2	148	.20	54	26	141	7.6
	9-26-52	72	-	-	-	-	-		82	-	2.5	.3	.9	-	-	-	-	142	-
	10- 2-52	72	-	-	-	-	-		80	-	2.5	.3	.7	-	-	-	-	140	-
	10-10-52	-	-	-	-	-	-		81	-	3.0	.4	.4	-	-	-	-	141	-
	10-16-52	-	71	.01	14	3.7	13		84	2.8	3.0	.3	.4	149	.20	50	35	139	7.4
	12- 3-52	71	73	.01	14	4.3	10		81	3.1	3.0	.3	.2	148	.20	52	30	140	7.5
	1- 6-53	71	75	.01	15	4.1	10		83	2.9	3.0	.3	.5	152	.21	54	29	141	7.4
	2- 3-53	71	75	.02	15	4.3	8.3		80	1.7	2.8	.4	.4	147	.20	55	25	141	7.0
	3- 3-53	71.5	74	.02	15	4.2	9.0		82	1.9	2.8	.4	.8	148	.20	55	26	141	7.6

Table 11.--Chemical quality of water.--Continued

Well number	Date of collection	Temp. (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C) Parts per million	Dissolved solids (residue at 180° C) Tons per acre-foot	Hardness as $CaCO_3$ Calcium, magnesium	Percent sodium	Specific conductance (micromhos at 25° C)	pH
	11- 2-51	55	54	0.01	8.8	2.0	10		50	5.2	2.0	0.4	1.6	109	0.15	30	42	101	7.3
	11- 5-51	56	-	-	-	-	-		51	-	2.0	.4	1.6	-	-	-	-	105	7.5
	7-16-52	58	57	1.4	7.5	3.2	8.3		50	3.5	2.2	.2	1.7	109	.15	32	36	101	7.8
	12- 3-52	54	62	.73	8.2	3.7	9.2		55	5.1	2.5	.2	1.5	120	.16	36	36	105	7.2
	1- 6-53	53	60	2.6	7.8	3.7	9.2		53	4.5	3.2	.2	1.6	116	.16	34	37	102	7.4
2A	2- 3-53	52	53	.2	7.3	1.2	14		51	4.5	2.5	.5	2.2	110	.15	23	57	102	7.3
	3- 3-53	53	57	.72	7.8	1.2	16		58	4.4	2.5	.5	1.7	121	.16	24	58	107	7.1
	4- 7-53	53	55	.07	7.0	1.3	14		51	4.5	2.8	.4	2.2	112	.15	23	57	105	7.7
	5- 5-53	50	61	.07	7.6	1.6	13		51	4.1	3.2	.3	1.8	118	.16	26	52	103	7.1
	6-10-53	52	59	1.0	7.8	1.2	12		48	4.0	3.5	.4	1.2	1/114	.16	24	51	103	7.2
	8-19-53	-	63	.93	8.0	2.3	11		52	4.3	3.0	.4	1.9	121	.16	30	45	108	7.2
	9-22-53	52	60	1.5	8.0	2.3	11		50	4.4	3.0	.4	2.5	118	.16	30	44	105	7.2
	1-19-52	74	73	0.05	20	6.6	11		108	4.4	3.8	0.4	1.1	173	0.24	77	23	192	7.6
	1-20-52	74	-	-	-	-	-		109	-	4.0	.6	1.5	-	-	-	-	192	-
	1-21-52	74	-	-	-	-	-		107	-	3.5	.6	1.8	-	-	-	-	193	-
	1-22-52	74	-	-	-	-	-		108	-	4.5	.6	1.3	-	-	-	-	191	-
	1-28-52	72	-	-	-	-	-		112	-	3.5	.6	1.4	-	-	-	-	188	-
	1-29-52	74	-	-	-	-	-		113	-	4.0	.6	2.2	-	-	-	-	193	-
	1-30-52	74	-	-	-	-	-		109	-	4.2	.6	1.5	-	-	-	-	194	-
	1-31-52	74	-	-	-	-	-		113	-	3.8	.6	1.5	-	-	-	-	193	-
	2- 1-52	74	-	-	-	-	-		111	-	4.0	.6	1.5	-	-	-	-	192	-
3	2- 2-52	74	-	-	-	-	-		111	-	4.0	.6	1.8	-	-	-	-	192	-
	2- 6-52	73	-	-	-	-	-		109	-	4.0	.6	1.8	-	-	-	-	188	-
	2-27-52	72.5	-	-	-	-	-		112	-	5.0	.6	1.5	-	-	-	-	190	-
	3- 3-52	75.5	-	-	-	-	-		113	-	5.5	.6	1.1	-	-	-	-	193	-
	3- 8-52	75	-	-	-	-	-		110	-	5.5	.6	.7	-	-	-	-	195	-
	3-13-52	75	-	-	-	-	-		111	-	5.5	.6	.9	-	-	-	-	191	-
	3-18-52	-	-	-	-	-	-		112	-	3.5	.4	1.6	-	-	-	-	196	7.5
	3-25-52	74	-	-	-	-	-		112	-	4.5	.4	1.6	-	-	-	-	193	7.6
	3-28-52	74	-	-	-	-	-		120	-	5.2	.3	.9	-	-	70	-	194	7.5
	12- 5-52	66	73	4.4	20	6.4	11		109	4.0	4.0	.5	.5	173	.24	76	24	194	7.4
	12-12-52	74	81	-	-	-	-		115	-	4.5	.5	.6	-	-	-	-	195	7.5
	1- 7-53	74	76	.01	19	6.2	14		113	3.8	4.8	.3	.2	180	.24	73	30	194	7.3
	2- 3-53	74	75	.02	19	4.6	17		112	4.0	4.2	.4	1.1	180	.24	66	36	195	7.4

Table 11.--Chemical quality of water.--Continued

Well number	Date of collection	Temp. (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C) Parts per million	Dissolved solids (residue at 180° C) Tons per acre-foot	Hardness as $CaCO_3$ Calcium, magnesium	Percent sodium	Specific conductance (micromhos at 25° C)	pH
	5-31-51	67.5	-	-	11	6.2	-		88	-	-	0.3	-	-	-	53	-	150	7.4
	5-31-51	65.5	-	-	11	5.9	-		90	-	-	.3	-	-	-	52	-	163	7.4
	6- 1-51	68.5	-	-	12	6.7	-		88	-	-	.2	-	-	-	58	-	154	7.7
	6- 2-51	-	65	0.41	11	6.6	12		91	2.4	2.5	0.2	0.2	145	0.20	54	33	149	8.0
	6- 3-51	-	-	-	-	-	-		91	-	-	.2	-	-	-	-	-	151	8.0
	6- 4-51	-	-	-	-	-	-		92	-	-	.2	-	-	-	-	-	149	7.7
	6-17-52	68	68	.03	12	6.7	12		91	3.5	3.0	.3	.2	151	.21	58	31	151	7.6
	6-18-52	70	-	-	-	-	-		90	-	2.0	.2	.4	-	-	-	-	152	-
4	6-19-52	69.5	-	-	-	-	-		92	-	2.0	.2	.5	-	-	-	-	154	-
	6-20-52	69.5	-	-	-	-	-		90	-	2.2	.2	.7	-	-	-	-	151	-
	6-22-52	70	-	-	-	-	-		92	-	1.8	.1	.7	-	-	-	-	151	-
	6-22-52	70	-	-	-	-	-		94	-	3.0	.1	.8	-	-	-	-	161	-
	6-27-52	70	-	-	-	-	-		94	-	3.0	.1	.9	-	-	-	-	155	-
	7-11-52	70	-	-	-	-	-		90	-	3.0	.1	1.0	-	-	-	-	154	-
	7-17-52	70	73	.02	11	7.1	9.4		87	1.8	2.2	.1	-	148	.20	56	27	149	7.2
	12- 3-52	70	81	.21	11	7.7	9.2		88	2.6	2.8	.1	.2	158	.21	59	25	148	7.4
	1- 7-53	70	74	.03	11	7.9	10		94	2.3	1.8	.2	.3	154	.21	60	27	147	7.6

a/ Contained 7 ppm carbonate (CO_3)
b/ Contained 0.3 ppm phosphate (PO_4)
c/ Contained 0.3 ppm phosphate (PO_4)
d/ Contained 0.2 ppm phosphate (PO_4)
e/ Contained 1.6 ppm phosphate (PO_4)
f/ Contained 2.0 ppm phosphate (PO_4)
g/ Contained 3.2 ppm phosphate (PO_4)
h/ Contained 6 ppm carbonate (CO_3)
i/ Contained 0.1 ppm phosphate (PO_4)

Apparently only a relatively small amount of plutonium and uranium moved from Acid Canyon into Pueblo Canyon. This probably was due to the retention of these ions in the alluvium in Acid Canyon and dilution in Pueblo Canyon. The concentration of plutonium rose slightly between wells PC-1 and PC-2, indicating that the increment of plutonium was added from Acid Canyon rather than upstream in Pueblo Canyon.

Radioactivity of the alluvium

The concentrations of gross alpha and uranium of alluvium in Acid Canyon were relatively low except for several samples collected at stations near wells AC-2 and AC-3 (table 10A). The station near well AC-2 is above the outfall from the treatment plant, and it is probable that the radioactivity found at depths of 2 and 3 feet was retained in the alluvium from wastes discharged before the plant was in operation. Most of the radioactivity at the station near well AC-3 appears to be from the same source. Radioactivity may have concentrated in this reach of Acid Canyon in small depressions in the alluvium. About 75-95 percent of the radioactivity was retained on particles which passed through an 18 mesh or smaller screen. The radioactivity decreased downstream below the station near well AC-3.

Radioactivity in samples from stations in Pueblo Canyon was low and uniform throughout the canyon.

Table 10A.--Radiological analyses of streambed alluvium in Acid and Pueblo Canyons

(Analyses by the Los Alamos Scientific Laboratory)

Acid Canyon, June and July, 1954

Depth	Gross alpha (counts per minute per dry gram)					Uranium (counts per minute per dry gram)				
	Sampling station[1/]									
	AC-1	AC-2	AC-3	AC-4	AC-5	AC-1	AC-2	AC-3	AC-4	AC-5
Surface	59	18	636	185	96	10	6	53	16	7
1 foot	8	54	2,125	161	72	[a/] 3	6	93	13	[a/] 14
2 foot	3	937	1,721	[a/] 52	[a/] 120	[a/] 8	170	116	-	[a/] 16
3 foot	[a/] 3	[a/] 2,177	[a/] 1,370	-	-	[a/] 4	[a/] 88	100	-	-
4 foot	[a/] 5	[a/] 605	-	-	-	[a/] 2	[a/] 27	-	-	-
5 foot	[a/] 1	-	-	-	-	[a/] 1	-	-	-	-

Table 10A.--Radiological analyses of streambed alluvium - Continued

Pueblo Canyon, July 19, 1954

Depth	Gross alpha (counts per minute per dry gram)									
	Sampling station 1/									
	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7	PC-8	PC-9	PC-10
Surface	7	17	9	29	5	20	30	7	8	9
1 foot	10	14	19	15	15	11	14	9	4	4
2 foot	6	13	20	3	13	11	16	5	5	11

1/ Sampling station is nearby observation well, as listed.

a/ one sample only; others average of two or three samples.

Test wells.

Hydrographs of water levels in the test wells (figs. 7 and 8.)

Figure 7.--Hydrographs of nonpumping water levels in test wells 1A and 2A.

Figure 8.--Hydrographs of nonpumping water levels in test wells 1, 2, 3, and 4.

indicate a possible correlation of water levels in test well 1, 1A, and 2A with precipitation and streamflow in Pueblo Canyon (fig. 9). The

Figure 9.--Precipitation at Los Alamos, 1950 through 1955.

perched aquifers yielding water to test wells 1A and 2A apparently are limited to the area beneath and adjacent to Pueblo Canyon. Test wells 1, 2, 3, and 4 apparently tap bodies of perched water which are not part of the main aquifer in the Los Alamos area.

The change in the seasonal fluctuation of the water level in test well 1A after the fall of 1952 (fig. 7) may have been due to the decrease of sewage effluent from the Central Sewage Plant beginning in early 1953 (table 4). The changes in water level in test well 1A after 1952 appear to correlate with precipitation, with a general rise lagging a period of rainfall by several weeks. This suggests that the well became more responsive to local rainfall and less responsive to sewage and waste disposal as discharge into Pueblo Canyon decreased. A possible correlation between the water level in the well and streamflow at station 6 indicates that some streamflow infiltrates upstream from Otowi Seep and reaches the perched aquifer in about 6 months.

Changes in water level in test well 2A, prior to the rising trend (fig. 7), seem to lag behind the increased discharge into Pueblo Canyon and flow at station 6 by about 8 tt 10 months. The different response to streamflow by test well 2A than by 1A, probably was due to the different materials and distance through which the water must move to reach the perched aquifers. Recharge to the aquifer at test well 2A moves through a section of consolidated tuff, whereas much of the recharge to test well 1A moves through a more permeable conglomerate.

The water level in test well 1 rose generally from the beginning of record in 1951 to early in 1954. This rise might have been related to higher precipitation in the years 1950-52. If so this may indicate that about two years are required for recharge to the aquifer.

The hydrograph of test well 2 (fig. 8) indicates no substantial change in water level over a 2-year period, except for a possible slight downward trend. The change in the water levels in test wells 3 and 4 (fig. 8) also have been small and no correlation with precipitation is indicated.

Quality of water

Changes in chemical quality of water from the test wells are useful in determining whether or not a hydraulic connection exists between surface flow in Pueblo Canyon and the aquifers yielding water to the wells, and are used in correlation with the water levels in the test wells. No data are available to indicate the original quality of water from the test wells. Duplicate samples for analysis by the Los Alamos Scientific Laboratory and the U.S. Geological Survey were collected through 1953, after which all analyses were made at Los Alamos. Samples analyzed by the Geological Survey are shown in table 11. A comparison of the quality of water from the test wells on one sampling date is shown in figure 10.

Figure 10.--Chemical quality of water from test wells, January 7, 1953.

Calcium is the predominant cation and bicarbonate is the predominant anion.

The concentrations of ions in samples of water from test well 1A were consideribly higher than those in samples from the other test wells, indicating some contamination of the aquifer before sampling started. The first samples were collected from test well 1A in 1951, whereas the discharge of wastes in Acid-Pueblo Canyons started about 1943. The quality of the water from the test well was similar to that collected from the stream. The concentrations of the bicarbonate, chloride, and nitrate ions varied irregularily, although they were generally in a range within or slightly less than the range of like concentrations in samples collected from the stream in the lower part of Pueblo Canyon. The specific conductance ranged from about 450 micromhos in mid 1951 to about 300 micromhos in early 1953, and the pH ranged between 6.9 and 7.9 without any trends. These changes may be related to the decrease in sewage discharged into Pueblo Canyon in 1952.

The chemical quality of water in samples from test well 2A remained relatively unchanged through 1955 with no trends apparent. The low concentration of most of the constituents in the water indicated no significant recharge from the stream. The specific conductance ranged between 101 and 108 micromhos, and the pH ranged between 7.1 and 7.8.

The quality of water from the four deep test wells was relatively similar and moderately stable. The higher concentration of nitrates in samples from test well 1 indicate there may be some recharge to the aquifer from the stream in Pueblo Canyon. Except for the higher concentration of nitrates, the character of the water from test well 1 was more closely related to that from test well 3 than to test wells 2 and 4.

The concentration of plutonium in samples from test well 1A increased irregularly through 1955 (table 12). The concentration remained below 2.6 d/m/l during intermittent pumping in 1951, however, during the 47-day pumping test on this well in 1952 the concentration rose to 7.0 d/m/l. The average concentration of plutonium continued to rise through 1954, after which it declined slightly. No trends in changes in the uranium concentration were detected, although they were highest in 1954. The relatively high concentrations in 1953 and 1954 may be due to less dilution by sewage and precipitation.

The concentration of plutonium was high in test well 2A during 1953 and 1954 and decreased during 1955. No trends in the concentrations of uranium were detected.

Table 12.--Range and average of the concentrations of plutonium and uranium in samples from test wells

(Analyses by the Los Alamos Scientific Laboratory)

Well number	Year analysed	Number of samples analysed	Plutonium (disintegrations per minute per liter)		Number of samples analysed	Uranium (micrograms per liter)	
			Range	Average		Range	Average
Test well 1A	1951	9	0.8- 2.6	2.1	-	-	-
	1952	10	.4- 8.4	3.7	3	0.7-0.9	0.8
	1953	12	.6- 9.8	4.3	10	.0-7.5	1.2
	1954	5	4.0-13.4	6.4	5	.0-9.5	2.3
	1955	6	1.4- 7.4	5.1	6	.3-1.2	.7
Test well 2A	1951	1	-	.3	-	-	-
	1952	4	.6- 1.2	.8	1	-	.0
	1953	12	2.4- 8.8	5.1	12	.0- .8	.2
	1954	4	3.4- 8.6	5.3	4	.0- .6	.1
	1955	5	.4- 3.8	2.6	5	.0- .0	.0
Test well 1	1952	10	.2- 1.8	.8	2	1.2-1.4	1.3
	1953	10	2.8- 7.8	4.3	10	.6-2.0	1.0
	1954	2	1.4- 4.0	2.7	2	.8-1.3	1.0
	1955	-	-	1.6	1	-	.8

Table 16.--Range and average of the concentrations - Continued

Well number	Year analyzed	Number of samples analyzed	Plutonium (disintegrations per minute per liter)		Number of samples analyzed	Uranium (micrograms per liter)	
			Range	Average		Range	Average
Test well 2	1951	10	1.0-3.8	1.8	0	-	-
	1952	0	.0-1.8	.6	0	-	-
	1953	3	1.4-2.8	2.1	3	.0- .5	0.2
	1954	1	-	2.0	1	-	.0
	1955	1	-	15.0	0	-	-
Test well 3	1951	1	-	.8	0	-	-
	1952	4	.0-4.8	2.8	4	.0- .6	.3
	1953	[illegible]	2.0-5.2	3.5	3	.2- .7	.5
	1954	3	2.0-7.2	5.7	3	.4- .6	.5
Test well 4	1952	[illegible]	.6-1.8	1.1	1	0	.3
	1953	1	-	1.8	1	-	.7

The concentrations of plutonium and uranium in samples from test wells 1, 2, 3, and 4 were, in general, lower than in samples of surface flow and in samples from Pueblo Canyon wells. The concentrations of plutonium were slightly higher in samples from test wells 1 and 3 than from test wells 2 and 4, except for one possible anamolously high concentration of plutonium (15 d/m/l) from test well 2. No trends of either the plutonium or uranium were evident.

DP Laundry and DP West disposal systems

Wastes have been discharged into earthen pits from DP Laundry and DP West Site since the fall of 1945, and treated wastes were discharged into DP Canyon since 1952. (fig. 2) These pits rarely have been known to overflow into the canyons. The radioactive liquids discharged into the pits have percolated downward and the liquid fraction of the wastes has evaporated or moved into the adjacent rock. An examination of these two pit sites indicates that residual concentrations of radioactivity are present at the surface of the pits and near the bottom of the original excavations. Other zones of radioactive concentration are also located sporadically in the backfill materials of the pits (oral communication, E. R. Hermann, 1953). Vertical or lateral percolation beneath and around the pits has apparently left the radioactive materials adsorbed in the clay, sand, and gravel of the backfill materials ~~pits~~ or in the Bandelier Tuff into which the pits are dug.

Treated liquid wastes discharged from DP West were sampled in DP Canyon well located north of the treatment plant. The range of constituents of this water is shown below:

Chloride	315 to 331 ppm
Fluoride	1.4 to 35 ppm
Nitrate (NO_3)	80 to 130 ppm
Total solids	1,368 to 1,842 ppm
pH	8.3 to 8.4
Plutonium	.5 disintegrations per minute per liter
Uranium	22 to 24 micrograms per liter

Clay mineralogy and ion-exchange capacity determinations were made on samples of Bandelier Tuff collected during the investigation of these sites. The ion-exchange capacity decreased with depth (table 13).

Table 13.--Ion-exchange capacity and mineral constituents of 4 samples of the Tshirege Member of the Bandelier Tuff

(Analysis by U.S. Geological Survey)

Ion-exchange capacity

Field number	Depth below land surface (feet)	Description	Ion-exchange capacities (milli-equivalents per 100 gm)
DP-[illegible]	5	Dark gray to white pumiceous tuff.	3.2
DP-3-12	8	Sandy to silty clay and gravel of gray pumiceous tuff.	1.7
DP-1-9-12	9 to 12	Gray slightly pumiceous tuff	1.2
DP-1-19	19	Gray tuff.	.7

Table 13.--Ion-exchange capacity and mineral constituents - Continued

Mineral constituents

Field number	Depth below land surface (feet)	Minerals Present		Quantitative estimate (parts in ten)
DPW-5-5	5	Clay	Feldspar	5
			Montmorillonite	2
			Cristobalite?	
		Silt	Feldspar	
			Tridymite?	
			Cristobalite?	
DPW-3-12	8	Clay (<2μ)	Feldspar	4
			Montmorillonite	3
			Hydrous mica	2
			Kaolin	
			Cristobalite	
			Tridymite	
			Quartz?	
		Silt (2-62μ)	Feldspar	4
			Cristobalite	4
			Tridymite	1
			Quartz	
DPL-1-9-12	9 to 12	Clay	Feldspar	5
			Cristobalite	3
			Tridymite	1
			Quartz	
			Montmorillonite	
		Silt	Feldspar	5
			Cristobalite	3
			Tridymite	2
			Quartz	
DPW-4-19	19	Clay	Feldspar	4
			Cristobalite	4
			Tridymite	
			Quartz	
		Silt	Feldspar	5
			Cristobalite	4
			Tridymite	1
			Quartz	

Springs and seeps in Los Alamos area

The chemical quality of water from Basalt Spring, Indian Spring, Hamilton Bend Spring, Ancho Spring, and Otowi Seep is shown in table 14. The quality of the water from Hamilton Bend Spring and Otowi Seep, which are in Pueblo Canyon, reflect the quality of the water common to the stream. The concentration of the phosphate ion appears to have increased irregularly at Otowi Seep during about 2 year period of sampling, with an average of 7.6 ppm and a maximum of 30 ppm. The high concentration of nitrates in samples from Basalt Spring, downgradient from the Pueblo Canyon and DP Canyon disposal systems, indicates a possible hydraulic connection with some source of waste or sewage. The chemical quality of water from Indian or Ancho Springs shows no indication of contamination.

Concentrations of plutonium and uranium in samples from Basalt and Indian Springs were about the same as from Otowi Seep and Hamilton Bend Spring, as shown below, and from the stream in Pueblo Canyon. The concentrations of plutonium were higher than those in samples from the test wells.

Table 14.--Chemical quality of water from springs and seeps near Los Alamos, N. Mex.

(Analysis by the U.S. Geological Survey Quality of Water Branch. Parts per million except as indicated.)

Spring or seep	Date of collection	Temp. (° F)	Discharge (gpm)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids: Parts per million	Dissolved solids: Tons per acre-foot	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Basalt Spring	11-20-51	41	15	36	0.01	40	8.5	16		130	31	16	0.5	7.9	-	220	0.30	135	28	20	331	7.1
	2- 5-52	39	25	-	-	-	-	-		120	-	14	.6	11	-	-	-	-	-	-	311	-
	3- 6-52	40	15	-	-	-	-	-		119	-	16	.6	11	-	-	-	-	-	-	316	-
	4- 4-52	51	15	-	-	-	-	-		127	-	14	.5	10	-	-	-	-	-	-	322	7.2
	5-22-52	43	35	41	.02	42	10	17		153	29	15	.6	7.6	-	237	.32	146	20	21	361	7.3
	6-20-52	52	18	42	.02	34	9.6	12		105	28	16	.3	15	-	209	.28	124	38	17	305	7.8
	9-15-52	52	35	40	.02	32	9.0	14		109	24	14	.3	15	-	202	.27	117	28	20	302	7.5
	12-10-52	49	15	41	.04	32	9.0	16		107	29	16	.3	14	-	210	.29	117	30	23	300	7.7
	3- 4-53	51	15-20	38	.02	35	9.4	11		104	27	16	.5	15	-	203	.28	126	41	15	305	7.4
	6- 9-53	53	5- 7	41	.02	32	9.3	11		102	29	17	.4	4.3	0.1	194	.26	118	34	17	309	7.2
	9-24-53	53	-	38	.01	31	9.0	14		102	29	16	.4	11	-	198	.27	114	31	22	300	7.4
	12-22-53	-	-	-	-	-	-	-		103	28	16	.4	12.0	0	-	-	-	-	-	299	7.3
	3-31-54	-	-	-	-	-	-	-		104	-	15	.3	10.0	.1	-	-	-	-	-	298	-
	6-24-54	-	-	-	-	-	-	-		103	-	16	.5	25.0	.1	-	-	-	-	-	306	-
	9-22-54	-	-	-	-	-	-	-		106	-	17	.4	12.0	.2	-	-	-	-	-	297	-
	2- 1-55	-	-	-	-	-	-	-		101	-	16	.5	15.0	.1	-	-	-	-	-	303	7.5
	4-28-55	-	-	-	-	-	-	-		104	-	15	.5	8.9	.2	-	-	-	-	-	307	7.8
Indian Spring	10-10-42	-	-	-	-	41	6.8	20		184	16	5.0	-	.2	-	180	.24	130	-	-	307	-
	4-15-47	-	-	-	-	44	7.2	20		205	12	2	-	.5	-	187	.25	140	0	-	334	-
	11-28-53	-	-	-	-	-	-	-		-	-	5	-	.4	-	-	-	111	-	-	310	-
Hamilton Bend Spring	4-14,15-55	-	-	-	-	-	-	-		105	-	31	.6	48	.5	-	-	-	-	-	429	-
	6-23-55	-	-	-	-	-	-	-		114	-	34	.2	41	.2	-	-	-	-	-	451	-
Ancho Spring	7-18-52	73	30	75	.01	12	4.0	10		74	2.3	2.8	.3	.5	-	143	.19	46	0	32	132	7.5
	11-19-51	59	7	36	.28	16	3.7	73		161	34	27	1.8	3.8	-	275	.37	55	0	74	432	7.2
	2- 5-52	52	7	-	-	-	-	-		154	-	30	1.4	12	-	-	-	-	-	-	421	-
	3- 6-52	-	25	-	-	-	-	-		167	-	32	1.2	5.1	-	-	-	-	-	-	433	-
	4- 4-52	54	15	-	-	-	-	-		157	-	32	1.2	12	-	-	-	-	-	-	443	7.3
	9-19-52	55	5	42	1.30	13	5.9	58		164	19	16	2.0	.6	-	239	.33	57	0	69	325	7.1
	12-10-52	33	5	20	.13	11	2.8	52		126	23	17	.2	1.3	-	189	.26	39	0	74	324	7.0
	3- 4-53	41	3	27	.14	12	3.3	46		90	28	21	.8	13	3.4	195	.27	44	0	70	303	7.1
	4- 7-53	62	2	34	.04	17	4.5	62		164	18	28	1.0	.6	2.0	246	.33	61	0	69	423	7.1
	5- 5-53	52	2	29	.82	18	5.4	60		116	35	30	.8	27	3.1	263	.36	67	0	66	401	7.1
	6- 9-53	81	1	38	.18	16	4.8	86		196	29	34	.9	.5	2.9	308	.42	60	0	76	483	6.8
	9-22-53	-	2	25	.40	13	3.9	54		124	25	18	.2	.2	7.0	208	.28	48	0	71	327	7.0
	9-23-53	-	-	-	-	-	-	-		124	25	18	.2	1.0	7.0	-	-	-	-	-	327	7.0
	10-27-53	-	-	-	-	-	-	-		118	26	19	1.5	1.1	4.6	-	-	-	-	-	319	7.1
	12-10-53	-	-	-	-	-	-	-		111	-	17	.8	3.9	6.4	-	-	-	-	-	288	-
	1-26-54	-	-	-	-	-	-	-		119	-	17	.8	4.5	6.0	-	-	-	-	-	263	-
	2-26-54	-	-	-	-	-	-	-		122	-	17	.8	5.1	6.9	-	-	-	-	-	283	-
	3-31-54	-	-	-	-	-	-	-		131	-	26	.8	4.0	5.0	-	-	-	-	-	367	-
	4-21-54	-	-	-	-	-	-	-		134	-	32	.8	21.0	4.8	-	-	-	-	-	440	-
																				-	498	-

	Plutonium (Disintegrations per minute per liter)	Uranium (Micrograms per liter)
Hamilton Bend Spring	10.0 to 25.8	0.6 to 0.7
Otowi Seep	4.0 to 20.0	.5 to 1.4
Basalt Spring	.4 to 10.6	.1 to 1.5
Indian Spring	31.6	.3
Ancho Spring	.2 to 4.0	.0 to .6

Supply wells, rivers, and reservoirs in the Los Alamos area

The ranges of the chemical and radiological properties of water from the supply wells are relatively small (table 15), and the concentrations substantially less than in samples from the test wells. The concentrations of the constituents in water from the two well fields are roughly comparable, except for some exceptionally high values in samples from Los Alamos 6. These are sodium, 120 ppm; total solids, 550 ppm; plutonium, 16.2 d/m/l; and uranium, 10.0 micrograms per liter. The presence of plutonium in samples from the supply wells, even in these minute quantities, indicates that some contamination has reached the aquifer or the samples were contaminated after collection from the wells. No trends of changes are noted.

The river water at Otowi Bridge is a mixture of water from the Rio Chama and the upper Rio Grande (table 15). Some constituents, such as the calcium and magnesium ions and the total solids, appear to have increased slightly between Otowi Bridge and Cochiti station. Concentrations of plutonium over about 7 d/m/l and concentrations of uranium over about 4 micrograms per liter generally were isolated values. The concentrations of the chemical and radiochemical constituents in samples from the reservoirs west of Los Alamos and in samples from Rito de los Frijoles were low and relatively consistent. Many of these samples were collected up gradient from the disposal areas and the presence of plutonium may have been due to fallout.

Table 15.--Range of chemical and radiological quality of water from Guaje and Los Alamos Canyon well fields, Rio Grande, Rio Chama, Rito de los Frijoles, and Los Alamos Guaje, and Water Canyon reservoirs

(Analyses by the Los Alamos Scientific Laboratory, parts per million except as indicated)

Sample location	Calicum (Ca)	Magnesium (Mg)	Sodium (Na)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total Solids	Total Hardness ($CaCO_3$)	pH	Plutonium d/m/l 1/	Uranium 2/
Guaje Canyon well field	13-19	1-10	12-22	3-8	0.2-1.0	0.0-4.0	121-184	36-68	7.4-8.5	1.0-13.4	0.2-1.0
Los Alamos Canyon well field	2-17	0-2	6-120	3-20	.3-2.0	.2-2.0	97-550	10-44	7.6-8.6	.1-16.4	.6-10.0
Rio Grande at Embudo	24-41	3-19	4-28	1-23	.3- .9	.0- .9	155-295	-	7.0-8.3	1.0-13.4	.7-17.5
Rio Chama at Chamita	7-73	3-78	5-60	5-24	.2- .7	.0-3.0	122-611	-	6.9-8.5	.0-10.4	.8-10.5
Rio Grande at Otowi	16-46	4-30	4-31	4-13	.2- .8	.0- .8	153-401	-	7.3-8.4	.4-19.4	1.6-9.2
Rio Grande at Cochiti	17-84	4-46	9-31	4-14	.2- .7	.0- .4	171-739	-	7.2-8.3	.2-10.4	1.2-5.0
Rito de los Frijoles	8-10	3-6	3-14	0-12	.0-3.0	.0-4.0	90-185	-	7.1-7.9	.2-3.0	.0-1.7
Los Alamos Canyon reservoir	8	4	3	5	2.0	-	107	-	8.0	.6	.1
Guaje Canyon reservoir	8	3	8	6	3.0	-	124	-	7.7	.6	.2
Water Canyon reservoir	9	5	2	5	1.0	-	107	-	7.7	.6	.2

1/ Disintegrations per minute per liter

2/ Micrograms per liter

Summary

The shallow test wells are bottomed in perched aquifers of limited extent and the deep test wells apparently are finished in aquifers above the main aquifer of the Los Alamos area. Aquifer tests indicated an average velocity of 150 feet per year for the movement of ground water in the lower part of the Puye Conglomerate. The values of transmissibility ranged from 200 to 7,800 gpd per foot in the upper part of the aquifer supplying deep test wells 1, 2, and 3, and 50 to 8,300 gpd per foot for the shallow perched zone.

The Acid-Pueblo Canyon disposal system is the only course of movement of contaminants about which some data are available. Liquid wastes discharged from the waste-treatment plant in Acid Canyon move downstream as surface flow and underflow in Acid Canyon. Underflow in Acid and Pueblo Canyons was sampled by wells that penetrate the alluvium in the streambed. Permeability of the Tshirege Member is low, compared with the permeability of the underlying pumiceous members, so that the rate of infiltration into this formation is small. However, well-developed joints offer a possible course of infiltration.

Streamflow data indicate that seepage to alluvium in Acid Canyon occurs during high-water stages. A reversible hydraulic relationship exists between the streamflow and underflow during low stages. However, the water that infiltrates deep into the tuff probably does not reappear as streamflow.

Streamflow alternately gains and loses in the reach of Pueblo Canyon between Acid Canyon and test wells 2 and 2A. After the Central Sewage Plant reduced the quantity of effluent discharged into the canyon, most of the water in the stream infiltrated the alluvium in the middle part of the canyon between test wells 2 and Hamilton Bend Spring.

Most of the radioactive contaminants discharged from the treatment plant into Acid Canyon were confined to Acid Canyon. Concentrations of plutonium and uranium were highest in the shallow wells in Acid Canyon. Plutonium was occasionally in greater concentrations in samples from these wells than in the discharge from the treatment plant. The higher concentrations could have been due to release of plutonium in processed wastes which was discharged prior to the construction of the treatment plant or to enrichment of wastes discharged from the treatment plant. Downstream in Pueblo and lower Los Alamos Canyons, concentrations of radioactive elements reached a maximum of about one quarter of the average concentration of the discharge from the treatment plant. Concentrations of plutonium and uranium in samples from the test wells, supply wells, and the Rio Grande were substantially less than in the surface and underflow samples from Pueblo Canyon. The concentrations were low in the reservoirs west of Los Alamos. No systematic trends other than a marked decrease from Acid Canyon to Pueblo Canyon were apparent.

Contamination might reach the Rio Grande from Pueblo Canyon during times of storm runoff. During periods of heavy rainfall near the head of Pueblo Canyon contaminated sediments picked up by stormflow in the upper reaches of the canyon may reach the Rio Grande. These contaminants may be a part of the sediments as a result of either ion-exchange or adsorption. The ion-exchange capacity of the sands and silts in the alluvium is low, but adequate, in terms of the relatively small quantities of exchangeable constituents in wastes discharged. However, it is possible that re-working of the sediments in water could re-dissolve some of the adsorbed contaminants.

Concentrations of nonradioactive contaminants in amounts above municipal tolerances were confined almost entirely to Acid Canyon, although some concentrations of fluoride, nitrates, and total solids in amounts slightly above these tolerances were found in some samples collected in the lower part of Pueblo Canyon. Some evidence was noted of increasing concentrations of nitrates in samples from test well 1A, presumably from streamflow in Pueblo Canyon. Concentrations of anions, used tentatively as tracers in the deep test wells and in the supply wells, were low and generally stable with no systematic trends detected. Minute quantities of plutonium have been reported in analyses of water from nearly all sampling points. The analyses may indicate that the sources of water have received some contamination or that the samples became contaminated after collection.

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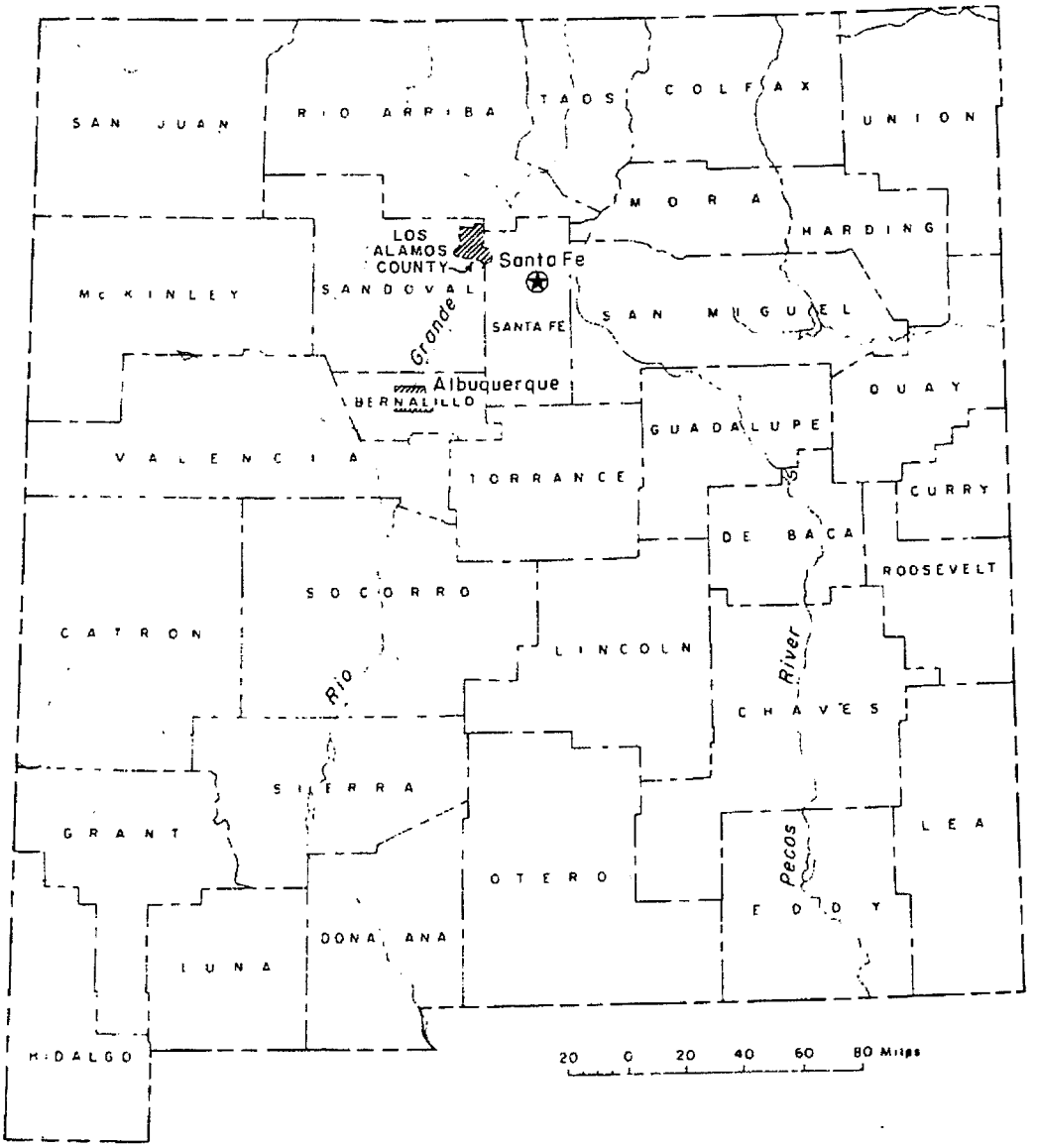

Figure 1.--Index map of New Mexico showing Los Alamos County.

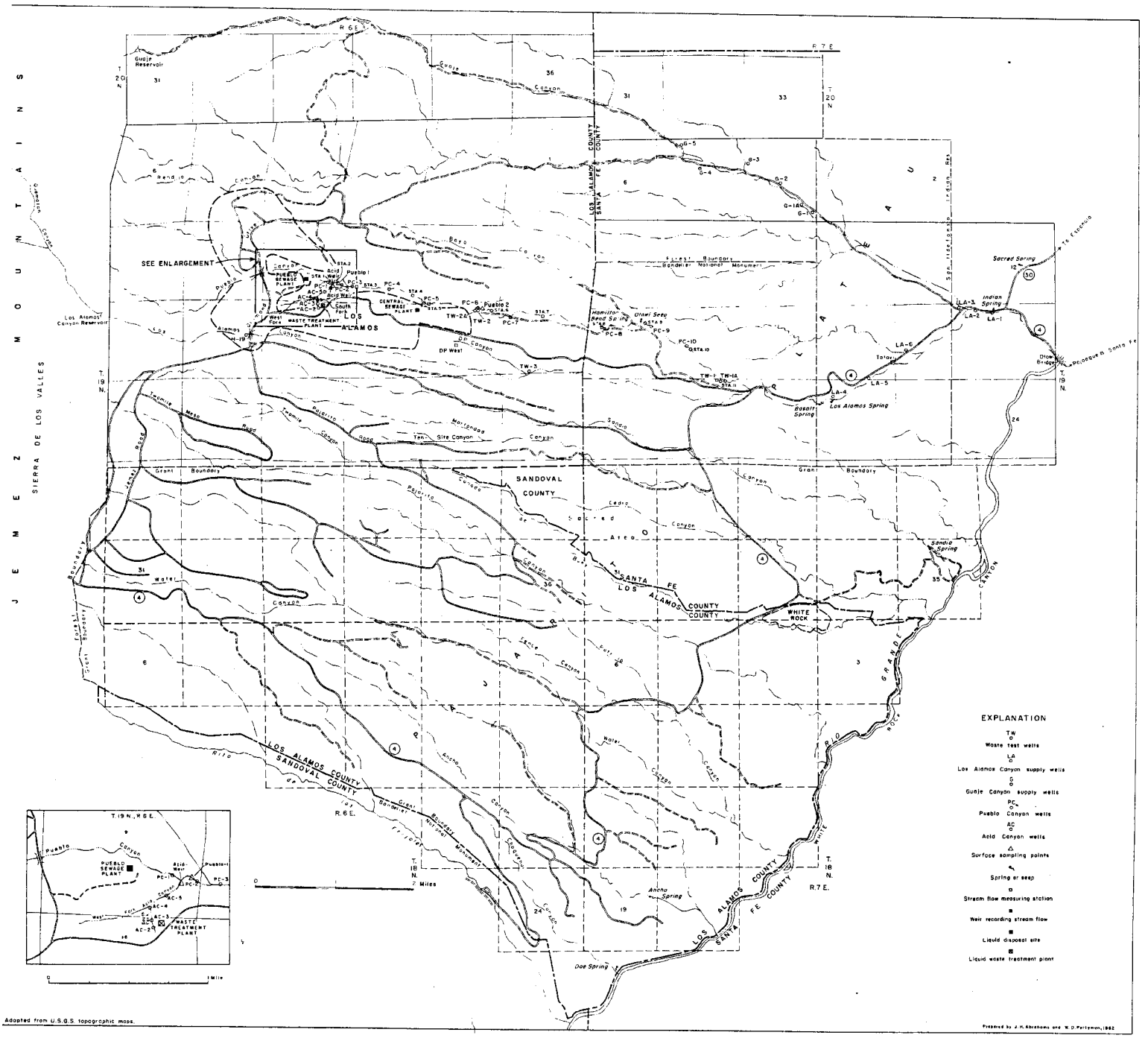

Figure 2.--Map showing locations of weirs and stations for streamflow measurements in Acid and Pueblo Canyons, waste and sewage disposal sites, and sampling points. Los Alamos and Santa Fe Counties, N. Mex.

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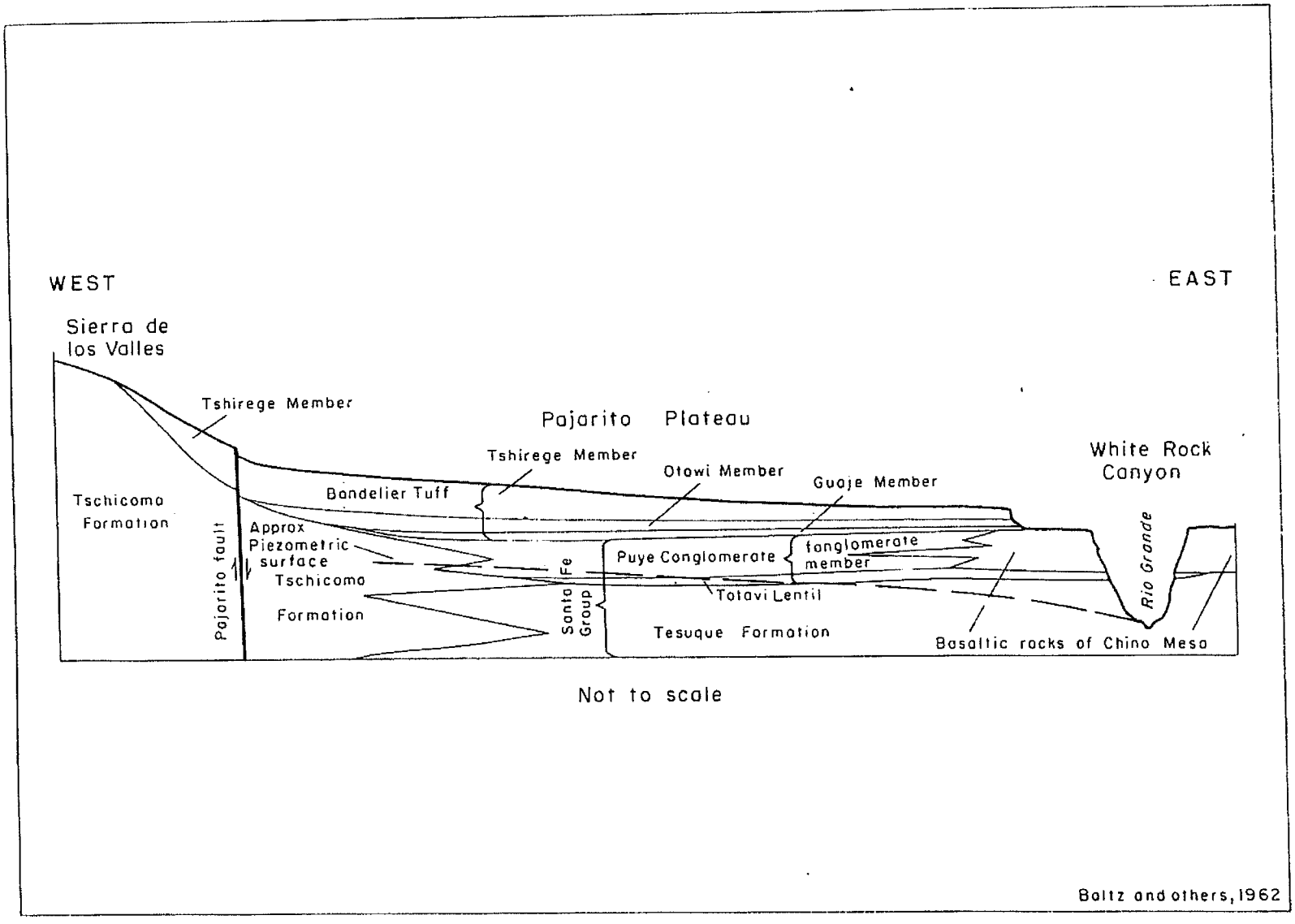

Figure 3.-- Diagrammatic cross section showing generalized stratigraphic relations of the Santa Fe Group, Tschicomo Formation, and Bandelier Tuff in the Los Alamos area.

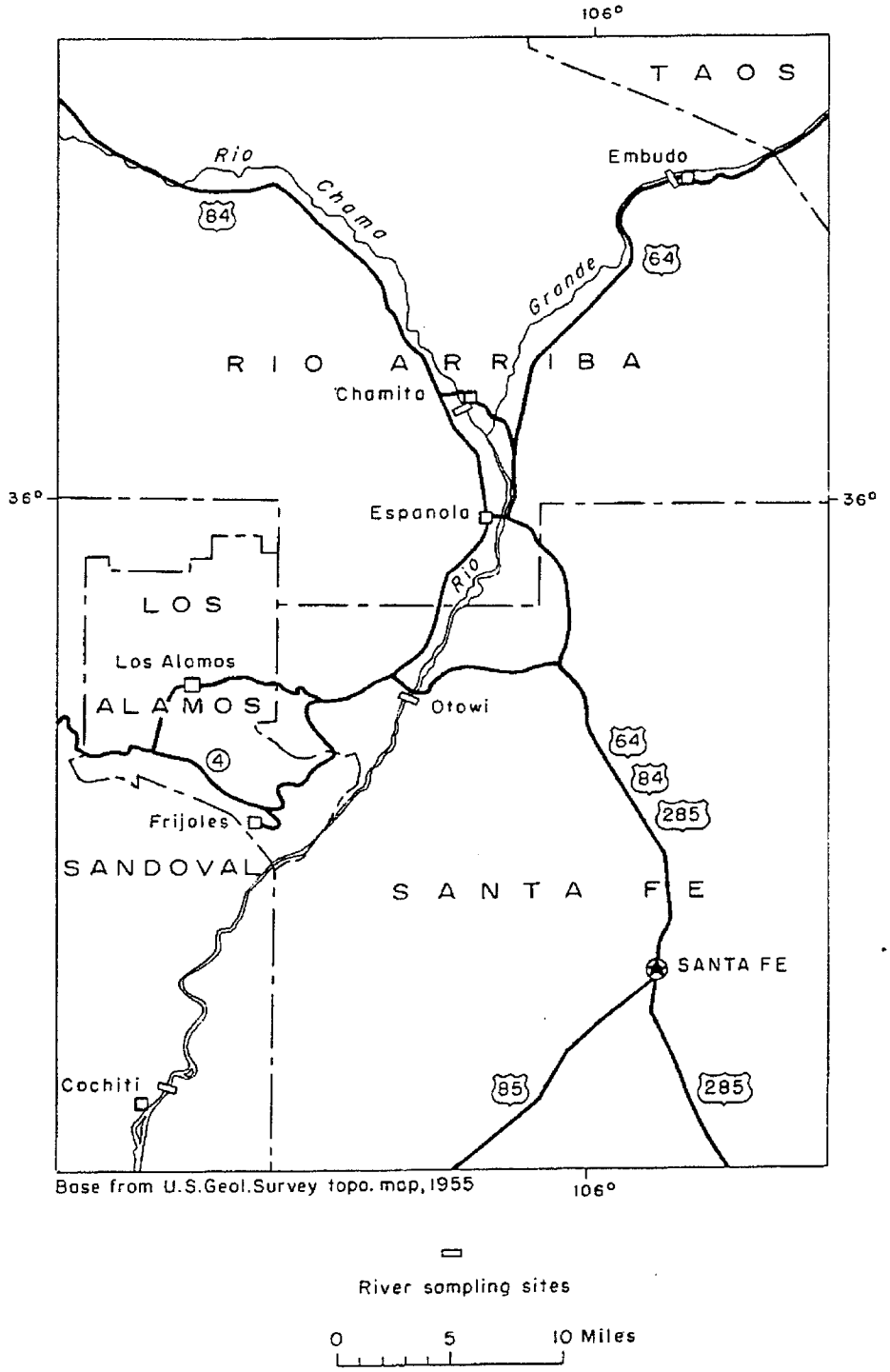

Figure 4.--Map of river-sampling sites on the Rio Chama and Rio Grande.

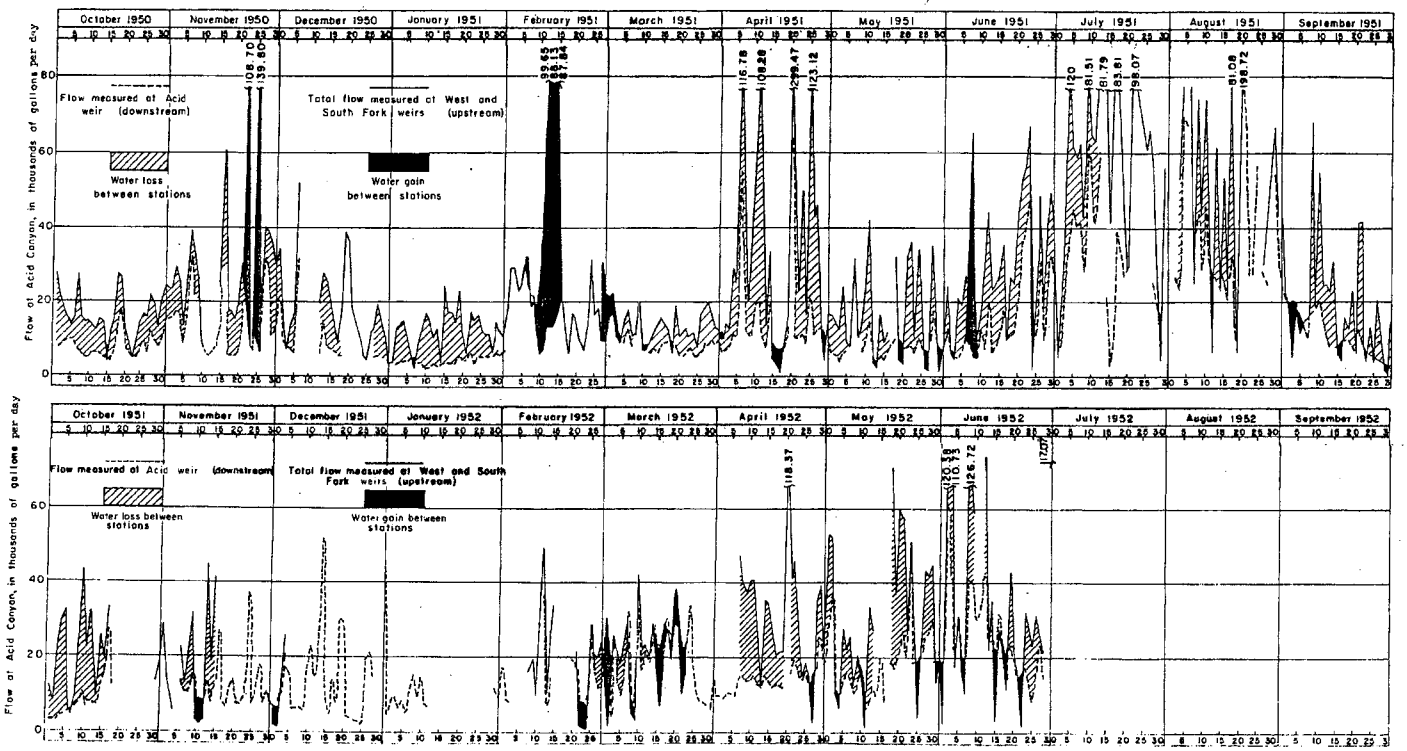

Figure 6.--Discharge of West Fork and South Fork weirs correlated with that of Acid weir to show gains and losses in flow in Acid Canyon, West Fork-South Fork weirs, and Acid weir.

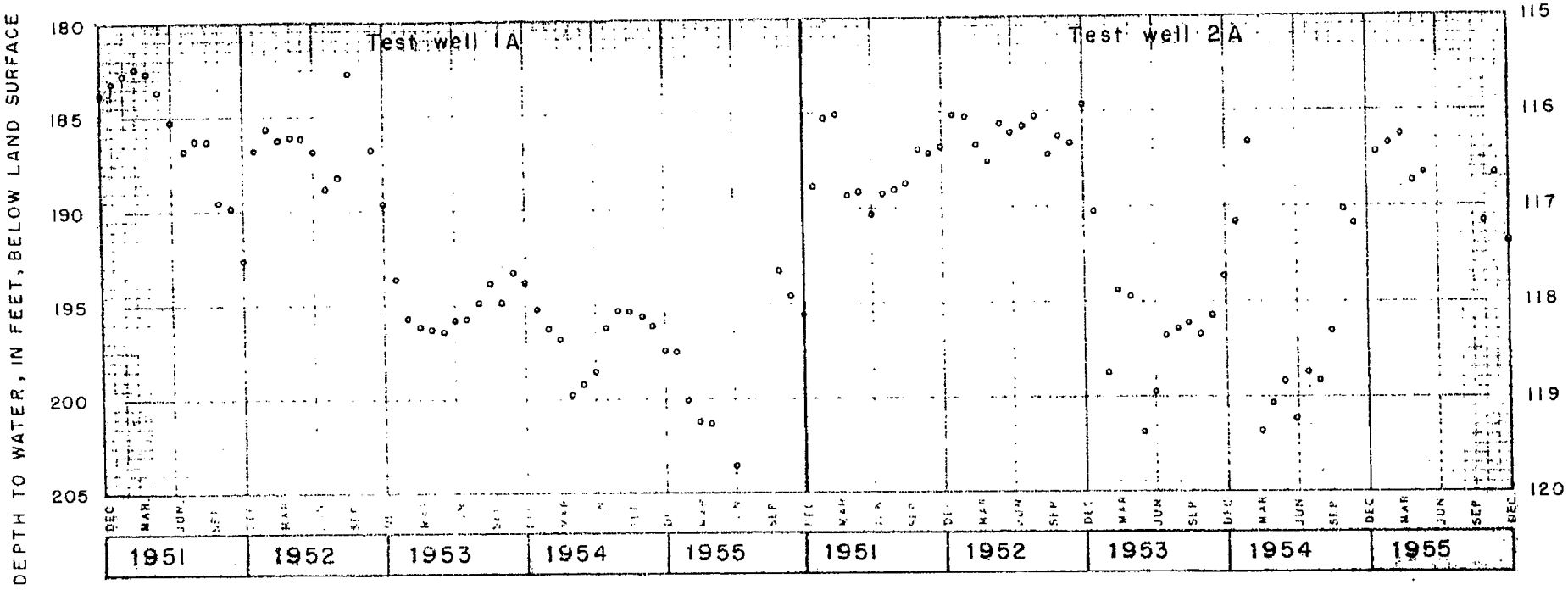

Figure 7.--Nonpumping water levels in test wells 1A and 2A.

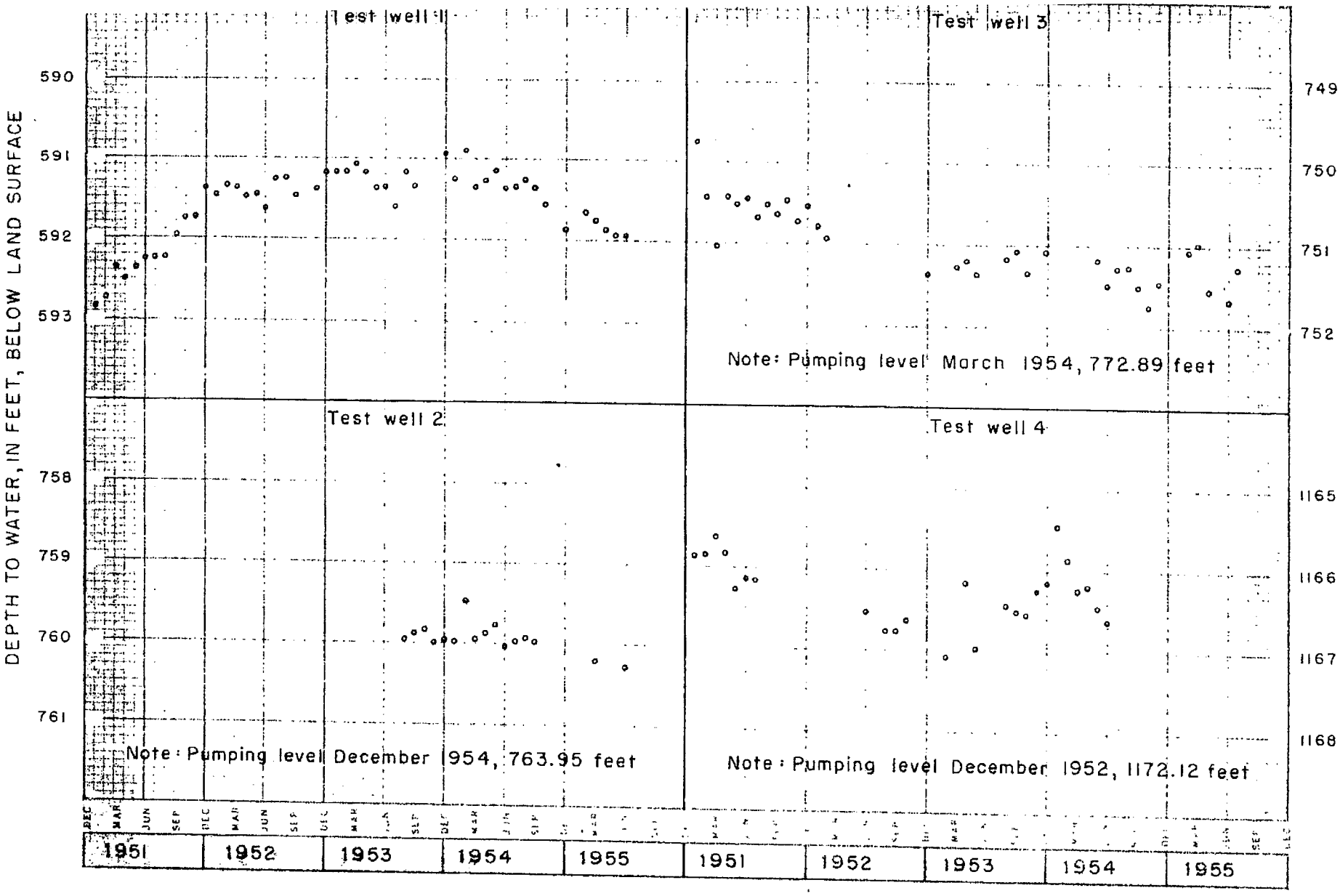

Figure 8.--Nonpumping water levels in test wells 1, 2, 3, and 4.

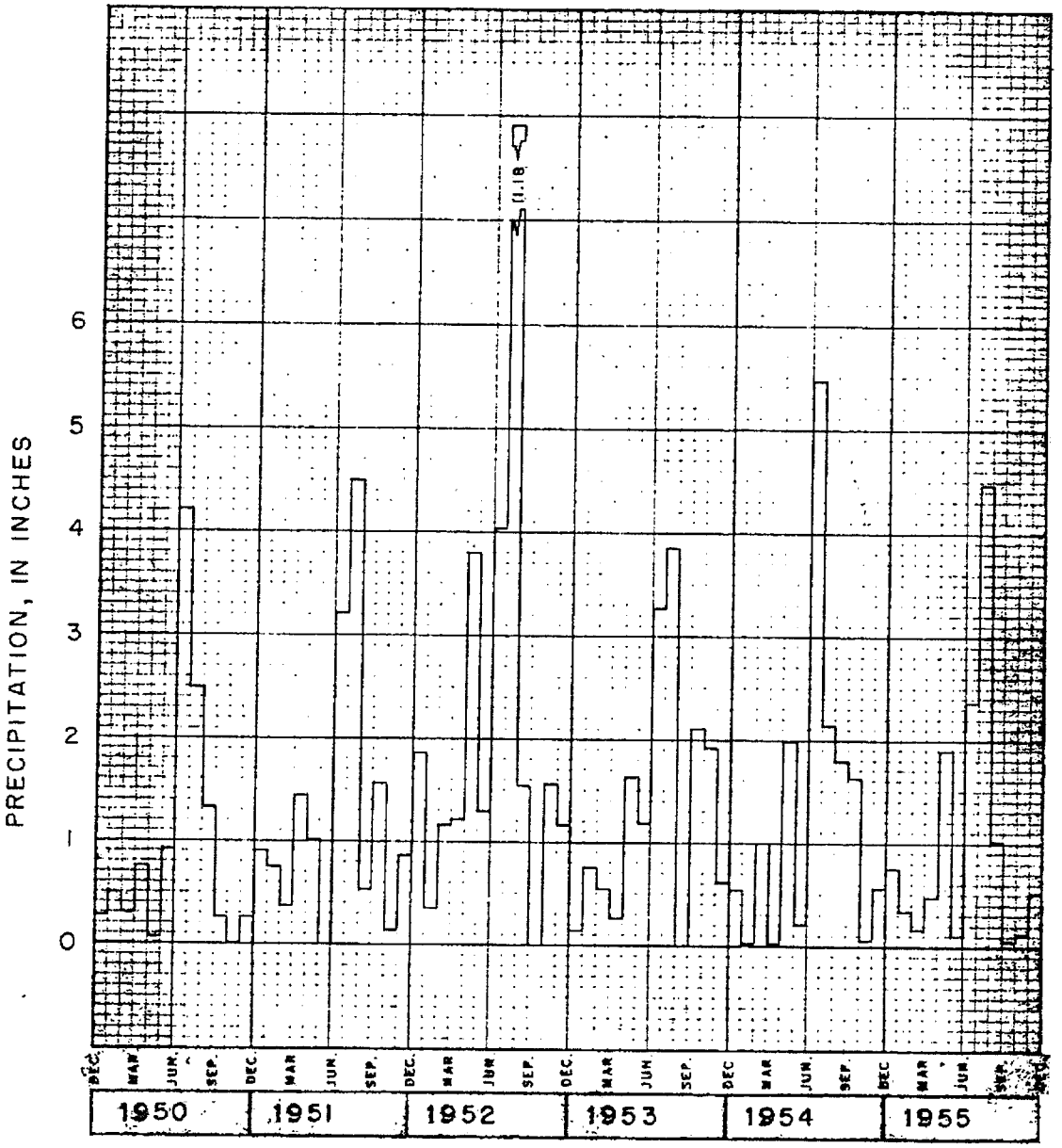

Figure 9.--Monthly precipitation at Los Alamos, 1950 through 1955.

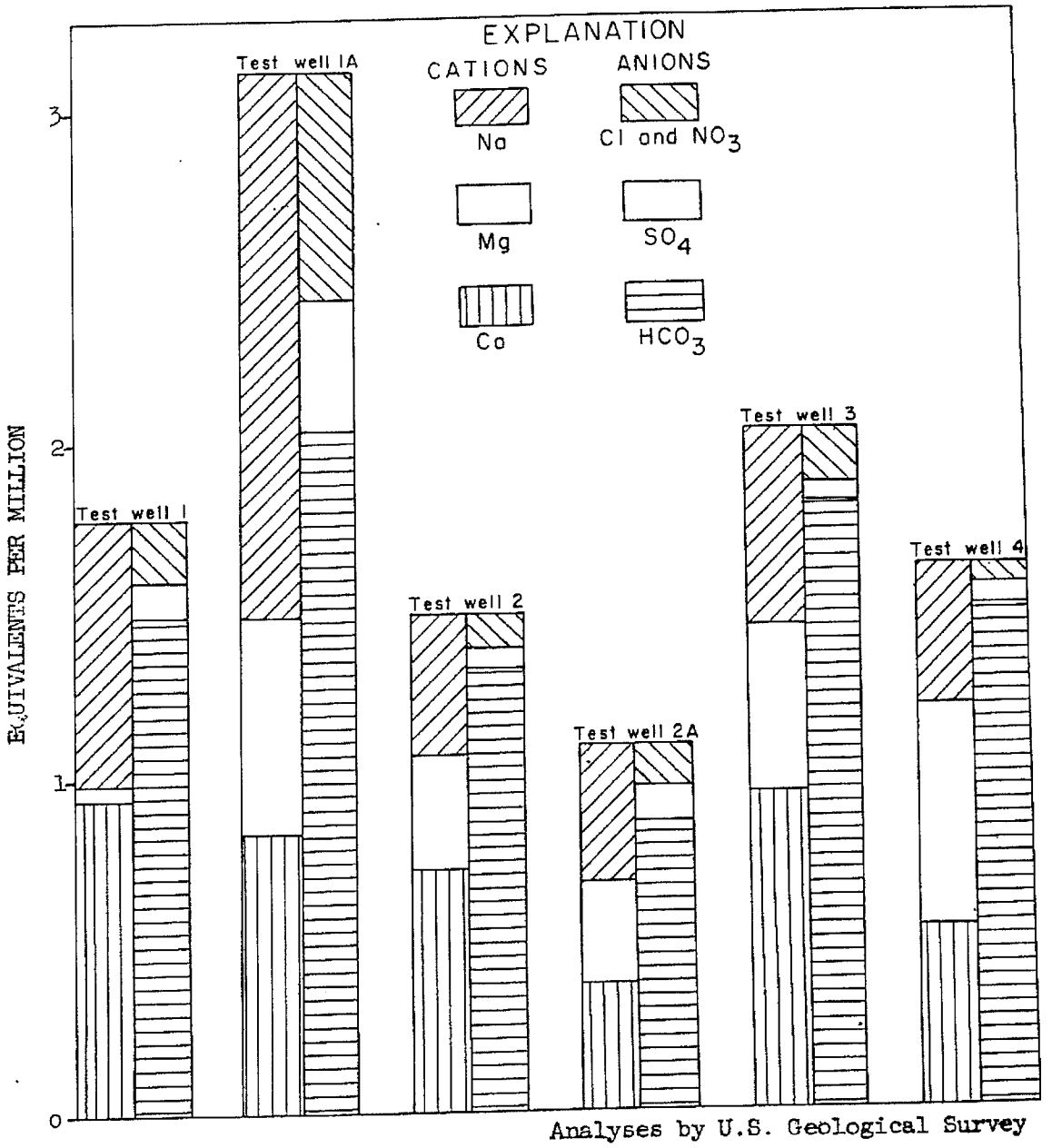

Figure 10.--Chemical quality of water from test wells, January 7, 1953.