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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

RECONNAISSANCE OF GROUND WATER FOR IRRIGATION, ACOMA INDIAN RESERVATION, VALENCIA COUNTY, NEW MEXICO

By

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A reconnaissance was made to determine the physical character and hydrologic properties of the geologic formations in the reservation. Pertinent data on wells and springs in the area were abstracted from the files of the Bureau of Indian Affairs. (See table 1.) Samples of water were collected from two wells for chemical analysis. These and previous analyses of ground-water samples from wells and springs in the area are shown in table 2.

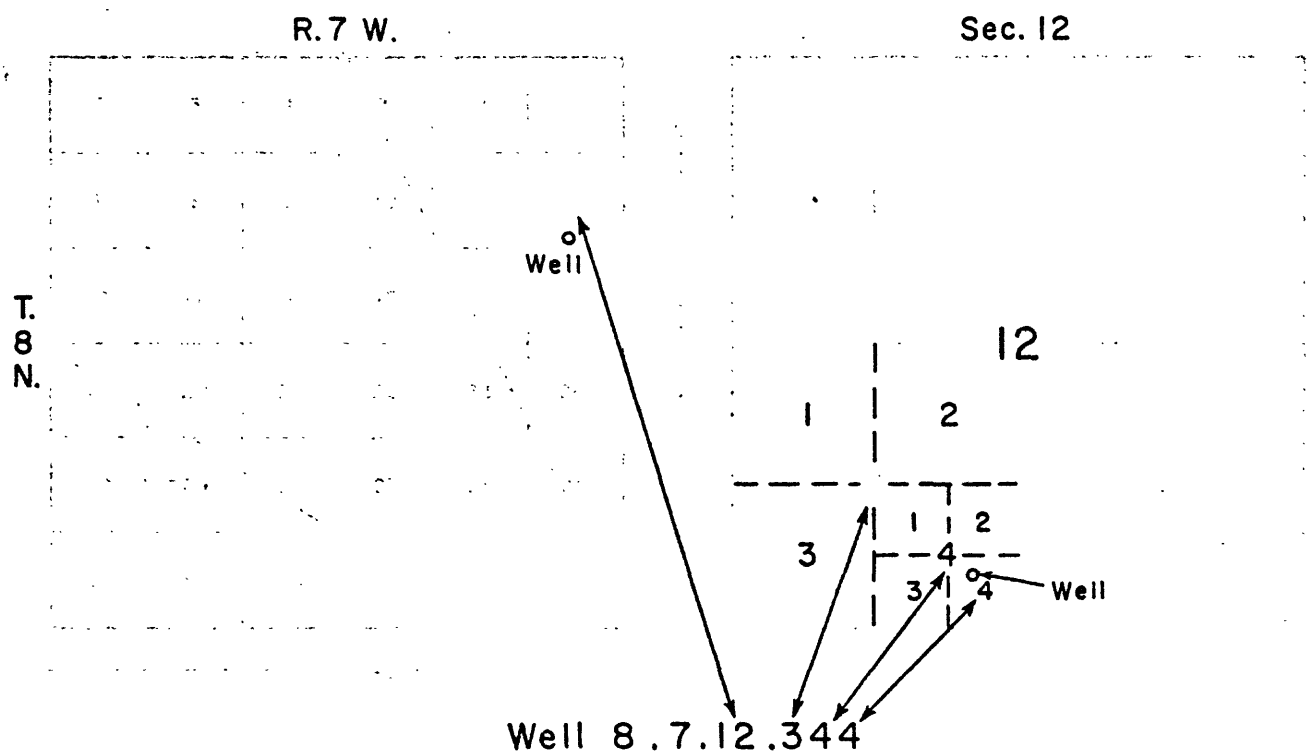
Areal hydrologic studies in the reservation have not been made in recent years, although several local investigations involving selection of sites for domestic and stock wells have been made and an irrigation well has been tested for the Bureau of Indian Affiars. The discussion of the availability of water for irrigation in the reservation is based largely on data collected during the local investigations and on published areal geologic information.

Topographic relief is sharp in the area. Mount Taylor, an eroded volcanic cone just north of the reservation, is the dominant physical feature, rising several thousand feet above the surrounding region. It has influenced profoundly the regional topography. The sheer cliffs of mesas and buttes along Acoma Valley are spectacular features; the best known of these are Acoma Mesa, on which the pueblo of Acoma was built, and Mesa Encantada.

The reservation is in the drainage basin of the Rio San Jose, which flows eastward across the extreme northern part of the reservation toward its confluence with the Rio Puerco about 30 miles to the southeast. The Rio San Jose is perennial in the reach through the reservation and has a gradient of about 20 to 25 feet per mile. Principal tributaries to the Rio San Jose that drain the southern part of the reservation are Acoma Creek and its tributaries Paradise Creek and the stream in Ojo Canyon, all of which are intermittent.

System of numbering wells in New Mexico

All wells referred to in this report are identified by the method 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. If a well has not been located closely enough to be placed within a particular section or tract, a zero is used for that part of the number. The letter "S" following a location is used to indicate a spring.



Acoma NM-64

GROUND-WATER GEOLOGY

The Acoma Reservation is underlain by sedimentary rocks ranging in age from Pennsylvanian(?) to Recent. The regional dip of the rocks is about 4° northward toward Mount Taylor, but locally the dip may be as much as 8° in any direction. Regionally, the geology is complex. Other discussions of the geology may be found in previous geological reports on the area by Freeman and Hilpert (1956)/ and Dane and Bachman (1957)/.

/Freeman, V. L., and Hilpert, L. S., 1956, Stratigraphy of the Morrison formation in part of northwestern New Mexico: U.S. Geol. Survey Bull. 1030-J.

/Dane, C. H., and Bachman, G. O., 1957, Preliminary geologic map of the northwestern part of New Mexico: U.S. Geol. Survey Misc. Geol. Inv. Map I-224.

The outcrop pattern of formations is shown on figure 1 and their age, thickness, general lithology, and water-bearing properties are summarized in table 2. Rocks older than Triassic are deeply buried and data on them are sparse; therefore, they are not described in this report. Geologic formations of Triassic to Recent age that were considered as possibly being potential aquifers in the Acoma Reservation are described briefly in the following paragraphs.

Chinle Formation

The Chinle formation of Late Triassic age consists mainly of beds of red, maroon, gray, and greenish-gray shale and siltstone, but locally it contains very fine- to very coarse-grained channel sandstones, especially in the upper part of the formation. The Chinle formation crops out in the extreme southeastern part of the reservation (fig. 1), but at most places it is several hundred feet below the surface.

The Chinle formation does not yield much water to wells on the reservation, because in most of the area it is deeply buried, and, perhaps, because it has not been adequately tested. In nearby areas, the channel sandstones of the Chinle yield small supplies of water to domestic and stock wells and to at least one irrigation well. Most of the wells that tap the Chinle in the reservation yield only 3 to 10 gpm (gallons per minute), hence the Chinle does not appear to be a potential source of irrigation water.

San Rafael Group and Zuni Sandstone

The lower part of the San Rafael group of Middle and Late Jurassic age is composed mainly of fine- to medium-grained massive to strongly crossbedded sandstone. The sandstones are tan, buff, gray, pink, and brick red to white. Rocks of the San Rafael group underlie the valley of Paradise Creek and Ojo Canyon and crop out in the lower part of the escarpments that border the lowland area in the southeastern part of the reservation (fig. 1). This unit is several hundred feet below the

Figure 1.--Map showing geology and locations of wells and springs in the Acoma Reservation, Valencia County, N. Mex.

surface in the northern and western parts of the reservation.

The Zuni sandstone of Late Jurassic age, which overlies the San Rafael group, consists of buff and tan to light-gray fine-grained sandstone. The Zuni generally is massively bedded, but locally it is thin bedded and crossbedded. It includes equivalents of the Morrison formation, which crops out in the northern part of the reservation, and the Bluff sandstone, the Summerville formation, and the Todilto limestone. These formations thin abruptly toward the south and grade into the Zuni sandstone. The Zuni sandstone crops out along the valleys of Acoma and Paradise Creeks, and in Ojo Canyon. It forms bluffs along the valley walls and mesa escarpments, and in places it underlies the valleys. It is several hundred feet beneath the surface in much of the northern and western parts of the reservation.

The lower part of the San Rafael group and the Zuni sandstone yield water individually to several stock and domestic wells and springs in the reservation. The yields of the wells generally are 3 to 5 gpm. No attempt was made to measure the discharge of the springs, but reportedly these discharges are small -- generally less than 5 gpm.

The water in the lower part of the San Rafael group and the Zuni sandstone generally is unconfined, but locally it is under artesian pressure. These units apparently are recharged by local infiltration of precipitation and by stream runoff from higher areas adjacent to the reservation to the west and the south. The movement of water through these formations is not fully understood. Igneous dikes, which cut the Jurassic formations, restrict or prevent deep movement or circulation of fresh water and probably are the cause of the presence of highly mineralized water in these formations in areas where they normally would be expected to contain fresh or only slightly mineralized ground water.

An irrigation test well (8.7.16.310) that tapped both the lower part of the San Rafael group and the Zuni sandstone was drilled to a depth of 405 feet. It was cased with 12-inch casing, which was perforated from 146 to 168 feet, from 232 to 254 feet, and from 361 to 405 feet.

Well 8.7.16.310 was tested by pumping for 2½ hours in December 1938 by G. C. Taylor, Jr., and C. S. Conover of the U.S. Geological Survey. The water level in the well prior to pumping was 10.02 feet below the land surface. After the well was pumped for 19 minutes at a rate of about 230 gpm, the drawdown was 315 feet (air-line measurement). The discharge was computed by measuring the components of the trajectory of the water stream issuing from the discharge pipe. Near the end of the test the yield had decreased to about 160 gpm and the drawdown was 308 feet. The average rate of discharge was estimated to be 180 gpm. The specific capacity of the well was about 0.6 gpm per foot of drawdown. The recovery of the water level was measured after pumping was stopped. The recovery curve indicated a coefficient of transmissibility of 250 gpd (gallons per day) per foot. This means that 250 gallons of water a day will flow through each vertical saturated strip of the aquifer 1 foot wide, under a hydraulic gradient of 1 foot per foot. A coefficient of transmissibility of 250 gpd per foot is low, when compared to coefficients in the order of 100,000 gpd per foot or more in many ground-water irrigation districts.

The specific capacity of the well during the test indicates that a discharge of 230 gpm could be obtained at a drawdown of 400 feet. Over long periods of pumping, however, the yield probably would decrease to 100 gpm or even less at a drawdown of 400 feet. The yield of well 8.7.16.310 is the largest of any that tap the lower part of the San Rafael group and Zuni sandstone in the region, and it is doubtful that these units could sustain a ground-water irrigation project..

Morrison formation

The Morrison formation of Late Jurassic age is composed of moderately soft claystone and siltstone and beds of very fine- to coarse-grained sandstone. The beds of claystone and siltstone are maroon, red-gray, yellow, orange, and green to gray. The beds of sandstone are light yellowish-gray, light reddish-brown, pale-orange, green, and white. Nodules and beds of limestone as much as 1 foot thick are common in the claystone units.

The Morrison formation crops out in the northeastern part of the reservation along the Rio San Jose and Acoma Creek valleys and in Canada, Arizona. The formation extends southward to about Mesa Encantada, where it grades into the Zuni sandstone, although the precise stratigraphic relation of the Morrison to the Zuni is not clearly understood.

No well is known to produce potable water from the Morrison formation in this area. Several wells drilled in the Rio San Jose Valley reportedly penetrated the Morrison; however, the wells were abandoned because only small yields of impotable water were obtained. The Morrison formation apparently cannot be considered as a potential source of irrigation water.

Dakota Sandstone

The Dakota sandstone of Early(?) and Late Cretaceous age consists of buff to gray sandstone containing beds of dark-gray to black carbonaceous shale. In many places the lower beds of the Dakota are coarse grained and gritty and locally they are conglomeratic. Where the lower beds of coarse-grained sandstone and the beds of shale are absent from the Dakota sandstone, that formation is difficult to differentiate from the overlying basal sandstone of the Tres Hermanos sandstone member of the Mancos shale. The Dakota sandstone, as shown on the generalized geologic map in this report (fig. 1), probably includes part or all of the Tres Hermanos sandstone member of the Mancos shale.

The Dakota sandstone crops out in the bluffs bordering the valleys of Acoma Creek and its tributaries and along the eastern reach of the valley of the Rio San Jose. It has a maximum thickness of about 75 feet in the northern part of the reservation; the thickness generally is not more than 20 feet. The Dakota sandstone is not the principal aquifer in any of the wells in the area. Some seeps occur along the area of outcrop, but the amount of water discharged from them is reported to be small.

The Dakota sandstone is not a potential source of irrigation water in the reservation, because it is thin and it has a low permeability.

Mancos Shale

The Mancos shale consists mostly of dark-gray shale, containing a few thin stringers of light-colored calcareous sandstone and, in the lower part, three beds of medium- to fine-grained buff sandstone named the Tres Hermanos sandstone member. The Mancos crops out in much of the western half of the reservation (fig. 1).

The Tres Hermanos sandstone member is recharged directly by precipitation and by stream runoff. The water moves northward downdip between relatively impermeable shales of the Mancos to points of discharge in the valley of the Rio San Jose and eastward in the valley of Acoma Creek and its tributaries. Ground water is discharged from the Tres Hermanos through seeps and springs, or is lost into the overlying alluvium.

The Tres Hermanos sandstone member is the only part of the Mancos that yields water to wells. Wells tapping the Tres Hermanos sandstone member generally yield about 12 to 15 gpm. The small yield of the Tres Hermanos member precludes it as a potential source of irrigation water.

Basalt and Diabase

Basalt flows and intrusive diabase dikes of Miocene(?) and Pliocene(?) age are common in the reservation. The flows cap upland areas bordering the main valleys and the dikes cut the older sedimentary formations. Neither are aquifers in the reservation. The dikes affect the regional hydrology, however, by restricting the movement of ground water and separating the water-bearing formations into segments.

Alluvium

The major stream valleys contain alluvium of Pleistocene and Recent ages that yields water to domestic and stock wells; in part of the Rio San Jose Valley basalt flows are interbedded with the alluvium. The alluvium is not shown on the generalized geologic map (fig. 1) because the exposures are too narrow to be shown at the scale used. The alluvium underlying the Rio San Jose Valley is mainly fine grained, but locally, lenses of coarse sand and gravel are common. The driller's log of well 8.7.16.310 in Acoma Creek valley indicates that sand and gravel (alluvium) extend to a depth of 145 feet, but the alluvium in this well was not tested for yield. (See table 3.) The alluvium in well 8.7.16.310 may have been mixed with silt and clay, as in exposures in the valley, but it is probable that lenses of gravel or sand free of silt and clay occur locally.

Alluvium beneath the valleys of the Rio San Jose and its main tributaries is recharged mainly by precipitation and by inflow from the bedrock aquifers, and is discharged mainly through underflow out of the area and by evapotranspiration. The luxuriant growth of phreatophytes along the stream valleys indicates that a considerable amount of water is transpired by these plants.

The alluvium in the Rio San Jose Valley probably will yield more water to wells than alluvium in tributary valleys, because the alluvium in the Rio San Jose Valley is coarser and better sorted than in tributary valleys. The alluvium is also more extensive in the Rio San Jose Valley than in the tributary valleys, and it receives recharge from both inflow of ground water and water infiltrating from the Rio San Jose.

The alluvium in places probably could supply water in quantities sufficient for irrigation in the reservation, but it has not been adequately tested. The general physical character of the alluvium suggests that it deserves testing as a potential source of irrigation water, especially in the Rio San Jose Valley near Anzac.

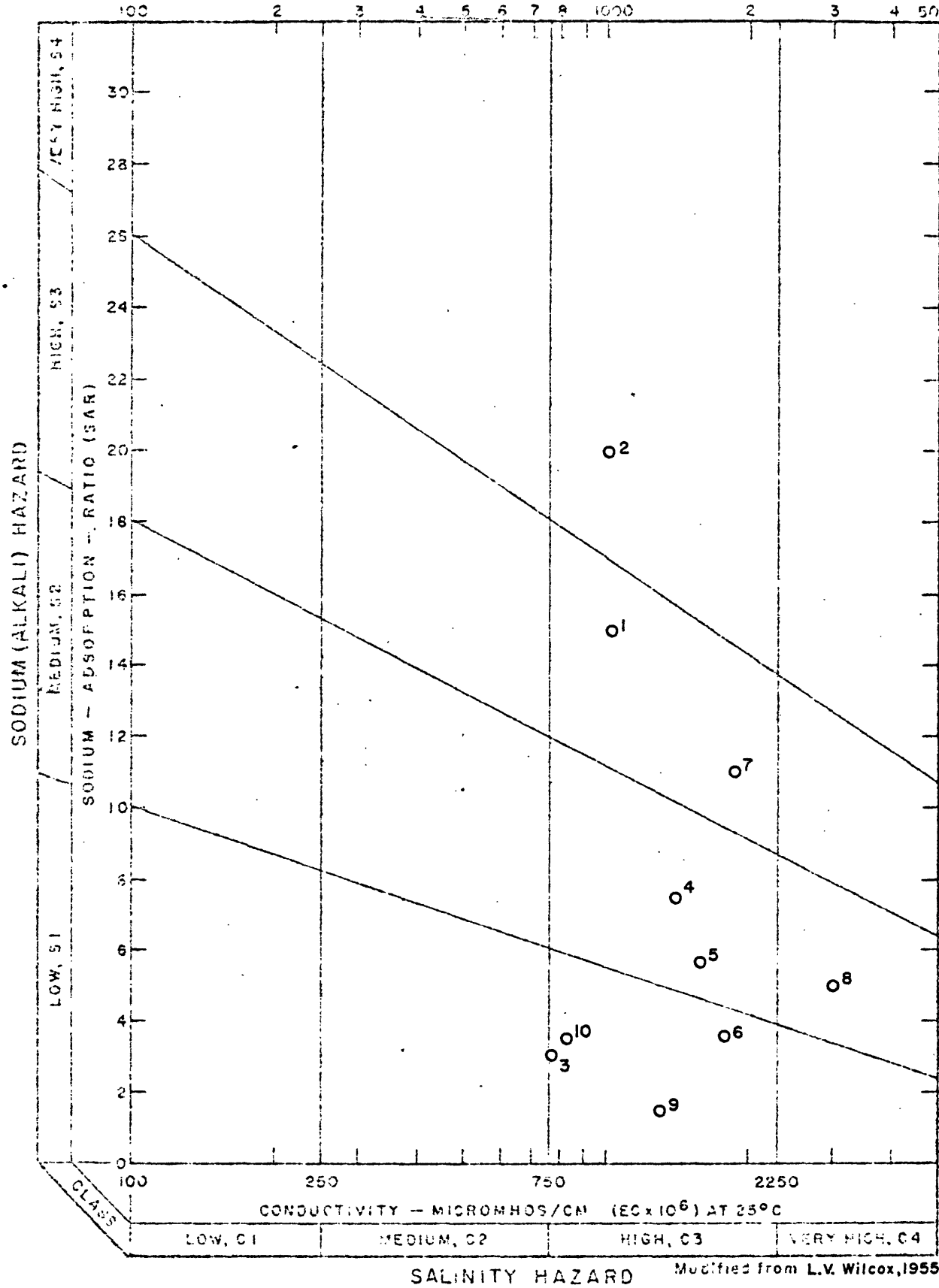


Figure 2.--Suitability of water for irrigation in the Acoma Reservation, Valencia County, N. Mex.

CHEMICAL QUALITY OF THE GROUND WATER

The chemical quality of ground water in the main aquifers in the reservation is satisfactory for irrigation of salt-tolerant plants on soils having good drainage according to the classification of Wilcox.[1]

[1] Wilcox, L. V., 1955, Classification and use of irrigation waters: U. S. Dept. Agriculture Circ. 969.

(See table 4 and fig. 2.) Seven of the 10 analyses plot in the S1 and S2 sodium-hazard classes and 9 plot in the C3 salinity-hazard class on figure 2. The S2 classification indicates that the water "may be used on coarse-textured or organic soils that have good permeability." The C3 classification means that the water cannot be used on soils having restricted drainage. Even with adequate drainage, special management for salinity control may be required, and plants having good salt tolerance should be selected. Four of the water samples fall within the "unsatisfactory to unsuitable" classification, and the water should be used for irrigation only under special conditions.

Figure 2.--Suitability of ground water for irrigation in the Acoma Reservation, Valencia County, N. Mex.

Boron in relatively small concentrations in irrigation water is toxic to plants. Two samples of ground water from wells in the reservation were analyzed for boron and contained 0.03 and 0.28 ppm (parts per million). These concentrations are below the permissible limit of 0.33 ppm for boron-sensitive crops, as defined by Wilcox (1955). Therefore, the boron content of the ground water in the reservation apparently is within the tolerance limit of all crops and would not be a problem.

SUMMARY

The three main aquifers in the Acoma Reservation are the lower part of the San Rafael group and Zuni sandstone, the Tres Hermanos sandstone member of the Mancos shale, and the alluvium.

The lower part of the San Rafael group and the Zuni sandstone separately yield water to domestic and stock wells and springs. The two formations were tested together in irrigation test well 8.7.16.310, and they yielded about 160 gpm at a drawdown of 308 feet at the end of a $2\frac{1}{2}$-hour test. The specific capacity of the well was about 0.6 gpm per foot of drawdown and the coefficient of transmissibility of the aquifer was 250 gpd per foot. The yield over a long period of pumping likely would be not more than 100 gpm and possibly much less than 100 gpm. At least five wells would be needed to produce 500 gpm. The wells would have to be widely spaced to assure a minimum of interference between pumped wells. Also, a yield this large is not typical of these units, and it may reflect locally favorable conditions that are not extensive.

The Tres Hermanos sandstone member yields water to wells in quantities sufficient for stock use, but it does not yield adequate quantities of water to wells for irrigation.

Alluvium in the stream valleys may yield water in quantities sufficient for irrigation. The log of only one well that penetrated alluvium is available, well 8.7.16.310, in the valley of Acoma Creek, which penetrated 145 feet of alluvium but was not tested for water yield. However, the log indicates that beds of gravel were penetrated. This well reportedly penetrated a thicker section of alluvium and more gravel than other wells in the valley. Gravel in the outcrops of the alluvium in Acoma Valley contain much silt and clay, but lenses of sorted sand or gravel free of silt and clay may occur locally in the subsurface. The alluvium underlying the valley of the Rio San Jose probably is coarser and better sorted than alluvium in its tributary valleys and should be tested for its ability to yield water to wells.

The chemical quality of the ground water in the main aquifers is suitable for the irrigation of salt-tolerant plants on permeable soils.

REFERENCES CITED

Dane, C. H., and Bachman, G. O., 1957, Preliminary geologic map of the northwestern part of New Mexico: U.S. Geol. Survey Misc. Geol. Inv. Map I-224.

Freeman, V. L., and Hilpert, L. S., 1956, Stratigraphy of the Morrison formation in part of northwestern New Mexico: U.S. Geol. Survey Bull. 1030-J.

Wilcox, L. V., 1955, Classification and use of irrigation waters: U.S. Dept. Agriculture Circ. 969.

Table 3.--Logs of wells in the Acoma Reservation,

Valencia County, N. Mex.

Table 3 contains logs of two irrigation test wells drilled with cable tools in Acoma Valley in 1937. The logs are copies of drillers' logs; however, the formation designations are interpretations of the logs by the author.

Well 8.7.9.100

Material	Thickness (feet)	Depth (feet)
Alluvium		
Surface soil (sandy clay)	20	20
Blow sand, quick	55	75
Zuni sandstone		
Sandstone, white	11	86
Sandstone, buff	4	90
Sandstone, gray	13	103
Shale, red, sandy	12	115
Sand, buff	6	121
Shale, red, sandy	59	180
Sand, white (very small amount of water)	5	185
Lime, gray	16	201
Todilto limestone[a/]		
Lime, gray, hard	11	212
San Rafael group (lower part)		
Sand, red (water)	178	390
Sand, light red (big flow of water; water rises to 12 ft.)	30	420
Sand, gray, soft	40	460
Sand, red, hard	10	470
Chinle formation		
Shale, red	26	496

Note: Water sand was shot from 380 to 400 feet with three cases of 40 percent dynamite and well cleaned out before liner was set.

a/ May include the above 16 feet recorded as gray lime.

Well 8.7.16.310

Material	Thickness (feet)	Depth (feet)
Alluvium		
Adobe surface soil	35	35
Quick-sand - some adobe	8	43
Silt or wash fill	14	57
Wash or quicky silt	23	80
Quick-sand, gravel and silt	20	100
Shale, light-blue	19	119
Gravel	6	125
Gravel	2	127
Gravel running in badly	3	130
Gravel	4	134
Gravel	2	136
Gravel and some shale	9	145
Zuni sandstone		
Shale, red, sandy	5	150
Sand and shale, buff	5	155
Sand, white - water	6	161
Todilto limestone		
Lime, gray	6	167

Well 8.7.16.310 - Continued

Material	Thickness (feet)	Depth (feet)
San Rafael group (lower part)		
Sandstone, gray	33	200
Sandstone, buff	145	345
Shale, red, sandy	31	376
Sand, light-red - water	23	399
Sand, red	31	430
Chinle formation		
Shale, red	15	445

Note: Shot water sand from 375 to 400 feet with 2½ cases of 40 percent dynamite before 12½-inch casing was set on bottom.

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Table 1.--Records of wells and springs in the Acoma Reservation, Valencia County, N. Mex. - Continued

Location	Owner or name	Driller	Year completed	Depth of well (feet)	Diameter of well (inches)	Geologic unit	Water level: Below land-surface (feet)	Water level: Date of measurement	Yield (gpm)	Method of lift	Use of water	Remarks
8.7.28.110	Acoma Tribe	Bureau of Indian Affairs	1938	205	6 5/8	Jz	20	Feb. 1938	10	Cy, W	D, S	Ca, L, Acoma No. 15
30.100	Bureau of Indian Affairs	J. D. Turner	1935	537	6 5/8	Jz, Jsrf	27	Feb. 1935	8	Cy, W	S	Ca, L, Acoma No. 10
8.8.5.200	do.	Bureau of Indian Affairs	1937	662	6 5/8	Km(?)	490	Feb. 1937	-	Cy, W	S	L, Acoma No. 2
14.100	do.	do.	1937	585	6 5/8	Jz			10	Cy, W	S	L, Acoma No. 13
9.7.15.200	do.	J. D. Turner	1935	599	6 5/8	Jz	299	Feb. 1935	10	Cy, W	S	L
9.8.3.300S	do.	-	-	Spring	-	Km	Flowing	Sep. 1952	-	-	D, S	Ca, Largo Spring
12.130S	do.	-	-	do.	-	Km	Flowing	Sep. 1952	-	-	D	Ca, Sheep Dip Spring
18.200	do.	J. D. Turner	1935	410	6 5/8	Km	298	Mar. 1935	15	Cy, W	S	L
30.300	do.	do.	1934	205	6 5/8	Km	150	Dec. 1934	12	Cy, W	S	L
10.7.28.300S	do.	-	-	Spring	-	Km	Flowing	Sep. 1952	-	-	D	Ca, Paytiamo Spring
28.400S	do.	-	-	do.	-	Km	Flowing	Sep. 1952	-	-	D	Ca, Shourlte Spring
31.300	do.		1939	310	-	Jz(?)	-	-	35	-	-	Plugged well, sulphur water
33.200	do.	Bureau of Indian Affairs	1937	1,000	8 5/8 to 6 5/8	Kc	Flowing	May 1957	12	-	-	L, Abandoned
10.8.27.320	do.	do.		240	-	Km	-	-	10-12	-	-	Ca
28.400S	do.	-	-	Spring	-	Km	Flowing	Sep. 1952	-	-	D	Ca, Star Spring
32.310	CAA		1936	373	-	Km	-		-	-	-	Ca, Acomita Airport well
10.9.25.324	Bureau of Indian Affairs 21	Bureau of Indian Affairs	1958	147	6 5/8	Km	54	Jan. 1958	100	-	-	Ca, Anzac well

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Table 1.--Records of wells and springs in the Acoma Reservation, Valencia County, N. Mex.

Geologic unit: Trc, Chinle formation; Jsr, San Rafael group; Jz, Zuni sandstone; Km, Mancos shale.

Method of lift: Cy, cylinder pump; N, none; W, wind.

Use of water: D, domestic; N, not used or abandoned; S, stock.

Remarks: Ca, chemical analysis; Dd, drawdown; L, log in this report or in the files of the Geological Survey, Albuquerque, N. Mex.; Acoma number is Bureau of Indian Affairs identification number.

Location No	Owner or name	Driller	Year completed	Depth of well (feet)	Diameter of well (inches)	Geologic unit	Water level Below land-surface (feet)	Date of measurement	Yield (gpm)	Method of lift	Use of water	Remarks
7.7.6.200	Bureau of Indian ~~BIA~~ Affairs	J. D. Turner	1935	510	6 5/8	Jsr?	435	Jan. 1935	15	Cy, W	S	L, Acoma ~~No.~~ 6
7.8.4.200	do.	do.	1935	497	-	Jz	-	Feb. 1935	-	-	-	L, Hole abandoned, Acoma No. 4
33.320	do.	do.	1935	541	6 5/8	Km	500	Apr. 1935	12	Cy, W	S	L, Acoma ~~No.~~ 5
36.100	do.	do.	1935	756	6 5/8	Km(?)	572	Apr. 1935	14	Cy, W	S	L, Acoma ~~No.~~ 8
8.7.6.420	do.	~~BIA~~ Bureau of Indian Affairs	1937	435	6 5/8	Jz	390(?)	June 1937	10	Cy, W	S	L, Acoma ~~No.~~ 12
8.300 S	do.	-	-	Spring	-	Jz	Flowing	Sep. 1952	-	-	S	Ca, Acoma spring
9.100	do.	~~BIA~~ Bureau of Indian Affairs	1937	496	12 to 8	Jz, Jsr?	12	Dec. 1936	-	N	N	L, Acoma ~~No.~~ 14
10.100	do.	J. D. Turner	1935	347	6 5/8	Jsr?	0	Mar. 1935	10	Cy, W	S	L, Acoma ~~No.~~ 7
16.310	do.	Bureau of Indian ~~BIA~~ Affairs	1937	445	15 to 12	Jz, Jsr?	10	Dec. 1938	180	N	N	Ca, Dd 308, L, sustained yield 100 gpm
22.220	do.	-	1921	267	5	Jsr?	20	Oct. 1952	-	Cy, W	D, S	Ca

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Table 2.--Generalized section of the geologic formations and their water-bearing characteristics, Acoma Reservation, Valencia County, N. Mex.

System	Series	Stratigraphic unit	Estimated thickness (feet)	Lithology	Water-bearing properties
Quaternary	Recent and Pleistocene	Alluvium	0-145±	Mainly beds of silt and sand containing lenses of clay and gravel; interbedded in places with basalt flows.	Supplies shallow domestic and stock wells along valleys of Rio San Jose and Acoma Creek.
		Basalt flows	0-20±	Olivine basalt ("malpais")	Catchment area for recharge from precipitation in valley of Rio San Jose.
Tertiary	Miocene(?) and Pliocene	Basalt flows	0-110±	do.	Catchment area for recharge from precipitation in uplands areas.
		Intrusive rocks		Diabase	Serve as barriers which divide water-bearing formations into segments.
Cretaceous	Upper Cretaceous	Gallup sandstone	0-65	Buff to tan, mainly fine-grained sandstone.	Does not yield water to wells in report area.
		Mancos shale	0-800	Mainly light to dark gray and black shale. Several beds of gray to tan sandstone comprising the Tres Hermanos sandstone member near base.	Sandstone of the Tres Hermanos member yields water to stock wells and springs.
	Upper and Lower(?) Cretaceous	Dakota sandstone	0-75	Buff to gray sandstone containing beds of dark gray to black carbonaceous shale.	Yields little water to springs and wells in the area.
Jurassic	Middle and Upper Jurassic	Morrison formation	0-450	Maroon, red-gray, yellow, orange, green to gray claystone and siltstone containing nodules to nodular beds of limestone and light yellowish-gray, pale orange, white, and light reddish-brown, very fine- to coarse-grained sandstone.	In adjacent areas yields water to domestic and stock wells.
		Zuni sandstone	0-300(?)	Buff, tan to light-gray, mainly fine-grained sandstone. Includes equivalents of Morrison formation, Bluff sandstone, Summerville formation, and Todilto limestone.	Yields water to domestic and stock wells.
		San Rafael group, lower part	0-225	Tan, buff, gray, pink, brick-red to white, mainly fine- but partly medium-grained, massive to cross-bedded sandstone. Equivalent to Entrada sandstone.	Do.
Triassic	Upper Triassic	Chinle formation	1,400	Maroon, brick-red, gray, and greenish-gray shale and silt-siltstone; locally contains channel sandstones in upper part.	Does not yield water to wells in area; yields small supplies of water for domestic and stock use in Laguna Reservation to east and small irrigation supplies about 1 mile west of Acoma Reservation.

Table 4.--Chemical analyses of water from wells and springs in the Isleta Reservation, Valencia County, N. Mex.

[Unpublished results for northern Rio Grande Valley except as noted. Analyses by U. S. Geological Survey]

Principal water-bearing formation: Tr, Chinle formation; Js, San Rafael group; Jz, Zuni sandstone; Km, Mancos shale.

Remarks: No. 1 etc. number of analysis as plotted on figure 5

Location No.	Owner or name	Depth of well (ft)	Depth of casing (ft)	Principal water-bearing formation	Type of water	Date collected	Temperature (°F)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Carbonate (CO3)	Bicarbonate (HCO3)	Sulfate (SO4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as CaCO3	Hardness, noncarbonate	Specific conductance (micromhos at 25° C)	pH	Remarks
8.7.8.300S	Bureau of Indian Affairs	Spring	–	Js	S	9-20-52	–	10	5.1	240	429	193	3.0	1.4	0.2	331	0.93	46	0	92	15	1,050	–	No. 1
22.220	do.	267	–	Jzrl	D, S	10-17-52	–	4.2	3.4	232	310	229	19	.6	.2	636	.89	24	0	95	20	1,030	–	No. 2
28.110	do.	205	–	Jz	S	6- 9-59	76	49	13	96	210	183	19	.8	16	438	.68	196	24	52	3.0	752	8.2	B (Boron), 0.03 ppm, No. 3
30.100	do.	537	–	Jz, Jzrl	S	6- 7-59	65	47	20	245	420	336	24	.9	.2	884	1.21	198	0	73	7.6	1,390	8.6	B (Boron), 0.28 ppm, No. 4
9.8.3.300S	do.	Spring	–	Km	D, S	9-19-52	–	76	39	246	362	519	32	1.1	0	1,110	1.51	350	54	60	5.7	1,580	–	No. 5
12.130S	do.	do.	–	Km	D	9-16-52	–	–	–	–	436	–	22	–	–	–	–	26	–	–	–	1,490	–	
10.7.28.300S	do.	do.	–	Km	D	9-20-52	–	124	72	197	414	519	106	1.5	0	1,770	1.73	606	266	41	3.5	1,790	–	No. 6
10.7.28.400S	do.	do.	–	Km	D	do	–	148	29	370	490	529	40	4.3	2.4	1,370	1.73	218	0	79	11	1,360	–	No. 7

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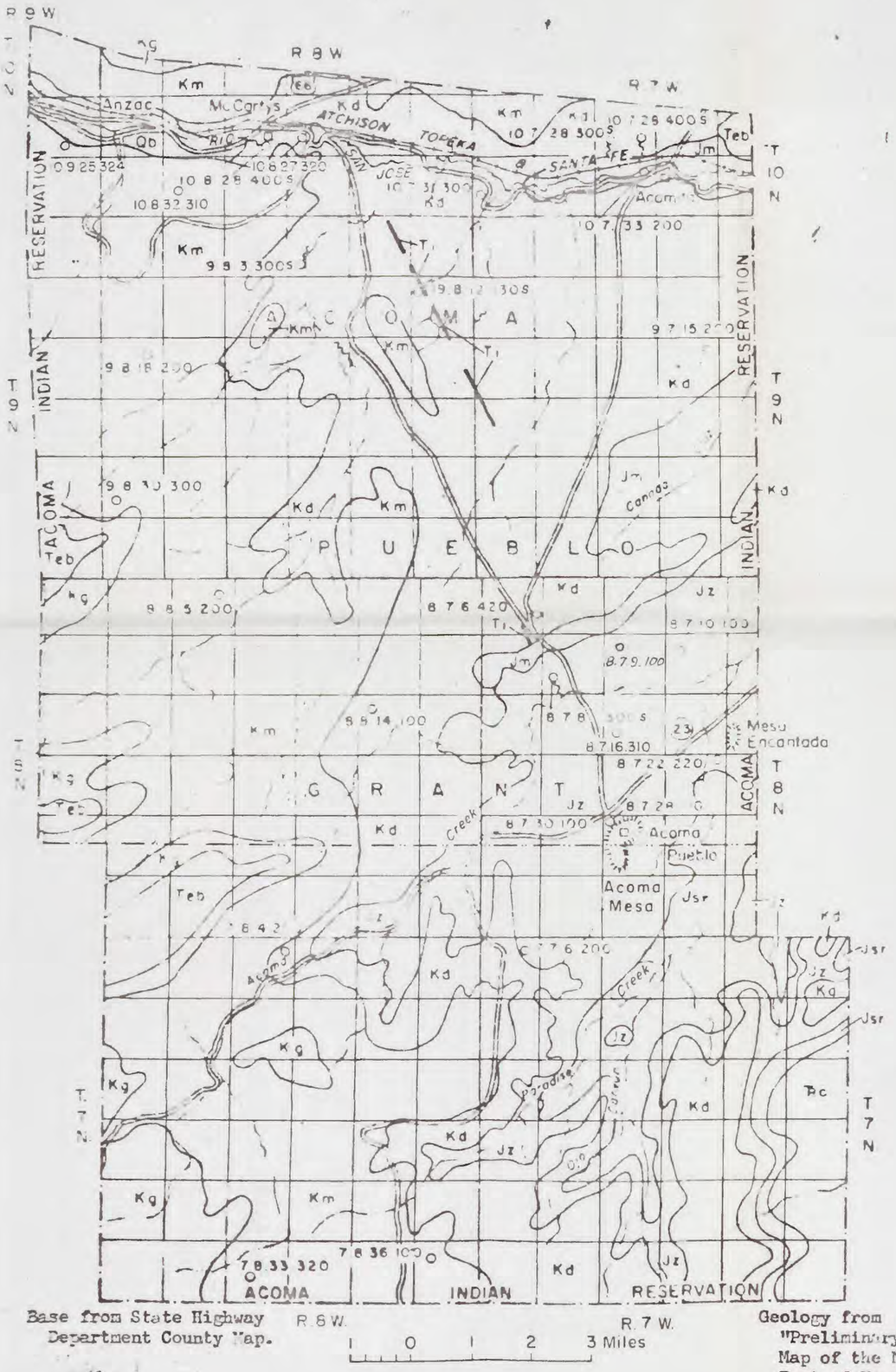
Table 4.--Chemical analyses of water from wells and springs in the Acoma Reservation, Valencia County, N. Mex. - Continued

Location number	Owner or name	Depth of well (ft)	Depth of casing (ft)	Principal water-bearing formation	Use of water	Date collected	Silica (SiO2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO3)	Sulfate (SO4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO3)	Dissolved solids: Calcium, Magnesium	Dissolved solids: Sodium, Potassium	Hardness as CaCO3: Calcium, Magnesium	Hardness as CaCO3: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Remarks
10.8.27.320	Bureau of Indian Affairs	3-1		Km	D	12-18-58	-	202	127	550	963	1,130	839	0.9	5.3	2,260	3.07	1,030	736	43	4.9	2,910	-	No. 8
28.400S	do.	3[illegible]		Km	D	3-19-[illegible]	-	171	60	[illegible]	[illegible]	466	27	.3	0	801	1.27	574	338	24	1.5	1,300	-	No. 9
32.310	Civil Aeronautics Authority	3[illegible]	—	Km	D	10-[illegible]-[illegible]	-	47	33	110	304	174	6	.6	0	[illegible]	.73	212	0	54	5.4	[illegible]	-	No. 10
10.9.25.324	Bureau of Indian Affairs	35	—	Km	D, S	1-11-59	-	-	-	-	350	-	105	-	-	-	-	1,030	700	-	-	2,700	7.4	



Base from State Highway Department County Map.

Geology from "Preliminary Geologic Map of the Northwestern Part of New Mexico," by C. H. Dane and G. O. Bachman, 1957. Quaternary alluvium, although not shown on map, covers other units in valleys.

EXPLANATION

Pleistocene and Recent	Qb	Basalt flows	QUATERNARY
Miocene (?) and Pliocene (?)	Teb	Basalt flows	TERTIARY
	Ti	Intrusive rocks	
Upper Cretaceous	Kg	Gallup sandstone Mainly fine- to medium-grained sandstone with beds of shale	CRETACEOUS
	Km	Mancos shale Mainly shale; contains beds of sandstone near base	
Lower(?) Cretaceous	Kd	Dakota sandstone Fine-grained sandstone and carbonaceous shale	
Upper Jurassic	Jm	Morrison formation fine- to coarse-grained shale and clay interbedded with sandstone	JURASSIC
	Jz	Zuni sandstone very fine- to fine-grained mainly sandstone	
Middle and Upper Jurassic	Jsr	San Rafael group (lower part) very fine- to fine grained mainly sandstone containing thin beds of shale, limestone, and gypsum	
Upper Triassic	Tc	Chinle formation Mainly red shale	TRIASSIC

○ 7.8.6.400
Water well

◇ 9.8.12.130
Spring

Figure 1.--Map showing geology and locations of wells and springs in the Acoma Reservation, Valencia County, N. Mex.