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THE GALLUP SANDSTONE AS A FRESH-WATER AQUIFER[1]

By S. W. WEST[2]

At the same time that an intensive search for oil and gas in the Gallup sandstone has been going on in the northern part of the San Juan Basin, there has been a little-publicized search for fresh water in the same formation in the southwestern part of the basin. The towns of Gallup and Crown Point are both dependent on the Gallup sandstone for their water supplies. Window Rock has recently begun exploration for water in the Gallup sandstone, because the supply from the Shinarump member of the Chinle formation and the DeChelly sandstone is inadequate. The Gallup sandtone also yields water to many privately owned wells.

The growth of Gallup has been accelerated by the establishment of an area office of the Bureau of Indian Affairs and by an increase in trade and industrial activity in the region. Coincident with the growth of Gallup, the demand for municipal and industrial water has increased rapidly. The threat of shortages of water for the town and for industrial expansion caused the town of Gallup and the New Mexico State Engineer to begin a study of the ground-water resources in the vicinity of Gallup in cooperation with the U. S. Geological Survey. This paper is based on data collected during that study.

Potable water is scarce in the Gallup area, and large supplies are expensive to develop. Even the best water-bearing formations yield only moderate supplies. The Gallup sandstone is the most productive aquifer in the immediate vicinity of Gallup, although small supplies of water are obtained from other formations in areas not underlain by the Gallup sandstone. Along the north slope of the Zuni uplift in an area extending about 20 miles eastward from Gallup, several wells penetrate the Glorieta sandstone of Permian age, the lowermost fresh-water aquifer. The overlying San Andres formation, also Permian in age, is missing from the section in parts of this area and has been penetrated by only a few of the wells. Limestone of the San Andres, where present, yields moderate to large quantities of potable water, but the Glorieta is much less productive. Where both formations are present in the section, they form a single aquifer. In general, the specific capacity of wells that penetrate the Glorieta sandstone is about 0.25 gpm (gallons per minute) per foot of drawdown; the highest observed to date is 3.0 gpd per foot. This well, 7 miles east of Gallup, probably penetrated some of the San Andres or was drilled in a fractured zone in the Glorieta. The water in the San Andres and Glorieta generally is hard, ranging from 108 to 779 parts per million (ppm), and also generally has high concentrations of sulfate (as high as 620 ppm). The minimum depth to the Glorieta sandstone at Gallup is about 3,000 feet.

The Sonsela sandstone bed (also called the "middle sandstone") of the Petrified Forest member of the Chinle formation of Late Triassic age is water bearing in some localities near Gallup. The yield of wells that produce from the Sonsela is small, ranging from 15 to 150 gpm, and drawdowns are great, generally a few hundred feet. The water in the Sonsela near Gallup is commonly poor in quality; it has high concentrations of chloride locally. The minimum depth to the Sonsela at Gallup is about 2,550 feet.

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A few wells, generally south of Gallup in the Zuni Indian Reservation, tap the Wingate sandstone. The sandstone yields small quantities of water of good quality.

Sandstones of the Jurassic system near Gallup yield only small quantities of water to wells because of low permeabilities. The sandstones usually are drained of water for considerable distances from their outcrops—which generally are in high escarpments. Some of the deep wells at Gallup penetrate the upper part of the Westwater Canyon sandstone member of the Morrison formation, but the yield of this member has not been segregated from that of sandstones higher in the section.

The Dakota sandstone of Early (?) and Late Cretaceous age yields water to wells at and near Gallup. The Dakota yields only small quantities of water to wells, usually not more than 15 to 20 gpm. The water in the Dakota ranges widely in quality but generally is potable.

The Gallup sandstone of Late Cretaceous age is the principal aquifer at Gallup. The Gallup sandstone consists of very fine- to very coarse-grained firmly cemented sandstone and thin to thick beds of shale and ranges in thickness from about 250 to about 350 feet. The grains of sand are angular to subrounded, poorly sorted, and firmly cemented.

The Gallup sandstone crops out in small areas in the town of Gallup, along the west side of the "hogback" to the east, and in large areas to the south and southwest. A relatively thin layer of unconsolidated alluvium overlies the Gallup sandstone along the Puerco River in the eastern part of Gallup and in some localities south of the town. The Gallup sandstone is in the subsurface between the "hogback" and the Torriveo anticline west of the town and to the north and northwest. The regional dip is to the north and northeast. Superimposed on the regional dip are strong east and west dips on the flanks of northwest-trending asymmetrical anticlines.

An asymmetrical anticline extending through the center of Gallup affects profoundly the depth to the top of the Gallup sandstone. The depth in the area extending eastward from the crest of the anticline to the "hogback" ranges from 50 to 370 feet; about a mile west of the crest the depth is about 1,000 feet.

The Gallup sandstone beneath the town of Gallup consists of 5 sandstone units separated by beds of shale. A detailed description of the Gallup sandstone based on an examination of cuttings from Gallup well Santa Fe No. 11 drilled recently just west of town follows . The lithologic description has been correlated with the electrical log of the well for better depth control and electric logs in other wells near Gallup correlate with the electric log of this well.

Material	Thickness (feet)
Sandstone, light-brownish-gray and pale-red, very fine- to fine-grained; fairly well sorted; subrounded; clear and stained quartz	10
Sandstone, pale-red, fine- to coarse-grained; poorly sorted; subangular to subrounded; chiefly clear and red-stained quartz, dark minerals and mica rare	30
Mudstone, medium-gray; partly carbonaceous; fragments of coal abundant	5
Sandstone, light-brownish-gray, fine- to very coarse-grained; poorly sorted; angular to subrounded,	

some overgrowths of crystalline quartz; chiefly clear and stained quartz, pink feldspar common	28
Mudstone, medium-light-gray; partly carbonaceous; some coal in lower part	25
Siltstone, light-olive gray; well sorted; grains of quartz sand common, mica rare; some coal	17
Sandstone, light-gray, very fine- to coarse-grained; poorly sorted; subangular to subrounded; clear and stained quartz; finer-grained and silty in lower part	35
Siltstone, medium-light-gray; well sorted; mica common	5
Sandstone, light-gray, very fine- to coarse-grained; poorly sorted; angular to subrounded; chiefly clear quartz, mica common	5
Mudstone, medium-gray; some coal	25
Sandstone, very light-gray, very fine- to medium-grained; fairly well sorted; subangular to subrounded; chiefly clear and smoky quartz; some white clay; calcareous	5
Mudstone, medium-gray to medium-dark-gray; partly carbonaceous; some sandy siltstone	10
Sandstone, light-olive-gray, fine-grained; well sorted; subangular to subrounded; chiefly clear quartz, stained quartz and dark minerals rare; some silt and pinkish-gray, coarse sandstone in lower part	30
Sandstone, light-olive-gray, very fine- to medium-grained; fairly well sorted; subangular to subrounded; chiefly clear quartz, stained quartz common, dark minerals rare; carbonaceous; some coal	10
Sandstone, silty, olive-gray, very fine- to fine-grained; chiefly clear quartz, stained quartz and dark minerals common; partly carbonaceous	15
Mudstone, medium-light-gray; partly carbonaceous; some coal	15
Siltstone, medium-light-gray; fairly well sorted; mica and quartz sand common; calcareous	15
Sandstone, light-gray, very fine- to fine-grained; partly silty; well sorted; subangular to subrounded; chiefly clear quartz, stained quartz and dark minerals common, mica rare; weak calcareous cement	50
Mudstone, medium-light-gray to medium-gray	5
Siltstone, medium-light-gray; well sorted; mica common; partly carbonaceous; some sandstone	5
Sandstone, very light-gray, very fine- to coarse-grained; mostly well sorted; subangular to subrounded; chiefly clear quartz, dark minerals and mica common	10
Total Gallup sandstone	355

Yields of wells that produce water from the Gallup sandstone generally range from 45 to 200 gpm; higher yields are obtained in a few places. The sandstone is recharged mainly by infiltration of precipitation and runoff in its areas of outcrop. Locally, it is recharged by downward percolation of water from overlying unconsolidated sediments. The annual rate of recharge to the Gallup sandstone has not been determined but probably is small.

Wells were drilled on the anticline in the center of Gallup in quest of water at an early date. These early wells penetrated the Dakota sandstone, from which flowing water was obtained in small quantity. The depth to water in the Gallup sandstone was less than 100 feet. Subsequently, wells were drilled both to the east, in the shallow syncline in the eastern part of town, and to the west in the deep syncline near the Santa Fe Railway. The rate of ground-water withdrawal has been such that the upper part of the Gallup sandstone has been dewatered in the shallow wells, and the yield of some of the wells has decreased to the point where pumping is uneconomical. The depth to water in all the wells now ranges from 125 to more than 400 feet. Recently the town has drilled wells in the deep syncline to the west, where the water is under artesian pressure. The water level in the deep syncline can be lowered several hundred feet before the Gallup sandstone is dewatered.

The wells in the deep syncline penetrate the Dakota sandstone and the Westwater Canyon sandstone member of the Morrison formation also, but the greatest part of the water is obtained from the Gallup sandstone.

The chemical quality of water in the Gallup sandstone generally is fair, although water from municipal wells in the eastern part of town (in the shallow syncline) has concentrations of iron, sulfate, and dissolved solids slightly higher than the limits recommended for public water supplies by the New Mexico Department of Public Health. This water is being used for drinking, however, seemingly without deleterious effects. The chemical quality of water from the most productive well in the eastern part of town (Gallup well No. 13) is typical of water in the Gallup sandstone in the shallow-well field. Water from a new municipal well (Gallup well Santa Fe No. 10) and from the Clarke's Dairy well, both in the deep syncline west of town, is of markedly better quality than water from the shallow syncline. The difference in chemical quality is believed to be due to derivation of the waters from different sources of recharge. In the analyses below the chemical constituents are in parts per million; other properties are as indicated.

Constituent	Concentration		
	Gallup No. 13	S. F. No. 10	Clark's Dairy
Silica	15	17	18
Calcium	84	18	9.5
Magnesium	23	12	5.0
Sodium	193	202	92
Potassium	2.0	-	-
Bicarbonate	447	313	214
Carbonate	0	0	0
Sulfate	320	243	59
Chloride	23	16	4.5
Flouride	.5	.6	.6
Nitrate	4.4	.1	.0
Dissolved solids	892	663	294
Hardness as $CaCO_3$	304	94	44
Temperature (°F)	57	79	62
pH	7.9	8.1	8.0

In conclusion, the Gallup sandstone is consistently the most productive aquifer within a radius of 20 miles of Gallup. Yields of about 50 to 200 gpm can be expected from wells tapping the Gallup sandstone in most places where it is saturated with water. The specific capacity of wells generally ranges from 0.5 to 0.6 gpm per foot. In general, the quality of the water is good for a distance of several miles from outcrops, except locally where the sandstone is recharged by water of poor quality, as in the shallow syncline in Gallup. The water generally becomes more highly mineralized with increasing distance from the outcrops, as shown by the water in oil wells to the north.