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Church Rock Uranium Monitoring Project 2003-2007

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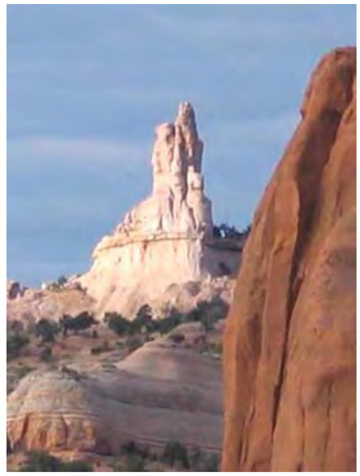

REPORT OF THE
CHURCH ROCK URANIUM MONITORING PROJECT
2003-2007

SPONSORED BY

CHURCHROCK CHAPTER, NAVAJO NATION
Church Rock, New Mexico

IN COLLABORATION WITH

SOUTHWEST RESEARCH AND INFORMATION CENTER
Albuquerque, New Mexico

AND THE

NAVAJO EDUCATION AND SCHOLARSHIP FOUNDATION
Window Rock, Navajo Nation (Arizona), USA

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REPORT OF THE CHURCH ROCK URANIUM MONITORING PROJECT (CRUMP), 2003-2007

PRINCIPAL COLLABORATING ORGANIZATIONS

CHURCH ROCK CHAPTER, NAVAJO NATION

SOUTHWEST RESEARCH AND INFORMATION CENTER

NAVAJO NATION ENVIRONMENTAL PROTECTION AGENCY

NAVAJO NATION ABANDONED MINE LANDS DEPARTMENT

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EXECUTIVE SUMMARY

The Church Rock Uranium Monitoring Project was initiated by Churchrock Chapter of the Navajo Nation in 2003 for the purposes of assessing environmental conditions in residential areas actually or potentially affected by abandoned uranium mines and building capacity to conduct community-based research and advocate for policies to address the long-term impacts of historic uranium development in the area. Churchrock Chapter requested the assistance of Southwest Research and Information Center (SRIC) to help implement and coordinate the Project's field studies and educational programs and the Navajo Education and Scholarship Foundation (NESF) to manage grants received from private foundations. The Chapter requested and received technical assistance from the Navajo Nation Environmental Protection Agency (NNEPA) as the principal governmental collaborator in the Project. CRUMP also received extensive in-kind support from the U.S. Environmental Protection Agency (USEPA), Navajo Nation Abandoned Mine Lands Reclamation Department (NNAML), and the New Mexico Environment Department (NMED). Several academic institutions also contributed to the Project, including the Uranium Education Program at Diné College in Shiprock, N.M., the University of New Mexico's Community Environmental Health Program, the Stanford University Environmental Engineering program, and Tufts University in Boston. The staff of the Diné Network for Environmental Health (DiNEH) Project, a community-based research program affiliated with the Eastern Navajo Health Board (ENHB) in Crownpoint, N.M., collaborated with CRUMP on work related to documenting individual and community exposures to radiological and chemical toxicants in the environment.

In addition to these in-kind services, which are conservatively valued at $100,000, the Project received $90,000 in two grants from the Citizens' Monitoring and Technical Assessment Fund (MTA-Fund) in Washington, D.C., and $20,000 in a short-term contract with the New Mexico Department of Health in 2004. These grants and contracts were used to pay the salary and benefits for the part-time position of Project coordinator, which was held by two different individuals who reside in the CRUMP study area, cover professional fees for outside technical consultants, purchase supplies and equipment, cover Chapter overhead for office space and services, and provide stipends to community members who served as key informants and participated regularly in Project activities and outreach.

The MTA-Fund grants were made largely because more than half of the 20 abandoned uranium facilities in the Churchrock area were developed by companies that sold uranium ore to the U.S. Atomic Energy Commission for use in the nation's nuclear weapons program in the 1950s and 1960s. The MTA-Fund was established in the late-1990s to give communities affected by contamination from the federal nuclear weapons production complex resources to conduct their own environmental and health studies around facilities now owned or overseen by the U.S. Department of Energy.

The primary work of CRUMP was a multi-media assessment of water quality in unregulated water wells, surface radiation levels, trace metals (including uranium) in soils, indoor radon concentrations, and airborne dust. CRUMP and its collaborators also helped evaluate clean-up needs and plans for two specific abandoned uranium mines, conducted tours of residential areas next to abandoned mining sites for policy makers, regulatory agencies, Chapter officials, students and media representatives, and engaged in widespread dissemination of Project information and findings at community meetings and in one-on-one talks with community members using the Navajo language as the primary oral communication mechanism. Project activities were conducted in an area that is often referred to as the "Church Rock Mining District" and includes all of Churchrock Chapter and portions of Coyote Canyon, Iyanbito, Nahodishgish, Pinedale and Standing Rock chapters of the Navajo Nation.

With respect to the technical assessment elements of the Project, CRUMP generated the following findings:

- Water quality in 17 unregulated water sources — drilled wells, dug wells and developed springs that are not regularly tested or treated to comply with federal and tribal safe drinking water standards — ranged from good to poor. *None* of the 17 sources tested were of sufficient quality to warrant recommendations for human drinking water use. Half of the water sources tested were *not* recommended for domestic uses, such as cooking, bathing and irrigating gardens, and most of the other half were recommended only with caution. Most of the water sources were suitable for livestock watering.

- Two wells were shut down and abandoned because of unsafe water quality during the course of the Project, and a "no human use" advisory was placed on another water source because of uranium levels exceeding the federal drinking water standard by more than two times. One of the abandoned wells may have been contaminated by mining-related activities, but a full hydrologic assessment is needed before a definitive conclusion can be reached.

- Only 1 of the 17 wells exceeded the federal drinking water standard for uranium, a rate (6%) that is substantially *lower* than recent water quality surveys conducted by federal agencies in the western part of the Navajo Nation that found that 14% to 20% of water sources tested exceeded the uranium standard of 30 micrograms per liter. Uranium, a well-documented kidney toxicant, is the focus of two ongoing health studies aimed at evaluating the role of environmental agents in the high rates of kidney disease in the Navajo population.

- Mine-water discharges to the Puerco River — the principal intermittent stream in the study area — in the 1960s, '70s and '80s were not safe for human or animal consumption, even though observational and anecdotal evidence indicated that residents often used mine water in the river and its tributaries for domestic uses and livestock watering was routine for least 18 years. The long-term effects of those discharges on surface water and shallow groundwater quality remain uncertain.

- In the northern half of the study area where past uranium mining was concentrated, gamma radiation rates were significantly elevated over background along public highways and roads, on Navajo grazing lands and in certain residential areas in close proximity to three abandoned uranium mines and a closed uranium mill and tailings disposal facility that is a federal Superfund site.

- Surface gamma radiation rates and uranium concentrations in soils near residences in the Red Water Pond Road area of Study Area A-1 were many times higher than background, indicating a potential public health emergency for residents of the area. CRUMP's assessment in this area was confirmed in November 2006 by soil sampling conducted by USEPA and contractors to the company that operated the Northeast Church Rock Mine in the area from 1968 through 1982. As a result, radium-contaminated soils are being excavated from around at least five homes in the area as part of a USEPA-led "time-critical removal action" that eventually will lead to reclamation of the mine site and its surroundings.

- Gamma radiation rates were not significantly different than background in the Springstead Estates tract where the Navajo Nation has proposed building up to 1,000 single-family homes. However, the site of the proposed housing development is located within 1 to 2 miles of three abandoned mines and additional assessments may be needed before the tract is certified safe for human occupancy.

- Background or "normal" gamma radiation levels were observed in Church Rock Village and around the Churchrock Chapter House.

- Outside of the Red Water Pond Road area, uranium and trace metal levels in soils at a dozen different monitoring sites were within the range of "background" reported in the literature.

- Indoor radon levels exceeded the USEPA's 4 picoCurie per liter-air "action level" in 25% of 150 homes tested in 2004, and another 20% of homes tested had indoor radon levels between 2 and 3.99 pCi/l-air. Most of the homes having high radon levels are located in a portion of the community where the principal uranium-bearing rock formation is present at the surface.

- The average indoor radon level of 2.9 pCi/l-air in the CRUMP study was half of the average concentration for homes located elsewhere in McKinley County and a third lower than the average level of 3.8 pCi/l-air for the entire state of New Mexico.

- Average indoor radon levels reflective of background were observed in homes in Church Rock Village and in the Sundance Road residential area south of Interstate 40.

- Monitoring of air particulates, i.e., dust, in the Red Water Pond Road and Pipeline Road areas (Study Area A) between May 2006 and February 2007 revealed maximum levels less than one-sixth of the federal 24-hour average limit. Sampling of particular matter (PM) at two samplers loaned to CRUMP by the TAMS Center will continue for the next year or so.

- The community's overall goal for reclamation of the Northeast Church Rock Mine — release for unrestricted use — was communicated to federal and tribal agencies in a resolution-petition signed by more than 100 residents in September 2006.

- Radiological surveys conducted by CRUMP and NNEPA collaborators at the Old Churchrock Mine in August 2006 following flash flooding at the site revealed the presence of mine wastes on Navajo trust land that had not previously been identified.

- Ten community meetings and a half-dozen tours of the mining-impacted portions of the community were conducted by CRUMP and its collaborating organizations since June 2003.

Results of the Project's work were communicated to Navajo Nation Council standing committees and in ad hoc technical meetings of agencies working on abandoned uranium mines issues. National and international media attention has been focused on the legacy of uranium mining impacts in the Churchrock area as a result of CRUMP activities.

The ensuring narrative of this report summarizes the field investigations, data analyses and policy initiatives of the Church Rock Uranium Monitoring Project between June 2003 and May 2007. Tables, charts and photographs are used extensively to illustrate the Project's findings. Detailed data compilations, Powerpoint presentations, information handouts and other documentation are included in appendixes that accompany the report. Recommendations for future actions are included at the end of the narrative.

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List of Acronyms

AEC	Atomic Energy Commission
AUM	Abandoned Uranium Mine(s)
CFR	Code of Federal Regulations
CRUMP	Church Rock Uranium Monitoring Project
DiNEH	Diné Network for Environmental Health Project
ENHB	Eastern Navajo Health Board
HRI	Hydro Resources, Inc.
MTA Fund	Citizens' Monitoring and Technical Assessment Fund
NAU	Northern Arizona University
NAUMC	Navajo Abandon Uranium Mine Collaboration
NECRM	Northeast Church Rock Mine
NESF	Navajo Education and Scholarship Foundation
NGO	Non-governmental Organization(s)
NHA	Navajo Housing Authority
NMEID	New Mexico Environmental Improvement Division
NNAML	Navajo Nation Abandoned Mine Lands Reclamation Department
NNDWR	Navajo Nation Department of Water Resources
NNEPA	Navajo Nation Environmental Protection Agency
NPDWS	National Primary Drinking Water Standards
NTUA	Navajo Tribal Utility Authority
NRC	Nuclear Regulatory Commission
OCRM	Old Church Rock Mine
PM	Particulate Matter
PWS	Public Water Supply
QA/QC	Quality Assurance/Quality Control
SDWA	Safe Drinking Water Act(s)
SRIC	Southwest Research and Information Center
TAMS	Tribal Air Monitoring Support Center
TDS	Total Dissolved Solids
UNC	United Nuclear Corporation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

I. Introduction

I.1. Background

Initial plans for creation of the Church Rock Uranium Monitoring Project (CRUMP) were developed by Churchrock Chapter[1] in 2002. Based on limited historical environmental data, Chapter leaders and community members were concerned that radiological contaminants may still be present in residential areas located near more than a dozen abandoned uranium mines (AUM) and mills, all of which had been inactive or abandoned for between 20 and 45 years. Chapter leadership was particularly concerned that such residual contamination may limit the construction of new housing and other development in areas near AUMs.

Concurrently, several Navajo Nation and Federal agencies and non-governmental organizations were participating in the informal Navajo Abandon Uranium Mine Collaboration (NAUMC) to promote intergovernmental and community involvement in AUM issues. Tours of mining-impacted areas in the Churchrock area were conducted through the auspices of the NAUMC, and these events educated agency staff and decision-makers about the need for environmental assessments in residential areas abutting AUM sites. Churchrock Chapter staff and leaders who received training in environmental health from the Eastern Navajo Health Board (ENHB) in 2002-2003 advocated for initiating an environmental assessment in the Churchrock area.

In early 2003, the Citizens' Monitoring and Technical Assessment Fund (MTA-Fund), administered by RESOLVE, Inc., in Washington, D.C., issued a request for proposals for grants to community groups to conduct environmental monitoring around sites and facilities associated with the Federal Government's nuclear weapons program. Since at least half of the AUMs in the Churchrock area was developed to supply uranium to the weapons program in the 1950s and 1960s, Churchrock Chapter was eligible to apply for an MTA-Fund grant. The Chapter requested help from Southwest Research and Information Center (SRIC) and the Navajo Nation Environmental Protection Agency (NNEPA) to develop a plan for a multi-agency collaboration to assess water quality, surface radiation levels, indoor radon, and airborne particulate levels and to inform and involve community members through outreach and information dissemination activities. Community members and staff members of several tribal and federal agencies, SRIC and the Tribal Air Monitoring Support (TAMS) Center were included in the plan as consulting experts. The Navajo Education and Scholarship Foundation (NESF), a tax-exempt charitable organization in Window Rock, Arizona, was hired as fiscal agent to manage the grants.

In September 2003, RESOLVE, Inc., awarded the first of two grants to NESF on behalf of Churchrock Chapter and CRUMP. The first grant in Round 5 (MTA-Fund No. 05-005) was for $50,000 ("CRUMP Phase I") and the second grant in Round 6 (MTA-Fund No. 06-010) in 2004 was for $40,000 ("CRUMP Phase II"). The grants provided funds for hiring a local project coordinator and community members as outreach consultants, contracting with technical consultants, and paying for analytical work, travel, document reproduction and Chapter overhead. The budgets and grant periods for these grants have been amended several times since 2005. This report serves as the narrative report required for both MTA-Fund grants.

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[1] In this report, "Churchrock" is spelled as one word when referring to Churchrock Chapter and as two words when used in other applications, such as in "Northeast Church Rock Mine." This is in accordance with local practice.

I.2 Brief History of Uranium Mining and Milling in the Churchrock Area

I.2.1 1950s-'60s Era Uranium Mines

Uranium mining began in the Churchrock area in the early 1950s. As shown in **Table I.1**, at least a dozen mines were developed in the 1950s and '60s in the Churchrock Mining District, which included parts of Bread Springs, Churchrock, Coyote Canyon, Iyanbito, Nahodishgish[2] and Pinedale chapters. The majority of these mines were located in the northern half of Churchrock Chapter, as shown in **Figure I.1**. Ore from these mines was produced by private companies and sold to the U.S. Government at Atomic Energy Commission (AEC) "buying stations" near Grants, N.M. The mines tended to be located on the sides of cliffs at the outcrops of uranium-bearing sandstones of the Dakota Formation and Morrison Formation (Westwater Canyon and Brushy Basin members). The mines were either open pit or "caved pits" or underground declines that followed the northward and downward tilt of the sedimentary rocks. Pits and waste dumps associated with these mines were located at the edge of the pit or decline. Of the 12 early-era mines, only two have been subject to reclamation; most, while difficult to reach, are in the same condition as they were the day they were abandoned.

I.2.2 Large-scale Mine and Mill Development, 1970s

Development of three large-scale underground mines in the northern portion of the mining district at the intersection of Churchrock, Coyote Canyon, Nahodishgish and Pinedale chapters began in the late-1960s. The Northeast Church Rock Mine (NECRM) began operations in 1968, the Church Rock 1 and 1E mines (which provided access to one continuous underground complex) began operating in 1972, and the Old Churchrock Mine (OCRM) (Section 17) — which was first developed and produced between 1960 and 1962 — was reopened in 1977. These mines were underground "room-and-pillar" mines accessed by vertical shafts. They ranged in depth from 700 to 900 feet at OCRM to 1,800 feet below ground at Church Rock 1. These mines operated until 1982-1983 when they were closed due to falling market prices. All produced ore from the Westwater Canyon Member of the Jurassic Morrison Formation. The Westwater is comprised of a series of interbedded, stacked and braided ancient river channels totaling between 250 and 300 feet in thickness, and is known widely throughout the Eastern Navajo Agency as a high-quality drinking water aquifer that serves at least 13,145 people.[3]

In 1974 and 1975, United Nuclear Corp. (UNC), which operated the NECRM and OCRM, began construction of a 4,000-ton-per-day uranium mill and tailings disposal facility on Section 2 in Township 16 North, Range 16 West. The land for the mill was purchased by UNC from the state of New Mexico in 1969, and had been used by Navajo families for homes sites and grazing until

[2] Official Navajo Nation chapter boundary maps show Nahodishgish Chapter abutting Coyote Canyon Chapter to the west and Pinedale Chapter to the south. But families who live in the Pipeline Road area northeast of the UNC mill tailings disposal facility and less than 0.5 mile from the Church Rock 1E mine site say they are members of Standing Rock Chapter, which is located northwest of Nahodishgish Chapter on chapter boundary maps.

[3] Declaration of Dr. John W. Leeper (Navajo Department of Water Resources engineer), Table 2, page 12; attached as Exhibit E to ENDAUM's and SRIC's Written Presentation on Groundwater Protection Issues, in the Matter of Hydro Resources, Inc., U.S. Nuclear Regulatory Commission, March 1, 2005.

Table I.1. AUMs in Churchrock Area[4]

Site Name(s) (Aliases, Alternate Names in Parentheses) **AEC mines in boldface**	Chapter	Period of Operation	Type of Operation	Ore or Tailings Produced (tons)	Reclamation?
Becenti (Eunice)	Churchrock	1952-58	OP-DH	846	Unknown
Becenti (Naomi)	Churchrock	1958-69	UG (decline)	8,536	Unknown
C D & S (Section 35)	Churchrock	1957	OP	57	Unknown
Christensen (Rimrock #2)	Churchrock	1953-58	UG (decline)	Unknown	Unknown
Church Rock #1	Coyote Canyon	1972-86	UG	400,000E	Yes: Quivira Mining pursuant to BLM
Church Rock #1E (eastern shaft of Church Rock #1)	Nahodishgish	1979-85	UG	Unknown	Partial: headframe removed
Church Rock #2	Coyote Canyon	1978-82	Waste dumps only	Unknown	Unknown
Church Rock Uranium Mill and Mill Tailings Facility (*USEPA Superfund site*)	Pinedale	1975-1986	Mill, tailings disposal cells	3.5 million	Mill dismantled in mid-90s; tailings covered in '90s
Diamond #2 (Largo #2)	Bread Springs	1952-70	UG (declines)	47,181	Yes: NNAML
Foutz #1 (Prospect #1)	Iyanbito	1953-54	Caved pit	324	Unknown
Foutz #2 (Prospect #2)	Churchrock	1953-54	Caved pit	242	Unknown
Foutz #3 (Yellow Jacket)	Churchrock	1953-55	UG (decline)	2,412	Yes: NNAML
Grace Nuclear (Section 23)	Churchrock	1975	ISL test	0	Unknown
Hogback #4 (Hyde, Tucker)	Churchrock	1952-60	UG-OP	6,354	Yes: NNAML
Northeast Church Rock Mine (*USEPA Time-Critical Removal Action site*)	Pinedale	1968-82	UG (2 shafts)	400,000E	Partial: bldgs., tailings removed in '90s; waste dumps, mine ponds still present
Old Churchrock Mine (Section 17)	Churchrock	1960-62; 1976-82	UG (shafts)	77,965	Minimal: Equipment, pond sludge removed
Rat's Nest Mine (Rimrock #1, Santa Fe Christensen)	Iyanbito	1957-58	UG (decline)	324	Unknown
Teton Pilot ISL (Section 13)	Churchrock	1980	ISL test	0	Unknown
Westwater #1 (Green Hornet)	Iyanbito	1957-60	UG (decline)	4,713	Unknown
Williams & Reynolds	Iyanbito	1953-58	OP	2,560	Unknown

Abbreviations: E = estimated; ISL = in situ leach mine; OP = open pit mine; UG = underground mine

cleared to make way for the mill and tailings operation. The mill tailings facility received a radioactive materials license from the New Mexico Environmental Improvement Agency in January 1977 and began operating in May 1977. The acid-leach mill produced more than 8 million pounds of uranium oxide from ores extracted from the three local underground mines

[4] This list includes both mines and mills; it does NOT include AUMs in Mariano Lake and Smith Lake chapters, 10 and 15 miles east of Churchrock, or in northern parts of Nahodishgish (Dalton Pass), Standing Rock and Crownpoint chapters. A list of AUMs located in the Eastern Navajo Agency is available from SRIC.

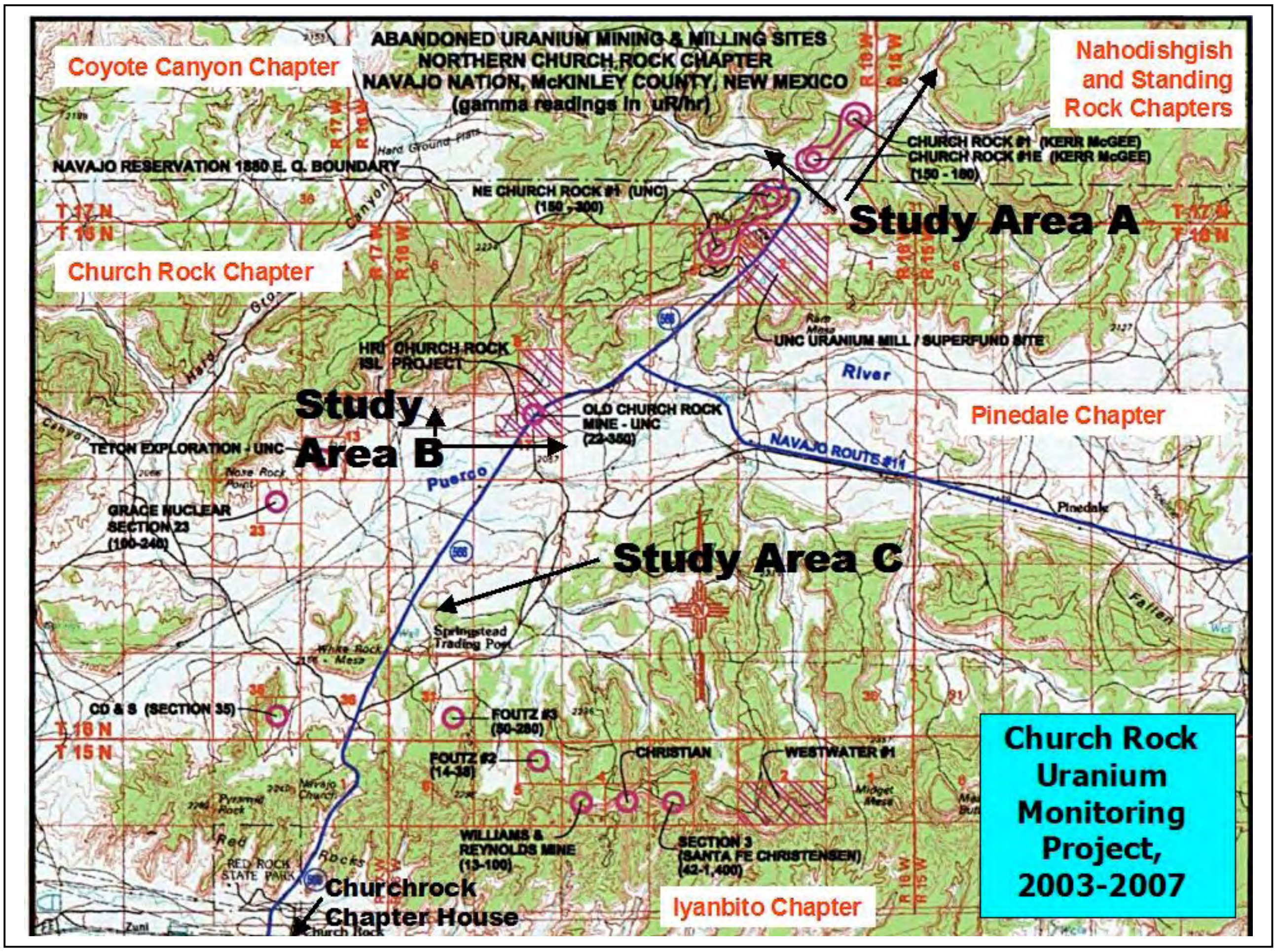

Figure I.1. Map of CRUMP Study Areas, AUMs

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between 1977 and 1982, when it was shut down in response to market conditions. The facility was never operated again, and in the 1990s, the mill was dismantled and the tailings stabilized and reclaimed pursuant to U.S. Nuclear Regulatory Commission (NRC) regulations.

An estimated 3.5 million tons of tailings were disposed in the 400-acre tailings impoundment during its five years of operation. **Figure I.2a**. Tailings were pumped from the mill to disposal cells in a slurry consisting of 40 percent solids and 60 percent fluids. The solids — fine-grained sands left over from crushing, grinding and processing of the ore — were deposited in four disposal cells. The solids settled to the bottom of the cells. The highly acidic (pH = 2.0) fluids collected in the four ponds. On July 16, 1979, the 75-foot-high dam holding the South Pond ruptured, releasing 94 million gallons of mill effluent and 1,100 tons of tailings. **Figure I.2b**. The effluent poured into the Pipeline Arroyo immediately adjacent to the tailings impoundment and emptied into the North Fork of the Puerco River about 1.5 miles downstream. Tailings effluent traveled in the Puerco through the city of Gallup, past the New Mexico-Arizona state line, and was last seen in the stream bed near Chambers, Arizona — about 100 miles from the breach point.

Figure I.2a. Church Rock Uranium Mill tailings facility in 1978; South Pond at breach site in left center of photo.

I.2.3 Environmental Studies of the 1980s-'90s

The Church Rock Tailings Spill, as it became known, received much local and regional public and media attention, but little national exposure even though it was, and remains, the largest single release of radioactive wastes, by volume, in U.S. history. Post-spill environmental monitoring by state and federal agencies continued through 1983. SRIC worked with local Navajo communities on surface water quality surveys in the Puerco between 1986 and 1991, and the U.S. Geological Survey (USGS) conducted a groundwater and surface water investigation in the Puerco River Basin in both states between 1988 and 1992. Results of these studies revealed concentrations of certain radionuclides in excess of Arizona stream water standards at the state line in the late-1980s and early-1990s.[5] But contributions from the 1979 tailings spill and nearly 20 years of continuous mine water discharges to these stream water quality violations could not be precisely determined.

Figure I.2b. The breach in the tailings dam was clearly visible in this photo taken a day after the spill on July 16, 1979. SRIC photos by Paul Robinson.

Concurrent with the investigation of dam break in 1979, the state Environmental Improvement Division (NMEID) ordered UNC to determine the extent of groundwater contamination under and around the tailings facility. Over several years, contaminant plumes were discovered in the alluvium under the south end of the facility and in two separate sandstone units of the Gallup Sandstone east and northeast of the tailings facility. The movement of these plumes off of the UNC-owned property prompted USEPA's designation of the facility as a federal Superfund site in 1983. That same year, the company acquired a 320-acre tract (Section 36, T17N, R16W) from the state to provide a buffer between the tailings facility and the Navajo Reservation boundary 0.5 mile to the north. A groundwater cleanup plan was approved by USEPA in 1988 and 1989, and is still being implemented by UNC to this day. The Navajo Nation EPA provides oversight of groundwater restoration activities conducted by UNC under NRC and USEPA requirements.[6]

[5] See, e.g., L Wirt, Radioactivity in the Environment — A Case Study of the Puerco and Little Colorado River Basins, Arizona and New Mexico. U.S. Geological Survey Water-Resources Investigations Report 94-4192, 1994.

[6] The vast record of technical and regulatory reports on groundwater contamination issues at the UNC tailings facility is too vast to summarize here, and is outside of the scope of CRUMP's work. Further information on this issue may be reviewed at www.epa.gov/earth1r6/6sf/pdffiles/0600819.pdf, or by contacting Mark Purcell, USEPA, (214) 665-6707, purcell.mark@epa.gov, or Diane Malone, NNEPA, 928-871-7820, dianemalone54@hotmail.com. A copy of USEPA Region 6's latest update on the mill site is included in **Appendix I.A**.

I.2.4. Public Health Concerns: Chronic Exposures and Radon

Despite extensive development of uranium resources in areas of the community where people lived, virtually no environmental monitoring was conducted in residential areas in the Church Rock Mining District during the height of the uranium boom of the 1950s-60s and again in the 1970s-80s. No comprehensive study of the health effects of chronic exposures to environmental contaminants among people who live next to or near abandoned mines was ever conducted. And no long-term community-wide health study was conducted following the tailings spill in 1979 or during the nearly 20 years that mine-water discharges dominated the Puerco River.[7]

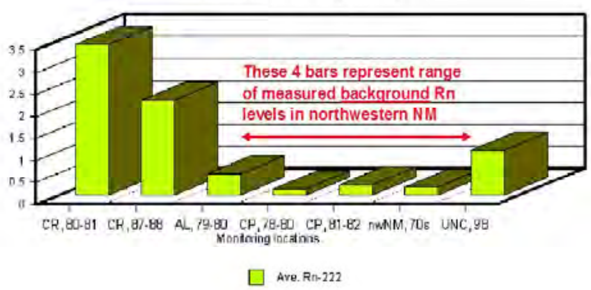
State and federal studies[8] conducted in the 1980s found that cattle and sheep that grazed in the area and drank water from the Puerco River during this period had accumulated significantly higher levels of uranium in edible muscle and organs than control animals raised in non-uranium mining areas. While radiation doses to people eating maximally exposed animals were calculated to be below federal limits, the state recommended in 1986 that residents could reduce their exposures by not eating cattle and sheep kidneys and liver or boiling bones.

While environmental monitoring generally was lacking in residential areas, monitoring of ambient (i.e., outdoor) radon levels was conducted by mining companies at existing or proposed mining sites in the Churchrock area between 1981 and 1996. The companies' radon monitoring — conducted for the purposes of collecting background data or demonstrating compliance with NRC license requirements for existing facilities — revealed average annual radon concentrations at several sites in the area significantly elevated over background. This relationship is shown in **Figure I.3**, a comparison of outdoor radon levels in the Churchrock area with those from background locations elsewhere in northwestern New Mexico.

Figure I.3

Comparison of Outdoor Radon Levels in Church Rock with other Background Locations in Northwestern NM

(Concentrations in pCi/l-air)



The average annual radon levels at the background sites ranged from 0.1 picoCuries per liter-air (pCi/l-air) to 0.8 pCi/l in studies conducted by NMEID in the late 1970s and

[7] Several individuals who waded into the acidic tailings fluid in the Puerco following the spill sustained acute acid burns to their feet and legs. These effects were never investigated. Neither was human exposure to mine water studied despite anecdotal reports that many people bathed in the water because it was warm.

[8] See, e.g., SC Lapham, JB Millard, JM Samet. Health implications of radionuclide levels in cattle raised near U mining and milling facilities in Ambrosia Lake, New Mexico. *Health Physics* 1989; 56(3):327-40, and JB Millard, SC Lapham, P Hahn. Radionuclide Levels in Sheep and Cattle Grazing Near Uranium Mining and Milling at Church Rock, NM. New Mexico Environmental Improvement Division (Santa Fe, N.M.), Oct. 1986.

early 1980s. Annual average concentrations at eight locations in the Churchrock area ranged from just over 1.0 pCi/l to nearly 3.5 pCi/l-air, or up to 30 times higher than background measured as locations in Crownpoint. Seven of the eight monitoring stations in Churchrock were next to AUMs. The only radon monitoring site *not located* next to a uranium mine was at a mobile home park at the site of the Springstead Trading Post in Churchrock Chapter. This site had the second highest average annual radon concentration of all monitoring stations in the area.

These data raised concerns among local officials that both current residents, and future residents of a 1,000-home community planned at the site of the former Springstead mobile home park, may be exposed to radon levels that represent significant health risks. Those concerns were not unfounded. USEPA estimates that exposure to indoor radon is the second leading cause of lung cancer in the U.S., next only to cigarette smoking. The consensus of the scientific community, based on at least seven major epidemiological studies since the 1950s, is that exposure to radon and its short-lived, but high-energy decay products (called "progeny" or "daughters") is the principal cause of high rates of lung cancer among underground uranium miners.[9]

I.3 Goals and Objectives of the Project

The Church Rock Uranium Monitoring Project was designed to fill these gaps in environmental monitoring and human exposure assessment. Chapter officials, especially former Community Services Coordinator Edward Carlisle, and community leaders insisted that the Project must (1) inform and educate community members and Navajo Nation leaders about possible environmental health risks from living near or next to abandoned uranium mines and (2) develop programs and policies to eliminate or mitigate such risks. Specific objectives of the Project, as set forth in both the CRUMP Phase I and Phase II MTA-Fund grant applications, were:

1. Review literature on water quality data for mine water and unregulated wells.
2. Collect and analyze 10-12 water samples from unregulated water sources.
3. Conduct gamma radiation surveys in residential areas near AUMs, and where needed, collect and analyze soil samples for uranium and other contaminants.
4. Collect and analyze airborne dust samples.
5. Analyze indoor radon levels in 175 homes and occupied structures and make recommendations for in-home mitigation measures were needed.
6. Review and develop technical comments on reclamation plans for the Northeast Church Rock Mine, and facilitate community involvement in reclamation issues.
7. Conduct 2 to 4 community educational meetings annually to inform residents of Project activities and results, and to make recommendations for future activities.
8. Prepare and disseminate to community members, Chapter leaders, Navajo Nation Council Delegates and Executive Branch officials, and the general public technical and narrative reports on the outcomes of the project.

[9] See, e.g., J Samet, DW Mapel. Diseases of Uranium Miners and Other Underground Miners Exposed to Radon. Chapter 98 in: *Environmental and Occupational Medicine*, WM Rom, ed. Philadelphia: Lippincott-Raven Publishers, 1998:1307-1315.

These objectives were generated among discussions of community leaders and members, Navajo Nation agency officials and organizations enlisted by the Chapter to provide project coordination, technical support and background information. Based on a public health model, they emphasized determining human exposures to radiological and nonradiological contaminants. CRUMP was not intended to develop data for regulatory purposes, and all of the assessments were conducted outside of mining sites, including those having current corporate ownership or control. However, monitoring results from certain areas were compelling enough to generate regulatory attention and, eventually, enforcement actions to force cleanup of contaminated residential areas *adjacent* to mine sites and, in one case, the AUM itself.

I.4 CRUMP Study Areas Defined and Mapped

Three specific study areas were selected for CRUMP, based on existing environmental data, population characteristics now and in the future, and recommendations of Chapter officials, residents and Navajo Nation agencies; they are shown on **Figure I.1**, and are summarized here:

- **Study Area A** — An estimated 50 families live in two valleys that are close to four of the AUMs listed in **Table I.1**. The valley to the west is locally called the Red Water Pond Road community, or "Church Rock Mine Area," and the homes of the 14 families who live there are sandwiched between the NECRM to the south and the Church Rock 1 Mine to the north. (This area is referred to herein as "Study Area A-1".) The community is located just north of the Navajo Reservation boundary in Coyote Canyon Chapter at the terminus of State Route 566. The residents of this area are relatives of the same extended family that they say has lived in the Red Water Pond Road valley for five generations. An estimated 35 families live in the Pipeline Canyon Road area on the east side of Study Area A (referred to as Study A-2). The UNC uranium mill tailings facility in Section 2 and Section 36 is located 1.0 to 1.5 miles to the south of these residences. The Church Rock 1E Mine is located next to Pipeline Canyon Road about 0.25 mile from the nearest residence in this area. While the location is within the boundaries of Nahodishdish Chapter, the residents say they are members of Standing Rock Chapter. During the time the tailings facility was operating, residents of this area they were concerned that dust blowing up the canyon from the southwest across the tailings impoundment was spreading contaminated materials onto Navajo Reservation lands north of Section 36. Study Area A also includes State Route 566, which was the main route for ore hauling before and after the UNC mill was constructed in the mid-1970s.

- **Study Area B** — Several families live within 0.25 to 1.5 miles of the abandoned Old Churchrock Mine in Section 17 of T16N, R16W. To the west is the Livingston Camp and to the east is the King Family Ranch area. The King Family's homes and permitted grazing areas coexist on parts of Section 17 with the OCRM site. The northeastern quarter of Section 17 and southeastern quarter of Section 8 to the north are also the sites of two proposed *in situ* leach uranium mines. The area includes the North Fork of the Puerco River to the south and both sides of SR 566, northeastward to its intersection with Navajo Route 49-11, also called the Pinedale Road. Before construction of the UNC mill to the northeast, SR 566 and the Pinedale Road where the main haul routes for ore trucks destined for uranium mills at Bluewater and Milan, N.M., about 50 to 60 miles to the east near Grants.

- **Study Area C** — The 640-acre tract in Section 30, T16N, R16W, included the location of the now abandoned Springstead Trading Post and the former site of the mobile home park situated along Springstead Loop. The location was selected for assessment because of the Navajo Housing Authority's (NHA) proposal to build up to 1,000 single-family homes on the site. An arroyo bisects the tract, and homes would be constructed on both sides of the wash. This unnamed arroyo drains an upland area to the south where several 1950s-era mines were located (in particular, Foutz #3 and Foutz #2; see **Figure I.1**). In addition, the high ambient radon levels measured at the site in the early 1980s, regardless of their origins, might still exist and present inhalation hazards to residents of the proposed Springstead Estates housing development. Churchrock Chapter, which supported the housing project, passed resolutions in 2003 requesting environmental assessments of the tract to ensure that its conditions were safe for an expected population of more than 4,000 people, or a nearly 150% increase over the Chapter's 2000 population of 2,802.

In addition to these specific study areas, water quality assessments and indoor radon monitoring were performed throughout the Churchrock area in parts of four Navajo chapters. As discussed in Section II of this report, the water quality assessments focused on unregulated water sources that residents reported used for human consumption, domestic purposes, and livestock watering.

I.5 Collaborators and Collaborating Groups

Collaboration among individuals and organizations to accomplish the goals and the objectives of the Project was a hallmark of CRUMP's work from its inception. Collaboration served not only to bring together local, tribal and regional groups around a common purpose, but also helped stretch limited grant funds with in-kind contributions of agency staff time, analytical services and field equipment. In addition to the two MTA-Fund grants totaling $90,000, and a one-time contract with the New Mexico Department of Health for $20,000, we estimate that the Project brought in at least another $100,000 in in-kind services. Individuals and groups that collaborated with the Project are listed in **Table I.2**. Several of the listed individuals were included as consulting experts in the Project's two grant applications to RESOLVE, and as such, completed required certification forms testifying that they were not employed by or otherwise receive benefits from the U.S. Department of Energy (DOE), whose funding established the MTA-Fund in the late 1990s.[10] However, many individuals from more than 20 different institutions who contributed time, expertise and services to the Project did not complete and submit such certifications. To the knowledge of Churchrock Chapter and SRIC, none of those individuals had a conflict of interest with DOE programs or funding that would have precluded their participation in CRUMP.

[10] DOE's financing of the MTA-Fund was the result of the settlement of a lawsuit brought in 1997 by the Natural Resources Defense Council on behalf of communities and community groups near DOE nuclear weapons facilities. The settlement required DOE to contribute funds to a separate and independently managed organization, which would provide grants to such communities to conduct their own environmental monitoring and health studies around nuclear weapons facilities. RESOLVE, Inc., a Washington, D.C.-based dispute-resolution organization, was selected to establish and administer the MTA-Fund under the guidance of an advisory group made up of representatives of environmental and public interest organizations. DOE has no direct influence or oversight over the work of the organizations that receive MTA-Fund grants.

Table I.2. CRUMP Collaborators and Collaborating Organizations

(Individuals shown in **boldface** type were listed as project staff or consultants in grant applications)

Individual	Organization	Expertise/Responsibilities
	CHURCHROCK CHAPTER OFFICIALS, STAFF, RESIDENTS	
Livingston, Johnny	Churchrock Chapter president	Project oversight, direction
Carlisle, Edward	Churchrock Chapter Community Services Coordinator (through June 2006)	Project oversight, direction and staff supervision
Largo, Alice	Churchrock Chapter Community Services Coordinator (June 2006-present)	Project fiscal oversight
Brown, Gerald	CRUMP Coordinator, Jan. 2004-Dec. 2005	Project implementation, administration, reporting, community outreach, public relations, information dissemination
Norton, Bernice	CRUMP coordinator, August 2006-March 2007	Air particular monitoring, administrative duties
King, Larry J.	Resident, Study Area B; community liaison, June 2003-present	Community outreach, education in Navajo language; participant in field radiation surveys
Begay, Scotty	Resident, Study Area A, and former miner; community informant, June 2003-present	Community outreach, education on mining, milling history
Hood, Edith	Resident, Study Area A, and former miner, Oct. 2003-Aug. 2006	Participant in field radiation surveys
Nez, Teddy	Resident, Study Area A; community informant, June 2005-present; SRIC staff member since February 2007	Community outreach, education in Navajo language; representative of Red Water Pond Road community
Yazzie, Ned	Resident and former miner; community informant, June 2003-present	Community outreach, education on mining, milling history
	CONSULTING EXPERTS AND TECHNICIANS	
Shuey, Chris	Environmental Health Specialist, Southwest Research and Information Center, June 2003-present	Overall coordination of field operations; data management and analyses; regular communication with Chapter officials, residents, Navajo Nation agencies; report compilation and preparation
Allison, Annabelle	Former director, TAMS Center, June 2003-March 2004	Training, direction on air particulate monitoring
Bain, Andrew	USEPA Region 9 Superfund Project Manager, June 2003-present	Participation in field radiation surveys, public presentations on mine-site cleanup processes
Charley, Perry	Director, Uranium Education Program, Diné College, Shiprock, NM; June 2003-April 2005	Navajo language specialist, traditional healer, expert in Navajo uranium history
Craig, Vivian	Coordinator, Navajo Nation EPA Radon Program, June 2003-present	Coordination of indoor radon monitoring program; data maintenance
DeLemos, Jamie	Geochemist and PhD candidate, Tufts University, July 2006-present	Volunteer technician for analyses of uranium, trace metal transport in surface sediments

Diaz-Marcano, Helly	USEPA Radiation and Indoor Environments Laboratory, June-Dec., 2003	Operation of USEPA radiation scanner van
Dilbeck, George	Former director, USEPA Radiation & Indoor Environments Lab, Las Vegas, NV; June 2003-Feb. 2006	Uranium analyses of water samples; principal contact with USEPA Las Vegas laboratory
Edison, Stanley	NNEPA Superfund Program, June 2003-present	Participant in all radiation surveys
Esplain, Eugene	Health physicist, NNEPA Superfund Program, June 2003-present	Participant in all radiation surveys
George, Christine	Undergraduate student, Stanford University, Dec. 2004-present	Volunteer technician for water quality sampling and analyses, and soil sampling and analyses in Study Area A
Henio-Adeky, Sarah	Navajo Community Liaison, SRIC, March 2005-present	Navajo language specialist; periodic community outreach
Holiday, Carl	Health physicist, NNAML Shiprock Office, Oct. 2003-present	Participant in all radiation surveys; public education and outreach on radiation issues
Kulis, Jerzy	Water Quality Specialist, New Mexico Environment Department, Oct. 2003-Dec. 2004	Participant and adviser on water sampling program
Lane, Lillie	Public Information Officer, Navajo EPA, June 2003-present	Public information, community outreach in Navajo language; principal content with NNEPA
Lewis, Johnnye	Toxicologist and director, Community Environmental Health Program, University of New Mexico	Periodic advice and direction on sampling strategies, exposure modeling
Luther, Arlene	Director, Waste Management Division, Navajo EPA, June 2003-present	Top-ranking NNEPA policy official as liaison to CRUMP
Malone, Diane	Director, NNEPA Superfund Program, June 2003-present	Principal liaison to USEPA on UNC mill cleanup; oversight of radiation monitoring
Plummer, John	Navajo Nation EPA Radon Program, June 2003-June 2004	Indoor radon monitoring, public education, outreach
Ronca-Battista, Melinda	Health Physicist, Tribal Air Monitoring Support Center, June 2003-Dec. 2005	Training, implementation of field gamma radiation surveys; maintenance, analyses of radiation data; report preparation; expert advice
Seschillie, Bess	Coordinator, Diné Network for Environmental Health (DiNEH) Project, 2004-present	Coordination of DiNEH health survey with Churchrock Chapter officials, residents
Shura, Roger	USEPA Radiation & Indoor Environments Laboratory, June 2003-Dec. 2004	Operation of USEPA radiation scanner van; preparation of validated data sets
Wong, Puiman	USEPA Region 9 Superfund Public Outreach Specialist, 2005-2006	Community outreach on mine-site cleanup processes

FISCAL MANAGEMENT

Charles, LaLora	Accountant, Navajo Education and Scholarship Foundation, Sept. 2003-present	Overall management of RESOLVE, Inc., grant funds
Lee, Tony	President, Board of Directors, Navajo Education and Scholarship Foundation	Periodic oversight of Project implementation, administration

II. Water Quality Assessments

II.1. Scope of Assessment: Unregulated Water Sources

Unregulated water sources are those which are not regularly tested or treated for human consumption; that is, they are not subject to the requirements of the Federal and Navajo Safe Drinking Water Acts (SDWA). In Navajo Country, unregulated water sources are referred to as "livestock only" wells, and those words often are stenciled on the sides of storage tanks. NNEPA discourages use of unregulated wells for human drinking water. However, Navajo regulatory officials and Chapter leaders are aware that human use of unregulated water remains extensive in Eastern Navajo Agency communities. While the use of unregulated water for drinking water appears to have declined in recent years as more homes are connected to public water supply (PWS) systems, residents of remote areas may still consume the water they haul from windmills, dug wells and developed springs. The potential health effects of consuming unregulated water could not be estimated because water quality data did not exist for most unregulated wells. Hence, an important objective of the CRUMP water quality assessment was to determine current water quality in unregulated sources for use in future health studies.

II.2 Methods

II.2.1 Water Source Selection Process

A list of water resources in the Churchrock area was compiled from published reports, Navajo Nation Department of Water Resources (NNDWR) databases, knowledge of Chapter officials and residents, and field reconnaissance during Summer 2003. While water sources located within Churchrock Chapter boundaries were prioritized, sources located on the periphery of the Chapter in Coyote Canyon, Nahodishgish and Pinedale chapters were added to the list in recognition of the fact that water use and water hauling transcend chapter boundaries and community of residence. From an initial list of more than 30 water sources, 14 were recommended by Chapter staff for sampling based on local knowledge about their accessibility, operational status, proximity to AUMs, and known uses for livestock watering, domestic purposes (e.g., cooking, bathing, washing), and human consumption.[11] These wells were sampled in 2003 and 2004.

Three other unregulated wells located in the western part of Pinedale Chapter were sampled by DiNEH Project staff in 2005 and 2006. The water quality results for these wells are reported here for completeness. One of the wells, 16T-513, was on the original CRUMP sampling list but was inoperable at the time of the October 2003 water quality survey. This windmill was repaired by NNDWR in 2005 and was available for sampling by DiNEH staff in 2006. The other two wells — 16T-514 at the Pinedale Chapter House and 16T-535 on Second Canyon Road in Pinedale — are used often by residents from both Churchrock and Pinedale chapters. **Table II.1** shows the final list of 17 water sources tested and **Figure II.1** shows their locations.

[11] Two water wells controlled by United Nuclear Corp. — one at the dismantled UNC uranium mill (shown on **Figure II.1**) and the other at the Northeast Church Rock Mine — were added to the database, but were not included in the CRUMP survey because they are inaccessible to the general public and not used by UNC for any purpose other than water quality assessment of aquifers underlying the mill and mine sites. At least two other water sources known to exist just north of Churchrock Village were not sampled because they, too, are inaccessible to the public.

Table II.1
Unregulated Water Sources in Churchrock Area
Sampled by CRUMP and *DiNEH Project* (italics), 2003-2006

Well No.	Name	Chapter	Type	Formation/ Depth (ft)	Uses
None	Annie Grey	Pinedale	Dug/HP	Qal/8	LS, DOM
None	Solar St.	Churchrock	Drilled/HP	Qal?/NR	LS
14K-313	Brown Bull	Coyote Cyn	Drilled/WM	Kg/622	LS, DOM
14T-586	Friendship I	Coyote Cyn	Drilled	Kmv-Kg/750	PWS[12]
15K-303	Pipeline Canyon	Nahodishgish	Drilled/WM	Kg/614	LS
16-4-10	Lime Ridge or Pine Tree	Churchrock	Dug/HP	Jmw?/NR	LS, DOM
16K-336	Puerco North Fork	Churchrock	Drilled/WM	Qal/122	LS
16K-340	Windmill Cluster	Churchrock	Drilled/WM	Qal/141	LS
16T-348	Lobo Valley	Pinedale	Drilled/WM	Kd/410	LS
16T-510	Nose Rock	Churchrock	Drilled/WM	Kd/680	LS, DOM
16T-513	*Uphill Road*	*Pinedale*	*Drilled/WM*	*Jmw/318*	*LS*
16T-514	*Chapter House Well*	*Pinedale*	*Drilled*	*Kd/496*	*DOM, LS, PWS*[8]
16T-534	Superman	Churchrock	Drilled/WM	Jmw/410	DOM, LS
16T-535	*Second Canyon*	*Pinedale*	*Drilled/WM*	*Je/140*	*DOM, LS*
16T-559	Coal Mine, Henry's	Churchrock	Drilled/WM	NR	DOM, LS
16T-606	King Ranch	Churchrock	Drilled/WM	Kd/417	LS
16T-608	Yazzie Fam	Churchrock	Drilled/WM	NR	DOM, LS

DOM = domestic; Hp = Handpump; Je = Entrada Formation; Jmw = Morrison Formation, Westwater Canyon Member; Kd = Dakota Sandstone; Kg = Gallup Sandstone; KMV = Mesa Verde Group; LS = livestock; NR = No Record(s); PWS = public water supply; Qal = alluvium; WM = windmill

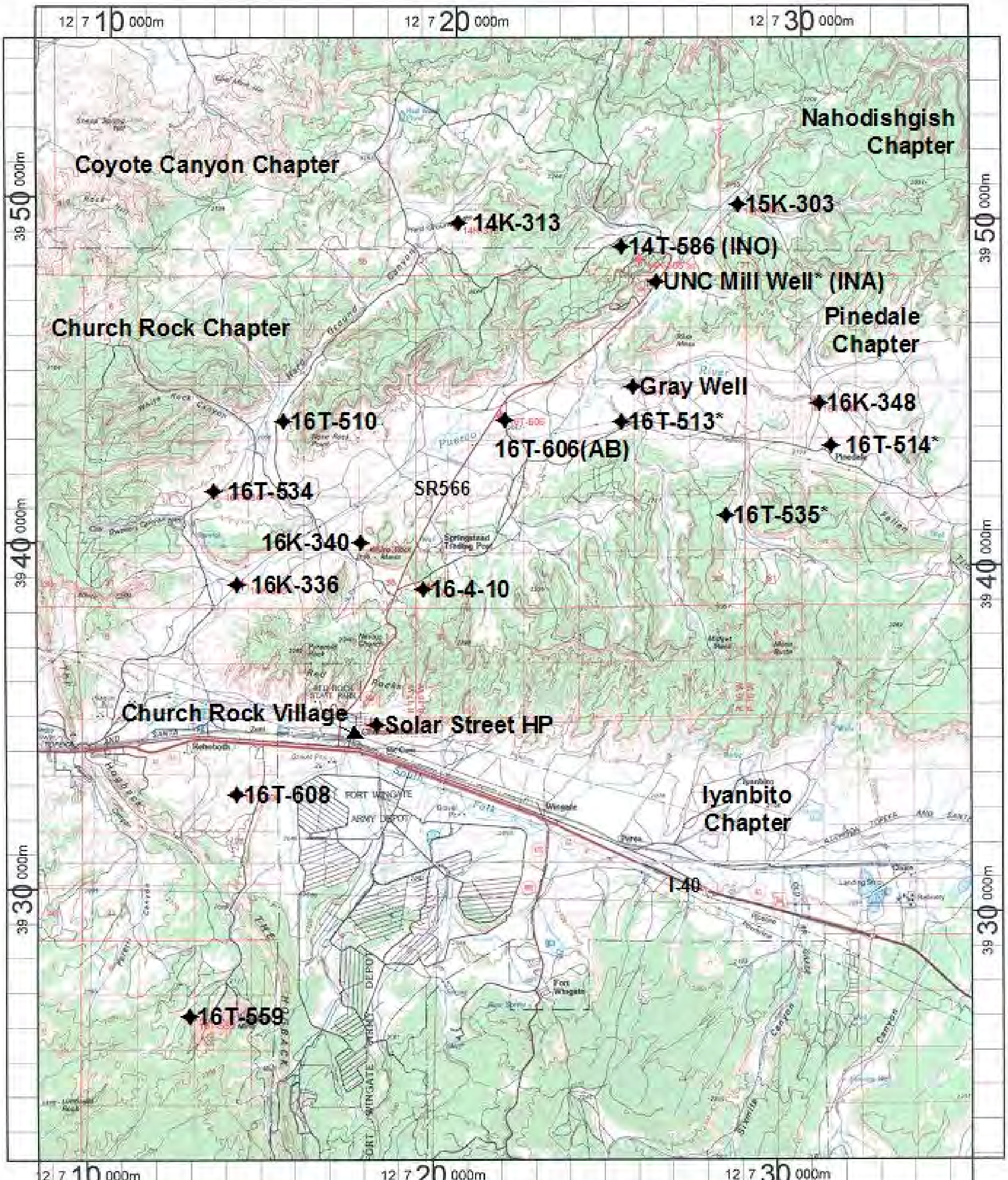
Complete water resource and water quality data for these wells are contained in the spreadsheets in **Appendix II.A**.

II.2.2. Sampling, Constituents and Analytical Methods

Fourteen water sources were field tested and sampled by CRUMP teams in August and October 2003 and December 2004. Three addition water sources located on the eastern extent of the Churchrock area in Pinedale Chapter were tested and sampled by a DiNEH Project team in 2005 and 2006. (See Sec. II.3 for water quality results.) The CRUMP teams consisted of NMED, NNEPA, SRIC, UNM-CEHP and USEPA personnel in 2003 and a volunteer Stanford University student, Christine George, working with CRUMP staff in December 2004. The DiNEH Project team included staff of SRIC and DiNEH Project and SRIC staff from the organization's Crownpoint office. Local residents and Chapter officials were informed when sampling took place and were invited to observe field operations.

[12] These two wells, 14T-586 and 16T-514, were designated public water supplies in the 1980s because they were believed to serve more than 25 persons continuously or be connected to at least 15 homes. Both were given PWS numbers by USEPA and NNEPA. Since July 2003, 14T-586 has been disconnected from homes in the Red Water Pond Road area of Coyote Canyon Chapter. 16T-514 is located at the Pinedale Chapter House and serves as a water hauling location for area residents, but is not connected to homes or offices in Pinedale Chapter.

Figure II.1. Map of Water Sources in Churchrock Area



Name: GALLUP
Date: 2/24/2004
Scale: 1 inch equals 2.254 miles
Source: Navajo Dept. Water Resources; Rev'd, SRIC 3/24/07

Location: 12 721718 E 3938716 N
Caption: Church Rock Well Listing
AB = abandoned; INO = inoperative; INA = inaccessible (as of 1/24/06); *Indicates well sampled by DiNEH Project

At each water source, field tests for indicator contaminants were performed using portable equipment and water samples for later laboratory analyses were collected in 1-liter bottles. All samples collected for laboratory analysis of trace metals and radionuclide were preserved with nitric acid to prevent precipitation of dissolved constituents inside the sample bottles. Latitude-longitude coordinates were take at each water sou using GPS (Global Positioning System) instruments, and these coordinates were included in the CRUMP water resource database.

Contaminants tested in both the field and laboratories and the methods used are listed in **Table II.2**. Two types of field tests were conducted, one using a single meter to measure pH, temperature, (electrical) conductivity and specific conductance, and the other using a portable spectrophotometer to measure concentrations of four indicator contaminants: fluoride, iron, nitrate and sulfate. These field tests give investigators a quick understanding of the overall quality of the water. For instance, conductivity — the measure of the ability of water to conduct an electric current, which in turn is proportional to the quantity of dissolved ions in the water — can be used to estimate the total dissolved solids (TDS) concentration. The TDS concentration is the most frequently used measure of overall water quality, and can be compared with state and federal "secondary" water quality standards.

Eight trace metals were selected for laboratory analysis because (1) they may be enriched in natural groundwaters in the sedimentary rocks of the New Mexico portion of the San Juan Basin and (2) all of them may be harmful to human kidneys over long periods of ingestion. Arsenic (As), cadmium, and uranium (U), for instance, are well-documented kidney toxicants, and As and U were observed in concentrations exceeding federal drinking water standards in every 1 out of 5 to 1 out of 7 unregulated water sources in the western part of the Navajo Nation in testing conducted by the USEPA and Army Corps of Engineers (USACE) in the late-1990s.

Analyses for trace metals were performed in late 2003 at the Navajo Tribal Utility Authority (NTUA) laboratory in Ft. Defiance, Arizona, and in early 2005 by Ms. George at the Stanford University Environmental Engineering laboratory in Palo Alto, California. CRUMP samples for uranium were analyzed at the USEPA's Radiation and Indoor Environments laboratory in Las Vegas, Nevada; and samples for radionuclide analyses were sent to the New Mexico State Laboratory Division (NMSLD) in Albuquerque. Samples collected by the DiNEH Project team were analyzed at the Carlsbad Environmental Monitoring and Research Center (CEMRC) laboratory in Carlsbad, N.M. CEMRC's laboratory analytical method reports concentrations for 40 different metals, including those listed in Table 4 and several "rare earth" elements that are not listed. All water quality data from these laboratory analyses have been recorded in spreadsheets for future reference. All five laboratories are USEPA-certified. Costs of analytical services at the NTUA lab were borne by CRUMP; costs of analytical services at the CEMRC lab were borne by the DiNEH Project. Analytical services at USEPA's Las Vegas lab, NMSLD and Stanford University were performed at no cost to CRUMP and are considered in-kind contributions to the program.

II.2.3. Contaminants Not Tested

Several categories of contaminants, and certain specific contaminants, were not tested for in the field or laboratories. These were:

Table II.2. Contaminants Tested and Analytical Methods

Contaminants	Methods
Field Tests (Indicators): Conductivity, pH, Specific Conductance, Temperature	Yellow Springs Instruments Model 63 portable pH-temperature-conductivity meter (field)
Field Tests, Major Ions (Aesthetic parameters): Fluoride (F), Iron (Fe), Nitrate (NO_3), Sulfate (SO_4)	Hach 2000 Spectrophotometer (portable field kit)
Major Ions/General Chemistry: Bicarbonate (HCO_3), Calcium (Ca),Carbonate (CO_3), Chloride (Cl), Magnesium (Mg), Potassium (K), Sodium (Na), Sulfate (SO_4), Total Dissolved Solids (TDS), Total Hardness	Inductively coupled plasma mass spectrometer (ICP-MS)
Trace Metals: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), Uranium (U)	Cold-vapor atomic adsoption (AA) for Cu; ICP-MS for all others
Radionuclides: Gross alpha activity, gross beta activity, radium-226, radium-228, uranium (mass), uranium-238, uranium-235, uranium-234	Gas proportional counting, gas scintillation by Lucas cell counting system; uranium isotopic: analysis uranium by alpha spectroscopy

- **Bacteria and other microorganisms** found in animal and human waste may be present in water from unregulated water sources. Various bacteria proliferate inside metal storage tanks and may be present on the ends of hoses that have been allowed to come in contact with the ground. Since harmful bacteria can be reduced or eliminated in untreated water sources by chlorinating or boiling water, CRUMP elected not to conduct sampling for bacteriological analyses.

- **Chlorination byproducts**, such as trihalomethanes, are formed when chlorine used to treat water supplies combines with other elements to produce harmful organic compounds. Since unregulated water sources are, by definition, not chlorinated, they would not be expected to contain chlorination byproducts.

- **Petroleum products**, including oil, grease, gasoline and fuel components, such as benzene and other polycyclic aromatic hydrocarbons, would not be expected in wells or developed springs that are not located next to or near a source of these contaminants, such as fuel storage tanks or oil and natural gas wells. A liquefied natural gas pipeline crosses parts of Churchrock, Nahodishgish and Standing Rock chapters. This pipeline is not known to have leaks or spills and none of the water sources identified in the Churchrock area were close to this potential contaminant source. Similarly, unregulated water resources are not known to exist near the Wingate Fractionation Plant, a natural gas processing plant located in Section – of T15N, R17W, just north of Interstate 40 and about 1.5 miles west of Churchrock Village.

- **Pesticides** are not used widely or frequently in rural areas of the Navajo Nation, including the study area, and therefore would not be expected in groundwater. The use of sheep dip vats containing toxaphene was phased out many years ago.

- **Radionuclides** of the uranium-decay series, including radium-226+228 (or, "total radium"), and gross alpha radiation and gross beta radiation, which are indicators of uranium decay. Those radionuclides were tested in the DiNEH Project samples of wells 16T-513, 16T-514 and 16T-535.

- **Solvents, cleaning fluids, degreasers and other industrial chemicals** are commonly found in urban and industrialized areas. Beyond limited uses in rural homes, large sources of solvents are not known to exist in the Churchrock area.

Large mining sites, such as the NECRM, Church Rock I and OCRM, may have had sources of petroleum products, solvents and other synthetic organic compounds, such as explosives, used in mining processes or transportation of ore and equipment. These sources could release pollutants to drinking-water wells located at the NECR mine site and UNC mill site. However, those wells are not accessible to community members and were not available for testing by CRUMP.

II.3 Federal and Navajo Drinking Water Standards Used for Comparisons

To rate the overall water quality of each of the 17 water sources in the Churchrock area, and the concentrations of specific contaminants in water, U.S. and Navajo Nation Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) for primary drinking water standards (NPDWS) and secondary drinking water standards[13] (NSDWS) were used for comparison. These standards legally apply only to regulated public water supplies, not to unregulated water sources like those tested by CRUMP. However, as noted previously, human use of unregulated water has been and continues to be a potentially significant source of exposure to toxic substances for people in the Eastern Agency. Accordingly, comparing water quality test results to SDWA standards provides the community with a barometer by which to gauge the relative safety or danger of a particular water source.

Primary standards are set for the most hazardous of pollutants in water; they are often referred to as "health-based standards because they are set at levels at which the lifetime risk of cancer or other major health effect is small (i.e., on the order of 1 in 100,000 to 1 in 1,000,000 persons exposed). Primary standards are not necessarily the *safest* or *lowest* levels because both the federal SDWA and the Navajo SDWA allow regulatory agencies to take into account the cost of treating water when setting enforceable standards.[14]

Secondary standards are set for contaminants that make water aesthetically unpleasing to humans. These "aesthetic" standards are set at levels designed to reduce or even eliminate foul tastes and odors and discoloration of water. They are often used to rate overall water quality

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[13] Primary and secondary drinking water standards adopted by NNEPA pursuant to the Navajo Safe Drinking Water Act are identical to those of USEPA, codified at 40 CFR 141 (primary) and 40 CFR 143 (secondary).

[14] Uranium is a good example of this. In 2000, USEPA established the first national drinking water standard for uranium at a level — 30 micrograms per liter (µg/l) or 0.03 milligrams per liter (mg/l) — that by its own admission was <u>not</u> the most protective limit that the agency could have established to reduce the risk of kidney disease in humans exposed to uranium in drinking water; that level was 20 µg/l. USEPA, National Primary Drinking Water Regulations, Radionuclides, 40 CFR 141.55 and 144.66; 65 Federal Register 76708-76753 (December 7, 2000). A later study commissioned by NMED determined that the calculated uranium level in drinking water to protect public health from kidney disease was 7 µg/l. See, B Malczewska-Toth, et al., Recommendations for a Uranium Health-based Ground Water Standard, May 2003. Based on that study, the state Water Quality Control Commission in 2004 revised its groundwater protection standard for uranium from 5,000 µg/l (5 mg/l) to 30 µg/l.

from poor to excellent. The measurement of "total dissolved solids" (TDS) is the principal secondary standard used most often to gauge overall water quality.

II.4 Water Quality Results and Use Recommendations

Complete field and laboratory water quality data for the 17 Churchrock-area water sources were compiled in spreadsheets that are included in **Appendix II.A**. Major water quality results are summarized in **Table II.3**. All of the 17 wells were sampled at least once during the CRUMP program; 11 were sampled twice for general chemistry and heavy metals. Concentrations of some contaminants in water sources sampled two or more times were averaged to obtain a composite concentration. Water from six of these wells did not exceed a primary or secondary drinking water standard on the first sample, but exceeded a standard on the second test. A good example is Well 16T-534, which had a composite arsenic concentration of 0.022 mg/l, or two times the federal drinking water standard of 0.010 mg/l, based on the average of two samples that were analyzed at different laboratories and had different results. Rather than try to determine why results from the labs varied, all of the results are reported here to ensure that the maximum concentrations are available for inclusion in future exposure assessments.

Table II.3 also shows CRUMP's recommended uses of water in each water source in three categories — human drinking water, domestic water, and livestock water. These recommendations are based on water quality results, professional judgment about local water-use patterns, and Navajo Nation policy that discourages consumption of unregulated water by people. The recommendations are symbolized by a red stop sign, yellow caution sign, and green light. A red sign indicates that the water is unsuitable for *any use*, exceeding at least one primary drinking water standard. A yellow sign indicates that caution should be exercised for the given water use because the water quality exceeds one or more secondary standards or, in the case of livestock water, is of very poor overall quality. *A yellow sign is the highest rating given for human consumption to be consistent with Navajo Nation policy discouraging human use of unregulated water.* A green light signifies the water is suitable for the given uses. This graphic representation of water quality was developed in 2006 by the DiNEH Project. We use it here to facilitate descriptions of the water quality in the 17 CRUMP water sources. Photos, numbers and words were used to describe the CRUMP water quality findings during community meetings at Churchrock Chapter in 2004 and 2005. (See Section VIII for details.)

II.4.1 Water Quality Summary for All Wells

The use recommendations in **Table II.3** are tied to the overall water quality in each water source. None of the 17 water sources is recommended for human consumption for one or all of the following reasons: (1) the water source exceeds a single NPDWS; (2) critical contaminants, such as bacteria and, in the case of three wells, radionuclides, were not tested and are therefore unknown; and-or (3) the Navajo Nation EPA discourages use of unregulated water sources for human consumption as a matter of policy.

The overall quality of the 17 water sources was highly varied. TDS concentrations ranged from 238 mg/l to 3,500 mg/l, averaging 1,133.4 ± 923.4 mg/l (mean and standard deviation) with a

Table II.3. Summary of Water Quality in Churchrock-area Water Sources and Use Recommendations

Well or Water Source	Pollutants Exceeding NPDWS	Pollutants Exceeding NSDWS	2006 Status	Use Recommendations		
				Human	Domestic	Livestock
Annie Grey	Uranium (1/2 std.)	Sulfate, TDS	OP	red octagon	red octagon	yellow triangle
Solar St.	Iron	pH, Sulfate, TDS	**INOP** (2004)	red octagon	yellow triangle	green circle
14K-313	Iron	Sulfate, TDS, Tot. Hardness	OP	red octagon	red octagon	green circle
14T-586	#Arsenic, Iron, #Selenium	Sulfate, TDS, Tot. Hardness	**ABD** (2003)	red octagon	red octagon	yellow triangle
15K-303	#Arsenic, Iron, Selenium	Sulfate, TDS	OP	red octagon	red octagon	yellow triangle
16-4-10	Gross alpha, Uranium		OP-LS only	red octagon "NO HUMAN USE" ADVISORY, 2004	red octagon	yellow triangle
16K-336	Iron	TDS	OP	yellow triangle	yellow triangle	green circle
16K-340	#Arsenic, Iron	Sulfate, TDS, Tot. Hardness	OP	red octagon	red octagon	yellow triangle
16T-348		pH, TDS	OP	yellow triangle	green circle	green circle
16T-510	Arsenic	Not tested	**INOP** (2006)	red octagon	red octagon	yellow triangle
*16T-513**	Iron	Sulfate, TDS**	OP	red octagon	yellow triangle	yellow triangle
*16T-514**		pH, TDS	OP	yellow triangle	green circle	green circle
16T-534	#Arsenic, Iron, #Selenium	pH, SO_4, TDS	OP	red octagon	yellow triangle	yellow triangle
*16T-535**	Iron	Fluoride, pH	OP	yellow triangle	yellow triangle	green circle
16T-559	#Selenium	PH	OP	yellow triangle	green circle	green circle
16T-606	Gross alpha, Iron, Radium	Sulfate, TDS, Tot. Hardness	**ABD** (2005)	red octagon	red octagon	red octagon
16T-608	#Selenium	Chloride, pH, TDS	OP	red octagon	red octagon	yellow triangle

***Notes:** * Wells sampled by DiNEH Project, 2005-2006; ** TDS estimated from conductivity values (750 uS/cm ~500 mg/l); # Indicates average of two or more values exceeds NPDWS. **Abbreviations:** ABD = abandoned; INOP = inoperative; LS = livestock-only use; OP = operating.*

median value of 811.8 mg/l. Only three of the 17 water sources had TDS levels below the secondary drinking water standard of 500 mg/l, and one of those three, Well 16-4-10 (called the Lime Ridge or Pine Tree handpump), is unsafe for human consumption because its average uranium concentration was more than two times the drinking water standard. Water in more than half of the wells (n = 9) had sulfate levels exceeding the NSDWS of 250 mg/l (range = 134 mg/l to 1,940 mg/l; mean = 497±537 mg/l; median = 310 mg/l).

II.4.1.1 Human Use for Drinking Water.

Notwithstanding the Navajo policy discouraging human use of unregulated water, the water quality survey found that *none* of the 17 wells produces water that is completely suitable for human consumption; that is, the water quality does not meet *all* primary and secondary drinking water standards. Twelve of the 17 wells received red sign recommendations for drinking water because their overall water quality is poor and/or the water contains one or more contaminants that exceed health-based primary standards. Five of the 17 wells have yellow caution recommendations because they exceeded one or two standards, even though their overall quality was generally good. Water in two of those five wells (16K-336 and 16T-535) exceeded only the primary standard for iron (at a level slightly higher than the standard of 0.3 mg/l), and one (16T-559) had an average selenium concentration of 0.05 mg/l, which is the same level as the primary standard. The other two wells receiving cautionary recommendations were 16T-348 and 16T-514, which had TDS levels between 500 and 1,000 mg/l.

Humans can drink water containing TDS concentrations up to about 1,000 mg/l, but the water is often described as tasting "hard" or "salty", and may contain elevated levels of other pollutants have more deleterious effects. Like TDS, sulfate is an indicator of overall water quality, and its secondary standard is set at a level designed to prevent a laxative effect on the human body.

II.4.1.2 Domestic Use Recommendations

Only three wells — 16T-348, 16T-514 and 16T-559 — merited green lights for domestic use, meaning that the water quality, on whole, is not unhealthy for cooking, bathing or laundering. Five wells — Solar Street Handpump, 16K-336, 16T-513, 16T-534, 16T-535 — were given yellow caution symbols because they had TDS levels between 500 mg/l and 1,000 mg/l and iron concentrations exceeding NPDWS. The other nine wells had more than one exceedance of a primary and secondary drinking water standard.

II.4.1.3. Livestock Use Recommendations

Seven wells had water quality suitable for livestock watering and received green light recommendations. Nine wells received caution signs, primarily because the TDS levels are greater than 2,000 mg/l, and in two cases, higher than 3,000 mg/l. Cattle, sheep and horses will drink such slightly saline water, even if it is not entirely beneficial for their health. But despite the marginal water quality, recommending against using unregulated water for livestock in an arid area where water is in short supply would place significant stress on local Navajo livestock owners who depend on their animals for food, income and local transportation. Only one well, 16T-606, received a red light for livestock watering. As discussed below, this well was contaminated by the radioactive element radium and by high concentrations of dissolved solids, and was taken out of service in 2006 at the request of local residents and Churchrock Chapter.

II.4.2 Summaries and Discussions for Individual Wells

Well 16T-534 — the Superman Canyon Windmill — is likely the most frequently used unregulated water source in the Churchrock area. It is conveniently located next to a main dirt road that links the northern part of the Chapter to the east side of the city of Gallup. Many residents haul water from this well on a daily basis. While most haulers say they use this water for domestic and livestock purposes, some haulers told CRUMP and DiNEH Project staffs that they also use water in the well for drinking. The CRUMP water quality results suggest, however, that 16T-534 is not good for human consumption. Water quality in this well exceeded the primary standards for arsenic (As), iron (Fe) and selenium (Se) in multiple samples (averages of 0.02 mg/l, 0.49 mg/l, and 0.06 mg/l, respectively) and was elevated in TDS and sulfate. CRUMP's red-sign recommendation *not* to use water from 16T-534 for drinking and to exercise caution using it for domestic purposes reflects the Project's weighing of the benefits of using a conveniently located and productive water source against the potential long-term health risks for consuming contaminated water.

Only two of the 17 water sources tested — 16T-348 and 16T-514, both located about 1 mile apart in Pinedale Chapter and completed in the Dakota Sandstone — had no exceedances of a primary drinking water standard. Yet water quality in both of these wells is marginal for human consumption: TDS (660 mgl and 752 mg/l[15], respectively) and pH levels (9.63 and 8.67, respectively) exceeded the NSDWS. The elevated TDS and pH levels give the water in these wells an alkaline taste.

Two wells — 14T-586 in Coyote Canyon Chapter and 16T-606 in Churchrock Chapter — were abandoned during the course of the Project because of unhealthy water quality.

Well 14T-586, or Friendship I, supplied water for drinking and domestic uses to about 15 homes in the Red Water Pond Road area between 1976 and 2003 what local people call the "Churchrock Mine Area" or "Kerr-McGee Camp". (See **Figure I.1**, Study Area A.) The well was disconnected from the community water system when the Navajo Tribal Utility Authority began supplying piped-in drinking water in mid-2003. NNDWR historic data dating back to the drilling of the well in 1976 showed poor water quality; TDS and sulfate levels exceeded secondary standards and manganese (Mn) concentrations exceeded the primary standard. The CRUMP sampling — conducted by NMEID and CRUMP staff in August 2003 and by Stanford University student Christine George and CRUMP staff in December 2004 — showed a worsening of overall water quality (TDS >2,100 mg/l) and average arsenic levels exceeding the 0.01 mg/l NPDWS. NMEID's test also showed a radium-226 concentration of 2.6 pCi/l, or about half of the drinking water standard of 5 pCi/l.

Well, 16T-606, located on Old Churchrock Mine Road within 0.5 miles of an AUM, was abandoned and dismantled by the Navajo Department of Water Resources in 2006 because of

[15] This TDS level for Well 16T-514 was estimated from an electrical conductivity field measurement. As a general matter, and for purposes of this study, the conductivity value is multiplied by 0.75 to obtain an estimate of total dissolved solids. Conductivity is the measure of the ability of water to conduct an electric current, proportional to the concentration of dissolved ions (charged particles) in the water. The higher the dissolved ions, the higher the conductivity, and by analogy, the higher the TDS.

CRUMP's finding of total radium levels (9.14 pCi/l) exceeding the NPDWS and high levels of TDS (3,500 mg/l) that are marginally suitable for livestock.

Well 15T-303, located in Study Area A 1.5 miles northeast of the UNC mill tailings disposal facility (**Figures I.1** and **II.1**), is not recommended for human or domestic use and, because of high TDS, has to be used with caution for livestock watering.

With respect to heavy metals and trace elements, iron (Fe) was the most prevalent contaminant, exceeding the secondary standard in 11 water sources. While iron is an essential nutrient in foods, too much iron in drinking water can impart poor taste and unpleasant color to water. Possible sources of iron in unregulated wells include the metal storage tank and naturally occurring iron in the groundwater. Water in five wells exceeded the primary standard for selenium (Se), all on the second test only. Similarly, of the five wells that exceeded the arsenic primary standard, four did so on the second sample tested. Arsenic in drinking water is associated with certain cancers and, like uranium, chronic kidney disease.

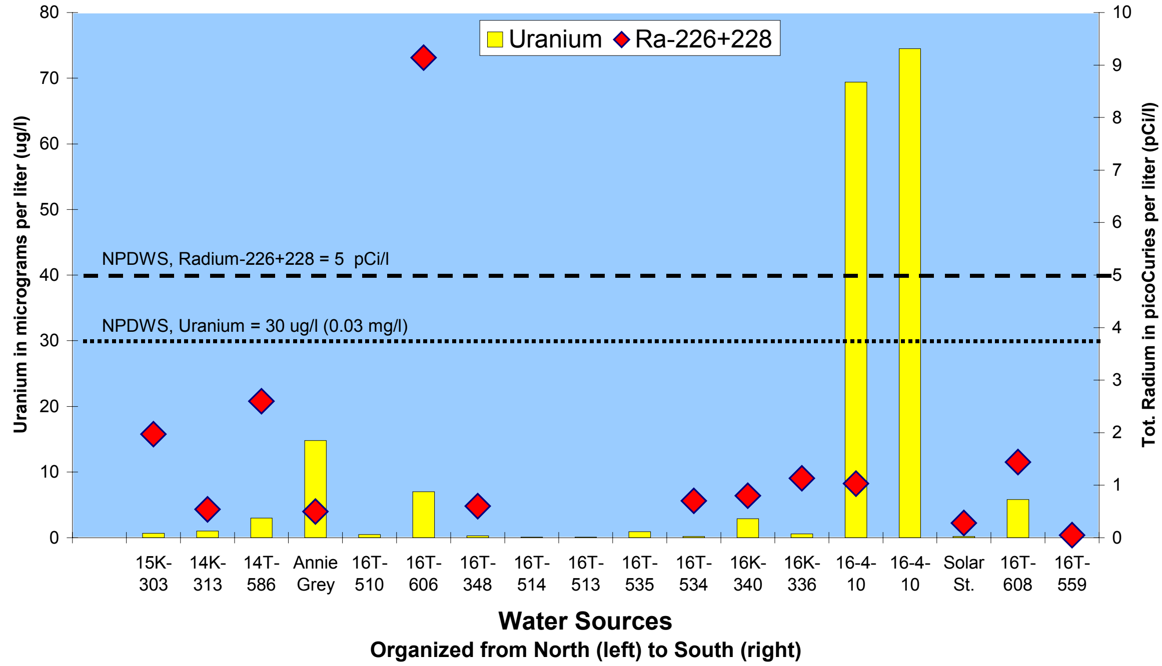
Uranium in excess of the NPDWS of 30 micrograms per liter (µg/l, or 0.03 milligrams per liter [mg/l]) was detected in 1 of the 17 water sources — Well 16-4-10, called the Lime Ridge or Pinetree handpump, which is a developed spring. Two samples collected in 2003 and 2004 had concentrations of 69 and 75 µg/l, or more than 2 times the drinking water standard. Even though this well had the best overall water quality of any well tested (TDS = 235 mg/l, or 235,000 µg/l), the uranium level alone disqualifies it as a human drinking water source. Water in this well also exceeded the primary standard for gross alpha radiation by nearly three times. Gross alpha particle activity indicates the presence of uranium decay chain radionuclides. The source of these radionuclides could be uranium deposits near the discharge point of the spring or an abandoned uranium mine located about 1 mile southeast of the spring's location.

Based on recommendations by NNEPA's Public Water Supply Supervision Program, CRUMP and SRIC staffs have advised people living in the Lime Ridge area not to drink this water or use it for domestic purposes. All the local families contacted indicated they are not using the water for drinking or domestic purposes. Some say they continue to use it for livestock watering, especially when weather conditions do not permit water hauling from other, cleaner sources.

One of the 17 water sources had a total radium (226+228) concentration that exceeded the drinking water standard of 5 picoCuries per liter (pCi/l). This well, 16T-606, a windmill, had very poor water quality and was taken out of service and dismantled by NNDWR in 2006. The well was completed in the Dakota Formation at the same horizon in which underground mining took place between 1960 and 1963. No site-specific studies of the possible relationship between mining and water quality deterioration in 16T-606 have been conducted.

As shown in **Figure II.2**, uranium and radium concentrations were below the federal and tribal drinking water standards for all other water sources in the Churchrock area. Only one other water source – the Annie Grey handpump in Pinedale Chapter – had a uranium level that represents a potential health risk. That level, 14.8 ug/l, while about half of the drinking water standard, is roughly equivalent to the level at which subclinical kidney disease has occurred in people who consumed water with this uranium level over many years.

Figure II.2. Uranium (ug/l) and Total Radium (pCi/l) in Churchrock-area Water Sources



II.5 Summary of Mine Water Quality Data

More than 20 years have passed since discharges of contaminated mine water from the three Churchrock-area underground uranium mines ended. The North Fork of the Puerco River — the principal stream that drains much of the CRUMP study area (see **Figures I.1** and **II.2**) — returned to its natural condition in February 1986, that of an ephemeral stream that flows only after spring snowmelt and summer thunderstorms. Between 1968 and 1986, however, flow in the stream was perennial, dominated by discharges of up to 5,800 gallons per minute (gpm) of mine water from the Northeast Church Rock Mine (1,800 gpm), the Kerr-McGee Church Rock I Mine (3,800 gpm) and the Old Churchrock Mine (200 gpm).

Yet at the outset of the CRUMP program in 2003, Churchrock Chapter officials remained concerned about the potential long-term impacts of past mine "dewatering"[16] on surface water and groundwater quality, levels of radioactive elements and trace metals in streambed sediments, and livestock and human health. They asked that SRIC review reports and water quality data on the mine water discharges, and summarize those data in a final report. This section responds to that request, and is supplemented by mine-water quality data in **Appendix II.B**.

[16] "Dewatering" is the practice of pumping groundwater out of underground mine workings to allow for access to the ore bodies by workers and equipment. Groundwater is exposed to oxygen in the mine workings, and contaminants native to the host rock are oxidized and dissolved in the water. The mine water is pumped to the surface to holding ponds where sediments in the water to settle out. Chemicals are added to treat the water to remove or reduce some contaminants (such as radium-226), and additional treatment, principally ion exchange, is used to reduce uranium levels before the mine water is discharge to arroyos or streams.

The Chapter officials' concerns about the impacts of mine water discharges were not unfounded. Water quality studies by federal and state agencies, nongovernmental organizations and mining companies between the mid-70s and early-90s had demonstrated that —

- Raw, untreated mine water contained levels of gross alpha particle radioactivity, radium-226, uranium, TDS and certain metals that far exceeded state stream water standards;
- Even treated mine water was not suitable for livestock watering, irrigation or domestic water supply, despite the fact that the Puerco River in the Churchrock area was used extensively for livestock watering during the mining era; and
- Recharge of mine water contributed to contamination of shallow, alluvial aquifers rendering the groundwater unsafe for human or animal consumption.[17]

Between 1968 and 1980, discharges of mine water were treated to lessen contaminant levels on a voluntary basis by the mine operators. Beginning in January 1980, all three mines were required to comply with limits on the volume of the discharges and levels of contaminants expected to be present in the discharges pursuant to National Pollutant Discharge Elimination System (NPDES) permits issued by USEPA under authority of the federal Clean Water Act. These limits were intended to achieve the Clean Water Act's "swimmable-fishable" goal of leaving surface water clean enough for people to wade in and for fish to survive in. The limits were never intended for the water to be safe for human and livestock consumption, even after treatment.[18]

Yet human and livestock use of the mine-water dominated Puerco River was pervasive in the Churchrock area and other downstream Navajo communities. Livestock owners who lived near the river routinely let their cattle, sheep and horses drink from the stream because it was a convenient watering source, and they were either unaware of the origins of the water or had been told by company officials that the water was safe for animal consumption.[19] Some people were said to have used the river for bathing because it was warm, especially near the discharge points.

While the *general* quality of the mine water in the Churchrock area was good (TDS concentrations averaged 580 mg/l in data reported by the state Environmental Improvement Division (predecessor to the Environment Department)), the water contained levels of uranium, radium-226 and total suspended solids that exceeded permit limits on numerous occasions, and in some cases, New Mexico and Arizona surface water standards. In fact, as shown in **Table II.4**, during the three-year period beginning in January 1980 and ending in March 1983, all three of the mines reported exceedances of permit limits for total and dissolved radium-226 and two of the three reported exceedances of limits for total uranium.[20]

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[17] BM Gallagher and SJ Cary, "Impacts of Uranium Mining on Surface and Shallow Groundwaters, Grants Mineral Belt, New Mexico," New Mexico Environmental Improvement Division, EID/GWH-86/2, September 1986.

[18] Sedimentation and flocculation in mine-water ponds and running the mine water through ion exchange columns to reduce uranium and radium-226 concentrations were the principal treatment methods used.

[19] C Shuey, "The Puerco River: Where Did The Water Go?", *The Workbook*, IX:1, January/March 1986.

[20] This compliance history was generated by SRIC in 1983 based on a review of all Discharge Monitoring Reports submitted by the companies to USEPA Region 6. Results were summarized in written testimony by SRIC at USEPA public hearings in July 1983 on the agency's proposed renewal of the mines' NDPES permits.

Table II.4
NPDES Compliance Record for Churchrock-area Mine Water Discharges
1980-1983

Mine	Period of Record	Noncompliance Months	Total Number of Exceedances of Permit Limits	Permit Parameters Exceeded
Church Rock I	5/80-3/83	7 of 34	7	Total U, dissolved Ra-226, maximum pH
Northeast Church Rock	1/80-2/83	13 of 37	19	Total U, dissolved Ra-226, total Ra-226, chemical oxygen demand
Old Churchrock	1/80-2/83	25 of 37	37	Dissolved Ra-226, total Ra-226, maximum pH, chemical oxygen demand, maximum TSS, average daily TSS

II.6 Discussions

The CRUMP assessment of water quality in unregulated water sources in the Churchrock area found a much lower percentage of wells having uranium concentrations exceeding the primary drinking water standard (1 out of 17, or 6%) than was observed in water quality surveys conducted by USEPA and the U.S. Army Corps of Engineers in the western portion of the Navajo Nation between 1997 and 2000.[21] Depending on the regions surveyed, the USEPA/USACE study found that 1 out of every 5 (20%) to 1 out of every 7 (14%) unregulated water sources had uranium concentrations greater than 30 µg/l. As noted previously in this section, the overall water quality of most of the 17 wells tested was generally fair to poor. The poorest water quality appears to be in the four wells that tap the Cretaceous Gallup Sandstone and Mesa Verde Formation (average TDS = 2,091 mg/l). However, correlation of water quality with producing formation is unreliable with only 15 wells in the database. As the DiNEH Project moves forward with its testing of unregulated water in 20 chapters in the Eastern Agency, additional data may allow for a more accurate correlation analysis.

The long-term effects of past mine-water discharges to the Puerco River, coupled with the one-time shock loading of the stream in the July 1979 tailings spill, remain uncertain. Transport of uranium and other metals in surface water and sediments is being studied by DiNEH Project collaborator Jamie deLemos, a Tufts University geochemist, and her findings may shed light on the extent of uranium and other contaminants released in historic discharges. Evaluation of changes in water quality in alluvial wells located next to the Puerco River over the last 30 years may also provide insight into the long-term effects, if any, of mining-related discharges.

[21] U.S. Environmental Protection Agency and U.S. Army Corps of Engineers. Project Atlas: Abandoned Uranium Mines Project, Arizona, New Mexico, Utah – Navajo Lands, 1994-2000. Prepared by TerraSpectra Geomatics (Las Vegas, Nev.) for USEPA Region 9 Superfund Program, December 2000.

III. Surface Gamma Radiation Surveys

III.1 Introduction.

This section summarizes the equipment, quality assurance/quality control (QA/AC) procedures, and methodologies used to assess gamma radiation levels in residential areas and along highways and roads in the greater Churchrock Chapter area in October 2003. Results of the assessment, including statistical analyses, are summarized here. Spreadsheets containing the raw field data have been copied to CDs, which are included in **Appendix III.A**.

III.2 Purpose of the Surveys and Collaborations

The CRUMP gamma radiation assessment was conducted to address community concerns about possible long-term environmental impacts of past uranium mining and processing in residential areas and along major highways and roads in the Church Rock Mining District. As noted in the **Section I,** uranium mining has a 50-year history in the area, and very little assessment of radiation levels outside of AUMs and along roads used as ore haul routes had ever been conducted. The CRUMP surveys were conducted up to, but outside of the boundaries of AUMs. Their purpose was for environmental and public health assessment; they were not conducted for regulatory purposes or for enforcement of laws and regulations.

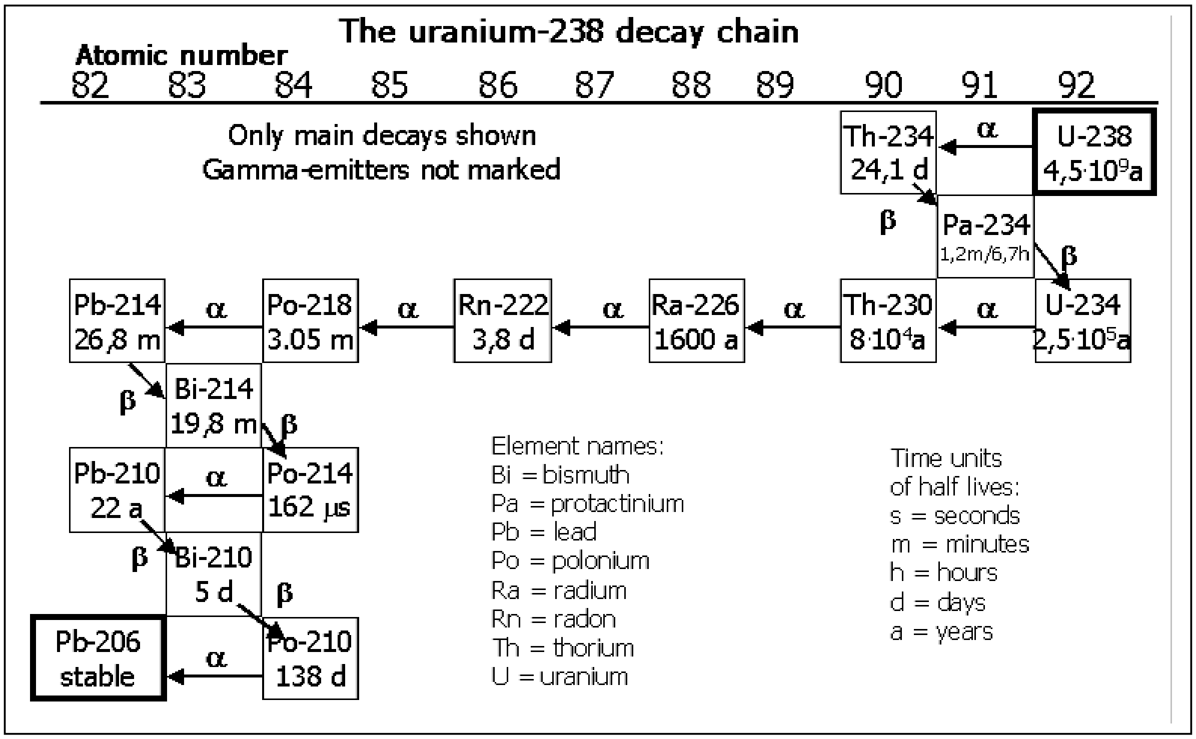
As noted in the **Section I.5**, the CRUMP gamma radiation assessment was conducted by individuals and groups with particular expertise in radiological surveys at and around sites contaminated by radioactive materials. Principal investigators for this part of the CRUMP program were Melinda Ronca-Battista, a health physicist with the Tribal Air Monitoring Support (TAMS) Center of Northern Arizona University (NAU) in Flagstaff; Diane Malone, Stanley Edison and Eugene Esplain of NNEPA's Superfund Program; Roger Shura and Helly Diaz-Marcano, environmental scientists at the USEPA Radiation & Indoor Environments (R&IE) Laboratory in Las Vegas, Nev.; and Carl Holiday, health physicist with the Navajo Nation AML program. George Dilbeck, former director of radiochemistry at the USEPA R&IE lab, was instrumental in obtaining use of the USEPA radiation "scanner van" (see **Section III.4.3** below) for parts of four days — an in-kind contribution to CRUMP valued conservatively at $15,000. More than 20 individuals took part in the actual on-the-ground assessments on October 27-30, 2003. Included among them were former Churchrock Chapter Community Services Coordinator Edward Carlisle and residents Larry J. King and Edith Hood. Numerous staff members of NNEPA, NNAML and USEPA's Region IX Superfund Program also participated; all of these individuals are listed in **Table I.2**.

Thousands of gamma radiation data points were generated collectively by the Scanner Van and surveyors using hand-held meters. Ms. Ronca-Battista, with assistance from Mr. Shuey, transcribed the raw gamma data from field notes and data sheets into Excel spreadsheets, validated the datasets, and conducted statistical analyses. She also wrote descriptions of the equipment, methods and QA/QC procedures used. Mr. Shura prepared validated data sets in Excel format for the Scanner Van gamma data. Mr. Shuey compiled and maintained these data files in electronic form, and provided the data to NNEPA's Jerry Begay, who prepared digital maps depicting the results of the gamma assessment.

III.3 Background on Ionizing Radiation

Naturally occurring radioactive materials (NORM) present in the Earth's crust constantly emit different types of ionizing radiation. Gamma radiation and beta and alpha particles are the three main types of ionizing radiation emitted by uranium (U-238) and its decay products. A chart of the uranium decay chain showing alpha and beta emissions is depicted in **Figure III.1**. Gamma radiation is emitted contemporaneously with alpha and beta particles from several of the uranium decay products, most notably radium-226.

Figure III.1. Uranium Decay Chain



III.3.1 Gamma Radiation Defined

Gamma radiation is high-frequency electromagnetic waves, or photons, emitted from the nucleus of an atom. X-rays used in medical applications are similar to gamma rays, but originate from the outer shells of electrons. Gamma radiation penetrates virtually any substance or material, except solid lead, including the human body. As a form of ionizing radiation, gamma radiation strips electrons from atoms that it passes through, leaving ions — charged particles — in their place. These ions can damage living tissue, and the higher the rate or level of ionizing radiation, the greater the biological damage.

Gamma radiation is measured in microRoentgens per hour (µR/hr) or counts (i.e., disintegrations) per second or minute (cps or cpm) by hand-held or truck-mounted equipment.

Gamma radiation is a useful assessment tool for determining the presence of uranium-related contamination because, as noted above, several of the uranium-decay chain radionuclides are strong gamma radiation emitters. Gamma-rate surveys also help determine radiation levels that exceed "natural background," or what is considered "normal." Since "normal" radiation levels vary depending on elevation above sea level, topography, geology and other factors, radiation and environmental specialists use the terms "impacted" and "non-impacted" to differentiate areas affected by human activities involving radioactive materials from areas having NORM.

III.3.2 Beta and Alpha Radiation and Biological Effects

Beta particles (essentially, electrons) and alpha particles (helium nuclei) are two other types of ionizing radiation that occur naturally or, in places where uranium has been developed, in higher levels indicative of human activities. Alpha particles, because of their relatively large size, cannot penetration human skin, but are particularly hazardous when inhaled or ingested because of the high levels of electrical energy they deliver to surrounding tissue.

As shown in **Figure III.1**, many of the uranium decay chain radionuclides are formed through the emission of an alpha particle. For instance, radon, an inert radioactive gas, is derived from the decay of radium-226 and decays in a relatively short time (half-life = 3.8 days) into a series of short-lived, but high-energy decay "daughter" products. When inhaled, radon and its solid progeny lodge deep in the breathing sacs of the lungs, irradiating surrounding tissue. For this reason, the biological effectiveness of alpha-emitters like radon is considered to be greater 20 times than that of gamma radiation.

Biological effects of ionizing radiation are expressed in units called "rems," which stands for "Roentgen-equivalent-man." A millirem is $1{,}000^{th}$ of a rem. Background radiation, depending on where a person lives, ranges from 200 to 300 mrem per year for all sources. 1 mrem is roughly equal to 1,000 μR of gamma radiation. Accordingly, a background gamma rate of 13 μR/hr yields an annual whole-body radiation dose of approximately 114 mrem/yr, assuming that an individual is constantly exposed to a gamma rate of that magnitude.

Nuclear Regulatory Commission regulations (10 CFR Part 20) limit radiation exposures to members of the public from radioactive materials *licensed by the NRC* to 100 mrem/yr, or in the case of pregnant women, 50 mrem/yr. USEPA regulations limit public exposures to radiation from nuclear fuel facilities to 25 mrem/yr, excluding contributions to the dose from radon.

III.4. Gamma Radiation Detection Equipment and Assessment Guidelines

Two types of gamma radiation instruments were used in this assessment: Hand-held Ludlum Model 19 detectors and two large sodium iodide detectors housed inside a 2-ton "Scanner Van" owned and operated by USEPA's Las Vegas laboratory. Operational characteristics of each of these types of instruments are summarized below.

III.4.1 Ludlum-19 Sodium Iodide Detectors

Ludlum Model 19 hand-held detectors loaned by the TAMS Center and NNEPA Superfund Program were used in the assessment of surface gamma radiation levels in the Churchrock area.

These detectors are rugged and portable and can be used is in situations where relatively low gamma emission rates are expected. They are especially useful for detecting gamma emissions from uranium and thorium decay products, such as radium, lead and bismuth, that would be expected in uranium mining areas.

The detectors are 1" X 1" sodium iodide (NaI)Tl crystals inside an aluminum container with an optical glass window that is connected to a photomultiplier tube. A gamma ray that interacts with the crystal produces light that travels out of the crystal and into the photomultiplier tube. There, electrons are produced and multiplied to produce a readily measurable pulse whose magnitude is proportional to the energy of the gamma ray incident on the crystal. Electronic filters accept the pulse as a count; this translates into a meter response. Sodium iodide survey meters measure gamma radiation in µR/hr or cpm with a minimum sensitivity of around 1-5 µR/hr, or 200-1,000 cpm, and a maximum range of up to 5,000 µR/hr. These gamma rates are displayed in a window on top of the meter for easy reading by the operator.

Hand-held meter method. The typical procedure employed in using hand-held gamma detectors is walking along a pre-determined grid line at about 0.5 meter/sec, holding the detector at approximately one meter (or waist high) from the surface, observing changes in the gammarate on the meter display, and recording the results every one to two meters. (See **Figures III.2a** and **III.2b**.) To gain additional information about the area, at approximately every three meters the detectors were also held at about one cm from the surface and the result recorded. The results of both measurements can be used as an indicator of the need for further measurements: if the near-contact results are much higher than the waist-high results it can be inferred that the gamma emission is fairly specific in location (e.g., a boulder or small patch of earth), while if the results are similar then it can be inferred that gamma radiation is being emitted from a wider area, resulting in a more uniform gamma exposure rate.

III.4.2 Quality control procedures for hand-held detectors.

Thorough quality control (QC) procedures were followed throughout the three-day assessment period. These procedures are summarized here and documented in detail in **Appendix III.A**. They not only demonstrated a common gamma radiation survey technique, but also served to train local residents, officials and agency representatives in proper use of hand-held gamma

Figures III.2a and III.2b. CRUMP collaborators following established procedures in measuring gamma radiation rates with hand-held meters

detectors. QC procedures were adhered to and documented during data gathering and data recording. These QC procedures are consistent with industry practice and government recommendations. Similar procedures are followed in radiation surveys at laboratories, military bases, and site restoration projects. Because the QC standards were adhered to, it is possible to use the resulting data to identify areas where cleanup actions may be needed.

III.4.3 Scanner Van Assessments

Two NaI (Tl) detectors mounted in the scanner van (see photos in **Figure III.3**) were used to measure and record the gamma flux data. The primary (main) detector is shielded, and has a 4"x16" opening to directionally collimate radiation "viewed" at 55 degrees by the detector. The secondary (background) detector is unshielded for a 360-degree "view" of the surrounding gammaflux. RealtimeRad™ recorded the count rate data from the two detectors and the coordinate location of each data point. By comparing the data from the two detectors in relation to the terrain types and detector geometry, gamma flux data were collected.


Figure III.3. Front and interior views of the USEPA gamma radiation Scanner Van used in the CRUMP radiation assessment.

III.4.4 MARSSIM Assessment Methodology

USEPA's Multi-Agency Radiation Survey and Site Investigation Manual, or MARSSIM, was used as the principal guidance for conducting ground-level radiation surveys in the Churchrock area. (For details, see http://www.epa.gov/radiation/marssim/; a summary of the document is contained in **Appendix III.B.**) MARSSIM describes a consistent approach for planning, conducting, evaluating, and documenting building surface and surface soil radiological surveys for demonstrating compliance with dose or risk-based regulations or standards while also encouraging effective use of resources. The MARSSIM is a multi-agency consensus document that was developed collaboratively by four Federal agencies having authority and control over radioactive materials: Department of Defense (DOD), DOE, USEPA, and Nuclear Regulatory Commission (NRC). It is flexible enough to use with many current state and Federal statutory programs, including the Superfund law (i.e., Comprehensive Environmental Response Compensation and Liability Act). And it can also be used, as it was for CRUMP, as guidance for environmental and public health assessments outside the boundaries of regulated facilities.

III.5 Gamma Radiation Assessment Locations

Gamma radiation levels in areas not impacted by uranium mining or other anthropogenic sources of ionizing radiation were determined using the USEPA scanner van and hand-held Ludlum-19 meters. The van measured gamma rates at 1-second intervals (with corresponding latitude-longitude coordinates) around the Churchrock Chapter House and in Churchrock Village north of Interstate 40 at the junction of Old US Route 66 and State Route 566. From Churchrock Village, the van traveled north of SR 566 to its terminus at the gate of the UNC Northeast Church Rock Mine, a distance of 10 miles. The van also measured gamma rates on major side roads, including Springstead Loop, Uphill Road, Old Churchrock Mine Road, Pipeline Road and Red Water Pond Road. Maps of the results of these surveys are included in **Appendix III.C**..

On-the-ground surveys using Ludlum-19 meters were conducted at the Springstead Estates development site in both the arroyo that bisects the site (Study Area C) and on and around the remains of a mobile home park that housed mine and mill workers in the 1970s and early 1980s. Hand-held readings were made on both sides of SR 566 at its junction with Old Churchrock Mine Road. In this area, called Study Area B, hand-held measurements were made outside of the fence of the Old Churchrock Mine in Section 17 and on the grazing lands of Larry J. King and his sisters, east of SR 566 and Old Churchrock Mine Road. In Study Area A, hand-held measurements were made along SR 566 in the vicinity of the UNC Church Rock Mill, on both sides of Pipeline Road from its intersection with SR 566 to past the site of the abandoned Kerr-McGee Church Rock IE mine site. Gamma meters were also used extensively in residential parts of the Red Water Pond Road area between the NECR Mine and KMNC Church Rock I Mine.

III.6. Gamma Radiation Assessment Results

Results of the CRUMP gamma radiation assessment are contained in three forms: More than 100 separate Excel files, charts showing the results of statistical analyses, and digital maps that depict gamma rates in three colors: green dots and lines for background gamma rates; yellow dots and lines for gamma rates between background and two times background; and red dots and lines for gamma rates more than 2 times background. For this report, the digital maps and graphs are used to depict and discuss the results because they are the most easily understood, and are more convenient that examining the data contained in dozens of spreadsheets. The data sets are copied to a CD, which is available from SRIC.

III.6.1. Determination of Background Gamma Radiation

Ms. Ronca-Battista compiled the validated scanner van and hand-held gamma radiation data in Excel spreadsheets, and conducted statistical tests to determine (1) “background,” or radiation levels in non-impacted areas, and (2) areas exhibiting gamma rates between background and 2 times background and above 2 times background. As demonstrated in the CRUMP assessment and discussed in this section, “normal” or background gamma rates in the Churchrock area ranged from 7 to 20 μR/hr, with averages of 11 to 13 μR/hr, depending on the location. Gamma rates exceeding those averages by more than two times were considered to represent areas “impacted” by human activities.

Gamma rates were determined for non-impacted areas of the community using the USEPA Scanner Van and hand-held instruments. The average gamma rate at the Churchrock Chapter House and in Church Rock Village was 11±3 uR/hr, based largely on Scanner Van results. The average gamma rate at the Springstead Estates housing development site three miles north of the village was 13±3 uR/hr. These two sites presented different topographical and geological characteristics that are sufficiently representative of the range of natural conditions in the area to be valid locations for determination of background.

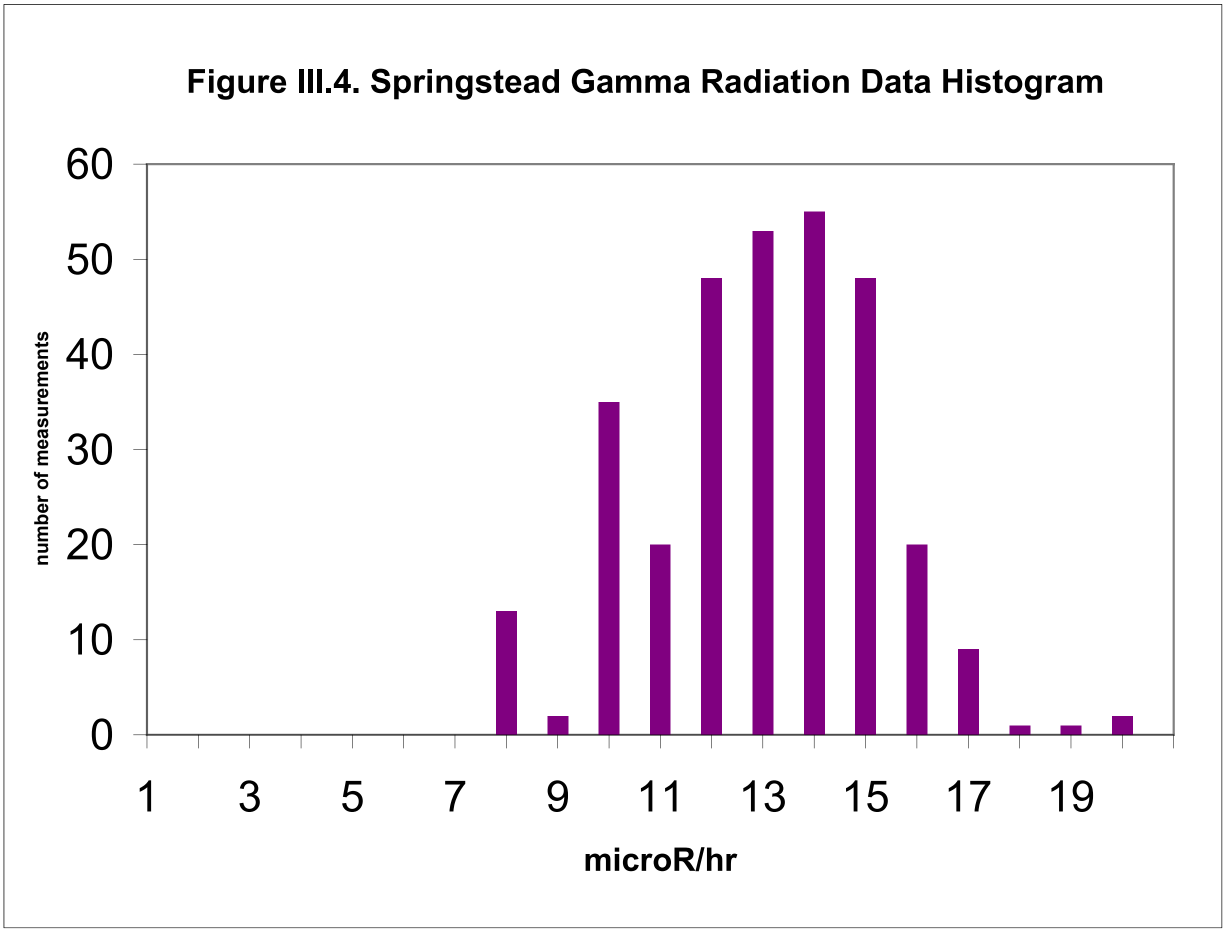
The average gamma rate for the Springstead site was based on hundreds of data points from the Scanner Van and from the field data sheets of individual surveyors using Ludlum-19 meters. More than a dozen people walked the Springstead site on October 29 and 30, 2003, recording gamma rates in the arroyo that bisects the site from the south to north and around what remains of the mobile home park that housed uranium workers in the 1970s and '80s. The arroyo drains an upland area that was the location of at least three mines that operated in the 1950s. Only one of those, Foutz No. 3, has been reclaimed.

Figure III.4 is a histogram of the Springstead Estates data prepared by Ms. Ronca-Battista that depicts the distribution of the gamma rate for that site. **Figure III.5** compares the two data sets for the Chapter House-Village area and Springstead Estates location. While the shapes of the curves are different, statistical analyses of the data by Ms. Ronca-Battista showed no significant difference between the two sets at the 90th confidence interval. Accordingly, we defined background as ranging from 11 to 13 uR/hr for the entire study area.

III.6.2. Gamma Radiation Results in Study Area B

The Scanner Van detected gamma rates exceeding two times background along SR 566 in the vicinity of the Old Churchrock Mine in Section 17 of T16N, R16W. Small red flags were stuck into the ground at regular intervals to mark these anomalies for further investigation. The Scanner Van also measured gamma rates on a portion of the dirt road that borders the OCR Mine site on the east and south. East of the intersection of SR 566 and Old Churchrock Mine Road, the Scanner Van made a circular pass-through of the King Family Ranch in Section 17; the ranch and the homes of Larry J. King and his two sisters are 0.25 mile due east of the OCR Mine.

To further delineate the extent of radiological contamination of this area, nearly 20 individuals using Ludlum-19 meters walked both sides of State Route 566 next to the OCR Mine, both sides of Old Churchrock Mine Road, and portions of the King Ranch grazing areas. The resulting data from both measurement techniques were analyzed by Ms. Ronca-Battista in late 2003 and mid-2005. Some of the results of that analysis are depicted in **Figure III.6**, which compares gamma rates along SR 566 with the background measurements made near the Chapter House and at Springstead Estates. The analysis showed that there was a significant difference at the 90th confidence interval between gamma rates close to the highway and those farther from the highway. This finding suggests that the residual effects of deposition of uranium ore from haul trucks operating at the site in the 1960s, '70s and early 80s can still be observed in the environment more than 20 years later.



A maximum gamma rate of 180 uR/hr was detected on the King grazing lands east of State Route 566. This rate is 13 to 16 times greater than the measured rates for the non-impacted background sites at the Churchrock Chapter House and Springstead Estates. An analysis of the location of this maximum rate along with maps of gamma rates generated by the Scanner Van (see **Figure III.7**) indicated that contaminated materials at the OCR Mine site had been spread by wind across SR 566 and onto the King family grazing lands. That contaminated materials were and still are present at the Section 17 AUM was documented in company reports submitted to the NRC in 1988 and more recently by gamma radiation surveys conducted on the periphery of the mine site by NNEPA and SRIC staff in August 2006. A Powerpoint summary of this investigation is reproduced for this report in **Appendix III.D**.

III.6.3. Gamma Radiation Results along SR 566 and in Study Areas A-1 and A-2

Gamma radiation rates along State Route 566 from the Old Churchrock Mine site (Section 17; Study Area B), past the dismantled UNC mill and mill tailings impoundment in Section 2 of T16N, R16W, and ending at the terminus of SR 566 at the entrance of the abandoned Northeast Church Rock Mine are depicted in **Figure III.8** and in **Appendix III.C.4**. These maps include gamma surveys conducted on both sides of Pipeline Canyon Road north of the UNC tailings facility (Study Area A-2) and in the Red Water Pond Road area (Study Area A-1). The map in

Figure III.5. Comparison of Springstead gamma data with background gamma rates around Churchrock Chapter House

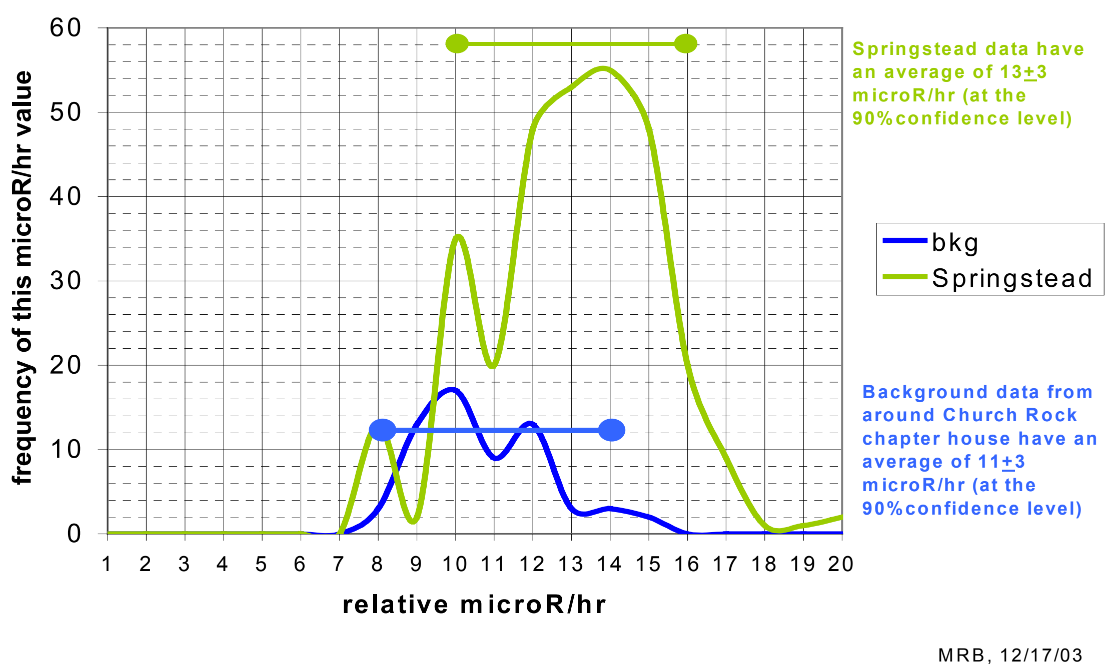


Figure III.6. Comparison of Gamma Rates (uR/hr) within 8 m of SR 566 and >8 m from SR 566 in the Vicinity of the Old Churchrock Mine, and Comparison to Background Rates at the Churchrock Chapter House

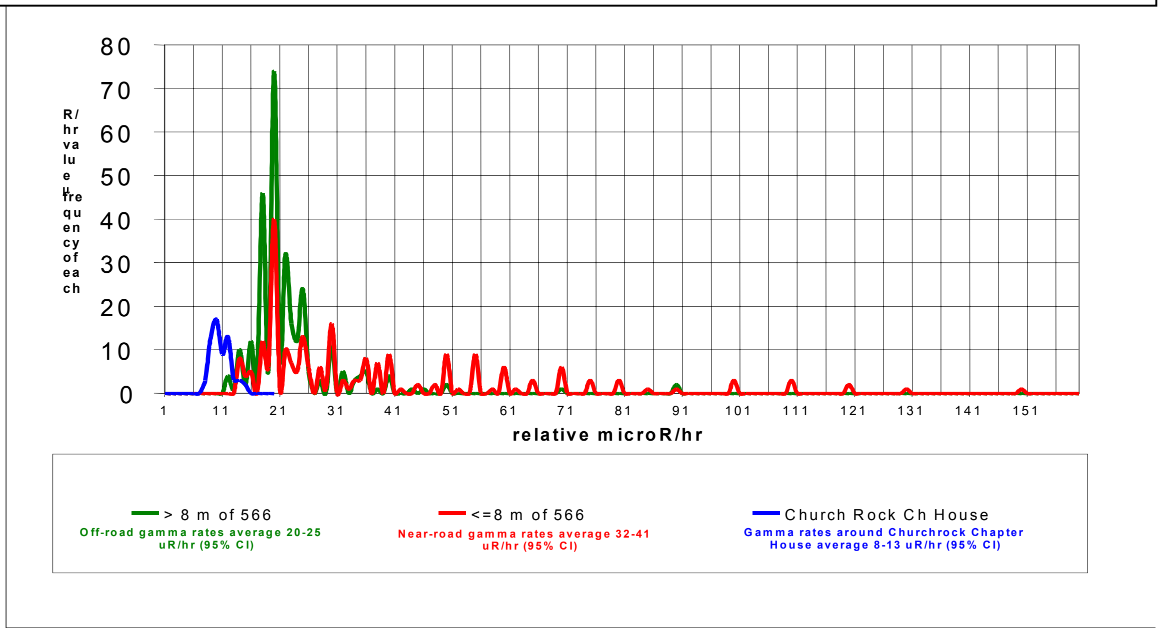
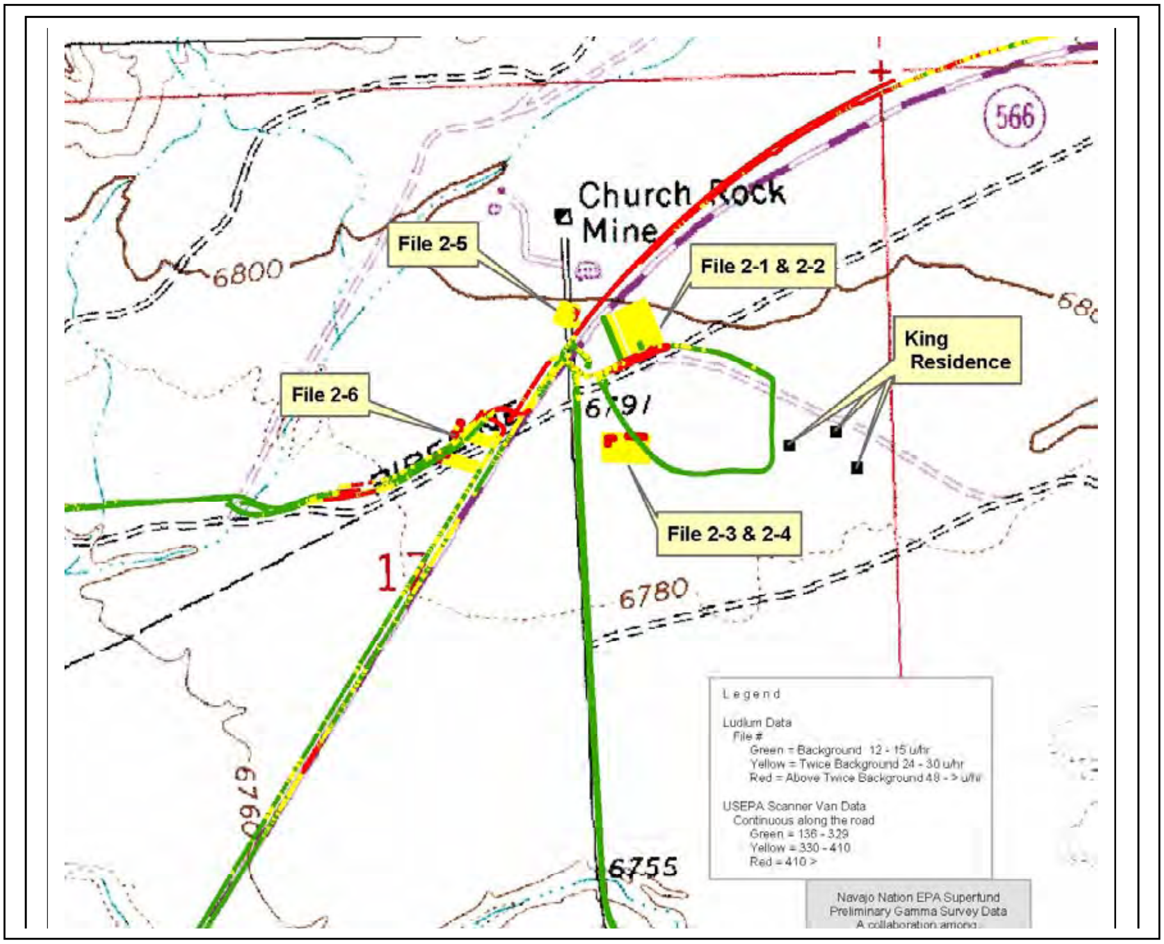


Figure III.7. Map of Gamma Rates in CRUMP Study Area B in Vicinity of Old Churchrock Mine and King Family Ranch



Appendix III.C.5 shows a closer view of gamma rates in the Red Water Pond residential area between the NECR Mine site to the south and the Kerr-McGee Church Rock I Mine to the north.

As shown on **Figure III.9** and **Appendix III.C.4**, gamma rates more than two times greater than background were detected on both sides of SR 566 in the vicinity of the UNC mill and tailings facility. These rates, represented by a series of red dots that form a solid red line, occur to the terminus of SR 566 at the NECR Mine and continue north onto Red Water Pond Road. Gamma rates along roads in the residential area remained above background (yellow and red dots). A concentration of yellow and red dots forming a series of parallel rows can be seen on the map in **Appendix III.C.5**, just north of the NECR Mine site; these dots represent hundreds of gamma meter readings from hand-held instruments. Maximum gamma rates reached 300 μR/hr just north of the NECR Mine waste dump and less than 500 feet from the closest resident. By comparison, background gamma rates were consistently less than 15 μR/hr in this area.

On Pipeline Road (**Figure III.9**), gamma rates were within background (i.e., <15 μR/hr) on a portion of the road through Section 36, increased to more than 2 times background where the road crosses the Pipeline Arroyo that received mine-water discharges from the NECR and CR-I mines, diminished to background again, and then increased to more than twice background again at a location adjacent to the site of the Kerr-McGee Church Rock I-E shaft. Gamma rates

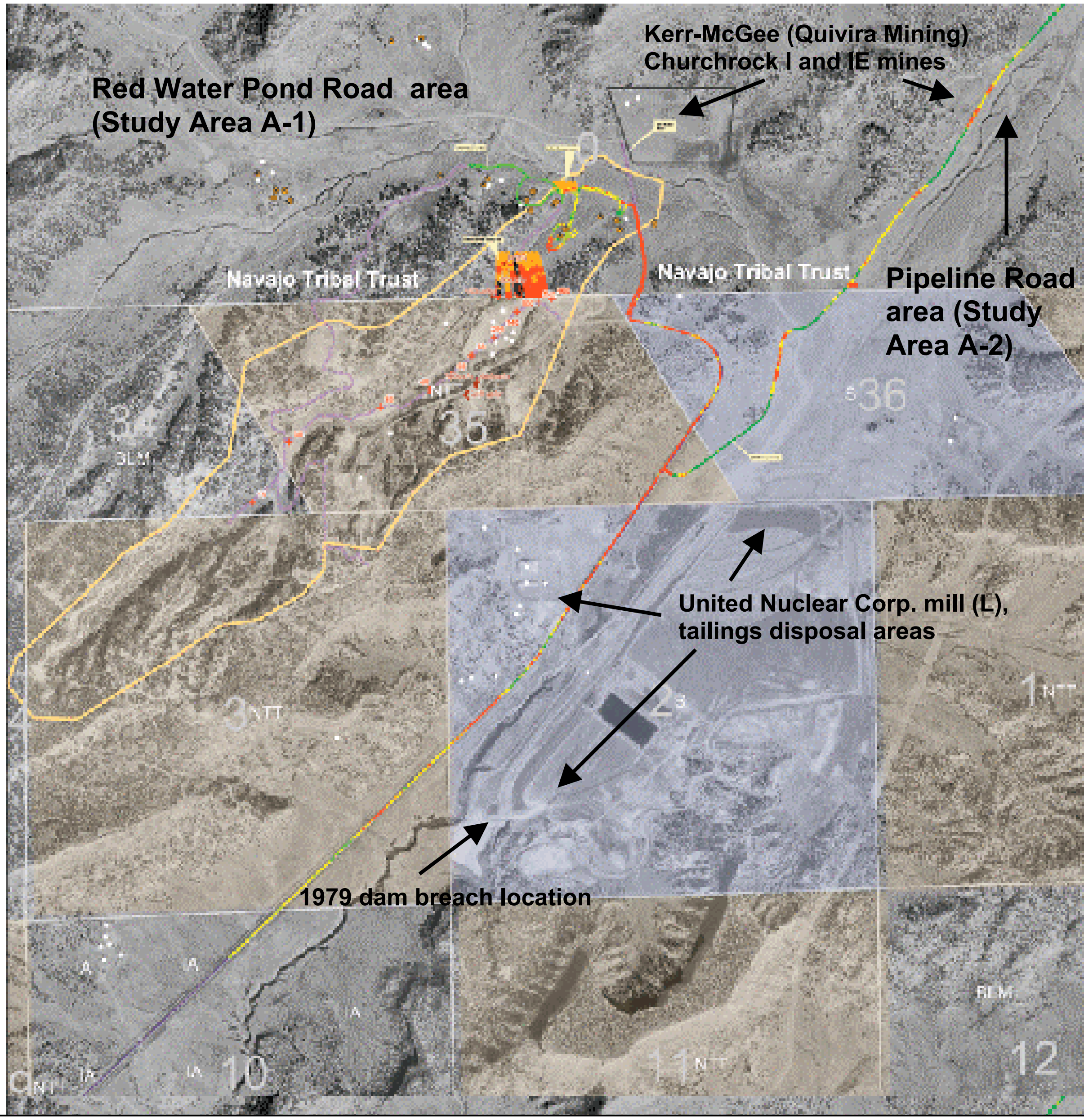


Figure III.8. Map Showing Gamma Radiation Rates (uR/hr) along State Rt. 566, Pipeline Road, and Red Water Pond Road in Churchrock MiningDistrict.

exceeding 100 μR/hr, or more than 6 times background, were recorded at a security fence bordering the east side of the CR-1E mine site.

III.6.4. Discussion

The CRUMP gamma radiation surveys in October 2003 marked the first time that an assessment of surface radiation levels had been attempted in the Churchrock Mining District, an area that covers nearly 10 miles from Churchrock Village to Pipeline Road in Nahodishgish Chapter. The surveys detected consistently elevated gamma rates where mining-related activities had occurred. Elevated gamma rates detected by the Scanner Van traveling at 5 mph were not isolated occurrences, as can be seen on the maps referenced here. Surveys conducted with hand-held instruments confirmed the presence of elevated gamma radiation along the highways and roads. The use of mechanized and hand-held detectors in tandem generated evidence of long-term radiological contamination of publicly accessible areas along highways and roads and next to occupied residences, especially those in the Red Water Pond Road area (Study Area A-1).

The principal source of the high gamma rates detected along State Route 566 in the vicinity of the Old Churchrock Mine was likely uranium ore hauled in trucks from the mine to the UNC mill from the mid-1970s through the early-1980s. Radioactive materials released routinely from the mill and tailings facility, both of which began operating in May 1977 and continued through 1982, likely contributed to the high gamma rates along SR 566 adjacent to these two facilities. In the Red Water Pond Road area (Study Area A-1), the concentrations of red dots and lines confirmed local concerns that radioactive materials from the mines had spread into residential areas between the two mines. Upon seeing the elevated gamma rates along Red Water Pond Road, residents of the area said they believed that materials from one or both of the mines had been used to elevate and level the road in the 1970s. Mining began in 1968-69 at the NECR Mine and in 1972 at the Church Rock I Mine and continued into 1982 and 1983. Mine water discharges to the Pipeline Arroyo from the CR-I Mine did not end until February 1986. As noted previously, mine wastes at the NECR site have not been reclaimed and remain much as they were when mining ended there in 1982. Reclamation of the KMC CR-I took place between 1993 and 1995, but the extent and long-term integrity of the reclamation have not been evaluated.

Elevated gamma rates along Pipeline Road in the area of the CR-IE mine site suggest that residual radioactive materials still exist at the site despite reclamation activities in the early-1990s. Another source of radioactive materials may be dust from the tailings facility, which was not covered pursuant to federal reclamation requirements until the mid-to-late 1990s. For many years, residents of the area to the northeast of the UNC tailings facility expressed concerns about the persistent wind transport of dusts from the tailings area. The CRUMP gamma radiation assessment ended just northeast of the CR-IE site. No other surface radiological surveys have been conducted in the Pipeline Road area where at least 25 families live.

Land ownership patterns in the area played a unique role in facilitating or inhibiting mine cleanup. The UNC mill and tailings facility were built on private lands (Section 2)[22] that had been occupied by Navajo families in the 1950s and 1960s when the land was used for grazing and homesteads. UNC acquired the 640-acre section from the State of New Mexico in 1969, and began site preparation for construction on the mill in 1974. The facility operated under a state license during the 1970s and 1980s. Decommissioning of the mill and reclamation of the tailings were done pursuant to NRC requirements, which took effect in 1986 when NRC took over regulation of uranium mills from the state. Designation of the tailings as a federal Superfund Site by USEPA in 1983 addressed only the off-site groundwater contamination issues.

[22] UNC acquired the parcel contiguous to the tailings area — Section 36 of T17N, R16W — from the New Mexico State Land Office 1983 in exchange for land UNC owned next to Interstate 40 near Grants. The effect of this acquisition was to move the boundary of UNC's "restricted area" one-half mile north from the tailings impoundment to encompass two groundwater contaminant plumes. Before acquiring Section 36, the plumes had migrated outside of the restricted area, placing UNC in violation of state regulations.

In the Red Water Pond Road area, reclamation of the Church Rock 1 and 1E mine sites was ordered by the U.S. Bureau of Land Management (BLM) in 1992 pursuant to a provision of a uranium mineral lease between Kerr-McGee Corporation and the Navajo Nation. The CR-1 and CR-1E sites were constructed inside the Navajo Reservation boundary, and BLM asserted authority on behalf of the Navajo Nation to require reclamation. No such reclamation provisions were required by the U.S. Bureau of Indian Affairs when it approved UNC's use of Section 35 of T17N, R16W for construction of the Northeast Church Rock Mine in 1968 and 1969. For many years, the tract was assumed to be state owned or privately owned. But a review of land records by the Navajo Nation in 2004 revealed that Section 35 had been placed in trust by the U.S. Government for use by the Navajo Nation in the 1930s, and had remained "Navajo trust land" since then. This confusion over land status contributed to delays in reclamation of the site.

IV. Uranium-in-Soil Assessments

IV.1 Scope and Sample Areas

In collaboration with the DiNEH Project staff, Ms. George also collected soil samples in several locations throughout the Churchrock area, choosing those locations in an effort to select locations impacted by uranium mining releases, locations not impacted by uranium mining, and locations that are not immediately known to be impacted or nonimpacted sites. Samples were collected in the Red Water Pond Road area near the NECR Mine waste dump and next to residences in the area in December 2004. In August 2005, Ms. George collected additional samples in RWPR area and at other locations not impacted or potentially impacted by uranium mining. CRUMP (Gerald Brown), SRIC (Sarah Henio-Adeky, Chris Shuey) and DiNEH Project staff (Aflred Bates, Bess Seschillie, Jerry Elwood) members assisted on both occasions.

IV.2 Methods

In the December 2004 sampling, surface soils were collected at 2-inch depths at 50-foot intervals in a modified grid format in the undeveloped fields and along the mine-water arroyo north of the NECR Mine site. Sample collection was limited to the area on or north of the Navajo Reservation boundary; no attempts were made to access the mine site or to collect mine-water samples, even through the waste dump that is located on the north end of the mine property was unfenced and publicly accessible. Samples were placed in 1-quart plastic bags, stored in a cooler and sent to the Environmental Engineering Department laboratory at Stanford University in Palo Alto, California.

Figures IV.1a and IV.1b Soil sampling techniques

In the August 2005 sample, soil samples were collected at locations in the Red Water Pond Road area (Study Area A-1), along Old Churchrock Mine Road (n = 7), in the streambed of the Puerco River at the Route 49-11 overpass and the SR 566 overpass (Study Area B), along Becenti Trail and Springstead Loop (Study Area C) and Pipeline Arroyo south of the UNC tailings facility (n=4), near uranium exploration sites in Nahodishgish Chapter (n = 8), and at several other locations in Churchrock and Pinedale chapters not believed to have been impacted by mining activities (n = 25). At most of these locations, samples were collected at depths of 2, 8, 18 and 36 inches below land surface. A hand auger borrowed by the New Mexico Environmental Department was used to obtain samples between the immediate surface of the ground (**Figure IV.1a**). A shovel was used to collect surface soil samples (**Figure IV.1b**). In all, more than 100 soil samples were collected from a dozen sites in the region.

Samples were analyzed at the Stanford lab by Ms. George under the supervision of her faculty advisor, Dr. Lynn Hildemann. ICP-MS (inductively coupled plasmas-mass spectrometer) was used to measure uranium and 29 other trace metals in soils.

IV.3 Results

The analytical results for the soil sampling are contained in spreadsheets in **Appendix IV.A** and summarized in a Powerpoint presentation given in August 2006 (**Appendix IV.B.). Table IV.1** summarizes U-soil levels at nonimpacted and potentially impacted monitoring sites, and **Table IV.2** provides statistics for soil samples collected in the residential area north of the Northeast Church Rock Mine along Red Water Pond Road in Coyote Canyon Chapter. Maps[23] of these monitoring sites are shown on Slides 5 and 7 of the August 2006 Powerpoint presentation duplicated in **Appendix IV.B**.

Table IV.1. Ranges of Uranium-Soil Concentrations (in ppm) at Nonimpacted and Potentially Impacted Sample Sites (i.e., "Background")

Sampling Sites	No. Samples	Range U in Soil (ppm)
Becenti Trail	3	0.98-1.32
Cornfield of Local Resident	3	0.35-1.08
Dalton Pass Uranium Exploration Site	7	0.31-0.85
Old Churchrock Mine Road	7	0.42-0.7
Pinedale Chapter Residences near Pipeline Arroyo	4	0.5-0.99
Pinedale Chapter/Lobo Valley near Puerco River	6	0.94-1.83
Pinetree Spring Well (Lime Ridge Handpump)	10	0.59-2.61
Puerco River Streambed at SR 566 Bridge	14	0.48-1.93
Red Water Pond Road Non-impacted sites	4	0.3-1.64
Springstead Loop	10	0.48-1.01
10 Sampling Locations	**68**	**0.3-2.61**

Virtually all soil samples collected from sites outside of the Red Water Pond Road area near the NECR Mine (Study Area A-1) exhibited uranium levels at the lower end of the range of "background". As shown in **Table IV.1**, nearly 70 soil samples from 10 different locations were collected and analyzed, and uranium in these samples ranged from 0.3 ppm and 2.6 ppm. Published literature indicates that normal uranium concentrations in soil can reach 12 ppm, but that any level greater than 5 ppm may indicate a contribution from human activities. The USEPA's Preliminary Remediation Goal (PRG)[24] for non-cancer effects of ingestion of uranium in soil is 16 ppm.

Fourteen families totaling 100 individuals, including children, live in the Red Water Pond Road area of Coyote Canyon Chapter, sandwiched between the NECR Mine to the south and the abandoned and partially reclaimed Church Rock I Mine to the north. Some of the homes can be

[23] Maps of abandoned uranium mines, soil sample sites and uranium concentrations were prepared by Jamie deLemos, MS, a geochemist and Tufts University doctoral candidate, using ArcMap GIS software. Ms. DeLemos is assisting the DiNEH Project by assessing uranium transport in sediments and runoff in the CRUMP study area.

[24] U.S. Environmental Protection Agency. Preliminary Remediation Goals, available at: http://www.epa.gov/region09/waste/sfund/prg/files/04prgtable.pdf

Table IV.2
Uranium-soil Concentrations (mg/kg, or ppm) by Depth and Distance from AUM, Red Water Pond Road Residential Area, Coyote Canyon Chapter
(Raw data from C. George, Stanford Univ.; statistical analyses by C. Shuey, SRIC)

	U Concentrations by Depth				U Concentrations by Distance from AUM			
	2”	8” to 12”	18”	36”	0-250’	251-500’	501-1,000’	1,001’+
N samples	26	12	8	4	22	13	6	7
Max.	88.74	74.80	64.07	72.01	74.8	88.74	26.83	14.12
Min.	0.4	0.3	0.48	13.95	0.48	1.16	5.16	0.3
Mean±SD	19.91± 21.6	24.63± 22.6	27.33± 23.6	43.62± 20.7	32.89± 23.2	25.07± 24.79	16.76± 8.23	4.35± 5.9
Median	15.59	19.13	23.48	39.96	31.61	21.52	17.24	1.39

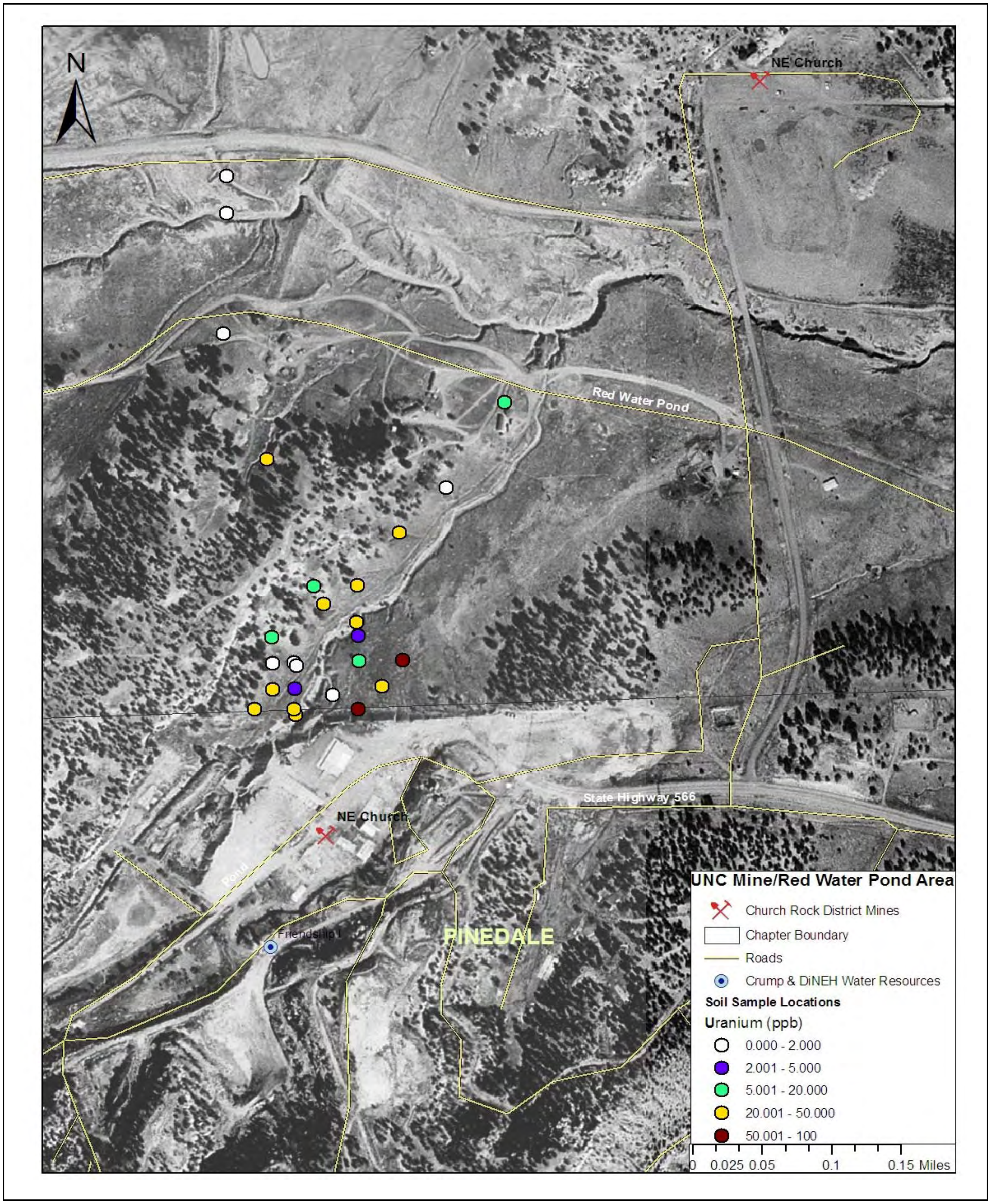
seen on the aerial map contained in **Figure IV.3,** which shows sample locations, uranium-in-soil concentrations, and abandoned uranium mines. Most of these individuals are members of the same extended family who say they have occupied the area for five generations, and were living in the area when the mines were constructed in 1968 and 1972. The abandoned UNC uranium mill is located about 1 mile southeast of the RWPR residential area. As such, local residents have been exposed chronically to uranium and other contaminants released from the mines for nearly 40 years, and some of those residents worked in the two underground mines during the 1970s.

As demonstrated in **Table IV.2**, soil samples collected in the RWPR area exhibited uranium levels consistently higher than local background (i.e., up to 2.61 ppm-U), and in more than half of the samples, greater than the PRG of 16 ppm-U. Average U-soil concentrations actually *increased* with depth, although the number of samples collected at 18 inches and 36 inches below land surface accounted for only a quarter of all samples analyzed for uranium and other trace metals. Nonetheless, the data suggest that uranium is *moving downward* in the soil column, presenting challenges for remediation of contaminated soils and increasing the risk of contamination of local groundwater resources.

The soil sampling data in **Table IV.2** also show that uranium concentrations generally *decrease* with distance from the NECR Mine waste dump. Uranium levels consistent with background (i.e., non-impacted areas) were detected next to a residence located about 1,500 feet north-northwest of the NECR Mine dump (U = 0.4 ppm) and in three of four soil samples collected at a location in the unnamed arroyo that bisects the valley from west of east, at a distance of about 2,100 feet from the NECR Mine site (see **Figure IV.3**) (U = 0.3 to 1.64 ppm). However, uranium-soil levels of 26.83 ppm, 14.12 ppm, and 11.823 ppm were found at sample sites located approximately 1,000 feet, 1,325 feet and 2,100 feet from the NECR Mine site. Further investigation is needed to determine if these elevated uranium levels are related to releases from the mine, are natural anomalies, or laboratory error.

Based on these data, Ms. George calculated that a child living on RWPR could ingest a quantity of uranium is this approximately *10 times greater* than the average annual uranium intake of between 0.27 milligram (mg) to 0.36 mg/year in the U.S. Adults living in the RWPR area would

Figure IV.2. Map of Red Water Pond Road Uranium-in-soil Concentrations (in ppm) and proximity to Abandoned Uranium Mines



be exposed to similarly elevated uranium levels. The local population spends considerable time outdoors. The adults herd sheep and cattle and gather wood and herbs on the nearby mesas, while the children play outside. Children have been observed and photographed riding bicycles onto the NECR Mine site and playing in the fine-grained sands of the mine-water arroyo. These images were recorded not only by CRUMP and local residents, but also by reporters and photographers with the *Los Angeles Times*, which chronicled the impacts of mining in the Red Water Pond Road area in a lengthy article on Nov. 21, 2006. (Visit, www.latimes.com/navajo; click on "Navajos' desert cleanup is a mirage" and on "Photo Gallery: Superfund".)

Uranium was not the only trace metal to be observed in higher-than-normal levels in soils in the greater Churchrock area. Nickel (Ni) levels exceeding the upper end of reported "background" values in the literature were observed at six of the 10 non-impacted sampling locations listed in **Table IV.1** above. Iron (Fe) and zinc (Zn) were elevated above reported background values at four different locations, and arsenic was concentrated at one of the non-impacted sampling sites in the RWPR area. Like uranium, nickel and arsenic are documented kidney toxicants.

IV.4 Discussion: Where Assessment Supports Enforcement

The detection of high levels of uranium in soils near the Northeast Church Rock Mine in the Red Water Pond Road residential area in 2004 and 2005 — levels up to 34 times greater than the high end of local background and nearly 6 times greater than the PRG for uranium in residential soils — served to confirm, at least indirectly, the presence of high rates of gamma radiation detected in the CRUMP assessment in 2003. While uranium is not a strong gamma emitter, it is the parent isotope of radium-226, which is one of the strongest gamma emitters of the natural uranium decay chain and a documented human carcinogen. And while the CRUMP gamma assessment and Ms. George's uranium-in-soils investigation were conducted for the purpose of assessing public health risks, in tandem they provided scientific data upon which NNEPA and the Navajo Nation advocated for federal intervention to compel cleanup of the Northeast Church Rock Mine.

In November 2005, USEPA granted the Navajo Nation's request to take over regulation of the NECR Mine from the state, pursuant to provisions of the federal Superfund law.[25] In particular, USEPA invoked its authority to expedite cleanup of waste sites that pose an imminent and substantial hazard to the public through declaration of a "time-critical removal action." USEPA ordered UNC and its parent company, General Electric Corp., to agree to conduct site assessments and materials characterizations pursuant to a consent order entered into in September 2006. Soil sampling conducted by UNC-GE and USEPA in November 2006 and reported to the Navajo Nation in March 2007 confirmed the presence of radium-226 in soils next to residences in concentrations high enough for USEPA to declare an emergency. In April, the agency announced it would spend about $2.2 million to remove up to 12 inches of contaminated soils around five homes, temporarily move residents of those homes to lodging in Gallup, and conduct additional surveys to determine if contaminants were present inside the homes. Soil removal around the homes began in the second week of May 2007 and was expected to take

[25] Until USEPA's decision, NMMMD had required UNC-GE to prepare reclamation plans under authority of the New Mexico Mining Act, dating back to 1996.

another three weeks. Press releases from USEPA and the Navajo Nation President's office, along with photos of the soil removal, are included in **Appendix IV.C**. Cleanup of the mine site could begin in late 2007 and may take up to three years, depending on the reclamation option or options selected.

V. Indoor Radon Assessments

V.1 Introduction

As noted in the Introduction, *a priori* information available to Churchrock Chapter and the collaborating organizations was that *outdoor* radon levels in the Churchrock area exceeded regional average annual background levels by anywhere from 10 to 35 times in the 1980s. The Springstead area of Churchrock (Study Area C) had the highest average annual radon levels recorded at a location thought to represent "background." As it turns out, the Springstead tract — the site of a proposed 1,000-unit housing development — was downstream from three AUMs and located on the outcrop of the principal uraniferous rock formation in the area.

Figure V.1. NNEPA's John Plummer explains the purpose of charcoal in an indoor radon canister to a Churchrock-area resident.

In light of this existing information, and because of radon's well-understood health effects as a human carcinogen,[26] Chapter officials and residents, in consultation with the NNEPA Radon Program and SRIC staffs, decided to conduct indoor radon monitoring in homes located throughout the Churchrock area, including in parts of Pinedale, Nahodishgish, Coyote Canyon and Churchrock chapters. In addition to homes located near AUMs or on the outcrops of uranium-bearing formations, homes sited in areas that did not have these characteristics were also targeted to develop a better understanding of "background" and "non-impacted" areas.

The indoor monitoring project was described in community meetings before staff members of the NNEPA Radon Program, CRUMP and SRIC went into the field beginning in January 2004. Homeowner consent to allow voluntary indoor radon monitoring was requested only after Navajo-speaking staff of the NNEPA Radon Program (John Plummer and Vivian Craig) and CRUMP staff (Project coordinator Gerald Brown) fully explained the program's purposes and benefits to the homeowners. (**Figure V.1.**) The staffs also provided informational brochures describing the methods and outcomes of the monitoring. Accordingly, indoor radon testing was done only on the basis of the informed consent of the homeowner.

V.2 Methods

Indoor radon was measured using 7-day charcoal canisters provided by the NNEPA Radon Program through a cooperative agreement with USEPA's Radiation and Indoor Environments laboratory in Las Vegas, Nev. In homes with multiple rooms, canisters were placed in livingrooms and bedrooms where residents spend most of their time at home. Project staff

[26] For more information, visit www.epa.gov/radon/healthrisks.html.

opened the test canisters before placing them on shelves or other high places, and instructed residents to leave the canisters open and untouched. Seven days later, Project staff revisited the homes to retrieve the exposed canisters, replacing the lids, sealing them with tape and placing them in mailing boxes for return to the USEPA laboratory for radon analysis.[27] Blank canisters were placed in a small number of homes for QA/QC purposes. These canisters were opened for a few seconds and then closed to verify the accuracy of laboratory analytical procedures. Project staff completed all chain of custody forms both at the time of initial placement and again upon retrieval. Originals of those forms were retained by the NNEPA Radon Program staff and copies were sent to the laboratory to ensure accurate accounting of all canisters.

Most of the indoor radon tests were conducted between January and March 2004 during the mid-to-late winter season when homes were less ventilated to retain heat. Follow-up testing was done in late June and early July 2004 in homes that had an initial test result that exceeded USEPA's "action level" of 4.0 pCi/l-air radon. The action level is purely a recommended guideline; it is not an enforceable standard. Nonetheless, the level itself represents a significant respiratory risk: USEPA estimates that an 8-hour daily exposure to 4.0 pCi/l radon in air carries the same lifetime lung cancer risk as smoking up to 2 packs of cigarettes per day.[28]

Radon concentrations were reported by the R&IE lab to NNEPA's Radon Program, which in turned relayed them to Churchrock Chapter, CRUMP and SRIC staff members. These staffers received training and education in how to communicate information about radon and results of the testing in a traditional Navajo cultural context from Perry Charley, director of the Uranium Education Program at Diné College in Shiprock, and Lillie Lane, public information officer for NNEPA. Ms. Craig, Mr. Plummer and Mr. Brown were the principal staffers who communicated the results to homeowners. SRIC staff maintained the records and results of the testing to ensure that they are confidential and preserved for future study.

V.3 Indoor Radon Results

Results of the CRUMP indoor radon monitoring program are tabulated in a spreadsheet contained in **Appendix V.A.** and summarized in **Table V.1** below. (The identities of the families and their house numbers have been deleted from these tables to maintain confidentiality of the individual results.) Between January and July 2004, 300 radon test canisters were placed in 150 homes. Of those, 255 valid test results were obtained from canisters placed in 143 homes. The average radon concentration of all 255 canisters was 2.9 ± 3.4 pCi/l-air with a median value of 1.7 pCi/l. About 25 percent of all the tests, including retests conducted in summer 2004, had radon concentrations equal to or greater than the USEPA action level of 4.0 pCi/l-air,[29] 20 percent of the tests had concentrations between 2.0 and 3.99 pCi/l-air, and 55 percent of the tests were less than 2.0 pCi/l.

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[27] The radon concentration in air is derived by "counting" the alpha particle disintegrations "etched" in the charcoal.

[28] A study by the National Cancer Institute (Lubin and Boice, *JNCI*, January 1, 1997) found that a person who lives in a home with an indoor radon level of 4 pCi/l-air for 30 years has a 14 percent higher chance of contracting lung cancer than a person who does not, and this elevated risk is even higher among people who smoke cigarettes.

[29] 4.0 pCi/l is equal to 150 Becquerels per cubic meter (Bq/m^3). A Becquerel is basic unit of measure of radioactivity in the International System (SI), equal to a rate of decay of one disintegration per second, or 3.7E-11 Curies.

Table V.1.
Results of CRUMP Indoor Radon (Rn) Monitoring (pCi/l-air) Across Geographic Regions of the Churchrock Area, 2004

Monitoring Area	N (all cani-sters)	>4 pCi/l #(%)	2.0-3.99 pCi/l #(%)	< 2.0 pCi/l Rn #(%)	Range	Rn Ave + sd	Median
All Areas Combined (Winter and Summer Results)							
Homes Tested, Winter '04	150						
Homes w/ Valid Results; Rn values averaged per home	143	36(25.2)	29(20.3)	78(54.5)	0.5-22.5	2.9+3.4	1.7
Canisters Placed	300						
Blanks, Invalid, No Results	45						
All Valid Results (Winter)	255	57(22.4)	46(18.0)	152(59.6)	0.5-22.5	2.8+3.3	1.4
Homes Retested, Sum '04	18						
Canisters Placed	43						
Blanks, Invalid, No Results	27						
Valid Results (Summer)	16	4(25.0)	3(18.8)	9(56.3)	0.5-6.0	2.6+1.7	1.9
Non-Impacted Areas (no mining or waste dumps; no outcrops)							
Church Rock Village	55	0(0.0)	6(10.9)	49(89.1)	0.5-3.1	1.0+0.6	0.7
Sundance-Coalmine	35	1(2.9)	2(5.8)	32(91.4)	0.5-5.4	1.2+0.9	1.0
CRUMP Study Area "A" (abandoned mines, waste dumps; no outcrops)							
Pipeline Canyon Road	12	0(0.0)	6(50.0)	6(50.0)	1.1-3.7	2.1+0.7	2.0
Red Water Pond Road	17	1(0.6)	2(11.7)	14(82.4)	0.5-5.6	1.5+1.3	1.2
State Rt. 566 (North of Rt. 49-11)	8	0(0.0)	2(25.0)	6(75.0)	0.5-2.2	1.3+0.7	1.3
CRUMP Study Area "B" (west of SR 566; abandoned mines; Morrison outcrop on south)							
Becenti Trails Road	9	2(22.2)	3(33.3)	4(44.4)	0.5-9.4	3.4+3.4	3.6
Flat Rock Road	11	2(18.2)	2(18.2)	7(63.4)	0.5-9.0	2.4+2.8	1.3
Hardground Road	10	6(60.0)	2(20.0)	2(20.0)	0.5-5.9	3.8+1.9	**4.6**
Livingston Camp	10	0(0.0)	2(20.0)	8(80.0)	0.5-2.7	1.3+0.7	1.2
State Rt. 566 (South of Rt. 49-11)	6	0(0.0)	2(33.3)	4(66.7)	0.9-2.9	1.8+0.8	1.4
Superman Canyon Road	21	7(33.3)	3(14.3)	11(52.4)	0.5-9.8	2.6+2.3	1.8
CRUMP Study Area "C" (east of SR 566; Morrison outcrop)							
Happy Valley Road	28	22(78.5)	2(7.1)	4(14.3)	0.5-16.8	**6.9+4.4**	**6.2**
Lime Ridge Road	16	4(25.0)	5(31.3)	7(43.8)	0.5-11.9	3.9+3.8	2.4
Old Churchrock Mine Rd	14	6(42.9)	5(35.7)	3(21.4)	0.9-22.5	**6.0+6.2**	3.3
Red Top-Tabernacle Roads	5	3(60.0)	2(40.)	0(0.0)	2.2-5.3	3.9+1.4	**4.5**
Uphill Road	7	3(42.9)	4(57.1)	4(50.0)	0.5-9.8	**4.5+4.7**	1.0

For comparison, average indoor radon levels for McKinley County reported by NMED in 1998 were 5.8 pCi/l-air, with 39 percent above the 4.0 pCi/-air action level, 28 percent between 2 and

3.99, and 33 percent less than 2.0 pCi/l-air. The average indoor level in New Mexico was 3.8 pCi/l with 71.5 percent of nearly 8,000 individual tests being less than 4.0 pCi/l. The New Mexico, McKinley County and Churchrock-area averages were substantially higher than the national average of 1.3 pCi/l-air.[30]

Indoor radon levels were lowest in the Sundance and Churchrock Village areas. This finding is consistent with the fact that these areas are not located on the outcrop of a uranium-bearing formation and have few AUMs. The highest levels of indoor radon were recorded in homes near Study Area C — near the site of the Springstead mobile home park that had recorded one of the highest average annual *outdoor* radon levels in testing conducted by uranium companies in 1980-81. Homes located on or near Happy Valley, Lime Ridge, Old Churchrock Mine, Red Top, Tabernacle and Uphill roads had average indoor radon levels ranging from 3.9 pCi/l-air to 6.9 pCi/l-air. The common characteristic of this area is that many of the homes are built on top of the Morrison Formation, which hosts the uraniferous rocks. Five AUMs left from the 1950s are located in the highlands south of these residential areas.

Indoor radon levels in homes near the NECR Mine and Churchrock I and IE mines in Study Areas A-1 and A-2 were slightly higher than the lowest indoor levels recorded in Churchrock Village and Sundance, but substantially lower than those in Study Area C. This finding calls into question whether abandoned uranium mines play as important a role in contributions to indoor radon as had been theorized at the beginning of the CRUMP program.

Valid retests were reported by the USEPA lab for eight homes that had exceeded the 4.0-pCi/l-air action level in the winter test. As shown in **Figure V.2**, radon levels in the summer retests mirrored the results of the winter tests, demonstrating that indoor radon levels decrease in the warmer months when homes are opened for increased ventilation, but even then, levels of radon exceeding the USEPA action level may be present, as they were at three of the eight homes.

V.4 Discussion

Considerable followup from the 2004 CRUMP indoor radon monitoring is needed in the Churchrock area. Homes that had radon levels exceeding the USEPA action level *and* invalid retests should be tested again, both in the summer and winter seasons. Churchrock Chapter and SRIC should work with NNEPA's Radon Program to develop and implement a follow-up indoor testing program. Indoor radon monitoring should be conducted in *all* homes in the Red Water Pond Road area, especially those homes that will be temporarily vacated in May and June 2007 while contaminated soils are being removed. Such testing will provide additional exposure data for the local families and information on whether contaminated soils *around and under* the homes present ongoing sources of radon emanation into these structures.

Inhalation risks from indoor radon can be mitigated through installation of low-cost air ventilation systems in existing homes. Mitigation strategies should be researched and reported to homeowners. Funding sources to purchase mitigation technologies should to be identified and pursued to allow low-income homeowners to install radon-mitigation systems.

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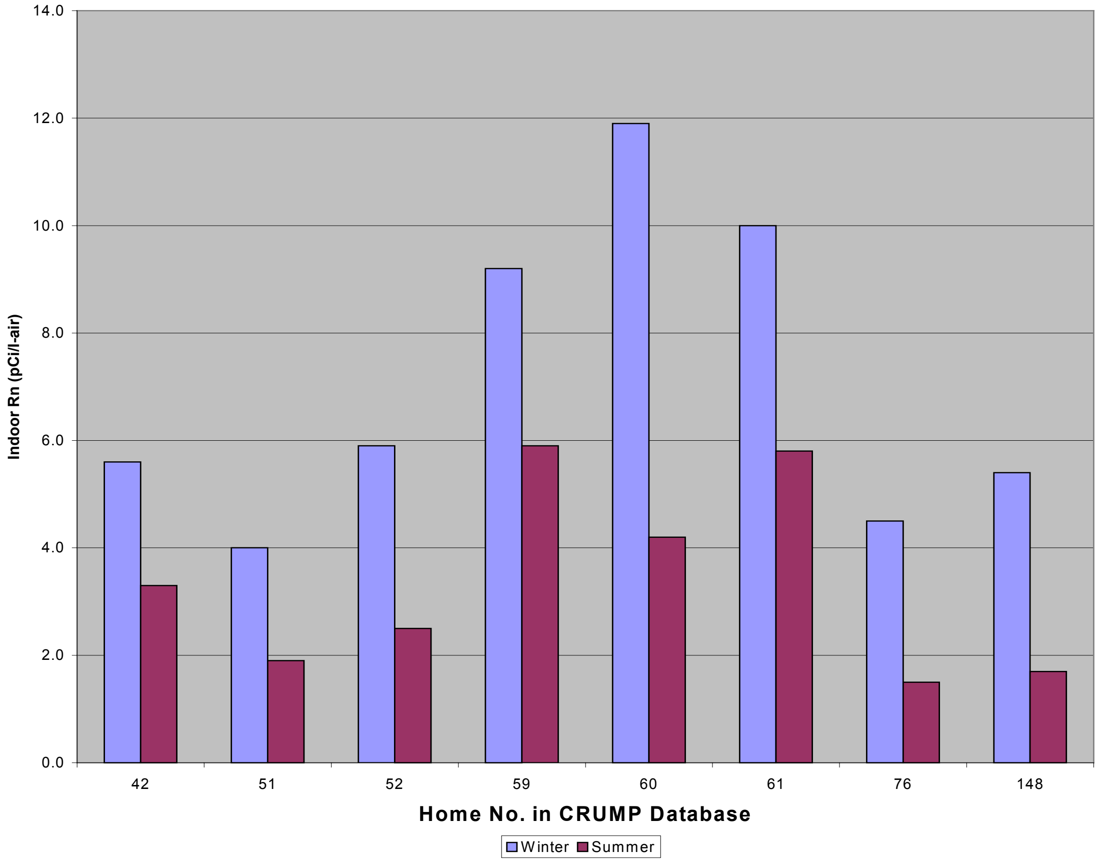
[30] These data were reported by Air Chek, Inc., from a national database contributed to by local and state governments, including the New Mexico Environment Department. The data can be viewed at www.radon.com.

Figure V.2. Comparison of Winter and Summer Indoor Radon Levels in Homes with First Test ≥4.0 pCi/l-air



VI. Air Particular Monitoring

VI.1 Introduction

Airborne particulates, which most people refer to simply as "dust," are known to contribute to upper respiratory distress and to exacerbate chronic respiratory diseases, such as asthma. In an arid region like Churchrock, clouds of dust rising from barren lands are commonplace, especially on windy days and during windy seasons, such as the spring. Dusts emanating from abandoned uranium mines may have the added risk of being contaminated with radioactive materials and heavy metals. Residents living north of the UNC mill tailings facility have expressed concerns for many years about the possible harm from breathing dust coming from the facility.

In developing the CRUMP objectives, Chapter officials, staff of NNEPA's Air Quality Division, and researchers with the DiNEH Project recommended that particulate matter (PM) be monitored in residential areas near uranium mines to provide real-world environmental data to validate assumptions about inhalation risks. Two PM grain sizes were considered: 2.5 microns or less and 10 microns or less. The smaller fraction lodges deep in the lung, increasing chronic lung disease risks; the larger fraction, which reflects the size of dust particles typically released from mine wastes, irritates the upper nasal and respiratory passages. Ultimately, both grain sizes were selected for analyses, alternating every six days between two samplers.

VI.2 Methods

Two Rupprecht & Patashnick (R&P) Partisol-FRM Model 2000 high-volume air particulate samplers were installed at locations in the Red Water Pond Road and Pipeline Road areas near residences that are located next to or in close proximity to abandoned uranium mines. (See **Figure VI.1**.) The samplers were loaned to CRUMP by the TAMS Center and USEPA's Las Vegas Laboratory. Platforms were built by Churchrock Chapter personnel in 2004 to mount the samplers, and 3-foot-deep trenches were dug to bury heavy-duty electrical cords to connect the samplers to outlets installed at nearby residences. Former TAMS Center director Annabelle Allison and former technician Glenn Gehring provided training to CRUMP and SRIC staffs in the operation and maintenance of the machines. SRIC staff trained two local residents to conduct verification procedures and exchange exposed filters for every sixth day. Chain-of-custody forms are completed by Project staff after every filter exchange and sent to the USEPA Las Vegas lab along with the exposed filters once every 3 to 4 weeks.

Figure VI.1. Red Water Pond Road resident Teddy Nez conducts verification tests on one of two CRUMP dust samplers.

In April 2006, the samplers were remounted on the platforms to prevent being blown down by strong winds, and were recalibrated and verified for use. Monitoring of PM-2.5 and PM-10 began during the third week of May 2006 and has continued uninterrupted since. Dust is collected on a 47-mm diameter filter installed in a cassette inside the sample chamber. The WINS impactor well, a metal cylinder that fits inside the sample chamber and regulates air flow through the main inlet tube, is removed for PM-10 monitoring and replaced for PM-2.5 monitoring. Ambient temperature and pressure and the date and time of each sampling period are recorded in an onboard computer. SRIC staff downloads these data at the end of every third batch of filters and sends them to R&IE laboratory staff with updated information on the exposure dates and times. The CRUMP monitors are considered part of the USEPA's national network of air samplers, and as such, are programmed to sample air for a 24-hour period (midnight to midnight) on the same sixth day nationally.

VI.3 Results

As of the date of this report, PM concentrations were reported by the USEPA R&IE lab for the first 15 batches (i.e., approximately 45 weeks) of CRUMP air filters through the end of February 2007. The data are reported as micrograms per cubic meter (μg/m^3) of air, and are compared with the 24-hour National Ambient Air Quality Standard (NAAQS) for PM of 150 μg/m^3. The data are summarized in **Table VI.1**. The maximum PM-10 and PM-2.5 concentrations reported to date were 15% and 4%, respectively, of the NAAQS standard. All but one of the highest single day concentrations occurred in June and July 2006. Four of the six highest single 24-hour PM concentrations were recorded at the Pipeline Canyon Road monitor site, which sits on a small hill overlooking the valley below. In contrast, the Red Water Pond Road monitor sits at the bottom of a valley surrounded by mesas several hundred feet in elevation higher.

Table VI.1. Summary of CRUMP Air Particulate Matter (PM) Monitoring May 2006-February 2007 (all concentrations in μg/m^3; 24-hr NAAQS for PM = 150 μg/m^3)

	N	Min	Max	Mean/SD	Median	3 Highest Days
PM-2.5	45	1.4	6.3	3.4±1.3	3.2	6/4/06, 6/22/06, 2/25/07
PM-10	48	1.7	22.5	8.8±5.1	8.1	6/4/06, 7/22/06, 6/22/07

VI.4 Discussion

The original plan for air particulate monitoring had included radionuclide analyses of a small percentage of dust samples through the R&IE lab in Las Vegas. However, because of the late start of the samplers in May 2006 and changes in personnel at both USEPA and TAMS Center, the original agreement to conduct these additional analyses could not be sustained. Discussions are now beginning among SRIC, TAMS Center and R&IE lab that may yet result in radionuclide analyses of the collected dusts. Both PM and radionuclide analyses will be important parameters in the next year as contaminated soils are removed from around homes in the Red Water Pond Road area and after reclamation of the nearby NECR Mine begins. SRIC staff will continue operating and maintaining the CRUMP air samplers through at least the end of 2007, and perhaps longer, to ensure there is a continuing source of inhalation exposure data.

VII. Technical Evaluation and Policy Initiatives on Mine Site Reclamation

The Northeast Church Rock Mine in Study Area A-1 and the Old Churchrock Mine in Study Area B have received heightened scrutiny from Chapter officials, community members and regulators over the past four years because of their close proximity to residences and lack of reclamation since shutting down in 1982.[31] The NECR Mine is now the focal point of a USEPA Superfund enforcement action aimed at cleaning up both the abandoned mine site and soils around homes located within a short distance of the mine waste dump (see **Figure VII.1**). The OCRM site is receiving more attention from regulators in light of the CRUMP findings that the site is the likely source of high gamma radiation rates on adjacent public highways and Navajo grazing lands, and because flash floods in July and August 2006 damaged a portion of the site's fence and exposed mine wastes much higher in radioactivity than previously measured.

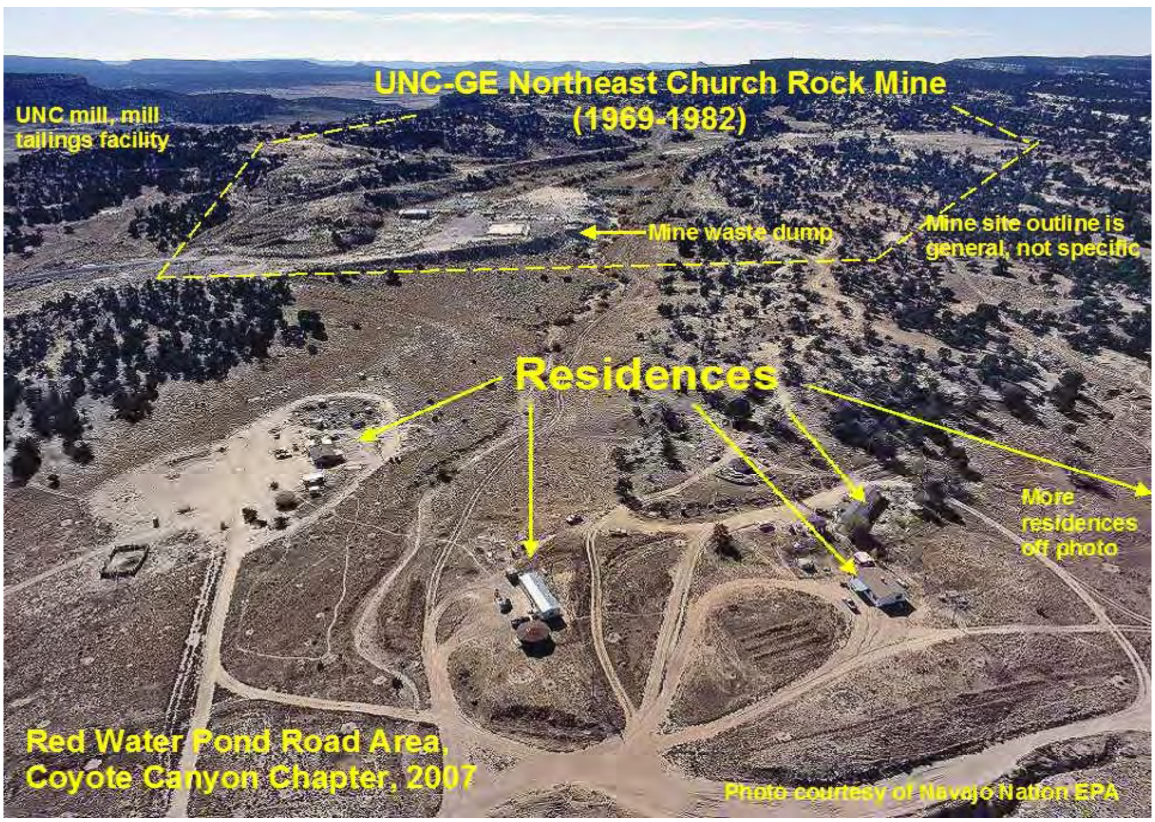


Figure VII.1. Aerial view of Northeast Church Rock Mine (top) and four nearby residences, 2007.

[31] The other two major uranium facilities in area, the UNC mill and tailings impoundment and the Kerr-McGee Churchrock I and IE Mine (see **Figures I.1** and **IV.2.**) are important sites from the perspective of environmental exposures to local residents. However, they were not focuses of CRUMP work because both have undergone reclamation of varying degrees. The UNC mill was dismantled and the tailings consolidated and covered in the 1990s pursuant to NRC requirements. Groundwater contaminated by tailings disposal operations in three separate aquifers under and outside of the facility boundary is being remediated pursuant to CERCLA; the site was added to the National Priority List by USEPA Region 6 (Dallas) in 1983. Reclamation of the Kerr-McGee mine, which is located on the Navajo Reservation, occurred between 1991 and 1995 pursuant to USBLM requirements.

A. Northeast Church Rock Mine (Study Area A-1)

Plans for site characterization and reclamation, along with summary reports on surface and groundwater quality, were prepared by UNC-GE and submitted to the New Mexico Mining and Minerals Division in 2003 and 2004. CRUMP and SRIC staff members reviewed these technical documents and provided oral comments to Navajo Nation agencies and to community members at community meetings in October 2004 and July 2005. As USEPA moved to take over regulatory authority for the site from the state in late-2005, CRUMP and SRIC staffs worked with community members to ensure that residents not only were aware that USEPA, with the encouragement of the Navajo Nation, was considering Superfund enforcement action to compel further site characterization and, ultimately, reclamation, but also that they had an opportunity to influence both the level of cleanup and effects of releases of contaminants from the mine on the residential area.

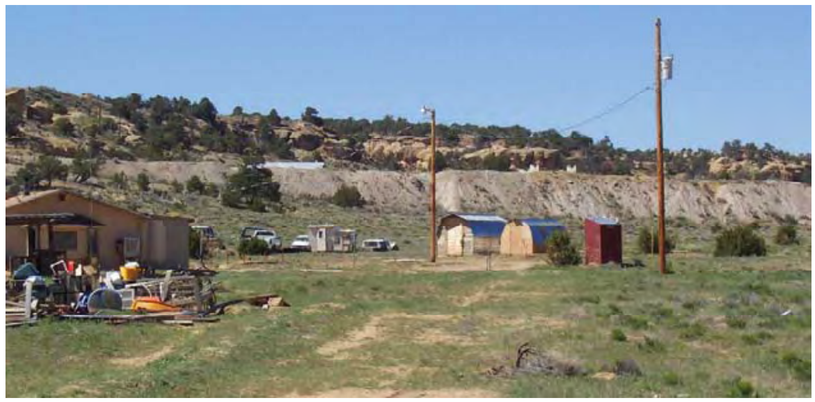


Figure VII.2. This home on Red Water Pond Road is located within 500 feet of the NECR Mine waste dump.

CRUMP and SRIC staffs and community members attended technical meetings on USEPA's proposed "time-critical removal action" on January 19, February 27 and May 24, 2006. The community members and CRUMP and SRIC staffs reported the results of CRUMP's gamma radiation surveys and uranium-in-soil analyses at these meetings to support the community's positions that (1) site characterization ordered by USEPA to be conducted by UNC-GE must include the residential areas north of the mine site, and (2) the mine site itself should be cleaned to the highest standard possible — release for unrestricted use to allow future human occupancy on the former mine site on tribal trust land in Section 35.

As USEPA was finalizing a consent order with UNC-GE to conduct additional site and materials characterization in Summer 2006, residents of the Red Water Pond Road community (Study Area A-1) and Pipeline Road community (Study Area A-2; see **Figure I.1**) requested assistance from CRUMP and SRIC in preparing a resolution that would set forth, in writing, their comments on the NECR Mine cleanup and site characterization plans while also alerting federal and tribal regulatory agencies to a wide range of concerns they have about living in a contaminated area. In addition to describing the desired level of cleanup (i.e., release for unrestricted use) and the need for additional environmental assessments among the residences, the residents made nearly 20 demands and requests on issues that were not covered in the regulatory plans. Among those were the need to protect ceremonial and burial sites on the mesas next to the mine, maintenance of access to the mesas for gathering wood for fuel and herbs for ceremonies, improvement of dirt roads in and out of the communities, assistance in conducting a health study among local residents, and support for fencing of the site, which had been open to public access for more than 25 years.[32]

SRIC staff prepared drafts of the resolution, which were circulated among community members for review and comment. Changes were made in the draft as results of the soil sampling conducted by Ms. George and CRUMP staff at community meetings on August 20 (Churchrock Chapter House) and August 27 (home of resident Teddy Nez). The resolution was finalized by the end of August and circulated for signatures by local residents and CRUMP staff. The final version, which is included in **Appendix VII.A**, was mailed to USEPA, NNEPA and other agencies in September and October 2006. The resolution-petition has become the community's principal written document for advocating for cleanup of the mine site for unrestricted human use, for conducting a health study among the local people, and for protecting ceremonial sites. It also served to elevate the community's role in USEPA's Superfund response after the agency announced in April 2007 that it would immediately start removing radium-contaminated soils from around residences to lessen environmental exposures (**Figure VII.3**).

Figure VII.3. Radium-contaminated soils are excavated from around these homes on Red Water Pond Road in May 2007. The reclaimed Church Rock I Mine site forms the ledge in the middle background.

Levels of radium-226 exceeding both background and soil action levels were measured in November 2006 by USEPA and consultants to UNC-GE, and the results were reported to Navajo Nation agencies in March 2007. NNEPA and USEPA officials began notifying residents of the results and the agencies' joint recommendations that at least three extended families would have to be moved to temporary lodging in Gallup, N.M., while 6 to 12 inches of contaminated soils were being excavated from around their homes and from dirt roads leading to the homes. The first two families were moved to temporary quarters in May 2007. Removal of contaminated materials was expected to be completed by the end of May, and clean soil was to have been emplaced next to the homes and on three residential roads by the middle of June 2007. USEPA officials said they would conduct additional radiological monitoring to determine if soil removal was needed around other homes. They also told residents during community meetings in April and May that the new installed clean soils may have to be removed again if reclamation of the NECR Mine site in 2007 and 2008 causes new contamination to the residences.

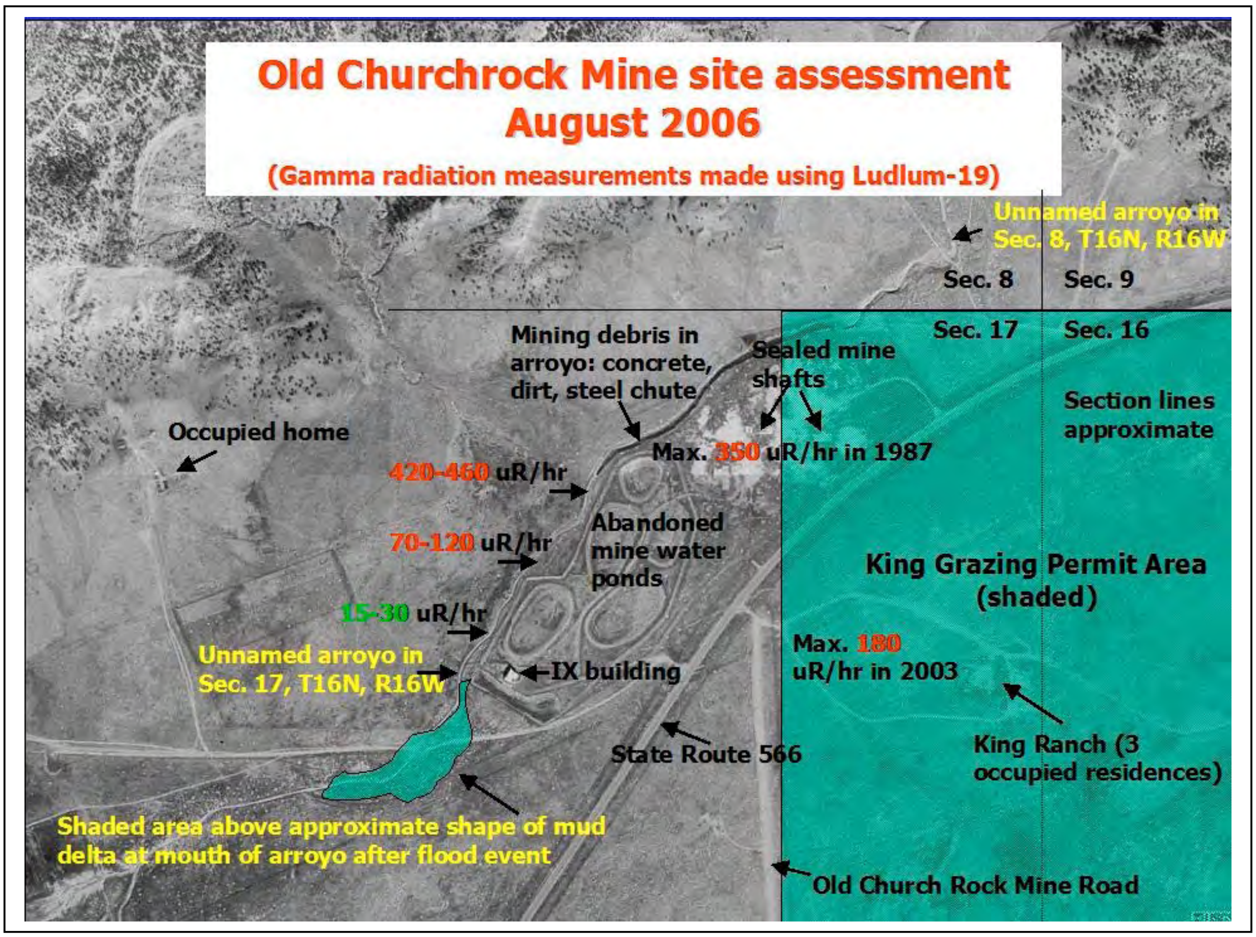
[32] A perimeter chain-link fence was installed around the mine site in late 2006. On the north side of the mine site, the fence was extended about 50 away from the mine waste dump that is visible in **Figures VII.1** and **VII.2**.

B. Old Churchrock Mine (Study Area B)

Heavy rains on July 31 and August 1, 2006, caused flash flooding throughout the Churchrock area, including in an arroyo that traverses the west side of the Old Churchrock Mine site. SRIC staff observed that runoff had dislodged a fence post and portion of the fence surrounding the site at the mouth of the arroyo, mobilized boulders and sediments in the outwash of the arroyo south of the mine site, and uncovered mining debris in the arroyo next to the site. Upon walking the arroyo, SRIC staff observed uncovered mine waste, notable for its conglomeritic character, gray and black colors, and white precipitate lenses — characteristics far different than those of the ochre-colored, shaley sediments present on the west bank of the arroyo.

SRIC staff reported these observations to Chapter, Navajo DOJ and NNEPA officials on August 2. Later that day, NNEPA Superfund staff, with SRIC's assistance, conducted a gamma radiation survey on both sides of the arroyo, finding gamma rates up to 460 uR/hr, or nearly 50 times background for the area (**Figure VII.4**). NNEPA prepared a written report of the radiological findings in mid-August, and SRIC prepared and later updated a Powerpoint slide

Figure VII.4. Map of site assessment at Old Churchrock Mine, August 2006.



show on the investigation. (See **Appendix VII.B.**) SRIC staff also briefed Churchrock Chapter officials and nearby residents on the findings.

The Old Churchrock Mine, which is located on Navajo trust land (surface) and Navajo grazing land (**Figure VII.4**), was first operated in 1960-1962 by Phillips Petroleum, and reopened and operated again by UNC between 1977 and 1982. UNC "sold" the property to Hydro Resources, Inc. (HRI) in 1992. HRI, which plans to construct an *in situ* leach uranium mine on the site under a NRC license, told the state Mining and Minerals Division (MMD) in 1995 and 1996 that state reclamation requirements should be waived because the company would reclaim the mine pursuant to NRC requirements. In 1997, the NRC staff told MMD that it would require reclamation as part of the license it issued to HRI in January 1998 authorizing ISL mining. In April 1999, MMD agreed to defer its state reclamation requirements in light of HRI's and NRC's commitments that the site would be cleaned up as part of the HRI license. However, in 2006, the five-member Commission upheld an administrative judge's ruling in 2005 that the existing contamination at the Section 17 site could not be included in the calculation of maximum radiation does to the public because the contaminants were in mine waste that NRC does not regulate. Hence, the Commission ruled, the waste is now part of "natural background." The effect of the ruling, which is being appealed in federal appeals court by citizens' groups, is to relieve HRI of its reclamation obligations for the existing radioactive wastes present at the site.

For this reason, the Navajo Nation — aware of the CRUMP findings that the Old Churchrock Mine had been the source of radioactive contamination on both sides of State Route 566 and on the adjacent King grazing land, and now being aware that any previous commitments to clean up the site have been annulled by the NRC rulings — has indicated it is exploring options to compel reclamation of the site under tribal statutory authorities.

VIII. Community Involvement and Dissemination Activities

CRUMP's community involvement and information dissemination activities were designed to ensure maximum *participation* of community members and chapter officials in all aspects of the Project. Community members are indispensable contributors to and collaborators with the Project, not simply passive witnesses. Residents were invited — indeed, *expected* — to take part in all Project activities, from conducting radiation surveys and testing water quality in unregulated wells to giving presentations at community meetings and attending technical sessions on mine-site cleanup plans. Several residents who live near abandoned mines and/or were former uranium workers were enlisted as resource people for five tours of the community conducted to educate legislators, regulators, chapter officials, teachers, students and the media about environmental health principles, the history of uranium development and its impacts in the area, and how environmental justice populations can change public policy through organizing, collaboration and community-based research.

As shown in **Table VIII.1**, community and house meetings were held on eight different occasions between June 2003 and April 2007 to brief residents on the results of the water quality assessments, radiation surveys, indoor radon monitoring and soil sampling for uranium and other trace metals. These meetings, which were held at the Churchrock Chapter House, were devoted exclusively to CRUMP reports. CRUMP staff also gave short updates to Chapter officials and community members at monthly Chapter Planning Committee meetings and Chapter meetings; these reports are not listed in **Table VIII.1**. The special community meetings provided opportunities for community members to receive detailed information and education on the technical aspects of the work that they could not receive at monthly Chapter meetings because of time constraints and packed agendas.

Figure VIII.1. Community meeting on NECR Mine cleanup, July 2006.

The special meetings also gave residents an opportunity to provide comments and recommendations for follow-up activities and policy initiatives at the local, state and national levels. Elderly community members became key informants, providing unique, historical information on land-use and mining activities that they themselves witnessed and experienced, but which is not otherwise documented. An important example were the testimonies of a half-dozen long-time community members about how their parents and grandparents used lands now targeted for new ISL mining for grazing, cattle drives, traditional ceremonies and water hauling *before* the mining companies arrived in the 1950s. These testimonies were recorded on digital video and copied to CDs that were included as exhibits in formal comments on USEPA's November 2005 proposal to determine if Section 8 (T16N, R16W; Study Area B) is "Indian Country" for purposes of federal and tribal regulation of underground injection of chemicals associated with proposed new ISL mining. In February 2007, USEPA announced it had determined that Section 8 — a 160-acre tract of private land surrounded by Navajo lands — is Indian Country and subject to federal and tribal regulation — a position shared by the Navajo Nation, Churchrock Chapter, various citizen groups, and Indian law scholars, and opposed by industry and the state of New Mexico. The residents' testimonies played an important role in USEPA's determination.

Figure VIII.2. Former uranium worker Scotty Begay leads a mining tour.

The direct participation of residents of the Red Water Pond Road and Pipeline Road areas in community and house meetings was instrumental in another major policy decision, USEPA's assertion of Superfund authority over cleanup of the Northeast Church Rock Mine and the removal of radium-contaminated soils around residences located close to the mine. As summarized in **Section VII.A**, a resolution-petition signed by 103 individuals from affected communities remains the residents' statement of their objective to restore the Section 35 lands to their pre-mining condition. This position has since been adopted by the Navajo Nation, and is likely to be one of four or five options for cleanup of the site when those alternatives are presented by USEPA and UNC-GE later in 2007.

Coordinated tours of the study area proved to be one of the most effective ways of *showing* the extensive, and largely unmitigated, impacts of past uranium exploration, mining and processing. By having legislators, chapter officials, regulators and community members *see* the close proximity of residences to mine sites, the technical details and data from the various environmental assessments were not only more understandable, but also more *real.* Despite the fact that uranium had been developed in the area since the 1950s, few policy makers and regulators had ever seen the remnants of the past impacts, especially near residences.

One of the first tours of the Churchrock-area abandoned mines was conducted by Churchrock Chapter officials and SRIC staff in October 2002 for tribal and federal regulators as part of what was then called the Navajo Abandoned Uranium Mines Collaboration. It was during this tour that several staff members of Navajo Nation regulatory agencies got their *first look* at the obvious mechanisms by which residents were, and still are, chronically exposed to contaminants from past mining. This tour occurred *before* CRUMP was initiated, and was instrumental in forming the CRUMP collaboration that came to fruition the following September.

From a policy perspective, two of the tours, one conducted in October 2004 and the other in February 2006, were especially effective for members of the Navajo Nation Council. The first served to educate delegates about the need to resist *new mining* until the impacts of past mining were addressed. In enacting the Navajo Nation's statutory ban on uranium mining and processing in April 2005, many delegates cited their own observations of the impacts of past mining in the Churchrock area, especially in the Red Water Pond Road area. The second tour galvanized the Council's support for the Navajo Nation's assertion of jurisdiction over Section 8 because of the community's "Indian Country character." CRUMP and SRIC provided information handouts for each of these tours. A copy of one of those handouts, which is an example of the materials presented on all of the tours, is included in **Appendix VIII.A**.

Table VIII.1
CRUMP Community Meetings and Major Dissemination Activities, 2003-2007

Date[33]	Topic	Place	Sponsors/Collaborators	Appx. # Attended
03.06.24	CRUMP organizational meeting, mining tour for collaborators	Churchrock Chapter House, field	Churchrock Chapter, SRIC, NNEPA	35
03.10.28	**Community meeting** to discuss radiation surveys, overall CRUMP work plan	Churchrock Chapter House, field	CRUMP, SRIC, NNEPA, NNAML, TAMS Center, USEPA	55
03.10.29,30	CRUMP collaborators working on radiation surveys, water sampling	Churchrock Chapter House, field	CRUMP, SRIC, NNEPA, NNAML, TAMS Center, USEPA	30
04.01.10	Planning meeting for indoor radon monitoring	Churchrock Chapter	NNEPA Radon Program, Churchrock Chapter, CRUMP, SRIC	12
04.02.24	**Community meeting** to review water quality results for unregulated water sources	Churchrock Chapter House	CRUMP, SRIC, NNEPA, NMED	40
04.09.30	**Community meeting** to review preliminary radiation survey results	Churchrock Chapter House	CRUMP, SRIC, NNEPA	15
04.10.14	Presentation to Navajo Nation Council Resources Committee; tour of residential areas affected by mining	Churchrock Chapter House, field	CRUMP, SRIC, ENDAUM, NMELC	25
05.02.20	**Community meeting** to discuss radiation survey results	Churchrock Chapter House, field	CRUMP, SRIC, ENDAUM, NMELC	35
05.07.11	Presentation of results of radiation surveys, monitoring	T. Hood home, RWPR	CRUMP, SRIC	6
05.07.17	**Community meeting** to present of results of radiation surveys, soil monitoring in RWPR area	Churchrock Chapter	CRUMP, SRIC	40
06.01.19	Presentation of results of radiation monitoring in Churchrock area	Navajo AUM Collaboration, Navajo Nation Museum, Window Rock	SRIC, CRUMP	35
06.01.20	**Community meeting** to discuss cleanup of Northeast Churchrock Mine	Churchrock Chapter	CRUMP, SRIC, NNEPA	55
06.03.03	**Community meeting** to discuss cleanup of NECR; Environmental Health Field Institute for UNM MPH classes	Churchrock Chapter; tour of mining sites	USEPA, NNEPA, CRUMP, SRIC, UNM	75
06.06.26	**CRUMP results summarized** as part of presentation on DiNEH	Pueblo Indian Cultural Center, Albuq.	DiNEH Project, SRIC, UNM-CEHP	40

[33] Dates abbreviated in this table are year, month, day (e.g., 06.08.27 is, in order, 2006 August 27).

	Project at New Mexico Tribal Health Research Summit			
06.07.26	**Community meeting** to update residents on cleanup of NECR Mine	Churchrock Chapter	USEPA, NNEPA, CRUMP, SRIC,	45
06.08.01	**Meeting w/ RWPR residents** to initiate gathering signatures on resolution-petition concerning cleanup of the NECR Mine	Churchrock Chapter, Study Area A-1, A-2	CRUMP, SRIC	12
06.08.20	**Community meeting** to review results of soil sampling and monitoring by C. George	Churchrock Chapter	Results of soil sampling and monitoring by C. George	30
06.08.27	**House meeting** to discuss results of soil sampling and monitoring by C. George, and receive comments, make changes in resolution-petition	T. Nez home, RWPR	Results of soil sampling and monitoring by C. George	35
06.09.05	**Circulation** of resolution-petition for signatures ends; packet sent to all residents	CRUMP office, Churchrock	CRUMP, SRIC	103 signatures collected
06.09.25	**CRUMP results summarized** at public forum on new uranium mining	El Morro Theater, Gallup, N.M.	McKinley Community Health Alliance, ENDAUM, CRUMP, SRIC, UNM-CEHP	125
06.21.07	***LA Times* "Blighted Homelands"** series features Church Rock Mine area, failures of Superfund		Reporter Judy Pasternak worked 3+ years on this series, including spending many days in Churchrock area in 2003, 2004	1,000s of readers of *LA Times*
06.11.29	**Tour of mining sites** for participants in Indigenous World Uranium Summit	Churchrock Chapter, field	Churchrock Chapter, SRIC, DiNEH Project, Dineh Bidziil Coalition	60
06.11.30	**Presentation of CRUMP results** at IWUS panel session	Navajo Nation Museum, Window Rock	Community (T. Nez), CRUMP (G. Brown), SRIC (C. Shuey)	55
07.03.22	Environmental Health Field Institute for UNM MPH students, faculty	Churchrock Chapter, field	CRUMP, SRIC, UNM	25

IX. Recommendations

Based on the data collected and analyses conducted for CRUMP since 2003, the following recommendations are warranted:

1. **The Federal Government should fund a clean-up program targeting abandoned uranium mines that produced uranium for the Government's nuclear weapons program.** Like many of the hundreds of AUMs scattered throughout the Navajo Nation and in the Grants Mineral Belt in northwestern New Mexico, most of the abandoned mines in the Churchrock area were developed to sell ore to Atomic Energy Commission buying stations in the region. While safety hazards like open adits, portals and shafts, and high walls at open pits, have been mitigated at many AUMs by programs like the Navajo Abandoned Mine Lands Reclamation Department, complete reclamation of mine wastes, pits and contaminated off-site lands has not been addressed. Difficult access to some AUM sites, jurisdictional impediments, and a lack of funding have delayed or thwarted cleanup. Some AUMs have never been assessed to determine their extent and potential for off-site releases of contaminants. These mines tended to be operated by small companies that stayed in business for only a few years in the 1950s and are no longer viable corporate entities. Congress should fund a program that allows tribes and states to investigate fully the extent of the AUM problem in their jurisdictions, including conducting environmental assessments and public health studies in areas where people still live in close proximity to AUMs. A federal program of this nature should authorize access by tribal and state governments to abandoned sites on private lands, allow for cooperative agreements to overcome jurisdictional barriers, and provide resources for environmental restoration. Reparations for lands destroyed by past uranium mining or lost to permanent disposal of wastes should be included in the program. The Navajo Nation, state of New Mexico, and communities affected by AUMs should begin working with members of Congress from the Four Corners states to develop legislation and advocate for its enactment.

2. **Comprehensive studies of the health of people who live in uranium mining districts of the Navajo Nation, including the Churchrock area, are needed and should be expedited.** Only one population-based epidemiological study of health effects possibly associated with exposure to uranium mining has ever been conducted on the Navajo Nation despite nearly 60 years of uranium development.[34] No health study has ever been conducted in the Churchrock area despite its lengthy and well-documented history of uranium-related impacts. Little scientific and medical data exist to determine if the health of dependents of uranium workers and residents of mining districts was adversely affected by their environmental exposures to uranium and other radiological and chemical toxicants. Yet anecdotal information and informal surveys suggest that public health has been adversely affected in mining districts. Population-based studies are needed in virtually every uranium-mining district of the Navajo Nation, including Churchrock. Such studies should assess all pathways of exposure, including occupational and environmental, and may require collection and analyses of human blood and urine.

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[34] Commonly referred to as the March of Dimes Birth Defects Study, this study is summarized in LM Shields, et al. Navajo Birth Outcomes in the Shiprock Uranium Mining District, *Health Physics*, 63:5, 542-551, November 1992.

Funding for such studies should come from the Federal Government, which bares substantial responsibility for facilitating uranium development on the Navajo Nation. Approval by tribal, federal and academic review boards should be expedited. In the highly impacted Red Water Pond Road and Pipeline Road areas of CRUMP Study Area A, residents are being invited to participate, on a voluntary basis, in a comprehensive health survey administered by trained Navajo staff of the DiNEH Project. While the principal interest of the DiNEH Project is the role of environmental exposures in kidney disease, the 10-page questionnaire addresses an individual's current and past exposures and current healthy status, and is the same survey instrument being used in the Project's routine protocol in 20 chapters of the Eastern Agency. Supplemental support for biomedical elements of the Project is being sought from the Navajo Area Indian Health Service, the Navajo Division of Health, and the University of New Mexico Health Sciences Center. This recommendation addresses Item K of the RWPR-PCR resolution-petition in **Appendix VII.A**.[35]

3. **The Navajo Nation should enact its own statutory and regulatory authorities to address the unique environmental, land status, and public health conditions at abandoned uranium mines in Navajo Country.** Recent experience has demonstrated that the Navajo Nation needs its own statutory and regulatory authorities to enforce cleanup of AUMs where Federal authorities do not exist or are poorly suited to address the unique conditions of Navajo sites, and where one or more corporate entities that share responsibility for unremediated sites still exist. The lack of such authority has impeded the Navajo Nation's response to reclamation of the Old Churchrock Mine and the Northeast Church Rock Mine, among many others. Navajo authority to develop and enforce clean-up standards and require appropriate financial assurance from past operators would not only accelerate the reclamation process, but also provide local communities with assurance that tribal government is available to fill regulatory gaps in existing Federal programs.

4. **The Lime Ridge Well (16-4-10, also known as the Pinetree Well) should be taken out of service because of unsafe uranium levels, and a replacement water source identified and developed.** In the alternative, a sign should be erected at the well site advising users not to use the water for human consumption. This option recognizes that, except for uranium, the well provides high-quality water and local residents desire that the well remain in service for livestock watering. If it remains in service, the well should be tested annually to observe changes, if any, in water quality.

5. **A new well should be developed to replace 16T-606, a windmill that was shut down and abandoned because of radium concentrations exceeding the federal and tribal drinking water standard.** A replacement well should be sited in the same general location (Study Area B) at a location that is easily accessible for livestock water haulers and in an aquifer that provides good-quality water. The overall quality of the Westwater Canyon Aquifer (WCA) in the area is suitable for human and livestock consumption; care

[35] The DiNEH Project's Kidney Health Study, which has been approved by the Navajo Human Research Review Board and the UNM Human Research Review Committee and funded by the National Institute of Environmental Health Sciences, can be a model for health studies in other Diné communities affected by uranium mining.

should be taken to avoid screening a well completed in the WCA in a uranium-bearing lens or near one of the abandoned mines in the area.

6. **Wells 16T-513, 16T-514 and 16T-535 in Pinedale Chapter should be tested for radionuclides.** All of these water sources are known to have had human use for drinking water, and 16T-535 is likely to still be used by some people for drinking water because of its generally good water quality and location in a remote area.

7. **A capped water well located in the Red Water Pond Road residential area[36] should be accessed by the Navajo Nation and evaluated for public water supply use.** This well, which residents say was drilled by United Nuclear Corporation in the 1970s, is not listed in the Navajo Department of Water Resources database. It could replace Well 14T-586, the so-called Friendship I well that was drilled by Kerr-McGee Corp. in 1976 for water supply to homes in the Red Water Pond Road. Friendship I was closed in 2003 because of poor water quality and the extension of NTUA's water system into the area. This recommendation addresses Item I of the RWPR-PCR resolution-petition.

8. **A comprehensive follow-up investigation of gamma radiation levels and radionuclides and trace metals in soils is needed in the northern end of the State Route 566 corridor.** This area extends roughly from the Puerco River bridge to the terminus of SR 566 at the entrance to the Northeast Church Rock Mine, and includes the Pipeline Road corridor north of the UNC tailings facility. The recommended assessment should expand upon the CRUMP assessments in this area to include soil sampling for laboratory analyses of radionuclides and trace metals. Ore hauling was routine on this route between the Old Churchrock Mine and the UNC mill and from the NECR Mine to the mill in the 1970s and early-'80s. Windblown mill tailings from the tailings impoundment in Section 2 (T16N, R16W) and releases from the Church Rock IE mine site may have contributed to higher-than-background gamma rates observed along Pipeline Road. SR 566 and Pipeline Road are heavily traveled by local residents, livestock routinely graze along the sides of these roads, and an estimated 50 families live in the area. Results of the expanded survey should be evaluated for possible regulatory responses under CERCLA (Superfund), the Atomic Energy Act,[37] or tribal statutory authorities.

9. **All mine waste should be removed from the NECR Mine site to facilitate cleanup to pre-mining conditions and release of Section 35 for human and livestock use.** Section 35 is Navajo tribal trust land and should not be used for permanent disposal of radioactive waste from mining. The land should be returned to as close to its pre-mining condition as practical, and released for unrestricted use. However, human occupancy of the land should be carefully considered, and if implemented, monitored over time to ensure that people are not living on contaminated ground. This recommendation is

[36] The approximate location of this well is 35.66820 north latitude and –108.50980 west longitude, based on using the on-line Microsoft Terraserver locator (http://terraserver.homeadvisor.msn.com).

[37] The AEA, 42 U.S.C. 2011 et seq., as amended by the Uranium Mill Tailings Radiation Control Act of 1978, provides for off-site cleanup of tailings released from licensed facilities such as tailings impoundments.

consistent with the first recommendation (Item A) of the RWPR-PCR resolution-petition, indicating the importance to the local community of the future of Section 35.

10. **USEPA's soil removal around five homes in the Red Water Pond Road community north of the NECR Mine should take into account the CRUMP uranium-in-soil findings.** CRUMP's soil assessment found migration of uranium in concentrations exceeding both background and Preliminary Remediation Goals at depths up to 3 feet below land surface. Ms. DeLemos's uranium solubility and sediment migration studies in support of the DiNEH Project's exposure model also suggest that contaminants are moving downward in the soil column in the RWPR area. USEPA and NNEPA should review these findings to determine if removal of 6 to 12 inches of radium-contaminated soils around five homes is adequate to protect the health of the families affected. Options for mitigating exposures, now and for future generations, should include replacement of existing homes located immediately north of site NECR Mine site at locations elsewhere in the community that have not been impacted by mine waste. This recommendation addresses Item G4 and, in part, Item H of the RWPR-PCR resolution-petition.

11. **All remaining recommendations and requests in the RWPR-PCR resolution-petition should be acted on by the responsible government agencies and named corporations.** As indicated here, several of the recommendations and requests contained in the RWPR-PCR resolution-petition have *not* been addressed. Among those are requests for improvements to access roads to the top of the mesas not disturbed by mining (Item D), dissemination of information of impacts to groundwater resources in around the NECR Mine site and the UNC tailings impoundment (Items G3 and N), cultural resource surveys of the mesa tops around the NECR Mine (Item J), examination of livestock raised in the area by a qualified veterinarian (Item L), review of the integrity of previous reclamation at the Church Rock I and IE mine sites (Item M), and improvement of dirt roads in both residential areas of Study Area A (Items O and P).

12. **The CRUMP indoor radon assessment program requires followup and mitigation strategies for homes exceeding the USEPA radon "action level."** Churchrock and surrounding chapters should work with the NNEPA Radon Program to conduct new testing in homes that exceeded the 4 pCi/l-air action level in 2004 and for which valid retests were not conducted. Mitigation strategies and methods should be communicated to homeowners. Programs that provide grants for home improvements and radon mitigation should be investigated and the information provided to homeowners. Homes that are located on the geological outcrops of uraniferous formations and/or close to AUMs should be targeted for new indoor testing.

13. **Sampling of particulate matter at the two CRUMP air samplers should continue at least through the end of 2007.** The sampling is a continuing source of inhalation exposure data and will be especially important as contaminated soils are removed from around homes in the Red Water Pond Road area and during reclamation of the nearby NECR Mine. SRIC is committed to ensuring the sampling is done and the USEPA R&IE laboratory in Las Vegas will continue to analyze the filters.