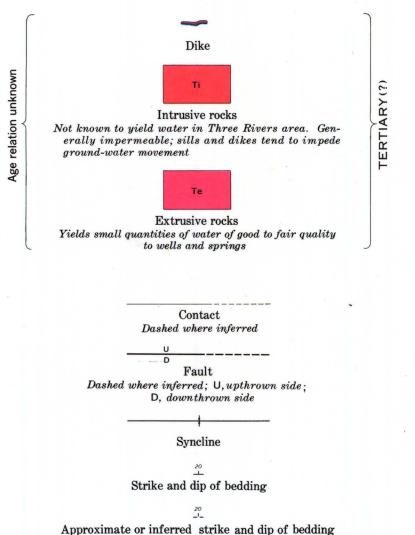
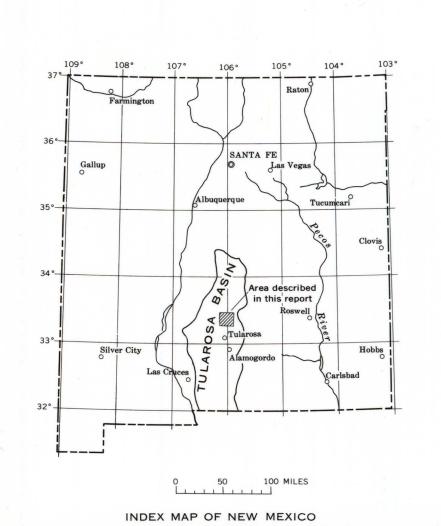


Dockum Grou

Not known to yield water to wells in Three Rivers



IGNEOUS ROCKS



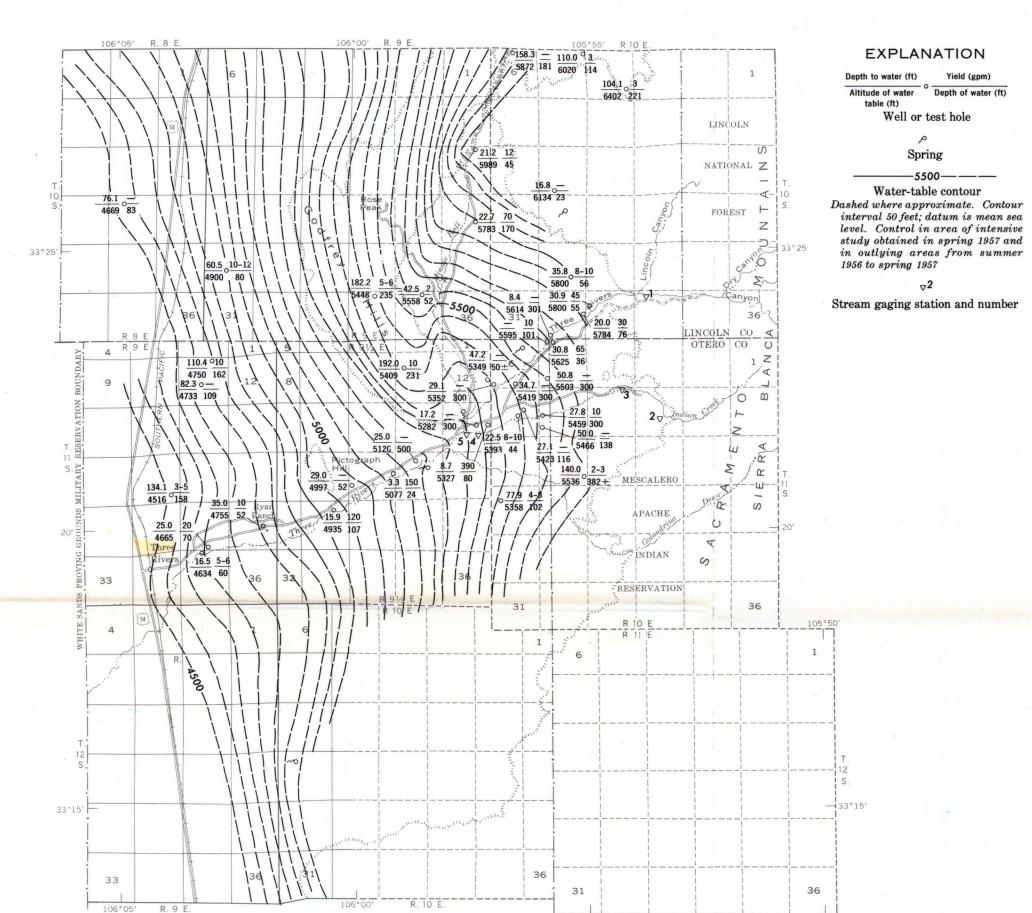


FIGURE 2.-MAP SHOWING CONTOURS ON THE WATER TABLE

DEPTH OF WELLS, DEPTHS TO WATER, AND YIELD OF WELLS

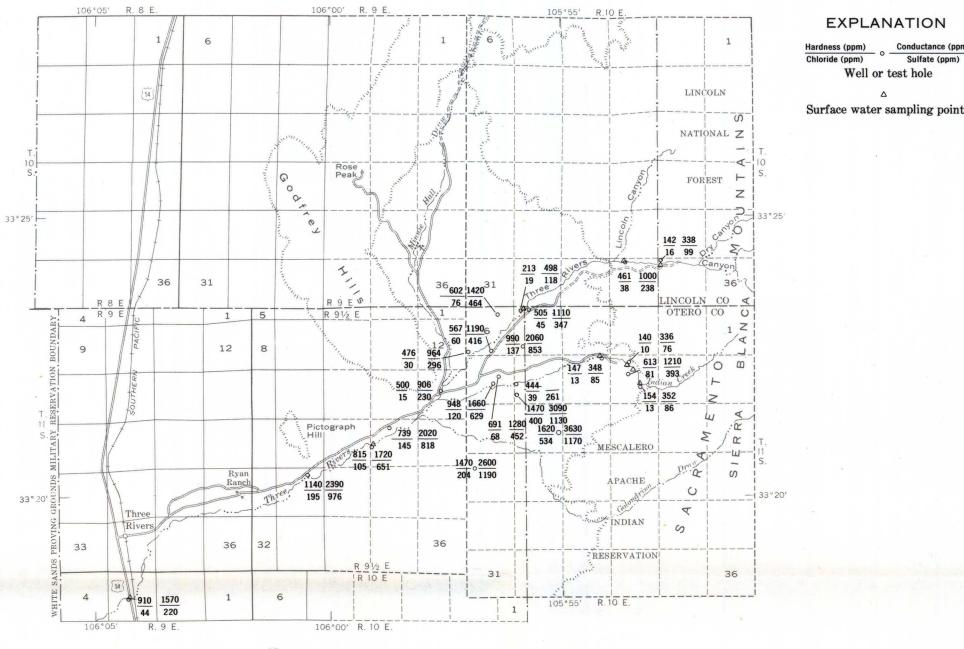


FIGURE 3.—MAP SHOWING CHEMICAL QUALITY OF GROUND WATER

TABLE 1.— Summary of approximate aquifer coefficients determined from test holes, 1957

Coefficient of Discharge at at end of test of test end of test (gpm per foot of (gpd per foot) (gpm) $SE\frac{1}{4}SW\frac{1}{4}NE\frac{1}{4}$ sec. 7, T. 11 S., R. 10 E. SE1/4SW1/4SW1/4 sec. 32, T. 10 S., R. 10 E. $SW_4SW_4SW_4$ sec. 6, T. 11 S., R. 10 E. $SW_4SW_4SE_4$ sec. 6,

T. 11 S., R. 10 E.

SE1/4SW1/4NE1/4 sec. 13, T. 11 S., R. 9½ E. $SE\frac{1}{4}NE\frac{1}{4}NW\frac{1}{4}$ sec. 23, T. 11 S., R. 9½ E. a Based on data from bailer tests Specific capacity is the yield of a well in gallons per foot of drawdown of the water level in the well. INTRODUCTION

The Three Rivers drainage basin is one of many tributaries to the vast semiarid Tularosa Basin of south central New Mexico. At the request of the U.S. Army, Corps of Engineers, the U.S. Geological Survey made a study to determine the availability and quality of water in the area that might be utilized by military installations in the Tularosa Basin. The study involved geologic mapping, well inventory, and the drilling and testing by pumping of exploratory test holes. The results of the study are given in this report.

The Three Rivers area includes about 150 square miles east of Three Rivers station on the Southern Pacific Railroad and U.S. Highway 54, about 20 miles north of Tularosa, N. Mex. It includes parts of T. 10 S., Rs. 8 and 10 E., Lincoln County, and parts of Tps. 11 and 12 S., Rs. 9, 91/2, and 10 E., Otero County, N. Mex. (See fig. 1.)

TOPOGRAPHY

The Three Rivers area is in the Sacramento section of the Basin and Range province (Fenneman, 1931, p. 394), at the east side of the Tularosa Basin. The eastern margin is on the west slope of Sierra Blanca, whose crest forms the divide between Tularosa Basin and the Pecos River basin. From the crest of Sierra Blanca, altitude 12,003 feet, the land slopes precipitously to the west, as much as 2,500 feet per mile. In the central part the slope is less, about 125 feet per mile at the confluence of the three streams constituting Three Rivers. At Three Rivers station on the Southern Pacific Railroad, altitude 4,568 feet, the slope is only about 50 feet per mile. The Godfrey Hills form a low range between Sierra Blanca, which dominates the landscape, and Tularosa Basin.

Except for the Three Rivers reentrant, most of the lower slopes adjacent to Sierra Blanca and Godfrey Hills are coalescing alluvial fans that slope westward; these are cut by subparallel arroyos and interrupted by small masses of consolidated rock. The Three Rivers reentrant, or embayment, is enclosed by Godfrey Hills on the west, an adjoining spur of Sierra Blanca on the north, Sierra Blanca on the east, and a high-level pediment on the southeast. The reentrant was formed because the sedimentary rocks were eroded more rapidly than the surrounding igneous rocks. The adjoining high-level pediment apparently was developed because streamflow was less on the pediment than it was in the reentrant. The most promising part of the area for development of ground water is within the Three Rivers reentrant.

CLIMATE The western part of the area is semiarid, characterized by scant precipitation, low relative humidity, and strong winds during the spring. Winters generally are mild, and the summers have hot days but cool nights. The eastern part, however, has a somewhat different climate because precipitation increases and air temperature decreases with altitude. Owing to the lower temperatures eastward, much of the precipitation, especially in winter, is stored as snow and ice, which contributes to the perennial flow in Three Rivers and its tributaries.

Local precipitation and runoff from the upper slopes is the source of recharge to water-bearing formations. About 60 percent of the annual precipitation is distributed from May through September, during the thundershower season. Precipitation varies widely ranging from nearly 70 percent below normal at Alamagordo in 1956 to about 65 percent above normal at Tularosa in 1958. The last of a series of drought years was 1956. Precipitation at all stations was near or slightly above normal in 1957, above normal in 1958, and near normal in 1959. These year-to-year fluctuations are reflected in the records of ground-water levels and streamflow.

Drainage is westward through arroyos that are dry except during and immediately after thundershowers. The large

arroyos head in mountain canyons; the small ones head on the alluvial fans. None drain large basins.

Three Rivers parallels the trend of the arroyos and has only a few short tributaries in its lower reaches. From the south end of Godfrey Hills eastward, however, the Three Rivers drainage system has a well-developed dendritic pattern. Four major tributaries join at the south end of Godfrey Hills: Minnie Hall Draw, an arroyo, drains southward; Three Rivers Canyon, which heads on Sierra Blanca, drains west-southwestward; Indian Creek, which also heads on Sierra Blanca, flows westward; and Golondrina Draw, which heads on the south slopes of Sierra Blanca, drains northwestward. Three Rivers Canyon and Indian Creek yield the most water, owing to the high altitudes of their upper reaches.

WATER RESOURCES

SURFACE WATER Three Rivers Canyon and Indian Creek are perennial in their upper reaches, and all the stream courses carry floodwater after infrequent thundershowers. The flow characteristics of the several lesser drainage basins are controlled by meteorologic conditions, topographic variations, lithology, geologic structure, and water-management works.

Daily rates of discharge at station 1 in Three Rivers Canyon generally do not fluctuate abruptly, but the annual discharge fluctuates more than 30 cfs (cubic feet per second). Flow past the station is maintained both by rainfall and by melting snow and ice. Flow resulting from snowmelt generally continues to about the middle of June. Forest cover in the upper reaches of the canyon aids in smoothing the response to summer rains by slowing the rate of runoff. The canyon channel above the station (altitude 6,175 feet) has a drainage area of 6.9 square

Daily discharge rates of Indian Creek at the uppermost gage (station 2, fig. 2) generally change smoothly partly because of the forest cover above the station. The annual range in daily discharge is about 35 cfs. Flow resulting from snowmelt generally ends in June. The canyon above the station (altitude 6,250 feet) has a drainage area of 6.8 square miles.

Diversion from Three Rivers Canyon is small and is used mainly for stock. Water from Indian Creek, however, is diverted by a rock dam in sec. 10, T. 11 S., R. 10 E. on the Mescalero Apache Indian Reservation for irrigating crops and watering stock. Water is diverted nearly always when the creek is flowing. Generally less than 10 acre-feet per month also is diverted from Indian Creek by a low dam immediately above gage 4 on Indian Creek near its mouth, in sec. 13, T. 11 S., R. 9½ E.

The lower reaches of Three Rivers Canyon, Indian Creek, the

lesser tributaries, and the main stem of Three Rivers generally are dry, except when runoff due to snowmelt is sufficient to reach the lower reaches or when thundershowers occur in the Three Rivers reentrant. Most of the time the stream courses lose water, but occasionally ground water may discharge to the

During dry or near-normal years Indian Creek at station 5 is dry, or nearly so. Daily discharge rates fluctuate abruptly as a result of flash floods; annual fluctuations are 65 cfs or more. Most flow in the creek probably results from rainfall, and only during wet years does much snowmelt pass the station. The Indian Creek drainage basin above the gage (altitude 5,300 feet) and below station 2 includes 10.9 square miles, 4.1 square miles more than that above the upper gage.

Some floods in the lower parts of the area last from 4 to 6 hours in the arroyos, but flows from the major tributaries may last several days. Owing to the steep slopes and relatively sparse cover, runoff from the lower parts is rapid—unlike the generally smooth runoff of the mountain canyons, where forest cover and ground-water discharge act as controls.

Potential supplies from the streams.—An appreciable amount of surface water is available. During 29 months of gaging in Three Rivers Canyon, 2,900 acre-feet of water passed the station, equivalent to 1.1 mgd (million gallons per day). During 28 months of gaging, 4,660 acre-feet (1.8 mgd) passed the upper gage on Indian Creek, and 2,030 acre-feet (0.7 mgd) passed the gage at the mouth of Indian Creek.

Chemical quality of surface water.—The most objectionable mineral constituent in water sampled in the Three Rivers area is sulfate. The U.S. Public Health Service (1962) recommends that a drinking water supply should not contain more than 250 ppm (parts per million) sulfate, 250 ppm chloride, or 500 ppm dissolved solids, where other more suitable supplies are or can be made available.

The water from the upper Three Rivers Canyon and Indian Creek generally contains only small amounts of dissolved solids. Rocks in the Sierra Blanca are igneous and contain only small amounts of readily soluble minerals. Water that issues from seeps and springs and maintains the low flow of the two streams comes from such rocks and from the soils derived from the rocks. Runoff from snowmelt and rain in the mountains should contain even less dissolved solids.

In the lower reaches of Three Rivers Canyon and on the main stem of Three Rivers, the surface water is of poorer quality. Owing to the wide range of discharge rates and the different geologic environments of the several runoff areas, the dissolved-solids content of water samples ranged from 346 to more than 1,000 ppm. Sulfate ranged from 2.7 to 651 ppm.

The quality of surface water during floods differs, these differences being attributed to events preceding the floods. During drought or periods of light rainfall, formations that contain readily soluble minerals develop a crust of minerals because water from light showers infiltrates only a short way into the ground, leaches soluble minerals, and, by capillary action, brings them to the surface, where the water is again evaporated during hot, dry periods. Along streambeds during low flow and in areas where the water table is immediately below the surface of the streambed, considerable quantities of water are evaporated during hot, dry periods, leaving crusts of soluble mineral matter. Subsequently, when heavy showers fall, the first water that runs off dissolves a large part of the soluble deposits and carries them away. Later runoff is progressively less mineralized.

The quality of surface water from the eastern higher part of the Three Rivers area is superior to that of most ground water. Surface water from the lower part is one to three times as mineralized as that from the upper part. The poorest surface water and the best ground water are roughly comparable in quality.

GROUND WATER

The principal aquifers are the alluvium of Quaternary age, the beds of sandstone in the lower part of the Cub Mountain Formation of Bodine (1956), and the upper part of the Mesaverde Group. (See fig. 1.) Older formations, owing to their great depth and poor circulation of water, probably contain highly mineralized water.

Water in the alluvium of the Three Rivers area generally is unconfined, although it may be confined locally beneath lenses of clay or silt. Water in the older, consolidated sedimentary rocks of the Cub Mountain Formation and the Mesaverde Group generally is confined under considerable pressure.

The depth to water in most of the Three Rivers reentrant ranges from about 50 feet below the land surface in some of the interstream areas to only a few feet beneath the streambeds. North of the reentrant, water levels are more than 100 feet below the land surface, as in the Batann Lodge well in the NW4SE4SE4 sec. 4, T. 10 S., R. 10 E. South of Indian Creek, the depth to water increases as the altitude of the land surface increases. West of the Three Rivers confluence and Godfrey Hills, the depth to water also is influenced by the altitude of the land surface. Levels in wells along Three Rivers range from about 3 to 35 feet below the land surface, but in the adjacent upland they may reach 134 feet, as in the well in the NE¹/₄NW¹/₄NE¹/₄ sec. 11, T. 11 S., R. 9 E.

Water is discharged by several small springs, such as the one in the SE¹/4NW¹/4NE¹/4 sec. 6, T. 11 S., R. 10 E., where northeastward-dipping impermeable rocks intersect the water table and act as subsurface dams. Some of the impermeable rocks are sills in the reentrant area. Water is perched on top of the Tertiary(?) igneous rocks of the Godfrey Hills where Chapel Spring in the SE¼NE¼NW¼ sec. 13, T. 11 S., R. 9½ E. discharges from porphyritic volcanic rock.

The water table in the Three Rivers area slopes in much the same direction as the land surface (fig. 2), southward from the northern part of the reentrant and westward from the eastern part. South and west of Godfrey Hills it slopes rather uniformly westward into Tularosa Basin.

The water-bearing formation in the Three Rivers reentrant are recharged from precipitation and infiltration of water from the several streams that issue from the Sierra Blanca. Some water that falls upon or flows over the coarse-grained alluvium sinks into the ground and continues downward to the water table. Water enters the consolidated sedimentary rocks at a lesser rate, partly by movement from temporary storage in the alluvium. Data are insufficient on which to estimate the amount of annual recharge. Some potential recharge is rejected because the aquifer is full locally.

Most ground water in the Three Rivers area is discharged by movement westward, and some is used by vegetation along the stream channels. Transpiration probably is greatest in the Three Rivers reentrant, where vegetation is comparatively abundant. Although the vegetation is sustained mainly by soil moisture, some undoubtedly is sustained in part by ground water, especially during drought. In addition to movement out of the area and transpiration, water is discharged naturally from the Three Rivers area by evaporation in areas of shallow water table and from open water surfaces. The water table is immediately below some streambeds, and during dry, windy periods much ground water is evaporated.

Discharge from wells in the Three Rivers area is small. The combined maximum discharge by pumping is about 1,000 gpm, insignificant compared to the amount available.

Transmissibility of the water-bearing formations.—The coefficient of transmissibility (T) is the rate of flow of water in gallons per day through a strip of an aquifer 1 mile wide under a hydraulic gradient of 1 foot per mile. Not all the pumping tests made during the investigation were sufficiently controlled or long enough to provide accurate aquifer data, but they indicate the general magnitude of the coefficient of transmissibility.

The results of the pumping tests are summarized in table 1. Chemical quality of the ground water. —Most water from the wells and springs is of fair to very poor quality for municipal or domestic use. The ground water is largely of the calcium-magnesium sulfate type, and the sulfate content generally governs its potability. Wherever the water is usable with regard to sulfate, it is usable also with regard to chloride.

The pattern of chemical quality (fig. 3) shows that usable ground water is restricted to a rather small area of the reentrant. In the northern part of the reentrant, from sec. 30, T. 10 S., R. 10 E. northward, ground water contains 700 ppm or more of sulfate. South of Indian Creek, three wells all yield water containing more than 1,000 ppm of sulfate. From these wells, and from the south end of Godfrey Hills downgradient to Three Rivers station, the ground water contains increasingly larger amounts of sulfate.

Ground water in the remaining area, 5 to 7 square miles in the central and southwestern parts of the reentrant, has a sulfate content generally ranging from 200 to 500 ppm. The alluvium here is largely derived from rocks having few readily soluble minerals. In other parts of the Three Rivers area, water moves through sedimentary rocks rich in sulfate minerals and through alluvium derived from those rocks.

Water from the Tertiary volcanic rocks in Godfrey Hills is high in dissolved solids, especially sulfate. The volcanic rocks of the Godfrey Hills apparently contain a separate water body not connected with that in the alluvium of Quaternary age and older sedimentary rocks. The aquifer is recharged by direct precipitation on the hills. The origin of the higher mineral content of the water is not known, but minerals may be carried into the volcanic rocks by hydrothermal activity in connection with some of the small bodies of intrusive rocks or into the area as dust carried by the prevailing southwesterly winds from the Tularosa Basin.

Potential development of ground-water supplies.—The best aguifer, with respect to both quantity and quality of water, is the alluvium of Quaternary age. The Cub Mountain Formation of Bodine (1956) and the Mesaverde Group also yield water that is potable (potable as used in this report is water containing no more than 250 ppm (parts per million) of chloride or sulfate ions), or nearly so, but in much smaller quantities. The largest quantities of ground water of the best quality in the reentrant are in the following tracts: SE1/4 sec. 12 and NE¼ sec. 13, T. 11 S., R. 9½ E.; the S½ sec. 6; and that part of sec. 7, T. 11 S., R. 10 E. north of Indian Creek. The area between the well in the SE¼SE¼NE¼ sec. 13, T. 11 S., R. 9½ E. and a test hole in the SE¼SW¼NE¼ sec. 7, T. 11 S., R. 10 E. seems to be the most promising. In most of the area thus described, carefully constructed and throughly developed wells no more than 300 feet deep should yield more than 100 gpm each. In the vicinity of the test hole in sec. 7, it should be possible to construct wells that would yield approximately 200 gpm each.

Elsewhere in the reentrant, prospects for potable ground water are not good. The alluvium in the northern part apparently is not thick and the quality of ground water probably is poor. The poor quality of ground water south of Indian Creek and west of Godfrey Hills removes those areas from consideration. Only one other part of the reentrant may be worth consideration—the vicinity of Three Rivers Canyon in sec. 32 and the W1/2 sec. 33, T. 10 S., R. 10 E. Yields from wells in the upper Three Rivers Canyon area probably would not exceed 100 gpm; however, the quality of the water apparently is much better than that downstream in the reentrant.

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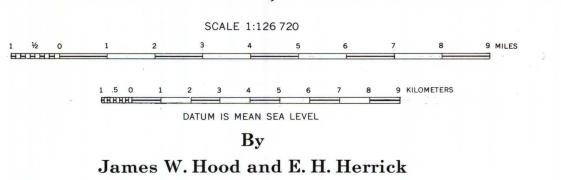
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NTERIOR-GEOLOGICAL SURVEY, WASHINGTON D. C.-1965-W643

WATER RESOURCES OF THE THREE RIVERS AREA, OTERO AND LINCOLN COUNTIES, NEW MEXICO

1965



Base maps from U.S. Geological Survey topographic quadrangles