UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Uranium mine waste water—A potential source of ground water in northwestern New Mexico

By

W. L. Hiss

Open-File Report 77- 625

1977

Uranium mine waste water—A potential source of ground water in northwestern New Mexico

By W. L. Hiss

Abstract

Substantial quantities of water are being pumped from the Morrison Formation of Late Jurassic age in uranium mines in the Grants mineral belt in northwestern New Mexico. The water often contains unacceptable amounts of dissolved uranium, radium, iron, and selenium and suspended solids, but with treatment it can be made suitable for municipal and industrial purposes. Water salvaged from current and projected mining operations constitutes the most readily available water in this otherwise water-deficient area.

Introduction

Large quantities of water will be required by the coal-gasification and coal-burning electric powerplants planned for installation in northwestern New Mexico. The population of nearby communities is expected to increase significantly as the economy expands. Therefore, the demand for potable water will increase.

Obtaining adequate supplies of potable ground water to meet even the existing demand is difficult, or, in many instances, impossible. The city of Gallup, in particular, has had great difficulty in providing an adequate supply of good-quality ground water for its municipal water system (Hiss, 1975, p. 13; City of Gallup, 1977, p. 3-4). The San Juan River and Rio Grande are the nearest reliable sources of large quantities of surface water. Transportation of surface water to areas of need would be more expensive generally than development of whatever local ground water might be available. Ownership of the land (surface and subsurface) and ownership, control, and (or) regulation of both ground and surface water often further complicate development and use of existing resources.

Uranium mining

New Mexico leads the nation in producing uranium concentrates and, perhaps of more importance, has about one-half of the undeveloped reserves of this valuable commodity (Fitch, 1974, p. 82). Most of the uranium mined to date and nearly all of the proven reserves occur in the Westwater Canyon Member of the Morrison Formation of Jurassic age in the Grants mineral belt (fig. 1). Production from most of the existing mines and those that will be developed in the future is and will be from depths well below the potentiometric surface of the Morrison Formation. During the mining, "long-holes" are drilled at the end of newly driven stopes, haulageways, or drifts to explore for and define the ore body and to drain the ground water from the rock. Removal of the water from the sandstone facilitates stoping and greatly increases the strength of the rock (Gay, 1963, p. 245-246; Hohne, 1963, p. 247). Eventually the network of mines will function as a vast underground collection system. Water must be pumped from these mines continuously in order to keep the various tunnels and shafts dry. The extent of Indian and Federal Land under lease is shown in figure 1. Although similar information is not available for State and private lands, the lease activity does reflect industry's interest in uranium mining in the Grants mineral belt.

Church Rock mining district

One abandoned mine and several producing uranium mines are located in the Church Rock mining district northeast of Gallup. The proximity of the mines to water-deficient Gallup enhances the potential for salvaging waste water from these mines for municipal use--a course of action this city is now evaluating (Hiss, 1975, p. 112, 119; City of Gallup, 1977). Ownership and availability of the waste water are uncertain and must be resolved before the water can be put to beneficial use (Hiss, 1975, p. 66, 113, 120; City of Gallup, 1977, p. 7-10).

Approximately 3,000 gpm (190 l/s) of ground water was being pumped in November 1973 from the Morrison Formation at two uranium mines in sec. 35, T. 17 N., R. 16 W., about 12 miles (20 km) northeast of Gallup in the Church Rock mining district (Hiss, 1975, p. 62, table 2). The discharge rate has subsequently increased to approximately 4,400 gpm (276 l/s). Further increases in waste-water production to more than 10,000 gpm (630 l/s) within a few years are predicted as new mines are opened (City of Gallup, 1977, p. 5, 8). The water generally contains less than 400 mg/l dissolved solids; sodium and bicarbonate are the most abundant constituents. Except for the dissolved uranium, radium, iron, and selenium, the waste water contains less dissolved solids than the water now produced from the Cretaceous aquifers near Gallup (table 1, this report; City of Gallup, 1977, table 2).

The waste water now is pumped to the land surface and into settling ponds where it is treated with barium chloride as a flocculating agent to remove suspended solids; this procedure simultaneously lowers the radium and uranium content (City of Gallup, 1977, p. 6). After most of the suspended particulate material has precipitated, the water is allowed to flow from the ponds into formerly dry arroyos that are tributaries of the Puerco River.

The United Nuclear Corp. Northeast Church Rock Mine, an abandoned uranium mine, also completed in the Westwater Canyon Member, is located about 8 miles (15 km) northeast of Gallup near a paved road, a natural gas pipeline right-of-way, and high-voltage electrical power lines. Substantial quantities of water might also be produced from this abandoned mine for use by the City of Gallup if the rights to this resource could be obtained. Some of the waste water from the Church Rock mines will be used in a mill to be constructed near the producing uranium mines. Reportedly, large amounts of salvaged waste water will also be used in a coal-fired electric generating plan to be built on the Navajo Reservation.

Behavior of potentiometric surface.--Periodic measurements of the water level in the shaft of the Northeast Church Rock Mine were made for several years by personnel from United Nuclear Corp. Subsequently, a continuous water-level recording instrument was installed by the U.S. Geological Survey in order to monitor the long-term effects of pumping on the aquifer (fig. 2). The head in the Westwater Canyon aquifer has declined at a rate of approximately 1.85 ft/mo (0.56 m/mo) indicating the reduction in the hydraulic head caused by dewatering of the active mines in the Church Rock mining district.

Ambrosia Lake mining district

Uranium is now being mined from the Westwater Canyon Member of the Morrison Formation within the zone of saturation in the Ambrosia Lake mining district. Millions and perhaps billions of gallons of waste water are discharged yearly as the mines are dewatered (Cooper and John, 1968, p. 38-42). Production of waste water can be expected to increase as the intensity of the mining increases and as new mines are developed. A small fraction of the water pumped from the mines is used in the uranium ore processing mills. Most of the waste water is discharged at the land surface and infiltrates or evaporates. Part of the water is channeled into formerly dry arroyos that carry the effluent southward out of the Ambrosia Lake area and into San Mateo Creek, a tributary of the Rio San Jose (Cooper and John, 1968, p. 40).

Generally, the ground water pumped from the uranium mines is only slightly radioactive but it occasionally exceeds the recommended limit for safe drinking water (Cooper and John, 1968, p.28, 40-42). As mining proceeds, however, the quality of water involved deteriorates rapidly and, as a consequence, usually does not meet safe drinking standards. The total of dissolved constituents found in water produced from the Westwater Canyon aquifer in the Ambrosia Lake mining district ranges from less than 300 to more than 1,400 mg/l. Most of the water sampled by Cooper and John (1968, table 3) contained less than 700 mg/l of total dissolved solids.

Smith Lake mining district

Public Service Company of New Mexico has proposed to construct a 2,000-megawatt power plant near Bisti. Water pumped from uranium mines to be located near Crownpoint, approximately 30 miles (50 km) to the south, reportedly may be used in the electric generating plant.

Conclusions

Reports from industry sources indicate that reserves in the Grants mineral belt will sustain uranium mining for many years. The large quantities of water pumped from the mines as they are dewatered now constitute a supply that could be salvaged and used beneficially after treatment to remove undesirable dissolved and suspended constituents. After mining ceases, the abandoned mines will comprise a large underground collection system. High-capacity pumps could then be installed in the abandoned shafts and water pumped from the mines as needed. However, this resource is finite and the long-term effects of dewatering will determine availability of water and economics of recovery at any particular location.

Ownership of the land surface, the subsurface, water and (or) water rights, and the legal control of the use of water are factors that will influence use of this supply of ground water.

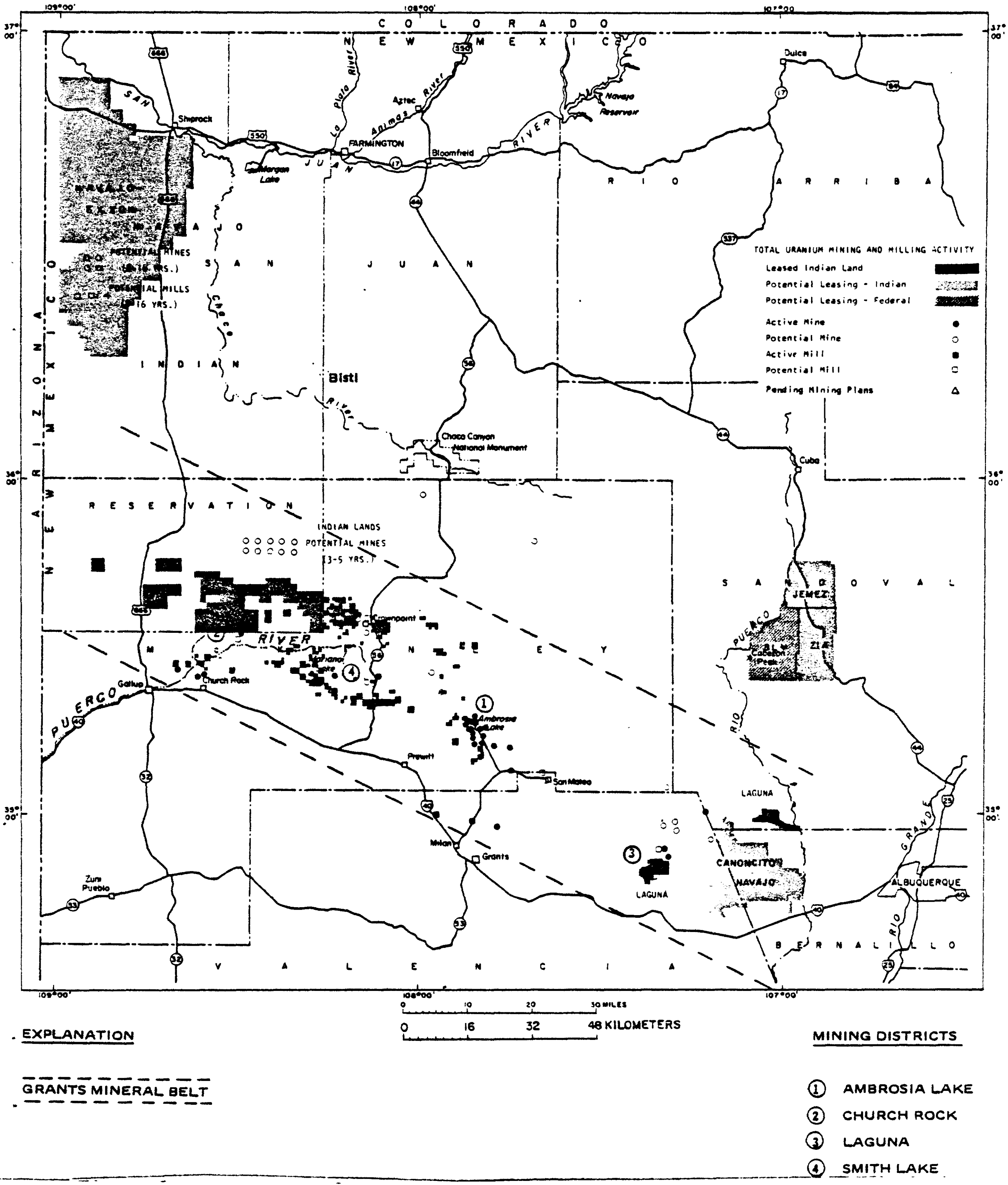

Figure 1 -- Location of mining districts in Grants mineral belt and uranium development on Federal and Indian lands in northwestern New Mexico. Adapted from map prepared by Department of the Interior, Office of the Secretary, Southwest Region, Albuquerque, New Mexico, September 1976.

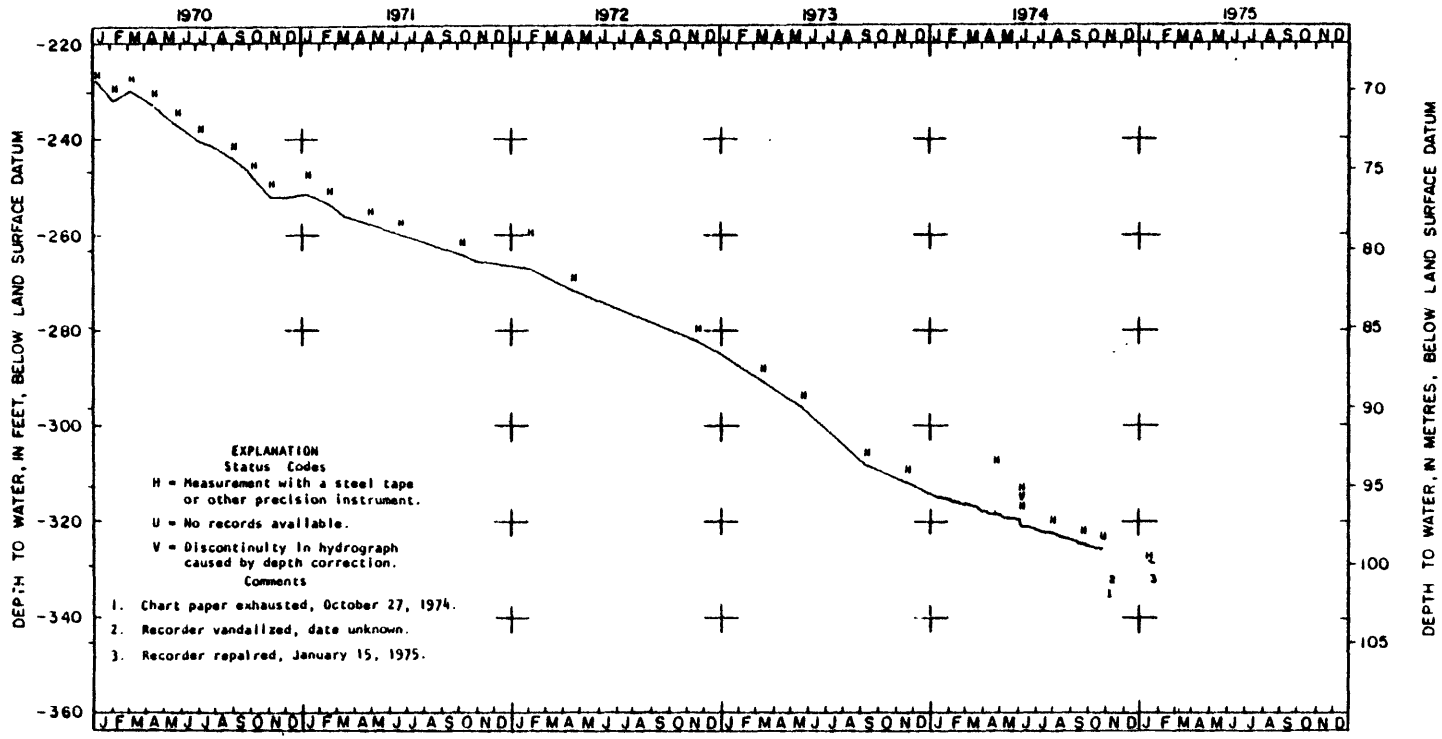

Figure 2 -- The water level observed in the shaft of the abandoned United Nuclear Corp. Northeast Church Rock Mine, SE1/4NW1/4NE1/4 sec. 17, T. 16 N., R. 16 W., McKinley County, New Mexico. [Water level prior to start of dewatering in October 1968 during sinking of new uranium mine shaft in sec. 35, T. 17 N., R. 16 W. reported to be 144 ft (44 m). Water level measured from land surface datum estimated from a topographic map to be 6,810 ft (2,076 m).]

Table 1 -- Dissolved and suspended chemical constituents in water from uranium mines, and wells in the vicinity of Church Rock, McKinley and San Juan Counties, New Mexico.

Sample number	Name of well or mine	Location	Aquifer	Depth of producing interval or sampling point from land surface in metres (feet)		Date (year, month, day)	Time of day (2400 clock)	Yield estimated l/s (gpm)	Source of water
				Top	Bottom				
1	Continental Oil Company Crownpoint Water Well 1	NW¼NW¼ sec.20 T.17 N., R.12 W.	Westwater Canyon Member, Morrison Formation (Jurassic)	654 (2,145)	714 (2,341)	74- 6- 8	1610	11 (180)	Well head
2	United Nuclear Corporation Northeast Church Rock well	NW¼SE¼ sec.35, T.17 N., R.16 W.	do.	472 (1,550)	503 (1,650)	71- 3-23	1430	1.25 (20)	Domestic and industrial water supply well
3	do.	NW¼SE¼ sec.35, T.17 N., R.16 W.	do.	472 (1,550)	503 (1,650)	71- 3-23	1430	1.25 (20)	do.
4	United Nuclear Corporation Northeast Church Rock mine	NW¼SE¼ sec.35, T.17 N., R.16 W.	do.	442 (1,450	457 (1,500)	71- 3-23	1545	< .06 (<1)	Mine seepage collected in mine
5	do.	NW¼SE¼ sec.35, T.17 N., R.16 W.	do.		457 (1,500)	73-11-13	1000	.06 (1)	do.
6	do.	NW¼SE¼ sec.35, T.17 N., R.16 W.	do.		518 (1,700)	73-11-13	1100	.09 (1.5)	do.
7	do.	NW¼SE¼ sec.35, T.17 N., R.16 W.	do.	457 (1,500)	549 (1,800)	73-11-13	1500	126 (2,000)	Seepage effluent pumped from mine shaft
8	Kerr McGee Corporation Sec. 35 Church Rock mine	NW¼NE¼ sec.35, T.17 N., R.16 W.	do.		549 (1,800)	73-11-13	1600	95 (1,500)	do.
9	El Paso Natural Gas Company Burnham Gasification Water Supply Well 1	NW¼SW¼ sec.3, 1/ T.23 N., R.14 W.	do.	1,518 (4,980)	1,585 (5,200)	73- 8-27	1430	22 (350)	Flow from well head

Sample number	Silica dissolved (SiO_2) mg/l	Iron dissolved (Fe) mg/l	Manganese dissolved (Mn) mg/l	Calcium dissolved (Ca) mg/l	Magnesium dissolved (Mg) mg/l	Sodium dissolved (Na) mg/l	Potassium dissolved (K) mg/l	Bicarbonate dissolved (HCO_3) mg/l	Carbonate dissolved (CO_3) mg/l	Carbon dioxide dissolved (CO_2) mg/l	Alkalinity as $CaCO_3$, Total mg/l	Sulphate dissolved (SO_4) mg/l	Chloride dissolved (Cl) mg/l
1	18	0.0	-	1.9	0.0	120	1.1	244	12	0.5	220	55	5.3
2	-	-	-	-	-	-	-	218	24	-	-	35	3.6
3	15	.50	0.02	2.0	2.6	110	0.7	216	37	-	143	32	3.5
4	-	-	-	-	-	-	-	-	-	-	-	38	-
5	15	.01	0	2.1	0.0	120	1.1	223	25	.3	225	33	4.8
6	16	.04	0	2.4	.0	110	.7	201	32	.3	218	32	2.5
7	17	.02	0	2.2	.3	120	1.4	215	31	.3	228	45	5.2
8	17	.02	0	11	8.4	130	1.6	220	21	.4	215	110	3.6
9	43	.01	.16	39	.5	250	2.5	166	0	2.1	136	490	17

Sample number	Fluoride dissolved (F) mg/l	Nitrite + Nitrate dissolved as N mg/l	Phosphorous dissolved orthophosphate as P mg/l	Orthophosphate dissolved (PO_4) mg/l	Residue Total dissolved solids calculated from sum of determined constituents		Hardness dissolved as $CaCO_3$ (Ca,Mg) mg/l	Noncarbonate hardness dissolved mg/l	Percent sodium %	Sodium adsorption ratio (SAR)	Specific conductance, micromhos at 25°C
					mg/l	T/ac-ft					
1	0.3	0.05	0.13	0.40	334, 345 2/	0.47	4	0	98	25	545
2	-	-	-	-	-	-	-	-	-	-	513
3	.6	.1	.02	.06	326 2/ 310	-	16	0	94	12	499
4	-	-	-	-	-	-	-	-	-	-	503
5	.2	.08	.03	.09	312	0.42	5	0	98	23	508
6	.2	.33	.03	.09	296	.40	6	0	97	20	493
7	.2	.21	.04	.12	329	.45	7	0	97	20	550
8	.3	.18	.03	.09	412	.56	62	0	82	7.2	663
9	1.0	.03	.14	.43	925	1.26	99	0	84	11	1,390

Table 1 -- Dissolved and suspended chemical constituents in water from uranium mines and wells in the vicinity of Church Rock, McKinley and San Juan Counties, New Mexico - continued.

Sample number	pH	Water temperature °C	Density at 20°C	Alpha gross dissolved as U natural µg/l	Alpha gross suspended as U natural µg/l	Beta gross dissolved as Cs 137 pCi/l	Beta gross suspended as Cs 137 pCi/l	Beta gross dissolved as Sr^{90}/Y^{90} pCi/l	Beta gross suspended as Sr^{90}/Y^{90} pCi/l	Radium-226 dissolved radon method (Ra^{226}) pCi/l	Uranium natural dissolved (U) µg/l	Residue total filtrable mg/l	Residue total nonfiltrable mg/l	Latitude	Longitude
1	8.9	37	-	<5.4	3.7	3.0	2.5	2.4	2.0	0.05	<0.4	360	60	35°41'34"N	108°08'23"W
2	9.0	-	-	-	-	-	-	-	-	-	-	-	-	35°39'26"N	108°30'28"W
3	8.8	-	-	-	-	-	-	-	-	-	-	-	-	35°39'26"N	108°30'28"W
4	-	-	-	-	-	-	-	-	-	-	-	-	-	35°39'26"N	108°30'28"W
5	9.1	-	-	1,070	.8	57	4.4	48	4.1	.62	264	420	3	35°39'26"N	108°30'28"W
6	9.2	-	-	110	< .4	12	.9	9.6	.8	.09	31	300	<1	35°39'26"N	108°38'28"W
7	9.2	-	-	2,000	3,000	150	1,100	120	860	8.1	1,210	340	490	35°39'26"N	108°30'28"W
8	9.0	-	-	-	-	-	-	-	-	-	-	-	-	35°39'30"N	108°30'27"W
9	8.1	61	-	<9.3	< .4	3.9	< .4	4.8	< .4	.24	.07	880	1	36°15'28"N	108°19'22"W

Sample number	Remarks
1	Collected by J. W. Shomaker during pump test of newly completed well. Static water level, 103 m (338 ft) from land surface. Boron, 70 µg/l. Dissolved uranium by fluorometric extraction, 0.09 µg/l. Land surface datum estimated to be 2,096 m (6,875 ft) above mean sea level.
2 and 3	Collected by W. A. Mourant from tap in washroom near mine shaft. Well drilled and completed December 1967. Casing with 0.121 m (4.75 in) inside diameter was set to depth of 503 m (1,650 ft). Lowermost 30 m (100 ft) has torch-cut slots. Casing not cemented. Water from Dakota Sandstone and other aquifers may be commingled with water from the Westwater Canyon Member. The well is equipped with an oilfield type cylinder pump operated by a pump jack with a 25 horsepower electric motor. Pump is set at 486 m (1,596 ft), has a 0.8 m (32 in) stroke, and yields 1.26 l/s (20 gpm) when the leathers are good. Initial water level was 122 m (400 ft) below land surface when drilled in December 1967 and was 274 m (900 ft) below land surface in January 1969--the last time that the pump was removed for maintenance. Storage is provided by two 38 m^3 (10,000 gal) metal tanks and flows by gravity through plastic and galvanized pipes to the buildings and trailers. The water is not treated prior to consumption.
4	Collected by W. A. Mourant from seepage from roof of "549 m" ("1,800 ft") drift at 457 m (1,500 ft) level. Sandstone is well fractured and friable. Most water was entering mine workings around roof rock bolts but there were also numerous flows of about 0.13 l/s (2 gpm) issuing from fractures in the sandstone.
5	Collected by W. L. Hiss from a drill hole at end of C-3 drift about 610 m (2,000 ft) southwest of the mine shaft. Near station 15-205+48 ft. Water clear.
6	Collected by W. L. Hiss from a drill hole near No. 1 vent hole in A-1 drift. Water clear.
7	Collected by W. L. Hiss from end of waste water discharge line at settling pond. Water had gray color and was very turbid. Mild clay odor. Suspended solids reported to be unusually high due to included muck from air shaft being driven.
8	Collected by W. L. Hiss from end of sump discharge line. Water was clear with no odor. Mine shaft completed but active mining had not yet commenced.
9	Collected by W. L. Hiss and J. W. Shomaker. Well was allowed to flow at about 22 l/s (350 gpm) for several hours prior to collecting the sample. Land surface datum 1,751 m (5,746 ft) above mean sea level.

1/ Projected section, township, and range.
2/ Total dissolved solids determined by evaporation at 180°C.

References

City of Gallup, 1977, Research study on use of uranium mine water as a municipal supply for the City of Gallup, New Mexico: Unpub. rept., City of Gallup, N. Mex., approx. 100 p.

Cooper, J.B., and John, E.C., 1968, Geology and ground-water occurrence in southeastern McKinley County, New Mexico: New Mexico State Engineer Tech. Rept. 35, 108 p.

Fitch, D.C., 1974, Uranium resources of New Mexico, in Hiss, W. L., and Shomaker, J.W., 1974, compilers, Papers presented at Energy Crisis Symposium, Albuquerque, New Mexico, 1973: New Mexico Bur. Mines and Mineral Resources Circ. 140, p. 82-99.

Gay, I.M., 1963, Uranium mining in the Grants district, in Kelley, V.C., chm., Geology and technology of the Grants uranium region: New Mexico Bur. Mines and Mineral Resources Mem. 15, p. 243-246.

Hiss, W.L., 1975, Evaluation and proposed study of potential ground-water supplies, Gallup area, New Mexico: U.S. Geol. Survey Open-File Report 75-522, 153 p., 4 figs., 2 tbls.

Hohne, F.C., 1963, Production geology methods at the Kermac mines, in Kelley, V.C., chm., Geology and technology of the Grants uranium region: New Mexico Bur. Mines and Mineral Resources Mem. 15, p. 247-255.