URANIUM ACTIVITIES' IMPACTS ON LAKOTA TERRITORY

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Uranium exploration, mining, and milling are the "front end" of the nuclear chain – the often-forgotten activities without which neither nuclear power nor nuclear weapons could exist. Uranium mining and milling were common on the northern Great Plains from the 1940s until the early 1980s. This paper focuses on the impacts of those activities on Lakota (western Sioux) Territory, broadly defined -- western South Dakota and North Dakota, eastern Montana and Wyoming, the panhandle of Nebraska, and northeastern Colorado. All of these areas have experienced uranium activity, and companies are exploring in each of these states. Currently, mining is only being done in Wyoming and Nebraska.

In the last several years, a boom in uranium exploration and proposed new mining projects has brought new attention to the ongoing impacts of old mining and milling sites. This new uranium boom is a result of the belief that nuclear power will have a "renaissance" as a "clean" alternative to fossil fuels in an era of climate change -- and to a resulting spike in uranium prices. However, nuclear power is not clean, as this paper illustrates, and mining and processing uranium use a significant amount of fossil fuels.

Before going into the specific impacts on Lakota Territory, an overview is provided of the uranium mining and milling processes and their general impacts. This will be followed by a summary of the known impacts on each past mining area, as well as brief information on current uranium activities.

URANIUM MINING OVERVIEW

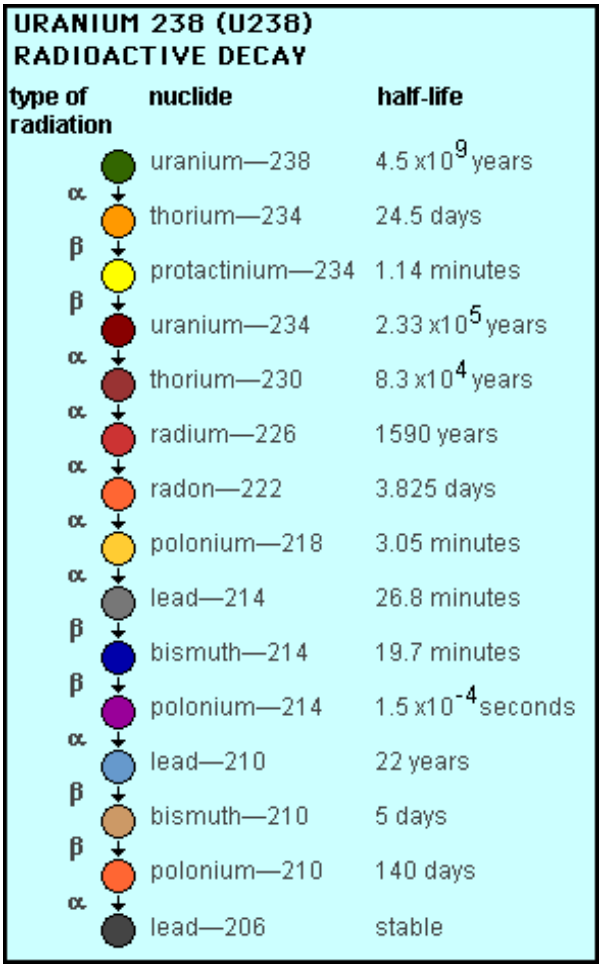
Uranium is unique because it emits radiation. When uranium is underground, it is not generally dangerous. But when it is brought to the surface and concentrated by mining activities, it emits dangerous levels of radiation.

Uranium breaks down into a series of other substances in a decay process, and each step of that process emits radiation. Each substance has a "half-life," the amount of time it takes for it to decrease by half. The half-life of uranium-238 – a major waste product of uranium milling – is 4.5 billion years. On the other end of the spectrum, some of the byproducts of uranium last only days or minutes. Some of these byproducts are far more dangerous than the uranium itself. Eventually, uranium decays into a stable form of lead.[i] Figure One summarizes this process.[ii]

Some types of radiation – tagged "alpha" and "beta" – are only dangerous to people if they are inhaled or ingested. "Gamma" radiation, on the other hand, will go through a person's skin and represents a more generalized hazard.

There are three major types of uranium mining, all of which have been used in Lakota Territory. The first is open pit mining, in which a hole is simply dug into the ground to recover uranium that is at a shallow depth. The second is underground mining, in which shafts are dug to get at the ore. The third is a newer process, *in situ* ("in place") leach mining. In situ leach (ISL) mining involves pumping a chemical/water solution into the ground, where it leaches uranium out of a water-bearing rock layer. The uranium solution is then pumped to the surface for further refining. Figure Two is a graphic of this process.

FIGURE ONE: DECAY PROCESS OF URANIUM-238

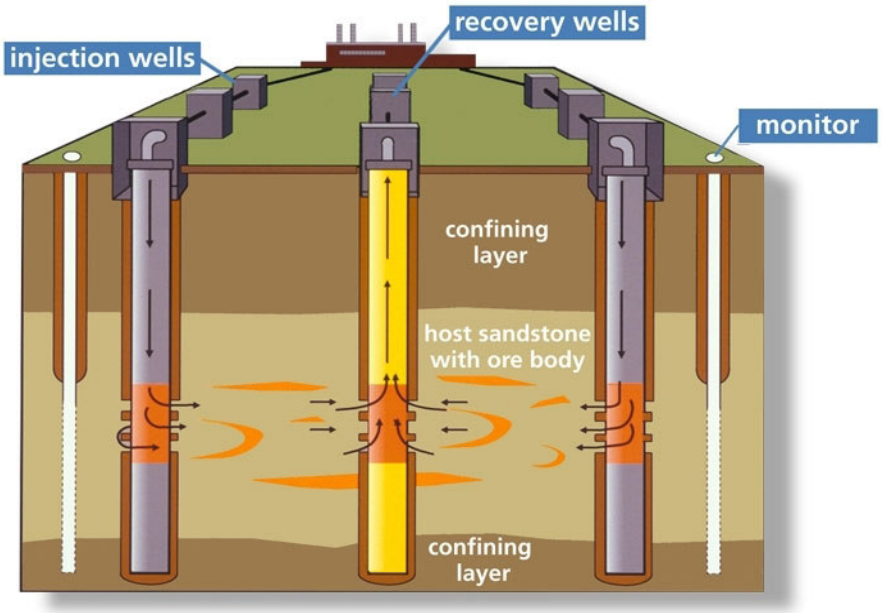


The ore recovered during open pit and underground mining must be milled to remove uranium-235, which is concentrated and used for nuclear power or weapons. The remaining ore is left in tailings piles, which are 85% as radioactive as the uranium that is taken for further processing. It takes several hundred thousand years for the radiation level in tailings piles to decrease. Tailings piles are also large – covering hundreds of acres and involving millions of tons. As of 2009, there were 235 million tons of uranium mill tailings in the US – enough to cover 2,300 football fields to a depth of ten feet. Tailings contain radioactive elements, as well as substances commonly found with uranium, such as molybdenum, arsenic, lead, and selenium.[iii]

Tailings are the consistency of sand and move easily in the wind or water. In some locations, people used them for construction materials before they understood the danger. Tailings may also be "disposed of" by mixing them with water in large ponds, as shown in Figure Three . Tailings pond dams have occasionally broken, causing radioactive water mixed with tailings to flow downstream. A 1979 dam break at Churchrock, NM, was the largest expulsion of radioactive materials in U.S. history. Three hours after the break, the tailings had reached fifty miles downstream. In total, tailings contaminated

80 miles of the streambed. In Lakota Territory, there have been three tailings releases in Wyoming and one in South Dakota.[iv]

FIGURE TWO: IN SITU LEACH MINING OF URANIUM



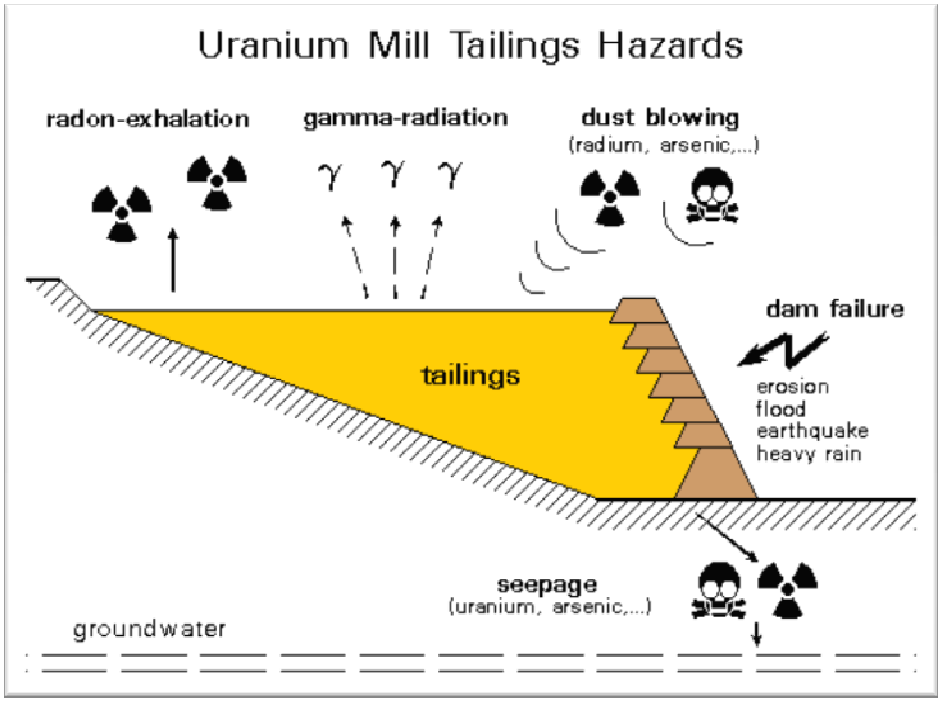
Uranium can also be milled by heap leaching – putting the ore in a pile and leaching the uranium out with acids. This was planned for the Black Hills in the 1980s.[v] The third method of removal is by burning the ore, which has been done when uranium is naturally mixed with lignite coal. This method was used in the northern part of Lakota Territory.[vi]

All types of mining and milling, like all nuclear activities, emit radiation into the environment. This may come from drill cores from exploration, waste rock from mining, tailings left from milling, mine or mill buildings, equipment, and even miners' clothing. At least 30 uranium sites have been listed under the Superfund Act (Comprehensive Environmental Response, Compensation, and Liability Act or CERCLA). This includes a number of tailings sites and two uranium mines.[vii]

Uranium exploration, mining, and milling contaminate surface and groundwater, soil, and air with radioactive materials and heavy metals. Plants and the animals that eat them, in turn, take up these contaminants. The animals that eat animals, including humans, can then ingest these contaminants at the top of the food chain.[viii]

These are some of the reasons why there are concerns about both current and old uranium operations in Lakota Territory. Those concerns will be discussed next.

FIGURE THREE: URANIUM MILL TAILINGS HAZARDS



OVERVIEW OF PAST OPERATIONS

As mentioned above, there are old uranium operations – most of them abandoned without having been reclaimed – across Lakota Territory. The US Environmental Protection Agency combined over a dozen lists of old and current mine and prospect sites to create the *Uranium Location Database Compilation: Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)*[ix] in 2006. As part of this research, the TENORM database was consulted, and the different lists were checked to prevent double counting. The results are shown in Table One.

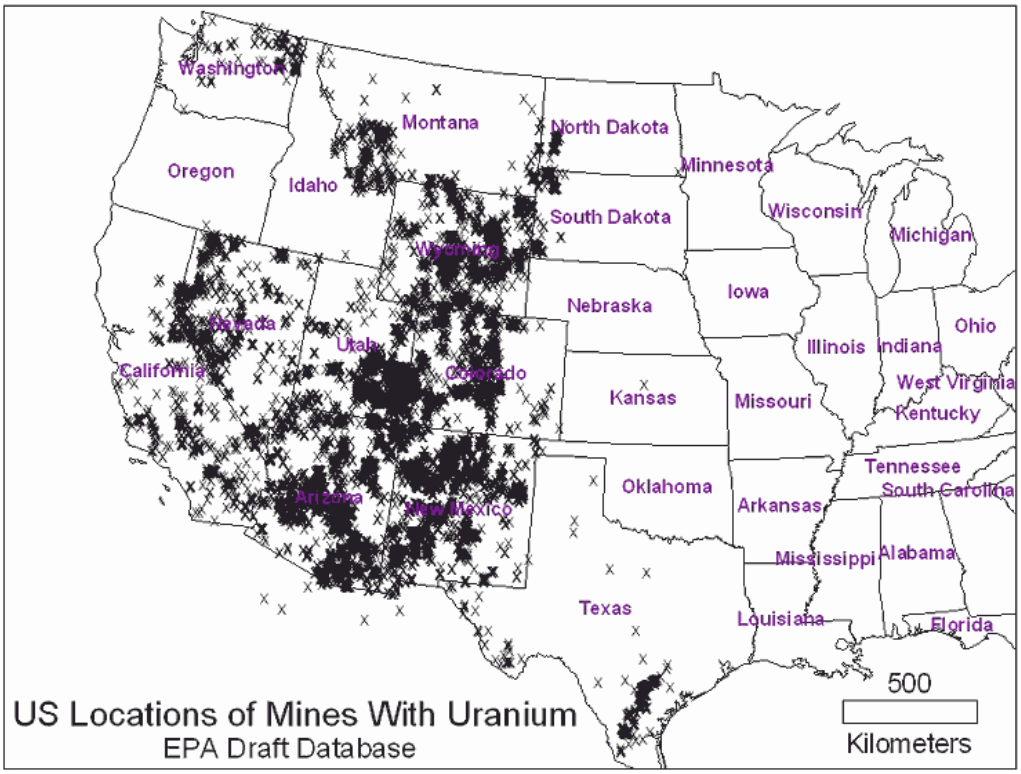
TABLE ONE: OLD AND OPERATING URANIUM MINES AND PROSPECTS: LAKOTA TERRITORY: NORTHERN MISSOURI RIVER BASIN

STATE	WATERSHED	NUMBER
COLORADO		
	SOUTH PLATTE	351
	NORTH PLATTE	36
STATE TOTAL		387
MONTANA		
	YELLOWSTONE	102
	MISSOURI	295
STATE TOTAL		397

NORTH DAKOTA		
	SOURIS	13
	MISSOURI	100
STATE TOTAL		113
SOUTH DAKOTA		
	CHEYENNE	169
	MOREAU/GRAND	103
STATE TOTAL		272
WYOMING		
	YELLOWSTONE	1039
	NORTH PLATTE	397
	CHEYENNE/BELLE FOURCHE	667
STATE TOTAL		2103
OVERALL TOTAL		**3272**

The database lists approximately 3,272 sites in Lakota Territory, all of them in the northern Missouri River basin. Nearly two-thirds are in Wyoming, with the fewest in North Dakota. On the watershed

FIGURE FOUR: PAST AND CURRENT URANIUM MINES



level, the most uranium sites are in the Yellowstone River watershed, with the fewest in the North Platte and Souris watersheds. These old mines and prospects are generally located on private, tribal, Bureau of Land Management, or National Forest Service land. Figure Four provides a good idea of where mines have been located.

While there were no laws that required exploration hole, mine, and mill reclamation in most places until the 1970s, that is beside the point when considering the impacts of past uranium activities. The reality is that impacts not only continue to exist – but will continue to exist for thousands of years. As noted above, even when regulations are strict, uranium activities release radiation and other toxins into the environment. In an overview of uranium activities' impacts, we will begin with impacts on humans, historical and cultural impacts, and impacts on local economies. Then we'll cover the impacts of the "front end" of the nuclear chain from the beginning – exploration – and move through the mining and milling processes. We will then turn to the specific impacts in Lakota Territory.

Health Impacts

Health impacts from uranium mining are well documented for miners. But because uranium mining is generally done in rural areas with low populations – and because many people move on when the mines close -- it is impossible to do a full-scale epidemiological study on impacts on the general population. Some studies that purport to show that there is no harm from local uranium activity fall prey to this and other methodology problems, including studies funded by the uranium industry.[x] However, it is undisputed that leading scientists agree that there is no safe level of exposure to radiation, and the credible research that has been done indicates that there are health impacts from uranium exposure.[xi]

Some health impacts are the result of the nature of uranium and its decay products which, as noted above, are typically alpha or beta particles that are ingested or inhaled. According to a federal government fact sheet, the major health concerns from ingested uranium are kidney damage, renal cancer, and bone cancer. The impacts of inhalation include asthma, lung cancer, cardiovascular issues, and premature death. Miners who breathe in radioactive particles have higher incidences of lung cancer and tissue atrophy, as well as increased susceptibility to disease. Radiation has been known to have negative health impacts for a hundred years and to cause gene mutations and chromosome changes since 1926.[xii]

Uranium milling has also been associated with increased health risks. Again, the studies are limited, and many fail to separate the impacts from milling and mining – which often occur in close proximity. However, the available evidence shows that there is probably an increase in birth defects among babies born to mothers who live near a uranium mill. Living near a uranium mill is also linked to increased lung cancer, leukemia, cell damage, renal cancer, and stomach cancer. One study compared Navajo who live close to and distant from mining and milling areas. The results show that those in mining areas suffer a:

- 1500% increase in testicular and ovarian cancer in children;
- 500% increase in bone cancer in children;
- 250% increase in leukemia; and
- 200% increase in miscarriage, infant death, congenital defects, and learning disorders.[xiii]

Radiation is not the only health risk associated with uranium. The heavy metals found with uranium are also released into the environment. Like radioactive materials, these may contaminate groundwater, surface water, and soil, as well as plant foods and animals that are raised in contaminated areas.[xiv] Most people are aware of the dangers of arsenic and lead. Selenium is a commonly-occurring mineral in some areas, including western South Dakota. In small amounts, as in vitamin supplements, it has positive impacts. When ingested in larger doses, most often by livestock, it is fatal and has killed whole herds within hours.[xv]

There are also mental health impacts from living near uranium operations. Families lose loved ones to cancer and lung disease. There are multiple losses within single families. The high rate of deaths within communities may cause people to live with fear, wondering "who is next?" Husbands feel guilty because they brought uranium dust home on their clothes, unknowingly exposing their families to radiation. In addition, these events may be seen as having spiritual impacts.[xvi]

Women in mining communities face specific health risks as a result of both physical and social factors. Contamination of women's bodies, by whatever means, has particular impacts because women bear children. Women also process and store toxins differently from men, which can have negative impacts when their bodies' metabolic needs change during pregnancy, breastfeeding, and aging. Women whose spouses are miners often live in isolated communities and face an uncertain future due to the industry's "boom and bust" cycle. Mining communities are also characterized by addiction, divorce, child abuse, violence against women, and sexual harassment.[xvii]

Health impacts are the most commonly discussed results of uranium activities. However, there are other important impacts on indigenous cultures, on cultural and historical resources, and on local economies.

Cultural and Historical Impacts

Uranium activities have a variety of cultural and historical impacts. These include exploration and mining that destroy Native American sacred sites, historical dwelling places, burial sites, and ancient petroglyphs. In Canada, whole lakes – the basis for local indigenous peoples' economies – have been drained, and the lakebeds have been mined. The remaining water in the area was contaminated, and serious health problems developed. Families were forced to move to other areas. Obviously, this severed their relationships to the land and to their historical homes. But it also destroyed communities and historical familial, ceremonial, and cultural relationships.[xviii]

Native Americans and native cultures are unique to certain land bases. Sacred places cannot be replaced if they are disturbed, and historical sites have significance that goes back thousands of years. In modern times, native cultural communities are also often place-bound on reservations. Reservation lands represent the last remnants of native peoples' historical land bases – remnants that people are determined to retain. Another important historical factor is that, throughout the Industrial Age, tribal governments have generally been unable to exercise enough political power to prevent companies from mining on or near reservations. The federal government and tribal attorneys have assisted companies in gaining access to reservation land – often through long-term leases with outrageously low royalties. Some tribal governments have also favored mining, seeing it as economic development.[xix]

Although these cultural and historical factors – and the resulting impacts -- are present to some extent wherever uranium is mined, there have been major spiritual and political issues at Mount Taylor in New

Mexico and at the Black Hills in Lakota Territory. Mount Taylor, the site of a large uranium deposit, is sacred to at least five southwestern tribes. It has been the site of a long struggle between native people and non-Indian ranchers and townspeople. [xx] We will return to uranium issues in the Black Hills in a later section.

Economic Impacts

The "boom and bust" cycle associated with mining has drastic impacts on communities in mining areas. The cycle begins when valuable deposits are discovered or when mining restarts in an area with historical mining, bringing a "boom." This "boom" is associated with an influx of new population, dislocation of the historical community, and the sudden and urgent need for new public facilities and infrastructure.[xxi]

After the mining ends, in the "bust" period, the population often shrinks just as quickly, hundreds of homes may stand vacant, and local businesses close. Some towns, like Jeffrey City, WY, and Uravan, CO, have become ghost towns.[xxii] Figure Five, a photo showing the past extent of Jeffrey City, which shrank to a few families, gives some of idea of the impacts.

FIGURE FIVE: PANORAMIC VIEW OF JEFFREY CITY, WY, A URANIUM GHOST TOWN

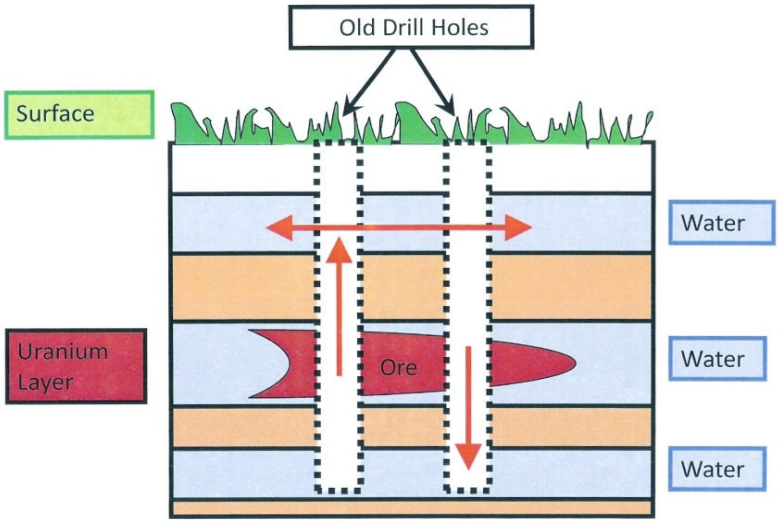
The "boom and bust" cycle impacts both native and non-native communities. While non-native communities suffer from empty main streets and unemployment, native communities also suffer from cultural dislocation and the return of extreme poverty. Because, as noted above, native communities are often located on long-term, traditional territories and/or on reservations, people are more likely to stay and be exposed to long-term damage. George Arthur of the Navajo Nation characterized uranium activities as "a never-ending federal experiment to see how much devastation can be endured by a people and a society."[xxiii]

Exploration Impacts

Turning to the impacts of each aspect of the "front end" of the nuclear chain – exploration -- uranium operations in Lakota Territory have left behind thousands of exploration holes and associated drill cores and drilling truck pads. An exploration operation in Colorado is shown in Figure Six. In recent years, drillers involved in uranium exploration have been reporting increased lung problems and cancer. [xxiv]

FIGURE SIX: URANIUM EXPLORATION IN NORTHERN COLORADO

FIGURE SEVEN: "VERTICAL LEAKS" INTO AQUIFERS FROM URANIUM EXPLORATION



Many exploration sites have not been reclaimed. Where attempts were made to reclaim the holes, they were often half-hearted. Some holes were left open. Some were covered with rocks or pie tins. Other holes were capped, but not sealed all the way down, allowing continuing water movement and potentially the mixture of clean and contaminated water. Water can move either up or down through drill holes and from one aquifer to another. This type of water movement is called a "vertical leak," and is illustrated in Figure Seven.[xxv]

Besides having impacts on area water wells, including contamination and water level changes, exploration holes can emit radiation into the air. Mud pits, which are created to hold drilling fluids, can leak either underground or on the surface. Exploration also brings radioactive materials and heavy metals to the surface. These are commonly laid on the ground as they are recovered, as shown in Figure Eight, and can be spread around by water or wind. Before exploration was regulated, drilling wastes were commonly left on the surface, and bulldozers were used to make exploratory "cuts" in the ground's surface. These cuts were generally also left without reclamation.[xxvi]

FIGURE EIGHT: DRILL CORES FROM EXPLORATION

Mining Impacts

Each type of old mine brings its own impacts. Open pit mines, as shown in Figure Nine, primarily threaten surface and ground water. They leave behind large amounts of soil and rock, including radioactive materials. The pits can fill with water, and animals – both livestock and wildlife -- are attracted to the open water. Runoff can spread radiation from the mine spoils piles. The problem is not just uranium, but also its byproducts. For example, plant litter and sediment at old open pit mines can have very high levels of Radium-226, which is more dangerous than uranium. Radioactive materials and heavy metals can also be spread by wind and deposited over the land by tornados, wildfires, and road dust.[xxvii]

FIGURE NINE: RABBIT LAKE OPEN PIT URANIUM MINE, CANADA

Underground mines primarily impact water, although the air in the mines has been deadly to miners and poses a threat to recreational visitors. Underground mines are also physical hazards, as they can cave in.[xxviii] Adits, defined as entrances to mines, are also left behind. In reality, adits are often small mines that may be characterized as "exploration" by mining companies. In addition to the actual mines, ventilation shafts may be left behind. These can be large enough for a person to fall into and may be hidden by vegetation. The combination of exploration holes, mines, adits, vents, and mine spoils brings not only radioactive dangers, but also physical dangers to the public, livestock, and wildlife. This has become more of a concern as outdoor recreationists reach areas that were once isolated and as urban areas expand.[xxix]

The impacts of in situ leach (ISL) mining are less visible, but ISL mining, by definition, involves the intentional pollution of groundwater -- with the hope that the pollution can be extracted during the mining process. However, spills and leaks are common at ISL mines. Underground leaks can be either vertical or horizontal and are known as "excursions" when they move out of the immediate mining area. Complete clean-up of in situ sites has proved impossible, and reclamation has never returned the water to its original condition. In fact, research indicates that mines that have been "reclaimed" may be "re-contaminated" after they are closed. This is because mining removes dangerous chemicals from a steady state and cuts them loose into the water. The minerals are not necessarily put back into a steady state after mining and reclamation cease, and contaminated water can still move around.[xxx]

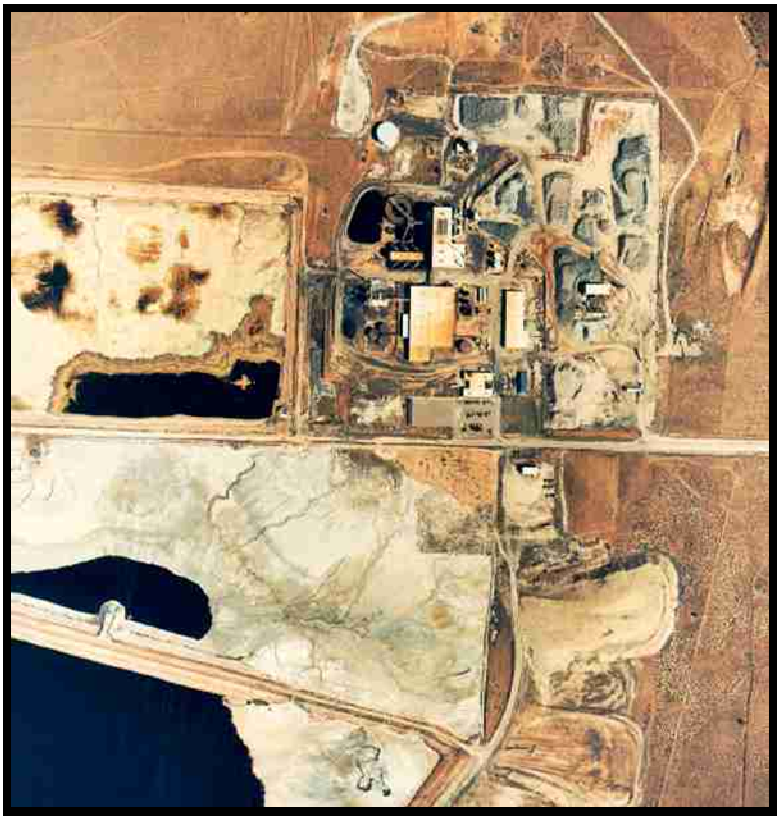
Contamination moves slowly through some types of aquifers and quickly through others. It can also move quickly through fractures, faults, breccia pipes, and other underground pathways. These, depending on their locations, may not be discovered before mining begins.[xxxi]

There are also aesthetic impacts from uranium activities, both because of unreclaimed holes and mines and because of abandoned equipment. The bottom line is that all types of uranium mining take radioactive materials from a stable and relatively safe situation, concentrate them, and move them into the broader environment where they can contaminate soil, water, and air.

Milling Impacts

The most toxic aspect of the "front end" of the nuclear chain is uranium milling. As noted above, milling leaves behind huge piles of toxic tailings, like those shown in Figure Ten. Tailings move in wind or water, and radiation escapes from tailings ponds. In addition, several methods of remediating tailings sites have failed. Covering them with dirt, even when vegetation is added, has proved inadequate in the long run. In the United States, a number of tailings piles have been moved and buried.[xxxii] Whether this proves to be a long-term solution remains to be seen.

FIGURE TEN: URANIUM MILL AND TAILINGS: INTERNATIONAL USA CORPORATION



Radioactive wastes have had far-flung impacts. High radium readings were found 80 km (50 miles) downstream from uranium operations on the Serpent River in Canada. In Central Asia, radon exhaled from uranium tailings was ten to sixty times higher than the standard value, and strong winds could lift as much as 1,000 square meters of dust and move it for miles. In Australia, plants growing on mill wastes had uranium levels as much as 100 times background. These examples are not unique, as will be seen in the discussion of Lakota Territory.[xxxiii]

An additional risk from uranium activities occurs during transportation. Accidents involving nuclear materials are not unusual. As an example, in a 1985 accident near Bowdon, North Dakota, the driver of an unmarked truck that sneaked across the Canadian border was killed when her truck hit a train.

Because the truck was unmarked and the driver was killed, thirty or forty local residents were exposed to yellowcake before the substance was identified.[xxxiv]

So a number of problems result from the front end of the nuclear chain – environmental, health, cultural, historical, and economic. With this general background, we will now turn to the specific impacts of uranium activities on Lakota Territory, beginning with southwestern North Dakota.

IMPACTS IN SOUTHWESTERN NORTH DAKOTA

In southwestern North Dakota, there were several uranium mines and two uranium-removal facilities in the 1960s. Both of these facilities burned uranium-bearing lignite coal, which concentrated the uranium. Kerr-McGee Oil Industries ran the first facility, which was near Bowman, from 1964-1967. The resulting ore was shipped to a mill in New Mexico. The second facility, which was one mile south of Belfield, was operated by Union Carbide Corporation from 1965-1967. The ore from this facility was shipped to Colorado.[xxxv]

At the Bowman site, wastes eventually covered 12 acres at depths of three feet. There were an estimated 28,000 cubic yards of contaminated materials on the site and 100,000 more outside the site boundary. Airborne materials contaminated 59 acres. Pollution leached into the ground, and water under the site was contaminated with sulfate, chromium, selenium, and uranium. Because of the contamination, one local rancher lost 2500 sheep. Before they died, the sheep glowed and lost their hair. The State of North Dakota has been responsible for remediation of the site, and it has not been cleaned up.[xxxvi]

FIGURE ELEVEN: OPEN BURNING OF URANIFEROUS LIGNITE: BELFIELD, ND

Forty years after the Bowman site closed, its impacts on stream sediments were studied. Researchers from the South Dakota School of Mines and Technology looked at sediments in the Bowman-Haley

Reservoir on the South Dakota-North Dakota border. They found the highest levels of uranium where Spring Creek entered the reservoir, a site about 15 miles downstream from the Bowman site. And they concluded that the Bowman facility was the source of these elevated readings.[xxxvii]

The Belfield site, shown in Figure Eleven, left 58,000 square yards of contaminated material covering 13 acres. Contamination, including airborne materials, covered 32 acres. Residents reported that a red dust blew over town when materials were loaded onto rail cars, and mine wastes were used to backfill buildings' foundations. Part of the contamination lay in the floodplain of the North Branch of the Heart River. In addition, an estimated 4.7 million gallons of groundwater were contaminated because pollution leaked into the ground. The contaminants included selenium, radium^{226} and $^{-228}$, molybdenum, and uranium. The State did clean up this site in 2004.[xxxviii]

There are also an estimated 113 old uranium mines and prospects in North Dakota. One of the larger mines was the Fritz Mine, shown in Figure Twelve. There, uranium was removed by burning the actual coal seam. Observers reported that there was no vegetation around the mine, and that the water that filled it was a dead green color.[xxxix]

FIGURE TWELVE: PORTION OF THE FRITZ MINE: NORTH DAKOTA

Seven of the abandoned mines -- a total of 440 acres -- have been reclaimed. Wastes were buried in clay-lined pits, monitoring wells were set up in the groundwater, and area residents were told to treat their drinking water. 115 acres were reclaimed at the Fritz Mine in 1992 at a cost of $500,000. Other reclamation projects may be undertaken, but the water monitoring process was suspended in the mid-1990s.[xl]

IMPACTS IN MONTANA

There are old exploration sites and two abandoned uranium mines in Custer National Forest in the Pryor Mountains in south-central Montana. In this area, a state study found that waste piles at one mine had

uranium readings that were up to 369 times the background level. At the second mine, readings were as high as 145 times background. Old prospects were as much as 6.5 times background. In this former mining area, as elsewhere, members of the public have explored the old mine sites. The authors of the study noted that radioactivity may be a hazard at both mines.[xli]

IMPACTS IN NORTHWESTERN SOUTH DAKOTA

Of all the areas covered in this report, the best records on the environmental impacts of uranium activity in Lakota Territory were created in what is now northwestern South Dakota. Due to a series of studies, most of them done by Oglala Lakota College and the South Dakota School of Mines and Technology, reports have been created on contamination of water, soil, stream sediment, and air around a number of old open pit mines. These studies show widespread contamination of the Grand River and Moreau River watersheds, which then flow east through the Standing Rock and Cheyenne River Reservations.

Uranium mining took place in northwestern South Dakota from 1954 until 1964, although uranium-bearing coal was mined beginning before 1920. Most mining was on US Forest Service land in four areas: the North Cave Hills, South Cave Hills, Slim Buttes, and Flint Buttes . As much as 80 feet of overburden was removed to reach the uranium, and thousands of cuts and prospects were made, in addition to the 103 identified former mining sites. Exploration sites, mines, and spoils covered almost 1,000 acres. No restoration was required when the mining was done, and Stone and Stetler described spoils piles as "mostly devoid of vegetation" with high erosion rates. Because mining was done on the tops of buttes, wastes often slid or were pushed downhill.[xlii] Researchers noted that the spoils piles at some mines were heavily eroded and subject to channeling. Soil had moved onto private land. In some cases, the mine walls were steep or falling into the abandoned mine. [xliii]

In this area, as in some other locations, uranium is found in deposits that also include arsenic. So both were often measured to determine risks to human health. [xliv]

An initial study of contamination in areas that might need clean-up was done in 1990 and 1991 – nearly 30 years after mining had ceased. This study looked at 304 acres of old sites on 12 bluffs at the Riley Pass uranium mines in the North Cave Hills, shown in Figure Thirteen. It found gamma radiation readings as much as 100 times the "background level" – considered the local "norm" when there has been no uranium activity. The report found that radioactive materials in the soil were three times higher than the background level at nine sites. Arsenic, molybdenum, and thorium were more than three times background at a number of sites.[xlv]

Surface water samples at and downstream from the mining area showed widespread contamination by arsenic, copper, lead, molybdenum, selenium, thorium, vanadium, and radium^{226}. Stream sediment samples were at least three times background for at least some of the contaminants at seven of the bluffs, including arsenic, molybdenum, radium^{226}, and uranium^{235}. Sediment ponds constructed in 1989 along the waterway were trapping some contaminated particles as the water moved downstream.[xlvi]

A second study was done in 2004 by Portage Environmental and again focused on the North Cave Hills. Soil and surface water samples were collected. The results for soil samples are shown in Table Two. The results for surface water samples are shown in Table Three.[xlvii]

FIGURE THIRTEEN: RILEY PASS MINE

Clearly, uranium activities had major negative impacts on the environment in the North Cave Hills. The report then went on to calculate the risks to humans from the old mine sites. The conclusions were that, in this area:

- Construction workers would be considered "radiation workers" under Nuclear Regulatory Commission (NRC) guidelines; and
- Recreational visitors and ranchers who held grazing permits faced unacceptable risks for cancer as a result of exposure to arsenic and radiation.[xlviii]

TABLE TWO: SOIL SAMPLE RESULTS FOR 2004 NORTH CAVE HILLS STUDY

	MAXIMUM READING	**NUMBER OF TIMES HIGHER THAN AVERAGE BACKGROUND**
Arsenic	3390 mg/kg	121
Molybdenum	6550 mg/kg	1638
Selenium	98 mg/kg	20
Radium^{226}	116 pCi/g	64
Uranium^{238}	151 pCi/g	151
Uranium^{234}	156 pCi/g	156
Thorium^{230}	161 pCi/g	107
Uranium^{235}	7.1 pCi/g	71

TABLE THREE: SURFACE WATER SAMPLE RESULTS FOR 2004 NORTH CAVE HILLS STUDY

	MAXIMUM READING	**NUMBER OF TIMES HIGHER THAN MAXIMUM BACKGROUND**
Arsenic	1420 µg/L	53
Copper	442 µg/L	50
Lead	442 µg/L	69
Molybdenum	335 µg/L	38
Selenium	34 µg/L	10
Vanadium	944 µg/L	41
Radium^{226}	16 pCi/L	13

A third study was done in 2000 – 2001. This study found that soil at Slim Buttes was as much as 1,704 times more radioactive than background levels. Another reading was 1,670 times higher than background, and a third was 366 times higher. Fifteen other samples exceeded the background level for uranium by more than 20 times.[xlix] In most of the studies done in the area, anything over three times higher than background was considered to be of concern.

A mix of South Dakota School of Mines (SDSMT) students and faculty and Oglala Lakota College faculty then completed a series of studies. Parts of these studies covered all four areas where mining took place in northwestern South Dakota. They looked at groundwater, airborne contaminants, stream sediment, and surface water, although not all of these media were studied at all four sites. In preliminary fieldwork using a scintillation meter (similar to a Geiger counter), readings of 643 times background were found, indicating that more thorough study was clearly needed.

Two of these studies considered groundwater and were done by SDSMT professors Stetler, Davis, and Stone. The first looked at 34 wells. The study found widespread gross alpha radiation in both shallow wells and deep wells, both upstream and downstream of the Riley Pass mine. The authors concluded that "Most likely the chemistry of surface water and local springs were affected by the presence of the mines but the deep aquifers should not have been impacted directly…. The exception to this would be the presence of deep fracture systems allowing local infiltration to reach the water table, i.e., a leaky aquifer condition." They suggested further study to determine if fractures existed.[l]

Stone, Stetler, and Schwalm suggested in another study that fractures could be the source of spreading contamination, saying:

> The presence of deep-seated fractures on massive sandstone beds at the base of many abandoned uranium mines suggest that deep ground water flow directions could be impacted by these features. Fracture systems are important in flow direction studies in that more volume of water may be conducted through factures (secondary porosity) than through the primary porosity and be in a different direction than the regional dip of the aquifers themselves…. For example, it is known from the Black Hills that fracture flow can be many orders of magnitude greater than incipient porosity flow.[li]

The second groundwater study looked at the potential for contamination in a well located 1.9 miles from the abandoned Riley Pass mines. The authors concluded that groundwater in that area was moving only .047 feet per day. In 53 years, they calculated, the water had moved between 270 and 1550 feet. The higher number was 15.5% of the distance to this well. At this rate, it would take contamination about 370 years to reach the well. This measured only one well, and it wasn't clear why this well was selected. It is fair to say that the overall effect of abandoned uranium mines on groundwater in that area has yet to be determined.[lii]

Moving to wind erosion of surface dust, this was studied at 30 locations in the North Cave Hills. The authors noted that soils could be moved beginning at a wind speed of 10 – 11 mph. They then say that the conservative threshold wind speed for the study area is 13 mph, and the winds blow harder than that about 23% of the time. Not surprisingly, the tests found high readings for uranium, arsenic, selenium, molybdenum, vanadium, and copper in the air – although not all of these were present at all sites. The authors concluded that "Uranium concentration distribution show the highest correlation to the abandoned mine sites and the prevailing wind direction," although other factors were likely to be at work. Figure Fourteen shows these results graphically.[liii]

Stream sediment and surface water testing, the third and fourth areas of study, were done at all four mining areas. In the Slim Buttes region, nearly half of the stream sediment samples exceeded background levels for uranium and for arsenic. Just over a third of the surface water samples exceeded background for uranium, and a quarter exceeded it for arsenic. The author concluded that old uranium mines posed "a great concern and potential for contamination of offsite drainages." However, this study actually minimized the potential risks, because of the way the researcher calculated "background" levels -- she used samples that were collected only 5 km downstream from abandoned mine sites. Since other studies showed that there was contamination at least eight times further downstream, her methodology inflated the "background" numbers and minimized the amount of contamination that was identified.[liv]

A study by Albertus-Benham measured stream sediments at the North Cave Hills, South Cave Hills, and Flint Hills in order to determine if arsenic and uranium had migrated onto private lands. The results indicated that they had at all three locations. In some places, there were also elevated levels of selenium (up to 12 times background) and molybdenum (up to 16 times background). Arsenic levels were as much as 33 times background, and were elevated as much as 42 km (26 miles) downstream from mining areas. Uranium was as much as 23 times background and was elevated as far as 37km (23 miles) downstream. There was also elevated arsenic in the Bowman-Haley Reservoir, 60km (37 miles) away, but the researcher did not consider it to be clearly linked to mining.[lv]

An interesting finding for the North Cave Hills was that the sedimentation ponds built in 1989 and noted above, which were designed to stop contamination from moving downstream, were no longer working. In fact, the highest levels of contamination were found where each pond discharged into the stream, and the retaining structures were in danger of being undermined.[lvi]

Stone and Stetler concluded, "Significant environmental degradation has occurred from transport of heavy metals and radionuclides downstream of abandoned uranium mines…."[lvii] Some of these mining sites qualified for clean-up under CERCLA, the Superfund law. Remediation was done on at some sites in the North Cave Hills under this law, but there was inadequate funding to do complete cleanup.

FIGURE FOURTEEN: WIND DEPOSITION OF CONTAMINANTS AROUND MINE SITE IN THE NORTH CAVE HILLS, SD

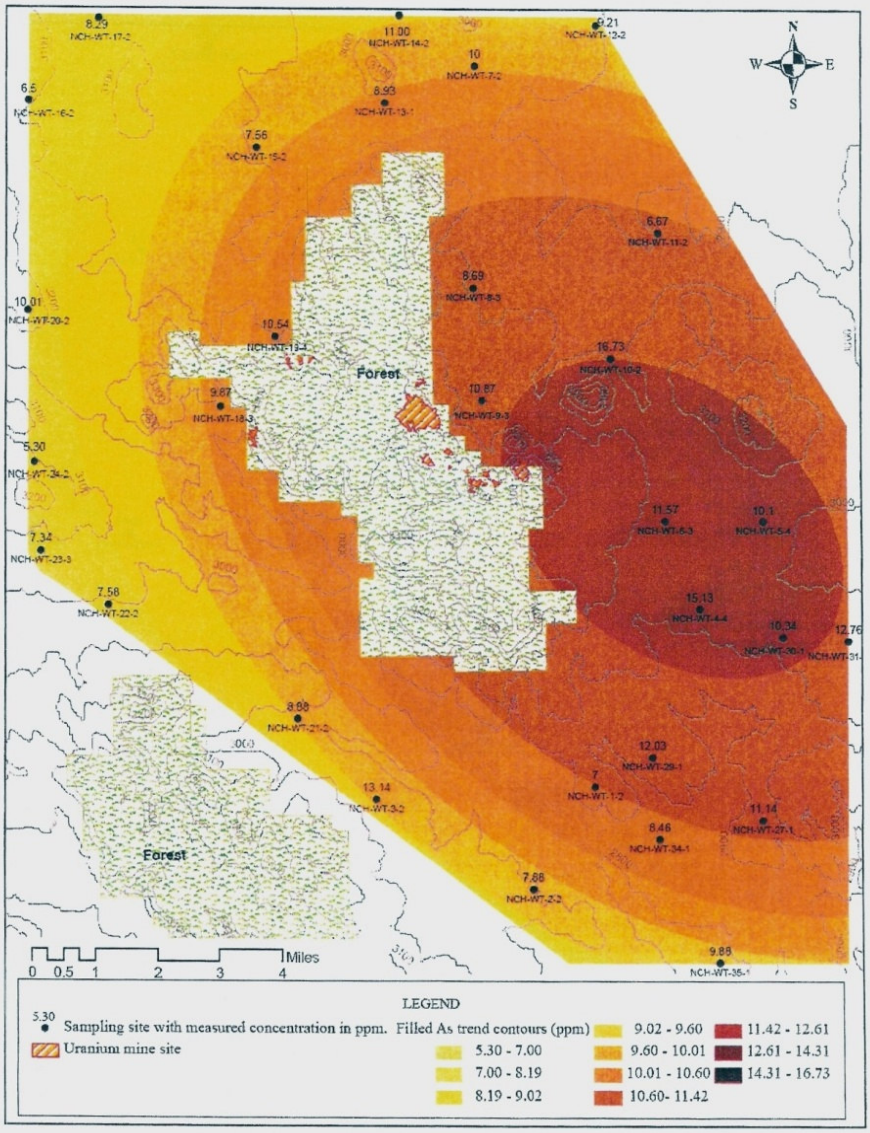


Figure 62. Map showing the global trend in the concentration of arsenic in the study area. Filled contour values may differ from measured values.

While all these studies were being done, farmers in the area asked for better clean up of the old mining areas. Tronox, Inc. was initially doing to do some clean up. It was a spin-off of Kerr-McGee Corporation, the company that had mined in Harding County. Unfortunately for local ranchers, when Tronox was made a separate company in 2006, Kerr-McGee made the new company responsible for environmental remediation and litigation costs. Not surprisingly, Tronox declared bankruptcy in 2009.[lviii] Nonetheless, this corporate maneuver let Kerr-McGee off the hook for cleaning up after its mining operations.

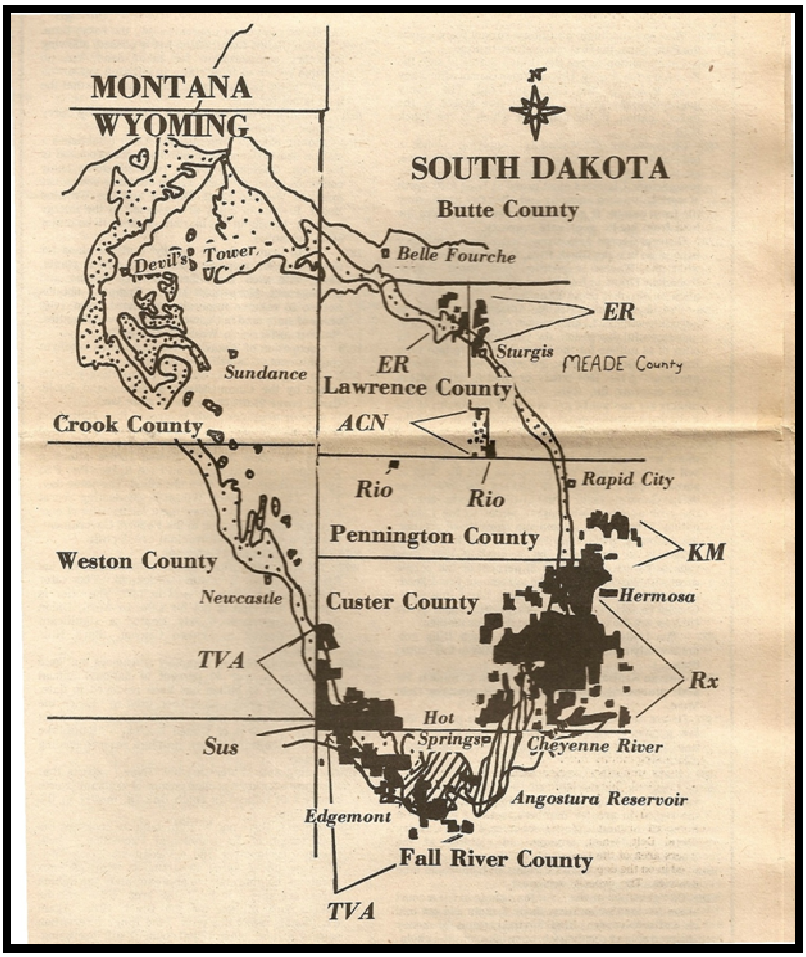
Today, local residents report that the trail to a local cave cannot be reached without going through radioactive spoils piles. Past mining destroyed archeological sites, and some that remain are too dangerous to visit. Mine dust still blows in the wind.[lix] And contamination flows toward the Cheyenne River and Standing Rock reservations in Lakota Territory.

IMPACTS IN SOUTHWESTERN SOUTH DAKOTA

There are at least 169 abandoned uranium mines and prospects in southwestern South Dakota in the Black Hills. The Hills are the sacred center of Lakota Territory, and digging up the ground is considered sacrilege. The majority of these mines are in Fall River County in the far southwestern corner of the state. There are also thousands of old exploration holes, a mill site at Edgemont, and ongoing problems with dangerous levels of radioactivity on the Pine Ridge Reservation.

Starting at the front end of the nuclear chain, exploration holes were drilled in the 1960s and 1970s along the rim of the Hills. Figure Fifteen shows where exploration was occurring in the late 1970s. As the map shows, uranium deposits are located in an oval around the outside rim of the Hills in the Inyan Kara geological formation.

FIGURE FIFTEEN: URANIUM LEASES IN THE BLACK HILLS: 1979



Exploration holes, as noted above, create pathways between groundwater aquifers, making it possible for contaminated water to pollute clean water. In the southern Black Hills, a 1980 study showed that these types of connections between aquifers exist near the town of Burdock. Unfortunately, this study only looked at aquifer connections, not at water quality. Other problems related to exploration have also been reported in the area, including "uranium test holes that were uncased, unplugged, and flowing at the surface." This wasted huge amounts of water, and water levels dropped in some wells.[lx] This created problems for ranchers and homeowners, who must then drill deeper wells.

Turning to mine sites, two studies of the southern Black Hills paint a dismal picture. Hall, a graduate student at the South Dakota School of Mines and Technology, prepared the first study in 1982. He identified 38 old mines at a time when old mine locations were not well documented. His research located 491 acres of disturbed areas and 390,620 square yards of spoils piles. He observed that, "Essentially no reclamation was done in the old mined areas," and that spoils piles were exposed and potentially dangerous.[lxi]

He also measured above-ground gamma rays, the most dangerous type of radiation associated with uranium mining. All the readings were at least four times higher than background levels, and one was 60 times higher than the background level. Measurements in adits were as much as 27 times higher than what the author set as a "safe" level for members of the public who visited the area.[lxii]

Besides looking at radiological hazards, the author looked at impacts on the land, noting, "Uranium mining usually involves considerable disturbances of surface lands and associated biota." Among the hazards identified were:

- Unplugged and hidden drill holes up to 8" in diameter and 200 feet deep, which were present at 30 out of 32 sites;
- Unreclaimed drill pads that were visible from the air;
- Numerous dozer scrapes, roads, and trenches that had not been revegetated;
- Eroded roads and spoils piles, including "extreme erosion" at half the sites;
- Mining trash at all the mines, with open pit mines being used as garbage dumps
- Blowing trash;
- 31 out of 32 mines were unfenced;
- Rims of open pit mines that were unstable;
- Cave-ins at underground mines;
- Two mines that "could easily be driven into at night as a result of their obscure nature;"
- Underground mines that were used as recreational sites and cattle shelters;
- Open pit mines that were full of water that was used by livestock and wildlife, and which also increased the presence of biting insects;
- Two unmarked and obscured mine ventilation shafts that were two feet wide and 60 feet deep. Hall provided a photo of his legs dangling into one of these holes, which was plenty large enough for a person to fall into.[lxiii]

Figure Sixteen shows the Ridgerunner mine, one of the sites considered in the study. Figure Seventeen shows the Darrow pit mine, which was also included in the study.

FIGURE SIXTEEN: RIDGERUNNER MINE, SOUTHWESTERN SOUTH DAKOTA

At best, the researcher continued, vegetation had returned to normal at 25% of the mined sites. Noxious weeds and selenium were common, but wild game was less common than in surrounding areas. The roads constructed for mining had brought more people into the area, increasing people's exposure to the mines' hazards.[lxiv]

Having said all this, the author was pro-mining. He feared that the impacts of unreclaimed sites hurt uranium mining's image. The negative impacts, he said, gave "radical groups" such as the Black Hills Alliance – an area organization -- fuel in their opposition to future uranium mining.[lxv]

The second study, done by Webb, Davis, and Hodge in 1995, looked specifically at conditions at old open pit mines. They collected water samples from two mines, a downstream stock dam, a nearby well, and the site of the former uranium mill in Edgemont, which had already been decommissioned at a cost of $33 million. One of the open pit mines was described as "a large, open pond of highly acidic and radioactive seepage water." [lxvi]

The study, done 13 years after the first research, recorded similar conditions: high radiation, cave-ins, collapsed sides of open pits, erosion of spoils, lack of revegetation, open ventilation shafts, unmarked open pits, and disturbance of surface lands. At the Diane-A mine, the levels of uranium in water were up to 500 times higher than background, and manganese was at 1.5 million times background. Contamination had reached the stock dam and ranch well below the mine, and it had reached Cottonwood Creek by the old uranium mill. The authors noted that the latter was a threat to groundwater, because the water in the creek's sediments and riverside wells could be linked to underground aquifers. Measurements of rare earth elements, which served as "markers," indicated that the mine was the source of the contamination in the well and the stock dam. [lxvii] To date, according to the State of South Dakota, four mines on US Forest Service land have been reclaimed, and a fifth has been partially reclaimed.[lxviii]

These problems are not unusual. As should be clear by now, mining poses a variety of risks. There are also major risks from uranium mills, and the former mill at the town of Edgemont has had dramatic impacts on the area. As noted above in the 1995 study, there were clear impacts on water even after the mill and its associated wastes had been removed and buried.

FIGURE SEVENTEEN: DARROW PIT MINE, BLACK HILLS

Uranium ore was milled just outside of Edgemont from 1956 – 1972. The mill site covered 213 acres, and 125 of those acres were covered with 2.5 million tons of tailings. When buildings and equipment were included, there were 5.4 million tons of radioactive wastes. The sand-like tailings blew across the area and were used in construction of houses and commercial buildings. A cluster of dwellings known as the Cottonwood Community was surrounded on three sides by mill operations, and windblown tailings "significantly contaminated" the area. Residents were estimated to receive radiation doses above the levels allowed by federal regulations. A basement room in one house had radiation levels 39 times the background level, and the family abandoned its home.[lxix]

The tailings also contaminated soil and plants. Soil at the tailings site had high concentrations of uranium, radium^{226}, lead^{210}, polonium^{210}, and gross alpha radiation. The highest uranium reading was 38 times higher than the highest offsite reading, and the highest rate for radium^{226} was 121 times higher. Uranium concentrations were significantly higher in plants, as well, providing a way for small animals to ingest high levels of the mineral.[lxx]

But the greatest damage was to surface water. In addition to the usual erosion, 200 tons of tailings washed into Cottonwood Creek in 1962 and were carried down the Cheyenne River. This is important partly because the Cheyenne River flows from Wyoming around the southern end of the Black Hills, across the corner of the Pine Ridge Reservation, and then acts as the southern boundary of the Cheyenne River Reservation before flowing into the Missouri River. Five studies of water quality have been done since the tailings spill. This research will be discussed in some detail, because of its implications for modern Lakota and their land base.

The first study was done by Tennessee Valley Authority – then the owner of the mill – as part of its plan for decommissioning the site. Unfortunately, the company averaged the results from 4-1/2 years of water sampling. Still, the highest uranium readings taken downstream of the mill were nearly 3 times more than the highest readings taken upstream of the site. Bottom sediments were also contaminated

with uranium, thorium, radium, lead, and polonium. More alarming, the highest uranium readings for groundwater at the mill were 71 times higher than the highest readings for wells that were away from the area.[lxxi]

The second study was done in 1988, 26 years after the accident. It was designed to show the safety of the area's water for irrigation, with a focus on Angostura Reservoir. The Reservoir is about 20 miles downstream from Edgemont and is a major agricultural and recreational water body. Unfortunately, Cottonwood Creek was used as a site for "background" water quality readings. This was noted as a problem in a later study.[lxxii]

The third study compared the 1988 data with 1994 data. Concentrations of uranium, selenium, boron, and molybdenum were comparable -- and high -- in both datasets.[lxxiii] In the fourth study in 1997, the Bureau of Reclamation looked at sediment contamination in the Cheyenne between Edgemont and Red Shirt, at the corner of the Pine Ridge Reservation. At the site nearest the reservoir's dam and at a downstream pond, the levels of uranium were elevated. Molybdenum and selenium were also elevated, and there were also higher levels of uranium contamination at Red Shirt. The authors noted that these minerals were associated with uranium mining in the area, and that the levels were higher than in the 1998 or 1994 data.[lxxiv] This indicated that the contamination was not getting better with time.

The fifth study is cited in the US Geological Survey's *Atlas of Water Resources in the Black Hills Area.* This 2001 study showed that the highest levels of uranium along the Cheyenne River were located in Edgemont and near the Pine Ridge Reservation. Elevated levels were present all along the Cheyenne River, and the authors noted that there had been uranium mining in the area. But they attributed the contamination to the outcrop of the uranium-bearing Inyan Kara formation.[lxxv] This seemed counterintuitive, considering the presence of dozens of unreclaimed mines and the 1962 tailings spill.

Taken together, the five studies track uranium contamination from the Edgemont mill site to the Reservation – a total of about 60 miles as the crow flies. On the Reservation, there have been chronic problems with radioactive contamination of water supplies. A 1980 community survey done by Women of All Red Nations showed higher levels of miscarriages and cancer than in a control population. In the same year, samples of groundwater showed high gross alpha levels at Red Shirt and ten other locations. Samples taken at Red Shirt in 1999-2002 also showed that gross alpha radiation was as much as four times the federal Maximum Contaminant Level (MCL). And a 2007 water sample taken just upstream of Red Shirt also found gross alpha radiation above the MCL. Signs were posted warning people not to use the water.[lxxvi]

Unfortunately, as for other past mining and milling, no water or sediment tests were done before uranium activities began, making it difficult to prove conclusively that uranium activities caused the contamination on the Pine Ridge Reservation. However, when high radiation levels can be traced from Edgemont to the Reservation along the Cheyenne River, the implications are clear.

The tailings at Edgemont were removed and buried at a site two miles to the south between 1986 and 1989. They were buried in an unlined disposal cell that had no groundwater monitoring system.[lxxvii]

In addition to the environmental impacts of uranium activities in southwestern South Dakota, Edgemont suffered the typical economic impacts as a result of the mining "boom and bust" cycle. After the uranium boom ended, the town's population dropped substantially, as workers sought employment elsewhere during the "bust" part of the mining cycle. Today, most buildings on the main street are

FIGURE EIGHTEEN: MAIN STREET IN EDGEMONT, SOUTH DAKOTA: 2010

empty, as shown in Figure Eighteen. A few bars, a municipal building, and the offices of a new uranium company are among the only operating buildings.

Rivers across western South Dakota have been impacted by past uranium mining and milling. The air, soil, groundwater, and economy have also suffered. But South Dakota has not experienced nearly as much uranium activity as Wyoming, to which we now turn.

IMPACTS IN EASTERN WYOMING

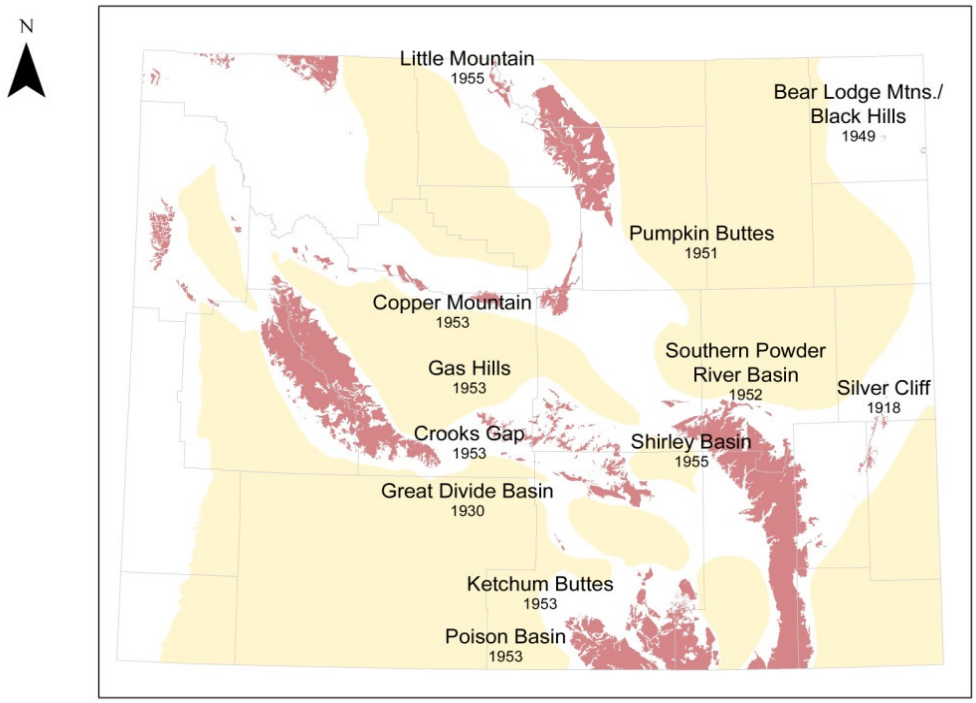
The state of Wyoming has more old uranium operations than any other state in Lakota Territory – over 2100 in the northeastern two-thirds of the state. There have been two boom-and-bust cycles for Wyoming's uranium industry. When the price of uranium dropped the last time, in the 1980's, all of the state's mills and nearly all of its mines shut down. Mining towns, like Jeffrey City in the central part of the state, quickly went bust. Businesses closed, homes became worthless -- or in company towns people simply lost their homes when they lost their jobs. Jeffrey City, shown in Figure Five, lost 95% of its population in just three years.[lxxviii]

Uranium was first discovered in Wyoming in 1918, at the Silver Cliff Mine, just west of Lusk. Uranium was eventually discovered throughout the state, so there have been a number of major uranium mining and milling areas. Different authors categorize the mining districts differently, and Figure Nineteen shows one author's categories. But for our purposes, mining areas in Lakota Territory will be broken down into the Powder River Basin, the Northern Black Hills, and the Gas Hills in the center of the state.

Pumpkin Buttes in the Powder River Basin became the first uranium district in the state in 1951 and extended from Campbell County west into Johnson County. Ore was taken to the mill at Edgemont, SD.[lxxix] To the south, the Monument Hill area produced 90% of the uranium mined in the Powder River Basin between 1953 and 1965. Most of this ore was also shipped to Edgemont, but there was also a uranium heap leaching facility -- aptly named the Spook Site -- located in Converse County. There, uranium was enriched between 1962 and 1965 and sent to the Western Nuclear mill near Jeffrey City. Heap leaching is literally making a heap of ore, then leaching the uranium out using acid. At the Spook Site, this left 55 acres of tailings, which were buried in an old open pit mine. Groundwater was contaminated both under the site and up to half a mile away with uranium, selenium, chromium,

molybdenum, radium, and other contaminants. The site is currently considered "stabilized," but there is still groundwater contamination.[lxxx]

FIGURE NINETEEN: URANIUM MINING DISTRICTS IN WYOMING AND YEAR THEY WERE DISCOVERED



In Johnson County, Cogema Mining (more recently Uranium One) has operated two in situ leach mines, the Irigary site and the Christensen Ranch site. From 1980 to 2000, 4.7 million pounds of uranium were recovered. In 2001, Cogema put its licensure on "possession-only" status.[lxxxi] It has since announced that it plans to restart mining at these sites.

The Christensen Ranch and Irigary sites, which are about seven miles apart, have been plagued with operational difficulties. According to the company's records, there have been over 1 million gallons of production and injection fluid spills at the two sites, both during past operations and after mining ended. At the Irigary project, spills at wellfields, ponds, and processing facilities between 1980 and 2004 totaled 463,164 gallons. This included both above-ground and below-ground spills. At Christensen Ranch, there were 628,109 gallons of spills and leaks between 1989 and 2004. There were also 34 underground "excursions" of mining fluids between 1992 and 2009. As of the end of 2009, seven of those excursions were still not controlled.[lxxxii]

Given these sloppy operations, it is not surprising that Cogema's own study indicated that post-restoration water quality at a Christensen Ranch mine field exceeded both "target restoration values" and federal or state groundwater standards. Groundwater standards were exceeded for radium^{226}, which was at 47 times the standard. And both target values and groundwater standards were violated for manganese, selenium, and uranium.[lxxxiii]

Further south in the Powder River Basin is the Highland area, which is still an active mining district. Historically, the area included a number of open pit mines, underground mines, and the Highland Mill, now owned by ExxonMobil, which operated from 1972 to 1984. While the impacts of past mining were not well documented in the Highland area, the impacts of milling have been recorded. At the Highland mill, the old tailings were buried, but a pit lake was left behind. It contained elevated levels of radon, gross alpha radiation, uranium, and selenium. In addition, a plume of contamination reached into the water under the tailings site. The company has denied that this pollution has migrated off the mill site. However, the Nuclear Regulatory Commission stated that there is offsite pollution, which includes contamination of a local well.[lxxxiv]

The second area under consideration here is the northwestern part of the Black Hills, which stretch into Wyoming. In that area, uranium production began in 1953 and continued until 1968, and the ore was milled at Edgemont. In the early 1970s, there was renewed exploration just west of Oshoto. Over 5500 exploration holes were drilled in the area, and a small in situ leach test was done to determine the feasibility of mining the deposit. In 1979, restoration at this project, known as the Nubeth site, was described as "imminent." Uranium, molybdenum, and vanadium were still above "upper restoration limits" (URL) approved by the NRC and the State of Wyoming. Uranium was 4.5 times higher than the URL, and vanadium was 88 times higher. The URLs, in turn, allowed contamination that was several times higher than pre-mining standards for radium, gross alpha radiation, and gross beta radiation. By 1982, restoration was described as "nearing completion."[lxxxv]

Currently, there is no uranium mining in the Black Hills. However, due to the increase in uranium prices, corporations are again exploring and planning ISL projects in the northwestern Black Hills, as will be discussed in more detail below.

The third uranium mining district within Lakota Territory and Wyoming is known as the Gas Hills district. It is in the central part of the state and – while spread out – focuses on Jeffrey City and Riverton. The Gas Hills district produced large amounts of uranium beginning in 1953. One mine is shown in Figure Twenty.

In the Gas Hills district, ore was milled at a number of sites. Early in the nuclear era, there was a mill at Riverton, operated by Susquehanna Western. The Riverton mill contaminated 115 acres, 72 of which were covered with 900,000 tons of tailings. These materials were buried between 1988 and 1990, but have been allowed to pollute the Little Wind River. Over time, three more major mills were built along the Natrona County–Fremont County line. These were operated by Federal-American Partners, Utah International (later Pathfinder and then Cogema), and Union Carbide Corporation (now UMETCO). The Union Carbide operation included both a conventional mill and a heap leaching operation. Two additional heap leaching mills were located at Western Nuclear's Split Rock and Day Loma sites.[lxxxvi]

Information is available on the three major mills, all of which left serious contamination behind them. The Utah International/Pathfinder mill, also known as the Lucky McMill, operated from 1958 to 1988. The milling left behind 241 acres of tailings that contaminated both ground and surface water. In the attempt to reclaim the site, 217 million gallons of contaminated water were pumped out of the tailings, and another 197 million gallons were pumped out of the ground and replaced with fresh water. It didn't clean up the site and, as in other situations, reclamation was expensive. Eventually the company and the government gave up.[lxxxvii]

FIGURE TWENTY: OPEN PIT URANIUM MINE: GAS HILLS, WYOMING

Instead of forcing the company to reclaim the site, the Nuclear Regulatory Commission (NRC) changed the reclamation standards to make them fit the situation. This is a common move in uranium reclamation that is known as "relaxing" water quality standards. In this situation, a company asks a government body to declare its current water reclamation efforts – however poor – to be "within the law." The current water quality standard is "relaxed" (raised), and more contamination is allowed. Then the company only has to meet the higher standard for its reclamation efforts to be considered successful. This may leave water many times more contaminated than current regulations allow. Table Four shows what happened at the Pathfinder mill. Uranium contamination that was 15.5 times higher than the current standard became "legal." As a result of these "relaxed" standards, reclamation at the Pathfinder mill was declared complete in 2004.[lxxxviii]

TABLE FOUR: RELAXED GROUNDWATER STANDARDS AT PATHFINDER MILL

CONTAMINANT	CURRENT STANDARD	RELAXED NRC STANDARD AT PATHFINDER MILL	NRC STANDARD = x TIMES CURRENT STANDARD
Uranium (milligrams/liter)	.11	1.70	15.5
Selenium (mg/l)	.01	1.10	110
Nickel (mg/l)	.09	.85	9.4
Radium226 + 228 (picoCuries/l)	5.0	7.50	1.5

The NRC also relaxed federal water quality standards at Western Nuclear's Split Rock mill near Jeffrey City, which operated from 1958 until 1984. The federal Department of Energy knew that it would eventually become the custodian of the mill wastes and objected to the idea. But the NRC made the changes anyway. There was also groundwater contamination, but the NRC let the company stop

reclamation that was designed to contain the pollution – allowing clean groundwater to become contaminated.[lxxxix]

At the Union Carbide/UMETCO site, the story was similar. The mill, which operated from 1960 to 1979, was dismantled, and tailings were moved into an old open pit mine. Some of the topsoil used to cover the old pits was dangerously radioactive, so the NRC relaxed the air quality standard for radium^{226} and allowed levels that were three times higher than the standard. Groundwater was also contaminated, and the company asked the NRC to relax water quality standards. The NRC obliged, as shown in Table Five. In this case, gross alpha radiation that was 350 times higher than the current federal standard became "legal."

TABLE FIVE: RELAXED GROUNDWATER STANDARDS AT UMETCO MILL

CONTAMINANT	CURRENT STANDARD	RELAXED NRC STANDARD AT UMETCO MILL	NRC STANDARD = x TIMES CURRENT STANDARD
Uranium (milligrams/liter)	.29	34.1	117.6
Selenium (mg/l)	.01	.53	53
Nickel (mg/l)	.04	9.34	233.5
Radium226 + 228 (picoCuries/l)	24.9	353	14.2
Arsenic (mg/l)	.05	1.8	36
Gross alpha radiation (pCi/l)	17.8	6223	349.6
Lead210 (pCi/l)	4.6	46.7	10.2
Thorium230	6.6	57.4	8.7

These were the impacts of conventional mining and milling operations. In addition to the Nubeth site, mentioned above, information was also collected on three additional old ISL mines. Company employees wrote a 1984 article about these three pilot projects – the Bison Basin, Leuenberger, and Reno Creek projects. These projects were very small -- two used only one set of wells, and the third used two sets. The projects were also short-term, as each operated for only a few months.[xc] So these small, brief projects might be expected to have little environmental impact, compared to decades-long projects with hundreds of wells.

Nonetheless, where post-restoration numbers were provided, they were stunning. At the Leuenberger project, radium remained nearly twice baseline (pre-mining) levels at the end of the project. More detailed information was provided on the Reno Creek project, which showed that post-mining uranium was as much as 122 times higher than the baseline level. At the Bison Basin project, the average concentration of uranium was 85 times higher than baseline. Bicarbonate, magnesium, manganese, calcium, zinc, and radium^{226} were also above baseline.[xci] What was perhaps most interesting about this article was that the authors were bragging about the "success" of their efforts.

In the portion of Wyoming that is within Lakota Territory, the environmental impacts of past uranium activities continue. Mill sites continue to pollute water because of the NRC's willingness to relax water quality standards to whatever level a company thinks is financially beneficial – and thus "good enough."

According to the State's Abandoned Mine Land Project Manager, there have been only 49 reclamation projects for old uranium mines, mostly large open pit mines.[xcii]

While the impacts of uranium activities on the portion of Lakota Territory that is now within Wyoming have not been thoroughly measured, the information that is available is not encouraging. There is clearly a lot of contamination that is not being cleaned up, and monitoring of old sites appears superficial. The lack of information can be attributed, at least in part, to the large number of mines. But the state is also economically dependent on energy mineral extraction, which would not encourage close study of the problems associated with uranium activities -- or consistent, strong regulatory action. State-level factors are, however, no excuse for repeated actions by federal regulators that have relaxed standards and allowed continued contamination of this portion of Lakota Territory.

IMPACTS IN NORTHEASTERN COLORADO

The Great Plains of Colorado formed the southwestern portion of Lakota Territory. In the 1950s-1970s, there were about 387 uranium mines and prospects in northeastern Colorado, as well as a test facility for in situ leach uranium mining. Most of these sites were small and were located in the South Platte River watershed. The larger uranium mines and the mills in Colorado have been located on the western slope of the Rocky Mountains along the Utah border.

In the Platte River watershed, exploration and mining took place in South Park, North Park, and along the Front Range of the Rocky Mountains. See Table Six for information from the Environmental Protection Agency about the number of sites in each county along the Front Range, which is by far the most populous area within Lakota Territory. To illustrate, Table Six also includes information on population and population growth.[xciii]

TABLE SIX: OLD URANIUM MINES AND DEMOGRAPHIC INFORMATION FOR NORTHEASTERN COLORADO

COUNTY	NUMBER OF OLD URANIUM SITES	2008 COUNTY POPULATION	PERCENT GROWTH SINCE 1985
Boulder	25	293,161	40%
Jefferson	47	533,339	26%
Larimer	31	292,825	72%
Weld	35	249,775	92%

There is no available research on contamination from past exploration, open pit mines, or underground mines. However, there has been elevated uranium in groundwater in an area that included small mines in central Larimer County, the Glacier Meadows area. In 2005, tests there revealed uranium levels that were as much as five times higher than federal drinking water standards.[xciv]

There are at least 2,600 abandoned exploration holes in the Wyoming/Nebraska/Colorado border region.[xcv] Figure Twenty-One shows holes in eastern Weld County that were not capped or filled. These holes pose a threat to groundwater, especially if ISL mining is started in the area, as planned.

FIGURE TWENTY-ONE: UNCAPPED DRILL HOLES NEAR KEOTA, CO

In addition to open pit and underground mining, there was experimental in situ leach mining in the late 1970s near the town of Grover, CO. The experiment, which was done by Wyoming Mineral Corporation, left elevated levels of gross alpha radiation, gross beta radiation, molybdenum, ammonia, nitrate, and selenium in the water. More troubling in the long run was the fact that, after the State signed off and said that the mine had been restored, the amount of contaminants in the water actually rose.[xcvi]

This indicated that the contaminated water that had been sucked out of the mining area during the "restoration" process was only part of the problem. After the company and the State considered restoration complete, contaminated water was still moving around underground. This was significant, because closed ISL mines only have to be monitored for a short period of time. Radioactive contamination, however, lasts for thousands of years. Contaminated groundwater may not reach people's wells for decades – or longer -- by which time mining companies are usually long gone.

Clearly, past uranium operations have had significant impacts in Lakota Territory. Past activities have left contamination from Montana and North Dakota to Colorado. Air, soil, stream sediment, and both surface and groundwater have been polluted. The end of the last uranium rush in the 1980s did little to correct this situation, as few mines were cleaned up and plumes of contamination reached out from old mining and milling sites. In Wyoming, the Smith Ranch – Highland mines continued to operate, and in western Nebraska the Crow Butte mine opened.

But, across Lakota Territory, the uranium was still in the ground, and mining companies still knew where it was located. All it took was talk of a "nuclear renaissance" for companies to return to former mining areas. So beginning in the mid-2000s, exploration activities began again. Companies staked claims, leased private land, and began to publicize their proposals for new uranium projects. Most of these proposals were for in situ leach mines. This report concludes with a summary of the current proposed and operating uranium projects in Lakota Territory.

CURRENT AND PROPOSED OPERATIONS

There are a number of current and proposed uranium operations in Lakota Territory. This section begins with a discussion of the one mine that has begun operation since the last "bust" in the uranium industry.

Western Nebraska

The Crow Butte in situ mine near Crawford, in the far northwestern part of Nebraska, began operating in 1991 and is owned by Cameco. The mine is about 70 miles from the Pine Ridge Reservation and operates in the Chamberlain Pass formation. A proposal to enlarge the mine is currently under consideration by the Nuclear Regulatory Commission. Citizens in the area, including individuals and an organization from the Pine Ridge Reservation, are formally opposing this proposal.[xcvii]

The Crow Butte mine, like other in situ mines, has had its share of problems. Those related to water quality have included:

- Failing to report the release of well development water onto the ground for nearly three years;
- Constructing mining wells in a manner that could have allowed contaminants to move into drinking water;
- Failure to restore water to baseline conditions after mining was completed, including contamination from alkalinity, arsenic, calcium, magnesium, potassium, radium[226], and vanadium;
- During the restoration process, levels of contaminants actually increased, leading the NRC to deny approval of the mine's clean-up process; and
- At least 35 violations of the mine's license to operate, including:
    - Wells that failed a mechanical integrity test;
    - Leaks in evaporation ponds;
    - Excursions of mining fluids out of the mining area; and
    - A 10,260-gallon spill of mining fluid.[xcviii]

In 2006, there were wildfires east of the Crow Butte central processing plant, and evacuation was discussed. This threat to in situ plants is commonly overlooked, but wildfires are common on western prairies.[xcix] Photos of the Crow Butte mine show tall grass – which is used to argue that the mine does not hurt the land. However, the area is also not grazed as much as surrounding ranchlands. And the tall grass provides plenty of fuel for wildfires.

Western North Dakota

At least two companies are exploring for uranium in Billings and Slope Counties in southwestern North Dakota. Prospect Uranium, Inc., has leased more than 1,000 acres for its Connors project, which might include in situ leach mining and/or open pit mining. Formation Resources, Inc., a subsidiary of Australian company PacMag Metals, has received exploration permits from the state. These are the first exploration permits issued in North Dakota since 1980. The permits cover exploration at the company's Sentinel project, which would extract uranium, germanium, and molybdenum. The company has said it wants to use an acid heap leaching process.[c]

Eastern Wyoming

Wyoming is the most active uranium mining area within Lakota Territory. There are both exploration and, as noted above, operating in situ leach mines.

The Smith Ranch and Highlands mines, which are both owned by Power Resources, Inc. (now Cameco), are usually considered one mining project. Together, they constitute the nation's largest in situ leach uranium mine. Some mine facilities are shown in Figure Twenty-Two.

FIGURE TWENTY-TWO: SMITH RANCH - HIGHLAND IN SITU LEACH URANIUM MINE FACILITIES IN WYOMING

Problems in past years were talked about earlier, and they continue. The Highland portion of the operation was suspended for several years, but was restarted in 2007. Since then, the company has been cited for failing to report uranium solution excursions into the surrounding aquifer and for a 198,500-gallon spill of injection fluid.[ci]

The Smith Ranch portion of the operation has been cited for violations that include:

- Failure to cap drill holes and monitoring wells;
- Failure to decommission mine units in a timely fashion;
- Radiation levels that exceed the public dose limit;
- Failure to store and control materials properly; and
- Hiring an unqualified radiation safety officer.[cii]

There have also been numerous spills.

The mines' most severe public relations setback came in 2008, when the State of Wyoming's Department of Environmental Quality apparently lost patience with the problems at the Smith Ranch-Highlands operation. The State issued a Notice of Violation citing, among other things:

- An "inordinate number of spills, leaks and other releases";
- Inadequate reclamation;

- Complete disturbance of native vegetation and soils (see Figure Twenty-Three);
- Surface and groundwater contamination;
- Reclamation that was taking three times as long as allowed by the company's permit; and
- Bonds designed to cover reclamation, in case the company left or went bankrupt, were woefully inadequate.[ciii]

The company and the state reached a settlement in which the company paid a fine of $900,000, with $400,000 suspended for good behavior. The company agreed to pay $500,000 for future, unspecified environmental projects. Bonding was increased to about half of what the state had said could be necessary in its Notice of Violation.[civ]

FIGURE TWENTY-THREE: SMITH RANCH IN SITU LEACH FIELD, WYOMING

In addition to the operating Smith Ranch-Highlands project, Uranium One proposes to restart the Irigary and Christensen Ranch projects. The Irigary project shut down in 1994, and the Christensen Ranch project shut down in 2000. In 2006, the company's predecessor, Cogema, began the process of amending their license from "nonoperating" to "operating" status. This process was completed in 2008, and the company has all the permits needed to resume mining. Past spills and leaks at these sites were noted above. In 2010, Uranium One completed its purchase of the mines and announced that it planned to incorporate three other facilities – Moore Range, Ludeman, and Allemand-Ross – under the same license.[cv]

A number of companies also plan to start new mines. As of the end of 2009, fifteen facilities are expected to apply for Nuclear Regulatory Commission permits, seven of them in the Powder River Basin. Energy Metals Corp., a subsidiary of Uranium One, intends to start an in situ mine at Moore Ranch in the Powder River Basin. This is the first uranium recovery facility application to the Nuclear Regulatory Commission since 1988.[cvi]

At least three companies are exploring along the northwestern Black Hills: Peninsula Minerals, Bayswater Uranium, and Powertech Uranium. Bayswater is closest to beginning a mining operation. It is also active in Campbell County, as is Uranerz Energy, which is exploring in the Pumpkin Buttes area. Strathmore Minerals is exploring in the Gas Hills district. [cvii] Because these operations are often "below

the radar" until claims or leases are made public, and because companies have been changing their names and buying each other out at a rapid pace, it is difficult to tell exactly what is going on. Nonetheless, citizens' organizations are attempting to do just that and to stop mining companies' proposals.

The existing in situ leach operations, the permitting of the Christensen Ranch-Irigary project, and the many exploration activities insure that eastern Wyoming will remain the most active uranium mining area within Lakota Territory.

FIGURE TWENTY-FOUR: EXPLORATION AT THE DEWEY-BURDOCK PROJECT

Western South Dakota

Four companies are known to be exploring in western South Dakota. The most active project is a proposed in situ leach mine along the Wyoming border, at the southwest corner of the Black Hills in the heart of Lakota Territory. This is known as the Dewey-Burdock project. Powertech Uranium, the company that proposes the mine, has been doing exploration drilling, as shown in Figure Twenty-Four. The company is working on getting the necessary permits from the US Nuclear Regulatory Commission, US Environmental Protection Agency, US Bureau of Land Management, and the state Department of Environment and Natural Resources.[cviii]

The company's original proposals to the NRC and the State were so inadequate that the company had to rewrite and resubmit them. The NRC said that, if the company did not withdraw the application, it would be rejected.

Local citizens are formally opposing the NRC application and have also been active in the State permitting process. Uranium mining has been successfully opposed in the past in the Black Hills, partly

because of staunch Lakota protection of their sacred area. There will undoubtedly continue to be resistance to uranium mining proposals in this area.

Northeastern Colorado

Six uranium companies – including companies from Canada and Australia – are exploring for uranium in northeastern Colorado. One of these, Powertech Uranium, is currently doing exploration work in Weld County along the Wyoming border, as shown in Figure Twenty-Five. This is called the Centennial project. The company's plan is to do in situ mining on part of its deposit and open pit mining on the other part. The proposed open pit mine is only seven miles from Fort Collins, a college town of 100,000 people. The proposal is being effectively opposed by local organizations, and the state legislature passed three pieces of legislation in 2008 that will make in situ uranium mining difficult.[cix]

FIGURE TWENTY-FIVE: EXPLORATORY DRILLING IN WELD COUNTY, CO: 2007

South Park in Park County has been the other active area in the South Platte River watershed. There, citizen opposition convinced New Horizon Uranium Corporation to abandon any immediate plans after it had made numerous uranium claims. Uranium mining in South Park was opposed by, among others, Denver Water, Colorado's largest water utility. The utility was concerned that the project would add radiation to its water source and lead to the need for more expensive water treatment.

There are several reasons that opposition to uranium mining has been relatively successful in northeastern Colorado. First, it is more difficult to "sell" uranium mining when 275,000 people live within twenty miles of the proposed mine. Second, the northern Front Range is one of the most highly educated areas in the nation. This means that experts are available who can rebut uranium company claims that mining will be safe. Third, healthcare professionals have taken the lead in opposing mining based on its negative health impacts. This is a powerful and respected segment of the population.

SUMMARY

Lakota Territory has been the site of extensive uranium activities since the dawn of the nuclear age. Some have been large. Some have been small. But from exploration to mining to milling, these activities have left a mark. Past and ongoing contamination has impacted water, soil, plants, livestock, wildlife, air, and people. Cultural and historical resources have been destroyed and continue to be threatened. The boom and bust cycle has created instability for local economies and communities.

Plans to begin, resume, or expand open pit and in situ leach mining threaten to expand the destruction. But Lakota people and their allies are opposing many mining proposals and are meeting with some success.

Unlike in the early years of the nuclear age, the impacts of the front end of the nuclear chain are now well known. People are becoming more aware of the results of these dirty operations, and there is strong opposition to the idea of a "nuclear renaissance." Whether public opposition, market forces, or other factors will prevent future uranium activities remains to be seen. But the issue is sure to remain contentious in much of Lakota Territory.

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