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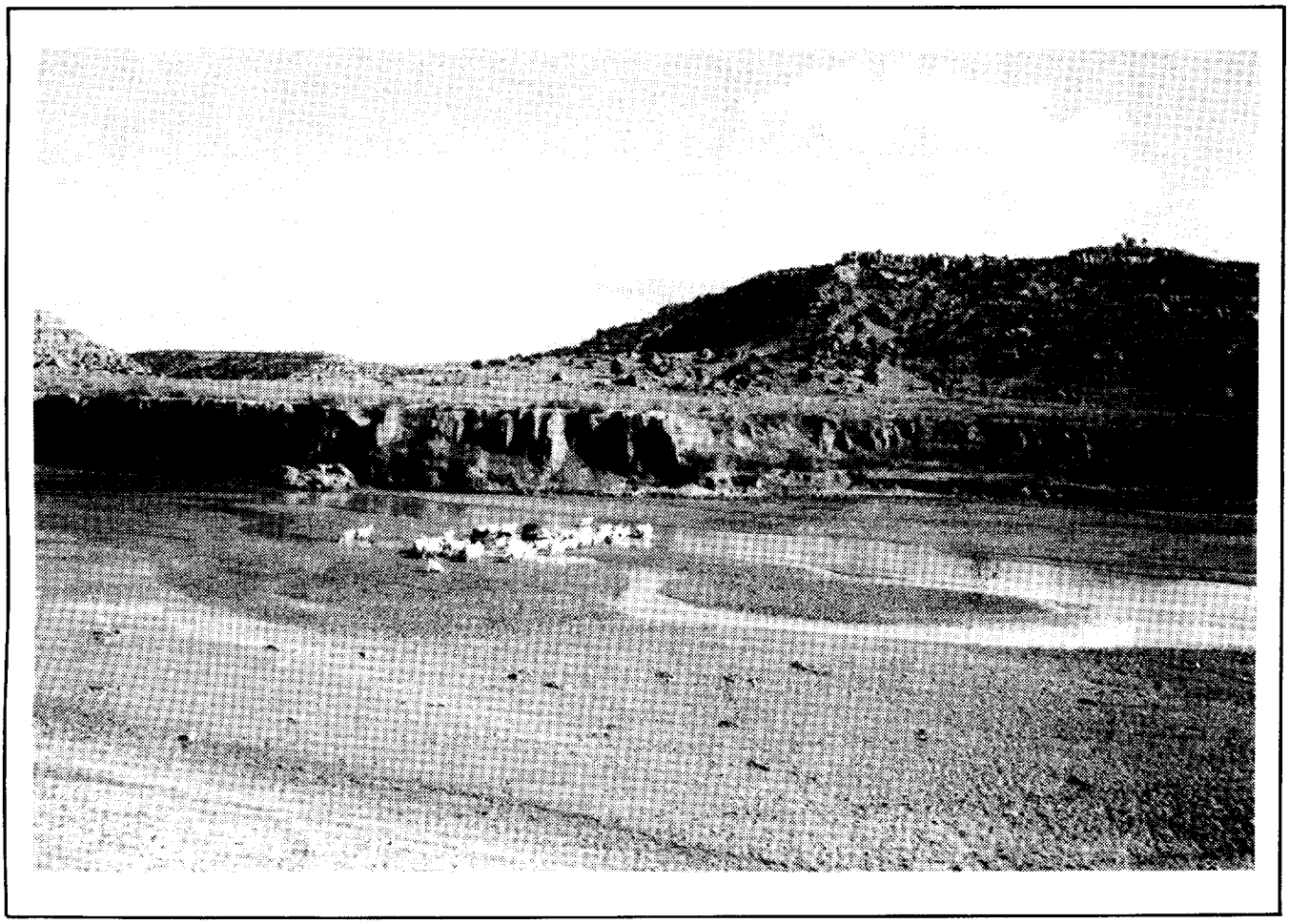

The Puerco River: WHERE DID THE WATER GO?

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The Puerco River: WHERE DID THE WATER GO?

by **Chris Shuey**

The Puerco River is once again an ephemeral stream. Like most streams in arid northwest New Mexico and northeast Arizona, it now flows only after occasional summer rains or after mountain snows have melted in the spring. Navajos who live next to the river say they remember a time when the Puerco was much the same as it is today: useful for watering livestock for just a few days or weeks each year, dusty and barren the rest of the time.

Between 1969 and February 1986, the Puerco flowed year-round, fed by millions of gallons of contaminant-laden water that poured daily into one of its tributaries (called the North Fork) from three underground uranium mines located in the Church Rock area about 15 miles northeast of Gallup, New Mexico (see map, page 2). Information on mining activities in the area prior to 1969 suggest that the river also flowed year-round during part of the 1950s and early 1960s when uranium was taken from about a dozen mines that dotted the hills northeast of Gallup. Added to the mine water flow was a smaller amount of water discharged primarily during the winter months from Gallup's sewage treatment plant.

The local Indians, who are the principal residents of the canyons and mesas that border the Puerco River Valley near the southern boundary of the Navajo Reservation, came to depend on the mine water-dominated stream as the main source of water for their sheep, goats, and cattle during those 35 years. Some used it for irrigating backyard gardens, and a handful say that they and their children often drank directly from the river. None questioned whether the river water was safe for themselves or their animals. All they knew was that a perennial source of water in this otherwise dry region had somehow materialized; they did not know how or why. The only problem was that no one bothered to tell the Navajos that the water that poured from the mines during the uranium boom years of 1952-1964 and 1969-1981 was not safe for man or beast.

Now that the mines have closed in response to the uranium market collapse of 1979-1980, the Puerco River is returning to a semblance of its natural state, fed by natural runoff and treated effluent from the Gallup sewage plant. The key difference between today's river and the ephemeral stream of yesterday is that the Puerco of 1986 is contaminated beyond use by a combination of natural and man-made pollutants. Water running off the erodable, uranium-bearing rocks of the region has contributed harmful substances to the river system for aeons, but only since the advent of uranium mining has the stream received radioactive and toxic wastes associated with human activities. The steady assaults on the river's water quality by the 18 to 35 years of mining discharges, and the "shock loading" of a massive 1979 uranium mill wastewater release (the so-called Church Rock spill), has transformed more than 100 miles of the stream into a chronically polluted body of water that may never be cleansed naturally or by the best of human interventions.

Despite the Puerco's history of contamination, the message that the water was unsafe did not reach the inhabitants of the river valley in New Mexico and Arizona until after the 1979 spill — a disaster that still ranks as one of the largest-ever releases of radioactive wastes in the U.S. To the best of local recollection, most of the rural Navajos had hauled drinking water from the nearest tribal chapter house wells — often distances of 10 to 30 miles — for many years before the spill. To this day, they continue the practice, as if hauling drinking water were part of their culture.

But for a short time after the accident, the local residents stopped using the Puerco for their livestock and began hauling water for the animals, too. Trucks took fresh water to chapter houses in the Puerco Valley for a while after the spill, but when the service ended in 1981 the people began to look elsewhere for water: first, to the city of Gallup, where they said they had to buy water; next, to areas of the reservation away from the Puerco River; and finally, back to the Puerco itself. There was, as many Navajos now remember, nowhere else to go, and their animals had to have water.

State and federal regulatory interest in the Puerco River peaked during the two years following the spill and then tapered off between 1982 and 1984 after

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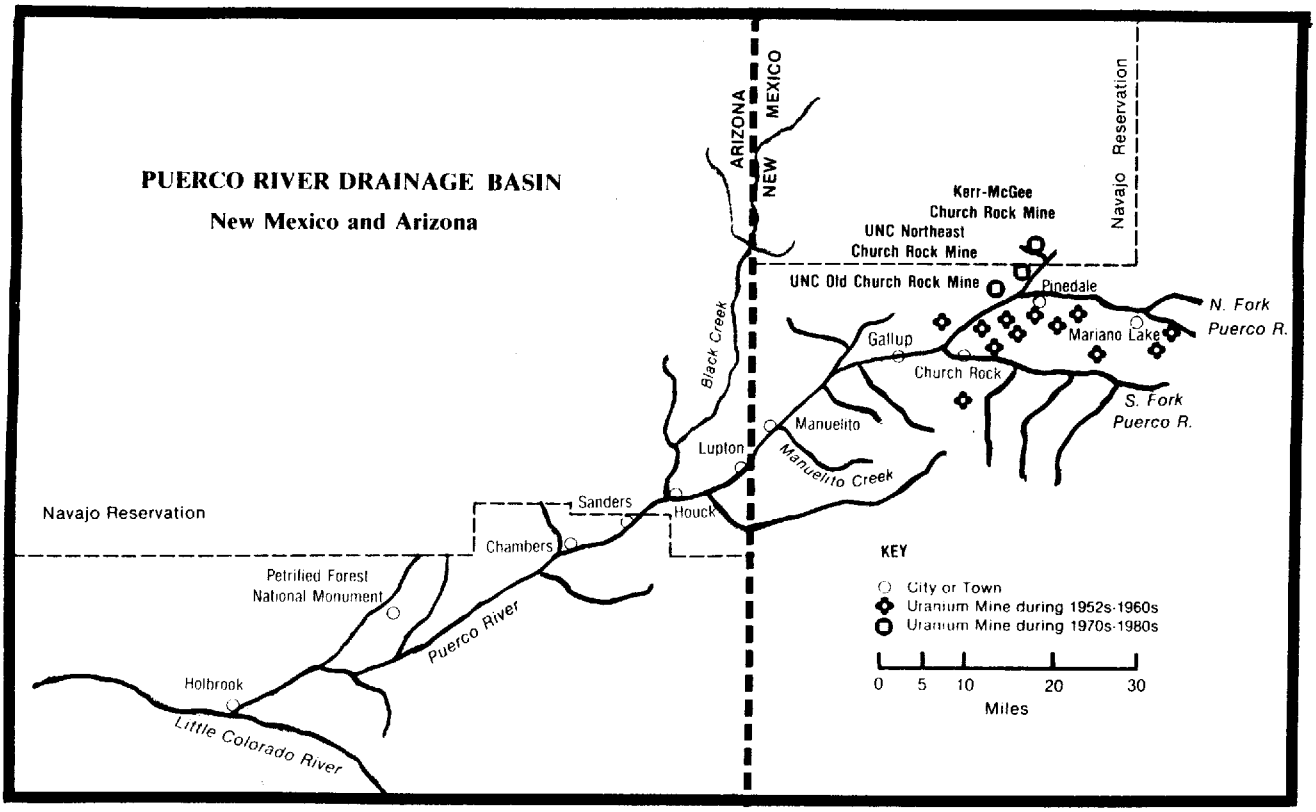


several agencies and at least one private scientific group announced that the impacts of the spill on the river system were no longer evident. Little water quality monitoring was conducted in those years, despite the Navajos' continued use of the stream for livestock watering. Only after the state of Arizona, in late 1983 and early 1984, raised questions about the adverse impacts of mine water discharges on water quality in the river and in the shallow ground water zone beneath it was regulatory interest rekindled. (Though the mines closed in the early 1980s, their owners continued dewatering operations for several years.)

That interest led to a resumption of monitoring in the stream in Arizona and New Mexico in 1985. Chemical analyses of river water at locations in both states show that the Puerco River remains contaminated with levels of radioactive materials and heavy metals that violate state and federal water quality standards *(1,2)*. The recent monitoring data confirm what the New Mexico Water Quality Control Commission concluded nearly two years ago: "Regardless of the source of contaminants, Puerco River water may be hazardous if used over several years as the primary source of drinking water, livestock water, or irrigation water. The severity of these hazards is not well known at this time" *(3)*.

Arguments about the extent to which mining activities in the past may have polluted the Puerco or contributed to increased health risks among the Navajo residents of the area tend to obscure the main problem faced by the Indians who live next to the river. Except for the estimated 860 families who live in small communities served by centralized water systems, much of the large rural population of the valley remains dependent on sources of water that are either miles away or are nearby but unsafe to use. The 700 or more families of the valley that federal and tribal agencies estimate do not currently have access to centralized water systems are left with few alternatives, none of which are without problems of their own: install potentially expensive, individual wells in the streamside alluvium to tap ground water that may or may not be contaminated, or simply continue to use the Puerco itself.

Events in the next few years will determine if clean and dependable water supplies are developed for the 10,000 or so rural and low-income Navajos who live between Pinedale, New Mexico, and Chambers, Arizona. Additional research on water availability in the valley seems to be a first step. More accurate figures must be obtained on the number of people who have access to centralized water systems and on the number who do not. It must be made known to the residents that it costs less to hook up to water mains (where they exist) than to haul water many miles every day. The people, in turn, must take a more active role in addressing their local water resource problems. And state, federal, and tribal officials must recognize that the water quality problem in the Puerco River Valley is primarily an issue of public health — not an issue of the convoluted workings of regulations few of the Navajos understand or really care about.

1985 SAMPLING RESULTS — A TALE OF POLLUTION

Chemical analyses of stream water samples collected by state and federal agencies in 1985 show that the Puerco River in northwest New Mexico and northeast Arizona is polluted with levels of radioactivity and heavy metals that exceed state and federal drinking water standards, in some cases by thousands of times *(1,2)*. The data show that the river water should not be used for domestic purposes or for watering livestock. The message to Navajo families who live and farm in the Puerco Valley is clear: Do not use the river water for drinking, cooking, or watering crops, and make every effort to keep animals away from the stream.

The analyses show that concentrations of such carcinogenic pollutants as radium, lead, and selenium in stream water at five monitoring locations in Arizona consistently exceeded that state's radiochemical stream water standards *(1)*. In New Mexico, concentrations of selenium and gross alpha radioactivity exceeded federal drinking water regulations at 14 sampling locations *(2)*. Levels of radium exceeded the same regulations at one of those locations *(2)*. The samples were collected by the Arizona Department of Health Services (ADHS) in Arizona and the federal Bureau of Indian Affairs (BIA) in New Mexico.

> 1985 SAMPLING DATA AVAILABLE. Tables showing the results of chemical analyses of Puerco River water samples collected by state and federal investigators in Arizona and New Mexico in 1985 may be obtained by contacting Chris Shuey at SRIC. Any reference cited in this article, or further information about the issue, may also be obtained from the author.

Comparing the concentrations of pollutants in the river water to human drinking water standards was found to be appropriate by ADHS's epidemiology and environmental services staff in mid-1985 *(1,4)*. The staff noted that the sampling results showed that in most cases the pollutants, especially radium, were attached to clay and silt particles that float in the river water *(1)*. Cognizant that animals belonging to local Navajos water regularly in the Puerco, the staff said that the animals "are likely to consume significant amounts" of these floating particles, which are called "suspended solids" *(4)*. Since animals, unlike humans, do not filter water before they drink it, they ingest all of the hazardous substances in the suspended solids, including the radium. State and federal studies have found that animals that drank regularly from the Puerco had higher-than-normal levels of radioactive elements in their bodies *(5,6,7)*. When the Navajos slaughter and eat the animals, they in turn consume the excess radioactive materials and as a result may face higher risks of developing cancer. The ADHS staff reasoned that the consumption of river water by the animals is, therefore, indirectly the same as if the residents had drunk the water themselves.

Arizona officials, concerned that the high levels of gross alpha radioactivity were caused by excessive concentrations of uranium in the water, and that the uranium, like radium, was attached to the suspended solids, suggested that the state adopt a numerical standard for uranium that also reflects human drinking water use *(4)*. ADHS's recommended uranium standard, which it based on the findings of a federal scientific panel, was shown to have been exceeded in 36 of 37 samples collected in the Arizona portion of the Puerco *(1)*.

ONE PROBLEM, TWO APPROACHES

The record of high concentrations of uranium, radium, and heavy metals like selenium in the Puerco in Arizona raised the question of whether discharges of mine water in New Mexico were causing violations of stream water standards in Arizona. According to a preliminary ADHS report, the Puerco's high levels of selenium suggested a link to past discharges of water from uranium mining and milling operations upstream in New Mexico. "Although mine dewatering may have ceased, the selenium violations observed during low flow may be attributable, in part, to residues from past discharges," the report said. "Mine dewatering discharges are suspected as sources of these violations" *(1)*.

New Mexico environmental officials dispute the contention that past mining activities in New Mexico have had a long-term, negative effect on water quality in the Puerco River. They insist that the available data do not "support a suggestion" that "a cause-and-effect relationship exists between uranium mining effluents discharged in New Mexico and exceedances of water quality standards in Arizona" *(8)*. The officials, who do not disagree with the contention that the Puerco is polluted and should not be used as a source of water for people, livestock, or crops, argue that there has not been a single violation of New Mexico's stream water regulations at any location in the Puerco River in New Mexico since 1982.

In light of the 1985 chemical analyses of the Puerco, how can stream water that originates in New Mexico and flows into Arizona meet standards in the upstream state and at the same time violate standards in the downstream state? Certainly, the quality of the water in the river does not automatically worsen when the Puerco reaches the New Mexico-Arizona state line.

The answer lies in two factors. The first and most important is that New Mexico's stream water regulations are, on their face, less stringent than Arizona's standards, even though the U.S. Environmental Protection Agency (EPA) has approved both sets of standards as meeting the federal Clean Water Act's criteria for achieving protection of surface water quality. The second factor lies simply in the absence of stream water quality data.

Key differences in the standards of the two states explain the seemingly paradoxical situation in which violations can occur in Arizona and not in New Mexico. The principal difference lies in how the states protect surface water quality. Arizona protects it on the basis of "existing uses." If an existing use is domestic water supply — the highest and best use of any body of water — Arizona imposes the most restrictive numerical limits on water in the stream. The numerical limits take into account the human health hazards of each specific pollutant.

Unlike Arizona's rules, New Mexico's assume that humans do not — either directly or indirectly, through animals or plants — drink river water unless it is extensively treated to remove harmful substances *(9)*. New Mexico assumes that, under most conditions, surface water is not chemically safe for people to drink. That assumption leads the state to conclude that it is unnecessary to adopt health-based drinking water standards for water that will never — or at least, should never — be used for human consumption. New Mexico protects surface water quality only for the least restrictive of all uses, fishing and recreation.

Arizona applied drinking water limits to the Puerco not only on the basis of its assumption that local residents eat meat from animals that watered in the stream, but also on the basis of its finding that the river is used indirectly as a source of drinking water for Navajos who live next to it. That finding is based on the understanding that the Puerco forms one continuous surface and subsurface hydrologic system in which water in the river eventually percolates through the sands and gravels of the riverbed to form a shallow ground water zone beneath the stream *(10)*. ADHS officials noted in testimony to EPA in July 1983 that this "alluvial" water is tapped by shallow wells and used for drinking by people near the river *(11)*. The state officially recognized the Puerco's drinking water use when it added "domestic water supply" to the other designated uses of the river (for livestock watering, irrigation, fishing, and recreation) in late 1984 *(12)*.

The effect of the two different approaches to protecting surface water quality can be seen in various numerical standards. A good example is radium. Arizona's numerical standard for radium (Ra-226 plus Ra-228) in surface water in the Puerco is 5 picoCuries per liter (pCi/1), *(13)* identical to EPA's national drinking water standard *(14)*. (A picoCurie is a measure of the amount of radiation given off by a specific radioactive material.) But New Mexico's radium standard for any surface water, including that in the Puerco, is 30 pCi/1, six times greater than Arizona's *(15)*. New Mexico's limit is not based on the potential health hazards of consuming excessive quantities of radium in water; rather, it is based on federal radiation protection regulations, which were adopted by the state many years ago and which themselves are based on the capacity of treatment equipment to reduce the levels of radioactive substances in water, soil, or air *(16)*.

The obvious difficulty with New Mexico's approach to protecting surface water is that it ignores the real

Chris Shuey

The photos above illustrate how flows in the Puerco River can fluctuate dramatically from one year to the next. The photo at the left shows high-flow conditions near Sanders, Arizona, in April 1985; the photo at the right shows low-flow conditions near Gallup, New Mexico in March 1986. Depth of the water at the left is three to nine inches; depth of the water at the right is one to two inches.

water use practices of people who live in arid climates. In the Puerco River Valley, the rural Indian population uses water wherever it is and with little regard for its chemical quality. While available information suggests that very few, if any, of the people still use water from the Puerco for drinking, there is extensive anecdotal information, based on statements of individual Navajos, showing that there was — and still is, to this day — extensive use of the stream for livestock watering. But under New Mexico's system, even livestock uses of the river are not protected.

A second factor which explains why surface water standards can be violated in Arizona and not in New Mexico lies in the fact that the New Mexico Environmental Improvement Division (NMEID) has not obtained water quality data for the Puerco in New Mexico since November 1983. That lack of data makes NMEID's assertion that there is no evidence of stream water standards violations in New Mexico misleading. Prior to late 1983, the last violation of a New Mexico stream standard in the Puerco was recorded in 1982 — more than three-and-a-half years ago *(17)*. Without recent water quality data, it can neither be proved nor disproved that violations have occurred, but the long lapse in testing suggests that the agency needs to collect new samples from the Puerco to determine its quality in 1986. (A NMEID radiation official said in December that he collected two samples from the river in November 1985 but had not yet received the analytical results *(18)*. The official could not be reached for additional comment during preparation of this article.)

The chemical analyses of the samples collected by federal personnel in New Mexico in 1985 did not provide evidence of a single violation of any New Mexico standard, despite showing levels of selenium, gross alpha radioactivity, and radium which violated EPA and Arizona drinking water standards.

CONTAMINATION — NATURAL OR MAN-MADE?

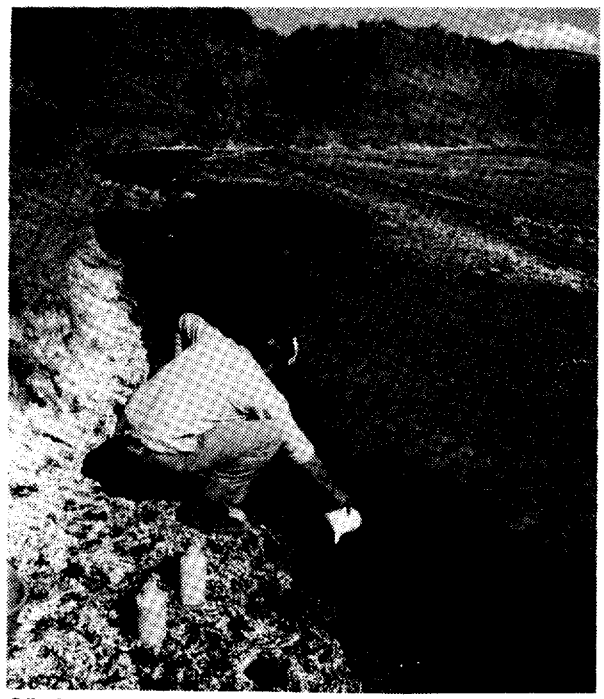
Differences in state standards aside, the important point is that the Puerco River remains polluted. How it got that way is the next question. Was it the 18 to 35 years of mine water discharges? Was it the 1979 tailings spill? Or did natural conditions make pollution of the river inevitable? As noted above, New Mexico officials discount mine dewatering because water in the Puerco in New Mexico does not violate state standards. The officials also say that the effects of the release of 94 millions gallons of toxic mill wastewater during the spill are no longer evident in the stream *(3)*.

That leaves natural conditions, which many New Mexico officials say is the root cause of impaired water quality in the Puerco River. The basis for that view lies in water quality analyses for samples collected in 1982 from two tributaries of the Puerco that NMEID surface water specialists said were unaffected by mining-related discharges *(19,17)*. The analyses from the South Fork of the Puerco and from the North Fork at a location which was said by NMEID to be upstream from the uranium mine discharges (see map, page 2) show that gross alpha radioactivity exceeded recommended standards for livestock water and that radium, in a few samples, exceeded New Mexico stream water standards *(17,20)*. In addition, an April 1985 sample collected by ADHS personnel from Black Creek, a tributary of the Puerco in Arizona which also is said not to be affected by mining discharges, showed gross alpha radioactivity exceeding Arizona standards *(1)*.

Those data show that natural conditions contribute to contamination of the Puerco River, but they do not show the extent of that contribution. Neither do they appear to be entirely unaffected by mining discharges. The North Fork sampling site is, in fact, about 12 miles downstream from abandoned uranium mines near Mariano Lake (see map, page 2). On the whole, the data state officials rely on to identify natural conditions as the the main culprit in the chronic pollution of the Puerco are simply outweighed by data which point to mine dewatering as the chief contributor to long-term contamination. Some lesser blame also can be attached to the spill and its aftermath and to discharges from the Gallup sewage plant.

There is general agreement among water quality specialists that all four major sources of pollutants have combined to adversely affect water quality in the Puerco River. But the results of the 1985 stream water tests appear to confirm information that in prior years linked contamination in the stream primarily to the discharges of polluted mine water. That information, which has been known to state and federal officials for several years, shows that:

- Discharges of mine water from the three Church Rock area mines that operated from 1969 to 1983 were not routinely treated to remove harmful substances until at least 1977 *(6)*.
- Those untreated discharges were found in the late 1970s to be grossly contaminated with concentrations of radium 226 and other radioactive substances that exceeded New Mexico's water quality standards *(21)*.
- Even after routine treatment of mine water began, discharges from two of the three mines in the Church Rock district persistently violated federal discharge permit limits for a number of radioactive materials *(11,22)*.



Chris Shuey

SRIC's Paul Robinson prepares to take water samples from Manuelito Creek, a tributary of the Puerco River in western New Mexico.

THE PUERCO RIVER EDUCATION PROJECT

SRIC staff members collected water samples from the Puerco River in March 1986 as part of a citizen effort to bring clean, dependable water supplies to residents of the river valley by 1991. (Sampling results will be available in April.)

The research and educational program, called the Puerco River Education Project, is intended to help residents of the valley learn more about their water resources so that they may become more actively involved in local water development. Supported in part by a grant from the Public Welfare Foundation, the project will gather information about water quality, historic use of the river, and current water delivery systems in the area. The information will be disseminated through meetings with the public, chapter officers, and agency officials.

Raymond Morgan of Thoreau, New Mexico, is the project's community education liaison. For further information contact Morgan at P.O. Box 155, Fort Wingate, New Mexico 87316, (505) 862-7202, or Chris Shuey, project coordinator, at SRIC.

• Even if the mine water had been properly treated to comply with permit limitations, it would not have met Arizona's radiochemical stream water standards, and in no case would it have been safe for human consumption *(11,23)*.

No single source of information provides data on the amounts of mine water discharged from the first uranium mines that operated in the Puerco River watershed in the 1950s and early 1960s. But published reports about the hydrologic conditions in some of the dozen mines in the area indicate that many, if not most, discharged large amounts of water to the North Fork. The significance of those reports is that contaminant loading of the Puerco River began more than 30 years ago and that the current water quality problem is not related exclusively to discharges from the three mines that operated in the Church Rock district between 1969 and 1983.

U.S. Geological Survey (USGS) reports and maps of the uranium deposits north of the community of Church Rock *(24,25)* show that uranium mined in the area in the 1950s and early 1960s was taken from rock formations that were, and still are, major sources of underground water. One report said that the ore body of one mine that opened in 1960 was 100 feet below the water table *(24)*. Obviously, water in the ore zone would have had to be pumped out prior to mining. The mine, later known as the Old Church Rock mine, was abandoned in 1963 because of flooding *(24)* but was reopened by United Nuclear Corporation (UNC) in 1979 *(21)*.

Uranium mining activities in the Church Rock district picked up steam again in the late 1960s, after a lull of some six years, during which time a number of the early mines were shut down and abandoned. In 1969, UNC began operating a 1,400-foot-deep mine at a site several miles north of the area that had been dotted with mines in the '50s. Dubbed the Northeast Church Rock mine, it began discharging up to 1,300 gallons per minute (gpm) of mine water to the Puerco that same year.

The volume of mine water dumped into the Puerco reached 5,000 gpm — or more than 7 million gallons per day — in 1972 when Kerr-McGee Corporation opened a mine on the Navajo Reservation about a mile north of the Northeast Church Rock mine *(6)*. The mine water flow increased again in 1979 when UNC reopened the Old Church Rock mine, contributing another 160 gpm to the stream *(21)*. The total discharge of more than 5,000 gpm continued until early 1983 when UNC, in the face of a collapsing uranium market, decided to shut down its two Church Rock mines and allow them to flood. Kerr-McGee also ceased producing uranium ore from its Church Rock mine in 1983 but did not end the discharge of mine water until early February 1986 when it received federal approval for a plan to put the mine on "standby," thereby allowing it to flood *(2,26)*.

Not until 1975, nearly a quarter-century after uranium mining began, was any of the water discharged to the Puerco treated to remove radium and other

radioactive materials *(6,21)*. Between 1977 and 1980, treatment was routine, but incomplete. Samples of mine water collected by NMEID in 1977 and 1978 showed concentrations of radioactive materials, including radium 226, that greatly exceeded numerical limits imposed by federal discharge permits issued by EPA in 1977 and 1978. The treatment requirements of those permits were not enforced until mid-1980 after EPA's authority to regulate discharges to ephemeral streams like the Puerco was upheld by federal courts.

Three years after the permits and their conditions went into effect, Southwest Research and Information Center (SRIC) reviewed the accumulated daily and monthly discharge monitoring reports filed by UNC and Kerr-McGee with EPA and found persistent and repeated violations of the chemical limitations in the permits *(22)*. The table below summarizes the findings of the review, which SRIC presented in testimony to EPA during hearings on the renewal of the permits in July 1983.

As the table shows, none of the three mines achieved 100-percent compliance with the conditions of their discharge permits. UNC's mines, in fact, were chronically out of compliance. Discharges from the Old Church Rock mine exceeded at least one numerical limit in 25 of 37 months, and discharges from the Northeast Church Rock mine exceeded at least one numerical standard in 13 of 38 months. Kerr-McGee's discharges fared much better, showing only seven separate violations in 7 of 35 months. NMEID officials say that Kerr-McGee's discharges were generally in compliance with permit standards from March 1983 until dewatering ceased early this year *(27)*.

SRIC's review found that numerical limits for discharges of radium 226 and uranium were exceeded 31 and 15 times, respectively, for all three mines combined during the 1980-1983 period. According to the 1985 sampling analyses, the pollutants that most consistently exceeded Arizona's recommended drinking water standard or its radiochemical stream water standard were, respectively, uranium and radium 226.

Based on UNC's record of permit violations, Arizona officials directly linked water quality problems in the Puerco in Arizona to the inadequately treated mine water discharges in New Mexico. In testimony to EPA in July 1983, the officials said, "United Nuclear Corporation's discharge...releases excessive doses of radium 226 into the Rio Puerco, and the radium and likely other radionuclides are of a chemical form that makes them of significant environmental concern. The discharge emanating from the Old Church Rock facility has been in almost continual noncompliance with...permit conditions and EPA-approved downstream water quality standards in Arizona. [UNC] has been notified on numerous occasions regarding these violations and has not remedied the situation" *(11)*.

Any one regulated chemical that exceeds a permit limit is considered a separate violation of the Clean Water Act and is subject to civil penalties. As Arizona officials noted, EPA had issued several administrative enforcement orders to the three companies during the early 1980s, demanding that each take action to correct the persistent violations *(11)*. But the agency never sought penalties, apparently because UNC ended mine water pumping at about the same time that the permits were renewed, and Kerr-McGee's discharges were never out of compliance severely enough to warrant tough enforcement action. EPA could have pursued penalties again UNC even after it shut down, but it was clear in 1983 that the company was getting out of the uranium business — an announcement it formally made in early 1985 *(28)*.

Table of Permit Violations by Discharges from Three Uranium Mines, Church Rock, New Mexico *(22)*

Mine Operator	Name of Mine	Period of Record	Compliance Months*	Number of Violations	Parameters Violated
Kerr-McGee	K-M Church Rock	5/80-3/83	7/35	7	Total uranium; radium 226, dissolved; maximum pH
United Nuclear	Northeast Church Rock	1/80-2/83	13/38	19	Total uranium; radium 226, dissolved; radium 226, total; chemical oxygen demand
United Nuclear	Old Church Rock	1/80-2/83	25/37	37	Radium 226, dissolved; maximum pH; radium 226, total; chemical oxygen demand; maximum TSS**; average TSS**

* The first number is the number of months in which violation of at least one numerical limit occurred. Second number is number of months in reporting period.
** TSS: Total suspended solids.

MINE DEWATERING AND HEALTH RISKS

Further evidence linking mine dewatering to the long-term contamination of the Puerco came in state and federal studies of radioactivity in animals which drank from or grazed next to the river near the mining operations *(5,6,7)*. Those studies, which were conducted to determine if the tailings spill had had a long-term, adverse effect on area animals and, in turn, on the health of residents of the river valley, showed that the same pollutants that were found in high concentrations in the mine water discharges had shown up in abnormally high levels in the muscles and organs of cattle, sheep, and goats which grazed near the North Fork *(5,6,7)*.

An initial study of radiation levels in the organs of area animals was conducted by the federal Centers for Disease Control in 1979 and 1980. The study found that a cow that grazed upstream from the site of the spill, but downstream from mine water discharges, had higher concentrations in the liver and kidneys of such radioactive elements as thorium 230, radium 226, lead 210, and polonium 210 — all decay products of uranium — than did animals that grazed in areas that were exclusively downstream of the spill *(5)*.

The authors of the initial CDC study concluded in 1984, in an updated report, that "years of chronic exposure to dewatering effluent may lead to radionuclide levels in animals that would exceed those expected from the pulse of tailings liquid released in the spill" *(6)*. The report said that the major contribution to human exposure to radioactive materials in the mining and milling district was "from mine dewatering effluent that has been continuously released into the river system for many years" *(6)*.

The preliminary results of a study conducted by state and federal investigators in 1983 further implicate mine water discharges in the chronic contamination of the Puerco drainage system *(7)*. According to an August 1985 draft report on the investigation, soil samples collected near the Old Church Rock mine and in a grazing area upstream from the UNC tailings pond (whose collapse caused the spill) had elevated levels of radioactive radium, lead, and polonium *(7)*. Vegetation samples collected near the Northeast Church Rock mine, which also is upstream from the tailings spill, showed concentrations of radium higher than in control samples collected from areas not affected by uranium activities *(7)*.

Sheep that grazed upstream from the tailings spill had higher concentrations of radium and thorium in their organs than sheep that grazed downstream, the preliminary study showed *(7)*. The study related those increased levels to the propensity of uranium, thorium, and radium in mine effluent to attach to suspended solids in the river water — a conclusion that seems to lend credence to ADHS's concern that animals in Arizona are drinking river water high in contaminated sediments.

The 1980 CDC study, its updated version, and the preliminary results of the 1983 investigation all showed that concentrations of radioactive elements in the muscles and organs of animals that drank from the Puerco or grazed nearby were elevated when compared with levels of the same materials in animals that lived in areas not affected by uranium mining and milling activities. Both the initial and the updated CDC studies concluded that radiation doses received by Navajos who eat meat from animals that live near the Puerco would not violate any federal radiation exposure standard.

The preliminary findings of the recent investigation showed that federal exposure standards for the general public would be exceeded only when livers and kidneys of exposed cattle were eaten over a period of 50 years *(7)*, and then only if the standard itself were changed to allow consideration of doses derived from exposure to uranium mining effluents. The findings said that continuous consumption of sheep and cattle from the Church Rock area over the next 20 years would result in 1.2 to 1.8 excess cancer deaths in 1 million people exposed *(7)* — a level of risk that is considerably lower than that which is considered "acceptable" by international committees of radiation experts *(29)*.

In language that the people who live next to the Puerco understand, those figures mean that if all 10,000 people who are estimated to live in the Puerco River Valley in New Mexico and Arizona equally ate the most contaminated animals for the next 20 years, 0.012 to 0.018 of them — or statistically less than 1 person — would die of cancer.

HISTORIC AND CURRENT USES OF THE PUERCO BY NAVAJOS

It has long been assumed, but never well documented, that the thousands of people who have lived along the Puerco through the ages have always found some use for it. The principal use has been for watering livestock. The Navajos "historically allowed their livestock to freely graze on either side and within the wash, and have been able to herd their sheep and goats in and across the wash for grazing purposes," according to papers filed in a 1980 lawsuit brought by the residents against United Nuclear *(30)*. "There's really no place else for the people to go to get water for their animals, other than the chapter house well, which stinks," said Justin Adakai, the 29-year-old postmaster at the Manuelito, New Mexico, chapter house. "We run sheep down to the Puerco all the time" *(31)*.

A few of the people recall drinking directly from the Puerco. "During the summer, when it stops flowing," said Manuelito resident Kieyone Begay in a February 1982 court deposition, "we would dig with the shovel and uncover some water, then we [would] drink it..." *(32)*. According to Adakai, the practice of digging pits to tap shallow ground water when the river is dry has never really stopped. "That's how they get water for the sheep," he said *(31)*.

Chris Shuey

Sheep and goats nibble on scrub brush on the banks of the Puerco River near Manuelito, New Mexico. The Puerco is approximately 200 feet across in this area.

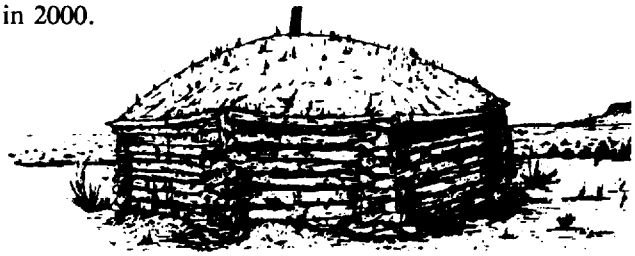
After the tailings spill, local Navajos tried to avoid the river, observing numerous signs warning against using the water *(33)*. As the '80s wore on — and as the signs fell victim to target practice and high winds — the physical and emotional impacts of the accident slowly faded from the minds of the local people. Chester Nez, president of the Manuelito chapter, said that when the lawsuit was settled out of court in 1985, with less than $550,000 divided among some 240 plaintiffs, many of the local people thought that the problem had gone away because they had been compensated for their losses *(34)*. Justin Adakai said the people "never really knew about the water contamination before the spill," and simply forgot about it after the settlement *(31)*.

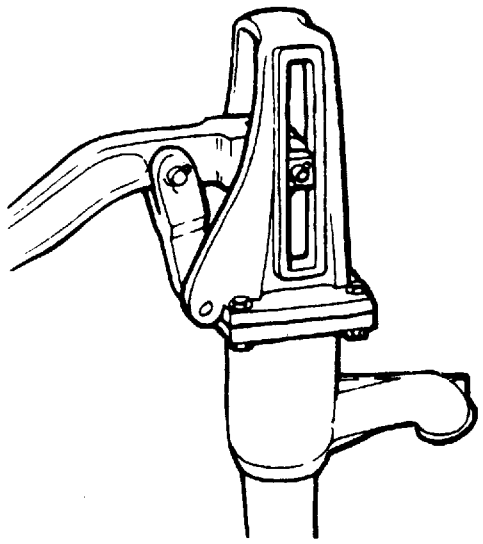
Not all livestock in the Puerco River Valley water in the stream. Many local people obtain water for their animals from stock wells constructed by federal agencies *(35,36)*. Still, many residents (and a few agency officials) say that the wells do not alleviate the need to haul water — or to use the Puerco. "There are very few places [in the river] where there are not animal tracks," said Jim Analla, a BIA environmental officer *(37)*. Both Analla and Charles Dowell, a U.S. Indian Health Service (IHS) official, confirmed that many rural Navajos continue to water their animals in the Puerco *(26,35)*.

Local chapter officials say the installation of centralized water systems in many of the small communities along the Puerco has only marginally reduced the number of families that routinely haul water for drinking purposes *(38,39)*. An elderly woman who was filling three 50-gallon plastic barrels from the Houck, Arizona, chapter house tank on a recent sunny afternoon said she hauls water "three to four days a week," eight miles each way *(40)*. Adakai estimates that most of the 3,500 or more residents of the Manuelito chapter depend on the chapter house well for drinking water, despite having to haul the water over long distances, sometimes as often as twice a day.

Masud Zaman, director of the Navajo Tribe's Department of Water Management, said that IHS figures show that fewer than 5,000 of the estimated 10,000 Navajos who live in the river valley are currently served by centralized water distribution systems *(36)*. The IHS figures show that more than 860 homes in the major Indian communities along the Puerco (excluding the city of Gallup) are currently served by public water systems, with another 480 to 740 homes still in need of service *(36)*. The communities of Church Rock and Pinedale in New Mexico, and Lupton and Houck in Arizona have central water systems; the Manuelito chapter does not. Each of those five communities has at least 60 homes that need service. Zaman said the number of homes still needing service is probably underestimated because the IHS figures do not include Indian families who live in remote, rural areas far from the river *(36)*. Austin A. Sam, manager of the Houck chapter, concurred in that assessment. "So many people in the hills come down to the river or to the chapter houses near the river to get their water," he said *(38)*.

A quick whiff of the water pouring from the Manuelito chapter house well confirmed Adakai's comment that the water stank. While the cause of the odor is not certain, the culprit cannot be the Puerco because the river is a mile-and-a-half from the chapter house. Yet the rotten-egg smell is an example of a problem that tribal officials say persists throughout the 25-million-acre Navajo Reservation — the lack of clean and reliable water supplies. But with additional research and an end to the reluctance of traditional Indian families to hook up to water mains, stories about Navajos who routinely hauled water dozens of miles every day in 1986 will be but distant memories in 2000.





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References

1. Arizona Department of Health Services. Water Quality Study: Puerco River, Arizona, 1985 (DRAFT REPORT). Ambient Water Quality Unit, Water Assessment Section, Office of Emergency Response and Environmental Analysis (Phoenix, Arizona), December 1985.
2. U.S. Bureau of Land Management. Environmental Assessment: Intermediate Standby Plan for the Church Rock Mine, Quivira Mining Company, Church Rock, McKinley County, New Mexico. Case File No. NM-017-86-7. U.S. BLM, Albuquerque District Office (Albuquerque, New Mexico), October 22, 1985
3. New Mexico Water Quality Control Commission. Water Quality and Water Pollution Control in New Mexico — 1984. (Santa Fe, New Mexico), July 1984, pp. 75-83
4. Arizona Department of Health Services. Memorandum from G.G. Caldwell, M.D., to Susan Keith, regarding "Puerco River Water Quality Standards." Office of Disease Control Services (Phoenix, Arizona), June 25, 1985.
5. Centers for Disease Control. Biological Assessment after Uranium Mill Tailings Spill, Church Rock, New Mexico. U.S. Public Health Service, CDC, Chronic Diseases Division, Bureau of Epidemiology, EPI-79-94-2, December 24, 1980.
6. Ruttenber, A. James, Jr.; Kreiss, Kathleen; Douglas, Richard L.; Buhl, Thomas E.; and Millard, Jere. The Assessment of Human Exposure to Radionuclides from a Uranium Mill Tailings Release and Mine Dewatering Effluent. *Health Physics*, 47:1, pp. 21-35, July 1984.
7. Millard, Jere B.; Lapham, Sandra C.; and Hahn, Paul. DRAFT REPORT: Radionuclide Levels in Sheep and Cattle Grazing Near Uranium Mining and Milling at Church Rock, N.M. New Mexico Environmental Improvement Division and U.S. Environmental Protection Agency (Santa Fe, New Mexico, and Las Vegas, Nevada), August 1985.
8. Sisneros, Kathleen (Chief, Surface Water Quality Bureau, New Mexico Environmental Improvement Division). Letter to Chris Shuey (Southwest Research and Information Center), December 3, 1985.
9. New Mexico Water Quality Control Commission. Water Quality Standards for Interstate and Intrastate Streams in New Mexico. NMWQCC (Santa Fe, New Mexico), January 1985.
10. Aldis, Hussein. United Nuclear Mine Tailings Spill — Hydrologic Assessment. Ecology and Environment, Inc. (Cincinnati, Ohio), report to U.S. Environmental Protection Agency Region VI (Dallas, Texas), October 9, 1979.
11. Anders, Charles D. Letter to Myron Knudson (U.S. Environmental Protection Agency, Water Management Division), transmitting "Statement by Division of Environmental Health, Arizona Department of Health Services, before the U.S. Environmental Protection Agency Public Hearing, July 27, 1983, Gallup, New Mexico," AWQU-512.120, July 22, 1983.
12 Swanson, Edwin (Ambient Water Quality Unit, Arizona Department of Health Services). Oral statement to a meeting of the Puerco River Working Group, April 26, 1985.
13. Arizona Department of Health Services. State of Arizona Official Compilation of Administrative Rules and Regulations. Chapter 21: "Water Quality Standards for Water of the State." 1985.
14. U.S. Environmental Protection Agency. National Interim Primary Drinking Water Regulations. EPA-570/9-76-003, 1976.
15. New Mexico Environmental Improvement Board. Radiation Protection Regulations. Part 4 — Standards for Protection Against Radiation (4-160 and Appendix A, Table II, Column 2). EIB/RPR 1, Amendment No. 1, 1981.
16. U.S. Nuclear Regulatory Commission. Code of Federal Regulations, Title 10, Part 20, Appendix B.
17. Gallaher, Bruce, and Cary, Steven J. Impacts of Uranium Mining on Surface and Shallow Ground Waters, Grants Mineral Belt, New Mexico. DRAFT REPORT, New Mexico Environmental Improvement Division (Santa Fe, New Mexico), May 1985.
18. Millard, Jere. Personal communication, December 6, 1985.
19. Gallaher, Bruce. The Puerco River: Muddy Issues Raised by a Mine Water Dominated Ephemeral Stream. In *Water Quality in New Mexico — Proceedings of the 28th Annual New Mexico Water Conference.* New Mexico Water Resources Research Institute, New Mexico State University (Las Cruces, New Mexico) WRRI Report No. 169, pp. 60-68, June 1983.
20. Puerco River Working Group. Parts 1, 2, and 3: Compilation of existing data; use-attainability analysis; Puerco River sediment loading model. Arizona Department of Health Services and New Mexico Environmental Improvement Division (Phoenix, Arizona, and Santa Fe, New Mexico), January 1986.
21. Goad, Maxine; Nylander, Charles L.; Gallaher, Bruce M.; Dudley, John G.; and Perkins, Betty L. Water Quality Data for Discharges from New Mexico Uranium Mines and Mills. New Mexico Environmental Improvement Division, Water Quality Control Bureau (Santa Fe, New Mexico), July 1980.
22. Shuey, Chris. Before the U.S. Environmental Protection Agency: Statement for the Records at the Public Hearings July 27-29, 1983, Gallup, New Mexico. In the matter of NPDES permits for UNC Mining and Milling Division and Kerr-McGee Nuclear Corporation, Applications for Renewal, July 27, 1983.
23. Vieregg, James D. Letter to Dick Whittington (Regional Administrator, U.S. EPA Region VI, Dallas). Request for Evidentiary Hearing: United Nuclear Corporation Mining and Milling, Gallup, New Mexico, National Pollutant Discharge Elimination System Permit Number NM0028550. Office of the Attorney General, State of Arizona (Phoenix), November 15, 1983.
24. Hilpert, Lowell S. Uranium Resources of Northwestern New Mexico. U.S. Geological Survey Professional Paper 603 (Washington, D.C.: U.S. Government Printing Office), 1969.
25. Hackman, R.J., and Olson, A.B. Geology, Structure, and Uranium Deposits of the Gallup 1° x 2° Quadrangle, New Mexico and Arizona. U.S. Geological Survey, Map I-981, 1977.
26. Analla, Jim (Branch of Environmental Quality Services, U.S. Bureau of Indian Affairs, Window Rock, Arizona). Personal communication, February 14, 1986.
27. Gould, John (Surface Water Quality Bureau, New Mexico Environmental Improvement Division). Personal communication, January 10, 1986.
28. Carlson, David. United Nuclear quits the mining business. *Gallup Independent*, p. 2, March 6, 1985.
29. International Commission on Radiological Protection. Recommendations of the International Commission on Radiological Protection. ICRP Publication No. 26 (Pergamon Press), 1977.
30. *Benally* v. *United Nuclear Corporation.* Complaint for Damages. District Court for the Navajo Nation (Window Rock, Arizona), August 13, 1980, p.2.
31. Adakai, Justin. Personal communication, March 5, 1986.
32. Kieyone Begay, Deposition of. *Benally* v. *UNC Resources, Inc.* District Court for the District of New Mexico (Albuquerque), No. CIV 80-750-HB, February 22, 1982, p. 30.
33. Shuey, Chris. "Calamity at Church Rock." Saturday Magazine, *Scottsdale* (Arizona) *Daily Progress*, February 14 and 21, 1981.
34. Nez, Chester. Oral statement at public meeting of Puerco River Education Project, Manuelito, New Mexico, February 28, 1986.
35. Dowell, Charles (Office of Environmental Health, U.S. Indian Health Service, Window Rock, Arizona). Personal communication, February 18, 1986.
36. Zaman, Masud (Division of Water Resources, Navajo Tribe, Fort Defiance, Arizona). Personal communication, February 21, 1986.
37. Guthrie, Patricia. Quivera plans mine closing. *Gallup Independent*, p. 2, December 20, 1985.
38. Sam, Austin A. Personal communication, March 5, 1986.
39. Smilie, Arcenio (Chapter Manager, Church Rock, New Mexico). Personal communication, November 5, 1985.
40. The woman quoted would not give her name.