

UNITED STATES
DEPARTMENT OF THE INTERIOR
Geological Survey
Albuquerque, New Mexico

OCCURRENCE AND QUALITY OF GROUND WATER IN THE
FORT UNION AREA, MORA COUNTY, N. MEX.

By

I. J. Winograd
Geologist

Prepared in cooperation with
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
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INTRODUCTION

The ruins of Fort Union, Mora County, N. Mex., were declared a National Monument in March 1956. Operation of the monument entails furnishing a supply of water adequate for the needs of four resident families and of all visitors to the monument. A well yielding 10 gpm is deemed adequate by the National Park Service, U. S. Department of the Interior. In order to determine the feasibility of obtaining such a water supply, a brief reconnaissance of the ground-water conditions in the area immediately adjacent to the ruins was made at the request of the Park Service.

This reconnaissance, conducted with Mr. Kittredge Wing, Park Superintendent, on July 25 and 26, 1956, was limited to Tps. 19 and 20 N., R. 18 E., and consisted largely of an inventory of several of the wells and springs in the area and of a brief examination of the geologic conditions. Conductivity measurements of well-, spring-, and surface-water samples were made in the field in an attempt to delineate zones of ground-water quality. Five samples of well and spring waters were collected and submitted to the quality-of-water laboratory of the U. S. Geological Survey at Albuquerque for chemical analysis.

GEOGRAPHY AND GEOLOGY

The area reconnoitered lies in south-central Mora County within the Las Vegas Plateau subsection of the Raton section of the Great Plains physiographic province. Fort Union is on the east side of the southward-trending valley of Wolf Creek, a tributary of the Mora River. (See fig. 1). This valley is bounded on the west by a prominent sandstone mesa, the escarpment of which rises 150 to 200 feet above the valley, and on the east and northeast by the Turkey Mountains. The villages of Watrous and Loma Parda lie respectively 8 miles southeast and 5 miles southwest of the fort.

The rock strata exposed in the area range in age from Jurassic to Recent. The areal distribution of the rock units discussed is shown on the geologic map, figure 1. The outcrop pattern of these rocks is controlled largely by a fault which bounds the valley on the west and by a dome-shaped uplift which constitutes the Turkey Mountains.

The oldest rock strata exposed are those of the Morrison formation of Jurassic age. This formation crops out in the Turkey Mountains in a circular band whose shape is due to the dome-shaped buckling which formed those mountains. The Morrison formation was not examined in the Fort Union area, but in San Miguel County immediately to the south it ranges from 250 to 400 feet in thickness and consists of sandstone, shale, and thin limestone.

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The Dakota sandstone of Early Cretaceous age overlies the Morrison formation, but the Purgatoire formation of Early Cretaceous age may lie between the Dakota sandstone and the Morrison formation at this locality. The Dakota sandstone and the Purgatoire formation can be differentiated only by means of paleontological evidence (Griggs and Hendrickson, 1951).^{1/} Therefore, the strata overlying the Morrison formation are referred to in this report as the Dakota and Purgatoire formations, undifferentiated, the Dakota and Purgatoire sandstone, or simply as the Dakota and Purgatoire. The outcrop pattern of the Dakota and Purgatoire on the east side of Wolf Creek Valley is also a circular band. The sandstone dips 1° to 3° northwest, west, and southwest beneath Wolf Creek valley and also forms the eastern escarpment of the mesa bordering the valley on the west. This escarpment was formed through upfaulting of the sandstone. The strata capping and forming this mesa are nearly horizontal. The Dakota and Purgatoire sandstone in this area is composed of a fine- to medium-grained well-cemented white sand which weathers to a reddish-brown hue. The formation is at least 200 feet thick--the approximate height of the sandstone escarpment. At Las Vegas, about 25 miles to the southwest, a thickness of 220 feet was reported in a railroad well (Griggs and Hendrickson, 1951).

^{1/} Griggs, R. L. and Hendrickson, G. E., 1951, Geology and ground-water resources of San Miguel County, N. Mex: New Mexico Bur. Mines and Mineral Resources, Ground-Water Rep. 2, p. 28-31, 110-111.

A black fissile shale and an overlying more massive dark-gray limy shale cover the Dakota and Purgatoire formations in the Fort Union area. The massive shale, which weathers to a cream color, forms a subdued ridge on the west side of the valley in secs. 15 and 22, T. 19 N., R. 18 E. No attempt was made to differentiate these shaly strata in the Fort Union area, but they appear to be equivalent to all or part of the shaly strata of Early and Late Cretaceous age, which include the Graneros shale, Greenhorn limestone, Carlile shale, and the Niobrara formation, which overlie the Dakota in San Miguel County, (Griggs and Hendrickson, 1951). Their thickness beneath Fort Union is believed to be less than 150 feet, on the basis of the low dips, the proximity of the contact with the Dakota and Purgatoire sandstone, and the topographic slope. (See fig. 2).

(1) The first part of the document is a letter from the President of the United States to the Congress, dated January 3, 1862. In this letter, the President discusses the state of the Union and the progress of the war. He mentions the recent victories of the Union forces and expresses confidence in the ultimate success of the Union cause. He also discusses the financial situation of the government and the need for additional resources to support the war effort.

(2) The second part of the document is a report from the Secretary of the War Department, dated January 10, 1862. This report provides a detailed account of the military operations of the Union forces during the previous month. It includes information about the movements of troops, the results of battles, and the status of the various military units. The report also discusses the logistical challenges faced by the Union forces and the measures taken to address these challenges.

(3) The third part of the document is a report from the Secretary of the Navy Department, dated January 15, 1862. This report provides a detailed account of the naval operations of the Union forces during the previous month. It includes information about the movements of ships, the results of naval battles, and the status of the various naval units. The report also discusses the logistical challenges faced by the Union forces and the measures taken to address these challenges.

(4) The fourth part of the document is a report from the Secretary of the Treasury Department, dated January 20, 1862. This report provides a detailed account of the financial operations of the government during the previous month. It includes information about the revenue collected, the expenditures made, and the status of the various financial accounts. The report also discusses the financial challenges faced by the government and the measures taken to address these challenges.

(5) The fifth part of the document is a report from the Secretary of the Interior Department, dated January 25, 1862. This report provides a detailed account of the operations of the various departments under the Interior Department during the previous month. It includes information about the management of the public lands, the operations of the various bureaus, and the status of the various projects. The report also discusses the challenges faced by the Interior Department and the measures taken to address these challenges.

Basalt flows of Quaternary age, probably derived from the north, partially overlies the shaly strata of Early and Late Cretaceous age in the Wolf Creek valley. The basalt also caps a mesa which is elongated east-west across secs. 17, 18, 19, and 20, T. 20 N., R. 18 E. Float derived from the shaly strata was noted on the slopes of this mesa, and these formations probably compose at least part of this tableland. The relation of the lava to the Dakota and Purgatoire formations is not clear. East of the escarpment which borders Wolf Creek valley on the west, the basalt is mapped (Geologic map of New Mexico, 1928) as truncated at the face of the escarpment, and the faulting thus appears to be younger than the basalt. The faulting does not, however, displace the basalt capping the east-west-trending mesa. Immediately south of this mesa the basalt appears to have flowed or to have been faulted into depressions in the sandstone surface. Assuming that the lava flow capping the mesa and the flow in the valley are of the same age, the fault forming the escarpment appears to have been of the hinge type, the displacement along which increases toward the south.

Recent alluvium in the bed of Wolf Creek, which ranges in thickness from several feet to more than 35 feet, overlies the shaly strata of Early and Late Cretaceous age, as well as the basalt flows. The alluvium is largely composed of white to gray silt. A 4-foot bed of boulders derived primarily from the Dakota and Purgatoire sandstone was noted in the creek bed west and southwest of the fort.

An examination of figure 2, a northeast-southwest geologic section across the Wolf Creek valley, shows that geologic structure is favorable for the occurrence of artesian water beneath the valley. The Dakota and Purgatoire sandstone, known to yield water to wells, dips gently westward and is overlain by the shaly sequence, which is of low permeability and may serve as an aquiclude.

GROUND WATER

Architectural plans of Fort Union, drafted in the latter half of the 19th century when this arsenal was still guarding the frontier, show the location of numerous dug wells. No data are available on the depths of these wells; however, their number indicates that water was available in only small quantities. It is possible that some of these "wells," at least, may have been cisterns.

At present, ground water for stock and domestic purposes in the Fort Union area is obtained from wells, springs, and seeps. Water for stock is obtained also from the small perennial flow in Wolf Creek.

Wells 19.18.17.400, 20.18.24.300, and 20.18.35.200 1/ obtain water from the Dakota and Purgatoire sandstone. The depths to water in these wells are respectively 151, 100, and 64 feet below the land surface. The yields of these wells range from 2 to 3 gpm, and the specific capacities from 0.25 to 2 gpm per foot of drawdown. Well 20.18.24.300 was reportedly drilled to a depth of 480 feet, which probably places the lower part of the well within the Morrison formation. Water reportedly was first encountered at 60 to 80 feet, presumably within the Dakota and Purgatoire. Drilling was continued in this well in an attempt to increase the yield of the well. The large depth to water in well 19.18.17.400 (151 feet) is due to its location atop the mesa formed by the Dakota and Purgatoire sandstone. Ground water beneath this mesa may drain to the Mora River to the south, which has incised a prominent canyon into this tableland.

Ground water discharges into Wolf Creek valley from several springs and seep zones which border or lie within the valley. The seepage maintains a perennial flow in Wolf Creek beginning at the fort. The most prominent spring is that at the Andrew Marshal home (spring 20.18.29.440). This spring is near the escarpment formed by the faulted Dakota and Purgatoire sandstone. The water at this locality bubbles up from a white sand, probably the Dakota, at the bottom of a pit dug 5 feet into the ground. The water stands 3 feet above the ground in a cement casing built around the spring, indicating that the water is under hydrostatic pressure. The spring discharges 4 gpm. The water level in a smaller spring, 100 feet to the north, stands at the land surface. The water from these two springs may be rising along the fault zone separating the Dakota and Purgatoire formations from the strata of the shaly sequence.

1/ The numbers composing the well number refer to the township, range section, and tract within the section.

Springs 20.18.20, on the south slope of the lava-capped mesa, and 19.18.3.340, at the Needham home, appear to emerge at the contact of the basalt and the underlying shales. The spring at the Needham home is a seep area into which a well has been dug. The water in this seep area also may originate along the fault zone to the west.

Spring 19.18.3.140, in an arroyo tributary to Wolf Creek, appears to emerge from the alluvium overlying the Lower and Upper Cretaceous shale strata and discharges approximately half a gallon per minute into the creek. Below this spring Wolf Creek is reported by old-time residents as having always been perennial. This indicates that at, and probably downstream from, this point the creek is being fed by ground water. On July 25 the flow at the bridge in sec. 3, T. 19 N., R. 18 E., was estimated at half a second-foot, or roughly 200 gallons per minute.

The water of the wells and springs sampled is moderately hard to hard but is potable. The hardness of the water as CaCO_3 ranges from 150 to 264 ppm. The dissolved solids, fluoride, and nitrate are well below the permissible limits advocated by health authorities. The chemical constituents of the well and spring water sampled are shown in table 2. The analyses shown in this table indicate only the chemical constituents and not the sanitary condition of the water.

The similarity in the chemical composition of spring water to well water indicates that the Dakota and Purgatoire sandstone, which supplies water to wells, is the source of the spring water also. Although one spring emerges from the alluvium and two others seemingly emerge at the contact of the lava and the shaly strata, neither the alluvium, lava, nor shale can readily be postulated as the sources of this spring water or the seepage into Wolf Creek.

In northern San Miguel County, the Graneros shale, Greenhorn limestone, Carlile shale, and Nibrara formation yield highly mineralized water, the specific conductances ranging from 1,110 to 3,820 micromhos in sampled wells (Griggs and Hendrickson, 1951). The conductance of the spring water in the Fort Union area ranges from 436 to 566 micromhos and is comparable to that of well water derived from the Dakota and Purgatoire. The shales thus do not appear to be likely sources for the spring water. The limited areal extent and thinness of both the basalt flows and the Recent alluvium necessitates a local source of recharge to these rocks (possibly from older rocks) to enable them to supply the springs and the flow in Wolf Creek. On the basis of this limited areal extent and the relatively large flow in Wolf Creek, neither the lava nor the alluvium seems likely to constitute the source of the seepage and spring flow. On the basis of chemical analyses and geologic considerations it appears that the water from the springs and the seepage into Wolf Creek originates from the Dakota and Purgatoire sandstone. The specific conductance of the creek water at the bridge as determined in the field was 425 micromhos.

The 3-foot head in the spring at the Andrew Marshal home, which emerges from the Dakota and Purgatoire sandstone, indicates that the water within the Dakota and Purgatoire is under artesian pressure, a condition readily explained by the geologic structure. The spring is located close to or above the fault zone along which the Dakota and Purgatoire was upfaulted, and possibly the water feeding this spring rises along a fracture zone produced during faulting. The artesian pressure within the Dakota and Purgatoire formations, evidenced by the spring, probably also exists beneath most of the Wolf Creek valley and Fort Union.

In response to the artesian head within the Dakota, ground water moves upward from the sandstone into the overlying shales and along the fault zone and associated fractures. Consequently, the spring water, the water that emerges from the alluvium, and the water that emerges at the shale-lava contact are similar to chemical composition to well water derived from the Dakota and Purgatoire sandstone. Probably the perennial flow in Wolf Creek can be attributed at least in part to the upward movement of ground water from the underlying sandstone. Figure 2 shows that the sandstone is saturated almost to the point of its surface contact with the overlying shales and indicates that the artesian head in the Dakota and Purgatoire beneath Fort Union is higher than the land surface at the fort. Therefore, a well drilled at the site may flow.

In summary, it appears that the spring water (excepting springs 20.18.20 and 20.18.19, which emerge from the south slope of the lava-capped mesa), like the well water, is derived from the Dakota and Purgatoire formations which contain water under artesian head. This origin is indicated by: 1) The similarity in the chemical composition of all the samples of the spring and well water tested; 2) The geologic structure beneath Wolf Creek valley; and 3) The artesian head in the spring at the Andrew Marshal home (20.18.29.440).

CONCLUSIONS

Water at Fort Union can be obtained by drilling a well into the Dakota and Purgatoire sandstone beneath the shaly strata which underlie most of Wolf Creek valley. The shales will probably range in total thickness from 75 to 150 feet. The well should penetrate at least 100 feet of the sandstone to allow for large drawdowns during pumping, and therefore should be from 175 to 250 feet deep. Small quantities of water may be obtained while drilling in the shaly strata (the probable source of the water in the numerous dug wells in use during the life of the fort), but a well drilled into the Dakota sandstone will yield a larger supply of water, possibly exceeding 5 gpm.

Water in the Dakota and Purgatoire sandstone is under artesian head and may flow. In order not to dissipate the head of the water in the Dakota, the casing that is set opposite the shales should be cemented at the top of the sandstone. This could be done by telescoping the casing - that is, setting a large-diameter unperforated casing opposite the shales and a smaller diameter casing from the surface down into the Dakota and Purgatoire.

The water in the Dakota and Purgatoire formations is of good quality in this area, but somewhat hard. A sample of water from the well should be submitted to the appropriate public agency for a bacterial analysis.

Table 1. - Amount of water and springs in the Fort Saline area, New Mexico, U. S. A.

Table

Location number 1/	Owner	Depth (ft.)	Flow (gal.)	Water Temp. (°F.)	Height of water above base of flow (ft.)	Remarks
19-28-27-100	Fort Saline Water	200	0	50-55	2.0	Measured discharge 1 gal. per day. velocity 1 cm per day. 1/2 gal per day of discharge. Water-bearing unit is and Porphyritic Formation, and is classified.
20-28-26-300	do.	100	7	50	2.0	Measured discharge 1 gal. per day. velocity 0.25 cm per day. 1/2 gal per day. Water-bearing unit is and Porphyritic Formation, and is classified.
21-28-25-200	do.	100	6	60	2.0	Measured discharge 1 gal. per day. velocity 1 cm per day. 1/2 gal per day of discharge. Water-bearing unit is and Porphyritic Formation, and is classified.

Table 1. --Location of wells and springs in the Fort Union area, New Mexico, N. Mex.

Section

Location number	Date	Remarks
10.1A.3.140	Fort Union mud	Dominated bluish-gray 0.5 m. Spring appears from lower Clinton overlying the Lower and Upper Cretaceous undifferentiated beds.
10.2A.3.140	do.	Well at surface level, 200 m. long pipe. Water appears to emerge at contact of sandstone beds and undifferentiated Lower and Upper Cretaceous beds.
10.3A.3.140	do.	Spring in shallow canyon located in sand bed of section. Estimated discharge 0.5 to 1 gal.
10.4A.3.140	do.	Located in north half of section. Spring appears to emerge at contact of sandstone beds and the Lower and Upper Cretaceous undifferentiated beds.
10.5A.3.140	Active mudstone	Dominated bluish-gray 0.5 m. Water bubbles up from within mud (Dolomite and large-scale mudstone) at bottom of 5-foot pit. Water appears to flow from sandstone. Smaller spring 100 feet north of measured spring.




 Section, range, section and fractional part of section.
 under level in foot below last section. Issued July 10 or 15, 1956.
 measuring point is top of spring.

Analyses by Geological Survey, United States Department of the Interior
(parts per million)

	10.19.5	19.18.3	20.18.2	21.2.25	20.18.29	13.18.17
	100 spring	300 spring	300 well	100 spring	200 well	100 well
Date of collection	7-25-56	7-25-56	7-25-56	7-25-56	7-25-56	7-20-56
Silica (SiO ₂)	32			34		
Iron (Fe), dissolved 1/						
Iron (Fe), total						
Manganese (Mn), dissolved 1/ ...	REPORTED LOWED RECORDS. SUBJECT TO REVISION					
Manganese (Mn), total						
Calcium (Ca)	11			31		
Magnesium (Mg)	29			21		
Sodium (Na)						
Potassium (K)	21	24		33	53	
Bicarbonate (HCO ₃)	306	282	290	245	289	
Carbonate (CO ₃)	0	0	0	0	0	
Sulfate (SO ₄)	24	15		21	23	
Chloride (Cl)	9	5	4	9	1	
Fluoride (F)	0.6	0.4	0.2	0.4	0.4	
Nitrate (NO ₃)	0.2	0.0		0.2	1.1	
Dissolved solids	REPORTED LOWED RECORDS. SUBJECT TO REVISION					
Sum	340			270		
Residue on evaporation						
at 180°C						
Hardness as CaCO ₃	264	202	217	144	150	
Non-carbonate	0	0	0	0	0	
Specific conductance						
(micromhos at 25°C)	506	465	477	456	493	~~506~~
pH	7.7	7.4	7.6	7.6	7.7	
Color						
Percent sodium	15	21		31	43	

1/In solution at time of analysis.

~~2/~~ Field conductivity measurement



Figure 2.--Geologic section (SW-NE) across Wolf Creek valley, Fort Union area, Mora County, N. Mex. For identification of symbols see figure 1.

Supplement 1.--Plat of Fort Union National Monument, Mora County,
N. Mex.



