LA--11210-PR

DE88 006496

LA-11210-PR
Progress Report

UC-11
Issued: March 1988

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the Vicinity of
Fenton Hill,
1985 and 1986*

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WATER QUALITY IN THE VICINITY OF FENTON HILL, 1985 AND 1986

by

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ABSTRACT

Water quality data have been collected since 1974 from established surface and groundwater stations at and in the vicinity of Fenton Hill (Hot Dry Rock Geothermal Demonstration Site) located in the Jemez Mountains. This is part of a continuing program of environmental studies. Data on chemical quality of water were determined for samples collected from 13 surface water and 19 groundwater stations in 1985 and 1986. There were slight variations in the chemical quality of the ground and surface water in 1985 and 1986 as compared with previous analyses; however, these variations are within normal seasonal fluctuations. Chemical uptake in soil, roots, and foliage is monitored in the canyon, which receives intermittent effluent release of water from tests in the geothermal circulation loop and occasional fluids from drilling operations. The chemical concentrations found in soil, roots, and vegetation as the result of effluent release have shown a decrease in concentration down-canyon and also have decreased in concentration with time since the larger releases that took place in the late 1970s and early 1980s.

I. INTRODUCTION

In 1973, a preliminary study of the Jemez River and the Rio Guadalupe drainages was made by the Los Alamos National Laboratory to establish base-line water quality data.

The study was made before the start of experimental work on the Hot Dry Rock Geothermal Project at the Fenton Hill Site (TA-57).¹ Geologic and hydrologic investigations were made in the area and at TA-57 from 1972 through 1974.^{2,3} These studies provided the basis for selecting locations for water quality monitoring stations. As new data became

available, additional stations were added to the first established stations. Water quality data from the stations have been published for 1974 through 1984.⁴⁻¹² Late in 1980, a hydrologic study was made of the aquifer that furnishes the water supply to the Fenton Hill Site.¹³ This study was followed by a geophysical (DC Resistivity) investigation of the aquifer to determine its western extent.¹⁴ The current report presents and evaluates the quality of water data from the monitoring stations and supply well and documents the water levels and production from the supply well for 1985 and 1986. The purpose of this report is to ensure a continuing

historical record of environmental surveillance of the area as related to the operations of the dry geothermal system developed at TA-57. The geothermal studies at the site are based on the concept of extracting heat from dry geothermal reservoirs by developing artificial hydrothermal systems. The site contains two deep holes (each ~10,000 ft) completed in dry Precambrian granitic rock. The holes are connected by a large fracture that was induced by hydraulic pressurization. Water is circulated under pressure through this system to extract heat from the fractured areas in the granite. The system is complete, and initial tests have been conducted. A second system has been developed at a depth of about 14,000 ft to test the system at a higher temperature. Some tests have been conducted; however, additional tests are planned.

Drilling of both circulation systems required the use of drilling mud containing some chemical additives. Chemicals can be released from this drilling mud or can be dissolved from the rocks of the geothermal reservoir by the circulating waters. Water from the geothermal circulation loops contains moderate concentrations of silica, calcium, sodium, magnesium, bicarbonate, sulfate, chloride, fluoride, arsenic, barium, and lithium, with moderate to high concentrations of total dissolved solids. Water containing drilling mud and water from the circulation loops are contained in ponds at the site.

II. FENTON HILL SITE

The Fenton Hill Site is located about 35 miles west of Los Alamos on the western flank of the Valles Caldera. It is located on a narrow, gently sloping, southwest-trending mesa that is bounded on the east by San Antonio Creek and on the west and southwest by the Rio Cebolla (Fig.1). Lake Fork Canyon to the south and an unnamed canyon to the north are adjacent to the site, contain intermittent streams. The lower 3 miles of Lake Fork Canyon above the confluence with the Rio Cebolla contain perennial flow from springs and seeps (Fig.1). Water from the springs and seeps is discharged from the aquifer that furnishes the water supply at the Fenton Hill Site.

III. SURFACE WATER AND GROUNDWATER

Water samples for analyses were collected in December 1985 and November 1986 from the immediate area of the site and in the major drainage of the Jemez River and Rio Guadalupe downgradient from the site. Routine analyses were made for silica, calcium, magnesium, potassium, sodium, carbonate, bicarbonate, sulfate, chloride, fluoride, nitrates, total hardness, total dissolved solids (TDS), conductance, and pH. Additional analyses for trace metals (arsenic, barium, boron, cadmium, chromate, copper, iron, lithium, manganese, mercury, lead, selenium, zinc, and total uranium) were performed on water samples collected in November 1986. The analyses were performed using methods described in U. S. Environmental Protection Agency (USEPA) documents or USEPA methods modified by Health and Environmental Chemistry Group (HSE-9) at Los Alamos.^{15,16}

The discussion of the quality of water is organized around stations with common chemical properties and around TDS. For each station, the mean and range of the standard deviation of the data for predominant ions and TDS for the period of record through 1984 are compared with the data from the 1985 and 1986 analyses.

The chemical concentrations from a particular station can vary widely because of variations in hydrologic characteristics such as changes in discharge of surface water through storm runoff or changes in the amount of water going to recharge a groundwater body. These are seasonal chemical quality changes that are reflected in the range of concentrations used for comparison. The accumulated data used to determine concentration means and standard deviations that are compared with the 1985 and 1986 data represent analyses from samples collected at various times during the year.

A. Surface Water

Surface water stations (nine on the Jemez River, the Rio Guadalupe, and their tributaries) are identified by capital letters in Figs. 1 and 2 and are

Fig. 1. Location of sampling stations at Fenton Hill.

keyed to detailed analyses presented in Appendix A for 1985 and 1986.

There are four general types of surface water based on predominant ions. These surface water types are (1) sodium and chloride, (2) calcium and bicarbonate, (3) calcium and sulfate, and (4) sodium and bicarbonate. The ranges of predominant ions and TDS for the period of record through 1984 are

compared with the data collected in 1985 and 1986 in Table I.

Each surface water station has a chemical characteristic reflecting the water source (base flow) in its drainage area. The chemical concentrations may be modified by water added as runoff from snowmelt or rainfall. Thus, as seen by the range of predominant ions and TDS in Table I, the chemical

Fig. 2. Location of sampling stations at La Cueva.

quality can vary widely at each individual station and from station to station over a period of time.

Sodium and chloride waters are found in base flow at Locations U, R, and S (Table I). Location U is on Redondo Creek, which drains the interbasin of the Valles Caldera. This interbasin was the site of hydrothermal (wet geothermal) development until testing indicated that the potential for power generation was insignificant. Locations R and S are on the lower reach of the Jemez River. Location R is below the confluence of the Jemez River with the Rio Guadalupe, and Location S is above the confluence (Fig. 1). This drainage area includes the communities of Jemez Springs and La Cueva as well as all of the Valles Caldera. It includes a wide range of surface water sources of varying chemical quality. Sodium, chloride, and TDS concentrations varied slightly in 1985 and 1986 when compared with the mean of these constituents for the period of record through 1984; however, the changes are below or within past variations.

Calcium and bicarbonate waters are found at Locations N, Q, and T (Fig. 1). Location N on San Antonio Creek, below La Cueva, contains drainage from the northern and western part of the Valles

Caldera. Location Q is on the Rio Guadalupe above its confluence with the Jemez River. Location T is on the Rio Cebolla below Lake Fork Canyon. Calcium and bicarbonate also are the predominant ions in four surface water stations in Lake Fork Canyon. The four surface water stations, LF-1, -2, -3, and -4, are located downgradient from the Fenton Hill Site (Fig. 1). Surface water at these stations has been sampled and analyzed annually since 1978 to determine if any changes have occurred that could be attributed to the ponds at TA-57. No significant changes in quality of water have occurred in the period 1978 through 1986 at these four stations. Chemical quality of surface water at Locations N, Q, and T has varied within the range of the 1974-1984 mean concentrations, showing no significant changes in chemical quality.

Calcium and sulfate waters are found in base flow at Locations V and F (Fig. 1). Location V is in Sulphur Creek, which drains a small interior basin of the Valles Caldera. The basin contains numerous thermal and mineral springs that contribute high mineral contents to the waters of Sulphur Creek. Location F also is in Sulphur Creek below the junction with Redondo Creek. The dilution of the surface water from Redondo Creek at Location F reduces chemical concentrations when compared with those concentrations at Location V (Table I). The chemical quality of water at these two stations has varied each year since 1974 but shows no trend or significant change when the 1985 and 1986 data are compared with previous analyses.

Sodium and bicarbonate waters are found at Location J. Location J is on the Jemez River below the confluence of the East Fork of the Jemez River and San Antonio Creek. These two streams drain the interior of the Valles Caldera (Fig. 1). There was no significant change in the quality of water at this station in 1985 and 1986 when compared with previous data.

Thirteen trace metal analyses were performed on waters collected at the 13 surface water stations in November 1986 (Table II). Low concentrations of iron and lithium were reported at all of the stations, with several stations reporting minor amounts of manganese and selenium. The trace metals in the surface water are in concentrations that occur in the

Table 1. Predominant Ions and Total Dissolved Solids in Surface Water

<u>Chemical Type-Station</u>	<u>Year</u>	<u>No. of Analyses</u>	<u>mg/L</u>		
<u>Sodium-Chloride</u>			<u>Na</u>	<u>Cl</u>	<u>TDS</u>
Loc. U	1974-1984	20	15 ± 8	31 ± 23	158 ± 60
(Redondo Creek)	1985	1	8	10	178
	1986	1	9	10	180
Loc. R	1974-1984	24	64 ± 28	79 ± 40	396 ± 105
(Jemez River)	1985	1	52	88	364
	1986	1	26	27	156
Loc. S	1974-1984	23	76 ± 28	97 ± 45	423 ± 111
(Jemez River)	1985	1	73	96	376
	1986	1	30	36	196
<u>Calcium-Bicarbonate</u>			<u>Ca</u>	<u>HCO₃</u>	<u>TDS</u>
Loc. N	1974-1984	23	16 ± 4	63 ± 15	159 ± 34
(San Antonio Creek)	1985	1	12	58	125
	1986	1	14	49	98
Loc. T	1974-1984	22	18 ± 3	70 ± 17	132 ± 22
(Rio Cebolla)	1985	1	21	70	71
	1986	1	18	65	60
Loc. Q	1974-1984	23	44 ± 12	144 ± 45	221 ± 75
(Rio Guadalupe)	1985	1	43	172	200
	1986	1	40	111	175
Loc. LF-1	1978-1984	8	16 ± 3	50 ± 17	143 ± 39
(Lake Fork Canyon)	1985	1	15	49	111
	1986	1	16	41	134

Table I. (cont)

<u>Chemical Type-Station</u>	<u>Year</u>	<u>No. of Analyses</u>	<u>mg/L</u>		
			<u>Ca</u>	<u>HCO₃</u>	<u>TDS</u>
Loc. LF-2 (Lake Fork Canyon)	1978-1984	9	19 ± 2	71 ± 21	183 ± 54
	1985	1	17	66	127
	1986	1	18	64	102
Loc. LF-3 (Lake Fork Canyon)	1978-1984	10	13 ± 2	60 ± 5	127 ± 24
	1985	1	11	52	115
	1986	1	13	53	98
Loc. LF-4 (Lake Fork Canyon)	1978-1984	11	16 ± 2	73 ± 6	142 ± 20
	1985	1	14	64	160
	1986	1	17	62	140
<u>Calcium-Sulfate</u>			<u>Ca</u>	<u>SO₄</u>	<u>TDS</u>
Loc. V (Sulphur Creek)	1974-1984	20	62 ± 23	254 ± 106	482 ± 160
	1985	1	41	220	404
	1986	1	26	120	240
Loc. F (Sulfur Creek)	1974-1984	23	34 ± 13	88 ± 51	234 ± 91
	1985	1	20	110	221
	1986	11	20	67	224
<u>Sodium-Bicarbonate</u>			<u>Na</u>	<u>HCO₃</u>	<u>TDS</u>
Loc. J (Jemez River)	1974-1984	24	16 ± 7	63 ± 15	152 ± 27
	1985	1	15	56	166
	1986	1	11	41	214

Table II. Trace Metals in Surface and Groundwater
(November 1986)

Station	Location	mg/L								Total Uranium (ug/L)
		As	B	Cu	Fe	Li	Mn	Se	Zn	
Surface Water										
F	Sulphur Creek	<0.05	<0.1	<0.05	0.041	0.027	0.19	0.04	<0.05	3
J	Jemez River	<0.05	<0.1	<0.05	0.043	0.032	<0.05	0.04	<0.05	2
N	San Antonio Creek	<0.05	<0.1	<0.05	0.582	0.019	<0.05	<0.02	<0.05	2
Q	Rio Guadalupe	<0.05	<0.1	<0.05	0.021	0.014	<0.05	<0.02	<0.05	2
R	Jemez River	<0.05	<0.1	<0.05	0.040	0.240	<0.05	<0.02	<0.05	3
S	Jemez River	<0.05	<0.1	<0.05	0.054	0.290	<0.05	0.04	<0.05	2
T	Rio Cebolla	<0.05	<0.1	<0.05	0.081	0.014	<0.05	<0.02	<0.05	2
U	Redondo Creek	<0.05	<0.1	<0.05	0.028	0.028	<0.05	0.06	<0.05	2
V	Sulphur Creek	<0.05	<0.1	<0.05	1.06	0.017	0.31	<0.02	<0.05	2
LF-1	Lake Fork Canyon	<0.05	<0.1	<0.05	1.18	0.011	0.86	<0.02	<0.05	3
LF-2	Lake Fork Canyon	<0.05	<0.1	<0.05	0.235	0.018	3.2	<0.02	<0.05	3
LF-3	Lake Fork Canyon	<0.05	<0.1	<0.05	0.019	0.021	<0.05	<0.02	<0.05	3
LF-4	Lake Fork Canyon	<0.05	<0.1	<0.05	0.053	0.020	<0.05	<0.02	<0.05	2
Groundwater										
JS-2,3	Jemez Village (Spr)	<0.05	<0.1	<0.05	<0.003	0.023	<0.05	<0.02	<0.05	4
JS-4,5	Jemez Village (Spr)	<0.05	<0.1	<0.05	0.039	0.031	<0.05	<0.02	0.11	3
FH-1	Fenton Hill (Well)	<0.05	<0.1	<0.05	0.008	0.026	<0.05	<0.02	0.11	3
JF-1	Jemez Canyon (Hot Spr)	<0.05	6.3	<0.05	0.005	6.70	0.06	<0.02	<0.05	3
JF-5	Soda Dam (Hot Spr)	172	13.1	<0.05	0.036	15.0	0.56	<0.02	<0.05	2
RV-2	San Antonio (Hot Spr)	<0.05	0.5	<0.05	0.010	0.036	<0.05	<0.02	<0.05	2
RV-4	Spence (Hot Spr)	<0.05	0.4	<0.05	<0.003	0.610	<0.05	<0.02	<0.05	2
RV-5	McCauley (Hot Spr)	<0.05	<0.1	<0.05	<0.003	0.290	<0.05	<0.02	<0.05	2
Loc. 4	La Cueva (Well)	<0.05	<0.1	<0.05	0.144	0.028	<0.05	<0.02	0.09	2
Loc. 6	La Cueva (Well)	<0.05	<0.1	<0.05	0.034	0.037	0.08	<0.02	<0.05	2
Loc. 27	La Cueva (Well)	<0.05	0.5	<0.05	0.355	0.076	0.19	<0.02	<0.05	2

Table II. (cont)

Station	Location	mg/L								Total Uranium (µg/L)
		As	B	Cu	Fe	Li	Mn	Se	Zn	
Loc. 31	Lake Fork (Spr)	<0.05	<0.1	<0.05	0.005	0.018	<0.05	<0.02	<0.05	4
Loc. 39	Lake Fork (Tank)	<0.05	<0.1	<0.05	0.008	0.010	<0.05	<0.02	<0.05	2
Loc. 42	La Cueva (Well)	<0.05	<0.1	<0.05	4.49	0.013	<0.05	<0.02	<0.05	1
Loc. 47	La Cueva (Well)	<0.05	0.7	0.14	0.044	0.140	<0.05	<0.02	<0.05	1
Loc. 48	La Cueva (Well)	<0.05	<0.1	<0.05	0.025	0.037	0.13	<0.02	<0.05	1
Loc. 53	Sulphur Creek (Well)	<0.05	<0.1	<0.05	0.048	0.032	<0.05	<0.02	1.0	1
Loc. 54	Sulphur Creek (Well)	<0.05	<0.1	0.07	0.009	0.063	<0.05	<0.02	<0.05	1
Loc. 55	Sulphur Creek (Well)	<0.05	<0.1	0.05	0.264	0.140	0.86	<0.02	<0.05	1

Note: Analyses were also performed on the 13 surface water and 19 groundwater stations listed above for the following constituents and were found to be below limits of detection for Ba <0.5 mg/L; Cd <0.01 mg/L; Cr <0.05 mg/L; Hg <0.0002 mg/L, and Pb <0.05 mg/L.

environment and are not related to the hot dry rock geothermal project. The reported concentrations of total uranium ranged from 2 to 3 micrograms/L, which is in the range of naturally occurring uranium.

In summary, a comparison of the chemical quality of surface water from the past period of record with the quality in 1985 and 1986 shows some variation in certain chemical constituents; however, no trends at individual stations were noted. As previously stated, changes in surface water discharge, resulting in dilution of base flow, can account for the observed variations in chemical quality. The range of the variations is not considered to be significant.

B. Groundwater

Groundwater locations sampled in 1985 and 1986 included five mineral and thermal springs, five cold springs, and seven wells. Each station location is shown by capital letters followed by a number or by a number alone (Figs. 1 and 2). These locations are keyed to detailed analyses presented in Appendix B. Three types of groundwater are categorized by predominant ions. The three types are (1) sodium and bicarbonate, (2) sodium and chloride, and (3) calcium and bicarbonate. The means and standard deviations of the analyses for predominant ions and TDS from the period of record are compared with similar ions and TDS in samples collected in 1985 and 1986 (Table III).

Sodium and bicarbonate waters are found in spring Locations JS-2,3 and JS-4,5. Sodium and bicarbonate waters also are found in springs and wells at Locations 4, 6, 31, and 47 and in waters from thermal springs RV-2, RV-4, and RV-5 (Table III). Locations JS-2,3 and JS-4,5 are springs located on the east and west walls of Jemez Canyon north of the community of Jemez Springs. These springs discharge from the base of the Bandelier Tuff overlying the Abo Formation. These springs furnish the water supply for the community of Jemez Springs. The spring at Location 4 is the water supply for several residences at La Cueva. Location 6 is a spring in the valley floor of San Antonio Creek at La Cueva. Location 31 is a spring on the north wall of

Lake Fork Canyon east of its confluence with the Rio Cebolla. The well at Location 47 is used for water supply in La Cueva. Thermal springs RV-2 (San Antonio Hot Springs), RV-4 (Spence Hot Springs), and RV-5 (McCauley Hot Springs) discharge from recent (probably less than 40,000 years old) volcanic rocks west and south of the Valles Caldera. The chemical concentrations and TDS of the waters from the thermal springs are low, as is the case for all sodium and bicarbonate groundwaters, with the exception of water from Locations 27 and 47. Water from Locations 27 and 47 is from wells completed in the Abo Formation, while the other wells and spring yield water from the alluvium or recent volcanic rocks. Aquifers in the red clays, siltstones, and sandstones of the Abo Formation tend to have higher mineral concentrations than aquifers in alluvium or recent volcanics. There have been no significant changes or trends in concentrations of predominant ions or TDS from individual stations during the period of record.

Sodium and chloride waters are found at Locations JF-1 and JF-5 (Fig. 1 and Table IV). Locations JF-1 and JF-5 are thermal and mineral springs that discharge along the Jemez Fault into the Jemez River. A series of thermal and mineral springs in this reach of the canyon affect the quality of water in the river, changing it from a sodium and bicarbonate type at Location J to a sodium and chloride type, as found downgradient in the Jemez River at Locations R and S. The spring at Location JF-5 (Soda Dam) contains a greater mineral concentration than the spring at Location JF-1. The quality of water from the hot springs has fluctuated slightly but has shown no significant change in quality for the period of record.

Calcium and bicarbonate waters are found at Location 39, a spring fed stock tank in Lake Fork Canyon, and two domestic wells at Locations 42 and 48 at La Cueva. Calcium and bicarbonate waters also are found at domestic wells at Locations 53, 54, and 55 along Sulphur Creek (Fig. 2). Water quality has remained about the same for the period of record (Table IV).

Thirteen trace metal analyses were performed on the groundwater collected in November 1986.

Table III. Predominant Ions (Sodium-Bicarbonate) and Total Dissolved Solids in Groundwater

<u>Chemical Type - Station</u>	<u>Year</u>	<u>No. of Analyses</u>	<u>mg/L</u>		
			<u>Na</u>	<u>HCO₃</u>	<u>TDS</u>
<u>Sodium-Bicarbonate</u>					
JS-2,3 (Springs)	1974-1984	23	16 ± 3	78 ± 12	180 ± 32
	1985	1	16	77	146
	1986	1	16	82	188
JS-4,5 (Springs)	1974-1984	23	16 ± 3	78 ± 17	171 ± 19
	1985	1	15	73	165
	1986	1	18	76	158
Loc. 4 (Well)	1974-1984	23	19 ± 7	73 ± 21	172 ± 25
	1985	1	30	123	224
	1986	1	17	65	188
Loc. 6 (Spring)	1978-1984	10	20 ± 5	88 ± 8	193 ± 29
	1985	1	22	114	183
	1986	1	24	144	186
Loc. 27 (Well)	1974-1980	15	114 ± 14	371 ± 42	377 ± 53
	1985	1	84	237	396
	1986	1	81	248	428
Loc. 31 (Spring)	1974-1984	23	13 ± 3	63 ± 5	142 ± 43
	1985	1	11	52	122
	1986	1	13	61	124
Loc. 47 (Well)	1974-1984	11	223 ± 35	526 ± 18	646 ± 22
	1985	1	240	542	682
	1986	1	270	519	710

Table III. (cont)

<u>Chemical Type - Station</u>	<u>Year</u>	<u>No. of Analyses</u>	<u>mg/L</u>		
			<u>Na</u>	<u>HCO₃</u>	<u>TDS</u>
Loc. RV-2 (Hot Spring)	1975-1984	10	24 $\pm$ 2	49 $\pm$ 3	154 $\pm$ 19
	1985	1	22	45	162
	1986	1	23	47	147
Loc. RV-4 (Hot Spring)	1975-1984	11	51 $\pm$ 6	115 $\pm$ 6	230 $\pm$ 31
	1985	1	52	107	221
	1986	1	51	115	198
Local RV-5 (Hot Spring)	1975-1984	11	20 $\pm$ 2	73 $\pm$ 4	149 $\pm$ 22
	1985	1	19	73	128
	1986	1	20	70	134

Table IV. Predominant Ions (Sodium-Chloride, Calcium-Bicarbonate) and Total Dissolved Solids in Groundwater

<u>Chemical Type - Station</u>	<u>Year</u>	<u>No. of Analyses</u>	<u>mg/L</u>		
<u>Sodium-Chloride</u>			<u>Na</u>	<u>Cl</u>	<u>TDS</u>
Loc. JF-1	1974-1984	23	315 ± 162	452 ± 188	1347 ± 282
(Hot Springs)	1985	1	479	710	1670
	1986	1	460	600	1570
Loc. JF-5	1974-1984	24	831 ± 143	1497 ± 223	3752 ± 268
(Hot Springs)	1985	1	989	1600	3146
	1986	1	940	1500	3100
<u>Calcium-Bicarbonate</u>			<u>Ca</u>	<u>HCO₃</u>	<u>TDS</u>
Loc. 39	1978-1984	11	14 ± 2	42 ± 11	92 ± 16
(Spring Tank)	1985	1	16	38	111
	1986	1	17	41	98
Loc. 42	1978-1984	11	12 ± 1	74 ± 2	166 ± 13
(Well)	1985	1	9	70	173
	1986	1	13	68	170
Loc. 48	1978-1984	9	23 ± 2	91 ± 3	194 ± 22
(Well)	1985	1	20	74	237
	1986	1	25	77	204
Loc. 53	1980-1984	7	45 ± 4	149 ± 12	276 ± 47
(Well)	1985	1	38	145	238
	1986	1	36	113	252
Loc. 54	1980-1984	6	57 ± 3	247 ± 15	361 ± 40
(Well)	1986	1	58	243	326

Table IV. (cont)

<u>Chemical Type - Station</u>	<u>Year</u>	<u>No. of Analyses</u>	<u>mg/L</u>		
			<u>Ca</u>	<u>HCO₃</u>	<u>TDS</u>
Loc. 55 (Well)	1983-1984	2	76 $\pm$ 4	216 $\pm$ 5	480 $\pm$ 28
	1985	1	70	230	310
	1986	1	92	209	507

Low concentrations of iron, lithium, and manganese were found in almost all of the groundwater samples (Table II). High concentrations of arsenic were found in the thermal and mineral spring JF-5, while springs JF-1, JF-5, RV-2, and RV-5 contained concentrations of boron that ranged from 0.4 to 13.1 mg/L. Trace concentrations of zinc occurred at several locations (JS-4, 5 and Locations 4 and 53). This zinc results from water transport through galvanized pipes.

The chemical quality of groundwater from springs and wells reflects the type of rock and the length of time that the water has been in contact with the rock from recharge to discharge. Seasonal changes in groundwater quality can occur as the result of rate and amount of recharge. A comparison of water quality for the period of record through 1984 with the data collected in 1985 and 1986 reflects the normal chemical variations that would be expected.

IV. FENTON HILL WATER SUPPLY

The water supply (domestic and experimental use) for Fenton Hill is furnished by well FH-1, which is completed into a perched aquifer at a depth of about 450 ft. This aquifer is in the Abiquiu Tuff and is perched on the clays and siltstones of the Abo Formation. It is of limited extent, terminating to the east along the canyon cut by San Antonio Creek. The water movement in the aquifer is to the southwest, where a part is discharged through springs and seeps in the lower part of Lake Fork Canyon and the Rio Cebolla. Water levels of the aquifer are monitored in the supply well, FH-1, and two observation wells, FH-2 and FH-3. The observation wells are completed through the Abiquiu Tuff into the top of the Abo Formation. Observation well FH-2 is located about 440 ft west-southwest of supply well FH-1, while FH-3 is located about 63 ft south of FH-1.

The supply well FH-1 was completed in November 1976. The production for the last two months of 1976 was 0.480×10^6 gal. (Fig. 3). The annual production for 1977 through 1986 ranged from 2.5×10^6 gal. in 1977 to 7.2×10^6 gal. in 1980

(Fig. 3). The production in 1985 was 5.7×10^6 gal. and in 1986 was 5.8×10^6 gal. The cumulative production from the well has been about 53.1×10^6 gal. (Fig. 4).

The monthly production during 1985 and 1986 has ranged from about 0.020×10^6 gal. in June 1986 to 1.685×10^6 gal. in March 1986. The wide variation in monthly production reflects the demand for drilling or tests using the circulation loop and hydrofracture to create the reservoir at depth. Water levels in FH-1 vary according to the amount of pumpage (Fig. 5).

The average monthly water levels were compiled for supply well FH-1 and observation wells FH-2 and FH-3 (Fig. 5). All three wells are completed into the same aquifer in the Abiquiu Tuff. The water levels in all three wells are affected by the production from FH-1.

The water level in FH-1 has declined from about 365 ft in 1976 to about 382 ft in 1986. The monthly water level fluctuation follows the monthly pumpage (Fig. 5). The production from FH-1 has resulted in a general water level decline in both observation wells. The water level in FH-3 has declined about 11 ft, from 373 ft in 1980 to 384 ft in 1986. The level in observation well FH-2 has declined about 4 ft, from 370 ft in 1980 to about 374 ft in 1986 (Fig. 5). The decline of the water levels indicates that withdrawal of water from the aquifer has exceeded recharge to the aquifer. These water level declines are to be expected as a result of the current and past pumpage. Although there have been water level declines, the aquifer still is capable of water supply to the site.

Calcium and bicarbonate are the principal ions in the water from the supply well (Fig. 6). Calcium concentrations have shown a general increase from 1976 through 1981, a subsequent decrease until 1985, and an increase again in 1986. Chloride has shown the same general trend as calcium. There has been little, if any, specific trend in the bicarbonate concentration, which has varied only slightly during the period of record. In general, the TDS concentration has followed the same trend as the calcium and chloride concentrations. The variations in concentrations, as shown by slight increases in

Fig. 3. Annual production from supply well FH-1, 1976-1986.

Fig. 4. Cumulative production from well FH-1, 1976-1986.

concentrations of carbonate, chloride, and TDS, are to be expected as the water level in the wells declines, resulting from dewatering of certain beds in the aquifer and increasing aquifer yields from the remaining saturated beds.

Fig. 5. Monthly water levels in supply well FH-1, observation wells FH-2 and FH-3, and monthly production from supply well FH-1 for 1985 and 1986.

Water from well FH-1 was analyzed for chemical and radiochemical constituents for comparison with standards set by the USEPA for municipal or domestic use. The chemical concentrations in the water from the well are below those established in the standards for municipal use (Table V). The radiochemical analyses of water from the well in 1985 and 1986 showed concentrations below those in the standards set for municipal use by the USEPA.^{17,18}

Fig. 6. Graphic comparison of predominant ions (calcium bicarbonate) and total dissolved solids in water from supply well FH-1, 1976-1986.

V. VEGETATION AND SOIL ANALYSES

Drilling fluids and water from the circulation loop are stored in two ponds at the Fenton Hill Site. Periodically, these ponds are released into the adjacent dry side canyon when additional storage is needed or drill cuttings are removed from the pond (see Appendix C for chemical analyses of ponds). This canyon drains to the southwest into Lake Fork Canyon. Water from pond GT-2 was discharged into the canyon in November 1986. When water is discharged, the discharge is under controlled conditions, so that most of it either evaporates or infiltrates into the alluvium within about 400 ft of the outfall. The accumulation of chemicals in canyon vegetation and soils is monitored as part of the continuing Fenton Hill studies.

Samples of vegetation and soil from the channel bottom and the canyon bank below the point of discharge are collected annually. The collected samples are analyzed for arsenic, boron, cadmium, fluoride, and lithium. The sampling locations are at distances of about 325, 650, 1300, and 3250 ft down-canyon from the discharge point. An additional sample is collected from the bottom of the canyon at its junction with Lake Fork Canyon, which is far below the region of influence of pond effluent discharge.

The data received to date are shown in Appendix D. The only new data since the report of 1983 and 1984¹² are the 1986 data for boron in vegetation, the 1985 and 1986 data for fluoride in vegetation and soils, and the 1985 data for lithium in vegetation. The 1986 boron data and the 1985 lithium data both show a decrease in concentration in grass foliage in the canyon channel below the effluent discharge point, which is consistent with several years of no discharge. The fluoride concentration in grass foliage, grass roots, and soil has essentially leveled off since 1982, which also is consistent with several years of no discharge. This tends to confirm the tentative conclusion reached in the previous progress report¹² that the accumulations of these elements noted in the years when discharges to the canyon were frequent are dissipating now that the discharges have ceased.

VI. SUMMARY

The chemical quality of surface and groundwater in 1985 and 1986 within the drainage of the Fenton Hill Site and the Valles Caldera varied slightly; however, the variations are within normal seasonal fluctuations. The water quality was within previously measured concentrations.

Production from the supply well was 5.7×10^6 gal. in 1985 and 5.8×10^6 gal. in 1986. Cumulative production since 1976 has been 53.1×10^6 gal. The water level in supply well FH-1 has declined from about 365 ft in 1976 to 382 ft in 1986. The water level in observation well FH-3, about 63 ft southwest of FH-1, has declined about 11 ft since 1980, while the water level in FH-2, about 440 ft west of FH-1,

**Table V. Chemical and Radiochemical Quality of Water from
Supply Well FH-1, 1985 and 1986**

<u>Chemical Standards (mg/L)</u>	<u>Supply Well FH-1</u>		<u>Standard or Criteria^a</u>
	<u>1985</u>	<u>1986</u>	
Primary			
Ag	<0.001	<0.001	0.05
As	<0.001	<0.002	0.05
Ba	0.07	0.06	1.0
Cd	<0.002	<0.002	0.01
Cr	0.005	<0.005	0.05
F	0.5	0.1	2.0
Hg	<0.0002	<0.0002	0.002
NO ₃	<0.9	1.3	45
Pb	<0.002	<0.002	0.05
Se	<0.003	<0.003	0.01
Second			
Cl	15	6	250
Cu	<0.005	<0.005	1.0
Fe	0.036	0.012	0.3
Mn	<0.001	<0.001	0.05
SO ₄	6	114	250
Zn	0.05	0.14	5.0
TDS	236	220	500
pH (no units)	7.8	8.1	6.5-8.5
Radiochemical Standards (pCi/L)			
³ H	<300	<300	20,000
¹³⁷ Cs	<40	61	200
²³⁸ Pu	<0.009	<0.004	15
^{239,240} Pu	<0.005	<0.004	15
Gross Alpha	2.4	1.2	15

^aReferences 17 and 18.

has declined about 4 ft since 1980. Water level trends are as anticipated under current pumpage.

There was only one period of discharge (November 1986) from the ponds during 1985 and 1986. This discharge contained drilling fluid and circulation water used during testing of the geothermal reservoir.

Monitoring of vegetation and soils for boron, fluoride, and lithium in the canyon release area below the ponds indicated that accumulations of these elements noted in previous years when discharge was more frequent are dissipating now that the frequency and amount of discharge have declined.

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APPENDIX A
Surface Water Quality 1985 and 1986

Station	Location	Date	mg/L							
			SiO ₂	Ca	Mg	K	Na	CO ₃	HCO ₃	P
F	Sulphur Creek	12/85	33	20	3.8	5.8	11	0	0	0.2
F	Sulphur Creek	11/86	32	20	2.9	4.3	10	0	8	0.1
J	Jemez River	12/85	47	12	2.7	3.2	15	0	56	0.3
J	Jemez River	11/86	38	12	2.1	2.4	11	0	41	0.1
N	San Antonio Creek	12/85	49	12	2.3	3.2	14	0	58	0.4
N	San Antonio Creek	11/86	42	14	2.2	2.6	11	0	49	0.1
Q	Rio Guadalupe	12/85	29	43	6.2	2.7	13	0	172	0.1
Q	Rio Guadalupe	11/86	17	40	3.8	1.5	8	0	111	<0.1
R	Jemez River	12/85	42	38	5.0	12.0	52	0	160	0.3
R	Jemez River	11/86	30	28	3.2	4.8	26	0	94	0.1
S	Jemez River	12/85	48	40	4.6	13.0	73	0	147	0.3
S	Jemez River	11/86	35	23	2.9	5.7	30	0	74	0.1
T	Rio Cebolla	12/85	37	21	2.3	3.0	10	0	70	0.2
T	Rio Cebolla	11/86	35	18	2.1	2.7	10	0	65	0.1
U	Redondo Creek	12/85	31	12	1.5	2.8	8	0	33	0.2
U	Redondo Creek	11/86	27	15	1.8	3.1	9	0	34	0.1
V	Sulphur Creek	12/85	48	41	7.4	10.0	16	0	0	0.3
V	Sulphur Creek	11/86	36	26	4.1	6.2	11	0	0	0.2

APPENDIX A (cont)

Station	Location	Date	mg/L							
			SiO ₂	Ca	Mg	K	Na	CO ₃	HCO ₃	P
LF-1	Lake Fork (6085) ^a	12/85	30	15	2.7	3.1	8	0	49	0.2
LF-1	Lake Fork (6085) ^a	11/86	23	16	2.7	2.8	7	0	41	0.1
LF-2	Lake Fork (7285) ^a	12/85	35	17	3.1	3.2	13	0	66	0.2
LF-2	Lake Fork (7285) ^a	11/86	32	18	3.0	4.3	12	0	64	0.1
LF-3	Lake Fork (8500) ^a	12/85	53	11	2.0	2.8	13	0	52	0.3
LF-3	Lake Fork (8500) ^a	11/86	55	13	2.0	2.5	14	0	53	0.2
LF-4	Lake Fork (9420) ^a	12/85	47	14	2.5	3.1	14	0	64	0.3
LF-4	Lake Fork (9420) ^a	11/86	45	17	2.4	2.8	15	0	62	0.2

^aNumber represents meters below Lower Pond (GTP-3) in Lake Fork Canyon.

APPENDIX A (cont)

Station	Location	Date	mg/L						Specific Conductance (µmho)	pH
			SO ₄	Cl	F	NO ₃	TDS	Total Hard		
F	Sulphur Creek	12/85	110	41	0.3	<1	221	65	280	5.6
F	Sulphur Creek	11/86	67	6	0.2	<1	224	62	235	6.9
J	Jemez River	12/85	14	4	0.9	<1	166	40	180	8.1
J	Jemez River	11/86	9	4	0.4	<1	214	39	125	7.8
N	San Antonio Creek	12/85	11	2	1.3	<1	125	70	250	7.8
N	San Antonio Creek	11/86	8	2	0.7	<1	98	44	140	7.9
Q	Rio Guadalupe	12/85	10	4	0.6	<1	200	132	350	8.1
Q	Rio Guadalupe	11/86	5	3	0.3	<1	175	120	250	8.2
R	Jemez River	12/85	16	88	1.1	<1	364	116	530	8.3
R	Jemez River	11/86	10	27	0.5	<1	156	83	300	8.2
S	Jemez River	12/85	16	96	1.2	<1	376	118	650	8.1
S	Jemez River	11/86	11	36	0.6	<1	196	69	310	8.2
T	Rio Cebolla	12/85	4	2	0.6	<1	71	61	195	7.6
T	Rio Cebolla	11/86	6	4	0.4	<1	60	54	165	7.9
U	Redondo Creek	12/85	9	10	0.2	<1	178	36	145	7.6
U	Redondo Creek	11/86	10	10	0.2	<1	180	45	125	7.8
V	Sulphur Creek	12/85	220	3	0.4	<1	404	132	615	3.7
V	Sulphur Creek	11/86	120	3	0.1	<1	240	82	315	4.4

APPENDIX A (cont)

Station	Location	Date	mg/L					Total Hard	Specific Conductance (μ mho)	pH
			SO ₄	Cl	F	NO ₃	TDS			
LF-1	Lake Fork (6085) ^a	12/85	12	3	0.5	<1	111	55	150	5.6
LF-1	Lake Fork (6085) ^a	11/86	22	8	0.4	<1	134	51	140	6.4
LF-2	Lake Fork (7285) ^a	12/85	8	10	0.6	<1	127	55	185	6.2
LF-2	Lake Fork (7285) ^a	11/86	5	4	0.6	<1	102	57	160	6.7
LF-3	Lake Fork (8500) ^a	12/85	4	3	1.2	<1	115	35	145	7.1
LF-3	Lake Fork (8500) ^a	11/86	5	4	0.8	<1	98	41	140	7.4
LF-4	Lake Fork (9420) ^a	12/85	5	3	0.5	<1	160	44	170	7.5
LF-4	Lake Fork (9420) ^a	11/86	8	7	1.0	<1	140	52	170	7.8

^aNumber represents meters below Lower Pond (GTP-3) in Lake Fork Canyon.

APPENDIX B
Groundwater Quality 1985 and 1986

Station	Location	Date	mg/L							
			<u>SiO₂</u>	<u>Ca</u>	<u>Mg</u>	<u>K</u>	<u>Na</u>	<u>CO₃</u>	<u>HCO₃</u>	<u>P</u>
JS-2,3	Jemez Village (Spr)	12/85	62	13	3.0	1.0	16	0	77	0.3
JS-2,3	Jemez Village (Spr)	11/86	65	20	3.0	2.4	16	0	82	0.2
JS-4,5	Jemez Village (Spr)	12/85	61	12	3.0	1.0	15	0	73	0.4
JS-4,5	Jemez Village (Spr)	11/86	70	17	2.7	0.9	18	0	76	0.2
FH-1	Fenton Hill (Well)	12/85	68	34	3.7	5.0	12	0	109	0.4
FH-1	Fenton Hill (Well)	11/86	69	41	4.2	4.8	14	0	114	0.2
JF-1	Jemez Canyon (Hot Spr)	12/85	41	159	20.0	67.0	479	0	450	0.2
JF-1	Jemez Canyon (Hot Spr)	11/86	46	180	14.0	55.0	460	0	506	0.7
JF-5	Soda Dam (Hot Spr)	12/85	41	302	24.0	191.0	989	0	810	0.3
JF-5	Soda Dam (Hot Spr)	11/86	46	330	15.0	180.0	940	0	940	0.2
RV-2	San Antonio (Hot Spr)	12/85	67	2	0.3	2.2	22	0	45	0.4
RV-2	San Antonio (Hot Spr)	11/86	76	4	0.3	1.8	23	0	47	0.2
RV-4	Spence (Hot Spr)	12/85	59	4	1.6	1.6	52	0	107	0.3
RV-4	Spence (Hot Spr)	11/86	66	7	1.5	1.5	51	0	115	0.2
RV-5	McCauley (Hot Spr)	12/85	50	7	4.6	1.1	19	0	73	0.4
RV-5	McCauley (Hot Spr)	11/86	54	10	4.6	1.1	20	0	70	0.2
Loc. 4	La Cueva (Well)	12/85	58	14	4.6	7.2	30	0	123	0.4
Loc. 4	La Cueva (Well)	11/86	8	10	2.4	2.0	17	0	65	0.3
Loc. 6	La Cueva (Spr)	12/85	48	40	11.0	6.3	22	0	114	0.4
Loc. 6	La Cueva (Spr)	11/86	57	70	12.0	5.2	24	0	144	0.8

APPENDIX B (cont)

Station	Location	Date	mg/L							
			<u>SiO₂</u>	<u>Ca</u>	<u>Mg</u>	<u>K</u>	<u>Na</u>	<u>CO₃</u>	<u>HCO₃</u>	<u>P</u>
Loc. 27	La Cueva (Well)	12/85	59	16	5.5	4.5	84	0	237	0.6
Loc. 27	La Cueva (Well)	11/86	66	20	5.6	3.4	81	0	248	0.6
Loc. 31	Lake Fork (Spr)	12/85	45	17	2.6	4.0	11	0	52	0.3
Loc. 31	Lake Fork (Spr)	11/86	52	13	3.2	3.5	13	0	61	0.3
Loc. 39	Lake Fork (Tank)	12/85	23	16	3.2	2.7	5	0	38	0.2
Loc. 39	Lake Fork (Tank)	11/86	25	17	2.9	2.2	7	0	41	0.1
Loc. 42	La Cueva (Well)	12/85	61	9	5.8	4.8	10	0	70	0.6
Loc. 42	La Cueva (Well)	11/86	65	13	5.8	4.4	12	0	68	0.4
Loc. 47	La Cueva (Well)	12/85	24	4	3.0	5.8	240	0	541	0.1
Loc. 47	La Cueva (Well)	11/86	18	5	3.1	5.2	270	29	519	0.1
Loc. 48	La Cueva (Well)	12/85	57	20	4.4	2.4	20	0	74	0.5
Loc. 48	La Cueva (Well)	11/86	56	25	4.5	2.1	26	0	77	0.3
Loc. 53	Sulphur Creek (Well)	12/85	55	38	5.5	6.2	15	0	145	0.5
Loc. 53	Sulphur Creek (Well)	11/86	59	36	4.6	5.5	21	0	113	0.4
Loc. 54	Sulphur Creek (Well)	11/86	55	58	7.9	6.0	15	0	243	0.3
Loc. 55	Sulphur Creek (Well)	12/85	80	70	10.0	20.0	48	0	230	0.6
Loc. 55	Sulphur Creek (Well)	11/86	77	92	11.0	18.0	43	0	209	0.6

APPENDIX B (cont)

Station	Location	Date	mg/L					Total Hard	Specific Conductance (µmho)	pH
			SO ₄	Cl	F	NO ₃	TDS			
JS-2,3	Jemez Village (Spr)	12/85	4	4	0.6	<1	146	46	175	7.9
JS-2,3	Jemez Village (Spr)	11/86	6	3	0.7	<1	188	62	200	7.8
JS-4,5	Jemez Village (Spr)	12/85	3	4	0.6	<1	165	43	175	8.1
JS-4,5	Jemez Village (Spr)	11/86	4	8	0.5	<1	158	54	175	8.0
FH-1	Fenton Hill (Well)	12/85	6	12	0.1	<1	228	100	185	8.0
FH-1	Fenton Hill (Well)	11/86	7	22	0.1	<1	212	120	305	7.9
JF-1	Jemez Canyon (Hot Spr)	12/85	32	710	3.2	<1	1670	480	3500	7.2
JF-1	Jemez Canyon (Hot Spr)	11/86	37	600	2.8	<1	1570	470	3260	7.2
JF-5	Soda Dam (Hot Spr)	12/85	28	1600	4.0	<1	3146	853	6590	6.6
JF-5	Soda Dam (Hot Spr)	11/86	34	1500	4.2	<1	3100	890	6640	6.6
RV-2	San Antonio (Hot Spr)	12/85	6	2	1.3	<1	162	6	125	7.9
RV-2	San Antonio (Hot Spr)	11/86	6	3	0.6	<1	147	11	120	7.9
RV-4	Spence (Hot Spr)	12/85	17	8	0.7	<1	221	16	295	8.2
RV-4	Spence (Hot Spr)	11/86	16	10	0.7	<1	198	15	280	8.0
RV-5	McCauley (Hot Spr)	12/85	5	4	1.0	<1	128	82	170	8.1
RV-5	McCauley (Hot Spr)	11/86	5	6	1.0	<1	134	43	185	8.0
Loc. 4	La Cueva (Well)	12/85	5	5	0.6	<1	224	55	320	7.3
Loc. 4	La Cueva (Well)	11/86	11	4	0.3	<1	188	35	150	7.7
Loc. 6	La Cueva (Spr)	12/85	12	7	0.7	66	183	146	290	7.5
Loc. 6	La Cueva (Spr)	11/86	10	11	0.6	<1	186	220	320	7.1

APPENDIX B (cont)

Station	Location	Date	mg/L					Total Hard	Specific Conductance (umho)	pH
			SO ₄	Cl	F	NO ₃	TDS			
Loc. 27	La Cueva (Well)	12/85	5	4	0.9	<1	396	62	510	7.6
Loc. 27	La Cueva (Well)	11/86	6	7	1.0	<1	428	73	510	8.0
Loc. 31	Lake Fork (Spr)	12/85	4	3	1.2	<1	122	53	150	7.4
Loc. 31	Lake Fork (Spr)	11/86	5	4	1.4	<1	124	91	150	7.4
Loc. 39	Lake Fork (Tank)	12/85	21	3	0.2	<1	111	52	130	--
Loc. 39	Lake Fork (Tank)	11/86	16	4	0.1	<1	98	54	135	6.7
Loc. 42	La Cueva (Well)	12/85	1	2	0.4	<1	173	47	160	7.0
Loc. 42	La Cueva (Well)	11/86	8	6	0.4	<1	170	56	170	7.0
Loc. 47	La Cueva (Well)	12/85	22	3	3.1	<1	682	23	1060	8.4
Loc. 47	La Cueva (Well)	11/86	21	4	2.8	<1	710	26	1060	8.2
Loc. 48	La Cueva (Well)	12/85	24	9	0.9	<1	237	68	270	7.2
Loc. 48	La Cueva (Well)	11/86	24	11	0.7	<1	204	81	270	7.1
Loc. 53	Sulphur Creek (Well)	12/85	11	4	0.4	<1	238	119	305	7.0
Loc. 53	Sulphur Creek (Well)	11/86	19	6	0.6	<1	252	110	295	7.0
Loc. 54	Sulphur Creek (Well)	11/86	12	6	0.5	<1	326	180	510	7.0
Loc. 55	Sulphur Creek (Well)	12/85	120	3	0.5	<1	310	217	700	7.3
Loc. 55	Sulphur Creek (Well)	11/86	120	3	0.5	<1	507	280	705	7.2

APPENDIX C

Chemical Quality of Water From the Supply Well and Storage Ponds at Fenton Hill

The chemical quality of water from the supply well and ponds is monitored to document the quality as well as to see if changes occur over a period of time. Chemical quality data are required for environmental studies and to determine the chemical type of the water used in testing the circulation loop. Data for this section were furnished by Pat Trujillo and Dale Counce, Los Alamos, Group ESS-1.

SUPPLY WELL

The water supply at Fenton Hill is from a well located near the eastern edge of the compound (Fig. C-1). The well supplies water for domestic use at the site, for drilling, and for tests of the circulation loop in the geothermal system. The annual productions in 1985 and 1986 were 5.7×10^6 and 5.8×10^6 gal., respectively. During 1985 and 1986, four water samples were collected from this well and analyzed (Table C-1).

The water from the well is a calcium-bicarbonate type. Total dissolved solids ranged from 274 to 295 mg/L. The quality of water is good for domestic or industrial use. There were no trends in chemical constituents for the last two years. Slight variations in concentrations reflect the intensity of pumpage before the sample was collected.

Fig. C-1. Map showing locations of ponds, energy extraction holes, and observation and supply wells.

STORAGE PONDS

There are two ponds located in the compound west of the supply well. Pond GT-1 has a capacity of about 500,000 gal. and is located north of Pond GT-3 (Fig. C-1). Pond GT-3 has a capacity of about 200,000 gal. The pond designation used in this report is located between GT-1 and GT-3, was small and was filled in to enlarge the area for storage and trailers. A 5,000,000-gal. lined pond outside the compound is not considered, as leakage from it would be minor if it occurred at all.

Pond GT-1 is used for holding water for drilling and for the experimental test circulation in the pairs of geothermal test holes. Drilling cuttings discharged into the pond are removed at the end of the drilling phase of work. Ten samples were collected from this pond during 1985 and 1986. Predominant ions in the pond are sodium and chloride (Table C-I). Sodium concentrations ranged from 410 to 2,360 mg/L over the 2-year period, while chloride concentrations ranged from 360 to 3,135 mg/L. The chemical concentrations varied during the 2-year period, showing a general increase in concentration. TDS concentrations also varied and indicated an increase from 2,109 to 6,764 mg/L (Table C-I).

The dam that holds water in Pond GT-3 was repaired in late 1984, and the pond held little water until late 1985. Two samples collected in 1986 indicated that the water was a sodium-chloride type. The sodium and chloride concentrations generally increased during the 7 months between samples (Table C-I). Sodium concentration increased from 245 mg/L to 350 mg/L, while chloride concentrations increased from 253 mg/L to 331 mg/L. The TDS increased during the period April to June from 908 mg/L to 1196 mg/L.

The chemical quality of surface water (LF-1, -2, -3, and -4) and groundwater (Locations 31 and 39) in Lake Fork Canyon did not reflect any deterioration of water quality as the result of water held in or released from Ponds GT-1 or GT-3 during 1985 and 1986.

Table C-1. Chemical Quality of Water from Supply Well and Storage Ponds at Fenton Hill

	Date	mg/l									
		SiO ₂	Ca	Mg	Na	CO ₃	HCO ₃	SO ₄	Cl	F	NO ₃
Supply Well FH-1	3-25-85	71	42	4	13	0	140	6	13	0.1	0.9
	1-21-86	71	32	4	11	0	135	7	10	<0.1	<0.1
	7-14-86	73	35	6	12	0	150	6	10	<0.1	0.8
	11-10-86	71	40	4	14	0	153	6	13	<0.1	0.7
GT-1 Pond	3-22-85	78	55	1	596	75	278	203	729	1.7	<0.5
	5-8-85	--	35	4	410	--	--	--	360	--	<0.5
	5-14-85	--	56	7	1060	--	--	--	1200	--	<0.1
	5-17-85	--	59	17	1330	--	853	368	1592	6.4	<0.1
	7-23-85	167	61	6	1120	0	902	271	1576	8.4	<0.1
	11-23-85	184	148	10	1390	0	632	235	2206	8.2	2.8
	12-20-85	75	29	2	1420	0	437	103	2110	2.8	0.5
	4-7-86	210	71	6	2360	0	976	120	3270	6.1	<0.5
	11-10-86	157	49	4	2034	72	178	154	2915	7.4	<0.2
	12-22-86	306	58	5	2060	0	666	152	3135	6.9	<0.5
GT-3	4-24-86	26	30	3	245	48	153	107	253	1.6	1.5
	6-23-86	65	28	4	350	102	87	118	331	5.0	0.3

Table C-I. (cont)

	Date	mg/l							Spec Cond	pH
		As	B	Bd	Cd	Hg	Li	TDS	µmho	
Supply Well FH-1	3-25-85	<0.1	0.17	0.07	<0.001	<0.9	<0.01	295	290	7.9
	1-21-86	<0.1	0.08	<0.01	<0.001	<0.1	<0.01	274	275	7.9
	7-14-86	<0.1	0.02	0.07	<0.001	<0.1	<0.01	279	265	7.2
	11-10-86	<0.1	<0.01	0.08	<0.001	<0.1	<0.01	280	287	7.7
GT-1 Pond	3-22-85	0.8	16	0.18	<0.001	<0.1	8.5	2109	3280	9.0
	5-8-85	0.3	12	--	--	--	4.4	--	--	--
	5-14-85	1.6	41	--	--	--	16	--	--	--
	5-17-85	2.4	55	--	--	--	21	--	6690	7.3
	7-23-85	7.5	107	2.0	<0.001	<0.1	20	4371	6840	7.9
	11-23-85	4.3	91	0.82	<0.001	<0.1	25	5131	7070	7.6
	12-20-85	3.4	45	0.18	<0.001	<0.2	32	4418	7510	8.0
	4-7-86	5.7	88	0.64	<0.001	0.1	41	7618	11830	7.6
	11-10-86	7.1	85	0.40	<0.001	<0.1	40	6181	11400	7.8
	12-22-86	4.9	92	0.37	<0.001	<0.1	41	6764	11700	7.3
GT-3	4-24-86	0.2	16	0.24	0.002	<0.1	2.4	908	1432	8.3
	6-23-86	0.4	15	0.13	0.002	<0.1	4.5	1196	2500	8.5

APPENDIX D
Chemical Analysis of Vegetation and Soil in Effluent Release Area, Fenton Hill

FENTON HILL - ARSENIC (ppm)

<u>Sample Location</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>
Foliage (bank)					
325 ft	0.13	<0.04	<0.08	0.11	0.02
650 ft	0.14	<0.04	<0.04	0.08	0.03
1300 ft	0.06	<0.02	<0.06	0.35	0.08
3250 ft	<0.05	<0.03	<0.03	<0.06	0.10
Foliage (channel)					
325 ft	0.22	0.44	<0.06	<0.11	0.23
650 ft	<0.05	0.21	<0.06	0.09	0.16
1300 ft	0.12	<0.04	<0.05	0.45	0.04
3250 ft	0.34	<0.06	<0.04	0.24	0.08
lower canyon	0.08	<0.04	<0.04	0.30	0.14
Roots (bank)					
325 ft	2.24	0.41	3.75	1.82	
650 ft	0.67	0.12	2.18	1.57	
1300 ft	0.45	0.76	2.87	1.62	
3250 ft	0.78	0.35	5.72	0.88	
Roots (channel)					
325 ft	0.97	8.37	13.3	8.47	
650 ft	5.39	5.86	5.69	6.99	
1300 ft	1.86	2.13	6.47	9.31	
3250 ft	1.60	0.31	1.93	1.53	
lower canyon	0.41	0.27	1.06	0.62	
Soil (bank)					
325 ft		3.10	2.80	3.10	
650 ft		4.20	3.30	3.10	
1300 ft		3.30	4.20	3.90	
3250 ft		4.80	3.60	5.40	
Soil (channel)					
325 ft		8.40	4.90	11.7	
650 ft		3.40	3.70	17.1	
1300 ft		5.70	3.80	12.1	
3250 ft		2.40	2.50	2.90	
lower canyon		3.20	3.40	2.80	

APPENDIX D (cont)

FENTON HILL - BORON (ppm)

<u>Sample Location</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1986</u>
Foliage (bank)						
325 ft	<25	32	15	11	8	8
650 ft	<25	30	14	13	8	9
1300 ft	<25	9	20	32	16	6
3250 ft	<25	9	12	9	15	5
Foliage (channel)						
325 ft	150	173	210	188	108	43
650 ft	286	182	110	434	240	63
1300 ft	350	113	130	110	118	28
3250 ft	26	18	13	12	24	17
lower canyon	<25	10	15	13	7	6
Roots (bank)						
325 ft	14	9	42	29	13	24
650 ft	<5	<5	29	37	14	28
1300 ft	9	13	28	30	13	19
3250 ft	8	<5	35	34	17	25
Roots (channel)						
325 ft	13	56	73	114	27	37
650 ft	21	64	140	139	45	32
1300 ft	28	34	61	130	43	46
3250 ft	20	9	36	30	12	20
lower canyon	<5	<5	21	32	16	15
Soil (bank)						
325 ft		10	16	14		
650 ft		13	16	23		
1300 ft		19	15	17		
3250 ft		23	15	31		
Soil (channel)						
325 ft		31	38	49		
650 ft		42	51	104		
1300 ft		36	17	54		
3250 ft		18	15	18		
lower canyon		20	19	15		

APPENDIX D (cont)

FENTON HILL - CADMIUM (ppb)

<u>Sample Location</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>
Foliage (bank)				
325 ft	<500	270	100	<20
650 ft	<500	190	290	28
1300 ft	<500	140	30	47
3250 ft	<500	270	110	55
Foliage (channel)				
325 ft	<500	170	340	120
650 ft	<500	150	370	53
1300 ft	<500	150	140	83
3250 ft	<500	190	170	
lower canyon	<500	150	210	49
Roots (bank)				
325 ft		180	680	180
650 ft		310	550	100
1300 ft		180	660	170
3250 ft		320	390	
Roots (channel)				
325 ft		40	400	200
650 ft		290	460	530
1300 ft		350	190	260
3250 ft		390	340	330
lower canyon		380	720	320
Soil (bank)				
325 ft		170	130	80
650 ft		170	170	160
1300 ft		110	110	80
3250 ft		290	160	510
Soil (channel)				
325 ft		250	160	210
650 ft		220	170	440
1300 ft		290	150	220
3250 ft		80	130	210
lower canyon		200	140	140

APPENDIX D (cont)

FENTON HILL - FLUORIDE (ppm)

<u>Sample Location</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>
Foliage (bank)							
325 ft	2.40	3.55	6.70	12.0	0.50	7.20	0.85
625 ft	13.0	6.15	1.80	170	1.90	4.10	2.00
1300 ft	0.60	5.45	6.00	10.0	1.00	5.30	3.80
3250 ft	1.20	5.45	3.80	1.80	3.00	5.50	2.80
Foliage (channel)							
325 ft	3.30	---	19.0	70.0	1.20	10.7	6.40
650 ft	1.20	3.45	2.70	84.0	3.30	13.2	7.30
1300 ft	8.80	6.60	11.0	8.40	2.90	2.50	4.00
3250 ft	0.80	2.10	6.00	19.0	1.90	4.90	4.30
lower canyon	0.30	1.70	5.20	28.0	3.40	5.20	1.80
Roots (bank)							
325 ft	66.0		45.0	45.0	8.10	32.9	32.8
650 ft	28.0		28.0	52.0	31.0	23.1	31.5
1300 ft	25.0		59.0	40.0	20.0	24.6	17.5
3250 ft	23.0		46.0	43.0	16.0	40.5	30.7
Roots (channel)							
325 ft	50.0		92.0	78.0	16.0	38.0	49.4
650 ft	34.0		96.0	170	25.0	45.7	51.0
1300 ft	78.0		70.0	61.0	22.0	31.0	39.4
3250 ft	47.0		52.0	37.0	10.0	43.1	12.4
lower canyon	14.0		34.0	77.0	40.0	30.2	37.0
Soil (bank)							
325 ft		69.0	90.0	121	98.0	84.0	79.1
650 ft		80.0	150	151	71.0	114	140
1300 ft		95.0	130	106	100	111	98.9
3250 ft		160	140	130	120	129	161
Soil (channel)							
325 ft		420	350	279	135	153	264
650 ft		140	250	459	115	381	237
1300 ft		180	170	249	81.0	150	150
3250 ft		105	160	129	100	69.0	132
lower canyon		210	180	202	120	232	295

APPENDIX D (cont)

FENTON HILL - LITHIUM (ppm)

<u>Sample Location</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1985</u>
Foliage (bank)							
325 ft	1.93	0.80	44.0	1.22	0.80	0.29	0.75
650 ft	1.93	0.80	3.40	0.86	0.70	0.55	0.60
1300 ft	0.69	3.30	0.38	2.10	1.30	1.30	0.50
3250 ft	1.00	0.80	0.86	0.75	0.60	0.28	0.50
Foliage (channel)							
325 ft	3.50	46.0	29.9	51.7	0.60	17.0	11.6
650 ft	9.10	109	15.9	32.0	10.0	66.0	56.6
1300 ft	12.9	239	53.0	19.2	4.80	28.0	4.80
3250 ft	1.93	2.60	2.50	0.61	1.50	5.10	2.60
lower canyon	1.00	2.60	0.35	4.30	0.60	8.90	1.00
Roots (bank)							
325 ft		6.80	2.00	23.4	0.70	4.40	6.50
650 ft		3.00	1.30	19.1	0.70	13.0	8.20
1300 ft		4.60	1.90	19.9	0.90	5.70	7.20
3250 ft		2.20	1.80	3.70	1.10	6.70	6.00
Roots (channel)							
325 ft		2.10	15.0	43.0	2.90	5.00	11.2
650 ft		4.90	8.70	15.8	2.70	4.00	18.5
1300 ft		12.0	12.0	6.00	2.20	10.0	10.0
3250 ft		5.20	2.20	4.50	0.90	2.10	5.10
lower canyon		3.90	4.00	3.60	1.50	15.0	4.60
Soil (bank)							
325 ft			35.1	29.7	10.0	15.0	
650 ft			32.1	30.3	28.0	30.0	
1300 ft			29.2	29.3	22.0	18.0	
3250 ft			33.1	25.9	27.0	26.0	
Soil (channel)							
325 ft			57.7	44.5	37.0	28.0	
650 ft			35.9	35.3	39.0	38.0	
1300 ft			38.9	31.6	39.0	43.0	
3250 ft			29.2	30.6	21.0	30.0	
lower canyon			39.9	39.7	33.0	51.0	