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ABSTRACT

The water quality at nine surface water stations, eight ground water stations, and the drilling operations at the Fenton Hill Site have been studied as a measure of the environmental impact of the Los Alamos Scientific Laboratory geothermal experimental studies in the Jemez Mountains. Surface water quality in the Jemez River drainage area is affected by the quality of the inflow from thermal and mineral springs. Ground water discharges from the Cenozoic Volcanics are similar in chemical quality. Water in the main zone of saturation penetrated by test hole GT-2 is highly mineralized, whereas water in the lower section of the hole, which is in granite, contains a higher concentration of uranium.

I. INTRODUCTION

A preliminary study was made in 1973 of water quality in the Jemez River and Rio Guadalupe drainage areas. Additional water quality data were obtained in 1974 from surface water samples taken from the vicinity of the Fenton Hill Site (TA-57) and from springs along Lake Fork Canyon and the Jemez River. La Cueva and Jemez Springs water supplies were also analyzed. This report presents data on the quality of water from the Fenton Hill Site vicinity collected and analyzed during 1974 as part of a continuing program of environmental impact studies conducted by the Los Alamos Scientific Laboratory.

The Fenton Hill Site is bounded on the east by San Antonio Creek and on the west and northwest by the Rio Cebolla. Lake Fork Canyon, to the south, drains the immediate area of the site and is tributary to the Rio Cebolla. Lake Fork Canyon and the canyon to the north of the site contain only intermittent streams. Preliminary water quality, geologic, and hydrologic investigations made during test drilling in the Jemez Mountains and at the Fenton Hill

Site provided a basis for selecting the location of water quality monitoring stations.¹⁻³

Test hole GT-2 at the Fenton Hill Site penetrated about 137 m of Cenozoic Volcanics, 238 m of shales, siltstones, and sandstones of the Abo Formation, and 355 m of limestones, shales, and sandstones of the Madera Limestone and Sandia Formations. The test hole was completed at a depth of 2961 m after penetrating about 2231 m of granite underlying the sediments.

The Cenozoic Volcanics thin from the source area (Valles Caldera east of the site) toward the southwest. The volcanics are deposited on the irregular surface of the Abo Formation, which also dips to the southwest. The volcanics contain ground water that is perched on the shales and siltstones of the Abo Formation. The water is moving down dip to the southwest and is partly discharged through seeps and springs along the Rio Cebolla and Lake Fork Canyon. Surface water station T and spring 31 were selected to monitor the quality of water discharged from the volcanics (Fig. 1). East of the site, water is

Fig. 1.
Location of sampling stations.

Station Location Key

F	Sulphur Creek above San Antonio Creek	JS-4, -5	Jemez Springs water supply:
J	Jemez River below Battleship Rock		Sino and Aqua Durme Springs
N	San Antonio Creek above Sulphur Creek	4	La Cueva water supply:
Q	Rio Guadalupe above Jemez River		Horseshoe Spring
R	Jemez River above Rio Guadalupe		La Cueva water supply:
S	Jemez River below Rio Guadalupe	LC-WS	well water and Horseshoe Spring
T	Rio Cebolla below Lake Fork Canyon		Mineral spring west of Battleship Rock
U	Redondo Creek	JF-1	Mineral and thermal spring, Soda Dam
V	Sulphur Creek above Redondo Creek	JF-5	Cold Spring, Lake Fork Canyon
JS-2, -3	Jemez Springs water supply:	31	Hofhein Flowing Well
	Church Canyon East and West Forks Springs	27	

discharged from volcanics overlying the Abo Formation at location 4 (Horseshoe Spring), which is a part of the water supply for La Cueva. The water supply for the village of Jemez Springs, springs JS-4 and JS-5, discharge from the volcanics west of the Jemez River. Springs JS-2 and JS-3, which also supply water for the village of Jemez Springs, discharge from near the base of the volcanics east of the Jemez River (Fig. 1).

The Abo Formation contains several perched ground water bodies; however, these appear to be only limited aquifers with small coefficients of permeability. The well at location 27 (completed into the Abo Formation) may be connected with one of the aquifers penetrated by test hole GT-2.

The main zone of saturation lies within the limestones of the Lower Madera and the sandstones, siltstones, and shales of the Sandia Formation. Several perched aquifers are present above the main saturation zone. The movement of water in these sedimentary beds is downdip to the southeast. Spring JF-1 discharges from the Upper Madera on the west wall of Jemez Canyon (Fig. 1). Water in the main zone of saturation moves to the southeast and probably discharges along the Jemez Fault in the area of Soda Dam (spring JF-5); see Fig. 1.

Routine chemical analyses were made for silica, calcium, magnesium, sodium, carbonate, bicarbonate, sulfate, chloride, fluoride, nitrate, hardness, total dissolved solids, conductance, and pH. Results of select constituents of samples collected on December 4 were graphed for comparison. Analyses were made following the methods given in Refs. 4 and 5. One set of samples (December 4, 1975) was analyzed for the trace elements, arsenic and selenium. Using methods described in Ref. 6, radiochemical analyses were made for gross alpha, gross beta, tritium, and total uranium.

II. SURFACE WATER

Surface water in the tributaries to the Jemez River (Redondo, Sulphur, and San Antonio Creeks) is monitored because of geothermal exploration in the Valles Caldera. The Rio Cebolla below Lake Fork Canyon and the Rio Guadalupe above the Jemez River are monitored because of ground water discharge from volcanics and surface water drainage from the Fenton Hill Site.

Analyses of surface water from nine stations along the Jemez River, the Rio Guadalupe, and their tributaries are tabulated in this section. Station locations are shown by capital letters in Fig. 1 and are keyed to the analyses shown in Table I. The base

flow of these streams is from a shallow ground water table in the Valles Caldera, from perched aquifers in volcanics, and from thermal or mineral springs. Each source of the base flow has a particular chemical characteristic which may vary with additional runoff from precipitation. Figure 2 compares results from a set of samples.

A. Routine Chemical Analyses

Location U, Redondo Creek, drains a small basin in the Valles Caldera. A number of geothermal test holes have been drilled and tested in the basin. Flow of Redondo Creek was about 15 //s. Total dissolved solids were 312 mg// with predominant ions of sodium and chloride (Fig. 2).

Fig. 2.

Chemical Analysis comparison of surface water, December 1974.

Location V, Sulphur Creek, which also drains a small basin in the Valles Caldera, contains geothermal test holes. Above the junction with Redondo Creek, base flow was about 15 //s. Total dissolved solids were 680 mg// with predominant ions of calcium and sulphate.

Location F on Sulphur Creek is below the junction with Redondo Creek. The flow, which combines flow from the two interior basins in the Caldera, ranged from 15 to 30 //s. Total dissolved solids ranged from 262 to 436 mg// with predominant ions of calcium and sulfate.

Location N on San Antonio Creek is above the confluence with Sulphur Creek. The stream drains the western and northern parts of the Caldera. Flow was about 85 //s. Total dissolved solids ranged from 164 to 240 mg// with predominant ions of calcium and bicarbonate.

Location J on the Jemez River receives the combined flow from Location F on Sulphur Creek, Location N on San Antonio Creek, and the East Fork of the Jemez River (Fig. 1). Total dissolved solids ranged from 136 to 226 mg// for flows ranging from 230 to 450 //s with predominant ions of sodium and bicarbonate.

Location R on the Jemez River is above the junction with the Rio Guadalupe. Total dissolved solids ranged from 230 to 550 mg// for flows ranging from 340 to 560 //s with predominant ions of sodium and chloride. Inflow from mineral and thermal springs (JF-5) from location J to below the village of Jemez Springs is a sodium-chloride water. The inflow from the springs, based on U. S. Geological Survey records from gaging stations in reach of the Jemez River, has been about 140 //s.

Location S on the Jemez River receives the combined flow of the Jemez River and Rio Guadalupe. Total dissolved solids ranged from 234 to 584 mg// for flows ranging from 560 to 700 //s. Water quality was about the same as at location R, with predominant ions of sodium and chloride.

Location T on the Rio Cebolla below Fenton Lake and Lake Fork Canyon is tributary to the Rio Guadalupe, draining the area west of the Valles Caldera (Fig. 1). Total dissolved solids ranged from 150 to 176 mg//. The base flow of the stream is from springs that discharge from the Cenozoic Volcanics. Stream discharge ranged from 40 to 60 //s with predominant ions of calcium and bicarbonate.

Location Q on the Rio Guadalupe drains the eastern flanks of the Sierra Nacimientos and the area west of the Valles Caldera. Total dissolved solids ranged from 226 to 408 mg//. The flow from several different rock types, sedimentary and ig-

neous, ranged from 110 to 230 //s with predominant ions of calcium and bicarbonate.

B. Trace Element Analyses

The trace elements, arsenic and selenium, were analyzed in surface water samples with the following analytical results.

Location	Stream	Arsenic ($\mu\text{g/l}$)	Selenium ($\mu\text{g/l}$)
U	Redondo Creek	6 ± 3	5 ± 2
V	Sulphur Creek	7 ± 3	5 ± 2
F	Sulphur Creek	10 ± 3	1 ± 2
N	San Antonio Creek	10 ± 3	1 ± 2
J	Jemez River	15 ± 3	7 ± 2
R	Jemez River	70 ± 3	5 ± 2
S	Jemez River	80 ± 3	7 ± 2
T	Rio Cebolla	5 ± 3	1 ± 2
Q	Rio Guadalupe	1 ± 3	1 ± 2

Arsenic and selenium concentrations were low (below $15 \mu\text{g/l}$) in most of the samples. Thermal and mineral spring inflow below location J on the Jemez River adds arsenic and selenium to locations R and S. Routine chemical analyses showed that the water quality in this reach of the Jemez River is affected by the water from these springs.

C. Radiochemical Analyses

Table I gives the radiochemical analyses of surface water. Additional radiochemical data were available from location R.

Gross alpha activity ranged from less than 0.1 to 3.5 pCi// with an average of about 0.7 pCi//. Gross beta ranged from 3.3 to 18.2 pCi// with an average of 9.7 pCi//. This is not significant activity.

Tritium concentrations ranged from 0.1 to 1.4 pCi/m/ with an average of 0.8 pCi/m/. The tritium levels are near the limits of detection and are not significant.

Total uranium ranged from 0.4 to 5.0 $\mu\text{g/l}$ with an average of 2.2 $\mu\text{g/l}$. The analyses reflect variations in discharge at location R as well as rock type where stream base flow originates.

III. GROUND WATER

Ground water samples were collected from six springs and one well, located adjacent to the Fenton Hill Site, which are a part of the water supply for the

village of Jemez Springs and La Cueva. Station locations are shown in Fig. 1 and are keyed to the analyses given in Table II.

A. Routine Chemical Analyses

A comparison given in Fig. 3 shows the similarity of water quality of springs JS-2 and -3, JS-4 and -5, location 4, and location 31, which discharge from near the base of the Cenozoic Volcanics.

Springs JS-2, -3, -4, and -5 supply the water for the village of Jemez Springs. Springs JS-2 and -3, located east of the village, flow from the east and west forks of Church Canyon. Samples were collected in the main part of the village for a combined flow from the two springs. Total dissolved solids ranged from 178 to 250 mg// with predominant ions of sodium and bicarbonate.

Water samples from springs JS-4 and -5, located northwest of the village on the west side of the Jemez River, were collected for a combined sample from the northern end of the village. Total dissolved solids ranged from 154 to 192 mg// with predominant ions of sodium and bicarbonate.

Location 4, Horseshoe Spring, supplies water for part of La Cueva. Here the total dissolved solids ranged from 154 to 202 mg// with predominant ions of sodium and bicarbonate. At times of high demand the spring is supplemented with well water. The combined source had total dissolved solids of 188

Fig. 3.

Chemical analysis comparison of ground water discharges from Cenozoic Volcanic overlying the Abo Formation.

mg// (LC-WS, Table II) also with predominant ions of sodium and bicarbonate.

Location 31, Cold Spring, is a small spring in the volcanic rocks of Lake Fork Canyon. Total dissolved solids ranged from 148 to 298 mg// with predominant ions of sodium and bicarbonate.

Thermal and mineral springs JF-1 and JF-5 discharge along the west wall of Jemez Canyon. A comparison of the water qualities is shown in Fig. 4.

JF-1 is a small spring that discharges from the Upper Madera Formation. Total dissolved solids ranged from 1108 to 1380 mg// with predominant ions of sodium and chloride.

The Soda Dam spring, JF-5, discharges from the Jemez Fault. The water is highly mineralized. Total dissolved solids ranged from 3892 to 3988 mg// with predominant ions of sodium and chloride. Accretion of water from these springs affects water quality in the Jemez River below the village of Jemez Springs.

Location 27, Hofhein Flowing Well, is completed into the Abo Formation. Total dissolved solids were 576 mg//, with predominant ions of sodium and bicarbonate (Fig. 4).

Fig. 4.

Chemical analysis comparison of ground water from thermal and mineral springs, Lower Madera and the granite section of test hole GT-2, and a well in the Abo Formation.

B. Trace Element Analyses

The ground water was analyzed for arsenic and selenium with the following results.

Location	Designation	Arsenic ($\mu\text{g/l}$)	Selenium ($\mu\text{g/l}$)
JS-2,-3	Jemez Springs	9 ± 3	1 ± 2
JS-4,-5	Jemez Springs	15 ± 3	2 ± 2
4	La Cueva	5 ± 3	5 ± 2
JF-1	Limestone Springs	5 ± 3	1 ± 2
JF-5	Soda Dam	1400 ± 50	15 ± 3
31	Cold Springs	18 ± 3	1 ± 2

Results were low (below $15 \mu\text{g/l}$) and not significant except in the thermal and mineral spring JF-5 at Soda Dam. The high arsenic concentration is manifest in the surface water below location J, as previously mentioned.

C. Radiochemical Analyses

Radiochemical analyses were performed on samples of ground water (refer to Table II). There were no significant amounts of gross alpha, gross beta, or total uranium in the water. Above-normal gross beta activity was found in only two samples from the mineral and thermal springs JF-1 and JF-5, where the activity was 36.5 and 193 pCi/, respectively. This activity is the natural result of ground water moving through the sediments of the Upper and Lower Madera Formations.

IV. WATER QUALITY AT FENTON HILL SITE (TA-57)

Water used in drilling operations at test hole GT-2 was analyzed in the same manner as the other water samples (refer to Table III).

The test hole was drilled using fluids, or fluids and air, to remove the cutting, thereby limiting the opportunity to collect contaminated samples. The sample taken from the test hole on March 18, collected at a depth of 536 m, is probably representative of the water in the Lower Madera Limestone. A packer test on July 28, from a depth of 1813 to 1890 m, recovered fluid that may be in part representative of water in other granite sections (Table III). Figure 4 compares the results of these two analyses.

The pond for drilling fluids also contains additives that keep cuttings in suspension or materials that reduce fluid loss in the sections of the hole. Quality varied with fresh water additions replacing fluid

losses and the type of additive used prior to sample collection. Total dissolved solids ranged from 2200 to 8700 mg/l, indicating highly mineralized water. Water from the granite section of the test hole, at 1072 m, had a total uranium concentration of 124 $\mu\text{g/l}$. This is quite high, but in all respects is probably normal for water found in granite at temperatures over 100°C . Uranium is also found in the pond sample, resulting from circulation of the drilling fluids. The drilling operation and fluids in the pond presently pose no problems with regard to quality of surface or ground water in the area. The pond is scheduled for clean up by removing cuttings and solids that have settled to the bottom. Addition of natural runoff will cause a decrease in concentration of cations and anions. Pond samples will be taken for periodic analysis.

V. SUMMARY

The quality of surface water in the drainage area of the Jemez River and the Rio Guadalupe is complex. Sources of the base flow in the various streams in the drainage area of the Jemez River differ in chemical quality. Predominant ions in streams that drain the Valles Caldera were sodium and chloride in Redondo Creek, calcium and sulfate in Sulphur Creek, and calcium and bicarbonate in San Antonio Creek. The mixture of water from these three streams in the Jemez River below the junction with the East Fork of the Jemez results in water which contains a significant quantity of sodium and bicarbonate. Inflow of mineral and thermal springs into the river below the East Fork is highly mineralized and contributes sodium and chloride. Inflow from the springs is the main contribution to a decrease in water quality in the remainder of the Jemez River.

Predominant ions in the water from the Rio Cebolla and Rio Guadalupe drainage area are calcium and bicarbonate. Springs discharging from the Cenozoic volcanics contain significant quantities of sodium and bicarbonate.

Water in the main zone of saturation encountered in test hole GT-2 in the Lower Madera was of a sodium and bicarbonate type, highly mineralized with total dissolved solids of about 2500 mg/l. Water from the granite section was also of a sodium and bicarbonate type and may have been partly contaminated with drilling fluid. Analyses of water in this section and from the pond (return drilling fluid) contain concentrations of total uranium characteristic of water in contact with granitic rock.

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TABLE I
SURFACE WATER QUALITY

Location	Sulphur Creek above San Antonio Creek (F) ^a					Jemez River below Battleship Rock (J) ^a				
Date of collection (1974)	3/29	6/5	8/27	10/1	12/4	3/29	6/5	8/27	10/1	12/4
<u>Chemical analysis (mg/l)</u>										
Silica (SiO ₂)	31	29	31	33	32	21	49	49	51	47
Calcium (Ca)	50	32	40	40	51	11	16	16	16	14
Magnesium (Mg)	4	5	7	5	7	3	5	3	2	3
Sodium (Na)	12	29	22	20	40	5	26	18	18	21
Carbonate (CO ₃)	0	0	0	0	0	0	0	0	0	0
Bicarbonate (HNO ₃ as CaCO ₃)	0	20	20	20	20	36	76	80	80	72
Sulfate (SO ₄)	174	63	114	108	140	<1	7	10	9	12
Chloride (Cl)	28	50	44	40	70	12	12	8	12	10
Fluoride (F)	0.2	0.2	0.6	0.1	0.4	0.4	0.8	1.1	0.8	0.9
Nitrate (N)	0.1	0.1	0.1	0.1	0.1	0.3	0.2	0.1	0.1	<0.1
Total dissolved solids	398	288	304	262	436	156	226	156	136	200
Total hardness (as CaCO ₃)	140	100	128	120	156	40	60	52	48	48
Specific conductance (μmho/cm)	430	320	360	410	540	100	180	160	180	170
pH	4.6	7.6	7.3	7.6	7.1	7.3	8.4	7.8	7.9	7.9
<u>Radiochemical analysis</u>										
Gross alpha (pCi/l)	---	---	---	---	0.0±0.4	---	---	---	---	0.3±0.4
Gross beta (pCi/l)	---	---	---	---	12.2±0.8	---	---	---	---	3.3±0.6
Tritium (pCi/ml)	---	---	---	---	1.0±0.4	---	---	---	---	1.4±0.4
Total uranium (μg/l)	---	---	---	---	0.4±0.1	---	---	---	---	0.4±0.1
Temperature (°C)	---	---	7	9	0	---	---	13	9	1
Discharge estimated (l/s)	---	---	15	15	30	---	---	230	300	450

^aFor location see Fig. 1.

TABLE I (cont)
SURFACE WATER QUALITY

Location	San Antonio Creek above Sulphur Creek (N) ^a					Rio Guadalupe above Jemez River (Q) ^a				
Date of collection (1974)	3/29	6/5	8/27	10/1	12/4	3/29	6/5	8/27	10/1	12/4
<u>Chemical analysis (mg/l)</u>										
Silica (SiO ₂)	23	54	56	55	51	19	23	28	29	22
Calcium (Ca)	11	18	18	18	16	43	51	58	64	56
Magnesium (Mg)	1	6	3	2	1	3	9	8	8	7
Sodium (Na)	5	26	14	14	15	7	21	18	18	18
Carbonate (CO ₃)	0	0	0	0	0	0	0	0	0	0
Bicarbonate (HCO ₃ as CaCO ₃)	44	80	80	80	64	136	176	212	224	188
Sulfate (SO ₄)	12	8	7	9	11	8	8	10	11	9
Chloride (Cl)	4	6	4	8	2	6	12	12	14	14
Fluoride (F)	0.5	1.1	1.2	1.3	1.3	0.3	1.1	0.5	0.4	0.4
Nitrate (N)	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1
Total dissolved solids	192	240	166	164	188	236	408	284	304	226
Total hardness (as CaCO ₃)	32	68	56	52	44	120	164	176	192	168
Specific conductance (μmho/cm)	110	172	160	170	150	265	340	430	420	400
pH	7.3	8.2	7.3	7.9	7.7	7.8	7.6	7.6	7.9	8.0
<u>Radiochemical analysis</u>										
Gross alpha (pCi/l)	---	---	---	---	0.5±0.4	---	---	---	---	0.5±0.4
Gross beta (pCi/l)	---	---	---	---	14.5±0.9	---	---	---	---	5.6±0.6
Tritium (pCi/ml)	---	---	---	---	0.7±0.4	---	---	---	---	0.5±0.4
Total uranium (μg/l)	---	---	---	---	4.5±0.1	---	---	---	---	5.0±0.2
Temperature (°C)	---	---	11	8	0	---	---	15	15	3
Discharge estimated (l/s)	---	---	85	85	85	---	---	230	170	110

^aFor location see Fig. 1.

TABLE I (cont)
SURFACE WATER QUALITY

Location	Jemez River above Rio Guadalupe (R) ^a							Rio Cebolla below Lake Fork Canyon (T) ^a		
Date of collection (1974)	2/25	3/29	6/5	7/31	8/27	10/1	12/4	8/27	10/1	12/4
<u>Chemical analysis (mg/l)</u>										
Silica (SiO ₂)	---	23	35	---	65	47	43	34	29	35
Calcium (Ca)	56	21	51	50	53	56	50	19	22	22
Magnesium (Mg)	6	2	7	8	5	5	5	3	2	1
Sodium (Na)	24	14	77	55	90	97	60	10	12	14
Carbonate (CO ₃)	0	0	8	0	0	0	0	0	0	0
Bicarbonate (HCO ₃ as CaCO ₃)	204	68	196	180	212	224	182	84	92	88
Sulfate (SO ₄)	---	14	12	---	18	16	78	<1	4	5
Chloride (Cl)	84	20	84	74	120	132	15	4	8	6
Fluoride (F)	1.2	0.5	0.9	0.9	1.2	1.2	1.2	0.3	0.7	0.5
Nitrate (N)	0.1	0.2	0.1	0.2	0.1	0.1	<0.1	0.1	0.1	0.1
Total dissolved solids	380	230	390	420	480	550	428	176	150	154
Total hardness (as CaCO ₃)	164	60	156	156	152	160	144	60	64	60
Specific conductance (μmho/cm)	600	210	610	570	770	840	575	170	180	160
pH	8.2	7.7	8.3	8.2	8.1	7.9	8.0	7.9	7.2	7.6
<u>Radiochemical Analysis</u>										
Gross alpha (pCi/l)	3.5±0.4	0.7±0.2	---	0.8±0.2	---	1.1±0.4	1.2±0.4	---	---	0.5±0.4
Gross beta (pCi/l)	18.2±0.9	7.5±0.7	---	13.0±0.6	---	15.6±0.9	1.8±0.8	---	---	3.7±0.6
Tritium (pCi/ml)	0.7±0.4	0.8±0.4	---	0.1±0.4	---	0.5±0.4	0.6±0.4	---	---	1.2±0.4
Total uranium (μg/l)	---	0.5±1.0	---	1.2±0.5	---	1.1±0.5	4.0±0.3	---	---	3.6±0.2
Temperature (°C)	---	---	---	---	15	14	3	14	14	1
Discharge estimated (l/s)	---	---	---	---	340	450	560	40	60	60

^a For location see Fig. 1.

TABLE I (cont)
SURFACE WATER QUALITY

Location	Jemez River below Rio Guadalupe (S) ^a					Redondo Creek (U) ^a	Sulphur Creek above Redondo Creek (V) ^a
	3/29	6/5	8/27	10/1	12/4	12/4	12/4
<u>Chemical analysis (mg/l)</u>							
Silica (SiO ₂)	23	47	50	53	52	27	46
Calcium (Ca)	19	46	51	51	46	32	90
Magnesium (Mg)	2	9	6	6	5	4	15
Sodium (Na)	14	112	100	112	85	40	34
Carbonate (CO ₃)	0	12	0	0	0	0	0
Bicarbonate (HCO ₃ as CaCO ₃)	60	208	212	220	184	44	0
Sulfate (SO ₄)	14	16	16	20	17	27	364
Chloride (Cl)	20	158	138	154	114	94	20
Fluoride (F)	0.5	1.3	1.3	1.2	1.4	0.3	0.1
Nitrate (N)	0.3	0.1	0.1	0.1	0.1	0.1	0.1
Total dissolved solids	234	582	518	584	500	312	680
Total hardness (as CaCO ₃)	56	152	152	152	136	96	284
Specific conductance (μmho/cm)	130	880	840	920	710	440	820
pH	7.5	8.4	8.2	7.8	8.0	7.1	3.7
<u>Radiochemical analysis</u>							
Gross alpha (pCi/l)	---	---	---	---	0.2±0.4	0.2±0.4	0.0±0.4
Gross beta (pCi/l)	---	---	---	---	3.6±0.6	8.6±0.7	18.0±1.0
Tritium (pCi/ml)	---	---	---	---	0.8±0.4	1.1±0.4	1.3±0.4
Total uranium (μg/l)	---	---	---	---	2.2±0.1	2.1±0.1	0.9±0.1
Temperature (°C)	---	---	17	13	4	0	2
Discharge estimated (l/s)	---	---	560	630	700	15	15

^a For location see Fig. 1.

TABLE II
GROUND WATER QUALITY

Location	Water Supply, Jemez Springs: Church Canyon East and West Forks Springs (JS-2, -3) ^a				Water Supply, Jemez Springs: Sino and Aqua Durme Springs (JS-4, -5) ^a				Water Supply, La Cueva: well water and Horseshoe Spring (LC-WS) ^a
Date of collection (1974)	5/30	8/27	10/1	12/4	5/2	8/27	10/1	12/4	6/5
<u>Chemical analysis (mg/l)</u>									
Silica (SiO ₂)	71	68	68	54	69	67	65	58	78
Calcium (Ca)	16	18	18	14	16	16	14	14	11
Magnesium (Mg)	4	2	3	3	3	4	4	4	4
Sodium (Na)	18	16	17	19	18	14	14	16	29
Carbonate (CO ₃)	0	0	0	0	0	0	0	0	0
Bicarbonate (HCO ₃ as CaCO ₃)	80	88	88	80	124	76	76	80	72
Sulfate (SO ₄)	10	8	10	10	7	2	<1	5	2
Chloride (Cl)	12	8	14	6	6	10	12	6	10
Fluoride (F)	0.5	0.6	0.3	0.6	0.4	0.5	0.2	0.5	0.1
Nitrate (N)	0.5	0.4	0.4	0.3	0.1	0.3	0.2	0.2	0.3
Dissolved solids	250	228	202	178	154	192	160	170	188
Total hardness (as CaCO ₃)	56	52	56	48	52	56	52	52	44
Specific conductance (μmho/cm)	190	190	200	160	160	170	170	150	150
pH	7.5	7.5	7.6	7.6	7.9	7.8	7.6	7.6	7.6
<u>Radiochemical analysis</u>									
Gross alpha (pCi/l)	---	---	---	0.8±0.4	---	---	---	0.6±0.4	---
Gross beta (pCi/l)	---	---	---	1.6±0.5	---	---	---	0.7±0.5	---
Tritium (pCi/ml)	---	---	---	0.7±0.4	---	---	---	0.8±0.4	---
Total uranium (μg/l)	---	---	---	2.2±0.1	---	---	---	2.9±0.2	---
Temperature (°C)	---	19	28	8	---	20	---	10	---

^a For location see Fig. 1.

TABLE II (cont)
GROUND WATER QUALITY

Location	Water Supply, La Cueva: Horseshoe Spring (4) ^a				Mineral Spring West of Battleship Rock (JF-1) ^a				
	3/6	8/27	10/1	12/4	3/29	6/5	8/27	10/1	12/4
<u>Chemical analysis (mg/l)</u>									
Silica (SiO ₂)	79	79	77	79	40	35	42	42	45
Calcium (Ca)	11	11	11	11	115	80	122	133	129
Magnesium (Mg)	4	4	4	2	10	15	11	13	16
Sodium (Na)	14	19	17	19	---	210	321	280	228
Carbonate (CO ₃)	0	0	0	0	0	0	0	0	0
Bicarbonate (HCO ₃ as CaCO ₃)	76	76	76	68	464	492	540	552	548
Sulfate (SO ₄)	5	4	9	6	30	33	28	27	27
Chloride (Cl)	10	10	10	10	290	348	425	400	425
Fluoride (F)	0.4	0.2	0.2	0.5	2.6	2.6	2.6	2.6	2.6
Nitrate (N)	0.2	0.2	0.2	0.3	0.1	<0.1	0.1	<0.1	0.1
Dissolved solids	202	154	198	170	1108	1226	1320	1310	1380
Total hardness (as CaCO ₃)	44	44	44	36	308	260	348	384	388
Specific conductance (μmho/cm)	120	190	160	150	1700	1950	2150	2100	2030
pH	7.5	7.8	7.4	7.5	6.9	7.8	6.8	6.7	6.7
<u>Radiochemical analysis</u>									
Gross alpha (pCi/l)	---	---	---	0.1±0.3	---	---	---	---	0.3±0.4
Gross beta (pCi/l)	---	---	---	1.6±0.5	---	---	---	---	36.4±1.5
Tritium (pCi/ml)	---	---	---	0.6±0.4	---	---	---	---	1.0±0.4
Total uranium (μg/l)	---	---	---	2.2±0.1	---	---	---	---	2.1±0.1
Temperature (°C)	---	---	---	---	---	---	19	28	27

^a For location see Fig. 1.

TABLE II (cont)
GROUND WATER QUALITY

Location	Mineral and Thermal Spring, Soda Dam (JF-5) ^a					Cold Spring, Lake Fork Canyon (31) ^a				Hofhehn Flowing Well (27) ^a
Date of collection (1974)	3/29	6/5	8/27	10/1	12/4	6/5	8/27	10/1	12/24	3/6
<u>Chemical analysis (mg/l)</u>										
Silica (SiO ₂)	42	40	44	43	42	49	47	46	79	61
Calcium (Ca)	320	312	296	336	307	14	13	14	11	34
Magnesium (Mg)	16	29	18	19	21	4	5	1	2	9
Sodium (Na)	850	775	770	500	965	21	13	13	19	141
Carbonate (CO ₃)	0	0	0	0	0	0	0	0	0	0
Bicarbonate (HCO ₃ as CaCO ₃)	1204	1280	1600	1280	1210	64	76	68	68	444
Sulfate (SO ₄)	38	25	36	41	36	3	4	5	6	8
Chloride (Cl)	1480	1500	1450	1460	1460	10	8	8	10	6
Fluoride (F)	3.3	2.9	3.4	3.1	3.1	1.0	1.4	1.3	0.5	1.3
Nitrate (N)	<0.1	<0.1	<0.1	0.1	<0.1	0.3	0.3	0.2	0.3	2.3
Dissolved solids	3988	3892	3932	3958	3934	148	188	298	170	576
Total hardness (as CaCO ₃)	864	900	816	920	856	52	52	40	36	120
Specific conductance (μmho/cm)	5950	5950	5500	6400	5960	140	140	140	150	680
pH	6.6	6.7	6.9	6.7	6.6	7.9	7.1	7.1	7.1	7.8
<u>Radiochemical analysis</u>										
Gross alpha (pCi/l)	---	---	---	---	12.9±1.0	---	---	---	2.3±0.5	---
Gross beta (pCi/l)	---	---	---	---	19.3±6	---	---	---	12.5±0.8	---
Tritium (pCi/ml)	---	---	---	---	0.4±0.4	---	---	---	0.1±0.4	---
Total uranium (μg/l)	---	---	---	---	0.4±0.1	---	---	---	2.6±0.2	---
Temperature (°C)	10	---	46	47	45	---	10	13	10	---

^a For location see Fig. 1.

TABLE III
FENTON HILL SITE WATER QUALITY

Source	Test Hole GT-2						
Depth (m)	536	731	1135	1225	1225	1934	(1)
Date collected (1974)	3/18 ^a	5/3 ^b	5/14 ^b	5/27 ^b	6/2 ^b	7/11 ^b	7/28 ^b
<u>Chemical analysis (mg/l)</u>							
Silica (SiO ₂)	115	98	70	65	27	58	31
Calcium (Ca)	78	16	21	22	1	18	16
Magnesium (Mg)	42	17	20	4	7	3	5
Sodium (Na)	550	5100	3840	3200	3100	178	275
Carbonate (CO ₃)	0	240	200	0	600	60	0
Bicarbonate (HCO ₃ as CaCO ₃)	1230	6060	3580	3960	3940	460	440
Sulfate (SO ₄)	200	1090	1040	1120	1150	14	62
Chloride (Cl)	400	2750	3800	2100	2025	58	200
Fluoride (F)	3.1	13	13	13	13	1.0	1.9
Nitrate (N)	<0.1	0.1	0.2	0.3	0.2	0.3	0.3
Total dissolved solids	2500	15000	8800	10800	10400	654	1030
Total hardness (as CaCO ₃)	368	108	132	72	28	56	60
Specific conductance (μmho/cm)	2900	19000	12800	13700	12000	880	1215
pH	7.4	8.6	7.8	8.0	9.0	8.8	8.2
Temperature (°C)	56	65	76	---	---	---	---
<u>Radiochemical analysis</u>							
Gross alpha (pCi/l)	---	---	---	---	---	---	---
Gross beta (pCi/l)	---	---	---	---	---	---	---
Tritium (pCi/ml)	---	---	---	---	---	---	---
Total uranium (μg/l)	3.1±0.2	---	(2)	---	---	---	---

^a Analysis GT-2 is representative of water in Lower Madera Limestone.

^b Analysis is from granite section and may be contaminated in part by drilling fluids.

REMARKS

(1) Packer test 1813 to 1890 m.

(2) Total uranium 124±17 μg/l at 1072 m.

TABLE III (cont)
FENTON HILL SITE WATER QUALITY

Source	Pond (Drilling Fluids)								
Date collected (1974)	3/3	4/1	4/8	4/16	5/1	6/1	8/27	10/1	12/4
<u>Chemical analysis (mg/l)</u>									
Silica (SiO ₂)	51	32	67	36	30	65	92	98	80
Calcium (Ca)	72	36	80	108	140	6	19	32	13
Magnesium (Mg)	23	15	7	<1	<1	<1	1	3	1
Sodium (Na)	---	550	1020	1020	1020	2550	510	395	748
Carbonate (CO ₃)	28	0	45	140	390	980	77	195	100
Bicarbonate (HCO ₃ as CaCO ₃)	1352	260	150	230	510	2820	1000	730	1000
Sulfate (SO ₄)	156	445	710	620	640	1040	291	325	205
Chloride (Cl)	44	870	1240	1200	1150	1950	310	330	390
Fluoride (F)	1.9	2.3	1.6	1.6	1.1	8.0	2.5	5.8	3.5
Nitrate (N)	225	0.4	0.4	0.3	0.3	0.3	3.9	2.3	4.2
Total dissolved solids	3730	2660	4380	4230	4240	8720	2210	1590	2802
Total hardness (as CaCO ₃)	276	150	230	270	350	16	52	92	36
Specific conductance (μmho/cm)	3800	3700	5190	5080	6080	11700	2170	2600	3090
pH	8.4	7.6	9.0	10.7	11.4	9.6	8.8	9.5	9.0
Temperature (°C)	---	---	---	---	---	---	---	---	---
<u>Radiochemical analysis</u>									
Gross alpha (pCi/l)	---	---	---	---	---	---	---	---	7.7±0.8
Gross beta (pCi/l)	---	---	---	---	---	---	---	---	62 ±2
Tritium (pCi/ml)	---	---	---	---	---	---	---	---	0.4±0.4
Total uranium (μg/l)	---	---	---	---	---	---	---	---	29.5±1.5