Effects of three irrigation wells on the flow of Rattlesnake Springs, Eddy County, New Mexico, February 1, 1961 to February 1, 1962

By

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DEPARTMENT OF THE INTERIOR
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Prepared by the U.S. Geological Survey in cooperation with the
U.S. National Park Service,
the New Mexico Department of Game and Fish, and
private irrigators

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Contents

Illustrations - long list

(All illustrations in pocket)

- long list

Illustrations - Continued

Illustrations - short list

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Abstract

Water from Rattlesnake Springs, in the upper Black River valley in southwestern Eddy County, N. Mex., is used by the U.S. National Park Service and the New Mexico State Department of Game and Fish for irrigation, public supply, domestic supply, and fish and wildlife propogation. A suit was filed in U.S. District Court in July 1959 by the National Park Service against owners of irrigation wells near Rattlesnake Springs when the flow of the springs seemed to decline as a result of pumping from these irrigation wells. The Federal judge hearing the case did not find for the plaintiff but directed that the flow from Rattlesnake Springs and pumpage from three nearby irrigation wells be measured for a period of 1 year beginning February 1, 1961. This report presents hydrologic data and an interpretation of effects of pumping the nearby irrigation wells on the flow of the springs.

The measured flow of Rattlesnake Springs, which issue from alluvium, has ranged from 0.17 to 4.7 cfs (cubic feet per second) from 1952 through 1961.

Pumping 1,200 gpm (gallons per minute) each from irrigation wells 25.24.27.124 and 25.24.27.421, which tap the alluvium 1.0 and 0.9 mile, respectively, southwest of Rattlesnake Springs, directly affects the water level in observation well 25.24.26.121, which is 550 feet south of Rattlesnake Springs, the pool level of the springs, and the flow from the pool within 2 hours. Effects of pumping 1,200 gpm from irrigation well 25.24.34.112a, which is 1.7 miles southwest of the springs, are small. Pumping 90 gpm from the pool to Carlsbad Caverns National Park affects the pool level but does not affect the flow of the springs or the ground-water levels.

The flow of Rattlesnake Springs decreases as the altitude of the pool declines. At flows greater than 1.75 cfs the water level in well 25.24.26.121 is higher than that of the pool. At flows of less than 1.75 cfs the water level in the well is less than that of the pool. The springs will cease flowing temporarily if the water level in the observation well is about 1.65 feet lower than the pool level. If the water level in observation well 25.24.26.121 declines to about 10.2 feet below land surface, Rattlesnake Springs will not flow and the pool will be dry. The lowest daily-highest water level recorded in the observation well from 1953 through 1961 was 3.53 feet below land surface on September 10, 1960. Some water bypasses Rattlesnake Springs and probably discharges at Blue Springs, about 11 miles northeast of Rattlesnake Springs.

Introduction

Water from Rattlesnake Springs has been used for irrigation for many years. The flow at present is shared by the U.S. National Park Service and the New Mexico State Department of Game and Fish. A part of the flow of the springs is pumped to Carlsbad Caverns National Park for domestic use by residents and visitors. A part of the spring flow is used near Rattlesnake Springs by the National Park Service and the New Mexico State Department of Game and Fish for irrigation, domestic supply, and fish and wildlife propagation. The Carlsbad ground-water basin was extended by the State Engineer on October 21, 1952, to include the upper Black River valley, closing the area to further irrigation development.

Irrigation with water from wells that tap alluvium in the upper Black River valley about 3.5 miles south of near Rattlesnake Springs reportedly began in 1946, and by 1953 approximately 720 acres of pasture and cropland were being irrigated in this area (Hale, 1955, p. 14).

The flow from Rattlesnake Springs seemed to decline in the early 1950's, and the National Park Service became concerned about the diminished flow during the summer [——] when use of water at Carlsbad Caverns is greatest. As a result, they filed suit in the U.S. District Court in Albuquerque, N. Mex., in July 1959 to enjoin certain private irrigators in the area from using their wells as to deprive the United States the use of the flow of Rattlesnake Springs (case No. 4194 Civil, U.S. Government vs. H. F. Ballard, et al.; New Mexico State Department of Game and Fish, intervenor). The Federal judge hearing the case did not find for the plaintiff, but he ordered detailed measurement of all flow from Rattlesnake Springs and pumpage from three nearby irrigation wells for a period of 1 year beginning February 1, 1961. The U.S. Geological Survey was given the responsibility of measuring the flow of the springs and the pumpage from the wells.

Purpose and scope of the study

On December 14, 1960, a meeting was attended by attorneys of the U. S. Department of Justice, representatives of the National Park Service, attorney and representatives of the defendants in the litigation, and representatives of the Geological Survey, at which time procedures were agreed upon for measuring the flow of Rattlesnake Springs and the pumpage from the three nearby irrigation wells. The responsibility of supervising the collection and interpretation of spring-flow data was assigned to the Surface Water Branch of the Geological Survey and that of the pumpage data from the three nearby irrigation wells was assigned to the Ground Water Branch of the Geological Survey. It was agreed that the Geological Survey would tabulate spring-flow and pumpage data for the year beginning February 1, 1961, and submit copies to the interested parties. ~~ey, the counsel for the defendants, the attorney for the State Department of Game and Fish, and the New Mexico State Engineer.~~

The National Park Service requested the Geological Survey to prepare a report describing the effects of pumping the three nearby irrigation wells on the flow of Rattlesnake Springs, as indicated by data collected during the year's intensive study. The National Park Service also expressed interest in determining conditions and periods when water could not be diverted from the springs for irrigation by the National Park Service and the State Department of Game and Fish, and when the flow of the springs was not sufficient to maintain the pool level when water was pumped to Carlsbad Caverns. This report presents hydrologic data and an interpretation of effects of pumping the nearby irrigation wells on the flow of Rattlesnake Springs.

Previous investigations

Rocks exposed in southwestern Eddy County, N. Mex., southeastern Otero County, N. Mex., and adjacent parts of Texas have been studied by many geologists. Two extensive publications on the regional geology of the area near Rattlesnake Springs are King (1948) and Newell and others (1953).

A report on the ground-water conditions in the vicinity of Rattlesnake Springs was published by the New Mexico State Engineer as Technical Report 3 (Hale, 1955). Other reports containing information on the hydrology of the upper Black River valley are Hendrickson and Jones (1952) and Bjorklund and Motts (1959).

Location and description of the area

Rattlesnake Springs is in the upper Black River valley in southwestern Eddy County. The valley trends northeast-southwest and is bounded on the north and west by the Guadalupe Ridge and on the south and east by hills of low relief which near the State line are called the Yeso Hills (fig. 1).

Figure 1.--Map of a part of southern Eddy County, N. Mex., showing location of Rattlesnake Springs and Carlsbad Caverns and area shown in figure 3 of this report.

Many canyons extend from near the crest of the Guadalupe Ridge to the flood plain of Black River. These canyons carry storm runoff at times into the upper Black River valley. Some of the canyons contain small springs.

Alluvial fans from the toe of Guadalupe Ridge to the flood plain of Black River slope about 200 feet per mile. These fans restrict irrigable land to within about 2 miles of the flood plain.

The channel of Black River extends northeastward from near the State line in T. 26 S., R. 21 E. to its confluence with the Pecos River near Malaga, N. Mex., about 25 miles east-northeast of Rattlesnake Springs. In the upper Black River valley the river channel borders the low hills on the southeast side of the valley. The river is normally dry in the upper valley except in about a 3.5-mile reach extending from the SE$\frac{1}{4}$ sec. 3, T. 26 S., R. 24 E. to the SW$\frac{1}{4}$ sec. 24, T. 25 S., R. 24 E.

Rattlesnake Springs issue from alluvium on relatively flat land in the SW$\frac{1}{4}$ sec. 23, T. 25 S., R. 24 E. The spring area is walled and a pool as much as 7.5 feet deep can be maintained. Water is pumped to Carlsbad Caverns from a sump in the pool. Water can be diverted from the pool through four ditches controlled by outlet gates to lands owned by the National Park Service and the State Department of Game and Fish. Water for domestic use is pumped and diverted from the pool to the ranger station adjacent to the springs and the State Game and Fish headquarters about three-quarters of a mile from the springs (fig. 2). Vegetation is thick

Figure 2.--Map showing locations of wells, pipeline; diversion ditches, and Parshall flumes in the vicinity of Rattlesnake Springs [and a capacity table for the Rattlesnake Springs pool], Eddy County, N. Mex.

near the springs and aquatic plants grow in the pool.

Methods of investigation

The National Park Service and the State Department of Game and Fish installed Parshall flumes on the four diversion ditches from Rattlesnake Springs in 1959. Prior to February 1, 1961, recorders were installed on the Parshall flumes on ditches 1 and 2, the only ditches to be used during the period of investigation. The head gate on ditch 3 was closed and the riser stem was removed. The head gate on ditch 4 was closed and locked and the ditch was filled between the the head gate and the flume. Water could be diverted only through ditches 1 and 2. A recording gage recorded the stage of the pool, and totalizing meters recorded flow at both ends of the pipe line to Carlsbad Caverns and on the line to the ranger station at the springs. A meter recorded pumping time on the remote-control switch operating the pump on the pipe line to Carlsbad Caverns. The amount of water diverted or pumped from Rattlesnake Springs and fluctuation of the pool level, therefore, could be measured with reasonable accuracy from February 1, 1961 to February 1, 1962.

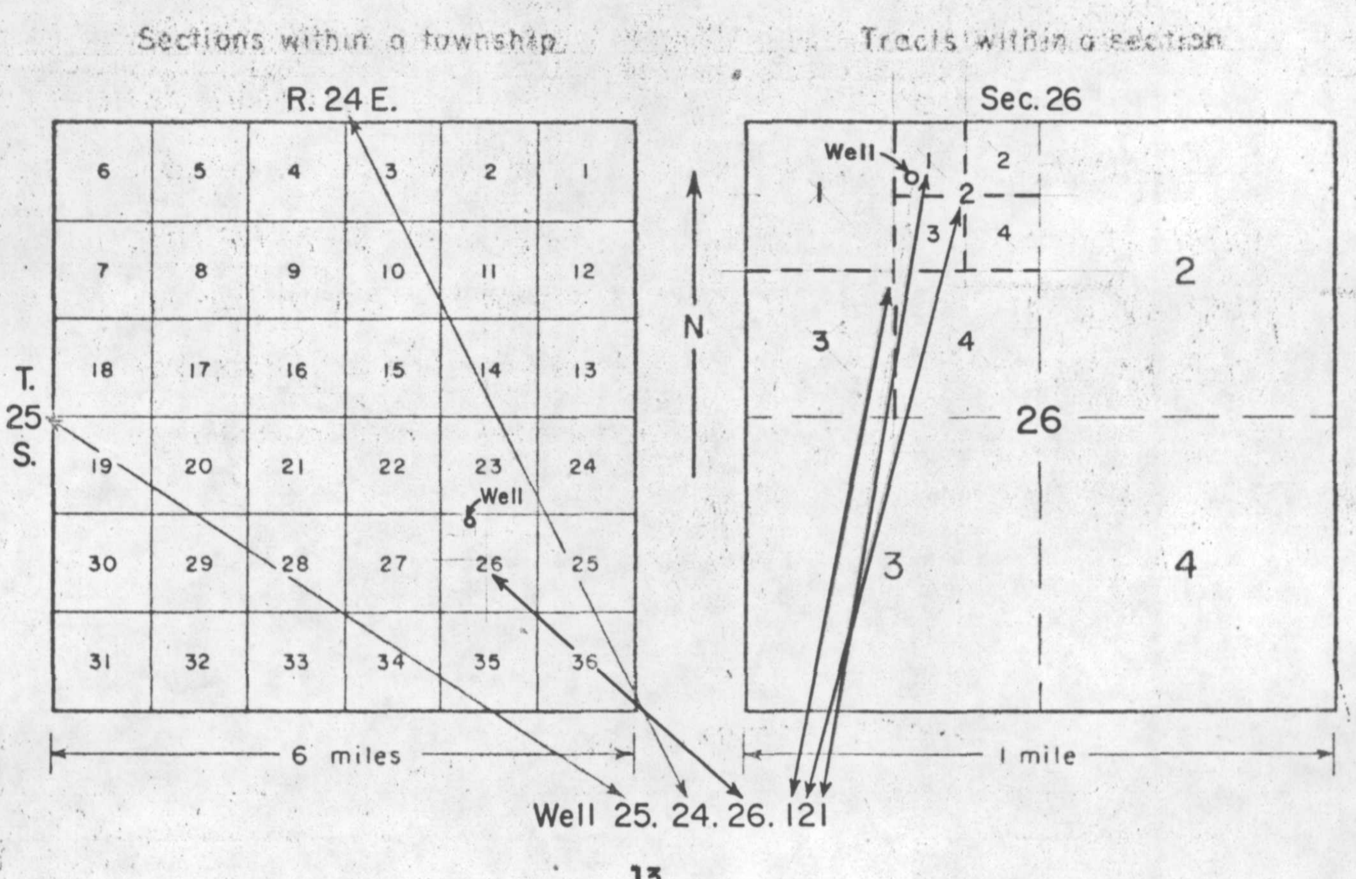
Personnel of the National Park Service changed charts on the weekly recorders on ditches 1 and 2 and the pool at Rattlesnake Springs. Because the flow into ditch 3 could not be shut off entirely, they observed the gage height in the Parshall flume on ditch 3 daily after July 25, 1961. They kept the flumes free from weeds and other obstructions and generally maintained the equipment.

A representative of the Surface Water Branch visited Rattlesnake Springs bi-weekly during the year beginning February 1, 1961. He measured the flow in each of the diversion ditches to rate the Parshall flumes, inspected the pool recorder, collected the recorder data, and transcribed the data from the totalizing meters. The accuracy of the two totalizing meters on the pipe line from Rattlesnake Springs to the Carlsbad Caverns was checked four times during 1961-62 by timing discharge from the pipe line into the storage reservoir near the Caverns headquarters. A topographic survey was made and a capacity table of the Rattlesnake Springs pool was computed.

Totalizing meters were installed on the discharge pipes of the three irrigation wells nearest Rattlesnake Springs by their owners before or during February 1961. A representative of the Ground Water Branch visited the three irrigation wells the first working day in each month from February 1, 1961 to February 1, 1962. At each visit to the wells he recorded the data on the totalizing meters and the electric meter readings, collected the data recorded by the well owners, and, if the wells were pumping, measured the discharge of each well by various methods to determine the quantity of water pumped per unit of electric power used. Data from the three irrigation wells and water-level data from observation wells near Rattlesnake Springs were interpreted and tabulated by the Ground Water Branch.

System of numbering wells in New Mexico

All wells referred to in this report are identified by a location number used by the Geological Survey and the State Engineer for numbering water wells in New Mexico. The location number is a description of the geographic location of the well, based on the system of public land surveys. It indicates the location of the well to the nearest 10-acre tract, when the well can be located that accurately. The location number consists of a series of numbers corresponding to the township, range, section, and tract within a section, in that order, as illustrated below. Letters (a, b, c, ...) are added to the last segment to designate the second, third, fourth, and succeeding wells in the same 10-acre tract. All wells in the area covered by this report are south of the New Mexico Base Line and east of the New Mexico Principal Meridian.



General geologic setting

The upper Black River valley is in a structural feature called the Delaware basin. Guadalupe Ridge forms the northwestern boundary of the Delaware basin proper. The ridge consists of reef limestone and reef talus and is part of the Capitan Limestone of the Guadalupe Series of Permian age. The reef talus beds dip steeply to the southeast and through a facies change to the southeast from the stratigraphically equivalent, dominantly sandstone beds of the Bell Canyon Formation, which is the uppermost unit of the Delaware Mountain Group in the Delaware basin. Hale (1955, p. 15) reported that the top of the Bell Canyon Formation is about 400 feet below land surface in secs. 9 and 10, T. 25 S., R. 24 E. and is at a lower altitude southeast of here beneath the Black River valley.

The Bell Canyon Formation is overlain by the Castile Formation, which is the lowermost unit of the Ochoa Series of Permian age. The Castile is predominantely gypsum and anhydrite. It underlies the alluvium in the Rattlesnake Springs area and crops out in the Yeso Hills and the low hills and ridges that form the southeastern boundary of the upper Black River valley.

Alluvium in the upper Black River valley consists of gravel, sand, silt, clay, and conglomerate. It is as much as 200 feet thick and locally it fills sinkholes developed in the underlying gypsum of the Castile Formation (Hale, 1955, p. 17).

Ground water

Most, if not all, of the usable ground water in the upper Black River valley is in the alluvium and the Castile Formation. Water in the Delaware Mountain Group is probably too highly mineralized to use even for watering livestock.

Water in the Castile Formation is hard and contains 1,200 to 1,500 ppm (parts per million) sulfate (Hale, 1955, p.22). In places where ground water cannot be obtained from the alluvium, a small amount of water is pumped from gypsum of the Castile Formation in the upper Black River valley and the area east of the valley, principally for watering livestock.

The Castile Formation is recharged by precipitation on the outcrop and in areas where alluvium overlying the Castile is thin. Hale (1955, p. 23) infered, because of differences in sulfate content of water in the alluvium, that some water in the Castile Formation moves laterally into the alluvium in the upper Black River valley.

Ground water is pumped from the alluvium in the upper Black River valley for irrigation, domestic, and stock uses. Most of the wells that yield sufficient quantities for irrigation are finished in solution channels in conglomerate beds in the alluvium. Wells in unconsolidated silt, sand, and gravel generally do not yield large quantities of water.

Recharge to the alluvium is from precipitation on the upper Black River valley and the Guadalupe Ridge, and in part from water moving through the Castile Formation laterally into the alluvium. Floodwaters in canyons heading along Guadalupe Ridge probably are the most important source of recharge to the alluvium.

Ground water in the alluvium moves generally northeastward down the upper Black River valley toward Rattlesnake Springs and Blue Spring, about 11 miles northeast of Rattlesnake Springs. The configuration of the water table in the alluvium in that part of the upper Black River valley south and southwest of Rattlesnake Springs in January 1962 is shown in figure 3. Interpretation of the water-table contours shown

Figure 3.--Map showing spring and well locations and water-table contours in part of the upper Black River valley, Eddy County, N. Mex.

on this map indicate that water moves through alluvium from the upper part of the valley toward Rattlesnake Springs.

Surface water

Perennial surface-water flow in the Black River valley in recent years has been the 3.5-mile reach of Black River near Rattlesnake Springs, flow in diversion ditches from Rattlesnake Springs, and flow from Blue Spring.

Black River generally has perennial flow from the headward springs in the SE$\frac{1}{4}$ sec. 3, T. 26 S., R. 24 E. to a diversion dam in the SW$\frac{1}{4}$ sec. 24, T. 25 S., R. 24 E. During the year beginning February 1, 1961, however, the river seemed to have flow only to a point about a quarter of a mile upstream from the diversion dam in sec. 24, T. 25 S., R. 24 E. In September 1961 the perennial reach seemed to decrease further, and the river probably had perennial flow throughout the year for about 3 miles below the springs in sec. 3, T. 26 S., R. 24 E. The perennial flow of Black River at a measuring site in sec. 3, T. 26 S, R. 24 E. is generally less than 1 cfs.

The perennial reach of Black River in the upper valley is a series of pools connected by small shallow channels. Water for irrigation is diverted from a pool created by a small dam near the center of sec. 35, T. 25 S., R. 24 E. by the State Department of Game and Fish. The quality of water in upper Black River is good, and it is similar to the quality of water in nearby wells in the alluvium.

Water is diverted from the pool at Rattlesnake Springs through four ditches (fig. 2). Ditch 1, at the northeast corner of the pool, carries water for irrigating lands owned by the National Park Service and the State Department of Game and Fish. Ditch 2, also at the northeast corner of the pool, carries water for irrigating pasture lands owned by the National Park Service near the ranger station. Ditch 3 issues from the east side of the pool, and it conveys water to duck ponds east of Rattlesnake Springs. Ditch 4 carries water from the south end of the pool for irrigating lands owned by the State Department of Game and Fish. In addition, water for domestic and public supply is pumped to Carlsbad Caverns, the ranger station near Rattlesnake Springs, and diverted to the headquarters of the State Department of Game and Fish.

The measured flow of Rattlesnake Springs from 1952 through 1961 has ranged from 0.17 cfs in July 1961 to 4.7 cfs in September 1952. The quality of the water from the springs is good, but it is more highly mineralized than water from well 25.24.27.124, about 1 mile west of the springs. The water is, however, of better quality than that of most wells in the area and that of Black River.

Blue Spring issues from conglomerate in the alluvium in the NW$\frac{1}{4}$ sec. 33, T. 24 S., R. 26 E. about 11 miles northeast of Rattlesnake Springs (fig. 1). The flow from Blue Spring comprises most of the flow in the perennial reach of Black River from there to its confluence with the Pecos River. The measured flow of Blue Spring from 1952 through 1961 ranged from 8.1 cfs in June 1960 to 14.1 cfs in January 1952.

Part of the flow of Blue Spring is diverted for irrigation in the Black River village area. The water from Blue Spring is more highly mineralized than water from Rattlesnake Springs, but it is potable.

Hydrologic conditions at Blue Springs have no bearing on hydrologic conditions at Rattlesnake Springs, except that ground water moving northeastward in alluvium in the upper Black River valley that does not discharge at Rattlesnake Springs, and water losses to the alluvium in the upper valley, from Black River, probably discharge at Blue Spring.

Fluctuation of ground-water levels and surface-water flow

Data collected in the upper Black River valley during 1952-61 indicate fluctuations of ground-water levels and surface-water flow. Water levels were measured in 12 wells approximately bi-monthly, and a water-level recorder was operated on well 25.24.26.121, about 550 feet south of Rattlesnake Springs, during this 10-year period. The discharge of Rattlesnake Springs, Blue Spring, and Black River in the NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 3, T. 26 S., R. 24 E. below Mayes' Ranch was measured approximately monthly from 1952-61. Additional ground-water and surface-water data were collected during the year February 1, 1961, to February 1, 1962.

Water levels in wells in the upper Black River valley are generally highest during the winter, [generally October 1 to March 1,] and lowest during the summer. This is due largely to pumpage of ground water for irrigation. The highest water level of the year is generally in January before pre-planting irrigation begins, and the lowest water level of the year is generally in July when irrigation demands probably are greatest (fig. 4). Weather conditions and individual irrigation

Figure 4.--Water level in selected wells [based on bimonthly measurements] in the upper Black River valley, Eddy County, N. Mex., 1952-61.

practices probably affect the cyclic seasonal fluctuations in some wells in the valley. The fluctuation of water level in well 25.24.26.121 (fig. 4) represents water levels in the principal aquifer near the springs.

From February 1, 1961 to February 1, 1962 the highest water level in well 25.24.26.121 was in March just prior to pumping from nearby irrigation wells, and the lowest water level was in August (fig. 5). The day-to-day fluctuations during the growing season

Figure 5.--Water level in well 25.24.26.121 near Rattlesnake Springs, Eddy County, N. Mex., February 1, 1961 to February 1, 1962.

are attributed mainly to cyclic pumping of nearby irrigation wells. Minor fluctuations are caused by evapotranspiration in the vicinity of Rattlesnake Springs, and changes in barometric pressure. Minor fluctuations in the non-growing season also may result when nearby irrigation wells are pumped occasionally for domestic and stock uses.

The flow of Rattlesnake Springs, Blue Spring, and Black River generally is greatest during the winter and least during the summer (fig. 6). This is due chiefly to a single aquifer furnishing the

Figure 6.--Flow of Blue Spring, Rattlesnake Springs, and Black River, in the NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 3, T. 26 S., R. 24 E. below Mayes' Ranch, Eddy County, N. Mex., [from] 1952-61 [through 1961]

ground water that is pumped for irrigation in the upper Black River valley and the surface-water flow.

The similarity of the fluctuation of flow from Blue Spring and Rattlesnake Springs (fig. 6) suggests a common source for the water. The flow of Black River in the perennial reach in the upper valley does not fluctuate as much as the flow from Rattlesnake Springs (fig. 6) although they both derive water from the alluvium. The fluctuations in flow of the river caused by changes in the water level in the alluvium due to pumping are masked by the return of irrigation water to the river from farms near the measuring site below Mayes' Ranch.

The flow of Rattlesnake Springs was greatest in the early part of March and least in July and August, during the period from February 1, 1961 to February 1, 1962 (fig. 7).

Figure 7.--Flow of Rattlesnake Springs, Eddy County, N. Mex., February 1, 1961 to February 1, 1962.

The overall decline of water levels in wells in the upper Black River valley and the decrease in flow from Blue Spring, Rattlesnake Springs, and the flow in Black River from 1952 through 1961 (figs. 5 and 7) are attributed to below average precipitation in the area during most of these years.

Relationship between pumpage from irrigation wells and the flow of Rattlesnake Springs

The similarity of the fluctuation of the water level in well 25.24.26.121 and the flow of Rattlesnake Springs (figs. 5 and 7) indicates a source of water common to the well and the springs. The fluctuation of the pool level at Rattlesnake Springs (fig. 8)

Figure 8.--Daily-maximum stage of the pool at Rattlesnake Springs, Eddy County, N. Mex., February 1, 1961 to February 1, 1962.

can be correlated with the flow of the springs, but the pool level also is affected by regulation of the headgates in diversion ditches and pumpage from the pool. Conditions causing a rise or decline of the water level in well 25.24.26.121, therefore, will cause a rise or decline of the pool level of the springs and an increase or decrease in the flow of Rattlesnake Springs. Moreover, the water level in well 25.24.26.121 can serve as an indication of the flow of Rattlesnake Springs.

The water level in well 25.24.26.121 and, hence, the flow of Rattlesnake Springs are affected by recharge to the aquifer in the alluvium and by withdrawal of water from the aquifer. The recharge is influenced by the amount and pattern of precipitation in the upper Black River valley and the adjacent Guadalupe Ridge. All the irrigation wells in the upper Black River valley may affect the discharge of Rattlesnake Springs indirectly, but those wells near the springs are most likely to affect the discharge of the springs directly.

Wells 25.24.27.124, 25.24.27.421, and 25.24.34.112a are the irrigation wells nearest Rattlesnake Springs and are the wells from which detailed pumpage data were collected from February 1, 1961 to February 1, 1962. These data indicate that pumping from wells 25.24.27.124 and 25.24.27.421 has a direct effect on the flow of Rattlesnake Springs. In addition, they indicate that pumping well 25.24.34.112a has only a slight [discernable] effect on the flow of the springs. Well 25.24.27.124 is 1.0 mile from Rattlesnake Springs; well 25.24.27.421 is 0.9 mile from the springs; and well 25.24.34.112a is 1.7 miles from the springs. Each of these wells yields about 1,200 gpm.

The period March 15 to April 3, 1961 was selected for detailed study of the effects of pumping the three irrigation wells on the flow of Rattlesnake Springs (fig. 9) because hydrologic conditions

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Figure 9.--Effects of pumping wells 25.24.27.124, 25.24.27.421, 25.24.34.112a, and the Carlsbad Caverns pump on water level in well 25.24.26.121, the pool level, and the flow of Rattlesnake Springs, Eddy County, N. Mex.

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were relatively stable just prior to March 15 and a variety of pumping schedules occurred during this period.

The schedule of pumping from irrigation wells 25.24.27.124 and 25.24.27.421 is reflected in fluctuation of water level in observation well 25.24.26.121. The two irrigation wells were pumped generally from about 6:00 a.m. to about 6:00 p.m. and the water level in the observation well generally began to decline between 8:00 a.m. and 10:00 a.m. Similarly, the water level in the observation well began to rise by about 10:00 p.m. after pumping from the irrigation wells stopped at 6:00 p.m. (fig. 9). The water level in the observation well was steady for about 2 hours generally from 7:00 to 9:00 a.m. and 8:00 to 10:00 p.m. Pumping from the irrigation wells, therefore, affects the water level in the observation well within 2 hours and probably within 1 hour.

Fluctuations of the flow of Rattlesnake Springs and the pool level of the springs are similar to that of observation well 25.24.26.121 except that pumping from the pool to Carlsbad Caverns lowers the pool level but it does not affect the spring flow [from the pool] or the water level in the observation well (fig. 9). The pumping from the pool is included in the computed spring flow. The pump to Carlsbad Caverns yields about 90 gpm. The pool level recovers rapidly after pumping to [the] Carlsbad Caverns stops. Moreover, the pool level and the water level in the observation well rose and the spring flow increased from midnight to 6:00 a.m. on March 20 and March 28 when the pump to [the] Carlsbad Caverns was running but the irrigation wells were not pumping (fig. 9). Changes of flow through the diversion ditches from the pool may also affect temporarily the pool level but they probably do not affect the spring flow or the water level in well 25.24.26.121.

Pumping from irrigation well 25.24.34.112a directly affects the flow of Rattlesnake Springs only slightly. This is based on the records of April 1 and April 2, 1961 (fig. 9). During these two days the only water pumped near Rattlesnake Springs was from well 25.24.34.112a but the water level in well 25.24.26.121 and the pool level of the springs rose and the flow of the springs increased. The ~~slope~~ rate of water-level rise and the spring-flow increase changed, however, when the irrigation well was pumping which indicated a slight direct effect on the water levels and the flow of the springs.

The relation between the water level in well 25.24.26.121 and the flow of Rattlesnake Springs indicates possible conditions when the flow of the springs may stop. The flow of the springs is dependent not only on the head of the aquifer in the alluvium, as represented by the water level in well 25.24.26.121, but also on the difference in head between the water-level in the well and the pool level of the springs. The flow of the springs decreases as the altitude of the pool decreases in relation to the altitude of the water level in well 25.24.26.121 (fig. 10). At flows less than about 1.75 cfs the altitude

Figure 10.--Relation between difference in altitude between water level in well 25.24.26.121 and the pool of Rattlesnake Springs and the flow of Rattlesnake Springs, Eddy County, N. Mex.

of the water level in the well is lower than that of the pool level, indicating a gradient from the springs to the well. At flows greater than 1.75 cfs the altitude of water level in the well is higher than that of the pool and the gradient is from the well to the springs.

By extending the curve shown in figure 10 it is evident that the springs will cease flowing if the water level in well 25.24.26.121 is about 1.65 feet lower in altitude than the pool level. The lowest spring opening is at altitude 3,627.8 feet. If the water level in well 25.24.26.121 declines to about altitude 3,626.2 or 10.2 feet below the land surface, Rattlesnake Springs will not flow and the pool will be dry. The lowest daily-highest water level recorded in well 25.24.26.121 from 1953 through 1961 was 3.53 feet below land surface on September 10, 1960. The highest daily-highest water level recorded during the same period was 0.76 feet above land surface on February 19, 1953.

Pumping the nearby irrigation wells affects the water level in the observation well more than it does the pool level. (See the comparative drawdown and recovery effects shown in fig. 9.) This reduces the gradient from the observation well to the springs and diverts ground water which was moving toward the springs to the pumping wells. Rattlesnake Springs can stop flowing with water remaining in the pool if the water level in well 25.24.26.121 were 1.65 feet or more below the altitude of the pool at Rattlesnake Springs. Personnel of the U.S. National Park Service report, and the recorded data show, periods of a few hours when the pool level declined with no diversion or pumpage from the pool. At such times there was apparently no flow from Rattlesnake Springs.

Hale (1955, p. 30) suggested that, on the basis of quality-of-water and water-level data, the source of water discharging at Rattlesnake Springs is the alluvium west to southwest of the springs. The fact that the water level in well 25.24.26.121 can be lower in altitude than the level of the pool of Rattlesnake Springs and the springs will continue to flow, therefore, indicates that Rattlesnake Springs is not the only discharge area for water in the alluvium in the upper Black River valley. Some water from southwest of Rattlesnake Springs must bypass the springs and probably move toward Blue Spring. Another possibility for the water level in well 25.24.26.121 being lower than the pool level is leakage of water from the artesian aquifer through or around the casing in the well into the overlying alluvium containing unconfined water.

The topographic survey of the Rattlesnake Springs pool (fig. 11)

Figure 11.--Map showing topography and a capacity table for Rattlesnake Springs pool, Eddy County, N. Mex.

indicates that the invert of the opening to the lowest diversion ditch (No. 3) is at stage 1.7 feet or altitude 3,629.5 feet. The inverts of diversion ditch 1 is 5.3 feet stage or altitude 3,633.1; No. 2 is 5.7 feet stage or altitude 3,633.5 feet; and No. 4 is 5.6 feet stage or altitude 3,633.4 feet. The bottoms of the Parshall flumes on ditches 1, 2, and 4, however, are higher than the openings to the ditches and the stages of the bottoms of the flumes indicate the lowest pool levels when water can be diverted through the ditches. The bottom of the flume on ditch 1 is at stage 6.1 feet or altitude 3,633.9 feet; in ditch 2 it is at stage 6.6 feet or altitude 3,634.4 feet; and in ditch 4 it is at stage 6.5 feet or altitude 3,634.3 feet. The lowest daily-maximum stage of the Rattlesnake Springs pool from February 1, 1961 to February 1, 1962 was 6.58 feet on June 23, 1961. Thus, no water could have been diverted through ditch 2 on this date. All other daily-maximum stages for the year were above stage 6.6 feet, and water could have been diverted through ditches 1, 3, and 4, at least at times, each day.

The lowest stage at which water could be pumped from the Rattlesnake Springs pool to Carlsbad Caverns was not determined.

Conclusions

Pumping irrigation wells 25.24.27.124 and 25.24.27.421 directly affects the flow of Rattlesnake Springs, the water level in well 25.24.26.121, and the pool level of the springs within 2 hours and probably within 1 hour. Pumping irrigation well 25.24.34.112a directly affects water levels in the well and the pool and the spring flow only slightly. Well 25.24.27.124 is 1.0 mile from Rattlesnake Springs; well 25.24.27.421 is 0.9 mile from the springs; well 25.24.34.112a is 1.7 miles from the springs. Each of these wells yields about 1,200 gpm from alluvium in the upper Black River valley.

Pumping from the pool at Rattlesnake Springs to Carlsbad Caverns National Park lowers the pool level but does not affect the flow of Rattlesnake Springs or the water level in well 25.24.26.121. The yield of the pump is about 90 gpm.

The relation between the water level in observation well 25.24.26.121 and the flow of Rattlesnake Springs indicates possible conditions when the flow of the springs may stop. The flow of the springs decreases as the altitude of the pool level decreases in relation to the altitude of the water level in well 25.24.26.121. At flows less than about 1.75 cfs the hydraulic gradient, normally from the well to the springs, reverses and water seems to move from the springs toward the observation well. The springs will cease flowing if the water level in observation well 25.24.26.121 is about 1.65 feet lower in altitude than the pool level. The lowest spring opening is at altitude 3,627.8 feet. If the water level in well 25.24.26.121 declines to about altitude 3,626.2 feet or 10.2 feet below land surface, Rattlesnake Springs will not flow and the pool will be dry. The lowest daily-highest water level recorded in the observation well from 1953 through 1961 was 3.53 feet below land surface on September 10, 1960.

The configuration of the water table indicates that the source of water discharging at Rattlesnake Springs is the alluvium in the upper Black River valley west and southwest of the springs. The fact that the water level in well 25.24.26.121 can be lower in altitude than the level of the pool and the springs continue to flow indicates that Rattlesnake Springs are not the only discharge area for water in the alluvium in the upper valley. Some water bypasses Rattlesnake Springs and probably moves toward Blue Spring. The water level in the observation well possibly could be lower in altitude than the pool level because of water leaking from the artesian aquifer through or around the casing in the well into the overlying alluvium containing unconfined water.

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