3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Introduction

This chapter of the Generic Environmental Impact Statement (GEIS) provides a description of the environmental conditions and resources in four regions of Wyoming, South Dakota, Nebraska, and New Mexico where previous and existing *in-situ* leach (ISL) uranium recovery operations have been licensed by NRC and where new ISL facilities may be proposed for U.S. Nuclear Regulatory Commission (NRC) review. These uranium milling regions are defined in Section 3.1.1 and provide the basis for the structure of Chapter 3, which describes the affected environments for each region. Section 3.1.2 includes general information that applies to each of the four regions.

3.1.1 Geographic Scope—Defining Uranium Milling Regions

For the purpose of analysis in this GEIS, NRC assumptions about potential future ISL facility locations were based on

- The locations of past and existing uranium milling operations in states where NRC has the regulatory authority over uranium recovery
- The locations where uranium milling companies have expressed interest in future uranium recovery using the ISL process
- The locations of historical uranium ore deposits in Wyoming, South Dakota, Nebraska, and New Mexico

In the United States, uranium ore deposits have been studied and developed in a number of western states: Arizona, Colorado, Montana, Nebraska, New Mexico, South Dakota, Utah, Washington, Wyoming, and Texas (see Figure 1.1-2). Regional ore deposits found in those states can encompass portions of several contiguous states.

The affected environment described in this chapter is further limited to states where NRC has authority to license ISL facilities. NRC does not have regulatory authority in all states, because at the state's request, NRC may relinquish its regulatory authority to the state. Therefore, in certain states, known as Agreement States, NRC has relinquished its regulatory authority to license uranium milling facilities. Colorado, Utah, and Texas are Agreement States with state, not NRC, regulation of uranium milling. NRC has retained its regulatory authority over uranium milling activities in non-Agreement States. Western non-Agreement States where NRC regulates uranium milling activities include Wyoming, South Dakota, Nebraska, and New Mexico. Montana, Arizona, and Nevada are also non-Agreement States with respect to uranium milling. No companies have indicated to NRC its plans at present to submit license applications to construct and operate ISL facilities in Montana, Arizona, or Nevada over the next several years (NRC, 2009).

Locations within Wyoming, South Dakota, Nebraska, and New Mexico that include ore deposits and where past, existing, or future uranium milling activities or interest has been identified are shown in Figures 3.1-1, 3.1-2, 3.1-3, and 3.1-4.

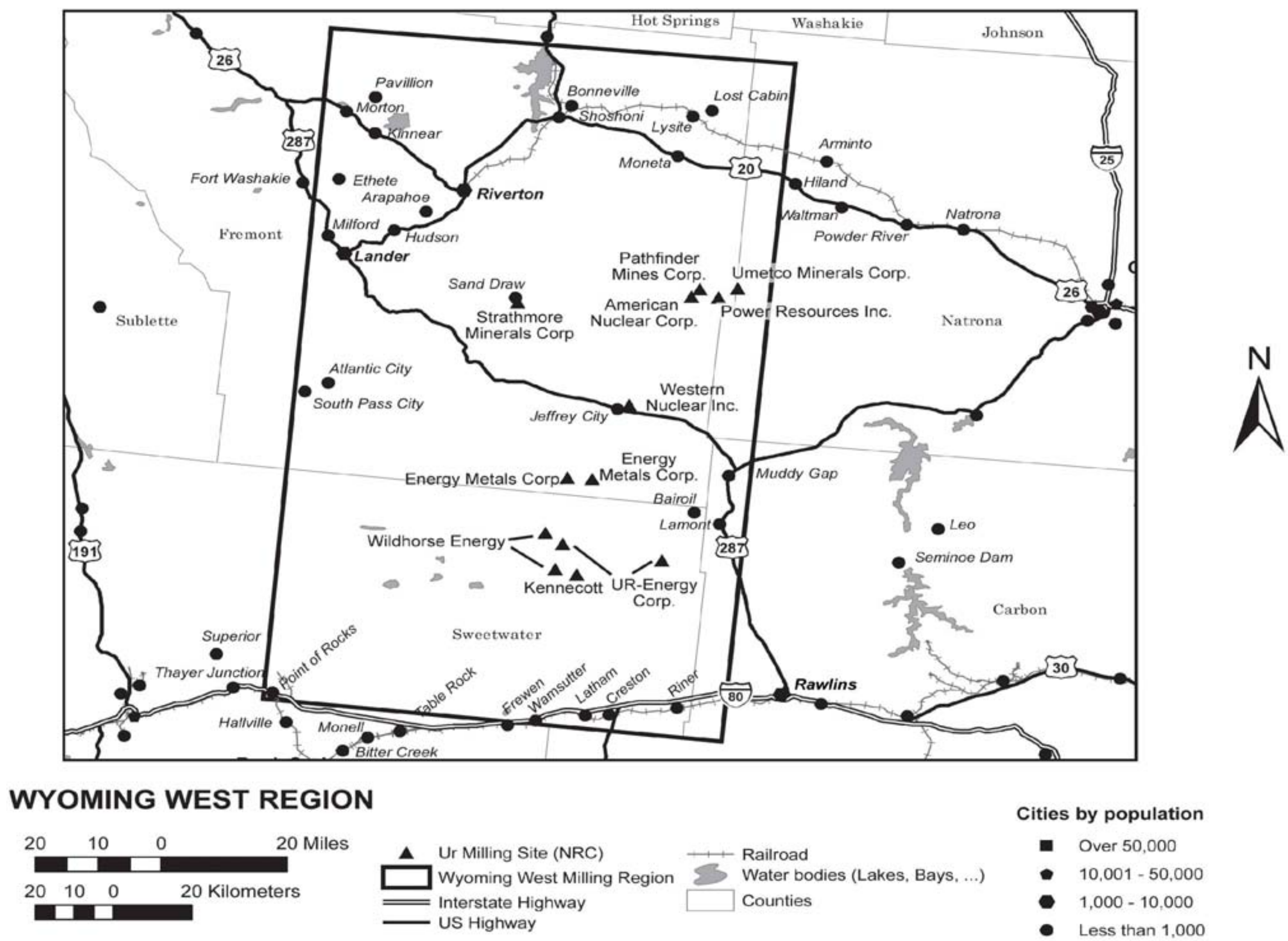

Figure 3.1-1. Wyoming West Uranium Milling Region With Current and Potential ISL Milling Sites

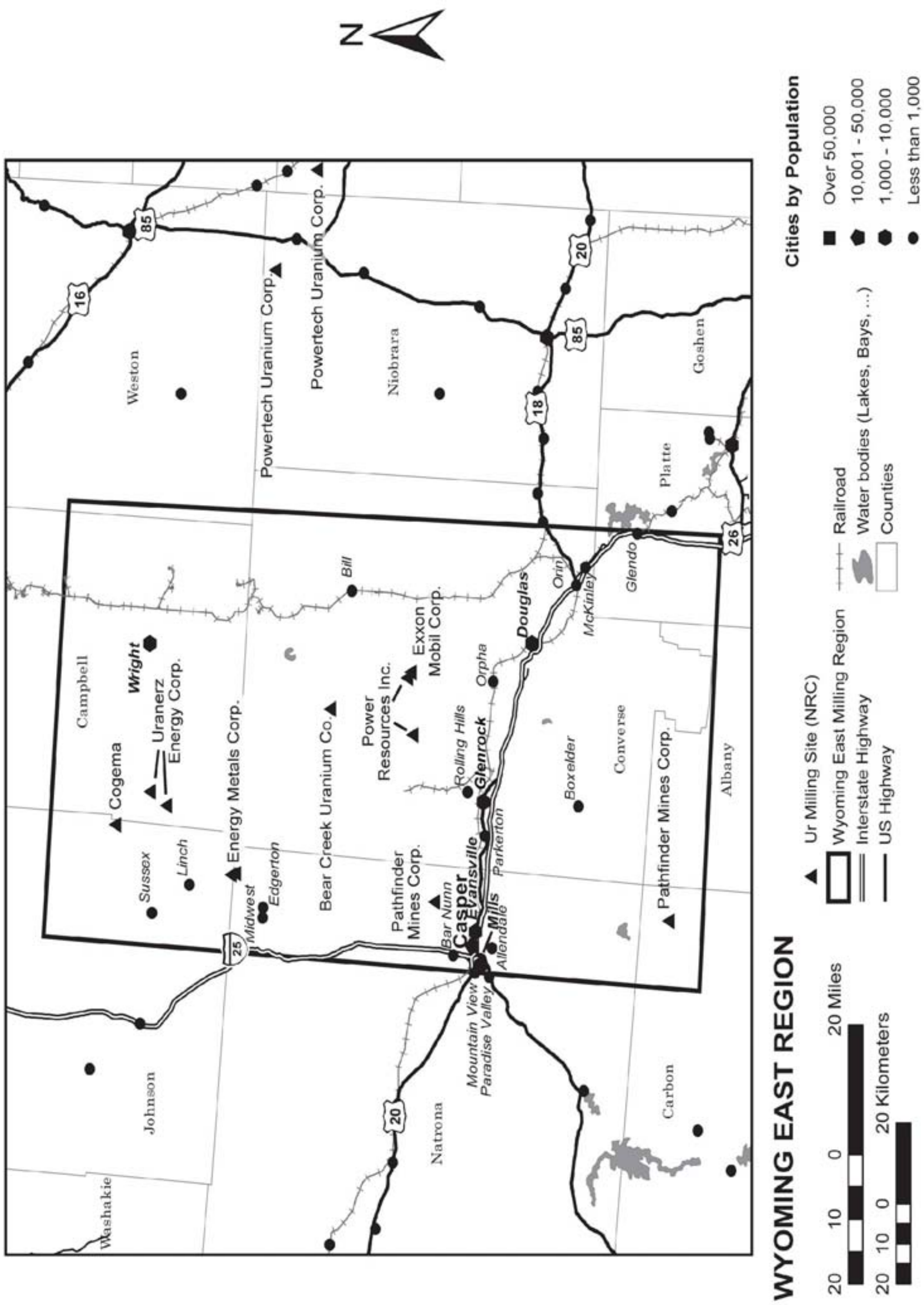

Figure 3.1-2. Wyoming East Uranium Milling Region With Current and Potential ISL Milling Sites

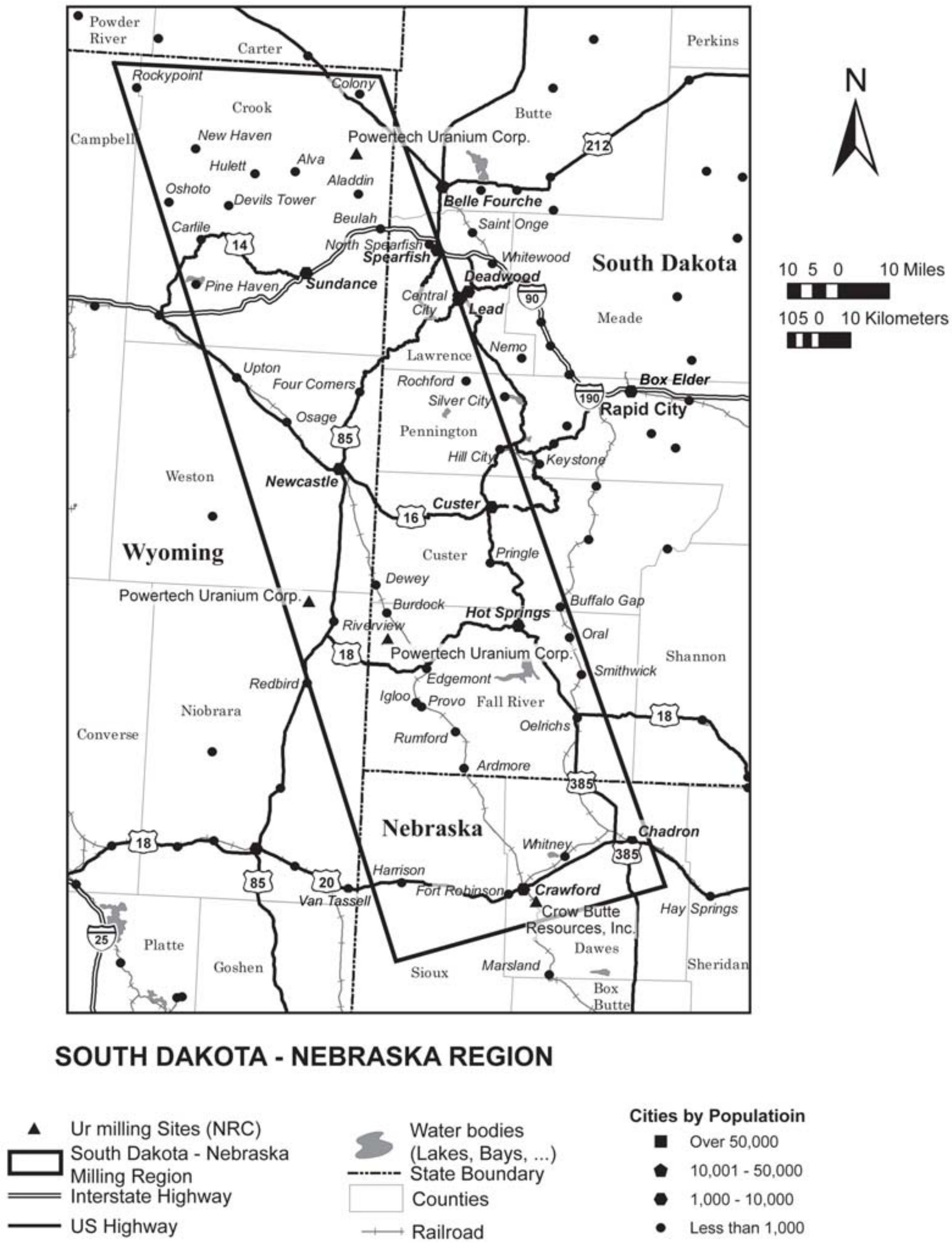

Figure 3.1-3. Nebraska-South Dakota-Wyoming Uranium Milling Region With Current and Potential ISL Milling Sites

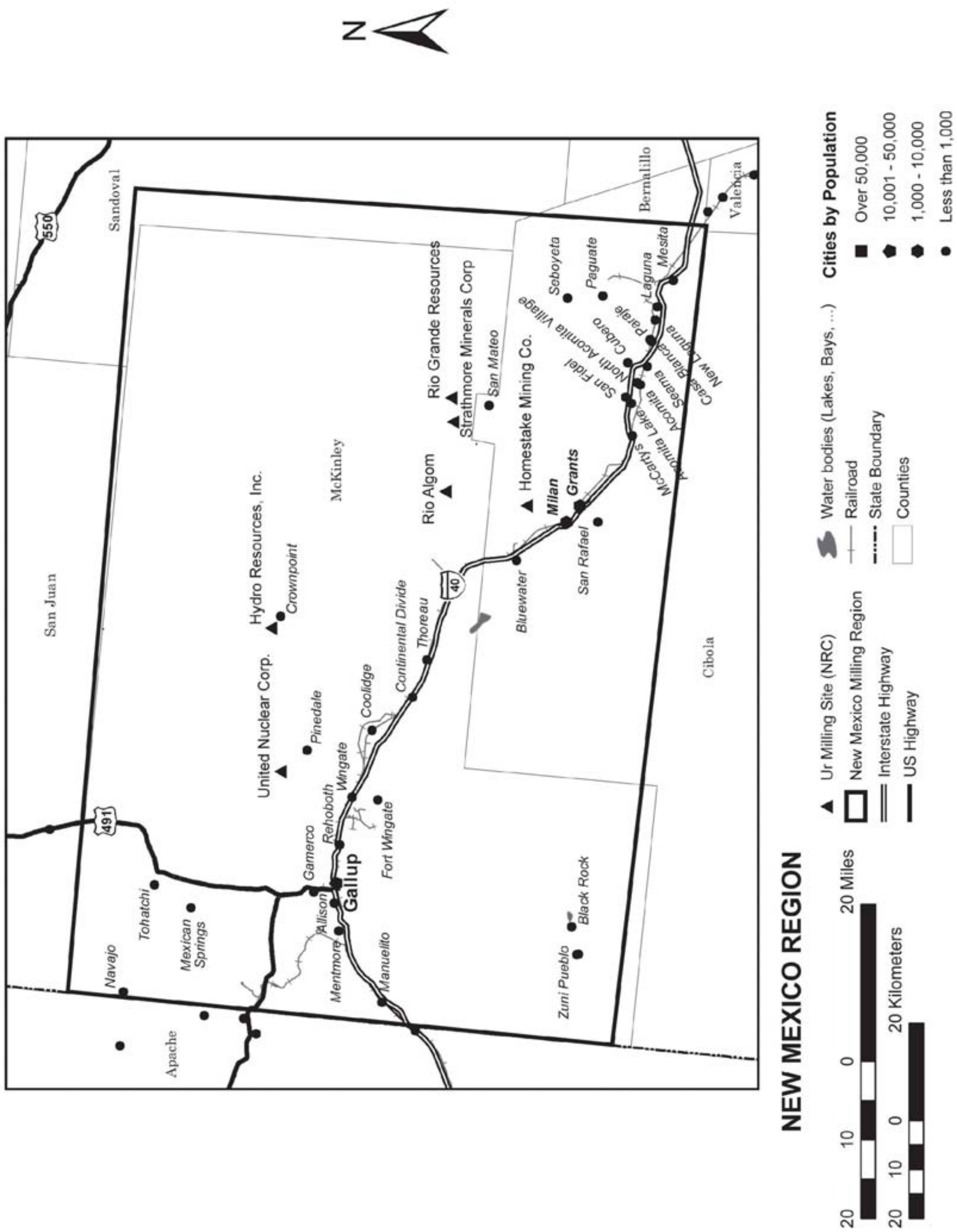

Figure 3.1-4. Northwestern New Mexico Uranium Milling Region With Current and Potential ISL Milling Sites

As shown in the figures, NRC has delineated separate uranium milling regions where the boundaries of each milling region encompass past, existing, and potential future ISL milling sites. In defining these regions, NRC also considered aspects of the affected environment (e.g., regional groundwater characteristics, regional demographics) such that potential future ISL milling sites within each region would more likely share those aspects for the purpose of evaluating potential environmental impacts. Therefore, NRC considers that these regions reasonably bound the geographic scope of the GEIS for describing the affected environment and for assessing potential environmental impacts within each region.

For the purposes of the GEIS, the regions have been named (see Section 1.4)

- Wyoming West Uranium Milling Region (Section 3.2)
- Wyoming East Uranium Milling Region (Section 3.3)
- Nebraska-South Dakota-Wyoming Uranium Milling Region (Section 3.4)
- Northwestern New Mexico Uranium Milling Region (Section 3.5)

Using this regional approach, the assessments of impacts in the GEIS may or may not be applicable or informative to reviews of ISL facilities proposed outside of the designated uranium milling regions. In such cases, the applicability of the GEIS would depend on the similarities of the proposed site and regional conditions with those described in the GEIS.

Identifying regions based on the locations of past, existing, and potential future uranium recovery operations as is done in the GEIS does not mean NRC prefers these locations or would prevent uranium recovery in other areas. It is the applicant or licensee that proposes the location of an ISL facility in the license application submitted to NRC, and NRC reviews such applications to fulfill its regulatory responsibilities.

3.1.2 General Information for All Uranium Milling Regions

To limit redundancies in discussing general information applicable to all four uranium milling regions addressed by the GEIS, that information is provided in this section.

3.1.2.1 Formation and Characteristics of Sandstone-Hosted Uranium Ore Deposits

Sandstone-hosted uranium deposits account for the vast majority of the uranium ore produced in Wyoming, South Dakota, Nebraska, and New Mexico (Chenoweth, 1988, 1991; Collings and Knode, 1984; McLemore and Chenoweth, 1989, 2003). Uranium mineralization in these sandstone deposits occurs primarily in what have been termed stratabound or roll-front deposits (Rackley, 1972; Renfro, 1969; Collings and Knode, 1984; McLemore, 2007). A conceptual model of a roll-front uranium deposit is illustrated in Figure 3.1-5. Roll fronts occur where water infiltrates from the surface and flows through an aquifer with slight amounts of uranium. Near the surface, oxidizing conditions cause the minerals and volcanic ash to weather (or dissolve) and release minute quantities of uranium into the groundwater. As groundwater continues to flow, it can encounter reducing conditions where the uranium is no longer stable in solution. In an aquifer, a reducing environment is characterized by the presence of hydrogen sulfide (H_2S), iron sulfides, or organic material. As a result, uranium precipitates from the groundwater and forms mineral coatings on the sediment grains in the formation. The principal ore minerals found in the roll-front deposits are uraninite (UO_2) and coffinite ($USiO_4$) with associated pyrite, marcasite (FeS_2), hematite (Fe_2O_3), ferroselite ($FeSe_2$), native selenium, jordisite (MoS_2), and calcite ($CaCO_3$). The zoning and alteration associated with the formation of a typical sandstone

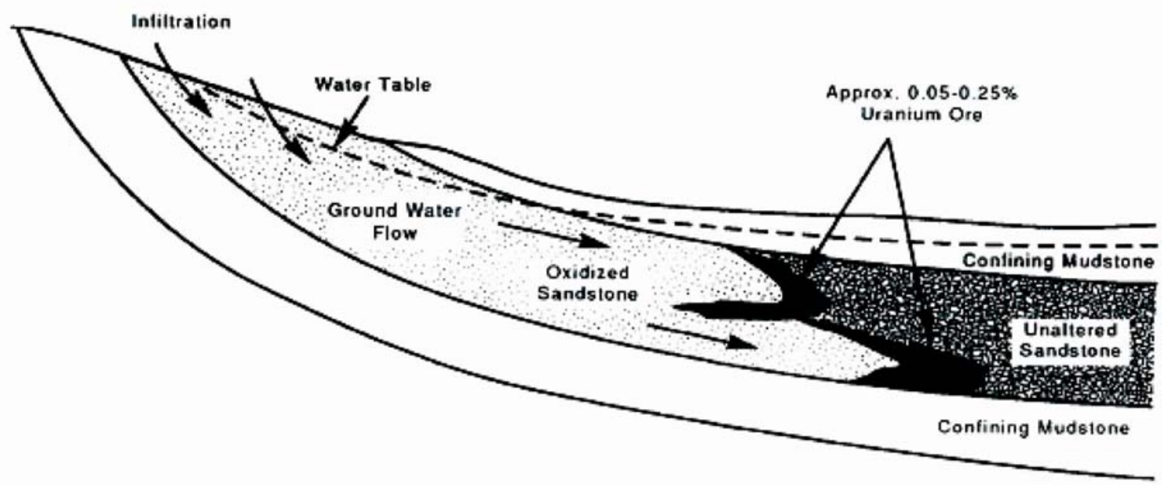

Figure 3.1-5. Simplified Cross Section of Sandstone Uranium Roll-Front Deposits Formed by Regional Groundwater Migration (NRC, 1997)

roll-front deposit are diagrammed in Figure 3.1-5. In addition to uranium, elements such as selenium, arsenic, molybdenum, and vanadium, which are generally mobile in oxidized conditions, are also precipitated in the vicinity of roll-front deposits because of the low solubility of their reduced forms. Harshman (1974) investigated the concentration and distribution of the ore and associated trace elements and minerals around the redox fronts of Wyoming ore deposits. Selenium, occurring as native selenium or ferroselite, was found at concentrations of several hundred ppm (parts per million) in zones at the edges of the altered sandstone or in reduced mineralized sandstone close to the redox interface. Molybdenum, occurring as jordisite, was found in highly variable concentrations, usually concentrated in the altered sandstone near the redox boundary. Vanadium, occurring as vanadium oxide (V_2O_4), was found at concentrations of several hundred ppm, deposited in the convex (reducing) side of the interface.

Roll-front deposits are ideally crescent- or C-shaped when viewed in cross section, with thin mineralization forming the tips of the crescents. Thick mineralization occurs in the center of the concave C-shaped ore body in the direction of groundwater flow. Individual mineralization fronts are typically from 0.6 m [2 ft] to more than 7.5 m [25 ft] thick and may be several hundred meters [feet] long. Fronts may coalesce to form ore bodies kilometers [miles] in length. Thin mineralized trails and more finely disseminated minerals branch off the main front and are located between fronts. High grade uranium roll-front deposits average about 0.2 percent U_3O_8. Lower grade ore (0.05–0.10 percent U_3O_8) is commonly present on the unaltered side of the higher grade roll front.

Several features are common to most major sandstone roll-front uranium deposits and their host rocks in Wyoming, South Dakota, Nebraska, and New Mexico (Rackley, 1972; McLemore, 2007). These features are: (1) sandstones of fluvial origin (i.e., produced by the action of a stream or river); (2) common association with arkosic (i.e., sediments with a considerable amount of the mineral feldspar) or micaceous sediment; (3) siltstones and mudstones interbedded with sandstones; (4) association with organic materials; (5) presence of pyrite in unweathered deposits; (6) gray color of the sandstones and light-gray or green color of the mudstones in unweathered deposits; (7) association with volcanic debris in the host formation or in overlying formations; (8) the discordant roll front features or solution fronts; and (9) the sharp contact between mineralized zones and adjacent carbonaceous-free or oxidized zones. The first seven features are related directly to the source rock, sedimentation, and the sedimentary environment; the last two features are related to the mineralizing process.

3.1.2.2 Complex Land Ownership Rights, Responsibilities, and Opportunities

The federal government, through the U.S. Bureau of Land Management (BLM) manages 2.8×10^8 ha [700 million acres] of subsurface mineral estate nationwide, including approximately 2.3×10^7 [58 million acres] where the surface is privately owned (BLM, 2007). In many cases, the surface rights and mineral rights were severed under the terms of the nation's homesteading laws. Applicable laws include the Coal Lands Act of 1909 and 1910; the Agricultural Entry Act of 1914; the Stock Raiding Homesteading Act of 1916; and the Mineral Leasing Act of 1920, as amended. These and other federal laws, regulations, and BLM policy directives provide the authority and direction for administering the development of federal mineral resources beneath privately owned surfaces.

The leasing and development of federal mineral resources occur in four phases including planning and leasing, permitting, drilling and production, and surface reclamation. In each phase, the BLM, the lessee/operator, and the private surface owner have rights, responsibilities, and opportunities.

Parcels of land or mineral estate that are open for leasing under the terms of a BLM land use plan may be nominated for leasing by companies or members of the public. BLM reviews every nomination to ensure that leasing the parcel would conform to the terms of the land use plan, which has been developed previously with broad public input.

The initial term for a federal mineral resource lease is 10 years, but lessees can apply to extend the lease at the end of the 10-year period. Successful bidding on and acquiring the lease gives the lessee or designated operator the right to enter and occupy as much of the surface as is reasonably required to explore, drill, and produce the mineral resources on the leasehold, subject to applicable federal laws, regulations, lease stipulations, and permit requirements. BLM works to encourage coordination and cooperation among all parties that have rights and responsibilities in these split estate situations.

Because federal mineral resources include uranium ore deposits, there is a potential for split estate situations to occur when there is interest in exploration or operations related to uranium milling in an ore deposit that is located on land where federal surface mineral resources are open for leasing under the terms of a BLM land use plan. BLM has programs and practices in place including planning, permitting and bonding that facilitate public involvement and encourage resolution of potential conflicts between surface owners and lessee/operators. Details of these programs including rights and responsibilities are discussed on the BLM website (www.blm.gov). BLM also must fulfill the requirements of the National Environmental Policy Act (NEPA), the National Historic Preservation Act (NHPA), the Endangered Species Act, the Clean Water Act, and other applicable laws regarding surface resources. NRC also has similar obligations with regard to licensing ISL facilities once an application for a license to operate has been submitted to NRC for review. NRC is currently working with BLM to develop working arrangements that will facilitate cooperation in efficiently meeting both agencies' obligations with respect to review of ISL facility proposals while limiting unnecessary duplication of effort. Results of these interactions (e.g., official agreements or memoranda of understanding) will be made available to the public once they have been developed.

3.1.3 References

BLM. "Split Estate: Rights, Responsibilities, and Opportunities." BLM/WO/GI–06/022+3`61/REV 07. Washington, DC: U.S. Department of Interior, BLM. 2007.

Chenoweth, W.L. "A Summary of Uranium Production in Wyoming." Mineral Resources of Wyoming, Wyoming Geological Association, 42nd Annual Field Conference Guidebook. Casper, Wyoming: Wyoming Geological Association. pp. 169–179. 1991.

Chenoweth, W.L. "Geology and Production History of the Uranium Deposits in the Northern Black Hills, Wyoming—South Dakota." Eastern Powder River Basin, Wyoming Geological Association, 39th Annual Field Conference Guidebook. Casper, Wyoming: Wyoming Geological Association. pp. 263–270. 1988.

Collings, S.F. and R.H. Knode. "Geology and Discovery of the Crow Butte Uranium Deposit, Dawes County, Nebraska." Practical Hydromet '83, 7th Annual Symposium on Uranium and Precious Metals. Littleton, Colorado: American Institute of Mining, Metallurgical, and Petroleum Engineering. 1984.

Energy Information Administration. "Uranium Reserve Estimates." 2004. <www.eia.doe.gov/cneaf/nuclear/page/reserves/ures.html> (14 September 2007).

Harshman, E.N. "Distribution of Some Elements in Some Roll-Type Uranium Deposits." *Formation of Uranium Ore Deposits.* Vienna, Austria: International Atomic Energy Agency. pp. 169–183. 1974.

McLemore, V.T. "Uranium Resources in New Mexico." Society of Mining and Metallurgical Engineering Annual Meeting, Denver, Colorado, February 25–28, 2007. Littleton, Colorado: Society of Mining and Metallurgical Engineering. 2007.

McLemore, V.T. and W.L. Chenoweth. "Uranium Resources in the San Juan Basin, New Mexico." *Geology of the Zuni Plateau: New Mexico Geological Society, Guidebook 54*. pp. 165–178. 2003.

McLemore, V.T. and W.L. Chenoweth. "Uranium Resources in New Mexico." New Mexico Bureau of Mines and Mineral Resources Map 18. Socorro, New Mexico: New Mexico Bureau of Mines and Mineral Resources. 1989.

NRC. “Expected New Uranium Recovery Facility Applications/Restarts/Expansions: Updated 04/24/2009.” 2009. <http://www.nrc.gov/info-finder/materials/uranium/2008-ur-projects-list-public.pdf> (28 April 2009).

NRC. NUREG–1508, “Final Environmental Impact Statement To Construct and Operate the Crownpoint Uranium Solution Mining Project, Crownpoint, New Mexico.” Washington, DC: NRC. February 1997.

Rackley, R.I. “Environment of Wyoming Tertiary Uranium Deposits.” American Association Petroleum Geologists Bulletin. Vol. 56, No. 4. 1972.

Renfro, A.R. “Uranium Deposits in the Lower Cretaceous of the Black Hills.” Contributions to Geology. Laramie, Wyoming: University of Wyoming. Vol. 8, No. 2-1. pp. 87–92. 1969.

3.2 Wyoming West Uranium Milling Region

3.2.1 Land Use

Approximately 53.3 percent of the land in the state of Wyoming is public land (47 percent federal ownership and 6.3 percent state ownership). Most of these federal lands are located in the western and northwestern parts of Wyoming, and the vast majority of private lands is located in the eastern half of the state. BLM administers the largest amount of public land in the state (28 percent). BLM lands are mixed with private and state lands. Forty-eight percent of Wyoming privately owned surface land has a split-estate status (BLM, 2008a) (Section 3.1.2.2).

Private lands, including Native American lands, which are administered by the Bureau of Indian Affairs, represent 45.9 percent of Wyoming land. In terms of general landscape, Wyoming big sagebrush (30.8 percent) and mixed grass (20.2 percent) occupy about half of the land in Wyoming, while irrigated agriculture occupies only 4.2 percent of the land (Wyoming Geographic Information Science Center, 2008).

For the purpose of this GEIS, the Wyoming West Uranium Milling Region encompasses parts of Carbon, Fremont, Natrona, and Sweetwater Counties (Figure 3.2-1). This region, which is a part of the Rocky Mountain System, straddles the Wyoming Basin to the east and the Middle Rocky Mountains to the west (U.S. Geological Survey, 2004). Based on known past, current, and planned uranium milling operations, Figure 3.2-2 shows that these operations are concentrated in two major uranium districts known as the Crooks Gap area in the Great Divide Basin straddling northeastern Sweetwater County and southeastern Fremont County and the Gas Hills area in the Wind River Basin located in eastern Fremont County (see details in the Geology and Soils Section 3.2.3).

BLM Grazing Permit/ License/Lease

BLM grants official written permission to private permitees or lessees to allow a certain number, type, and class of their livestock to graze on public lands for a specified time period and on a defined rangeland.

The land ownership and use statistics for the Wyoming West Uranium Milling Region shown in Table 3.2-1 were calculated using the Geographic Information System used to prepare the map shown in Figure 3.2-1. The majority of the land of the four counties of this region is composed of federal land (66 percent) and Native American land (9 percent) (Table 3.2-1). Private lands, intermixed with BLM land, occupy approximately 25 percent of the region. The eastern tips of the Shoshone and Bridger National Forests form a very small part on the western edge of this region (1 percent). A portion of the Wind River Indian Reservation and land administered by the U.S. Bureau of Reclamation represent approximately 13 percent of the land at the northwestern corner of the Wyoming West Uranium Milling Region. Riverton, located in this corner, is the largest town of the region with almost 10,000 inhabitants (Figure 3.2-1). Riverton is located more than 80 km [50 mi] from the Crooks Gap area and the Gas Hills area. Towns in the vicinity of these two uranium districts include Jeffrey City, Sand Draw, and Bairoil, each of which has a population of a few hundred or less (Figure 3.2-2).

As shown on Figure 3.2-1, BLM manages the vast majority of the land in the Crooks Gap and the Gas Hills areas. The land is mostly used as rangeland for cattle and sheep grazing under the BLM permit system. Other land uses under BLM management include oil and gas development, wildlife habitat, and public recreation.

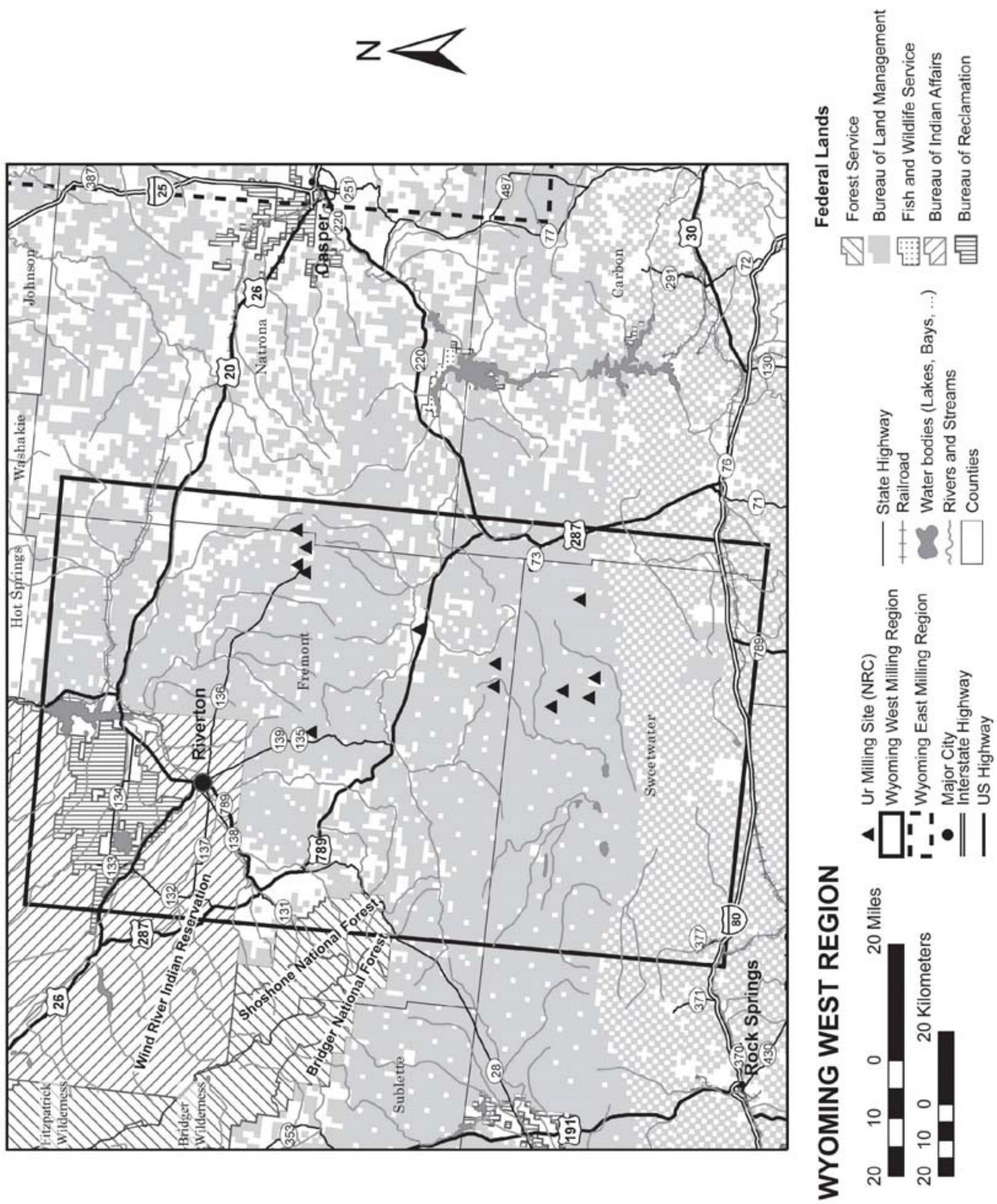

Figure 3.2-1. Wyoming West Uranium Milling Region General Map With Current and Future Uranium Milling Site Locations

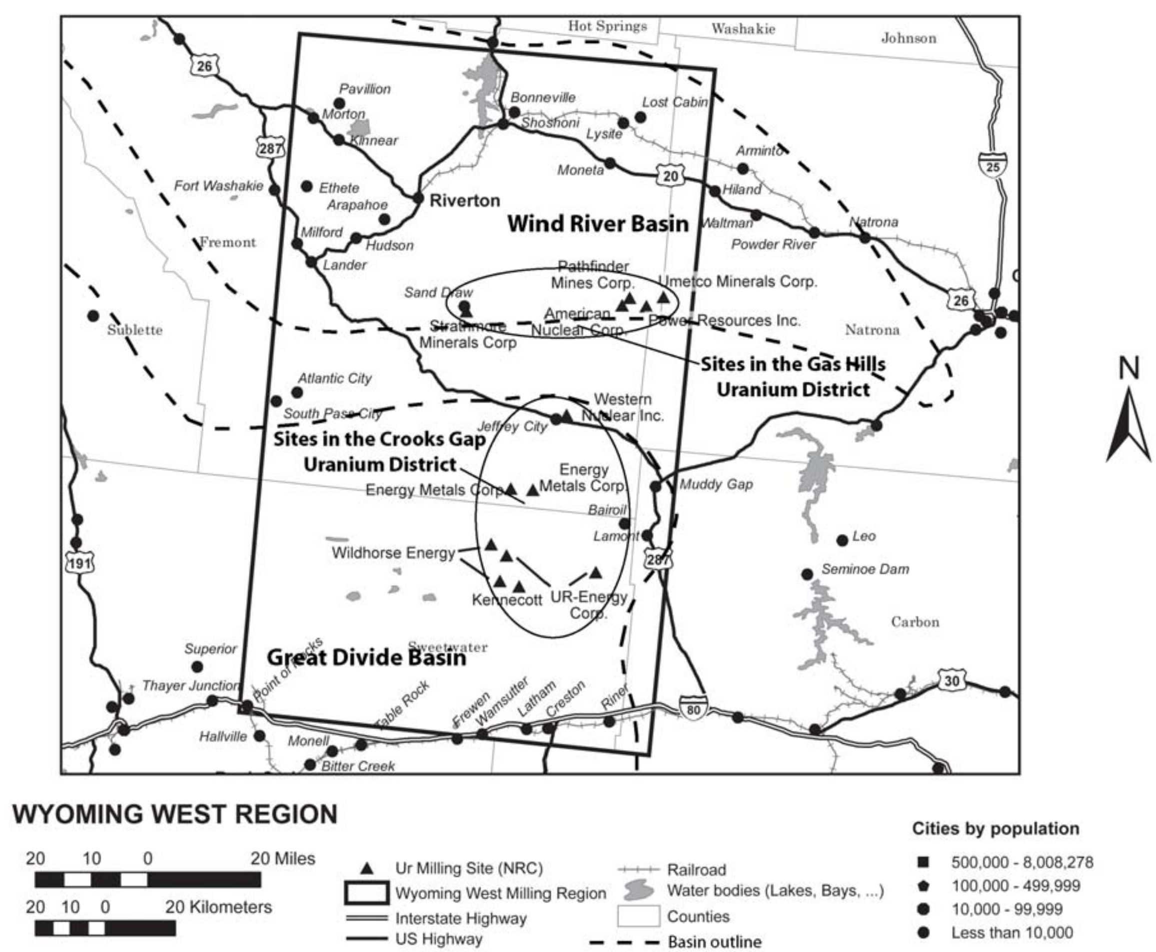

Figure 3.2-2. Map Showing Outline of the Wyoming West Uranium Milling Region and Locations of the Crooks Gap Uranium District in the Great Divide Basin and the Gas Hills Uranium District in the Wind River Basin

Table 3.2-1. Land Surface Ownership and General Use in the Wyoming West Uranium Milling Region			
Land Surface Ownership and General Use	**Area (mi^2)**	**Area (km^2)**	**Percent**
U.S. Bureau of Land Management, Public Domain Land	5,476	14,184	61.4
Private Lands	2,191	5,675	24.6
Bureau of Indian Affairs, Indian Reservations	809	2,095	9.1
Bureau of Reclamation	352	911	3.9
U.S. Forest Service, National Forest	87	226	1
Totals	8,915	23,090	100.0

Most of the private land in the eastern and southern part of the region is intermixed with BLM grazing land and is used to produce hay for feeding cattle in winter. Other scattered land uses in this region include wildlife habitat, wilderness areas, hunting, dispersed recreation and off-road vehicle use, oil and gas recovery, gas and carbon dioxide pipelines and transmission lines, and cultural and historical sites, such as the Oregon/Mormon Pioneer National Historic Trail (BLM, 1987, 2007e). The presence and extent of these land uses will have to be addressed on a site-specific basis at, and in the vicinity of, any new potential uranium milling facility.

3.2.2 Transportation

Past experience at NRC-licensed ISL facilities indicates these facilities rely on roads for transportation of goods and personnel (Section 2.8). As shown on Figure 3.2-3, the Wyoming West Uranium Milling Region is accessible by Interstate 80, which borders the south of the region between Rock Springs and Rawlins. The Wyoming West Uranium Milling Region is also accessed from the west by State Highway 28, from the northwest by U.S. Highway 26, from the north by U.S. Highway 20, and from the east by U.S. Highway 20 and State Route 220. Rail lines traverse the northern and southern portions of the region.

Areas of past, present, or future interest in uranium milling in the region are also shown in Figure 3.2-3. These areas are located in four main subregions when considering site access by local roads. Areas of milling interest that are located in the northeastern part of the region near the Natrona and Fremont County borders are accessible by State Route 136 from Riverton or by a local access road that travels south from Waltman until intersection with State Route 136. Another area of milling interest is in the central portion of the milling region adjacent to State Route 135, which is accessed from the north from Riverton or from the south from U.S. Highway 789. Traveling east from that point on U.S. Highway 789 to Jeffrey City is another area of milling interest. Other sites of interest in the southeastern portion of the Wyoming West Uranium Milling Region (Great Divide Basin Area in Sweetwater County) are accessible by unpaved local access roads that extend west from U.S. Highway 287 at Bairoil and a location farther south between Bairoil and Rawlins. These west-trending roads intersect a north and south-trending unpaved road that connects Wamsutter on the southern border of the region at Interstate 80 to Jeffrey City and Moneta to the north. U.S. Highway 287 continues south to Interstate 80.

Table 3.2-2 provides available traffic count data for roads that support areas of past or future milling interest in the Wyoming West Uranium Milling Region. Counts are variable with the

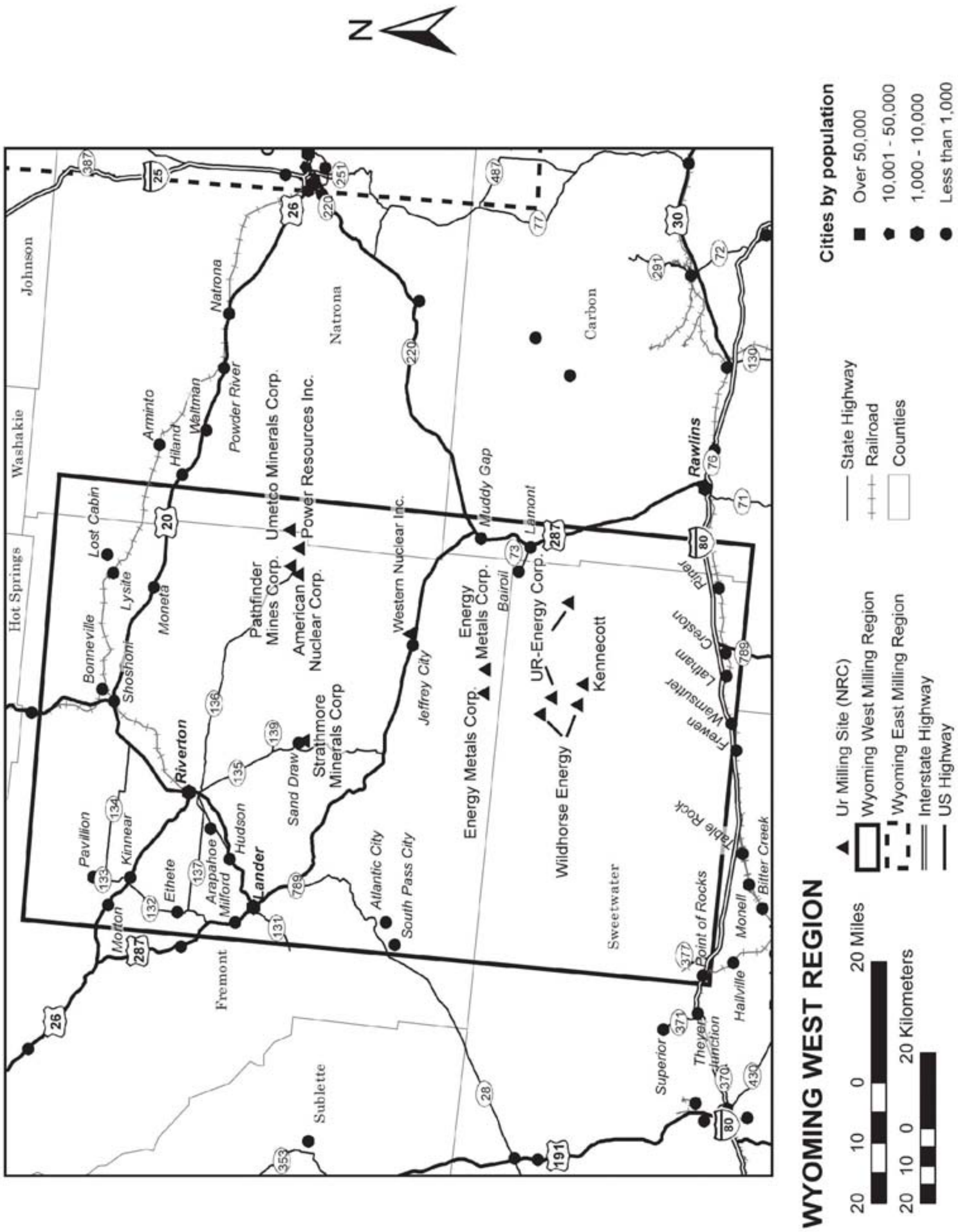

Figure 3.2-3. Wyoming West Uranium Milling Region Transportation Corridor

Table 3.2-2. Average Annual Daily Traffic Counts for Roads in the Wyoming West Uranium Milling Region*					
Road Segment	**Distance (mi)**	**Trucks**		**All Vehicles**	
		2005	**2006**	**2005**	**2006**
State Route 136 to Riverton	44	10–20	20–30	130–260	200–270
State Route 135 from State Route 136 to State Route 789	1.04	170	210	840	1,090
State Route 789 from State Route 135 to U.S. Highway 26	1	570–650	570–650	11,500–17000	11,650–17,100
U.S. Highway 20/26 from Riverton to Shoshoni	22	520–650	520–650	3,340–19,580	5,100–19,620
U.S. Highway 20/26 from Shoshoni to Waltman	51	270–580	470–550	2,350–3,090	2,190–3,060
U.S. Highway 20/26 from Waltman to Casper	49	470–670	480–650	2,480–13,740	2,450–13,580
Interstate 25 from Casper to State Route 95	21	570–1,030	610–1,030	2,610–10,220	2,710–10,220
U.S. Highway 287 (State Route 789) at Lander South	-	390	400	5,080	4,550
U.S. Highway 287 (State Route 789) at Jeffrey City	-	140	140	850	890
U.S. Highway 287 at Muddy Gap	-	140	140	910	910
State Route 220 at Muddy Gap North	-	620	620	1910	1910
State Route 73 from Bairoil to Lamont	4.64	30	30	230	230
U.S. Highway 287 from Lamont to Muddy Gap	11	700	690	2,400	2,400
*Wyoming Department of Transportation. “Wyoming Department of Transportation Vehicle Miles.” Data for Calendar Year 2005 and 2006 Provided on Request. Casper, Wyoming: Wyoming Department of Transportation, District 2 Office. April 18, 2008.					

minimum all-vehicle count at 130 vehicles per day on State Route 136 to Riverton and the maximum on U.S. Highway 20 from Riverton to Shoshoni at 19,620 vehicles per day. Most all-vehicle counts in the Wyoming West Uranium Milling Region are above 800 vehicles per day. Yellowcake product shipments are expected to go from the milling facility to a uranium hexafluoride production (conversion) facility in Metropolis, Illinois (the only facility currently licensed by NRC in the United States for this purpose). Major interstate transportation routes are expected to be used for these shipments, which are required to follow NRC packaging and transportation regulations in 10 CFR Part 71 and U.S. Department of Transportation hazardous material transportation regulations at 49 CFR Parts 171–189.

Table 3.2-3 describes representative routes and distances for shipments of yellowcake from locations of uranium milling interest in the Wyoming West Uranium Milling Region. Representative routes are considered owing to the number of routing options available that could be used by a future ISL facility. Because transportation risks are dependent on shipment

Table 3.2-3. Representative Transportation Routes for Yellowcake Shipments From the Wyoming West Uranium Milling Region*			
Origin	**Destination**	**Major Links**	**Distance (mi)**
South of Moneta, Wyoming	Metropolis, Illinois	Local access road to Waltman, Wyoming U.S. Highway 20 east to Casper, Wyoming Interstate 25 south to Denver, Colorado Interstate 70 east to St. Louis, Missouri Interstate 64 east to Interstate 57 Interstate 57 south to Interstate 24 Interstate 24 south to U.S. Highway 45 U.S. Highway 45 west to Metropolis, Illinois	1,390
Sand Draw, Wyoming	Metropolis, Illinois	Local access roads to State Route 135 State Route 135 south to U.S. Highway 287 U.S. Highway 287 south to Interstate 80 Interstate 80 east to Cheyenne, Wyoming Interstate 25 south to Metropolis, Illinois (as above)	1,400
Jeffrey City, Wyoming	Metropolis, Illinois	Local access roads to U.S. Highway 287 U.S. Highway 287 to Interstate 80 Interstate 80 east to Cheyenne, Wyoming Interstate 25 south to Metropolis, Illinois (as above)	1,360
Great Divide Basin Area, Wyoming	Metropolis, Illinois	Local access road south to Wamsutter Interstate 80 east to Cheyenne, Wyoming Interstate 25 south to Metropolis, Illinois (as above)	1,360
*American Map Corporation. "Road Atlas of the United States, Canada, and Mexico." Long Island City, New York: American Map Corporation. p. 144. 2006.			

distance, identification of representative routes is used to generate estimates of shipment distances for evaluation of transportation impacts in Chapter 4 Section 4.2.2). An ISL facility could use a variety of routes for actual yellowcake shipments, but the shipment distances for alternate routes are not expected to differ significantly from those estimated for the representative routes.

3.2.3 Geology and Soils

Wyoming contains the largest known reserves of uranium in the United States and has been the nation's leading producer of uranium ore since 1995 (Wyoming State Geological Survey, 2005). Sandstone-hosted uranium deposits account for the vast majority of the ore produced in Wyoming (Chenoweth, 1991). In the Wyoming West Uranium Milling Region, uranium mineralization is found in fluvial sandstones in two major uranium districts: the Crooks Gap area of the Great Divide Basin and the Gas Hills area of the Wind River Basin (Figure 3.2-2). The uranium mineralization in the sandstone-hosted deposits in the Crooks Gap and Gas Hills areas is amenable to recovery by ISL milling. Since 1991, all uranium produced from sandstones in these two districts has been by the ISL method (Wyoming State Geological Survey, 2005).

The Crooks Gap area is located in Fremont and Sweetwater Counties and encompasses approximately 9,100 km^2 [3,500 mi^2] in south-central Wyoming (Bailey, 1969; Rackley, 1972; Boberg, 1981). In 1954, ore-grade mineralization was found at Crooks Gap, and by late 1957, 3,800 metric tons [4,200 tons] of ore had been mined, mostly from shallow workings (Bailey, 1969). Production plus minable reserves at Crooks Gap are estimated to be between 5,000 and 5,400 metric tons [5,500 and 6,000 tons] U_3O_8.

The Gas Hills Uranium District is located along the southeastern margin of the Wind River Basin in central Wyoming (Anderson, 1969; Rackley, 1972; Boberg, 1981). Uranium in the Gas Hills district was discovered in 1953, and ore production began in 1955 (Anderson, 1969). The mineralized ground encompasses an area of about 160 km^2 [100 mi^2]. Prior to 1968, the Gas Hills uranium district produced approximately 26 million metric tons [29 million tons] of U_3O_8, which accounted for about 12 percent of total uranium production in the United States (Chenoweth, 1991).

The dominant source of sediment in the Great Divide and the Wind River Basins was Precambrian (greater than 540-million-year-old) granitic rock of the Sweetwater Arch (Rackley, 1972) (Figure 3.2-4). The Sweetwater Arch is also referred to as the Granite Mountains (Bailey, 1969; Anderson, 1969; Lageson and Spearing,1988). The Sweetwater Arch is a large mass of granitic rock 140 km [87 mi] long, with a maximum width of 50 km [31 mi]. Uplift of the Sweetwater Arch began to affect sedimentation in the adjacent Great Divide Basin and Wind River Basin in Late Cretaceous time (65 to 99 million years ago). Rapidly subsiding portions of these basins received thick clastic wedges (i.e., wedges made up of fragments of other rock) of predominantly arkosic sediments (i.e., sediments containing a significant fraction of feldspar), while larger, more slowly subsiding portions of the basins received a greater proportion of paludal (marsh) and lacustrine (lake) sediments.

Sediment transported southward into the Great Divide Basin was deposited on an apron of alluvial fans (Rackley, 1972). One of the major fans is centered near the Crooks Gap Uranium District, and another is northwest of the Lost Soldier anticline. Sedimentation in the Gas Hills area of the Wind River Basin was on an alluvial (i.e., deposited by running water) fan in which ridges of older resistant rock protruded through the fan and controlled the movement of the streams and their pattern of deposition. Beginning in the middle Eocene (41 to 49 million years ago) and increasing in the Oligocene (23.8 to 33.7 million years ago), regional volcanic activity contributed a significant amount of tuffaceous materials (i.e., materials made from volcanic rock and mineral fragments in a volcanic ash matrix) to local sediments. Deposition within the basins probably continued through the Miocene (5.3 to 23.8 million years ago), but post-Miocene erosion has completely removed Oligocene and Miocene units.

A generalized stratigraphic section of Tertiary (1.8- to 65-million-year-old) formations in the Wyoming West Uranium Milling Region is shown in Figure 3.2-5. Stratigraphic descriptions presented here are limited to formations that may be involved in potential milling operations or formations that may have environmental significance, such as important aquifers and confining units above and below potential milling zones.

Formations hosting major sandstone-type uranium deposits in the Wyoming West Uranium Milling Region are the Wind River Formation in the Wind River Basin and the Bottle Springs Formation in the Great Divide Basin. Both the Wind River and Bottle Springs are lower Eocene (49 to 54.8 million years old) in age (Houston, 1969) and consist of interbedded, arkosic sandstone; conglomerate; siltstone; mudstone; and carbonaceous shale—all compacted but poorly cemented (Harshman, 1968). The source beds for uranium deposits are sandstones

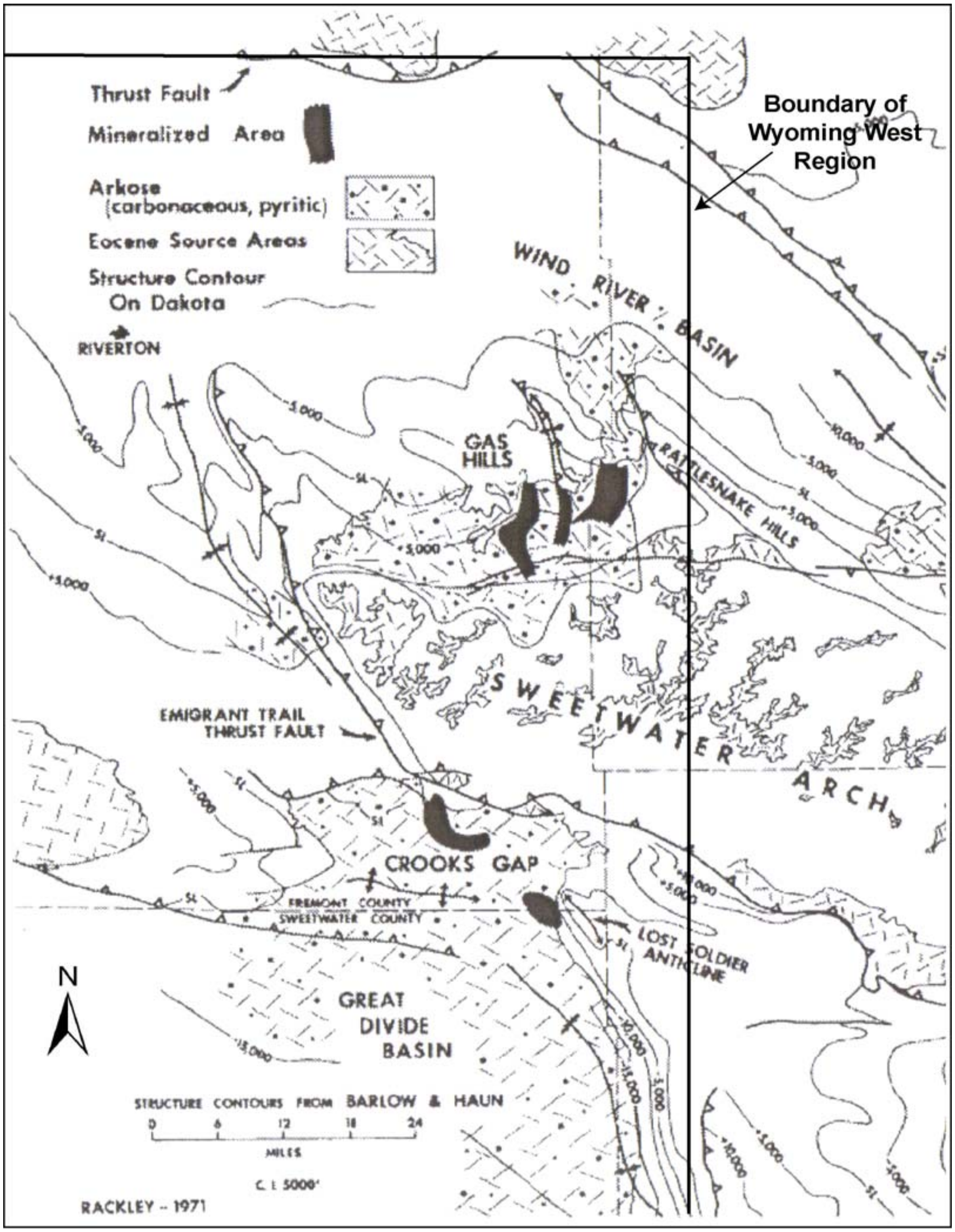

Figure 3.2-4. Index and Structure Map of Central Wyoming Showing Relation of Sweetwater Arch to the Great Divide Basin and the Wind River Basin. The Distribution of Arkosic, Carbonaceous Sediments, and Mineralized Areas in the Crooks Gap and Gas Hills Uranium Districts Are Also Shown (Modified From Rackley, 1972).

Central Wyoming

System	Series		Formation	
Tertiary	Pliocene		Moonstone Formation	
	Miocene		Browns Park Formation	Split Rock Formation
	Oligocene		White River Formation	
	Eocene	Upper	Wagon Bed Formation	
		Middle		
		Lower	Battle Springs Formation	Wind River Formation
	Paleocene		Fort Union Formation	
Cretaceous	Upper		Lance Formation	

Figure 3.2-5. Stratigraphic Section of Tertiary Age Formations in the Great Divide Basin and Wind River Basin of Central Wyoming. Major Sandstone-Type Uranium Deposits Are Hosted in the Battle Springs Formation in the Great Divide Basin and the Wind River Formation in the Wind River Basin (Modified From Harshman, 1968).

interstratified with lensing mudstones and shales (Anderson, 1969). The mineralized zone in the Battle Springs Formation at Crooks Gap occurs in a stratigraphic range of as much as 460 m [1,500 ft] {i.e., occurs in a zone up to 460 m [1,500 ft] thick} (Stephens, 1964). In the Gas Hills Uranium District, mineralization in the Wind River Formation occurs in a stratigraphic range of perhaps 150 m [500 ft] (Bailey, 1969).

The Wagon Bed Formation conformably overlies the Wind River and Bottle Springs Formations. The Wagon Bed is composed of a series of interbedded arkosic sandstones and silicified claystones. Regionally, the Wagon Bed Formation may not be present in the central parts of the basins, having been removed by erosion. The White River Formation unconformably overlies the Wagon Bed Formation or the Wind River and Bottle Springs formations where the Wagon Bed has been removed by erosion. The White River consists of tuffaceous siltstone, claystone, and conglomerate with subordinate amounts of tuff. The White River overlaps older Tertiary formations and wedges out against pre-Tertiary rocks on the flanks of the basins. The White River Formation is overlain by the Browns Park Formation in the Great Divide Basin and the Split Rock Formation in the Wind River Basin. The Browns Park and Split Rock consist of tuffaceous siltstone and sandstone beds that sometimes cap prominent ridges (Harshman, 1968).

The Fort Union Formation underlies the Wind River and Bottle Springs Formations and, to a limited extent, is also a host of sandstone-type uranium deposits (Davis, 1969; Langden, 1973).

The Fort Union is a fluvial deposit consisting of alternating and discontinuous mudstones, siltstones, carbonaceous shales, and coarser arkosic sandstone. The Fort Union is unconformably underlain by sediments of the Lance Formation, which is in turn underlain by a thick sequence of older sandstones, mudstones, and shales.

The uranium deposits in the Wyoming West Uranium Milling Region are genetically related to geochemical interfaces or roll fronts (see Section 3.1.1). Principal ore minerals at Crooks Gap are meta-autunite, uraninite, and coffinite. The uranium minerals occur as earthy brown to black coatings on and interstitial fillings between quartz sand grains. In the Gas Hills district, roll fronts can be followed for long distances and individual ore bodies are found along them that may reach hundreds of meters [thousands of feet] in length.

The source of uranium in sandstone roll-front deposits in central Wyoming is a topic of conjecture. Four theories on the source of uranium in these occurrences have been suggested: (1) leached uranium from overlying ash-fall tuffs; (2) leached uranium from igneous and metamorphic rocks in the highlands surrounding the basins; (3) leached uranium from the host sandstones themselves; and (4) hydrothermal uranium from a magma source at depth (Harris and King, 1993). Combinations of these theories have been proposed as well (Boberg, 1981). The most popular theories are the (1) tuff leach and (2) highland leach. The tuff leach theory is supported by extensive geochemical studies on uranium removal from tuff (Zielinski, 1983, 1984; Trentham and Orajaka, 1986). Further, it was the tuff leach theory that led to the discovery of most of the large uranium deposits in Wyoming (Love, 1952). On the other hand, many sandstone-hosted uranium deposits in Wyoming are found adjacent to crystalline rocks, especially the uraniferous granites of the northern Laramie and Granite Mountains (Harris and King, 1993). Oxidized uranium leached from these crystalline terrains could have been transported to the sites of present mineralization.

Soils within the Wyoming West Uranium Milling Region are diverse and can vary substantially over relatively short distances. The distribution and occurrence of soils in central Wyoming can vary both on a regional basis (mountains, foothills, basins) and locally with changes in slope, geology, vegetation, climate, and time. The Great Divide Basin and the Wind River Basin present a mixture of old, tilted sedimentary rocks that often occur in bands along the basin margins and younger sediments showing varying degrees of incision by erosion in basin centers.

The topographic position and texture of typical soils in the Great Divide Basin and Wind River Basin areas of central Wyoming were obtained from Munn and Arneson (1998). This map was designed primarily for statewide study of groundwater vulnerability to contamination and would not be expected to be used for site-specific soil interpretations at proposed ISL milling facilities. For site-specific evaluations, detailed soils information would be expected to be obtained from published county soil surveys or the U.S. Department of Agriculture Natural Resource Conservation Service.

In the Great Divide and Wind River Basins areas, loamy-skeletal soils (rocky soils) with little or no subsoil development occur along bedrock outcrops that form ridges along the flanks of the basins. On gently sloping to moderately steep slopes associated with ridge flanks, alluvial fans, and alluvial terraces, fine to fine-loamy soils with well-developed horizons of clay accumulation are found. These soils are generally light colored and depleted in moisture. Moderately deep fine loamy over sandy and coarse loamy soils with well-developed soil horizons occur on terraces along major streams. Soils found on floodplains and drainageways include clay loams and fine-sand loams. Dark-colored, base-rich soils formed under grass are generally associated with floodplains along streams with permanent high-water tables. These soils are generally very deep and have well-developed soil horizons.

3.2.4 Water Resources

Water resources of the Wyoming West Uranium Milling Region are described in terms of surface waters, wetlands and “Waters of the United States,” and groundwater.

Areas regulated under Section 404 are collectively referred to as “Waters of the United States.” Included are parts of the surface water tributary system down to the smallest streams; lakes, ponds, or other water bodies on those streams; and adjacent wetlands.

3.2.4.1 Surface Waters

The Wyoming West Uranium Milling Region (Figure 3.2.-1) includes major portions of Fremont and Sweetwater Counties and small portions of Carbon and Natrona Counties. Surface runoff to streams, in terms of average annual flow per unit area of a watershed, in the Wyoming West Uranium Milling Region varies from more than 13 cm/yr [5 in/yr] in the mountains to less than 1.3 cm/yr [0.5 in/yr] in the intermontane plains and valleys (Gebert, et al., 1987). The potential uranium milling sites are located in the intermontane areas. The watersheds within the Wyoming West Uranium Milling Region are listed in Table 3.2-4 along with the range of designated uses of surface water bodies assigned by the State of Wyoming (WDEQ, 2001). Because surface water uses are designated for specific water bodies, such as stream segments and lakes, within a watershed and the specific locations of future uranium milling activities are not known at this time, the range of designated uses is provided rather than a listing of designated uses for each water body within a watershed. Not all water bodies within a watershed may have all of the designated uses listed in Table 3.2-4. For example, a watershed may contain perennial streams, intermittent streams that flow only during portions of the year, and ephemeral streams that flow only because of surface runoff from local precipitation events. The perennial streams, and possibly portions of intermittent streams, may be designated as “fisheries,” whereas ephemeral streams are unlikely to be designated as fisheries. The descriptions of the water bodies and their classifications in this section focus on perennial streams that generally have higher designated uses than the intermittent and ephemeral streams. For information regarding specific water bodies, refer to the Wyoming Department of Environmental Quality Surface Water Standards webpage (deq.state.wy.us/wqd/watershed/ surfacestandards).

Attainment Status

The attainment status of a water body refers to whether or not its water quality meets the standards for its designated use. The designated use of a water body is assigned by the state, such as swimming, drinking, and protection and propagation of aquatic life. If the chemical pollutants or other water quality parameters, such as temperature or turbidity, exceed the standards for its designed use, the attainment status of the water body is described as impaired.

The historical uranium milling districts included in the Wyoming West Uranium Milling Region are Gas Hills in the east-central portion of the Wyoming West Uranium Milling Region and Crooks Gap near the Fremont-Sweetwater County line (Figure 3.2-2). Watersheds in the Wyoming West Uranium Milling Region are Great Divide Closed Basin, Sweetwater River, Muskrat Creek, Little Wind River, Popo Agie River, Lower Wind River, Badwater Creek, and their associated tributaries. Historical or potential uranium milling sites are present in the Great

Table 3.2-4. Primary Watersheds in the Wyoming West Uranium Milling Region Range of Designated Uses of Water Bodies Within Each Watershed	
Watershed	**Range of State Classification of Designated Uses***
Great Divide Closed Basin	2AB to 4C
Main Stem Sweetwater River	1 (above Alkali Creek)
Sweetwater River and Tributaries	Generally 2AB (below Alkali Creek) with some tributaries 3B and 4B
Muskrat Creek	Generally 2AB with some tributaries 3B and 4B
Little Wind River	Generally 2AB with some tributaries 3B and 4B
Popo Agie River	Generally 2AB with some tributaries 3B and 4B
Lower Wind River	Generally 2AB with some tributaries 3B and 4B
Badwater Creek	Generally 2AB with some tributaries 3B and 4B

*Class 1 waters are described as "outstanding waters" and have designated uses including Drinking Water, Game Fish, Nongame Fish, Fish Consumption, Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Class 2AB waters have designated uses including Drinking Water, Game Fish, Non-Game Fish, Fish Consumption, Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Class 2A waters have designated uses including Drinking Water, Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Class 2B waters exclude Drinking Water from the Class 2AB uses. Class 2C waters exclude Drinking Water and Game Fish from the Class 2AB uses.
Classes 3A, 3B and 3C waters have designated uses including Other Aquatic Life, Recreation, Wildlife Agriculture, Industry, Scenic Value.
Classes 4A, 4B and 4C waters have designated uses including Recreation, Wildlife Agriculture, Industry, Scenic Value.
Official definitions of surface water classes and uses are in Wyoming Department of Environmental Quality Water Quality Rules and Regulations (http://soswy.state.wy.us/Rules/RULES/6547.pdf).

Divide, Sweetwater River, Muskrat Creek, Littlewind River, and Lower Wind River Watersheds (Figure 3.2-6).

The Great Divide Closed Basin is located in northeastern Sweetwater County and western Carbon County in an area with internal drainage and no outlet to either the Atlantic or Pacific Oceans (Figure 3.2-6). Surface water flows from the upland areas on the perimeter of the basin toward playa lakes near the center of the basin. The State of Wyoming has assigned surface classifications to streams in this watershed ranging from 2AB to 4C (WDEQ, 2001). Most of the streams are classified as 3A or 3B. The attainment status of these streams has not been assessed. The Crooks Gap Uranium District is partly located within the Great Divide Closed Basin.

The Sweetwater River Watershed is located north of the Great Divide Closed Basin Watershed in Sweetwater County. The Sweetwater River is a Class 1 water above Alkali Creek and Class 2AB water below Alkali Creek (Table 3.2-4). Crooks Creek is reported to be impaired due to oil and grease from oil and natural gas production (WDEQ, 2008). The average flow in the Sweetwater River near Alcova, Wyoming, for water years 1939 through 1973 (the period of continuous record) was 3.2 m^3/s [110 ft^3/s] (U.S. Geological Survey, 2008). The Crooks Gap Uranium District is partially within the Sweetwater River Watershed and is drained primarily by Crooks Creek and its tributaries. Topographic maps of the area show a number of unnamed springs and small impoundments on the ephemeral streams within the district.

The Muskrat Creek Watershed is located north of the Sweetwater River Watershed in Fremont County. Classifications of water bodies in the Muskrat Creek Watershed range from 2AB to 2C (Table 3.2-4). No data are available on average flow in Muskrat Creek. The Gas Hills uranium district is within the Muskrat Creek Watershed, which drains to the Wind River and ultimately to the Powder River (Figure 3.2-5). Muskrat Creek is ephemeral within the Gas Hills uranium

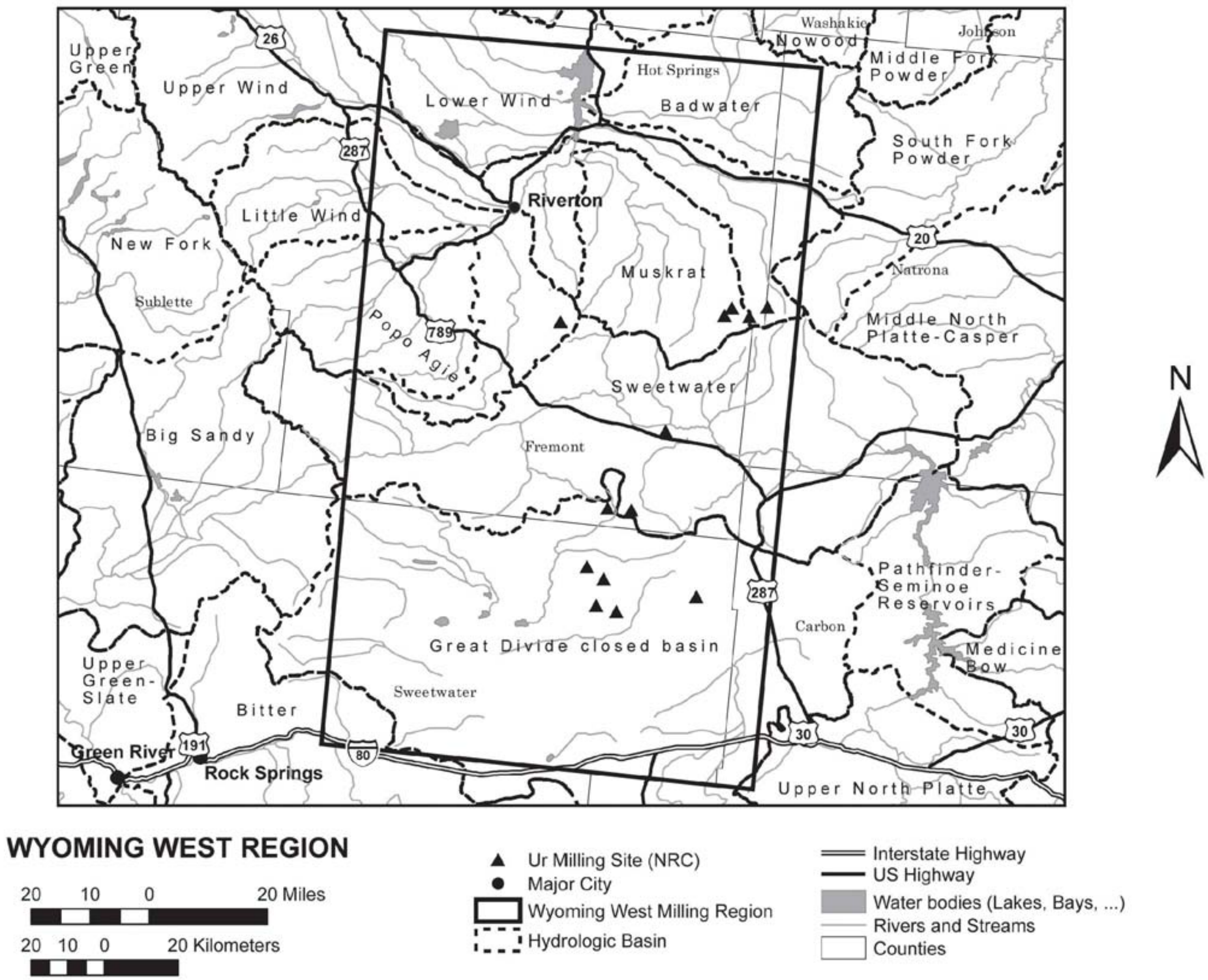

Figure 3.2-6. Watersheds in the Wyoming West Uranium Milling Region

district. The Gas Hills district is also drained by a number of other ephemeral stream channels with small surface water impoundments. Mapped springs in the district are Puddle Spring and Willow Spring.

The Little Wind River Watershed is located west of the Muskrat Creek Watershed and roughly centered on Riverton, Wyoming. The Little Wind River is classified as 2AB (Table 3.2-4). The average flow of the Little Wind River at Riverton for water years 1942 through 2008 was 16 m^3/s [556 ft^3/s] (U.S. Geological Survey, 2008).

The Popo Agie River Watershed is located west of the Little Wind River Watershed on the eastern flank of the Wind River Mountains in Fremont County. The Popo Agie River is classified as 2AB (Table 3.2-4). The average flow of the Popo Agie River between 1947 and 1971 was 2.3 m^3/s [80 ft^3/s] (U.S. Geological Survey, 2008). No historical uranium mining or milling has occurred within the Popo Agie Watershed.

The Lower Wind River Watershed is located north and downstream of the Little Wind River Watershed. Water bodies in the Lower Wind River Watershed are generally classified as 2AB with some tributaries classified as 3B; the difference is that 3B waters are not designated and protected for drinking water, fisheries, or fish consumption (Table 3.2-4). Lower Muddy Creek and Lower Poison Creek are described as impaired due to fecal coliform (WDEQ, 2008). The average flow of the Wind River below Boysen Reservoir is 29.5 m^3/s [1,040 ft^3/s] (U.S. Geological Survey, 2008).

The Badwater Creek Watershed is located on the northern edge of the Wyoming West Uranium Milling Region northeast of the Muskrat Creek Watershed. Water bodies in the Badwater Creek Watershed are generally classified as 2AB with some tributaries classified as 3B and 4B. The difference between 3B and 4B waters is that 4B waters do not have “other aquatic life” as a designated use (Table 3.2-4). No data are available on average flow in Badwater Creek.

3.2.4.2 Wetlands and Waters of the United States

The regulatory program of the U.S. Army Corps of Engineers (USACE) plays a critical role in the protection of the aquatic ecosystem and navigation. Under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899, the USACE performs the following services:

- Conducts jurisdictional determinations for wetlands and other Waters of the United States and navigable waters of the United States

- Authorizes activities in these jurisdictional areas through individual and general permits

- Ensures compliance of issued permits

- Enforces requirements of the law for unpermitted activities

Under Section 404 of the Clean Water Act, the Secretary of the Army is responsible for administering a regulatory program that requires permits to discharge dredged or fill material into waters of the United States, including wetlands.

Isolated waters such as playa lakes, prairie potholes, old river scars, cutoff sloughs, and abandoned construction and milling pits may also be waters of the United States if they meet certain criteria. Wetlands are found in many different forms including bottomland hardwood forests, wooded swamps, marshes, wet meadows, bogs, and playa lakes. Wetlands are of particular concern because they are valuable to restoring and maintaining the quality of the waters of the United States. Their functions include sediment trapping, nutrient removal, chemical detoxification, shoreline stabilization, aquatic food chain support, fish and wildlife habitat, floodwater storage, and groundwater recharge.

According to USACE (1987), wetlands are defined as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.” A minimum of one positive indicator from each parameter (vegetation, hydrology, and soils) must be found to make a positive wetland determination.

- Vegetation—Under normal circumstances, an area is considered to have hydrophytic vegetation when more than 50 percent of dominant species, from all plant strata, are classified as Obligate (OBL), Facultative wet (FACW), or Facultative (FAC). Plants listed as Facultative Upland (FACUP), Not Listed (NL), or No Indicator (NI) are considered nonwetland plants for the purposes of wetland delineations.

- Hydrology—USACE (1987) requires that wetland soils must be continually saturated for a prolonged period (at least 5 percent) during the growing season.

- Soils—Hydric soils are those that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in their upper parts. Typical field indicators of hydric soils are the presence of thick organic layers, or in the case of predominantly mineral soils, a low chroma matrix (gray color) and/or bright mottling.

Man-made ponds and other surface features not immediately adjacent to traditional navigable waters do not fall under the jurisdiction of USACE. The landward regulatory limit for waters (in the absence of adjacent wetlands) is the ordinary high-water mark. The ordinary high-water mark is the line on the shores established by the fluctuations of water and indicated by physical characteristics such as

- A clear natural line impressed on the bank

- Shelving

According to the U.S. Fish and Wildlife Wetland Mapper (2007), numerous types of wetlands and waters are located within the region:

- **Perennial Streams**—A perennial stream has flowing water year round during a typical year. The water table is located above the streambed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow (USACE, 2000).

- **Intermittent Streams**—An intermittent stream has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow (USACE, 2000).

- **Ephemeral Streams/Arroyos** (term used in arid regions)—An ephemeral stream has flowing water only during, and for a short duration after, precipitation events in a typical year. Ephemeral streambeds are located above the water table year round. Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow (USACE, 2000).

- Changes in the character of the soil
- Destruction of terrestrial vegetation
- The presence of litter and debris
- Other appropriate means that consider the characteristics of the surrounding areas

Waters of the United States and special aquatic sites that include wetlands would need to be identified and the impact delineated upon individual site selection for a potential ISL facility. Based on impacts and consultation with each area, an appropriate permit would need to be obtained from the local USACE district. Under Section 401 of the Clean Water Act, state water quality certification is required for work in waters of the United States. Within this region, the State of Wyoming regulates isolated wetlands and waters. Cumulative total project impacts greater than 0.04 ha [1 acre] require a general permit for wetlands mitigation by the Wyoming Department of Environmental Quality (WDEQ).

The majority of wetland areas located within the region consists of fresh water, ponds, emergent, or ponds with floating or submerged aquatic vegetation. These wetland areas are typically temporarily flooded on a seasonal basis. Numerous intermittent streams that are temporarily flooded are also found in the Wyoming West Uranium Milling Region.

3.2.4.3 Groundwater

Groundwater resources in the Wyoming West Uranium Milling Region are part of regional aquifer systems that extend well beyond the areas of uranium milling interest in this part of Wyoming. Uranium-bearing aquifers exist within these regional aquifer systems in the Wyoming West Uranium Milling Region. This section provides a general overview of the regional aquifer systems to provide context for a more focused discussion of the uranium-bearing aquifers in the Wyoming West Uranium Milling Region, including hydrologic characteristics, level of confinement, groundwater quality, water uses, and important surrounding aquifers.

3.2.4.3.1 Regional Aquifer Systems

The location of the Wyoming West Uranium Milling Region is shown in Figures 3.2-1 and 3.2-2. The Upper Colorado River Basin aquifer system is the major regional aquifer system (large-scale underground layer of water-bearing permeable rock or unconsolidated materials) in the southwest Wyoming West Uranium Milling Region. The Upper Colorado River Basin aquifer system extends over 51,800 km^2 [20,000 mi^2] in the Green River, the Great Divide, and the Washakie structural basins in the southwestern parts of Wyoming (Whitehead, 1996).

Groundwater in the Upper Colorado River Basin aquifer system flows from aquifer recharge areas toward the centers of the structural basins. Discharge from the aquifers is by upward leakage to shallower aquifers and to major streams. Groundwater is less than 61 m [200 ft] below the land surface in most parts of the aquifer system and is nearest the land surface near the major streams. In and near mountainous areas, depth to groundwater ranges from 152 to 305 m [500 to 1,000 ft].

The Upper Colorado River Basin aquifer system in southwestern Wyoming consists of layered sedimentary formations. Whitehead (1996) grouped the sedimentary formations into five principal aquifers. From shallowest to deepest, they are the Laney aquifer, the Wasatch-Fort Union aquifer, the Mesaverde aquifer, a series of sandstone aquifers from the Dakota Sandstone through the Nugget Sandstone aquifers, and the Paleozoic aquifers.

The uppermost aquifer in the Wyoming part of the Upper Colorado River Basin aquifer system is the Laney aquifer. It is the highest permeability member of the Green River Formation. This aquifer consists of fractured sandstone beds and yields sufficient water for domestic and livestock watering supplies. Water in the Laney aquifer is fresh to slightly saline.

The Wasatch-Fort Union aquifer (that includes the Wasatch Formation and the Fort Union Formation) is composed of the major water-yielding sandstones interbedded with shale, mudstone, and some coal beds. The thickness of the Wasatch-Fort Union aquifer is notable and reported to be about 3,350 m [11,000 ft] thick in Sublette County and about 2,135 m [7,000 ft] thick near the center of the Great Divide Basin in south-central Wyoming. The regional groundwater flow direction in the eastern part of the aquifer is from recharge areas at basin margins toward the Great Divide Basin and southward into Colorado toward the center of the Washakie Basin. In the western part of the aquifer, water flows from recharge areas toward the Green River and its tributaries and toward the Flaming Gorge Reservoir in South Wyoming. Most of the fresh water in the Upper Colorado River Basin aquifer system is in the Wasatch-Fort Union aquifer, but the aquifer locally, where it is deeply buried, contains saline water. The Green River Formation overlies the Wasatch-Fort Union aquifer and forms an effective confining unit in most places.

The Mesaverde aquifer is composed of sandstone beds. In most places, the Mesaverde aquifer and the Wasatch-Fort Union aquifer are hydraulically connected. However, the Lewis Shale locally overlies the Mesavarde aquifer in the Great Divide and the Washakie Basins. The Mesaverde aquifer crops out at the land surface surrounding the Rock Springs Uplift. The groundwater flow direction in the Mesaverde aquifer is from recharge areas at the Rock Springs Uplift and near the eastern limit of the aquifer system toward the centers of structural basins. The aquifer contains fresh water locally at outcrop (recharge) areas, but it contains saline or brine water where the aquifer is deeply buried (e.g., in the Washakie Basin in southwestern Wyoming). The Mesaverde aquifer is hydraulically separated from deeper aquifers in Mesozoic rocks through thick confining layers that consist primarily of shale.

The Dakota and the Nugget aquifers consist of several sandstone formations separated by confining units. These aquifers crop out only locally in southwestern Wyoming and contain very saline water or brine in most places. A thick confining unit of Triassic- and Permian-aged rocks hydraulically separates them from the deeper Paleozoic aquifers.

The Tensleep Sandstone and the Madison Limestone are the principal aquifers in Paleozoic rocks. Groundwater in these aquifers flows toward the centers of the structural basins from adjacent topographically high areas. Groundwater discharges from the Tensleep Sandstone to the shallower aquifers occur by upward leakage. Much of the discharge from the Madison Limestone occurs by lateral movement of the groundwater into adjacent structural basins to the southeast and northeast. Because the Paleozoic aquifers are mostly deeply buried and contain saline water, they are not extensively used for water supply in southwestern Wyoming.

Recharge to the aquifers in most of the area is likely small, due to low annual precipitation and high evaporation rates (AATA International Inc., 2005). The mean annual precipitation in the Wyoming West Uranium Milling Region is typically in the range of 15–28 cm/yr [6–11 in/yr], but at high elevations, it locally exceeds 50 cm/yr [20 in/yr] based on precipitation data from

1971 to 2000 (AATA International Inc., 2005). The evaporation rate was estimated to be 105.9±7.1 cm/yr [41.7±2.8 in/yr] using the Kohler-Nordenson-Fox equation at the station in Lander, Wyoming (Curtis and Grimes, 2004).

In the central and northern portions of the Wyoming West Uranium Milling Region (near the Gas Hills region), the Wind River Formation contains the aquifers of primary importance. It consists of water-bearing sands and conglomerate units. The Wind River aquifer is underlain by a thick sequence of aquifers and aquitards. The primary aquifers in this sequence are the Cloverly Formation, the Nugget Formation, and the Pennsylvanian Tensleep Formation. Aquitards, which underlie the Wind River aquifer, are the Frontier, Mowry, Thermopolis, Morrison, Sundance, Chugwater, Dinwoody, and the Amsden Formations. The Chugwater and Sundance Formations comprise the primary aquitards underlying the Wind River Formation. The Wind River aquifer is overlain by the Wagon Bed, White River, and Split Rock Formation. Of these formations, the primary aquifer is the Split Rock Formation (NRC, 2004).

3.2.4.3.2 Aquifer Systems in the Vicinity of Uranium Milling Sites

An underlying hydrogeological system in past and current areas of uranium milling interest in the Wyoming West Uranium Milling Region consists of a thick sequence of primarily sandstone aquifers and shale aquitards. Uranium-bearing sandstone aquifers in the Wind River Formation (equivalent to the Battle Springs Formation at the proposed Lost Creek site and to the Green River Formation at the regional scale) are important sources for water supplies in the milling region.

Areas of uranium milling interest in the southern parts of the Wyoming West Uranium Milling Region near the Great Divide Basin (Crooks Gap) are underlain, from shallowest to deepest, by sedimentary deposits and sandstone layers (Quaternary aged), the Green River Formation, the Wasatch/Battle Springs Formation, the Fort Union Formation, and the Lance/Fox Hills Formation. This hydrogeological sequence is separated from the underlying Mesaverde Formation by the regionally continuous and impermeable Lewis Shale aquitard (AATA International Inc., 2005; Lost Creek ISR, LLC, 2007). All these formations host sandstone aquifers.

Areas of uranium milling interest in the northern parts of the Wyoming West Uranium Milling Region near the Gas Hills are underlain by the Late Tertiary-aged formation and deposits including the Split Rock, White River, and Wagon Bed Formations. Among these formations, the Split Rock Formation is the primary aquifer. This system is underlain by the Wind River Formation, the Fort Union Formation, and the Lance Formation. This sequence is underlain by a thick sequence of confined aquifers and aquitards. The most important underlying water supply aquifers involve the Cloverly aquifer, the Nugget Sandstone, and the Tensleep Sandstone (NRC, 2004).

3.2.4.3.3 Uranium-Bearing Aquifers

Uranium mineralization at locations of milling interest is typically hosted by the Early Tertiary-age confined sandstone aquifers in the Wyoming West Uranium Milling Region.

Confined sandstone beds in the Battle Springs Formation are the uranium-bearing aquifers in the Great Divide Basin (south-central Wyoming) within the southern portion of the Wyoming West Uranium Milling Region (AATA International Inc., 2005). Similarly, the Wind River Formation in the northern parts of the Wyoming West Uranium Milling Region near the Gas Hills is the uranium-bearing aquifer. Uranium mineralization in the Gas Hills has been identified in six different sandstone layers in the Wind River Formation, which are named 30, 40, 60, 70, and 80 Sands. In some areas, these sand layers are hydraulically separated by confining units including siltstone, clay, and shale beds, while in other areas they are hydraulically and stratigraphically connected (NRC, 2004).

For ISL operations to begin, portions of the uranium-bearing sandstone aquifers in the Battle Springs Formation and in the Wind River Formation in the Wyoming West Uranium Milling Region would need to be exempted by the Underground Injection Control (UIC) Program administered by WDEQ (Section 1.7.2.1) for the purposes of uranium recovery (NRC, 2004).

Hydrogeological characteristics: In the Wyoming West Uranium Milling Region, the production aquifer system typically consists of confined sandstone aquifers. Aquifer properties (e.g., transmissivity, thickness, storage coefficient) vary spatially in the region. Based on field test data at the Gas Hills and in the Great Divide Basin, transmissivity of the ore-bearing aquifers ranges from 0.01–90 m^2/day [0.1–1,000 ft^2/day] in the region. For ISL operations to be practical, the hydraulic conductivity of the production aquifer must be large enough to allow reasonable water flow from injection to production wells. Hence, portions of the production aquifers with low hydraulic conductivities may not be amenable to uranium recovery using ISL techniques. The average storage coefficient of the ore-bearing aquifer is on the order of 10^{-4}, indicating the confined nature of the production aquifer (typical storage coefficients for confined aquifers range from 10^{-5}–10^{-3} (Driscoll, 1986, p. 68).

Hydrologic Terminology

Transmissivity: It is used to define the flow rate through the vertical section of an aquifer unit considering width and extending the full saturated height of an aquifer under unit hydraulic gradient. Transmissivity is a function of the aquifer's saturated thickness and hydraulic conductivity.

Storage Coefficient: It is used to characterize the capacity of an aquifer to release groundwater from storage in response to a decline in hydraulic head.

Hydraulic Conductitvity: It is a measure of the capacity of a porous medium to transmit water. It is used to define the flow rate per unit cross sectional area of an aquifer under unit hydraulic gradient.

Sandstone aquifers in the Battle Springs Formation are typically confined at the Lost Soldier and Lost Creek areas. However, the Battle Springs Formation locally crops out in the region, and hence the formation becomes locally unconfined. The transmissivity of the aquifer ranges from 8,690 to 24,800 L/day/m [700 to 2,000 gal/day/ft] {9–25 m^2/day [95 ft^2/day–270 ft^2/day]}, and the aquifer storage coefficient ranges from 3.0×10^{-4} to 8.0×10^{-4} (AATA International Inc., 2005; Lost Creek ISR, LLC, 2007). Lateral hydraulic gradients range from 0.05 at the Lost Soldier area to 0.0125 at the Lost Creek area, and range from 0.002 to 0.006 between these two sites (AATA International Inc., 2005). Hence, the lateral hydraulic gradients are an order of magnitude larger within the Lost Creek area and the Lost Soldier area than between these two sites. Collentine, et al. (1981, pp. 52–53) reported that wells in the Battle Spring aquifer typically yield 110–150 L/min [30–40 gal/min], but they are capable of yielding at least 570 L/min [150 gal/min].

Groundwater levels in the shallow, intermediate, and deep monitoring wells in the uranium-bearing aquifer were 55, 58, and 64 m [180, 190, and 210 ft] below the ground surface (AATA International Inc., 2005). These measurements indicate potential upward vertical flow within the Battle Springs Formation.

In the northern parts of the Wyoming West Uranium Milling Region, the uranium-bearing sandstone aquifers are typically confined as in the southern parts of the Wyoming West Uranium Milling Region. Transmissivity values in the uranium-bearing aquifers vary from 0.07 to 90 m^2/day [0.7 to 965 ft^2/day]. Aquifer storage coefficients vary in the range of 8.5×10^{-5} to 8.0×10^{-3}, with an average storage coefficient of 3.0×10^{-4} (NRC, 2004).

Level of confinement: The production aquifer is typically confined in the Wyoming West Uranium Milling Region; however, local unconfined conditions exist. The thickness of the confinement varies spatially.

At the regional scale, the thickness of the upper confinement of the Battle Springs Formation spatially varies. At the Lost Soldier and Lost Creek areas, the Battle Springs Formation is confined above by a 3- to 6-m [10- to 20-ft]-thick claystone unit (AATA International Inc., 2005). But, as noted previously, the Battle Springs Formation crops out over the northeastern portion of the Great Divide Basin, and hence locally unconfined conditions exist (Lost Creek ISR, LLC, 2007). The Battle Springs Formation is confined below by the continuous Lewis Shale at the local and regional scales. At the Lost Creek area, the Lewis Shale is up to 820 m [2,700 ft] thick (Lost Creek ISR, LLC, 2007). Thus, the sandstone aquifers in the Battle Springs Formation are confined at the Lost Soldier and Lost Creek areas. Aquitard vertical conductivity ranges from 1.2×10^{-3} to 2.2×10^{-3} m/day [4.0×10^{-3} to 7.3×10^{-3} ft/day] (AATA International Inc., 2005).

At the Gas Hills site, the production aquifers are typically confined. Five potential ISL sites are identified, and the thickness of the confinement spatially varies with the location of the potential ISL sites. For example, at Mine Unit 1, the uranium-bearing 70 Sand is confined above and below by relatively thick, continuous, low permeability units of the Wind River Formation. At Mine Unit 2, the 30, 50, 60, 70, and 80 Sands are typically separated by up to 6-m [20-ft]-thick confining layers. At Mine Unit 3, the 30, 40, and 50 Sands are separated by relatively thin {1.5- to 9-m [5- to 30-ft]-thick} confining layers. At Mine Unit 4, a 3- to 12-m [10- to 40-ft]-thick confining layer, overlies the 80 Sand locally in some parts of the region, while the 70 and 80 Sands are unconfined in other parts. The 60 Sand is locally confined above by a 3- to 6-m [10- to 20-ft]-thick confining layer and the 50 Sand is typically underlain by a 1.5- to 9-m [5- to 30-ft]-thick confining layer in the region. The 50 Sand at Mine 5 is confined above by a 4.5- to 12-m [15- to 40-ft]-thick confining unit and confined below by a 6- to 12-m [20-to 40-ft]-thick confining layer (NRC, 2004).

Groundwater quality: In some parts of the Wyoming West Uranium Milling Region, the total dissolved solids (TDS) levels in the uranium-bearing aquifers exceed the U.S. Environmental Protection Agency's (EPA's) drinking water standards. The uranium and radium-226 concentrations in the uranium-bearing aquifers typically exceed their respective EPA Maximum Contaminant Levels.

Groundwater of the Battle Springs Formation is of bicarbonate-sulfate-calcium type or bicarbonate-calcium type. The TDS level ranges from 200 to 400 mg/L [200 to 400 ppm], which is below the EPA's Secondary Drinking Water Standard of 500 mg/L [500 ppm]. In general, groundwater quality in the Battle Spring aquifer has the best overall quality in the county. The only notable exceptions were from high concentration of radionuclides (radium-226 and radium-228) in several samples (Mason and Miller, 2004). The quality of groundwater near the town of Bairoil meets drinking water quality standards for all chemical constituents except for the elevated uranium and radium-226 concentrations associated with the roll-front uranium deposits

(AATA International Inc., 2005). Uranium and radium-226 concentrations typically exceed their respective EPA Maximum Contaminant Levels of 0.03 mg/L [0.03 ppm] and 5 pCi/L.

Groundwater from the Wind River Formation in the Gas Hills area is of calcium-sulfate and calcium-sodium-bicarbonate-sulfate type. The TDS level in the Wind River Formation is commonly higher {623 to 1,887 mg/L [623 to 1,887 ppm]} than in the Battle Springs Formation and exceeds the EPA's Secondary Drinking Water Standard. Similar to the Battle Springs Formation, both the uranium {0.04 mg/L [0.04 ppm on the average]} and radium-226 (5–50 pCi/L away from the ore zone) exceed respective EPA Maximum Contaminant Levels (NRC, 2004).

Current groundwater uses: Groundwater withdrawn from the Battle Springs Formation is primarily used for public water supply and agricultural purposes of the town of Bairoil (AATA International Inc., 2005). Groundwater use in the Gas Hills area is typically limited to livestock, wildlife watering, and to a lesser extent, industrial uses. In vicinity of the Gas Hills area, groundwater is not used for domestic and irrigation supplies (NRC, 2004). At the regional scale, the Laney aquifer also yields sufficient water for domestic and livestock watering (Whitehead, 1996).

3.2.4.3.4 Other Important Surrounding Aquifers for Water Supply

At the regional scale, the Laney aquifer, the Wasatch-Fort Union aquifer, the Mesaverde aquifer, the Dakota and the Nugget aquifers, and the Paleozoic aquifers are the important aquifers for water supply in the region (Whitehead, 1996). Among these aquifers, the Paleozoic aquifers are used less extensively, because they are mostly deeply buried and contain saline water. The Laney and the Wasatch-Fort Union aquifers are locally hydraulically connected. The Mesaverde aquifer is also locally hydraulically connected to the overlying Wasatch-Fort Union aquifer. However, in most places, these two aquifers are separated by the Lewis Shale at the regional scale.

At the Great Divide, the Battle Springs Formation interfingers with sandstone aquifers in the Wasatch Formation and the Green River Formation, and it is underlain by sandstone aquifers in the Fort Union Formation and Lance/Fox Hills Formation. The Fox Hill Formation is considered to be a minor aquifer, but the others are usually considered to be relatively important aquifers in the region (AATA International Inc., 2005). The Fort Union aquifer is largely undeveloped in the Lost Creek area, and the reported transmissivity values are typically less than 30 m^2/day [325 ft^2/day] (Collentine, et al., 1981). The TDS levels in the Wasatch Formation in the west and south parts of the Great Divide Basin are typically higher than the EPA drinking water standards of 500 mg/L [500 ppm]. However, the TDS levels in the Battle Springs/Wasatch aquifers are generally less than 500 mg/L [500 ppm] along the northern side of the region (Lost Creek ISR, LLC, 2007).

In most parts of the Gas Hills area, the Wind River Formation is underlain by an aquitard that consists of the Chugwater (between the Nugget Sandstone and the Tensleep Sandstone) and Sundance Formations (between the Clovery Formation and the Tensleep Sandstone). The other important aquifers, including the Clovery Formation (equivalent to the Dakota Sandstone), Nugget Sandstone, and Pennsylvanian Tensleep Sandstone, are separated from the Wind River Formation by a series of thick aquitards.

3.2.5 Ecology

3.2.5.1 Terrestrial

A generalized overview and description of the habitat types and terrestrial species that may be found in areas used for milling operation are discussed in this section. These areas are broad and contain many subregions. For specific future locations of new milling sites, potential license applicants and the NRC review would be expected to address site-specific habitat types and terrestrial species.

Wyoming West Uranium Milling Region Flora

According to the EPA, the identified ecoregions in the Wyoming West Uranium Milling Region primarily consist of the Wyoming Basin and the Middle Rockies ecoregions (Chapman, et al., 2004). Figure 3.2-7 depicts the various ecoregions found within the Wyoming West Uranium Milling Region. Uranium milling districts within the uranium districts in the region are located within the Rolling Sagebrush Steppe and the Salt Desert Shrub Basin ecoregions of the Wyoming Basin.

The Wyoming Basin ecoregion is a broad, arid, intermontane basin interrupted by hills and low mountains and dominated by grasslands and shrublands. Nearly surrounded by forest-covered mountains, the region is drier than the Northwestern Great Plains to the northeast and does not have the extensive cover of pinyon-juniper woodland found in the Colorado Plateaus to the south. Much of the region is used for livestock grazing, although many areas lack sufficient forage to support this activity (Chapman, et al., 2004). Within the Wyoming Basin, the Wyoming West Uranium Milling Region contains several subecoregions that are described next, based on the descriptions of Chapman, et al. (2004).

The Rolling Sagebrush Steppe area of the Wyoming Basin is composed of rolling plains with hills, mesas, and terraces. Areas near the mountains may contain footslopes, ridges, alluvial fans, and outwash fans (Chapman, et al., 2004). The most abundant shrub vegetation in the region is Wyoming big sagebrush (*Artemisia tridentata* ssp*. wyomingensis*), with silver sagebrush (*Artemisia cana*) and black sagebrush (*Artemisia nova*) occurring in the lowlands and mountain big sagebrush (*Artemisia tridentata* ssp*. vaseyana*) in the higher elevations. Grass species include western wheatgrass (*Pascopyrum smithii*), needle-and-thread grass (*Stipa comata*), blue grama (*Bouteloua gracilis*), Sandberg bluegrass (*Poa secunda*), prairie junegrass (*Koeleria macrantha*), rabbitbrush (*Chrysothamnus nauseosus*), and fringed sage (*Artemisia frigida*) (Chapman, et al., 2004).

The Bighorn Basin is primarily an arid region influenced by the rainshadow effect of the Beartooth Mountains, Absaroka Range, and Pryor Mountains. This higher portion of the greater Bighorn Basin forms a transition from arid desert shrubland to semiarid shrubland. Sagebrush steppe vegetation dominates this region and is composed of species such as Wyoming big sagebrush, western wheat grass, blue wheatgrass (*Elymus magellanicus*), needle-and thread grass, blue grama, Sandberg bluegrass, junegrass (*Koeleria,* sp.), rabbitbrush, and fringed sage (Chapman, et al., 2004).

The Foothill Shrublands ecoregion serves as a transitional zone between the forested Dry Mid-Elevation Sedimentary Mountains ecoregion to the arid grassland and sagebrush regions in the Wyoming Basin and the High Plains (Chapman, et al., 2004). Vegetation found within this

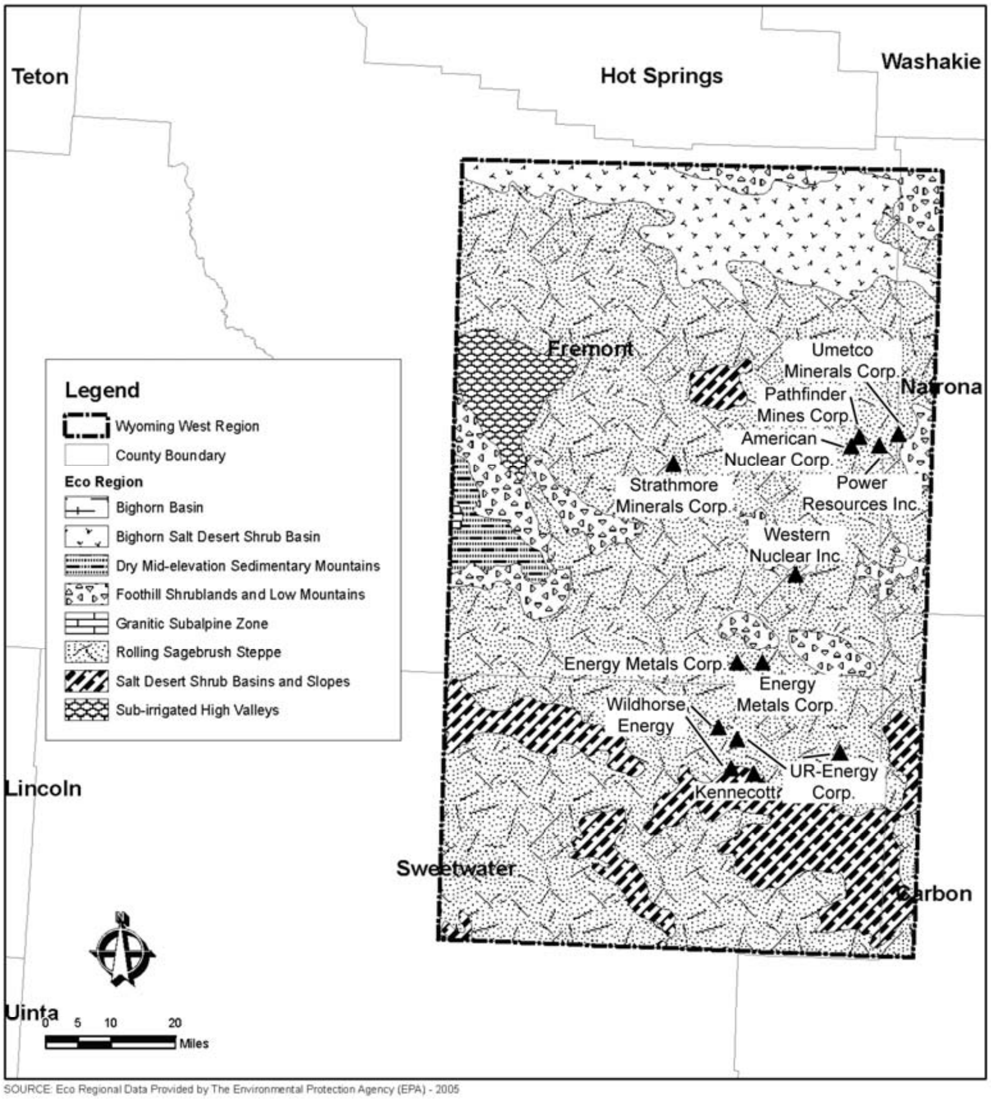

Figure 3.2-7. Ecoregions of the Wyoming West Uranium Milling Region (Based on Chapman, et al., 2004)

region include Sagebrush steppe communities, mountain mahogany woodlands that are often interspersed with mountain big sagebrush, blue grama, prairie junegrass, western wheatgrass, and ponderosa pine (*Pimas ponderosa*) savanna in the Laramie foothills (Chapman, et al., 2004).

The Subirrigated High Valleys are wet meadow systems located in areas of high drainage density beneath surrounding mountain ranges. Soil in this region remains moist due to the presence of a high water table. This region is abundant with floodplains, low terraces, riparian wetlands, and alluvial fans. As a result, the riparian areas and wet meadows are dominated by willows, alders, cottonwoods and wetland plants, such as horsetail (*Equisetum* sp.), spikerush (*Eleocharis* sp.), sedges (*Cyperaceae* sp.), and tufted hairgrass (*Deschampsia cespitosa*) found in low drainage areas. Shrubland areas may include Wyoming big sagebrush, western wheatgrass, needle-and-thread grass, blue grama, Sandberg blue grass, prairie junegrass, rabbitbrush, and fringed sage (Chapman, et al., 2004).

The Salt Desert Shrub Basins ecoregion is an arid environment that includes isolated playa lakes and sand dunes scattered throughout the Wyoming Basin. Vegetation in this area consists of arid land alkaline tolerant shrubs such as shadscale (*Atriplex confertifolia*), greasewood (*Sarcobatus vermiculatus*), and Gardner saltbush (*Atriplex gardneri*) low in abundance. Plant life is more diverse on sand dunes, which provide greater moisture, higher permeability, and lower alkalinity than the basin floor. Vegetation found on stable sand dune areas includes alkali cordgrass (*Spartina gracilis*), Indian grass (*Sorghastrum nutans*), blowout grass (*Redfieldia flexuosa*), alkali wildrye (*Leymus simplex)*, and needle-and-thread grass (Chapman, et al., 2004).

The Bighorn Salt Desert Shrub Basins are composed of two large, arid, alkaline depressions surrounded by mountains. This region is geographically isolated from the other salt desert shrub basins in southern Wyoming. This region has a greater human influence due to the proximity to major rivers (Bighorn, Shoshone, and Greybull Rivers), which provide water for irrigation. This region receives approximately 15 cm [6 in] of precipitation per year and supports desert shrubs and grasses. Vegetation found in this region may consist of greasewood, Gardner saltbush, shadscale, alkali sacaton (*Sporobolus airoides*), and saltgrass (*Distichlis spicata*) (Chapman, et al., 2004). The vegetation around major rivers consists of open woodland of plains cottonwood (*Populus deltoides*), narrowleaf cottonwood (*Populus angustifolia*), peachleaf willow (*Salix amygdaloides*), and wild plum (*Prunus americana*).
The Middle Rockies ecoregion is composed of steep-crested, high mountains that are largely covered by coniferous forests.

The Bighorn and Beartooth Mountains and the Wind River and Teton Ranges comprise the Granitic Subalpine Zone. Snowmelt moisture, absorbed and released throughout the spring and summer, provides water for humans and wildlife living at lower elevations in the droughty, sedimentary fringes of these mountains. Subalpine forests are dominated by lodgepole pine (*Pinus contorta*) at the lower elevations, with subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) found in the higher elevations. The diversity of the understory is low and consists mostly of grouse whortleberry (*Vaccinium scoparium*), Oregon grape (*Mahonia aquifolium*), and birchleaf spirea (*Spiraea betulifolia*). The subalpine spruce-fir zone is not as heavily grazed by livestock as mid-elevation areas; it serves as summer range for mule deer (*Odocoileus hemious*) and elk (*Cervus Canadensis*) (Chapman, et al., 2004).

The Dry Mid-Elevation Sedimentary Mountains ecoregion includes the mid-elevation Bighorn Mountains and the drier northeastern portion of the Wind River Range that are underlain by sedimentary rocks. The lack of moisture in the soil is enhanced by the rainshadow effects of the two mountain ranges. Upland forest cover is open and patchy due to arid conditions. Forests of the Wind River Range are dominated by Douglas firs (*Pseudotsugai* ssp.) with an understory of grasses, forbs, and shrubs. Forest cover is more extensive on the east slopes of the Bighorns where there is more summer precipitation. A ponderosa pine/juniper/mountain mahogany association exists here similar to one in the Black Hills region to the east, but it is of limited extent. The forest of the eastern Bighorn Mountains lacks enough precipitation to support the eastern deciduous species and boreal vegetation present in the Black Hills. Some quaking aspen groves occur in this region, particularly in the Wind River Range (Chapman, et al., 2004).

A comprehensive listing of habitat types and species found in the aforementioned ecoregions has been compiled as part of the Wyoming Gap Analysis project (Wyoming Geographic Information Science Center, 2007a,b).

The Wyoming Gap Analysis project is part of the National Gap Analysis Program. It began in 1991 and was officially completed in November 1996. The program's main goal was to analyze the status of biodiversity within Wyoming, focusing on two biodiversity elements: land cover types and terrestrial vertebrate species. Land ownership and management for the state of Wyoming was combined with the data on land cover and species distributions in a geographic overlay. A Geographical Information System was used to determine which biodiversity elements were inadequately protected within the current system of areas managed for conservation (Wyoming Geographic Information Science Center, 2007a,b).

Wyoming West Uranium Milling Region Fauna

According to the official state list of birds, mammals, amphibians, and reptiles in Wyoming compiled by the Wyoming Game and Fish Department, approximately 246 bird, 127 mammal, 12 amphibian, and 27 reptile species are found in Wyoming. The official state list of the common and scientific names of the birds, mammals, amphibians, and reptiles in Wyoming can be obtained from the Wyoming Game and Fish Department (2007a).

According to the World Wildlife Fund's species database (World Wildlife Fund, 2007a,b), approximately 285 different species are found within the Wyoming Basin. Common animals found in this region include large game mammals such as moose (*Alces alce*), pronghorn (*Antilocapra americana*), elk, mule deer, white tailed deer (*Odocoileus virginianus*), bighorn sheep (*Ovis Canadensis*), and American black bear (*Ursus americanus*). Numerous rodents such as chipmunks (*Tamias* spp.), squirrels (*Speermophilus* spp.), shrews (*Sorex* spp.), and rabbits (*Sylvilagus* spp.) and numerous myotic bat species are found within this region. Reptiles and amphibians found in the region include species such as the western rattlesnake (*Crotalus viridis*), gopher snake (*Pituophis caterifer*), garter snake (*Thamnophis elegans*), tiger salamander (*Ambystoma tigrium*), Woodhouse's toad (*Bufo woodhouii*), and spadefoot toad (*Scaphiopus* spp.). A diverse number of birds also inhabit this region, including hawks like the Cooper's hawk (*Accipter cooperii*), goshawk (*Accipiter gentilis*), and red-tailed hawk (*Buteo jamaicensis*) and the golden eagle (Aquila chrysaetos). Common birds in the region include finches (*Leucosticte* spp.), sparrows, owls (*Otus* spp.), swallows (*Tachycinets* spp.), and vireos (*Vireo* spp.) in addition to other songbirds. A noted species within this region is the white-tailed prairie dog (*Cynomys leucurus*). The white-tailed prairie dog towns in this region provide food for predators such as the coyote (*Canis latrans*), the swift fox (*Vulpes velox*), and the black-footed ferret (*Mustela nigripes*)—a federally recognized endangered species (World Wildlife Fund, 2007a,b).

The Foothill Shrublands ecoregion is a transition region between the Dry Mid-Elevation Sedimentary Mountains ecoregion, Wyoming Basin Shrublands, the Northwest Great Plains, and the South Central Rockies Forest. Species found in this region will overlap all regions. Again, large mammal species such as bighorn sheep, cougar (*Puma concolor*), American bison (*Bison bison*), pronghorn, moose, elk, and coyotes can be found in this region. Shrews, voles (*Microtus* spp.), rabbits, squirrels, and prairie dogs common to the other ecoregions can also be found in this transition area. Raptors such as Cooper's hawk, goshawk, red-tailed hawk, golden eagles, and numerous owl species are bird predators in this area. Common bird species in the region include finches, sparrows, swallows, vireos, warblers, and kingbirds (*Tyrannus* spp.) in addition to other songbirds (World Wildlife Fund, 2007a–e).

The Middle Rockies ecoregion contains over 300 different species. This region features large, important herds of elk and mule deer, which are the main game species in this region. Large predators such as cougar and black bear are also abundant. Other mammals found in this region include the wolverine (*Gulo gulo*), lynx (*Lynx canadensis*), pronghorn, beaver (*Castor canadensis*), coyote (*Canis latrans*), Gunnison's prairie dog (*Cynomys gunnisoni*), black-tailed prairie dog (*Cynomys ludovicianus*), porcupine (*Eremophila dorsatum*), bat, and American marten (*Martes americana*). Numerous rodents such as squirrels, voles, rabbits, rats, and mice occur in this region. Common birds in the region include many of the species found throughout Wyoming like bluebirds (*Sialia* ssp.), sparrows, ducks, woodpeckers, owls, hawks, and eagles. Reptile and amphibian species include the soft-shelled turtle (*Apalone* spp.), plateau striped whiptail (*Cnemidophorus velox*), western rattlesnake, many-lined skink (*Eumeces multivirgatus*), fence lizard (*Sceloporus* spp.), tiger salamander, western toad (*Bufo boreas*), and the Baird's spotted toad (*Bufo punctatus*) (World Wildlife Fund, 2007a–e).

According to the Wyoming Game and Fish Department, crucial wintering habitats are found within this region for large game mammals and nesting leks for the greater sage grouse (*Centrocercus urophasianus*) (Wyoming Game and Fish Department, 2007b). Figures 3.2-8 through 3.2-14 depict the crucial winter and yearlong ranges for large mammals and game birds found in this region. Crucial wintering areas for some species were not identified in the region. However, maps of the region were included for completeness whether species were identified or not. Most of the crucial areas for big game animals in the Wyoming West Uranium Milling Region are located in the Rattlesnake Hills and Granite Mountains in the central and northwestern parts of the region, or along the Sweetwater River and its tributaries. Sites identified within Crook's Gap and Gas Hills Uranium Districts are located in or near crucial winter/yearlong habitat for antelope, moose, and mule deer. Numerous sage-grouse leks and nesting areas are located near sites in both uranium districts, particularly in the southeastern portion of the study region (i.e., Crook's Gap Uranium District).

3.2.5.2 Aquatic

Within the Wyoming West Uranium Milling Region, several watersheds have been listed as aquatic habitat areas. These areas include the Lower Wind River/Boysen Reservoir Watershed, Upper Sweetwater River Watershed, lower Sweetwater Watershed, Middle Fork Popo Agie, Middle North Platte River Corridor, and the South Fork Powder River Watersheds. These watersheds are part of the larger Lower Wind River, Sweetwater, South Fork Powder River, and Middle North Platte-Casper Watersheds previously discussed in Section 3.2.4.1 (Wyoming Game and Fish Department, 2007b). The two uranium districts within the Wyoming West

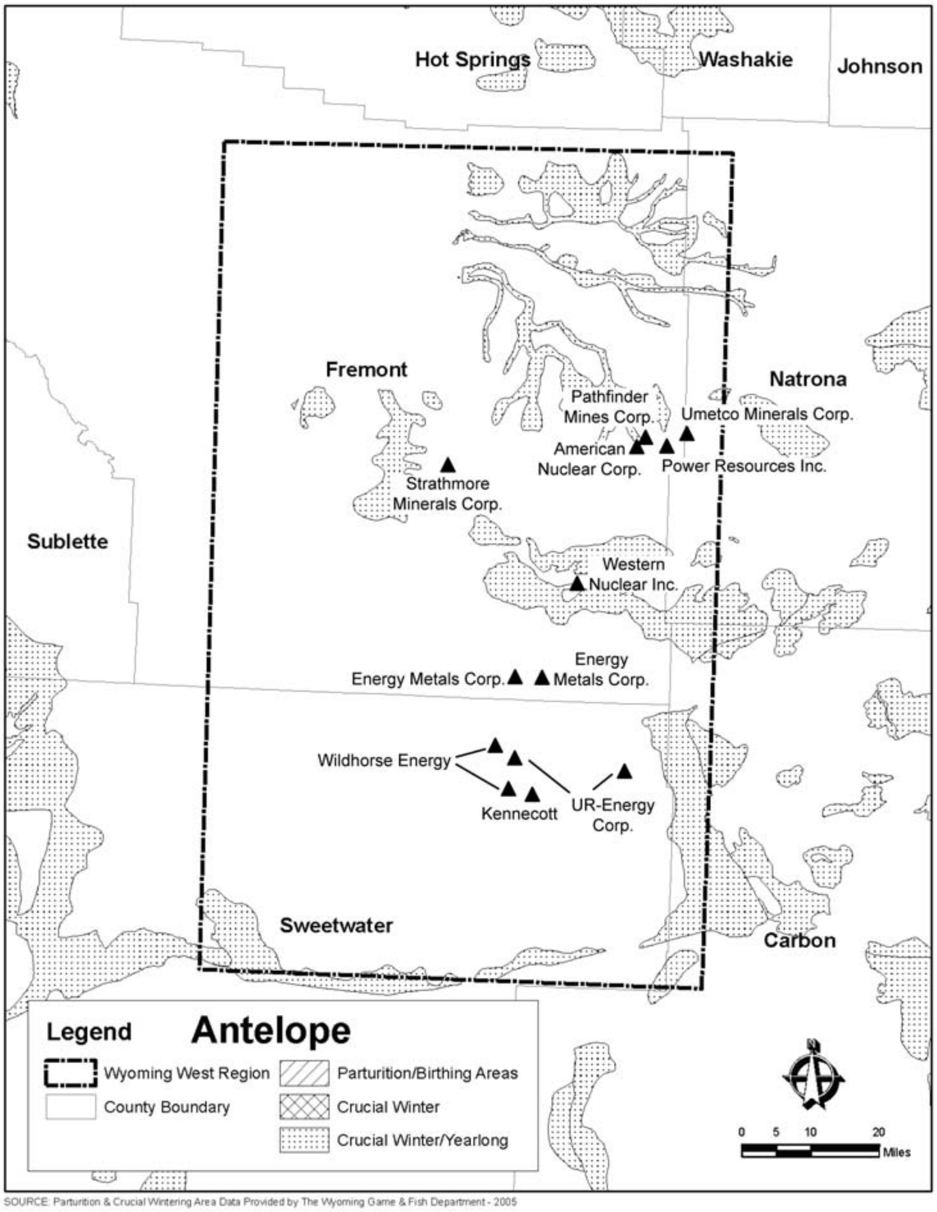

Figure 3.2-8. Antelope Wintering Areas for the Wyoming West Uranium Milling Region

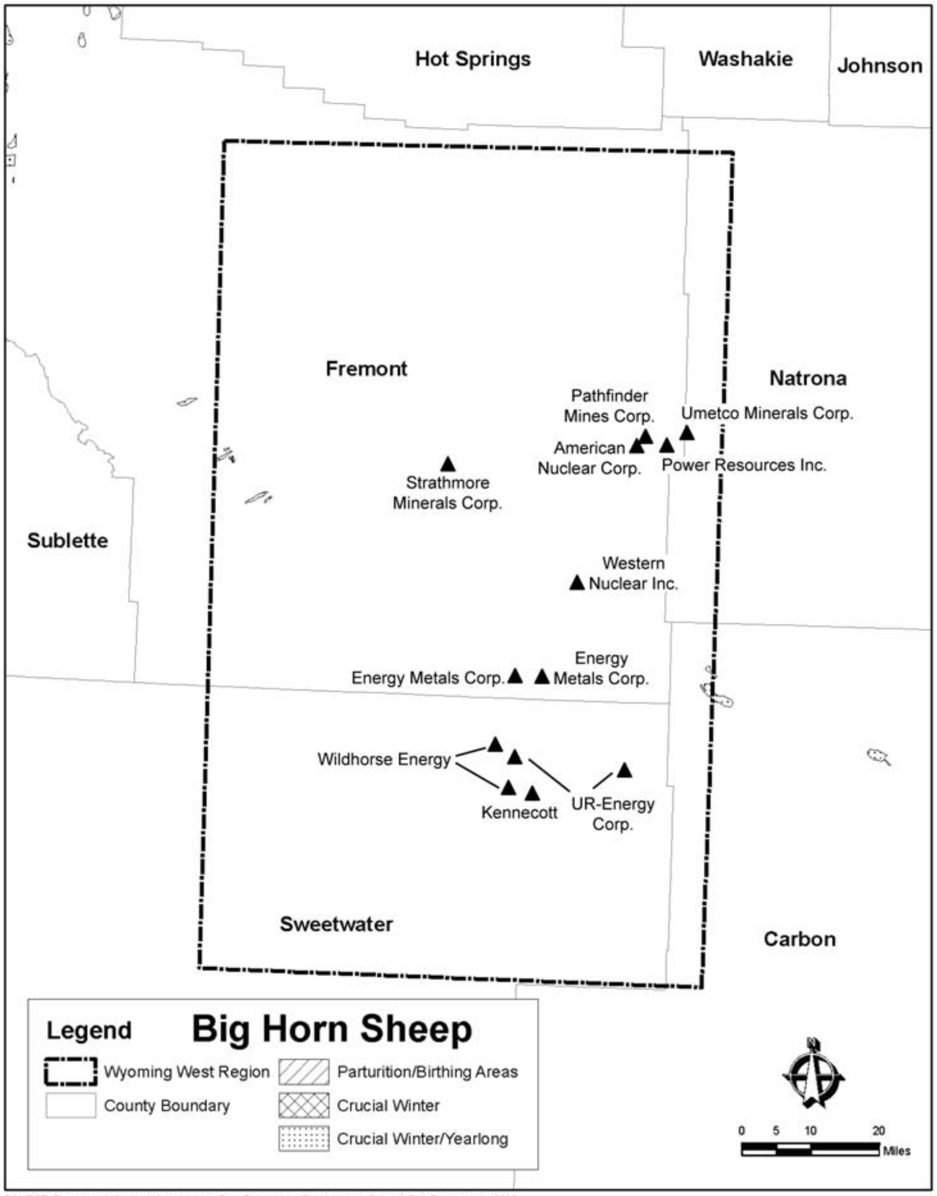

Figure 3.2-9. Big Horn Wintering Areas for the Wyoming West Uranium Milling Region

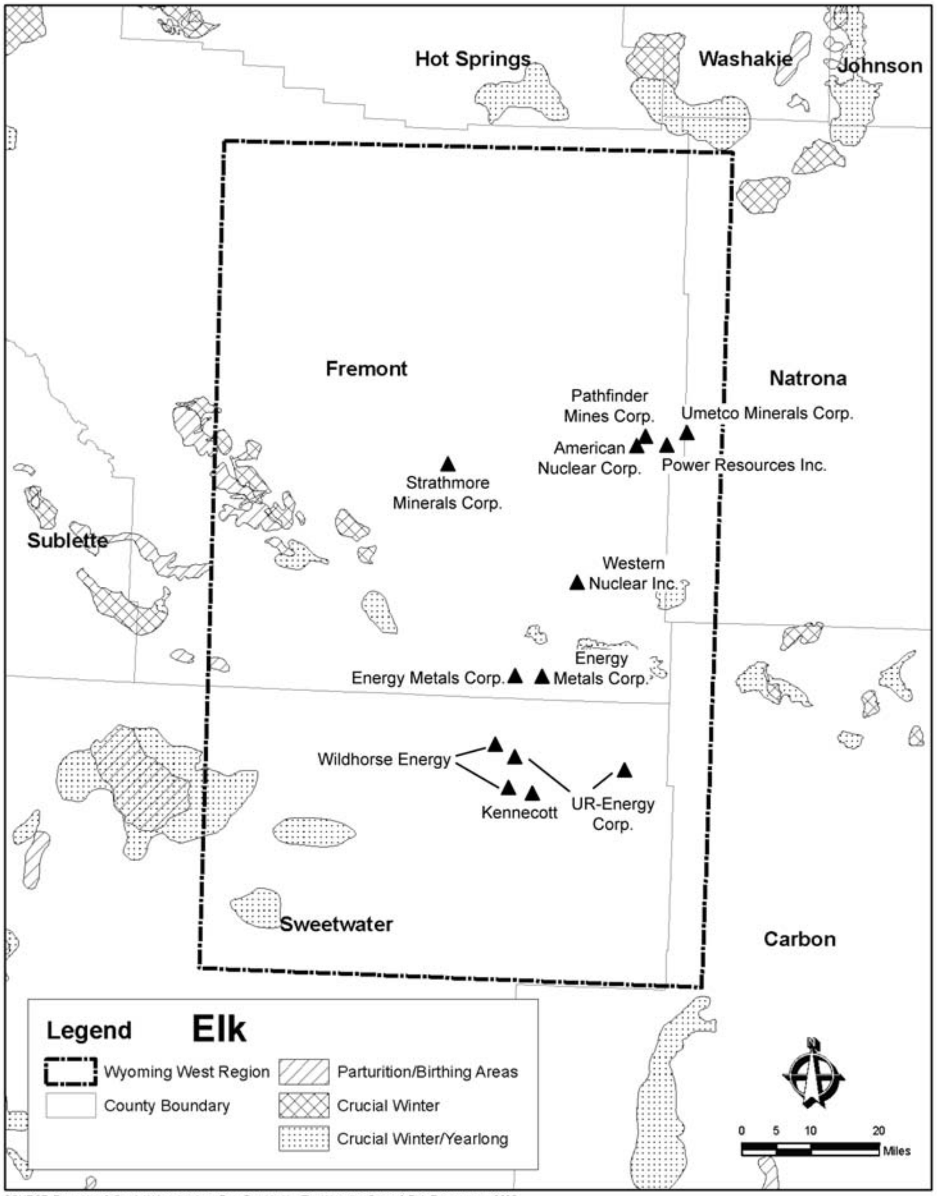

Figure 3.2-10. Elk Wintering Areas for the Wyoming West Uranium Milling Region

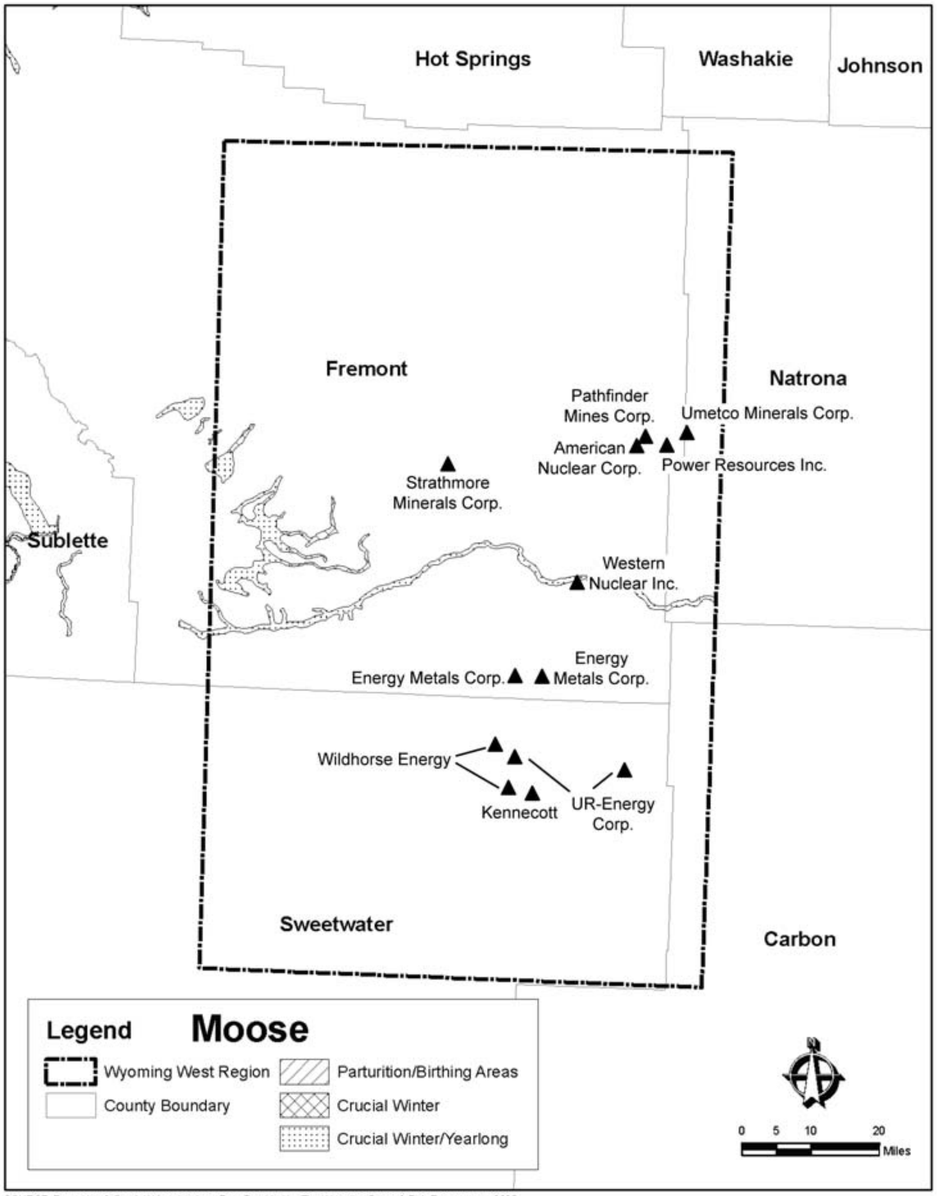

Figure 3.2-11. Moose Wintering Areas for the Wyoming West Uranium Milling Region

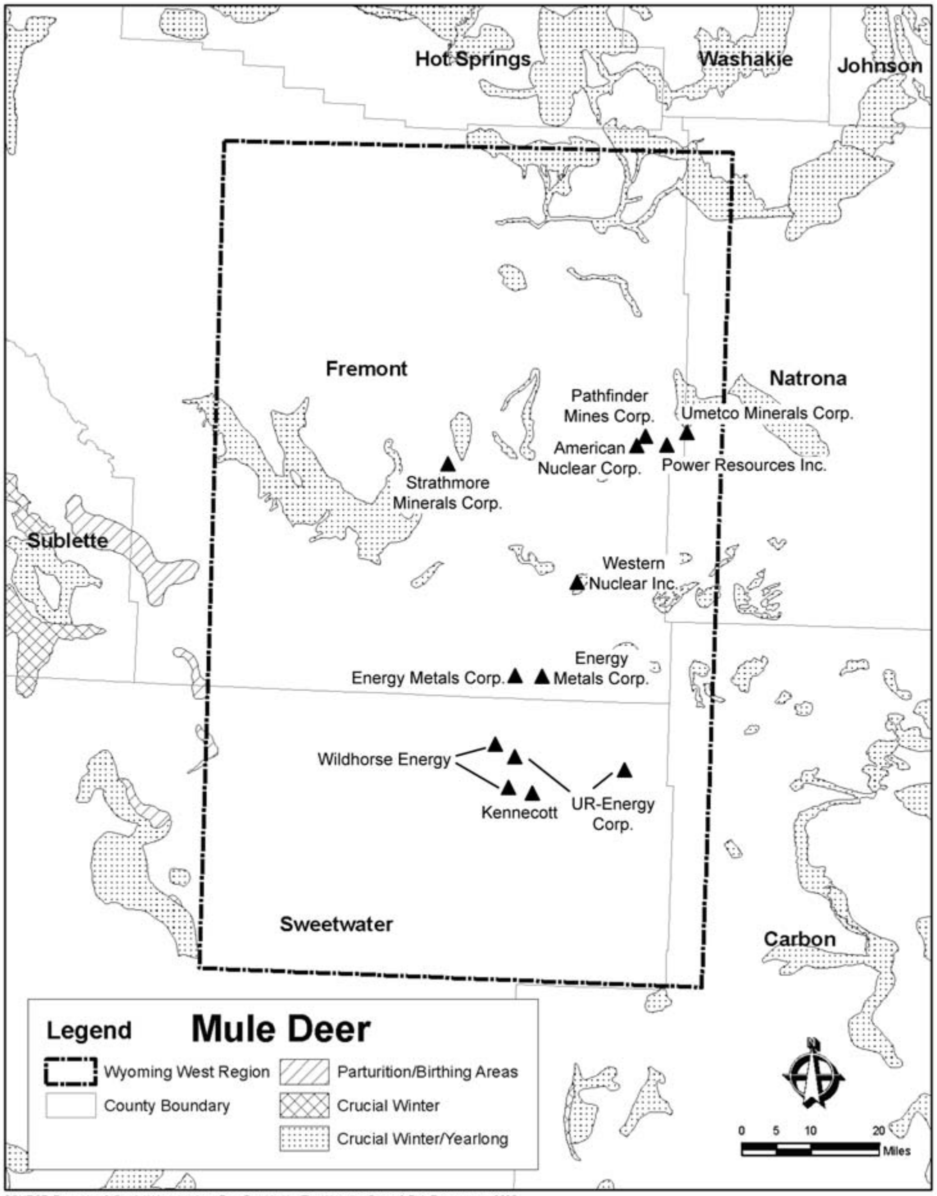

Figure 3.2-12. Mule Deer Wintering Areas for the Wyoming West Uranium Milling Region

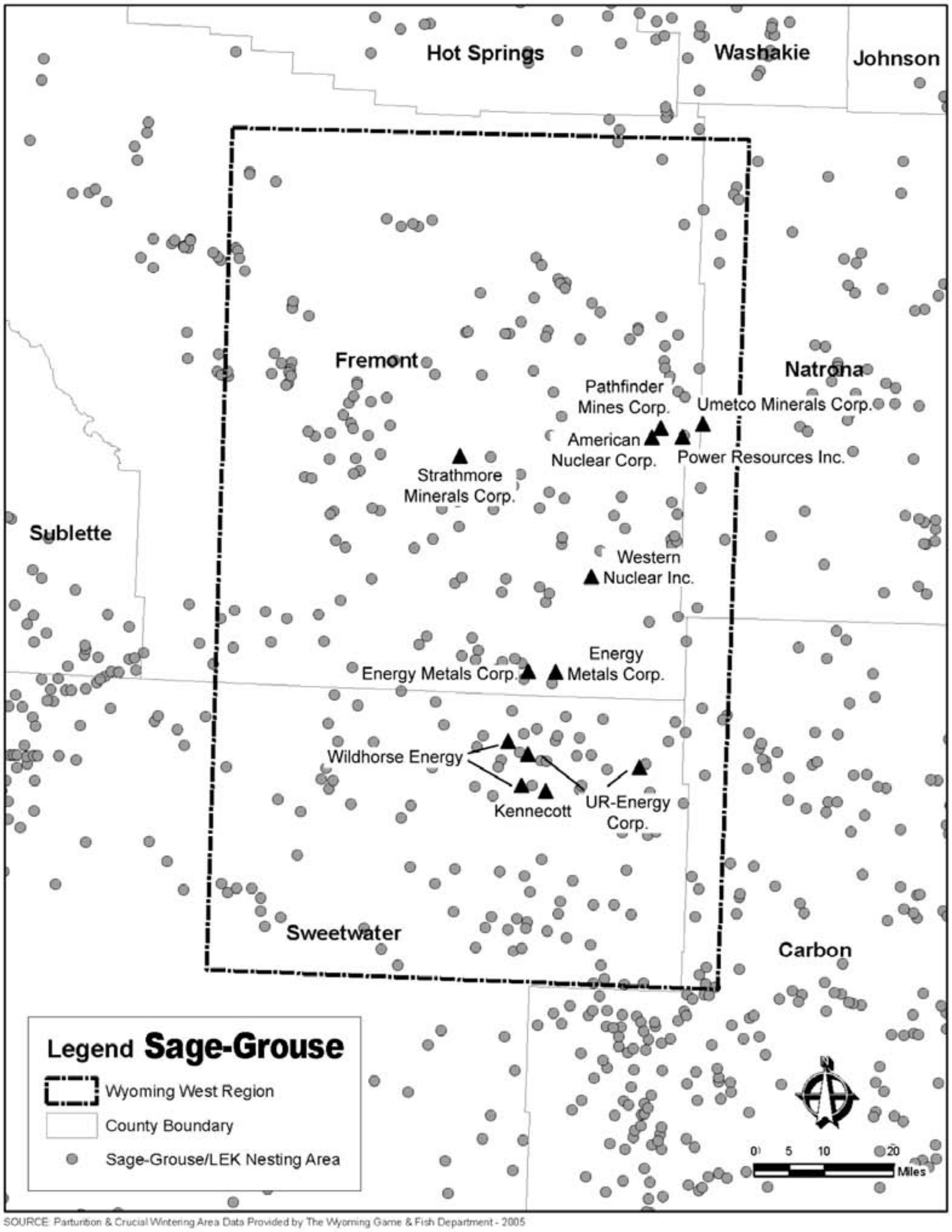

Figure 3.2-13. Sage-Grouse/Lek Nesting Areas for the Wyoming West Uranium Milling Region

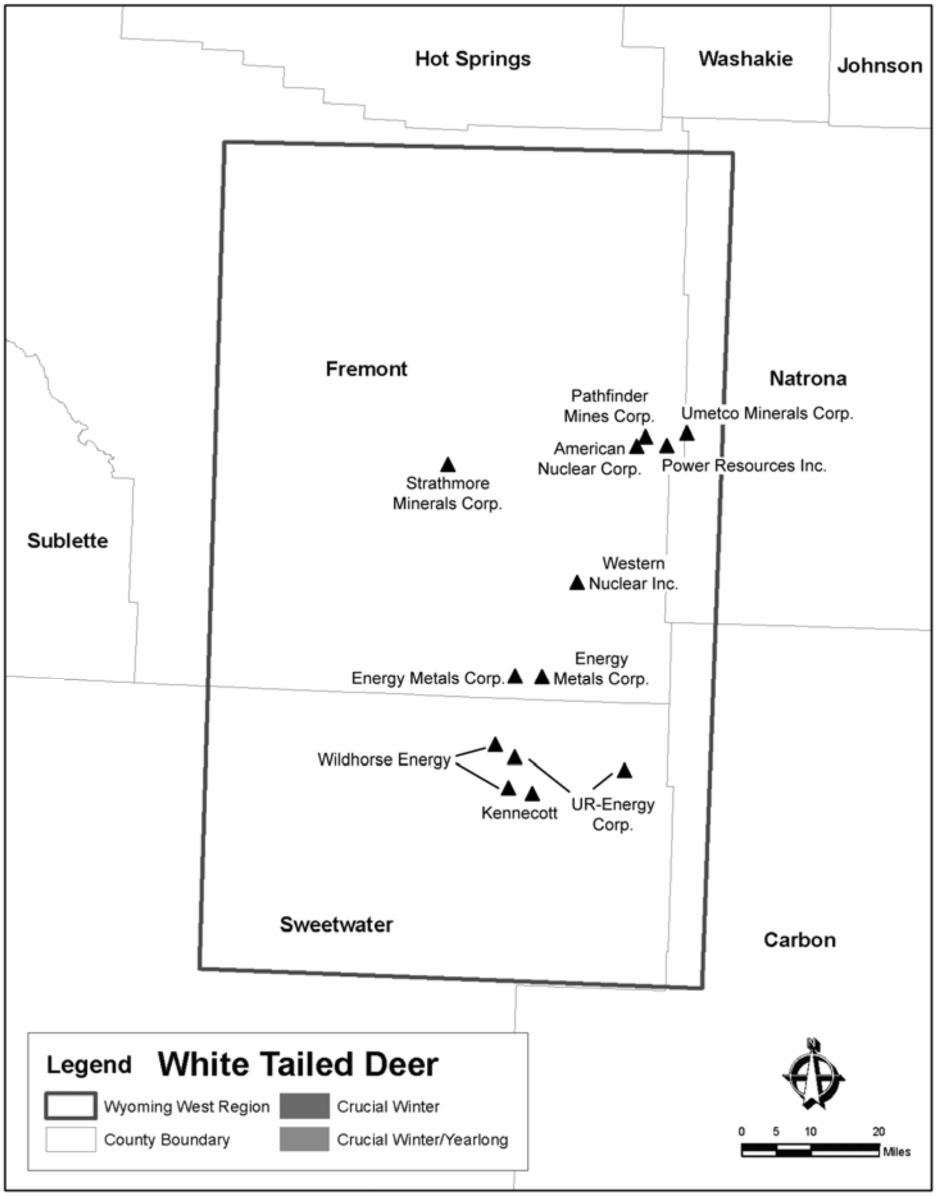

Figure 3.2-14. White Tailed Deer Wintering Areas for the Wyoming West Uranium Milling Region

Uranium Milling Region are located in the Sweetwater (Crooks Gap) and Wind River (Gas Hills) Watersheds.

According to the Wyoming Game and Fish Department (Wyoming Game and Fish Department, 2007b), there are approximately 49 native fish species found in the watersheds throughout the state. These species are identified in Table 3.2-5. Current conditions of these watersheds have been evaluated, and fish species that would benefit from conservation measures within the watersheds have been identified.

Table 3.2-5. Native Fish Species Found in Wyoming

Common Name	Scientific Name
Arctic Grayling	*Thymallus arcticus*
Bigmouth Shiner	*Notropis dorsalis*
Black Bullhead	*Ameiurus melas*
Bluehead Sucker	*Catostomus discobolus*
Brassy Minnow	*Hybognathus hankinsoni*
Burbot	*Lota lota*
Central Stoneroller	*Campostoma anomalum*
Channel Catfish	*Ictalurus punctatus*
Common Shiner	*Luxilus cornutus*
Creek Chub	*Semotilus atromaculatus*
Cutthroat Trout	*Oncorhynchus clarki*
Fathead Minnow	*Pimephales promelas*
Finescale Dace	*Phoxinus neogaeus*
Flannelmouth Sucker	*Catostomus latipinnis*
Flathead Chub	*Platygobio gracilis*
Goldeye	*Hiodon alosoides*
Hornyhead Chub	*Nocomis biguttatus*
Iowa Darter	*Etheostoma exile*
Johnny Darter	*Etheostoma nigrum*
Lake Chub	*Couesius plumbeus*
Leatherside Chub	*Gila copei*
Longnose Dace	*Rhinichthys cataractae*
Longnose Sucker	*Catostomus catostomus*
Mottled Sculpin	*Cottus bairdi*
Mountain Sucker	*Catostomus platyrhynchus*
Mountain Whitefish	*Prosopium williamsoni*
Orangethroat Darter	*Etheostoma spectabile*
Paiute Sculpin	*Cottus beldingi*
Pearl Dace	*Margariscus margarita*
Plains Killifish	*Fundulus zebrinus*
Plains Minnow	*Hybognathus placitus*
Plains Topminnow	*Fundulus sciadicus*
Quillback	*Carpiodes cyprinus*
Red Shiner	*Cyprinella lutrensis*
Redside Shiner	*Richardsonius balteatus*
River Carpsucker	*Carpiodes carpio*
Roundtail Chub	*Gila robusta*
Sand Shiner	*Notropis stramineus*

Table 3.2-5. Native Fish Species Found in Wyoming (continued)	
Common Name	**Scientific Name**
Sauger	*Stizostedion canadense*
Shorthead Redhorse	*Moxostoma macrolepidotum*
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*
Speckled Dace	*Rhinichthys osculus*
Stonecat	*Noturus flavus*
Sturgeon Chub	*Macrhybopsis gelida*
Suckermouth Minnow	*Phenacobius mirabilis*
Utah Chub	*Gila atraria*
Utah Sucker	*Catostomus ardens*
Western Silvery Minnow	*Hybognathus argyritis*
White Sucker	*Catostomus commersoni*

The Lower Wind River discharges into the Boysen Reservoir. Additional waterways that are included in the basin are the Stagner Creek, Gold Creek, Cottonwood Creek, Birdseye Creek, Reservoir Creek, Muddy Creek, Poison Creek, and Cottonwood Drain. Aquatic species found in this system include sauger (*Stizostedion canadense*), burbot (*Lota lota*), mountain whitefish (*Prosopium williamsoni*), stonecat (*Noturus flavus*), channel catfish (*Ictalurus punctatus*), longnose dace (*Rhinichthys cataractae*), northern redhorse (*Moxostoma aureouim*), and flathead chub (*Platygobio gracilis*). Sport fish that occur in the watershed include rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), walleye (*Sander vitreus*), brook trout (*Salvelinus fontinalis*), lake trout (*Salvelinus namaycush*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), and black bullhead (*Ameiurus melas*) (Wyoming Game and Fish Department, 2007b).

The Middle Fork Popo Agie Watershed is found in the western and southern portion of the Wyoming West Uranium Milling Region. Contributing waterways include Saw and Sawmill Creeks. Species in this watershed have been impacted by erosion and sediment processes that have been accelerated by human activities such as prolonged annual herbivory, increased drainage from roads and trails, removal of water for irrigation, dewatering of wetlands, and rural subdivision development. Native species found within this watershed include the lakechub (*Couesius plumbeus*), longnose dace, longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commersonii*), mountain sucker (*Catostomus platyrhynchus*), mountain whitefish, and fathead minnow (*Pimephales promelas)*. Sport fish found in this watershed include rainbow trout, brown trout, brook trout, Yellowstone trout (*Oncorhynchus clarki bouvieri*), Snake River cutthroat trout (*Oncorhynchus clarki* ssp.), and grayling (*Thymallus thymallus*) (Wyoming Game and Fish Department, 2007b).

The Upper Sweetwater River headwaters in the Wind River Mountains flows across the South Pass uplift area. Native species found within this watershed include the lake chub, creek chub (*Semotilus atromaculatus*), longnose dace, longnose sucker, white sucker, mountain whitefish, fathead minnow, Iowa darter (*Etheostoma exile*), and mountain sucker. Sport fish found in this watershed include rainbow trout, brown trout, brook trout, Fall River rainbow (*Oncorhynchus mykiss gairdnerii*), Yellowstone cutthroat trout, Snake River cutthroat, and Bear River cutthroat (Wyoming Game and Fish Department, 2007b).

The Lower Sweetwater River Watershed is found in the south central portion of the Wyoming West Uranium Milling Region. Contributing waterways include Crook Creek and Willow Creek.

Species in this watershed have been impacted by erosion and sediment processes that have been accelerated by human activities such as prolonged annual herbivory and increase drainage from roads and trails as a result of previous uranium milling operations in the Green Mountain Area. Native species found within this watershed include the lake chub, creek chub, longnose dace, longnose sucker, white sucker, mountain sucker, fathead minnow, bigmouth sucker (*Ictiobus cyprinellus*) and Iowa darter. Sport fish found in this watershed include rainbow trout, brown trout, brook trout, Fall River rainbow, and Bear River cutthroat (Wyoming Game and Fish Department, 2007b).

The South Fork Powder River-Murphy Creek basin is relatively dry and sparsely vegetated. Most of the streams are ephemeral or intermittent with few perennial streams. Many of these stream channels are degraded or actively degrading. Native fish species that can be found in this watershed include the creek chub, fathead minnow, flathead chub, longnose dace, plains minnow, sand shiner (*Notropis stramineus*), mountain sucker, and the plains killifish (*Fundulus zebrinus*) (Wyoming Game and Fish Department, 2007b).

The Middle North Platte River Corridor portion of the watershed is located on the eastern side of the Wyoming West Uranium Milling Region. Species found within this watershed include the brassy minnow (*Hybognathus hankinsoni*), common shiner, creek chub, fathead minnow, longnose dace, sand shiner (*Notropis stramineus*), stoneroller (*Campostoma anomalum*), longnose sucker, and white sucker with the rainbow trout, brown trout, cutthroat trout and channel catfish being sport fish (Wyoming Game and Fish Department, 2007b).

The Sweetwater River Muddy Creek and Horse Creek Watersheds are located in the southern portion of the Wyoming West Uranium Milling Region. This watershed region has been impacted by intense herbivory; the successional advance of big sagebrush steppe and absence of beaver dams are the perceived bottlenecks limiting watershed function. Native species found within this watershed include the bigmouth shiner, creek chub, fathead minnow, longnose dace, sand shiner, longnose sucker, white sucker, and Iowa darter. Sport fish in the watershed include rainbow trout, brown trout, cutthroat trout, and brook trout.

3.2.5.3 Threatened and Endangered Species

Federally listed threatened and endangered species known to exist in habitats in the West Wyoming Uranium Milling Region include the following:

- Black-Footed Ferret (*Mustela nigripes*)—Ferrets were once found throughout the Great Plains, from Texas, New Mexico, and Arizona to southern Saskatchewan, Canada. Ferrets eat prairie dogs and live in prairie dog burrows. Typical wild ferret behavior revolves around prairie dog towns. Wild ferrets hunt prairie dogs at night, but occasionally they are active above ground during the day. This is especially true of female ferrets hunting to feed their young. In search of prey, they move from one prairie dog burrow to the next (U.S. Fish and Wildlife Service, 2008).

- Blowout Penstemon (*Penstemon haydenii*)—Limited to the sandhills region of west-central Nebraska, and sand dune habitat in the northeastern Great Divide Basin in Wyoming. In Nebraska this plant typically occurs in “blowouts”—sparsely vegetated depressions in active sand dunes created by wind erosion. In Wyoming it occurs on sandy aprons or the lower half of steep sandy slopes deposited at the base of granitic or sedimentary mountains or ridges. It occurs at elevations ranging from 850–1,150 m

[2,800–3,800 ft] in Nebraska to 2,030–2,270 m [6,680–7,440 ft] in Wyoming. This species can be found in west-central Nebraska in Box Butte, Cherry, Garden, Morrill and Thomas Counties, and in the Wyoming West Uranium Milling Region in northwestern Carbon County (Center for Plant Conservation, 2008).

- Bonytail Chub (Gila elegans)—Found in slower water habitats in the main stream such as eddies, pools, sidechannels, and coves. They are found in streams below 1,220 m [4,000 ft] elevation. The bonytail chub is endemic to the Colorado River basin and found throughout the mainstemrivers and backwaters of the Upper and Lower Basins. This species is one of the rarest of the Colorado River fishes and is close to extinction (U.S. Fish and Wildlife Service, 2008).

- Canada Lynx (*Lynx canadensis*)—The Canada lynx inhabits mountain regions, primarily at elevations between 2,356 and 2,869 m [7,730 and 9,410 ft] and on slopes of 8 to 12 percent. It usually occurs in extensive tracts of dense coniferous forest, primarily Engelmann spruce and subalpine fir. It feeds primarily on snowshoe hares, especially during winter (thereby making habitat for showshoe hares a key consideration for lynx habitat). Older forests with a substantial understory of conifers or small patches of shrubs and young trees provide good quality lynx foraging habitat. The most important component of denning habitat is large woody debris, especially dense tangles of fallen trees and root wads. Such preferred habitat is relatively limited in Wyoming and occurs primarily in multiple use areas of the Shoshone and Bridger-Teton National Forests along the western boundary of the Wyoming West Uranium Milling Region. The national parks and designated wilderness areas in Wyoming tend to be marginal lynx habitat as they are either dominated by dry even-aged lodgepole pine forests, or are too steep and at too high an elevation (Wyoming Game and Fish Department, 2008).

- Colorado Pikeminnow (*Ptychocheilus lucius*)—Colorado pikeminnow were once abundant in the main reach of the Colorado River and most of its major tributaries in Colorado, Wyoming, Utah, New Mexico, Arizona, Nevada, California and Mexico. Now, they exist primarily in the Green River below the confluence with the Yampa Rive;, the lower Duchesne River in Utah; the Yampa River below Craig, Colorado; the White River from Taylor Draw Dam near Rangely, Colorado downstream to the confluence with the Green River; the Gunnison River in Colorado; and the Colorado River from Palisade, Colorado, downstream to Lake Powell. It is believed that the Colorado pikeminnow populations in the upper Colorado River basin are now relatively stable and in some areas may even be growing (U.S. Fish and Wildlife Service, 2008).

- Humpback Chub (*Gila cypha*)—The humpback chub lives primarily in canyons with swift currents and white water. Historically, it inhabited canyons of the Colorado River and four of its tributaries: the Green, Yampa, White and Little Colorado rivers. Now, there are two populations near the Colorado/Utah border—one at Westwater Canyon in Utah and one in an area called Black Rocks, in Colorado. Though now smaller in number than they were historically, the two populations seem to be fairly stable in these two areas (U.S. Fish and Wildlife Service, 2008).

- Interior Least Tern (*Sterna antillarum athalassos*)—The nesting habitat of the interior least tern includes bare or sparsely vegetated sand, shell, and gravel beaches; sandbars; islands; and salt flats associated with rivers and reservoirs. The birds prefer open habitat and tend to avoid thick vegetation and narrow beaches. Sand and gravel bars within a wide unobstructed river channel, or open flats along shorelines of lakes and reservoirs, provide favorable nesting habitat. Nesting locations are often at the higher elevations away from the water's edge because nesting usually starts when river levels are high and relatively small amounts of sand are exposed. The size of nesting areas depends on water levels and the extent of associated sandbars and beaches. Highly adapted to nesting in disturbed sites, terns may move colony sites annually, depending on landscape disturbance and vegetation growth at established colonies (Texas Parks and Wildlife Department, 2007).

- Pallid Sturgeon (*Scaphirhynchus albus*)—This species is a bottom dweller, found in areas of strong current and firm sand bottom in the main channel of large turbid rivers such as the Missouri and Plotte River. The pallid sturgeon is a member of a primitive family that, like other sturgeon, has lengthwise rows of bony plates covering its body, rather than scales. Pallids are slow growing, late-maturing fish that feed on small fishes and immature aquatic insects. Spawning occurs from June through August (Platte River Endangered Partnership, 2008).

- Piping Plover (*Charadrius melodus)*—Piping plovers breed only in North America in three geographic regions: the Atlantic Coast, the Northern Great Plains, and the Great Lakes. Plovers in the Great Plains make their nests on open, sparsely vegetated sand or gravel beaches adjacent to alkali wetlands, and on beaches, sand bars, and dredged material islands of major river systems (U.S. Fish and Wildlife Service, 2008).

- Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*)—This species lives primarily in heavily vegetated, shrub-dominated riparian (streamside) habitats and immediately adjacent upland habitats along the foothills of southeastern Wyoming south to Colorado Springs along the eastern edge of the Front Range of Colorado. Documented distribution includes Albany, Laramie, Platte Goshen, and Converse counties in Wyoming (U.S. Fish and Wildlife Service, 2008)

- Razorback Sucker (*Xyrauchen texanus*)—This is a large river species not found in smaller tributaries and headwater streams. Found in water from 1–3 m [4–10 ft] in depth, adults are associated with areas of strong current and backwaters (Colorado Division of Wildlife, 2008). This species has been extirpated from Wyoming; however, it can be occasionally found in Sweetwater County (University of Wyoming, 2008).

- Ute Ladies' Tresses Orchid (*Spiranthes diluvialis*)—Populations of Ute ladies'-tresses orchids are known from three broad general areas of the interior western United States—near the base of the eastern slope of the Rocky Mountains in southwestern Wyoming and adjacent Nebraska and north-central and central Colorado; in the upper Colorado River basin, particularly in the Uinta Basin; and in the Bonneville Basin along the Wasatch Front and westward in the eastern Great Basin, in north-central and western Utah, extreme eastern Nevada, and southeastern Idaho. The orchid also has been discovered in southwestern Montana and in the Okanogan area and along the Columbia River in north-central Washington. The orchid occurs along riparian edges, gravel bars, old oxbows, high flow channels, and moist to wet meadows along perennial streams. It typically occurs in stable wetland and seepy areas associated with old landscape features within historical floodplains of major rivers. It also is found in wetland and seepy areas near fresh-water lakes or springs (U.S. Fish and Wildlife Service, 2008).

- Western Prairie Fringed Orchid (*Platanthera praeclara*)—The western prairie fringed orchid is a plant of the tallgrass prairie and requires direct sunlight for growth. It is most often found in moist habitats or sedge meadows (U.S. Fish and Wildlife Service, 2008).

- Whooping Crane (*Grus americana*)—The whooping crane prefers fresh-water marshes, wet prairies, shallow portions of rivers and reservoirs, grain and stubble fields, shallow lakes, and lagoons for feeding and loafing during migration. The whooping crane formerly nested from central Illinois west to eastern North Dakota and north through the Canadian prairie provinces. It presently breeds in Wood Buffalo National Park in the Northwest Territories, Canada. It overwinters on the Texas Gulf Coast on and in the vicinity of the Aransas National Wildlife Refuge. A second foster population migrates from Grays Lake National Wildlife Refuge in Idaho to the Bosque del Apache National Wildlife Refuge on the Rio Grande River in New Mexico. In South Dakota, the whooping crane is a predictable spring and fall migrant in the Missouri River drainage and in western South Dakota (Platte River Endangered Partnership, 2008).

- Yellow-Billed Cuckoo (*Coccyzus americanus*)—Candidate—Throughout their range, preferred breeding habitat includes open woodland (especially where undergrowth is thick), parks, and deciduous riparian woodland. In the West, they nest in tall cottonwood and willow riparian woodlands. Nests are found in trees, shrubs, or vines an average of 1 to 3 m [3 to 10 ft] above ground (Harrison, 1979). Western subspecies require patches of at least 10 ha [25 acres] of dense, riparian forest with a canopy cover of at least 50 percent in both the understory and overstory (Montana Natural Heritage Program, 2008).

The state of Wyoming does not maintain a list of threatened or endangered plant or animal species, but has established a nongame bird and mammal plan that includes a list of species of special concern. The state considers all of the federally listed animal species to be species of special concern. Wyoming Species of Concern are described as Wyoming Native Species Status matrix 1 (populations are greatly restricted or declining—extirpation appears possible) and 2 (populations are declining or restricted in numbers and/or distribution—extirpation is not imminent. Wyoming Species of Concern that may be found in the Wyoming West Uranium Milling Region include the following:

- Flannelmouth Sucker (*Catostomus latipinnis*) Native Species Status 1—This species prefers large rivers with deep riffles and runs, they can also be found in smaller streams and sometimes in lakes. Native to the Colorado River drainage basin, in Wyoming it is found in the Green and Little Snake River drainages. In the spring it leaves the large rivers and ascend small tributary streams to spawn; migrations of over 225 km [140 mi] have been documented (Wyoming Game and Fish Department, 2008).

- Boreal Toad (*Bufo boreas*) Native Species Status 1—The southern Rocky Mountain population occurs from south-central Wyoming southward through the mountainous regions of Colorado to extreme north-central New Mexico. The toads inhabit a variety of wet habitats (i.e., marshes, wet meadows, streams, beaver ponds, glacial kettle ponds, and lakes interspersed in subalpine forest) at altitudes primarily between 2,400–3,400 m [8,000–11,500 ft] (U.S. Fish and Wildlife Service, 2008).

- Common Loon (*Gavia Immer*) Native Species Status 1—Lakes that are suitable for breeding are extremely limited in Wyoming and must have the following characteristics (Wyoming Game and Fish Department, 2008):

  — At least 4 ha [10 acres], although reproductive success is better on lakes that are greater than 10 ha [25 acres]

  — Free of human disturbance or in areas that are secluded from human activity

  — Between 1,800 and 2,400 m [1,000 and 8,000 ft] in elevation

  — Have clear water with a minimum visibility of 3 to 4 m [10 to 13 ft], as loons are visual predators

  — Islands or protected shore areas for nesting and raising young

  — Abundant populations of small to mid-sized fish

  — Greater than 2 m [6 ft] deep to prevent winter kill of fish

  — Remain ice free for at least 4 months to allow young to fledge

  — For nesting, lakes with partially forested, rocky shorelines; an area of shallow water with emergent vegetation; and a steep slope adjacent to the shoreline for an underwater approach to the nest

- Burbot (*Lota lota*) Native Species Status 1—The burbot lives in cold, deep lakes and large rivers. Immature fish prefer rubble substrate, while adults remain in deep water to prey on other fish. In Wyoming, the burbot is native to the Big Horn and Tongue River systems. It is found in larger lakes in the Lander and Dubois area, including Boysen Reservoir and Ocean Lake. It also occurs south to Missouri and Kansas and east to New England, as well as throughout Canada (Wyoming Game and Fish Department, 2008).

- Sauger (*Sander canadensis*) Native Species Status 2—The sauger prefers large rivers but may also be found in reservoirs. The fish is tolerant of turbid waters. In rivers the key component of sauger habitat is velocity. In the summer and spring they select low velocity areas having sand or silt substrates. Pool habitats are preferred by sauger especially in winter where they tend to select low velocity pools greater than 2 m [6 ft] deep. Native to streams east of the Continental Divide, today the sauger occurs in Wyoming in the Wind Big Horn River drainage and in the Tongue and Powder River drainages. It has apparently been extirpated from the North Platte River, where it had once been common (Wyoming Game and Fish Department, 2008).

- Yellowstone Cutthroat (*Oncorhynchus clarki bouvieri*) Native Species Status 2—The Yellowstone cutthroat lives in lakes, large rivers, and small tributary streams. Native to the Yellowstone River drainage downstream to the Tongue River, including the Big Horn and Clarks Fork River drainages, this trout is also found in Pacific Creek and other Snake River tributaries. All other occupation by this species east of the Continental Divide is from introductions (Wyoming Game and Fish Department, 2008).

- Cliff Tree Lizard (*Urosaurus ornata wrightii*) Native Species Status 2—This lizard prefers cliffs and rocky canyon slopes in sagebrush desert habitats. It is often found on the vertical surfaces of large boulders or rock cliffs. In Wyoming, the cliff tree lizard occurs in the extreme southwestern part of the state. It also ranges south through Utah and western Colorado to northern Arizona and northern New Mexico (Wyoming Game and Fish Department, 2008).

- Great Basin Gopher Snake (*Pituophis melanoleucas deserticola)*, Native Species Status 1—This snake prefers sagebrush communities and deserts in the plains zone. In Wyoming, it can be found in the south-central counties at lower elevations and west of the Continental Divide in the Wyoming Basin. Elsewhere, it is distributed from the Great Basin to eastern California, Oregon, and Washington (Wyoming Game and Fish Department, 2008).

- Rubber Boa (*Charina bottae)* Native Species Status 2—The rubber boa prefers areas with an abundance of flat rocks and water nearby. It does not inhabit Wyoming's arid regions, but may be found in the foothills and lower mountain zones of the northwestern corner of the state, south into Star Valley and east to the Big Horn Mountains. It is also distributed west of Wyoming to the Pacific Coast from British Columbia to northern California (Wyoming Game and Fish Department, 2008).

- Canada Lynx (*Lynx canadensis*) Native Species Status 1—The Canada lynx inhabits mountain regions, primarily at elevations between 2,356 and 2,869 m [7,730 and 9,413 ft] and on slopes of 8 to 12 percent. It usually occurs in extensive tracts of dense coniferous forest, primarily Engelmann spruce (*Picea englemannii*) and subalpine fir (*Abies lasiocarpa*). It feeds primarily on snowshoe hares (*Lepus americanus*), especially during winter, and the prime consideration for lynx is habitat for snowshoe hares. Older forests with a substantial understory of conifers or small patches of shrubs and young trees provide good quality lynx foraging habitat. The most important component of denning habitat is large woody debris, especially dense tangles of fallen trees and root wads. Such preferred habitat is relatively limited in Wyoming and occurs primarily in multiple use areas of the Shoshone and Bridger-Teton National Forests. The national parks and designated wilderness areas in Wyoming tend to be marginal lynx habitat as they are either dominated by dry even-aged lodgepole pine forests or steep and high elevation (Wyoming Game and Fish Department, 2008).

- Pale Milk Snake (*Lampropeltis triangulum multistrata*), Native Species Status 2—The pale milk snake prefers grasslands, sandhills, and scarp woodlands below 1,800 m [6,000 ft] in elevation. It is distributed throughout the northern Great Plains. In Wyoming, it can be found in the eastern counties and the Big Horn Basin (Wyoming Game and Fish Department, 2008).

- Smooth Green Snake (*Opheodrys vernalis*), Native Species Status 2—This snake occupies forested areas of the foothills and montane zones, preferring to spend much of its time under rocks, logs, and other objects. It is usually associated with lush vegetation. Two subspecies occur in Wyoming. *O. vernalis vernalis*, the eastern smooth green snake, is a relict population that occurs only in the Black Hills of Wyoming and South Dakota. *O. vernalis blanchardi* is the western subspecies and can be found in southeast and south-central Wyoming. Additionally, the smooth green snake occurs in parts of Canada, the northeastern and north-central United States, and as far west as

Utah, Idaho and New Mexico. In the west, the snake's distribution is highly disjointed (Wyoming Game and Fish Department, 2008).

- Yellow-Billed Cuckoo (*Coccyzus americanus*) Native Species Status 2—The yellow-billed cuckoo nests primarily in large stands of cottonwood-riparian habitat below 2,100 m [7,000 ft], including such habitats that occur in urban areas. It is a riparian obligate species that prefers extensive areas of dense thickets and mature deciduous forests near water, and requires low, dense, shrubby vegetation for nest sites (Wyoming Game and Fish Department, 2008).

- Greater Sage-Grouse (*Centrocercus urophasianus*) Native Species Status 2—Sage-grouse depend on a variety of sagebrush community types and associated habitats, including basin-prairie and mountain foothill shrublands and wet-moist meadows. Alfalfa and irrigated meadows also serve as habitat when immediately adjacent to sagebrush. Sage-grouse use different habitats during different times of the year (Wyoming Game and Fish Department, 2008).

- Bald Eagle (*Haliaeetus leucocephalus*) Native Species Status 2—The bald eagle nests near large lakes and rivers in forested habitat where adequate prey and old, large-diameter cottonwood or conifer trees are available for nesting. Highly productive nesting areas in the Greater Yellowstone Area were found to have open water available in winter, low severity of early spring weather, limited human activity, and high sinuosity and an abundance of islands, riffles, runs, and pools in the river. Migrating and wintering eagles congregate near open water areas where concentrations of prey are available, such as carcasses of game animals, and spawning areas for kokanee, trout, and other fish (Wyoming Game and Fish Department, 2008).

- Trumpeter Swan (*Cygnus buccinator*), Native Species Status 2—The trumpeter swan inhabits shallow marshes, ponds, lakes, and river oxbows. It prefers stable, quiet, and shallow waters where small islands, muskrat houses, or dense emergent vegetation provide nesting and loafing sites. Nutrient-rich waters, with dense aquatic plant and invertebrate growth, provide the most suitable habitat. Adequate forage in the prenesting period (April to May) is critical for nesting success. Winter habitat must provide extensive beds of aquatic plants that remain ice free. In Wyoming, cold temperatures and ice restrict trumpeters to sites where geothermal waters, springs, or outflow from dams maintain ice-free areas (Wyoming Game and Fish Department, 2008).

- Fringed Myotis (*Myotis thysanodes*), Native Species Status 2—The fringed myotis is found in a wide range of habitats, including coniferous forests, woodlands, grasslands, and shrublands, although it is probably most common in xeric woodlands, such as juniper, ponderosa pine, and Douglas fir. It typically forages over water, along forest edges, or within forests and woodlands. During summer, it uses a variety of roosts, including rock crevices, tree cavities, caves, abandoned mines, and buildings. During winter, it hibernates in caves, abandoned mines, and buildings (Wyoming Game and Fish Department, 2008).

- Long-Eared Myotis (*Myotis evotis*), Native Species Status 2—The long-eared myotis primarily inhabits coniferous forest and woodland, including juniper, ponderosa pine, and spruce fir. It typically forages over rivers, streams, and ponds within the forest-woodland environment. During summer, it roosts in a wide variety of structures, including cavities in snags, under loose bark, stumps, buildings, rock crevices, caves, and abandoned mines. During winter, it is thought to hibernate primarily in caves and abandoned mines (Wyoming Game and Fish Department, 2008).

- Long-Legged Myotis (*Myotis volans*), Native Species Status 2—The long-legged myotis inhabits open, mature forest with standing dead trees, including montane and subalpine forest and ponderosa pine and juniper woodlands, primarily from 1,500 m to more than 3,300 m [5,000 to more than 11,000 ft]. It usually forages over open areas such as campgrounds and small forest clearings; over vegetated riparian areas; and within, above, and under the forest canopy. During summer, it roosts in tree cavities, buildings, rock crevices, caves, abandoned mines, and under loose bark. During winter, it hibernates primarily in caves and abandoned mines (Wyoming Game and Fish Department, 2008).

- Pallid Bat (*Antrozous pallidus*), Native Species Status 2—The pallid bat generally inhabits low desert shrublands, juniper woodlands, and grasslands and occasionally cottonwood riparian zones in those habitats. It is most common in low, arid regions with rocky outcroppings, particularly near water. During summer, it usually roosts in rock crevices and buildings, but also uses rock piles, tree cavities, shallow caves, and abandoned mines (Wyoming Game and Fish Department, 2008).

- Spotted Bat (*Euderma maculatum*), Native Species Status 2—The spotted bat occupies a wide variety of habitats, from desert scrub to coniferous forest, although it is most often observed in low deserts and basins and juniper woodlands. It roosts in cracks and crevices in high cliffs and canyons. It also may occasionally roost in buildings, caves, or abandoned mines, although cliffs are the only roosting habitat in which reproductive females have been documented (Wyoming Game and Fish Department, 2008).

- Townsend's Big-Eared Bat (*Plecotus townsendii*), Native Species Status 2—The Townsend’s big-eared bat occupies a variety of xeric to mesic habitats, including coniferous forests, juniper woodlands, deciduous forests, basins, and desert shrublands, and is absent only from the most extreme deserts and highest elevations. However, this species requires caves or abandoned mines for roost sites during all seasons and stages of its life cycle, and its distribution is strongly correlated with the availability of these features (Wyoming Game and Fish Department, 2008).

3.2.6 Meteorology, Climatology, and Air Quality

3.2.6.1 Meteorology and Climatology

Wyoming’s elevation results in relatively cool temperatures. Much of the temperature variations within the state can be attributed to elevation with average values dropping 1 to 2 °C [1.8 to 3.6 °F] per 300 m [1,000 ft] (National Climatic Data Center, 2005]. Summer nights are normally cool although daytime temperatures may be quite high. The fall, winter, and spring can experience rapid changes with frequent variations from cold to mild periods. Freezes in early fall and late spring are typical and result in long winters and a short growing season. In the mountains and high valleys, freezes can occur any time in the summer. During winter warm spells, nighttime temperatures can remain above freezing. Valleys protected from the wind by mountain ranges can provide ideal pockets for cold air to settle and temperatures in the valley

Table 3.2-6. Information on Two Climate Stations in the Wyoming West Uranium Milling Region*				
Station (Map Number)	County	State	Longitude	Latitude
Gas Hills 4 E (042)	Fremont	Wyoming	107°31W	42º50N
Jeffrey City (049)	Fremont	Wyoming	107°50W	42º30N
*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.				

can be considerably lower than on nearby mountainsides. Table 3.2-6 identifies two climate stations located in the Wyoming West Uranium Milling Region. Climate data for these stations are found in the National Climatic Data Center's Climatography of the United States No. 20 Monthly Station Climate Summaries for 1971–2000 (National Climatic Data Center, 2004). This summary contains climate data for 4,273 stations throughout the United States and some territories. Table 3.2-7 contains temperature data for two stations in the Wyoming West Uranium Milling Region.

Precipitation within Wyoming varies, with spring and early summer being the wettest time for much of the state. Mountain ranges are generally oriented in a north-south direction. This is perpendicular to the prevailing westerlies. Therefore, these mountains often act as moisture barriers. Air currents for the Pacific Ocean rise and drop much of their moisture along the western slopes of the mountains. Summer showers are frequent, but typically result in rainfall amounts of a few hundredths of an inch. Usually several times a year in the state, local thunderstorms will result in 2.5 to 5 cm [1 to 2 in] of rain in a 24-hour period. On rare occasions, rainfall in a 24-hour period can reach 7.5 to 12.5 cm [3 to 5 in] (National Climatic Data Center, 2005). Heavy rains can create flash flooding in headwater streams, and this flooding intensifies if these storms coincide with snowpack melting. Table 3.2-7 contains precipitation data for two stations in the Wyoming West Uranium Milling Region. The wettest month for both stations identified in Table 3.2-7 is May, which based on the snow depth data, coincides with snow pack melting (National Climatic Data Center, 2004). Both of these stations are in Fremont County. Data from the National Climatic Data Center's Storm Events Database from 1950 to 2007 indicate that the vast majority of thunderstorms in Fremont County occur between June and September with the most occurring in July (National Climatic Data Center, 2007).

Table 3.2-7. Climate Data for Stations in the Wyoming West Uranium Milling Region*			
		Gas Hills 4 E	Jeffrey City
Temperature (°C)†	Mean—Annual	5.5	5.3
	Low—Monthly Mean	−7.0	−7.0
	High—Monthly Mean	19.5	19.0
Precipitation (cm)‡	Mean—Annual	24.9	27.1
	Low—Monthly Mean	0.86	0.89
	High—Monthly Mean	3.33	5.71
Snowfall (cm)	Mean—Annual	154	143
	Low—Monthly Mean	0	0
	High—Monthly Mean	34.3	26.9
*National Climatic Data Center. "Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004. †To convert Celsius (ºC) to Fahrenheit (ºF), multiply by 1.8 and add 32. ‡To convert centimeters (cm) to inches (in), multiply by 0.3937.			

Hailstorms are the most destructive storm event for Wyoming. Most hailstorms pass over open rangeland with minimal impact. When a hailstorm passes over a city or farmland, the property and crop damage can be severe. Most of the severe hailstorms occur in the southeast corner of the state.

Low elevations typically experience light to moderate snowfall from November to May. Snowfall within Wyoming varies by location with the mountain ranges typically receiving the most. Significant storms of 25 to 40 cm [10 to 16 in] of snowfall are infrequent outside of the mountains. Wind often coincides or follows snowstorms and can form snow drifts several meters [feet] deep. Snow can accumulate to considerable depths in the high mountains. Blizzards that last more than 2 days are uncommon. Table 3.2-7 contains snowfall data for two stations in the Wyoming West Uranium Milling Region.

Wyoming is windy and ranks first in the United States with an annual average speed of 6 m/s [12.9 mph]. During winter, Wyoming frequently experiences periods where wind speed reaches 13 to 18 m/s [30 to 40 mph] with gusts to 22 to 27 m/s [50 or 60 mph] (National Climatic Data Center, 2005). Prevailing wind direction varies by location but usually ranges from west-southwest through west to northwest. Because the wind is normally strong and constant from those directions, trees often lean to the east or southeast.

The pan evaporation rates for the Wyoming West Uranium Milling Region range from about 76 to 127 cm [30 to 50 in] (National Weather Service, 1982). Pan evaporation is a technique that measures the evaporation from a metal pan typically 121 cm [48 in] in diameter and 25 cm [10 in] tall. Pan evaporation rates can be used to estimate the evaporation rates of other bodies of water such as lakes or ponds. Pan evaporation rate data is typically available only from May to October. Freezing conditions often prevent collection of quality data during the other parts of the year.

3.2.6.2 Air Quality

As described in Section 1.7.2.2, the permitting process is the mechanism used to address air quality. If warranted, permits may set facility air pollutant emission levels, require mitigation measures, or require additional air quality analyses. Except for Indian Country, New Source Review permits in Wyoming are regulated under the EPA-approved State Implementation Plan. For Indian Country in Wyoming, the New Source Review permits are regulated under 40 CFR 52.21 (EPA, 2007a).

State implementation plans and permit conditions are based in part on federal regulations developed by the EPA. As promulgated in 40 CFR Part 50, National Primary and Secondary Ambient Air Quality Standards (NAAQS), the NAAQS define acceptable ambient air concentrations for six common nonradiological air pollutants: nitrogen oxides, ozone, sulfur oxides, carbon monoxide, lead, and particulates. Primary NAAQS are established to protection public health, and secondary NAAQS are established to protect public welfare by safeguarding against environmental and property damage. Primary and secondary NAAQS are presented in Table 3.2-8. Some pollutants have multiple standards. Particulates are divided into two categories: PM_{10} defined as particulate matter smaller than 10 μm [3.9×10^{-4} in], and $PM_{2.5}$, defined as particulate matter smaller than 2.5 μm [9.8×10^{-5} in]. In June 2005, EPA revoked the 1-hour ozone standard nationwide in all locations except certain early action compact areas. None of the 1-hour ozone Early Action Compact Areas are in Wyoming. States may develop

Table 3.2-8. National Ambient Air Quality Standards*			
Pollutant	**Primary Standards**	**Averaging Times**	**Secondary Standards**
Carbon Monoxide	9 ppm (10,000 μg/m^3)†	8 hours‡	None
	35 ppm (40,000 μg/m^3)†	1 hour‡	None
Lead	1.5 μg/m^3†	Quarterly average	Same as primary
Nitrogen Dioxide	0.053 ppm (100 μg/m^3)†	Annual (arithmetic mean)	Same as primary
Particulate Matter 10-μm diameter (PM_{10})	150 μg/m^3†	24 hours§	Same as primary
Particulate Matter 2.5-μm diameter ($PM_{2.5}$)	15.0 μg/m^3†	Annual‖ (arithmetic mean)	Same as primary
	35 μg/m^3†	24 hours¶	Same as primary
Ozone	0.08 ppm	8 hours#	Same as primary
	0.12 ppm	1 hour**	Same as primary
Sulfur Oxides	0.03 ppm	Annual (arithmetic mean)	Not applicable
	0.14 ppm	24 hours‡	Not applicable
	Not applicable	3 hours‡	0.5 ppm (1,300 μg/m^3)†

*Modified from U.S. Environmental Protection Agency. "National Ambient Air Quality Standards (NAAQS)." 2007. <http://www.epa.gov/air/criteria.html> (15 October 2007).
†Multiply μg/m^3 value by 2.7×10^{-8} to convert units to oz/yd^3.
‡Not to be exceeded more than once per year.
§Not to be exceeded more than once per year on average over 3 years.
‖To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 μg/m^3.
¶To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35.0 μg/m^3 (effective December 17, 2006).
#To attain this standard, the 3-year average of the fourth highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
**(a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤1, as determined by Appendix H. (b) As of June 15, 2005, the U.S. Environmental Protection Agency revoked the 1-hour ozone standard in all areas except the fourteen 8-hour ozone nonatttainment Early Action Compact Areas.

standards that are stricter or supplement the NAAQS. Wyoming has a more restrictive annual average standard for sulfur dioxide at 60 μg/m^3 [1.6×10^{-6} oz/yd^3] and a supplemental 50 μg/m^3 [1.3×10^{-6} oz/yd^3] PM_{10} standard with an annual averaging time (WDEQ, 2008).

As promulgated in 40 CFR Part 52, Prevention of Significant Deterioration requirements identify maximum allowable increases in concentrations for particulate matter, sulfur dioxide, and nitrogen dioxide for areas designated as attainment. Different increment levels are identified for different classes of areas. Table 3.2-9 contains the maximum allowable Prevention of Significant Deterioration increments for Class I and Class II areas. Class I areas are locations with special natural, recreational, scenic, or historic value such as national parks or wilderness areas and have the most stringent set of allowable increments. Most other areas in the United States are categorized as Class II areas and have a less stringent set of allowable increments.

Table 3.2-9. Allowable Prevention of Significant Deterioration Class I and Class II Areas*

Pollutant	Class 1 (μg/m^3)†	Class II (μg/m^3)†	Measurement
Nitrogen Dioxide (NO_2)	2.5	25	Annual average
PM_{10}‡	4	17	Annual average
	8	30	24 hours‡
Sulfur Dioxide (SO_2)	2	20	Annual average
	5	91	24 hours§
	25	512	3 hours§

*Modified from Code of Federal Regulations. "Prevention of Significant Air Deterioration of Air Quality." Title 40—Protection of the Environment, Part 52. Washington, DC: U.S. Government Printing Office. 2005.
†Multiply μg/m^3 value by 2.7×10^{-8} to convert units to oz/yd^3.
‡Not to be exceeded on more than 1 day/year on the average over 3 years.
§Not to be exceeded more than once per year.

One goal identified in the Clean Air Act is to address visibility impairment from haze at the Prevention of Significant Deterioration Class I areas in the country. Regional haze is visibility impairment caused by cumulative air pollutant emissions from numerous sources over a wide geographic area (EPA, 1999). Key contributors to regional haze are sulfur dioxide, nitrogen oxides, and particulate matter. One source of particulate matter is soil dust or fugitive dust. EPA, in 40 CFR Part 51, requires states to address regional haze in their implementation plans.

The Wyoming West Uranium Milling Region air quality description focuses on two topics: NAAQS attainment status and Prevention of Significant Deterioration classifications in the region.

NAAQS compliance attainment status is typically determined at the county level. Each NAAQS pollutant is designated into one of the following categories: attainment, nonattainment, or maintenance. Areas are designated as attainment for a particular pollutant if atmospheric concentrations meet NAAQS. If atmospheric concentrations of a pollutant do not meet NAAQS, that area is designated as nonattainment for that pollutant. The maintenance category describes areas formerly designated as nonattainment, but that now meet NAAQS requirements. Figure 3.2-15 identifies counties in Wyoming and surrounding areas that are partially or entirely designated as nonattainment or maintenance for NAAQS at the time this GEIS was prepared (EPA, 2007b). All of the area within the Wyoming West Uranium Milling Region is classified as attainment. In fact, Wyoming only has one area that is not in attainment. The city of Sheridan in Sheridan County is designated as nonattainment for PM_{10}. Portions of several Colorado counties along the southern Wyoming border are classified as not in attainment. However, the southern boundary of the Wyoming West Uranium Milling Region is north of the Wyoming/Colorado border.

Table 3.2-10 identifies the Prevention of Significant Deterioration Class I areas in Wyoming. These areas are shown in Figure 3.2-16. There are no Class I areas in the Wyoming West Uranium Milling Region (40 CFR Part 81).

EPA also encourages states to work with tribes and federal agencies in regional partnerships to address the regional haze issue. Wyoming is a member of the Western Regional Air Partnership. Also, specific provisions in 40 CFR Part 51 allow nine western states, including Wyoming, to implement the recommendations of the Grand Canyon Visibility Transport Commission within the regional haze program.

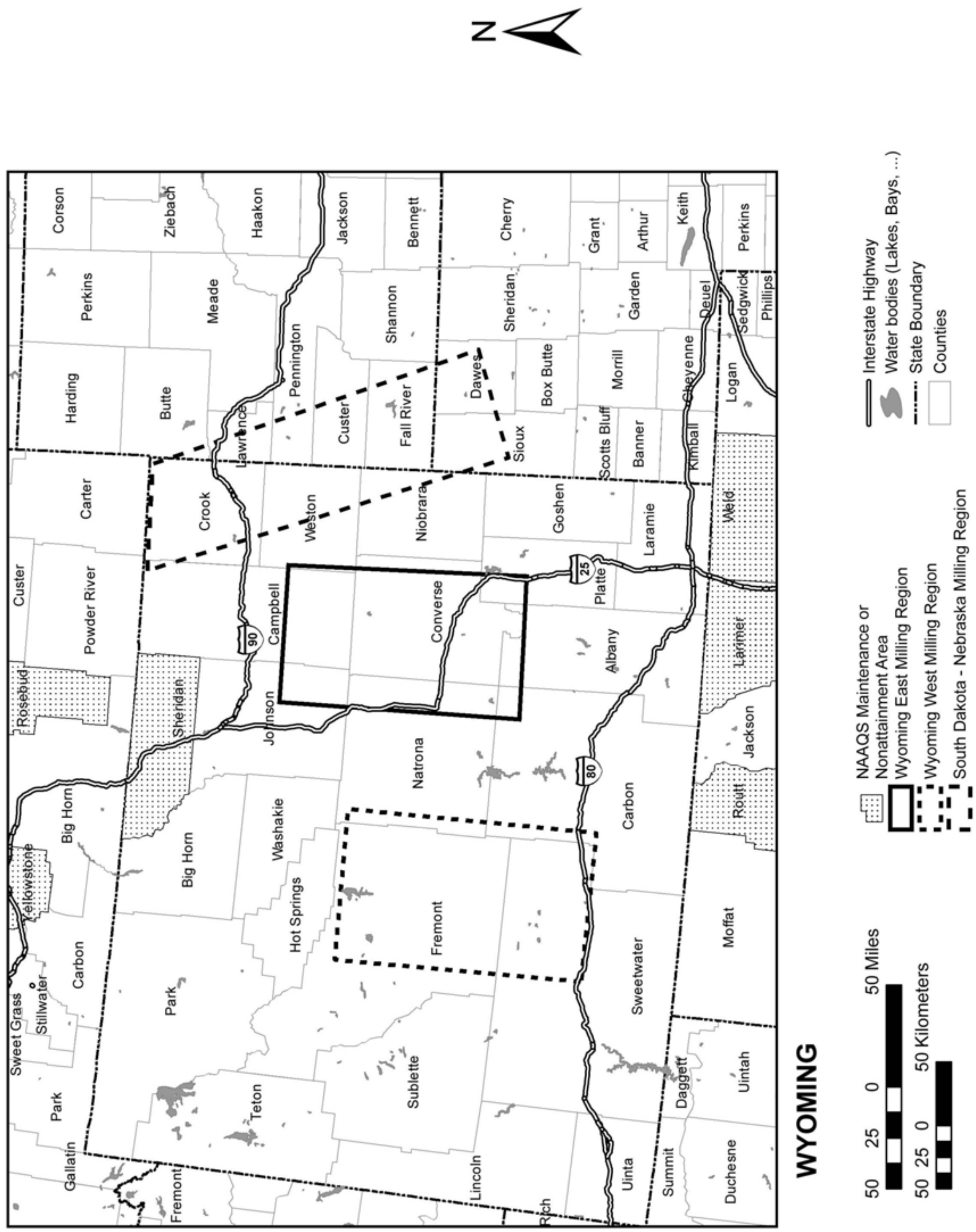

Figure 3.2-15. Air Quality Attainment Status for Wyoming and Surrounding Areas (EPA, 2007)

Table 3.2-10. U.S. Environmental Protection Agency Class I Prevention of Significant Deterioration Areas in Wyoming*
Bridger Wilderness
Fitzpatrick Wilderness
Grand Teton National Park
North Absaroka Wilderness
Teton Wilderness
Washakie Wilderness
Yellowstone National Park
*Modified from Code of Federal Regulations. "Prevention of Significant Air Deterioration of Air Quality." Title 40—Protection of the Environment, Part 81. Washington, DC: U.S. Government Printing Office. 2005.

3.2.7 Noise

Noise is technically defined as unwanted sound. Noise is a potential occupational hazard because prolonged exposure to noise may cause long-term hearing loss. In the United States, noise levels are regulated at the federal level by the Occupational Health and Safety Administration and the Mining Safety and Health Administration (Bauer and Kohler, 2000). To provide a sense of magnitude, noise levels associated with common activities are presented in Figure 3.2-17.

What are Sound and Noise?

When an object vibrates, some of the energy causes air molecules to vibrate. Nearby people or animals translate these vibrations into sound using the eardrum and brain. Noise is simply unwanted sound. Sound waves are characterized by frequency and measured in hertz (Hz); sound pressure is expressed as decibels (dB). Noises that are perceptible to human hearing range vary from 31 to 20,000 Hz. Audible sounds (those that can be heard) range from about 60 dB at a frequency of 31 Hz to less than about 1 dB between 900 and 8,000 Hz. Noise levels for perceptible frequencies are typically reported in A-weighted decibels to account for the way people respond to noise; this type of measurement assumes a human receptor to a particular noise-producing activity.

Existing ambient noise levels can be used to establish baseline conditions and determine potential site-specific disturbances associated with ISL milling activities. The Wyoming West Uranium Milling Region is predominantly rural and undeveloped. Rural areas tend to be quiet, open sagebrush-grass and forested areas where natural phenomena such as wind, rain, insects, birds, and other wildlife account for most natural background sounds. Baseline noise levels for typical undeveloped desert or arid environments range from day-night sound levels of 22 dB on calm days to 38 dB on windy days (Brattstrom and Bondello, 1983; DOE, 2007).

Larger communities in the region include Riverton and Lander, with populations of between 5,000 and 10,000. Fort Washakie (population about 1,500), the location of the headquarters for the Wind River Indian Reservation, is within the region. In addition, Rawlins (population about 8,500) is just east of the southeast corner of the region on Interstate 80 (see Section 3.2.10). In these more urbanized areas, ambient noise levels would be expected to be influenced by noise-generating activities such as street noise, traffic, emergency vehicles, and construction equipment. Noise levels in these types of suburban residential/urban areas range from 45 to about 78 dB, with lower noise levels at night (Washington State Department of Transportation, 2006).

As described in Section 2.8, several highways cross the region, including U.S. Highways 20, 26, and 287, as well as Interstate 80. A summary of noise effects on wildlife populations (Federal Highway Administration, 2004) includes reference to measured average traffic noise levels at 15 m [50 ft] of 54–62 dBA for passenger cars and 58–70 dBA for heavy trucks

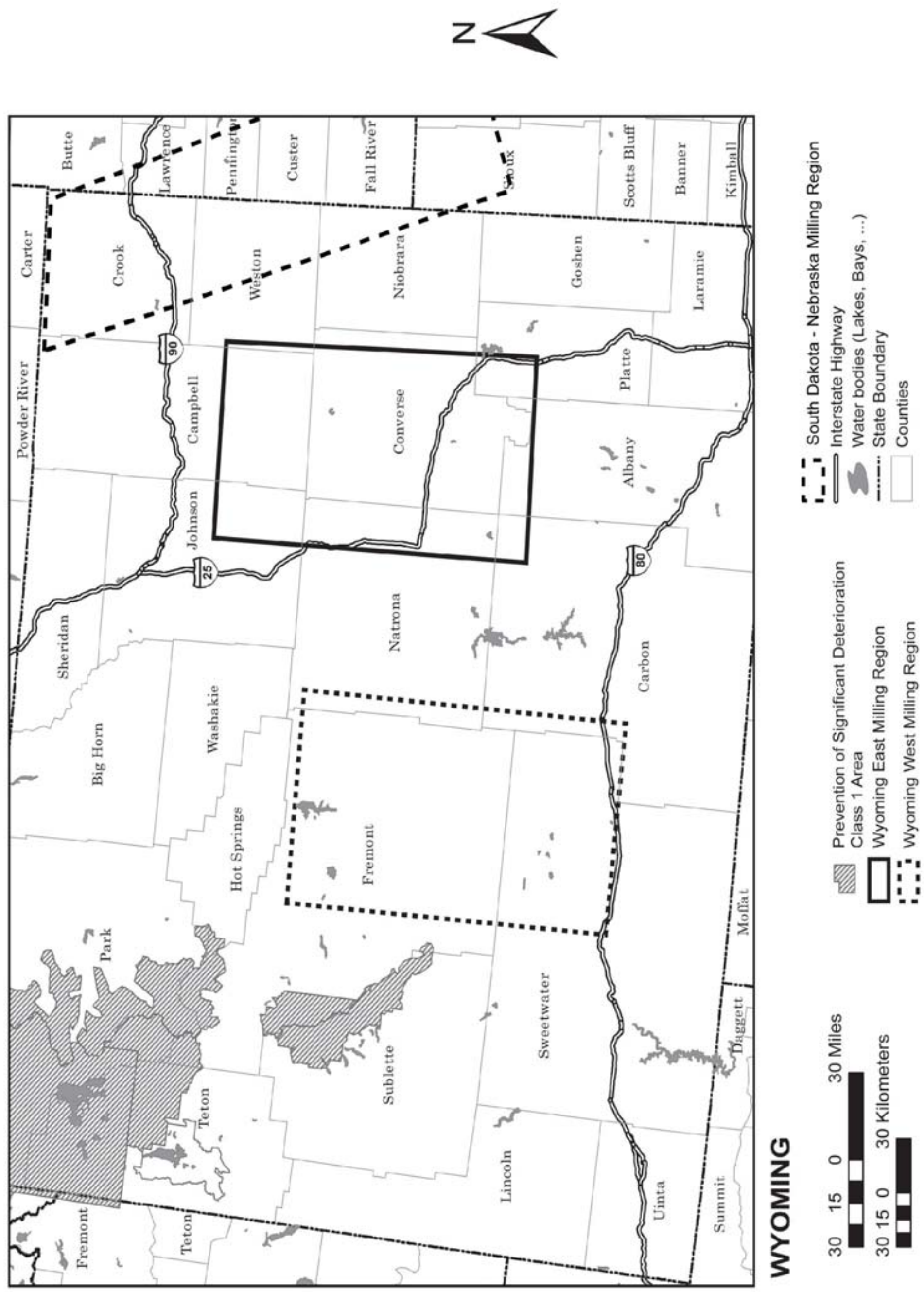

Figure 3.2-16. Prevention of Significant Deterioration Class I Areas in the Wyoming West Uranium Milling Region and Surrounding Areas (40 CFR Part 81)

COMMON SOUNDS	DECIBELS*	EFFECT
Jet Operation	140	Painfully Loud
	130	
Jet Takeoff Thunder Rock Concert	120	Maximum Vocal Effort
Pile Drivers	110	
Garbage Truck	100	
Heavy Truck (50 ft)	90	Very Annoying Hearing Damage at 8 hr
Alarm Clock Hair Dryer	80	Annoying
Freeway Traffic Man's Voice (3 ft)	70	Telephone Use Difficult
Air Conditioning Unit (20 ft)	60	Intrusive
Light Auto Traffic (100 ft)	50	Quiet
Living Room Quiet Office	40	
Library Soft Whisper (15 ft)	30	Very Quiet
Broadcasting Studio	20	
	10	Just Audible

*To the ear, each 10 dB increase seems twice as loud. 70 dB is the point at which noise begins to harm hearing.

Figure 3.2-17. Comparison of Noise Levels Associated with Common Activities (After EPA, 1981)

(Federal Highway Administration, 2004) along Interstate 80. Baseline ambient noise levels would be similar to or less than those for the U.S. and state highways in the region, as they are mostly undivided highways and tend to carry less traffic (particularly heavy trucks) than a major interstate highway like Interstate 80. For example, a 2005 traffic analysis at Interstate 80 milepost 208.65 just west of Rawlins indicates an average traffic count of about

> **How Is Sound Measured?**
>
> The human ear responds to a wide range of sound pressures. The range of sounds people normally experience extends from low to high pressures by a factor of 1 million. Sound is commonly measured using decibels (dB). Another common sound measurement is the A-weighted sound level (dBA). The A-weighting measures different sound frequencies and the variation of the human ear's response over the frequency range. Higher frequencies receive less A-weighting than lower ones. Noise levels are often reported as the equivalent sound level (DOE, 2007). The equivalent sound level is expressed as an A-weighted sound level over a specified period of time—usually 1 or 24 hours. The equivalent sound level is an equivalent steady sound level that, if it continued during a specified time period, would contain the same total energy as the actual time-varying sound over the monitored or modeled time period. Noise levels are also expressed as day-night sound levels: the average of the day and nighttime A-weighted sound level with a built-in penalty of 10 dBA at night when noise levels are likely lower. The day-night sound level is particularly useful for evaluating community-level noise effects. If noise is regulated, municipalities often have local ordinances specifying upper limits on evening noise levels, with specific hours for residential and commercial zones.

12,400 vehicles per day. Of this, almost 50 percent was heavy truck traffic (Wyoming Department of Transportation, 2005). In comparison, for U.S. Highway 26 milepost 125.75 northwest of Riverton, the 2005 traffic count was about 3,700 vehicles with almost 90 percent passenger truck and car traffic (Wyoming Department of Transportation, 2005).

The two principal uranium districts in the Wyoming West Uranium Milling Region (the Great Divide Basin in the southeast part of the region and the Wind River Basin in the northeast part of the region) are located more than about 30 to 80 km [20 to 50 mi] from the larger communities, in rural undeveloped areas where the ambient noise levels would be expected to be low. There are a number of smaller communities along highways and roads through the uranium districts, including Jeffrey City and Bairoil near U.S. Highway 287 in the Great Divide Basin and Ervay and Sand Draw in the Wind River Basin, where noise levels would be expected to be slightly higher as a result of human activities. Areas of special sensitivity may be located on the Wind River Indian Reservation in the northwest corner of the region, but the reservation boundary is more than 16 km [10 mi] from the closest potential uranium ISL facility near Sand Draw, and more than 50 km [30 mi] from the center of the two uranium districts.

3.2.8 Historical and Cultural Resources

The following sections summarize the historical and cultural resources background and legislation and authorities regarding historical and cultural resources for the Uranium GEIS regions in the states of Nebraska, New Mexico, South Dakota, and Wyoming. The information is provided on a state-by-state basis rather than by the regions of interest as the historical and cultural resource information and agencies are organized at the state level. A brief discussion of NHPA cultural and historical resource management processes is included in Appendix D.

3.2.8.1 Cultural Resources Overview

The Wyoming State Historic Preservation Office (SHPO) administers and is responsible for oversight and compliance with the National Register of Historic Places (NRHP), compliance and review for Section 106 of NHPA, traditional cultural properties review, enforcement of the Native American Graves Protection and Repatriation Act (NAGPRA), and compliance with other federal and state historic preservation laws, regulations, and statutes. The Wyoming SHPO and BLM have also entered into a programmatic agreement that describes the manner in which the Wyoming SHPO and the Wyoming BLM would interact and cooperate under the BLM national Programmatic Agreement. State level agreements between Wyoming and the National Resource Conservation Service (NRCS) and the U.S. Forest Service (USFS) are in draft form.

Wyoming SHPO's webpage with links to all of their resources can be found at: (http://wyoshpo.state.wy.us/). The state of Wyoming also has a law pertaining to archaeological sites and human remains, entitled Archaeological Sites (Wyoming Statute Ann. §36-1-114, et seq).

The following provides a brief overview of prehistoric and historical cultures recognized in the central and northern plains region, which includes the Wyoming West Uranium Milling Region. Figure 3.2-18 illustrates the division of the plains into regional subdivisions. The dating of cultural periods for the prehistoric period is provided in years before present (B.P.). Most prehistoric and historical period Native American archaeological sites are concentrated along major river systems and their tributaries, but can also be found along many drainage basins in the eastern and central portions of the state. In addition, historical period sites such as the Oregon-California National Historic Trail and the Bozeman National Historic Trail cross the Wyoming West and Wyoming East Regions.

Paleoindian Big Game Hunters (12,000 to 6,500 B.P.). The earliest well-defined cultural tradition in the northern and central plains region is the Paleoindian. Early humans entered the area shortly after deglaciation allowed movement onto the northern and central plains sometime after 14,000 B.P. A variety of cultures, each defined by the presence of distinctive, lanceolate projectile points, are recognized during the Paleoindian period: Clovis, Goshen, Folsom, Hell Gap-Agate Basin, Alberta, Cody Complex, and the late Paleoindian-Early Archaic Foothills/Mountain Complex. Most post-Clovis Paleoindian sites on the northern and upper central plains are known from bison kill sites. The Clovis culture (12,000 to 10,000 B.P.) is recognized by a distinctive projectile point style and a subsistence mode heavily reliant on hunting large, now-extinct mammals, notably mammoth, which became extinct at the end of the Clovis period, and ancient bison. The poorly defined Goshen Complex is found at the Carter/Kerr-McGee site in northeastern Wyoming and the Jim Pitts site in the Black Hills at the Wyoming-South Dakota border. Goshen is technologically similar to Clovis and may be contemporary with Clovis and perhaps Folsom. The Folsom culture (ca. 10,000 to 8,500 B.P.) is also known for a distinctive fluted, projectile point style, and evidence of the culture has been found at the Carter/Kerr-McGee site associated with bison and red ochre deposits. Folsom subsistence is also characterized by reliance on large game (the ancient bison). Folsom sites consist of campsites and kill sites. The latter tend to be located near cliffs and around water, such as ponds and springs.

The Hell Gap-Agate Basin Complex, Alberta Complex, and Cody Complex are widely distributed in the northern and central portions of the southern plains region at the Agate Basin, Hell Gap, and Carter/Kerr-McGee archaeological sites in eastern Wyoming. These late Paleoindian cultural complexes are, in their earliest forms, a continuation of preceding Paleoindian hunting traditions. The distinctive projectile point forms that define these cultural complexes in central and eastern Wyoming and western South Dakota are, in comparison to earlier Clovis, Goshen, and Folsom, much more restricted in geographic distribution. Toward the end of the Paleoindian period, however, there is a transition in subsistence modes following the extinction of the ancient bison, and the transition to hunting the modern form of bison ultimately leading to the transition to Archaic broad-spectrum foraging. Post molds and stone circles suggesting the presence of ephemeral shelters are sometimes found, primarily toward the end of the period.

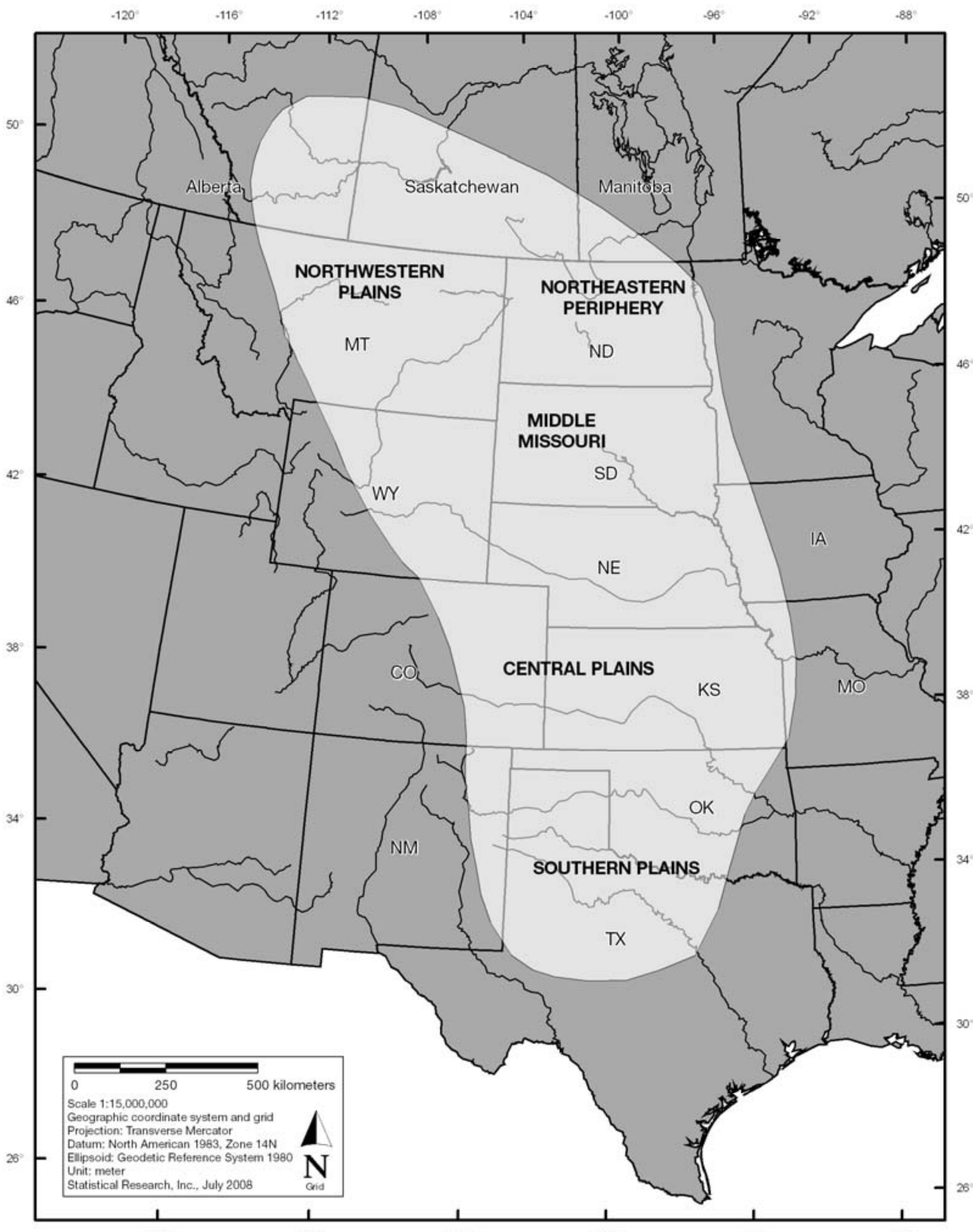

Figure 3.2-18. General Divisions of the American Plains

The late Paleoindian Foothills/Mountain Complex is characterized by a reliance on medium-sized game animals rather than big game hunting. Sites are found in upland, mountainous regions, leading some to suggest that Paleoindian groups may have split into lowland big game hunters and upland/mountain small- and medium-game hunters (Frison, 1991). The upland/mountain sites show increased use of small seed-bearing plants as indicated by the presence of groundstone implements and suggests the presence of an early archaic lifestyle. Habitation sites of this complex are found in rock shelters and caves such as Mummy Cave in the Absaroka Mountains of northwestern Wyoming.

Archaic Foragers (6,500 to 2,500 B.P.). The Plains Archaic period represents the continuation of change in subsistence and settlement linked to an increasingly arid environment that occurs in the latter portion of the preceding late Paleoindian cultures. At the end of the Paleoindian period there is also a change in projectile point styles from lanceolate to somewhat smaller corner- and side-notched projectile points, suggesting that the atlatl (spearthrower) was in use. Distinctive Archaic cultures, from early to late, include Mummy Cave, Oxbow, McKean, and Pelican Lake complexes and are found throughout the northern plains. Large bison kill sites, characteristic of the preceding Paleoindian period are virtually absent. Hunting and gathering wild plant foods is the primary mode of subsistence. Dietary breadth, indicated by increasing diversity and numbers of subsistence items, is believed to expand significantly with more medium and small mammals being hunted and the introduction of seed-bearing plants, dietary staples indicated by the introduction of stone seed-grinding implements. The Early Archaic Medicine House site in southeastern Wyoming contained evidence of structures, hearths, storage pits, and milling basins. At the McKean site in the Black Hills of Wyoming, a shallow pithouse was found. Through time, settlement is increasingly tethered to highly productive resource areas and sites tend to become larger and increasingly complex, indicating the presence of somewhat more sedentary lifestyles relative to earlier periods. Settlement is focused on river valleys and elevated areas. Artifact styles, principally projectile points, become increasingly diversified, suggesting increasing regionalization and cultural differentiation. In southeastern Wyoming, Pelican Lake projectile points are sometimes found in association with stone circles, firepits, and pithouses.

Late Prehistoric/Plains Woodland (2,500 to 300 B.P.). Early in the period, the preceding late Archaic broad-spectrum foraging subsistence and settlement patterns continue with little change. In the Northern Plains, the Besant and Avonlea Complexes continued virtually unchanged Archaic lifestyles until contact with European and American cultures. A significant technological change from atlatl to bow and arrow occurs during the Late Prehistoric period. Subsistence focused on scheduled small- and medium-game hunting, plant food gathering, and bison hunting according to a seasonal round. In central and northeastern Wyoming, a basic hunting and gathering lifestyle differing little from the preceding Late Archaic period predominates. Although eastern Wyoming is considered peripheral to the eastern Woodland tradition, Woodland pottery is sometimes found in association with Besant points in the northern plains. The Butler-Risser site south of Casper, Wyoming, contained both Besant points and pottery. Food procurement and site location during this period appears to be focused primarily on elevated landforms near larger riverine systems and tributaries with increasing utilization of upland resources later in time. The Late Prehistoric/Plains Woodland of Wyoming is also characterized by the appearance of ceramics late in the period (Besant and Avonlea Complexes), introduced from the Eastern Woodland cultural area. The late Avonlea Complex and later Old Woman Complex sites in northern Wyoming contain artifact types that suggest a high degree of specialization in hunting large, upland game animals, primarily bison.

In the eastern portions of Wyoming, the Upper Republican phase (ca. 1000–300 B.P.) is characterized by the presence of seasonal or permanent sedentary villages. These sites are usually on ridges and bluffs and have evidence of domesticated plants (corn, beans, squash, and sunflowers). Although horticulture was an important part of the subsistence base, wild plants and game animals formed a substantial part of the diet. Storage pits for food and other items are located within the structures, and grinding tools are common. Pottery was diverse with globular jars, and decorated exterior rims are common. The later Dismal River Aspect (ca. 500–300 B.P.) in southeastern Wyoming is focused primarily on hunting and gathering with only limited evidence of horticultural pursuits and a distinctive form of pottery.

In the 1500s to early 1700s A.D., large migrations by Native American tribes occurred. The ancestors of modern Apache, Arapaho, Comanche, Apache-Kiowa, and Kiowa migrated southward through western Wyoming in the 1500s and 1600s.

Post-Contact Tribes (300 to 100 B.P.). The post-contact period on the northern plains is that period after initial contact with Europeans and Americans. Although Euro-American trade goods may have appeared as early as the mid-1600s, the earliest documented contact in the northern and central plains is by Spanish and French explorers in the early 1700s A.D. The horse appears to have been introduced at about the same time. The lifeways of the late Avonlea and post-Avonlea/Old Woman nomadic bison-hunting cultural complexes in central and northeastern Wyoming and the Upper Republican and Dismal River horticulturalists of eastern and southeastern Wyoming appear to have continued well into the mid to late 1700s A.D. At the time of European exploration, the Dakota and Nakota moved into eastern Wyoming from what is now Minnesota. The Shoshone were present in southeastern Wyoming in the 1600s and 1700s. About this time, the Crow moved into northeastern and north-central Wyoming and the Apache-Kiowas moved out of the Black Hills into southeastern Wyoming. The Apache-Kiowa migration through the Black Hills was followed by that of the Cheyenne who moved through western South Dakota and then into central Wyoming where they were joined by the Arapaho who settled in southern Wyoming (Reher, 1977). By the mid-1800s, much of the eastern and central portions of the state was occupied by nomadic Siouan-speaking tribes, primarily the Hunkpapa, Minneconjou, Brule, and Oglala.

Europeans and Americans (300 to 100 B.P.). The earliest European presence in Wyoming was by French explorers of the de la Vénendrye family in 1743. In 1803, the United States completed the purchase of the Louisiana Territory from France. Early expeditions and trappers provide descriptions of varying quality for some of the early historical tribes in the region. In the later 1700s and early 1800s, more intensive contact and settlement occurred first through missionaries and the fur trade period in the 1810s through the 1840s. In 1807, Manuel Lisa of St. Louis established a trading post on the Bighorn River. Others, including Jedediah Smith, began fur trading companies that quickly spread along the major river systems of Wyoming. Each year the fur traders and trappers would establish a rendezvous site where they would gather. Rendezvous sites are known throughout much of central and western Wyoming. By the late 1830s, the fur trade in Wyoming was in decline. By the mid-1800s, missionary, settler, and military contacts led to increasing conflict with the Siouan tribes of Wyoming. The slowly increasing number of settlers passing through traditional tribal use areas on well-established trails in the mid-1800s led to increasing conflict over time. The establishment of military forts on tribal lands to protect the settlers was yet another irritant to tribes.

Treaties, notably the Fort Laramie Treaty of 1851, were signed with the intent of removing tribes from along the emigrant trails and allowing for the building of trails and forts to protect settlers moving west on the Texas, Oregon, California, Mormon, Bozeman, and Bridger Trails in central and eastern Wyoming. Continued conflict resulted in the creation of the Great Sioux Reservation bounded by the Missouri River on the east, the Big Horn Mountains on the west, and the 46th and 43rd parallels to the north and south, respectively. Continued conflict with the U.S. military over the failure of the government to abide by treaty obligations led to several punitive expeditions to return tribes to reservations. In 1874, General George Armstrong Custer led an expedition to the Black Hills of Wyoming and South Dakota where the presence of gold, previously only rumored, was confirmed. The intense interest by Americans to go to the Black Hills to mine for gold led to numerous treaty violations; the Black Hills regions was, by treaty, part of the Sioux reservation. The continued conflict over the Black Hills, along with reduction of the buffalo herds, led to the final military conquest of the Great Sioux Nation and their confinement to small reservations. In November 1875, President Grant ordered the Indians of the Powder River and Big Horn country in eastern and central Wyoming to return to their tribal agencies. The Sioux refused and were forced militarily onto their reservations. The Black Hills gold rush facilitated the subsequent settlement of much of Wyoming and the development of towns and cattle ranching.

Ranching, a livelihood well suited to the grassland plains of Wyoming, was practiced by settlers by the early 1870s. Most of the early ranching occurred in well-watered areas along existing trail systems to facilitate moving cattle to market. The arrival of the railroads in 1868 (first the Union Pacific in southern Wyoming, then branch lines in other parts of Wyoming) led to increased settlement and opened Wyoming to a flood of new settlers. In the 1880s, farmers began homesteading much of the open range leading to conflict with ranchers over fencing. They settled mostly around well-watered regions, with many of the new farmers pursuing newly developed dry-land farming techniques. These homestead farmers began a period of extensive agriculture throughout the state that lasted from the 1880s to the 1930s. The Great Depression and the droughts that occurred at the same time led to the abandonment of many farms and the outmigration of a significant portion of Wyoming's population. Many of the individual homesteads were bought out in the 1930s and 1940s to create larger farms that used mechanized equipment.

3.2.8.2 National Register of Historic Properties and State Registers

Table 3.2-11 includes a summary of sites in the Wyoming West Uranium Milling Region that are listed on the Wyoming state and/or NRHP. Most of the sites are located in Fremont County, at least 32 km [20 mi] west of the two uranium districts in the Gas Hills and near Crooks Gap.

Table 3.2-11. National Register Listed Properties in Counties Included in the Wyoming West Uranium Milling Region

County	Resource Name	City	Date Listed YYYY-MM-DD
Carbon	Duck Lake Station Site	Wamsutter	1978-12-06
Fremont	BMU Bridge Over Wind River	Ethete	1985-02-22
Fremont	Decker, Dean Sites (48FR916; 48SW541)	Honeycomb Buttes	1986-03-12
Fremont	Delfelder Schoolhouse	Riverton	1978-03-29
Fremont	ELY Wind River Diversion Dam Bridge	Morton	1985-02-22
Fremont	Fort Washakie Historic District	Fort Washakie	1969-04-16
Fremont	Green Mountain Arrow Site (48FR96)	Stratton Rim	1986-03-12
Fremont	Jackson Park Town Site Addition Brick Row	Lander	2003-02-27
Fremont	King, C.H., Company, and First National Bank of Shoshoni	Shoshoni	1994-09-08

Table 3.2-11. National Register Listed Properties in Counties Included in the Wyoming West Uranium Milling Region (continued)

County	Resource Name	City	Date Listed YYYY-MM-DD
Fremont	Lander Downtown Historic District	Lander	1987-05-05
Fremont	Quien Sabe Ranch	Shoshoni	1991-04-18
Fremont	Riverton Railroad Depot	Riverton	1978-05-22
Fremont	Shoshone-Episcopal Mission	Fort Washakie	1973-04-11
Fremont	South Pass	South Pass City	1966-10-15
Fremont	South Pass City	South Pass City	1970-02-26
Fremont	St. Michael's Mission	Ethete	1971-06-21
Fremont	Union Pass	Unknown	1969-04-16
Fremont	U.S. Post Office and Courthouse—Lander Main	Lander	1987-05-19
Fremont	Wind River Agency Blockhouse	Ft. Washakie	2000-12-23
Natrona	Archaeological Site No. 48NA83	Arminto	1994-05-13
Natrona	Big Horn Hotel	Arminto	1978-12-18
Natrona	Bishop House	Casper	2001-03-12
Natrona	Bridger Immigrant Road—Waltman Crossing	Casper	1975-01-17
Natrona	Casper Army Air Base	Casper	2001-08-03
Natrona	Casper Buffalo Trap	Casper	1974-06-25
Natrona	Casper Federal Building	Casper	1998-12-21
Natrona	Casper Fire Department Station No. 1	Casper	1993-11-04
Natrona	Casper Motor Company—Natrona Motor Company	Casper	1994-02-23
Natrona	Chicago and Northwestern Railroad Depot	Powder River	1988-01-07
Natrona	Church of Saint Anthony	Casper	1997-01-30
Natrona	Consolidated Royalty Building	Casper	1993-11-04
Natrona	DUX Bessemer Bend Bridge	Bessemer Bend	1985-02-22
Natrona	Elks Lodge No. 1353	Casper	1997-01-30
Natrona	Fort Caspar	Casper	1971-08-12
Natrona	Fort Caspar (Boundary Increase)	Casper	1976-07-19
Natrona	Independence Rock	Casper	1966-10-15
Natrona	Martin's Cove	Casper	1977-03-08
Natrona	Masonic Temple	Casper	2005-08-24
Natrona	Midwest Oil Company Hotel	Casper	1983-11-17
Natrona	Natrona County High School	Casper	1994-01-07
Natrona	North Casper Clubhouse	Casper	1994-02-18
Natrona	Ohio Oil Company Building	Casper	2001-07-25
Natrona	Pathfinder Dam	Casper	1971-08-12
Natrona	Rialto Theater	Casper	1993-02-11
Natrona	Roosevelt School	Casper	1997-01-30
Natrona	South Wolcott Street Historic District	Casper	1988-11-23
Natrona	Split Rock, Twin Peaks	Muddy Gap	1976-12-22
Natrona	Stone Ranch Stage Station	Casper	1982-11-01
Natrona	Townsend Hotel	Casper	1983-11-25
Natrona	Tribune Building	Casper	1994-02-18
Sweetwater	Eldon—Wall Terrace Site (48SW4320)	Westvaco	1985-12-13

3.2.8.3 Tribal Consultation

There are several Native American tribes located within or immediately adjacent to the state of Wyoming that have interests in the state and in the Wyoming West Uranium Milling Region (Figure 3.2-19). These include the

- Arapaho Tribe of the Wind River Reservation
- Shoshone Tribe of the Wind River Reservation
- Cheyenne River Sioux
- Flandreau Santee Sioux
- Lower Brulé Sioux
- Oglala Sioux
- Rosebud Sioux
- Sisseton-Whapeton Oyate
- Standing Rock Sioux
- Yankton Sioux
- Crow Tribe of Montana

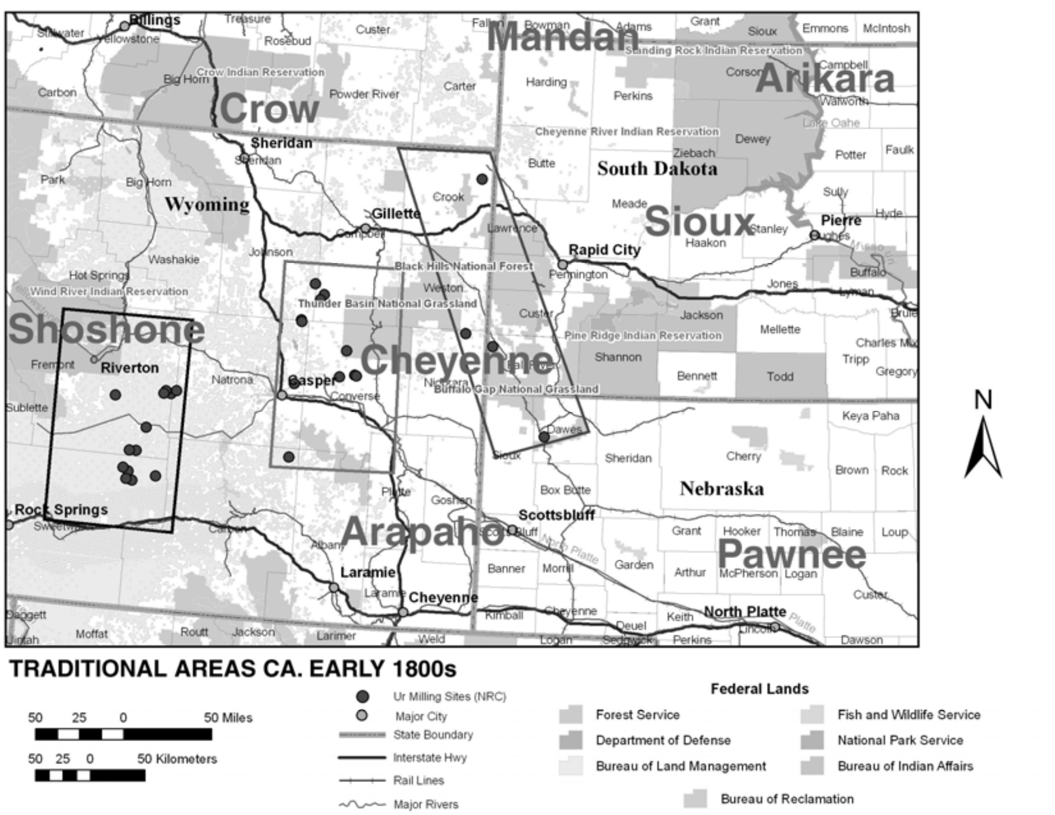

Figure 3.2-19. Regional Distribution of Native American Tribes in the Early 1800s in Wyoming, South Dakota, and Nebraska

The Siouan tribes are located throughout South and North Dakota, and the Crow are located in Montana but have interests in Wyoming. Other Siouan-speaking tribes as well as other tribes in North Dakota, Wyoming, Montana, and Nebraska may have traditional land use claims in the Wyoming West Uranium Milling Region.

The U.S. government and the State of Wyoming recognize the sovereignty of certain Native American tribes. These tribal governments have legal authority for their respective reservations. Executive Order 13175 requires executive branch federal agencies to undertake consultation and coordination with Native American tribal governments on a government-to-government basis. NRC, as an independent federal agency, has agreed to voluntarily comply with Executive Order 13175.

In addition, the NHPA provides these tribal groups with the opportunity to manage cultural resources within their own lands under the legal authority of a Tribal Historic Preservation Officer (THPO). To date, the Northern Arapaho Tribe is the only tribe in Wyoming to have attained status as a THPO as provided for in the NHPA. Some tribes have historic and cultural preservation offices that are not recognized as THPOs, but they should be consulted where they exist. NRC, in meeting its responsibilities under the NHPA, contacts tribal cultural resources personnel as part of the consultation process, along with consulting with the Wyoming SHPO.

3.2.8.4 Places of Cultural Significance

Traditional cultural properties are places of special heritage value to contemporary communities because of their association with cultural practices and beliefs that are rooted in the histories of those communities and are important in maintaining the cultural identity of the communities (Parker and King, 1998; King, 2003). Religious places are often associated with prominent topographic features like mountains, peaks, mesas, springs, and lakes. In addition, shrines may be present across the landscape to denote specific culturally significant locations and vision quest sites where an individual can place offerings.

Information on traditional land use and the location of culturally significant places is often protected information within the community (e.g., King, 2003). Therefore, the information presented on religious places is limited to those that are identified in the published literature and is therefore restricted to a few highly recognized places on the landscape within southwestern South Dakota.

There are no culturally significant places in the NRHP or state register located in the Wyoming West Uranium Milling Region. However, the Lakota Sioux or other Sioux bands (Cheyenne River Sioux, Lower Brulé Sioux, Oglala Sioux, Rosebud Sioux) along with the Crow Tribe, the Arapaho, the Kiowa, and Wind River Shoshone who once occupied portions of the Wyoming West Uranium Milling Region consider the Black Hills in Wyoming and South Dakota, Devil’s Tower in northeastern Wyoming, and Bear Butte in southwestern South Dakota to be culturally significant; these were once used for personal rituals and the Sun Dance and are the source of origin legends.

Areas of central and eastern Wyoming once used by these tribes may contain additional, undocumented culturally significant sites and traditional cultural properties. Mountains, peaks, buttes, prominences, and other elements of the natural and cultural environment are often considered important elements of a traditional culturally significant landscape.

Traditional cultural properties are those that have been passed down over the generations and that refer to beliefs, customs, and practices of a living community. Native American traditional cultural properties are often not found on the state or national registers of historic properties nor described in the extant literature or in SHPO files. There is, however, a range of cultural property types of religious or traditional use that might be identified during the tribal consultation process. These might include

- Sites of ritual and ceremonial activities and related features
- Shrines
- Marked and unmarked burial grounds
- Traditional use areas
- Plant and mineral gathering areas
- Traditional hunting areas
- Caves and rock shelters
- Springs
- Trails
- Prehistoric archaeological sites

The U.S. Bureau of Indian Affairs website contains a list, current as of May 2007, of tribal leaders and contact information <http://www.doi.gov/bia/Tribal%20Leaders-June%202007-2.pdf>. The National Organization of Tribal Historic Preservation Officers also maintains a list of THPOs on its website at http://www.nathpo.org/THPO/state_list.htm. These tribal groups should be contacted for consultations associated with ISL milling activities in their respective states (see Table 3.2-12). Additional tribal contact information may be obtained from the respective SHPO in Nebraska, Montana, South Dakota, and Wyoming.

Table 3.2-12. List of Tribal Contacts for Tribes With Interests in Nebraska, Montana, South Dakota, and Wyoming
Nebraska
Santee Sioux Nation, 108 Spirit Lake Ave. West, P(402) 857-2772 F(402) 857-2307, Roger Trudell, Chairman, Niobrara, NE 68760-7219
Ponca Tribe of Nebraska, P.O. Box 288, P(402) 857-3391 F(402) 857-3736, Larry Wright, Jr., Chairman, Niobrara, NE 68760
Omaha Tribal Council, P.O. Box 368, P(402) 837-5391 F(402) 837-5308, Mitchell Parker, Chairperson, Macy, NE 68039
Iowa Tribe of Kansas & Nebraska, 3345 Thrasher Rd., P(785) 595-3258 F(785) 595-6610, Leon Campbell, Chairman, White Cloud, KS 66094
Sac and Fox Nation of Missouri, 305 N. Main Street, P(785) 742-7471 F(785) 742-3785, Fredia Perkins, Chairperson, Reserve, KS 66434
Ponca Tribe of Nebraska, P.O. Box 288, P(402) 857-3391 F(402) 857-3736, Larry Wright, Jr., Chairman, Niobrara, NE 68760
Montana
Blackfeet Tribal Business Council, P.O. Box 850, P(406) 338-7276 F(406) 338-7530, Earl Old Person, Chairman, Browning, MT 59417 <btbc@3rivers.net>
Chippewa Cree Business Committee, RR 1, P.O. Box 544, P(406) 395-4282 F(406) 395-4497, John “Chance” Houle, Chairman, Box Elder, MT 59521
Crow Tribal Council, P.O. Box 169, P(406) 638-3715 F(406) 638-3773, Carl Venne, Chairman, Crow Agency, MT 59022

Table 3.2-12. List of Tribal Contacts for Tribes With Interests in Nebraska, Montana, South Dakota, and Wyoming (continued)
Montana (continued)
Fort Belknap Community Council, RR 1, Box 66, P(406) 353-2205 F(406) 353-4541, Julia Doney, President, Harlem, MT 59526
Fort Peck Tribal Executive Board, P.O. Box 1027, P(406) 768-5155 F(406) 768-5478, John Morales, Chairman, Poplar, MT 59255
Northern Cheyenne Tribal Council, P.O. Box 128, P(406) 477-6284 F(406) 477-6210, Eugene Littlecoyote, President, Lame Deer, MT 59043
Confederated Salish & Kootenai Tribes, Tribal Council, Box 278, P(406) 675-2700 F(406) 675-2806, James Steele, Jr., Chairman, Pablo, MT 59855 <csktadmn@ronan.net>
South Dakota
Cheyenne River Sioux Tribe, P.O. Box 590, P(605) 964-4155 F(605) 964-4151, Joseph Brings Plenty, Chairman, Eagle Butte, SD 57625
Crow Creek Sioux Tribal Council, P.O. Box 50, P(605) 245-2221 F(605) 245-2470, Lester Thompson, Chairman, Fort Thompson, SD 57339
Flandreau Santee Sioux Executive Committee, P.O. Box 283, P(605) 997-3891 F(605) 997-3878, Joshua Weston, President, Flandreau, SD 57028 <president@fsst.org>
Lower Brule Sioux Tribal Council, 187 Oyate Circle, P(605) 473-5561 F(605) 473-5606, Michael Jandreau, Chairman, Lower Brule, SD 57548
Oglala Sioux Tribal Council, P.O. Box 2070, P(605) 867-6074 F(605) 867-6076, John Yellow Bird Steele, President, Pine Ridge, SD 57770
Rosebud Sioux Tribal Council, P.O. Box 430, P(605) 747-2381 F(605) 747-2905, Rodney Bordeaux, President, Rosebud, SD 57570 <www.rosebudsiouxtribe.org>
Sisseton-Wahpeton Oyate of the Lake Traverse Reservation, P.O. Box 509, P(605) 698-3911 F(605) 698-7907, Michael Selvage, Sr., Chairman, Agency Village, SD 57262 <http://swcc.cc.sd.us/>
Standing Rock Sioux Tribal Council, P.O. Box D, P(701) 854-8500 F(701) 854-7299, Ron His Horse Is Thunder, Chairman, Fort Yates, ND 58538
Yankton Sioux Tribal Business & Claims Committee, P.O. Box 248, P(605) 384-3641 F(605) 384-5687, Robert Cournoyer, Chairman, Marty, SD 57361-0248 <bobbycournoyer@yahoo.com> <www.yanktonsiouxtribe.org/index.html>
Wyoming
Arapaho Business Committee, P.O. Box 396, P(307) 332-6120 F(307) 332-7543, Richard B. Brannon, Chairman, Fort Washakie, WY 82514
Shoshone Business Committee, P.O. Box 217, P(307) 332-3532 F(307) 332-3055, Ivan D. Posey, Chairman, Fort Washakie, WY 82514

3.2.9 Visual/Scenic Resources

Assigning values to visual and scenic resources is subjective, but basic design elements such as form, line, color, and texture can be used to describe and evaluate landscapes.

Modifications that repeat the landscape's basic elements tend to match the surroundings well. Modifications that do not match basic landscape features can look out of place and jar the viewer. Potential visual impacts can be evaluated based on likely features that may result from anticipated activities (drilling masts, well heads, header houses, satellite ion exchange facilities, and centralized milling facilities) from the perspective of both design (space, height, color) and time (permanent versus temporary structures).

Federal land management agencies such as the BLM and the USFS have established guidelines to inventory and manage visual resources. Because there are a variety of visual values, different levels of management are necessary. These activities are typically part of a visual resource management (VRM) system.

The BLM guidelines for VRM are identified in BLM Manual 8400 (BLM, 2007a). The VRM system identifies and inventories existing scenic values (BLM, 2007a–c) and establishes management objectives for those values. These area-specific objectives provide the standards for planning, designing, and evaluating the potential visual resource impacts resulting from future management projects. The VRM system also provides for mitigation measures that can reduce potentially adverse visual impacts.

Objectives for Visual Resource Classes (After BLM, 2007a,b)

Class I: To preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.

Class II: To retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

Class III: To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

Class IV: To provide for management activities that require major modifications of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

In practice, the VRM system as described by BLM consists of two stages:

- Inventory—Visual Resource Inventory (BLM, 2007b)
- Analysis—Visual Resource Contrast Rating (BLM, 2007c)

Landscape inventories are determined by taking scenic quality, visual sensitivity, and distance from the existing travel routes and dividing these factors into as many as four classes. The final VRM class determinations are typically established in the resource management plans developed by BLM field offices. The USFS system for VRM is slightly different from that used by the BLM, with five classifications based on visual quality and scenic integrity objectives (USFS, 1974, 1995).

Based on the BLM Visual Resource Handbook, the uranium districts in the Wyoming West Uranium Milling Region are located in the Wyoming Basin physiographic province (BLM, 2007a). Although BLM does not manage all of the land in the Wyoming West Uranium Milling Region, the BLM resource management plans prepared by the regional field offices establish VRM classifications for all of the region, including private land or land managed by other agencies. The regional management plans that cover the Wyoming West Uranium Milling

Region include the Casper (BLM, 2007d; Bennett, 2003), Lander (BLM, 1987), Rock Springs (BLM, 2007e), and Rawlins (BLM, 2008b) field offices (see the BLM Wyoming website at http://www.blm.gov/wy/st/en.html). The VRM classifications assigned within these resource plans are presented in Figure 3.2-20. The Lander resource management plan is in the process of being revised; as a result, the current VRM classification for the northern part of the Wyoming West Uranium Milling Region is not available at this time (BLM, 2007f). Public concerns expressed to BLM include visual and scenic resources relating to the quality of recreational experiences on public lands and the protection of landscapes along sensitive resources such as the National Historic Trails (BLM, 2007d).

The bulk of the southern part of the Wyoming West Uranium Milling Region is categorized by BLM as VRM Class III (along highways) and Class IV (open grassland, oil and natural gas, urban areas) (Figure 3.2-20). The BLM resource management plans do not identify any VRM Class I (most sensitive) resources that fall entirely within the Wyoming West Uranium Milling Region. Located in the northwestern corner of Carbon County, however, the Ferris Mountains Wilderness Study Area is identified as Class I (BLM, 2008b) and borders the eastern boundary of the region, about 72 km [45 mi] north of Rawlins. The closest potential uranium ISL facility, however, is located about 24 km [15 mi] from the closest boundary of the Ferris Mountains Wilderness Study Area. VRM Class II areas are generally identified in ranges such as the Granite Mountains, and the Rock Springs field office identifies Red Lake, Alkali Basin, Alkali Draw, South Pinnacles, and Honeycomb Buttes Wilderness Study Areas in the southwestern corner of the region as Class II (Figure 3.2-20). These Class II areas, however, are more than 32 km [20 mi] from the closest point in either of the two uranium districts located within the Wyoming West Uranium Milling Region. In addition, scenic areas along the Sweetwater and Powder Rivers provide unique viewsheds (USFS, 2005). One potential facility may be located near Jeffrey City, within a few kilometers [miles] of the Sweetwater. All of the other potential facilities are located 24 km [15 mi] or more from these two rivers. As described in Section 3.2.6.2, there are no areas identified by EPA as Class 1 Prevention of Significant Deterioration areas in the Wyoming West Uranium Milling Region (see Figure 3.2-16). In addition, the state of Wyoming Environmental Quality Council also has developed two

Visual Quality and Scenic Integrity Objectives of the USFS
(From USFS, 1974, 1995)

The USFS established visual quality objectives as part of a visual management system in its 1974 forest landscape management handbook. These objectives described the different degrees of alteration associated with a proposed management strategy that the USFS would find acceptable in terms of visual contrast with the surrounding natural landscape. The visual quality objectives have been updated and replaced by scenic integrity objectives as part of the USFS scenery management system (USFS, 1995). There has been some overlap in their application, and both systems have been used by the USFS to define visual resources.

Preservation: This visual quality objective represents essentially unaltered landscape with only minute if any deviations. This is equivalent to an area with very high scenic integrity.

Retention: This visual quality objective represents landscape that appears to be intact to the casual viewer. Alterations may be present, but are consistent with the form, line, color, and texture of the landscape. It is equivalent to a classification of high scenic integrity.

Partial Retention: This visual quality objective represents landscape that appears slightly altered. New form, line, color, or texture may be introduced as long as it remains visually subordinate. This objective is equivalent to a classification of moderate scenic integrity.

Modification: This visual quality objective represents landscape that appears moderately altered. Changes may be introduced that visually dominate the characteristic landscape, but must reflect naturally established form, line, color, and texture to be compatible with natural surroundings. This objective is equivalent to a classification of low scenic integrity.

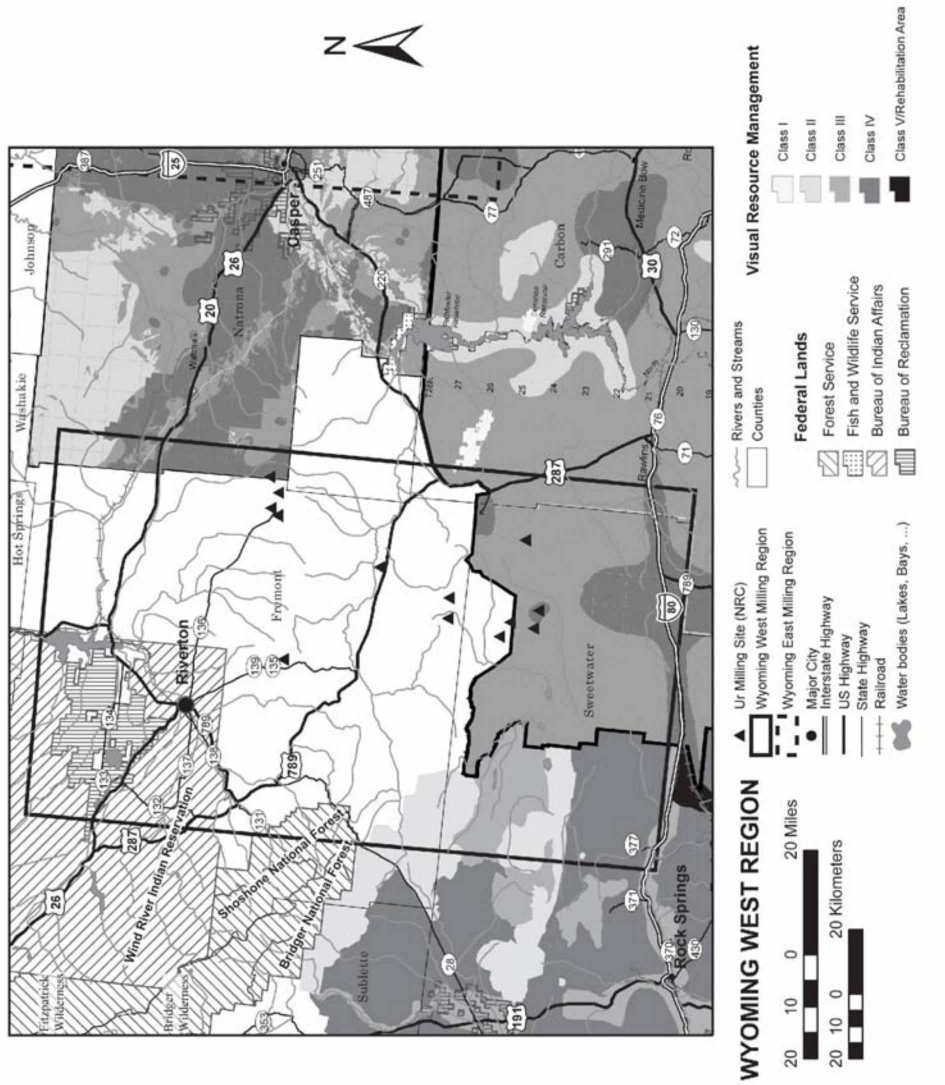

Figure 3.2-20 BLM Visual Resource Classifications for the Wyoming West Uranium Milling Region (BLM, 2008b, 2007d,e)

designations for scenic resources: (1) Unique and Irreplaceable and (2) Rare or Uncommon. These designations are limited to a small number of locations (seven), and none are located within the two uranium districts in the Wyoming West Uranium Milling Region (Girardin, 2006).

The Wind River Indian Reservation occupies the northwestern corner of the region, including the Boysen and Pilot Reservoirs managed by the U.S. Bureau of Reclamation. These areas fall within the area covered by the BLM Lander field office, and VRM classifications are not available. These regions are more than 16 km [10 mi] northwest from the closest potential ISL facility at Sand Draw, however, and more than 50 km [30 mi] from the center of the two uranium districts at Gas Hills and Crooks Gap.

3.2.10 Socioeconomics

For the purpose of this GEIS, the socioeconomic description for the Wyoming West Uranium Milling Region includes communities within the region of influence for a potential ISL facility. Communities that have the highest potential for socioeconomic impacts are considered the affected environment. These potentially affected communities are defined by (1) proximity to an ISL facility {generally within 48 km [30 mi]}; (2) economic profile, such as potential for income growth or destabilization; (3) employment structure, such as potential for job placement or displacement; and (4) community profile, such as potential for growth or destabilization to local emergency services, schools, or public housing. The affected environments are listed in Table 3.2-13.

The following subsections describe areas most likely to have implications to socioeconomics. In some sub-sections, Core-Based Statistical Areas (CBSAs) and Metropolitan Areas are also discussed. A CBSA, according to the U.S. Census Bureau, is a collective term for areas ranging from a population of 10,000 to 50,000. A Metropolitan Area is greater than 50,000, and a town is considered less than 10,000 in population (U.S. Census Bureau, 2008). A number of small towns with populations less than 1,000 exist in the affected environment but are not called out by name in Table 3.2-13 or in data presented in this section. Towns such as Moneta, Jeffrey City, Bairoil, Lamont, Wamsutter, and others are represented collectively by the applicable county-level socioeconomic information provided in this section.

Table 3.2-13. Summary of the Affected Environment Within the Wyoming West Uranium Milling Region

<table>
<tr><th>Counties Within Wyoming West</th><th>Towns Within Wyoming West</th><th>Native American Communities Within Wyoming West</th></tr>
<tr><td>Carbon</td><td>Arapaho</td><td rowspan="7">Wind River Indian Reservation</td></tr>
<tr><td>Fremont</td><td rowspan="2">Ethete</td></tr>
<tr><td>Natrona</td></tr>
<tr><td rowspan="4">Sweetwater</td><td>Ft. Washakie</td></tr>
<tr><td>Lander</td></tr>
<tr><td>Riverton</td></tr>
<tr><td>St. Stephens</td></tr>
</table>

3.2.10.1 Demographics

For the GEIS, demographics are based on 2000 U.S. Census data on population and racial characteristics of the affected environment (Table 3.2-14), Figure 3.2-21 illustrates the populations of communities within the Wyoming West Uranium Milling Region. Most 2006 data compiled by the U.S. Census Bureau was not available for the region at the time of writing.

The most populated county in the Wyoming West Uranium Milling Region is Natrona County and the most sparsely populated county is Carbon County. Riverton has the largest population in the region, and and the smallest populated town is Ethete (Wind River Indian Reservation). The county with the largest percentage of nonminorities is Natrona County with a white population of 94.2 percent, and Lander has a white population of 90.8 percent. The largest minority-based county is Fremont County with a white population of 76.5 percent. The largest minority-based town is Ethete, with a white population of only 4.9 percent.

Although not listed in Table 3.2-14, the 2000 U.S. Census total population count for the Wind River Indian Reservation was 23,250. The Wind River Indian Reservation is shared by the Eastern Shoshone and Northern Arapaho tribes and is located in Fremont and Hot Springs Counties, Wyoming. Riverton is the largest town on the reservation (U.S. Census Bureau, 2008).

3.2.10.2 Income

Income information from the 2000 U.S. Census including labor force, income, and poverty levels for the affected environment, is based on data collected at the state and county levels. Data collected at the state level also includes information on towns, CBSAs, or Metropolitan Areas and considers an outside workforce. An outside workforce may be a workforce willing to commute long distances {greater than 48 km [greater than 30 mi]} for income opportunities or may be a workforce needed to fulfill specialized positions (if local workforce is unavailable or does not have the appropriate skill set). In Wyoming, the workforce frequently commutes long distances to work. For example, in the Wyoming West Uranium Milling Region, all of the affected counties experienced net inflows of workers during the fourth quarter of 2005. Net inflows ranged from 370 for Carbon County to 10,600 for Natrona County, predominantly for jobs related to the energy industry (Wyoming Workforce Development Council, 2007). Data collected at the county level is generally the same as for the affected environment presented in Table 3.2-13 and also includes information on Native American communities. State-level information for the surrounding region is provided in Table 3.2-15 for comparison, and county data is listed in Table 3.2-16.

For the surrounding region, the state with the largest labor force population is Montana. The population with the largest labor force is Billings, Montana, 320 km [200 mi] to the nearest potential ISL facility. The population in the surrounding region with the highest per capita income is Cheyenne, Wyoming, 225 km [140 mi] from the nearest potential ISL facility. The lowest per capita income population is Laramie, Wyoming, 160 km [100 mi] to the nearest potential ISL facility. The population with the highest percentage of individuals and families below poverty level is in Billings, Montana.Based on review of Table 3.2-16, the county in the Wyoming West Uranium Milling Region with the largest labor force population is Natrona County and the smallest labor force population is in Carbon County. The town with the largest labor force population in the region is Riverton (Wind River Indian Reservation), and the smallest labor force population is in Ethete (Wind River Indian Reservation). Sweetwater County has the highest per capita income, and the smallest per capita income is in Fremont County. Per capita

Table 3.2-14. 2000 U.S. Bureau of Census Population and Race Categories of the Wyoming West Uranium Milling Region*									
Affected Environment	**Total Population**	**White**	**African American**	**Native American**	**Some Other Race**	**Two or More Races**	**Asian**	**Hispanic Origin†**	**Native Hawaiian and Other Pacific Islander**
Wyoming	493,782	454,670	3,722	11,133	12,301	8,883	2,771	31,669	302
Percent of total		92.1%	0.8%	2.3%	2.5%	1.8%	0.6%	6.4%	0.1%
Carbon County	15,639	14,092	105	9	808	321	105	2,163	9
Percent of total		90.1%	0.7%	0.1%	5.2%	2.1%	0.7%	13.8%	0.1%
Fremont County	35,804	27,388	44	7,047	417	793	106	1,566	9
Percent of total		76.5%	0.1%	19.7%	1.2%	2.2%	0.3%	4.4%	0.0%
Natrona County	66,533	62,644	505	686	1,275	1,121	277	3,257	25
Percent of total		94.2%	0.8%	1.0%	1.9%	1.7%	0.4%	4.9%	0.0%
Sweetwater County	37,613	34,461	275	380	1,349	892	240	3,545	16
Percent of total		91.6%	0.7%	1.0%	3.6%	2.4%	0.6%	9.4%	0.0%
Lander	6,867	6,236	10	411	48	140	22	239	0
Percent of total		90.8%	0.1%	6.0%	0.7%	2.0%	0.3%	3.5%	0.0%
Arapaho (Wind River Indian Reservation)	1,766	318	2	1,423	9	13	0	91	1
Percent of total		18.0%	0.1%	80.6%	0.5%	0.7%	0.0%	5.2%	0.1%
Ethete (Wind River Indian Reservation)	1,455	72	0	1,371	1	10	1	30	0
Percent of total		4.9%	0.0%	94.2%	0.1%	0.7%	0.1%	2.1%	0.0%

Table 3.2-14. 2000 U.S. Bureau of Census Population and Race Categories of the Wyoming West* Uranium Milling Region (continued)

Affected Environment	Total Population	White	African American	Native American	Some Other Race	Two or More Races	Asian	Hispanic Origin†	Native Hawaiian and Other Pacific Islander
Fort Washakie (Wind River Indian Reservation)	1,477	87	1	1,368	10	11	0	48	0
Percent of total		5.9%	0.1%	92.6%	0.7%	0.7%	0.0%	3.2%	0.0%
Riverton (Wind River Indian Reservation)	9,310	8,082	16	752	173	240	44	660	3
Percent of total		86.8%	0.2%	8.1%	1.9%	2.6%	0.5%	7.1%	0.0%
St. Stephens (Wind River Indian Reservation)	NA‡	NA	NA	NA	NA	NA	NA	NA	NA
Percent of total		NA	NA	NA	NA	NA	NA	NA	NA

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).
†Hispanic origin can be any race and is calculated as a separate component of the total population (i.e., if added to the other races would total more than 100 percent).
‡NA—not available.

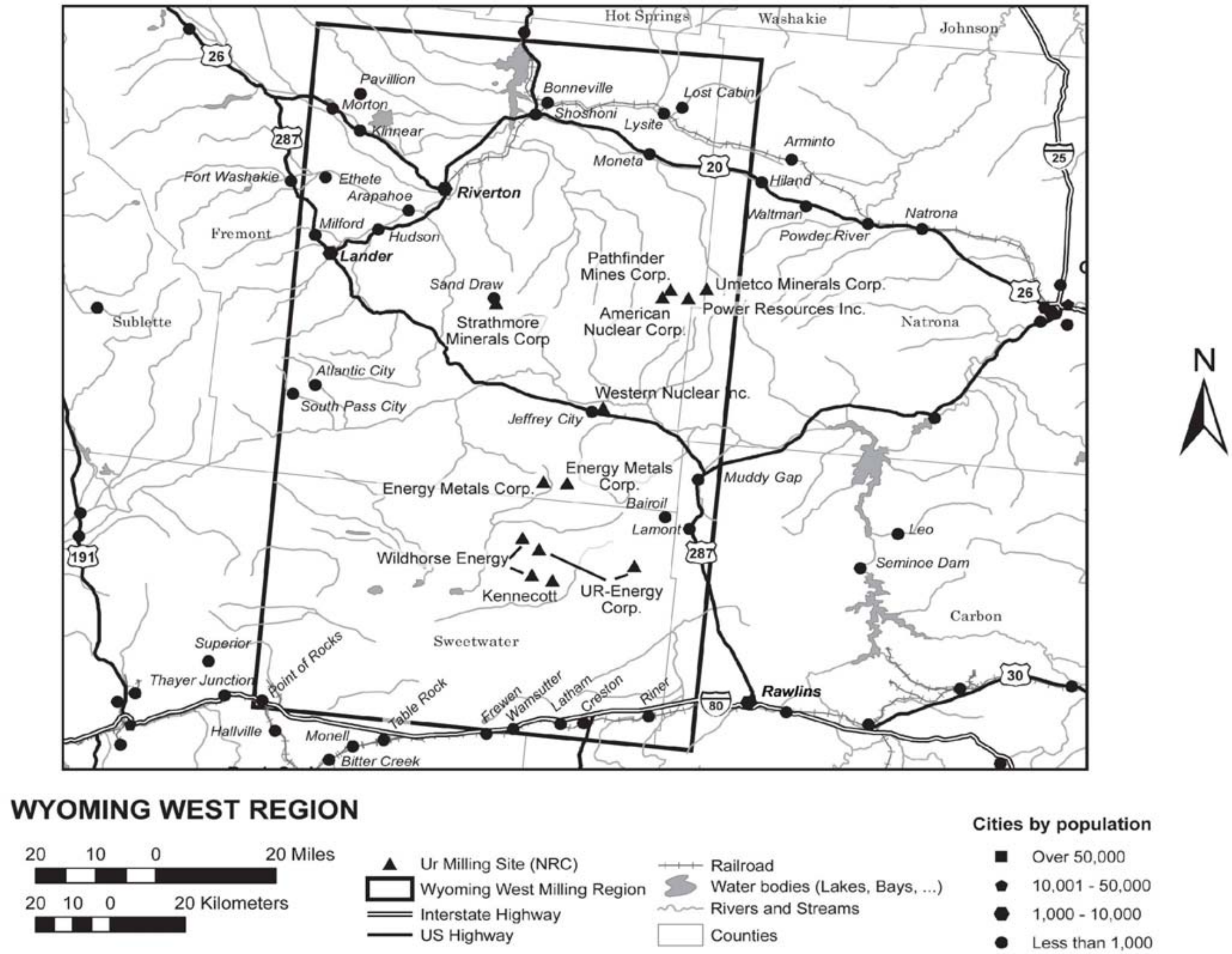

Figure 3.2-21. Wyoming West Uranium Milling Region With Population

Table 3.2-15. U.S. Bureau of Census State Income Information for the Region Surrounding the Wyoming West Uranium Milling Region*						
Affected Environment	**2000 Labor Force Population (16 years and over)**	**Median Household Income in 1999**	**Median Family Income in 1999**	**Per Capita Income in 1999**	**Families Below Poverty Level in 2000**	**Individuals Below Poverty Level in 2000**
Montana	458,306	$33,024	$40,487	$17,151	25,004	128,355
Wyoming	257,808	$37,892	$45,685	$19,134	10,585	54,777
Billings, Montana	47,584	$35,147	$45,032	$19,207	2,130	10,402
Percent of total†	67.7%	NA	NA	NA	9.2%	12.0%
Cheyenne, Wyoming	27,647	$38,856	$46,771	$19,809	891	4,541
Percent of total†	66.7%	NA	NA	NA	6.3%	8.8%
Lander, Wyoming	3,337	$32,397	$41,958	$18,389	178	859
Percent of total†	62.5%	NA	NA	NA	9.95%	13.2%
Laramie, Wyoming	15,504	$27,319	$43,395	$16,036	633	5,618
Percent of total†	67.2%	NA	NA	NA	11.1%	22.6%

*U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007, 25 February 2008, and 15 April 2008).
†Percent of total based on a population of 16 years and over.

Table 3.2-16. U.S. Bureau of Census County and Native American Income Information for the Wyoming West Uranium Milling Region*						
Affected Environment	**2000 Labor Force Population (16 years and over)**	**Median Household Income in 1999**	**Median Family Income in 1999**	**Per Capita Income in 1999**	**Families Below Poverty Level in 2000**	**Individuals Below Poverty Level in 2000**
Carbon County, Wyoming	7,744	$36,060	$41,991	$18,375	411	1,879
Percent of total†	62.5%	NA‡	NA	NA	9.8%	12.9%
Fremont County, Wyoming	17,637	$32,503	$37,983	$16,519	1,267	6,155
Percent of total†	64.9%	NA	NA	NA	13.3%	17.6%
Natrona County, Wyoming	35,081	$36,619	$45,575	$18,913	1,548	7,695
Percent of total†	68.3%	NA	NA	NA	8.7%	11.8%
Sweetwater County, Wyoming	20,022	$46,537	$54,173	$19,575	548	2,871
Percent of total†	70.6%	NA	NA	NA	5.4%	7.8%
Arapaho (Wind River Indian Reservation)	636	$22,679	$24,659	$8,943	134	784
Percent of total†	58.1%	NA	NA	NA	35.5%	45.0%
Ethete (Wind River Indian Reservation)	517	$24,130	$24,762	$7,129	95	453
Percent of total†	60.5%	NA	NA	NA	33.9%	34.4%

Table 3.2-16. U.S. Bureau of Census County and Native American Income Information for the Wyoming West Uranium Milling Region* (continued)						
Affected Environment	**2000 Labor Force Population (16 years and over)**	**Median Household Income in 1999**	**Median Family Income in 1999**	**Per Capita Income in 1999**	**Families Below Poverty Level in 2000**	**Individuals Below Poverty Level in 2000**
Fort Washakie (Wind River Indian Reservation)	567	$18,906	$20,658	$7,700	151	636
Percent of total†	57.6%	NA‡	NA	NA	42.9%	42.7%
St. Stephens (Wind River Indian Reservation)	na	na§	na	na	na	na
Percent of total†	na	NA	NA	NA	na	na
Riverton (Wind River Indian Reservation)	4,694	$31,531	$37,079	$16,720	267	1,400
Percent of total†	64.5%	NA	NA	NA	11.0%	15.7%

* U.S. Census Bureau. "American FactFinder." <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).
†Percent of total based on a population of 16 years and over.
‡NA—Not applicable.
§na—not available.

income ranges from Lander ($18,389) to the town of Ethete ($7,129). The county with the highest percentage of individuals and families below poverty level is Fremont County. The town with the highest percentage of individuals and families below poverty level is Fort Washakie (Wind River Indian Reservation).

3.2.10.3 Housing

Housing information from the 2000 U.S. Census is provided in Table 3.2-17. Housing information for the Wind River Indian Reservation was only available for the town of Riverton (U.S. Census Bureau, 2008).

The availability of housing within the immediate vicinity of the potential ISL facilities in the Wyoming West Uranium Milling Region is limited. The majority of housing is available in larger populated areas such as the towns of Riverton (20 miles to nearest ISL facility) and Casper {97 km [60 mi] to nearest ISL facility}. Temporary housing such as apartments, lodging, and trailer camps within the immediate vicinity of the proposed ISL facilities is not as limited. The majority of apartments are available in larger populated areas such as the towns of Lander, Riverton, and Rawlins with a total of 18 apartment complexes (MapQuest, 2008). There are also five hotels/motels along major highways or towns near potential ISL facilities in the two uranium districts in the Wyoming West Uranium Milling Region. In addition to apartments and lodging, there are trailer camps situated near potential ISL facilities (along major roads or near towns) in this region (MapQuest, 2008).

Table 3.2-17. U.S. Bureau of Census Housing Information for Wyoming*

Affected Environment	Single Family Owner-Occupied Homes	Median Value in Dollars	Median Monthly Costs With a Mortgage	Median Monthly Costs Without a Mortgage	Occupied Housing Units	Renter-Occupied Units
Wyoming	95,591	$96,600	$825	$229	193,608	55,793
Carbon County	7,744	$76,500	$685	$196	6,129	1,708
Fremont County	6,281	$89,300	$714	$217	13,545	3,496
Natrona County	15,250	$84,600	$746	$218	26,819	7,993
Sweetwater County	7,283	$104,200	$953	$231	14,105	3,488
Lander	1,479	$97,300	$701	$226	2,777	833
Riverton (Wind River Indian Reservation)	2,146	$83,200	$683	$203	3,792	1,221

*U.S. Census Bureau. "American FactFinder." 2000. <http://factfinder.census.gov/home/saff/main.html?_lang=en> (18 October 2007 and 25 February 2008).

3.2.10.4 Employment Structure

Employment structure from the 2000 U.S. Census including employment rate and type is based on data collected at the state and county level. Data collected at the state level also includes information on towns, CBSAs, or Metropolitan Areas and considers an outside workforce. An outside workforce includes workers willing to commute long distances {more than 48 km [30 mi]} for employment opportunities or external labor necessary to fulfill specialized positions (if the local workforce is unavailable or does not have the necessary skill sets). Data collected at the county level is the same as for the affected environment presented in Table 3.2-13 and also includes information on Native American communities.

Based on review of state-level information, Wyoming has a low unemployment rate (3.5 percent).

Unemployment at the county level ranges from 3.3 percent (Carbon County) to 5.7 percent (Fremont County). The town with the highest percentage of employment is Lander, and the town with the highest unemployment rate is Arapaho on the Wind River Indian Reservation.

3.2.10.4.1 State Data

3.2.10.4.1.1 Montana

The state of Montana has an employment rate of 60.8 percent and unemployment rate of 4.1 percent. The largest sector of employment is management, professional, and related occupations at 33.1 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Billings

Billings has an employment rate of 64.8 percent and unemployment rate of 2.8 percent. The largest sector of employment is sales and office occupations at 31.9 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.2.10.4.1.2 Wyoming

The state of Wyoming has an employment rate of 63.1 percent and unemployment rate of 3.5 percent. The largest sector of employment is sales and office occupations. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Cheyenne

Cheyenne has an employment rate of 59.2 percent and unemployment less than the state at 3.3 percent. The largest sector of employment is management, professional, and related occupations at 33.0 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

Lander

Lander has an employment rate of 59.4 percent and an unemployment rate lower than that of the state at 2.8 percent. The largest sector of employment is management, professional, and related occupations at 39.3 percent. The largest type of industry is educational, health, and social services at 37.9 percent. The largest class of worker is private wage and salary workers at 62.6 percent (U.S. Census Bureau, 2008).

Laramie

Laramie has an employment rate of 63.4 percent and unemployment less than the state at 3.7 percent. The largest sector of employment is management, professional, and related occupations at 40.5 percent. The largest type of industry is educational, health, and social services. The largest class of worker is private wage and salary workers (U.S. Census Bureau, 2008).

3.2.10.4.2 County Data

Carbon County, Wyoming

Carbon County has an employment rate of 59.2 percent and an unemployment rate lower than that of the state at 3.3 percent. The largest sector of employment is management, professional, and related occupations at 23.4 percent followed by sales and office occupations at 21.9 percent. The largest type of industry is educational, health, and social services at 17.1 percent. The largest class of worker is private wage and salary workers at 65.6 percent (U.S. Census Bureau, 2008).

Fremont County, Wyoming

Fremont County has an employment rate of 59.0 percent and an unemployment rate relatively high at 5.7 percent when compared to the state average. The largest sector of employment is management, professional, and related occupations at 33.9 percent followed by sales and office occupations at 22.5 percent. The largest type of industry is educational, health, and social services at 28.5 percent. The largest class of worker is private wage and salary workers at 64.1 percent (U.S. Census Bureau, 2008).

Natrona County, Wyoming

Natrona County has an employment rate of 64.6 percent and an unemployment rate similar to that of the state at 3.5 percent. The largest sector of employment is sales and office occupations at 29.9 percent followed by management, professional, and related occupations at 28.5 percent. The largest type of industry is educational, health, and social services at 21.2 percent. The largest class of worker is private wage and salary workers at 76.2 percent (U.S. Census Bureau, 2008).

Sweetwater County, Wyoming

Sweetwater County has an employment rate of 66.4 percent and an unemployment rate slightly higher than that of the state at 4.0 percent. The largest sector of employment is sales and office occupations at 23.4 percent followed by management, professional, and related occupations at 23.3 percent. The largest type of industry is educational, health, and social services at

18.2 percent. The largest class of worker is private wage and salary workers at 76.5 percent (U.S. Census Bureau, 2008).

Native American Communities

Information on labor force and poverty levels for the Wind River Indian Reservation is based on 2003 Bureau of Indian Affairs data and is provided in Table 3.2-18. The Northern Arapaho Tribe reports unemployment rates much higher than the statewide levels (U.S. Department of the Interior, 2003).

3.2.10.5 Local Finance

Local finance such as revenue and tax information for the affected environment is provided in this section. Table 3.2-19 shows 2007 annual sales and use tax distribution of the affected counties (including cities and towns) in the Wyoming West Uranium Milling Region.

Wyoming

The State of Wyoming does not have an income taxnor does it assess tax on retirement income received from another state. . Wyoming has a 4 percent state sales tax, 2 percent to 4 percent county lodging tax, and 4 percent use tax. Counties have the option of collecting an

Table 3.2-18. Employment Structure of the Wind River Indian Reservation Within the Affected Area*

Affected Environment	2003 Labor Force Population	Unemployed as Percent of Labor Force	Employed Below Poverty Guidelines	
Arapaho Tribe of the Wind River Indian Reservation	1,386	72%	106	8%

* U.S. Department of the Interior. "Affairs American Indian Population and Labor Force Report 2003." <http://www.doi.gov/bia/labor.html>. Washington, DC: U.S. Department of the Interior, Bureau of Indian Affairs, Office of Tribal Affairs. 2003.

Table 3.2-19. 2007 State and Local Annual Sales and Use Tax Distribution of Affected Counties Within the Wyoming West Uranium Milling Region*

Affected Counties	Use Tax		Sales Tax		Gross Revenue
	State	Local	State	Local	
Carbon County	$3,778,037	$4,328,728	$15,087,797	$16,953,793	$40,812,784
Fremont County	$1,520,637	$734,665	$20,205,131	$9,710,326	$32,624,896
Natrona County	$4,135,490	$3,322,747	$51,551,636	$41,420,622	$102,046,519
Sweetwater County	$9,856,907	$11,435,504	$51,423,220	$59,342,366	$133,613,150

*Wyoming Department of Revenue. "State of Wyoming Department of Revenue 2007 Annual Report." <http://revenue.state.wy.us/PortalVBVS/uploads/2007%20DOR%20Annual%20Report.pdf>. (7 April 2009).

additional 1 percent tax for general revenue and 2 percent tax for specific purposes. Wyoming also imposes “ad valorem taxes” on mineral extraction properties. Taxes levied for uranium production were 10.0 percent in 2007 (6.0 percent “ad valorem” and 4 percent severance) totaling $1.7 million dollars (Wyoming Department of Revenue, 2007). For 2007, in the Wyoming West Uranium Milling Region a small portion of this uranium tax revenue ($715.90) was generated in Sweetwater County. Annual sales and use tax distribution information for the affected counties (including cities and towns) in the Wyoming East Uranium Milling Region are presented in Table 3.3-14.

Native American Communities

The Wind River Indian Reservation’s largest sources of revenue come from the Northern Arapaho and Eastern Shoshone Tribal Governments; the Bureau of Indian Affairs; the Ethete, Fort Washakie, and Arapaho School Districts; the Indian Health Service; and Native American household income (University of Wyoming, 1997).

3.2.10.6 Education

Based on review of the affected environment, the county with the largest number of schools is Natrona County and the county with the smallest number of schools is Carbon County. The town with the largest number of schools is Lander and the towns with the smallest number of schools (Ethete, Aropaho) are located on the Wind River Indian Reservation.

Lander

Lander has one school district, Fremont County School District No. 1, with a total 2007 enrollment of approximately 1,930 students. There are five elementary schools, four middle schools, three high schools, seven public schools, and one private school. The majority of schools provide bus services (Greatschools.com, 2008).

Carbon County

Carbon County has two school districts, Carbon County School Districts #1 and #2, with a combined total 2007 enrollment of approximately 2,650 students. There are a total of nine elementary schools, two middle school, two high school, and two private schools. The majority of schools within each school district provide bus services (Carbon County School District No.1 and No. 2, 2008a,b).

Fremont County

Fremont County has over eight school districts, with a combined total 2007 enrollment of approximately 7,125 students. There are more than 25 public and private elementary, middle, and high schools. The majority of school districts provides bus services (Schoolbug.org, 2007).

Natrona County

Natrona County has one school district: Natrona County School District No. 1, with a total enrollment of approximately 11,500 students in 2007. There are more than 30 public and private elementary and secondary schools. The majority of schools provide bus services (Natrona County School District No. 1, 2007).

Sweetwater County

Sweetwater County has 2 school districts with a total of 10 elementary schools, 3 intermediate/middle schools, 4 high schools, and 4 private or parochial schools. There are a total of about 7,175 students. The majority of schools within each district provides bus services (Sweetwater County School District No.1, 2007; Sweetwater County School District No. 2, 2005).

Native American Communities

The Wind River Indian Reservation has several school districts in the towns of Arapaho, Ethete, Fort Washakie, and Saint Stephens. There are a total of approximately 1,060 students. Schools are the Arapaho School, Wyoming Indian School, Fort Washakie School, and Saint Stephens Indian School. All four schools accommodate elementary through 12th grades. There is no information available as to whether bus services are provided by any of these schools (Easternshoshone.net, 2008).

3.2.10.7 Health and Social Services

Health Care

The majority of the health care facilities that provide service in the vicinity of the Wyoming West Uranium Milling Region is located within the larger population centers. The closest health care facilities within the vicinity of the potential ISL facilities are located in Riverton, Lander, Casper, Cheyenne, Laramie, and Thermopolis with a total of 14 facilities (MapQuest, 2008). These consist of hospitals, clinics, emergency centers, and medical services. Hospitals located within the vicinity of the potential ISL facilities include Lander (one), Riverton (one), Rock Springs (one), Rawlins (one), Casper (one), Laramie (one), and Thermopolis (one).

Local Emergency

Local police in the Wyoming West Uranium Milling Region are under the jurisdiction of each county. There are 16 police, sheriff, or marshals offices within the region: Carbon County (6), Fremont County (3), Natrona County (4), and Sweetwater County (3) (USACops, 2008a).

Fire departments within the Wyoming West Uranium Milling Region are comprised at the county, town, CBSA, or city level. There are 7 fire departments within the milling region: Lander (one), Natrona County (one), Dubois (one), Rawlins (two), Fort Washakie (one), and Riverton (one) (50States, 2008).

3.2.11 Public and Occupational Health

3.2.11.1 Background Radiological Conditions

For a U.S. resident, the average total effective dose equivalent from natural background radiation sources is approximately 3 mSv/yr [300 mrem/yr] but varies by location and elevation (National Council of Radiation Protection and Measurements, 1987). In addition, the

> **How Is Radiation Measured?**
>
> Radiation dose is measured in units of either sievert or rem and often referred to in either milliSv/mSv or millirem/mrem where 1,000 mSv=1 Sv and 1,000 mrem=1 rem. The conversion for sieverts to rem is Sv=100 rem. These units are used in radiation protection to measure the amount of damage to human tissue from a dose of ionizing radiation. Total effective dose equivalent, or TEDE, refers to the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). See Table 3.2-20 for public radiation doses from common activities.

Table 3.2-20. Public Radiation Doses*	
Activity or Event	**Dose**
Flying from NY to LA	2.5 mrem/trip
Chest x-ray	10 mrem/exam
Full mouth dental x-ray	9 mrem/exam
U.S. average background	360 mrem/yr
* Voss, J.T. "Los Alamos Radiation Monitoring Notebook." LA–UR–00–2584. Los Alamos, New Mexico: Los Alamos National Laboratory. 2000.	

average American receives 0.6 mSv/yr [60 mrem/yr] from man-made sources including medical diagnostic tests and consumer products (National Council of Radiation Protection and Measurements, 1987). Therefore, the total from natural background and man-made sources for the average U.S. resident is 3.6 mSv/yr [360 mrem/yr]. For a breakdown of the sources of this radiation, see Figure 3.2-22.

The total effective dose equivalent is the total dose from external sources and internal material released from licensed operations. Doses from sources in the general environment (such as terrestrial radiation, cosmic radiation, and naturally occurring radon) are not included in the dose calculation for compliance with 10 CFR Part 20, even if these sources are from technologically enhanced naturally occurring radioactive material, such as preexisting radioactive residues from prior mining (Atomic Safety and Licensing Board, 2006).

Background dose varies by location primarily because of elevation changes and variations in the dose from radon. As elevation increases so does the dose from cosmic radiation and hence the total dose. Radon is a radioactive gas produced from the decay of U-238, which is naturally found in soil. The amount of radon in the soil/bedrock depends on the type, porosity, and moisture content. Areas that have types of soils/bedrock like granite have higher radon levels than those with other types of soils/bedrock (EPA, 2006). For the Wyoming West Uranium

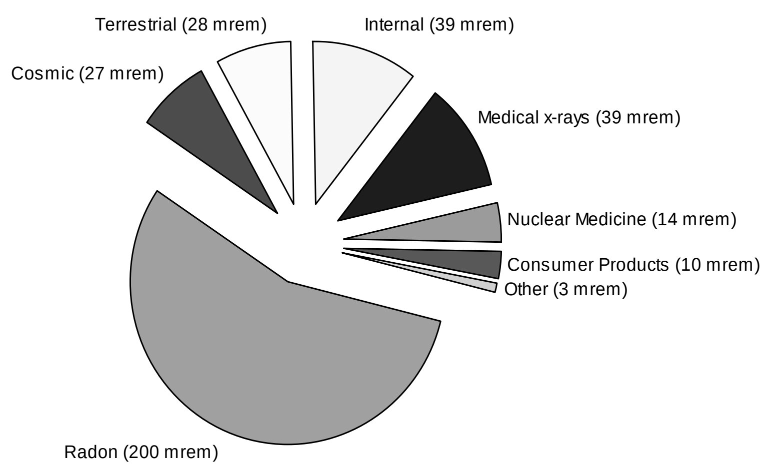

Figure 3.2-22 Average Annual Background Radiation in the United States {Units of mrem [1 mSv=100 mrem]} (NRC, 2006)

Milling Region, the average background radiation dose for the state of Wyoming is used, which is 3.16 mSv/yr [316 mrem/yr] (EPA, 2006). This value includes natural and man-made sources. This dose is slightly lower than the U.S. average primarily because the radon dose is lower {U.S. average of 2 mSv/yr [200 mrem/yr] versus Wyoming average of 1.33 mSv/yr [133 mrem/yr]}. Because of the higher elevation, the dose from cosmic radiation is slightly higher than the U.S. average: 0.515 mSv/yr [51.5 mrem/yr] versus 0.27 mSv/yr [27 mrem/yr]. The remaining contributions from terrestrial, internal, and man-made radiation combined are the same as the U.S. average of 1.318 mSv/yr [131.8 mrem/yr].

Outdoor radon concentrations are generally a small fraction of the average indoor concentrations. Outdoor radon concentrations can also be influenced by prior mining of any mineral (e.g., uranium, copper) in the area. To develop an open-pit or underground mine, soil and rock need to be excavated to reach the ore. This excavated rock, or overburden, can naturally contain higher levels of uranium and thorium than was present on the surface. Additionally, low grade ore may be left in the area around the mine, especially in the case of abandoned mines. Also, ore processed to extract elements other than uranium and thorium (such as copper, titanium, ruthenium, and other rare earth elements) could result in concentrating the natural uranium or thorium that was in the ore. The process of removing the rock or processing these ores could also change the physical and chemical characteristics controlling radon release, thus allowing additional radon to be released. The overburden and any ore left around the mine could elevate the local outdoor radon concentrations above the levels seen in other parts of the region. In close proximity to the mines, the level of terrestrial radiation could be elevated by the presence of mine waste. The overburden, low grade ore, and tailings from ore processed for other than uranium or thorium is called technologically enhanced naturally occurring radioactive material. Technologically enhanced naturally occurring radioactive material is not regulated by NRC. Radiation from these sources is considered part of the background for compliance with NRC regulations.

3.2.11.2 Public Health and Safety

NRC has the statutory responsibility, under the Atomic Energy Act of 1954, as amended, to protect the public health and safety and the environment. NRC’s regulations in 10 CFR Part 20 specify annual dose limits to members of the public of 1 mSv [100 mrem] total effective dose equivalent and 0.02 mSv/hr [2 mrem/hr] from any external sources.

3.2.11.3 Occupational Health and Safety

Occupational health and safety risks to workers include exposure to radioactive materials. Radiation safety practices for workers at uranium ISL facilities should be such that the dose to the workers is kept as low as is reasonably achievable. Radiation exposure limits are specified in 10 CFR Part 20. Occupational dose is determined by the more limiting of (1) 0.05 Sv [5 rem] total effective dose equivalent or (2) sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 0.5 Sv [50 rem]. The lens of the eye is limited to a dose equivalent of 0.15 Sv [15 rem] and the skin (of the whole body or any extremity) is limited to a shallow dose equivalent of 0.5 Sv [50 rem]. The monitoring requirements for occupational dose are covered in greater detail in Section 2.9 and Chapter 8.

3.2.12 References

50States. “Wyoming.” <www.50states.com> (15 April 2008).

AATA International Inc. Environmental and Social Due Diligence Report Great Divide Basin ISL Uranium Project. Lost Soldier and Lost Creek Claim Areas, Wyoming. Fort Collins, Colorado: AATA International Inc. 2005.

Anderson, D.C. “Uranium Deposits of the Gas Hills.” Contributions to Geology, Wyoming Uranium Issue. Laramie, Wyoming: University of Wyoming. Vol. 8, No. 2.1. pp. 93–104. 1969.

Atomic Safety and Licensing Board. “Atomic Safety and Licensing Board Transcript in the Matter of Hydro Resources Inc.” Docket No. 40–8968–ML. Washington, DC: Atomic Safety and Licensing Board. May 16, 2006.

Bailey, R.V. “Uranium Deposits in the Great Divide Basin-Crooks Gap Area, Fremont and Sweetwater Counties, Wyoming.” Contributions to Geology, Wyoming Uranium Issue. Laramie, Wyoming: University of Wyoming. Vol. 8, No. 2.1. pp. 105–120. 1969.

Bauer, E.R. and J.L. Kohler. “Cross-Sectional Survey of Noise Exposure in the Mining Industry.” G. Bockosh, M. Karmis, J. Langton, M.K. McCarter, and B. Rowe, eds. Proceedings of the 31st Annual Institute of Mining Health, Safety, and Research, Roanoke, Virginia, August 27–30, 2000. Roanoke, Virginia: Institute of Mining Health, Safety, and Research. 2000.

Bennett, E. “The Visual Resource Inventory for the Casper Field Office.” Casper, Wyoming: BLM, Casper Field Office. March 2003.

BLM. “Split Estate.” Washington, DC: BLM. 2008a. <http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices/split_estate.html> (29 January 2008).

BLM. “Proposed Resource Management Plan and Final Environmental Impact Statement for Public Lands Administered by the Bureau of Land Management Rawlins Field Office.” Rawlins, Wyoming: BLM, Rawlins Field Office. 2008b. <http://www.blm.gov/rmp/wy/rawlins/> (3 March 2008).

BLM. “Visual Resource Management.” Manual 8400. Washington, DC: BLM. 2007a. <http://www.blm.gov/nstc/VRM/8400.html> (17 October 2007).

BLM. “Visual Resource Inventory.” Manual H–8410–1. Washington, DC: BLM. 2007b. <http://www.blm.gov/nstc/VRM/8410.html> (17 October 2007).

BLM. “Visual Resource Contrast Rating.” Manual 8431. Washington, DC: BLM. 2007c. <http://www.blm.gov/nstc/VRM/8431.html> (17 October 2007).

BLM. “Proposed Resource Management Plan and Final Environmental Impact Statement for the Casper Field Office Planning Area.” BLM/WY/PL–07/017+1610. Casper, Wyoming: BLM, Casper Field Office. June 2007d. <http://www.blm.gov/rmp/casper/PRMP-FEIS.htm> (17 October 2007).

BLM. “Green River Resource Management Plan.” Rock Springs, Wyoming: BLM. Rock Springs Field Office. 2007e. <http://www.blm.gov/rmp/WY/application/index.cfm?rmpid=87> (17 October 2007).

BLM. “Notice of Intent to Prepare a Resource Management Plan Revision and Associated Environmental Impact Statement, for the Lander Field Office, Wyoming.” Lander, Wyoming: BLM, Lander Field Office. *Federal Register* 72. pp. 6741–6742. 2007f.

BLM. “Final South Powder River Basin Coal Environmental Impact Statement.” Casper, Wyoming: BLM, Casper Field Office. December 2003.

BLM. “Lander Resource Management Plan.” Lander, Wyoming: BLM, Lander Field Office. June 1987. <http://www.blm.gov/rmp/WY/Lander/rmp.pdf> (17 October 2007).

Boberg, W.W. “Some Speculations on the Development of Central Wyoming as a Uranium Province.” Wyoming Geological Association 32nd Annual Field Conference Guidebook. Casper, Wyoming: Wyoming Geological Association. pp. 161–180. 1981.

Brattstrom, B.H. and M.C. Bondello. “Effects of Off-Road Vehicle Noise on Desert Vertebrates.” *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*. R.N. Webb and H.G. Wilshire, eds. New York City, New York: Springer-Verlag Publishing. 1983.

Carbon County School District No.1. “Carbon County School District 1.” 2008 <www.crb1.k12.wy.us/> (27 February 2008).

Carbon County School District No. 2. “Carbon County School District 2.” 2008. <www.crb2.k12.wy.us/> (27 February 2008).

Center for Plant Conservation. “National Protection Plant Profile, Recovering Americas Vanishing Flora.” 2008. <http://www.centerforplantconservation.org/ASP/CPC_ViewProfile.asp?CPCNum=3241> (15 February 2008).

Chapman, S.S., S.A. Bryce, J.M. Omernik, D.G. Despain, J. ZumBerge, and M. Conrad. “Ecoregions of Wyoming.” U.S. Geological Survey Map. Scale 1:1,400,000. 2004.

Chenoweth, W.L. “A Summary of Uranium Production in Wyoming.” Mineral Resources of Wyoming, Wyoming Geological Association, 42nd Annual Field Conference Guidebook. Casper, Wyoming: Wyoming Geological Association. pp. 169–179. 1991.

Collentine, M., R. Libre, and K.R. Feathers. “Occurrence and Characteristics of Ground Water in the Great Divide and Washakie Basins, Wyoming.” Vol. VI–A. Laramie, Wyoming: University of Wyoming, Wyoming Water Resources Research Institute. 1981.

Colorado Division of Wildlife. “National Diversity Information Source.” 2008. <http://ndis.nrel.colostate.edu/wildlifespx.asp?SpCode=010595> (12 February 2008).

Curtis J. and K. Grimes. (2004). Wyoming Climate Atlas. 2004. <http://www.wrds.uwyo.edu/wrds/wsc/climateatlas/> (29 April 2008).

Davis, J.F. “Uranium Deposits of the Powder River Basin.” Contributions to Geology, Wyoming Uranium Issue. Laramie, Wyoming: University of Wyoming. Vol. 8, No. 2.1. pp. 131–142. 1969.

DOE. DOE/EA–1535, “Uranium Leasing Program Final Programmatic Environmental Assessment.” Washington, DC: DOE, Office of Legacy Management. 2007. <http://www.lm.doe.gov/documents/sites/uraniumleasing/ulm_ea2007.pdf> (12 October 2007).

Driscoll, F.G. *Groundwater and Wells*. Second edition. St. Paul, Minnesota: Johnson Filtration Systems Inc., p. 1,089. 1986.

Easternshoshone.net. “Eastern Shoshone Tribe Local Area Schools and Colleges of Wyoming.” <http://www.easternshoshone.net/EasternShoshoneLocalSchools2.htm> (02 April 2008).

EPA. “National Assessment Database.” 2008. <http://www.epa.gov/waters/305b/index.html> (28 February 2008).

EPA. “Counties Designate Nonattainment or Maintenance for Clean Air Act’s National Ambient Air Quality Standards (NAAQS).” 2007a. <http://www.epa.gov/oar/oaqps/greenbk/mapnmpoll.html> (29 September 2007).

EPA. “Prevention of Significant Deterioration (PSD) Permit Program Status: May 2007.” 2007b. <http://www.epa.gov/nsr/where.html> (26 September 2007).

EPA. “Assessment of Variations in Radiation Exposure in the United Sates (Revision 1).” Contract Number EP–D–05–02. Washington, DC: EPA. 2006.

EPA. “Regional Haze Regulations, Final Rule.” Title 40—Protection of Environment, Chapter 51, Requirements for Preparation, Adoption, and Submittal of Implementation Plans. 40 CFR Part 51. *Federal Register:* Vol. 64, No. 126. pp. 35714–35774. July 1, 1999.

Federal Highway Administration. “Synthesis of Noise Effects on Wildlife Populations.” FHWA–HEP–06–016. Washington, DC: Federal Highway Administration, Department of Transportation. 2004.

Frison, G.C. *Prehistoric Hunters of the High Plains*. 2nd Edition. San Diego, California: Academic Press. 1991.

Gebert, W.A., D.J. Graczyk, and W.R. Krug. “Average Annual Runoff in the United States, 1951–1980.” U.S. Geological Survey Hydrologic Investigations Atlas HA-710. Scale 1:7,500,000. 1987.

Girardin, J. “A List of Areas Designated Unique and Irreplaceable or Designated Rate or Uncommon by the Council.” Letter (November 29) to T. Lorenzon, Director, Environmental Quality Council. Cheyenne, Wyoming: Environmental Quality Council. 2006.

Greatschools.com. “Lander, Wyoming.” 2008. <www.greatschools.com> (27 February 2008).

Harris, R.E. and J.K. King. "Geological Classification and Origin of Radioactive Mineralization in Wyoming." A.W. Snoke, J.R. Steidtmann, and S.M Roberts, eds. Geology of Wyoming: Geological Survey of Wyoming Memoir No. 5. pp. 898–916. 1993.

Harrison, H.H. "A Field Guide to Western Birds' Nests." Boston, Massachusettes: Houghton Mifflin Company. p. 279. 1979.

Harshman, E.N. "Uranium Deposits of Wyoming and South Dakota." *Ore Deposits in the United States 1933–1967*. New York City, New York: American Institute of Mining, Metallurgical, and Petroleum Engineers. pp. 815–831. 1968.

Houston, R.S. "Aspects of the Geologic History of Wyoming Related to the Formation of Uranium Deposits." Contributions to Geology, Wyoming Uranium Issue. Laramie, Wyoming: University of Wyoming. Vol. 8, No. 21. pp. 67–79. 1969.

King, T. *Places That Count: Traditional Cultural Properties in Cultural Resources Management*. Walnut Creek, California: Altamira Press. 2003.

Lageson, D. and D. Spearing. *Roadside Geology of Wyoming*. Missoula, Montana: Mountain Press Publishing Company. 1988.

Langden, R.E. "Geology and Geochemistry of the Highland Uranium Deposit." Wyoming Geological Association Earth Science Bulletin. pp. 41–48. 1973.

Lost Creek ISR, LLC. "Lost Creek Project, South-Central Wyoming—Environmental Report." Docket No. 40-9068. Littleton, Colorado: Lost Creek ISR, LLC. 2007.

Love, J.D. "Preliminary Report on Uranium Deposits in the Pumpkin Buttes Area, Powder River Basin, Wyoming." U.S. Geological Survey Circular 176. 1952.

MapQuest. "Wyoming." <www.mapquest.com> (15 April 2008).

Mason, J.P. and K.A. Miller. "Water Resources of Sweetwater County, Wyoming." U.S. Geological Survey Scientific Investigation Report 2004-5214. 2004.

Montana Natural Heritage Program. "Animal Field Guide." 2008. <http://fwp.mt.gov/fieldguide/detail_ABNRB02020.aspx> (12 February 2008).

Munn, L.C. and C.S. Arneson. "Soils of Wyoming—A Digital Statewide Map at 1:500,000-Scale." B–1069. Laramie, Wyoming: University of Wyoming Agricultural Experiment Station, College of Agriculture. 1998.

National Climatic Data Center. "NCDC U.S. Storm Events Database." 2007. <http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms> (14 April 2008).

National Climatic Data Center. "Climates of the States, Climatology of the United States No. 60 (New Mexico, Nebraska, South Dakota, and Wyoming)." Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2005. <http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM60&subrnum=> (30 January 2005).

National Climatic Data Center. “Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2000.” Asheville, North Carolina: National Oceanic and Atmospheric Administration. 2004.

National Council on Radiation Protection and Measurements. “Report No. 094—Exposure of the Population in the United States and Canada From Natural Background Radiation.” Bethesda, Maryland: National Council on Radiation Protection and Measurements. 1987.

National Weather Service. “NOAA Technical Report NWS 33: Evaporation Atlas for the Contiguous 48 United States.” Washington, DC: National Oceanic and Atmospheric Administration. 1982.

Natrona County School District No. 1. “Natrona County School District.” 2007. <www.natronaschools.org> (15 October 2007).

NRC. NUREG/BR–0322, “Radiation Protection and the NRC.” Washington, DC: NRC. February 2006.

NRC. “Environmental Assessment for the Operation of the Gas Hills Project Satellite *In-Situ* Leach Uranium Recovery Facility.” Docket No. 40-8857. Washington, DC: NRC. 2004.

Parker, P. and T. King. “Guidelines for Evaluating and Documenting Traditional Cultural Properties.” National Register Bulletin 38. Washington, DC: National Park Service. 1998.

Platte River Endangered Partnership. “Platte River Endangered Partnership.” 2008. <http://www.platteriver.org/> (15 February 2008).

Rackley, R.I. “Environment of Wyoming Tertiary Uranium Deposits.” American Association Petroleum Geologists Bulletin. Vol. 56, No. 4. 1972.

Reher, C.A. “Chapter 6: Ethnology and Ethnohistory.” *Archaeology of the Eastern Powder River Basin Wyoming.* G.M. Zeimens and D. Walker, eds. Laramie, Wyoming: University of Wyoming, Office of the Wyoming State Archaeologist, Department of Anthropology. 1977.

Schoolbug.org. “Fremont County, Wyoming Public Schools.” 2007. <www.schoolbug.org> (15 October 2007).

Stephens, J.G. “Geology and Uranium Deposits at Crooks Gap, Fremont County, Wyoming.” U.S. Geological Survey Bulletin 1147F. pp. F1–F82. 1964.

Sweetwater County School District No. 1. 2007. “Sweetwater County School District One.” <www.sweetwater1.org> (15 October 2007).

Sweetwater County School District No. 2. “Sweetwater County School District Two.” 2005. <www.sw2.k12.wy.us> (15 October 2007).

Texas Parks and Wildlife Department. “Hunting and Wildlife.” Austin, Texas: Texas Parks and Wildlife Department. 2007. <www.tpwd.state.tx.us/huntwild/> (15 October 2007).

Trentham, R.C. and I.P. Orajaka. “Leaching of Uranium From Felsic Volcanic Rocks: Experimental Studies.” *Uranium*. Vol. 3. pp. 55–67. 1986.

University of Wyoming. “Wyoming Natural Diversity Database.” Laramie, Wyoming: University of Wyoming. 2008. <http://uwadmnweb.uwyo.edu/wyndd/> (15 February 2008).

University of Wyoming. “Economic Impact of the Wind River Reservation on Fremont County.” Laramie, Wyoming: University of Wyoming. November 1997.

USACE. “Find Notice of Issues and Modification of Nationwide Permits.” Vol. 65, No. 47. pp. 12,897–12,899. Washington, DC: USACE. 2000.

USACE. “Corps of Engineers Wetlands Delineation Manual.” Technical Report Y–87–1. Washington, DC: USACE. <http://www.mvn.usace.army.mil/ops/regulatory/wlman87.pdf> 1987.

USACops. “Wyoming.” <www.usacops.com> (15 April 2008).

U.S. Census Bureau. “American FactFinder 2000 Census Data.” 2008. <http://factfinder.census.gov> (25 February 2008).

U.S. Department of the Interior. “American Indian Population and Labor Force Report.” Washington, DC: U.S. Department of the Interior, Bureau of Indian Affairs. 2003.

USFS. “Bighorn National Forest, Final Environmental Impact Statement for the Revised Land and Resource Management Plan.” Golden, Colorado: USFS, Rocky Mountain Region. November 2005. <http://www.fs.fed.us/r2/bighorn/projects/planrevision/documents/final/index.shtml> (17 October 2007).

USFS. “Landscape Aesthetics: A Handbook for Scenery Management.” *Agricultural Handbook No. 702*. Washington, DC: USFS. 1995.

USFS. “National Forest Landscape Management. Volume 2, Chapter 1. The Visual Management System.” Agriculture Handbook No. 462. Washington, DC: USFS. 1974.

U.S. Fish and Wildlife Service. “Mountain Prairie Region.” 2008. <http://www.fws.gov/mountain%2Dprairie/> (15 February 2008).

U.S. Fish and Wildlife Service. “National Wetland Inventory Mapper.” 2007. <http://www.fws.gov/nwi/> (29 February 2008).

U.S. Geological Survey. “Water Watch.” 2008. <http://water.usgs.gov/waterwatch> (28 February 2008).

U.S. Geological Survey. “A Tapestry of Time and Terrain.” Denver, Colorado: U.S. Geological Survey. 2004. <http://tapestry.usgs.gov/Default.html> (25 February 2008).

Washington State Department of Transportation. “WSDOT's Guidance for Addressing Noise Impacts in Biological Assessments—Noise Impacts.” Seattle, Washington: Washington State Department of Transportation. 2006. <http://www.wsdot.wa.gov/TA/Operations/Environmental/NoiseChapter011906.pdf> (12 October 2007).

WDEQ. "Wyoming's 2008 305(b) Integrated State Water Quality Assessment Report and 2008 303(d) List of Waters Requiring TMDLs." Cheyenne, Wyoming: WDEQ, Water Quality Divisions. 2008. <http://deq.state.wy.us/wqd/watershed/Downloads/305b/2008/2008%20Integrated%20Report.pdf> (27 January 2009).

WDEQ. "Wyoming Surface Water Classification List." Cheyenne, Wyoming: WDEQ, Water Quality Division, Surface Water Standards. 2001.

Wedel, W.R. *Prehistoric Man on the Great Plains.* Norman, Oklahoma: University of Oklahoma Press. 1961.

Whitehead, R.L. "Groundwater Atlas of the United States, Montana, North Dakota, South Dakota, Wyoming." U.S. Geological Survey Report HA 730–I. Denver, Colorado: U.S. Geological Survey. 1996. <http://pubs.usgs.gov/ha/ha730/ch_i/> (27 January 2009).

World Wildlife Fund. "Wildfinder—Mapping the World's Species: Ecoregion NA1313 (Wyoming Basin Shrub Steppe)." Washington, DC: World Wildlife Fund. 2007a. <http://www.worldwildlife.org/wildfinder/searchByPlace.cfm?ecoregion=Na1313> (15 October 2007).

World Wildlife Fund. "Wyoming Basin Shrub Steppe." Washington, DC: World Wildlife Fund. 2007b. <http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na1313_full.html> (13 September 2007).

World Wildlife Fund. "Colorado Rockies Forests." Washington, DC: World Wildlife Fund. 2007c. <http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0511_full.html> (10 October 2007).

World Wildlife Fund. "Northern Short Grasslands." Washington, DC: World Wildlife Fund. 2007d. <http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0811_full.html> (13 September 2007).

World Wildlife Fund. "South Central Rockies Forests." Washington, DC: World Wildlife Fund. 2007e. <http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0528_full.html> (10 October 2007).

Wyoming Department of Revenue. "State of Wyoming Department of Revenue 2007 Annual Report." <http://revenue.state.wy.us/PortalVBVS/uploads/2007%20DOR%20Annual%20Report.pdf>. (7 April 2009).

Wyoming Department of Revenue. "Sales and Tax Distribution Report by County 2007." <http://revenue.state.wy.us/PortalVBVS/DesktopDefault.aspx?tabindex=3&tabid=10> (18 October 2007 and 25 February 2008).

Wyoming Department of Transportation. "WYDOT Traffic Analysis." Cheyenne, Wyoming: Wyoming Department of Transportation. 2005. <http://www.dot.state.wy.us/Default.jsp?sCode=hwyta> (25 February 2008).

Wyoming Game and Fish Department. "Comprehensive Wildlife Conservation Strategy." Cheyenne, Wyoming: Wyoming Game and Fish. 2008. <http://gf.state.wy.us/wildlife/CompConvStrategy/Species> (19 February 2008).

Wyoming Game and Fish Department. "Official State List of Birds, Mammals, Amphibians, and Reptiles in Wyoming." Cheyenne, Wyoming: Wyoming Game and Fish. 2007a. <http://gf.state.wy.us/wildlife/nongame/SpeciesList/index.asp> (15 October 2007).

Wyoming Game and Fish Department. "Terrestrial Habitat/Aquatic Habitat/Habitat Management." Cheyenne, Wyoming: Wyoming Game and Fish. 2007b. <http://gf.state.wy.us/habitat/aquatic/index.asp> (13 September 2007).

Wyoming Geographic Information Science Center. "Land Ownership and Management for Wyoming." Laramie, Wyoming: University of Wyoming, Wyoming Geographic Information Service Center. 2008. <www.wygisc.uwyo.edu/wbn/gap/landown.html> (15 February 2008).

Wyoming Geographic Information Science Center. "Wyoming Gap Analysis." Laramie, Wyoming: University of Wyoming, Wyoming Geographic Information Science Center. 2007a. <http://www.wygisc.uwyo.edu/wbn/gap.html> (25 February 2008).

Wyoming Geographic Information Science Center. "Wyoming Gap Analysis—Download." Laramie, Wyoming: University of Wyoming, Wyoming Geographic Information Science Center, Wyoming Bioinformation Node. 2007b. <http://www.sdvc.uwyo.edu/wbn/data.html> (25 February 2008).

Wyoming State Geological Survey, Industrial Minerals and Uranium Section. "Uranium Page." <http://www.wsgs.uwyo.edu/minerals/uranium> (15 July 2005).

Wyoming Workforce Development Council. "Wyoming Workers Commuting Patters Study." Cheyenne, Wyoming: Wyoming Workforce Development Council. 2007.

Zielinski, R.A. "Volcanic Rocks as Sources of Uranium." *Uranium Deposits in Volcanic Rocks*. Vienna, Austria: International Atomic Energy Agency. pp. 83–95. 1984.

Zielinski, R.A. "Tuffaceous Sediments as Source Rocks for Uranium—A Case Study of the White River Formation, Wyoming." *Journal of Geochemical Exploration*. Vol. 18. pp. 285–306. 1983.