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, but also with 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 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 are to another, and 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, that 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 above 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 operation 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 be 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 traveling roads with the lowest levels of current traffic. 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, depending on the proximity of residences, other regularly occupied structures, or grazing areas to ISL facility access roads. 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 described for construction and operations because transportation activities will be primarily limited to supplies (including chemicals), chemical waste shipments, on site 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) by-product wastes (as defined in the Atomic Energy Act) would 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 top soil 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. Generally, earth-moving activities would result in only SMALL (approximately. 10 percent of entire site) and temporary (several months) disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Section 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.

Construction activities at ISL facilities in the Nebraska-South Dakota-Wyoming 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. Operators of ISL facilities typically adopt construction practices that prevent or substantially reduce erosion. 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.

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 6 feet below the ground to avoid any potential freezing problem. 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 they are typically backfilled with the excavated material 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 Nebraska-South Dakota-Wyoming Milling Region would be SMALL because of the limited time of the activity (months), the limited affected area (less than 10 percent of site), and the shallow depth of excavation (4-6 feet).

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 from the target sandstones during ISL operations would result in a permanent change to the composition of uranium-bearing 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 hundreds of feet (Section 3.4.3) and, therefore, impacts to geology from ground subsidence would 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, this change in pressure is not expected to be significant enough to reactivate local faults and it is expected to be extremely unlikely that any earthquakes would be generated. Based on historical ISL operations in the Nebraska-South Dakota-Wyoming Milling Region, reactivation of faults has not been observed.

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) run off 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., Se 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 expected 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 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 non-radiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of non-radiological 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.

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, 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 currently inspects the embankments regularly 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 waste water 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. 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, which typically regulate land application of wastewater, may impose release limits on non-radiological constituents. 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 re-injection 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 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 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 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 currently inspects the embankments regularly as part of the federal Dam Safety program.

As with ISL operations, land application of treated waste water during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated waste water 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, which typically regulate land application of wastewater, may impose release limits on non-radiological constituents. 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 more than in most portions of the Wyoming West Uranium Milling Region, the potential for surface water impacts is slightly greater in the Nebraska-South Dakota-Wyoming Uranium Milling Region (U.S. Geological Survey, 2008). 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 Operational 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 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 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 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 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 are 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 ground water 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 mechanical integrity testing (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., Se 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 waste water 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 re-injected. 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 waste water control program and is not re-injected 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 per hectare [1.18 acre-ft/acre]. Similarly, the average irrigation rate (for irrigated land) in Nebraska is 3.84 million L per hectare [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 one 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 one year.

Consumptive water use during operations could impact local water users who use water from the production aquifer (outside of the exempted zone) by lowering water levels in local wells. 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 pre-operations 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 m [8.5 ft], 2.0 m [6.6 ft], and 1.5 m [4.9 ft] at locations 1 m [3.3 ft], 10 m [33 ft], and 100 m [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 m [61 ft], 14 m [47 ft], and 10 m [33 ft] at locations 1 m [3.3 ft], 10 m [33 ft], and 100 m [330 ft] away from a hypothetical pumping well representing the withdrawals from an entire ISL facility.

In the calculations above, 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 pre-operational class-of-use conditions, if possible. If the aquifer cannot be returned to pre-operational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in Table 5C of 10 CFR 40 Appendix A or to and Alternate Concentration Limit (ACL) 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 towards 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 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 groundwater level (piezometric head) differences between the adjacent aquifers and the thickness and vertical hydraulic conductivity of aquitards that hydraulically separate them (McWhorter and Sunada, 1977; Driscoll, 1986).

In the South Dakota section of the Nebraska-South Dakota-Wyoming Uranium Milling Region, for example, for a vertical hydraulic gradient 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, for a vertical hydraulic gradient 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 are 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 Sandstone 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 pre-operational 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 U.S. 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 Crown Butte Uranium Project area (NRC, 1998). Additional information would be needed to determine whether a deep aquifer with low water yields and poor water quality exists below the Pierre Shale that may be suitable for injection of leaching solutions.

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 waste water, and potential deep disposal of brine slurries resulting from reverse osmosis. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the wellfield 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 re-injected 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 re-injection. In that case, the actual amount of water that is re-injected 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 re-injected during groundwater sweep. Water is not re-injected 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 wellfields 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 re-injection 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 wellfields, 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 per hectare [1.18 acre-ft/acre]. Similarly, the average irrigation rate (for irrigated land) in Nebraska is 3.84 million L per hectare [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 one 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 the U.S. EPA or authorized State and approval from the 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, 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 wellfields, re-injecting treated water, and re-circulating groundwater. In general, aquifer restoration is continued until NRC and applicable state requirements for groundwater quality are met. As discussed in Section 4.3.4.2.2.2, NRC licensees are required to restore the production aquifer to baseline or pre-operational class-of-use conditions, if possible. If the aquifer cannot be returned to pre-operational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in Table 5C of 10 CFR 40 Appendix A or to Alternate Concentration Limits (ACL) approved by the NRC. 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, re-vegetation, and reclaiming 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 of below plough 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, 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 re-vegetated 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 well-fields 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 were to be located within these ranges, guidelines have been issued by the Wyoming Game and Fish Department (2006) 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 theses 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 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 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
- Western Prairie Fringed Orchid
- Whooping Crane

4.4.5.2 Operation Impacts to Ecological Resources

Because much less land disturbance would be anticipated during 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 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 non-radiological 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 is limited to modifying, supplementing, or summarizing the Wyoming West Uranium Milling Region analyses that is presented in Section 4.2.6, as appropriate.

In general, ISL milling facilities are not major non-radiological 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 (PSD) 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, but if the air quality region of influence for a potential ISL facility includes this Class I area, then the more stringent Class I allowable increments would apply.

4.4.6.1 Construction Impacts to Air Quality

Non-radiological 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 $\mu g/m^3$ [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 two percent of the federal $PM_{2.5}$ ambient air standard, under one percent of the previous federal and current Nebraska and Wyoming PM_{10} ambient air standards, seven percent of the Class I Prevention of Significant Deterioration allowable increment, and under two 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 one percent of both the federal and more restrictive Wyoming ambient air standards, nine percent of the Class I Prevention of Significant Deterioration allowable increment, and under one 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 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 PSD 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, non-radiological 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, non-radiological emissions from yellowcake drying would be SMALL.

Other potential operation phase non-radiological air quality impacts include fugitive dust and vehicle emissions from many of the same sources identified for the construction phase. 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. 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 PSD 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 non-radiological 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. 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 non-radiological 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 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.

4.4.7.3 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 of this GEIS. 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 ethno-historical 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 of this GEIS. 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, that is, 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, 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 less 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, 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, 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). Impacts to previously known historical, cultural, archaeological and traditional cultural properties documented during the initial inventory during decommissioning can result from earth-disturbing activities that may be required for the decommissioning process. Because cultural resources within the existing area of potential effect are known, potential impacts can be avoided or lessened by redesign of decommissioning project.

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 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 pre-operational 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 range up to about 200 people, including construction (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 US, 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 be 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 (pop. 1,350), Niobrara County, Wyoming, and the towns of Osage, Wyoming (pop. 200) and Hill City, South Dakota (pop. 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 Wyoming West 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. 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-termed) 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 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 rely 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 $ 17 million from this tax (WY Dept. of Revenue). Sources of Revenue for the State of Nebraska come from the income, sales, cigarette, motor, and lodging taxes. Personal income taxes rates for Nebraska range from 2.56 percent to 6.84 percent. The sales and use tax rates 5.5 percent. Information on "ad valorem (or mineral) taxes" from the extraction of uranium are 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 workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to re-locate 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 [non-regional] 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.

4.4.10.2 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 (see text box), there could be an influx of between 35 and 56 jobs (i.e., 50-80 x 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.

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).

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 x 0.7 economic multiplier) 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 would be 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 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 much 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 (Sec 3.4.10.6). Even if all the ISL worker's 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 (health care, utilities, shopping, recreation, etc.) 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 pre-ISL 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 continues 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 Recovery 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 workforce would result towards 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 to be 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. As shown, these doses are well below the public dose limit of 1 mSv/yr [100 mrem/yr]. 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 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 since 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 Non-radiological 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.

4.4.11.2.4 Non-radiological Impacts to Public and Occupational Health and Safety From Accidents

Non-radiological 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, providing 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

Operations 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 pre-operational 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 waste water 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 waste water 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 pre-operational 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, would be temporary 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 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 within the permitted site, and 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, that 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 traveling roads with the lowest levels of current traffic. Low-trafficked roads may also be more susceptible to wear and tear from increased traffic. Localized intermittent and short-term SMALL to MODERATE impacts associated with noise, dust, and incidental livestock or wildlife kills are possible, depending on the proximity of residences, or other regularly occupied structures, to ISL facility access roads. 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 are 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 described for construction and operations because transportation activities would be primarily limited to supplies (including chemicals for reverse osmosis), chemical waste shipments, on site 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) by-product wastes (as defined in the Atomic Energy Act) would 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 top soil 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. Generally, earth-moving activities will result in only SMALL (approximately 10 percent of the permitted site) and temporary (several months) disturbance of soils—impacts that are commonly mitigated using accepted best management practices (see Section 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.

Construction activities at ISL facilities in the Northwestern New Mexico Uranium Milling Region would 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. Operators of ISL facilities typically adopt construction practices that prevent or substantially reduce erosion. 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, areas where topsoil was temporarily removed would be replaced and re-vegetated once construction was completed (NRC, 1997).

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 6 feet below the ground to avoid any potential freezing problem. 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 they are backfilled with the excavated material 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 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 from the target sandstones during ISL operations would result in a permanent change to the composition of uranium-bearing rock 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 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). 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, this change in pressure is not expected to be significant enough to reactivate local faults and it is expected to be extremely unlikely that any earthquakes would be generated. Based on historical ISL operations in the Northwestern New Mexico Uranium Milling Region, reactivation of faults has not been observed.

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) run off 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. Licensees are expected 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 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 non-radiological chemicals stored at the processing facility, spill responses would be similar to those described for yellowcake transportation, although the spill of non-radiological 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.

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, 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 currently inspects the embankments regularly 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 waste water 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. 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, which typically regulate land application of wastewater, may impose release limits on non-radiological constituents. The licensee uses its environmental monitoring program (see Chapter 8) to identify soil impacts caused by land application of treated process water. Monitoring would 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 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 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 currently inspects the embankments regularly as part of the federal Dam Safety program.

As with ISL operations, land application of treated waste water during aquifer restoration could potentially impact soils (Sections 2.7.2, 4.2.12.2). For example, the salinity of the treated waste water 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, which typically regulate land application of wastewater, may impose release limits on non-radiological constituents. 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 western 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 are 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 ground water 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 western 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 mechanical integrity testing (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 waste water could cause radiological or other constituents (e.g., Se 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 waste water 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 re-injected. 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 waste water control program and is not re-injected 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 per hectare [3.22 acre-ft/acre]. Thus, the consumptive use of 240 million L [190 acre-ft] of water due to production bleed in one year of operation is roughly equivalent to the water used to irrigate 24 ha [59 acres] in New Mexico for one year.

Consumptive water use during operations could impact local water users who use water from the production aquifer (outside of the exempted zone) by lowering water levels in local wells. 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 pre-operations 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 m [3.3 ft], 10 m [33 ft], and 100 m [330 ft]away from a pumping well (representing the well field) would be 3.5 m [11 ft], 2.8 m [9.2 ft], and 2.1 m [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 the calculations above, 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 pre-operational class-of-use conditions, if possible. IF the aquifer cannot be returned to pre-operational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in Table 5C of 0CFR 40 Appendix A or to Alternate Concentration Limits (ACL) 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 towards 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 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 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 groundwater level (piezometric head) differences between the adjacent aquifers and the thickness and vertical hydraulic conductivity of an aquitard that hydraulically separates them (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 are 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 mechanical integrity testing 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 pre-operational 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 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 Sandstone 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 wellfield 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 re-injected 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 re-injection. In that case, the actual amount of water that is re-injected 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 re-injected during groundwater sweep. Water is not re-injected 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 wellfields 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 re-injection 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 wellfields, 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 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 per hectare [3.22 acre-ft/acre]. Thus, consumption of 280 million L [74 million gal or 230 acre-ft] in one year of restoration would be roughly equivalent to the water used to irrigate 29 ha [72 acres] in New Mexico for one 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 authorized State and approval from the 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, 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 wellfields, re-injecting treated water, and re-circulating groundwater. In general, aquifer restoration is continued until NRC and applicable state requirements for groundwater quality are met. As discussed in Section 4.3.4.2.2.2, NRC licensees are required to restore the production aquifer to baseline or pre-operational class-of-use conditions, if possible. If the aquifer cannot be returned to pre-operational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in Table 5C of 10 CFR 40 Appendix A or to Alternate Concentration Limits (ACL) approved by the NRC. 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, re-vegetation, and reclaiming 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 of below plough 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 [170 ac] to 6,480 ha [16,000 ac] (Section 2.10.1). Typically, the amount of land disturbance within these permitted areas range from 49 ha to 485 ha [120 ac to 1,200 ac]. The percent of vegetation removed (disturbed land) ranges from a low of 1 percent to as much as 20 percent, but is typically less than 10 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 re-vegetation 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 right-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 re-colonize the temporary construction right-of-way and staging areas, they would re-colonize 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 of the amount of surrounding wooded area.

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

Even if available habitat exists within the site and adjacent areas to support displaced individuals some impact from competition for resources between pre-existing 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 were to be located within these ranges, guidelines have been issued by the New Mexico Department of Game and Fish. 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 Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996 (Avian Power Line Interaction Committee,1996). Raptors breeding in the site may be impacted by construction activities or mining operations may be temporarily impacted depending on the time of year construction activities occur.

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), 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 woody vegetation from designated habitat.

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

- Impacts to the South Western Willow Fly Catcher would occur if the removal of patchy to dense riparian habitats along streams, reservoirs, or other wetlands. Vegetative buffers and avoidance of areas 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 specie as a result of the facility construction if this specie 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 or not followed during construction if the listed water way occurs with in the facility's boundaries.

- Yellow Billed Cuckoo—(candidate) Habitat is described in Section 3.2.5.3 of the Wyoming West Uranium Milling Region

- Surveys conducted in the 1990 determined the distribution of Zuni bluehead (candidate) sucker in New Mexico to be limited mainly to the Río Nutria drainage upstream of the mouth of the 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 re-vegetation 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 on site personnel. Generally these are SMALL impacts that would not generally effect 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 which 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 and 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 head and leaks from pipeline that would be handled using best management practices (NRC, 2007). Leak detection systems, 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 exist for conflict 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 from decommissioning would, in part, be similar to those discussed it the construction of the facility, and would be short-termed. The removal of piping would impact vegetation that has re-established itself, and wildlife could come in conflict with heavy equipment. During decommissioning, reclamation activities would re-vegetate previously disturbed vegetative areas and restore streams and drainages to their pre-construction contours. It is expected that temporally displaced wildlife would return to the area.

4.5.6 Air Quality Impacts

For the Northwestern New Mexico Uranium Milling Region, potential non-radiological 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 is presented in Section 4.2.6.

In general, ISL milling facilities are not major non-radiological 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 National Ambient Air Quality Standards

- 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 National Ambient Air Quality Standards (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 from the Northwestern New Mexico uranium milling region border, however, the 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, non-radiological 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, non-radiological emissions from yellowcake drying would be SMALL.

Other potential operation phase non-radiological 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. 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 non-radiological 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 uses equipment that generates gaseous emissions. These emissions would be limited in duration and result in SMAL, short-term effects. 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 non-radiological 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 were 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 Sections 3.5.8 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 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, that is, 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, 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, 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, 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). Impacts to previously known historical, cultural, archaeological and traditional cultural properties documented during the initial inventory during decommissioning can result from earth-disturbing activities that may be required for the decommissioning process. 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.

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 Visual Resource Management 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 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 pre-operational 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 range up to about 200 people, including construction (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 be 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 (pop. 1,000) in McKinley County, and Laguna (pop. 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-termed) 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 outside workforce would be expected to have MODERATE impacts to communities with high unemployment rates. If the majority of construction activities rely 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 – 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, and more significant, is the 'ad valorem production tax' and the 'ad valorem production equipment tax.' In 2000 for minerals other than oil and gas the state collected $ 8.9 million from this tax (New Mexico Taxation and Revenue Department). It is anticipated that ISL facility development could have a MODERATE impact on local finances within the region.

Even if the majority of workforce is filled from outside, impacts to education from construction activities would be SMALL. This is because construction workers are less likely to re-locate 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 [non-regional] 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.

4.5.10.2 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 are 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 x 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. However, because an outside workforce would be more likely to settle into a 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.

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).

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 x 0.7 economic multiplier) 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 would be 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 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 much 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 worker's 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 (health care, utilities, shopping, recreation, etc.) 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 pre-ISL 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 continues 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 Northwestern New Mexico Uranium Recovery 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 workforce would result towards 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 to be 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. As shown, these doses are well below the public dose limit of 1 mSv/yr [100 mrem/yr]. 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 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 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 since 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 affect on the workers.

4.5.11.2.3 Non-radiological 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.

4.5.11.2.4 Non-radiological Impacts to Public and Occupational Health and Safety From Accidents

Non-radiological 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

Operations 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 pre-operational 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 waste water 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 waste water 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 pre-operational 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.

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10. SUPPLEMENTARY NOTES

11. ABSTRACT *(200 words or less)*

This Draft Generic Environmental Impact Statement (Draft GEIS) was prepared in compliance with the National Environmental Policy Act (NEPA) of 1969 and NRC regulations for implementing NEPA found at Title 10, "Energy," of the U.S. Code of Federal Regulations (CFR) Part 51 (10 CFR Part 51). This Draft GEIS evaluates on a programmatic basis, the potential environmental impacts associated with the construction, operation, ground water restoration, and decommissioning of uranium milling facilities employing the in-situ leach (ISL) process.

In the ISL process, a leaching agent, such as oxygen with sodium bicarbonate, is added to native ground water for injection through wells into the subsurface ore body to dissolve the uranium. The leach solution, containing the dissolved uranium, is pumped back to the surface and sent to the processing plant, where ion exchange is used to separate the uranium from the solution. The underground leaching of the uranium also frees other metals and minerals from the host rock. Operators of ISL facilities are required to restore the ground water affected by the leaching operations. The milling process concentrates the recovered uranium into the product known as "yellowcake" (U_3O_8). This yellowcake is then shipped to uranium conversion facilities for further processing in the overall uranium fuel cycle.

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