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CONTAMINANT LOADING ON THE PUERCO RIVER — A HISTORICAL OVERVIEW

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ABSTRACT

The Puerco River is a natural ephemeral stream that drains more than 3,000 square miles in northwestern New Mexico and northeastern Arizona. Between the early 1950s and 1986, the stream was dominated by discharges of treated and untreated uranium mine dewatering effluents. Contaminants also were derived from three other sources: the one-time release of 94 million gallons of uranium mill process waters in 1979; intermittent discharges of treated and untreated sewage effluent; and natural runoff. This paper summarizes the data and evidence that are related to the anthropogenic sources of contaminants discharged to the Puerco River in the past 40 years. Water quality monitoring data reported by state, federal, tribal and private institutions through 1987 are reviewed. Historic uses of the river and its tributaries by rural Navajos also are discussed.

INTRODUCTION

The Puerco River is derived from two major tributaries in its headwaters in northwestern New Mexico: the North Fork, which heads in the Pinedale Trough near Hosta Butte, New Mexico, and the South Fork, which heads on the northern flank of the Zuni Mountains east of Gallup, New Mexico. (See Figure 1.) The North and South Forks meet at the eastern edge of the city of Gallup. Major tributaries to the Puerco downstream of Gallup include Manuelito Canyon 12 miles west of Gallup and Black Creek, which rises in the Chuska Mountains north of Window Rock, Arizona, and empties into the Puerco at Houck, Arizona.

Prior to the early-1950s, the Puerco River was an ephemeral stream. Since February 1986 when discharges of uranium mine dewatering effluent ceased, the river has resumed its intermittent conditions. (Shuey 1986) The North and South forks generally are dry throughout most of the year, except during periods

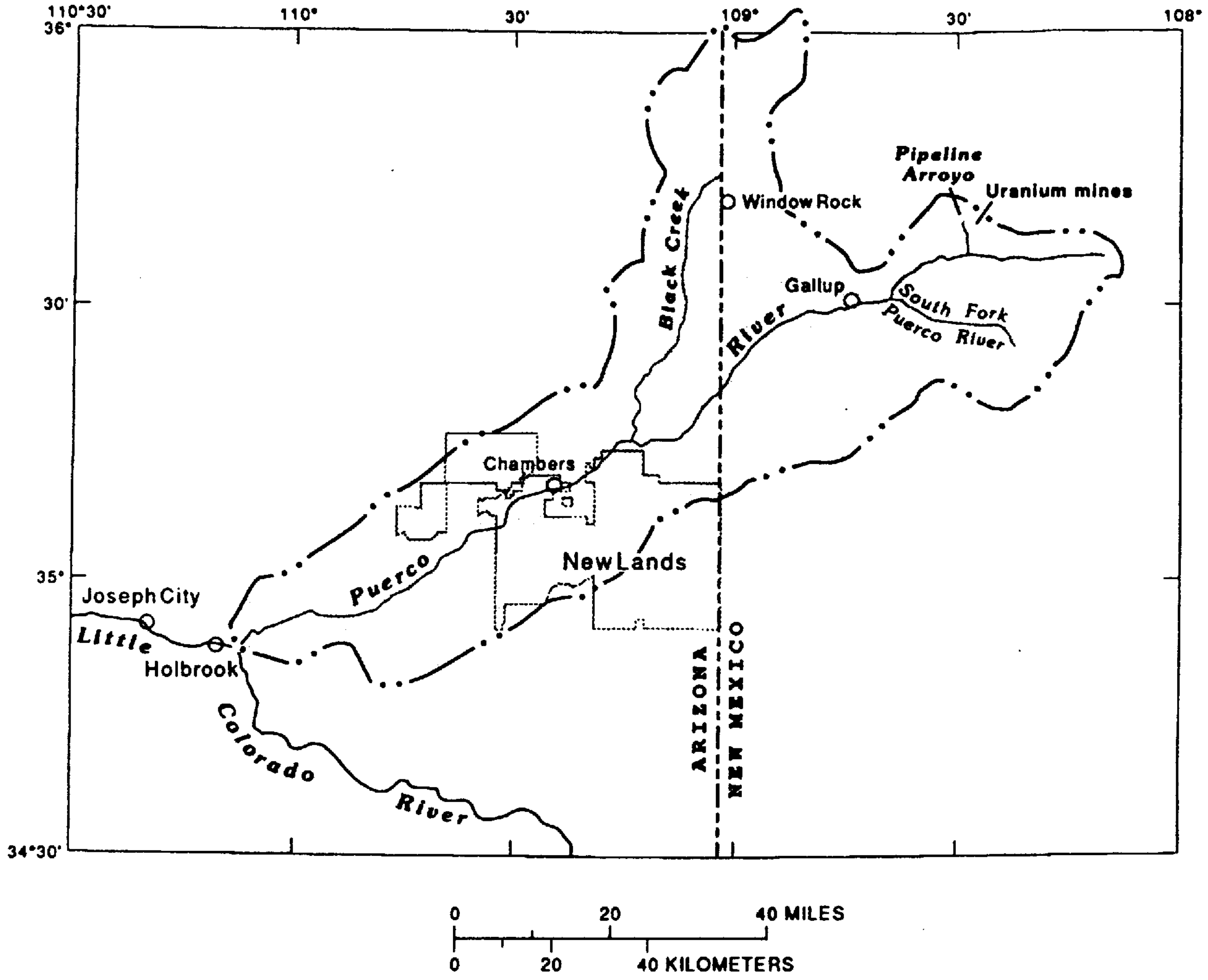

Figure 1. Puerco River Basin, New Mexico and Arizona
(from Wirt et al., 1991, p. 2)

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of snowmelt in the spring and runoff from summer thunderstorms. Routine discharges of more than 2 million gallons per day of treated sewage effluent from the Gallup Waste Water Treatment Plant (GWWTP) create perennial flow conditions in the river from Gallup to the New Mexico-Arizona border. Flood events can also create extended periods of continuous flow in the downstream portions of the Puerco in Arizona. In fact, peak discharges during flood events can exceed 3,000 cubic feet per second (cfs) in flows in the Puerco near Chambers, Arizona. (Webb et al., 1987)

ANTHROPOGENIC SOURCES OF CONTAMINANTS

Table 1 shows that the Puerco River main stem and the North Fork of the river have been subject to three distinct anthropogenic sources of contaminants: (1) treated and untreated uranium mine dewatering effluent; (2) untreated uranium mill process water released in a July 16, 1979, tailings impoundment break; and (3) treated and untreated sewage discharged routinely by the city of Gallup and, intermittently, by trailer courts and truck stops located next to the river in New Mexico. (Shuey 1986) Each of these contaminant sources are reviewed below.

Table 1. Anthropogenic Sources of Contaminants to the Puerco River, New Mexico and Arizona

River Segment(s)	Uranium Mine Dewatering Effluent	July 16, 1979 Tailings Spill	Sewage Discharges
North Fork, upstream of Pipeline Arroyo	yes	no	no
North Fork at Rt. 566 bridge downstream of Pipeline Arroyo	yes	yes	no
South Fork at Rt. 566 bridge, 4 mi. e/Gallup	no	no	no
South Fork .5 mi e/ confluence w/ North Fork	yes	no	no
Puerco main stem, downstream of confluence of North, South Forks	yes	yes	yes
Puerco main stem, downstream of Gallup WWTP	yes	yes	yes
Puerco main stem at NM-AZ state line	yes	yes	yes

Uranium Mine Dewatering Effluent Discharges

Between the early-1950s and mid-1960s, flows in the North Fork of the Puerco were characterized by intermittent discharges of uranium mine dewatering effluents. Little data about the volumes and quality of those discharges were recorded. (Hearne 1977; Hilpert 1969) Between approximately 1968 and 1986, flow in the stream was perennial, characterized by routine discharges of uranium mine dewatering effluents from three uranium mines located approximately 12 miles northeast of Gallup. (See Figure 1.) As shown in Table 2, discharges of mine dewatering effluent peaked at more than 5,800 gallons per minute (gpm), or more than 8.3 million gallons per day, between 1979 and 1981. (Gallaher and Cary 1986) Two of the three mines operating in the Church Rock-Pinedale area closed in 1983. Between 1983 and 1984, the remaining mine discharged about 2,700 gpm of uranium mine water. Discharges were less than 1,100 gpm when the remaining mine ceased discharging in February 1986. (Shuey 1986)

Water quality data for those discharges were reported periodically between 1975 and 1979 and routinely, under authority of federal NPDES (National Pollutant Discharge Elimination System) permits, between 1980 and 1984. Data that were reported during the 1970s and which were summarized in Wirt et al. (1991) showed concentrations of gross alpha and gross beta particle activity and radium-226 (total) in mine-water effluent exceeding applicable stream-water and drinking water standards by one to four orders of magnitude. (Wirt et al., 1991; NMEID 1984; Goad et al., 1980) Since the NPDES permits issued to each of the three mines were being contested in federal court in the 1970s, treatment of the mine water to reduce contaminant concentrations was not mandatory. Hence, untreated mine waters were discharged periodically to the Pipeline Arroyo (see Figure 1), a tributary of the North Fork, on several occasions between 1975 and 1980. (Wirt et al., 1991)

Effluent limitations in the federal discharge permits became enforceable in 1980 at the conclusion of the litigation. Based on a review of NPDES discharge monitoring reports obtained under a Freedom of Information Act request to the U.S. Environmental Protection Agency (U.S. EPA) in 1983, Shuey (1986 and 1983) reported 63 violations of permit conditions between January 1980 and March 1983 for all three mines. The mine-water discharge from one of the mines, the Old Church Rock Mine, was shown to violate at least one permit condition or limitation in 25 of 37 months between January 1980 and February 1983. (Shuey 1986) Limitations for total and dissolved radium-226 were most often exceeded, suggesting that the ion-exchange treatment technology employed by the mining companies was not effective at all times.

Table 2. Chronology of Point-Source Waste Discharges to Puerco River, 1952-1989

Year(s)	Facility(s)	Location(s)	Vol./Rate
1952-64	Unspecified uranium mines	Drainage area for North Fork	unreported
1958	Gallup WWTP	T15N.R19W.Sec.23	<1 Mgd
1960-63	(Old) Church Rock Mine	T16N.R16W.Sec.17.2	<450 gpm
1968-82	NE Church Rock Mine (UNC)	T17N.R16W.Sec.35	≈1,800 gpm
1972-81	Church Rock Mine (KMNC)	T17N.R16W.Sec.36*	≈3,800 gpm
1981-84	Chruch Rock Mine (KMNC)	T17N.R16W.Sec.36*	≈2,700 gpm
1984-86	Church Rock Mine (KMNC)	T17N.R16W.Sec.36*	≈1,100 gpm
1979-82	Old Church Rock Mine (UNC)	T16N.R16W.Sec.17.2	≈200 gpm
1979	UNC Uranium Mill Tailings Dam Break	T16N.R16W.Sec.2	94 million gallons
1988	Gallup WWTP (raw sewage)	T15N.R19W.Sec.23	6.1 million gallons
1989	Gallup WWTP	T15N.R19W.Sec.23	≈2.5 Mgd

Sources: Wirt et al., 1991; Gallaher and Cary 1986; Shuey 1986; Hearne 1977. **Abbreviations**: gpm = gallons per minute; KMNC = Kerr-McGee Nuclear Corporation; Mgd = Million gallons per day; NE = Northeast; UNC = United Nuclear Corporation; WWTP = Waste Water Treatment Plant; and * = Located on Navajo Reservation just north of section 36 boundary.

Similar data have been reported by Wirt et al. (1991), who listed 28 exceedances of permit limitations for radium-226 (total and dissolved) for two of the three mines between 1980 and 1982.

The presence of above-background concentrations of uranium in treated and untreated uranium mine water was correlated with statistically elevated concentrations of uranium in sheep and cattle that grazed in the North Fork area in the early-1980s. (Millard et al., 1986) Lifetime cancer risks from consumption of the edible muscle and organs of the animals were calculated not to exceed federal and international recommended limits, however.

The July 1979 Uranium Mill Tailings Spill and Long-Term Water Quality Impairments

As shown in Table 2, an estimated 94 million gallons of acidic waste water were released to the Pipeline Arroyo, and hence to the North Fork of the Puerco, when an earthern tailings dam located at the United Nuclear Corporation Church Rock Uranium Mill failed on the morning of July 16, 1979. The mill process fluids, which had a pH of less than 2 and a gross alpha particle activity of 128,000 picoCuries per liter (pCi/l) (Shuey and Morgan 1988), traveled downstream into Arizona before dissipating into the stream bed near Chambers. (Shuey 1982) The incident, which became known as the "Church Rock Tailings Spill," remains the largest release (by volume) of low-level radioactive waste in U.S. history.

Hundreds of surface water samples were collected and analyzed by a variety by state and federal agencies between July 16, 1979 and 1985. Regulatory concern for the long-term impacts of the tailings spill and chronic dewatering releases waned in the mid-1980s after New Mexico environmental officials reported that surface waters in the Puerco had returned to "pre-spill conditions." (NMEID 1982) This pronouncement produced a false reassurance that led local residents to believe that flows in the Puerco were safe for consumption by animals. The reference to "pre-spill conditions" further clouded the public's understanding that the river water was dominated by contaminant-laden uranium mine waters for many years prior to the spill. (Shuey 1986)

Subsequent surface water sampling and analyses by the Arizona Department of Health Services (ADHS) in 1985 and by Southwest Research and Information Center (SRIC) in 1986 and 1987 confirmed the continued presence of high concentrations of gross alpha radioactivity and radium-226 in stream flows. ADHS reported exceedances of state surface-water quality limits for gross alpha radioactivity and radium-226. (ADHS 1985) Similarly, SRIC, reporting on analytical results of samples it collected in runoff waters in the Puerco in July 1986 and July 1987, documented the highest gross alpha and gross beta particle activities and radium-226 concentrations recorded since the days immediately following the tailings spill. (Shuey and Morgan 1988) Radium-226 (total) concentrations, for example, were 180 pCi/l and 130 pCi/l in samples collected from the Puerco at Lupton, Arizona, on July 16, 1986, and on July 31, 1987, respectively. Those radium concentrations exceeded applicable stream water standards in both New Mexico and Arizona. They were accompanied by high levels of suspended sediments: 82,100 milligrams per liter (mg/l) and 92,100 mg/l in July 1986 and July 1987, respectively. Particle-size analyses conducted by the U.S. Geological Survey on the SRIC samples collected in 1987 suggested that the radium is attached to fine-grained clays and is transported farther down stream with each successive runoff event. (Shuey and Morgan 1988)

The Role of Natural Runoff in Elevated Contaminant Levels

The high radium concentrations in the SRIC samples raised questions about the role that natural runoff plays in contributing to elevated pollutant levels in the Puerco River. That radionuclides and other trace elements occur naturally in water and rocks throughout the region is not disputed. (Wirt et al., 1991) Indeed, gross alpha plus gross beta particle activity was three to four times higher in runoff waters in the South Fork of the Puerco than in the North Fork in samples collected by SRIC on the same day in July 1987. (Shuey and Morgan 1988) Runoff conditions characterized both streams on that day. Additionally, no uranium mining activities were known to have been conducted upstream of the SRIC sampling point on the South Fork. Seemingly, natural conditions were playing a greater role in elevated radionuclide levels than were past uranium mining discharges.

Subsequent analyses showed, however, that radioactivity found in the river water in the North Fork was higher than that found in water in the South Fork when the activity level was measured as a percentage of suspended sediment. Table 3 shows these ratios for gross alpha and gross beta activity, radium-226 (total) and uranium (total). In each case, the activity level or concentration as a function of suspended sediment content was higher in the North Fork than in the South Fork. Suspended sediment concentrations in the South Fork were about an order of magnitude higher than those in the North Fork. This suggests that radioactivity would have been higher in the North Fork had the suspended fraction been equal to that in the South Fork. These results also suggest that more radioactivity rests in the bottom sediments of the North Fork at a point only five miles downstream from the uranium mining and milling complex in Pipeline Arroyo than in the sediments of the South Fork, which is influenced only by natural conditions.

Table 3. Comparison of Radioactivity with Suspended Sediment Concentrations in Surface Waters in the North and South Forks*

Parameter	Location	Concentration	Radioactivity / Suspended Sediments
Suspended Sed.	South Fork	27,700 mg/l	---
Suspended Sed.	North Fork	2,620 mg/l	---
Gross Alpha	South Fork	450 pCi/l	0.016
Gross Alpha	North Fork	190 pCi/l	0.073
Gross Beta	South Fork	780 pCi/l	0.028
Gross Beta	North Fork	130 pCi/l	0.0496
Radium-226	South Fork	18 pCi/l	0.0006
Radium-226	North Fork	6.3 pCi/l	0.0024
Uranium (tot.)	South Fork	0.044 mg/l	0.000002
Uranium (tot.)	North Fork	0.030 mg/l	0.000011

*All samples collected on July 31, 1987, and preserved the same day. All analytical results by Barringer Laboratories, Golden, Colorado, except those for total suspended solids, which were analyzed and reported by USGS, Tucson, Ariz. **Source:** Shuey and Morgan 1988.

Sewage Discharges

As shown in Table 2, treated and untreated municipal sewage has been discharged to the Puerco by the city of Gallup since at least 1958. As of mid-1989, discharges were about 2.5 million gallons per day. (Wirt et al., 1991) These flows can be observed in the Puerco from the Gallup WWTP to the state line.

A 6.1-million gallon spill of raw sewage occurred from a main line break just upstream of the Gallup WWTP in December 1988. The spill was the most serious of 15 unpermitted discharges of sewage in the city of Gallup in 1988 and the only sewage discharge to reach the Puerco. (Sutton-Mendoza 1989) It resulted in an EPA administrative order which requested that the city demonstrate to the federal agency that additional bypasses and upsets can be prevented. (USEPA 1989) (Attempts by the author to determine if additional sewage spills have occurred in Gallup since early 1990 were unsuccessful.)

The sewage spill was characterized by a greenish sludge that was noticeable in the Puerco as far downstream as Manuelito, about 12 miles away. Navajo residents of the area were concerned that the sewage had caused the unexplained deaths of several sheep. (Linkin 1989) The New Mexico Environmental Improvement Division (NMEID) concluded in March 1989 that the sludge had been cleaned up "satisfactorily" and that fecal coliform levels downstream were within legal limits. (Sisneros 1989) A strong sewage odor was documented the following spring by local residents and Manuelito Chapter officials, who took photographs of greenish-colored sludges present on the river bed. (PVNCWA 1990)

HISTORIC USES OF THE PUERCO RIVER

Navajos in the Puerco River valley have used surface waters in the river for livestock watering purposes for decades. (Shuey 1986) Occasionally, they have used the shallow ground water under the river bottom for drinking water and other domestic purposes, either through shallow wells or hand-dug holes. (Shuey 1986) There is little domestic use of the river as a result of increased awareness and knowledge among the local people about the history of contaminant loading on the Puerco. However, shallow water wells continue to be used for domestic purposes in both New Mexico and Arizona. (Wirt et al., 1991; Webb 1987)

There was little knowledge among local Navajos about the sources of the perennial flows that characterized the river between the late-1960s and the mid-1980s. Local leaders have testified that they did not learn that the river was dominated by uranium mine dewatering effluents until after information about the adverse effects of the 1979 tailings spill was widely distributed in the Navajo chapters in the late 1980s. (Benally 1989) A public education and information program conducted by SRIC at the request of Navajo chapters in the river valley was instrumental in building local knowledge and awareness. (Benally 1989; Negri 1988; Shuey 1986)

Local Navajo leaders also have sought assistance from government agencies. Citing their knowledge of local uses of the Puerco for livestock and agricultural purposes and long-term water quality impairments, elected officials of several chapters in the region requested in May 1987 that the U.S. EPA designate the Puerco River from Pinedale, New Mexico, on the east to Sanders, Arizona, on the west for cleanup under the federal Superfund program. (Becenti et al., 1987) A preliminary site investigation under Superfund authority was conducted by consultants to EPA in 1988. The resulting study found evidence of significant water quality problems in the Puerco River and the potential for adverse health effects in humans from exposure to pollutants in surface and ground waters, but recommended against Superfund designation on the grounds that not all of the contamination was from human activities. (Carter 1988)

In an effort to continue the public education programs of the late-1980s and to build local and regional support for development of clean water supplies in the river valley, local Navajo elected and community leaders formed the Puerco Valley Navajo Clean Water Association in 1989. (Begay and Shuey 1989) The Association links officials and citizens of Navajo communities from Pinedale to the New Lands near Sanders, Arizona. Its goals are to educate and inform local people, especially the youth; develop new water supplies for expanded agricultural activities; and promote the cleanup and protection of existing water supplies. PVNCWA is one of a growing number of grass-roots citizens groups now active on the Navajo Nation.

CONCLUDING COMMENTS

The Puerco River once was known among local Navajos as *Tó Nízhóní* — or, "beautiful water." Today, the river is considered a dumping ground and unsafe for use by either animals or people. Still, sheep, horses and cattle can be seen on virtually any day of the year watering in the river when it is flowing. Many Navajo families say they have no choice but to allow their animals to drink from the river because there are few other convenient sources of livestock water for miles around. (Benally 1989) Regardless of the cause or causes of continued contamination of the surface water in the river, new water supplies must be developed to decrease the use of the river for agricultural or domestic purposes. But should ongoing scientific studies by USGS demonstrate a link between today's contaminant levels and yesterday's discharges of mining or municipal wastes, the parties responsible for discharging those wastes should be held accountable financially and technically for the restoration of the Puerco River.

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