STATEMENT OF CHRIS SHUEY
Before the Subcommittee on National Parks, Forests, and Public Lands
Natural Resources Committee
U.S. House of Representatives

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This statement is provided at the request of the Subcommittee for the purposes of (1) summarizing the health and environmental impacts of historic uranium mining and processing, particularly in communities on the Navajo Nation; (2) summarizing what is known about past uranium mining around the Grand Canyon; (3) describing the results of recent environmental assessments and ongoing public health studies in uranium-impacted communities in New Mexico, and the implications of these studies for uranium development around Grand Canyon National Park; and (4) describing the potential impacts of new uranium mining around GCNP.

In nearly 30 years of work studying the effects of uranium mining, I have conducted water quality and radiological assessments and soil sampling in residential areas near abandoned uranium mines; learned and studied the medical literature on health status among uranium workers and effects of long-term exposure to uranium; testified as an expert witness in state regulatory proceedings on groundwater protection standards for uranium; and designed and participated in epidemiological studies in Navajo communities affected by uranium mining. I am the director of the Uranium Impact Assessment Program at Southwest Research and Information Center (SRIC), a multicultural, educational and scientific organization founded in Albuquerque in 1971; I have been employed at SRIC since 1981. I am a co-Principal Investigator for two federally funded health studies in the Eastern Agency of the Navajo Nation: the Diné Network for Environmental Health (DiNEH) Project and the Navajo Uranium Assessment and Kidney Health Project ("Kidney Study").[1] And I managed field operations for the Church Rock Uranium Monitoring Project (CRUMP) on the Navajo Nation between 2003 and 2007.

I hold a bachelor of university studies degree and masters in public health degree from the University of New Mexico. My MPH degree focused on environmental health science and epidemiology, and my professional project examined epidemiological challenges for conducting population-based health studies of the effects of ingestion of uranium in drinking water. My biographic sketch is attached as **Exhibit A** to this written statement.

Based on my education and experience in environmental science and public health, and on the analyses and evidence presented in this statement, I conclude that new uranium mining around Grand Canyon National Park is not prudent government policy. New uranium mining threatens the world-class natural resources of the Park, especially its hundreds of springs and streams. Environmental impacts from mining are unavoidable, regardless of the level of operational controls. To the extent that there is uncertainty about the potential for irreversible impacts from new uranium mining, withdrawing public land from mineral development is sound public health and environmental policy consistent with the Precautionary Principal.

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I. Summary of Impacts of Historic Uranium Development in the Four Corners Area

Before describing the range of potential impacts of uranium mining in the region of the Grand Canyon, I believe it is worthwhile to review commonly accepted findings about the health impacts of exposure to uranium and the history of uranium mining on the Colorado Plateau. Previously, I prepared a brief review and summary of the literature on this matter, and have appended a copy hereto as **Exhibit B.** The following findings supplement the literature review:

- Uranium is not only a Class A human carcinogen because of its radioactive properties, but is also a potent kidney toxicant, and its USEPA limit in drinking water is based on uranium's chemical toxicity to the human kidney. In short, uranium is very much a poison, and every effort should be made to limit its release to the environment by human activities. (Exhibit B, footnote 6)

- Thousands of uranium mines were developed on the Colorado Plateau since the 1940s, and a large proportion of these were abandoned by 1970. Reclamation of these "Cold War Era" mines — so-called because the uranium ore was purchased exclusively by the Federal Government for the nuclear weapons program — was focused on eliminating or mitigating safety hazards, such as open shafts and adits. Controlling environmental releases from waste piles or cleaning up contaminated lands and water supplies has lagged far behind, and many past mining sites have had no reclamation.

- A lack of baseline environmental data characterized many uranium mining sites developed between 1970 and the mid-1980s. As a result, environmental effects of these recent mining operations have been difficult to ascertain. Additionally, long-term monitoring and surveillance is nonexistent at many former mining sites.

- Uranium mining by conventional open-pit or underground methods was *never* regulated by the Federal Government, and only in the last 15 to 20 years have state governments enacted regulations for uranium mining. Federal land management agencies have relied largely on general standards for mineral development pursuant to their land-management obligations under federal law.

- Uranium mines generate wastes in the form of overburden, waste rock and low-grade ore. When exposed to air, the hazardous and radioactive substances native to the rock are oxidized and released to the environment through runoff and wind dispersion. The toxic constituents of mine waste include uranium, arsenic, cadmium, lead, molybdenum and selenium, and the radioactive constituents include uranium, thorium, radium, and lead.

- Milling, or processing, of uranium ore to extract uranium oxide for use as fuel in nuclear reactors was not regulated by the federal government or the states until the late 1970s. Since 1978, more than 50 "inactive" and "active" uranium mills and tailings disposal facilities — more than half of which are located on the Colorado Plateau — have been consolidated and covered to mitigate releases of radioactive tailings and radon gas. *Every* uranium mill has extensive, localized groundwater contaminant plumes that are still years, if not decades, from being fully remediated.

- While numerous epidemiological studies have been conducted among uranium workers, no comprehensive public health study has ever been conducted in Navajo communities where uranium mining and processing took place. (Shuey, 2007b) Health studies in uranium-mining communities are expensive, time-consuming and scientifically challenging, but they can and should be done.

The legacy of abandoned uranium mines on the Navajo Nation has received increasing attention recently as a result of national news coverage in 2006 (Pasternak) and congressional oversight hearings in October 2007 (U.S. House of Representatives, 2007). The Navajo Nation's description of the extent of the uranium problem is described in the testimonies of Navajo officials and residents of communities affected by mining. I recommend the Subcommittee take notice of these testimonies and other evidence gathered by the House Committee on Oversight and Government Reform. See, http://oversight.house.gov/story.asp?ID=1560.

II. Results of Recent Environmental and Health Studies in Navajo Communities in New Mexico

II.A. Churchrock Environmental Assessments

The Church Rock Mining District in northwestern New Mexico near the town of Gallup was heavily mined in the 1950s and 1960s, and again between 1969 and 1983. Nearly 20 mines and 1 uranium mill and tailings facility were located in the district, which includes portions of the Navajo chapters of Churchrock, Coyote Canyon, Iyanbito, Nahodishgish and Pinedale. The community is noted, infamously, for the July 16, 1979, uranium mill tailings spill at the United Nuclear Corporation (UNC) uranium mill. (See Exhibit B, footnote 17.) However, more radioactivity was released in nearly 20 years of dewatering of three major underground mines than in the one-time tailings dam breach. (Wirt, 1994)

Uranium mining and processing in the Church Rock district ended in 1983, and little long-term environmental monitoring was conducted by state or federal agencies after that. In 2003, Churchrock Chapter of the Navajo Nation obtained a private grant to conduct monitoring of water, soils, and outdoor and indoor air around abandoned mines and in residential areas located close to abandoned mines. With the assistance of various Navajo Nation, state and federal agencies, including USEPA, extensive radiological assessments were performed along major highways and roads in the community; soils were sampled for uranium and other trace metals in areas not impacted, moderately impacted, and highly impacted by mining wastes; radon was measured in the indoor air of more than 150 homes; and dust levels were monitored in communities close to abandoned mines. The results of these studies, which I coordinated and participated in, were documented in the "Report of the Church Rock Uranium Monitoring Project (CRUMP), 2003-2007" (SRIC, 2007); the executive summary and recommendations of the report can be viewed at www.sric.org/Uranium. Findings relevant from the CRUMP studies for potential new uranium mining around the Grand Canyon included:

- Gamma radiation rates from two times background to more than 20 times background were detected in soils along highways and roads where uranium ore was last hauled *nearly 25 years ago.* (SRIC, 2007)

- Soils around homes in an area sandwiched by two abandoned uranium mines contained concentrations of uranium nearly 100 times greater than local background, and concentrations of radium more than 400 times greater than local background; uranium was observed to have *increased* with depth in the soil column. (Shuey, 2007a)

- Field studies of storm runoff and sediment transport, coupled with bench-scale leaching tests on contaminated soil samples, indicated that uranium is present in a highly soluble form (+VI) and mobile in both surface waters and soils. (deLemos and others, 2007) The potential for uranium to leach into shallow, alluvial groundwater supplies was previously demonstrated in studies conducted by the U.S. Geological Survey (USGS) in the early 1990s. (Wirt, 1994; Van Metre and Gray, 1992)

The environmental assessments conducted by CRUMP demonstrated that it is never too late to look for long-term environmental effects of past uranium mining. The radiological and heavy metal contaminants from uranium mining do not disappear or go away with time; they simply move to other locations. The CRUMP assessments also provided scientifically valid data that was later used by USEPA and the Navajo Nation to conduct regulatory investigations under authority of the federal Superfund law. As a result, USEPA conducted a Superfund emergency removal of nearly 6,000 cubic yards of radium-contaminated soils from around six Navajo residences in May and June 2007.

II.B. Eastern Navajo Health Studies

To address the paucity of health studies in uranium mining-impacted communities and to investigate the causes of high rates of chronic kidney disease in the Eastern Navajo Agency population in northwestern New Mexico, a consortium of community-based, academic and medical organizations embarked on a series of environmental health and epidemiological studies in 2001. Funded by grants from the National Institute of Environmental Health Sciences (NIEHS), the Diné Network for Environmental Health (DiNEH) Project[2] is conducting a thorough health and water-use survey among 1,300 residents of 20 chapters of the Eastern Navajo Agency, testing and sampling water in up to 160 unregulated water sources, using soil data from the CRUMP studies to estimate environmental exposures, and obtaining permission from participants in the study to test blood and urine samples for uranium and for biomarkers of kidney damage and kidney disease. The second phase of the DiNEH Project, the Navajo Uranium Assessment and Kidney Health Study, is the largest cross-sectional epidemiological study of the role of environmental exposures in kidney disease ever conducted in the U.S.

As of this month, the DiNEH Project team has surveyed more than 550 residents of the study area; sampled nearly 100 unregulated water sources for uranium and other trace metals that

[2] Partners in the DiNEH Project are the Eastern Navajo Health Board, Southwest Research and Information Center, University of New Mexico Community Environmental Health Program, Crownpoint Service Unit of the Indian Health Service, and University of Texas-Houston Medical School.

are documented kidney toxicants; and collected blood and urine samples from 22 individuals out a projected sample of 450 participants in Kidney Study. Findings of this work include:

- The number of abandoned uranium mines in a Navajo community is a predictor of four self-reported diseases: certain auto-immune diseases; chronic kidney disease; diabetes and high blood pressure. (Lewis, 2007)

- Arsenic and uranium occurred in concentrations exceeding the USEPA's maximum contaminant levels of 10 micrograms per liter (µg/l) As and 30 µg/l U in only 14 percent and 6 percent, respectively, of water sources tested. (Shuey, 2007b)

Later this year, our team will be reporting results of logistic-regression modeling of kidney disease risk factors for more than 500 survey participants. Included in the model are socioeconomic data, body mass index, existing health and disease patterns, environmental exposures to uranium wastes, occupational exposures (uranium mining and milling and other jobs), and distance of residence from abandoned mines. Initial results of the modeling indicate that environmental exposures, including living within 0.8 kilometer of an abandoned mine site, are significant predictors of kidney disease and diabetes. These findings are consistent with self-reported disease status in relationship to living in a community with greater numbers of abandoned mines, and will be replicated several times as the study progresses. We will share these results with the Subcommittee when they are published.

III. Historic Uranium Development Near the Grand Canyon

In preparing for this testimony, I reviewed available data on historical uranium production in the region; assessments of uranium mining sites on both the South Rim and North Rim; plans of operation for new uranium exploration and mining; and published literature and data on water quality of springs in the Grand Canyon and hydrogeologic models of groundwater flow in the region. Between 1980 and 1985, I reviewed and commented on regional environmental assessments for uranium mining in the Arizona Strip and for site-specific mining proposals in the Kaibab National Forest south of the Grand Canyon. Historically, uranium was produced from Orphan Mine on the South Rim in the 1950s and 1960s, and from several mines that were constructed in the Kanab Creek area on the North Rim in the 1980s. The uranium was deposited in breccia pipes, which are described in more detail later in this testimony.

III.A. Orphan Mine

The Orphan Mine is located on the South Rim between Powell Point and Maricopa Point. It produced 4.26 million pounds of uranium between 1953 and 1969 (ADGF, 2007), and consists of two parts: The upper level on the lip of the South Rim, which still hosts the mine headframe, ore pads and support buildings, and the lower level sited on a terrace in the canyon wall about 1,500 feet below the South Rim. In the early days of the mine, ore was transported in a large bucket from the lower level to the upper level by a tram and pulley system. Later, ore was brought to the upper level on the South Rim through a main vertical shaft.

Several radiological and environmental assessments have been conducted at both levels of the Orphan Mine. (Day and others, 1981; Tetrault, 1985; Harding Lawson Associates, 1993; Harding Lawson Associates, 1996; SSPORTS Environmental Detachment, 1999; Aguirre Engineers, Inc., 2001) These surveys showed gamma radiation levels exceeding local background by up to 500 times *outside* of the safety fence that surrounds the upper level section of the mine (Harding Lawson Associates, 1996, figure 2.3), and gamma rates nearly 800 times background inside the fenced area. These radiation readings underscore the fact that radiological impacts of uranium mining last virtually forever, and certainly long after ore was last produced.

Mine wastes are still present at lower level of the mine. This site is located between Horn Creek on the east and Salt Creek on the west. Two separate water quality surveys in these creeks suggest that mine waste at the lower level may be contributing to uranium levels exceeding the USEPA drinking water standard of 30 µg/l. An investigation by Fitzgerald and colleagues between 1993 and 1995 revealed a maximum uranium concentration of 92.7 µg/l in Horn Creek during high-flow conditions. (Fitzgerald and others, 1997) A second and more comprehensive water quality assessment of South Rim springs and seeps was conducted in by USGS and NPS in 2000-2001. (Monroe and others, 2004) Uranium levels in water in Horn Creek ranged from 8.6 µg/l to 29 µg/l, and from 29 to 31 µg/l in Salt Creek. At the upper end of these ranges, the uranium levels approached or exceeded the USEPA drinking water standard of 30 µg/l.

Fitzgerald and others concluded that the probable source of uranium in the creek was waste rock from the mine that had intermixed with streambed alluvium. The authors of the USGS study did not assess reasons for the elevated uranium levels in Salt Creek and Horn Creek. However, those two water sources had the *highest* uranium levels in the 20 springs and seeps tested in the study. No other spring had a uranium level greater than 8.3 µg/l, and about half of the samples had uranium concentrations between 1.1 and 2.7 µg/l — levels typically thought of as "naturally occurring" in groundwaters throughout much of the Earth's crust.

The Orphan Mine was acquired by the National Park Service in 1987, and since then, NPS and Grand Canyon National Park have worked closely with the USEPA to conduct remedial action investigations that will eventually lead to reclamation and cleanup of both parts of the mine. Tens of thousands of tourists walk by the mine site on the South Rim trail every year. Accordingly, excavation and removal of contaminated soils and wastes, especially from the upper mine next to the South Rim trail, would be prudent to protect the public health.

III.B. Kanab Mines

The original Hack Mine produced nearly 5,000 pounds of uranium between 1951 and 1964. (ADGF, 2007) Between 1980 and 1990, more than 17 million pounds of uranium were produced from six new mines developed in the Kanab Creek area north of the Canyon — Hack 1, 2 and 3, Pigeon, Hermit, and Kanab North. Three more uranium mines were developed in the Kanab Creek area, but never produced uranium. Similarly, the Canyon Mine was constructed on Forest Service land a few miles west of the village of Tusayan, but no uranium ore was produced from this facility. Little publicly available information exists on environmental conditions at the Kanab Creek mine sites. Photos on the Internet show that the Hack Canyon 1 and Pigeon mines were reclaimed after mining ended in the late-1980s. (Weinrich, 2008)

IV. Potential Impacts of New Uranium Mining Around the Grand Canyon

IV.A. Types of Mining Expected in Grand Canyon Area

Several mining companies have identified sites for exploration and possible future mining (see, e.g., VANE Minerals, 2007), and virtually of all them are targeting uranium-mineralized breccia pipes. Mining of the breccia pipes common on both the North and South Rims in the Grand Canyon area will most likely involve underground methods, consistent with the limited history of mining of these pipes since the 1950s. Mines previously developed in the breccia zones included shafts sunk on one side of the pipes, with the orebody inside the pipe accessed *beneath* the zone of mineralization.

The breccia ore deposits are not likely to be mined by the *in situ* leach (ISL) mining, or solution mining, method.[3] ISL mining is amenable only in relatively thin, narrow and horizontally elongated fluvial sandstone beds derived from ancient stream channels. These beds are almost always water-bearing, and in fact, successful extraction of uranium from the host rock depends on using the native groundwater to move uranium-laden fluids from injection wells to production wells. Most often, the ore deposits (variously called "roll fronts" or "redistributed ores") are on bounded above and below by less permeable beds, called "confining layers," or by tighter and less transmissive rocks that bound the ore deposits on either side. This generalized ore depositional pattern is typical of operating and proposed ISL mines in Nebraska, New Mexico, Texas and Wyoming.[4]

The breccia zones, by contrast, are oriented vertically with dimensions measuring up to 300 feet in diameter and from 1,000 to 3,000 feet from top to bottom. They are conglomeritic and poorly cemented, and according to company reports, water passes through the breccia pipes readily, meaning little water is stored in the pipes themselves. (Weinrich and others, 1995)

IV.B. Potential Groundwater Impacts of Breccia Pipe Mining

That little groundwater is stored in breccia pipes does not necessarily eliminate the potential for water quality impacts from uranium mining near GCNP. The Kaibab Formation contains the surface expressions of literally thousands of copper- and uranium-mineralized

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[3] ISL "mining" is actually a form of uranium processing, and as such, is regulated by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and by the U.S. Environmental Protection Agency pursuant to the Safe Drinking Water Act, as amended. Uranium mining in breccia pipes is considered "conventional" underground mining and would be regulated only under federal land-use statutes and/or state or tribal mining statutes.

[4] Not all lenticular sandstone rocks are amenable to ISL mining, especially those that are highly fractured, are discontinuous over short distances and areas, or have been intruded by volcanic or other igneous has rarely exceeded 1,000 feet below land surface. Other problems plague uranium ISL mining, including the failure of virtually all commercial ISL projects to restore groundwater quality to *pre-mining conditions*, without regulatory intervention to relax restoration standards.

breccia pipes. (Billingsley, 2000) The published and academic literature is replete with references to the rapid recharge of snow pack and rainfall through the karst limestone topography of the Kaibab Formation, into the underlying sedimentary strata, especially on the North Rim. (Ross, 2005; Huntoon, 2000) Roaring Springs, a perennial spring on the Bright Angel Fault that provides municipal water supply for both the North Rim and South Rim facilities of GCNP, is said to recharge over a very small area of the mesa. (Ross 2005) On the South Rim in the immediate vicinity of Grand Canyon Village, springs in the Mississippian Redwall-Muav Limestone complex are recharged through snowmelt and rain flowing through the Kaibab and Toroweap formations, Coconino Sandstone, Hermit Formation and Supai Group. (Monroe and others, 2004) Groundwater flow is northward to dozens of springs on the South Rim. At some point near or south of the village of Tusayan, groundwater flow is to the south toward the village of Valle and town of Williams. (GCNP 2003)

Huntoon (2000) postulated that uranium mineralization in the breccia pipes was caused by the *upward* movement of groundwater from the Redwall in Triassic time. Today, however, groundwater flow through the breccias in the GCNP area is *downward*, and Huntoon states that many if not most of the breccias that are buried inside the high-elevation Permian-Pennsylvanian sequence in GCNP and on the Kanab Plateau to the north are unsaturated. Nonetheless, a 1981 investigation *inside* the underground workings of the Orphan Mine encountered 3 feet of standing water (likely originating from the Coconino Sandstone and Esplanade unit of the Supai Group) in the mine tunnel at the 400-foot level. (Tetrault, 1981)

Breccia pipes clearly are conduits for groundwater flow — whether upward in response to hydraulic pressures, downward in response to gravity, or even laterally as a result of poorly cemented fractures and solution cavities in the pipes themselves. They are by no means “dry.” The implication of the pipes carrying groundwater is that the uranium minerals would be oxidized in mining operations, allowing uranium and a host of native, and toxic, trace metals — Ag, As, Ba, Cd, Co, Cu, Mo, Ni, Pb, Se, V and Zn — to be dissolved into the flowing groundwater. Increased contaminant concentrations could occur at discharge points from the pipes, such as the springs on the Canyon walls or in springs and wells producing from the underlying Redwall Limestone around the village of Tusayan.

As noted by several investigators, groundwater recharging through the Kaibab Formation and into underlying sediments discharges to hundreds of springs and seeps in the walls of the Grand Canyon and its dozens of major tributaries. Water quality in these springs and seeps varies from one location to another, and on occasion, trace metals like arsenic occur naturally in concentrations exceeding human drinking water standards. But a close examination of the available water quality data shows clearly that the *overall quality* of the Canyon’s water resources is exceptionally good. (Monroe and others, 2004; Mazzu and Rihs, 1995) The springs and seeps of the Canyon are crucial for maintaining riparian habitats, sustaining stream flows that provide water for wildlife and hikers, and providing water supply for the Native Americans who live downstream in and outside of the Canyon.

In a water-short region where numerous long-term water-supply strategies have been proposed to address the massive population growths of the region, the Redwall Limestone is seen as a vital but diminishing storehouse of high-quality groundwater for current and future human drinking water supply. The Redwall also hosts the bottom third of most of the mineralized breccia zones. Virtually every geologic drawing in the literature shows the base of the breccia pipes bottoming out in the middle of the Redwall. Mining of the breccias would introduce oxygen into the ore zones, oxidizing the rock. From our experience in New Mexico, we know that uranium, when oxidized, dissolves readily (as U+6) and moves rapidly downward in the soil column. Little attention seems to have been given to the impacts of oxidation of the uranium — and consequently, adverse effects on groundwater quality — in the breccia zones *after* mining were to begin. Should mining cause changes in the chemistry of groundwater leaving the breccia pipes, high-quality groundwater that now supplies water to wells near Tusayan and to springs and seeps in the Canyon could become contaminated. Restoration of the original groundwater quality after mining is highly unlikely because of the porous nature of the pipes themselves.

IV.C. Mining and Milling Wastes

Conventional uranium mines, including breccia-pipe mines, generate large volumes of solid mining wastes: overburden, waste rock from the ore zones, and low-grade ores that are not profitable for processing. These wastes also contain trace metals and radioactive elements and must be consolidated and controlled *during mining operations* to prevent releases to adjacent lands, arroyos and alluvial groundwater systems. After mining has ended, these wastes must be consolidated, covered and armored to protect against erosion from water and wind. That mine wastes present at the lower level of the Orphan Mine are the likely source of high concentrations of uranium in Horn Creek is evidence enough of the potential for breccia pipe mines to be significant sources of radioactive and chemical contaminants to the Grand Canyon environment.

No new uranium milling capacity has been identified for the uranium ore that would be produced from mines built by VANE Minerals, Liberty Star or other companies seeking exploration permits around the Grand Canyon. If mining is approved on Forest Service and Bureau of Land Management lands without the necessary milling capacity to support it, uranium ores would have to be stored on or near the mining sites. Storage of uranium ore in the open environment could lead to contaminant releases to surrounding lands and water resources.

V. Conclusions and Recommendations

Uranium mining in the Four Corners Area has been, and in many cases continues to be, a source of widespread environmental contamination and potential public health risk for residents of communities where mining was conducted. Reclamation of abandoned mines has been the *exception*, not the rule, for many mining companies, even those operating under new regulations. Certainly, uranium mining practices have improved since the 1970s, as evidenced by the fact that companies that operated mines in the Arizona Strip appear to have reclaimed significant portions of their mine sites. But the fact is that mining disturbs the land and landscape in irreversible ways, even when controls are in place. Reclamation of mines only *mitigates* their long-term effects; it does not *eliminate* them, or return the land to its original conditions. Water quality, wildlife, native plants and the ecosystem at large are permanently *altered* by mining.

As predicted by some scientists, new mining may *not* leave noticeable scars on the landscape, commit large tracts of land to waste disposal, or adversely affect groundwater and the hundreds of springs that breathe life to the Canyon's plant and animal life. But if mining *does* detract from the recognizable vistas, require commitment of land for long-term waste management, and adversely impact water quality, those impacts are likely to be irreversible. In that case, then, the conditions attendant with proposed uranium mining around the Grand Canyon warrant evoking the 1998 Wingspread Statement on the Precautionary Principle. (See http://www.sehn.org/precaution.html.) The principle reads:

> "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof. The process of applying the precautionary principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action."

Based on my experience observing the uranium industry, I believe there is *more uncertainty* than not that new mining operations would be conducted safely and in compliance with all applicable rules and regulations. The industry's track record, despite its assurances to the contrary, speaks loudly here. Accordingly, withdrawing Forest Service and BLM lands from mineral development contiguous to some of the most sensitive areas of the Grand Canyon is prudent policy to protect the natural resources that give the Canyon its global reputation — sparkling water from springs and seeps, unspoiled vistas revealing hundreds of millions of years of Earth's history, unique flora and fauna, and the remarkably sustainable cultures of the First People who have called the Canyon home for a millennium or two.

REFERENCES

Adams, 2005. EA Adams. Determining Ephemeral Spring Flow Timing with Laboratory and Field Techniques: Applications to Grand Canyon, Arizona. Thesis paper, master of science degree in geology, Northern Arizona University, AE Springer, committee chair; May.

Aguirre Engineers, Inc., 2001. Letter from JR Ward to S Mulligan, National Park Service, transmitting data for Lost Orphan Mine, AEI Project No. 30031, April 10.

AGFD, 2007. Arizona Game and Fish Department and Commission. Uranium Mining Activities, Past and Present. May.

Billingsley, 2000. GH Billingsley. Geologic Map of the Grand Canyon 30' x 60' Quadrangle, Coconino and Mohave Counties, Northwestern Arizona. U.S. Geological Survey, Geologic Investigations Series I-2688, Version 1.0.

Day and others, 1981. GJ Day, JG Sepulveda, RJ Jackson. Report of Radiation Survey, Orphan Mine, Grand Canyon National Park, Arizona. Mine Safety and Health Administration, U.S. Department of Labor (Phoenix), November 5-7.

deLemos and others, 2007. JL deLemos, M Menache, D Brugge, G Durant, B Bostick, T Rock, C George, J Lewis. Geochemical controls on uranium mobility to inform human health exposure assessment in the Church Rock Mining District: Navajo Nation, NM. Presentation at American Public Health Association Annual Meeting (Washington, DC), November 7.

Fitzgerald and others, 1997. JK Fitzgerald, DK Kreamer, KH Johannesson, J Rihs. Delineation of non-point sources of uranium. Untitled masters thesis.

GCNP, 2003. Grand Canyon National Park. "Native Waters," National Park Service bulletin (Grand Canyon, Arizona).

Harding Lawson Associates, 1993. Phase I Preliminary Assessment, Orphan Mine, Grand Canyon National Park, Arizona, July 6. Administrative Record 0000036 et seq.

Harding Lawson Associates, 1996. Draft Risk Assessment/Engineering Alternatives Evaluation for the Orphan Mine Site, Grand Canyon National Park, Arizona. December 20.

Huntoon, 2000. PW Huntoon. Large-Basin Ground Water Circulation and Paleo-Reconstruction of Circulation Leading to Uranium Mineralization in Grand Canyon Breccia Pipes, Arizona. *The Mountain Geologist*, The Rocky Mountain Association of Geologists, 33(3): 71-84, July.

Lewis, 2007. JL Lewis. The Navajo Uranium Assessment and Kidney Health Project -- DiNEH Project Phase II. Presentation at American Public Health Association Annual Meeting (Washington, DC), November 7.

Mazzu and Rihs, 1995. LC Mazzu, J Rihs. Final Report: Intensive Reconnaissance Sampling of Grand Canyon Tributaries, Grand Canyon National Park. National Park Service (Grand Canyon, Arizona).

Pasternak, 2006. J. Pasternak. "Blighted Homeland": Four-part series on Navajo uranium mining. *Los Angeles Times*, Nov. 19-22, 2006.

Ross, 2005. LEV Ross. Interpretative Three-Dimensional Numerical Groundwater Flow Modeling, Roaring Springs, Grand Canyon, Arizona. Thesis paper, master of science degree in geology, Northern Arizona University, AE Springer, committee chair; December.

Shuey, 2007a. C Shuey. Letter to A Kellerman, House Committee on Oversight and Government Reform, re: Summary of Recent Environmental Monitoring Data in the Church Rock Uranium Mining District, Navajo Nation (McKinley County, New Mexico). Southwest Research and Information Center (Albuquerque), October 22.

Shuey, 2007b. C Shuey, JL deLemos, C George. Diné Network for Environmental Health (DiNEH) Project/Navajo Uranium Assessment and Kidney Health Project: Uranium mining and community exposures on the Navajo Nation. Presentation at American Public Health Association Annual Meeting (Washington, DC), November 7.

SSPORTS Environmental Detachment, 1999. Orphan Mine Site, Grand Canyon, Arizona, Phase I Radiological Survey Report submitted to National Park Service, September 9. Administrative Record 0002033 et seq.

Tetreault, 1985. Report on the Orphan Mine, Grand Canyon National Park. U.S. Bureau of Land Management (Albuquerque, N.M.). Administrative Record 002376 et seq.

U.S. House of Representatives, 2007. Hearing on the Health and Environmental Impacts of Uranium Contamination in the Navajo Nation. Committee on Oversight and Government Reform, U.S. House of Representatives, October 23.

VANE Minerals, 2007. VANE Minerals Uranium Exploration Drilling Project Location Map. Tusayan Ranger District, Kaibab National Forest.

Van Metre and Gray, 1992. PC Van Metre, JR Gray. Effects of uranium mining discharges on water quality in the Puerco River Basin, Arizona and New Mexico. *Hydrological Sciences Journal*; 37(5):463-480, Oct. 1992.

Weinrich, 2008. Internet paper on uranium mining in Northern Arizona breccia pipes. See: http://www.libertystaruranium.com/sub.asp?sub_id=36&section_id=8.

Weinrich and others, 1995. KJ Weinrich, BS Van Gosen, WI Finch. Solution-Collapse Breccia Pipe U Deposits; Model 32e. Chapter 31 in: Preliminary Compilation of Descriptive Geoenvironmental Mineral Deposit Models (EA du Bray, editor), U.S.Geological Survey Open-file Report 95-0831.

Wirt, 1994. 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 (Tucson, Ariz.), Water-Resources Investigations Report 94-4192, 1994.