4 ENVIRONMENTAL IMPACTS OF CONSTRUCTION, OPERATION, AQUIFER RESTORATION, AND DECOMMISSIONING ACTIVITIES

4.1 Introduction

Classifying Impact Significance (After NRC, 2003)

- *Small Impact*: The environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource considered.
- *Moderate Impact*: The environmental effects are sufficient to alter noticeably, but not destabilize, important attributes of the resource considered.
- *Large Impact*: The environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource considered.

The potential impacts to environmental resources during the construction, operation, aquifer restoration, and decommissioning phases at *in-situ* leach (ISL) uranium recovery facilities are analyzed in this chapter. As discussed in Section 1.4.3, the potential environmental impacts are evaluated for each of the four geographic regions that form the basis for this generic environmental impact statement (GEIS). In essence, the analysis involves placing an ISL uranium recovery facility with the characteristics described in Chapter 2 of the GEIS within each of the four regional areas described in Chapter 3. The potential impacts for each resource are described and evaluated separately for each region at each stage in an ISL facility's lifetime: construction, operation, aquifer restoration, and decommissioning/reclamation. Impact significance is evaluated and reported based on the SMALL, MODERATE, LARGE classification described in U.S. Nuclear Regulatory Commission (NRC) guidance in NUREG–1748 (NRC, 2003) and summarized in Section 1.4.3.

Reference

NRC. NUREG–1748, "Environmental Review Guidance for Licensing Actions Associated With NMSS Programs. Final Report." Washington, DC: NRC. August 2003.

4.2 Wyoming West Uranium Milling Region

The general introductory impact information presented here will be applicable to NRC's review of license applications for new ISL facilities in the Wyoming West Uranium Milling Region. As appropriate, information that is also generally applicable to NRC's reviews for potential new ISL facilities to be located in the three other regions will be identified and discussed in the GEIS.

4.2.1 Land Use Impacts

In the Wyoming West Uranium Milling Region, current information indicates that potential ISL facilities would primarily be developed in two uranium districts (Gas Hills and Crooks Gap) that are located on rangeland used for livestock grazing and to a lesser extent for farming. Areas of past and present uranium milling interest in the Wyoming West Uranium Milling Region are shown in Figures 3.2-1 and 3.2-2. These areas of milling interest are generally located on unpopulated rangeland managed by the U.S. Bureau of Land Management (BLM) and can be in proximity to cultivated areas, private or public lands used for recreation and wildlife management, timber management, oil and gas exploration and production, coal and metals mining, and cultural and historical resources areas.

The permitted areas of existing ISL facilities can be large, ranging from about 1,134 ha [2,800 acres] for the Crow Butte ISL facility site in Dawes County, Nebraska, to over 6,480 ha [16,000 acres] for the Smith Ranch Uranium Project site in Converse County, Wyoming (Section 2.11.1). However, the central processing facility at a commercial-scale facility may occupy only 1 to 6 ha [2.5 to 15 acres], and satellite plants may be even smaller (NRC, 2006). For the purposes of this discussion, the site areas of current and new ISL facilities to be licensed can be bounded as follows:

- Total permit area of a new ISL site: 1,000 to 7,000 ha [2,471 to 17,297 acres]
- Total (disturbed land) surface area of a new ISL site including multiple well fields, a central processing facility, and satellite plants within the overall permit area: 50 to 750 ha [120 to 1,860 acres] (Section 2.11.1)

Much of the total permitted area of ISL facilities would be expected to remain undisturbed since surface operations (well fields and processing facilities) would affect only a small portion of the permitted area. Operations and activities that cause the greatest disturbance of the land and the subsurface would be expected to take place in the well fields.

ISL surface facilities are considered controlled areas that are fenced to limit access. Entire well fields or areas around pump houses and well heads may also be fenced for safety, security, and to prevent livestock grazing or other types of access.

4.2.1.1 Construction Impacts to Land Use

The construction of an ISL facility can potentially impact land uses by: (1) changing and disturbing existing land uses, (2) restricting access or establishing right-of-way for access, (3) affecting mineral rights, (4) restricting livestock grazing areas, (5) restricting recreational activities, and (6) altering ecological, cultural and historical resources.

Changes and Disturbances in Land Uses: Construction of an ISL facility would temporarily prevent land from being used for other purposes. Because the predominant land use in areas of milling interest is rangeland managed by BLM (Section 3.2.1), grazing and cultivated areas would be temporarily lost. If an ISL facility was located in forest land, access to timber could be impeded by construction and some forest resources could be potentially lost. If an ISL facility abutted public or private land used for recreational activities and for protecting ecological resources (e.g., National or State Parks, National Forests or Grasslands), these activities and resources could also be affected.

Land use changes and disturbances would be expected to be most intense during the construction, period but these disturbances are typically temporary, spanning one to three construction seasons (Freeman and Stover, 1999). Drilling, trenching, excavating, grading, and surface facilities construction would be expected to disturb the land most during the construction phase. Compared to the overall total permit area of a new ISL facility, only a relatively small fraction (on average, approximately 15 percent) of the permitted site area would be expected to be changed and disturbed (Section 2.11.1). In addition, the amount of disturbed land would be small compared to the total ranchland area managed by BLM in the Wyoming West Uranium Milling Region (see Table 3.2-1). Therefore, impacts to land use changes would be SMALL. Additionally, licensees implement postconstruction actions, such as recontouring and restoring surface cover, well sites, staging areas, trenches and parts of dirt access roads to minimize the temporary loss of pasture land, grazing rights, or timber resources. The licensees would coordinate these postconstruction mitigation measures with responsible federal or state agencies such as BLM, U.S. Fish and Wildlife Service (USFS) or private entities.

Access Restrictions: Access restrictions would be expected to be limited but continue beyond the construction phase over the operational lifecycle of an ISL facility. As previously noted (Section 2.11.1), the area of fenced surface facilities would be relatively SMALL (typically around restricted areas only). The well fields could remain open, but also could be fenced to limit access. The land around the wells and pump houses would be restored and reseeded. Right-of-way for access to dirt roads and well fields would be established for the duration of the project but such rights would not be permanent. Overall, the relatively small areas involved and the temporary nature of construction indicate the access restriction impacts for potential ISL facilities in the Wyoming West Uranium Milling Region would be SMALL.

Mineral Rights: It is anticipated that future mineral rights for resources in the permit area other than uranium, could be either delayed for the duration of an ISL project or intermixed within the overall permit area of an ISL facility. It is expected that any potential oil and gas, or coal and metals mining exploration and production activities would be addressed by obtaining mineral rights and surface owner consent before an ISL facility is built. For example, the Wyoming Department of Environmental Quality (WDEQ) requires a surface owner consent form for all surface owners (WDEQ, 2007). Existing oil and gas exploration and production or coal bed methane well sites could coexist within an ISL total permit area given that the actual footprint of an ISL facility is small relative to the total permit area. There has been relatively little coal bed methane development in the Wyoming West Uranium Milling Region, with a few wells located near the Carbon-Sweetwater County line (Ruckelshaus Institute and

Mineral Rights, Mining Rights, Oil Rights, or Drilling Rights

Rights may be conferred to remove minerals, oil, or sometimes water that may be present on and under some land. In jurisdictions supporting such rights, they may be separate from other rights to the land. The rights to develop minerals, and the purchase and sale of those rights, are contractual matters that must be agreed between the parties involved.

Environment and Natural Resources, 2005). It is expected that the coexistence and potential conflicts among different mineral rights on an ISL permit area on public or private lands, would be negotiated and agreed upon between the different mineral rights owners involved. Thus the potential impacts to current or future mineral rights for resources other than uranium on an ISL facility permit area are expected to be SMALL.

Livestock Grazing and Agricultural Restrictions: One of the main commercial uses of publicly or privately owned open rangelands in the west is livestock grazing, but rangelands also provide scenic vistas, open spaces, wildlife, and recreational opportunities. Livestock grazing is an integral and historical part of the western rangeland and contributes to maintaining its ecological, historical, and social values for owners, residents, and visitors. The potential impairment to these rangeland values associated with the loss of livestock grazing should also be considered by ISL operators. Where used, fencing would potentially restrict livestock access to forage on private or federal lands along dirt roads, on well fields, and on satellite and central processing facilities. Use of the land as rangeland or cultivated fields and pasture land would likely be excluded from these fenced areas during the life of the project. For example, for the Reynolds Ranch satellite plant area, an addition to the Smith Ranch-Highlands property in Converse County, Wyoming, it was estimated that livestock would be prevented from grazing on about 131 ha [325 acres] of land that would be used for uranium recovery and related activities (e.g., access road construction, pipelines, satellite facility construction) (NRC, 2006). This is in comparison to the 3,500 ha [8,700 acres] within the Reynolds Ranch permitted area. If part of the land is cultivated or if grazing permits are in effect, mitigation or compensation measures would need to be defined and implemented through agreements between surface owners or grazing permit holders and ISL operators to mitigate the loss of agricultural production or grazing rights in areas with restricted access and fenced areas. Examples of mitigation or compensation measures could include relocation of livestock and water, pasture and rangeland improvement on alternate public or private land, purchase of hay to replace the loss of cultivated pasture or open rangeland, purchase of additional grazing rights, or reimbursement to livestock ranchers for loss of grazing or pasture land.

Impacts to grazing from other ISL facilities would be expected to be similar to the example cited. Overall, about 150 ha [370 acres] of grazing area could be restricted, compared to the thousands of hectares [acres] for the whole permitted area of a new ISL facility that would remain available for grazing. Because a relatively small portion of the grazing permit area available in the Wyoming West Uranium Milling Region would be restricted on fenced portions of the land, overall impacts to grazing and farming would be SMALL. In terms of duration, these impacts would not necessarily last for the entire duration of an ISL operation and decommissioning phases, because uranium extraction operations often move from one well field to the next and the land of a particular well field where operations ceased could partly or totally be reclaimed and returned to previous grazing, farming, or recreational uses.

Restriction on Recreational Activities: Fencing and right-of-way conditions would minimally restrict hunting and off-road vehicle access to previously open areas. These recreational activities are most common on the grass- or shrub-covered rolling hills of the Wyoming West Uranium Milling Region where new ISL facilities would be developed on BLM and private lands. Because the fenced area of an ISL facility, as previously described, would be relatively SMALL and temporary, and because there would be abundant open space available around the ISL facility, the impacts to these recreational activities would be SMALL.

Altering Ecological, Historical, and Cultural Resources: Depending on the specific locations of a proposed ISL facility and characteristics of the land and environment, the construction of a new ISL facility could potentially impact portions of managed lands that contain localized ecological, historical, and cultural resources (see details in Sections 4.2.5 and 4.2.8, respectively). These resources could be altered, destroyed, restricted, or made inaccessible. If these types of impacts were to occur, they would be expected during the construction phase when most of the land surface disturbances would occur. Impacts would be expected to be mitigated by consultations with appropriate federal, tribal, and state agencies to identify appropriate planning and surveying prior to the construction phase that would clearly identify and delineate those site-specific resources. Such planning could help to avoid or mitigate the degree and intensity of impacts from construction activities. However, surveying and due diligence activities might not be sufficient to identify historical and cultural resources. These buried resources could be altered or destroyed during excavation, drilling, and grading activities; thus impacts to portions of the land containing localized ecological, historical; and cultural resources would range from SMALL to LARGE, depending on local conditions.

4.2.1.2 Operation Impacts to Land Use

The types of land use impacts for operational activities would be expected to be similar to construction impacts regarding access restrictions because the infrastructure would be in place. Additional land disturbances would not be expected from conducting the operational activities described in Section 2.4. During the operational period of an ISL facility, the primary changes to land use would be the expansion of well fields, which is addressed as a construction impact in Section 4.2.1.1. Sequentially moving active operations from one well field to the next would shift potential impacts. For example, a well field where uranium recovery activities have ceased could be partly restored and reopened for grazing or recreation while a new well field is being developed, which would have impacts similar to those described in the preceding section for the construction phase.

The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to ensure release limits would be met and soil sampling to establish background and monitor for uranium, radium, and other metals. Land that is used for irrigation is also included in decommissioning surveys to ensure potentially impacted areas would be appropriately characterized and remediated, as necessary, in accordance with NRC and applicable state regulations. Because access restriction and land disturbance impacts would be expected to be similar to or less than those expected for construction, the overall potential impacts to land use from operational activities would be SMALL.

4.2.1.3 Aquifer Restoration Impacts to Land Use

During aquifer restoration, the land use impacts described previously for the construction phase and the operations phase would remain. In terms of specific activities, the aquifer restoration uses the same infrastructure as the operations phase and maintenance would be at a similar level. Land use impacts from aquifer restoration could also decrease as fewer wells and pump houses would be used and overall equipment traffic and use diminish. Thus, the overall potential impacts to land use during the aquifer restoration phase are comparable to those of the operation phase and would be SMALL.

4.2.1.4 Decommissioning Impacts to Land Use

The types of land use impacts described for construction, operations, and aquifer restoration would be similar during the decommissioning of an ISL facility. The specific site activities and their effects would temporarily increase during decommissioning compared to the operation and aquifer restoration phases, because there would be greater use of earth- and material-moving equipment and other heavy equipment associated with land reclamation, dismantling, removal, and disposal of well field materials, pipelines, and central and satellite processing facilities. Additionally, surface reclamation activities would involve use of earth-moving equipment in regrading certain areas or in removing evaporation pond embankments. Reclaimed areas would be replanted in accordance with appropriate state or federal regulations and standards. Because most of the decommissioning phase would occur on previously disturbed and potentially restricted land, the additional potential impacts to land use during the decommissioning phase would range from SMALL to MODERATE. Impacts would decrease to SMALL as decommissioning and reclamation are completed and land is restored to previous uses.

The principal outcomes of aquifer restoration and decommissioning activities would be to end uranium recovery activities, restore the land to its original condition, and to reestablish the prior land uses or to redevelop the land for other potential uses.

4.2.2 Transportation Impacts

Truck and automobile use is associated with all phases of the ISL facility lifecycle including construction, operation, aquifer restoration, and decommissioning. The estimated low magnitude of road transportation from all phases of the ISL lifecycle (Section 2.8), when compared with local traffic volumes in the Wyoming West Uranium Milling Region (Section 3.2.2), is not expected to significantly change the amount of traffic or accident rates. One possible exception to this conclusion is that commuting traffic for facility workers, in particular, during periods of peak employment (during construction), would have greater impacts when roads with the lowest levels of current traffic are traveled. These low traffic roads may also be more susceptible to wear and tear from increased traffic. Localized intermittent and temporary SMALL to MODERATE impacts associated with noise, dust, and incidental livestock or wildlife kills are possible on all roads but in particular on remote local and unpaved access roads. The magnitude of these impacts would be influenced by site-specific conditions including the proximity of local residential housing, other regularly occupied structures, wildlife habitat, farming, or grazing areas to ISL facility access roads. Unique local road and environmental conditions (e.g., local hazards, local resource impacts) would be considered in an NRC-site-specific environmental review. Potential local impacts include loss of forage palatability from road dust and interference with livestock herding and grazing activities. A more detailed assessment of transportation impacts for each phase of the ISL facility lifecycle is provided in the following sections.

4.2.2.1 Construction Impacts to Transportation

ISL facilities, in general, are not large-scale or time-consuming construction projects (Sections 2.3 and Table 2.7-1). The magnitude of estimated construction-related transportation (Section 2.8) is expected to vary depending on the size of the facility; however, when considered with the regional traffic counts provided in Section 3.2.2, most roads that would be used for construction transportation in the Wyoming West Uranium Milling Region would not gain significant increases in daily traffic, and therefore traffic-related impacts would be SMALL. Roads with the lowest average annual daily traffic counts would have higher (MODERATE) traffic and potential infrastructure impacts, in particular, when facilities are experiencing peak employment. The limited duration of construction activities (12–18 months) suggests impacts would be temporary in many areas where an ISL facility would be sited. Temporary SMALL to MODERATE dust and noise impacts are possible for residents living in the vicinity of unpaved access roads used for construction transportation activities in the vicinity of ISL facilities.

4.2.2.2 Operation Impacts to Transportation

Operational transportation activities include employee commuting, supply shipments, waste transportation, ion exchange resin transport (where applicable), and yellowcake transportation. Overall, the estimated magnitude of operational truck transportation (Section 2.8) is generally low (a few trucks per day or less) and unlikely to generate any significant environmental impacts above those mentioned in Section 4.2.2.1. Commuting impacts will depend on the size of the workforce; however, most of the roads assessed for average annual daily traffic counts in the Wyoming West Uranium Milling Region (Section 3.2.2) have sufficiently high counts that the increase in traffic due to ISL facility commuting (Section 2.8) is not expected to significantly change traffic conditions or accident rates. For these roads, traffic impacts would be SMALL. For the roads with the lowest traffic counts, ISL facility commuting could significantly increase traffic and impacts would be MODERATE, particularly during times of peak employment.

Yellowcake Transportation. NRC and others have previously analyzed the hazards associated with yellowcake transportation for both the generic case (Mackin, et al., 2001; NRC, 1980, NRC, 1977) and in site-specific environmental assessments (e.g., in NRC, 1997). These analyses are conservative and tend to overestimate impacts (e.g., release model, accident rates, dosimetry selections, exposed population density); however, they are appropriate for screening-level calculations. The risk analyses combined with past experience show that accidents resulting in potential yellowcake release must be considered when uranium milling activities are evaluated for safety. Estimated and actual consequences of such accidents are small, however, in part, due to the appropriate use of safety controls and emergency response protocols.

<u>Calculating Potential Radiation Exposure</u>

Radiation Dose. Radiation dose estimates are quantified in units of either **sievert** or **rem** and are often referred to in either milliSievert (mSv) or millirem (mrem) where 1,000 mSv=1 Sv and 1,000 mrem=1 rem (Sv=100 rem). These units are used in radiation protection to quantify the amount of damage to human tissue expected from a dose of ionizing radiation.

Person-Sv. Person-Sv [Person-rem] is a metric used to quantify population radiation dose (also referred to as collective dose). It represents the sum of all estimated doses received by each individual in a population and is commonly used in calculations to estimate latent cancer fatalities in a population exposed to radiation.

Latent Cancer Fatality (LCF). Latent cancer fatality is a measure of the calculated number of excess cancer deaths expected in a population as a result of exposure to radiation. Latent cancers can occur from one to many years after the exposure takes place.

International Commission on Radiological Protection (1990) suggests a conversion factor that for every person-Sv [100 person-rem] of collective dose, about 0.06 individuals would develop a cancer induced by radiation exposure. If the conversion factor is multiplied by the collective dose to a population, the result is the number of latent cancer fatalities in excess of what would be expected without the radiation exposure.

Because these results are statistical estimates, values for expected latent cancer fatalities can be, and often are, less than one for cases involving low doses or small populations.

After yellowcake is produced at an ISL facility, it is transported to a conversion facility in Metropolis, Illinois (the only conversion facility in the United States), to produce uranium hexafluoride (UF_6) for use in the production of nuclear reactor fuel.

Potential routes and distances from the Wyoming West Uranium Milling Region are discussed in Section 3.2.2.

A prior transportation analysis (NRC, 1980) estimated risks of transporting yellowcake 2,414 km [1,500 mi] to a conversion plant in Illinois—a distance that is bounding for routes originating from the Wyoming West Uranium Milling Region to the conversion facility (Section 3.2.2). In the prior analysis, annual production estimates (the basis for the estimated number of shipments) were assumed to be 589,670 kg [1,300,000 lb]. This amount of yellowcake results in a facility making approximately 34 shipments per year {based on 40 drums per shipment carrying 430 kg [950 lb] of yellowcake per drum}. This number of shipments is within the range of shipments reported by ISL facilities discussed in Section 2.8. Yellowcake release was calculated considering the degree of loss of package containment for a range of accident severities and information on the likelihood that an accident of a particular severity class would occur when an accident happens. Two models for package response to accident conditions were considered. Model 1 assumed complete loss of package contents for any accident severe enough to breach packages, whereas Model 2 used results from package tests indicating only partial release of contents for accidents sufficient to breach packages. The resulting population dose estimates for these estimated releases from a single accident in an area containing 61 people per km^2 [158 people per mi^2] (i.e., rural residential population living on a given area of land) were 200 person-rem [2 person-Sv] for Model 1 and 14 person-rem [0.14 person-Sv] for Model 2 (NRC, 1980).

When the accident dose results are weighted by accident probabilities (computed as the product of the vehicle accident rate per unit distance traveled, the number of shipments, and the shipment distance) and converted to estimated latent cancer fatalities (Mackin, et al., 2001), the results are 0.01 and 0.0008 cancer deaths per year from yellowcake accidents for a single ISL facility. These risk results can be recalculated for facilities with higher production estimates, longer shipment distances, or increased accident rates by adjusting the computed accident probability term. For comparison, the Smith Ranch-Highlands property in Converse County, Wyoming, is licensed at 2,500,000 kg [5,500,000 lb] yellowcake per year (NRC, 2006; Energy Metals Corporation, U.S., 2007; Energy Information Administration, 2004), which would translate to 145 yellowcake shipments if they were to produce at their maximum permitted level, thereby increasing the aforementioned risk results of 0.01 and 0.0008 latent cancer fatalities by a factor of 4.3 to 0.04 and 0.003 latent cancer fatalities.

Previously reported accidents involving yellowcake release indicate up to 30 percent of shipment contents were released (Mackin, et al., 2001; Grella, 1983), which is less than the fraction used in the previously mentioned calculations. In all cases reviewed, spills from accidents have been contained and cleaned up quickly (by the shipper with state involvement) without significant health or safety impacts to workers or the public.

Safety controls and compliance with existing transportation regulations in 10 CFR Part 71 add confidence that yellowcake can be shipped safely with a low potential of affecting the environment. For example, transport drums must meet specifications of 49 CFR Part 173, which is incorporated in NRC regulations at 10 CFR Part 71. To further minimize transportation risk, NRC recommends that delivery trucks meet safety certifications and that drivers hold appropriate licenses (NRC, 1997).

As described in Mackin, et al. (2001, Section 4.5), the potential radiological impacts associated with yellowcake transportation are SMALL.

Ion Exchange Resin Transport: Sites that include remote ion exchange processing will transport loaded ion exchange resins (usually by sole-use trucks) from the remote ion exchange processing sites to a central processing facility (one truck per day, 7 days per week). The radiological impacts of these shipments are expected to be lower than estimated risks from the finished yellowcake product because (1) ion exchange resins are less concentrated {about 50 g/L [0.009 oz/gal]} than yellowcake and therefore will contain less uranium per shipment than a yellowcake (about 85 percent uranium by weight) shipment, (2) the uranium in ion exchange resins is chemically bound to the resins; therefore, it is less likely to spread and easier to remediate in the event of a spill or release of shipped material, and (3) while the shipment distance for remote ion exchange varies for each ISL site, the total annual distance traveled by ion-exchange shipments is normally less than the same for yellowcake shipments. The NRC regulations at 10 CFR Part 71 and the incorporated U.S. Department of Transportation regulations for shipping ion exchange resins, which are enforced by NRC onsite inspections, also provide confidence that safety will be maintained and the potential for environmental impacts would be SMALL.

Radioactive Waste Transportation: Operational 11e.(2) byproduct wastes (as defined in the Atomic Energy Act of 1954, as amended) can be shipped offsite by truck for disposal at a licensed disposal site (Section 2.8). All radioactive waste shipments are shipped in accordance with the applicable NRC requirements in 10 CFR Part 71 and U.S. Department of Transportation requirements in 49 CFR Parts 171–189. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments, owing to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Therefore, impacts from transporting ISL facility byproduct wastes would be SMALL.

Hazardous Chemical Transportation: The number of operational chemical supply shipments is discussed in Section 2.8 (one facility reported 272 bulk chemical shipments per year). These shipments must follow U.S. Department of Transportation hazardous materials shipping regulations and requirements. Spill responses would be similar to the aforementioned for yellowcake transportation, although a spill of nonradiological materials is reportable to the appropriate state agency, the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Transportation. The Occupational Safety and Health Administration sets worker exposure limits for these chemicals. Mackin, et al. (2001) concluded that the risks associated with handling and transporting hazardous chemicals can be minimized by using accepted codes and standards and compliance with Occupational Safety and Health Administration Standards. The consequences of a chemical transportation incident, however, if it were to occur in a populated area, could have significant impacts. A chemical transportation incident at the ISL facility could also affect the impacts associated with radiological processes carried out at an ISL facility. However, given the precautions taken with such materials, the likelihood of an incident in a populated area is considered low and therefore the overall risk of a high consequence accident is considered small. As a result of the low frequency of shipments (<1 per day) and the low risk of high consequence accidents, the potential environmental impacts of chemical transportation to potential ISL facilities within the Wyoming West Uranium Milling Region would be SMALL.

4.2.2.3 Aquifer Restoration Impacts to Transportation

Aquifer restoration transportation impacts are expected to be less than previously discussed impacts for construction and operations because transportation activities will be primarily limited to supplies (including chemicals for reverse osmosis), chemical waste shipments, onsite transportation, and employee commuting. No additional unique transportation activities are expected during aquifer restoration; therefore, no additional types of impacts associated with aquifer restoration are anticipated and impacts would be SMALL to MODERATE considering the potential impacts of commuting during peak employment periods (Section 2.8) on low traffic roads in the Wyoming West Uranium Milling Region (Section 3.2.2).

4.2.2.4 Decommissioning Impacts to Transportation

Decommissioning 11e.(2) byproduct wastes (as defined in the Atomic Energy Act) can be shipped offsite by truck for disposal at a licensed disposal site. Section 2.8 provides estimates of the number of decommissioning-related waste shipments. All radioactive waste shipments must be shipped in accordance with the applicable NRC safety requirements in 10 CFR Part 71. As shown in Section 2.8, the number of estimated decommissioning waste shipments is fewer than those needed to support facility operations, and therefore potential traffic and accident impacts are expected to decrease during the decommissioning period. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments owing to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Commuting impacts would decrease from peak employment (Section 2.8) due to cessation of operations, though this effect would be offset to some degree by an increase in decommissioning workers. Overall, based on the magnitude of transportation activities expected for potential ISL facilities in the Wyoming West Uranium Milling Region during decommissioning, impacts would be SMALL.

4.2.3 Geology and Soils Impacts

Construction, operation, aquifer restoration, and decommissioning activities at ISL facilities may impact geology and soils. The potential impacts to geology and soils from these activities in the Wyoming West Uranium Milling Region are discussed in the following sections.

4.2.3.1 Construction Impacts to Geology and Soils

During construction of ISL facilities, the principal impacts to geology and soils would result from earth-moving activities associated with constructing surface facilities, wastewater evaporation ponds, access roads, well fields, and pipelines (Section 2.3). Earth-moving activities would include

- Clearing of ground or topsoil and preparing surfaces for the processing plant, satellite facilities, pump houses, access roads, drilling sites, and associated structures

- Excavating and backfilling trenches for pipelines and cables

- Excavating evaporation ponds and developing evaporation pond embankments

The impact of construction activities on geology and soils will depend on local topography, surface bedrock geology, and soil characteristics. Construction activities at ISL facilities in the Wyoming West Uranium Milling Region may increase the potential for erosion from both wind and water due to the removal of vegetation and the physical disturbance from vehicle and heavy equipment traffic. Likewise, compaction of soils and removal of vegetation resulting from construction activities may increase the potential for surface runoff and sedimentation in local drainages and streams outside disturbed areas.

Generally, earth-moving activities will result in only SMALL (on average, approximately 15 percent of permitted site area) impacts and temporary disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Chapter 7). For example, soil horizons will be disrupted to construct the processing facilities, evaporation ponds, and well field houses. In the well field, soil disturbance will be limited to drill pad grading, mud pit excavation, well completion, and access road construction.

Operators of ISL facilities typically adopt best management construction practices to prevent or substantially reduce soil impacts (see Table 7.4-1). For example, soils removed during construction of surface facilities are generally stockpiled and stabilized for later use during decommissioning and land reclamation. These stockpiles are typically located, shaped, and seeded with a cover crop by the operator to control erosion. Other practices include constructing structures to divert surface runoff from undisturbed areas around disturbed areas; using silt fencing, retention ponds, and hay bales to retain sediment within the disturbed areas; and reestablishing native vegetation as soon as possible after disturbance.

As part of the underground infrastructure at ISL facilities, a network of buried process pipelines and cables is typically constructed. Pipeline systems are installed between the pump house and well field for injecting and recovering lixiviant, between the pump house and the satellite facility or processing plant for transporting lixiviant and resin, and between the processing facilities and deep injection wells. Trenches for the pipelines are excavated as deep as 1.8 m [6 ft] below the ground to avoid any potential freezing problem. Operators typically segregate topsoil from subsoil (i.e., underlying rock) when excavating trenches so that the general soil profile can be restored during backfilling. Excavating trenches for pipelines and cables normally results in only SMALL and temporary disturbance of rock and soil. After piping and cable are placed in the trenches, the trenches are backfilled with the excavated rock and soil and graded to surrounding ground topography.

Based on the previous discussion, the impacts of construction activities on geology and soils at ISL facilities in the Wyoming West Uranium Milling Region would be SMALL because of the limited time the activity takes place (months), the limited area of site disturbance (on average, approximately 15 percent of permitted site area), and the shallow depth of excavation 1.2–1.8 m [4–6 ft].

4.2.3.2 Operation Impacts to Geology and Soils

During ISL operations (Section 2.4), a non-uranium-bearing (barren) solution or lixiviant is injected through wells into the mineralized zone. The lixiviant moves through the pores in the host rock, dissolving uranium and other metals. Production wells withdraw the resulting "pregnant" lixiviant, which now contains uranium and other dissolved metals, and pump it to a central processing plant or to a satellite processing facility for further uranium recovery and purification.

The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the mineralogical composition of uranium-producing formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure. In addition, the source formations for uranium in the Wyoming West Uranium Milling Region occur at depths of hundreds of meters [hundreds to thousands of feet] (Section 3.2.3), and individual mineralization fronts are typically 0.6 to 7.5 m [2 to 25 ft] thick (Section 3.1.2). At these depths and thicknesses and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. Therefore, impacts to geology from ground subsidence would be expected to be SMALL.

The pressure of the producing aquifer is decreased during operation activities because a negative water balance is maintained in the well field to ensure water flows into the well field from its edges, reducing the potential for spread of contamination. This change in pressure theoretically could impact the transmissivity of faults in permitted areas. However, because uranium producing sandstones tend to be highly porous and transmissive, it is unlikely that changes in fluid pressure would reactivate faults or trigger or induce earthquakes. Based on historical ISL operations, reactivation of faults has not been observed in the Wyoming West Uranium Milling Region.

A potential impact to soils arises from the necessity to move barren and pregnant uranium-bearing lixiviant to and from the processing facility in aboveground and underground pipelines. If a pipe ruptures or fails, lixiviant can (1) be released and pond on the surface, (2) runoff into surface water bodies, (3) infiltrate and adsorb in overlying soil and rock, or (4) infiltrate and percolate to groundwater.

In the case of spills from pipeline leaks and ruptures, spills could release either radionuclides or other constituents (e.g., selenium or other metals). Any impacts of these two types of spills are likely to be bounded by a spill of pregnant lixiviant (Mackin, et al., 2001). If the spill is allowed to dry, it can pose an ingestion or inhalation hazard to both humans and wildlife. Upon detection, licensees are required to establish immediate spill responses through onsite standard operation procedures (e.g., NRC, 2003, Section 5.7). For example, immediate spill responses might include shutting down the affected pipeline, recovering as much of the spilled fluid as possible, and collecting samples of the affected soil for comparison to background values for uranium, radium, and other metals.

As part of the monitoring requirements at ISL facilities, licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). This documentation helps in final site decommissioning activities. Licensees of ISL facilities in the Wyoming West Uranium Milling Region must also comply with applicable WDEQ requirements for spill response and reporting.

Soil contamination during ISL operations could also occur from transportation accidents resulting in yellowcake or ion exchange resin spills. As for lixiviant spills, licensees must report certain of these yellowcake or resin spills to both the NRC and WDEQ. License conditions may also require licensees to report the corrective actions taken and the results achieved. For nonradiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of nonradiological materials is primarily reportable to the appropriate state agency or EPA.

In the short term, impacts to soils from spills could range from small to large depending on the volume of soil affected by the spill. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils would be expected to be SMALL.

Uranium mobilization and processing during ISL operations produce excess water containing lixiviants and minerals leached from the aquifer. Other liquid waste streams produced by ISL operations can include rejected brine from the reverse osmosis system and spent eluant from the ion exchange system. Any of these waste streams may be discharged to evaporation ponds or injected into deep waste disposal wells. In addition, wastewater may be treated and applied to the land using irrigation methods or discharged to surface water drainages. The impacts of and requirements for discharging treated waste streams to surface water bodies during ISL activities in the Wyoming West Uranium Milling Region are discussed in Section 4.2.4.1. The impacts of using evaporation ponds or applying treated wastewater to the land are discussed in this section.

Although waste streams are treated before discharge to evaporation ponds, they may still contain radionuclides and other metals that may become concentrated during evaporation. Therefore, evaporation pond liner failures and pond embankment failures could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of failure, pond embankments at ISL facilities are monitored and inspected by licensees in accordance with NRC-approved inspection programs, and NRC also regularly inspects the embankments as part of the federal Dam Safety program.

Land application of treated wastewater involves irrigating select parcels of land and allowing the water to be evapotranspired by native vegetation or crops (Sections 2.7.2, 4.2.12.2). Land application of treated wastewater could potentially impact soils. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents (e.g., selenium or other metals) to accumulate in the soils, thereby degrading the site potential for subsequent recreational or agricultural use. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable limits.

Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be expected to be SMALL.

4.2.3.3 Aquifer Restoration Impacts to Geology and Soils

Aquifer restoration programs typically use a combination of (1) groundwater transfer; (2) groundwater sweep; (3) reverse osmosis, permeate injection, and recirculation; (4) stabilization; and (5) water treatment and surface conveyance (Section 2.5).

The groundwater sweep and recirculation process does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. The water pressure in the aquifer is decreased during restoration because a negative water balance is maintained in the well field being restored to ensure water flows into the well field from its edges, reducing the spread of contamination. However, the change in pressure is limited by recirculation of treated groundwater, and therefore it is very unlikely that ISL operations will reactivate local faults and extremely unlikely that any earthquakes would be generated. Therefore, the impacts on geology in the Wyoming West Uranium Milling Region from aquifer restoration would be expected to be SMALL, if any.

The main potential impact on soils during aquifer restoration would be spills of contaminated groundwater resulting from pipeline leaks and ruptures. As with spills of lixiviant during operations, spill response recommendations during aquifer restoration activities have been carried forward into NRC guidance of ISL facilities (e.g., NRC, 2003, Section 5.7). Licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the dose limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). Licensees in the Wyoming West Uranium Milling Region are also required to comply with WDEQ requirements for spill response and reporting. The short-term impact on soils from spills of contaminated groundwater could range from small to large depending on the volume of the affected soil. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils is SMALL.

During aquifer restoration, the groundwater is passed through semipermeable membranes that yield a brine or reject liquid. This reject liquid cannot be injected back into the aquifer or discharged directly to the environment. The reject liquid is typically sent to an evaporation pond or to deep well disposal, while the treated wastewater may be reinjected into the aquifer or applied to the land.

If reject water is sent to an evaporation pond, failure of the pond liner or pond embankment could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures and are visually inspected on a regular basis. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of pond embankment failures, NRC requires licensees to monitor and inspect pond embankments at ISL facilities in accordance with NRC-approved inspection programs. NRC also regularly inspects the embankments as part of the federal Dam Safety program.

As with ISL operations, land application of treated water during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents to accumulate in the soils. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable standards. Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the potential impacts to soil from land application of treated wastewater would be expected to be SMALL.

4.2.3.4 Decommissioning Impacts to Geology and Soils

Decommissioning of ISL facilities includes dismantling process facilities and associated structures, removing buried piping, and plugging and abandoning wells using accepted practices. The main impacts to geology and soils in the Wyoming West Uranium Milling Region during decommissioning would be from activities associated with land reclamation and cleanup of contaminated soils. These activities are described in Section 2.6.

Before decommissioning and reclamation activities begin, the licensee is required to submit a decommissioning plan to NRC for review and approval. The licensee’s spill documentation—an NRC requirement—would be used to identify potentially contaminated soils requiring offsite disposal at a licensed facility. Any areas potentially impacted by operations would be included in surveys to ensure all areas of elevated soil concentrations are identified and properly cleaned up to comply with NRC regulations at 10 CFR Part 40, Appendix A, Criterion 6-(6).

Most of the impacts to geology and soils associated with decommissioning are temporary and SMALL. Because the goal of decommissioning and reclamation is to restore the facility to preproduction conditions, to the extent practical, the overall long-term impacts to the geology and soils would be SMALL.

4.2.4 Water Resources Impacts

4.2.4.1 Surface Water Impacts

4.2.4.1.1 Construction Impacts to Surface Water

There would be potential impacts to surface water bodies and wetlands as a result of constructing ISL uranium recovery facilities (Section 2.3): (1) water quality degradation from temporary increases in suspended solids concentrations above background levels during in-stream construction or runoff from disturbed lands; (2) increased sedimentation in waterbodies resulting from either in-stream construction or construction activities on adjacent upland areas; (3) channel and bank modifications that affect channel morphology and stability; (4) reduced flows in waterbodies where fills have occurred; (5) water quality degradation in water bodies, lakes, impoundments, or surface water-based public water supplies from spills or leaks of fuel, lubricants, or hazardous materials during construction; and (6) fills and destruction of wetland areas (e.g., USACE, 2007a–c).

Depending on the construction methods used, installing pipelines and roads across waterbodies may affect surface water quality in any of these ways. Clearing land for roads, well pads, pipelines, and other structures exposes bare soil to water and wind erosion thereby increasing the erosion potential. Erosion potential can be increased further from the decreased permeability of roads and well pads (i.e., compaction of soil from vehicles increases water runoff). Increasing the number of low permeability areas increases the energy of runoff, which in turn can carry more sediment to streams, change flow characteristics, and increase stream erosion. Best management practices that would be expected to be implemented, as needed, to limit impacts to surface water are discussed in Chapter 7.

Linear transportation crossings over waterbodies can be built using bridges, pipe culverts, and box culverts. Impacts from road development would be a direct result of design and the extent of the waterway and would be handled on a site-specific basis through the U.S. Army Corps of Engineers (USACE) Section 404 permitting process. Under Section 404 of the Clean Water Act (see Appendix B), the USACE—and specifically, the Secretary of the Army—is responsible for administering a regulatory program that requires permits to discharge dredged or fill material into U.S. waters, including wetlands. If these activities satisfy general conditions, they may be authorized under various nationwide permits (USACE, 2007a–c). Specific construction practices that may reduce construction impacts to surface waterbodies are defined as part of the USACE permitting process (USACE, 2007a–c). The use of these permits also requires that the actions satisfy the individual state Section 401 certification with regard to water quality. If the project does not meet the requirements for a nationwide permit, then an individual Section 404 permit from USACE would be required. Permanent fills from placing bridge columns within the waterway or impacts from construction equipment may be long-term effects of constructing a bridge crossing. The placement of pipe and box culverts could have impacts to the waterway, along with any temporary impacts from construction.

Clearing existing vegetation when the collection pipelines and linear crossings are built would be as minimal as necessary to prepare for grading. Grading is typically directed away from the waterbody to reduce the potential for sediment to enter. Temporary erosion control measures (e.g., silt fences, straw bales) are installed as necessary to minimize the potential for disturbed soils to enter the waterbody from the right-of-way. Staging areas near waterbody crossings would typically be set back from the water's edge as permitted by topographic and other site conditions.

Other measures related to minimizing temporary impacts to waterbody crossings such as managing spoil, timing crossing, providing temporary access, and limiting equipment working in waterbodies would be considered, as appropriate, during the planning process. For example, spoil containment devices such as silt fences or straw bales would be installed and set back from the waterbody bank, minimizing potential for sediment leaving the construction right-of-way and reentering the waterbody. Operation- or transportation-related spills, collected product storage, or equipment failure in or near a waterbody could affect aquatic resources and contaminate the waterbody downstream of the release point. Spill responses at ISL facilities are described in Section 2.11.2.

Any construction activity in waters protected for fisheries uses is likely to exceed Wyoming's water quality criteria for turbidity; however, temporary increases in turbidity above the numeric criteria in Wyoming's Surface Water Quality Standards for a specific activity may be authorized in response to an application for a variance provided the application is submitted to the state for review and approval prior to exceeding the standards.

In summary, potential impacts to surface waters from the construction of an ISL facility would be expected to be SMALL based on the application of federal and state clean water regulations in conjunction with the use of best management practices. Should the facility require an individual permit from the USACE, the facility could have MODERATE impacts. However, as a result of the permitting process, those impacts would be expected to be mitigated though various mitigation options such as mitigation banking, riparian/wetland enhancement, or creation of new Waters of the United States. Storm water runoff during construction would be controlled through a Storm Water Pollution Prevention Plan that is part of a Wyoming Pollutant Discharge Elimination System permit issued by WDEQ (Section 1.7.5.1). Temporary wastewater discharges from hydrostatic testing of pipes, tanks, or other vessels; construction dewatering; and well pump tests would be regulated by a temporary discharge permit from WDEQ. Well pump tests in uranium-bearing zones would also need to comply with WDEQ monitoring and effluent limits for total radium and uranium. Isolated wetlands and associated mitigation measures are also regulated by the WDEQ. Overall, compliance with the applicable federal and state regulations and permit conditions and the implementation of best management practices and other mitigation measures would result in potential impacts during construction that would be SMALL.

4.2.4.1.2 Operation Impacts to Surface Water

During operations (Section 2.4), surface waters could be impacted by accidental spills from the ISL facility or by permitted discharges. Spills from the central processing plant or well fields, as well as spills during transportation, could impact surface waters by contaminating storm water runoff or by contaminating surficial aquifers that are hydraulically connected to surface waters.

As described in Section 4.2.4.2.2.1, flow monitoring and spill response procedures are expected to limit the impact of potential spills to surficial aquifers. Impacts of spills to surface waters that are hydraulically connected to surficial aquifers may be SMALL to MODERATE, depending on the size of the spill, success of remediation, use of the surface water (e.g., for domestic or agricultural water supply), proximity of the spill to the surface water, and relative contribution of the aquifer discharge to the surface water.

Storm water discharges are controlled through a Storm Water Pollution Prevention Plan that is part of a Wyoming Pollutant Discharge Elimination System permit issued by the WDEQ. The Storm Water Pollution Prevention Plan describes the potential sources of storm water contamination at the facility, routes by which storm water may leave the facility, and the best management practices that would be used to prevent storm water contamination. For example, concrete curbing and berms are typically used to contain spills and facilitate cleanup in accordance with approved operating procedures. Although the Wyoming Pollutant Discharge Elimination System permit for storm water discharges does not provide specific numerical water quality standards, it does include monitoring requirements and specifies that storm water discharge shall not cause pollution, contamination or degradation of waters of the state. Waters of the state include wetlands; surface water channels, whether perennial or not; and lakes and reservoirs. Thus storm water discharges compliant with the Wyoming Pollutant Discharge Elimination System would be expected to result in SMALL impacts to surface waters.

If the licensee wishes to discharge treated wastewater to a surface water body (Section 2.7.2), the licensee must obtain a Wyoming Pollutant Discharge Elimination System permit from the WDEQ. The Wyoming Pollutant Discharge Elimination System permit would contain numerical discharge limits for various pollutants intended to protect surface water quality. Any discharges must be treated as necessary to meet these limits. The State of Wyoming issues Wyoming Pollutant Discharge Elimination System permits under authority delegated by the National Pollutant Discharge Elimination System (NPDES). Compliance with permit requirements would result in SMALL impacts to surface waters from ISL facility operation activities.

Should the facility require expansion or new pipelines or linear crossings, then the same impacts from construction are anticipated (SMALL to MODERATE).

Most ISL operations extract slightly more groundwater than they reinject into the uranium-bearing formation (Section 2.4.1). The groundwater extracted from the formation could result in a depletion of flow in nearby streams and springs if the ore-bearing aquifer is hydraulically connected to such features. Most, if not all, ISL operations would take place in ore bodies within confined aquifers. For the operations to impact local surface water features, the ore-bearing aquifer would need to have Artesian head and the upper confining beds would need to have sufficient permeability to allow groundwater to flow to the surface features. Such conditions near the ISL facility would not be favorable to permitting an ISL in the first place and would have allowed groundwater contaminated by the ore body to discharge to the surface water features even in the absence of any ISL operation. Thus, NRC finds it unlikely that ISL activities would take place at sites with ore-bearing aquifers with any significant connection to surface water features. Assuming the ore-bearing aquifer at an ISL facility had a weak hydraulic connection to a local surface water feature, the effect of the net groundwater extractions during operation would also be weak and the potential impact to the surface water feature would be SMALL. Discharge of produced water to local drainage channels could also result in channel erosion and headcutting. The impact of any such erosion processes would be SMALL if mitigated by using properly designed discharge structures.

4.2.4.1.3 Aquifer Restoration Impacts to Surface Water

Activities occurring during aquifer restoration that could impact surface waters include management of produced water, storm water runoff and accidental spills, and management of brine reject from the reverse osmosis system (Sections 2.5 and 2.7.2). Storm water quality would be controlled under a Storm Water Pollution Prevention Plan in the same manner as during operations.

Alternatives for disposal of produced water that could affect surface water quality include land application of the treated water, discharge to solar evaporation ponds, and discharge of treated wastewater to surface waters, depending on site-specific facility planning (Section 2.7.2).

Prior to disposal by land application, water would be treated to remove contaminants and naturally occurring dissolved solids to levels established by the state. In addition, NRC requires that public and occupational dose limits of 10 CFR Part 20 be met during and after disposal by land application. Despite water treatment to meet these requirements, residual contaminants and dissolved solids could accumulate on the surface and in the root zone of the irrigated land. The extent to which these materials would accumulate in the soil at a specific site depends on the degree to which actual evapotranspiration exceeds the applied irrigation rate plus precipitation at the site, and the sorptive properties of the soil with respect to specific constituents.

Contaminants and accumulated natural salts could leave the facility and enter surface water due to runoff from excess irrigation or storm events. During land application, these impacts could be mitigated in accordance with permit requirements by adjusting water application rates to be consistent with site-specific climate, soil, and vegetation conditions. Residual contaminants, if any, that remain in soil when operations are shut down would be included in land surveys and cleaned up, as needed, during decommissioning (Section 2.6) to meet NRC safety regulations. Because of permit requirements and subsequent decommissioning, potential impacts from permitted land application would be SMALL.

Produced water permitted to be discharged to local waterways (Section 2.7.2), including ephemeral stream channels, under a Wyoming Pollutant Discharge Elimination System permit would need to be treated to remove contaminants to meet state and federal water quality standards. Potential impacts associated with surface water discharge could include leaching of natural salts from unsaturated soils and accidental releases of water not meeting discharge standards, but compliance with permit requirements for discharge would be expected to result in SMALL potential impacts.

Groundwater extracted from the formation during aquifer restoration could result in a depletion of flow in nearby streams and springs if the ore-bearing aquifer is hydraulically connected to such features. Because most, if not all ISL aquifer restoration would be expected to occur where the ore-bearing aquifers are confined and would have a weak connection to surface water bodies, local depletion of streams and springs would be unlikely, and potential impacts would be expected to be SMALL.

4.2.4.1.4 Decommissioning Impacts to Surface Water

During decommissioning of the facility (Section 2.6), temporary impacts to surface waters are anticipated from sediment loading associated with removal of piping, linear crossings, and other facility infrastructure. Decommissioning and reclamation would be expected to return the Waters of the United States to preconstruction/operation status. Storm water runoff would also be controlled by implementing a Storm Water Pollution Prevention Plan during decommissioning activities. Impacts to surface water from decommissioning and reclamation activities would be SMALL.

4.2.4.2 Groundwater Impacts

Potential environmental impacts to groundwater resources in the Wyoming West Uranium Milling Region can occur during each phase of the ISL facility's lifecycle. ISL activities can impact aquifers at varying depths (separated by aquitards) above and below the uranium-bearing aquifer as well as adjacent surrounding aquifers in the vicinity of the uranium-bearing aquifer. Surface activities that can introduce contaminants into soils are more likely to impact shallow (near-surface) aquifers, while ISL operations and aquifer restoration are more likely to impact the deeper uranium-bearing aquifer, any aquifers above and below, and adjacent surrounding aquifers.

ISL facility impacts to groundwater resources can occur from surface spills and leaks, consumptive water use, horizontal and vertical excursions of leaching solutions from production aquifers, degradation of water quality from changes in the production aquifer's chemistry, and waste management practices involving land application, evaporation ponds, or deep well injection. Detailed discussion of the potential impacts to groundwater resources from construction, operations, aquifer restoration, and decommissioning is provided in the following sections.

4.2.4.2.1 Construction Impacts to Groundwater

During construction of ISL facilities, the potential for groundwater impacts is primarily from consumptive groundwater use, introduction of drilling fluids and muds from well drilling, and spills of fuels and lubricants from construction equipment (see Section 2.3).

As discussed in Section 2.11.3, groundwater use during construction is limited to routine activities such as dust suppression, mixing cements, and drilling support. The amounts of groundwater used in these activities are small relative to pumpable water and would have a SMALL and temporary impact to groundwater supplies within the Wyoming West Uranium Milling Region. Groundwater quality of near-surface aquifers during construction would be protected by best management practices such as implementation of a spill prevention and cleanup plan to minimize soil contamination (Section 7.4). Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a SMALL impact to the water quality of those aquifers. Thus, construction impacts to groundwater resources would be SMALL based on the limited nature of construction activities and implementation of management practices to protect shallow groundwater.

4.2.4.2.2 Operation Impacts to Groundwater

During ISL operations, potential environmental impacts to shallow (near-surface) aquifers are related to leaks of lixiviant from pipelines, wells, or header houses and to waste management practices such as the use of evaporation ponds and disposal of treated wastewater by land application. Potential environmental impacts to groundwater resources in the production and surrounding aquifers involve consumptive water use and changes to water quality. Water quality changes would result from normal operations in the production aquifer and from possible horizontal and vertical lixiviant excursions beyond the production zone (see Section 2.4). Disposal of processing wastes by deep well injection (see Section 2.7.2) during ISL operations also can potentially impact groundwater resources.

4.2.4.2.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

A network of pipelines, as part of the underground infrastructure, is used during ISL operations for transporting lixiviants between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside pumping header houses. The failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers, could result in leaks and spills of pregnant and barren lixiviant (Section 2.3.1.2), which could impact water quality in shallow (near-surface) aquifers.

The potential environmental impacts of pipeline, valve, or well integrity failures to shallow aquifers could be MODERATE to LARGE, if

- The groundwater table in shallow aquifers is close to the ground surface (i.e., small travel distances from the ground surface to the shallow aquifers)
- The shallow aquifers are important sources for local domestic or agricultural water supplies
- Shallow aquifers are hydraulically connected to other locally or regionally important aquifers

The potential environmental impacts could be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydraulically separated from other locally and regionally important aquifers.

In some parts of the Wyoming West Uranium Milling Region, local shallow aquifers exist and they are important sources of groundwater locally [e.g., in the vicinity of the Lost Creek area (Lost Creek ISR, LLC, 2007)]. Hence, for some sites in the Wyoming West Uranium Milling Region, potential environmental impacts due to spills and leaks from pipeline networks or failures of well mechanical integrity in shallow aquifers could be MODERATE to LARGE, depending on site-specific conditions. Potential impacts would be reduced by flow monitoring to detect pipeline leaks and spills early and implementation of required spill response and cleanup procedures. In addition, preventative measures such as well mechanical integrity testing (MIT) (Section 2.3.1.1) would limit the likelihood of well integrity failure during operations.

The use of evaporation ponds or land application to manage process water generated during operations also could impact shallow aquifers. For example, failure of evaporation pond embankments or liners could allow contaminants to infiltrate into shallow aquifers. Similarly, land application of treated wastewater could cause radiological or other constituents (e.g., selenium or other metals) to accumulate in soils or infiltrate into shallow aquifers. In general, the potential impacts of these waste management activities are expected to be limited by NRC and state requirements. For example, NRC requirements for leak detection systems, maintenance of reserve pond capacity, and pond embankment inspections are expected to minimize the likelihood of evaporation pond failures. Similarly, NRC and state release limits related to land application of waste are expected to limit potential effects of land application of wastewater on shallow aquifers. Section 4.2.12.2 discusses the impacts of the use of evaporation ponds and land application of treated wastewater in greater detail and characterizes the expected impacts as SMALL.

4.2.4.2.2.2 Operation Impacts to Production and Surrounding Aquifers

The potential environmental impacts to groundwater supplies in the production and other surrounding aquifers are related to consumptive water use and groundwater quality.

Water Consumptive Use: NRC-licensed flow rates for ISL facilities typically range from about 15,100 to 34,000 L/min [4,000 to 9,000 gal/min] (Section 2.1.3). Most of this water is returned to the production aquifer after being stripped of uranium (see Section 2.4.1.2). The term "consumptive use" refers to water that is not returned to the production aquifer. During operations, consumptive use is due primarily to production bleed (typically between 1 and 3 percent of the total flow) and also includes other smaller losses. As described in Section 2.4.1.2, the purpose of the production bleed is to ensure that more groundwater is extracted than reinjected. Maintaining this negative water balance helps to ensure that there is a net inflow of groundwater into the well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field. Because the bleed water must be removed from the well field to maintain a negative water balance, the bleed is disposed through the wastewater control program and is not reinjected into the well field.

Hypothetically, if a well field at an ISL facility in the Wyoming West Uranium Milling Region is pumped at a constant rate of 22,700 L/min [6,000 gal/min] with 2 percent bleed, the total volume of production bleed in a year of operation would be 240 million L {63 million gal [190 acre-ft]}. For comparison, in 2000, approximately 6.2×10^{12} L [5.05 million acre-ft] of water was used to irrigate 469,000 ha [1.16 million acres] of land in Wyoming (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 13.2 million L per ha [4.36 acre-ft/acre]. Thus, the consumptive use of 240 million L [190 acre-ft] of water due to production bleed in 1 year of operation is roughly equivalent to the water used to irrigate 18 ha [44 acres] in Wyoming for 1 year.

Consumptive water use during operations could lower water levels in local wells, impacting local water users who use water from the production aquifer (outside of the exempted zone). In addition, if production aquifers are not completely hydraulically isolated from aquifers above and below, consumptive use may impact local users of these connected aquifers by lowering water levels in those aquifers. However, effects on aquifers above and below are expected to be limited in most cases by the confining layers typical of aquifers used for ISL production. As discussed in Section 2.4.1.3, licensees conduct preoperations testing to assess the degree of hydraulic isolation of potential production aquifers at proposed ISL sites.

To assess the potential drawdown that could be caused by consumptive use during operations, drawdowns were calculated for a hypothetical case in which the water withdrawn by an entire ISL facility operating at 15,100 L/min [4,000 gal/min] with 2 percent bleed is assumed to be withdrawn from a single well. This scenario would significantly overestimate the drawdown caused by ISL operations using water from a similar production aquifer because water withdrawal at a typical ISL facility is distributed among hundreds of wells (Section 2.3.1.1) and tens to hundreds of hectares [tens to thousands of acres] (Section 4.2.1). In this extreme case, drawdowns at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from the hypothetical well would be 71, 55, and 39 m [233, 55, and 128 ft] after 10 years of operation. These hypothetical values were calculated using the Theis Equation (McWhorter and Sunada, 1977) with transmissivity and storage coefficient values of 10 m^2/day [108 ft^2/day] and 1×10^{-4}, respectively (chosen from the range of respective parameter values discussed in Section 3.2.4.3).

To quantify the sensitivity of the drawdowns to aquifer properties, additional drawdowns were computed by decreasing the aquifer transmissivity or storage coefficient by an order of magnitude. An order of magnitude (factor of 10) decrease in aquifer transmissivity {i.e., from 10 m^2/day [108 ft^2/day] to 1 m^2/day [11 ft^2/day]} may not be consistent with the transmissivity of a production aquifer; for an ISL facility to be practical, the hydraulic conductivity of the production aquifer must be large enough to allow reasonable water flow from injection to production wells. Therefore, the analysis presented here is only intended to demonstrate the sensitivity of drawdown to transmissivity. The effect of reducing the transmissivity was to increase the hypothetical drawdowns in the production aquifer to 190, 142, and 94 m [623, 142, and 308 ft] at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from a single hypothetical pumping well used to represent an entire ISL facility. If the aquifer storage coefficients were 10 times smaller, drawdowns would be 24, 19, and 14 m [79, 62, and 46 ft] at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from the hypothetical well. These calculations indicate that drawdowns are more sensitive to aquifer transmissivity than storage coefficient. Drawdowns near the producing wells would be slightly smaller for larger storage coefficients. However, drawdowns would be much smaller for larger transmissivity values.

In these calculations, the potential effect of natural recharge to the production aquifers on groundwater levels is not considered. Consideration of natural recharge would reduce the calculated drawdowns. However, neglecting natural recharge is not expected to have as much of an effect as approximating the withdrawal from an entire facility with one hypothetical well. As previously discussed, this approximation is expected to yield significant overestimates of the expected drawdowns.

Near a well field, the short-term impact of consumptive use could be MODERATE if there are local water users who use the production aquifer (outside of the exempted zone) or if the production aquifer is not well isolated from other aquifers that are used locally. However, because localized drawdown near well fields would dissipate after pumping stops, these localized effects are expected to be temporary. The long-term impacts would be expected to be SMALL in most cases, depending on site-specific conditions. Important site-specific conditions would include the consumptive use of the proposed facility, the proximity of water users' wells to the well fields, the total volume of water in the production aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

Excursions and Groundwater Quality: Groundwater quality in the production aquifer is degraded as part of the ISL facility's operations (Section 2.4). The restoration of the production aquifer is discussed in Section 2.5. In order for ISL operations to occur, the uranium-bearing production aquifer must be exempted as an underground source of drinking water through the Wyoming Underground Injection Control (UIC) program. When uranium recovery is complete in a well field, the licensee is required to initiate aquifer restoration activities to restore the production aquifer to preoperational conditions, if possible. If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in 10 CFR Part 40, Appendix A, Table 5C or to alternate concentration limits approved by the NRC. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISL operations would be expected to be SMALL and temporary. The remainder of this section discusses the potential for groundwater quality in the surrounding aquifers or in the producing aquifer outside of the well field to be affected by excursions during ISL operations.

During normal ISL operations, inward hydraulic gradients are expected to be maintained by production bleed so that groundwater flow is toward the production zone from the edges of the well field. If this inward gradient is not maintained, horizontal excursions can occur and lead to the spread of leaching solutions in the ore-bearing aquifer beyond the mineralization zone and the well field. The rate and extent of spread is largely driven by the collective effects of the aquifer transmissivity, groundwater flow direction, and aquifer heterogeneity. The impact of horizontal excursions could be MODERATE to LARGE if a large volume of contaminated water leaves the production zone and moves downgradient within the production aquifer while the production aquifer outside the mineralization zone is used for water production. To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventative measures prior to starting operations. For example, licensees must install a ring of monitoring wells within and encircling the production zone to permit early detection of horizontal excursions (Chapter 8). If there are oil, gas, coal bed methane, or other production layers near the ISL facility, and if NRC determines that there could be potentials for cross contamination between the ISL production zone and other production layers based on environmental impact assessments, NRC may require the licensee to expand the monitoring well ring for detection of potential contamination between the ISL production zone and other mineral production layers. If excursions are detected, the monitoring well is placed on excursion status and reported to NRC. Corrective actions are taken, and the well is placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

The following discussion focuses on the potential for groundwater quality in the surrounding aquifers to be affected during ISL operations. The rate of vertical flow and the potential for excursions between the production aquifer and an aquifer above or below is determined by multiplying vertical hydraulic gradient across a confining layer by vertical hydraulic conductivity of a confining layer and dividing the result by porosity of a confining layer (McWhorter and Sunada, 1977; Driscoll, 1986). For example, for the ratio of vertical hydraulic gradient to the porosity of a confining layer of 0.1 in the upward direction between two aquifers and a vertical hydraulic conductivity of 1.0×10^{-3} m/day [3.3×10^{-3} ft/day] for an aquitard (upper confinement of the Battle Springs Formation) separating those two aquifers (Section 3.2.4.3), a leaching solution would move vertically upward from the production aquifer to an overlying aquifer at a rate of nearly 3.6 cm/yr [1.4 in/yr]. If the vertical migration rate of a leaching solution {i.e., 3.6 cm/yr [1.4 in/yr]} was assumed be constant in the next 10 years, then the leaching solution would move vertically 36 cm [1.2 ft] away from the production zone. If the thickness of the aquitard is 1 m [3.3 ft] or more, then the leaching solution would not enter the overlying aquifer in the next 10 years. The thickness of confining layers is typically greater than 1 m [3.3 ft] in the Wyoming West Uranium Milling Region (Section 3.2.4.3), and it would take many decades for the vertical excursion to reach the upper aquifer. If excursions are observed at the monitoring wells, the licensee is required to implement responses that include increasing sampling and commencing corrective actions to recover the excursion. The excursions typically would be reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

Vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers could be altered by potential increases in pumpage from the overlying or underlying aquifers for water supply purposes in the vicinity of an ISL facility (e.g., from the overlying Green River Formation or the underlying Fort Union Formation near the Great Divide Basin), which may enhance potential vertical excursions from the production aquifer (e.g., the Battle Springs Formation near the Great Divide Basin). Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could lead to vertical flow and excursions.

In addition, potential well integrity failures during ISL operations could lead to vertical excursions. Well casings above or below the uranium-bearing aquifer—through inadequate construction, degradation, or accidental rupture—could allow lixiviant to travel from the well bore into the surrounding aquifer. Moreover, deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create vertical pathways for excursions of lixiviant from the production aquifers to the adjacent aquifers.

Some relevant factors when considering the significance of potential impacts from a vertical excursion (such as local geology and hydrology, proximity of injection wells to drinking water supply wells) are discussed in Section 2.4.1. Additionally, past experience with excursions reported at NRC-licensed ISL facilities is discussed in Section 2.11.5.

To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventive measures prior to starting operations. For example, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees are required to conduct aquifer pump tests prior to starting operations in a well field. The purpose of these pump tests is to determine aquifer parameters (e.g., aquifer transmissivity and storage coefficient, and the vertical hydraulic conductivity of aquitards) and also ensure that confining layers above and below the production zone are expected to preclude the vertical movement of fluid from the production zone into the overlying and underlying units. The licensee must also develop and maintain monitoring programs to detect both vertical and horizontal excursions and must have operating procedures to analyze an excursion and determine how to remediate it. The monitoring programs prescribe the number, depth, and location of monitoring wells, sampling intervals, sampling water quality parameters, and the upper control limits (UCLs) for particular water quality parameters (Chapter 8). These specifications typically are made conditions in the NRC license.

WDEQ noted that monitoring wells should be completed in the lower portion of the first aquifer above the ore-bearing aquifer and in the upper portion of the first aquifer below the ore-bearing aquifer. As discussed in Section 3.2.4.3.2, in the Lost Creek area, Quaternary-aged sedimentary deposits and sandstone layers are above the ore-bearing aquifer and the Fort Union Formation is below the ore-bearing aquifer. Near the Gas Hills area, the Split Rock Formation is above the ore-bearing aquifer and the Fort Union Formation is below the ore-bearing aquifer.

As discussed in Section 3.2.4.3., in the Wyoming West Uranium Milling Region, the Lewis Shale, with a vertical hydraulic conductivity on the order of 10^{-3} m/day [3.3×10^{-3} ft/day], is continuous and thick {e.g., it is 820 m [2,700 ft] thick in the Lost Creek area (Lost Creek ISR, LLC, 2007)}. The Lewis Shale underlies the aquifer system that includes, from shallowest to deepest, the Wasatch/Battle Spring (equivalent to the ore-bearing Wind River Formation), Fort Union, and Lance Formation and the Fox Hill sandstone. Uranium-bearing sandstone layers in the Wind River Formation near the Gas Hills area are confined by low permeability layers. At the potential Lost Creek ISL facility, the ore-bearing Battle Springs Formation is confined below by the thick Lewis Shale (Section 3.2.4.3.3.), which could preclude downward vertical excursions from the production aquifer. However, although the upper confinement is reported to be continuous and effective at the local scale at the proposed ISL sites discussed in

Section 3.2.4.3, the discontinuous nature of the upper confinement of the Battle Springs Formation at the regional scale (AATA International Inc., 2005) could allow vertical excursions of leaching solutions from the production aquifer to the aquifers above at some sites.

In general, the potential environmental impacts of vertical excursions to groundwater quality in surrounding aquifers would be SMALL if the vertical hydraulic head gradients between the production aquifer and the adjacent aquifer are small, the vertical hydraulic conductivity of the confining units is low, and the confining layers are sufficiently thick. On the other hand, the environmental impacts would be expected to be MODERATE to LARGE if confinements are discontinuous, thin, or fractured (i.e., high vertical hydraulic conductivities). To limit the likelihood of vertical excursions, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees also must conduct preoperational pump tests to ensure adequate confinement of the production zone. In addition, licensees must develop and maintain programs to monitor above and below the ore-bearing zone to detect both vertical and horizontal excursions and flow rates, and must have operating procedures to analyze an excursion and determine how to remediate it.

At the previously discussed ISL facilities in the Wyoming West Uranium Milling Region, the ore-bearing aquifers (the Battle Springs and the Green River Formations) are confined below and above by continuous and thick confining layers. Preliminary calculations discussed previously suggest that the confinements would effectively restrict potential vertical excursions. Additionally, if the licensee installs and maintains the monitoring well network properly, potential impacts of vertical excursions would be temporary and the long-term effects would be expected to be SMALL. However, the potential discontinuous nature of the upper confinement at the regional scale (AATA International Inc., 2005) should be taken into account in assessing potential environmental impacts of other potential ISL facilities in the Wyoming West Uranium Milling Region.

4.2.4.2.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

Potential environmental impacts to confined deep aquifers below the production aquifers could be due to deep well injection of processing wastes into deep aquifers. Under different environmental laws such as the Clean Water Act, the Safe Drinking Water Act, and the Clean Air Act, EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from EPA (Section 1.7.2) or from an authorized state UIC program. As discussed in Section 1.7.5.1, Wyoming requires UIC Class III permits for injection wells in areas not previously mined using conventional mining and milling. UIC Class V permits are required for injection wells leaching from older conventional uranium recovery sites.

In the Wyoming West Uranium Milling Region, the Paleozoic aquifers included in the Upper Colorado River Basin aquifer system are typically deeply buried, contain saline water, and are not commonly tapped for water supply (Whitehead, 1996). The Paleozoic aquifers are separated from the overlying aquifers (including the ore-bearing aquifer) by the regionally extensive Lewis Shale. Hence, the Paleozoic aquifers (e.g., Tensleep Sandstone) could be suitable for disposal of leaching solutions.

The potential environmental impacts of injection of leaching solutions into deep aquifers below ore-bearing aquifers would be expected to be SMALL, if water production from deep aquifers is not economically feasible or the groundwater quality from these aquifers is not suitable for domestic or agricultural uses (e.g., high salinity), and they are confined above by sufficiently thick and continuous low permeability layers.

4.2.4.2.3 Aquifer Restoration Impacts to Groundwater

The potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including discharge of wastes to evaporation ponds, land application of treated wastewater, and potential deep disposal of brine slurries resulting from reverse osmosis. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the well field being restored.

Aquifer restoration typically involves a combination of the following steps: (1) groundwater transfer, (2) groundwater sweep, (3) reverse osmosis with permeate injection, and (4) groundwater recirculation. These steps are discussed in more detail in Section 2.5. In addition to these processes, potential new restoration processes are being developed. These processes include the use of controlled biological reactions to precipitate uranium and other contaminants by restoring chemically reducing conditions to production aquifers. However, these processes have not yet been used at a commercial scale and their likely impacts will not be known until the processes have been developed further.

Groundwater consumptive use for groundwater transfer would be minimal, because milling-affected water in the restoration well field is displaced with baseline quality water from the well field prior to commencing milling. Groundwater consumptive use would be large for groundwater sweep, because it involves pumping groundwater from a well field without injection. The rate of groundwater consumptive use would be lower during the reverse osmosis phase, because up to 70 percent of the pumped groundwater treated with reverse osmosis can be reinjected into the aquifer. Groundwater consumptive use could be further decreased during the reverse osmosis phase if brine concentration is used, in which case up to 99 percent of the withdrawn water could be suitable for reinjection. In that case, the actual amount of water that is reinjected into the well field may be limited by the need to maintain a negative water balance to achieve the desired flow of water from outside of the well field into the well field.

Groundwater consumptive use during aquifer restoration is generally reported to be greater than groundwater consumption during ISL operation (Freeman and Stover, 1999; NRC, 2003; Chapter 2 of this GEIS). One reason for increased consumptive use during restoration is that, as previously discussed, no water is reinjected during groundwater sweep. Water is not reinjected during groundwater sweep, because the purpose of the sweep phase is to remove contaminated water from a well field and draw unaffected water into the well field. For example, at the Irigaray Mine in Campbell County, Wyoming, between 1.4 and 4.2 pore volumes of water were removed from six restoration units (comprising nine well fields, some of which were combined for restoration). The total volume of water consumed to perform groundwater sweep on all of the well fields was 545 million L [144 million gal].

As discussed in Section 2.5, restoration typically is performed as well fields end production, so all of the well fields do not undergo groundwater sweep at the same time. For example, at the Irigaray Mine (Cogema Mining, Inc., 2004), average pumping rates for groundwater sweep ranged from approximately 100 L/min [27 gal/min] to pump 120 million L [31 million gal] from two well fields between June 1991 and August 1993 to 380 L/min [100 gal/min] to pump 190 million L [49 million gal] from three well fields between May 1990 and April 1991. At the Smith Ranch/Highland Uranium Project in Converse County, Wyoming, an average pumping rate of approximately 38 L/min [10 gal/min] was used to pump 3.2 pore volumes {49 million L [13 million gal]} from the A-Wellfield during almost 3 years of groundwater sweep (Power Resources, Inc., 2004).

The actual rate of groundwater consumption at an ISL facility at any time depends, in part, on the various stages of operation and restoration of the individual well fields at the facility. For example, consider a hypothetical case in which three well fields at a site undergo groundwater sweep while three undergo reverse osmosis treatment with permeate reinjection and another three continue production. Hypothetically, while 380 L/min [100 gal/min] are consumed during groundwater sweep of three well fields, 110 L/min [30 gal/min] may be consumed to perform reverse osmosis treatment in another three well fields, and another 38 L/min [10 gal/min] may be consumed by production bleed in the remaining three well fields. The total water consumption rate while these processes continued would be 530 L/min [140 gal/min].

At a rate of 530 L/min [140 gal/min], 280 million L [74 million gal] would be consumed in 1 year. For comparison, in 2000, approximately 6.2×10^{12} L [5.05 million acre-ft] of water was used to irrigate 469,000 ha [1.16 million acres] of land in Wyoming (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 13.2 million L/ha [4.36 acre-ft/acre]. Thus, consumption of 280 million L [74 million gal or 230 acre-ft] in 1 year of restoration would be roughly equivalent to the water used to irrigate 21 ha [53 acres] in Wyoming for 1 year.

Potential environmental impacts are affected by the restoration techniques chosen, the severity and extent of the contamination, and the current and future use of the production and surrounding aquifers in the vicinity of the ISL facility. The potential environmental impacts of groundwater consumption during restoration could be SMALL to MODERATE depending on site-specific conditions. Site-specific impacts also would depend on the proximity of water users' wells to the well fields, the total volume of water in the aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

During aquifer restoration, the most heavily contaminated groundwater may be disposed through the facility wastewater treatment system (e.g., deep well injection, solar evaporation ponds, land application after treatment). The impacts of discharging wastes to solar evaporation ponds or applying treated wastewater to land during restoration are expected to be similar to the impacts of these waste management practices during operations (SMALL) (Section 4.2.4.2.2.1).

As discussed in Section 4.2.4.2.2.3, underground injection of fluid requires a permit from the EPA or the authorized state and approval from NRC. Additionally, the briny slurry produced during the reverse osmosis process may be pumped to a deep well for disposal (Section 2.7.2). The deep aquifers suitable for injection must have poor water quality, have low water yields, or be economically infeasible for production. They also need to be hydraulically separated from overlying aquifer systems. Under these conditions, the potential environmental impacts would be expected to be SMALL.

Aquifer restoration processes also affect groundwater quality directly by removing contaminated groundwater from well fields, reinjecting treated water, and recirculating groundwater. In general, aquifer restoration continues until NRC and applicable state requirements for groundwater quality are met. As discussed in Section 2.5, NRC licensees are required to return well field water quality parameters to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) or to another standard approved in their NRC license. Historical information about aquifer restoration at several NRC-licensed facilities is discussed in Section 2.11.5.

4.2.4.2.4 Decommissioning Impacts to Groundwater

The environmental impacts to groundwater during dismantling and decommissioning ISL facilities are primarily associated with consumptive use of groundwater, potential spills of fuels and lubricants, and well abandonment. The consumptive groundwater use could include water use for dust suppression, revegetation, and reclamation of disturbed areas (Section 2.6). The potential environmental impacts during the decommissioning phase are expected to be similar to potential impacts during the construction phase. Groundwater consumptive use during the decommissioning activities would be less than groundwater consumptive use during ISL operation and groundwater restoration activities. Spills of fuels and lubricants during decommissioning activities could impact shallow aquifers. Implementation of best management practices (Chapter 7) during decommissioning can help to reduce the likelihood and magnitude of such spills and facilitate cleanup. Based on consideration of best management practices to minimize water use and spills, impacts to the groundwater resources in shallow aquifers from decommissioning would be expected to be SMALL.

After ISL operations are completed, improperly abandoned wells could impact aquifers above the production aquifer by providing hydrologic connections between aquifers. As part of the restoration and reclamation activities, all monitoring, injection, and production wells will be plugged and abandoned in accordance with the Wyoming UIC program requirements. The wells would be filled with cement and clay and then cut off below plow depth to ensure that groundwater does not flow through the abandoned wells (Stout and Stover, 1997). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be expected to be SMALL.

4.2.5 Ecological Resources Impacts

4.2.5.1 Construction Impacts to Ecological Resources

Vegetation

ISL uranium recovery facility construction primarily affects terrestrial vegetation through (1) the removal of vegetation from the milling site during construction (and associated reduction in wildlife habitat and forage productivity and an increased risk of soil erosion and weed invasion); (2) the modification of existing vegetative communities as a result of milling maintenance; (3) the loss of sensitive plants and habitats as a result of construction clearing and grading; and (4) the potential spread of invasive species and noxious weed populations as a result of construction.

ISL facilities are typically located in large remote areas of the region. Permit areas of past facilities have ranges from 1,034 ha to 6,480 ha [2,552 to 16,000 acres] of land (Section 2.10.1). Typically the impact within these permit areas have been from 49 ha to 490 ha [120 acres to 1,200 acres]. The percent of vegetation removed or land disturbance has been from below 1 to 20 percent, which would be a SMALL impact in relation to the total permit area and surrounding plant communities.

Clearing herbaceous vegetation during construction in a open grassland or shrub steppe community is anticipated to have a short-term impact. If active revegetation measures were used with seed mixtures approved by the WDEQ, Land Quality Division, rapid colonization by annual and perennial herbaceous species in the disturbed staging areas and rights-of-way would restore most vegetative cover within the first growing season. Impacts from clearing in this community would be SMALL.

Clearing woody shrubs and trees would have a primary long-term impact on vegetation associated with the project if the project is located in a wooded area. Woody shrubs and trees would recolonize after construction of the right-of-way and staging areas, although recolonization of disturbed areas would be slower than for herbaceous species. As natural succession is allowed to proceed in these areas, the early successional or forested communities that existed before construction would eventually be reestablished. Clearing trees in the milling site could affect forest vegetation growing along the edges of the cleared areas. Exposing some edge trees to elevated levels of sunlight and wind could increase evaporation rates and the probability of tree knockdown. Due to the increased light levels penetrating the previously shaded interior, shade-intolerant species would be able to grow, and the species composition of the newly created forest edge may change. Clearing could also temporarily reduce local competition for available soil moisture and light and may allow some early successional species to become established and persist on the edge of the uncleared areas adjacent to the milling site. Impacts from clearing this community would be SMALL to MODERATE depending on the amount of surrounding wooded area.

Noxious weeds that may invade areas disturbed by construction would be expected to be controlled on a regular basis. The applicant would be expected to employ minimal use of herbicides to control noxious weeds, so as not to affect native species on the site. Application would be by hand sprayers or broadcasting using truck-mounted spraying equipment, as necessary. Using applicable control techniques, impacts from noxious weeds would be SMALL.

Wildlife

There are three primary impacts of ISL uranium recovery facility construction on terrestrial wildlife: (1) habitat loss or alteration and incremental habitat fragmentation; (2) displacement of wildlife from project construction; and (3) direct and/or indirect mortalities from project construction and operation.

Construction activities in wellfields would result in some loss of wildlife habitat; however, this loss can be minimized if disturbed areas are reseeded when construction is completed in that area. The impacts would expected to be greatest in vegetative communities where clearing would be required to construct wells, access roads, header houses, and pipelines from the well fields to the header houses. In general, most wildlife, including the larger and more mobile animals, would disperse from the project area as construction activities approach. Displaced species may recolonize in adjacent, undisturbed areas or return to their previously occupied habitats after construction ends and suitable habitats are reestablished. Some smaller, less mobile wildlife such as amphibians, reptiles, and small mammals may die during clearing and grading activities. Small mammals and songbirds dependent on shrubs and trees for food, nesting, and cover would be impacted in areas where clearing is needed for construction. Wildlife habitat fragmentation, temporary displacement of animal species, and direct or indirect mortalities is possible, therefore construction impacts would be SMALL to MODERATE.

Even if available habitat within the site and in adjacent areas supported displaced individuals, some impact from competition for resources between preexisting species may occur. Some localized foraging areas may be avoided by big game during construction periods when workers are present. Noise, dust, and increased presence of workers in or adjacent to foraging areas may temporarily preclude use by wildlife (NRC, 2004). Habitat loss and fragmentation could be reduced if the percentage of land affected compared to the total undisturbed vegetative community acreage within the permitted area and or surrounding area was small. Standard management practices issued by the Wyoming Game and Fish Department can help to minimize habitat fragmentation, wildlife stress, and incidental death. Impacts to wildlife species could range from SMALL to MODERATE, depending on site-specific conditions.

Crucial wintering and year-long ranges vital for survival of local populations of big game and sage-grouse leks or breeding ranges are located within the region (Figures 3.2-8 through 3.2-14). If the proposed facility exists within these ranges, guidelines have been issued by the Wyoming Game and Fish Department for the development of oil and gas resources that would apply to ISL facility operations (Wyoming Game and Fish Department, 2004) and limit the impacts to a SMALL magnitude. In addition, BLM has issued guidelines for sage-grouse management, which can be used to help mitigate impacts from ISL facilities. Consultation with the Wyoming Game and Fish Department and a site-specific analysis would help determine impacts from the facility to these species.

Disturbed areas revegetated with a seed mixture of grasses, forbs, and shrubs approved by the WDEQ, Land Quality Division, would further mitigate impact to wildlife after construction of the well fields and facility infrastructure. Mitigation measures would reduce the overall impacts to be SMALL.

Wellfield operations would require the construction of power distribution lines. Lines may be supported by single-pole wood structures with a wooden cross arm. The conductors would be configured to assure adequate spacing between the shield wire (i.e., ground wire) and conductors to avoid potential electrocution of raptors that land on the cross arms. Other alternatives may include the construction of underground power lines to minimize impacts. Construction of the distribution lines would be expected to follow guidance in Avian Power Line Interaction Committee (2006). Raptors breeding in the site may be affected by construction activities, or mining operations may be temporarily impacted depending on the time of year construction activities occur. Potential impacts to this species would be SMALL.

Impacts to raptors would be reduced at facilities that avoided disturbing areas within 800 m [0.5 mi] of active raptor nests and prior to fledging of young. Impacts can also be reduced by employing mitigation in areas that cannot be avoided based on approval by the fish and wildlife service and the Wyoming Game and Fish Department. Proposed mitigation could include construction of alternate nest sites on natural features (e.g., trees, rock outcrops, and cliffs) and erection of appropriate nesting platforms on wooden poles (NRC, 2004). Construction activities will be required to comply with the Migratory Bird Treaty Act. Consultation with the U.S. Department of Interior should occur prior to construction activities.

Aquatic

ISL uranium recovery facility construction primarily affects aquatic resources through (1) short-term physical disturbances to stream channels; (2) short-term increases in suspended sediments from in-stream activities and erosion from adjacent disturbed lands; (3) increases in downstream sedimentation, during construction, from in-stream activities and erosion from adjacent disturbed lands; (4) potential fuel spills from equipment and refueling operations during construction; and (5) short-term reductions in habitat and potential loss of individual specimens from water appropriations if needed.

Due to disturbances associated with construction, movement of fish upstream and downstream of waterbody crossings could be temporarily affected when pipelines or roads are installed. The physical disturbance of the streambed could temporarily displace adult fish and could dislodge other aquatic organisms, including invertebrates. Some limited mortality of less mobile organisms such as small fish and invertebrates could occur within the immediate area of the crossing. Aquatic plants, woody debris, and boulders that provide an in-stream fish habitat would also be expected to be removed if trenching occurred. Noise upstream and downstream of the site could deter fish that might otherwise inhabit the area. These disturbances would be expected to be temporary and are not expected to significantly affect fisheries resources. Studies have shown that natural recolonization of the disturbed areas would begin soon after the streambed is restored; areas would be completely recolonized within 1 year after construction (Schubert, et al., 1985; Anderson, et al., 1997). Therefore impacts, would be SMALL.

Sediment loads could be temporarily increased downstream during construction. These increased loads could temporarily affect sensitive fish eggs, fish fry, and invertebrates inhabiting the downstream area. However, sediment levels would quickly taper off both over time and distance and would not be expected to adversely affect resident fish populations or permanently alter existing habitats (McKinnon and Hnytka, 1988), and long-term impacts would be SMALL.

Removal of riparian vegetation could increase the amount of light able to penetrate the water, thus increasing the water temperature. Changes in the light and temperature characteristics of some waterbodies could affect the behavioral patterns of fish, including spawning and feeding activities, at the crossing location.

Standard management practices issued by the Wyoming Game and Fish Department would help to limit impacts to aquatic life and surface waters to a SMALL magnitude.

Threatened and Endangered Species

There are three primary impacts of ISL uranium recovery facility construction on threatened and endangered species: (1) habitat loss or alteration and incremental habitat fragmentation; (2) displacement of wildlife from project construction; and (3) direct and indirect mortalities from project construction and operation.

Numerous threatened and endangered species and state species of concern are located within the region. These species with habitat descriptions are provided in Section 3.2.5.3. After a site has been selected, the habitats and impacts would be evaluated for federal and state species of concern that may inhabit the area. For site-specific environmental reviews, licensees and NRC staff consult with the U.S. Fish and Wildlife Service and Wyoming Game and Fish Department for potential survey requirements and explore ways to protect these resources. If any of the species are identified in the project site during surveys, impacts could range from SMALL to

LARGE, depending on site-specific conditions. Mitigation plans to avoid and reduce impacts to the potentially affected species would be developed.

- The black-footed ferret behavior revolves around prairie dog towns. Should prairie dog towns be present within close proximity to the construction area, impacts from construction activities would be MODERATE or LARGE. Destruction of prairie dog towns and/or conflict with machinery could impact black-footed ferret populations.

- The blowout penstemon are located in the sand dune habitat in the northeastern Great Divide Basin in Wyoming on sandy aprons or the lower half of steep sandy slopes deposited at the base of granitic or sedimentary mountains or ridges in northwestern Carbon County. The clearing of vegetation as a result of milling activities would have a LARGE impact to this species population if located in the impact area.

- The bonytail chub is found in slower water habitats in the mainstream such as eddies, pools, side channels, and coves. Proper best management practices with regard to erosion, vegetation removal, siltation, and the discharge of wastewater would result in SMALL potential impacts to this species.

- Canada lynx generally require cool and moist coniferous forests with cold, snowy winters and abundant snowshoe hares. Lynx are extremely mobile and will occasionally move across and be recorded in unsuitable habitats, even shrublands and true grasslands. In general, ISL facilities are not located with the main habitat of the lynx. Potential exists that these species may cross the project area. Impacts from construction to this species would be temporary and SMALL if encountered.

- The downstream populations of the Colorado pikeminnow could be affected from construction activities from increased stream sedimentation and degrading of waterways in the region that connect to the upper Colorado River Basin. Proper best management practices with regard to erosion, vegetation removal, siltation, and the discharge of wastewater would result in SMALL potential impacts to this species.

- The downstream populations of the humpback chub could be impacted from construction activities from increased stream sedimentation and degrading of waterways in the region that connect to the upper Colorado River Basin. Proper best management practices with regards to erosion, vegetation removal, siltation, and the discharge of wastewater would result in SMALL potential impacts to this species.

- Impacts to the interior least tern would be SMALL if nesting habitat of bare or sparsely vegetated sand, shell, and gravel beaches and sandbars, islands, and salt flats associated with rivers and reservoirs is avoided.

- The downstream pallid sturgeon could be impacted from construction activities from increased stream sedimentation and degrading of waterways in the region that connect to the Missouri River. Proper best management practices with regards to erosion, vegetation removal, siltation, and the discharge of wastewater would result in SMALL potential impacts to this species.

- The impacts to the piping plover will be SMALL or mitigated if construction activities avoid open, sparsely vegetated sand or gravel beaches adjacent to alkali wetlands and on beaches, sand bars, and dredged material islands of major river systems.

- The Preble's meadow jumping mouse is found in heavily vegetated, shrub-dominated riparian habitats and immediately adjacent upland habitats along the foothills of Albany, Laramie, Platte Goshen, and Converse Counties in Wyoming. Impact to this species would be SMALL or mitigated if the construction activities avoid vegetation removal and buffers along riparian habitats are established. Critical habitat has been established for this species.

- The razorback sucker is a large river species not found in smaller tributaries and headwater streams. Found in water from .06–3 m [4–10 ft] in depth, adults are associated with areas of strong current and backwaters. This species has been extirpated from Wyoming; however, it can have occasional occurrences in Sweetwater County. Impacts to this species would be SMALL if waterways do not meet habitat requirements.

- Impacts to the Ute ladies' tresses orchid would be MODERATE to LARGE if construction activities remove vegetation along riparian edges, gravel bars, old oxbows, high flow channels, and moist to wet meadows along perennial streams or in wetland and seepy areas near freshwater lakes or springs.

- Impacts to the Western prairie fringed orchid would be MODERATE to LARGE if construction activities occur in the tall grass prairies in moist habitats or sedge meadows in which this species has been identified within the region.

- The whooping crane is a predictable spring and fall migrant in the Missouri River drainage. Impacts to this species from construction activities would be SMALL due to the transient nature of this species.

- Potential impact to the yellow-billed cuckoo would be SMALL to MODERATE if vegetation removal from construction occurs in cottonwood and willow riparian woodlands.

4.2.5.2 Operation Impacts to Ecological Resources

The primary impacts of ISL facility operation on terrestrial wildlife are (1) habitat alteration and incremental habitat fragmentation; (2) displacement/stress to wildlife from human activity; and (3) direct and/or indirect mortalities from project construction and operation.

Big game distribution in this region of Wyoming is limited by availability of winter range and water. Movement of pronghorn and mule deer through the area is not expected to be impacted by most mining operations. The limited the use of fencing that impedes ingress to and egress from the permit region would further mitigate impact to wildlife's use of the area. Within this region, the recommended fencing is that preferred by the Wyoming Game and Fish Department, which consists of three wires with a smooth bottom wire 41 cm [16 in] off the ground, a 30-cm [12-in] gap between the top two wires, and a total height of 97 cm [38 in]. This type of fencing will provide for relatively unimpeded movement of big game through the site (NRC, 2004).

Some SMALL impacts to wildlife would be expected to occur from direct conflict with vehicular traffic and the presence of onsite personnel. Generally these would be SMALL impacts that would not affect the total population of a species. However, proximity to crucial wintering ranges and active sage-grouse leks or raptor nests have the potential to have a MODERATE to LARGE impact. Seasonal guidelines with respect to noise, vehicular traffic, human proximity, and operational timing have been established by the Wyoming Game and Fish Department (Wyoming Game and Fish, 2004).

Potential impacts to migratory birds and other wildlife from exposure to selenium concentrations and radioactive materials in the evaporation ponds may occur. Past experience at NRC-licensed ISL facilities has not identified impacts to wildlife from evaporation ponds. Typically, evaporation ponds are lined with a synthetic liner that inhibits the growth of aquatic vegetation which might otherwise serve as a potential source of exposure to radioactive materials via a food pathway. Such vegetation could also potentially provide habitat for wildlife (NRC, 2004). Mitigative measures including perimeter fencing and surface netting would limit potential impacts to wildlife from evaporation ponds to SMALL.

Impacts to the aquatic resources and vegetation from facility operations resulting from spills around well heads and leaks from pipelines would be SMALL and would be handled using best management practices (NRC, 2007). Leak detection systems and spill response plans to remove affected soils and capture release fluids would be expected to reduce the impact to aquatic systems.

Impacts to federal threatened and endangered species beyond those that occurred during construction would be SMALL. The potential exists for mobile species to experience conflicts with vehicles during facility operations.

Potential impacts to vegetation may occur as a result of land application of wastewater generated from the operation. These impacts could range from increased vegetation growth due to the increase of available water and/or the destruction of vegetation from the build-up of salts in the soils. Additional details related to waste disposal operation are described in Section 4.2.12.2. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive and other constituents (e.g., arsenic, selenium, molybdenum) within allowable release standards. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to ensure release limits would be met and soil sampling to establish background and to monitor for uranium, radium, and other metals. The impacts from land application of treated wastewater would be SMALL.

4.2.5.3 Aquifer Restoration Impacts to Ecological Resources

Because the existing infrastructure is already in place, aquifer restoration activities would produce potential ecological impacts similar to facility operations, and therefore potential impacts would be SMALL.

4.2.5.4 Decommissioning Impacts to Ecological Resources

Impacts from decommissioning would, in part, be similar to those discussed for construction of the facility. However, these impacts would be temporary (12–18 months) and reduce with time as decommissioning and reclamation proceed. The removal of piping would impact vegetation that has reestablished itself. Wildlife could come in conflict with heavy equipment. During decommissioning, reclamation activities would revegetate previously disturbed areas and restore streams and drainages to their preconstruction contours. It is expected that temporarily displaced wildlife would return to the area once decommissioning and reclamation are completed. As a result, the potential impacts to ecological resources during decommissioning would be expected to be SMALL.

Land that is used for irrigation is also included in decommissioning surveys to ensure potentially impacted (contaminated) areas would be appropriately characterized and remediated, as necessary, in accordance with NRC regulations. Because of the NRC review of site-specific conditions prior to approval, the routine monitoring program, and the inclusion of irrigated areas in decommissioning surveys, the impacts from land application of treated wastewater would be SMALL.

4.2.6 Air Quality Impacts

In general, ISL milling facilities are not major nonradiological air emission sources, and the impacts would be classified as SMALL if the following conditions are met:

- Gaseous emissions are within regulatory limits and requirements
- Air quality in the region of influence is in compliance with NAAQS
- The facility is not classified as a major source under the New Source Review or operating (Title V) permit programs described in Section 1.7.2

These conditions apply to activities conducted as part of all four phases of the ISL facility lifecycle: construction, operation, aquifer restoration, and decommissioning. Therefore, a general discussion is presented here with appropriate details provided in the impact analyses for these activities. These conditions reflect the fact that determining the significance of ISL milling facilities' impacts on air quality depends on the emission levels of the proposed action and the existing air quality in the defined region of influence. The GEIS significance assessment is a general one. Site-specific environmental reviews would be conducted that account for the local affected environment and the specific action proposed. Complying with requirements imposed for the protection of the environment is one of the factors identified in the National Environmental Policy Act regulations for determining impact significance (see 40 CFR 1508.27). Actions where the region of influence includes NAAQS nonattainment or maintenance areas typically would generate more scrutiny in the permitting process. Because of the existing air quality condition in these areas, any activity generating gaseous emissions could potentially create impacts to air quality that could be classified as MODERATE or LARGE. Classification as a major source under any permit program indicates facility emission levels warrant analyses to determine whether impacts would be at the MODERATE or LARGE level.

The area within the Wyoming West Uranium Milling Region is classified as attainment for NAAQS (see Figure 3.2-15). This also includes the counties immediately surrounding this region. The Wyoming West Uranium Milling region does not include any Prevention of Significant Deterioration Class I areas (see Figure 3.2-16). Therefore, the less stringent Class II area allowable increments apply.

Regulatory thresholds, compliance status, and Prevention of Significant Deterioration classifications can change over time. Any site-specific environmental review should determine whether any regulatory thresholds or classification designations presented in this GEIS have changed. The air quality impacts analyzed in Section 4.2.6 only cover nonradiological emissions. Radiological emissions and dose information are addressed in the public and occupational health and safety impacts analyses in Section 4.2.11.

4.2.6.1 Construction Impacts to Air Quality

Nonradiological gaseous emissions in the construction phase include fugitive dust and combustion emissions (Section 2.7.1). Most of the combustion emissions are diesel emissions and are expected to be limited in duration during the construction phase and result in SMALL, short-term effects.

For the purposes of evaluating potential impacts to air quality for a large, commercial-scale ISL facility, Table 2.7-2 contains the annual total releases and average air concentrations of particulate (fugitive dust) and gaseous (diesel combustion products) emissions estimated for the construction phase of the ISL facility proposed for Crownpoint, New Mexico, as documented in NRC (1997). These emission levels are below the major source threshold for NAAQS attainment areas. The annual average particulate (fugitive dust) concentration was estimated to be 0.28 $\mu g/m^3$ [8×10^{-9} oz/yd^3] (NRC, 1997). However, this estimate did not categorize the particulates as PM_{10} or $PM_{2.5}$. This estimate is under 2 percent of the federal $PM_{2.5}$ ambient air standard, under 1 percent of the previous federal and current Wyoming PM_{10} ambient air standard, and under 2 percent of the Class II Prevention of Significant Deterioration allowable increment. The annual average sulfur dioxide concentration was estimated to be 0.18 $\mu g/m^3$ [5×10^{-9} oz/yd^3] (NRC, 1997). This estimate is less than 1 percent of both the federal and more restrictive Wyoming ambient air standard and less than 1 percent of the Class II Prevention of Significant Deterioration allowable increment. Finally, the annual average nitrogen oxide concentration was estimated to be 2.1 $\mu g/m^3$ [5.8×10^{-8} oz/yd^3] (NRC, 1997). This estimate is slightly over 2 percent of the federal and Wyoming ambient air standard and less than 9 percent of the Class II Prevention of Significant Deterioration allowable increment.

In general, ISL facilities use best management practices to reduce fugitive dust and emissions (e.g., wetting of dirt roads and cleared land areas to suppress fugitive dust emissions). Table 7.4-1 provides a list of potential best management practices and management actions for various resources including air quality.

The Wyoming West Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility would be expected to comply with applicable regulatory limits and restrictions (Section 3.2.6.2). Therefore, construction impacts to air quality from ISL facilities would be SMALL.

4.2.6.2 Operation Impacts to Air Quality

Operating ISL facilities are not major point source emitters and are not expected to be classified as major sources under the operation (Title V) permitting program (Section 1.7.2). One gaseous emission source introduced in the operational phase is the release of pressurized vapor from well field pipelines. Excess vapor pressure in these pipelines could be vented at various relief valves throughout the system. In addition, ISL operations may release gaseous effluents during resin transfer or elution. These gases come from two sources: (1) the liquefied gases such as oxygen and carbon dioxide used in the lixiviant that come out of solution and (2) gases in the underground environment that are mobilized. The greatest concern from venting the well pipeline system is the release of naturally occurring radon gas. Radon release impacts are addressed in the public and occupational health and safety impacts analyses in Section 4.2.11. In general, nonradiological emissions from pipeline system venting, resin transfer, and elution would be rapidly dispersed in the atmosphere and would be SMALL, primarily due to the low volume of effluent produced.

Gaseous effluents produced during drying yellowcake operations vary based on the particular drying technology. Multihearth dryers operate at relatively high temperatures and produce combustion products that are typically scrubbed before they are released into the atmosphere. Vacuum driers basically release no gaseous effluents other than water vapor (Section 2.4.2.3). The greatest air quality concern for yellowcake drying is the release of uranium particles. This concern is addressed in the public and occupational health and safety impacts analyses in Section 4.2.11. In general, nonradiological emissions from yellowcake drying would be SMALL and reduced further by required filtration systems [e.g., high-efficiency particulate air (HEPA) filters].

Other potential operation phase nonradiological air quality impacts include fugitive dust and vehicle emissions from many of the same sources identified earlier for activities related to construction. ISL operations phase fugitive dust emissions sources include onsite traffic related to operations and maintenance, employee traffic to and from the site, and heavy truck traffic delivering supplies to the site and product from the site. The ISL operations phase would use the existing infrastructure, and emissions would not include fugitive dust and diesel emissions associated with well field construction. Therefore, operations phase impacts would be expected to be less than the construction phase impacts.

The Wyoming West Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. These emissions are not expected to reach levels that result in the ISL facility being classified as a major source under the operating (Title V) permit process. Therefore, operation impacts to air quality from ISL facilities would be SMALL. If impacts were assessed at a higher level, permit conditions would be expected to impose conditions or mitigation to reduce impacts.

4.2.6.3 Aquifer Restoration Impacts to Air Quality

Potential aquifer restoration phase nonradiological air impacts include fugitive dust and vehicle emissions from many of the same sources identified earlier in the operations phase. The plugging and abandonment of production and injection wells use equipment that generates gaseous emissions. These emissions would be expected to be limited in duration and result in small, short-term effects. The ISL aquifer restoration phase would use the existing infrastructure, and the impacts would not be expected to exceed those of the construction phase. Therefore, aquifer restoration phase impacts to air quality would be SMALL.

4.2.6.4 Decommissioning Impacts to Air Quality

Potential decommissioning phase air quality impacts would include fugitive dust, vehicle emissions, and diesel emissions from many of the same sources identified earlier in the construction phase. In the short term, emission levels could increase, especially for particulate matter from activities such as dismantling buildings and milling equipment, removing any contaminated soil, and grading the surface as part of reclamation activities. Potential impacts from decommissioning activities would be expected to be similar to construction phase impacts and would decrease as decommissioning proceeds. Therefore, decommissioning phase impacts to air quality would be expected to be SMALL.

4.2.7 Noise Impacts

4.2.7.1 Construction Impacts to Noise

It is anticipated that because of the use of heavy equipment (e.g., bulldozers, graders, drill rigs, compressors), potential noise impacts would be greatest when an ISL facility is being built, especially for new ISL facilities developed in rural, previously undeveloped areas, because the baseline noise levels are likely to be lower for these areas than for more developed settings such as existing uranium recovery facilities, urban environments, or near highways (Section 3.3.7). For this reason, the analysis presented here considers impacts compared to typical background noise in rural, undeveloped areas.

Standard construction techniques using appropriate heavy equipment would be used to build well fields and buildings and to grade access roads for a new ISL facility (Section 2.3). Drill rigs, construction vehicles, heavy trucks, bulldozers, and other equipment used to construct and operate the well fields, drill the wells, develop the necessary access roads, and build the production facilities would generate noise that would be audible above the undisturbed background levels (NRC, 1997; Reinke, 2005; Washington State Department of Transportation, 2006; Spencer and Kovalchik, 2007). Representative noise ranges at 15 m [50 ft] are presented in Table 4.2-1.

Table 4.2-1. Average Noise Levels at 15 m [50 ft] From Representative Construction Heavy Equipment

Equipment*	Noise Level (dBA)
Heavy Truck	82–96
Bulldozer†	92–109
Grader	79–93
Excavator	81–97
Crane	74–89
Concrete Mixer	75–88
Compressor	73–88
Backhoe	72–90
Front Loader	72–90
Generator	71–82
Jackhammer/Rock Drill	75–99
Pump	68–80

*Washington State Department of Transportation. "WSDOT's Guidance for Addressing Noise Impacts in Biological Assessments—Noise Impacts." Seattle, Washington: Washington State Department of Transportation. November 2006. <http://www.wsdot.wa.gov/TA/Operations/Environmental/NoiseChapter011906.pdf> (9 October 2007).
†Spencer, E. and P. Kovalchik. "Heavy Construction Equipment Noise Study Using Dosimetry and Time-Motion Studies." *Noise Control Engineering Journal*. Vol. 55. pp. 408–416. 2007.

Initial construction of larger surface facilities such as a central processing facility would be completed early in the project, but because of the staged nature of uranium ISL facilities, construction activities would be expected to continue throughout the life of the project as well as when fields are developed and brought into production.

The Occupational Safety and Health Administration current permissible exposure limit for workplace noise is 90 dBA for a duration of 8 hours per day (29 CFR 1910.95). Employers are required to have hearing conservation programs in all workplaces where noise levels equal or exceed 85 dBA as an 8-hour time-weighted average—the recommended exposure limit for noise established by the National Institute for Occupational Safety and Health (1998). A similar level is used by the Mine Safety and Health Administration (Bauer and Kohler, 2000). In all cases, higher exposure levels are permissible, but only if the exposure time is shortened. Depending on the type of construction and the equipment being used, noise levels (other than occasional instantaneous levels) resulting from construction activities might reach or occasionally exceed 85 dBA at 15 m [50 ft] from the source (Table 4.2-1). Personal hearing protection would be required for workers in these areas.

Noise levels lessen with distance from the source (Golden, et al., 1979). Noise from a line source like a highway is reduced by about 3 dB per doubling of distance. For example, road noise at 15 m [49 ft] from a highway is reduced by 3 dB at 30 m [98 ft] and further reduced by an additional 3 dB at 60 m [197 ft]. For point sources like compressors and pumps, the reduction factor with distance is greater at about 6 dB per doubling of distance. During construction, noise levels associated with a typical water well drill rig may exceed 100 dBA within 2 m [7 ft] of the compressor, but quickly drop to less than 90 dBA within 6 m [20 ft] (Figure 4.2-1). The U.S. Department of Energy (DOE) calculated that in an arid environment similar to that in the Wyoming West Uranium Milling Region, sound levels as high as 132 dBA will taper off to the lower limit of human hearing (20 dBA) at a distance of 6 km [3.7 mi] (DOE, 2007, Section 4.1.9.1). The presence of vegetation and topography between the noise-generating activity and the receptor reduces noise levels even more (Washington State Department of Transportation, 2006; Federal Highway Administration, 1995).

Noise resulting from construction activities could occasionally be annoying to residents within 300 m [1,000 ft] of the noise sources, particularly during the night (Figure 4.2-2). Traffic associated with construction activities for an ISL facility would include workers commuting to and from the jobsite, as well as relocation of construction equipment to different parts of the project. This might affect small communities located along existing roads. Because well field and facility construction activities would generally occur during daytime hours (see Section 2.7), related noise would not be expected to exceed the 24-hour average sound-energy guideline of 70 dBA EPA (1978) determined to protect hearing with a margin of safety.

Residents or users of multiuse facilities such as churches or community centers located less than 300 m [1,000 ft] from construction activities might experience outdoor noise levels greater than 70 dBA. This exceeds 55 dBA, the level EPA (1978) gives as protective against activity interference and annoyance with a margin of safety. Indoor noise levels typically range from 15 to 25 dBA lower than outdoor levels, depending on whether windows are open or closed. With windows open during construction hours, indoor noise levels could be substantially greater than the 45 dBA level EPA (1978) gives as protective against indoor interference and annoyance with a margin of safety. In both cases, however, at distances greater than 300 m [1,000 ft] from ongoing construction activities, potential noise impacts will be small. Elevated

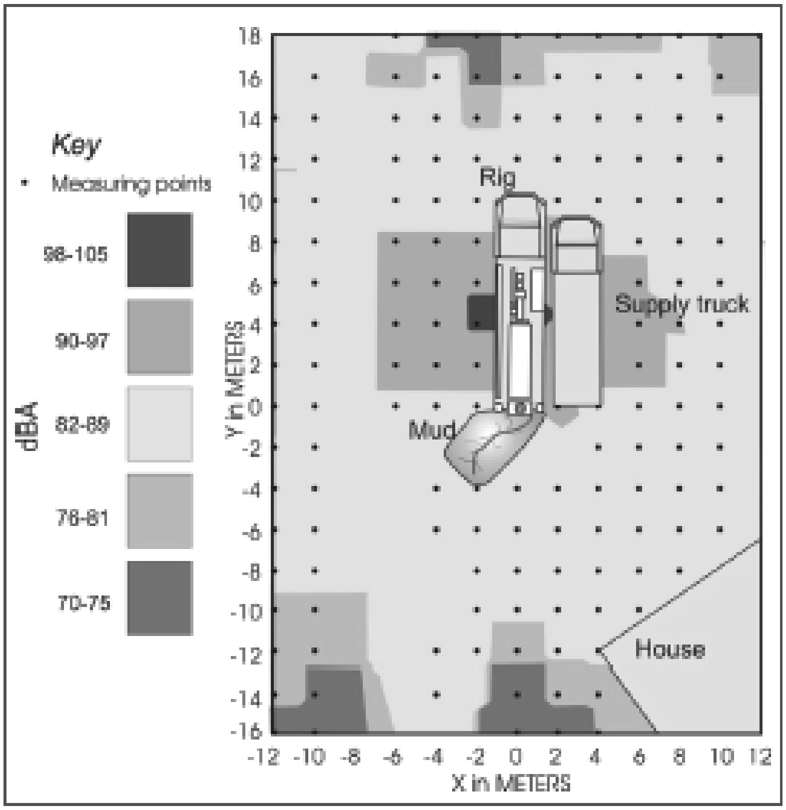

Figure 4.2-1. Sound Levels Around a Typical Water Well Work Site (From Reinke, 2005) [1 m = 3.28 ft]

noise levels associated with construction activities could affect wildlife behavior (Federal Highway Administration, 2004; Brattstrom and Bondello, 1983; BLM, 2008). For example, continuous elevated noise levels may reduce the breeding success of sage grouse near equipment by making it more difficult for the female sage hens to locate and respond to the vocalizations of the male leks (BLM, 2008; Holloran, 2005) (see Section 4.2.5.1).

The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, construction activities and associated traffic would have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise-generating activities.

Construction worker hearing would be protected by compliance with Occupational Safety and Health Administration noise regulations. During construction, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Therefore, overall noise impacts during construction would be SMALL to MODERATE.

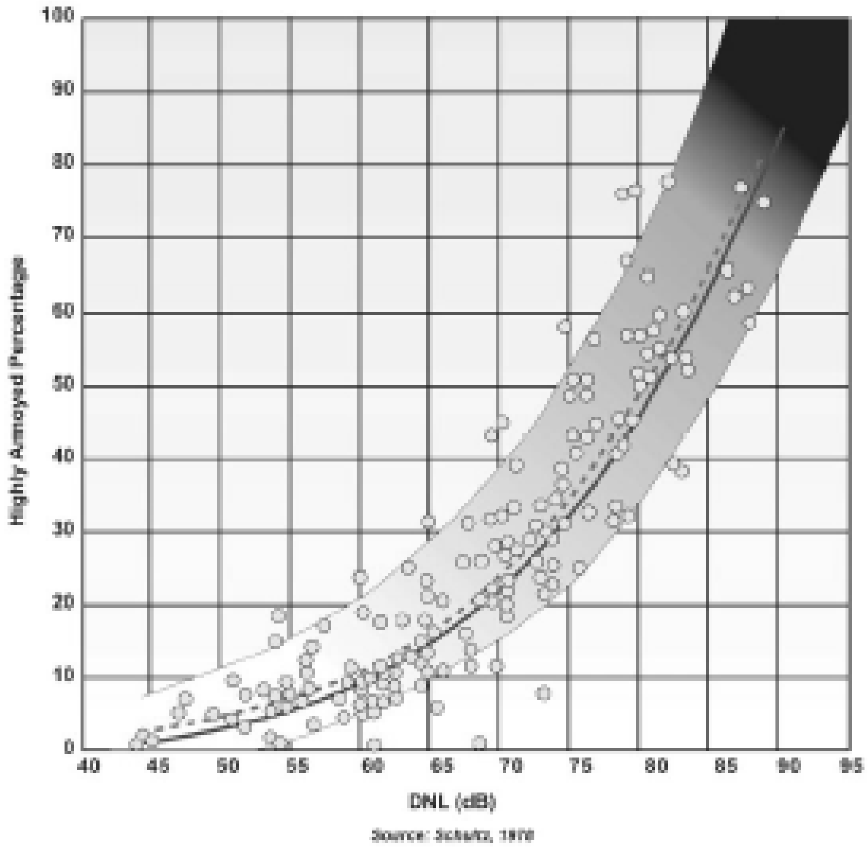

Figure 4.2-2. Community Surveys of Noise Annoyance (From U.S. Air Force, 2007, After Schultz, 1978). DNL is the Day-Night Average Sound Level—a Way To Account for the Fact That Noise Tends To Be More Intrusive at Night Than During the Day. Calculating the DNL Involves Adding a 10-dB Penalty to the 24-Hour Average Sound Level for Those Noise Events That Occur at a Given Location After 10:00 p.m. and Before 7:00 a.m.

4.2.7.2 Operation Impacts to Noise

Except for heavy truck traffic associated with the operation, operations at ISL uranium recovery facilities generally do not create important sources of noise for offsite receptors. In the well fields, the only noise sources would be the groundwater pumps and occasional truck traffic required to perform maintenance and inspections. For operations, heavy truck traffic associated with transporting uranium-loaded resins to the central processing facility and shipments of yellowcake would also result in short-term noise (see Section 4.2.2.2). Depending on traffic, the sound levels near heavily traveled highways might reach as high as 85 dBA or more, depending on the speed limits and amount of heavy truck traffic (Washington State Department of Transportation, 2006). Compared to daily traffic counts of 12,400 vehicles per day on Interstate-80 (Wyoming Department of Transportation, 2005; see also Section 3.2.2), additional traffic associated with ISL operations would have only a SMALL impact on noise levels near the highway. As noted in Section 4.2.7.1, noise levels at 78 dBA at 30 m [98 ft] would decrease with distance from the highway, reaching levels of 60 dBA or less within about 360 m [1,180 ft] (Washington State Department of Transportation, 2006). Some country roads with the lowest average annual daily traffic counts would be expected to have higher relative increases in traffic and noise impacts, especially when facilities are experiencing peak employment. These impacts would be MODERATE.

Operational noises at an ISL facility would be typical of an industrial facility. Noise would be generated by trucks, pumps, generators, and other heavy equipment used around the mill site. This noise would likely be less than that generated during construction, but the production facilities would still generate noise that would be audible above the undisturbed background levels of 50–60 dBA (see Table 4.2-1). Administrative and engineering controls would be used to ensure that noise levels meet Occupational Safety and Health Administration exposure limits (29 CFR 1910.95). Personal hearing protection would be used for those working in areas that exceed these noise levels.

Noise from operations within the milling facility would be reduced outside of the buildings, but noise resulting from operations could occasionally be annoying to nearby residents, particularly during the night (see Section 4.2.7.1).

Overall, because most activities will be conducted inside buildings, potential noise impacts during ISL operations are anticipated to be less than those during construction. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, operations activities and associated traffic would be expected to have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise-generating activities. Noise impacts to workers during operations would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During operations, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Compared to existing traffic counts, truck traffic associated with yellowcake and chemical shipments and traffic noise related to commuting would have a SMALL, temporary impact on communities located along the existing roads. Therefore, overall noise impacts during operations would be SMALL.

4.2.7.3 Aquifer Restoration Impacts to Noise

General noise levels during aquifer restoration would be expected to be similar to or less than those during the operational period, and workplace noise exposure would be managed using the same administrative and engineering controls. In the well fields, the greatest source of temporary noise would be from equipment used during plugging and abandonment of production and injection wells. Cement mixers, compressors, and pumps would potentially be the largest contributors to noise (see Table 4.2-1) but would be operated only for a relatively short daytime duration. Potential noise impacts during aquifer restoration would be expected to be less than those during construction (see Section 4.2.7.1) and of short duration. Aquifer restoration activities may, however, continue over much of the life of the project as uranium recovery operations are completed in different well fields. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, aquifer restoration activities and associated traffic would have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise generating activities. Noise impacts to workers during aquifer restoration would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During aquifer restoration, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Therefore, overall noise impacts during the aquifer restoration period would be SMALL to MODERATE.

4.2.7.4 Decommissioning Impacts to Noise

General noise levels during decommissioning and reclamation would be expected to be similar to or less than those during the construction period, and workplace noise exposure would be managed using the same administrative and engineering controls (see Section 4.2.7.1). As with construction impacts, the anticipated noise impacts from decommissioning activities would be expected to be greatest for an ISL facility in a rural, previously undeveloped area. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, decommissioning activities and associated traffic would be expected to have only SMALL and short-term noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise-generating activities. Noise impacts to workers during decommissioning would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. Equipment used to dismantle buildings and milling equipment, remove any contaminated soils, or grade the surface as part of reclamation activities would generate noise levels that would exceed the background (see Table 4.2-1). These noise levels would be temporary, and once decommissioning and reclamation activities were complete, noise levels would return to baseline, with occasional vehicle traffic for any longer term monitoring activities. Therefore, overall noise impacts from the decommissioning and reclamation activities would be SMALL.

4.2.8 Historical and Cultural Resources Impacts

Construction-related impacts to cultural resources (defined here as historical, cultural, archaeological, and traditional cultural properties) can be direct or indirect and can occur at any stage of an ISL uranium recovery facility project (i.e., during construction, operation, aquifer restoration, and decommissioning).

A general cultural overview of the affected environment for the Wyoming West Uranium Milling Region is provided in Section 3.2.8 of this GEIS. Construction involving land disturbing activities, such as grading roads, installing wells, and constructing surface facilities and well fields, are the most likely to affect cultural and historical resources. Prior to engaging in land-disturbing activities, licensees and applicants review existing literature and perform region-specific records searches to determine whether cultural or historical resources are present and have the potential to be disturbed. Along with literature and records reviews, the project site area and all its related facilities and components are subjected to a comprehensive cultural resources inventory (performed by the licensee) that meets the requirements of responsible federal, state, and local agencies [e.g., the Wyoming State Historic Preservation Office (SHPO)]. The literature and records searches will help identify known or potential cultural resources and Native American sites and features. The cultural resources inventory will identify the previously documented sites and any newly identified cultural resources sites. The eligibility evaluation of cultural resources for listing in the National Register of Historic Places (NRHP) under criteria in 36 CFR 60.4(a)–(d) and/or as traditional cultural properties is conducted as part of the site-specific review and NRC licensing procedures undertaken during the National Environmental Policy Act (NEPA) review process. Long linear features such as the Bozeman National Historic Trail in the Wyoming East Uranium Milling Regions require detailed assessment of potential construction and operation impacts. The evaluation of impacts to any historic properties designated as traditional cultural properties and tribal consultations regarding cultural resources and traditional cultural properties also occur during the site-specific licensing application and review process. Consultation to determine whether significant cultural resources would be avoided or mitigated occurs during state SHPO, agency, and tribal consultations as part of the site-specific review. Additionally, as needed, the NRC license applicant would be required, under conditions in its NRC license, to adhere to procedures regarding the discovery of previously undocumented cultural resources during initial construction, operation, aquifer restoration, and decommissioning. These procedures typically require the licensee to stop work and to notify the appropriate federal and state agencies.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance or mitigation) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC and licensees/applicants may enter into a memorandum of agreement with the responsible state and tribal agencies to ensure protection of historical and cultural resources, if encountered.

4.2.8.1 Construction Impacts to Historical and Cultural Resources

Most of the potential for significant adverse effects to NRHP-eligible or potentially NRHP-eligible historic properties and traditional cultural properties, both direct and indirect, will likely occur during land-disturbing activities related to building an ISL uranium recovery facility. Buried cultural features and deposits that were not visible on the surface during initial cultural resources inventories might also be discovered during earth-moving activities.

Indirect impacts may also occur outside the ISL uranium recovery project site and related facilities and components. Visual intrusions, increased access to formerly remote or inaccessible resources, impacts to traditional cultural properties and culturally significant landscapes, as well as other ethnographically significant cultural landscapes may adversely affect these resources. These significant cultural landscapes should be identified during literature and records searches and may require additional archival, ethnographic, or ethnohistorical research that encompasses areas well outside the area of direct impacts. Indirect impacts to some of these cultural resources may be unavoidable and exist throughout the lifecycle of an ISL facility.

Because of the localized nature of land-disturbing activities related to construction, impacts to cultural and historical resources are anticipated to be SMALL, unless the facility is located adjacent to a known resource. Wyoming historical sites listed in the NRHP and traditional cultural properties are provided in Section 3.2.8.4. In addition, the Wind River Indian Reservation is located in the northwest corner of the Wyoming West Uranium Milling Region. Based on current information, the potential ISL facility closest to the Wind River Indian Reservation is about 16 km [10 mi] away at Sand Draw. Proposed facilities or expansions adjacent to an ISL facility would be likely to have the greatest potential impacts, and mitigation measures (e.g., avoidance, recording, and archiving samples) and additional (NRC) consultations with the Wyoming SHPO and affected Native American tribes would be needed to reduce the impacts. From the standpoint of cultural resources, the most significant impacts to sites that are present will occur during the initial construction within the area of potential effect. Subsequent changes in the footprint of the project (i.e., expansion outside of the original area of potential effect) may also result in significant impact to any cultural resources that might be present. Impacts would be expected to be SMALL, MODERATE, or LARGE, depending on the presence or absence of cultural and historical resources at a specific site.

4.2.8.2 Operation Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during operation of an ISL uranium recovery project. Impacts during operation are expected to occur through new earth-disturbing activities, new construction, maintenance, and repair.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during operation. Overall impacts to cultural and historical resources during operations would be expected to be less than those during construction, as operations are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.2.8.3 Aquifer Restoration Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the aquifer restoration phase of an ISL uranium recovery project. Impacts during aquifer restoration may occur through new earth-disturbing activities or other new construction that may be required for the restoration process. Such activities may have inadvertent impacts to cultural resources and traditional cultural properties in or near the site of aquifer restoration activities located within the extended ISL project area.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during aquifer restoration would be expected to be less than those during construction, as aquifer restoration activities are generally limited to the existing infrastructure and previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.2.8.4 Decommissioning Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the decommissioning phase of an ISL uranium recovery project. Impacts can result from earth-disturbing activities that may be required for the decommissioning process. Inadvertent impacts to cultural resources and traditional cultural properties on or near the site of decommissioning activities may potentially occur.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during decommissioning. Overall impacts to cultural and historical resources during decommissioning would be expected to be less than those during construction, as decommissioning activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites). Because cultural resources within the existing area of potential effect are known, potential impacts can be avoided or lessened by redesign of decommissioning project activities. As a result, the overall impacts to historic and cultural resources from decommissioning would be expected to be SMALL.

4.2.9 Visual/Scenic Resources Impacts

4.2.9.1 Construction Impacts to Visual/Scenic Resources

During construction, most impacts to visual resources in the Wyoming West Uranium Milling Region would result from well field development, when drilling rig masts contrast with the general topography. Visual impacts from facilities construction (e.g., drilling and land disturbance) would generally be temporary (short term), and visual impacts from buildings would be SMALL. Additional construction impacts would include dust that occurs during clearing for parking, access roads, well sites, storage pads, retention or evaporation ponds, monitoring wells, and piping. The potential visual and scenic impacts would be expected to be greatest for new ISL facilities developed in rural, previously undeveloped areas. This is because the baseline visual landscape is likely to be less disturbed for these areas than for more developed settings that may have existing uranium recovery facilities, may be located in urban environments, or may be located near highways. Therefore, in a previously undeveloped area, ISL construction would be expected to present more contrast with the existing landscape. For this reason, this analysis considers impacts compared to the typical baseline visual landscape for rural areas to be bounding.

Because of the number of wells that may be involved in an ISL operation, multiple drill rigs are likely to be operating during well field construction. For example, at the proposed Crownpoint ISL site, it was estimated that four or more drill rigs could be operating at each well field (NRC, 1997), and at the Smith Ranch ISL facility, drilling peaked during construction with 20 drill rigs in operation (Freeman and Stover, 1999). Because of limitations in deploying equipment, well fields at Crownpoint were estimated to be placed into production at about 2 ha [5 acres] at a time. This estimate suggests that drilling activities would affect only a small percentage of each project site at any one time. As an example of the duration of drilling activities, NRC (1997) estimated that drilling would typically be conducted 12 hours/day for more shallow deposits, but could be conducted 24 hours/day where the uranium deposit is deeper (NRC, 1997; Hydro Resources, Inc., 1995, 1993). For nighttime operation, the drill rigs would be lighted, and this would create a visual impact because the drill rigs would be most visible and provide the most contrast if they were located on elevated areas.

A typical truck-mounted rotary drill rig may be about 9–12 m [30–40 ft] tall (USACE, 2001). Once a well is completed and conditioned for use, the drill rig would be moved to a new location to drill the next hole. Because temperatures in the affected environment in the Wyoming West Uranium Milling Region drop below freezing during the winter, wellheads for completed wells would be covered to prevent freezing and protect the well. These covers would be low structures {1–2 m [3–6 ft] high} and present only a slight contrast with the existing landscape. Unless the topography is extremely flat and void of vegetation, it is likely that these structures would not be visible from distances on the order of 1 km [0.6 mi] or more. Actual boundaries of well fields and the number of wells would not be known until final preoperational exploration was completed. Planned access roads, pipelines, and potential locations of retention ponds would also be uncertain within each well field.

Most visual and scenic impacts associated with earth-moving activities during construction would be temporary. Roads and structures would be more long lasting, but would be removed and reclaimed after operations cease. As noted in Section 3.2.9, most of the areas in the affected environment of the Wyoming West Uranium Milling Region are identified as Visual Resource Management (VRM) Class II through Class IV according to the BLM classification system. This classification allows for an activity to contrast with basic elements of the characteristic landscape to a limited extent (VRM Class II) or to a much greater extent (VRM Class IV). Depending on the location of a proposed ISL facility relative to viewpoints such as highways, process facility construction and drill rigs could be visible. In the Wyoming West Uranium Milling Region, facilities located near the Class II areas surrounding the Wilderness Study Areas in the southwestern corners of the region or on the eastern border near the Class I Ferris Mountains Wilderness Study Area (see Figure 3.2-20) would be the most sensitive. These areas are not, however, closer than about 24 km [15 mi] to the current understanding of where potential uranium ISL facilities would be located (see Section 3.2.9). In addition, there are no Prevention of Significant Deterioration Class I areas located within the Wyoming West Uranium Milling Region. During construction of ISL well fields and facilities, mitigation through best management practices (e.g., dust suppression and coloration of well covers) would further reduce overall visual and scenic impacts of project construction so that total impacts would be SMALL.

4.2.9.2 Operation Impacts to Visual/Scenic Resources

An ISL facility in a previously undeveloped area would be expected to present more contrast with the existing landscape. The potential visual and scenic impacts from ISL operations in the Wyoming West Uranium Milling Region would be expected to be greatest for new facilities operating in rural, previously undeveloped areas. Existing uranium processing facilities or satellite facilities would constitute Class IV areas for visual resources, and operations in existing facilities are unlikely to produce additional contrast. For this reason, this analysis considers operational impacts to the visual landscape for rural areas to be bounding.

Most of the pipes and cables associated with well field operation are anticipated to be buried to protect them from freezing, and they will not be visible during operations. Because well fields would be phased into operation as uranium reserves are defined, there is generally not a large expanse of land undergoing development at one time (NRC, 1997). Because the location of uranium deposits is typically irregular, the network of pipes, wells, and power lines {6 m [20 ft] tall} would not be regular in pattern or appearance (i.e., not a grid), reducing visual contrast and associated potential impacts. The wellhead covers would be typically low {1–2 m [3–6 ft]} structures, and the overall visual impact of an operating well field would be SMALL.

Centralized processing plants, satellite facilities, and pump houses would be the main operational facilities affecting the visual landscape. Because of the rolling topography of most of the Wyoming West Uranium Milling Region, the visibility of aboveground infrastructure would vary, depending on the location of the observer, intervening topography, distance, and lighting considerations (NRC, 1997). The potential visual impacts would be greatest for facilities located near the Class II areas surrounding the Wilderness Study Areas in the southwestern corners of the region or on the eastern border near the Class I Ferris Mountains Wilderness Study Area (see Figure 3.2-18). However, these areas are more than 24 km [15 mi] from the closest potential uranium ISL facility, based on current indications (see Section 3.2.9). Mitigation through best management practices (e.g., dust suppression) would further reduce overall visual and scenic impacts of operations so that total impacts would be SMALL.

4.2.9.3 Aquifer Restoration Impacts to Visual/Scenic Resources

Aquifer restoration would not occur until after an ISL facility has been in operation for a number of years. Much of the same equipment (e.g., pumps and ion exchange columns) and infrastructure used during the operational period would be employed during aquifer restoration, so impacts to the visual landscape in the Wyoming West Uranium Milling Region would be expected to be similar or less than during operations. In the well fields, the greatest source of visual contrast would be from equipment used when production and injection wells are plugged and abandoned. Because there is no active drilling, potential visual impacts during aquifer restoration are anticipated to be less than those during construction (see Section 4.2.9.1) and of short duration. As with construction impacts, the anticipated impacts to the visual landscape from aquifer restoration activities would be expected to be greatest for new ISL facilities developed in rural, previously undeveloped areas or near the sensitive viewsheds identified in Section 3.2.9. These areas are more than 24 km [15 mi] from the closest potential uranium ISL facility, based on current indications (see Section 3.2.9). Mitigation through best management practices (e.g., dust suppression) would further reduce overall visual and scenic impacts of aquifer restoration so that total impacts would be SMALL.

4.2.9.4 Decommissioning Impacts to Visual/Scenic Resources

Once project operations are completed, all facilities would be decommissioned and removed. Reclamation efforts are intended to return the visual landscape to baseline contours and should result in reducing the impacts from operations and minimizing permanent impacts to visual resources. Before the NRC license is terminated, the licensee must submit an acceptable site reclamation plan according to 10 CFR Part 40. Recontouring disturbed surfaces (including access roads) and reseeding them with vegetation that can adapt to the climate and soil conditions will help return the facility to undisturbed conditions. The major limiting factor to establishing vegetation in the Wyoming West Uranium Milling Region would be available moisture. Timing of seeding is therefore critical and would generally be synchronized with periods of highest expected precipitation (April to June; see Section 3.2.6) to increase the likelihood that the vegetation would become established.

During decommissioning and reclamation, temporary impacts to the visual landscape would be expected to be similar to or less than those during the construction period (see Section 4.2.9.1). For example, equipment used to dismantle buildings and milling equipment, remove any contaminated soils, or grade the surface as part of reclamation activities would generate temporary visual contrasts. Overall impacts to the visual landscape would be expected to be SMALL and temporary; once decommissioning and reclamation activities were complete, the visual landscape would be returned to baseline with the potential exception of equipment related to longer term monitoring activities. Potential visual/scenic impacts would be greatest for facilities located near the Class I and Class II resource areas or the Wind River Indian Reservation, as described in Section 3.2.9, but based on current understanding, the closest potential uranium ISL would be located more than 24 km [15 mi] away. Mitigation through best management practices (e.g., dust suppression) would further reduce overall visual and scenic impacts of aquifer restoration so that total impacts would be SMALL.

4.2.10 Socioeconomic Impacts

Although a proposed facility size and production level can vary, the peak annual employment at an ISL facility could reach up to about 200 people, including construction workforce (Freeman and Stover, 1999; NRC, 1997; Energy Metals Corporation, U.S., 2007). In Wyoming, the workforce frequently commutes long distances to work, sometimes from out of state. For example, each of the counties in the Wyoming West Uranium Milling Region experienced net inflows during the fourth quarter of 2005, ranging from about 370 for Carbon County to 10,600 for Natrona, primarily for jobs related to the energy industry (Wyoming Workforce Development Council, 2007). Depending on the composition and size of the local workforce, overall socioeconomic impacts from ISL milling facilities for the Wyoming West Uranium Milling Region would range from SMALL to MODERATE.

Assuming the number of persons per household in Wyoming is about 2.5 (U.S. Census Bureau, 2008), the number of people associated with an ISL facility workforce could be as many as 500 (i.e., 200 workers times 2.5 persons/household). The demand for public services (schools, police, fire, emergency services) would be expected to increase with the construction and operation of an ISL facility. There may also be additional standby emergency services not available in some parts of the region. It may be necessary to develop contingency plans and/or additional training for specialized equipment. Infrastructure (streets, waste management, utilities) for the families of a workforce of this size would also be affected.

4.2.10.1 Construction Impacts to Socioeconomics

The majority of construction requirements would likely be filled by a skilled workforce from outside of the Wyoming West Uranium Milling Region. Assuming a peak workforce of 200, this influx of workers is expected to result in SMALL to MODERATE impact in the Wyoming West Uranium Milling Region. Impacts would be greatest for communities with small populations, such as Carbon County (population 15,600) and the towns of Jeffrey City (100) and Bairoil (100). However, due to the short duration of construction (12–18 months), workers would have only a limited effect on public services and community infrastructure. Further, construction workers are less likely to relocate their entire family to the region, thus minimizing impacts from an outside workforce. In addition, if the majority of the construction workforce is filled from within the region, impacts to population and demographics would be SMALL.

Construction impacts to regional income and the labor force for a single ISL facility in the Wyoming West Uranium Milling Region would likely be SMALL. In addition, even if multiple facilities were developed concurrently, the potential for impact upon the labor force would still be SMALL. For example, Carbon County has the smallest labor force (7,744) in the region. It would require four ISL facilities to be constructed simultaneously to affect the labor market of Carbon County by more that 10 percent, if all the workers came from Carbon County. Construction of an ISL is likely, to the extent possible, to draw upon the labor force within the region before going outside the region (and state). The greatest economic benefit to the region would be to have the labor force drawn from within the region. However, economic benefit may still be achieved (in the form of the purchased of goods and services) even if the labor force is derived from outside the region. The potential impact upon smaller communities (Jeffrey City and Bairoil) and counties (Freemont) could be MODERATE.

Impacts to housing from construction activities would be expected to be SMALL (and short term) even if the workforce is primarily filled from outside the region. It is likely that the majority of construction workers would use temporary housing such as apartments, hotels, or trailer camps. Many construction workers use personal trailers for housing on short-term projects. Impacts on the region's housing market would therefore be considered SMALL. However, the impact upon specific facilities (apartment complexes, hotels, or campgrounds) could potentially be MODERATE, if construction workers concentrated in one general area.

Assuming the majority of employment requirements for construction is filled by outside workers (a peak of 200), there would be SMALL to MODERATE impacts to employment structure. The use of outside workforce would be expected to have MODERATE impacts to communities with high unemployment rates, such as Laramie, Wyoming, due to the potential increase in job opportunities. If the majority of construction activities relies on the use of a local workforce, impacts would be anticipated to be SMALL to MODERATE depending upon the size of the local workforce. Communities such as Fremont County and the Northern Arapaho and Eastern Shoshone Tribes of the Wind River Indian Reservation would experience MODERATE impacts, due to their high unemployment rate and potential increase in employment opportunities.

Local finance would be affected by ISL construction through additional taxation and the purchase of goods and services. Though Wyoming does not have an income tax, it does have a state sales tax (4 percent), a lodging tax (2–5 percent), and a use tax (5 percent). Construction workers are anticipated to contribute to these as they purchase goods and services within the region and within the state while working on an ISL facility. In addition, and more significant, is the “ad valorem tax” the state imposes on mineral extraction. In 2007 for uranium alone, the state collected $1.2 million from this tax (Wyoming Department of Revenue, 2008). It is anticipated that ISL facility development could have a MODERATE impact on local finances within the region.

Even if the majority of the workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to relocate their entire family for a relatively short duration (12–18 months). Impacts to education from a local workforce would also be SMALL, as they are already established in the community.

Potential impacts from construction [from either the use of local or outside (nonregional) workforce] to local health services such as hospitals or emergency clinics would be SMALL. Accidents resulting from construction of an ISL facility are not expected to be different than those from other types of similar industrial facilities.

4.2.10.2 Operational Impacts to Socioeconomics

Operational requirements of an ISL necessitate the use of specialized workers, such as plant managers, technical professionals, and skilled tradesmen. While operational activities would be longer term (20–40 years) than construction (12–18 months), instead of up to 200 workers, an operating ISL generally requires a labor force of from 50 to 80 personnel. If the majority of operational requirements is filled by a workforce from outside the region, assuming a multiplier of about 0.7 (see text box),

Economic Multipliers

The economic multiplier is used to summarize the total impact that can be expected from change in a given economic activity. It is the ratio of total change to initial change. The multiplier of 0.7 was used as a typical employment multiplier for the milling/mining industry (Economic Policy Institute, 2003).

there could be an influx of between 35 and 56 jobs (i.e., 50–80 × 0.7) per ISL facility (up to 140, including families). The potential impact to the local population and public services resulting from the influx of workers and their families would range from SMALL to MODERATE, depending upon the location (proximity to a population center) of an ISL within the region. However, because an outside workforce would be more likely to settle into a more populated area with increased access to housing, schools, services, and other amenities, these impacts may be reduced. If the majority of labor is of local origin, potential impacts to population and public services would be expected to be SMALL, as the workers would already be established in the region.

It is assumed, however, that because of the highly technical nature of ISL operation (requiring professionals in the areas of health physics, chemistry, laboratory analysis, geology and hydrogeology, and engineering), the majority (approximately 70 percent) of the work force (35 to 56 personnel) would be staffed from outside the region for, at least, the initial ISL facility. Subsequent ISL facilities may draw personnel from established or decommissioned facilities. This is expected to have a SMALL impact upon the regional labor force.

If it is assumed that as many as 56 families (80 workers × 0.7 economic multiplier) are required to relocate into the Wyoming West Uranium Milling Region, the most likely available housing markets would be located in the larger communities, such as Lander and Riverton (within the region) and Rawlins (located just outside the region). Unless the workforce is distributed throughout the region, the impact of an ISL on the housing market would be MODERATE, depending upon location, due to the limited number of available units.

Impacts to income and the labor force structure within the Wyoming West Uranium Milling Region would be similar to construction impacts, but longer in duration. Impacts from ISL operation would be SMALL to MODERATE, depending on where the majority of the workforce settles.

Assuming a local workforce is used, there would be SMALL impacts to the local employment structure similar to construction impacts. If the entire labor force for the ISL facility came from outside the affected community, the workforce would be SMALL to MODERATE relative to the employment structure for most of the affected counties. Impacts from inflow of an outside workforce would be similar to construction impacts.

Assuming the majority of the workforce is derived from outside the Wyoming West Uranium Milling Region, potential impacts to education from operation activities would be SMALL. Even though the number of people associated with an ISL facility workforce could be as many as 140 (including families), there would only be about 30 school-aged children involved. While the influx of new students would be the greatest in the smaller school districts, even in these districts the impacts are anticipated to be SMALL. For example, the city of Lander has one school district with 1,930 students (elementary through high school) in 12 schools. With an average of 160 students per school, even if all the ISL workers' children attended the same school (which is unlikely), the increase in that school's student population would be less than 20 percent.

Effects on other community services (e.g., health care, utilities, shopping, recreation) during operation are anticipated to be similar to construction (less in volume/quantity, but longer in duration). Therefore, the potential impacts would be SMALL.

4.2.10.3 Aquifer Restoration Impacts to Socioeconomics

The same ISL facility components and workforce would be involved in aquifer restoration as during operations use. Thus, the number of personnel involved would also be the same, and the potential impacts would be similar. These potential impacts would extend beyond the life of the facility (typically 2–10 years), but still would be SMALL.

Income and labor force requirements during aquifer restoration are anticipated to be the same as during operations (technical requirements are similar), and therefore potential impacts would be SMALL.

The employment structure during aquifer restoration would be expected to be unchanged and continue after the operational phase. However, a smaller number of specialized workers may be required to return the site to preISL levels. The potential impacts to the region would be considered SMALL.

Impacts to housing, education, health, and social services during aquifer restoration would also be expected to be the similar to operations, but continue beyond the life of the site. The overall potential impacts would be SMALL.

4.2.10.4 Decommissioning Impacts to Socioeconomics

Decommissioning is essentially deconstruction and is expected to require a similar work force (up to 200 personnel) with similar skills as the construction phase. The impacts to affected communities in the Wyoming West Uranium Milling Region during decommissioning would therefore be similar to the construction phase. The decommissioning phase may last up to a year longer than the construction phase, depending upon the condition of the ISL at termination. However, the overall potential impacts are still expected to be SMALL to MODERATE.

The income levels and labor force requirements during decommissioning are also anticipated to be similar to the construction phase, and the potential impacts to the region would therefore be considered SMALL to MODERATE.

The employment structure during decommissioning would be similar to the construction phase; however, a reduction of the workforce would result toward the end of the decommissioning phase. Impacts to employment would be SMALL to MODERATE.

Potential impacts to housing during the decommissioning phase would be similar to the construction phase and would be SMALL for the larger communities within the region, but may be MODERATE if the temporary housing was concentrated in a smaller community.

Decommissioning would be expected to involve similar numbers (up to 200) of workers (likely without families because of the short duration of the activity) as construction. Therefore, the anticipated impacts to the local education system would be SMALL.

Impacts to community services (health care, entertainment, shopping, recreation) would also be similar to construction, and thus, would be considered SMALL.

4.2.11 Public and Occupational Health and Safety Impacts

4.2.11.1 Construction Impacts to Public and Occupational Health and Safety

Construction activities involve building well fields, surface processing structures, and support roads (Section 2.3). Fugitive dust would result from construction activities and vehicle traffic but would likely be of short duration. For the Smith Ranch facility in Converse County, Wyoming (NRC, 2006), radiation measurements for soil show low levels of radionuclides. Therefore, inhalation of fugitive dust would not result in any significant radiological dose. Construction equipment would likely be diesel powered and would result in diesel exhaust, which includes small particles. The impacts from these emissions would be expected to be SMALL because the releases are usually of short duration and are readily dispersed into the atmosphere (Sections 2.7, 4.2.6.1). Construction would be expected to have a SMALL impact on the workers and general public.

4.2.11.2 Operation Impacts to Public and Occupational Health and Safety

4.2.11.2.1 Radiological Impacts to Public and Occupational Health and Safety From Normal Operations

Licensees are required to implement radiological monitoring and safety programs that comply with 10 CFR Part 20 requirements to protect the health and safety of workers and the public. NRC periodically inspects those programs to ensure compliance (Section 2.9).

Radionuclides can be released to the environment during ISL facility operation. As discussed in Section 2.7.1, radon gas is emitted from ISL well fields and processing facilities during operations and is the only radiological airborne effluent for those facilities that use vacuum dryer technology. Quarterly and biannual measurements of downwind concentrations of radon at an operational ISL facility boundary from 1991 to early 2007 were below 74 Bq/m^3 [2.0 pCi/L] with a majority of measurements below 37 Bq/m^3 [1 pCi/L] {an exception during the second half of 2003 where potentially anomalous results peaked at 137 Bq/m^3 [3.7 pCi/L]} (Crow Butte Resources, Inc., 2007). For comparison, these measured values are well below the NRC effluent limit for radon at 10 CFR Part 20, Appendix B of 370 Bq/m^3 [10 pCi/L].

Argonne National Laboratory developed the MILDOS-AREA computer code (Argonne National Laboratory, 1989) to calculate radiation doses to individuals and populations from releases occurring at operating uranium recovery facilities. The code is capable of modeling airborne radiological effluent releases applicable to ISL facilities (Section 2.7.1) including radon gas from well fields and processing facilities and yellowcake particulates from thermal drying operations, were applicable. MILDOS-AREA considers a variety of environmental pathways: external and inhalation and ingestion of soil, plants, meat, milk, aquatic foods, and water. Because a vacuum dryer system is assumed, the only releases are radon. MILDOS-AREA uses a sector-average Gaussian plume dispersion model to estimate downwind concentrations which assume the concentration is the same across the width of the sector. Historical environmental impact statements and environmental assessments were reviewed to provide a range of estimated offsite doses from various ISL facilities that are either currently active or were active in the past.

For the purposes of assessing doses to the general public from an ISL facility, annual estimated doses to offsite individuals are shown for various facilities in Table 4.2-2. This table also shows a descriptor of the location of the receptor as shown in the referenced report. Calculated doses in Table 4.2-2 are solely for radon releases for all sites listed except the Christensen Ranch and Irigaray sits that include radon and uranium particulate releases from drying operations. The remaining sites listed in Table 4.2-2 that have no yellowcake emissions use vacuum dryer technology or are satellite well fields that do not involve drying operations. The highest dose was reported for Reynolds Ranch in Converse County, Wyoming, but was for a potential receptor at an unoccupied house. All doses reported are well within the 10 CFR Part 20 annual radiation dose limit for the public of 1 mSv [100 mrem/yr] and within the EPA fuel cycle annual limit of 0.25 mSv [25 mrem], which does not include dose due to radon and its progeny. The dose received by the offsite individual is directly proportional to the amount of radioactive material released from the ISL facility. Variations in the size of the facility, the number of well fields in operation and restoration at any one time, and the facility processing flow rates can affect the dose. Downwind dose also decreases as a function of distance as discussed in Section 2.7.1. While receptor distances were not provided for all locations, doses could be

Table 4.2-2. Dose to Offsite Receptors From *In-Situ* Leach Facilities

Facility	Offsite Maximum Dose (mSv/mrem)	Description of Receptor	Reference
Crow Butte	0.317/31.7	0.4 km [0.25 mi] northeast of Central Plant site	Crow Butte Resources, Inc.*
Crow Butte	0.058/5.8	Closest resident downwind of North Trend Satellite Plant	Crow Butte Resources, Inc.*
Smith Ranch/ Sunquest Ranch	0.175/17.5	Nearest resident	NRC, 2007†
Smith Ranch/ Vollman Ranch	0.135/13.5	Nearest resident	NRC, 2007†
Reynolds Ranch	0.04/4	Nearest resident at Reynolds Ranch	NRC, 2006‡
Reynolds Ranch	0.27/27	Unoccupied Mason House	NRC, 2006‡
Gas Hills	0.07/7	Hypothetical individual on eastern boundary	NRC, 2004§
Christensen Ranch	0.006/0.6	Adult nearest resident	NRC, 1998‖
Irigaray	0.004/0.4	Adult nearest resident	NRC, 1998‖

*Crow Butte Resources, Inc. "License Renewal Application: SUA–1534." Crawford, Nebraska: Crow Butte Resources, Inc. 2007.
†NRC. "Environmental Assessment Construction and Operation of *In-Situ* Leach SR–2 Amendment No. 12 to Source Materials License No. SUA–1548 Power Resources, Inc. Smith Ranch-Highland Uranium Project (SR_HUP) Converse County, Wyoming." Docket No. 40-8964. Washington, DC: NRC. 2007.
‡NRC. "Environmental Assessment for the Addition of the Reynolds Ranch Mining Area to Power Resources, Inc.'s Smith Ranch/Highlands Uranium Project Converse County, Wyoming." Source Material License No. SUA–1548. Docket No. 40-8964. Washington, DC: NRC. 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.
‖NRC. "Environmental Assessment for Renewal of Source Material License No. SUA–1341. Docket No. 40-8502. Washington, DC: NRC. 1998.

expected to decrease as the receptor becomes further away from the source. Because of the distance to offsite receptors, radiological doses from normal operations are expected to have a SMALL impact on the general public.

It is expected that worker doses from ISL facilities would be similar regardless of the facility's location. This is because workers are expected to be involved in similar activities regardless of geographic location. As an example of dose to workers, the license renewal application for the Crow Butte ISL facility in Davis County, Nebraska (Crow Butte Resources, Inc., 2007), reports the average individual total effective dose equivalents for monitored employees for 1994–2006. This facility is assumed to be representative of an operating u0ranium recovery facility using ISL methods because it is a commercial facility with many years of operating history. The largest annual average dose during the time period was 7.00 mSv [700.0 mrem] in 1997. More recently, the maximum total effective dose equivalents were reported for 2005 and 2006 as 6.75 and 7.13 mSv [675 and 713 mrem], respectively. These doses represent 15 and 14 percent of the annual dose limit for workers of 0.05 Sv [5 rem], respectively.

As part of the Crow Butte ISL facility's license renewal application (Crow Butte Resources, Inc., 2007), average individual exposure levels for radon daughter products are provided for 1994–2006. Exposure to radon daughters is reported as working-level months, which is a unit commonly used in occupational environments and refers to exposure to a set concentration of radon and its associated progeny. The annual occupational exposure limit is 4 working-level months. Maximum individual internal exposure for radon daughters was 0.643 working-level months in 1997. Maximum values ranged from 0.213 working-level months to 0.643 for the entire 13-year period. Averages ranged from 0.101 working-level months to 0.467 working-level months for the period with the maximum of the averages occurring in 1997. Because these average and maximum exposure levels range from 2.5 to 16 percent of the occupational exposure limit of 4 working-level months, doses from normal radon releases would be expected to have a SMALL impact on the workers.

4.2.11.2.2 Radiological Impacts to Public and Occupational Health and Safety From Accidents

A radiological hazards assessment was performed by Mackin, et al. (2001) that considered the various stages within the ISL process. Consequences from accident scenarios were conservatively modeled and if the analyses revealed sufficiently small consequences, no further assessment was needed. If consequences were greater than regulatory limits, mitigating actions were explored. Likelihood of the accidents was not discussed.

Thickeners are used to concentrate the yellowcake slurry before it is transferred to the dryer as discussed in Section 2.4.2.3. Radionuclides could be inadvertently released to the atmosphere through a thickener failure and spill. For the purposes of the analysis, Mackin, et al. (2001) assumed a tank failure or pipe break that caused the tank contents to spill, with 20 percent of the thickener content being spilled inside and outside the building. Mackin, et al. (2001) analyzed this scenario for a variety of wind speeds, stability classes, release durations and receptor distances. For receptor distances of 100 and 500 m [330 and 1,600 ft] doses from such spills were calculated to be 0.25 and less than 0.01 mSv [25 and 1 mrem], respectively. Both of these are less than 25 percent of the 10 CFR Part 20 annual dose limit for the public of 1 mSv [100 mrem]. Because dose estimates increase for closer distances, smaller consequences would be expected to members of the public in urban developments. There could be external doses from the spill to workers, but offsite individuals would be too far away to observe any effects. Doses to the unprotected worker could exceed the 0.05 Sv [5 rem] annual dose limit specified in 10 CFR Part 20 if workers did not evacuate the area soon enough after the accident. ISL facilities are designed to contain controls to possibly reduce the exposure to individuals in the event of an accident, and spills or leaks would normally be detected by loss of system pressure, observation, or flow imbalance. Operating procedures are developed for spill response. Air samples are also routinely collected and action levels are set at 25 percent of limits so that samples can be taken more frequently and investigations can be undertaken.

Radon-222 released to the air, especially in an enclosed area without adequate ventilation, presents a potential hazard. A pipe or valve failure at the ion-exchange columns used in ISL processing facilities could be a source for such a hazard (Mackin, et al., 2001). Dose calculations were performed assuming the highest radon-222 concentration {3×10^4 Bq/L [8×10^5 pCi/L]} that was reported inside a uranium recovery facility, and all the radon-222 contained within the pregnant lixiviant was assumed to be instantaneously released into the facility. For a 30-minute exposure, doses to a worker within the building performing light activity without respiratory protection was 1.3×10^{-2} Sv [1.3 rem], which is 26 percent of the 0.05 Sv [5 rem] annual dose limit specified in 10 CFR Part 20. Mackin, et al. (2001) did not calculate doses to offsite individuals for this scenario. Even though radon concentration within the facility could be high if such a scenario occurred, only a small amount would be released to the environment to potentially expose a member of the public 500 m [1,640 ft] away, because not much radon is expected to leave the building. ISL facilities are designed to contain controls to possibly reduce the exposure to individuals in the event of an accident. Air samples are also routinely collected, and action levels are set at 25 percent of limits so that samples can be taken more frequently and investigations can be undertaken.

Dryers used to turn wet yellowcake into dry powder present another potential hazard at an ISL facility (NRC, 1980). The two main types of dryers used are multihearth dryers for the older facilities and rotary vacuum dryers for the new facilities. The multihearth dryers are assumed to be more hazardous than the rotary vacuum dryers because they operate at higher temperatures and may be direct gas-fired. An explosion in the dryer could disperse yellowcake into the central processing facility. Using a conservative assumption about the amount released {1 kg [2.2 lb]} and the fraction respirable (100 percent), the dose to offsite individuals at 200 m [656 ft] was below the 10 CFR Part 20 public dose limit of 1 mSv [100 mrem]. The analyses also showed that dose to a worker in a full-face-piece powered air-purifying respirator would result in a dose of 0.088 Sv [8.8 rem], which would exceed the annual worker dose limit of 0.05 Sv [5 rem] by 76 percent. ISL facilities are designed to contain controls to possibly reduce the exposure to individuals in the event of an accident. Emergency response procedures would be in place to direct employees what to do in the event of an accident. As part of worker protection, respiratory protection programs would be in place.

In the unlikely event of an unmitigated accident, doses to the workers could have a MODERATE impact depending on the type of accident, but doses to the general public would have only a SMALL impact.

In addition to the mitigation items discussed after each accident, additional measures would be in place to protect workers and members of the public. Employee personnel dosimetry programs are required. As part of worker protection, respiratory protection programs are in place as well as bioassay programs that detect uranium intake in employees. Contamination control programs involve surveying personnel, clothing, and equipment prior to their removal to an unrestricted area.

4.2.11.2.3 Nonradiological Impacts to Public and Occupational Health and Safety From Normal Operations

While hazardous chemicals are used at ISL facilities (Section 2.4.2), small risks would be expected in the use and handling of these chemicals during normal operations at ISL facilities. However, accidental releases of these hazardous chemicals can produce significant consequences and impact public and occupational health and safety. An analysis of such hazards and potential risks for impacts is provided in the following section.

4.2.11.2.4 Nonradiological Impacts to Public and Occupational Health and Safety From Accidents

ISL facilities use hazardous chemicals to extract uranium, process wastewater, and restore groundwater quality. As described in Section 2.4.2 and shown in Table 2.11-2, the following 11 hazardous chemicals are typically used at ISL facilities in the largest quantities:

- Ammonia
- Sodium hydroxide
- Sulfuric acid
- Hydrochloric acid
- Oxygen
- Hydrogen peroxide
- Carbon dioxide
- Sodium carbonate
- Sodium chloride
- Hydrogen sulfide
- Sodium sulfide

If released, these chemicals could pose significant hazards to public and occupational health and safety. As with other industrial operations, releases of hazardous chemicals of sufficient magnitude to adversely impact public and occupational health and safety are possible, but are generally considered unlikely, given commonly applied safety practices and the history of safe use of these chemicals at NRC-regulated ISL facilities.

An accident analysis for each of these chemicals is provided in Appendix E. As shown in the accident analyses, chemicals commonly used at ISL facilities can pose a serious safety hazard if not properly handled. In addition, strong bases such as ammonia (NH_3) and sodium hydroxide (NaOH) and strong acids such as sulfuric acid (H_2SO_4) and hydrochloric acid (HCl) will strongly react with each other, and with water, if accidentally mixed. During operations, precautions are taken to ensure that these chemicals do not inadvertently come into contact with each other. Oxidizers such as hydrogen peroxide (H_2O_2) and oxygen (O_2) also can react strongly with natural gas (piped to the ISL facility) should a spark or ignition source be present.

Potential hazards to workers or the public due to specific types of high consequence, low probability accidents (e.g., a fire or large magnitude sudden release of chemicals from a major tank or piping system rupture) are not specifically analyzed in Appendix E. The application of common safety practices for handling and use of chemicals is expected to lower the likelihood of these severe release events and therefore lower the risk to acceptable levels. The use of hazardous chemicals at ISL facilities is not regulated by NRC, but rather by government agencies such as the Mine Safety and Health Administration, the Occupational Safety and Health Administration, and EPA.

Standards for handling and managing hazardous chemicals in the workplace have been developed by relevant regulatory agencies and industries. NRC's authority does not include developing, modifying, or critiquing these standards. Nonetheless, NRC inspectors of ISL facilities report any concerns about the use of hazardous chemicals to these agencies. The standards generally apply to all types of facilities including uranium ISL facilities. Specific quantities or uses of chemicals that require certain controls, procedures, or safety measures are defined in these standards. Key aspects of five applicable regulations are presented here:

- 40 CFR Part 68, Chemical Accident Prevention Provisions. This regulation lists regulated toxic substances and threshold quantities for accidental release prevention.

- 29 CFR 1910.119, Occupational Safety and Health Administration Standards—Process Safety Management of Highly Hazardous Chemicals. This regulation lists highly hazardous chemicals and toxic and reactive substances (chemicals that can potentially cause a catastrophic event at or above the threshold quantity).

- 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response. This regulation instructs employers to develop and implement a written safety and health program for their employees involved in hazardous waste operations. The program shall be designed to identify, evaluate, and control safety and health hazards and provide for emergency response for hazardous waste operations.

- 40 CFR Part 355, Emergency Planning and Notification. This regulation lists extremely hazardous substances and their threshold planning quantities so that emergency response plans can be developed and implemented. There are about 360 extremely hazardous substances. Over a third of them are also Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) hazardous substances. This regulation also lists reportable quantity values for these substances for reporting releases. The reportable quantities are for any CERCLA hazardous substances identified in 40 CFR Part 302, Table 302.4.

- 40 CFR 302.4, Designation, Reportable Quantities, and Notification—Designation of Hazardous Substances. This regulation lists CERCLA hazardous substances. There are approximately 800 of these substances, and they are compiled from the (1) Clean Water Act, Sections 311 and 307(a); (2) Clean Air Act, Section 112; (3) Resource Conservation and Recovery Act, Section 3001; and (4) Toxic Substance Control Act, Section 7.

Requirements from these regulations for the chemicals in use at uranium ISL facilities are summarized in Table 4.2-3. Comparing these requirements with typical onsite quantities shown in Table 2.10.3 indicates there is a potential that some of the chemicals may exceed the minimum reporting quantities in Table 4.2-3. This would trigger an increased level of regulatory oversight regarding possession, storage, use, and subsequent disposal of these chemicals. Compliance with the necessary requirements (see Appendix E) would reduce the likelihood of a release. Offsite impacts would be SMALL, while impacts to workers involved in response and cleanup could receive MODERATE impacts that would be mitigated by establishing procedures and training requirements.

4.2.11.3 Aquifer Restoration Impacts to Public and Occupational Health and Safety

Because the activities during aquifer restoration overlap with similar operational activities (e.g., operation of well fields, wastewater treatment and disposal), the types of impacts on public and occupational health and safety are expected to be similar to operational impacts. The reduction of some operational activities (e.g., yellowcake production and drying, remote ion exchange) further limits the relative magnitude of potential worker and public health and safety hazards. Therefore, aquifer restoration is expected to have a SMALL impact on workers (primarily from radon gas) and the general public.

Table 4.2-3. Pertinent Regulations for Chemicals Used at *In*-Situ Leach Facilities

Chemical	Regulations	Minimum Reporting
Ammonia (NH_3)	Threshold Quantity from Clean Air Act for 40 CFR Part 68 Risk Management Planning	4,536 kg [10,000 lb]
	Threshold Quantity for Occupational Safety and Health Administration (OSHA) 29 CFR 1910.119 Process Safety Management	4,536 kg [10,000 lb]
	Threshold Planning Quantities for 40 CFR Part 355 Emergency Response Plans	227 kg [500 lb]
	Reportable Quantity for Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) from 40 CFR 302.4	45.4 kg [100 lb]
Sulfuric Acid (H_2SO_4)	Threshold Planning Quantities for 40 CFR Part 355 Emergency Response Plans	454 kg [1,000 lb]
Hydrogen Peroxide (H_2O_2)	Threshold Planning Quantities for 40 CFR Part 355 Emergency Response Plans (concentration >52%)	454 kg [1,000 lb]
	Threshold Quantity for OSHA for 29 CFR 1910.119 Process Safety Management (concentration >52%	3,402 kg [7,500 lb]
Oxygen (O_2)	Not Listed in any of the four regulations	NA*
Carbon Dioxide (CO_2)	Not listed in any of the four regulations	NA
Sodium Carbonate (Na_2Co_3)	Not listed in any of the four regulations	NA
Sodium Chloride (NaCl)	Not Listed in any of the four regulations	NA
Barium Chloride ($BaCl_2$)	Not listed in any of the four regulations	NA

Table 4.2-3. Pertinent Regulations for Chemicals Used at *In*-Situ Leach Facilities (continued)

Chemical	Regulations	Minimum Reporting
Hydrochloric Acid (HCl)	Threshold Quantity from Clean Air Act for 40 CFR Part 68 Risk Management Planning (concentration >37%)	6,804 kg [15,000 lb]
	Threshold Quantity from OSHA for 29 CFR 1910.119 Process Safety Management (for anhydrous HCl)	2,268 kg [5,000 lb]
	Reportable Quantity for CERCLA from 40 CFR 302.4	2,268 kg [5,000 lb]
Hydrogen Sulfide (H_2S)	Threshold Quantity from CAA for 40 CFR Part 68 Risk Management Planning	4,536 kg (10,000 lb)
	Threshold Quantity from OSHA for 29 CFR 1910.119 Process Safety Management	680 kg (1,500 lb)
	Threshold Planning Quantities for 40 CFR Part 355 Emergency Response Plans	227 kg (500 lb)
	Reportable Quantity for CERCLA from 40 CFR 302.4	45.4 kg (100 lb)
Sodium Sulfide (Na_2S)	Not Listed in any of the four regulations	NA
*NA = Not applicable		

4.2.11.4 Decommissioning Impacts to Public and Occupational Health and Safety

There can be SMALL environmental impacts during ISL facility decommissioning that would be expected to decrease as hazards are removed or reduced, surface soils and structures are decontaminated, and disturbed lands are reclaimed.

To ensure the safety of workers and the public during decommissioning, the NRC requires licensed facilities submit a decommissioning plan for review (Section 2.6). Such a plan includes details of how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable safety regulations are complied with. A combination of (1) NRC review and approval of these plans, (2) the application of site-specific license conditions where necessary, and (3) regular NRC inspection and enforcement activities to ensure compliance with radiation safety requirements constrain the magnitude of potential public and occupational health impacts from ISL facility decommissioning actions to SMALL levels.

4.2.12 Waste Management Impacts

ISL facilities generate radiological and nonradiological liquid and solid wastes that must be handled and disposed of properly. Waste streams and waste management practices applicable to ISL facilities are described in Section 2.7. Radiation safety associated with the collection, handling, and storage of waste materials is maintained at all ISL facilities through the application of an NRC approved radiation safety program compliant with the requirements at 10 CFR Part 20 (Section 2.9). Before operations begin, NRC requires an ISL facility to have an agreement in place with a licensed disposal facility to accept 11e.(2) byproduct wastes that would be associated with facility operations, aquifer restoration, and decommissioning. Such agreements ensure sufficient disposal capacity for 11e.(2) byproduct wastes would be available throughout the life of the facility. Transportation impacts associated with waste management are discussed in Section 4.2.2, which characterizes impacts as SMALL. Overall, waste management impacts would be SMALL. Specific impact discussions for each phase of the ISL facility lifecycle are discussed in the following sections.

4.2.12.1 Construction Impacts to Waste Management

The relatively small scale of construction activities (Section 2.3) and incremental development of well fields at ISL facilities generate low volumes of construction waste. Table 2.7-1, which includes a listing of engine-driven construction equipment needed for construction of a satellite ISL facility, provides some insight into the magnitude of well field construction activities. As a result of the limited volumes of construction waste that would be generated during construction of a new ISL facility, waste management impacts from construction would be SMALL.

4.2.12.2 Operation Impacts to Waste Management

As discussed in Section 2.7, operational wastes are primarily liquid waste streams consisting of process bleed (1 to 3 percent of the process flow rate) and aquifer restoration water. Wastes would also be generated from well development, flushing of depleted eluant to limit impurities, resin transfer wash, filter washing, uranium precipitation process wastes (brine), and plant washdown water. The methods used for handling and processing these wastes include water treatment (with barium chloride, and reverse osmosis), followed by disposal methods involving evaporation ponds, land application, deep well injection, and surface water discharge. The treatment and disposal methods are effective at separating wastes to reduce waste volumes destined for disposal at an approved facility, thereby reducing waste-related environmental impacts. State permitting actions, NRC license conditions, and NRC inspections ensure the proper practices would be used to comply with safety requirements to protect workers and the public, and overall impacts would be SMALL.

Both surface discharge and deep well injection are liquid wastewater disposal methods that require special approval and permits designed to limit potential impacts to either surface or ground waters. Licensees must obtain a UIC permit from EPA or the appropriate state agency, and obtain NRC approval (Section 1.7.2). Surface discharge of treated wastewaters to local waterways, including ephemeral stream channels, would be approved by the NPDES permitting process (Section 1.8). Water discharged in this way must be treated to remove contaminants to meet state and federal water quality standards. These permit approval processes provide confidence that potential environmental impacts would be limited. Therefore, impacts would be SMALL, whether from surface discharge or deep well injection activities.

Evaporation ponds (Section 2.7.2) would be constructed, operated, and monitored for leakage in accordance with NRC regulations at 10 CFR Part 40, Appendix A. Leaks may still occur over the operational life of a pond; however, the pond design helps to contain leaks and the monitoring would detect leaks before a significant release of material to the environment occurs. The licensee is also required to maintain sufficient reserve capacity in the retention pond system to enable the contents of a pond to be transferred to other ponds in the event of a leak. The residual solid waste materials normally remain in ponds until the ponds are decommissioned and sludges are disposed of as 11e.(2) byproduct material at a licensed disposal facility (Section 2.6). The aforementioned required agreement with a licensed facility prior to operations ensures disposal capacity is available to accept evaporation pond waste when an ISL facility is eventually decommissioned. As a result, impacts from the use of ponds would be SMALL.

Land application of treated wastewater (Section 2.7.2) could potentially impact soils by allowing accumulation of residual radiological or chemical constituents in the irrigated soils that were not removed from the water during treatment. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive and other constituents (e.g., arsenic, selenium, molybdenum) within allowable release standards. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to ensure release limits would be met and soil sampling to establish background and monitor for uranium, radium, and other metals. Land that is used for irrigation is also included in decommissioning surveys to ensure potentially impacted (contaminated) areas would be appropriately characterized and remediated, as necessary, in accordance with NRC regulations. Because of the NRC review of site-specific conditions prior to approval, the routine monitoring program, and the inclusion of irrigated areas in decommissioning surveys, the impacts from land application of treated wastewater would be SMALL.

Solid wastes generated from operations that are classified as 11e.(2) byproduct wastes can be sent to a licensed facility for disposal. Contaminated materials, equipment, and buildings would be similarly disposed or decontaminated and released for unrestricted use according to NRC requirements. Nonradioactive hazardous wastes would be segregated and disposed of at a hazardous waste disposal facility. Nonradiological uncontaminated wastes are disposed of as ordinary solid waste at a municipal solid waste facility. Disposal impacts would be SMALL for radioactive wastes as a result of required preoperational disposal agreements. Impacts for hazardous and municipal waste would also be expected to be SMALL, assuming the amount of contaminated soil is SMALL. For remote areas with limited available disposal capacity, such wastes may need to be shipped greater distances to facilities that have capacity; however, the number of such shipments would still be low (Section 2.8).

4.2.12.3 Aquifer Restoration Impacts to Waste Management

Waste management activities during aquifer restoration utilize the same treatment and disposal options implemented for operations; therefore, impacts associated with aquifer restoration would be similar to the operational impacts discussed in Section 4.2.12.2. Additional wastewater volume and the associated volume of water treatment wastes may be generated during aquifer restoration; however, this would be offset to some degree by the reduction in production capacity from the removal of a well field from production activities. While the amount of wastewater generated during aquifer restoration is dependent on site-specific conditions, Section 2.5.2 provides an illustrative estimate of water volume per pore volume and Section 2.11.5 provides experience regarding the number of pore volumes required for aquifer restoration in past efforts. Furthermore, the NRC review of future ISL facility licensing would verify that sufficient water treatment and disposal capacity (and the associated agreement for disposal of byproduct material discussed in Section 4.2.12) are addressed. As a result, waste management impacts from aquifer restoration would be SMALL.

4.2.12.4 Decommissioning Impacts to Waste Management

There can be SMALL environmental impacts during ISL facility decommissioning, even though the overall goal is to reduce impacts by removing facilities and restoring disturbed lands to preoperational conditions.

Waste disposal is an unavoidable, but SMALL, impact associated with decommissioning an ISL facility. 11e.(2) byproduct wastes from decommissioning ISL facilities (including contaminated excavated soil, evaporation pond bottoms, process equipment) can be disposed at a licensed facility. NRC regulations (10 CFR Part 40, Appendix A, Criterion 2) require that 11e.(2) byproduct material be disposed at existing disposal sites unless such offsite disposal is impractical or the benefits of onsite disposal clearly outweigh those of reducing the number of waste disposal sites. Licensees are required to have an agreement in place with a licensed disposal facility prior to starting operations. Requiring such an agreement ensures sufficient disposal capacity will be available for 11e.(2) byproduct wastes generated by decommissioning activities.

Ensuring safe handling, storage, and disposal of decommissioning wastes is addressed by requiring licensed facilities to submit a decommissioning plan for NRC review (Section 2.6) prior to starting decommissioning activities. Such a plan would include details of how a 10 CFR Part 20 compliant radiation safety program (Section 2.9) would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable safety regulations are complied with. NRC and NRC licensee actions provide assurance that potential radiation safety impacts associated with waste management during decommissioning are minimized. These actions include (1) the licensee's conduct of decommissioning in accordance with an NRC-approved plan; (2) the licensee's compliance with site-specific NRC license conditions, as needed; and (3) regular NRC inspection activities to determine compliance with the appropriate radiation safety regulations and requirements. Therefore, the potential waste management radiation safety impacts from ISL facility decommissioning would be SMALL.

The estimated volume of decommissioning wastes for a large ISL facility (i.e., Smith Ranch, Table 2.11-1) is provided in Table 2.6-1. The total volume of estimated byproduct waste is approximately 4,593 m^3 [6,008 yd^3] or about 300 truckloads. To state this another way, this volume would occupy a hypothetical cube that is approximately 17 m [18 yd] on each side. This waste would be generated over an estimated period of 2 to 3 years for completion of decommissioning activities. The more concentrated waste material such as pond sludge from decommissioning an ISL facility is the equivalent of about three truckloads of waste material (Sections 2.6 and 2.7). Section 4.2.2 addresses potential impacts from transportation of waste materials. Nonradioactive, uncontaminated solid wastes are recycled, buried onsite, or disposed of as municipal waste. If buried onsite, a state permit (authorization) would be required. The total volume of solid wastes estimated for a large ISL facility (i.e., Smith Ranch, Table 2.11-1) is approximately 715 m^3 [935 yd^3] {e.g., this volume would occupy a hypothetical cube that is approximately 9 m [10 yd] on each side} or about 47 truckloads. The nature of potential impacts associated with disposal of uncontaminated solid wastes from decommissioning would be similar to those described for operations in Section 4.2.12.2 because the waste management practices are the same. The magnitude of uncontaminated solid wastes from decommissioning is larger than comparable operational waste volumes but would not present any unique problems regarding available disposal capacity. Facilities in locations with limited solid waste disposal capacity may need to ship waste for longer distances, but the number of shipments would be similar to that for a similarly sized site in a region with ample disposal capacity. The required preoperational agreement for disposal of byproduct material and the small volume of solid waste generated for offsite disposal suggest the waste management impacts would be SMALL. Related transportation impacts are discussed separately in Section 4.2.2.

4.2.13 References

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4.3 Wyoming East Uranium Milling Region

4.3.1 Land Use Impacts

Information on ISL facility size (Section 2.11) and the types of potential impacts to land use described for the Wyoming West Uranium Milling Region in Section 4.2.1 would also generally apply for ISL facilities in the Wyoming East Uranium Milling Region.

4.3.1.1 Construction Impacts to Land Use

The overall landscape and land uses in the Wyoming East Uranium Milling Region are similar to those of the Wyoming West Uranium Milling Region. Therefore, the types of construction impacts to land use from new ISL facilities in the Wyoming East Uranium Milling Region would be expected to be similar to those described for the Wyoming West Uranium Milling Region. Construction activities would (1) change and disturb the land uses, (2) restrict access and establish right-of-way for access, (3) affect mineral rights, (4) restrict livestock grazing areas, (5) restrict recreational activities, and (6) alter ecological, cultural, and historical resources (Section 4.2.1.1). Land use impacts would differ in that the Wyoming East Uranium Milling Region has a larger percentage of private land surface ownership than the Wyoming West Uranium Milling Region. Consequently, there are likely more split-estate situations in this east region than in the west region. This could lead to potential impacts that would need to be resolved through arrangements (e.g., leases, mineral rights sales, royalties) with individual land owners. The uranium districts in this region are generally located in a mix of private lands and lands managed by the BLM and U.S. Forest Service.

Potential impacts to most aspects of land use from the construction of an ISL facility would be SMALL. This is because (1) the amount of area disturbed by the construction would be small in comparison to the available lands; (2) the majority of the site would not be fenced; (3) potential conflicts over mineral access would be expected to be negotiated and agreed upon; (4) only a small portion of the available land would be restricted from grazing; and (5) the open spaces for hunting and off-road vehicle access would be minimally impacted by the fencing associated with the ISL facility. Potential impacts to historic and cultural resources would range from SMALL to LARGE, depending on site-specific conditions, as resources not previously identified could be altered or destroyed during excavation, drilling, and grading activities.

4.3.1.2 Operation Impacts to Land Use

The type of land use impacts for operational activities is expected to be similar to construction impacts regarding access restrictions because the infrastructure would be in place. Additional land disturbances would not be expected from conducting the operational activities described in Section 2.4. During the operational period of an ISL facility, the primary changes to land use would be the development (sequencing) of well fields from one area of the site to another; this is addressed as a construction impact in Section 4.3.1.1. Sequentially moving active operations from one well field to the next would shift potential impacts. For example, a well field where uranium recovery activities have ceased could be restored and fully reopened for grazing or recreation while a new well field is being developed elsewhere, which would have impacts similar to those described in the preceding section for the construction phase. Because access restriction and land disturbance impacts would be similar to or less than those expected for construction, the overall potential impacts to land use from operational activities would be SMALL.

4.3.1.3 Aquifer Restoration Impacts to Land Use

During aquifer restoration, the land use impacts described previously for the construction phase and the operations phase would be similar. In terms of specific activities, aquifer restoration uses the same infrastructure as the operations phase and maintenance would be at a similar level. Land use impacts from aquifer restoration would decrease as fewer wells and pump houses are used and overall equipment traffic and use diminish. Thus, the overall potential impacts to land use during the aquifer restoration phase are comparable to those of the operations phase and would be SMALL.

4.3.1.4 Decommissioning Impacts to Land Use

The types of decommissioning impacts to land use would be similar to the impacts described for this region during the construction, operations, and aquifer restoration phases, but the intensity of activities disturbing the land uses would temporarily increase relative to operations due to increased use of earth- and material-moving equipment and other heavy equipment. As decommissioning and reclamation proceed, the amount of disturbed land would decrease, and the overall potential impacts to land use during the decommissioning phase would range from SMALL to MODERATE.

4.3.2 Transportation Impacts

Truck and automobile use is associated with all activities during the ISL facility lifecycle including construction, operation, aquifer restoration, and decommissioning. The estimated low magnitude of road transportation from all phases of the ISL lifecycle (Section 2.8), when compared with local traffic volumes in the Wyoming East Uranium Milling Region (Section 3.3.2), is not expected to significantly change the amount of traffic or accident rates. One possible exception to this conclusion is that commuting traffic for facility workers, in particular, during periods of peak employment (during construction), would have greater impacts when roads with the lowest levels of current traffic are traveled. These low traffic roads may also be more susceptible to wear and tear from increased traffic. Localized intermittent and temporary SMALL to MODERATE impacts associated with noise, dust, and incidental livestock or wildlife kills are possible on all roads but in particular on remote local and unpaved access roads. The magnitude of these impacts would be influenced by site-specific conditions including the proximity of local residential housing, other regularly occupied structures, wildlife habitat, farming, or grazing areas to ISL facility access roads. Unique local road and environmental conditions (e.g., local hazards, local resource impacts) would be considered in an NRC site-specific environmental review. Potential local impacts include loss of forage palatability from road dust and interference with livestock herding and grazing activities. A more detailed assessment of transportation impacts for each phase of the ISL facility lifecycle is provided in the following sections.

4.3.2.1 Construction Impacts to Transportation

ISL facilities, in general, are not large-scale or time-consuming construction projects (Sections 2.3 and Table 2.7-1). The magnitude of estimated construction-related transportation

(Section 2.8) is expected to vary depending on the size of the facility; however, when considered with the regional traffic counts provided in Section 3.3.2, most roads that would be used for construction transportation in the Wyoming East Uranium Milling Region would not gain significant increases in daily traffic, and therefore traffic-related impacts would be SMALL. Roads with the lowest average annual daily traffic counts would have higher (MODERATE) traffic and potential infrastructure impacts, in particular, when facilities are experiencing peak employment. The limited duration of construction (12–18 months) activities suggest impacts would be of short duration in many areas where an ISL facility would be sited. Temporary SMALL to MODERATE dust, noise, and incidental livestock or wildlife kill impacts are possible on or in the vicinity of access roads used for construction transportation.

4.3.2.2 Operation Impacts to Transportation

The discussion of impacts in Section 4.2.2.2 for the Wyoming West Uranium Milling Region also applies to the Wyoming East Uranium Milling Region because (1) the same types of transportation activities would be conducted regardless of location, (2) the same regulatory controls and safety practices apply, (3) the same magnitude of transportation activities would be conducted, and (4) the assessment of accident risks is generally applicable to all regions. Applicable transportation conditions for the Wyoming East Uranium Milling Region are discussed in Section 3.3.2. The magnitude of existing traffic conditions in the region is similar to that described for Wyoming West with regard to potential impacts, and therefore operational traffic related impacts would be similar: SMALL to MODERATE. The methods and assumptions considered in the accident analysis in Section 4.2.2.2 for yellowcake shipments are applicable to the Wyoming East Uranium Milling Region, and therefore the impact from yellowcake, resin transfer, and byproduct waste shipments would be SMALL. The same practices and requirements that serve to limit the risks from chemical shipments for the Wyoming West Uranium Milling Region would also apply to the Wyoming East Uranium Milling Region and would result in SMALL impacts.

4.3.2.3 Aquifer Restoration Impacts to Transportation

Aquifer restoration transportation impacts are expected to be less than those described for construction and operations because transportation activities would be primarily limited to supplies (including chemicals), chemical waste shipments, onsite transportation, and employee commuting. No additional unique transportation activities are expected during aquifer restoration; therefore, no additional types of impacts associated with aquifer restoration are anticipated and impacts would be SMALL to MODERATE.

4.3.2.4 Decommissioning Impacts to Transportation

Decommissioning 11e.(2) byproduct wastes (as defined in the Atomic Energy Act) can be shipped offsite by truck for disposal at a licensed disposal site. Section 2.8 provides estimates of the number of decommissioning-related waste shipments, which are small compared to average annual daily traffic counts provided in Section 3.3.2. All radioactive waste shipments must be shipped in accordance with the applicable NRC safety requirements in 10 CFR Part 71. As shown in Section 2.8, the number of estimated decommissioning waste shipments is fewer than those needed to support facility operations, and therefore potential traffic and accident impacts are expected to decrease during the decommissioning period. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments owing to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Commuting impacts would decrease from peak employment due to cessation of operations, though this effect would be offset to some degree by an increase in decommissioning workers. Overall, based on the magnitude of transportation activities expected during decommissioning, impacts would be SMALL.

4.3.3 Geology and Soils Impacts

Construction, operation, aquifer restoration, and decommissioning activities and processes at ISL facilities may impact geology and soils. The potential impacts on geology and soils from these activities in the Wyoming East Uranium Milling Region are discussed in the following sections.

4.3.3.1 Construction Impacts to Geology and Soils

During construction of ISL facilities, the principal impacts on geology and soils would result from earth-moving activities associated with constructing surface facilities, wastewater evaporation ponds, access roads, well fields, and pipelines (Section 2.3). Earth-moving activities would include

- Clearing of ground or topsoil and preparing surfaces for the processing plant, satellite facilities, pump houses, access roads, drilling sites, and associated structures

- Excavating and backfilling trenches for pipelines and cables

- Excavating evaporation ponds and developing evaporation pond embankments

The impact of construction activities on geology and soils will depend on local topography, surface bedrock geology, and soil characteristics. Construction activities at ISL facilities in the Wyoming East Uranium Milling Region may increase the potential for erosion from both wind and water due to the removal of vegetation and the physical disturbance from vehicle and heavy equipment traffic. Likewise, compaction of soils and removal of vegetation resulting from construction activities may increase the potential for surface runoff and sedimentation in local drainages and streams outside disturbed areas.

Generally, earth-moving activities would result in only SMALL (on average, approximately 15 percent of permitted site area) and temporary (months) disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Chapter 7). For example, soil horizons would be disrupted to construct the processing facilities, evaporation ponds, and well field houses. In the well field, soil disturbance will be limited to drill pad grading, mud pit excavation, well completion, and constructing access roads.

Operators of ISL facilities typically adopt best management construction practices to prevent or substantially reduce soil impacts (see Table 7.4-1). For example, soils removed during construction of surface facilities are generally stockpiled and stabilized for later use during decommissioning and land reclamation. These stockpiles are typically located, shaped, and seeded with a cover crop by the operator to control erosion. Other practices include constructing structures to divert surface runoff from undisturbed areas around disturbed areas;

using silt fencing, retention ponds, and hay bales to retain sediment within the disturbed areas; and reestablishing native vegetation as soon as possible after disturbance.

As part of the underground infrastructure at ISL facilities, a network of buried process pipelines and cables is constructed. Pipeline systems are installed between the pump house and well field for injecting and recovering lixiviant, between the pump house and the satellite facility or processing plant for transporting lixiviant and resin, and between the processing facilities and deep injection wells. Trenches for the pipelines are excavated as deep as 1.8 m [6 ft] below the ground to avoid any potential freezing problem. Operators typically segregate topsoil from subsoil (i.e., underlying rock) when excavating trenches so that the general soil profile can be restored during backfilling. Excavating trenches for pipelines and cables normally results in only small and temporary disturbance of rock and soil. After piping and cable are placed in the trenches, the trenches are backfilled with the excavated rock and soil and graded to surrounding ground topography.

Based on the above discussion, the impacts of construction activities on geology and soils at ISL facilities in the Wyoming East Uranium Milling Region would be SMALL, because of the duration of the activity (months), the limited affected area (on average, approximately 15 percent of the permitted site area), and the relatively shallow depth of excavation involved {1.2–1.8 m [4–6 ft]}.

4.3.3.2 Operation Impacts to Geology and Soils

During ISL operations (Section 2.4), a non-uranium-bearing (barren) solution or lixiviant is injected through wells into the mineralized zone. The lixiviant moves through the pores in the host rock, dissolving uranium and other metals. Production wells withdraw the resulting "pregnant" lixiviant, which now contains uranium and other dissolved metals, and pump it to a central processing plant or to a satellite processing facility for further uranium recovery and purification.

The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the mineralogical composition of uranium-producing formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. In addition, the source formations for uranium in the Wyoming East Uranium Milling Region occur at depths of hundreds of meters [hundreds of feet] (Section 3.3.3) and individual mineralization fronts are typically 0.6 to 7.5 m [2 to 25 ft] thick (Section 3.1.2). At these depths and thicknesses and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. Therefore, impacts on geology from ground subsidence are expected to be SMALL, if any.

The pressure of the producing aquifer is decreased by injecting solutions during operation activities because a negative water balance is maintained in the well field to ensure water flows into the well field from its edges, reducing the spread of contamination. This change in pressure theoretically could impact the transmissivity of faults in permitted areas. However, because uranium-producing sandstones tend to be highly porous and transmissive, it is unlikely that changes in fluid pressure would reactivate faults or trigger or induce earthquakes. Based on historical ISL operations, reactivation of faults is not anticipated in the Wyoming East Uranium Milling Region.

A potential impact to soils arises from the necessity to move barren and pregnant uranium-bearing lixiviant to and from the processing facility in aboveground and underground pipelines. If a pipe ruptures or fails, lixiviant can be released and (1) pond on the surface, (2) runoff into surface water bodies, (3) infiltrate and adsorb in overlying soil and rock, or (4) infiltrate and percolate to groundwater. For example, from 2001 to 2007, the operators of the Smith Ranch-Highlands uranium recovery facility in Converse County, Wyoming, reported spills ranging from a 190- to 380-L [50- to 100-gal] spill in February 2004 to a 751,400-L [198,500-gal] spill in June 2007 (WDEQ, 2007; NRC, 2006). The spills most commonly involved injection fluids {0.5 to 3.0 mg/L uranium [0.5 to 3.0 parts per million]}, although spills of production fluids {10.0 to 15.5 mg/L uranium [10.0 to 15.5 parts per million]} also have occurred. The predominant cause for these spills has been the failure of joints, flanges, and unions of pipelines as well as failures at wellheads (NRC, 2006). The large June 2007 release involved a spill of injection fluids resulting from a failed fitting. The spill flowed into drainage and continued downstream for about 700 m [2,300 ft], affecting an estimated area of 0.44 ha [1.08 acres] (WDEQ, 2007).

In the case of spills from pipeline leaks and ruptures, spills could release either radionuclides or other constituents (e.g., selenium or other metals). Any impacts of these two types of spills are likely to be bounded by a spill of pregnant lixiviant (Mackin, et al., 2001). Upon detection, licensees are required to establish immediate spill responses through onsite standard operation procedures (e.g., NRC, 2003, Section 5.7). For example, immediate spill responses might include shutting down the affected pipeline, recovering as much of the spilled fluid as possible, and collecting samples of the affected soil for comparison to background values for uranium, radium, and other metals.

As part of the monitoring requirements at ISL facilities, licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). This documentation helps in final site decommissioning activities. Licensees of ISL facilities in the Wyoming East Uranium Milling Region must also comply with applicable WDEQ requirements for spill response and reporting.

Soil contamination during ISL operations could also occur from transportation accidents resulting in yellowcake or ion exchange resin spills. As for lixiviant spills, licensees must report certain of these spills to both NRC and WDEQ. License conditions also may require licensees to report the corrective actions taken and the results achieved. For nonradiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of nonradiological materials is primarily reportable to the appropriate state agency or EPA.

In the short term, impacts to soils from spills could range from SMALL to LARGE depending on the volume of soil affected by the spill. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils would be expected to be SMALL.

Uranium mobilization and processing during ISL operations produce excess water containing lixiviants and minerals leached from the aquifer. Other liquid waste streams produced by ISL operations can include rejected brine from the reverse osmosis system and spent eluant from the ion exchange system. Any of these waste streams may be discharged to evaporation ponds or injected into deep waste disposal wells. In addition, wastewater may be treated and applied to the land using irrigation methods or discharged to surface water drainages. The impacts of and requirements for discharging treated waste streams to surface water bodies during ISL activities in the Wyoming East Uranium Milling Region are discussed in Section 4.3.4.1. The impacts of using evaporation ponds or applying treated wastewater to the land are discussed in this section.

Waste streams discharged to evaporation ponds can contain radionuclides and other metals that may become concentrated during evaporation. Therefore, evaporation pond liner failures and pond embankment failures could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of failure, pond embankments at ISL facilities are required to be monitored and inspected in accordance with NRC-approved inspection programs, and NRC also regularly inspects the embankments as part of the federal Dam Safety program.

Land application of treated wastewater involves irrigating select parcels of land and allowing the water to be evapotranspired by native vegetation or crops (Sections 2.7.2, 4.2.12.2). Land application of treated wastewater could potentially impact soils. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents (e.g., selenium or other metals) to accumulate in the soils, thereby degrading the site’s potential for subsequent recreational or agricultural use. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable limits. Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.3.3.3 Aquifer Restoration Impacts to Geology and Soils

Aquifer restoration programs typically use a combination of (1) groundwater transfer; (2) groundwater sweep; (3) reverse osmosis, permeate injection, and recirculation; (4) stabilization; and (5) water treatment and surface conveyance (Section 2.5).

The groundwater sweep and recirculation process does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. The water pressure in the aquifer is decreased during restoration because a negative water balance is maintained in the well field being restored to ensure water flows into the well field from its edges, reducing the spread of contamination. However, the change in pressure is limited by recirculation of treated groundwater, and therefore it is very unlikely that ISL operations will reactivate local faults and extremely unlikely that any earthquakes would be generated. Therefore, the impacts to geology in the Wyoming East Uranium Milling Region from aquifer restoration are expected to be SMALL, if any.

The main impact on soils during aquifer restoration would be spills of contaminated groundwater resulting from pipeline leaks and ruptures. As with spills of lixiviant during operations, spill response recommendations during aquifer restoration activities have been carried forward into NRC guidance of ISL facilities (e.g., NRC, 2003, Section 5.7). Licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). Licensees in the Wyoming East Uranium Milling Region are also required to comply with WDEQ requirements for spill response and reporting. The short-term impact on soils from spills of contaminated groundwater could range from SMALL to LARGE depending on the volume of the affected soil. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils would be expected to be SMALL.

During aquifer restoration, the groundwater is passed through a semipermeable membrane that yields a brine or reject liquid. This reject liquid cannot be injected back into the aquifer or discharged directly to the environment. The reject liquid is typically sent to an evaporation pond or to deep well disposal. In addition, treated wastewater may be applied to the land.

If reject water is sent to an evaporation pond, failure of the pond liner or pond embankment could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures and are visually inspected on a regular basis. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of pond embankment failures, NRC requires licensees to monitor and inspect pond embankments at ISL facilities in accordance with NRC-approved inspection programs. NRC also regularly inspects the embankments as part of the federal Dam Safety program.

As with ISL operations, land application of treated wastewater during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents to accumulate in the soils. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and also soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable standards. Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.3.3.4 Decommissioning Impacts to Geology and Soils

Decommissioning of ISL facilities includes (1) dismantling process facilities and associated structures, (2) removing buried piping, and (3) plugging and abandoning wells using accepted practices. The main impacts to geology and soils in the Wyoming East Uranium Milling Region during decommissioning would be from activities associated with land reclamation and cleanup of contaminated soils. These activities are described in Section 2.6.

Before decommissioning and reclamation activities begin, the licensee is required to submit a decommissioning plan to NRC for review and approval. The licensee's spill documentation—an NRC requirement—would be used to identify potentially contaminated soils requiring offsite disposal at a licensed facility. Any areas potentially impacted by operations would be included in surveys to ensure all areas of elevated soil concentrations are identified and properly cleaned up to comply with NRC regulations at 10 CFR Part 40, Appendix A, Criterion 6-(6).

Most of the impacts to geology and soils associated with decommissioning are temporary (short term) and SMALL. Because the goal of decommissioning and reclamation is to restore the facility to preproduction conditions, to the extent practical, the overall long-term impacts to the geology and soils would be SMALL.

4.3.4 Water Resources Impacts

4.3.4.1 Surface Water Impacts

4.3.4.1.1 Construction Impacts to Surface Water

The potential causes and nature of construction impacts for the Wyoming East Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.1.1). Although the average annual precipitation in the Wyoming East Uranium Milling Region is slightly greater than that in the Wyoming West Uranium Milling Region, the average annual surface runoff is similar to or slightly less than that in the Wyoming West Uranium Milling Region (Gebert, et al., 1987). Thus, the potential for surface water impacts due to storm water runoff will be similar to those in the Wyoming West Uranium Milling Region. Compliance with applicable federal and state regulations and permit conditions and use of best management practices and required mitigation measures would reduce construction impacts to surface waters, and overall impacts would be expected to be SMALL.

4.3.4.1.2 Operations Impacts to Surface Water

Surface water impacts for the Wyoming East Uranium Milling Region are expected to be similar to impacts described for the Wyoming West Uranium Milling Region (Section 4.2.4.1.2). Except for the Shirley Basin area, there are fewer perennial streams in the Wyoming East Uranium Milling Region than in the Wyoming West Uranium Milling Region. For sites within the Platte River Basin, any impacts of groundwater pumping on surface water that might affect fish and wildlife would be assessed and mitigated as required by the Platte River Recovery Implementation Plan in consultation with the U.S. Fish and Wildlife Service (Platte River Recovery Implementation Plan, 2006). Compliance with permit conditions during operations would reduce impacts to surface water from storm water runoff and discharges of treated water. For these reasons, potential impacts to surface waters from operations would be SMALL.

4.3.4.1.3 Aquifer Restoration Impacts to Surface Water

The potential causes and nature of impacts for the Wyoming East Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.1.3). Except for the Shirley Basin area, there are fewer perennial streams in the Wyoming East Uranium Milling Region (see Section 3.3.4.1) than in the Wyoming West Uranium Milling Region. For sites within the Platte River Basin, any impacts of groundwater pumping on surface water that might affect fish and wildlife would be assessed and mitigated as required by the Platte River Recovery Implementation Plan in consultation with the U.S. Fish and Wildlife Service (Platte River Recovery Implementation Plan, 2006). Compliance with permit conditions during aquifer restoration would reduce impacts to surface water from storm water runoff and discharges of treated water. For these reasons, the potential impacts to surface waters during aquifer restoration would be SMALL.

4.3.4.1.4 Decommissioning Impacts to Surface Water

The potential causes and nature of impacts for the Wyoming East Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.1.4). Except for the Shirley Basin area, there are fewer perennial streams in the Wyoming East Uranium Milling Region than in the Wyoming West Uranium Milling Region. Compliance with permit conditions during decommissioning would reduce impacts to surface water from storm water runoff and discharge of treated water. For these reasons, the potential impacts to surface waters would be SMALL.

4.3.4.2 Groundwater Impacts

Potential environmental impacts to groundwater resources in the Wyoming East Uranium Milling Region can occur during all phases of the ISL facility’s lifecycle. ISL activities can impact aquifers at varying depths (separated by aquitards) above and below the uranium-bearing aquifer as well as adjacent surrounding aquifers in the vicinity of the uranium-bearing aquifer. Surface activities that can introduce contaminants into soils are more likely to impact shallow (near-surface) aquifers, while ISL operations and aquifer restoration are more likely to impact the deeper uranium-bearing aquifer, any aquifers above and below, and adjacent surrounding aquifers.

ISL facility impacts to groundwater resources can occur from surface spills and leaks, consumptive water use, horizontal and vertical excursions of leaching solutions from production aquifers, degradation of water quality from changes in the production aquifer's chemistry, and waste management practices involving land application, evaporation ponds, or deep well injection. Detailed discussion of the potential impacts to groundwater resources from construction, operations, aquifer restoration, and decommissioning is provided in the following sections.

4.3.4.2.1 Construction Impacts to Groundwater

During construction of ISL facilities, the potential for groundwater impacts is primarily from consumptive groundwater use, injection of drilling fluids and muds during well drilling, and spills of fuels and lubricants from construction equipment (Section 2.3).

As discussed in Section 2.11.3, groundwater use during construction is limited to routine activities such as dust suppression, mixing cements, and drilling support. The amounts of groundwater used in these activities are small and would have a SMALL and temporary impact to groundwater supplies. Groundwater quality of near-surface aquifers during construction is protected by best management practices such as implementation of a spill prevention and cleanup plan to minimize soil contamination (Section 7.4). Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a SMALL impact to the water quality of those aquifers. Thus, construction impacts to groundwater resources would be SMALL based on the limited nature of construction activities and implementation of management practices to protect shallow groundwater.

4.3.4.2.2 Operation Impacts to Groundwater

During ISL operations, potential environmental impacts to shallow (near-surface) aquifers are related to leaks of lixiviant from pipelines, wells, or header houses and to waste management practices such as the use of evaporation ponds and disposal of treated wastewater by land application. Potential environmental impacts to groundwater resources in the production and surrounding aquifers involve consumptive water use and changes to water quality. Water quality changes would result from normal operations in the production aquifer and from possible horizontal and vertical lixiviant excursions beyond the production zone (Section 2.4). Disposal of processing wastes by deep well injection (Section 2.7.2) during ISL operations also can potentially impact groundwater resources.

4.3.4.2.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

A network of pipelines, as part of the underground infrastructure, is used during ISL operations for transporting lixiviants between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside pumping header houses. The failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers, could result in leaks and spills of pregnant and barren lixiviant (Section 2.3.1.2), which could impact water quality in shallow (near-surface) aquifers. The potential environmental impacts of pipeline, valve, or well integrity failures could be MODERATE to LARGE, if

- The groundwater table in shallow aquifers is close to the ground surface (i.e., small travel distances from the ground surface to the shallow aquifers)

- The shallow aquifers are important sources for local domestic or agricultural water supplies

- Shallow aquifers are hydraulically connected to other locally or regionally important aquifers

The potential environmental impacts could be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydraulically separated from other locally and regionally important aquifers.

In some parts of the Wyoming East Uranium Milling Region, local shallow aquifers (alluvium type) exist, and they usually yield small quantities of water only for local uses [e.g., in the vicinity of the Reynolds Ranch area (Power Resources, Inc., 2005)]. Hence, potential environmental impacts due to spills and leaks from pipeline networks or failures of well integrity in shallow aquifers would be expected to be SMALL to MODERATE, depending on site-specific conditions. Potential impacts would be reduced based on flow monitoring to detect pipeline leaks and spills early and implementation of required spill response and cleanup procedures. In addition, preventative measures such as well MIT (Section 2.3.1.1) would limit the likelihood of well integrity failure during operations.

The use of evaporation ponds or land application to manage process water generated during operations also could impact shallow aquifers. For example, failure of evaporation pond embankments or liners could allow contaminants to infiltrate into shallow aquifers. Similarly, land application of treated wastewater could cause radiological or other constituents (e.g., selenium or other metals) to accumulate in soils or infiltrate into shallow aquifers. In general, the potential impacts of these waste management activities are expected to be limited by NRC and state requirements. For example, NRC requirements for leak detection systems, maintenance of reserve pond capacity, and pond embankment inspections are expected to minimize the likelihood of evaporation pond failures. Similarly, NRC and state release limits related to land application of waste are expected to limit potential effects of land application of wastewater on shallow aquifers. Section 4.2.12.2 discusses the impacts of the use of evaporation ponds and land application of treated wastewater in greater detail and characterizes the expected impacts as SMALL.

4.3.4.2.2.2 Operation Impacts to Production and Surrounding Aquifers

The potential environmental impacts to groundwater supplies in the production and other surrounding aquifers are related to consumptive water use and groundwater quality.

Water Consumptive Use: NRC-licensed flow rates for ISL facilities typically range from about 15,100 to 34,000 L/min [4,000 to 9,000 gal/min] (Section 2.1.3). Most of this water is returned to the production aquifer after being stripped of uranium (see Section 2.4.1.2). The term "consumptive use" refers to water that is not returned to the production aquifer. During operations, consumptive use is due primarily to production bleed (typically between 1 and 3 percent of the total flow) and also includes other smaller losses. As described in Section 2.4.1.2, the purpose of the production bleed is to ensure that more groundwater is extracted than reinjected. Maintaining this negative water balance helps to ensure that there is a net inflow of groundwater into the well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field. Because the bleed water must be removed from the well field to maintain a negative water balance, the bleed is disposed through the wastewater control program and is not reinjected into the well field.

Hypothetically, if a well field at an ISL facility in the Wyoming East Uranium Milling Region is pumped at a constant rate of 22,700 L/min [6,000 gal/min] with 2 percent bleed, the total volume of production bleed in a year of operation would be 240 million L {63 million gal [190 acre-ft]}. For comparison, in 2000, approximately 6.2×10^{12} L [5.05 million acre-ft] of water was used to irrigate 469,000 ha [1.16 million acres] of land in Wyoming (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 13.2 million L/ha [4.36 acre-ft/acre]. Thus, the consumptive use of 240 million L [190 acre-ft] of water due to production bleed in 1 year of operation is roughly equivalent to the water used to irrigate 18 ha [44 acres] in Wyoming for 1 year.

Consumptive water use during operations could lower water levels in local wells, impacting local water users who use water from the production aquifer (outside of the exempted zone). In addition, if production aquifers are not completely hydraulically isolated from aquifers above and below, consumptive use may impact local users of these connected aquifers by causing a lowering water levels in those aquifers. However, effects on aquifers above and below are expected to be limited in most cases by the confining layers typical of aquifers used for ISL production. As discussed in Section 2.4.1.3, licensees conduct preoperations testing to assess the degree of hydraulic isolation of potential production aquifers at proposed ISL sites.

To assess the potential drawdown that could be caused by consumptive use during operations, drawdowns were calculated for a hypothetical case in which the water withdrawn by an entire ISL facility operating at 15,100 L/min [4,000 gal/min] with 2 percent bleed is assumed to be withdrawn from a single well. This scenario would significantly overestimate the drawdown caused by ISL operations using water from a similar production aquifer because water withdrawal at a typical ISL facility is distributed among hundreds of wells (Section 2.3.1.1) and tens to hundreds of hectares [tens to thousands of acres] (Section 4.2.1). In this extreme case, drawdowns at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from the hypothetical well (representing the well field) would be 88, 70, and 52 m [289, 230, and 171 ft] after 10 years of operation. These values were calculated using the Theis Equation (McWhorter and Sunada, 1977) with transmissivity and storage coefficient values of 8.8 m^2/day [95 ft^2/day] and 1.5×10^{-5}, respectively (chosen from the ranges discussed in Section 3.3.4.3). As discussed in Section 4.3.4.2.2.2, drawdowns are more sensitive to the aquifer transmissivity than storage coefficient.

In these calculations, the potential effect of natural recharge to the production aquifers on groundwater levels is not considered. Consideration of natural recharge would reduce the calculated drawdowns. However, neglecting natural recharge is not expected to have as much of an effect as approximating the withdrawal from an entire facility with one hypothetical well. As previously discussed, this approximation is expected to yield significant overestimates of the expected drawdowns.

Near a well field, the short-term impact of consumptive use could be MODERATE if there are local water users who use the production aquifer (outside of the exempted zone) or if the production aquifer is not well isolated from other aquifers that are used locally. However, because localized drawdown near well fields would dissipate after pumping stops, these localized effects are expected to be temporary. The long-term impacts would be expected to be

SMALL in most cases, depending on site-specific conditions. Important site-specific conditions would include the consumptive use of the proposed facility, the proximity of water users' wells to the well fields, the total volume of water in the production aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

Excursions and Groundwater Quality: Groundwater quality in the production aquifer is degraded as part of the ISL facility's operations (Section 2.4). The restoration of the production aquifer is discussed in Section 2.5. In order for ISL operations to occur, the uranium-bearing production aquifer must be exempted as an underground source of drinking water through the Wyoming UIC program. When uranium recovery is complete in a well field, the licensee is required to initiate aquifer restoration activities to restore the production aquifer to baseline or preoperational class-of-use conditions, if possible. If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in 10 CFR Part 40, Appendix A, Table 5C or to alternate concentration limits approved by the NRC. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISL operations would be expected to be SMALL and temporary. This remainder of this section discusses the potential for groundwater quality in the surrounding aquifers or in the producing aquifer outside of the well field to be affected by excursions during ISL operations.

During normal ISL operations, inward hydraulic gradients are expected to be maintained by production bleed so that groundwater flow is toward the production zone from the edges of the well field. If this inward gradient is not maintained, horizontal excursions can occur and lead to the spread of leaching solutions in the ore-bearing aquifer beyond the mineralization zone and the well field. The rate and extent of spread is largely driven by the collective effects of the aquifer transmissivity, groundwater flow direction, and aquifer heterogeneity. The impact of horizontal excursions could be MODERATE to LARGE if a large volume of contaminated water leaves the production zone and moves downgradient within the production aquifer while the production aquifer outside the mineralization zone is used for water production. To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventative measures prior to starting operations. For example, licensees must install a ring of monitoring wells within and encircling the production zone to permit early detection of horizontal excursions (Chapter 8). If there are oil, gas, coal bed methane, or other production layers near the ISL facility, and if NRC determines that there could be potentials for cross contamination between the ISL production zone and other production layers based on environmental impact assessments, NRC may require the licensee to expand the monitoring well ring for detection of potential contamination between the ISL production zone and other mineral production layers. If excursions are detected, the monitoring well is placed on excursion status and reported to the NRC. Corrective actions are taken, and the well is placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

The following discussion focuses on the potential for groundwater quality in the surrounding aquifers to be affected during ISL operations. The rate of vertical flow and the potential for excursions between the production aquifer and an aquifer above or below is determined by multiplying vertical hydraulic gradient across a confining layer by vertical hydraulic conductivity of a confining layer, and dividing the result by porosity of a confining layer (McWhorter and Sunada, 1997; Driscoll, 1986). The vertical hydraulic conductivity of the upper confining layer of the ore-bearing K unit at the Christensen Ranch ISL site ranges from

8.2×10^{-6} to 1.1×10^{-4} m/day [27×10^{-6} to 3.6×10^{-4} ft/day] (see Section 3.3.4.3). For the ratio of vertical hydraulic gradient to the porosity of a confining layer of 0.1 in the upward direction and a vertical hydraulic conductivity of 1.1×10^{-4} m/day [3.6×10^{-4}] (representing the most leaky condition), a leaching solution would move vertically upward from the production unit to an overlying aquifer, J unit (Cogema Mining, Inc., 1998), at a rate of nearly 0.4 cm/yr [0.16 in/yr]. If the vertical migration rate of a leaching solution is assumed to be constant in the next 10 years, then the leaching solution would move 4 cm [1.6 in] away from the production zone. Because the thickness of the upper confinement is 23 m [76 ft] (Section 3.3.4.3) at the Christensen Ranch ISL site, the excursion would not be expected to enter the overlying aquifer in the next 10 years. If excursions are observed at the monitoring wells, the licensee is required to implement responses that include increasing sampling and commencing corrective actions to recover the excursion. The excursions typically would be reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

Vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers could be altered by potential increases in pumpage from the overlying J unit or the underlying L unit of the Wasatch Formation, which may enhance potential vertical excursions from the production zone (the K unit of the Wasatch Formation) at the Christensen Ranch ISL site. Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could also lead to vertical flow and excursions.

In addition, potential well integrity failures during ISL operations could lead to vertical excursions. Well casings above or below the uranium-bearing aquifer—through inadequate construction, degradation, or accidental rupture—could allow lixiviant to travel from the well bore into the surrounding aquifer. Moreover, deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create vertical pathways for excursions of lixiviant from the production aquifers to the adjacent aquifers.

Some relevant factors when considering the significance of potential impacts from a vertical excursion (such as local geology and hydrology and the proximity of injection wells to drinking water supply wells) are discussed in Section 2.4.1. Additionally, past experience with excursions reported at NRC-licensed ISL facilities is discussed in Section 2.11.5.

To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventive measures prior to starting operations. For example, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees are required to conduct aquifer pump tests prior to starting operations in a well field. The purpose of these pump tests is to determine aquifer parameters (e.g., aquifer transmissivity and storage coefficient, and the vertical hydraulic conductivity of aquitards) and also ensure that confining layers above and below the production zone are expected to preclude the vertical movement of fluid from the production zone into the overlying and underlying units. The licensee must also develop and maintain monitoring programs to detect both vertical and horizontal excursions and must have operating procedures to analyze an excursion and determine how to remediate it. The monitoring programs prescribe the number, depth, and location of monitoring wells, sampling intervals, sampling water quality parameters and the UCL for particular water quality parameters (Chapter 8). These specifications typically are made conditions in the NRC license.

WDEQ noted that monitoring wells should be completed in the lower portion of the first aquifer above the ore-bearing aquifer and in the upper portion of the first aquifer below the ore-bearing aquifer. As described in Section 3.3.4.3.2, in the Reynolds Ranch area in Converse County, the Wasatch Formation is above the ore-bearing aquifer and the Lance Formation is below the ore-bearing aquifer.

In general, the potential environmental impacts of vertical excursions to groundwater quality in surrounding aquifers would be SMALL if the vertical hydraulic head gradients between the production aquifer and the adjacent aquifer are small, the vertical hydraulic conductivity of the confining units is low, and the confining layers are sufficiently thick. On the other hand, the environmental impacts could be MODERATE to LARGE if confinements are discontinuous, thin, or fractured (i.e., high vertical hydraulic conductivities). To limit the likelihood of vertical excursions, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees also must conduct preoperational pump tests to ensure adequate confinement of the production zone. In addition, licensees must develop and maintain programs to monitor above and below the ore-bearing zone to detect both vertical and horizontal excursions and flow rates, and must have operating procedures to analyze an excursion and determine how to remediate it.

At the Christensen Range ISL site, the ore-bearing unit (the K unit of the Wasatch Formation, corresponding to upper Irigaray sandstone at the Irigaray ISL site) is confined below and above by continuous and at least 20-m [65-ft]-thick confining layers at the Christensen Ranch and Irigaray Ranch ISL sites (Cogema Mining, Inc., 1998). At the Smith Ranch and Reynolds Ranch ISL sites, the ore-bearing aquifer (the Fort Union Formation that contains the U/S sand) is confined below and above by continuous and thick confining layers. The thickness of the aquitards is reportedly variable in the region (NRC, 2006). As noted in Section 3.3.4.3.2, aquifer tests revealed that the confining shale members would effectively limit the vertical excursions at the ISL facility in the Reynolds Ranch area (Power Resources, inc., 2005). Preliminary calculations discussed previously suggest that the confinements would effectively restrict potential vertical excursions. Additionally, if the licensee installs and maintains the monitoring well network properly, potential impacts of vertical excursions would be temporary and the long-term effects would be expected to be SMALL.

4.3.4.2.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

Potential environmental impacts to confined deep aquifers below the production aquifers could be due to deep well injection of processing wastes into deep aquifers. Under different environmental laws such as the Clean Water Act and the Safe Drinking Water Act, EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from the EPA (Section 1.7.2) or an authorized state-administered UIC program. As discussed in Section 1.7.5.1, Wyoming requires UIC Class III permits for injection wells in areas not previously mined using conventional mining and milling. UIC Class V permits are required for injection wells leaching from older conventional uranium recovery operations.

In the Wyoming East Uranium Milling Region, the Paleozoic aquifers are deeply buried in most places and contain little fresh water. The Paleozoic aquifers are hydraulically separated from the aquifer sequence that includes, from the shallowest to deepest, the Wasatch Formation, the Fort Union Formation, the Lance Formation, and the Fox Hills Formation by thick low permeability confining layers that include the Pierre Shale, the Lewis Shale, and the Steele Shale (Whitehead, 1996). Hence, nonkarstic Paleozoic aquifers (e.g., Tensleep Sandstone) can be investigated further for suitability of disposal of leaching solutions. Karstic (e.g., those with large dissolution features) Paleozoic aquifers are likely to be excluded from consideration, because flow directions and rates in karstic aquifers (e.g., Madison Limestone) are highly uncertain and flow rates are commonly much higher than in nonkarstic aquifers.

The potential environmental impacts of injection of leaching solutions into deep aquifers below ore-bearing aquifers would be expected to be SMALL, if water production from deep aquifers is not economically feasible or the groundwater quality from these aquifers is not suitable for domestic or agricultural uses (e.g., high salinity), and they are confined above by sufficiently thick, low permeability layers. In the Wyoming East Uranium Milling Region, considering relatively low water quality in and less water yields from nonkarstic Paleozoic aquifers (e.g., Tensleep Sandstone) and the presence of thick and regionally continuous aquitards confining them above (Section 3.3.4.3), the potential environmental impacts due to deep injection of leaching solution into nonkarstic Paleozoic aquifers could be SMALL. The Pierre Shale was reported to be fractured in some places at the regional scale (Whitehead, 1996), although it was reported to be continuous and nonfractured based on available field data in the Reynolds Ranch area. Considering potential heterogeneities in hydrogeological properties of the Pierre Shale, the potential impacts could be SMALL to MODERATE where the Pierre Shale might be locally fractured.

4.3.4.2.3 Aquifer Restoration Impacts to Groundwater

The potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including discharge of wastes to evaporation ponds, land application of treated wastewater, and potential deep disposal of brine slurries resulting from reverse osmosis. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the well field being restored.

Aquifer restoration typically involves a combination of the following methods: (1) groundwater transfer, (2) groundwater sweep, (3) reverse osmosis with permeate injection, and (4) groundwater recirculation. These methods are discussed in more detail in Section 2.5. In addition to these processes, potential new restoration processes are being developed. These processes include the use of controlled biological reactions to precipitate uranium and other contaminants by restoring chemically reducing conditions to production aquifers. However, these processes have not yet been used at a commercial scale and their likely impacts will not be known until the processes have been developed further.

Groundwater consumptive use for groundwater transfer would be minimal, because milling-affected water in the restoration well field is displaced with baseline quality water from the well field commencing milling. Groundwater consumptive use would be large for groundwater sweep, because it involves pumping groundwater from the well field without injection. The rate of groundwater consumptive use would be lower during the reverse osmosis phase, because up to 70 percent of the pumped groundwater treated with reverse osmosis can be reinjected into the aquifer. Groundwater consumptive use could be further decreased during the reverse osmosis phase if brine concentration is used, in which case up to 99 percent of the withdrawn water could be suitable for reinjection. In that case, the actual amount of water that is reinjected into the well field may be limited by the need to maintain a negative water balance to achieve the desired flow of water from outside of the well field into the well field.

Groundwater consumptive use during aquifer restoration is generally reported to be greater than during ISL operations (Freeman and Stover, 1999; NRC, 2003; Chapter 2 of this GEIS). One reason for increased consumptive use during restoration is that, as previously discussed, no water is reinjected during groundwater sweep. Water is not reinjected during groundwater sweep, because the purpose of the sweep phase is to remove contaminated water from a well field and draw unaffected water into the well field. For example, at the Irigaray Mine in Campbell County, Wyoming, between 1.4 and 4.2 pore volumes of water were removed from six restoration units (comprising nine well fields, some of which were combined for restoration). The total volume of water consumed to perform groundwater sweep on all of the well fields was 545 million L [144 million gal].

As discussed in Section 2.5, restoration typically is performed as well fields end production, so all of the well fields do not undergo groundwater sweep at the same time. For example, at the Irigaray Mine (Cogema Mining, Inc., 2004), average pumping rates for groundwater sweep ranged from approximately 100 L/min [27 gal/min] to pump 120 million L [31 million gal] from two well fields between June 1991 and August 1993 to 380 L/min [100 gal/min] to pump 190 million L [49 million gal] from three well fields between May 1990 and April 1991. At the Smith Ranch/Highland Uranium Project in Converse County, Wyoming, an average pumping rate of approximately 38 L/min [10 gal/min] was used to pump 3.2 pore volumes {49 million L [13 million gal]} from the A-Wellfield during almost 3 years of groundwater sweep (Power Resources, Inc., 2004).

The actual rate of groundwater consumption at an ISL facility at any time depends, in part, on the various stages of operation and restoration of the individual well fields at the facility. For example, consider a hypothetical case in which three well fields at a site undergo groundwater sweep while three undergo reverse osmosis treatment with permeate reinjection and another three continue production. Hypothetically, while 380 L/min [100 gal/min] are consumed during groundwater sweep of three well fields, 110 L/min [30 gal/min] may be consumed to perform reverse osmosis treatment in another three well fields, and another 38 L/min [10 gal/min] may be consumed by production bleed in the remaining three well fields. The total water consumption rate while these processes continued would be 530 L/min [140 gal/min].

At a rate of 530 L/min [140 gal/min], 280 million L [74 million gal] would be consumed in 1 year. For comparison, in 2000, approximately 6.2×10^{12} L [5.05 million acre-ft] of water was used to irrigate 469,000 ha [1.16 million acres] of land in Wyoming (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 13.2 million L/ha [4.36 acre-ft/acre]. Thus, consumption of 280 million L [74 million gal or 230 acre-ft] in 1 year of restoration would be roughly equivalent to the water used to irrigate 21 ha [53 acres] in Wyoming for 1 year.

Potential environmental impacts are dependent on the restoration techniques chosen, the severity and extent of the contamination, and the current and future use of the production and surrounding aquifers in the vicinity of the ISL facility. The potential environmental impacts of groundwater consumptive use during restoration could be SMALL to MODERATE. Site-specific impacts also would depend on the proximity of water users' wells to the well fields, the total volume of water in the aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

During aquifer restoration, the most heavily contaminated groundwater may be disposed through the wastewater treatment system. The impacts of discharging wastes to solar evaporation ponds or applying treated wastewater to land during restoration are expected to be similar to the impacts of these waste management practices during operations (SMALL) (Section 4.3.4.2.2.1).

As discussed in Section 4.2.4.2.2.3, underground injection of fluid requires a permit from EPA or the authorized state and approval from NRC. Additionally, the briny slurry produced during reverse osmosis process may be pumped to a deep well for disposal (Section 2.7.2). The deep aquifers suitable for injections must have poor water quality, have low water yields, or be economically infeasible for production. They also need to be hydraulically separated from overlying aquifer systems. Under these conditions, the potential environmental impacts would be SMALL.

Aquifer restoration processes also affect groundwater quality directly by removing contaminated groundwater from well fields, reinjecting treated water, and recirculating groundwater. In general, aquifer restoration continues until NRC and applicable state requirements for groundwater quality are met. As discussed in Section 2.5, NRC licensees are required to return well field water quality parameters to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) or to another standard approved in their NRC license. Historical information about aquifer restoration at several NRC-licensed facilities is discussed in Section 2.11.5.

4.3.4.2.4 Decommissioning Impacts to Groundwater

The environmental impacts to groundwater during dismantling and decommissioning ISL facilities are primarily associated with consumptive use of groundwater, potential spills of fuels and lubricants, and well abandonment. The consumptive groundwater use could include water use for dust suppression, revegetation, and reclamation of disturbed areas (Section 2.6). The potential environmental impacts during the decommissioning phase are expected to be similar to potential impacts during the construction phase. Groundwater consumptive use during the decommissioning activities would be less than groundwater consumptive use during ISL operation and groundwater restoration activities. Spills of fuels and lubricants during decommissioning activities could impact shallow aquifers. Implementation of best management practices (Chapter 7) during decommissioning can help to reduce the likelihood and magnitude of such spills. Based on consideration of best management practices to minimize water use and spills, impacts to the groundwater resources in shallow aquifers from decommissioning would be SMALL.

After ISL operations are completed, improperly abandoned wells could impact aquifers above the production aquifer by providing hydrologic connections between aquifers. As part of the restoration and reclamation activities, all monitors, injection, and recovery wells will be plugged and abandoned in accordance with the Wyoming UIC program requirements. The wells will be filled with cement and clay and then cut off below plow depth to ensure that groundwater does not flow through the abandoned wells (Stout and Stover, 1997). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be SMALL.

4.3.5 Ecological Resources Impacts

4.3.5.1 Construction Impacts to Ecological Resources

Vegetation

Vegetation in the region is similar to the vegetation found in the Wyoming West Uranium Milling Region. As a result, potential impacts to terrestrial vegetation from ISL uranium recovery facility construction within the Wyoming East Uranium Milling Region would also be similar (SMALL to MODERATE), as described in Section 4.2.5.

Wildlife

The potential impacts from an ISL uranium recovery facility construction on terrestrial wildlife in the Wyoming East Uranium Milling Region would also be similar to those found in the Wyoming West Uranium Milling Region as described in Section 4.2.5 (SMALL to MODERATE), depending on site-specific conditions.

Disturbed areas would be revegetated with a seed mixture of grasses, forbs, and shrubs approved by the WDEQ, Land Quality Division, to further mitigate impact to wildlife after construction of the well fields and facility infrastructure.

Crucial wintering and year-long ranges vital for survival of local populations of big game and sage-grouse leks or breeding ranges are also located within the region (Figures 3.3-8 through 3.3-14). For facilities to be located within these ranges, guidelines have been issued by the Wyoming Game and Fish Department (2004) for the drilling associated with the development of oil and gas resources. Because many of the activities (e.g., drilling, access roads) would be similar between oil and gas and ISL facility construction, these guidelines would also be expected to apply to ISL facility construction. Consultation with the Wyoming Game and Fish Department would be conducted, as well as a site-specific analysis to determine potential impacts from the facility to these species.

Aquatic

Because the reported aquatic species are the same, potential impacts from ISL uranium recovery facility construction to aquatic resources would be expected to be similar to those found in the Wyoming West Uranium Milling Region (SMALL). Consultation with the Wyoming Game and Fish Department is expected to be conducted, as well as a site-specific analysis to determine impacts from the facility to theses species.

Threatened and Endangered Species

Numerous threatened and endangered species and State Species of Concern are located within the region. These species with habitat descriptions are provided in Section 3.3.5.3. After a specific ISL site has been selected, the habitats and impacts would be evaluated for federal and state species of concern that may inhabit the area. For site-specific environmental reviews, licensees and NRC staff would consult with the U.S. Fish and Wildlife Service and Wyoming Game and Fish Department for potential survey requirements and explore ways to protect these resources. If any of the species are identified in the project site during surveys, impacts could range from SMALL to LARGE depending on site-specific conditions. Mitigation plans to avoid and reduce impacts to the potentially affected species would be developed. Many of these species have been discussed previously for the Wyoming West Uranium Milling Region (Section 4.2.5.1). Other species noted in the Wyoming East Uranium Milling Region are described next.

- The Colorado butterfly plant typically occurs on subirrigated, stream-deposited soils on level floodplains and drainage bottoms. Potential impacts to this species could be MODERATE to LARGE if construction activities remove vegetation along flood plains and drainage bottoms.

- The Wyoming toad is only found in Albany County, Wyoming. Potential impact to this species could occur if construction activities remove riparian and wetland vegetation found along streams, seeps, and floodplains.

Threatened and endangered species discussed in the Wyoming West Uranium Milling Region (Section 4.2.5.1) that are also identified within the Wyoming East Uranium Milling Region include

- Black-footed ferret
- Blowout penstemon
- Bonytail
- Canada lynx
- Colorado pikeminnow
- Humpback chub
- Interior least tern
- Pallid sturgeon
- Piping plover
- Preble's meadow jumping mouse
- Razorback sucker
- Ute ladies' tresses orchid
- Western prairie fringed orchid
- Whooping crane
- Yellow-billed cuckoo (candidate)

4.3.5.2 Operation Impacts to Ecological Resources

Because the ecoregions are similar, the types of potential impacts to ecological resources from the operation of an ISL facility in the Wyoming East Uranium Milling Region are expected to be similar to those described in the Wyoming West Uranium Milling Region. Additional land-disturbing activity would be less than expected during the construction phase (SMALL) and would be evaluated during the site-specific environmental review.

4.3.5.3 Aquifer Restoration Impacts to Ecological Resources

Because the existing infrastructure would be used during aquifer restoration, potential impacts to ecological resources would be similar to impacts from ISL facility operations; therefore, they would be SMALL.

4.3.5.4 Decommissioning Impacts to Ecological Resources

Because similar types of earth-moving activities would be involved, potential impacts as result of decommissioning would, in part, be similar to those discussed in the construction of the facility (see Section 4.3.5). However, these impacts would be temporary (generally, 18–30 months) in nature. The removal of piping would impact vegetation that has reestablished itself. Wildlife or endangered and threatened species could come in contact with heavy equipment. During decommissioning, reclamation activities would revegetate previously disturbed areas and restore streams and drainages to their preconstruction contours. It is expected that temporarily displaced wildlife would return to the area after the completion of decommissioning and reclamation activities. As a result, the potential impacts to ecological resources during decommissioning would be expected to be SMALL.

Land that is used for irrigation is also included in decommissioning surveys to ensure potentially impacted (contaminated) areas would be appropriately characterized and remediated, as necessary, in accordance with NRC regulations. Because of the NRC review of site-specific conditions prior to approval, the routine monitoring program, and the inclusion of irrigated areas in decommissioning surveys, the ecological impacts from land application of treated waste water would be SMALL.

4.3.6 Air Quality Impacts

For the Wyoming East Uranium Milling Region, potential nonradiological air impacts from activities during all four uranium milling phases would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.6.

In general, ISL milling facilities are not major nonradiological air emission sources, and the impacts would be classified as SMALL if the following conditions are met:

- Gaseous emissions are within regulatory limits and requirements
- Air quality in the region of influence was is in compliance with NAAQS
- The facility is not classified as a major source under the New Source Review or operating (Title V) permit programs described in Section 1.7.2

The Wyoming East Uranium Milling Region is classified as attainment for NAAQS (see Figure 3.3-15). This also includes the counties immediately surrounding this region. The Wyoming East Uranium Milling Region does not include any Prevention of Significant Deterioration Class I areas (see Figure 3.3-16). Therefore, the less stringent Class II area allowable increments apply.

4.3.6.1 Construction Impacts to Air Quality

Nonradiological gaseous emissions in the construction phase include fugitive dust and combustion emissions (Section 2.7.1). Most of the combustion emissions are diesel emissions and are expected to be limited in duration to construction activities and result in small, short-term effects. The Wyoming East Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions (Section 3.2.6.2). Therefore, construction impacts for ISL facilities would be SMALL.

4.3.6.2 Operation Impacts to Air Quality

Operating ISL facilities are not major point source emitters and are not expected to be classified as major sources under the operation (Title V) permitting program (Section 1.7.2). One gaseous emission source introduced in the operational phase is the release of pressurized vapor from well field pipelines. Excess vapor pressure in these pipelines could be vented at various relief valves throughout the system. In addition, ISL operations may release gaseous effluents during resin transfer or elution. In general, nonradiological emissions from pipeline system venting, resin transfer, and elution are small. Gaseous effluents produced during drying yellowcake operations vary based on the particular drying technology. In general, nonradiological emissions from yellowcake drying would be SMALL due to the volume of effluent produced.

Other potential operation phase nonradiological air quality impacts include fugitive dust and vehicle emissions from many of the same sources identified earlier in the construction phase. ISL operations phase fugitive dust emissions sources include onsite traffic related to operations and maintenance, employee traffic to and from the site, and heavy truck traffic delivering supplies to the site and product from the site. The ISL operations phase would use the existing infrastructure, and emissions would not include fugitive dust and diesel emissions associated with well field construction. Therefore, operations phase impacts would be less than the construction phase impacts.

The Wyoming East Uranium Milling Region is in attainment for NAAQS and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. These emissions are not expected to reach levels that result in the ISL facility being classified as a major source under the operating (Title V) permit process. Therefore, operation impacts for ISL facilities would be SMALL.

4.3.6.3 Aquifer Restoration Impacts to Air Quality

Potential nonradiological air impacts during the aquifer restoration phase (Section 2.11.5) include fugitive dust and combustion emissions from many of the same sources identified earlier in the operations phase. The plugging and abandonment of production and injection wells would use equipment that generates gaseous emissions. These emissions would be expected to be limited in duration and result in small, short-term effects. The ISL aquifer restoration phase would use the existing infrastructure, and the impacts would not be expected to exceed those of the construction phase. Therefore, aquifer restoration phase impacts would be SMALL.

4.3.6.4 Decommissioning Impacts to Air Quality

Potential decommissioning phase nonradiological air impacts include fugitive dust, vehicle emissions, and diesel emissions from many of the same sources identified earlier in the construction phase. In the short term, emission levels could increase, especially for particulate matter from activities such as dismantling buildings and milling equipment, removing any contaminated soil, and grading the surface as part of reclamation activities. Decommissioning phase impacts would be expected to be similar to construction phase impacts. Therefore, decommissioning phase impacts would be SMALL.

4.3.7 Noise Impacts

4.3.7.1 Construction Impacts to Noise

For the Wyoming East Uranium Milling Region, potential noise impacts during well field construction, drilling, and facility construction would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.1. The three uranium districts in the Wyoming East Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, construction activities and associated traffic would be expected to have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise-generating activities. Construction worker hearing would be protected by compliance with Occupational Safety and Health Administration noise regulations. During construction, wildlife would be anticipated to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during construction would be SMALL to MODERATE.

4.3.7.2 Operation Impacts to Noise

For the Wyoming East Uranium Milling Region, potential noise impacts during well field construction, drilling, and facility construction would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.2. Overall, because most activities will be conducted inside buildings, potential noise impacts during ISL operations are anticipated to be less than those during construction. The three uranium districts in the Wyoming East Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, operations activities and associated traffic would have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise generating activities. Noise impacts to workers during operations would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During operations, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Compared to existing traffic counts, truck traffic associated with yellowcake and chemical shipments and traffic noise related to commuting would have a SMALL, temporary impact on communities located along the existing roads. Some country roads with the lowest average annual daily traffic counts would be expected to have higher relative increases in traffic and noise impacts, in particular, when facilities are experiencing peak employment (these impacts would be MODERATE). Therefore, overall noise impacts during operations would be SMALL to MODERATE.

4.3.7.3 Aquifer Restoration Impacts to Noise

For the Wyoming East Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.3. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, aquifer restoration activities and associated traffic would be expected to have only SMALL and temporary noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise generating activities. Noise impacts to workers during aquifer restoration would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During aquifer restoration, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Therefore, overall noise impacts during aquifer restoration would be SMALL to MODERATE.

4.3.7.4 Decommissioning Impacts to Noise

For the Wyoming East Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.4. The two uranium districts in the Wyoming West Uranium Milling Region are located in undeveloped rural areas, at least 16 km [10 mi] from the closest communities. Because of decreasing noise levels with distance, decommissioning activities and associated traffic would be expected to have only SMALL and short-term noise impacts for residences, communities, or sensitive areas that are located more than about 300 m [1,000 ft] from specific noise generating activities. Noise impacts to workers during decommissioning would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During decommissioning, wildlife would be anticipated to avoid areas where noise-generating activities were ongoing. Therefore, overall noise impacts during decommissioning would be SMALL to MODERATE.

4.3.8 Historical and Cultural Resources Impacts

Construction-related impacts to cultural resources (defined here as historical, cultural, archaeological, and traditional cultural properties) can be direct or indirect and can occur at any stage of an ISL uranium recovery facility project (i.e., during construction, operation, aquifer restoration, and decommissioning).

A general cultural overview of the affected environment for the Wyoming East Uranium Milling Region is provided in Sections 3.2.8 and 3.3.8. Construction involving land-disturbing activities, such as grading roads, installing wells, and constructing surface facilities and well fields, would be expected to be the most likely to affect cultural and historical resources. Prior to engaging in land-disturbing activities, applicants would review existing literature and perform region-specific records searches to determine whether cultural or historical resources are present and have the potential to be disturbed. Along with literature and records reviews, the project site area and all its related facilities and components would be subjected to a comprehensive cultural resources inventory (performed by the licensee or applicant) that meets the requirements of responsible federal, state, and local agencies (e.g., the Wyoming SHPO). The literature and records searches help identify known or potential cultural resources and Native American sites and features. The cultural resources inventory would be used to identify the previously documented sites and any newly identified cultural resources sites. The eligibility evaluation of cultural resources for listing in the NRHP under criteria in 36 CFR 60.4(a)–(d) and/or as traditional cultural properties would be conducted as part of the site-specific review and NRC licensing procedures undertaken during the NEPA review process. Long linear features such as the Bozeman National Historic Trail in the Wyoming East Uranium Milling Regions require detailed assessment of potential construction and operation impacts. The evaluation of impacts to any historic properties designated as traditional cultural properties and tribal consultations regarding cultural resources and traditional cultural properties would also occur during the site-specific environmental review process. Consultation to determine whether significant cultural resources would be avoided or mitigated would occur during state SHPO, agency, and tribal consultations as part of the site-specific review. Additionally, as needed, the NRC license applicant would be required, under conditions in its NRC license, to adhere to procedures regarding the discovery of previously undocumented cultural resources during initial construction, operation, aquifer restoration, and decommissioning. These procedures typically require the licensee to stop work and to notify the appropriate federal and state agencies.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance or mitigation) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC and licensees/applicants may enter into a memorandum of agreement with the responsible state and tribal agencies to ensure protection of historical and cultural resources, if encountered.

4.3.8.1 Construction Impacts to Historical and Cultural Resources

Most of the potential for significant adverse effects to NRHP-eligible or potentially NRHP-eligible historic properties and traditional cultural properties, both direct and indirect, would be expected to occur during land-disturbing activities related to constructing an ISL uranium recovery facility. Buried cultural features and deposits that were not visible on the surface during initial cultural resources inventories might also be discovered during earth-moving activities.

Indirect impacts may also occur outside the ISL uranium recovery project site and related facilities and components. Visual intrusions, increased access to formerly remote or inaccessible resources, impacts to traditional cultural properties and culturally significant landscapes, as well as other ethnographically significant cultural landscapes may adversely affect these resources. These significant cultural landscapes should be identified during literature and records searches and may require additional archival, ethnographic, or ethnohistorical research that encompasses areas well outside the area of direct impacts. Indirect impacts to some of these cultural resources may be unavoidable and exist throughout the lifecycle of an ISL uranium recovery project.

Because of the localized nature of land disturbing activities related to construction, impacts to cultural and historical resources would be expected to be SMALL, but could be MODERATE or LARGE if the facility is located on a known resource. Wyoming historical sites listed in the NRHP and traditional cultural properties are provided in Section 3.2.8. Proposed facilities or expansions adjacent to these properties would be likely to have the greatest potential impacts, and mitigation measures (e.g., avoidance, recording and archiving samples) and additional consultations with the Wyoming SHPO and affected Native American tribes would be needed to assist in reducing the impacts. From the standpoint of cultural resources, the most significant impacts to any sites that are present would occur during the initial construction within the area of potential effect. Subsequent changes in the footprint of the project (i.e., expansion outside of the original area of potential effect) may also result in significant impact to any cultural resources that might be present.

4.3.8.2 Operation Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during operation of an ISL uranium recovery project. Potential impacts during operation would be expected to occur through new earth-disturbing activities, new construction, maintenance, and repair.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during operation. Overall impacts to cultural and historical resources during operations are expected to be less than those during construction, as operations are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites), and would be SMALL.

4.3.8.3 Aquifer Restoration Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the aquifer restoration phase of an ISL uranium recovery project. Potential impacts during aquifer restoration may occur through new earth-disturbing activities or other new construction that may be required for the restoration process. Such activities may have inadvertent impacts to cultural resources and traditional cultural properties in or near the site of aquifer restoration activities located within the extended ISL project area.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during aquifer restoration would be expected to be less than those during construction, as aquifer restoration activities are generally limited to existing infrastructure in previously disturbed areas (e.g., access roads, central processing facility, well sites), and would be SMALL.

4.3.8.4 Decommissioning Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the decommissioning phase of an ISL uranium recovery project. Potential impacts can result from earth-disturbing activities that may be required for the decommissioning process. Inadvertent impacts to cultural resources and traditional cultural properties in or near the site of decommissioning activities may occur.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction would be expected to continue during decommissioning and reclamation. Overall impacts to cultural and historical resources during decommissioning are expected to be less than those during construction, as decommissioning activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites). Because cultural resources within the existing area of potential effect are known, potential impacts can be avoided or lessened by redesign of decommissioning project activities. As a result, the overall impacts to historic and cultural resources from decommissioning would be expected to be SMALL.

4.3.9 Visual/Scenic Resources Impacts

4.3.9.1 Construction Impacts to Visual/Scenic Resources

During construction, most impacts to visual resources in the Wyoming East Uranium Milling Region would be similar to those in the Wyoming West Uranium Milling Region (see Section 4.2.9.1). Most visual and scenic impacts associated with drilling and other land-disturbing construction activities would be temporary. Roads and structures would be more long lasting, but would be removed and reclaimed after operations cease. As noted in Section 3.3.9, no VRM Class I areas are identified in the Wyoming East Uranium Milling Region, and most of the areas are identified as VRM Class II through Class IV according to the BLM classification system. Visual contrast during construction would be the least intrusive in those areas that are already developed such as the region around Casper or in the natural-gas-producing areas of the Powder River Basin to the north. VRM Class II areas are located in the southern part of the region within view of sensitive areas in the Bighorn and Laramie Mountains, historic trails (Bozeman, Oregon, and Bridger), or along the North Platte River. All of the existing and potential ISL facilities identified in the three uranium districts of the Wyoming East Uranium Milling Region are located within Class III through Class V/Rehabilitation VRM areas. Visual/scenic impacts introduced by ISL construction in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.3.9.2 Operation Impacts to Visual/Scenic Resources

Similar to the visual impacts described for the Wyoming West Uranium Milling Region in Section 4.2.9.2, the potential visual and scenic impacts from ISL operations in the Wyoming East Uranium Milling Region would be SMALL and less than those impacts associated with construction. The greatest potential for visual impacts would be for new facilities operating in rural, previously undeveloped areas or within view of the sensitive regions described in Section 4.3.9.1. All of the existing and potential ISL facilities identified in the three uranium districts of the Wyoming East Uranium Milling Region are located within Class III through Class V/Rehabilitation VRM areas. Visual/scenic impacts introduced by ISL operations in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.3.9.3 Aquifer Restoration Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region in Section 4.2.9.3, the potential visual and scenic impacts from ISL aquifer restoration operations in the Wyoming East Uranium Milling Region would be SMALL. Aquifer restoration would not occur until after the facility had been in operation for a number of years, and additional potential impacts would be the same as or less than those during the construction or operations periods. Although overall impacts from aquifer restoration activities would be SMALL, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Section 4.3.9.1. All of the existing and potential ISL facilities identified in the three uranium districts of the Wyoming East Uranium Milling Region are located within Class III through Class V/Rehabilitation VRM areas. Visual/scenic impacts introduced by ISL aquifer restoration in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.3.9.4 Decommissioning Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.4, the potential visual and scenic impacts from decommissioning and reclaiming ISL facilities in the Wyoming East Uranium Milling Region would be SMALL. Decommissioning and reclamation activities would occur after the facility had been in operation for a number of years, and one of the purposes of the decommissioning process is to remove surface infrastructure and reclaim the area to preoperational conditions, resulting in less visual contrast for the facility. Overall impacts from decommissioning and reclamation activities would be the same as, or less than, those for construction and operation. Potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Section 4.3.9.1. All of the existing and potential ISL facilities identified in the three uranium districts of the Wyoming East Uranium Milling Region are located more than 32 km [20 mi] from VRM Class II areas, within VRM Class III through Class V/Rehabilitation areas. Visual/scenic impacts introduced by ISL decommissioning and reclamation operations in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.3.10 Socioeconomic Impacts

Although a proposed facility size and production level can vary, the peak annual employment at an ISL facility could reach up to about 200 people, including construction workforce (Freeman and Stover, 1999; NRC, 1997; Energy Metals Corporation, U.S., 2007). In Wyoming, the workforce frequently commutes long distances to work, sometimes from out of state. For example, each of the counties in the Wyoming East Uranium Milling Region experienced net inflows during the fourth quarter of 2005, ranging from about 1600 for Johnson County to 7,600 for Campbell County. These inflows were primarily for jobs related to the energy industry (Wyoming Workforce Development Council, 2007). Depending on the composition and size of the local workforce, overall socioeconomic impacts from ISL milling facilities for the Wyoming East Uranium Milling Region would range from SMALL to MODERATE.

Assuming the number of persons per household in Wyoming is about 2.5 (U.S. Census Bureau, 2008), the number of people associated with an ISL facility workforce could be as many as 500 (i.e., 200 workers times 2.5 persons/household). The demand for public services (schools, police, fire, emergency services) would be expected to increase with the construction and operation of an ISL facility. There may also be additional standby emergency services not available in some parts of the region. It may be necessary to develop contingency plans and/or additional training for specialized equipment. Infrastructure (streets, waste management, utilities) for the families of a workforce of this size would also be affected.

4.3.10.1 Construction Impacts to Socioeconomics

The majority of construction requirements would likely be filled by a skilled workforce from outside of the Wyoming East Uranium Milling Region. Assuming a peak workforce of 200, this influx of workers is expected to result in SMALL to MODERATE impact in the Wyoming East Uranium Milling Region. Impacts would be greatest for communities with small populations, such as Johnson County (population 8,100) and Weston County (6,644) and the towns of Lynch (200) and Edgerton (175). However, due to the short duration of construction (12–18 months), workers would have only a limited effect on public services and community infrastructure.

Further, construction workers are less likely to relocate their entire family to the region, thus minimizing impacts from an outside workforce. In addition, if the majority of the construction workforce is filled from within the region, impacts to population and demographics would be SMALL.

Construction impacts to regional income and the labor force for a single ISL facility in the Wyoming East Uranium Milling Region would likely be SMALL. In addition, even if multiple facilities were developed concurrently, the potential for impact upon the labor force would still be SMALL. For example, Weston County has the smallest labor force (3,183) in the region. It would require at least two ISL facilities to be constructed simultaneously to affect the labor market of just Weston County by more that 10 percent, if all the workers came from Weston County. Construction of an ISL is likely, to the extent possible, to draw upon the labor force within the region before going outside the region (and state). The greatest economic benefit to the region would be to have the labor force drawn from within the region. However, economic benefit may still be achieved (in the form of the purchased of goods and services) even if the labor force is derived from outside the region. The potential impact upon smaller communities (Lynch and Edgerton) and counties (Johnson and Weston) could be MODERATE.

Impacts to housing from construction activities would be expected to be SMALL (and short term) even if the workforce is primarily filled from outside the region. It is likely that the majority of construction workers would use temporary housing such as apartments, hotels, or trailer camps. Many construction workers use personal trailers for housing on short-term projects. Impacts on the region's housing market would therefore be considered SMALL. However, the impact upon specific facilities (apartment complexes, hotels, or campgrounds) could potentially be MODERATE, if construction workers concentrated in one general area.

Assuming the majority of employment requirements for construction are filled by outside workers (a peak of 200), there would be SMALL to MODERATE impacts to employment structure. The use of an outside workforce would be expected to have MODERATE impacts to communities with high unemployment rates, such as Laramie, Wyoming, due to the potential increase in job opportunities. If the majority of construction activities relies on the use of a local workforce, impacts would be anticipated to be SMALL to MODERATE depending upon the size of the local workforce. Counties such as Campbell and Albany would experience MODERATE impacts, due to their high unemployment rate and potential increase in employment opportunities.

Local finance would be affected by ISL construction through additional taxation and the purchase of goods and services. Though Wyoming does not have an income tax, it does have a state sales tax (4 percent), a lodging tax (2–5 percent), and a use tax (5 percent). Construction workers are anticipated to contribute to these as they purchase goods and services within the region and within the state while working on an ISL facility. In addition, and more significant, is the "ad valorem tax" the state imposes on mineral extraction. In 2007 for uranium, alone, the state collected $1.2 million from this tax (Wyoming Department of Revenue, 2008). It is anticipated that ISL facility development could have a MODERATE impact on local finances within the region.

Even if the majority of the workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to relocate their entire family for a relatively short duration (12–18 months). Impacts to education from a local workforce would also be SMALL, as they are already established in the community.

Potential impacts from construction [from either the use of local or outside (nonregional) workforce] to local health services such as hospitals or emergency clinics would be SMALL. Accidents resulting from construction of an ISL facility are not expected to be different than other types of similar industrial facilities.

> **Economic Multipliers**
> The economic multiplier is used to summarize the total impact that can be expected from change in a given economic activity. It is the ratio of total change to initial change. The multiplier of 0.7 was used as a typical employment multiplier for the milling/mining industry (Economic Policy Institute, 2003).

4.3.10.2 Operation Impacts to Socioeconomics

Operational requirements of an ISL necessitate the use of specialized workers, such as plant managers, technical professionals, and skilled tradesmen. While operational activities would be longer term (20–40 years) than construction (12–18 months), instead of up to 200 workers, an operating ISL generally requires a labor force of from 50 to 80 personnel. If the majority of operational requirements is filled by a workforce from outside the region, assuming a multiplier of about 0.7 (see text box), there could be an influx of between 35 and 56 jobs (i.e., 50–80 × 0.7) per ISL facility (up to 140, including families). The potential impact to the local population and public services resulting from the influx of workers and their families would range from SMALL to MODERATE, depending upon the location (proximity to a population center) of an ISL within the region. However, because an outside workforce would be more likely to settle into a more populated area with increased access to housing, schools, services, and other amenities, these impacts may be reduced. If the majority of labor is of local origin, potential impacts to population and public services would be expected to be SMALL, as the workers would already be established in the region.

It is assumed, however, that because of the highly technical nature of ISL operation (requiring professionals in the areas of health physics, chemistry, laboratory analysis, geology and hydrogeology, and engineering), the majority (approximately 70 percent) of the work force (35 to 56 personnel) would be staffed from outside the region for at least the initial ISL facility. Subsequent ISL facilities may draw personnel from established or decommissioned facilities. This is expected to have a SMALL impact upon the regional labor force.

If it is assumed that as many as 56 families (80 workers × 0.7 economic multiplier) are required to relocate into the Wyoming East Uranium Milling Region, the most likely available housing markets would be located in the larger communities, such as Casper and Douglas (within the region), and Gillette and Sheridan (located outside the region). Unless the workforce is distributed throughout the region, the impact of an ISL on the housing market would be MODERATE, depending upon location, due to the limited number of available units.

Impacts to income and the labor force structure within the Wyoming East Uranium Milling Region would be similar to construction impacts, but longer in duration. Impacts from ISL operation would be SMALL to MODERATE, depending on where the majority of the workforce settles.

Assuming a local workforce is used, there would be SMALL impacts to the local employment structure, and these would be similar to construction impacts. If the entire labor force for the ISL facility came from outside the affected community, the workforce impact would be SMALL to

MODERATE relative to the employment structure for most of the affected counties. Impacts from inflow of an outside workforce would be similar to construction impacts.

Assuming the majority of the workforce is derived from outside the Wyoming East Uranium Milling Region, potential impacts to education from operation activities would be SMALL. Even though the number of people associated with an ISL facility workforce could be as many as 140 (including families), there would only be about 30 school-aged children involved. While the influx of new students would be the greatest in the smaller school districts, even in these districts the impacts are anticipated to be SMALL. For example, Weston County has 1,134 students (elementary through high school) in 5 schools. With an average of 227 students per school, even if all the ISL workers' children attended the same school (which is unlikely), the increase in that school's student population would only be 13 percent.

Effects on other community services (e.g., health care, utilities, shopping, recreation) during operation are anticipated to be similar to construction (less in volume/quantity, but longer in duration). Therefore, the potential impacts would be SMALL.

4.3.10.3 Aquifer Restoration Impacts to Socioeconomics

The same ISL facility components and workforce would be involved in aquifer restoration as during operations use. Thus, the number of personnel involved would also be the same, and the potential impacts would be similar. These potential impacts would extend beyond the life of the facility (typically 2–10 years), but still would be SMALL.

Income and labor force requirements during aquifer restoration are anticipated to be the same as during operations (technical requirements are similar), and therefore potential impacts would be SMALL.

The employment structure during aquifer restoration would be expected to be unchanged and continue after the operational phase. However, a smaller number of specialized workers may be required to return the site to preISL levels. The potential impacts to the region would be considered SMALL.

Impacts to housing, education, health, and social services during aquifer restoration would also be expected to be the similar to operations, but continue beyond the life of the site. The overall potential impacts would be SMALL.

4.3.10.4 Decommissioning Impacts to Socioeconomics

Decommissioning is essentially deconstruction and is expected to require a similar workforce (up to 200 personnel) with similar skills as the construction phase. The impacts to affected communities in the Wyoming East Uranium Milling Region during decommissioning would therefore be similar to the construction phase. The decommissioning phase may last up to a year longer than the construction phase, depending upon the condition of the ISL at termination. However, the overall potential impacts are still expected to be SMALL to MODERATE.

The income levels and labor force requirements during decommissioning are also anticipated to be similar to the construction phase, and the potential impacts to the region would therefore be considered SMALL to MODERATE.

The employment structure during decommissioning would be similar to the construction phase; however, a reduction of the workforce would result toward the end of the decommissioning phase. Impacts to employment would be SMALL to MODERATE.

Potential impacts to housing during the decommissioning phase would be similar to the construction phase and would be SMALL for the larger communities within the region, but may be MODERATE if the temporary housing was concentrated in a smaller community. Decommissioning would be expected to involve similar numbers (up to 200) of workers (likely without families because of the short duration of the activity) as construction. Therefore, the anticipated impacts to the local education system would be SMALL.

Impacts to community services (health care, entertainment, shopping, recreation) would also be similar to construction, and thus would be considered SMALL.

4.3.11 Public and Occupational Health and Safety Impacts

4.3.11.1 Construction Impacts to Public and Occupational Health and Safety

Construction impacts on public and occupational health and safety for the Wyoming East Uranium Milling Region would be similar to those discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.1.

4.3.11.2 Operation Impacts to Public and Occupational Health and Safety

4.3.11.2.1 Radiological Impacts to Public and Occupational Health and Safety From Normal Operations

A potential ISL facility would be required by its NRC license to implement a radiation safety program that complies with the requirements of 10 CFR Part 20 (Section 2.9). Estimated doses to members of the public would be reported for a variety of commercial-scale and satellite facilities in Section 4.2.11.2.1. These doses are well below the 10 CFR Part 20 public dose limit of 1 mSv/yr [100 mrem/yr] and the 40 CFR Part 190 annual limit of 0.25 mSv [25 mrem]. Doses at other locations would depend on a variety of factors including receptor location, topography, and weather conditions. When releases occur from ground level, doses decrease the farther the receptor is away from the release location because the radioactive material is diluted as the wind mixes it. The amount of dilution, which is referred to as dispersion, is determined by the weather (meteorological conditions). For areas in which meteorological conditions are more stable (less turbulent), a higher dose could occur. As the radioactive material travels via the wind, changes in topography can affect the dose received by the receptor. Doses for the various ISL facilities shown in Table 4.2-2 are at least a factor of three below the regulatory limit, and most are less than that. Based on operational history and dose-modeling results, doses at operating ISL facilities in different regions are not likely to exceed regulatory limits, and overall potential radiological impacts from ISL operations would be SMALL.

4.3.11.2.2 Radiological Impacts to Public and Occupational Health and Safety From Accidents

The consequences of potential accidents would be similar regardless of an ISL facility's location and are described in Section 4.2.11.2.2. Distance to the nearest receptor, topography, and meteorological data account for potential differences in resulting dose. For facilities in which the maximally exposed offsite individual would be closer, there would be higher doses for ground-level releases. Changes in topography would also have an impact on the resulting dose because this could allow the receptor to be closer to, or farther away from, the radioactive material as it travels by wind. Meteorological conditions vary based on location and could result in a higher or lower dose. Compliance with the required radiological safety program that includes monitoring and emergency response procedures, potential impacts resulting from a potential unmitigated accident would have a SMALL effect on the general public and, at most, a MODERATE impact to workers.

4.3.11.2.3 Nonradiological Impacts to Public and Occupational Health and Safety From Normal Operations

While hazardous chemicals are used at ISL facilities (Section 2.4.2), SMALL risks would be expected in the use and handling of these chemicals during normal operations. However, releases of these hazardous chemicals could produce significant consequences and affect public and occupational health and safety. An analysis of such hazards and potential risks for impacts is provided in the following section.

4.3.11.2.4 Nonradiological Impacts to Public and Occupational Health and Safety From Accidents

Because the same chemicals would be handled, nonradiological impacts to public and occupational health and safety for the Wyoming East Uranium Milling Region from releases of hazardous chemicals would be expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.2.4. The likelihood of releases would be low based on historical operational experience and required safety procedures. Overall impacts to public and occupational health and safety would be SMALL.

4.3.11.3 Aquifer Restoration Impacts to Public and Occupational Health and Safety

Because the existing infrastructure is used, aquifer restoration impacts on public and occupational health and safety would be similar to operational impacts discussed in Section 4.3.11.2, with overall SMALL impacts to public and occupational health and safety.

4.3.11.4 Decommissioning Impacts to Public and Occupational Health and Safety

During ISL facility decommissioning, as hazards are removed or reduced, surface soils and structures are decontaminated, and disturbed lands are reclaimed, there would be a SMALL potential for environmental impact.

To ensure the safety of workers and the public during decommissioning, the NRC requires licensed facilities to submit a decommissioning plan for review (Section 2.6). Such a plan includes details of how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable safety regulations are complied with. A combination of (1) NRC review and approval of these plans, (2) the application of site-specific license conditions where necessary, and (3) regular NRC inspection and enforcement activities to ensure compliance with radiation safety requirements would be expected to reduce the magnitude of potential public and occupational health impacts from ISL facility decommissioning actions. Therefore, potential impacts to public health and safety would be SMALL.

4.3.12 Waste Management Impacts

Waste management impacts for the Wyoming East Uranium Milling Region would be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another.

4.3.12.1 Construction Impacts to Waste Management

The relatively small scale of construction activities (Section 2.3) and incremental development of well fields at ISL facilities would generate low volumes of construction waste. Table 2.7-1, which includes a listing of engine-driven construction equipment needed for construction of a satellite ISL facility, provides some insights into the magnitude of well field construction activities. As a result of the limited volumes of construction waste that would be generated by ISL facility construction, waste management impacts from construction would be SMALL.

4.3.12.2 Operation Impacts to Waste Management

Operation waste management impacts for the Wyoming East Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.2 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. Operational waste management impacts would be SMALL, based on the required preoperational disposal agreement for byproduct material; regulatory controls including applicable permitting, license conditions, and inspection practices; and typical facility design specifications and management practices including waste treatment and volume reduction techniques, pond leak detection, and other routine monitoring activities.

4.3.12.3 Aquifer Restoration Impacts to Waste Management

Waste management activities during aquifer restoration utilize the same treatment and disposal options implemented for operations; therefore, impacts associated with aquifer restoration would be similar to the operational impacts discussed in Section 4.3.12.2. Additional wastewater volume and the associated volume of water treatment wastes may be generated during aquifer restoration; however, this would be offset to some degree by the reduction in production capacity from the removal of a well field from production activities. While the amount of wastewater generated during aquifer restoration is dependent on site-specific conditions, Section 2.5.2 provides an illustrative estimate of water volume per pore volume and Section 2.11.5 provides experience regarding the number of pore volumes required for aquifer restoration in past efforts. Furthermore, the NRC review of future ISL facility licensing would verify that sufficient water treatment and disposal capacity (and the associated agreement for disposal of byproduct material discussed in Section 4.2.12) are addressed. As a result, waste management impacts from aquifer restoration would be SMALL.

4.3.12.4 Decommissioning Impacts to Waste Management

Decommissioning waste management impacts for the Wyoming East Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.4 because the waste volumes and management practices, waste management safety and environmental concerns, waste management regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. The required preoperational agreement for disposal of 11e.(2) byproduct material, NRC review and approval of a decommissioning plan and radiation safety program, and the small volume of solid waste generated for offsite disposal suggest the waste management impacts would be SMALL. Related transportation impacts are discussed separately in Section 4.3.2.

4.3.13 References

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4.4 Nebraska-South Dakota-Wyoming Uranium Milling Region

4.4.1 Land Use Impacts

Information on ISL facility size (Section 2.11) and the types of potential impacts to land use previously described for the two Wyoming regions (see Sections 4.2.1 and 4.3.1) would also generally apply for ISL facilities in the Nebraska-South Dakota-Wyoming Uranium Milling Region.

4.4.1.1 Construction Impacts to Land Use

The overall land uses in the Nebraska-South Dakota-Wyoming Uranium Milling Region are similar to the Wyoming East Uranium Milling Region with predominantly private land ownership and also land managed by federal and state agencies (e.g., USFS grasslands, Custer State Park, Devil's Tower National Monument). The type and intensity of construction impacts to land use from new ISL facilities in this region would, therefore, be anticipated to be similar to those described for the two Wyoming regions. Construction activities would also (1) change and disturb the land uses, (2) restrict access and establish right-of-way for access, (3) affect mineral rights, (4) restrict livestock grazing areas, (5) restrict recreational activities, and (6) alter ecological, cultural, and historical resources. In this region, the uranium districts are located predominantly on grassland and forest land managed by the USFS, while in the two Wyoming regions, land use is predominantly BLM lands. In addition, almost 60 percent of the land in the Nebraska-South Dakota-Wyoming Uranium Milling Region is privately owned. This could lead to potential impacts that would need to be resolved through arrangements (e.g., leases, mineral rights sales, royalties) with individual land owners. Because the amount of area affected by an ISL facility in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to that in the two Wyoming regions, and only a small portion of that area would be fenced, access would be minimally affected. As a result, potential impacts to most aspects of land use from the construction of an ISL facility would be SMALL. Potential impacts to historic and cultural resources would range from SMALL to LARGE, depending on site-specific conditions, as resources not previously identified could be altered or destroyed during excavation, drilling, and grading activities.

4.4.1.2 Operation Impacts to Land Use

The types of land use impacts for operational activities would be expected to be similar to construction impacts regarding access restrictions, primarily because the infrastructure would be already in place. Additional land disturbances would not be expected during the operational activities described in detail in Section 2.4. During the operational period of an ISL facility, the primary changes to land use would be the movement (sequencing) of well fields from one area to another; this is addressed as a construction impact in Section 4.4.1.1. Sequentially moving active operations from one well field to the next would shift potential impacts. For example, a well field where uranium recovery activities have ceased could be restored and reopened for grazing or recreation while a new well field is being developed, which would have impacts similar to those described in the preceding section for the construction phase. Because access restriction and land disturbance impacts would be expected to be similar to, or less than, those expected for construction, the overall potential impacts to land use from operational activities would be SMALL.

4.4.1.3 Aquifer Restoration Impacts to Land Use

During aquifer restoration, the land use impacts described previously for the construction phase and the operations phase would be similar. In terms of specific activities, the aquifer restoration uses the same infrastructure as the operations phase and maintenance would be at a similar level. Land use impacts from aquifer restoration would decrease as fewer wells and pump houses are used and overall equipment traffic and use diminish. Thus, the overall potential impacts to land use during the aquifer restoration phase are comparable to those of the operations phase and would be SMALL.

4.4.1.4 Decommissioning Impacts to Land Use

The types of decommissioning impacts to land use in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to the construction, operations, and aquifer restoration impacts. As previously described, the level of decommissioning activities disturbing the land uses would increase during this phase because greater use of earth- and material-moving equipment and other heavy equipment would occur. As decommissioning and reclamation proceed, the amount of disturbed land would decrease. Consequently, the overall potential decommissioning impacts to land use in the Nebraska-South Dakota-Wyoming Uranium Milling Region would range from SMALL to MODERATE.

4.4.2 Transportation Impacts

Truck and automobile use is associated with all phases of the ISL facility lifecycle including construction, operation, aquifer restoration, and decommissioning. The estimated low magnitude of road transportation from all phases of the ISL lifecycle (Section 2.8), when compared with local traffic volumes in the Nebraska-South Dakota-Wyoming Uranium Milling Region (Section 3.4.2), is not expected to significantly affect the amount of traffic or accident rates. One possible exception to this conclusion is that commuting traffic for facility workers, in particular, during periods of peak employment (during construction), would have greater impacts when roads with the lowest levels of current traffic are traveled. This impact would be more pronounced in the Nebraska-South Dakota-Wyoming Uranium Milling Region owing to the relatively lower traffic counts in this region. These low-trafficked roads may also be more susceptible to wear and tear from increased traffic. Localized, short-term, and intermittent SMALL to MODERATE impacts associated with noise, dust, and incidental livestock or wildlife kills are possible on all roads but in particular on remote local and unpaved access roads. The magnitude of these impacts would be influenced by site-specific conditions, including the proximity of residences, other regularly occupied structures, wildlife habitat, farming, or grazing areas to ISL facility access roads. Unique local road and environmental conditions (e.g., local hazards, local resource impacts) would be considered in an NRC site-specific environmental review. Potential local impacts include loss of forage palatability from road dust and interference with livestock herding and grazing activities. A more detailed assessment of transportation impacts for each phase of the ISL facility lifecycle follows.

4.4.2.1 Construction Impacts to Transportation

ISL facilities, in general, are not large-scale or time-consuming construction projects (Section 2.3 and Table 2.7-1). The magnitude of estimated construction-related transportation (Section 2.8) is expected to vary depending on the size of the facility. However, when compared to the regional traffic counts provided in Section 3.4.2, most roads that would be used for construction transportation in the Nebraska-South Dakota-Wyoming Uranium Milling Region would not cause significant increases in daily traffic, and therefore traffic-related impacts would be SMALL. The roads with the lowest average annual daily traffic counts would have higher (MODERATE) traffic and potential infrastructure impacts, in particular, when facilities are experiencing peak (construction) employment. The limited duration of ISL construction activities (12–18 months) suggests impacts would be of short duration. Temporary SMALL to MODERATE dust, noise, and incidental livestock or wildlife impacts are possible on, or in the vicinity of, access roads used for construction transportation.

4.4.2.2 Operations Impacts to Transportation

The discussion of impacts in Section 4.2.2.2 for the Wyoming West Uranium Milling Region also applies to the Nebraska-South Dakota-Wyoming Uranium Milling Region because the same types of transportation activities would be conducted regardless of location, the same regulatory controls and safety practices apply, the same magnitude of transportation activities would be conducted, and the assessment of accident risks is generally applicable to all regions. Applicable transportation conditions for the Nebraska-South Dakota-Wyoming Uranium Milling Region are discussed in Section 3.4.2. With the magnitude of existing traffic conditions in the region somewhat less than in the other milling regions, the intensity of traffic-related impacts would be similar and range from SMALL to MODERATE considering potential peak employment commuting impacts to low traffic roads. The methods and assumptions considered in the accident analysis in Section 4.2.2.2 (Wyoming West Uranium Milling Region) for yellowcake shipments are applicable to the Nebraska-South Dakota-Wyoming Uranium Milling Region, and therefore the impact from yellowcake, resin transfer, and byproduct waste shipments would be similar (SMALL). The same practices and requirements that serve to limit the risks from chemical shipments also apply to the Nebraska-South Dakota-Wyoming Uranium Milling Region and would also result in SMALL impacts.

4.4.2.3 Aquifer Restoration Impacts to Transportation

Aquifer restoration transportation impacts are expected to be less than those described for construction and operations because transportation activities will be primarily limited to supplies (including chemicals), chemical waste shipments, onsite transportation, and employee commuting. No additional unique transportation activities are expected during aquifer restoration; therefore, no additional types of impacts associated with aquifer restoration are anticipated and impacts would be SMALL to MODERATE.

4.4.2.4 Decommissioning Impacts to Transportation

Decommissioning 11e.(2) byproduct wastes (as defined in the Atomic Energy Act) can be shipped offsite by truck for disposal at a licensed disposal site. Section 2.8 provides estimates of the number of decommissioning-related waste shipments, which are small compared to average annual daily traffic counts provided in Section 3.4.2. All radioactive waste shipments must be shipped in accordance with the applicable NRC safety requirements in 10 CFR Part 71. As shown in Section 2.8, the number of estimated decommissioning waste shipments is fewer than those needed to support facility operations, and therefore potential traffic and accident impacts are expected to decrease during the decommissioning period. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments owing to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Commuting impacts would decrease from peak employment due to cessation of operations, though this effect would be offset to some degree by an increase in decommissioning workers. Overall, based on the magnitude of transportation activities expected during decommissioning, impacts would be SMALL.

4.4.3 Geology and Soils Impacts

Construction, operation, aquifer restoration, and decommissioning activities and processes at ISL facilities may impact geology and soils. The potential impacts to geology and soils from these activities in the Nebraska-South Dakota-Wyoming Milling Region are discussed in the following sections.

4.4.3.1 Construction Impacts to Geology and Soils

During construction of ISL facilities, the principal impacts on geology and soils would result from earth-moving activities associated with constructing surface facilities, wastewater evaporation ponds, access roads, well fields, and pipelines (Section 2.3). Earth-moving activities would include

- Clearing of ground or topsoil and preparing surfaces for the processing plant, satellite facilities, pump houses, access roads, drilling sites, and associated structures

- Excavating and backfilling trenches for pipelines and cables

- Excavating evaporation ponds and developing evaporation pond embankments

The impact of construction activities on geology and soils will depend on local topography, surface bedrock geology, and soil characteristics. Construction activities at ISL facilities in the Nebraska-South Dakota-Wyoming Uranium Milling Region may increase the potential for erosion from both wind and water due to the removal of vegetation and the physical disturbance from vehicle and heavy equipment traffic. Likewise, compaction of soils and removal of vegetation resulting from construction activities may increase the potential for surface runoff and sedimentation in local drainages and streams outside disturbed areas.

Generally, earth-moving activities would result in only SMALL (on average, approximately 15 percent of the permitted site area) impacts and temporary (several months) disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Chapter 7). For example, soil horizons will be disrupted to construct the processing facilities, evaporation ponds, and well field houses. In the well field, soil disturbance would be limited to drill pad grading, mud pit excavation, well completion, and access road construction.

Operators of ISL facilities typically adopt best management construction practices to prevent or substantially reduce soil impacts (see Table 7.4-1). For example, soils removed during construction of surface facilities are generally stockpiled and stabilized for later use during decommissioning and land reclamation. These stockpiles are typically located, shaped, and seeded with a cover crop by the operator to control erosion. Other practices include constructing structures to divert surface runoff from undisturbed areas around disturbed areas;

using silt fencing, retention ponds, and hay bales to retain sediment within the disturbed areas; and reestablishing native vegetation as soon as possible after disturbance.

As part of the underground infrastructure at ISL facilities, a network of buried process pipelines and cables is typically constructed. Pipeline systems are installed between the pump house and well field for injecting and recovering lixiviant, between the pump house and the satellite facility or processing plant for transporting lixiviant and resin, and between the processing facilities and deep injection wells. Trenches for the pipelines are excavated as deep as 1.8 m [6 ft] below the ground to avoid any potential freezing problem. Operators typically segregate topsoil from subsoil (i.e., underlying rock) when excavating trenches so that the general soil profile can be restored during backfilling. Excavating trenches for pipelines and cables normally results in only SMALL, short-term disturbance of rock and soil. After piping and cable are placed in the trenches, the trenches are backfilled with the excavated material and graded to surrounding ground topography.

Based on the previous discussion, the impacts of construction activities on geology and soils at ISL facilities in the Nebraska-South Dakota-Wyoming Milling Region would be SMALL because of the limited time of the activity (months), the limited affected area (on average, approximately 15 percent of the permitted site are), and the shallow depth of excavation {1.2–1.8 m [4–6 ft]}.

4.4.3.2 Operation Impacts to Geology and Soils

During ISL operations (Section 2.4), a non-uranium-bearing (barren) solution or lixiviant is injected through wells into the mineralized zone. The lixiviant moves through the pores in the host rock, dissolving uranium and other metals. Production wells withdraw the resulting “pregnant” lixiviant, which contains uranium and other dissolved metals, and pump it to a central processing plant or to a satellite processing facility for further uranium recovery and purification.

The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the mineralogical composition of uranium-producing rock formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. In addition, the source formations for uranium in the Nebraska-South Dakota-Wyoming Milling Region occur at depths of tens to hundreds of meters [hundreds of feet] (Section 3.4.3) and individual mineralization fronts are typically 0.6 to 7.5 m [2 to 25 ft] thick (Section 3.1.2). At these depths and thicknesses and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. Therefore, impacts to geology from ground subsidence would be expected to be SMALL.

The pressure of the producing aquifer is decreased during operation activities because a negative water balance is maintained in the well field to ensure water flows into the well field from its edges, reducing the spread of contamination. This change in pressure theoretically could impact the transmissivity of faults in permitted areas. However, because uranium producing sandstones tend to be highly porous and transmissive, it is unlikely that changes in fluid pressure would reactivate faults or trigger or induce earthquakes. Based on historical ISL operations in the Nebraska-South Dakota-Wyoming Milling Region, reactivation of faults is not anticipated.

A potential impact to soils arises from the need to move barren and pregnant uranium-bearing lixiviant to and from the processing facility in aboveground and underground pipelines. If a pipe ruptures or fails, lixiviant can be released and (1) pond on the surface, (2) runoff into surface water bodies, (3) infiltrate and adsorb in overlying soil and rock, or (4) infiltrate and percolate to groundwater. For example, during 1996, the operator of the Crow Butte Uranium Project in Dawes County, Nebraska, logged 27 spill incidents, which ranged in volume from 45 to 65,000 L [12 to 17,305 gal] (NRC, 1998).

In the case of spills from pipeline leaks and ruptures, spills could release either radionuclides or other constituents (e.g., selenium or other metals). Any impacts of these two types of spills are likely to be bounded by a spill of pregnant lixiviant (Mackin, et al., 2001). Licensees are required to establish immediate spill responses through onsite standard operation procedures (e.g., NRC, 2003, Section 5.7). For example, immediate spill responses might include shutting down the affected pipeline, recovering as much of the spilled fluid as possible, and collecting samples of the affected soil for comparison to background values for uranium, radium, and other metals.

As part of the monitoring requirements at ISL facilities, licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the dose limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). This documentation helps in final site decommissioning activities. Licensees of ISL facilities in the Nebraska-South Dakota-Wyoming Milling Region must also comply with any applicable state permitting agency requirements for spill response and reporting.

Soil contamination during ISL operations could also occur from transportation accidents resulting in yellowcake or ion exchange resin spills. As for lixiviant spills, licensees must report certain of these yellowcake or resin spills to both the NRC and the appropriate state permitting agency. License conditions also may require licensees to report the corrective actions taken and the results achieved. For nonradiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of nonradiological materials is primarily reportable to the appropriate state agency or EPA. At the Crow Butte Uranium Project in Nebraska, concrete berms that can retain the volume of the tank are used to contain spills from process chemical storage tanks and simplify cleanup (NRC, 1998).

Uranium mobilization and processing during ISL operations produces excess water containing lixiviants and minerals leached from the aquifer. Other liquid waste streams produced by ISL operations can include rejected brine from the reverse osmosis system and spent eluant from the ion exchange system. Any of these waste streams may be discharged to evaporation ponds or injected into deep waste disposal wells. In addition, wastewater may be treated and applied to the land using irrigation methods or discharged to surface water drainages. The impacts and requirements for discharging treated waste streams to surface water bodies during ISL activities in the Nebraska-South Dakota-Wyoming Milling Region are discussed in Section 4.4.4.1. The impacts of using evaporation ponds or applying treated wastewater to the land are discussed in this section.

Waste streams discharged to evaporation ponds can contain radionuclides and other metals that may become concentrated during evaporation. Therefore, soil contamination could result if either the liner or embankment of an evaporation pond was to fail. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures. For example, several minor leaks were identified through the monitoring of the leak detection system at the Crow Butte Uranium Project, and repairs were made before contamination became an issue (NRC, 1998). The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of failure, pond embankments at ISL facilities are monitored and inspected by licensees in accordance with NRC-approved inspection programs, and NRC also regularly inspects the embankments as part of the federal Dam Safety program.

Land application of treated wastewater involves irrigating select parcels of land and allowing the water to be transpired by native vegetation or crops (Sections 2.7.2, 4.2.12.2). Land application of treated wastewater could potentially impact soils. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents (e.g., selenium and other metals) to accumulate in the soils, thereby degrading the site’s potential for subsequent recreational or agricultural use. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. For example, efforts to identify impacts to soil resulting from land application at the Crow Butte Uranium Project include (1) water analysis prior to release for land application to assure compliance with release limits; (2) soil sampling to establish background for uranium, radium, and other metals; (3) soil sampling for Ra-226 after each irrigation season; (4) groundwater sampling from monitoring wells near irrigation areas; and (5) surface water sampling from impoundments and streams near irrigation areas (NRC, 1998). Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be expected to be SMALL.

4.4.3.3 Aquifer Restoration Impacts to Geology and Soils

Aquifer restoration programs typically use a combination of (1) groundwater transfer; (2) groundwater sweep; (3) reverse osmosis, permeate injection, and recirculation; (4) stabilization; and (5) water treatment and surface conveyance (Section 2.5).

The groundwater sweep and recirculation process does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. The water pressure in the aquifer is decreased during restoration because a negative water balance is maintained in the well field being restored to ensure water flows into the well field from its edges, reducing the spread of contamination. However, the change in pressure is limited by reinjection and recirculation of treated groundwater, and therefore it is very unlikely that ISL operations will reactivate local faults and extremely unlikely that any earthquakes would be generated. Therefore, the impacts to geology in the Nebraska-South Dakota-Wyoming Milling Region from aquifer restoration are expected to be SMALL, if any.

The main impact on soils during aquifer restoration would be spills of contaminated groundwater resulting from pipeline leaks and ruptures. As with spills of lixiviant during operations, spill response recommendations during aquifer restoration activities have been carried forward into NRC guidance of ISL facilities (e.g., NRC, 2003, Section 5.7). Licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the does limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). Licensees in the Nebraska-South Dakota-Wyoming Milling Region are also required to comply with spill response and reporting requirements of the appropriate state permitting agency. The short-term impact on soils from spills of contaminated groundwater could range from SMALL to LARGE depending on the volume of affected soil. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils is SMALL.

During aquifer restoration, the groundwater is passed through semipermeable membranes that yield a brine or reject liquid. This reject liquid cannot be injected back into the aquifer or discharged directly to the environment. The reject liquid is typically sent to an evaporation pond or to deep well disposal. In addition, treated wastewater may be applied to the land.

If reject water is sent to an evaporation pond, failure of the evaporation pond liner or pond embankment could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures and are visually inspected on a regular basis. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of pond embankment failures, NRC requires licensees to monitor and inspect pond embankments at ISL facilities in accordance with NRC-approved inspection programs. NRC also regularly inspects the embankments as part of the federal Dam Safety program.

As with ISL operations, land application of treated wastewater during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents to accumulate in the soils. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable standards. Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.4.3.4 Decommissioning Impacts to Geology and Soils

Decommissioning of ISL facilities includes (1) dismantling process facilities and associated structures, (2) removing buried piping, and (3) plugging and abandoning wells using accepted practices. The main impacts to geology and soils in the Nebraska-South Dakota-Wyoming Milling Region during decommissioning would be from activities associated with land reclamation and cleanup of contaminated soils. These activities are described in Section 2.6.

Before decommissioning and reclamation activities begin, the licensee is required to submit a decommissioning plan to NRC for review and approval. The licensee's spill documentation, an NRC requirement, would be used to identify potentially contaminated soils requiring offsite disposal at a licensed facility. Any areas potentially impacted by operations would be included in surveys to ensure all areas of elevated soil concentrations are identified and properly cleaned up to comply with NRC regulations at 10 CFR Part 40, Appendix A, Criterion 6-(6).

Most of the impacts to geology and soils associated with decommissioning are temporary and SMALL. Because the goal of decommissioning and reclamation is to restore the facility to preproduction conditions to the extent practical, the overall long-term impacts to the geology and soils would be SMALL.

4.4.4 Water Resources Impacts

4.4.4.1 Surface Water Impacts

4.4.4.1.1 Construction Impacts to Surface Water

The potential causes and nature of impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.1). Because the average annual runoff in the Nebraska-South Dakota-Wyoming Uranium Milling Region is similar to or less than that of most portions of the Wyoming West Uranium Milling Region, the potential for surface water impacts is no greater in the Nebraska-South Dakota-Wyoming Uranium Milling Region (Gebert, et al., 1987). Storm water runoff water quality is regulated by permits issued by Nebraska, South Dakota, and Wyoming (Section 1.7.5.2). Potential impacts to wetlands would be addressed through the appropriate consultations and permitting processes (e.g., USACE, state). As noted in Section 4.2.4.1.1, Wyoming has jurisdiction over isolated wetlands. While no state-administered permitting process is in place for wetlands in Nebraska, they are protected under Title 117 of the Nebraska Surface Water Quality Standards. Compliance with applicable federal and state regulations and permit conditions and use of best management practices and required mitigation measures would reduce impacts to SMALL to MODERATE, depending on site-specific conditions.

4.4.4.1.2 Operation Impacts to Surface Water

Because precipitation and the number of perennial streams is similar (Section 3.4.4.1), the potential causes and nature of impacts to surface water resources in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.2). Storm water runoff water quality and other discharges to surface water are regulated by state pollutant discharge elimination system permits issued by Nebraska, South Dakota, and Wyoming (Section 1.7.2.1). Compliance with permit conditions and use of best management practices and required mitigation measures would reduce operations impacts to surface water to SMALL to MODERATE, depending on local conditions.

4.4.4.1.3 Aquifer Restoration Impacts to Surface Water

Because precipitation and the number of perennial streams is similar (Section 3.4.4.1), the potential causes and nature of impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.3). Storm water runoff water quality and other discharges to surface water are regulated by state pollutant discharge elimination system permits issued by Nebraska, South Dakota, and Wyoming (Section 1.7.2.1). Compliance with permit conditions and use of best management practices and required mitigation measures would reduce impacts from aquifer restoration to surface water to SMALL to MODERATE, depending on local conditions.

4.4.4.1.4 Decommissioning Impacts to Surface Water

Because precipitation and the number of perennial streams is similar (Section 3.4.4.1), the potential causes and nature of impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.4). Storm water runoff water quality is regulated by state pollutant discharge elimination system permits issued by Nebraska, South Dakota, and Wyoming (Section 1.7.2.1). Compliance with permit conditions and use of best management practices and required mitigation measures would reduce decommissioning impacts to surface water to SMALL to MODERATE, depending on local conditions.

4.4.4.2 Groundwater Impacts

Potential environmental impacts to groundwater resources in the Nebraska-South Dakota-Wyoming Uranium Milling Region can occur during all phases of the ISL facility’s lifecycle. ISL activities can impact aquifers at varying depths (separated by aquitards) above and below the uranium-bearing aquifer as well as adjacent surrounding aquifers near the uranium-bearing aquifer. Surface activities that can introduce contaminants into soils are more likely to impact shallow (near-surface) aquifers, while ISL operations and aquifer restoration are more likely to impact the deeper uranium-bearing aquifer, any aquifers above and below, and adjacent surrounding aquifers.

ISL facility impacts to groundwater resources can occur from surface spills and leaks, consumptive water use, horizontal and vertical excursions of leaching solutions from production aquifers, degradation of water quality from changes in the production aquifer’s geochemistry, and waste management practices involving land application of treated wastewater, evaporation ponds, or deep well injection. Detailed discussion of the potential impacts to groundwater resources from construction, operations, aquifer restoration, and decommissioning is provided in the following sections.

4.4.4.2.1 Construction Impacts to Groundwater

During construction of ISL facilities, the potential for groundwater impacts is primarily from consumptive groundwater use, drilling fluids and muds from well drilling, and spills of fuels and lubricants from construction equipment (Section 2.3).

As discussed in Section 2.11.3, groundwater use during construction is limited to routine activities such as dust suppression, mixing cements, and drilling support. The amounts of groundwater used in these activities are small and would have a SMALL and temporary impact to groundwater supplies. Groundwater quality of near surface aquifers during construction is protected by best management practices such as implementation of a spill prevention and cleanup plan to minimize soil contamination (Section 7.4). Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a SMALL impact to the water quality of those aquifers. Thus, construction impacts to groundwater resources would be SMALL based on the limited nature of construction activities and implementation of management practices to protect shallow groundwater.

4.4.4.2.2 Operation Impacts to Groundwater

During ISL operations, potential environmental impacts to shallow (near-surface) aquifers are related to leaks of lixiviant from pipelines, wells, or header houses and to waste management practices such as the use of evaporation ponds and disposal of treated wastewater by land application. Potential environmental impacts to groundwater resources in the production and surrounding aquifers involve consumptive water use and changes to water quality. Water quality changes would result from normal operations in the production aquifer and from possible horizontal and vertical lixiviant excursions beyond the production zone (Section 2.4). Disposal of processing wastes by deep well injection (Section 2.7.2) during ISL operations also can potentially impact groundwater resources.

4.4.4.2.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

A network of pipelines, as part of the underground infrastructure, is used during ISL operations for transporting lixiviants between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside pumping header houses. The failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers, could result in leaks and spills of pregnant and barren lixiviant (Section 2.3.1.2), which could impact water quality in shallow (near-surface) aquifers. The potential environmental impacts of pipeline, valve, or well integrity failures could be MODERATE to LARGE, if

- The groundwater table in shallow aquifers is close to the ground surface (i.e., small travel distances from the ground surface to the shallow aquifers)

- The shallow aquifers are important sources for local domestic or agricultural water supplies

- Shallow aquifers are hydraulically connected to other locally or regionally important aquifers

The potential environmental impacts could be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydrologically separated from other locally and regionally important aquifers.

In the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, local shallow alluvium aquifers exist. They are not important aquifers for water supplies in most areas, but are used for local supplies in some areas (Section 3.4.4.3.1). Hence, potential environmental impacts due to spills and leaks from pipeline networks or well integrity failures in shallow aquifers could be SMALL to MODERATE, depending on site-specific conditions. Potential impacts would be reduced by flow monitoring to detect pipeline leaks and spills early and implementation of required spill response and cleanup procedures. In addition, preventative measures such as well MIT (Section 2.3.1.1) would limit the likelihood of well integrity failure during operations.

The use of evaporation ponds or land application to manage process water generated during operations also could impact shallow aquifers. For example, failure of evaporation pond embankments or liners could allow contaminants to infiltrate into shallow aquifers. Similarly, land application of treated wastewater could cause radiological or other constituents (e.g., selenium or other metals) to accumulate in soils or infiltrate into shallow aquifers. In general, the potential impacts of these waste management activities are expected to be limited by NRC and state requirements. For example, NRC requirements for leak detection systems, maintenance of reserve pond capacity, and pond embankment inspections are expected to minimize the likelihood of evaporation pond failures. Similarly, NRC and state release limits related to land application of waste are expected to limit potential effects of land application of wastewater on shallow aquifers. Section 4.2.12.2 discusses the impacts of the use of evaporation ponds and land application of treated wastewater in greater detail and characterizes the expected impacts as SMALL.

4.4.4.2.2.2 Operation Impacts to Production and Surrounding Aquifers

The potential environmental impacts to groundwater supplies in the production and other surrounding aquifers are related to consumptive water use and groundwater quality.

Water Consumptive Use: NRC-licensed flow rates for ISL facilities typically range from about 15,100 to 34,000 L/min [4,000 to 9,000 gal/min] (Section 2.1.3). Most of this water is returned to the production aquifer after being stripped of uranium (see Section 2.4.1.2). The term “consumptive use” refers to water that is not returned to the production aquifer. During operations, consumptive use is due primarily to production bleed (typically between 1 and 3 percent of the total flow) and also includes other smaller losses. As described in Section 2.4.1.2, the purpose of the production bleed is to ensure that more groundwater is extracted than reinjected. Maintaining this negative water balance helps to ensure that there is a net inflow of groundwater into the well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field. Because the bleed water must be removed from the well field to maintain a negative water balance, the bleed is disposed through the wastewater control program and is not reinjected into the well field.

Hypothetically, if a well field at an ISL facility in the Nebraska-South Dakota-Wyoming Uranium Milling Region is pumped at a constant rate of 22,700 L/min [6,000 gal/min] with 2 percent bleed, the total volume of production bleed in a year of operation would be 240 million L {63 million gal [190 acre-ft]}. For comparison, in 2000, approximately 5.16×10^{11} L [418,000 acre-ft] of water was used to irrigate 143,000 ha [354,000 acres] of land in South Dakota (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 3.60 million L/ha [1.18 acre-ft/acre]. Similarly, the average irrigation rate (for irrigated land) in Nebraska is 3.84 million L/ha [1.26 acre-ft/acre] (Hutson, et al., 2004). Thus, the consumptive use of 240 million L [190 acre-ft] of water due to production bleed in 1 year of operation is roughly equivalent to the water used to irrigate 67 ha [166 acres] in South Dakota or 63 ha [156 acres] in Nebraska for 1 year.

Consumptive water use during operations could lower water levels in local wells, impacting local water users who use water from the production aquifer (outside of the exempted zone). In addition, if production aquifers are not completely hydraulically isolated from aquifers above and below, consumptive use may impact local users of these connected aquifers by causing a lowering of water levels in those aquifers. However, effects on aquifers above and below are expected to be limited in most cases by the confining layers typical of aquifers used for ISL production. As discussed in Section 2.4.1.3, licensees conduct preoperations testing to assess the degree of hydraulic isolation of potential production aquifers at proposed ISL sites.

To assess the potential drawdown that could be caused by consumptive use during operations, drawdowns were calculated for a hypothetical case in which the water withdrawn by an entire ISL facility operating at 15,100 L/min [4,000 gal/min] with 2 percent bleed is assumed to be withdrawn from a single well. This scenario would significantly overestimate the drawdown caused by ISL operations using water from a similar production aquifer because water withdrawal at a typical ISL facility is distributed among hundreds of wells (Section 2.3.1.1) and tens to hundreds of hectares [tens to thousands of acres] (Section 4.2.1). Drawdowns for this hypothetical case were calculated using the Theis Equation (McWhorter and Sunada, 1977) with representative values of the transmissivity and storage coefficient for the South Dakota and Nebraska sections of the Nebraska-South Dakota-Wyoming Uranium Milling Region. As discussed in Section 4.3.4.2.2.2, drawdowns are found to be more sensitive to the aquifer transmissivity than storage coefficient.

In the South Dakota section of the milling region, representative values of the transmissivity and storage coefficient of the Inyan Kara ore-bearing aquifer are 300 m^2/day [3,229 ft^2/day] and 5×10^{-4}, respectively (chosen from the range of respective parameter values discussed in Section 3.4.4.3). In this case, drawdowns resulting from bleed production at a constant rate over 10 years of ISL operations are 2.6, 2.0, and 1.5 m [8.5, 6.6, and 4.9 ft] at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from a hypothetical pumping well representing the withdrawals from an entire ISL facility.

In the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, representative values of the transmissivity and storage coefficient of the ore-bearing aquifer are 38 m^2/day [409 ft^2/day] and 5×10^{-4}, respectively (chosen from the range of respective parameter values discussed in Section 3.4.4.3). In this case, drawdowns resulting from bleed production (pumped water volume not returned to the ore-bearing aquifer) at a constant rate over 10 years of ISL operations are 19, 14, and 10 m [61, 47, and 33 ft] at locations 1, 10, and 100 m [3.3, 33, and 330 ft] away from a hypothetical pumping well representing the withdrawals from an entire ISL facility.

In these calculations, the potential effect of natural recharge to the production aquifers on groundwater levels is not considered. The significance of recharge will depend on the isolation of the producing aquifer and the infiltration into any outcrops. For example, the Chadron Sandstone crops out in northwest Nebraska, where it is likely that recharge occurs (Collings and Knode, 1984). Consideration of natural recharge would reduce the calculated drawdowns. However, neglecting natural recharge is not expected to have as much of an effect as approximating the withdrawal from an entire facility with one hypothetical well. As previously discussed, this approximation is expected to yield significant overestimates of the expected drawdowns.

Near a well field, the short-term impact of consumptive use in the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling Region aquifer could be MODERATE if there are local water users who use the production aquifer (outside of the exempted zone) or if the production aquifer is not well isolated from other aquifers that are used locally. In the South Dakota section of the region, short-term impacts are expected to be SMALL to MODERATE, depending on aquifer characteristics (e.g., transmissivity). In both sections of the region, these localized effects are expected to be temporary because drawdown near well fields would dissipate after pumping stops. Thus in both sections of the region, the long-term impacts are expected to be SMALL in most cases, depending on site-specific conditions. Important site-specific conditions include the consumptive use of the proposed facility, the proximity of water users' wells to the well fields, the total volume of water in the production aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

Excursions and Groundwater Quality: Groundwater quality in the production aquifer is degraded as part of the ISL facility's operations (Section 2.4). The restoration of the production aquifer is discussed in Section 2.5. In order for ISL operations to occur, the uranium-bearing production aquifer would need to be exempted as an underground source of drinking water through the appropriate EPA or state-administered UIC program. When uranium recovery is complete in a well field, the licensee is required to initiate aquifer restoration activities to restore the production aquifer to baseline or preoperational class-of-use conditions, if possible. If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in 10 CFR Part 40, Appendix A, Table 5C or to alternate concentration limits approved by the NRC. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISL operations would be expected to be SMALL and temporary. The remainder of this section discusses the potential for groundwater quality in the surrounding aquifers or outside of the production zone of the producing aquifer to be impacted by excursions during ISL operation.

During normal ISL operations, inward hydraulic gradients are expected to be maintained by production bleed so that groundwater flow is toward the production zone from the edges of the well field. If this inward gradient is not maintained, horizontal hydraulic gradients can occur and lead to the spread of leaching solutions in the ore-bearing aquifer beyond the mineralization zone. The rate and extent of spread is largely driven by the collective effects of the aquifer transmissivity, groundwater flow direction, and aquifer heterogeneity. The impact of horizontal excursions could be MODERATE to LARGE if a large volume of contaminated water leaves the production zone and moves downgradient within the production aquifer while the production aquifer outside the mineralization zone is used for water production. To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventative measures prior to starting operations. For example, licensees must install a ring of monitoring wells within and encircling the production zone to permit early detection of horizontal excursions (Chapter 8). If there are oil, gas, coal bed methane, or other production layers near the ISL facility, and if NRC determines that there could be potentials for cross contamination between the ISL product ion zone and other production layers based on environmental impact assessments, NRC may require the licensee to expand the monitoring well ring for detection of potential contamination between the ISL production zone and other mineral production layers. If excursions are detected, the monitoring well is placed on excursion status and reported to the NRC. Corrective actions are taken, and the well is placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

The following discussion focuses on the potential for groundwater quality in the surrounding aquifers to be impacted during ISL operations. The rate of vertical flow and the potential for excursions between the production aquifer and an aquifer above or below is determined by multiplying vertical hydraulic gradient across a confining layer by vertical hydraulic conductivity of a confining layer and dividing the result by porosity of a confining layer (McWhorter and Sunada, 1977; Driscoll, 1986).

In the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, for example, for the ratio of vertical hydraulic gradient to the porosity of a confining layer of 0.1 in the upward direction between two aquifers (the overlying Mudstone and underlying Inyan Kara aquifer) and the vertical hydraulic conductivity of 4.0×10^{-7} m/day [1.3×10^{-6} ft/day] for the Skull Creek Shale (Section 3.4.4.3), a leaching solution would move vertically upward from the production aquifer (the Inyan Kara aquifer) to the overlying aquifer (Mudstone) at a rate of nearly 0.001 cm/yr [0.0004 in/yr]. If the vertical migration rate of a leaching solution is assumed be constant in the next 10 years, then the leaching solution would move 0.01 cm [0.004 in] away from the production zone. Because the thickness of Skull Creek Shale (the upper confinement) is 46–82 m [150–270 ft] (Section 3.3.4.3), the leaching solution would not be able to enter the overlying aquifer in the course of 10 years of ISL operation. If excursions are observed at the monitoring wells, the licensee is required to implement responses that include increasing sampling and commencing corrective actions to recover the excursion. The excursions typically would be reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

In the Nebraska section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, for example, the ratio of vertical hydraulic gradient to the porosity of a confining layer of 0.1 in the upward direction between two aquifers and a vertical hydraulic conductivity of 5.0×10^{-7} m/day [1.6×10^{-6} ft/day] for an aquitard separating those two aquifers (representing the upper confinement of the Basal Chadron sandstone in Section 3.4.4.3), a leaching solution would move vertically upward from the production aquifer to an overlying aquifer at a rate of nearly 0.002 cm/yr [0.0008 in/yr]. If the vertical migration rate of a leaching solution is assumed be the same in the next 10 years, then the leaching solution would move 0.02 cm [0.008 in] away from the production zone. Because the thickness of upper confinement of the Basal Chadron Sandstone is up to 3–8 m [10–25 ft] (Section 3.3.4.3), the excursion would not be expected to enter the overlying aquifer during 10 years of ISL operation. If excursions are observed at the monitoring wells, the licensee is required to implement responses that include increasing sampling and commencing corrective actions to recover the excursion. Excursions typically are reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

Vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers could be altered by potential increases in pumpage from the overlying or underlying aquifers for water supply purposes in the vicinity of an ISL facility (e.g., from the overlying Newcastle Sandstone or the underlying Morrison Formation in the western South Dakota section of the milling region), which may enhance potential vertical excursions from the production aquifer (sandstone aquifers in the Inyan Kara Group). Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could lead to vertical flow and excursions.

In addition, potential well integrity failures during ISL operations could lead to vertical excursions. Well casings above or below the uranium-bearing aquifer—through inadequate construction, degradation, or accidental rupture—could allow lixiviant to travel from the well bore into the surrounding aquifer. Moreover, deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create vertical pathways for excursions of lixiviant from the production aquifers to the adjacent aquifers.

Some relevant factors when considering the significance of potential impacts from a vertical excursion (such as local geology and hydrology, and the proximity of injection wells to drinking water supply wells) are discussed in Section 2.4.1. Additionally, past experience with excursions reported at NRC-licensed ISL facilities is discussed in Section 2.11.5.

To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventive measures prior to starting operations. For example, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees are required to conduct aquifer pump tests prior to starting operations in a well field. The purpose of these pump tests is to determine aquifer parameters (e.g., aquifer transmissivity and storage coefficient, and the vertical hydraulic conductivity of aquitards) and also to ensure that confining layers above and below the production zone are expected to preclude the vertical movement of fluid from the production zone into the overlying and underlying units. The licensee must also develop and maintain monitoring programs to detect both vertical and horizontal excursions and must have operating procedures to analyze an excursion and determine how to remediate it. The monitoring programs prescribe the number, depth, and location of monitoring wells, sampling intervals, sampling water quality parameters, and the UCLs for particular water quality parameters (Chapter 8). These specifications typically are made conditions in the NRC license.

Monitoring wells typically are completed in the lower portion of the first aquifer above the ore-bearing aquifer and in the upper portion of the first aquifer below the ore-bearing aquifer. As discussed in Section 3.3.4.3.2, the Basal Chadron Sandstone is underlain by a thick Pierre Shale and it is overlain by the Brule Formation.

In general, the potential environmental impacts of vertical excursions to groundwater quality in surrounding aquifers would be SMALL if the vertical hydraulic head gradients between the production aquifer and the adjacent aquifer are small, the vertical hydraulic conductivity of the confining units is low, and the confining layers are sufficiently thick. On the other hand, the environmental impacts could be MODERATE to LARGE if confinements are discontinuous, thin, or fractured (i.e., if they have high vertical hydraulic conductivities). To limit the likelihood of vertical excursions, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees also must conduct preoperational pump tests to ensure adequate confinement of the production zone. In addition, licensees must develop and maintain programs to monitor above and below the ore-bearing zone to detect both vertical and horizontal excursions and flow rates, and must have operating procedures to analyze an excursion and determine how to remediate it.

Briefly, the Inyan Kara aquifer is effectively confined above by the Skull Creek Shale and by the Pierre Shale below. Both confinements have small vertical hydraulic conductivities (Section 3.3.4.3.3), which could preclude downward vertical excursions from the production aquifer. Similarly, at the Crow Butte site in Nebraska, the Basal Chadron Sandstone is confined below by the thick Pierre Shale and above by the clay layers with a thickness up to 3–8 m [10–25 ft]. Both confinements have small vertical hydraulic conductivities (Section 3.3.4.3.3), which could preclude downward vertical excursions from the production aquifer. Preliminary calculations discussed previously suggest that the confinements in both sections of the uranium milling region would effectively restrict potential vertical excursions from the ore-bearing aquifers. Additionally, if the licensee installs and maintains the monitoring well network properly, potential impacts of vertical excursions would be temporary and the long-term effects would be SMALL.

4.4.4.2.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

Potential environmental impacts to confined deep aquifers below the production aquifers could be due to deep well injection of processing wastes into deep aquifers. Under different environmental laws such as the Clean Water Act and the Safe Drinking Water Act, EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from either the EPA or the authorized state (e.g. Nebraska or Wyoming) (Section 1.7.2).

In the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, all the aquifers between the Inyan Kara Group (ore mineralization zone) and the impermeable base rocks, including, from shallowest to deepest, the Minnekahta Limestone, the Minnelusa Formation, the Madison Formation, and the Deadwood Formation, are considered to be important aquifers for water supplies and reportedly have been extensively used for water supplies in the region (Williamson and Carter, 2001). Thus, none of the deep aquifers below the Inyan Kara Group appear to be suitable for deep injection in the region.

In the Nebraska section of the western Nebraska-South Dakota-Wyoming Uranium Milling Region, the Basal Chadron aquifer is underlain by thick Pierre Shale at the Crow Butte Uranium Project area (NRC, 1998). The UIC permit was granted for both Morrison and Sundance Formations below the Pierre Shale at the Crow Butte Facility in 1995. The Crow Butte ISL facility has been disposing liquid waste into the Morrison Formation since 1996. The total dissolved solids in the Morrison and Sundance Formations was reported to be as high as 24,000–40,000 mg/L at a regional scale, and these formations are not being used as water supplies in the area (request for modification of Class UIC Permit Crow Butte Project, Dawes County, Nebraska, March 27, 2000).

4.4.4.2.3 Aquifer Restoration Impacts to Groundwater

The potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including discharge of wastes to evaporation ponds, land application of treated wastewater, and potential deep disposal of brine slurries resulting from reverse osmosis. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the well field being restored.

Aquifer restoration typically involves a combination of the following methods: (1) groundwater transfer, (2) groundwater sweep, (3) reverse osmosis with permeate injection, and (4) groundwater recirculation. These methods are discussed in more detail in Section 2.5. In addition to these processes, potential new restoration processes are being developed. These processes include the use of controlled biological reactions to precipitate uranium and other contaminants by restoring chemically reducing conditions to production aquifers. However, these processes have not yet been used at a commercial scale and their likely impacts will not be known until the processes have been developed further.

Groundwater consumptive use for groundwater transfer would be minimal, because milling-affected water in the restoration well field is displaced with baseline quality water from outside the well field. Groundwater consumptive use would be large for groundwater sweep, because it involves pumping groundwater from well field without injection. The rate of groundwater consumptive use would be lower during the reverse osmosis phase, because approximately 70 percent of the pumped groundwater treated with reverse osmosis can be reinjected into the aquifer. Groundwater consumptive use could be further decreased during the reverse osmosis phase if brine concentration is used, in which case up to 99 percent of the withdrawn water could be suitable for reinjection. In that case, the actual amount of water that is reinjected into the well field may be limited by the need to maintain a negative water balance to achieve the desired flow of water from outside of the well field into the well field.

Groundwater consumptive use during aquifer restoration is generally reported to be greater than during ISL operations (Freeman and Stover, 1999; NRC, 2003; Chapter 2 of this GEIS). One reason for increased consumptive use during restoration is that, as previously discussed, no water is reinjected during groundwater sweep. Water is not reinjected during groundwater sweep, because the purpose of the sweep phase is to remove contaminated water from a well field and draw unaffected water into the well field. For example, at the Irigaray Mine in Campbell County, Wyoming, between 1.4 and 4.2 pore volumes of water were removed from six restoration units (comprising nine well fields, some of which were combined for restoration). The total volume of water consumed to perform groundwater sweep on all of the well fields was 545 million L [144 million gal].

During aquifer restoration at Mine Unit 1 at the Crow Butte ISL facility, 6.5×10^6 L [1.7×10^6 gal], corresponding to 0.09 pore volume, was used between April 1994 and July 1994 during groundwater sweep. As part of restoration activities at Mine Unit 1 at the Crow Butte ISL facility, 57×10^6 L [15×10^6 gal] groundwater, corresponding to 0.89 pore volume, was transferred from Mining Unit 1 to other mining units between May 1994 and July 1997; $1{,}730 \times 10^6$ L [457×10^6 gal] groundwater, corresponding to 26.62 pore volume, underwent ion exchange treatment between September 1994 and February 1999; 390×10^6L [103×10^6 gal] groundwater, corresponding to 6.02 pore volume, underwent groundwater reverse osmosis treatment between October 1995 and July 1998; and 185×10^6 L [49×10^6 gal] groundwater, corresponding to 2.85 pore volume, was recirculated from August 1998 through February 1999. By the end of the aquifer restoration, 2,370 × 10^6 L [626 × 10^6 gal] groundwater, corresponding to 36.47 pore volume, underwent ion exchange treatment between May 1994 and August 1999 (Crow Butte Resources, Inc., 2001).

The actual rate of groundwater consumption at an ISL facility at any time depends, in part, on the various stages of operation and restoration of the individual well fields at the facility. For example, consider a hypothetical case in which three well fields at a site undergo groundwater sweep while three undergo reverse osmosis treatment with permeate reinjection and another three continue production. Hypothetically, while 380 L/min [100 gal/min] are consumed during groundwater sweep of three well fields, 110 L/min [30 gal/min] may be consumed to perform reverse osmosis treatment in another three well fields, and another 38 L/min [10 gal/min] may be consumed by production bleed in the remaining three well fields. The total water consumption rate while these processes continued would be 530 L/min [140 gal/min].
At a rate of 530 L/min [140 gal/min], 280 million L [74 million gal] would be consumed in one year. For comparison, in 2000, approximately 5.16 × 10^{11} L [418,000 acre-ft] of water was used to irrigate 143,000 ha [354,000 acres] of land in South Dakota (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 3.60 million L/ha [1.18 acre-ft/acre]. Similarly, the average irrigation rate (for irrigated land) in Nebraska is 3.84 million L/ha [1.26 acre-ft/acre] (Hutson, et al., 2004). Thus, the consumptive use of 280 million L [74 million gal] is roughly equivalent to the water used to irrigate 78 ha [190 acres] in South Dakota or 73 ha [180 acres] in Nebraska for 1 year.

Potential environmental impacts are affected by the restoration techniques chosen, the severity and extent of the contamination, and the current and future use of the production and surrounding aquifers in the vicinity of the ISL facility. The potential environmental impacts of groundwater consumptive use during restoration could be SMALL to MODERATE. Site-specific impacts also would depend on the proximity of water users' wells to the well fields, the total volume of water in the aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

During aquifer restoration, the most heavily contaminated groundwater may be disposed through the wastewater treatment system. The impacts of discharging wastes to solar evaporation ponds or applying treated wastewater to land during restoration are expected to be similar to the impacts of these waste management practices during operations (SMALL) (Section 4.4.4.2.2.1).

As discussed in Section 4.2.4.2.2.3, underground injection of fluid requires a permit from EPA or the authorized state and approval from the NRC. Additionally, the briny slurry produced during the reverse osmosis process may be pumped to a deep well for disposal (Section 2.7.2). The deep aquifers suitable for injections must have poor water quality, have low water yields, or be economically infeasible for production. They also need to be hydraulically separated from overlying aquifer systems. Under these conditions, the potential environmental impacts would be SMALL.

Aquifer restoration processes also affect groundwater quality directly by removing contaminated groundwater from well fields, reinjecting treated water, and recirculating groundwater. In general, aquifer restoration continues until NRC and applicable state requirements for groundwater quality are met. As discussed in Section 2.5, NRC licensees are required to return well field water quality parameters to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) or to another standard approved in their NRC license. Historical information about aquifer restoration at several NRC-licensed facilities is discussed in Section 2.11.5.

4.4.4.2.4 Decommissioning Impacts to Groundwater

The environmental impacts to groundwater during dismantling and decommissioning ISL facilities are primarily associated with consumptive use of groundwater, potential spills of fuels and lubricants, and well abandonment. The consumptive groundwater use could include water use for dust suppression, revegetation, and reclamation of disturbed areas (Section 2.6). The potential environmental impacts during the decommissioning phase are expected to be similar to potential impacts during the construction phase. Groundwater consumptive use during the decommissioning activities would be less than groundwater consumptive use during ISL operation and groundwater restoration activities. Spills of fuels and lubricants during decommissioning activities could impact shallow aquifers. Implementation of best management practices (Chapter 7) during decommissioning can help to reduce the likelihood and magnitude of such spills. Based on consideration of best management practices to minimize water use and spills, impacts on the groundwater resources in shallow aquifers from decommissioning would be expected to be SMALL.

After ISL operations are completed, improperly abandoned wells could impact aquifers above the production aquifer by providing hydrologic connections between aquifers. As part of the restoration and reclamation activities, all monitor, injection, and recovery wells will be plugged and abandoned. The wells will be filled with cement and clay and then cut below plow depth to ensure that no groundwater flows through the abandoned wells (Stout and Stover, 1997). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be SMALL.

4.4.5 Ecological Resources Impacts

4.4.5.1 Construction Impacts to Ecological Resources

Vegetation

Because the ecoregions identified in the Nebraska-South Dakota-Wyoming Uranium Milling Region are similar to those found in the Wyoming West Uranium Milling Region and Wyoming East Uranium Milling Region, potential impacts to terrestrial vegetation from ISL uranium recovery facility construction would be SMALL to MODERATE, as described in Section 4.2.5.

Wildlife

Because of similar ecoregions, potential impacts of ISL uranium recovery facility construction on terrestrial wildlife identified in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to those found in the Wyoming West Uranium Milling Region (SMALL to MODERATE), as described in Section 4.2.5.

Disturbed areas would be revegetated with a seed mixture of grasses, forbs, and shrubs approved by the WDEQ, Land Quality Division; South Dakota Department of Environment and

Natural Resources; and Nebraska Department on Environmental Quality to mitigate potential impacts to wildlife and habitat after construction of the wellfields and facility infrastructure. Crucial wintering and yearlong ranges vital for survival of local populations of big game and sage-grouse leks or breeding ranges are also located within the Wyoming portion of the region (Figures 3.4-12 through 3.4-18). If a potential ISL was to be located within these ranges, guidelines have been issued by the Wyoming Game and Fish Department (2004) for the development of oil and gas resources, which could be applied to construction activities associated with an ISL facility. Consultation with the Wyoming Game and Fish Department should be conducted, as well as a site-specific analysis to determine potential impacts from the facility to these species if located in Wyoming.

Aquatic

Impacts from an ISL uranium recovery facility construction to aquatic resources would be similar to those found in the Wyoming West Uranium Milling Region.

Threatened and Endangered Species

Numerous threatened and endangered species, as well as state species of concern are located within the region. These species with habitat descriptions are provided in Section 3.4.5.3. After a site has been selected, the habitats and impacts would be evaluated for federal and state species of concern that may inhabit the area. For site-specific environmental reviews, licensees and NRC staff would (1) consult with the U.S. Fish and Wildlife Service, Wyoming Game and Fish Department, South Dakota Game and Fish Department, and the Nebraska Game and Park Commission for potential survey requirements and (2) explore ways to protect these resources. If any of the species are identified in a project site during surveys, impacts could range from SMALL to MODERATE to LARGE depending on site-specific conditions. Mitigation plans to avoid and reduce impacts to the potentially affected species would be expected to be developed. These endangered and threatened species have been reported in the Nebraska-South Dakota-Wyoming Uranium Milling Region and have been discussed previously in the Wyoming West Uranium Milling Region in Section 4.2.5.1.

- Black-footed ferret
- Blowout penstemon
- Interior least tern
- Piping plover
- Pallid sturgeon
- Ute ladies' tresses orchid
- Western prairie fringed orchid
- Whooping crane

4.4.5.2 Operation Impacts to Ecological Resources

Because much less land disturbance would be anticipated during the operations phase at an ISL facility, potential impacts to ecological resources from the operation of a ISL facility would be SMALL and similar to those discussed in the Wyoming West Uranium Milling Region.

4.4.5.3 Aquifer Restoration Impacts to Ecological Resources

Because the existing infrastructure would be used during aquifer restoration and no additional construction is expected, potential impacts to ecological resources would be similar to those of facility operation and therefore would be SMALL.

4.4.5.4 Decommissioning Impacts to Ecological Resources

Because the ecoregions are similar, the types of potential impacts to ecological resources from the operation of an ISL facility would be expected to be similar to those discussed in the Wyoming West Uranium Milling Region (SMALL). Additional land-disturbing activity would be less than expected during the construction phase and would be evaluated during the site-specific environmental review.

4.4.6 Air Quality Impacts

For the Nebraska-South Dakota-Wyoming Uranium Milling Region, the types of potential nonradiological air impacts for activities conducted as part of all four uranium milling phases would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.6. The Nebraska-South Dakota-Wyoming Uranium Milling Region analyses in this section are limited to modifying, supplementing, or summarizing the Wyoming West Uranium Milling Region analyses that are presented in Section 4.2.6, as appropriate.

In general, ISL milling facilities are not major nonradiological air emission sources, and the impacts would be classified as SMALL if the following conditions are met:

- Gaseous emissions are within regulatory limits and requirements
- Air quality in the region of influence is in compliance with NAAQS
- The facility is not classified as a major source under the New Source Review or operating (Title V) permit programs described in Section 1.7.2

The Nebraska-South Dakota-Wyoming Uranium Milling Region is classified as in attainment for NAAQS (see Figure 3.4-19). This also includes the counties immediately surrounding this region. The Nebraska-South Dakota-Wyoming Uranium Milling Region does include Wind Cave National Park that is classified as a Prevention of Significant Deterioration Class I area (see Figure 3.4-20). Current information indicates that the three uranium districts in the region are at least 40 km [25 mi] from Wind Cave. If applicable, information concerning Class I areas relevant to the location of the proposed site would be incorporated in the description of the affected environment at the site-specific environmental review level by NRC. As described in Section 1.7.2.2, NRC is not the regulatory authority for permitting. Permitting authorities are identified in Table 1.7-1. Specific requirements would be determined by the appropriate regulatory authority on a site-specific basis.

4.4.6.1 Construction Impacts to Air Quality

Nonradiological gaseous emissions in the construction phase include fugitive dust and combustion emissions (see Section 2.7.1). Most of the combustion emissions are diesel emissions and are expected to be limited in duration to construction activities and result in small, short-term effects. For the purposes of evaluating potential impacts to air quality for a large, commercial-scale ISL facility, Table 2.7-2 contains the annual total releases and average air concentrations of particulate (fugitive dust) and gaseous (diesel combustion products) emissions estimated for the construction phase of the ISL facility proposed for Crownpoint, New Mexico, as documented in NRC (1997). The annual average particulate (fugitive dust) concentration was estimated to be 0.28 µg/m^3 [8×10^{-9} oz/yd^3] (NRC, 1997). However, this estimate did not categorize the particulates as PM_{10} or $PM_{2.5}$. This estimate is under 2 percent of the federal $PM_{2.5}$ ambient air standard, under 1 percent of the previous federal and current Nebraska and Wyoming PM_{10} ambient air standards, 7 percent of the Class I Prevention of Significant Deterioration allowable increment, and under 2 percent of the Class II Prevention of Significant Deterioration allowable increment. The annual average sulfur dioxide concentration was estimated to be 0.18 µg/m^3 [5×10^{-9} oz/yd^3] (NRC, 1997). This estimate is less than 1 percent of both the federal and more restrictive Wyoming ambient air standards, 9 percent of the Class I Prevention of Significant Deterioration allowable increment, and under 1 percent of the Class II Prevention of Significant Deterioration allowable increment. Finally, the annual average nitrogen oxide concentration was estimated to be 2.1 µg/m^3 [5.8×10^{-8} oz/yd^3] (NRC, 1997). This estimate is about 2 percent of the federal and state ambient air standards, 84 percent of the Class I Prevention of Significant Deterioration allowable increment, and under 9 percent of the Class II Prevention of Significant Deterioration allowable increment.

The Nebraska-South Dakota-Wyoming Uranium Milling Region is in attainment for NAAQS. This region does contain a Prevention of Significant Deterioration Class I area. There is a potential for elevated nitrogen oxide emission levels (see the levels estimated for the proposed Crownpoint ISL facility). However, the majority of the Nebraska-South Dakota-Wyoming Uranium Milling Region is categorized as a Class II area and gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. Therefore, construction impacts to air quality from constructing ISL facilities would be SMALL.

4.4.6.2 Operation Impacts to Air Quality

Operating ISL facilities are not major point source emitters and are not expected to be classified as major sources under the operation (Title V) permitting program (Section 1.7.2). One gaseous emission source introduced in the operational phase is the release of pressurized vapor from well field pipelines. Excess vapor pressure in these pipelines could be vented at various relief valves throughout the system. In addition, ISL operations may release gaseous effluents during resin transfer or elution. In general, nonradiological emissions from pipeline system venting, resin transfer, and elution are SMALL. Gaseous effluents produced during drying yellowcake operations vary based on the particular drying technology. Filters and baghouses are used to limit particulate emissions. In general, nonradiological emissions from yellowcake drying would be SMALL.

Other potential operation phase nonradiological air quality impacts include fugitive dust and vehicle emissions from many of the same sources identified for the construction phase. The ISL operations phase fugitive dust emissions sources would be expected to include onsite traffic related to operations and maintenance, employee traffic to and from the site, and heavy truck traffic delivering supplies to the site and product from the site. The ISL operations phase would use the existing infrastructure, and emissions would not include fugitive dust and diesel emissions associated with well field construction. Therefore, operations phase impacts would be less than the construction phase impacts.

The Nebraska-South Dakota-Wyoming Uranium Milling Region is currently in NAAQS attainment. This region does, however, contain a Prevention of Significant Deterioration Class I area at Wind Cave National Park. There is a potential for elevated nitrogen oxide emission levels (see the levels estimated for the proposed Crownpoint ISL facility). However, as discussed previously, current information indicates that the closest potential ISL facility is at least 40 km [25 mi] from Wind Cave, and the majority of the Nebraska-South Dakota-Wyoming Uranium Milling Region is categorized as a Class II area. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. These emissions are not expected to reach levels that result in the ISL facility being classified as a major source under the operating (Title V) permit process. Therefore, operation impacts for ISL facilities would be SMALL.

4.4.6.3 Aquifer Restoration Impacts to Air Quality

Potential nonradiological air quality impacts from aquifer restoration activities (Section 2.11.5) include fugitive dust and combustion emissions from many of the same sources identified previously for the operations phase. The plugging and abandonment of production and injection wells use equipment that generates gaseous emissions. These emissions would be expected to be limited in duration and result in SMALL, short-term effects. The ISL aquifer restoration phase would use the existing infrastructure, and the impacts would not be expected to exceed those of the construction phase. Therefore, aquifer restoration phase impacts would be SMALL.

4.4.6.4 Decommissioning Impacts to Air Quality

Potential decommissioning phase nonradiological air impacts include fugitive dust, vehicle emissions, and diesel emissions from many of the same sources identified previously for the construction phase. In the short term, emission levels could increase, especially for particulate matter from activities such as dismantling buildings and milling equipment, removing any contaminated soil, and grading the surface as part of reclamation activities. Decommissioning phase impacts would be expected to be similar to construction phase impacts and decrease as decommissioning and reclamation activities are completed. Therefore, decommissioning phase impacts would be SMALL.

4.4.7 Noise Impacts

4.4.7.1 Construction Impacts to Noise

For the three uranium districts located in the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential noise impacts during well field construction, drilling, and facility construction would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.1. There are additional sensitive areas that would be considered within this region (see Section 3.4.7), but because of decreasing noise levels with distance, construction activities would be expected to have only SMALL and temporary noise impacts for residences, communities, or sensitive areas located more than about 300 m [1,000 ft] from specific noise-generating activities. The noise impacts associated with constructing either a central or satellite production facility would be of short duration compared to the operations period. Noise impacts to workers during construction would be SMALL because of compliance with Occupational Safety and Health Administration noise regulations. During construction, wildlife would be anticipated to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during construction would be SMALL to MODERATE.

4.4.7.2 Operation Impacts to Noise

For the three uranium districts located in the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential noise impacts during ISL operations would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.2. There are additional sensitive areas that should be considered within this region (see Section 3.4.7), but because of decreasing noise levels with distance, operations at facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area would be expected to have only SMALL noise impacts. Because the same infrastructure would be used, noise-generating activities during aquifer restoration would be similar to the operation phase. Noise impacts to workers during operations would be SMALL because of compliance with Occupational Safety and Health Administration noise regulations. During operations, wildlife are anticipated to avoid areas where noise-generating activities are ongoing. Compared to existing traffic counts, truck traffic associated with yellowcake and chemical shipments and traffic noise related to commuting would have a SMALL, temporary impact on communities located along the existing roads. Some country roads with the lowest average annual daily traffic counts would be expected to have higher relative increases in traffic and noise impacts, in particular, when facilities are experiencing peak employment (these impacts would be MODERATE). Therefore, overall noise impacts during operations would be SMALL to MODERATE.

4.4.7.3 Aquifer Restoration Impacts to Noise

For the three uranium districts located in the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.3. There are additional sensitive areas that should be considered within this region (see Section 3.4.7), but because of decreasing noise levels with distance, aquifer restoration activities at facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area would have only SMALL noise impacts. Noise impacts to workers during aquifer restoration would also be SMALL because of compliance with Occupational Safety and Health Administration noise regulations. During aquifer restoration, wildlife are anticipated to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during aquifer restoration would be SMALL to MODERATE.

4.4.7.4 Decommissioning Impacts to Noise

For the three uranium districts located in the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.4. There are additional sensitive areas that should be considered within this region (see Section 3.4.7), but for facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area, decommissioning would have only SMALL noise impacts. Noise impacts to workers during decommissioning would also be SMALL because of compliance with Occupational Safety and Health Administration noise regulations. During decommissioning, wildlife would be anticipated to temporarily avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during decommissioning would be SMALL.

4.4.8 Historical and Cultural Resources Impacts

Construction-related impacts to cultural resources (defined here as historical, cultural, archaeological, and traditional cultural properties) can be direct or indirect and can occur at any stage of an ISL uranium recovery facility project (i.e., during construction, operation, aquifer restoration, and decommissioning).

A general cultural overview of the affected environment for the Nebraska-South Dakota-Wyoming Uranium Milling Region is provided in Sections 3.2.8 and 3.4.8. Construction involving land-disturbing activities, such as grading roads, installing wells, and constructing surface facilities and well fields, are expected to be the most likely to affect cultural and historical resources. Prior to engaging in land-disturbing activities, licensees and applicants would review existing literature and perform region-specific records searches to determine whether cultural or historical resources are present and have the potential to be disturbed. Along with literature and records reviews, the project site area and all its related facilities and components would be subjected to a comprehensive cultural resources inventory (performed by the licensee or applicant) that meets the requirements of responsible federal, state, and local agencies (e.g., the Nebraska, South Dakota, or Wyoming SHPO). The literature and records searches would help identify known or potential cultural resources and Native American sites and features. The cultural resources inventory would identify the previously documented sites and any newly identified cultural resources sites. The eligibility evaluation of cultural resources for listing in the NRHP under criteria in 36 CFR 60.4(a)–(d) and/or as traditional cultural properties is conducted as part of the site-specific review and NRC licensing procedures undertaken during the NEPA review process. The evaluation of impacts to any historic properties designated as traditional cultural properties and tribal consultations regarding cultural resources and traditional cultural properties also occur during the site-specific licensing application and review process. Consultation to determine whether significant cultural resources would be avoided or mitigated would occur during consultations with the other agencies, state SHPO, and tribal representatives as part of the site-specific review. Additionally, as needed, the NRC license applicant would be required, under conditions in its NRC license, to adhere to procedures regarding the discovery of previously undocumented cultural resources during initial construction, operation, aquifer restoration, and decommissioning. These procedures typically require the licensee to stop work and to notify the appropriate federal and state agencies.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance or mitigation) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC and licensees/applicants may enter into a memorandum of agreement with the responsible state and tribal agencies to ensure protection of historical and cultural resources, if encountered.

4.4.8.1 Construction Impacts to Historical and Cultural Resources

Most of the potential for significant adverse effects to NRHP-eligible or potentially NRHP-eligible historic properties and traditional cultural properties, both direct and indirect, would likely occur during land-disturbing activities related to building an ISL uranium recovery facility. Buried cultural features and deposits that are not visible on the surface during initial cultural resources inventories could be discovered during earth-moving activities.

Indirect impacts may also occur outside the ISL uranium recovery project site and related facilities and components. Visual intrusions (see Section 4.4.9.1), increased access to formerly remote or inaccessible resources, impacts to traditional cultural properties and culturally significant landscapes, as well as other ethnographically significant cultural landscapes may adversely affect these resources. These significant cultural landscapes should be identified during literature and records searches and may require additional archival, ethnographic, or ethnohistorical research that encompasses areas well outside the area of direct impacts. Indirect impacts to some of these cultural resources may be unavoidable and exist throughout the lifecycle of an ISL uranium recovery project.

Because of the localized nature of land-disturbing activities related to construction, impacts to cultural and historical resources are anticipated to be SMALL, but could be MODERATE to LARGE if the facility is located adjacent to a known resource. Wyoming historical sites listed in the NRHP and traditional cultural properties are provided in Section 3.2.8. South Dakota and Nebraska historical sites and traditional cultural properties are described in Section 3.4.8. Additional sensitive areas include properties under the management of the National Park Service such as Devils Tower, Jewel Cave, and Mt. Rushmore National Monuments, and Wind Cave National Park. Proposed facilities or expansions adjacent to these properties are likely to have the greatest potential impacts, and mitigation measures (e.g., avoidance, recording, and archiving samples) and additional consultations with the appropriate state (Wyoming, South Dakota, or Nebraska) SHPO and affected Native American tribes would be needed to assist in reducing the impacts. From the standpoint of cultural resources, the most significant impacts to any sites that are present will occur during the initial construction within the area of potential effect. Subsequent changes in the footprint of the project (i.e., expansion outside of the original area of potential effect) may also result in significant impacts to cultural resources that might be present.

4.4.8.2 Operation Impacts to Historical and Cultural Resources

Depending on the location, impacts to NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during operation of an ISL uranium recovery project. Potential impacts during operation are expected to occur through new earth-disturbing activities, new construction, maintenance, and repair. Because fewer earth-disturbing activities are expected during operations, potential impacts would be SMALL (less than during construction). The three uranium districts in the Nebraska-South Dakota-Wyoming Uranium Milling Region are located more than 16 km [10 mi] from these sensitive areas, further reducing potential impacts.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during operation. Overall impacts to cultural and historical resources during operations are expected to be less than those during construction, as operations are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.4.8.3 Aquifer Restoration Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the aquifer restoration phase of an ISL uranium recovery project. Potential impacts during aquifer restoration may occur through new earth-disturbing activities or other new construction that may be required for the restoration process. Such activities may have inadvertent impacts to cultural resources and traditional cultural properties in or near the site of aquifer restoration activities located within the extended ISL project area.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during aquifer restoration are expected to be less than those during construction, as aquifer restoration activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.4.8.4 Decommissioning Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the decommissioning phase of an ISL uranium recovery project. Potential impacts can result from earth-disturbing activities that may be required for the decommissioning process. Inadvertent impacts to cultural resources and traditional cultural properties in or near the site of decommissioning activities may potentially occur.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during decommissioning are expected to be less than those during construction, as decommissioning activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites). Because cultural resources within the existing area of potential effect are known, potential impacts can be avoided or lessened by redesign of the decommissioning project. As a result, the overall impacts to historic and cultural resources from decommissioning would be expected to be SMALL.

4.4.9 Visual/Scenic Resources Impacts

4.4.9.1 Construction Impacts to Visual/Scenic Resources

During construction, most impacts to visual resources in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to those in the Wyoming West Uranium Milling Region. Most visual and scenic impacts associated with drilling and other land-disturbing construction activities would be temporary. Roads and structures would be more long lasting, but would be removed and reclaimed after operations cease. As noted in Section 3.4.9, most of the areas in the Nebraska-South Dakota-Wyoming Uranium Milling Region are identified as VRM Class II through Class IV according to the BLM classification system or as having a low to moderate scenic integrity objective classification according to the USFS classification system. As described in Section 3.4.9, there are a number of potentially sensitive visual resources in the

Nebraska-South Dakota-Wyoming Uranium Milling Region. The existing and potential ISL facilities identified in the three uranium districts of the Nebraska-South Dakota-Wyoming Uranium Milling Region are generally located more than 16 km [10 mi] from VRM Class II areas and 40 km [25 mi] from the Prevention of Significant Deterioration Class I area located at Wind Cave National Park. The existing Crow Butte ISL facility in Dawes County, Nebraska, is located near the Pine Ridge unit of the Nebraska National Forest, but it has been in operation since the late 1980s and is an established part of the landscape. Visual/scenic impacts introduced by construction activities in these areas would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.4.9.2 Operation Impacts to Visual/Scenic Resources

Similar to the visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.2, the potential visual and scenic impacts from ISL operations in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be SMALL and the same as or less than those impacts associated with construction. The greatest potential for visual impacts would be for new facilities operating in rural, previously undeveloped areas or within view of the sensitive regions described in Section 3.4.9. Given the distances of existing and potential uranium ISL facilities from these areas, visual and scenic impacts introduced by ISL operations would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.4.9.3 Aquifer Restoration Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.3, the potential visual and scenic impacts from ISL aquifer restoration operations in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be SMALL. Aquifer restoration would not occur until after the facility had been in operation for a number of years, and potential impacts would be the same as or less than those during the construction or operations periods. Although overall impacts from aquifer restoration activities would be SMALL, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Section 3.4.9. Given the distances of existing and potential uranium ISL facilities from these areas, visual and scenic impacts introduced by ISL aquifer restoration activities would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.4.9.4 Decommissioning Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.4, the potential visual and scenic impacts from decommissioning and reclaiming ISL facilities in the Nebraska-South Dakota-Wyoming Uranium Milling Region would be SMALL. Decommissioning and reclamation activities would occur after the facility had been in operation for a number of years, and one of the purposes of the decommissioning process is to remove surface infrastructure and reclaim the area to preoperational conditions. This would result in less visual contrast for the facility. Although overall impacts from decommissioning and reclamation activities would be the same as, or less than, those for construction and operation, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Section 3.4.9. Given the distances of existing and potential uranium ISL facilities from these areas, visual and scenic impacts introduced by ISL decommissioning and reclamation activities would be SMALL and reduced further through best management practices (e.g., dust suppression).

4.4.10 Socioeconomic Impacts

Although a proposed facility size and production level can vary, the peak annual employment at an ISL facility can reach up to about 200 people, including construction workforce (Freeman and Stover, 1999; NRC, 1997; Energy Metals Corporation, U.S., 2007). The workforce in this region frequently commutes long distances, many times out of state. Depending on the composition and size of the local workforce, overall socioeconomic impacts from ISL milling facilities for the Nebraska-South Dakota-Wyoming Uranium Milling Region would range from SMALL to MODERATE.

Assuming the number of persons per household in Nebraska-South Dakota-Wyoming Uranium Milling Region is similar to that of the United States, the number is about 2.5 (U.S. Census Bureau, 2008). As a result, the number of people associated with an ISL facility workforce could be as many as 500 (i.e., 200 workers times 2.5 persons/household). The demand for public services (schools, police, fire, emergency services) would be expected to increase with the construction and operation of an ISL facility. There may also be additional standby emergency services not available in some parts of the region. It may be necessary to develop contingency plans and/or additional training for specialized equipment. Infrastructure (streets, waste management, utilities) for the families of a workforce of this size would also be affected.

4.4.10.1 Construction Impacts to Socioeconomics

The majority of construction requirements would likely be filled by a skilled workforce from outside of the Nebraska-South Dakota-Wyoming Uranium Milling Region. Assuming a peak workforce of 200, this influx of workers is expected to result in SMALL to MODERATE impact in the Nebraska-South Dakota-Wyoming Uranium Milling Region. Impacts would be greatest for communities with small populations, such as Sioux County, Nebraska (population 1,350); Niobrara County, Wyoming; and the towns of Osage, Wyoming (200), and Hill City, South Dakota (870). However, due to the short duration of construction (12–18 months), workers would have only a limited effect on public services and community infrastructure. Further, construction workers are less likely to relocate their entire family to the region, thus minimizing impacts from an outside workforce. In addition, if the majority of the construction workforce is filled from within the region, impacts to population and demographics would be SMALL.

Construction impacts to regional income and the labor force for a single ISL facility in the Nebraska-South Dakota-Wyoming Uranium Milling Region would likely be SMALL. In addition, even if multiple facilities were developed concurrently, the potential for impact upon the labor force would still be SMALL. Only in Sioux County, Nebraska, with the smallest labor force (749) in the region, would there be a MODERATE to LARGE impact if the entire workforce was to be derived from that county alone. Construction of an ISL is likely, to the extent possible, to draw upon the labor force within the region before going outside the region (and state). The greatest economic benefit to the region would be to have the labor force drawn from within the region. However, economic benefit may still be achieved (in the form of the purchased of goods and services) even if the labor force is derived from outside the region. The potential impact upon smaller communities (Osage, Wyoming, and Hill City, South Dakota) and Sioux County could be MODERATE.

Impacts to housing from construction activities would be expected to be SMALL (and short term) even if the workforce is primarily filled from outside the region. It is likely that the majority of construction workers would use temporary housing such as apartments, hotels, or trailer camps. Many construction workers use personal trailers for housing on short-term projects. Impacts on the region's housing market would therefore be considered SMALL. However, the impact upon specific facilities (apartment complexes, hotels, or campgrounds) could potentially be MODERATE, if construction workers concentrated in one general area.

Assuming the majority of employment requirements for construction is filled by outside workers (a peak of 200), there would be SMALL to MODERATE impacts to employment structure. The use of an outside workforce would be expected to have MODERATE impacts to communities with high unemployment rates, such as Laramie, Wyoming, due to the potential increase in job opportunities. If the majority of construction activities relies on the use of a local workforce, impacts would be anticipated to be SMALL to MODERATE depending upon the size of the local workforce. Communities such as Sioux County and the Oglala Sioux Tribe of the Pine Ridge Indian Reservation would experience MODERATE impacts, due to their high unemployment rate and potential increase in employment opportunities.

Local finance would be affected by ISL construction through additional taxation and the purchase of goods and services. Though Wyoming does not have an income tax, it does have a state sales tax (4 percent), a lodging tax (2–5 percent), and a use tax (5 percent). Construction workers are anticipated to contribute to these as they purchase goods and services within the region and within the state while working on an ISL facility. In addition, and more significant, is the "ad valorem tax" the state imposes on mineral extraction. In 2007 for uranium, alone, the state collected $1.2 million from this tax (Wyoming Department of Revenue, 2008). Sources of revenue for the State of Nebraska come from the income, sales, cigarette, motor, and lodging taxes. Personal income tax rates for Nebraska range from 2.56 percent to 6.84 percent. The sales and use tax rate is 5.5 percent. Information on ad valorem taxes from the extraction of uranium is not available (Nebraska Department of Revenue, 2007). Sources of revenue for the State of South Dakota come from 36 different state taxes and are grouped into four main categories: (1) sales, use, and contractor's excise taxes; (2) motor fuel taxes; (3) motor vehicles fees and taxes; and (4) special taxes. Once collected, these tax revenues are distributed into the state's general fund, local units of government, and the state highway fund. South Dakota also imposes an energy minerals tax on owners of energy minerals (such as uranium). In 2006, the tax rate base was 4.5 percent of the taxable value and approximately 50 percent was dispersed to local government (South Dakota Department of Revenue and Regulation, 2007). It is anticipated that ISL facility development could have a MODERATE impact on local finances within the region.

Even if the majority of the workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to relocate their entire family for a relatively short duration (12–18 months). Impacts to education from a local workforce would also be SMALL, as they are already established in the community.

Potential impacts from construction [from either the use of local or outside (nonregional) workforce] to local health services such as hospitals or emergency clinics would be SMALL.

Accidents resulting from construction of an ISL facility are not expected to be different than those from other types of similar industrial facilities.

4.4.10.2 Operation Impacts to Socioeconomics

> **Economic Multipliers**
> The economic multiplier is used to summarize the total impact that can be expected from change in a given economic activity. It is the ratio of total change to initial change. The multiplier of 0.7 was used as a typical employment multiplier for the milling/mining industry (Economic Policy Institute, 2003).

Operational requirements of an ISL necessitate the use of specialized workers, such as plant managers, technical professionals, and skilled tradesmen. While operational activities would be longer term (20–40 years) than construction (12–18 months), instead of up to 200 workers, an operating ISL generally requires a labor force of from 50 to 80 personnel. If the majority of operational requirements is filled by a workforce from outside the region, assuming a multiplier of about 0.7, there could be an influx of between 35 and 56 jobs (i.e., 50–80 × 0.7) per ISL facility (up to 140, including families). The potential impact to the local population and public services resulting from the influx of workers and their families would range from SMALL to MODERATE, depending upon the location (proximity to a population center) of an ISL within the region. However, because an outside workforce would be more likely to settle into more populated areas with increased access to housing, schools, services, and other amenities, these impacts may be reduced. If the majority of labor is of local origin, potential impacts to population and public services would be expected to be SMALL, as the workers would already be established in the region.

It is assumed, however, that because of the highly technical nature of ISL operation (requiring professionals in the areas of health physics, chemistry, laboratory analysis, geology and hydrogeology, and engineering), the majority (approximately 70 percent) of the work force (35 to 56 personnel) would be staffed from outside the region for at least the initial ISL facility. Subsequent ISL facilities may draw personnel from established or decommissioned facilities. This is expected to have a SMALL impact upon the regional labor force.

If it is assumed that as many as 56 families (80 workers × 0.7) are required to relocate into the Nebraska-South Dakota-Wyoming Uranium Milling Region, the most likely available housing markets would be located in the larger communities, such as Spearfish and Hot Springs in South Dakota (within the region) and Rapid City, South Dakota (located just outside the region). Unless the workforce is distributed throughout the region, the impact of an ISL on the housing market would be MODERATE, depending upon location, due to the limited number of available units.

Impacts to income and the labor force structure within the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to construction impacts, but longer in duration. Impacts from ISL operation would be SMALL to MODERATE, depending on where the majority of the workforce settles (is housed).

Assuming a local workforce is used, there would be SMALL impacts to the local employment structure, and these would be similar to construction impacts. If the entire labor force for the ISL facility came from outside the affected community, the workforce would have a SMALL to MODERATE impact relative to the employment structure for most of the affected counties. Impacts from inflow of an outside workforce would be similar to construction impacts.

Assuming the majority of the workforce is derived from outside the Nebraska-South Dakota-Wyoming Uranium Milling Region, potential impacts to education from operation activities would be SMALL. Even though the number of people associated with an ISL facility workforce could be as many as 140 (including families), there would only be about 30 school-aged children involved. While the influx of new students would be the greatest in the smaller school districts, even in these districts the impacts are anticipated to be SMALL. For example, with the exception of Sioux County, Nebraska, the smaller school districts average about 200–300 pupils per school (Section 3.4.10.6). Even if all the ISL workers' children attended the same school (which is unlikely), the increase in that school's student population would only be 10–15 percent.

Effects on other community services (e.g., health care, utilities, shopping, recreation) during operation are anticipated to be similar to construction (less in volume/quantity, but longer in duration). Therefore, the potential impacts would be SMALL.

4.4.10.3 Aquifer Restoration Impacts to Socioeconomics

The same ISL facility components and workforce would be involved in aquifer restoration as during operations use. Thus, the number of personnel involved would also be the same, and the potential impacts would be similar. These potential impacts would extend beyond the life of the facility (typically 2–10 years), but still would be SMALL.

Income and labor force requirements during aquifer restoration are anticipated to be the same as during operations (technical requirements are similar), and therefore potential impacts would be SMALL.

The employment structure during aquifer restoration would be expected to be unchanged and continue after the operational phase. However, a smaller number of specialized workers may be required to return the site to preISL levels. The potential impacts to the region would be considered SMALL.

Impacts to housing, education, health, and social services during aquifer restoration would also be expected to be the similar to operations, but continue beyond the life of the site. The overall potential impacts would be SMALL.

4.4.10.4 Decommissioning Impacts to Socioeconomics

Decommissioning is essentially deconstruction and is expected to require a similar work force (up to 200 personnel) with similar skills as the construction phase. The impacts to affected communities in the Nebraska-South Dakota-Wyoming Uranium Milling Region during decommissioning would therefore be similar to the construction phase. The decommissioning phase may last up to a year longer than the construction phase, depending upon the condition of the ISL at termination. However, the overall potential impacts are still expected to be SMALL to MODERATE,

The income levels and labor force requirements during decommissioning are also anticipated to be similar to the construction phase, and the potential impacts to the region would therefore be considered SMALL to MODERATE.

The employment structure during decommissioning would be similar to the construction phase; however, a reduction of the workforce would result toward the end of the decommissioning phase. Impacts to employment would be SMALL to MODERATE.

Potential impacts to housing during the decommissioning phase would be similar to the construction phase and would be SMALL for the larger communities within the region, but may be MODERATE if the temporary housing was concentrated in a smaller community.

Decommissioning would be expected to involve similar numbers (up to 200) of workers (likely without families because of the short-duration of the activity) as construction. Therefore, the anticipated impacts to the local education system would be SMALL.

Impacts to community services (health care, entertainment, shopping, recreation) would also be similar to construction, and thus would be considered SMALL.

4.4.11 Public and Occupational Health and Safety Impacts

Licensees are required to implement radiological monitoring and safety programs that comply with 10 CFR Part 20 requirements to protect the health and safety of workers and the public. NRC periodically inspects these programs to ensure compliance.

4.4.11.1 Construction Impacts to Public and Occupational Health and Safety

Construction impacts on public and occupational health and safety for the Nebraska-South Dakota-Wyoming Uranium Milling Region would be similar to those discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.1.

4.4.11.2 Operation Impacts to Public and Occupational Health and Safety

4.4.11.2.1 Radiological Impacts to Public and Occupational Health and Safety From Normal Operations

Estimated doses to members of the public are reported for a variety of commercial-scale and satellite facilities in Section 4.2.11.2.1. These doses are well below the 10 CFR Part 20 public dose limit of 1 mSv/yr [100 mrem/yr] and the 40 CFR Part 190 annual limit of 0.25 mSv [25 mrem]. Doses at other locations could be higher or lower depending on a variety of factors including receptor location, topography, and weather conditions. When releases occur from the ground level, doses decrease the farther the receptor is away from the release location because the radioactive material is diluted as the wind mixes it. The amount of dilution, which is referred to as dispersion, is determined by the weather (meteorological conditions). For areas in which meteorological conditions are more stable (less turbulent), a higher dose could occur. As the radioactive material travels via the wind, changes in topography can affect the dose received by the receptor. Doses for the various ISL facilities shown in Table 4.2-2 are at least a factor of three below the regulatory limit, and most are less than that. Doses at operating ISL facilities in different regions are not likely to exceed regulatory limits, and the overall potential radiological impacts from ISL operations would be SMALL.

4.4.11.2.2 Radiological Impacts to Public and Occupational Health and Safety From Accidents

The consequences of potential accidents are expected to be similar regardless of an ISL facility's location and are described in Section 4.2.11.2.2. Distance to the nearest receptor, topography, and meteorological data account for potential differences in resulting dose. For facilities in which the maximally exposed offsite individual would be closer, there would be higher doses for ground-level releases. Changes in topography could also have an impact on the resulting dose because this would allow the receptor to be closer to, or farther away from, the radioactive material as it travels by wind. Meteorological conditions vary based on location and could result in a higher or lower dose. The consequences resulting from a potential unmitigated accident would have a SMALL impact on the general public and, at most, a MODERATE impact on the workers.

4.4.11.2.3 Nonradiological Impacts to Public and Occupational Health and Safety From Normal Operations

While hazardous chemicals are used at ISL facilities (Section 2.4.2), SMALL risks would be expected in the use and handling of these chemicals during normal operations. However, accidental releases of these hazardous chemicals can produce significant consequences and impact public and occupational health and safety. An analysis of such hazards and potential risks for impacts is provided in the following section.

4.4.11.2.4 Nonradiological Impacts to Public and Occupational Health and Safety From Accidents

Nonradiological impacts to public and occupational health and safety for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.2.4. Compliance with applicable 10 CFR Part 20, EPA, and Occupational Safety and Health Administration requirements would ensure safe handling of radiological and hazardous materials. The likelihood of accidental releases would be reduced, and the potential impacts would be SMALL.

4.4.11.3 Aquifer Restoration Impacts to Public and Occupational Health and Safety

Aquifer restoration impacts to public and occupational health and safety are expected to be similar to operational impacts discussed in Section 4.4.11.2. Compliance with applicable 10 CFR Part 20 (Section 2.9) and Occupational Safety and Health Administration requirements would ensure SMALL impacts.

4.4.11.4 Decommissioning Impacts to Public and Occupational Health and Safety

During ISL decommissioning activities, hazards are removed or reduced, surface soils and structures are decontaminated, and disturbed lands are reclaimed. During these activities, SMALL impacts could occur.

To ensure safety of workers and the public during decommissioning, the NRC requires licensed facilities to submit a decommissioning plan for review (Section 2.6). Such a plan includes details of how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable safety regulations are complied with. A combination of (1) NRC review and approval of these plans, (2) the application of site-specific license and permit conditions where necessary, and (3) regular NRC and Occupational Safety and Health Administration inspection and enforcement activities to ensure compliance with applicable health and safety requirements constrain the magnitude of potential public and occupational health impacts from ISL facility decommissioning actions to SMALL levels.

4.4.12 Waste Management Impacts

Waste management impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another.

4.4.12.1 Construction Impacts to Waste Management

The relatively small scale of construction activities (Section 2.3) and incremental development of well fields at ISL facilities is expected to generate low volumes of construction waste. Table 2.7-1, which includes a listing of engine-driven construction equipment needed for construction of a satellite ISL facility, provides insight into the magnitude of well field construction activities. As a result of the limited volumes of construction waste that are generated by ISL facility construction, waste management impacts from construction would be SMALL.

4.4.12.2 Operation Impacts to Waste Management

Operation waste management impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.2 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. Operational waste management impacts would be SMALL, based on the required preoperational disposal agreement for byproduct material; regulatory controls including applicable permitting, license conditions, and inspection practices; and typical facility design specifications and management practices including waste treatment and volume reduction techniques, pond leak detection, and other routine monitoring activities.

4.4.12.3 Aquifer Restoration Impacts to Waste Management

Waste management activities during aquifer restoration utilize the same treatment and disposal options implemented for operations; therefore, impacts associated with aquifer restoration would be similar to the operational impacts discussed in Section 4.4.12.2. Additional wastewater volume and the associated volume of water treatment wastes may be generated during aquifer restoration; however, this would be offset to some degree by the reduction in production capacity from the removal of a well field from production activities. While the amount of wastewater generated during aquifer restoration is dependent on site-specific conditions, Section 2.5.2 provides an illustrative estimate of water volume per pore volume and Section 2.11.5 provides experience regarding the number of pore volumes required for aquifer restoration in past efforts. Furthermore, the NRC review of future ISL facility licensing would verify that sufficient water treatment and disposal capacity (and the associated agreement for disposal of byproduct material discussed in Section 4.2.12) are addressed. As a result, waste management impacts from aquifer restoration would be SMALL.

4.4.12.4 Decommissioning Impacts to Waste Management

Decommissioning waste management impacts for the Nebraska-South Dakota-Wyoming Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.4 because the waste volumes and management practices, waste management safety and environmental concerns, waste management regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. The required preoperational agreement for disposal of byproduct material, NRC review, and approval of a decommissioning plan and radiation safety program, and the small volume of solid waste generated for offsite disposal suggest the waste management impacts would be SMALL. Related transportation impacts are discussed separately in Section 4.4.2.

4.4.13 References

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4.5 Northwestern New Mexico Uranium Milling Region

4.5.1 Land Use Impacts

Information on ISL facility size (Section 2.11) and the type of potential impacts to land use previously described for the two Wyoming and the Nebraska-South Dakota-Wyoming Uranium Milling Regions would also generally apply for ISL facilities in the Northwestern New Mexico Uranium Milling Region. For example, the total amount of land estimated to be impacted and disturbed by surface facilities and well fields at the proposed commercial-scale ISL facility at Crownpoint, New Mexico, was between 100 and 600 ha [247 and 1,483 acres] (NRC, 1997). These estimates fall within the range previously presented in Section 4.2.1 for the Wyoming West Uranium Milling Region.

4.5.1.1 Construction Impacts to Land Use

The types of land use in this region are similar in many respects to land uses in the Wyoming and Nebraska-South Dakota-Wyoming regions. Therefore, the types of construction impacts to land use from new ISL facilities in the region would also be similar. New construction activities would potentially (1) change and disturb the land uses, (2) restrict access and establish right-of-way for access, (3) affect mineral rights and land use by allottees and others, (4) restrict livestock grazing areas and revoke grazing permits, (5) restrict recreational activities, and (6) alter ecological, cultural, and historical resources.

Because of the complicated land use in the checkerboard region near tribal lands in the Northwestern New Mexico Uranium Milling Region, new ISL facilities could directly abut private land, allottees, and residences. Additional land use impacts could include denial of access to private land being leased for ISL operations and conflicts with other land uses that would need to be resolved with individual land owners and allottees. Such impacts, as is the case with most land use impacts due to construction and subsequent phases, could last for the life of the ISL facilities (NRC, 1997). In the Northwestern New Mexico Uranium Milling Region, overall potential construction impacts to land use from a potential ISL facility would range from SMALL to LARGE, depending on proximity to a sensitive land use.

4.5.1.2 Operation Impacts to Land Use

The types of land use impacts for operational activities would be expected to be similar to construction impacts regarding access restrictions, primarily because the infrastructure would already be in place. Additional land disturbances would not be expected during the operational activities described in detail in Section 2.4. During the operational period of an ISL facility, the primary changes to land use would be the movement (sequencing) of well fields from one area to another within the permitted site, and this is addressed as a construction impact in Section 4.5.1.1. Sequentially moving active operations from one well field to the next would shift potential impacts. For example, a well field where uranium recovery activities have ceased could be partly restored and reopened for grazing or recreation while a new well field is being developed, which would have impacts similar to those described in the preceding section for the construction phase. Because access restriction and land disturbance impacts would be similar to, or less than, those expected for construction, the overall potential impacts to land use from operational activities would be SMALL.

4.5.1.3 Aquifer Restoration Impacts to Land Use

The types of impacts to land use during aquifer restoration would be similar in nature to the potential impacts of the construction and operations phases, but because the existing infrastructure is used, they would be generally less frequent or intense. For example, as aquifer restoration activities proceed, impacts may shift from one well field area to another and allow certain access rights, grazing permits, and recreational activities to be restored. Overall, potential aquifer restoration impacts to land use are comparable to those of the operation phase and would be expected to be SMALL.

4.5.1.4 Decommissioning Impacts to Land Use

Potential types of decommissioning impacts to land use would be similar to the potential impacts seen during the construction, operation, and aquifer restoration phases. However, the frequency and intensity of certain activities disturbing the land uses would temporarily increase because there would be greater use of earth- and material-moving equipment and other heavy equipment. As decommissioning and reclamation proceed, the amount of disturbed land would decrease. Consequently, in the Northwestern New Mexico Uranium Milling Region, overall potential decommissioning impacts to land use would be greater than during the operation and aquifer restoration phases and would range from SMALL to MODERATE.

4.5.2 Transportation Impacts

Truck and automobile use is associated with all phases of the ISL facility lifecycle including construction, operation, aquifer restoration, and decommissioning. The estimated low magnitude of road transportation from all phases of the ISL lifecycle (Section 2.8) is not expected to significantly affect the amount of traffic or accident rates. One possible exception to this conclusion is that commuting traffic for facility workers, in particular, during periods of peak (construction) employment, would have greater impacts when roads with the lowest levels of current traffic. Low-trafficked roads may also be more susceptible to wear and tear from increased traffic are traveled. Localized intermittent and short-term SMALL to MODERATE impacts associated with noise, dust, and incidental livestock or wildlife kills are possible on all roads but in particular on remote local and unpaved access roads. The magnitude of these impacts would be influenced by site-specific conditions including the proximity of residences, or other regularly occupied structures, wildlife habitat, or grazing areas, to ISL facility access roads. Unique local road and environmental conditions (e.g., local hazards, local resource impacts) would be considered in an NRC site-specific environmental review. Potential local impacts include loss of forge palatability from road dust and interference with livestock herding and grazing activities. A more detailed assessment of transportation impacts for each phase of the ISL facility lifecycle follows.

4.5.2.1 Construction Impacts to Transportation

ISL facilities, in general, are not large-scale or time-consuming construction projects (Sections 2.3 and Table 2.7-1). The magnitude of estimated construction-related transportation (Section 2.8) is expected to vary depending on the size of the facility. However, when compared with the regional traffic counts provided in Section 3.5.2, most roads that would be used for construction transportation in the Northwestern New Mexico Uranium Milling Region would not cause significant increases in daily traffic, and therefore traffic-related impacts would be SMALL. A few roads with the lowest average annual daily traffic counts would have higher (MODERATE) traffic and potential infrastructure impacts, in particular, when facilities are experiencing peak (construction) employment. The limited duration of ISL construction activities (12–18 months) suggests impacts would be of short duration. Temporary SMALL to MODERATE dust, noise, and incidental livestock or wildlife kill impacts are possible on, and in the vicinity of, access roads used for construction transportation.

4.5.2.2 Operation Impacts to Transportation

The discussion of impacts in Section 4.2.2.2 for the Wyoming West Uranium Milling Region also applies to the Northwestern New Mexico Uranium Milling Region because the same types of transportation activities would be conducted regardless of location, the same regulatory controls and safety practices apply, the same magnitude of transportation activities would be conducted, and the assessment of accident risks is generally applicable to all regions. Applicable transportation conditions for the Northwestern New Mexico Uranium Milling Region are discussed in Section 3.5.2. The magnitude of existing traffic conditions in the region is similar to that described for Wyoming West with regard to potential impacts, and therefore operational traffic-related impacts would be similar (SMALL to MODERATE). The methods and assumptions considered in the accident analysis in Section 4.2.2.2 (Wyoming West Uranium Milling Region) for yellowcake shipments are applicable to the Northwestern New Mexico Uranium Milling Region, and therefore the impact from yellowcake, resin transfer, and byproduct waste shipments would be similar (SMALL). The same practices and requirements that serve to limit the risks from chemical shipments also apply to the Northwestern New Mexico Uranium Milling Region and would also result in SMALL impacts.

4.5.2.3 Aquifer Restoration Impacts to Transportation

Aquifer restoration transportation impacts are expected to be less than those described for construction and operations because transportation activities would be primarily limited to supplies (including chemicals for reverse osmosis), chemical waste shipments, onsite transportation, and employee commuting. No additional unique transportation activities are expected during aquifer restoration; therefore, no additional types of impacts associated with aquifer restoration are anticipated and impacts would be SMALL to MODERATE considering the potential impacts of commuting during peak employment periods on low traffic roads.

4.5.2.4 Decommissioning Impacts to Transportation

Decommissioning 11e.(2) byproduct wastes (as defined in the Atomic Energy Act) can be shipped offsite by truck for disposal at a licensed disposal site. Section 2.8 provides estimates of the number of decommissioning-related waste shipments, which are small compared to average annual daily traffic counts provided in Section 3.5.2. All radioactive waste shipments must be shipped in accordance with the applicable NRC safety requirements in 10 CFR Part 71. As shown in Section 2.8, the number of estimated decommissioning waste shipments is fewer than those needed to support facility operations, and therefore potential traffic and accident impacts are expected to decrease during the decommissioning period. Risks from transporting yellowcake shipments during operations bound the risks expected from waste shipments owing to the concentrated nature of shipped yellowcake, the longer distance yellowcake is shipped relative to waste destined for a licensed disposal facility, and the relative number of shipments for each type of material. Commuting impacts would decrease from peak employment due to cessation of operations, though this effect would be offset to some degree by an increase in decommissioning workers. Overall, based on the magnitude of transportation activities expected during decommissioning, impacts would be SMALL.

4.5.3 Geology and Soils Impacts

Construction, operation, aquifer restoration, and decommissioning activities and processes at ISL facilities may impact geology and soils. The potential impacts on geology and soils from these activities in the Northwestern New Mexico Uranium Milling Region are discussed in the following sections.

4.5.3.1 Construction Impacts to Geology and Soils

During construction of ISL facilities, the principal impacts to geology and soils would result from earth-moving activities associated with constructing surface facilities, wastewater evaporation ponds, access roads, well fields, and pipelines (Section 2.3). Earth-moving activities would include

- Clearing of ground or topsoil and preparing surfaces for the processing plant, satellite facilities, pump houses, access roads, drilling sites, and associated structures
- Excavating and backfilling trenches for pipelines and cables
- Excavating evaporation ponds and developing evaporation pond embankments

The impact of construction activities on geology and soils will depend on local topography, surface bedrock geology, and soil characteristics. Construction activities at ISL facilities in the Northwestern New Mexico Uranium Milling Region may increase the potential for erosion from both wind and water due to the removal of vegetation and the physical disturbance from vehicle and heavy equipment traffic. Likewise, compaction of soils and removal of vegetation resulting from construction activities may increase the potential for surface runoff and sedimentation in local drainages and streams outside disturbed areas.

Generally, earth-moving activities will result in only SMALL (on average, approximately 15 percent of the permitted site area) impacts and temporary (several months) disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Chapter 7). For example, soil horizons will be disrupted to construct the processing facilities, evaporation ponds, and well field houses. In the well field, soil disturbance would be limited to drill pad grading, mud pit excavation, well completion, and access road construction.

Operators of ISL facilities typically adopt best management construction practices to prevent or substantially reduce soil impacts (see Table 7.4-1). Soils removed during construction of surface facilities are generally stockpiled and stabilized for later use during decommissioning and land reclamation. These stockpiles would be specifically located, shaped, and seeded with a cover crop by the operator to control erosion. For example, during the construction of the proposed Crownpoint ISL facility, topsoil would be replaced in areas where it was temporarily removed and the areas would be revegetated once construction was completed (NRC, 1997). Other practices include constructing structures to divert surface runoff from undisturbed areas around disturbed areas; using silt fencing, retention ponds, and hay bales to retain sediment within the disturbed areas; and reestablishing native vegetation as soon as possible after disturbance.

As part of the underground infrastructure at ISL facilities, a network of buried process pipelines and cables is typically constructed. Pipeline systems are installed between the pump house and well field for injecting and recovering lixiviant, between the pump house and the satellite facility or processing plant for transporting lixiviant and resin, and between the processing facilities and deep injection wells. Trenches for the pipelines are excavated as deep as 1.8 m [6 ft] below the ground to avoid any potential freezing problem. Operators typically segregate topsoil from subsoil (i.e., underlying rock) when excavating trenches so that the general soil profile can be restored during backfilling. Excavating trenches for pipelines and cables normally results in only a SMALL, short-term disturbance of rock and soil. After piping and cable are placed in the trenches, the trenches are backfilled with the excavated material and graded to surrounding ground topography.

Based on the previous discussion, the impacts of construction activities on geology and soils at ISL facilities in the Northwestern New Mexico Uranium Milling Region would be SMALL.

4.5.3.2 Operation Impacts to Geology and Soils

During ISL operations (Section 2.4), a non-uranium-bearing (barren) solution or lixiviant is injected through wells into the mineralized zone. The lixiviant moves through the pores in the host rock, dissolving uranium and other metals. Production wells withdraw the resulting “pregnant” lixiviant, which contains uranium and other dissolved metals, and pump it to a central processing plant or to a satellite processing facility for further uranium recovery and purification.

The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the composition of uranium-producing formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure. The source formations for uranium in the Northwestern New Mexico Uranium Milling Region occur at depths of hundreds of meters [hundreds of feet] below the ground surface. For example, the top of the uranium-bearing sandstone (Westwater Canyon Member of the Morrison Formation) at the Crownpoint and Church Rock sites near Crownpoint, New Mexico are at depths of 560 m [1,840 ft] and 140 to 230 m [460 to 760 ft], respectively (NRC, 1997). At these depths and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. However, ground subsidence at conventional underground mine workings has been cited as a potential issue (NRC, 1997).

The pressure of the producing aquifer is decreased during operation activities because a negative water balance is maintained in the well field to ensure water flows into the well field from its edges, reducing the spread of contamination. This change in pressure theoretically could impact the transmissivity (e.g., resistance to flow) of faults in permitted areas. However, because sandstones tend to be highly porous and transmissive, it is unlikely that changes in fluid pressure would reactivate faults or trigger or induce earthquakes. Based on historical ISL operations in the Northwestern New Mexico Uranium Milling Region, reactivation of faults is not anticipated.

A potential impact to soils arises from the necessity to move barren and pregnant uranium-bearing lixiviant to and from the processing facility in aboveground and underground pipelines. If a pipe ruptures or fails, lixiviant can be released and (1) pond on the surface, (2) runoff into surface water bodies, (3) infiltrate and adsorb in overlying soil and rock, or (4) infiltrate and percolate to groundwater.

In the case of spills from pipeline leaks and ruptures, spills could release either radionuclides or other constituents (e.g., selenium or other metals). Any impacts of these two types of spills are likely to be bounded by a spill of pregnant lixiviant (Mackin, et al., 2001). If the spill is allowed to dry, it can pose an ingestion or inhalation hazard to both humans and wildlife. Upon detection, licensees are required to establish immediate spill responses through onsite standard operation procedures (e.g., NRC, 2003, Section 5.7). For example, immediate spill responses might include shutting down the affected pipeline, recovering as much of the spilled fluid as possible, and collecting samples of the affected soils for comparison to background values for uranium, radium, and other metals.

As part of the monitoring requirements at ISL facilities, licensees must report certain spills to the NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). This documentation helps in final site decommissioning activities. Licensees of ISL facilities in the Northwestern New Mexico Uranium Milling Region must also comply with any applicable state permitting agency requirements for spill response and reporting.

Soil contamination during ISL operations could also occur from transportation accidents resulting in yellowcake or ion exchange resin spills. As for lixiviant spills, licensees must report certain of these spills to NRC and the appropriate state permitting agency. License conditions also may require licensees to report the corrective actions taken and the results achieved. For nonradiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of nonradiological materials is primarily reportable to the appropriate state agency or EPA.

In the short term, impacts to soils from spills could range from SMALL to LARGE depending on the volume of soil affected by the spill. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils is SMALL.

Uranium mobilization and processing during ISL operations produces excess water containing lixiviants and minerals leached from the aquifer. Other liquid waste streams produced by ISL operations can include rejected brine from the reverse osmosis system and spent eluant from the ion exchange system. Any of these waste streams may be discharged to evaporation ponds or injected into deep waste disposal wells. In addition, wastewater may be treated and applied to the land using irrigation methods or discharged to surface water drainages. The impacts and requirements for discharging treated waste streams to surface water bodies during ISL operations in the Northwestern New Mexico Uranium Milling Region are discussed in

Section 4.5.4.1. The impacts of using evaporation ponds or applying treated wastewater to the land are discussed in this section.

Waste streams discharged to evaporation ponds can contain radionuclides and other metals that may become concentrated during evaporation. Therefore, soil contamination could result if either the liner or embankment of an evaporation pond was to fail. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of failure, pond embankments at ISL facilities are monitored and inspected by licensees in accordance with NRC-approved inspection programs, and NRC also regularly inspects the embankments as part of the Federal Dam Safety Program.

Land application of treated wastewater involves irrigating select parcels of land and allowing the water to be evapotranspired by native vegetation or crops (Sections 2.7.2, 4.2.12.2). Land application of treated wastewater could potentially impact soils. For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. At the proposed ISL site near Crownpoint, New Mexico, the soil electrical conductivity of areas irrigated with treated wastewater would be monitored to mitigate the effects of soil salination.

Land application of the treated wastewater would also cause radiological and/or other constituents (e.g., selenium and other metals) to accumulate in the soils, thereby degrading the site potential for subsequent recreational or agricultural use. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive and toxic constituents within allowable release standards In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable limits. Areas of a site where land application of treated water has been used would also be included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine nature of the monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.5.3.3 Aquifer Restoration Impacts to Geology and Soils

Aquifer restoration programs typically use a combination of (1) groundwater transfer; (2) groundwater sweep; (3) reverse osmosis, permeate injection, and recirculation; (4) stabilization; and (5) water treatment and surface conveyance (Section 2.5).

The groundwater sweep and recirculation process does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. The water pressure in the aquifer is decreased during restoration because a negative water balance is maintained in the well field being restored to ensure that water flows into the well field from its edges, reducing the spread of contamination. However, the change in pressure is limited by recirculation of treated groundwater, and therefore it is unlikely that ISL operations would reactivate local faults and extremely unlikely that any earthquakes would be generated. Therefore, the impacts to geology in the Northwestern New Mexico Uranium Milling Region from aquifer restoration are expected to be SMALL.

The main impact on soils during aquifer restoration would be spills of contaminated groundwater resulting from pipeline leaks and ruptures. As with spills of lixiviant during operations, spill response recommendations during aquifer restoration activities have been carried forward into NRC guidance of ISL facilities (e.g., NRC, 2003, Section 5.7). Licensees must report certain spills to NRC within 24 hours. These spills include those that cause unplanned contamination that meets the criteria of 10 CFR 40.60 and those spills that could cause exposures that exceed the limits established in 10 CFR Part 20, Subpart M. Additional reporting requirements may be imposed by the state or by NRC license conditions. For example, NRC license conditions may require that licensees report spills to the NRC project manager and subsequently submit a written report describing the conditions leading to the spill, the corrective actions taken, and the results achieved (NRC, 2003). Licensees in the Northwestern New Mexico Uranium Milling Region are also required to comply with any applicable state permitting agency requirements for spill response and reporting. The short-term impact on soils from spills of contaminated groundwater could range from SMALL to LARGE depending on the volume of the affected soil. Because of the required immediate responses, spill recovery actions, and routine monitoring programs, impacts from spills are temporary, and the overall long-term impact to soils is SMALL.

During aquifer restoration, the groundwater is passed through semipermeable membranes that yield a brine or reject liquid. This reject liquid cannot be injected back into the aquifer or discharged directly to the environment. The reject liquid is typically sent to an evaporation pond or to deep well disposal. In addition, treated wastewater may be applied to the land.

If reject water is sent to an evaporation pond, failure of the evaporation pond liner or pond embankment could result in soil contamination. Evaporation ponds at NRC-licensed ISL facilities are designed with leak detection systems to detect liner failures and are visually inspected on a regular basis. The licensee is also required to maintain sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to other ponds in the event of a leak and subsequent corrective action and liner repair. To minimize the likelihood of pond embankment failures, NRC requires licensees to monitor and inspect pond embankments at ISL facilities in accordance with NRC-approved inspection programs. NRC also regularly inspects the embankments as part of the federal Dam Safety program.

As with ISL operations, land application of treated wastewater during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated wastewater could increase the salinity of soils (soil salination) and reduce the permeability of soils in the irrigation area. Land application of the treated wastewater could also cause radiological and/or other constituents to accumulate in the soils. At NRC-licensed ISL facilities, the licensee is required to monitor and control irrigation areas, if used, to maintain levels of radioactive constituents within allowable release standards. In addition, states typically regulate land application of wastewater and may impose release limits on nonradiological constituents to reduce negative impacts on soils and vegetation resulting from soil salination. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable standards. Areas of a site where land application of treated water has been used are also included in decommissioning surveys to ensure soil concentration limits are not exceeded. Because of the routine monitoring program and inclusion of land application areas in decommissioning surveys, the impacts to soil from land application of treated wastewater would be SMALL.

4.5.3.4 Decommissioning Impacts to Geology and Soils

Decommissioning of ISL facilities includes (1) dismantling process facilities and associated structures, (2) removing buried piping, and (3) plugging and abandoning wells using accepted practices. The main impacts to geology and soils in the Northwestern New Mexico Uranium Milling Region during decommissioning would be from activities associated with land reclamation and cleanup of contaminated soils. These activities are described in Section 2.6.

Before decommissioning and reclamation activities begin, the licensee is required to submit a decommissioning plan to NRC for review and approval. The licensee’s spill documentation—an NRC requirement—would be used to identify potentially contaminated soils requiring offsite disposal at a licensed facility. Any areas potentially impacted by operations would be included in surveys to ensure all areas of elevated soil concentrations are identified and properly cleaned up to comply with NRC regulations at 10 CFR Part 40, Appendix A, Criterion 6-(6).

Most of the impacts to geology and soils associated with decommissioning are temporary and SMALL. Because the goal of decommissioning and reclamation is to restore the facility to preproduction conditions to the extent practical, the overall long-term impacts to the geology and soils would be SMALL.

4.5.4 Water Resources Impacts

4.5.4.1 Surface Water Impacts

4.5.4.1.1 Construction Impacts to Surface Water

Potential impacts to Waters of the U.S. are regulated by permit under Section 404 of the Clean Water Act (Appendix B). The use of these permits also requires that the actions satisfy the individual state Section 401 certification with regard to water quality. In New Mexico, the Surface Water Quality Bureau of the New Mexico Environment Department has issued condition Section 401 Certification for discharges into ephemeral streams. In addition, the Surface Water Quality Bureau requires that a project-specific Section 401 Water Quality Certification must be obtained [see 33 CFR 330.4(c)] for discharges to any intermittent, perennial, and wetland surface waters and to any Outstanding National Resource Waters prior to construction. The Surface Water Quality Bureau requires a complete application and USACE permit verification prior to commencing the water quality certification review (New Mexico Surface Water Quality Bureau, 2007). If the project does not meet the requirements for a nationwide permit, then an individual Section 404 permit will be required.

Storm water runoff during construction would be controlled through a Storm Water Pollution Prevention Plan that is part of a NPDES permit issued by EPA (Section 1.7.2.1). Because average annual runoff in the Northwestern New Mexico Uranium Milling Region is less than in the Wyoming West Uranium Milling Region (U.S. Geological Survey, 2008), where the construction impact to surface waters would be SMALL, the potential for surface water impacts in this region would also be SMALL.

4.5.4.1.2 Operation Impacts to Surface Water

The potential causes and nature of surface water impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to those discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.2). Because of the small number of perennial streams in the Northwestern New Mexico Uranium Milling Region, the potential impacts upon surface waters would be SMALL. Storm water runoff and other discharges to surface water in New Mexico are controlled by a Storm Water Pollution Prevention Plan and NPDES permit issued by EPA rather than a state agency (Section 1.7.2.1). Compliance with the requirements for these permits is expected to result in SMALL impacts to surface water from operations activities.

4.5.4.1.3 Aquifer Restoration Impacts to Surface Water

The potential causes and nature of surface water impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to those discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.3). Because of the small number of perennial streams in the Northwestern New Mexico Uranium Milling Region, the potential impacts from aquifer restoration would be SMALL. Storm water runoff and other discharges to surface water in New Mexico are controlled by a Storm Water Pollution Prevention Plan and NPDES permit issued by EPA rather than a state agency (Section 1.7.2.1). Compliance with the requirements for these permits would result in SMALL impacts to surface water from aquifer restoration.

4.5.4.1.4 Decommissioning Impacts to Surface Water

The potential causes and nature of impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region (Section 4.2.4.2.4). Because of the small number of perennial streams in the Northwestern New Mexico Uranium Milling Region, the potential impacts from decommissioning are expected to be SMALL. Storm water runoff and other discharges to surface water in New Mexico are authorized through a Storm Water Pollution Prevention Plan and NPDES permit issued by EPA rather than a state agency (Section 1.7.2.1). Compliance with the requirements for these permits would result in SMALL impacts to surface water from decommissioning.

4.5.4.2 Groundwater Impacts

Potential environmental impacts to groundwater resources in the Northwestern New Mexico Uranium Milling Region can occur during all phases of the ISL facility’s lifecycle. ISL activities can impact aquifers at varying depths (separated by aquitards) above and below the uranium-bearing aquifer, as well as adjacent surrounding aquifers in the vicinity of the uranium-bearing aquifer. Surface activities that can introduce contaminants into soils are more likely to impact shallow (near-surface) aquifers, while ISL operations and aquifer restoration are more likely to impact the deeper uranium-bearing aquifer, any aquifers above and below, and adjacent surrounding aquifers.

ISL facility impacts to groundwater resources from all phases of the ISL facility lifecycle can occur from surface spills and leaks, consumptive water use, horizontal and vertical excursions of leaching solutions from production aquifers, degradation of water quality from changes in the production aquifer's geochemistry, and waste management practices involving deep well injection. Detailed discussion of the potential impacts to groundwater resources from construction, operations, aquifer restoration, and decommissioning is provided in the following sections.

4.5.4.2.1 Construction Impacts to Groundwater

During construction of ISL facilities, the potential for groundwater impacts is primarily from consumptive groundwater use, drilling fluids and muds from well drilling, and spills of fuels and lubricants from construction equipment (Section 2.3).

As discussed in Section 2.11.3, groundwater use during construction is limited to routine activities such as dust suppression, mixing cements, and drilling support. The amounts of groundwater used in these activities are small and would have a SMALL and temporary impact to groundwater supplies. Groundwater quality of near-surface aquifers during construction is protected by best management practices such as implementation of a spill prevention and cleanup plan to minimize soil contamination (Section 7.4). Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a SMALL impact to the water quality of those aquifers. Thus, construction impacts on groundwater resources would be SMALL based on the limited nature of construction activities and implementation of management practices to protect shallow groundwater.

4.5.4.2.2 Operation Impacts to Groundwater

During ISL operations, potential environmental impacts to shallow (near-surface) aquifers are related to leaks of lixiviant from pipelines, wells, or header houses and to waste management practices such as the use of evaporation ponds and disposal of treated wastewater by land application. Potential environmental impacts to groundwater resources in the production and surrounding aquifers involve consumptive water use and changes to water quality. Water quality changes would result from normal operations in the production aquifer and from possible horizontal and vertical lixiviant excursions beyond the production zone (Section 2.4). Disposal of processing wastes by deep well injection (Section 2.7.2) during ISL operations also can potentially impact groundwater resources.

4.5.4.2.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

A network of pipelines, as part of the underground infrastructure, is used during ISL operations for transporting lixiviants between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside pumping header houses. The failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers, could result in leaks and spills of pregnant and barren lixiviant (Section 2.3.1.2), which could impact water quality in shallow (near-surface) aquifers. The potential environmental impacts of pipeline, valve, or well integrity failures could be MODERATE to LARGE, if

- The groundwater table in shallow aquifers is close to the ground surface (i.e., small travel distances from the ground surface to the shallow aquifers)

- The shallow aquifers are important aquifers for local domestic or agricultural water supplies

- Shallow aquifers are hydraulically connected to other locally or regionally important aquifers

The potential environmental impacts would be expected to be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydrologically separated from other locally and regionally important aquifers.

In some parts of the Northwestern New Mexico Uranium Milling Region, local shallow aquifers with small water yields exist and are often used for local water supplies. Hence, for some sites, potential environmental impacts due to spills and leaks from pipeline, valve, or well integrity failures to the shallow aquifers could be SMALL to MODERATE, depending on site-specific conditions. Potential impacts would be reduced based on flow monitoring to detect pipeline leaks and spills early and implementation of required spill response and cleanup procedures. In addition, preventative measures such as well MIT (Section 2.3.1.1) would limit the likelihood of well integrity failure during operations.

The use of evaporation ponds or land application to manage process water generated during operations also could impact shallow aquifers. For example, failure of evaporation pond embankments or liners could allow contaminants to infiltrate into shallow aquifers. Similarly, land application of treated wastewater could cause radiological or other constituents (e.g., selenium or other metals) to accumulate in soils or infiltrate into shallow aquifers. In general, the potential impacts of these waste management activities are expected to be limited by NRC and state requirements. For example, NRC requirements for leak detection systems, maintenance of reserve pond capacity, and pond embankment inspections are expected to minimize the likelihood of evaporation pond failures. Similarly, NRC and state release limits related to land application of waste are expected to limit potential effects of land application of wastewater on shallow aquifers. Section 4.2.12.2 discusses the impacts of the use of evaporation ponds and land application of treated wastewater in greater detail and characterizes the expected impacts as SMALL.

4.5.4.2.2.2 Operation Impacts to Production and Surrounding Aquifers

The potential environmental impacts to groundwater supplies in the production and other surrounding aquifers are related to consumptive water use and groundwater quality.

Water Consumptive Use: NRC-licensed flow rates for ISL facilities typically range from about 15,100 to 34,000 L/min [4,000 to 9,000 gal/min] (Section 2.1.3). Most of this water is returned to the production aquifer after being stripped of uranium (see Section 2.4.1.2). The term “consumptive use” refers to water that is not returned to the production aquifer. During operations, consumptive use is due primarily to production bleed (typically between 1 and 3 percent of the total flow) and also includes other smaller losses. As described in Section 2.4.1.2, the purpose of the production bleed is to ensure that more groundwater is extracted than reinjected. Maintaining this negative water balance helps to ensure that there is a net inflow of groundwater into the well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field. Because the bleed water must be removed from the well field to maintain a negative water balance, the bleed is disposed through the wastewater control program and is not reinjected into the well field.

Hypothetically, if a well field at an ISL facility in the Northwestern New Mexico Uranium Milling Region is pumped at a constant rate of 22,700 L/min [6,000 gal/min] with 2 percent bleed, the total volume of production bleed in a year of operation would be 240 million L {63 million gal [190 acre-ft]}. For comparison, in 2000, approximately 3.96×10^{12} L [3.21 million acre-ft] of water was used to irrigate 404,000 ha [998,000 acres] of land in New Mexico (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 9.81 million L/ha [3.22 acre-ft/acre]. Thus, the consumptive use of 240 million L [190 acre-ft] of water due to production bleed in 1 year of operation is roughly equivalent to the water used to irrigate 24 ha [59 acres] in New Mexico for 1 year.

Consumptive water use during operations could lower water levels in local wells, impacting local water users who use water from the production aquifer (outside of the exempted zone). In addition, if production aquifers are not completely hydraulically isolated from aquifers above and below, consumptive use may impact local users of these connected aquifers by causing a lowering of water levels in those aquifers. However, effects on aquifers above and below are expected to be limited in most cases by the confining layers typical of aquifers used for ISL production. As discussed in Section 2.4.1.3, licensees conduct preoperations testing to assess the degree of hydraulic isolation of potential production aquifers at proposed ISL sites.

To assess the potential drawdown that could be caused by consumptive use during operations, drawdowns were calculated for a hypothetical case in which the water withdrawn by an entire ISL facility operating at 15,100 L/min [4,000 gal/min] with 2 percent bleed is assumed to be withdrawn from a single well. This scenario would overestimate the drawdown caused by ISL operations using water from a similar production aquifer because water withdrawal at a typical ISL facility is distributed among hundreds of wells (Section 2.3.1.1) and tens to hundreds of hectares [tens to thousands of acres] (Section 4.2.1). In this hypothetical case, drawdowns at locations 1, 10, and 100 m [3.3, 33, and 330 ft]away from a pumping well (representing the well field) would be 3.5, 2.8, and 2.1 m [3.5, 2.8, and 6.9 ft], respectively, after 10 years of operation. These estimates were calculated using the Theis Equation (McWhorter and Sunada, 1977) with transmissivity and storage coefficient values of 240 m^2/day (2,580 ft^2/day) and 8×10^{-5}, respectively (chosen from the range of respective parameter values discussed in Section 3.5.4.3). As discussed in Section 4.3.4.2.2.2, drawdowns are found to be more sensitive to the aquifer transmissivity than storage coefficient.

In these calculations, the potential effect of natural recharge to the production aquifers on groundwater levels is not considered. Consideration of natural recharge would reduce the calculated drawdowns. However, neglecting natural recharge is not expected to have as much of an effect as approximating the withdrawal from an entire facility with one hypothetical well. As previously discussed, this approximation is expected to yield overestimates of the expected drawdowns.

Near a well field, the short-term impact of consumptive use is expected to be SMALL to MODERATE, depending on site-specific conditions (e.g., aquifer transmissivity). Impacts could be MODERATE in relatively low transmissivity aquifers if there are local water users who use the production aquifer (outside of the exempted zone) or if the production aquifer is not well-isolated from other aquifers that are used locally. However, because localized drawdown near well fields would dissipate after pumping stops, these localized effects are expected to be temporary. The long-term impacts would be expected to be SMALL in most cases, depending on site-specific conditions. Important site-specific conditions would include the consumptive use of the proposed facility, the proximity of water users' wells to the well fields, the total volume of water in the production aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

Excursions and Groundwater Quality: Groundwater quality in the production aquifer is degraded as part of the ISL facility's operations (Section 2.4). The restoration of the production aquifer is discussed in Section 2.5. For operations to occur, the uranium-bearing production aquifer would need to be exempted as an underground source of drinking water through the appropriate EPA or state-administered UIC program. When uranium recovery is complete in a well field, the licensee is required to initiate aquifer restoration activities to restore the production aquifer to baseline or preoperational class-of-use conditions, if possible. If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in 10 CFR Part 40, Appendix A, Table 5C or to alternate concentration limits approved by the NRC. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISL operations would be expected to be SMALL and temporary. The remainder of this section discusses the potential for groundwater quality in the surrounding aquifers or outside of the production zone of the producing aquifer to be impacted by excursions during ISL operation.

During normal ISL operations, inward hydraulic gradients are expected to be maintained by production bleed so that groundwater flow is toward the production zone from the edges of the well field. If this inward gradient is not maintained, horizontal excursions could occur and lead to the spread of leaching solutions in the ore-bearing aquifer beyond the mineralization zone. The rate and extent of spread is largely driven by the collective effects of the aquifer transmissivity, groundwater flow direction, and aquifer heterogeneity. The impact of horizontal excursions could be MODERATE to LARGE if a large volume of contaminated water leaves the production zone and moves downgradient within the production aquifer while the production aquifer outside the mineralization zone is used for water production. To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventative measures prior to starting operations. For example, licensees must install a ring of monitoring wells within and encircling the production zone to permit early detection of horizontal excursions (Chapter 8). If there are oil, gas, coal bed methane, or other production layers near the ISL facility, and if NRC determines that there could be potentials for cross contamination between the ISL production zone and other production layers based on environmental impact assessments, NRC may require the licensee to expand the monitoring well ring for detection of potential contamination between the ISL production zone and other mineral production layers. If excursions are detected, the monitoring well is placed on excursion status and reported to the NRC. Corrective actions are taken, and the well is placed on a more frequent monitoring schedule until the well is found to no longer be in excursion.

The following discussion focuses on the potential for groundwater quality in the surrounding aquifers to be impacted during ISL operations. The rate of vertical flow and the potential for excursions between the production aquifer and an aquifer above or below is determined by multiplying vertical hydraulic gradient across a confining layer by vertical hydraulic conductivity of a confining layer and dividing the result by porosity of a confining layer (McWhorter and Sunada, 1977; Driscoll, 1986).

Vertical hydraulic head gradients between the production aquifer and the underlying and overlying aquifers could be altered by potential increases in pumpage from the overlying or underlying aquifers for water supply purposes in the vicinity of an ISL facility (e.g., from the overlying Dakota Sandstone or the underlying Cow Springs Sandstone), which may enhance potential vertical excursions from the production aquifer (the Morrison Formation including the ore-bearing Westwater Canyon aquifer). Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could lead to vertical flow and excursions.

In addition, potential well integrity failures during ISL operations could lead to vertical excursions. Well casings above or below the uranium-bearing aquifer—through inadequate construction, degradation, or accidental rupture—could allow lixiviant to travel from the well bore into the surrounding aquifer. Moreover, deep monitoring wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create vertical pathways for excursions of lixiviant from the production aquifers to the adjacent aquifers.

Some relevant factors when considering the significance of potential impacts from a vertical excursion (such as local geology and hydrology and the proximity of injection wells to drinking water supply wells) are discussed in Section 2.4.1. Additionally, past experience with excursions reported at NRC-licensed ISL facilities is discussed in Section 2.11.5.

To reduce the likelihood and consequences of potential excursions at ISL facilities, NRC requires licensees to take preventive measures prior to starting operations. For example, licensees must conduct MIT to ensure that lixiviant would remain in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees are required to conduct aquifer pump tests prior to starting operations in a well field. The purpose of these pump tests is to determine aquifer parameters (e.g., aquifer transmissivity and storage coefficient, and the vertical hydraulic conductivity of aquitards) and also to ensure that confining layers above and below the production zone are expected to preclude the vertical movement of fluid from the production zone into the overlying and underlying units. The licensee must also develop and maintain monitoring programs to detect both vertical and horizontal excursions and must have operating procedures to analyze an excursion and determine remediation actions. The monitoring programs prescribe the number, depth, and location of monitoring wells, sampling intervals, sampling water quality parameters, and the UCLs for particular water quality parameters (Chapter 8). These specifications typically are made conditions in the NRC license.

If excursions are observed at the monitoring wells, the licensee would increase sampling and commence corrective actions. The excursions typically would be reversed by increasing the overproduction rate and drawing the lixiviant back into the extraction zone.

Monitoring wells typically are completed in the lower portion of the first aquifer above the ore-bearing aquifer and in the upper portion of the first aquifer below the ore-bearing aquifer. As described in Section 3.5.4.3.2, the Dakota Sandstone overlies the ore-bearing aquifer and the Cow Springs Sandstone underlies the ore-bearing aquifer in the vicinity of the existing ISL sites.

In general, the potential environmental impacts of vertical excursions to groundwater quality in surrounding aquifers would be SMALL if the vertical hydraulic head gradients between the production aquifer and the adjacent aquifer are small, the vertical hydraulic conductivity of the confining units is low, and the confining layers are sufficiently thick. On the other hand, the environmental impacts could be MODERATE to LARGE if confinements are discontinuous, thin, or fractured (i.e., high vertical hydraulic conductivities). To limit the likelihood of vertical excursions, licensees conduct MIT of the injection and production wells to ensure that lixiviant remains in the well and not escape into surrounding aquifers (Section 2.3.1). Licensees also must conduct preoperational pump tests to ensure adequate confinement of the production zone. In addition, licensees must develop and maintain programs to monitor above and below the ore-bearing zone to detect both vertical and horizontal excursions and flow rates, and must have operating procedures to analyze an excursion and determine remediation actions.

In the Northwestern New Mexico Uranium Milling Region, the ore-bearing aquifer (the Westwater Canyon aquifer in the Morrison Formation) is confined below and above by continuous and thick confining layers at the ISL sites. The thickness of the aquitards is reportedly variable in the milling region (NRC, 1997). There is no evidence on the fracture nature of these confining layers in the region. If the licensee installs and maintains the monitoring well network properly, potential impacts of vertical excursions would be temporary and the long-term effects would be SMALL.

4.5.4.2.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

Potential environmental impacts to confined deep aquifers below the production aquifers could be due to deep well injection of processing wastes into deep aquifers. Under different environmental laws such as the Clean Water Act, the Safe Drinking Water Act, and the Clean Air Act, EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from the EPA (Section 1.7.2).

At the proposed ISL facility site in Crownpoint, New Mexico, the Cow Springs Aquifer and Entrada Sandstone do not appear to be potential aquifers for deep injection, because data indicate that the Cow Springs Aquifer contains good quality water (Hydro Resources, Inc., 1996; NRC, 1997) and this aquifer is not hydraulically separated from the underlying Entrada Sandstone. Thus, no deep aquifer has been identified in that portion of the uranium milling region for deep injection of leaching solutions.

The potential environmental impacts of injection of leaching solutions into deep aquifers below ore-bearing aquifers would be expected to be SMALL if water production from deep aquifers is not economically feasible or the groundwater quality from these aquifers is not suitable for domestic or agricultural uses (e.g., high salinity), and they are confined above by sufficiently thick, low permeability layers. As discussed previously, licensees seeking to dispose of liquid effluents by deep well injection would need to be granted a permit to do so from the EPA or appropriate state agency.

4.5.4.2.3 Aquifer Restoration Impacts to Groundwater

The potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including discharge of wastes to evaporation ponds, land application of treated wastewater, and potential deep disposal of brine slurries resulting from reverse osmosis. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the well field being restored.

Aquifer restoration typically involves a combination of the following methods: (1) groundwater transfer, (2) groundwater sweep, (3) reverse osmosis with permeate injection, and (4) groundwater recirculation. These methods are discussed in depth in Section 2.5. In addition to these processes, potential new restoration processes are being developed. These processes include the use of controlled biological reactions to precipitate uranium and other contaminants by restoring chemically reducing conditions to production aquifers. However, these processes have not yet been used at a commercial scale and their likely impacts will not be known until the processes have been developed further.

Groundwater consumptive use for groundwater transfer would be minimal, because milling-affected water in the restoration well field is displaced with baseline quality water from outside the well field. Groundwater consumptive use would be large for groundwater sweep, because it involves pumping groundwater from well field without injection. The rate of groundwater consumptive use would be lower during the reverse osmosis phase, because up to 70 percent of the pumped groundwater treated with reverse osmosis can be reinjected into the aquifer. Groundwater consumptive use could be further decreased during the reverse osmosis phase if brine concentration is used, in which case up to 99 percent of the withdrawn water could be suitable for reinjection. In that case, the actual amount of water that is reinjected into the well field may be limited by the need to maintain a negative water balance to achieve the desired for of water from outside the well field into the well field.

Groundwater consumptive use during aquifer restoration is generally reported to be greater than during ISL operations (Freeman and Stover, 1999; NRC, 2003; Chapter 2 of this GEIS). One reason for increased consumptive use during restoration is that, as previously discussed, no water is reinjected during groundwater sweep. Water is not reinjected during groundwater sweep, because the purpose of the sweep phase is to remove contaminated water from a well field and draw unaffected water into the well field. For example, at the Irigaray Mine in Campbell County, Wyoming, between 1.4 and 4.2 pore volumes of water were removed from six restoration units (comprising nine well fields, some of which were combined for restoration). The total volume of water consumed to perform groundwater sweep on all of the well fields was 545 million L [144 million gal].

As discussed in Section 2.5, restoration typically is performed as well fields end production, so all of the well fields do not undergo groundwater sweep at the same time. For example, at the Irigaray Mine, (Cogema Mining, Inc., 2004), average pumping rates for groundwater sweep ranged from approximately 100 L/min [27 gal/min] to pump 120 million L [31 million gal] from two well fields between June 1991 and August 1993 to 380 L/min [100 gal/min] to pump 190 million L [49 million gal] from three well fields between May of 1990 and April of 1991. At the Smith Ranch/Highland Uranium Project in Converse County, Wyoming, an average pumping rate of approximately 38 L/min [10 gal/min] was used to pump 3.2 pore volumes {49 million L [13 million gal]} from the A-Wellfield during almost 3 years groundwater sweep (Power Resources, Inc., 2004).

The actual rate of groundwater consumption at an ISL facility at any time depends, in part, on the various stages of operation and restoration of the individual well fields at the facility. For example, consider a hypothetical case in which three well fields at a site undergo groundwater sweep while three undergo reverse osmosis treatment with permeate reinjection and another three continue production. Hypothetically, while 380 L/min [100 gal/min] are consumed during groundwater sweep of three well fields, 110 L/min [30 gal/min] may be consumed to perform reverse osmosis treatment in another three well fields, and another 38 L/min [10 gal/min] may be consumed by production bleed in the remaining three well fields. The total water consumption rate while these processes continued would be 530 L/min [140 gal/min].

At a rate of 530 L/min [140 gal/min], 280 million L [74 million gal] would be consumed in 1 year. For comparison, in 2000, approximately 3.96×10^{12} L [3.21 million acre-ft] of water was used to irrigate 404,000 ha [998,000 acres] of land in New Mexico (Hutson, et al., 2004). This irrigation rate is equivalent to an annual application of approximately 9.81 million L/ha [3.22 acre-ft/acre]. Thus, consumption of 280 million L [74 million gal or 230 acre-ft] in 1 year of restoration would be roughly equivalent to the water used to irrigate 29 ha [72 acres] in New Mexico for 1 year. Potential environmental impacts are affected by the restoration techniques chosen, the severity and extent of the contamination, and the current and future use of the production and surrounding aquifers in the vicinity of the ISL facility or at the regional scale. The potential environmental impacts of groundwater consumptive use during restoration could be SMALL to MODERATE. Site-specific impacts also would depend on the proximity of water users' wells to the well fields, the total volume of water in the aquifer, the natural recharge rate of the production aquifer, the transmissivity and storage coefficient of the production aquifer, and the degree of isolation of the production aquifer from aquifers above and below.

During aquifer restoration, the most heavily contaminated groundwater may be disposed through the wastewater treatment system. The impacts of discharging wastes to solar evaporation ponds or applying treated wastewater to land during restoration are expected to be similar to the impacts of these waste management practices during operations (SMALL) (Section 4.5.4.2.2.1).

As discussed in Section 4.2.4.2.2.3, underground injection of fluid requires a permit from EPA or the authorized state and approval from the NRC. Additionally, the briny slurry produced during the reverse osmosis process may be pumped to a deep well for disposal (Section 2.7.2). The deep aquifers suitable for injection must have poor water quality, have low water yields, or be economically infeasible for production. They also need to be hydraulically separated from overlying aquifer systems. Under these conditions, the potential environmental impacts would be SMALL.

Aquifer restoration processes also affect groundwater quality directly by removing contaminated groundwater from well fields, reinjecting treated water, and recirculating groundwater. In general, aquifer restoration continues until NRC and applicable state requirements for groundwater quality are met. As discussed in Section 2.5, NRC licensees are required to return well field water quality parameters to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) or to another standard approved in their NRC license. Historical information about aquifer restoration at several NRC-licensed facilities is discussed in Section 2.11.5.

4.5.4.2.4 Decommissioning Impacts to Groundwater

The environmental impacts to groundwater during dismantling and decommissioning ISL facilities are primarily associated with consumptive use of groundwater, potential spills of fuels and lubricants, and well abandonment. The consumptive groundwater use could include water use for dust suppression, revegetation, and reclamation of disturbed areas (Section 2.6). The potential environmental impacts during the decommissioning phase are expected to be similar to potential impacts during the construction phase. Groundwater consumptive use during the decommissioning activities would be less than groundwater consumptive use during ISL operation and groundwater restoration activities. Spills of fuels and lubricants during decommissioning activities could impact shallow aquifers. Implementation of best management practices (Chapter 7) during decommissioning can help to reduce the likelihood and magnitude of such spills. Based on consideration of best management practices to minimize water use and spills, impacts to the groundwater resources in shallow aquifers from decommissioning would be expected to be SMALL.

After ISL operations are completed, improperly abandoned wells could impact aquifers above the production aquifer by providing hydrologic connections between aquifers. As part of the restoration and reclamation activities, all monitors, injection, and recovery wells will be plugged and abandoned. The wells will be filled with cement and clay and then cut off below plow depth to ensure that no groundwater flows through the abandoned wells (Stout and Stover, 1997). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be SMALL.

4.5.5 Ecological Resources Impacts

4.5.5.1 Construction Impacts to Ecological Resources

Vegetation

ISL uranium recovery facility construction primarily affects terrestrial vegetation through (1) the removal of vegetation from the milling site during construction (and associated reduction in wildlife habitat and forage productivity and an increased risk of soil erosion and weed invasion); (2) the modification of existing vegetative communities as a result of milling maintenance; (3) the loss of sensitive plants and habitats as a result of construction clearing and grading; and (4) the potential spread of invasive species and noxious weed populations as a result of construction.

ISL facilities typically are located on large tracts of land in remote areas. Permit areas of past facilities have ranges from 69 ha to 6,480 ha [170 to 16,000 acres] (Section 2.11.1). Typically, the amount of land disturbance within these permitted areas ranges from 49 to 750 ha [120 to 1,860 acres]. The percentage of vegetation removed (disturbed land) ranges from a low of 1 percent to as much as 70 percent, but is on average approximately 15 percent. This results in a relatively SMALL impact in relation to the total permit area and surrounding plant communities.

Clearing herbaceous vegetation during construction in an open grassland or shrub steppe community is anticipated to have a short-term impact. If active revegetation measures are used with seed mixtures approved by the New Mexico Environmental Department, colonization by annual and perennial herbaceous species in the disturbed staging areas and rights-of-way would restore most vegetative cover within the first growing season, and impacts from clearing would be SMALL.

Clearing woody shrubs and trees would have a longer-term impact than herbaceous clearing. While woody shrubs and trees would recolonize the temporary construction right-of-way and staging areas, they would recolonize more slowly than would herbaceous species. As natural succession is allowed to proceed in these areas, the early successional or forested communities that existed before construction would eventually be reestablished. Clearing trees in the milling site could affect forest vegetation growing along the edges of the cleared areas. Exposing some edge trees to elevated levels of sunlight and wind could increase evaporation rates and the probability of tree “knockdown.” Due to the increased light levels penetrating the previously shaded interior, shade-intolerant species would be able to grow and the species composition of the newly created forest edge may change. Clearing could also temporarily reduce local competition for available soil moisture and light and may allow some early successional species to become established and persist on the edge of the uncleared areas adjacent to the milling site. Impacts from clearing this community would be SMALL to MODERATE depending on the amount of surrounding wooded area.

Noxious weeds that may invade areas disturbed by construction would be controlled through the use of herbicides. Application would employ the use of hand sprayers or broadcasting using truck-mounted spraying equipment. If these methods are used, potential impacts from noxious weeds would be SMALL. Based on these considerations, potential impacts to wildlife would be SMALL to MODERATE.

Wildlife

There are three primary impacts of ISL uranium recovery facility construction on terrestrial wildlife: (1) habitat loss or alteration and incremental habitat fragmentation; (2) displacement of wildlife from project construction; and (3) direct and/or indirect mortalities from project construction and operation.

Construction activities in well fields would result in some loss of wildlife habitat; however, this loss can be minimized if disturbed areas are reseeded when construction is completed in that area. The impacts would expected to be greatest in vegetative communities where clearing is required to construct wells, access roads, header houses, and pipelines from the well fields to the header houses. In general, most wildlife, including the larger and more mobile animals, would disperse from the project area as construction activities approach. Displaced species may recolonize in adjacent, undisturbed areas or return to their previously occupied habitats after construction ends and a suitable habitat is reestablished. Some smaller, less mobile wildlife such as amphibians, reptiles, and small mammals may die during clearing and grading activities. Small mammals and songbirds dependent on shrubs and trees for food, nesting, and cover would be impacted in areas where clearing is needed for construction. Wildlife habitat fragmentation, temporary displacement of animal species, and direct or indirect mortalities is possible, therefore construction impacts would be SMALL to MODERATE.

Even if available habitat exists within the site and adjacent areas to support displaced individuals, some impact from competition for resources between preexisting species may occur. Some localized foraging areas may be avoided by big game during construction periods when workers are present. Noise, dust, and increased presence of workers in, or adjacent to, foraging areas may temporarily preclude use by wildlife (NRC, 2004). Habitat loss and fragmentation can be reduced if the percentage of land affected compared to the total undisturbed vegetative community acreage within the permitted area and or surrounding area is minimal. Standard management practices issued by the New Mexico Department of Game and Fish can help to minimize habitat fragmentation, wildlife stress, and incidental death.

Critical wintering habitat vital for the survival of local elk populations is located within the region (Figure 3.5-9). If a potential facility was to be located within these ranges, guidelines have been issued by the New Mexico Department of Game and Fish to limit the impacts to a SMALL magnitude. Consultation with the New Mexico Department of Game and Fish would be conducted, and a site-specific analysis performed to determine impacts from the facility to these species.

Well field operations would require the construction of power distribution lines. Lines would be supported by single-pole wood structures with a wooden cross arm. The conductors would be configured to assure adequate spacing between the shield wire (i.e., ground wire) and conductors to avoid potential electrocution of raptors that land on the cross-arms. Construction of the distribution lines would follow guidance in Avian Power Line Interaction Committee (1996). Raptors breeding in the site may be impacted by construction activities or mining operations and may be temporarily impacted depending on the time of year construction activities occur. Potential impacts to this species would be SMALL.

To minimize impacts, where possible, the facility would avoid construction in areas within 0.8 km [0.5 mi] of active raptor nests and prior to fledging of young. Mitigation should be carried out in areas that cannot be avoided based on approval by the U.S. Fish and Wildlife Service and the New Mexico Department of Game and Fish. Proposed mitigation could include construction of alternate nest sites on natural features (e.g., trees, rock outcrops, and cliffs) and on mine high walls in the site and vicinity, and erection of appropriate nesting platforms on wooden poles (NRC, 2004).

Aquatic

ISL uranium recovery facility construction primarily affects aquatic resources through (1) short-term physical disturbances to stream channels; (2) short-term increases in suspended sediments from in-stream activities and erosion from adjacent disturbed lands; (3) increases in downstream sedimentation, during construction, from in-stream activities and erosion from adjacent disturbed lands; (4) potential fuel spills from equipment and refueling operations during construction; and (5) short-term reductions in habitat and potential loss of individual specimens from water appropriations if needed. Impacts to aquatic resources from construction would be similar in nature to those described for other milling regions (SMALL).

Threatened and Endangered Species

There are three primary impacts of ISL uranium recovery facility construction on threatened and endangered species: (1) habitat loss or alteration and incremental habitat fragmentation; (2) displacement of wildlife from project construction; and (3) direct and indirect mortalities from project construction and operation.

Numerous threatened and endangered species and state species of concern are located within the region. These species with habitat descriptions are provided in Section 3.5.5.3. After a site has been selected, the habitats and impacts would be expected to be evaluated for federal and state species of concern that may inhabit the area. For site-specific environmental reviews, licensees and NRC staff consult with the U.S. Fish and Wildlife Service and New Mexico Department of Game and Fish for potential survey requirements and explore ways to protect these resources. If any of the species are identified in the project site during surveys, potential impacts could range from SMALL to MODERATE to LARGE depending on site-specific conditions. Mitigation plans to avoid and reduce impacts to the potentially affected species would be expected to be developed.

- The black-footed ferret is reported to be extirpated from New Mexico and is no longer present in the region. No impacts to black-footed ferrets are expected to occur from milling activities within this region.

- The bald eagle has been delisted and is undergoing monitoring. While not a listed species, the bald eagle is still offered protection, and impacts should be avoided.

Impacts to this species are unlikely if vegetation during construction removal avoids nesting and hunting habitat along riparian areas.

- The Mexican spotted owl has critical habitat designated within the region. Mexican spotted owls nest, roost, forage, and disperse in a diverse assemblage of biotic communities. In the region, owls occur primarily in rocky canyons. They nest in these areas on cliff ledges, in stick nests built by other birds, on debris platforms in trees, and in tree cavities. In southern Utah, Colorado, and some portions of northern New Mexico, most nests are in caves or on cliff ledges in rocky canyons. Potential large impacts may occur to this species from land disturbance and removal of woody vegetation from their designated habitat.

- The Pecos puzzle sunflower is found in areas that have permanently saturated soils, including desert wetlands (cienegas) that are associated with springs and potentially in stream and lake margins. The removal of vegetation for construction would have a large impact to this species if the species is found within the construction zone.

- Impacts to the Southwestern willow fly catcher would occur if patchy to dense riparian habitats along streams, reservoirs, or other wetlands were removed creating vegetative buffers and avoiding areas in which this species breeds would minimize impacts.

- The Zuni fleabane grows in selenium-rich clay soils derived from the Chinle and Baca formations. Plants are found at elevations from 2,230–2,440 m [7,300–8,000 ft] in pinyon-juniper woodland. Potential impact from vegetation removal may occur to this species as a result of the facility construction if this species is found at the facility.

- The Rio Grande silvery minnow is believed to occur only in one reach of the Rio Grande in New Mexico, a 280-km [174-mi] stretch of river that runs from Cochiti Dam to the headwaters of Elephant Butte Reservoir. SMALL to MODERATE impacts to this species could occur if vegetation removal, erosion, or sedimentation control measures are not followed during construction if the listed waterway occurs within the facility's boundaries.

- The yellow-billed cuckoo—(candidate) habitat is described in Section 3.2.5.3 of the Wyoming West Uranium Milling Region.

- Surveys conducted in 1990 determined the distribution of Zuni bluehead sucker (candidate) in New Mexico to be limited mainly to the Río Nutria drainage upstream of the mouth of the Rio Nutria Box Canyon. This included the mouth of Río Nutria Box Canyon, upper Río Nutria, confluence of Tampico Draw and Río Nutria, Tampico Spring, and Agua Remora. If the listed waterways occur within the permit area, potential impacts to this species may occur from construction of crossings and vegetation removal. These impacts would be temporary in nature if revegetation and or avoidance of these areas were employed.

4.5.5.2 Operation Impacts to Ecological Resources

The primary potential impacts of ISL uranium recovery facility operation on terrestrial wildlife are (1) habitat alteration and incremental habitat fragmentation; (2) displacement/stress of wildlife from human activity; and (3) direct and/or indirect mortalities from project construction and operation.

Some impacts to wildlife would occur from direct conflict with vehicular traffic and the presence of onsite personnel. Generally these are SMALL impacts that would not affect the total population of a species. Mitigation guidelines with respect to noise, vehicular traffic, and human proximity have been established by the New Mexico Department of Game and Fish (New Mexico Department of Game and Fish, 2007).

Potential impacts to migratory birds and other wildlife from exposure to selenium concentrations and radioactive materials in the evaporation ponds may occur. No guidelines have been established concerning acceptable limits for radiation exposure for protection of species other than humans. It is generally agreed that radiation protection standards for humans are conservative for other species (NRC, 2004). The concentrations of radioactive materials in the evaporation ponds are not anticipated to be at levels that could result in significant radiation exposure to biota other than humans. Typically, evaporation ponds are lined with a synthetic liner that inhibits the growth of aquatic vegetation which might otherwise serve as a potential source of exposure to radioactive materials via a food pathway. Such vegetation could also potentially provide habitat for wildlife (NRC, 2004). Mitigation measures such as perimeter fencing, surface netting, and the infrequency of wildlife visitation would reduce potential impacts.

Impacts to the aquatic resources and vegetation from facility operations would be SMALL and generally result from spills around well heads and leaks from pipeline. These would be handled using best management practices (NRC, 2007). Leak detection systems and spill response plans to remove affected soils and capture release fluids would reduce the impact to aquatic systems. Impacts to federal threatened and endangered species beyond those that occurred during construction would be SMALL. The potential exists for contact with vehicles to occur during facility operations for those species which are mobile, if they occur in the area.

4.5.5.3 Aquifer Restoration Impacts to Ecological Resources

Impacts similar to those found from facility operation are expected as a result of this activity.

4.5.5.4 Decommissioning Impacts to Ecological Resources

Impacts as result of decommissioning would, in part, be similar to those discussed in the construction of the facility and would be short term. The removal of piping would impact vegetation that has reestablished itself, and wildlife could come in contact with heavy equipment. During decommissioning, reclamation activities would revegetate previously disturbed areas and restore streams and drainages to their preconstruction contours. It is expected that temporarily displaced wildlife would return to the area. As a result, the potential impacts to ecological resources during decommissioning would be expected to be SMALL.

4.5.6 Air Quality Impacts

For the Northwestern New Mexico Uranium Milling Region, potential nonradiological air impacts for all four uranium milling phases would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.6. The Northwestern New Mexico Uranium Milling Region analyses in Section 4.5.6 would be limited to the modification, supplementation, or summarization of the Wyoming West Uranium Milling Region analyses presented in Section 4.2.6.

In general, ISL milling facilities are not major nonradiological air emission sources and the impacts would be classified as SMALL if the following conditions are met:

- Gaseous emissions are within regulatory limits and requirements
- Air quality in the region of influence is in compliance with NAAQS
- The facility is not classified as a major source under the New Source Review or operating (Title V) permit programs described in Section 1.7.2

The Northwestern New Mexico Uranium Milling Region is classified as attainment for NAAQS (see Figure 3.5-11). The city of Albuquerque in Bernalillo County is designated as maintenance for carbon monoxide. The northwest part of Bernalillo County is only several kilometers [miles] from the Northwestern New Mexico Uranium Milling Region border, however, Albuquerque is about 50 km [31 mi] from this border. The Northwestern New Mexico Uranium Milling Region does not include any Prevention of Significant Deterioration Class I areas (see Figure 3.5-12). Therefore, the less stringent Class II area allowable increments apply.

4.5.6.1 Construction Impacts to Air Quality

Nonradiological gaseous emissions in the construction phase include fugitive dust and combustion emissions (Section 2.7.1). Most of the combustion emissions are diesel emissions and are expected to be limited in duration to construction activities and result in small, short-term effects. The Northwestern New Mexico Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. Therefore, construction impacts for ISL facilities would be SMALL.

4.5.6.2 Operation Impacts to Air Quality

Operating ISL facilities are not major point source emitters and are not expected to be classified as major sources under the operation (Title V) permitting program (Section 1.7.2). One gaseous emission source introduced in the operational phase is the release of pressurized vapor from well field pipelines. Excess vapor pressure in these pipelines could be vented at various relief valves throughout the system. In addition, ISL operations may release gaseous effluents during resin transfer or elution. In general, nonradiological emissions from pipeline system venting, resin transfer, and elution are SMALL. Gaseous effluents produced during drying yellowcake operations vary based on the particular drying technology. In general, nonradiological emissions from yellowcake drying would be SMALL.

Other potential operation phase nonradiological air quality impacts include fugitive dust and combustion emissions from many of the same sources identified earlier in the construction phase. ISL operations phase fugitive dust emissions sources include onsite traffic related to operations and maintenance, employee traffic to and from the site, and heavy truck traffic delivering supplies to the site and product from the site. The ISL operations phase would use the existing infrastructure, and emissions would not include fugitive dust and diesel emissions associated with well field construction. Therefore, operations phase impacts would be expected to be less than the construction phase impacts.

The Northwestern New Mexico Uranium Milling Region is in NAAQS attainment and contains no Prevention of Significant Deterioration Class I areas. Gaseous emission levels from an ISL facility are expected to comply with applicable regulatory limits and restrictions. These emissions are not expected to reach levels that result in the ISL facility being classified as a major source under the operating (Title V) permit process. Therefore, operation impacts for ISL facilities would be SMALL.

4.5.6.3 Aquifer Restoration Impacts to Air Quality

Potential aquifer restoration phase nonradiological air impacts include fugitive dust and combustion emissions from many of the same sources identified earlier in the operations phase. The plugging and abandonment of production and injection wells use equipment that generates gaseous emissions. These emissions would be limited in duration and result in SMALL, short-term effects. The ISL aquifer restoration phase would use the existing infrastructure, and the impacts would not exceed those of the construction phase. Therefore, aquifer restoration phase impacts would be SMALL.

4.5.6.4 Decommissioning Impacts to Air Quality

Potential decommissioning phase nonradiological air impacts include fugitive dust, vehicle emissions, and diesel emissions from many of the same sources identified earlier in the construction phase. In the short term, emission levels could increase, especially for particulate matter from activities such as dismantling buildings and milling equipment, removing any contaminated soil, and grading the surface as part of reclamation activities. Decommissioning phase impacts would be expected to be similar to construction phase impacts. Therefore, decommissioning phase impacts would be SMALL.

4.5.7 Noise Impacts

4.5.7.1 Construction Impacts to Noise

For the Northwestern New Mexico Uranium Milling Region, potential noise impacts during well field construction, drilling, and facility construction would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.1. There are additional sensitive areas that should be considered within this region (see Section 3.5.7), but because of decreasing noise levels with distance, construction activities would have only SMALL and short-term noise impacts for residences, communities, or sensitive areas located more than about 300 m [1,000 ft] from specific noise-generating activities. The noise impacts associated with constructing either a central or satellite production facility would be of short duration compared to the operations period. Noise impacts to workers during construction would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During construction, wildlife are likely to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during construction would be SMALL to MODERATE.

4.5.7.2 Operation Impacts to Noise

For the Northwestern New Mexico Uranium Milling Region, potential noise impacts during ISL operations would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.2. There are additional sensitive areas that should be considered within this region (see Section 3.5.7), but operations at facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area would have only SMALL noise impacts. Noise impacts to workers during operations would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During operations, wildlife would be anticipated to avoid areas where noise-generating activities are ongoing. Compared to daily traffic counts of more than 12,000 to 16,000 vehicles per day on Interstate 40 and U.S. Highway 491 near Gallup (New Mexico Department of Transportation, 2007; see also Section 3.5.7), additional traffic associated with ISL operations would have only a SMALL impact on noise levels near the highway. As noted in Section 4.2.7.1, noise levels measured at 78 dBA at 30 m [98 ft] would decrease with distance from the highway to 60 dBA at 360 m [1,180 ft] (Washington State Department of Transportation, 2006). Some country roads with low average annual daily traffic counts would have higher relative increases in traffic and noise impacts, in particular, when facilities are experiencing peak (construction) employment (these impacts would be MODERATE). Therefore, overall noise impacts during operations would be SMALL to MODERATE.

4.5.7.3 Aquifer Restoration Impacts to Noise

For the Northwestern New Mexico Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.3. There are additional sensitive areas that should be considered within this region (see Section 3.5.7), but for facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area, aquifer restoration would be expected to have only SMALL noise impacts. Noise impacts to workers during operations would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. Noise impacts to workers during aquifer restoration would also be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During aquifer restoration, wildlife would be anticipated to avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during aquifer restoration would be expected to be SMALL to MODERATE.

4.5.7.4 Decommissioning Impacts to Noise

For the Northwestern New Mexico Uranium Milling Region, potential noise impacts during aquifer restoration would be similar to the impacts described for the Wyoming West Uranium Milling Region in Section 4.2.7.4. There are additional sensitive areas that should be considered within this region (see Section 3.5.7), but for facilities more than 300 m [1,000 ft] from the nearest residence, community, or sensitive area, decommissioning would be expected to have only SMALL noise impacts. Noise impacts to workers during decommissioning would be SMALL because of adherence to Occupational Safety and Health Administration noise regulations. During decommissioning, wildlife would avoid areas where noise-generating activities are ongoing. Therefore, overall noise impacts during decommissioning would be SMALL.

4.5.8 Historical and Cultural Resources Impacts

Construction-related impacts to cultural resources (defined here as historical, cultural, archaeological, and traditional cultural properties) can be direct or indirect and can occur at any stage of an ISL uranium recovery facility project (i.e., during construction, operation, aquifer restoration, and decommissioning).

A general cultural overview of the affected environment for the Northwestern New Mexico Uranium Milling Region is provided in Section 3.5.8. Construction involving land-disturbing activities, such as grading roads, installing wells, and constructing surface facilities and well fields, are the most likely to affect cultural and historical resources. Prior to engaging in land-disturbing activities, licensees and applicants review existing literature and perform region-specific records searches to determine whether cultural or historical resources are present and have the potential to be disturbed. Along with literature and records reviews, the project site area, and its related facilities and components, would be subjected to a comprehensive cultural resources inventory that meets the requirements of responsible federal, state, and local agencies (e.g., the New Mexico SHPO). The literature and records searches will help identify known or potential historical and cultural resources and Native American sites and features. The cultural resources inventory would identify the previously documented sites and any newly identified cultural resources sites.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance, or recording, and archiving samples) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC and licensees/applicants may enter into a memorandum of agreement with the responsible state and tribal agencies to ensure protection of historical and cultural resources, if encountered. The eligibility evaluation of cultural resources for listing in the NRHP under criteria in 36 CFR 60.4(a)–(d) and/or as traditional cultural properties is conducted as part of the site-specific review and NRC licensing procedures undertaken during the NEPA review process. The evaluation of impacts to any historic properties designated as traditional cultural properties and tribal consultations regarding cultural resources and traditional cultural properties also occur during the site-specific licensing application and review process. Consultation to determine whether significant cultural resources would be avoided or mitigated occurs during state SHPO, agency, and tribal consultations as part of the site-specific review. Additionally, as needed, the NRC license applicant would be required, under conditions in its NRC license, to adhere to procedures regarding the discovery of previously undocumented cultural resources during initial construction, operation, aquifer restoration, and decommissioning. These procedures typically require the licensee to stop work and to notify the appropriate federal and state agencies.

Licensees and applicants typically consult with the responsible state and tribal agencies to determine the appropriate measures to take (e.g., avoidance or mitigation) should new resources be discovered during land-disturbing activities at a specific ISL facility. NRC, licensees, and applicants may enter into memoranda of understanding with the responsible state and tribal agencies to ensure protection of historical and cultural resources, if encountered.

4.5.8.1 Construction Impacts to Historical and Cultural Resources

Most of the potential for significant adverse effects to NRHP-eligible, or potentially NRHP-eligible, historic properties and traditional cultural properties, both direct and indirect, would likely occur during land-disturbing activities related to building an ISL uranium recovery facility. Buried cultural features and deposits that are not visible on the surface during initial cultural resources inventories could be discovered during earth-moving activities.

Indirect impacts may also occur outside the ISL uranium recovery project site and related facilities and components. Visual intrusions, increased access to formerly remote or inaccessible resources, impacts to traditional cultural properties and culturally significant landscapes, such as Mt. Taylor, as well as other ethnographically significant cultural landscapes may adversely affect these resources. These significant cultural landscapes should be identified during literature and records searches and may require additional archival, ethnographic, or ethnohistorical research that encompasses areas well outside the area of direct impacts. Indirect impacts to some of these cultural resources may be unavoidable and exist throughout the lifecycle of an ISL uranium recovery project.

Because of the localized nature of land disturbing activities related to construction, impacts to cultural and historical resources are anticipated to be SMALL, unless the facility is located adjacent to a known resource. New Mexico historical sites and traditional cultural properties are described in Section 3.5.8. Proposed facilities or expansions adjacent to these properties and other tribal lands would be likely to have the greatest potential impacts, and mitigation measures (e.g., avoidance, recording and archiving samples) and additional consultations with affected Native American tribes would be needed to reduce the impacts. From the standpoint of cultural resources, the most significant impacts to any sites that are present would occur during the initial construction within the area of potential effect. Subsequent changes in the footprint of the project (i.e., expansion outside of the original area of potential effect) may also result in significant impact to any cultural resources that might be present.

4.5.8.2 Operation Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during operation of an ISL uranium recovery project. Potential impacts during operation would be expected to occur through new earth-disturbing activities, new construction, maintenance, and repair.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during operation. Overall impacts to cultural and historical resources during operations are expected to be less than those during construction, as operations are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.5.8.3 Aquifer Restoration Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the aquifer restoration phase of an ISL uranium recovery project. Potential impacts during aquifer restoration may occur through new earth-disturbing activities or other new construction that may be required for the restoration process. Such activities may have inadvertent impacts to historical and cultural resources and traditional cultural properties in or near the site of aquifer restoration activities located within the extended ISL project area.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during aquifer restoration are expected to be less than those during construction, as aquifer restoration activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites) and would be SMALL.

4.5.8.4 Decommissioning Impacts to Historical and Cultural Resources

Depending on the location, both direct and indirect adverse effects on NRHP-eligible properties, potentially NRHP-eligible historical properties, traditional cultural properties, and other cultural resources are possible during the decommissioning phase of an ISL uranium recovery project. Potential impacts can result from earth-disturbing activities that may be required for the decommissioning process. Inadvertent impacts to cultural resources and traditional cultural properties in or near the site of decommissioning activities may potentially occur.

Inadvertent impacts to historic and cultural resources located within the extended ISL permitted area and other cultural landscapes that are identified before construction are expected to continue during aquifer restoration. Overall impacts to cultural and historical resources during decommissioning are expected to be less than those during construction, as decommissioning activities are generally limited to previously disturbed areas (e.g., access roads, central processing facility, well sites). Because cultural resources within the existing area of potential effect are known, potential impacts can be avoided or lessened by redesign of decommissioning project activities. As a result, the overall impacts to historic and cultural resources from decommissioning would be expected to be SMALL.

4.5.9 Visual/Scenic Resources Impacts

4.5.9.1 Construction Impacts to Visual/Scenic Resources

During construction, most impacts to visual resources in the Northwestern New Mexico Uranium Milling Region would be similar to those in the Wyoming West Uranium Milling Region. Most visual and scenic impacts associated with drilling and other land-disturbing construction activities would be temporary. Roads and structures would be more long lasting, but would be removed and reclaimed after operations cease. As noted in Section 3.5.9, most of the areas in the affected environment of the Northwestern New Mexico Uranium Milling Region are identified as VRM Class II through Class IV according to the BLM classification system. In the Northwestern New Mexico Uranium Milling Region, a number of VRM Class II areas surrounding the national monuments (El Morro and El Malpais), the Chaco Culture National Historic Park, and the sensitive areas managed within the Mt. Taylor district of the Cibola National Forest would have the most potential for impacts to visual resources. Most of these areas, however, are located to the north, south, and east of the potential ISL facilities, at distances of 16 km [10 mi] or more. The facilities would be located in VRM Class III and IV areas. Current understanding indicates that several potential ISL facilities may be located near the Navajo Nation or near Mt. Taylor in the San Mateo Mountains. The general visual and scenic impacts associated with ISL facility construction are anticipated to be temporary and SMALL. However, from a Native American perspective, any construction activities are likely to result in adverse impacts to the landscape, particularly for facilities located in areas within view of tribal lands and areas of special significance such as Mt. Taylor.

4.5.9.2 Operation Impacts to Visual/Scenic Resources

Similar to the visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.2, the potential visual and scenic impacts from ISL operations in the Northwestern New Mexico Uranium Milling Region would be SMALL and the same as, or less than, those impacts associated with construction. For example, in a similar assessment for the Farmington Field Office area near Grants, New Mexico, BLM estimated that drilling associated with oil and gas lease development would minimally change the visual quality of the landscape (BLM, 2003). The greatest potential for visual impacts would be from new facilities developed in rural, previously undeveloped areas or within view of the sensitive regions described in Sections 3.5.9 and 4.5.9.1.

4.5.9.3 Aquifer Restoration Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.3, the potential visual and scenic impacts from ISL aquifer restoration operations in the Northwestern New Mexico Uranium Milling Region would be SMALL. Aquifer restoration would not occur until after the facility had been in operation for a number of years, and potential impacts would be the same as, or less than, during the operations period. Although overall impacts from aquifer restoration activities would be the same as, or less than, those for construction and operation, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Sections 3.5.9 and 4.5.9.1.

4.5.9.4 Decommissioning Impacts to Visual/Scenic Resources

Similar to the potential visual impacts described for the Wyoming West Uranium Milling Region discussed in Section 4.2.9.4, the potential visual and scenic impacts from decommissioning and reclaiming ISL facilities in the Northwestern New Mexico Uranium Milling Region would be SMALL. Decommissioning and reclamation activities would occur after the facility had been in operation for a number of years, and one of the purposes of the decommissioning process is to remove surface infrastructure and reclaim the area to preoperational conditions. This would result in less visual contour for the facility. Although overall impacts from decommissioning and reclamation activities would be the same as or less than those for construction and operation, the potential visual impacts would be greatest for facilities located in previously undeveloped areas or within view of the sensitive regions described in Sections 3.5.9 and 4.5.9.1.

4.5.10 Socioeconomic Impacts

Although a proposed facility size and production level can vary, the peak annual employment at an ISL facility can reach up to about 200 people, including construction workforce (Freeman and Stover, 1999; NRC, 1997; Energy Metals Corporation, U.S., 2007). Depending on the composition and size of the local workforce, overall socioeconomic impacts from ISL milling facilities for the Northwestern New Mexico Uranium Milling Region would range from SMALL to MODERATE.

Assuming the number of persons per household in New Mexico is about 3.6 (U.S. Census Bureau, 2008), the number of people associated with an ISL facility workforce could be as many as 720 (i.e., 200 workers times 3.6 persons/household). The demand for public services (schools, police, fire, emergency services) would be expected to increase with the construction and operation of an ISL facility. There may also be additional standby emergency services not available in some parts of the region. It may be necessary to develop contingency plans and/or additional training for specialized equipment. Infrastructure (streets, waste management, utilities) for the families of a workforce of this size would also be affected.

4.5.10.1 Construction Impacts to Socioeconomics

The majority of construction requirements would likely be filled by a skilled workforce from outside of the Northwestern New Mexico Uranium Milling Region. Assuming a peak workforce of 200, this influx of workers is expected to result in SMALL to MODERATE impact in the Northwestern New Mexico Uranium Milling Region. Impacts would be greatest for communities with small populations, such as Tohatchi (population 1,000) in McKinley County and Laguna (400) in Cibola County. However, due to the short duration of construction (12–18 months), workers would have only a limited effect on public services and community infrastructure. Further, construction workers are less likely to relocate their entire family to the region, thus minimizing impacts from an outside workforce. In addition, if the majority of the construction workforce is filled from within the region, impacts to population and demographics would be SMALL.

Construction impacts to regional income and the labor force for a single ISL facility in the Northwestern New Mexico Uranium Milling Region would likely be SMALL. In addition, even if multiple facilities be developed concurrently, the potential for impact upon the labor force would still be SMALL. For example, the town of Grants, Cibola County, has a labor force of 3,800. It would require two ISL facilities to be constructed simultaneously to affect the labor market of just the town of Grants by only 10 percent, if all the workers came from the town of Grants, alone. Construction of an ISL is likely, to the extent possible, to draw upon the labor force within the region before going outside the region (and state). The greatest economic benefit to the region would be to have the labor force drawn from within the region. However, economic benefit may still be achieved (in the form of the purchased of goods and services) even if the labor force is derived from outside the region. The potential impact upon smaller communities (Tohatchi and Laguna) could be MODERATE.

Impacts to housing from construction activities would be expected to be SMALL (and short term) even if the workforce is primarily filled from outside the region. It is likely that the majority of construction workers would use temporary housing such as apartments, hotels, or trailer camps. Many construction workers use personal trailers for housing on short-term projects. Impacts on the region’s housing market would therefore be considered SMALL. However, the impact upon specific facilities (apartment complexes, hotels, or campgrounds) could potentially be MODERATE if construction workers concentrated in one general area.

Assuming the majority of employment requirements for construction is filled by outside workers (a peak of 200), there would be SMALL to MODERATE impacts to employment structure. The use of an outside workforce would be expected to have MODERATE impacts to communities with high unemployment rates. If the majority of construction activities relies on the use of a local workforce, impacts would be anticipated to be SMALL to MODERATE depending upon the size of the local workforce. Communities such as the town of Grants and the Native American communities in the Indian Reservations (Acoma, Tohajiilee, Laguna, Navajo Nation, Ramah Navajo, and Zuni) would experience MODERATE impacts, due to their high unemployment rate and potential increase in employment opportunities.

Local finance would be affected by ISL construction through additional taxation and the purchase of goods and services. New Mexico has a personal income tax that ranges from 1.7 to 5.3 percent. In addition, it has a gross receipt sales tax. Construction workers are anticipated to contribute to these as they purchase goods and services within the region and within the state while working on an ISL facility. In addition, state tax revenues generated from mineral (non-oil and gas) production activities include state trust land mineral lease royalties, rentals and bonuses and severance, as well as resource excise and conservation tax revenues. In 2006, revenues from mineral production activities other than oil and gas generated about $37.3 million for New Mexico (New Mexico Energy, Minerals and Natural Resources Department, 2007). Although there are no active uranium production facilities in New Mexico, in 2006 almost 130 people were employed in permitting, care, maintenance, and reclamation activities associated with closing historic uranium operations (New Mexico Energy, Minerals and Natural Resources Department, 2007). It is anticipated that ISL facility development could have a MODERATE impact on local finances within the region.

Even if the majority of the workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to relocate their entire family for a relatively short duration (12–18 months). Impacts to education from a local workforce would also be SMALL, as this workforce is already established in the community.

Potential impacts from construction [from either the use of local or outside (nonregional) workforce] to local health services such as hospitals or emergency clinics would be SMALL. Accidents resulting from construction of an ISL facility are not expected to be different than those from other types of similar industrial facilities.

4.5.10.2 Operation Impacts to Socioeconomics

Operational requirements of an ISL necessitate the use of specialized workers, such as plant managers, technical professionals, and skilled tradesmen. While operational activities would be longer term (20–40 years) than construction (12–18 months), instead of up to 200 workers, an operating ISL generally requires a labor force of from 50 to 80 personnel. If the majority of operational requirements are filled by a workforce from outside the region, assuming a multiplier of about 0.7, there could be an influx of between 35 and 56 jobs (i.e., 50–80 $\times$ 0.7) per ISL facility (up to 200, including families). The potential impact to the local population and public services resulting from the influx of workers and their families would range from SMALL to MODERATE, depending upon the location (proximity to a population center) of an ISL within the region.

> **Economic Multipliers**
> The economic multiplier is used to summarize the total impact that can be expected from change in a given economic activity. It is the ratio of total change to initial change. The multiplier of 0.7 was used as a typical employment multiplier for the milling/mining industry (Economic Policy Institute, 2003).

However, because an outside workforce would be more likely to settle into a more populated area with increased access to housing, schools, services, and other amenities, these impacts may be reduced. If the majority of labor is of local origin, potential impacts to population and public services would be expected to be SMALL, as the workers would already be established in the region.

It is assumed, however, that because of the highly technical nature of ISL operation (requiring professionals in the areas of health physics, chemistry, laboratory analysis, geology and hydrogeology, and engineering), the majority (approximately 70 percent) of the work force (35 to 56 personnel) would be staffed from outside the region for at least the initial ISL facility. Subsequent ISL facilities may draw personnel from established or decommissioned facilities. This is expected to have a SMALL impact upon the regional labor force.

If it is assumed that as many as 56 families (80 workers × 0.7) are required to relocate into the Northwestern New Mexico Uranium Milling Region, the most likely available housing markets would be located in the larger communities, such as Gallup and Grants (within the region) and Albuquerque (located outside the region). Unless the workforce is distributed throughout the region, the impact of an ISL on the housing market would be MODERATE, depending upon location, due to the limited number of available units.

Impacts to income and the labor force structure within the Northwestern New Mexico Uranium Milling Region would be similar to construction impacts, but longer in duration. Impacts from ISL operation would be SMALL to MODERATE, depending on where the majority of the workforce settles.

Assuming a local workforce is used, there would be SMALL impacts to the local employment structure, and these would be similar to construction impacts. If the entire labor force for the ISL facility came from outside the affected community, the workforce would have a SMALL to MODERATE impact relative to the employment structure for most of the affected counties. Impacts from inflow of an outside workforce would be similar to construction impacts.

Assuming the majority of the workforce is derived from outside the Northwestern New Mexico Uranium Milling Region, potential impacts to education from operation activities would be SMALL. Even though the number of people associated with an ISL facility workforce could be as many as 200 (including families), there would be about 90 school-aged children involved. There are five school districts in the region. If all of the ISL workers' children were to enroll in the Grants school district (the region's smallest, with only 2,414 pupils), there would only be a 4 percent increase in the student population.

Effects on other community services (e.g., health care, utilities, shopping, recreation) during operation are anticipated to be similar to construction (less in volume/quantity, but longer in duration). Therefore, the potential impacts would be SMALL.

4.5.10.3 Aquifer Restoration Impacts to Socioeconomics

The same ISL facility components and workforce would be involved in aquifer restoration as during operations use. Thus, the number of personnel involved would also be the same, and the potential impacts would be similar. These potential impacts would extend beyond the life of the facility (typically 2–10 years), but still would be SMALL.

Income and labor force requirements during aquifer restoration are anticipated to be the same as during operations (technical requirements are similar), and therefore potential impacts would be SMALL.

The employment structure during aquifer restoration would be expected to be unchanged and continue after the operational phase. However, a smaller number of specialized workers may be required to return the site to preISL levels. The potential impacts to the region would be considered SMALL.

Impacts to housing, education, health, and social services during aquifer restoration would also be expected to be the similar to operations, but continue beyond the life of the site. The overall potential impacts would be SMALL.

4.5.10.4 Decommissioning Impacts to Socioeconomics

Decommissioning is essentially deconstruction and is expected to require a similar work force (up to 200 personnel) with similar skills as the construction phase. The impacts to affected communities in the Northwestern New Mexico Uranium Milling Region during decommissioning would therefore be similar to the construction phase. The decommissioning phase may last up to a year longer than the construction phase, depending upon the condition of the ISL at termination. However, the overall potential impacts are still expected to be SMALL to MODERATE.

The income levels and labor force requirements during decommissioning are also anticipated to be similar to the construction phase, and the potential impacts to the region would therefore be considered SMALL to MODERATE.

The employment structure during decommissioning would be similar to the construction phase; however, a reduction of the workforce would result toward the end of the decommissioning phase. Impacts to employment would be SMALL to MODERATE.

Potential impacts to housing during the decommissioning phase would be similar to the construction phase and would be SMALL for the larger communities within the region, but may be MODERATE if the temporary housing was concentrated in a smaller community.

Decommissioning would be expected to involve similar numbers (up to 200) of workers (likely without families because of the short-duration of the activity) as construction. Therefore, the anticipated impacts to the local education system would be SMALL.

Impacts to community services (health care, entertainment, shopping, recreation) would also be similar to construction, and thus would be considered SMALL.

4.5.11 Public and Occupational Health and Safety Impacts

4.5.11.1 Construction Impacts to Public and Occupational Health and Safety

Construction impacts to public and occupational health and safety for the Northwestern New Mexico Uranium Milling Region would be similar to those discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.1.

4.5.11.2 Operation Impacts to Public and Occupational Health and Safety

4.5.11.2.1 Radiological Impacts to Public and Occupational Health and Safety From Normal Operations

Estimated doses to members of the public are reported for a variety of commercial-scale and satellite facilities in Section 4.2.11.2.1. These doses are well below the 10 CFR Part 20 public dose limit of 1 mSv/yr [100 mrem/yr] and the 40 CFR Part 190 annual limit of 0.25 mSv [25 mrem]. Doses at other locations could be higher or lower depending on a variety of factors including receptor location, topography, and weather conditions. When releases occur from the ground level, doses decrease the farther the receptor is from the release location because the radioactive material is diluted as the wind mixes it. The amount of dilution, which is referred to as dispersion, is determined by the weather (meteorological conditions). For areas in which meteorological conditions are more stable (less turbulent), a higher dose could occur. As the radioactive material travels via the wind, changes in topography can affect the dose received by the receptor. Doses for the various ISL facilities shown in Table 4.2-2 are at least a factor of three below the regulatory limit, and most are much less than that. Doses at operating ISL facilities in different regions are not likely to exceed regulatory limits, and overall impacts to public and occupational health and safety would be SMALL.

4.5.11.2.2 Radiological Impacts to Public and Occupational Health and Safety From Accidents

The consequences of potential accidents are expected to be similar regardless of an ISL facility's location and are described in Section 4.2.11.2.2. Distance to the nearest receptor, topography, and meteorological data account for potential differences in resulting dose. For facilities in which the maximally exposed offsite individual would be closer, there would be higher doses for ground-level releases. Changes in topography could also have an impact on the resulting dose because this would allow the receptor to be closer to, or farther away from, the radioactive material as it travels by wind. Meteorological conditions vary based on location and could result in a higher or lower dose. The consequences resulting from a potential unmitigated accident would have a SMALL effect on the general public and, at most, a MODERATE effect on the workers.

4.5.11.2.3 Nonradiological Impacts to Public and Occupational Health and Safety From Normal Operations

While hazardous chemicals are used at ISL facilities (Section 2.4.2), SMALL risks would be expected in the use and handling of these chemicals during normal operations. However, accidental releases of these hazardous chemicals can produce significant consequences and impact public and occupational health and safety. An analysis of such hazards and potential risks for impacts is provided in the following section.

4.5.11.2.4 Nonradiological Impacts to Public and Occupational Health and Safety From Accidents

Nonradiological impacts to public and occupational health and safety for the Northwestern New Mexico Uranium Milling Region are expected to be similar to impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.11.2.4. Compliance with applicable 10 CFR Part 20, EPA, and Occupational Safety and Health Administration requirements would safe handling of radiological and hazardous materials. The likelihood of accidental releases would be reduced, and the impacts would be SMALL.

4.5.11.3 Aquifer Restoration Impacts to Public and Occupational Health and Safety

Aquifer restoration impacts on public and occupational health and safety would be similar to operational impacts discussed in Section 4.5.11.2.

4.5.11.4 Decommissioning Impacts to Public and Occupational Health and Safety

During ISL facility decommissioning, hazards are removed or reduced, surface soils and structures are decontaminated, and disturbed lands are reclaimed. As a result of these activities, some SMALL impacts could potentially occur.

To ensure the safety of workers and the public during decommissioning, the NRC requires licensed facilities to submit a decommissioning plan for review (Section 2.6). Such a plan includes details of how a 10 CFR Part 20 compliant radiation safety program would be implemented during decommissioning to ensure safety of workers and the public is maintained and applicable safety regulations are complied with. A combination of (1) NRC review and approval of these plans, (2) the application of site-specific license conditions where necessary, and (3) regular NRC inspection and enforcement activities to ensure compliance with radiation safety requirements constrain the magnitude of potential public and occupational health impacts from ISL facility decommissioning actions to acceptable (SMALL) levels.

4.5.12 Waste Management Impacts

Waste management impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another.

4.5.12.1 Construction Impacts to Waste Management

The relatively small scale of construction activities (Section 2.3) and incremental development of well fields at ISL facilities generate low volumes of construction waste. Table 2.7-1, which includes a listing of engine-driven construction equipment needed for construction of a satellite ISL facility provides insights into the magnitude of well field construction activities. As a result of the limited volumes of construction waste that would be generated by ISL facility construction, waste management impacts from construction would be SMALL.

4.5.12.2 Operation Impacts to Waste Management

Operation waste management impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.2 because the waste volumes, management practices, waste management safety and environmental concerns, waste management permitting and regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. Operational waste management impacts would be SMALL, based on the required preoperational disposal agreement for byproduct material; regulatory controls including applicable permitting, license conditions, and inspection practices; and typical facility design specifications and management practices including waste treatment and volume reduction techniques, pond leak detection, and other routine monitoring activities.

4.5.12.3 Aquifer Restoration Impacts to Waste Management

Waste management activities during aquifer restoration utilize the same treatment and disposal options implemented for operations; therefore, impacts associated with aquifer restoration would be similar to the operational impacts discussed in Section 4.5.12.2. Additional wastewater volume and the associated volume of water treatment wastes may be generated during aquifer restoration; however, this would be offset to some degree by the reduction in production capacity from the removal of a well field from production activities. While the amount of wastewater generated during aquifer restoration is dependent on site-specific conditions, Section 2.5.2 provides an illustrative estimate of water volume per pore volume and Section 2.11.5 provides experience regarding the number of pore volumes required for aquifer restoration in past efforts. Furthermore, the NRC review of future ISL facility licensing would verify that sufficient water treatment and disposal capacity (and the associated agreement for disposal of byproduct material discussed in Section 4.2.12) are addressed. As a result, waste management impacts from aquifer restoration would be SMALL.

4.5.12.4 Decommissioning Impacts to Waste Management

Decommissioning waste management impacts for the Northwestern New Mexico Uranium Milling Region are expected to be similar to the impacts discussed for the Wyoming West Uranium Milling Region in Section 4.2.12.4 because the waste volumes and management practices, waste management safety and environmental concerns, waste management regulations, and relevant aspects of the NRC licensing are not expected to change significantly (either in practice or effectiveness) with facility location from one region to another. The required preoperational agreement for disposal of byproduct material, NRC review and approval of a decommissioning plan and radiation safety program, and the small volume of solid waste generated for offsite disposal suggest the waste management impacts would be SMALL. Related transportation impacts are discussed separately in Section 4.5.2.

4.5.13 References

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