DATA ON WATER RESOURCES

OF THE

HUNTER MOUNTAIN AREA

DEATH VALLEY NATIONAL MONUMENT

CALIFORNIA

OPEN-FILE REPORT

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division
Menlo Park, California, 1970
PREPARED IN COOPERATION WITH THE
NATIONAL PARK SERVICE

UNITED STATES
DEPARTMENT OF THE INTERIOR
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By

G. A. Miller

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CONTENTS

ILLUSTRATIONS

TABLES

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By G. A. Miller

ABSTRACT

Data collected on 48 spring areas during 1968-69 indicate that a moderate supply of good quality water is available in this part of Death Valley National Monument. The flow from springs ranged from extremes of less than 0.01 gallon to more than 70 gallons per minute. Flow from most springs ranges from a fraction of a gallon per minute to a few gallons per minute. The average dissolved solids in the discharge water was about 325 milligrams per liter.

Most of the springs issue from fractured and weathered quartz monzonite. The few large springs are at bedrock constrictions in alluvial channels.

INTRODUCTION

At the request of the National Park Service, the U.S. Geological Survey conducted a reconnaissance investigation of the water resources of the Hunter Mountain area of Death Valley National Monument, Calif. (fig. 1). The purpose of the study was to verify the locations of and obtain discharge data for several springs in the Hunter Mountain area. The scope of the investigation included a canvass of springs, reconnaissance geologic mapping, periodic hydrologic observations and flow measurements at selected springs, and preparation of a brief report of the findings. The fieldwork was completed during the period March 1968-April 1969. Periodic measurements at a few selected springs will be made in the future, and the data will be made available by the Geological Survey. Forty-eight spring areas were canvassed.

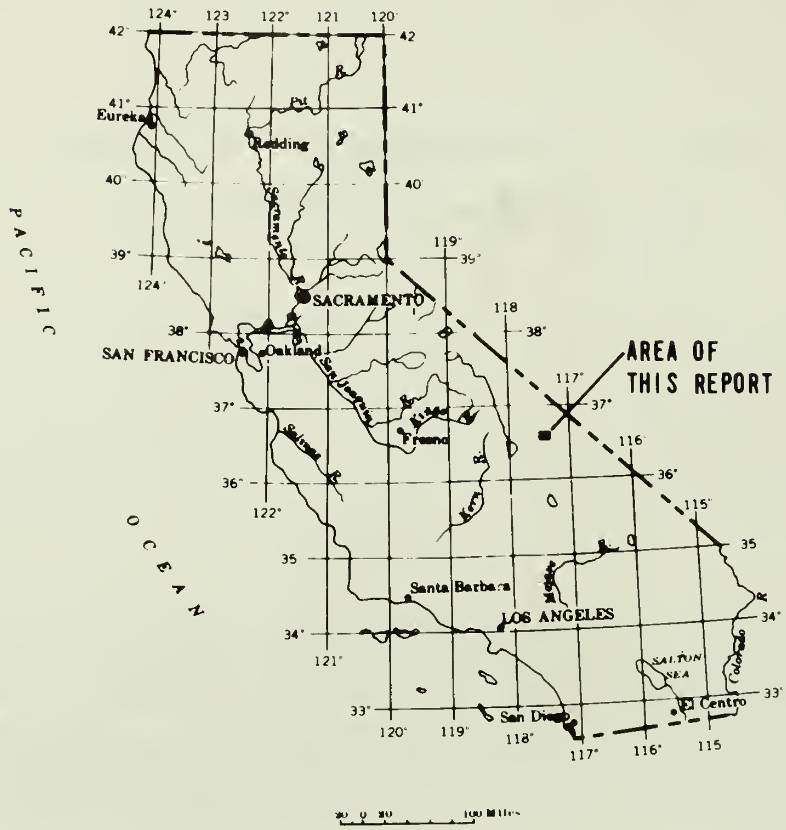


FIGURE 1.--Index map.

The major part of the fieldwork consisted of a canvass of selected springs. Most of the canvass was completed during two pack trips that totaled 10 days in the field, one in March and one in April 1968. The remaining part of the canvass was done in April 1968 by 4-wheel-drive vehicle and by shanks' mare. The rugged country and limited field time precluded an examination of all springs. However, most of the springs were visited and measurements of discharge, water temperature, and specific conductance were made. At three springs these parameters were measured several times during the period of investigation. These springs were selected because they probably are representative of most springs in the area and because of ready access. Water from two springs was analyzed for chemical constituents. Temperature and electrical conductance of water from a total of 28 springs were measured. Streamflow was measured at one location where the flow of the stream was fed by several springs. Discharge of the small springs was measured by volumetric methods. A 3-inch Parshall flume was used to measure the discharge from large springs. These data are summarized in table 1, and locations are reflected in figure 2.

TABLE 1.--*Data on water resources*

Location and/or name: General area and drainage system; local name.

Latitude longitude: To nearest second; one second of latitude equals approximately 100 feet; one second of longitude equals approximately 82 feet; most stations are ±1 second.

State location number: The number given is the U.S. Geological Survey number assigned to the spring or site on a stream according to the method described in text.

Altitude (feet): All altitudes are interpolated from the topographic map and are to the nearest 10 feet.

Date of observation: Where more than one date is shown, the dates are in chronological order.

Discharge (gpm): Measured by volumetric methods or by Parshall flume; estimated where measurement not practicable.

Temperature: Water temperature as measured in the field; temperature in small seeps and springs may not reflect local ground-water temperatures.

Chemical quality: General quality as reflected in electrical conductance; computed dissolved-solids concentration rounded to nearest 10 milligrams per liter. Two complete analyses provide control (see table 3).

Remarks: Additional information about the spring, stream, measurement, or other factors.

Location and/or name	Latitude longitude	State location number	Altitude (feet)	Date of observation	Discharge (gpm)	Temperature °F	Temperature °C	Chemical quality: Specific conductance[1] (micromhos)	Chemical quality: Dissolved solids[2] (mg/l)	Remarks
Marble Canyon	36°35'53" 117°26'01"	15S/42E-28PS1	4,600	3- 6-68	dry	-	-	-	-	Spring shown on topographic map; dense vegetation, no flow or moist ground.
Marble Canyon headwaters	36°35'29" 117°27'47"	15S/42E-31GS1	5,640	4-25-68	0.43	57	14	310	200	Measured at old tank inlet.
				7- 9-68	.39	59	15	360	230	Measured at old tank inlet.
				7- 9-68	.37	64	18	380	240	Measured at new tank, uphill from old tank.
				10-12-68	.45	54	12	350	220	
				4-17-69	.85	52	11	570	360	
Shorty Harris Canyon	36°25'21" 117°27'35"	15S/42E-31JS1	5,720	4-26-68	dry	-	-	-	-	Reported spring area; four areas of dense vegetation, no moist ground or flow.
Marble Canyon	36°35'47" 117°26'40"	15S/42E-32BS1	5,020	4-25-68	a.1	55	13	480	310	
Goldbelt Spring, east spring	36°35'50" 117°26'51"	15S/42E-32CS1	5,020	4-25-68	a.1	-	-	-	-	No visible outflow; depth to water in spring box is 2.15 feet below cribbed cover; water 2.5 feet deep in box.
				4-17-69	1.8	56	13	950	610	Spring box full.

Location and/or name	Latitude longitude	State location number	Altitude (feet)	Date of observation	Discharge (gpm)	Temperature		Chemical quality		Remarks
						°F	°C	Specific conductance[1] (micromhos)	Dissolved solids[2] (mg/l)	
Goldbelt spring, west spring	36°35'51" 117°26'55"	15S/42E-32CS2	5,040	4-25-68	0.10	55	13	400	260	Measured at inlet to tank.
				7- 9-68	.08	77	25	400	260	
				10-12-68	.06	60	16	420	270	
				4-17-69	.14	62	17	620	400	
Marble Canyon tributary	36°35'08" 117°24'43"	15S/42E-34PS1	4,050	3- 6-68	seep	-	-	-	-	Disappears into sandy alluvium.
Marble Canyon tributary	36°35'10" 117°24'17"	15S/42E-34RS1	3,920	3- 6-68	11	54	12	500	320	Bedrock narrows above waterfall, maximum flow in stream here.
Marble Canyon	36°35'14" 117°24'00"	15S/42E-35MS1	3,760	3- 6-68	a.5	52	11	590	380	At bedrock narrows.
Marble Canyon tributary at mouth	36°35'11" 117°24'05"	15S/42E-35NS1	3,740	3- 6-68	13	55	13	690	440	
Hunter Mountain	36°33'21" 117°28'37"	16S/41E-12JS1	6,670	4-25-68	.23	48	9	420	270	
	36°33'21" 117°28'37"	12JS2	6,670	4-25-68	.11	46	8	470	300	
	36°33'21" 117°28'37"	12JS3	6,670	4-25-68	.24	50	10	460	290	
	36°33'21" 117°28'37"	12JS4	6,670	4-25-68	.42	51	11	460	290	
	36°33'21" 117°28'37"	12JS5	6,670	4-25-68	.21	54	12	460	290	
Hunter Mountain	36°32'52" 117°29'15"	16S/41E-13CS1	6,820	3- 5-68	.83	43	6	510	330	Measured at pond, open tank.
				3- 7-68	.64	-	-	-	-	
				4-23-68	2.2	44	7	440	280	
				4-26-68	1.8	-	-	-	-	
				7- 8-68	1.1	50	10	440	280	
				7- 9-68	1.1	-	-	-	-	
				10-12-68	.17	47	8	420	270	
				10-13-68	.17	-	-	-	-	
				11-12-68	.13	-	-	-	-	
				12- 6-68	.10	41	5	480	310	
				4-17-69	.57	43	6	400	260	
Hunter Mountain, northern spring at cabin	36°32'54" 117°29'16"	16S/41E-13CS2	6,850	3- 5-68	a.1	45	7	300	190	Part of domestic supply.
				10-12-68	.01	48	9	300	190	

Location and/or name	Latitude longitude	State location number	Altitude (feet)	Date of observation	Discharge (gpm)	Temperature °F	Temperature °C	Chemical quality: Specific conductance[1] (micromhos)	Chemical quality: Dissolved solids[2] (mg/l)	Remarks
Hunter Mountain, southern spring at cabin	36°32'54" 117°29'16"	16S/41E-13CS3	6,850	3- 5-68 4-26-68 10-12-68	a.1 .09 .05	47 - 48	8 - 9	310 - 310	200 - 200	Part of domestic supply, pipeline to cabin broken.
Hunter Mountain	36°32'47" 117°29'21"	16S/41E-13ES1	6,870	3- 5-68	a.1	47	8	290	190	Small pool, no visible surface outflow.
Hunter Mountain	36°32'47" 117°22'22"	16S/41E-13ES2	6,940	3- 5-68	dry	-	-	-	-	
Dead Horse Canyon	36°34'29" 117°22'29"	16S/42E-1KS1	3,350	3- 6-68	11	57	14	615	390	
Dead Horse Canyon	36°34'26" 117°22'37"	16S/42E-1LS1	3,510	3- 6-68	a10	-	-	-	-	Flow disappears into alluvium about 50 yards downstream.
Dead Horse Canyon	36°34'39" 117°23'28"	16S/42E-2GS1	3,720	3- 6-68	4.5	57	14	490	310	
Dead Horse Canyon tributary	36°34'17" 117°23'35"	16S/42E-2QS1	4,000	3- 6-68	a2	-	-	-	-	Waterfall at bedrock narrows, difficult access.
Dead Horse Canyon tributary	36°34'20" 117°23'30"	16S/42E-2QS2	3,860	3- 6-68	3.8	50	10	390	250	
Dead Horse Canyon	36°34'37" 117°24'10"	16S/42E-3HS1	4,060	3- 6-68	a2	-	-	-	-	Sandy spring area.
Dead Horse Canyon	36°34'10" 117°25'03"	16S/42E-3NS1	5,000	3- 7-68	dry	-	-	-	-	Spring shown on topographic map.
Dead Horse Canyon	36°34'08" 117°24'55"	16S/42E-3PS1	4,920	3- 7-68	a1	-	-	-	-	Flow begins about 500 feet downstream from 3NS1.
Hunter Mountain, Marble Canyon headwaters	36°34'35" 117°28'12"	16S/42E-6FS1	6,400	4-26-68	a.01	65	18	550	350	
Hunter Mountain, Marble Canyon headwaters	36°34'22" 117°28'16"	16S/42E-6MS1	6,420	4-26-68	a2	47	8	750	480	

Location and/or name	Latitude longitude	State location number	Altitude (feet)	Date of observation	Discharge (gpm)	Temperature °F	Temperature °C	Chemical quality: Specific conductance[1] (micromhos)	Chemical quality: Dissolved solids[2] (mg/1)	Remarks
Hunter Mountain, Cottonwood Canyon headwaters	36°34'12" 117°27'24"	16S/42E-6RS1	6,440	4-25-68	dry	-	-	-	-	Spring shown on topographic map is dry; discolored ground marks site; no unusual vegetation or other evidence of near-surface ground water.
Hunter Mountain, Cottonwood Canyon headwaters	36°33'43" 117°27'28"	16S/42E-7HS1	6,430	44-25-68	1.2	62	17	450	290	
Dead Horse Canyon headwaters	36°34'02" 117°25'47"	16S/42E-9CS1	5,390	3- 7-68	dry	-	-	-	-	Spring shown on topographic map is dry.
Dead Horse Canyon headwaters	36°34'05" 117°25'46"	16S/42E-9CS2	5,350	3- 7-68 4-25-68	.34 .36	49 54	9 12	710 700	450 450	
Cottonwood Canyon headwaters	36°33'50" 117°24'41"	16S/42E-10GS1	4,970	3- 7-68 4-24-68 4-25-68	.33 1.3 1.3	53 - 55	12 - 13	295 - 450	190 - 290	
Cottonwood Canyon drainage	36°33'51" 117°23'04"	16S/42E-11HS1	4,200	4-24-68	a.01	-	-	-	-	Small pool in sandy wash.
Cottonwood Canyon drainage	36°33'51" 117°22'50"	16S/42E-12ES1	4,180	4-24-68	a.01	49	9	500	320	
Cottonwood Canyon drainage	36°33'49" 117°22'50"	16S/42E-12ES2	4,180	4-24-68	dry	-	-	-	-	Spring shown on topographic map.
Cottonwood Canyon drainage	36°32'44" 117°24'15"	16S/42E-15JS1	4,540	4-24-68	.51	59	15	450	290	Measured by National Park Service.
Cottonwood Canyon drainage	36°32'33" 117°25'43"	16S/42E-16Q	4,660	4-23-68	31	54	12	520	330	Streamflow measured at narrows.
Hunter Mountain, Cottonwood Canyon headwaters	36°32'55" 117°27'48"	16S/42E-18GS1	6,520	4-23-68	.17	37	3	370	240	

Location and/or name	Latitude longitude	State location number	Altitude (feet)	Date of observation	Discharge (gpm)	Temperature °F	Temperature °C	Chemical quality: Specific conductance[1] (micromhos)	Chemical quality: Dissolved solids[2] (mg/1)	Remarks
Hunter Mountain, Cottonwood Canyon headwaters	36°32'56" 117°27'41"	16S/42E-18GS2	6,450	4-23-68	dry	-	-	-	-	
Cottonwood Canyon headwaters	36°32'41" 117°27'02"	16S/42E-18RS1	5,760	4-23-68	3.1	50	10	b712	b459	
Hunter Mountain, Cottonwood Canyon headwaters	36°31'57" 117°27'29"	16S/42E-19HS1	6,680	4-23-68	.03	35	2	490	310	
Cottonwood Canyon drainage	36°32'09" 117°24'10"	16S/42E-22AS1	4,380	4-24-68	.07	55	13	500	320	
Cottonwood Springs area, total outflow	36°30'42" 117°22'21"	16S/42E-25KS1	3,540	4-24-68	73	51	11	520	330	Bedrock narrows below spring area, flow disappears into alluvium about 100 yards downstream.
Cottonwood Springs	36°30'46" 117°22'38"	16S/42E-25LS1	3,630	4-24-68	a1	-	-	-	-	Upstream end of spring area.
Cottonwood Canyon	36°31'57" 117°20'41"	16S/43E-20FS1	2,980	4-28-68	4.6	-	-	b652	b409	
Cottonwood Canyon	36°31'56" 117°20'43"	16S/43E-20FS2	3,010	4-28-68	1.3	-	-	-	-	
Cottonwood Canyon	36°31'31" 117°20'50"	16S/43E-20NS1	3,150	4-24-68	dry	-	-	-	-	

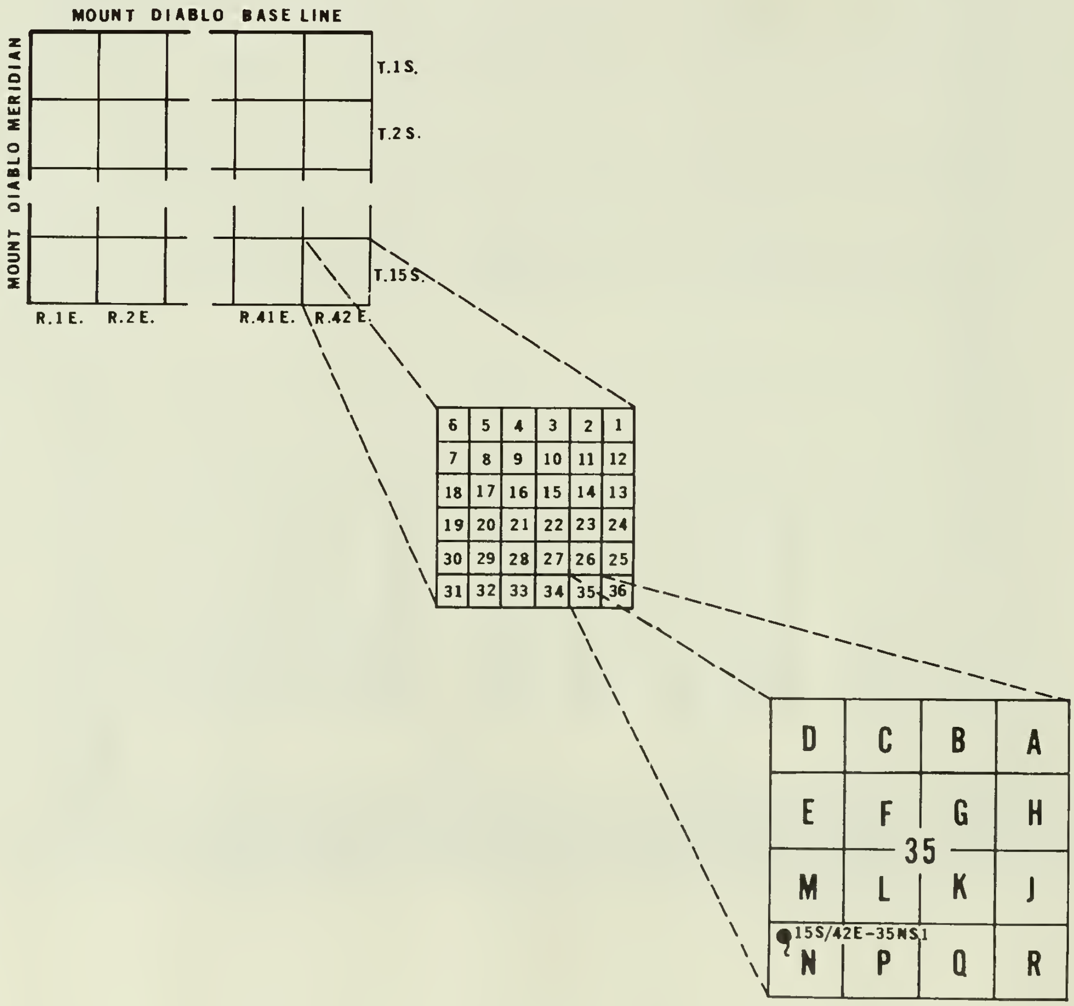
[1]Conductance measured in field, converted to equivalent at 25°C.
[2]Except as noted, dissolved solids computed from conductance, conversion factor = 0.64.

a. Discharge estimated.
b. Conductance and dissolved solids by laboratory analysis.

The pack trips were carried out under the supervision of the Water Resources Section of the Office of Land Acquisition and Water Resources at the Western Service Center of the National Park Service. The author gratefully acknowledges the assistance and cooperation of Chief Ranger Leach and District Ranger Carney of Death Valley National Monument, both of whom contributed materially to the successful completion of the fieldwork.

Springs in the State of California are assigned numbers according to their location in the rectangular system for the subdivision of public land. For example, as shown in the accompanying diagram, in the State location number 15S/42E-35NS1 the part of the number preceding the slash indicates the township (T. 15 S.), the part between the slash and the hyphen indicates the range (R. 42 E.), the number between the hyphen and the letter indicates the section (sec. 35), the first letter after the hyphen indicates the 40-acre subdivision of the section. The S after the hyphen indicates that the location number is for a spring.

Within the 40-acre tract springs are numbered serially, as indicated by the final digit. Thus, spring 15S/42E-35NS1 is the first spring to be listed in the SW¼SW¼ sec. 35, T. 15 S., R. 42 E., Mount Diablo base line and meridian.



In addition to the State location number, which is useful insofar as location in a land-net grid, the Geological Survey assigns a spring location number based on latitude and longitude. This number, in most instances, reflects the location of the spring to the nearest one second of latitude and longitude, or within an area of about 1/5 acre.

The system described above can be used to locate other features or sites. The location of a measuring point on a stream in table 1 is shown by dropping the "S" and the serial number.

Mr. R. W. Hunter of Olancha, Calif., has numbered most of the springs discussed in this report. Table 2 is a cross-index of Hunter numbers and State location numbers, used by the U.S. Geological Survey, as furnished by G. S. Witucki, Chief, Water Resources Section, Western Service Center, National Park Service, San Francisco, Calif.

TABLE 2.--*Cross index of spring numbers*

State location number	Hunter number	Remarks
16S/41E-13CS2,3	1	Two small springs at Hunter's cabin.
16S/41E-13CS1	2	Spring at round galvanized tank in wash.
16S/41E-12JS1-5	3	Five outlets at one spring area.
16S/42E-6FS1	4	
15S/42E-31GS1	5	Spring alongside road.
15S/42E-31JS1	6	Dry.
15S/42E-32CS2	7	Goldbelt, westernmost of two springs.
15S/42E-32BS1	8	Spring with concrete tank below Goldbelt.
16S/42E-7HS1	9	Spring in tules at head of steep canyon.
16S/42E-18GS1	10	Western of two springs.
16S/42E-19HS1	11	Old leaky tank in tules.
16S/42E-17LS1	12	Did not visit--noted spring in steep canyon (17LS1) at approximate location of Hunter no. 12.
	13	Did not locate spring reported to be here.
	14	Did not locate spring reported to be here.
16S/42E-9CS2	15	CS1 dry; CS2 flowing.
16S/42E-3PS1	16	Dry spring area; 3NS1 a short distance away.
16S/42E-10GS1	17	Head of alluvial valley in Cottonwood canyon.
16S/42E-3HS1	18	In Dead Horse Canyon.
15S/42E-34PS1	19	Larger flows downstream.
16S/42E-2QS1	20	2QS1 just upstream.
16S/42E-1KS1	21	At bedrock falls, 1LS1 just upstream.
16S/42E-12ES1	22	12ES2 dry; 11HS1 in same area.
	23	Did not locate spring reported to be here.
16S/42E-22AS1	24	
16S/42E-25KS1	25	25LS1 just upstream.
16S/43E-20NS1	26	Dry.

GENERAL GEOLOGY

Hunter Mountain is an area of rugged terrain and high relief. Much of the landscape is carved out of an intrusive body of massive quartz monzonite, a rock similar in composition to granite. This material is shown as granitic rocks in figure 2. The intrusive body probably is Mesozoic in age (McAllister, 1956; Hall and Stephens, 1962). The northern boundary of the intrusive here is in contact with folded and faulted sedimentary rocks, chiefly carbonates, of Paleozoic age (fig. 2). The aggregate thickness of these sedimentary rocks is several thousand feet. A thin cover of sandy alluvium, derived locally from the quartz monzonite, mantles some of the areas of gentle relief atop Hunter Mountain. Coarser alluvium, locally made up mostly of large boulders, gravel, and sand, occurs in narrow, discontinuous strips along the floors of many of the canyons.

GROUND WATER AND THE OCCURRENCE OF SPRINGS

Most of the springs in the Hunter Mountain area are on north- and east-facing slopes, which correspond to the general northeast slope of the area (fig. 2). There are no springs in the few large areas of south-facing slopes, except in the highlands along the southeast side of Hunter Mountain. This tendency for springs to occur on more north-facing slopes probably reflects the environment of generally cooler temperatures and reduced evapotranspiration that prevails on such slopes.

The hydrologic system associated with springs is made up of three components: (1) a catchment or recharge area, (2) a transit storage component or aquifer system, and (3) a discharge system. The carrying capacity of an aquifer system is the product of permeability, area of saturated cross section, and hydraulic gradient. A decrease in any of the three parameters will reduce the carrying capacity, and spring flow may occur. Most of the springs in the Hunter Mountain area are related to a decrease in cross-sectional area of the aquifer.

In contrast to many desert areas in southern California, no spring or group of springs in the Hunter Mountain area appears to be controlled by major faulting. Most of the small springs seem to be related to local areas where a suitable combination of catchment basin and transit storage exists.

The fresh, unfractured quartz monzonite is almost impermeable. Most springs in the area issue from near-surface fractured and weathered zones in the quartz monzonite. The permeability of the fractured and weathered material generally is low, and the discharge from these springs is small, typically between 0.1 and 1 gpm (gallon per minute). This low permeability and the low discharge contribute to the permanence of many of the springs, because a high rate of discharge would rapidly deplete the local supply of ground water in storage.

Many of the springs that flow from fractured and weathered quartz monzonite are marked by an irregular, halo-like area of generally light-colored rock, which is the result of chemical alteration of the quartz monzonite by ground water. Some spring areas are marked by light-colored, low-density puffy ground, which is related to the evaporation of ground water in the capillary zone at or near the surface. Some water occurs in deep fractures and faults in the monzonite; these deeper zones probably are part of the aquifer system of some of the springs on the steep eastern face of Hunter Mountain. The fractures convey to the springs recharge water that originates as rain and snow on the higher part of the area.

The sedimentary rocks north of the quartz monzonite body (fig. 2) consist chiefly of limestone and dolomite, with some quartzite and shale. The fresh, unfractured sedimentary rocks, like the fresh quartz monzonite, are almost impermeable. However, fractured zones, especially fractures in the carbonate rocks that are subject to enlargement by the solution activity of ground water, are highly permeable. Apparently the permeability of this mass of sedimentary rocks as a whole is so great that no springs issue from its fractures in this area. Evidently almost all of the water that enters these rocks, most of it from the upstream area of quartz monzonite, percolates to depths of several hundred feet to a regional ground-water body that eventually discharges in Death Valley, several miles east of the area.

The sandy alluvium that mantles areas of low relief on the higher part of of Hunter Mountain is, at most, a few tens of feet thick and is of low permeability; however, it functions as a catchment for recharge, especially from snow melt, and transmits the recharge both directly to local springs and to deeply fractured zones in the quartz monzonite.

FIGURE 2.--Generalized geology and location of selected springs and streams.

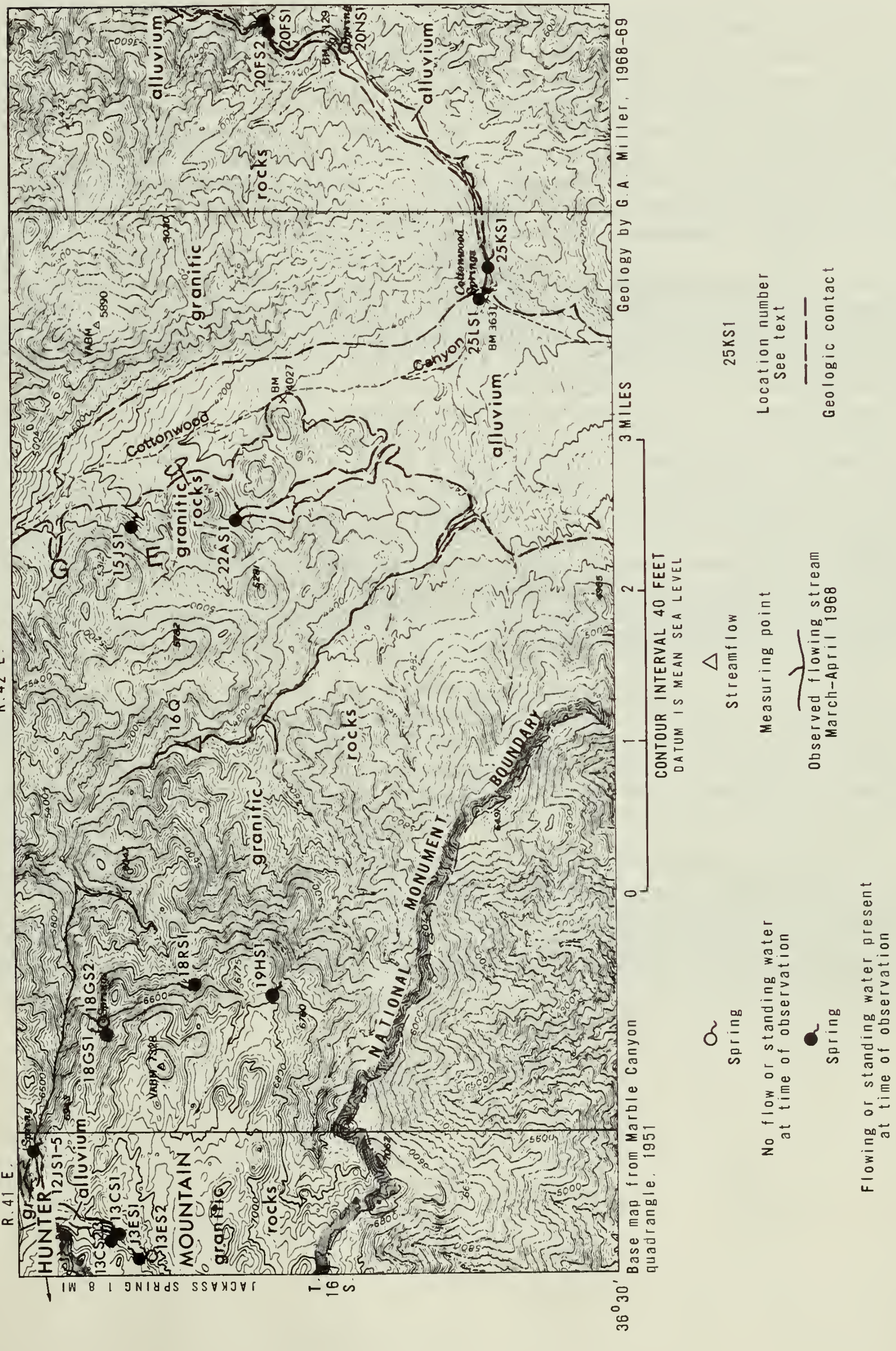


FIGURE 2.--Continued.

The alluvium in most of the canyon floors is highly permeable, but in most canyons it is neither continuous nor more than about 20-30 feet thick. Where this material thins because of shallow bedrock or because of local erosion features caused by flash floods, springs and reaches of surface flow are common. Some of the major constrictions in channels associated with shallow bedrock, such as Cottonwood Springs, tend to be sites of fairly permanent springs. The large area of alluvium above Cottonwood Springs is a group of coalescing alluvial-fan deposits that collect, store, and transmit most of the water that appears at the springs. Here the alluvium locally probably attains a maximum thickness of about 100 feet.

Many of the springs on the canyon floors discharge water that quickly disappears into the alluvium and reappears at some point downstream. The springs in Dead Horse Canyon and in Cottonwood Canyon are of this nature. The ground-water system here gains water from tributary canyons and loses water by evapotranspiration, and, to some degree, by percolation into underlying fractured bedrock. Thus, some of the measurements in table 1 represent water at various points in transit in the same hydraulic system. In Dead Horse Canyon and in a tributary to Marble Canyon in secs. 34 and 35, T. 15 S., R. 42 E., the ground-water system shows a net gain in flow in a downstream direction, from a few gallons per minute in the upper reaches to more than 10 gallons per minute at the lowermost spring in each canyon. In contrast, the flow in Cottonwood Canyon is reduced more than 90 percent in the reach between the bedrock narrows below Cottonwood Springs (25KS1) and a spring (20FS1) about 2 miles downstream. Most of this loss is probably due to deep percolation to underlying bedrock.

The location and quantity of discharge at many of the springs in the canyon floors are subject to significant changes by the scour-and-fill action of flash floods. If the alluvium thins or is removed by a flood, the point of ground-water discharge tends to be displaced upstream, but if the cover of alluvium is increased, the point of discharge is displaced downstream. This process is shown diagrammatically in figure 3.

The geology, drainage system, and topography of the Hunter Mountain area indicate that water discharged from springs here is derived from local precipitation. The fluctuation in discharge of some of the smaller springs is greatly influenced by evapotranspiration, probably in some instances more so than by fluctuations in seasonal precipitation. The fluctuations in discharge for the three springs with periodic measurements shown in table 1 are caused by a combination of these two factors.

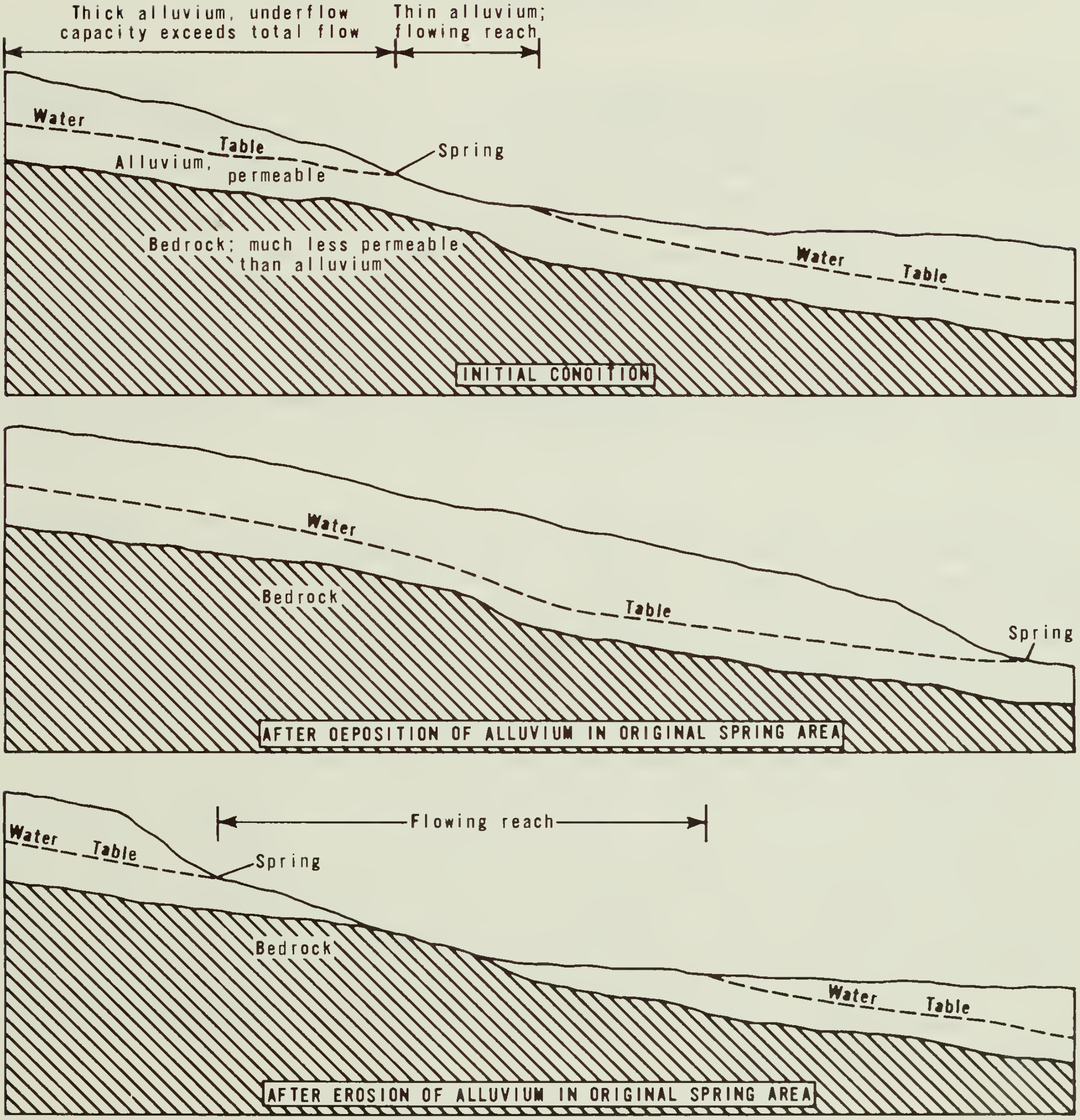


FIGURE 3.--Diagrammatic section along canyon floor showing changes in location of a spring.

CHEMICAL QUALITY

The chemical quality of the water in all of the springs examined ranges from good to excellent. Water from two springs, one on Hunter Mountain in the Cottonwood Canyon headwaters area, and one in Cottonwood Canyon at the lowest elevation of all springs canvassed, was analyzed for chemical constituents. These analyses provided a basis for evaluating the individual dissolved constituents in water in the area. They also provide, along with analyses of water from similar geologic terranes nearby, a fairly reliable estimate of the average relation between dissolved solids and electrical conductance for water in the area. This relation, in which the approximate concentration of total solids in milligrams per liter is equal to 0.64 times the specific conductance in micromhos per cubic centimeter at 25 degrees Celsius (centigrade), was utilized to compute dissolved solids from the conductance obtained in the field.

The dissolved solids in all but one of the measured samples ranged from 190 to 480 mg/l (milligrams per liter). Total dissolved solids in the one exception was about 610 mg/l. The mean value of total solids for all samples is about 325 mg/l and the median value is about 320 mg/l. The two complete analyses (table 3) probably are representative of the relative abundance of individual ions in spring water in the area. The analyses show that, for most uses, no single constituent is present in an objectionable concentration.

The chemical quality of water in several of the springs probably is adversely affected to some extent by urine and fecal matter from the many wild burros in the area. Most certainly the biological quality is worsened by contamination from this source. The animals tend to congregate in shady areas at watering places, which results in large accumulations of animal waste in the spring discharge area. During the canvass, while on a pack trip to the Cottonwood Springs area, the water in the reach from the spring to the lowermost intermittent flow in the canyon, about 1 mile downstream, was of such color and odor that the field party considered it to be too contaminated for human consumption. This reach includes the largest flow measured in the entire Hunter Mountain area.

TABLE 3.--*Chemical analyses of water*

Spring number Latitude-longitude	16S/42E-18RS1 36°32'41"-117°27'02"	16S/43E-20FS1 36°31'57"-117°20'41"
Constituents, in milligrams per liter		
Silica	45	46
Iron	<.03	<.03
Calcium	86	61
Magnesium	22	23
Sodium	49	52
Potassium	1.2	2.7
Bicarbonate	462	352
Carbonate	0	0
Sulfate	8.0	16
Chloride	18	34
Fluoride	.8	.6
Nitrate	0	0
Boron	.23	.41
Sum of determined constituents	459	409
Hardness as $CaCO_3$	306	247
Noncarbonate hardness as $CaCO_3$	0	0
Percent sodium	26	31
Specific conductance (micromhos at 25°C)	712	652
pH	8.2	8.2
Temperature (°F/°C)	50/10	
Discharge (gallons per minute)	3.14	4.64
Date collected	4-23-68	4-28-68
U.S. Geological Survey laboratory number	57029	57025

DESCRIPTION OF SPRINGS

The following descriptions are limited to a brief statement of the geologic and hydrologic setting, and in some instances of the physical conditions at the spring. Conditions observed are as of the date or dates listed in table 1.

15S/42E-28PS1.--Dry March 6, 1968, with no evidence of recent flow. A concentration of vegetation growing in alluvium at the site above a bedrock narrows in Marble Canyon suggests that flow occurs only during wet periods.

15S/42E-31GS1.--Water issues from highly weathered and fractured quartz monzonite on a north-facing slope near the head of Marble Canyon drainage. The water is piped downhill to two open storage tanks.

15S/42E-31JS1.--This spring area, dry April 26, 1968, reportedly flows during wet periods. There are four small areas of dense vegetation, all growing on a shallow accumulation of alluvium that overlies highly weathered and fractured quartz monzonite.

15S/42E-32BS1.--Water at this spring issues from highly weathered and fractured quartz monzonite, near the contact zone with sedimentary rocks. The spring area is on a steep slope above the floor of Marble Canyon. Part of the small outflow is piped to an open concrete tank on the south bank of the canyon floor. Dense clumps of vegetation occur at the spring and in several nearby areas.

15S/42E-32CS1. Goldbelt Spring (east spring).--This spring is in a shallow wash where a thin cover of alluvium overlies highly weathered quartz monzonite. The alluvium is derived from the weathered bedrock and resembles the bedrock in texture. A dense growth of vegetation marks the site. The spring orifice is contained in a buried wooden spring box. There was no visible outflow from the standing water in the spring box April 25, 1968. On April 17, 1969, after several inches of seasonal precipitation, the spring box was overflowing.

15S/42E-32CS2. Goldbelt Spring (west spring).--This spring issues from highly weathered quartz monzonite in a small draw that is floored by a thin cover of sandy, poorly sorted alluvium. A trench about 10 feet wide and 3 feet high leads to a tunnel beneath the dry wash. A buried pipeline leads northeast for a few hundred feet to a metal storage tank.

15S/42E-34PS1.--This small seep issues from the alluvial fill that overlies quartz monzonite in a steep-walled canyon. There are abundant phreatophytes in the reach above and below the spring. A small pool at the seep had no apparent surface outflow; however, the alluvial fill appears to be permeable, and a flow of several gallons per minute probably moves through it as underflow.

15S/42E-34RS1.--This spring occurs where the thin alluvium in a steep canyon floor pinches out above and its flow forms a waterfall over quartz monzonite bedrock. A dense growth of phreatophytes occurs above and below the falls.

15S/42E-35MS1.--A bedrock narrows in Marble Canyon, floored by quartz monzonite in the contact zone with sedimentary rocks, is the site of this spring. Sparse phreatophytes occur a short distance upstream from the spring.

15S/42E-35NS1.--Flow at a bedrock narrows in a steep-walled canyon about 200 feet upstream from the confluence with Marble Canyon. Flow occurs in the wash upstream from the narrows, but the maximum flow is at the narrows. The flow disappears into the alluvium a short distance downstream.

16S/41E-12JS1-5.--This spring area occurs high on the gently rolling top of Hunter Mountain at a constriction in the alluvium along a wash. Discharge appears at five points along the toe of an east-facing slope at the edge of a small flood plain. A very small part of the discharge of JS1 apparently flows to an open steel tank, and part of the discharge of JS3-4 is to a leaking storage tank which is almost filled with sediment.

16S/41E-13CS1.--A constriction in the alluvial flood plain in a broad canyon atop Hunter Mountain marks this spring site. Phreatophytes are abundant in the canyon, and a dense growth marks the site of the spring. Most of the outflow is piped to a low, open storage tank. The pipeline is buried at the spring orifice. The nature of the hydraulic connection between the buried pipe and the spring discharge is not known. It appears that the spring is not affected by surface saturation. For example, during April and July 1968 the area was noticeably drier than in April 1969. However, the flow from the pipe was greater during the dry period than in April 1969 (table 1) when the ground was saturated with snowmelt and approximately 2 cubic feet per second was flowing over the area of the buried pipe at the spring orifice. The surface runoff reportedly began shortly after a storm in late February 1969.

16S/41E-13CS2,3.--These two springs issue from small dug-out areas in the weathered quartz monzonite. The springs are uphill from a nearby cabin, and a broken pipeline leads toward the cabin from CS3, the southernmost spring.

16S/41E-13ES1.--A small pool and dense vegetation mark this spring, which apparently flows from weathered and fractured quartz monzonite on the west side of an alluvial flood plain.

16S/41E-13ES2.--A dense growth of phreatophytes in a steep draw marks this spring site, which was dry in March 1968. The vegetation grows on a thin cover of alluvium that overlies weathered and fractured quartz monzonite.

16S/42E-1KS1.--This spring is at a bedrock narrows at the downstream end of an alluviated reach of Dead Horse Canyon. The area is near the contact zone of the quartz monzonite and sedimentary rocks and the bedrock here is in part quartz monzonite and in part metamorphosed sedimentary rocks that make up a large block that resembles a roof pendant. The spring discharge probably represents almost all of the total ground-water outflow from the canyon.

16S/42E-1LS1.--Flow appears at a constriction in the alluvium in Dead Horse Canyon, a short distance upstream from KS1. The flow disappears into the alluvium about 150 feet downstream from the spring.

16S/42E-2GS1.--A bedrock narrows made up of quartz monzonite is the site of this spring on the floor of Dead Horse Canyon. The flow disappears into alluvium a short distance downstream.

16S/42E-2QS1.--This spring appears where thin alluvium in a canyon floor pinches out above a quartz monzonite bedrock ledge that forms a waterfall. Very dense vegetation covers the canyon floor above and below the spring.

16S/42E-2QS2.--Several large cottonwood trees mark the site of this spring, which occurs where alluvium along the canyon floor thins at a narrow point. Weathered and fractured quartz monzonite underlies the area.

16S/42E-3HS1.--Flow occurs here in a sandy reach of alluvium in the stream channel of Dead Horse Canyon. Apparently, the alluvium is somewhat thinner here than immediately upstream and downstream. The flow disappears into the alluvium about 150 feet downstream from the spring.

16S/42E-3NS1.--This spring area is near the head of Dead Horse Canyon. A small patch of alluvium is constricted at a narrows just upstream from an abrupt steepening of the canyon. The spring area, dry in March 1968, is marked by a dense growth of cottonwood trees and other vegetation. The root system of this vegetation effectively protects the alluvium upstream from erosion by flash floods. The bedrock is quartz monzonite.

16S/42E-3PS1.--Flow appears at this spring at the downstream pinchout of alluvium below spring 3NS1. The bedrock is quartz monzonite.

16S/42E-6FS1.--This small spring issues from highly weathered quartz monzonite near the top of a hill, about 100 feet above the canyon floor. A dense clump of small bushes marks the site.

16S/42E-6MS1.--Flow occurs here at a constriction in thin alluvium along the floor of a small canyon that is cut into quartz monzonite bedrock. The flow disappears into the sandy alluvium about 100 feet downstream from the spring.

16S/42E-6RS1.--This spring site, dry in April 1968, is marked only by a discolored zone in weathered quartz monzonite. There is no evidence of discharge, such as an unusual amount of vegetation or damp or puffy ground, common at many such springs.

16S/42E-7HS1.--This spring flows from thin alluvium where an abrupt constriction in the channel coincides with rapid downstream steepening of the channel gradient. Weathered and fractured quartz monzonite is in the channel downstream from the spring. A dense growth of phreatophytes hides the spring and extends downstream for several hundred feet. An open metal storage tank, now empty, is at the site.

16S/42E-9CS1.--This spring is at a bedrock narrows in a sandy wash that is cut into quartz monzonite. Clumps of dense vegetation mark the site. The spring was dry in March 1968.

16S/42E-9CS2.--Flow issues from sandy alluvium in a wash a few hundred feet downstream from spring 9CS1. The outflow apparently is caused by a thinning of the alluvium. The flow disappears about 50 feet downstream. Dense clumps of phreatophytes occur at the spring and for several yards upstream.

16S/42E-10GS1.--Several large cottonwood trees mark this spring at the base of a small topographic bench that is underlain by coarse-grained alluvium and bouldery colluvium (unconsolidated, unsorted rock debris, accumulated mainly by gravity), both locally derived from quartz monzonite. The cottonwood trees apparently have formed a root system that protects the bench from erosion. A rusted and leaking pipe leads part of the discharge a few feet away from the spring orifice.

16S/42E-11HS1.--This spring occurs at a constriction in an alluvium-filled reach of a dry wash. No outflow was visible from the small pool. Dense vegetation marks the site.

16S/42E-12ES1,2.--These two springs occur about 100 feet above a canyon floor on a steep hillside that is underlain by highly weathered quartz monzonite. Dense clumps of vegetation mark the sites. The southern of the two springs, ES2, is dry.

16S/42E-15JS1.--Flow issues here from weathered and fractured quartz monzonite that is mantled by colluvium. The spring is on a steep slope and is marked by dense, low vegetation that grows in a line downslope from the orifice.

16S/42E-18GS1.--This spring occurs in a steep draw where a few feet of alluvium overlie weathered and fractured quartz monzonite. A dense growth of low vegetation covers the wash near the spring.

16S/42E-18GS2.--This site is on a steep slope of weathered quartz monzonite. A few clumps of vegetation dot the area. The spring was dry in April 1968.

16S/42E-18RS1.--Flow issues from thin alluvium and weathered quartz monzonite in a steep wash about 100 feet upstream from a bedrock falls. Bedrock crops out in the wash below the spring.

16S/42E-19HS1.--This spring is in a draw at the base of an area of steeply sloping alluvium and colluvium. The draw and general ground slope steepen abruptly below the spring. A short pipeline leads from the spring to an open, leaking tank in an area of dense growth below the spring.

16S/42E-22AS1.--This spring is near the base of a steep hillside, above a topographic saddle. Several clumps of phreatophytes occur in an area of light-colored weathered quartz monzonite that has been chemically altered as a result of the spring discharge.

16S/42E-25KS1.--This spring is at a bedrock narrows near the downstream end of the phreatophyte area at Cottonwood Springs (25LS1). The narrows marks the point of maximum discharge; below here the flow disappears into alluvium about 300 feet downstream and reappears intermittently and much diminished for the next mile.

16S/42E-25LS1.--A large spring area here is fed by ground water stored in in a broad area of alluvium (fig. 2). The weathered and fractured quartz monzonite beneath the alluvium probably stores and transmits some ground water to the spring. The discharge area is a marked constriction in the alluvium where the drainage enters a narrow part of Cottonwood Canyon (fig. 2). The spring area supports a dense growth of large cottonwood trees and other phreatophytes. The area of dense growth is about 200 feet wide and about 1,500 feet long, or slightly less than 7 acres. Ground water is at or near the land surface over most of this area, and more than 30 acre-feet of water annually probably is consumed here by evapotranspiration.

16S/43E-20FS1.--This spring is near the upstream end of a 3/4-mile long phreatophyte area in Cottonwood Canyon. The discharge occurs where gently folded and faulted semiconsolidated sand and gravel crop out in the streambed. These deposits appear to be much older than the loose alluvium in the stream channel. The semiconsolidated sediments overlie quartz monzonite and locally appear to be several hundred feet thick. They are a few tens of feet thick at the spring.

16S/43E-20FS2.--About 100 feet downstream from 20FS1 this spring flows from alluvium across a series of steplike falls. The falls are about 6 feet high and are cut in the semiconsolidated sediments mentioned in the description of spring 20FS1.

16S/43E-20NS1.--This spring area is marked by a group of large cottonwood trees growing in an alluvium-filled channel in Cottonwood Canyon. The spring was dry in April 1968. The presence or absence of a spring in this area apparently is dependent in large part upon the geometry of the channel which is related to erosion and deposition by flash floods.

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