5.0 POTENTIAL ECOLOGICAL IMPACTS FROM URANIUM MINES

This document has focused on the potential risks to humans from exposures to unreclaimed uranium mining materials. The potential effects on relevant ecosystems have not been addressed, because they are beyond the scope of this report. Although not analyzed here, ecosystem effects are briefly mentioned because of the potential importance of the topic in the consideration of unreclaimed uranium mines. Although the Superfund characterization process includes radionuclides in the ecological risk assessment and for some individual species, the lack of an accepted standard methodology for demonstrating protection of ecosystems from radiation makes the identification of potential effects due to uranium mining difficult. There is, however, a general framework for ecological risk assessment. As defined in the 1992 Framework for Ecological Risk Assessment (U.S. EPA 1992), an ecological risk assessment (ERA) is a process for evaluating the likelihood that adverse ecological effects may occur, or are occurring, as a result of exposure to one or more stressors.[1] This framework was applied in the Superfund guidance, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, Interim Final (U.S. EPA 1997b).

Ecological risk assessment addresses two major elements, characterization of effects and characterization of exposure, which provide the focus for three primary phases of activities: problem formulation, analysis, and risk characterization (U.S. EPA 1998). In these three phases, the risk assessment process provides a way to develop, organize and present scientific information so that it is relevant to environmental decisions. Issues to consider are spatial and temporal, along with assessment endpoints, and whether it is the terrestrial or aquatic environments that are of concern (U.S. EPA 2000a). When conducted for a particular area such as a watershed, the ecological risk assessment process can be used to identify vulnerable and valued resources, prioritize data collection activity, and link human activities with their potential effects. However, a risk does not exist unless: (1) the stressor has the ability to cause one or more adverse effects, and (2) it co-occurs with or contacts an ecological component long enough and at a sufficient intensity to elicit the identified adverse effect (U.S. EPA 1997b). As discussed in this chapter, it is very possible that the stressors to the surrounding ecosystem may not be the radioactive materials, but rather the other hazardous constituents that may be associated with uranium mine sites.

Efforts are underway to extend the ecological risk assessment approach to radiation. In recent work, Jones et al. (2003) state that, "potentially susceptible receptors [to radiation] include vertebrates and terrestrial plants." EPA has no radiation dose standards for the protection of flora and fauna, but the Department of Energy (DOE) (Jones et al. 2003) has suggested levels of exposure for the protection for the following: natural populations of aquatic biota (1 rad d-1 or 10 mGy d-1), terrestrial plants (1 rad d-1 or 10 mGy d-1) and animals (0.1 rad d-1 or 1 mGy d-1).[2] The question remains whether these levels are indeed protective.

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[1] A "stressor" is any chemical, physical, or biological entity that can induce adverse effects on individuals, populations, communities, or ecosystems.

[2] 1 gray = 100 rad; thus 1 mGy = 0.001 Gy = 0.1 rad or 100 mrad.

DOE has recently issued a technical standard on applying these levels in the document *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (U.S. DOE 2002). The graded screening approach uses three tiers, becoming progressively more rigorous and detailed: a scoping assessment, a screening ERA, and a more detailed ERA that uses site-specific information (Jones et al. 2003). As the tiers become more site-specific, the assumptions become less conservative. In the screening phase, this process uses biota concentration guides (BCGs) for water and sediment for evaluating aquatic systems, and water and soil for evaluating a terrestrial system. These BCGs are set “so that doses received by real biota exposed to such concentrations are not expected ever to exceed the biota dose limits” (Higley et al. 2003). The BCGs for aquatic and terrestrial systems are reproduced in Tables 5.1 and 5.2. The radiation levels found at some of the uranium mines where sub-ore and ore-grade materials have been left on site could exceed the levels identified by DOE, especially for radium.

Table 5-1. Biota Concentration Guides (BCGs) for Water and Sediment for Evaluation of an Aquatic System

Nuclide	BCG for Water		Organism Responsible for Limiting Dose in Water	BCG for Sediment		Organism Responsible for Limiting Dose in Water
	Bq/m^3	*pCi/L*		*Bq/kg*	*pCi/g*	
^{226}Ra	2×10^2	5.4×10^0	Riparian[a] Animal	4×10^3	1.1×10^2	Riparian Animal
^{228}Ra	2×10^2	5.4×10^0	Riparian Animal	3×10^3	8.1×10^1	Riparian Animal
^{232}Th	1×10^4	2.7×10^2	Aquatic Animal	5×10^4	1.4×10^3	Riparian Animal
^{233}U	7×10^3	1.9×10^2	Aquatic Animal	2×10^5	5.4×10^3	Riparian Animal
^{234}U	7×10^3	1.9×10^2	Aquatic Animal	2×10^5	5.4×10^3	Riparian Animal
^{235}U	8×10^3	2.2×10^2	Aquatic Animal	1×10^5	2.7×10^3	Riparian Animal
^{238}U	8×10^3	2.2×10^2	Aquatic Animal	9×10^4	2.4×10^3	Riparian Animal

[a] A “Riparian Animal” is an animal that lives on a riverbank and hence spends time on land and in water, e.g., a muskrat.

Source: Reproduced from Higley et al. 2003.

Table 5-2. Biota Concentration Guides for Water and Soil for Evaluation of a Terrestrial System

Nuclide	BCG for Water		Organism Responsible for Limiting Dose in Water	BCG for Sediment		Organism Responsible for Limiting Dose in Water
	Bq/m^3	pCi/L		Bq/kg	Bq/m^3	
^{226}Ra	3×10^5	$8.1 x 10^3$	Terrestrial Animal	$2 x 10^3$	$5.4 X 10^1$	Terrestrial Animal
^{228}Ra	3×10^5	8.1×10^3	Terrestrial Animal	2×10^3	5.4×10^1	Terrestrial Animal
^{232}Th	2×10^6	5.4×10^4	Terrestrial Animal	6×10^4	1.6×10^3	Terrestrial Animal
^{233}U	1×10^7	2.7×10^5	Terrestrial Animal	2×10^5	5.4×10^3	Terrestrial Animal
^{234}U	1×10^7	2.7×10^5	Terrestrial Animal	2×10^5	5.4×10^3	Terrestrial Animal
^{235}U	2×10^7	5.4×10^5	Terrestrial Animal	1×10^5	2.7×10^3	Terrestrial Animal
^{238}U	2×10^7	5.4×10^5	Terrestrial Animal	6×10^4	1.6×10^3	Terrestrial Animal

Note: 1 pCi/L = 37 Bq/m3, 1 pCi/g = 37 Bq/kg

Source: Reproduced from Higley et al. 2003.

5.1 Other Metals

There could be multiple stressors from uranium mining, especially in watersheds where a high density of uranium mines could have a larger effect than a single mine. The metals associated with uranium may cause adverse ecological effects, depending on the concentration and bioavailability. Arsenic, a human carcinogen, is one and it was discussed in Chapter 3. Other common associations include copper, phosphate, molybdenum, and vanadium. Lead and selenium are additional metals noted in some Arizona mines in the EPA Abandoned Mine Lands portion of the CERCLIS3 database. See Table 5.3 for mineral ores with which uranium (and radium) may be associated. Vanadium and uranium are commonly mined together on the Colorado Plateau (U.S. EPA 2006a).

Most of the mines located in the sedimentary sandstone deposits of the southwestern United States are not in pyritic formations, and the resulting runoff waters or pit lakes are generally neutral to alkaline in character (pH of 7 or higher). Low precipitation rates and the resultant lack of water may further reduce the potential for generation of acid mine or rock drainage (AMD or ARD) from waste rock, for example, in both the Colorado Plateau and the Shirley Basin of Wyoming (U.S. EPA 2006a). For mines elsewhere, AMD/ARD can be a problem. Midnite Mine in Washington State is an example of a large uranium mine in which AMD did occur. While AMD/ARD can enhance contaminant mobility by promoting leaching from exposed wastes and mine structures, releases can also occur under neutral pH conditions (U.S. EPA 2000a).

The effects of the metals can be assessed within the Superfund methodology. An example of this was mentioned as part of the discussion of the White King/Lucky Lass Superfund site. In that ecological risk assessment, no adverse ecological effects were seen from the radioactive materials, but the associated metals did pose a potential ecological threat to a local shrew species. Other mining sites have created environmental problems, and some are on the National Priorities List for cleanup. Midnite Mine, for example, underwent a preliminary ecological risk assessment (URS 2003), and a number of metals were examined, including copper, lead, arsenic, selenium, uranium, vanadium, zinc, molybdenum, and chromium. Uranium-235, uranium-238 and thorium-232 were also evaluated. According to the final ecological risk assessment, there were situations where both the radioactivity and the metals exceeded guidelines (Lockheed Martin 2005). The record of decision concludes that, “Contaminants in surface water, ground water, surface materials, and air represent a threat to human and ecological receptors” (U.S. EPA 2006c).

Although not analyzed here, there may be environmental effects, in addition to potential human health effects, from unreclaimed uranium mines. While many of the mines are remote and may not be visited by humans, the flora and fauna would be exposed for much longer periods of time, and thus could be affected by unreclaimed mines. Issues to be considered for an ecological risk

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[3] The Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) Database contains general information on sites across the nation and U.S. territories including location, contaminants, and cleanup actions taken. The database can be downloaded from the web at http://www.epa.gov/superfund/programs/aml/amlsite/nonnpl.htm.

assessment of unreclaimed mines could include the identification of stressors for the different types of uranium mines, affected species at different sites, the potential exposures, and the endpoints for determining effects.

Although radiological and chemical toxicity should be treated as concerns, the closure of mine shafts that have long remained unreclaimed must also be considered carefully. In parts of the country where open mine shafts have long been part of the landscape, animal species—most notably bats—may rely on those mines shafts as critical habitat. Endangered bat species have been documented nesting in unreclaimed mines. If a survey by a biologist determines the presence of bat species in an abandoned mine, adequate closure may be accomplished by means of a "bat gate," a metal grate that prevents humans from entering but allows the free passage of bats (Burghardt 2003).

Table 5-3. Mineral Commodities with Uranium Associations

Several mineral ores often, though not always, have TENORM-associated wastes resulting from co-occurrence of uranium and radium.

Aluminum (bauxite)
Coal (and coal ash)
Copper
Fluorospar (fluorite)
Gypsum
Molybdenum
Niobium
Phosphate (phosphorus)
Potassium (potash)
Precious metals (gold, silver)
Rare earths: yttrium, lanthanum, monazite, bastanite, etc.
Tin
Titanium (leucoxene, ilmenite, rutile)
Tungsten
Vanadium
Zircon

Source: U.S. EPA 2003d.