Chapter 5. Conclusion

Uranium, a naturally occurring element, contributes to low levels of natural background radiation in the environment, and is found in virtually all rock and soil, as well as groundwater. Contained in a variety of ore bearing rocks, it can be extracted and chemically converted into uranium oxide or other chemical forms usable in industry. Uranium undergoes radioactive decay into a long series of different radionuclides before finally reaching a stable state as lead. These radionuclides each emit alpha or beta radiation, and some also emit gamma radiation of widely varying energies. Some of these progeny radionuclides are highly radioactive and can pose significant human health risks, most notably radium and the radioactive gas radon.

Mining is the process by which mineral and metal bearing ores are extracted from the earth. Protore is mined uranium ore that is not rich enough to meet the market demand and price. This subeconomic ore is often stockpiled at the mine site for future exploitation under the appropriate economic or market demand conditions. Radioactive waste materials for which EPA, Tribal, state, or local government agencies have statutory authority, that are or could be classified as TENORM from conventional open-pit and underground uranium mining include overburden (although most overburden is not necessarily enriched in uranium as is protore), unreclaimed protore, waste rock, evaporites from mine water, mine and pit water, drill core and cuttings, and refuse. Liquid and solid waste materials generated at heap leaching, ISL, or uranium mills are considered byproduct that is regulated by the NRC or its Agreement States.

Most uranium mining in the United States took place in the Colorado Plateau region straddling the Four Corners where Utah, Colorado, New Mexico, and Arizona meet, though more than a dozen states have hosted uranium mines during the last century. Significant changes in the uranium market price for uranium after the early 1980s previously resulted in inactivation or closing nearly all mines and uranium mills in the country. Recent increases in uranium price and demand have resulted in renewed interest in re-opening mines that were closed or on standby. While some mines focus on extraction of just uranium minerals, many mines have produced uranium along with a host of other valuable minerals that were found together in the same rock ore.

The early small mining endeavors generated small quantities of waste typically discarded within a few to hundreds of feet (100 meters) of the mine opening or pit. Major surface mines tend to disturb large surface areas from the extent of both the pit and the spoils areas. Generally, tens to hundreds of acres may be covered by overburden and waste rock. At some sites, as mining progressed, the overburden was used to backfill mined-out areas of the open-pit in anticipation of later reclamation. Most of the older surface mines (pre to-mid-1970s) were not backfilled during mining operations, while some of the more recent mining included modest backfilling operations. The surface area affected by major underground mining activities generally involves less than about 50 acres (20 hectares).

Waste volumes produced by surface, open-pit mining are a factor of 45 greater than for underground mining, based on their respective averages. Thus, the amount of overburden and waste rock generated from open-pit mines far exceeds that from underground mines. The U.S. Geological Survey (Otton 1998) estimated that the total amount of overburden and waste rock generated by the approximately 4,000 operating conventional mines in its data set is from 1 billion and 9 billion metric tons, with a likely estimate of 3 billion metric tons. Overburden and waste rock from surface mines can include huge boulders that may have been broken down with explosives and heavy machinery into particles ranging from a micrometer to boulders about 3 feet (a meter) or more in diameter. The characteristics of overburden and waste rock from conventional mines depend on the geology of the zone where the ore was originally mined, and how the waste was subsequently treated. This may ultimately affect the availability of metals and radioactivity to the environment as contaminants.

Radionuclide leaching primarily from mine waste piles adjacent to open-pit mines—but also possibly derived by leaching from mine pit walls or by groundwater infiltration from underlying uranium deposits—can result in significant levels of radiation in water-filled pit lakes, though some pit waters may not become very contaminated. Surface and underground mines that intersect aquifers have the potential to contaminate the aquifers.

In the 1980s, primarily due to cost, ISL operations, which began in the 1970s, displaced surface and underground mining methods as the principal means of extracting uranium in the United States. In general, ISL generates small amounts of surface solid waste comprised of: (1) soil and weathered bedrock material disturbed during surface preparation of the site, (2) liquid and solid waste from drilling of injection and production wells, and (3) solids precipitated during storage and processing of fluids in holding ponds. Available data are insufficient to estimate the total amount of solid and liquid wastes generated by existing and previous ISL operations.

Some uranium mines pose such a hazard that they are Superfund sites. Two uranium mines are on the National Priorities List, and CERCLA removals were undertaken in 2001 for two houses constructed with uranium mine waste rock on Tribal lands, and a recent removal action took place in Washington state for off-site spills of uranium ore materials along a haul road between a mine and a mill. The reclamation and remediation of uranium mines is an important consideration when contemplating the impact of past and present uranium mining operations. Data from a Department of Energy/Energy Information Administration study reveal that the costs of reclamation without site monitoring ranged from a low of $0.24/MT of ore, $0.18/kg of uranium produced, and $2,337/hectare of disturbance to a high of $33.33/MT of ore, $23.74/kg of uranium produced, and $269,531/hectare of disturbance for all 21 mines. The average total estimated cost is $13.9 million per mine. Many smaller mines less than 25 acres (10 hectares), which may constitute the majority of mine-scarred lands currently unreclaimed, especially in arid regions, may require much lower remediation costs. on the order of $45,000 or lower; this cost would be incurred to bury waste piles back in a pit or underground mine opening, clean up the soil to lower radionuclide and metal levels, and close or armor the mine opening with rock.

When conventional mining and uranium extraction facilities are closed, stewardship and monitoring may be required for long periods of time to ensure that reclamation and remediation goals have been met, depending on regulatory agency requirements. However, in many cases, once a facility has been reclaimed and there are no indications of increasing levels of radionuclide or pollutant discharge, it is considered released for other uses.