

United States
Department of the Interior
Geological Survey

Water-supply investigation, Montezuma Pass,
Coronado National Memorial,
Cochise County, Arizona

By

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drinking and for restrooms. In 1965, about 60,000 persons visited the Memorial; based on this figure and the estimated future trends of attendance, a possible maximum of 2,600,000 gallons of water per year or 5 gpm (gallons per minute) will be needed to develop the facilities.

In July 1965 the National Park Service asked the U. S. Geological Survey to appraise the ground-water resources of the Montezuma Pass area. Fieldwork was done intermittently between August and October 1965.

The authors are grateful for the assistance given by John Stephens, former superintendent of the Memorial, and by other personnel of the National Park Service, particularly George Brown, for information concerning the yield and dependability of the existing water supplies and the construction of wells. Special credit is given to P. T. Hayes of the U. S. Geological Survey, who kindly furnished a geologic map of the southeast part of the Huachuca Mountains that was essential to this investigation.

Hydrogeology

The Coronado National Memorial is along the west flank of the San Pedro River valley (fig. 1). The San Pedro River valley contains more than 1,000 feet of unconsolidated alluvial sand and gravel, which yields sufficient water for irrigation. In contrast, the Memorial

area is underlain by consolidated rocks that generally are unfavorable for ground-water reservoirs. An inventory of 9 wells and 7 springs in and adjacent to the Memorial (table 1) shows that water yields are small—usually less than 2 gpm (gallons per minute) for springs and less than 5 gpm for wells. Altitudes range from about 4,000 feet above mean sea level near the San Pedro River to 6,864 feet on Coronado Peak near Montezuma Pass.

No major streams cross the Memorial, but an ephemeral stream in Montezuma Canyon, which is along the north boundary of the Memorial, flows periodically during the summer thunderstorm season. The principal source of ground water is from direct infiltration by precipitation and from the flow of small ephemeral streams. Since 1956, precipitation at the Memorial headquarters has averaged 20 inches annually, of which about 13 inches falls from May through September. According to the U. S. Weather Bureau, the average annual precipitation at nearby weather stations for the same period is: Bisbee, 16 inches; Canelo, 18 inches; and Fort Huachuca, 14 inches.

The Huachuca Mountains consist of igneous, volcanic, and sedimentary rocks of Precambrian to possible early Mesozoic age. The rocks have been subjected to complex structural movements—uplift, folding, thrusting, and normal faulting. The main structural alignments are west-northwest to northwest, which are nearly parallel

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Table 1
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Table 1. -- Well and spring inventory, MORITA FORMATION, COLORADO

Type of water supply: D, dug well; Dr, drilled well; S, spring.

Improvements: C, chlorinator; EP, electric pump; N, none; P, pipeline; PdT, piped downhill to trough;

PH, piped to house; PT, piped to trough; Ta, tank; Tr, trough; W, windmill.

Field: E, estimated; R, reported.

Use of water: D,
Remarks: C, che
in report.

Well or spring number	Type of water supply	Date developed or completed (month, year)	Topography	Altitude above mean sea level (feet)	Construction data					Water-bearing strata
					Depth of well (feet)	Casing or cribbing		Finish	Improve- ments	
						Diameter (drilled well in inches, dug well in feet)	Depth (feet)			
MP-1	S	.....	Side of canyon...	6, 800	.....	.....	.....	14-inch dam at mouth of mine tunnel.	PdT	Sandy limestor Morita Forma tion.
MP-2	S	.....	Bottom of canyon.	6, 200	.....	.....	.....	2-foot dam to impound water, filled with sediment.	N	Morita Forma tion.
MP-3	S	.....	... do.	5, 490	.....	.....	.....	None	N	Limestone blo in Glance Conglomerat
MP-4	Dr	.....	Wash, on ter- race above main channel.	5, 345	.....	.....	.....	.....	Ta, Tr, W	Basin fill
MP-5	S	.....	Mouth of canyon.	6, 030	.....	.....	.....	Impounded in mine tunnel.	PdT	Volcanic rock Glance Conglomerat
MP-6	S	.....	Side of draw ...	6, 025	.....	.....	.....	4-foot dam in mine tunnel.	PH	Morita Forma tion.

MP-6	S	.....	Side of draw	6,025	.....	.....	.....	4-foot dam in mine tunnel.	PH	Morita Forma tion.
MP-7	D	1943	Canyon, next to main channel.	5,580	20	.....	.....	Cement cover.	EP, P, Ta	Alluvium ...
MP-8	Dr	May 1959	... do.	5,270	100	8	88	Perforated 20 to 88 feet.	C, Ta	Purple mudsto Morita Form tion, 88 feet thick.
MP-9	S	.....	Steep draw	5,800	.....	.....	.....	Tunneled into hill about 20 feet, built dam across entrance.	PT	Mudstone, Mor Formation.
MP-10 ...	S	.....	Near head of draw.	6,450	.....	.....	.....	Shaft dug to impound water.	Tr	Quartz monzonite.
MP-11 ...	Dr	1945	Terrace	5,190	115	6	115	Lower 40 feet perforated.	Ta, Tr, W	Decomposed quartz monzonite.
MP-12 ...	Dr	1917	Dissected terrace.	4,640	342	4	315	.....	Ta, W	Basin fill
MP-13 ...	Dr	1945	Terrace	5,025	200	6	200	.....	EP, Ta	Decomposed quartz monzonite.
MP-14 ...	Dr	1943	... do.	5,110	90	6	.....	.....	Ta, Tr, W	... do.
MP-15 ...	D	1937	Stream terrace.	5,350	60	5	.....	.....	.....	... do.
MP-16 ...	Dr	1959	... do.	5,200	103	6	.....	Sealed. ....	.....	Sand and grave

(Bottom) Table 1

2(TOP)

TABLE 1

Use of water: D, domestic; P, public supply; S, stock.

downhill to trough;

Remarks: C, chemical analysis included in table 3; F, flows all year; L, log available but not included in report.

Location data		Water-bearing strata	Hydrologic data				Use of water	Remarks
Finish	Improvements		Static water level		Yield			
			Depth (feet)	Date measured	Rate (gpm)	Date measured		
14-inch dam at mouth of mine tunnel.	PdT	Sandy limestone, Morita Formation.	.....	.....	> 3	8-24-65	S	C; F; highest yield of any spring on inventory; water issues from fractures in mine tunnel.
2-foot dam to impound water, filled with sediment.	N	Morita Formation.	.....	.....	< 1 E	..do....	S	Temperature, 63° F; usually dries up in early summer.
None	N	Limestone block in Glance Conglomerate	.....	.....	< 2 E	..do....	S	C; F; Yaqui Spring; made up of seeps; difficult to measure yield.
.....	Ta, Tr, W	Basin fill	5.8	10-25-65	.....	.....	S	C; adequate stock supply.
Impounded in mine tunnel.	PdT	Volcanic rocks, Glance Conglomerate.	.....	.....	.....	.....	S	Temperature, 61° F; F; piped half a mile downhill to trough; pipe plugged, could not measure yield.
4-foot dam in mine tunnel.	PH	Morita Formation.	.....	.....	1	8-24-65	D	C; F; unable to get accurate ground-water temperature.

tunnel.									
Cement cover.	EP, P, Ta	Alluvium . . . . .	.....	.....	2-3 R	.....	D, S	C; usually adequate supply all year.	
Perforated 20 to 88 feet.	C, Ta	Purple mudstone, Morita Formation, 88 feet thick.	30	5-11-59	3.5 6	8- 3-64 7- 1-65	D, P	C; L; pumping test, 20 gpm for 2 hours; 100-foot dry hole drilled in canyon a quarter of a mile to the east.	
Tunneled into hill about 20 feet, built dam across entrance.	PT	Mudstone, Morita Formation.	.....	.....	< 1 E	8-25-65	S	Piped about 2,000 feet to trough; <u>has never gone dry; C.</u>	
Shaft dug to impound water.	Tr	Quartz monzonite.	.....	.....	< 1 R	.....	S	Did not visit or sample.	
Lower 40 feet perforated.	Ta, Tr, W	Decomposed quartz monzonite.	.....	.....	4-5 R	.....	S	C; water at 85 feet, rose to 80 feet; dependable supply.	
.....	Ta, W	Basin fill	319	8- -64	5 R	.....	D, S	C; deepened from 315 to 342 feet in 1953; reported 15-foot decline from 1963 to 1964.	
.....	EP, Ta	Decomposed quartz monzonite.	180	8- -65	5 R	.....	D, S	Temperature, 70° F.	
.....	Ta, Tr, W	... do. ....	.....	.....	5 R	.....	D, S	C.	
.....	.....	... do. ....	.....	.....	.....	.....	.....	Dry hole.	
Sealed.....	.....	Sand and gravel..	.....	.....	.....	.....	.....	Do.	

2 (Bottom) TABLE 1

with the trend of the mountains. A broad thrust zone occurs along the crest of the mountains, and in its southeast part the zone is about 1-1/2 to 2 miles north of Montezuma Canyon. Another thrust zone, in places a quarter of a mile wide, extends west-northwest in Montezuma Canyon. The canyon was developed principally by erosion that removed the less resistant rocks along the fractured fault zone. In addition, several normal faults in the Montezuma Pass area trend northeastward and transect the other structures. In the Montezuma Pass area all the beds are steeply inclined and, for the most part, dip away from the mountains at angles between 10° and 80° SW.; most dips are about 40° to 50° SW. In places on the north side of Montezuma Canyon some of the rocks dip as much as 45° N.

The outcrops of consolidated rocks in the Coronado National Memorial consist of the Naco Group of Permian and Pennsylvanian age (table 2); volcanic rocks of the Huachuca Mountains and Canelo Hills Volcanics of Jurassic and Triassic age; quartz monzonite of Jurassic age; and the Glance Conglomerate, Morita Formation, Mural Limestone, and Cintura Formation of the Bisbee Group of Cretaceous age. Around the flanks of the mountains, alluvial deposits—mainly of Quaternary age—overlie the consolidated rocks on an irregular and locally channeled erosion surface.

In general, the consolidated rocks in the Coronado National Memorial are unfavorable for ground-water storage, although some of

the formations yield water in other parts of the Huachuca Mountains. Because of the complex faulting, the thick sequence of limestone units of Paleozoic age that contains water elsewhere in the Huachuca Mountains (Brown and others, 1966) is present in the Memorial in only a few places and is represented only by the Naco Group, the topmost units of the sequence. The rocks of Triassic to Cretaceous age contain only a small amount of water, which, when present, accumulates mainly along fractures and large bedding planes.

All the volcanic rocks of the Huachuca Mountains are altered by metamorphism and sheared by severe fault movements; in general, they have a very low permeability. A quartz monzonite stock northeast of the Memorial has a low overall permeability because most fractures are tight. However, where it is deeply weathered it yields a small amount of water to wells. In general, rocks of the Bisbee Group either have low permeabilities and (or) are in an unfavorable structural position for the accumulation of ground water. The Glance Conglomerate crops out at Montezuma Pass. The volcanic unit in the Glance Conglomerate may be relatively permeable where fractured. Yaqui Spring issues from this unit in the SW $\frac{1}{4}$ sec. 14, T. 24 S., R. 20 E. (MP-3, fig. 1). The Morita Formation has a low permeability. However, west of the Memorial headquarters in Montezuma Canyon a shallow well (MP-8) 100 feet deep tapped the Morita Formation, and water was

encountered at 30 feet. The amount of water available varies during the year, but it is adequate for the Memorial headquarters and three homes. The well is close to a fault, which separates the Morita Formation and the quartz monzonite stock, and the Morita Formation probably is fractured enough to increase the permeability. Here, a perched water table may exist in the Morita Formation because 1,300 feet east of the headquarters a test hole 100 feet deep penetrated only alluvial gravel and did not encounter water. Springs occur along or near faults that separate the Morita Formation and the other rock units (MP-1, 2, 6, and 10, fig. 1). Therefore, the Morita Formation may be a source of stored ground water in places along faults.

Alluvial gravel overlies the consolidated rocks in the east and southwest parts of the Memorial. The thickness of these alluvial deposits is not known, except in a few places where thicknesses of 50 to 100 feet have been reported. In other places the alluvium forms only a thin mantle overlying the older rocks. The greatest thickness of alluvium probably occurs along the eastern boundary of the Memorial. Adequate stock and domestic water supplies have been developed in the gravel in three wells near the east and southwest boundaries of the Memorial.

Water samples from 10 selected wells and springs were analyzed for chemical quality (table 3). Although the hardness values were

TABLE 3
(2 sheets)

Table 3. --Selected chemical analyses of ground water, Montezuma Pass, Coronado National Monument

[Analyses in parts per million, except as indicated; analyses by the Soil and Water Testing Laboratory, University of Arizona]

Well or spring number	Date of collection	Temperature (° F)	Silica (SiO ₂)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K) (calculated)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)
MP-1	Aug. 24, 1965	67	17	108	24	29	393	0	60	16
MP-3	do	66	14	132	13	21	317	0	122	18
MP-4	do .....	.....	21	111	11	34	317	0	82	18
MP-6	do .....	.....	26	76	14	37	239	0	74	14
MP-7	do	65	24	128	23	36	430	0	80	20
MP-8	Jan. 14, 1965	70	28	133	18	17	430	0	72	8.8
MP-9	Aug. 25, 1965	67	19	131	11	26	295	0	124	20
MP-11	do .....	.....	26	67	9	60	244	0	60	26
MP-12	do .....	.....	29	50	6	49	200	0	30	16
MP-14	do	68	26	52	13	53	234	0	50	16

er, Montezuma Pass, Coronado National Memorial, Cochise County, Ariz.

esting Laboratory, University of Arizona, with the exception of that by the Geological Survey for well MP-8]

Bicar- bonate (HCO ₃)	Car- bonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluo- ride (F)	Nitrate (NO ₃)	Dissolved solids (calculated)	Hardness as CaCO ₃	Percent sodium	Specific conduct- ance (micro- mhos at 25° C)	pH
393	0	60	16	0.3	3	451	372	14	700	7.8
317	0	122	18	.3	0	476	385	11	700	7.6
317	0	82	18	.3	1	434	327	19	700	7.7
239	0	74	14	.3	1	360	248	24	500	8.0
430	0	80	20	.3	0	523	418	16	780	7.4
430	0	72	8.8	.2	.4	488	405	8	777	7.5
295	0	124	20	.3	8	484	373	13	760	7.9
244	0	60	26	.4	1	369	205	39	520	8.0
200	0	30	16	.3	1	279	151	42	400	7.8
234	0	50	16	.5	1	326	185	38	500	7.6

high, all the water analyzed is suitable for most domestic purposes. The hardness values ranged from 151 to 418 ppm (parts per million). The softest water was from wells east of the Memorial. The total dissolved-solids content ranged from 279 to 523 ppm. Only water from well MP-7 contained more than 500 ppm total dissolved solids, which is the recommended upper limit for public water supplies (U. S. Public Health Service, 1962). The sulfate and chloride content was much less than the recommended upper limit of 250 ppm. The fluoride content was not more than 0.5 ppm in the water samples analyzed. The recommended upper limit for fluoride is 0.8 to 1.7 ppm, depending on the average maximum daily air temperature (U. S. Public Health Service, 1962). The nitrate content ranged from 0 to 8 ppm, which is much less than the upper recommended limit of 45 ppm.

Proposed Sites for Development of a Water Supply

As a result of the field investigation, four possibilities can be considered for the development of a water supply for Montezuma Pass. These are: (1) Yaqui Spring; (2) the alluvial gravel southwest of Montezuma Pass; (3) upper Montezuma Canyon; and (4) a catchment basin.

Site 1. --A water supply can be developed at Yaqui Spring south of Montezuma Pass (fig. 1). The spring issues in the bottom