DOE Remediation of Uranium Mills: A Progress Report

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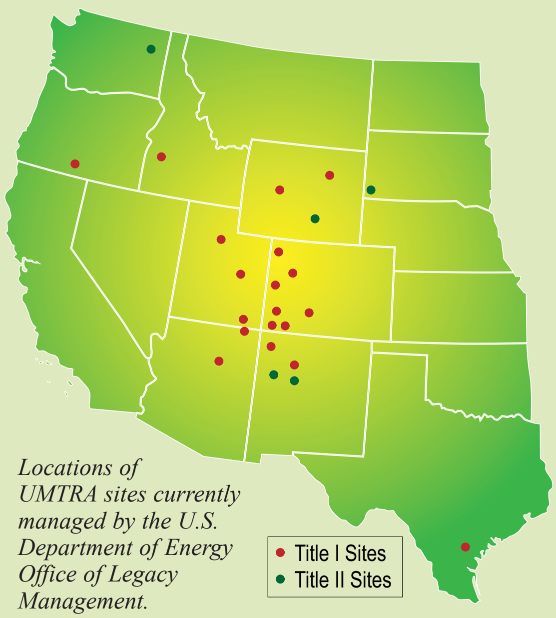
Surface and underground mining of uranium occurred in the United States throughout much of the 20th century, mostly in Colorado, Utah, New Mexico, and Wyoming and on tribal lands. Most uranium production was carried out under contract with the Atomic Energy Commission (AEC) for use in defense research and weapons development. Decades of unregulated uranium-ore processing resulted in uncontrolled mill tailings ponds and piles, and contaminated fluids discharged to surface drainages and groundwater. Many facilities were abandoned after government contracts were fulfilled, leaving the land and groundwater contaminated. Other facilities continued to operate, largely to support the nuclear power industry.

Federal Responsibilities Assigned

Before the 1950s, the federal government imposed few regulations on the mining and processing of uranium. In 1954, AEC was given regulatory authority over the production and use of nuclear materials. Its authority began when ores were received at processing mills, leaving other entities such as state agencies to regulate uranium mines.

Potential hazards at the ore-processing facilities from direct gamma radiation, radon gas emissions, and dissolved contaminants in groundwater and surface water began to be recognized in the 1960s, but it was not until 1974 that Congress called for a systematic inventory of inactive mill sites. Thousands to millions of cubic meters of contaminated materials were identified at individual sites; contaminated land areas ranged from about 25 to 600 acres. Off-site locations were often affected by windblown contamination. Seepage from tailings piles and leaky evaporation ponds resulted in groundwater contaminant plumes, typically extending from 600 to 3,000 feet or more. Aqueous-phase contaminants consisted mostly of inorganic constituents that included arsenic, cadmium, chromium, lead, molybdenum, nitrate, selenium, radium isotopes, and uranium. Uranium concentrations in groundwater ranged from less than 0.01 milligrams per liter (mg/l) to 10 mg/l.

Seepage from tailings piles and evaporation ponds resulted in groundwater contaminant plumes extending 3,000 feet or more.



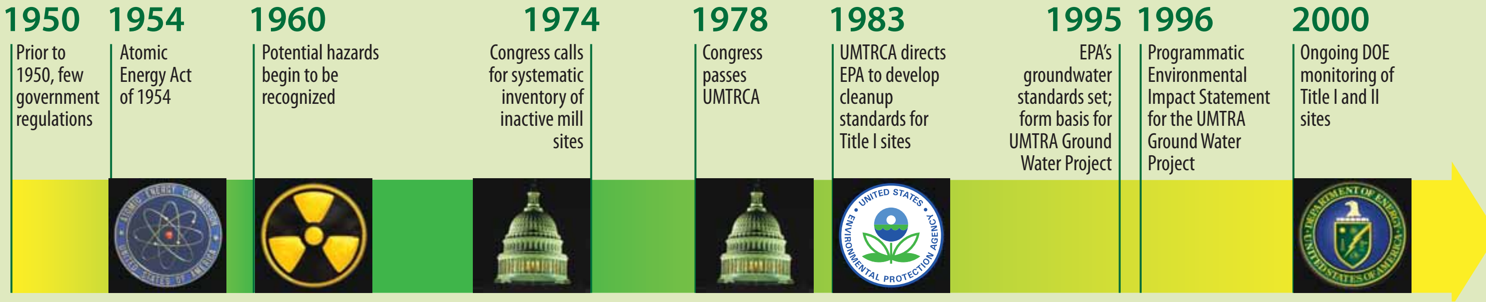
Locations of UMTRA sites currently managed by the U.S. Department of Energy Office of Legacy Management.

In 1978, Congress passed the Uranium Mill Tailings Radiation Control Act (UMTRCA), directing government agencies to stabilize, dispose of, and control materials contaminated by milling operations in a safe and environmentally sound manner (it does not address mine sites; see sidebar). Title I of UMTRCA required the Department of Energy (DOE) to complete remediation at the 22 then-inactive uranium mill sites and Title II directed the Nuclear Regulatory Commission (NRC) to regulate active facilities. DOE is the long-term custodian for both types of sites after cleanup and decommissioning is complete.

UMTRCA directed the Environmental Protection Agency (EPA) to develop cleanup standards for Title I sites. In 1983, EPA's final cleanup and disposal standards for inactive mills were challenged in court and upheld except for the groundwater standards. As a result, the surface cleanup program moved forward, and groundwater cleanup was deferred until groundwater standards could be finalized. DOE established the Uranium Mill Tailings Remedial Action (UMTRA) Project and began work on the UMTRA Surface Project in 1983. Processing sites were remediated in accordance with EPA standards for contaminated buildings, tailings, and soils. Tailings were placed in on-site or off-site engineered cells for final disposal. Low-permeability radon barriers (clay or silt) covered the disposal cells, typically overlaid by a layer of granular bedding material to provide a capillary break, and surface layers of rock for erosion protection. Drain systems for collecting tailings leachate were installed at most disposal sites, and ditches were frequently used to divert surface water away from the cells.

Groundwater Standards Set

EPA's groundwater standards for cleanup and disposal of inactive uranium-ore processing sites were finalized in January 1995 and formed the basis for implementing the UMTRA Ground Water Project. The final regulations established numerical groundwater protection standards for uranium, molybdenum, and other metals common to processing sites along with constituents known to occur there, such as lindane and nitrate. The regulations also provide for the use of background concentrations (in groundwater unaffected by uranium-ore processing), alternate



concentration limits, or supplemental standards for groundwater protection. Alternate concentration limits may be higher than maximum concentration limits or background but are still protective of human health and the environment. Supplemental standards apply to aquifers of naturally poor quality or low yield.

DOE's Programmatic Environmental Impact Statement for the UMTRA Ground Water Project (DOE, 1996) provided a framework for characterizing groundwater at the inactive processing sites, assessing potential risks, and selecting an appropriate strategy for meeting EPA groundwater standards. Remediation strategies were selected in consultation with NRC, the states involved, and tribes where applicable.

Strategies for Meeting Compliance

Three general compliance strategies were identified: no action, natural flushing, and active remediation. The no-action alternative was applied to sites where groundwater constituents did not exceed background concentrations, maximum concentration limits, or supplemental standards; it was also considered for sites where alternate concentration limits could be established that were protective. Active remediation was applied to sites needing relatively aggressive groundwater cleanup methods to achieve standards, such as manipulation of hydraulic gradients, groundwater extraction and treatment, or in-situ remediation. Natural flushing (similar to what EPA calls monitored natural attenuation) was applied to sites where natural attenuation processes are considered a viable route of achieving groundwater standards within 100 years. Groundwater modeling is generally required to support a natural flushing decision, and performance monitoring of the system is required to measure progress in meeting cleanup goals.

Surface remediation is considered complete at all 22 of the original Title I processing sites. DOE has responsibility for managing and monitoring the long-term integrity of 19 Title I disposal cells. Groundwater remediation is considered complete for 12 Title I processing sites where a no-action alternative groundwater compliance strategy was selected, but some continue to be monitored. For 10 Title I processing sites, active remediation

see DOE, page 35

Meanwhile, Back at the Mine Sites

While UMTRCA and its related programs address problems related to uranium *mill* sites, who looks after the more than 4,000 *mines* with a history of uranium production that are listed in EPA's database? Mines fall under the purview of several EPA statutes, including the Clean Water, Safe Drinking Water, and Clean Air acts and various programs under them, for which most states and many tribes have primary enforcement responsibility. Mines on federal lands also are subject to requirements enforced by Department of Interior agencies.

Recently, EPA completed a study of Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) from uranium mining (2008), which examined the nature and risks of mine wastes. Mine waste classified as TENORM includes ore of insufficient quality to be mined, waste rock, drill core and cuttings, and mine and pit water. The volume of such waste generated by open-pit mines far surpasses that of underground mines, and has been estimated to be three billion metric tons nationwide.

According to EPA, most abandoned uranium mines are likely to have elevated concentrations of uranium and radium, as well as other constituents such as arsenic, but two factors reduce the risk to most human populations: location and climate. Most abandoned mines are on federal land, where primary exposure is through short-term recreational activities that entail only minimal health risk. And many are in areas with low precipitation and deep groundwater, so the risk of groundwater contamination is low, at least for the short term (tens of years). In contrast, those who live close to mine sites and use mine waste in building materials (as occurred on the Navajo reservation) face substantial health risks.

Federal, state, and tribal agencies have worked to prioritize remediation and closure of abandoned mine sites, but budget constraints will preclude remediation of them all. Hundreds of small mines likely will be left alone. But at the other end of the scale, over 500 abandoned uranium mines have been identified on the Navajo Nation, and earlier this year EPA, the Department of Energy, Bureau of Indian Affairs, Indian Health Service, and the Nuclear Regulatory Commission finalized a five-year plan for remediation of these mines. Several removal actions addressing contaminated sites and structures have been undertaken on the reservation through EPA's Superfund program.

Reference

EPA, 2008. Technologically Enhanced Naturally Occurring Radioactive Materials from Uranium Mining, vols. 1 & 2, www.epa.gov/rpdweb00/tenorm/pubs.html.

DOE, continued from page 27

(at three sites) or natural flushing (seven sites) was the selected compliance strategy, and remediation is ongoing.

Active groundwater remediation has generally been conducted at most Title II sites, though specific remedies vary. For many of the completed sites, remediation has not achieved background levels or maximum concentration limits and applications have been submitted to NRC for alternate concentration limits. NRC must approve cleanup of Title II sites, including groundwater, before the license is terminated and the site transferred to DOE for long-term custody. Ongoing groundwater monitoring is generally required at these sites along with annual site inspections. In addition to the five Title II sites that have transferred to DOE, several are in transition, with target transfer dates ranging from several months to many years away.

Monitoring Continues

DOE regularly monitors groundwater at completed Title I and Title II sites to verify that constituent concentrations remain below alternate concentration limits and evaluate progress toward site cleanup goals where active remediation and natural flushing are employed. This evaluation is largely based on observing trends in site-related constituents such as uranium and nitrate. Immediately following the selection of a groundwater compliance strategy, groundwater sampling typically occurs quarterly to semiannually; sampling is decreased to annually or every five years once baseline data or trends are established.

Annual inspections of disposal cells are required. The cells seem to be performing as expected: minor seepage over the very long-term design life (1,000 years) has been recognized as unavoidable, but effects are confined to the immediate vicinity of disposal areas and are not expected to adversely affect water resources outside site boundaries. Established long-term-monitoring plans provide criteria that trigger certain actions if disposal cells require maintenance.

Continued monitoring of groundwater at most UMTRA Ground Water Project sites still under remediation indicates that contaminant concentration levels are either remaining relatively constant or gradually decreasing. At some sites, residual contamination in the subsurface appears to provide an ongoing source of dissolved constituents. Trend analyses at several sites indicate that it may take multiple decades before all residual contamination is removed. Because natural flushing sites have 100 years to achieve compliance, assessing performance based on a relatively short monitoring record is a challenge, particularly given the uncertainty associated with subsurface flow and transport.

Contact Judy Miller at judy.miller@lm.doe.gov for more information.

Reference

DOE, 1996. Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project, DOE/EIS-0198, September. www.lm.doe.gov/documents/3_pro_doc/guidance/gw/peis/umtraTOC.htm