Fort Huachuca Area
720.2 (SPKIM) 1st Wrapper Ind.

Headquarters Ninth Service Command, Fort Douglas, Utah, February 1, 1943.

TO: The Commanding General, Services of Supply, Washington, D. C.
ATTENTION: The Surgeon General.

1. The attached material obtained by the undersigned recently, while on an inspection trip to Fort Huachuca, is believed to be sufficiently informative to be added to the 720.2 File on Water and Sewerage installations of this Station.

For the Commanding General:

For the Director, S and S Division:

F. H. Stover

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Ground-water supplies in the Fort Huachuca area, Cochise and Santa Cruz Counties, Arizona

by

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INTRODUCTION

The Quartermaster Corps, War Department, requested the Ground Water Division of the Geological Survey, Department of the Interior, to investigate the ground water resources of the Fort Huachuca Area, Cochise and Santa Cruz Counties, Arizona.

The Fort Huachuca Military Reservation lies along the northeast side of the Huachuca Mountains approximately 25 miles west northwest of Bisbee, and 21 miles southwest of Tombstone, Arizona.

Valuable assistance in the form of blueprints and reports, both written and verbal, was given the authors by the members of the Quartermaster Corps at Fort Huachuca; the firm of Headman, Ferguson, and Carollo; Mr. O'Neil, post Engineer; Pete Wilkins, in charge of pipe lines from springs; and W.E. Lane and Winninger Brothers, well drillers.

HISTORY OF EXISTING WATER SUPPLY SYSTEM

The original army post at the base of the Huachuca Mountains was established in March, 1877. The water supply was obtained from springs in Huachuca Canyon for a period of almost thirty-four years. In 1911 a collecting works was constructed near the junction of Garden and McClure Canyons with small pipe lines up the canyons to several springs. An eight inch steel pipe line, seven miles long, was constructed from the collecting box to a 250,000 gallon masonry storage reservoir and a small round tank, (20 feet in diameter and 10 feet deep). During the same year, investigations were started and considerable sums were spent in prospecting for additional water supplies. Many test holes were drilled near the mouths of Garden and Huachuca Canyons to depths up to 1,000 feet without much success. A small amount of water was found on one eight-inch diameter well (well 320 in Garden Canyon. This was drilled and an air lift pump installed in 1912. Seventy gallons a minute could be pumped from this well for about half the time, or about 50,000 gallons a day. This well was used to augment the spring flow in times of drought. In 1919, concrete inlet boxes were constructed on many of the springs and several more springs were brought into the system. At a still later date several samll concrete dams were built to catch small surface flows from deep springs in the canyons between the larger springs already developed.

In 1936, the water problem again became acute and in that year a six-inch diameter test well (see log. well 33) was drilled near the east gate of the reservation. Good water was found in

quantities beyond the capacity of any test pump that could be used in this well. A plunger-type pump was installed in the well in September, 1938. This new source was further developed in January, 1939, when a fourteen-inch diameter well (see log, well 34) was completed 90 feet west of well 33. A supply of water was encountered at approximately the same depth as in well 33, and tests showed a discharge of 700 gallons a minute with a drawdown of forty-three feet. A pump was installed in the well that delivered 500 gallons a minute to a concrete "clear-well" from which the water was boosted to the Post reservoir through a new ten-inch, steel, high pressure main. A new 250,000 gallon concrete reservoir was constructed just below the old reservoir in connection with this development.

In 1940, further development was carried on with the drilling of a second fourteen-inch diameter well (see log, well 35) approximately 500 feet west of well 34. This well was completed in November 1940, and is now being equipped with an electric motor and turbine. A tank that has a capacity of 500,000 gallons has just been constructed in the new cantonment area and will soon be put in use.

To briefly summarize, the available supplies of water at Fort Huachuca in April, 1941, were: (1) $\frac{1}{4}$ to $\frac{1}{2}$ million gallons of water a day from springs and small collecting dams in Huachuca and Garden Canyons with gravity flow through 4-inch and 8-inch pipe lines to the old reservoir; (2) 1,200 gallons a minute or 1-3/4 million gallons a day from two 14-inch diameter wells near the east gate of the reservation (wells 34 and 35); (3) 100,000 gallons a day from a 6-inch diameter test well (well 33) near east gate. A plunger-type pump is installed on this well. (4) 50,000 gallons a day by full time pumping with air lift from old Garden Canyon Well (well 32). The pump on this well is now broken. The existing storage tanks are: one 250,000 gallon masonry reservoir, one 250,000 gallon concrete reservoir, and one 500,000 gallon elevated steel tank.

GEOLOGY

Huachuca Mountains.-

The Huachuca Mountains consist of pre-Cambrian granite overlain by Paleozoic limestones and quartzites and Cretaceous rocks. As in most mountains of this character that rise out of alluvial valleys, the structual relations at the side and ends are not revealed. The foothills on the northeast side of the range are of granite. The typical succession of sedimentary beds is as follows: 100 to 200 feet of quartzite overlain by 200 to 300 feet of slabby limestone containing layers of sandstone and shale, in turn overlain by 500 to 1,000 feet of massive limestones. Near the top of the mountains these Paleozoic beds are overlain in places by conglomerate, sandstone and shale of Lower Cretaceous age. Granite and porphry are intruded into these desimentary rocks in small areas in the northwest part of the range and in a large area in the southeast part.

There is a system of large faults that trend parallel to the range, or from northwest to southeast. These faults are cut by a system of smaller transverse faults. Thus, in ascending Garden Canyon from the northeast edge of the mountains, granite, quartzite and then limestone are revealed on the surface, but ascending farther the quartzite and limestone layers are repeated as a result of faulting.

The granites weather easily but transmit very little ground water. The quartzites are well cemented but have been somewhat fractured by the faulting and thus carry some water in the fracture zones. Spring No. 1 (see Map, spring 52) in Huachuca Canyon flows from a fault zone near the quartzite-granite contact. The basal limestone is slabby and impure and does not contain many cavities; thus the main ground water channels in this limestone are also in fault zones and along the contact of the limestone with the underlying quartzite. Spring No. 2 (see map, spring 53) in Huachuca Canyon flows from a faulted contact of limestone against quartzite. Mud Springs in Garden Canyon are near the lowest outcrop of this limestone in the canyon. The upper limestones are much purer and probably dissolve more easily than the lower layers. This is indicated by the many weathered openings in the upper limestone. Rain or snow falling on the outcrops of the upper limestone flows downward to the less permeable limestone and then through fault zones or crevices to the lowest level of escape. This is usually near the bottom of creek beds at either a faulted or normal contact of the limestones with the quartzite or with some of the shale members of the lowest limestone. Where the structure could be ascertained, practically all of the springs visited have their sources in fault zones.

Alluvial Fill.-

Streams rising in the Huachuca Mountains have carried a large amount of coarse material out from the mountains and have deposited this material in alluvial cones in the valley to the northeast. The material is usually poorly sorted and consists of all graduations between silt and boulders. In a few of the cones the sorting was more complete and very fine material was carried farther from the mountains and merged with lake beds in the present valley of the San Pedro River. This probably happened when the climate was wetter and the streams carried much more water than at the present time. The logs of the Fort Huachuca wells show unsorted material near the surface and sorted material at greater depths. The deep water-bearing beds that have been found in the center of the valley near the river are very thin and are of very fine-grained materials and the yeild from them is small.

GROUND WATER

Huachuca Mountains.-

The limestone springs in Huachuca and Garden Canyons in the Huachuca Mountains have been fully developed. In a few cases spring sites were blasted in an effort to increase the supply and as a result, the flow of these springs was lost to some lower level. Apparently blasting did not increase the supply from any of

the springs. The flow of some springs has been greatly increased by concentrating or gathering the flow into a central spring by tunnels. Some of the spring improvements and pipe lines are in bad repair and the total flow could be increased by a careful cleaning of the springs and by cleaning out and repairing the pipe lines.

The water from the springs is of a calcium-magnesium-bicarbonate type with very little other mineral matter. It is quite hard and might be called a typical limestone water. The mineral content may increase somewhat in inverse proportion to the decreased flows during drought periods.

There is a good possibility that a well of high capacity could be drilled in the limestone near spring 55 at the junction of McClure and Garden Canyons. Careful geological work should be done in this vicinity before the exact location of the well is picked, but there should be several hundred feet of limestones under the creek near this point. The existing road passes this point and trucks and drilling apparatus could reach it without difficulty. Steady pumping from a well at this point would probably dry up Mud Springs (springs 54 and 55) but should have no effect on the springs father up the canyons. The proposed well should use cavities in the underlying limestone as an equalizing reservoir, pumping from storage in seasons when additional water is needed to supplement flow from the upper springs, and allowing storage to increase when the springs furnish enough water to fill the pipe lines to the Army Post. This well could thus be used to keep the pipe lines from the upper springs full in drought seasons, since there is a gravity flow from the McClure-Garden Canyon Junction to the storage reservoirs above the Fort. Such a well could also be used as a reserve supply for the Fort. There is a possibility that large additional supplies of water might be developed by wells in the limestones in this vicinity.

Alluvial Materials.-

The existing wells in the alluvial fill surrounding the Huachuca Mountains are nearly all of small diameter, with cylinder pumps powered by windmills. These wells are used chiefly for domestic and stock supplies and the discharge from them ranges from 1 to 10 gallons a minute.

In the Elgin area, which is the area around the Upper Babocomari River and slightly west of the north end of the Huachuca Mountains, the existing wells are shallow, going only to the first waterbearing strata. The water level in these wells has a large seasonal fluctuation but the supply is usually sufficient for domestic and stock use and the ranchers have not had to drill deeper. An irrigation well drilled at a ranch north of the Elgin area, and in a geologic and topographic situation similar to that in the Elgin area, is reported to produce 1,000 gallons a minute. This, coupled with the high elevation causing ahigher precipitation on the Elgin area, suggests that it deserves further study and a test well, if additional ar reserve supplies are needed.

There have not been any very deep wells drilled between the mountains and the San Pedro River in the area southeast of Garden Creek. The wells drilled to the first water-bearing strata have furnished enough water for the existing ranches. Deep well in this area should produce as much or more water than the wells in the area at the East Gate of the Fort because the mountains are higher in the vicinity of Carr Peak and the canyons have more flowing water than those in the reservation. Therefore, deep wells in the southeast corner of the reservation or south from this corner might constitute a further additional or reserve supply if needed. A test well should be drilled if the development of this area becomes necessary.

In the area northeast of the Fort, bounded by Huachuca Canyon, Babocomari River, San Pedro River and Garden Canyon, the wells are deeper than in either the Elgin or the Southeastern area. The water surface appears to have an even slope from the Fort to the east-northeast, and the chemical analyses of water samples from most wells in this area show that the water is of uniform quality, therefore the authors believe that ground water in this area is either in one system or interconnecting systems with a common source.

The source of the ground water in the alluvial fill must be near the edge of the Huachuca Mountains where the canyons bring rain, snow, and spring water out from the mountains. In general, the alluvial surface is sealed by adobe and caliche in the soil but there may be a few places where the adobe and caliche are missing and where recharge could take place. There may be some recharge from the upper part of the Babocomari River but the water levels in that area indicate that recharge is not large. The lower Babocomari River and the San Pedro River have little or no affect on the ground-water supply. These rivers may receive a little water from springs drawing on the ground-water but they apparently do not recharge the supply.

Wells 34 and 35 near the east gate of the reservation have a specific capacity of 16 to 20 gallons a minute per foot of drawdown, according to reports. The drillers of these wells verbally questioned whether the wells were in rock at 700 feet as noted in the logs- one driller stating that he believed that there were a few hundred feet more of water-bearing strata before granite would be reached, and the other stating the drilling was stopped because it was believed they had encountered a sufficient amount of water.

It was noticed that the water level at the Fort wells has dropped since it was first recorded in well 33 as 459 feet to water. Correcting for surface elevations the reading of the depth to water in wells 33, 34 and 35 is as follows: 459 in May, 1936; 459.5 feet in February, 1939; and 465 feet in November, 1940. The 5.5 feet drop in 1939 and 1940 was probably caused by heavy pumping from well 34.

There is a fairly large ground water reservoir in the area northeast of the Fort with a large amount of water in storage, but the recharge to this reservoir appears to be small. Therefore, it is

expected that the water level will drop fairly rapidly under heavy pumping. If this drop becomes too great after several years of pumping, and a large supply is still needed, additional water may have to be developed in the limestones in the mountains or in the Elgin or the Southeastern areas.

RECOMMENDATIONS

1. At least two wells are recommended, to be spaced at one-half mile intervals to the north of wells 34 and 35. The new wells should be drilled to a depth of 700 to 1,000 feet or into clay and/or rock.

2. A record of water levels should be kept for each well. Water levels should be measured and recorded at least once a week or before each pump is started. Such a record will indicate the fluctuations of the water table and will allow sufficient time for the development of additional supplies if this becomes necessary.

3. All available spring water should be used and all springs should be cleaned out. An enlargement of the pipe lines or additional lines to carry more flow from these springs during the wet seasons should be considered.

4. The development of a well in the limestone in the vicinity of Mud Springs (springs 54 and 55) should also be considered.

Table of Drillers' Logs, Fort Huachuca Area, Arizona

	Thickness (feet)	Depth (feet)
Driller's Log of well 32 Fort Huachuca Garden Canyon well		
Loam and boulders	20	20
Gray granite	5	25
Decomposed granite	15	40
Water bearing strata	5	45
Decomposed granite	42	87
Water bearing strata	8	95
Gray granite	105	200
TOTAL DEPTH		200
Driller's log of well 33 Fort Huachuca 6 inch test well, 290 feet west of east gate		
Adobe with hard nigger head boulders	90	90
Loose gravel, dry	6	96
Adobe with hard nigger head boulders	374	470
Hard sandstone, first showing of water at 471 feet	1	471
Sand and gravel, compacted	18	489
Loose sand, gravel and boulders	133	622
TOTAL DEPTH		622
Driller's log of well 34 Fort Huachuca number 1 well, 380 feet west of east gate		
Adobe	8	8
Boulder bed	19	27
Adobe and boulders	61	88
Sand, gravel, and boulders	24	112
Adobe and boulders	58	170
Loose boulders, very hard	86	256
Adobe, gravel, and boulders	16	272
Adobe, sand, gravel, and boulders	47	319
Boulders, very hard, and clay	46	365
Adobe and gravel	52	417
Hard sand and gravel, cemented	9	426
Adobe, sand, and gravel	39	465
Hard sand	4	469
Water gravel and sand, showing water at 470 feet	1	470
Sand and gravel, compacted	18	488
Loose sand and gravel, water showing strong at 488 feet	36	524

Table of Drillers' Logs, Fort Huachuca Area, Arizona--continued

	Thickness (feet)	Depth (feet)
Driller's log of well 34--continued		
Hard sand, gravel, and boulders	21	545
Loose sand and gravel	35	580
Loose boulders	11	591
Loose water sand and gravel	24	615
Loose sand, gravel and boulders	5	620
Hard boulders	9	629
Loose sand and boulders	16	645
Hard sand	10	655
Loose sand and gravel	25	680
Adobe	12	692
Hard drilling, apparently drilling in rock	9	701
TOTAL DEPTH		701
Water raised to 460 feet, measured by driller Feb. 4, 1939		
Driller's log of well 35 Fort Huachuca Number 2 well, 900 feet west of east gate		
Conglomerate, medium hard	40	40
Clay and gravel	20	60
Sandstone and conglomerate, medium hard	70	130
Conglomerate, medium hard	70	200
Conglomerate with hard stratas	70	270
Conglomerate, medium	25	295
Conglomerate with soft stratas	15	310
Conglomerate, medium	30	340
Sand	30	370
Large boulders	40	410
Sand and gravel	30	440
Water sand conglomerate	37	477
Conglomerate with lots of water	43	520
Hard conglomerate	30	550
Sand conglomerate with water	50	600
Conglomerate, medium, with hard stratas	30	630
Gravel carrying water	20	650
Hard conglomerate	40	690
Rock	20	710
TOTAL DEPTH		710

Description on well cuttings from Fort Huachuca No. 2 well

by R. B. Morrison

The only available samples of drill cuttings are from the No. 2 well. These samples were taken every 10 feet. They are all similar in composition of component rock materials and differ mainly in size of particles and in degree of sorting. The rock materials in all the samples are largely derived from gneissic or granitic rocks, now in the form of fragments of pink or white feldspar, quartz, gneiss, or granite. A moderate amount (about 5 to 15 percent) of gray or purple quartzite is present. A pinkish-red quartz feldspar (sanadine) porphyry is distinctive but less abundant (generally less than 5 percent). Gray, white, or buff-colored limestone occurs as relatively small fragments in all the samples but only in small amounts (generally less than 2 percent0. Occasionally there are a few fragments of a gray chert-like rock with conchoidal fracture. In general the limestone particles are well-rounded but those of the other rocks are angular to sub-rounded.

As all the samples apparently had been washed free of silt and clay by the collector, they represent only the coarser portions of the strata encountered. Apparantly, however, the materials range frm medium sized sand to at least medium sized gravel. Below 600 feet and especially below 680 feet the material is largely a more or less pebbly medium grained sand.

None of the samples (the lowermost is from 700 feet) are of such a character or composition as to suggest that the well passed entirely through the alluvial deposits and entered hard rock.

Table of Drillers' Logs, Fort Huachuca Area, Arizona--continued

	Thickness (feet)	Depth (feet)
Driller's logs of well 41 W. E. Lane, 13½ miles southeast of east gate at Fort Huachuca.		
Boulders	275	275
Tight clay	12	287
Clean gravel	7	294
Tight clay	24	318
Decomposed granite	6	324
TOTAL DEPTH		324