3.5.3 Groundwater

As indicated in the GEIS (Section 3.2.4.3.2), the Crooks Gap Uranium District is underlain, from shallowest to deepest, by sedimentary deposits and sandstone layers (Quaternery aged), the Green River Formation, the Wasatch/Battle Spring Formation, the Fort Union Formation, and the Lance/Fox Hills Formation. This hydrogeologic sequence is separated from the underlying Mesaverde Formation by regionally continuous and impermeable Lewis Shale aquitard. All of these formations contain sandstone aquifers. The Green River is not present in the project area and Quaternary deposits, where present, lie directly on the Wasatch/Battle Spring Formation. Due to its impermeable nature, the Lewis Shale is considered the base of the hydrogeologic sequence of interest within the Great Divide Basin. Units deeper than the Lewis Shale, the top of which is 4,771 m (14,000 ft) bgs in the project area, are generally too deep to economically develop for water supply or have elevated TDS concentration that renders them unusable for human consumption.

The Fox Hills Formation, which directly overlies the Lewis Shale and is of Cretaceous Age, consists of very fine-grained sandstone, siltstone, and coal beds. It is not considered to be an important aquifer in the project area. The overlying Wasatch/Battle Spring Formation, the Fort Union Formation, and the Lance Formation are all of Tertiary age and are considered part of the Tertiary aquifer system. The Tertiary aquifer system is identified as "the most important and most extensively distributed and accessible groundwater source in the study area" (Collentine et al., 1981).

As previously discussed in Section 3.4.1 of this EA, the Battle Spring Formation outcrops in the study area and represents the most superficial deposits in the area except for limited Quaternary deposits within surface drainages. The sandstone beds within the Battle Spring Formation comprise the shallowest aquifers within the project area. Within the project area, the Battle Spring/Wasatch Formations are over 1,890 m (6,200 ft) thick. There are commonly multiple water-bearing sands within the Battle Spring/Wasatch Formation. Due to their higher permeability, these water bearing sands provide the primary sources for groundwater withdrawal within the area. Groundwater within the Battle Spring aquifers is typically under confined conditions, although locally unconfined conditions may exist. Regionally, the potentiometric surface within the Battle Spring aquifers is usually within 61 m (200 ft) of the ground surface. Most wells drilled for water supply in this unit are less than 305 m (1,000 ft) deep. The Great Divide Basin, in which the project area is located, is topographically closed with all surface water drainage being to the interior of the basin. Correspondingly, groundwater flow in the Tertiary aquifers of the Great Divide Basin is generally toward the center of the basin. In the Lost Creek project area groundwater flow is generally to the southwest toward the center of the basin.

As discussed in Section 3.4.1, the top 213 m (700 ft) of the Battle Spring Formation has divided by the applicant into at least five horizons marked from top to bottom as BC, DE, FG, HJ, and KM. The primary uranium production zone for the Lost Creek project area is identified as the HJ Horizon. The HJ Horizon is subdivided into the Upper (UHJ), Middle (MHJ) and Lower (LHJ) Sands. The HJ Horizon is bounded above and below by aerially extensive confining units identified as the Lost Creek Shale and the Sage Brush Shale, respectively. The shallowest occurrence of groundwater within the project area occurs within the DE Horizon, which is above the FG Horizon.

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The bulk of the uranium mineralization is present in the MHJ Sand. The total thickness of the HJ Horizon ranges from 30 to 49 m (100 to 160 ft), averaging approximately 36.5 m (120 ft; see Figure 3-6). The top of the HJ Horizon ranges from approximately 91 to 137 m (300 to 450 ft) bgs within the project area. The three sands are generally separated by thin clayey units that are not laterally extensive, and based on pumping test results do not act as confining units to prevent groundwater movement vertically between the HJ Sands. The underlying aquifer to the HJ Horizon, separated by the SB Shale, is the UKM Sand, which is also a potential uranium production zone.

INSERT FIGURE 3-6

3.5.3.1 Uranium Bearing Aquifers

The applicant has described the HJ Horizon as the primary proposed production aquifer. As discussed in Section 3.4.1, the HJ Horizon has been divided into upper, middle and lower sub-units of these sandstones (UHJ Sand, MHJ Sand, and LHJ Sand). These three sand units are generally separated by thin clayey units that are not laterally extensive and, based on pumping test results, do not act as confining units to prevent groundwater movement vertically between the HJ Sands (LCI, 2008a). The applicant considers the combined HJ Sands as a single aquifer and has designated these aquifers as the production zone aquifer. The HJ Sands are separated from the overlying FG Horizon by the Lost Creek Shale and the underlying KM Sand by the Sage Brush Shale. The LFG sand has be designated by the applicant as the aquifer overlying the production zone, and the UKM sand has been designated as the aquifer underlying the production zone.

Monitoring wells have been completed in HJ Horizon, the overlying aquifers (DE and LFG) and the underlying aquifer (UKM). Water levels have been measured in these wells to assess the potentiometric surface, groundwater flow direction, and hydraulic gradient of these units. Water level data is available from 2006 and 2007 monitoring events as well as from historical data taken in 1982. Based on 2007 data taken from wells screened in the HJ Horizon approximately 30.5 m (100 ft) apart on each side on the Fault, the potentiometric surface on the north side of the Fault is 4.6 m (15 ft) higher than on the south side of the Fault. The difference between water levels on either side of the Fault suggests that the Fault is a barrier to groundwater flow. Pumping tests conducted on site seem to support this view. However, some hydraulic influence was noted across the Fault during these tests, indicating that while the Fault acts as a barrier to flow, it does not act as an impermeable barrier. Based on the potentiometric maps, groundwater is inferred to flow to the west-southwest, generally consistent with the regional flow system. The Fault may direct groundwater in a more westward direction than if the Fault were not present.

The horizon hydraulic gradient for the HJ Sand, determined from water level data from 1982, 2006, and 2007, ranged from 0.0034 to 0.0056. The potentiometric surfaces developed from water level data for the LFG Sand are similar to those developed for the HJ Horizon. However, the data for the UKM Sand indicate that the difference in hydraulic heads across the Fault does not appear as pronounced for the UKM sand as for the other shallow sands. However, this observation may be influenced the limited number of monitoring wells in the UKM Sand. Horizontal hydraulic gradients calculated for the UKM Sand from available water level data ranged from 0.0053 to 0.0063. The available water level data were also used to evaluate vertical gradients. The data indicate that vertical gradients range from 0.05 to 0.34 between the LFG, HJ, and UKM aquifers and consistently indicate decreasing hydraulic head with depth.

3.5.3.1.1 Hydrogeologic characteristics

Aquifer properties for the Battle Spring aquifers within the project area have been estimated from historic and recent pumping tests. Hydro-Search Inc. performed a hydrologic evaluation in 1982 to determine the feasibility of in situ production of the Conoco uranium orebody at Lost Creek. More recently in October 2006, several short term single well pumping tests and three longer multi-well pumping tests were performed (Hydro-Engineering, Inc., 2007). The range of transmissivity values for the HJ aquifer calculated from the data collected during the 2006 tests was from 4.1 to 37.2 m^2/day (44 to 400 ft^2/day [330 to 3,000 gallons per day/ft]). Although the 2006 testing was limited, none of the 2006 pumping tests of the HJ horizon indicates significant communication with the overlying or underlying aquifers. There was also no indication of hydraulic communication across the Fault in any of the 2006 pumping tests.

In June and July 2007, another long-term pumping test was conducted in the HJ aquifer at Well LC19M (Petrotek Engineering Corporation, 2007). While well LC19M had previously been tested during the 2006 pumping tests, the objectives of this test was to further develop aquifer characteristics of the HJ Horizon, to evaluate the hydraulic impacts of the Fault, and to demonstrate confinement of the production zone (HJ Horizon) aquifer. While LC19M is located on the north side of the Fault, HJ monitor wells were included on both sides of the Fault within distances likely to be impacted by the test were included as observation wells. The transmissivity calculated from five wells completed in the HJ aquifer on the north side of the Fault were similar, ranging from 2.8 to 7.0 m^2/day (30.0 to 75.5 ft^2/day) and averaging 6.3 m^2/day (68.3 ft^2/day). Storativity calculated from those wells range from 6.6×10^{-5} to 1.5×10^{-4} and averaged 1.1×10^{-4}.

In October 2007, an additional long-term pumping test was conducted in the HJ aquifer on the south side of the Fault in LC16M (LCI, 2008b). During the test, water levels were measured in monitoring wells in the HJ aquifer on both sides of the fault, as well as in the overlying and underlying aquifer on the south side of the Fault. The transmissivity calculated from five wells completed in the HJ aquifer on the south side of the Fault were similar, ranging from 5.6 to 9.3 m^2/day (60.3 to100.5 ft^2/day) and averaging 7.1 m^2/day (76.2 ft^2/day). Storativity calculated from those wells range from 3.5×10^{-5} to 9.1×10^{-4}.

The calculation of the transmissivity values in the two 2007 long-term pumping tests did not consider the effect of the fault, which limits groundwater flowing from the south in the first test and from the north in the second test, resulting in reduced estimates of transmissivity. As a result these transmissivities have been considered effective rather than actual transmissivities by the applicant. Actual transmissivities are likely to be larger than those calculated from the 2007 test data.

Minor responses to pumping were also observed across the Fault during both pumping tests. This response suggests that the Fault, while not entirely sealing, significantly impedes groundwater flow, even under considerable hydraulic stress. Small responses in water levels in the overlying and underlying aquifers were also observed during the both 2007 long-term pumping tests. While their cause is not clear, these responses suggest some hydraulic communication between the proposed production zone and the overlying and underlying aquifers.

3.5.3.1.2 Level of confinement

As discussed in Section 3.4.1, the HJ horizon is bounded above and below by aerially extensive confining units identified as the Lost Creek Shale and the Sage Brush Shale, respectively. While these shales are extensive, large sections of the Sage Brush Shale are less than 3.4 m (10 ft) thick in the proposed project area, and several areas of the Lost Creek Shale are less than 3.4 m (10 ft) thick in the proposed project area. Data presented by the applicant indicate that in some locations within the mining units these confining units are only 1.5 m (5 ft) thick. These areas of thinning in the overlying and underlying confining layers suggest that there may be some hydraulic connection between the production aquifer and the overlying and underlying aquifers. These concerns are supported by the results of the 2007 pumping tests. Minor responses in the overlying and underlying aquifer were observed during these tests. A number of potential causes for these responses have been suggested in addition to leakage across the confining layers, including potential impacts from off-site pumping, leakage through abandoned boreholes, or communication across the Fault. However, the cause of these responses observed in the overlying and underlying aquifers during the 2007 pumping test have not been clearly identified. Thus, there remain some concerns regarding the degree of confinement of the HJ production aquifer. The applicant indicates that each mine unit would be subject to further extensive testing during the Mine Unit Test required before initiating solution mine in each mine unit. This addition testing would employ a greater density of monitoring wells within the production zone aquifer and overlying aquifer on both sides of the fault. This additional hydrologic testing would provide better information regarding the cause of the drawdown response in overlying and underlying wells. These results would be provided in the Mine Unit Data Packages. Regardless, the applicant indicates that engineering practices are available to isolate the lixiviant form overlying and underlying aquifers.

3.5.3.1.3 Groundwater quality

Baseline groundwater quality programs have characterized the quality of groundwater within the shallow Wasatch aquifer within the Lost Creek project area. Groundwater quality in these aquifers commonly exceed WDEQ Class I standards for TDS and sulfate. Radionuclides radium-226 and uranium are elevated above EPA maximum contaminant levels (MCLs) in the majority of samples collected from the production zone aquifer and the underlying aquifer. The average radium 226-228 concentration in the production zone is an order of magnitude greater than the EPA MCL. Elevated concentration of these constituents is consistent with the presence of uranium ore-bodies. The applicant is currently expanding its groundwater quality monitoring program to better characterize groundwater quality outside the mine units in the production, overlying, and underlying aquifers.

3.5.3.1.4 Current Groundwater uses

The applicant has identified the groundwater users within 3.2-km (2-mi) and 8-km (5-mi) radii of the project area using the WSEO Water Rights Database (WSEO, 2006) and correspondence with the BLM. The majority of the groundwater-use permitted in the vicinity of the project area is for monitoring or miscellaneous mining-related purposes, and do not represent consumptive use of groundwater. Many of these permits are associated with the Kennecott Sweetwater Mine, which the applicant indicates is in Reclamation. Within a 3.2-km (2-mi) radius of the project area, all water use permits are those of the BLM. Each of these permits is associated with a well that supplies a stock pond (or tank). In addition, there is a fourth BLM well supply; a stock pond for which no water-use permit was found.

Within an 8-km (5-mi) radius, the applicant has identified fifteen active domestic or stock wells (including the four stock wells indentified within a 3.2-km [2-mi] radius). Of these fifteen wells, the BLM has ten active or potentially active wells (and four associated stock ponds), located outside of the project area, but within an 8-km (5-mi) radius of impact around the project area boundary (LCI, 2008b). All of these wells are used for livestock watering. There are five other potentially active domestic or stock wells within the 8-km (5-mi) radius of the project area. Eight of the BLM wells are at or shallower than the proposed ISR depths in the HJ Horizon, while two are of unknown depth. Three of the non BLM wells are much deeper than the HJ Sand, although the specific screened interval of these wells is not known.

3.5.3.2 Surrounding Aquifers

As indicated above, the Wasatch/Battle Spring Formation, the Fort Union Formation, and the Lance Formation are all of Tertiary age. They are considered part of the Tertiary aquifer system, which has been identified as the most important source of groundwater in the study area. Although some stock wells are known to be present in the Lance Formation along the formation's outcrop areas along the border of the Great Divide Basin, the groundwater in Lance Formation is largely undeveloped. Similarly, the Fort Union aquifer is largely undeveloped and unknown as a source of groundwater supply except in areas where it occurs at shallow depth along the margins of the basin.

The most important aquifers within the Great Divide Basin are in the Wasatch and Battle Spring Formation. Most wells drilled for water supply in the Battle Spring Formation are less than 305 m (1,000 ft) deep. (Collentine et al., 1981) reports that wells completed in the Battle Spring aquifers typically yield 114 to 152 Lpm (30 to 40 gpm); but that yields as high as 568 Lpm (150 gpm) are possible. Water quality within the Battle Spring aquifer is generally good in the northeast portion of the basin with TDS levels usually less than 1,000 mg/L and frequently less than 200 mg/L. Sulfate levels are also generally low in the shallow aquifers of the Battle Spring aquifer. Notable exceptions to the relatively good water quality include waters with elevated radionuclides. The presence of high levels of uranium in Tertiary sediments and groundwater of the Great Divide Basin has been well documented.

4.5.3 Groundwater Impacts

Potential environmental impacts to groundwater resources in the Lost Creek ISR Project can occur during each phase of the ISR facility's lifecycle. ISR 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 ISR operations and aquifer restoration are more likely to impact the deeper uranium-bearing aquifer, any aquifers above and below, and adjacent surrounding aquifers.

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

In describing the significance of potential impacts in this EA, the following significance levels for groundwater impacts have been identified:

SMALL: Impacts (chemical, radiological, and/or hydraulic) on groundwater would not be detectable or so minor as not to alter groundwater quality or water levels in any meaningful way.

MODERATE: Impacts (chemical, radiological, and/or hydraulic effects) would be detectable but would not adversely impact the current or potential future uses of groundwater in the area.

LARGE: Impacts (Chemical, radiological, and/or hydraulic effects) would be readily detectable and would result in potentially significant adverse impacts on the current or potential future uses of groundwater in the area.

4.5.3.1 Alternative A (No-Action)

The No-Action Alternative would result in no construction or operational activities on site that might impact shallow groundwater. This alternative also would not require the injection of lixiviant into the production aquifer or the consumptive use of groundwater. The disposal of waste liquids and solids would no longer be necessary and therefore would pose no threat to groundwater quality. Consequently Alternative A would result in no impacts to groundwater.

4.5.3.2 Alternative B (Proposed Action)

4.5.3.2.1 Construction Impacts to Groundwater

During construction of ISR facilities, the potential for groundwater impacts is primarily from consumptive groundwater use, introduction of drilling fluids and muds from well drilling, and spills of fuels and lubricants from construction equipment.

Groundwater use during construction is limited to routine activities such as dust suppression, mixing cements, and drilling support. The amounts of groundwater used in these activities are small relative to available water and would have a SMALL and temporary impact to groundwater supplies within the Lost Creek ISR Project. Groundwater quality of near-surface aquifers during construction would be controlled by BMPs such as implementation of a spill prevention and cleanup plan to minimize soil contamination. Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a short-term, SMALL adverse 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.

4.5.3.2.2 Operation Impacts to Groundwater

As indicated in Section 4.2.4.2.2 of the GEIS, during ISR 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 also include 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. Disposal of processing wastes by deep well injection during ISR operations also can potentially impact groundwater resources (NRC, 2008).

4.5.3.2.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

The GEIS (Section 4.2.4.2.2.1) discusses the potential impacts to shallow aquifers during ISR operations. A network of buried pipelines is used during ISR operations for transporting lixiviant between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside the 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 which could impact water quality in shallow aquifers. In addition, two ponds would be used to store waste fluids prior to deep well injection. Leakage from these ponds may impact shallow groundwater. The potential environmental impact of such pipeline, valve, well integrity failure, or pond leakage depends on a number of factors, including the depth to shallow groundwater, the use of shallow groundwater, and the degree of hydraulic connection of shallow aquifers to regionally important aquifers. As indicated in the GEIS, potential environment impacts could be MODERATE to LARGE if 1) the groundwater in the shallow aquifers is close to the ground surface, 2) the shallow aquifers are important sources for local domestic or agricultural water supplies, or 3) the shallow aquifers are hydraulically connected to other locally or regionally important aquifers.

As previously discussed in Sections 3.4 and 3.5.3 of this EA, the top 213 m (700 ft) of the Battle Spring Formation in the study area has been divided into at least five horizons marked from top to bottom as BC, DE, FG, HJ, and KM. These horizons are sandstone layers separated from one another by various thicknesses of shale, mudstone and siltstone. The first saturated horizon is the DE Horizon. The overlying BC Horizon is unsaturated and separated from the underlying DE Horizon by a shale sequence. The DE Horizon is described as comprised of alternating very fine to coarse grained sandstone, mudstone and siltstone. The top of the DE Horizon ranges from 30 to 61 m (100 to 200 ft) bgs. Water level data indicate that a water table generally exists within DE Horizon, although it may be locally confined. The shallow water table in this area is typically 24 to 46 m (80 to 150 ft) bgs. Directly underlying the DE Horizon is the FG Horizon which contains the aquifer directly overlying the production zone (HJ Horizon).

A survey of groundwater wells in the area (see Section 3.5.3 of this EA) indicates that shallow groundwater is an important source of water and is used within 3.2-km (2-mi) radius of the project area. However, the depth to the water table and its separation from the land surface by the relatively impermeable BC horizon and the intervening impermeable shale overlying the DE Horizon indicates that the potential for infiltrating fluids released at the surface to reach the shallowest aquifer would be small. Any releases would likely perch on the impermeable beds within the BC Horizon or on the underlying shale unit separating the BC and DE Horizons. Thus the potential impacts during operations to the shallow aquifer from releases from the surface would be localized and SMALL.

As indicated by the GEIS, any potential impact of releases at or near the ground surface on shallow groundwater can be greatly reduced by leak detection programs required by the NRC. The applicant plans an aggressive leak detection and spill cleanup program. In addition, preventative measures such as well mechanical integrity testing would limit the likelihood of well integrity failure during operations.

Moreover, the potential leakage from the planned storage ponds can be minimized by the design and operation of these ponds. The applicant has indicated that these ponds would be built with impermeable liners with leak detection systems underlying the liner. Any detection of leaks beneath the liner would lead to the closure of that pond and the necessary repairs to the liner. During operations, the leak detection standpipes would be checked for evidence of leakage. Visual inspection of the pond embankments, fences and liners and the measurement of pond freeboard would also be performed during normal operations. A Pond Inspection Program would be developed for the project and would meet the guidance contained in NRC Regulatory Guide 3.11 and commitments made by the applicant.

Because the DE Horizon has been shown to coalesce with the FG Horizon, which directly overlies the production aquifer in the HJ Horizon, shallow groundwater in the DE Horizon may be subject to contamination during operation by the leakage of lixiviant from the production zone. This potential environmental impact is address below in Section 4.5.3.2.2.2.

4.5.3.2.2.2 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: As discussed in the GEIS (Section 4.2.4.2.2.2), groundwater is withdrawn and reinjected into the production zone during ISR operations. Most of the water withdrawn from the aquifer is returned to the aquifer. The portion that is not returned to the aquifer is referred to as consumptive use. The consumptive use is due primarily to production bleed and also includes other smaller losses. The production bleed is the net withdrawal maintained to ensure groundwater gradients toward the production network. This net withdrawal ensures there is an inflow of groundwater into the wellfield to minimize the potential movement of lixiviant and its associated contaminants out of the wellfield.

Consumptive water use during ISR operations could impact local water user who use water from the production aquifer outside the exempted zone. This potential impact would result from lowering the water levels in nearby wells and reducing the yield of these wells. In addition, if the production zone is hydraulically connected to other aquifers above and/or below the water zone, consumptive use may impact the water levels in these overlying and underlying aquifers and reduce the yield in any nearby wells withdrawing water from these aquifers.

Assuming an average withdrawal rate over the life of the project of 656 Lpm (175 gpm), the applicant has provided predictions of the drawdown (reduction in hydraulic head) at the end of production/restoration operations (LCI, 2008b). The average withdrawal used in making these predictions is based on withdrawals during both production and restoration phase of the project. These predictions assume that all withdrawals are from the HJ Horizon and that the HJ Horizon is extensive and confined from above and below. The predictions also assume that the Fault acts as barrier to flow and, consequently, all flow comes from one side of the Fault. The drawdown at the end of production/restoration operations is predicted to be 53 m (177 ft) at 3.2 km (2 mi) from the centroid of production and 45 m (147 ft) at 4.8 km (3 mi).

As discussed in Section 3.5.3.1 of this EA, fifteen wells have been identified within 8 km (5 mi) of the project area that could be impacted by these drawdowns. Water levels in any of these wells screened in the HJ horizon would be significantly impacted. Many of these wells do not appear to be screened at the same depth as the production wells, although there are a number of wells that appear to be screened in the sands immediately overlying the production aquifer. However, the assumption used in making the predictions that the HJ Horizon is extensive and confined from above and below may not be accurate, and some groundwater may be drawn from overlying and underlying sand layers. This would result in an accompanying reduction in water levels in wells screened in these sands and could result in drawdowns in the nearby wells. Some of the wells within an 8-km (5-mi) radius are likely to be impacted, at least to some degree, by consumptive use of groundwater during operation and restoration at the proposed facility. After production and restoration are complete and groundwater withdrawals are terminated at the Lost Creek ISR Project, water levels would tend to recover. However, the recharge in this area is limited and recovery may be slow. Rebound to pre-operation water levels may take years to occur, and water levels may never fully recover.

A reduction in water levels in nearby wells could either make the wells go dry or increase the pumping requirements for these wells. Many of the nearby BLM wells are known to tap confined aquifers that have sufficient hydraulic head that groundwater flows to the surface without the need for a pump. Reduction in hydraulic head at these wells may stop the wells from naturally flowing to the surface and require pumps to raise water to the ground surface. Thus, the short-term impact of consumptive groundwater use during mine operation is likely to be MODERATE and possibly LARGE. Due to the potentially slow recovery of water levels after restoration is complete, the potential long-term environmental impact from consumptive use during the operational phase at Lost Creek remains MODERATE to LARGE.

It must be noted that the predictions of drawdowns are based on conservative assumptions and may overestimate the drawdowns resulting from consumptive use at the proposed facility. Since it is only approximately 1.6 km (1 mi) long, the Fault may provide the extensive barrier to groundwater flow assumed in making the above predictions. As discussed some groundwater may be drawn from overlying and underlying aquifers as well as from the HJ Horizon. This would have the effect of reducing the drawdown relative to those predicted above. These impacts can also be mitigated by providing pumps to flowing wells that stop flow in response to mine groundwater withdrawals. Similarly, greater pumping capacity and/or drilling wells to a deeper level mitigate these impacts. The applicant has committed to a program of monitoring water levels in nearby wells and to provide additional pumping capacity as necessary.

Excursions and Groundwater Quality: As discussed in the GEIS, groundwater quality in the production zone is degraded as part of ISR operations. The portion of the production aquifer used for production must be exempted as an underground source of drinking water though the Wyoming UIC program. After production is completed, the licensee is required to initiate aquifer restoration activities to restore the production zone to baseline or pre-operational class-of-use conditions, if possible. If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the MCLs provided in Table 5C of 10 CFR 40 Appendix A or to Alternate Concentration Limits (ACLs) approved by NRC. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISR operations would generally be expected to be SMALL and temporary.

To prevent horizontal excursions, inward hydraulic gradients are expected to be maintained in the production aquifer during ISR operations. These inward hydraulic gradients are created by the net groundwater withdrawals (production bleeds) maintained through continued pumping during ISR operations. Groundwater flows in response to these inward hydraulic gradients, thus ensuring that groundwater flow is toward the production zone. This inward groundwater flow toward the extraction wells prevents horizontal excursions of leaching solutions away from the production zone.

The NRC also requires the licensee to take preventive measures to reduce the likelihood and consequences of potential excursions. A ring of monitoring wells within and encircling the production zone is required for early detection of horizontal excursions. If excursions are detected, corrective actions are required outside of the exempted portion of the production aquifer.

Vertical excursions may also potentially occur into aquifers overlying or underlying the production zone aquifer. As analysis presented in the GEIS indicates, the potential for migration of leaching solution into an overlying or underlying aquifer is small if the thickness of the aquitard separating the production zone from the overlying and underlying is sufficient and the permeability of the aquitard is low. Hydraulic gradient between the production zone and overlying or underlying aquifers also help to determine the potential for vertical excursions. Vertical excursions can also occur due to improperly sealed boreholes, to poorly completed wells, or to a loss of mechanical integrity of ISL injection and extraction wells. To ensure the detection of vertical excursions, the NRC also requires monitoring in the overlying and underlying aquifers. A program of mechanical integrity testing of all ISL well is also required. Corrective action is required if any vertical excursions are detected.

Many of the hydrogeologic conditions at the proposed Lost Creek ISL facility are similar to those found at other ISL facility in the Crooks Gap District. Groundwater in the HJ production aquifer is confined and the aquifer appears to have sufficient hydraulic conductivity to allow ISL mining. The drawdown created by pumping in the production zone should facilitate containment of the lixiviant in the mining zone and allow the recovery of any horizontal or vertical excursions, should they occur.

However, the hydrogeology of the site presents several unique features that result in special issues for the Lost Creek site. Foremost among these features is the Fault that runs through the project area (see Section 3.4 of this EA). Displacement along the fault results in geologic beds that are off-set across the Fault. Thus, production zone, overlying, and underlying aquifers are not continuous across the Fault. The Fault has also been shown to be a barrier to groundwater flow but does not appear to be impermeable. These factors present a number of complications when trying to ensure hydraulic control and monitoring of the production zone and overlying and underlying aquifers, particularly for those areas adjacent to the Fault. The fault may similarly complicate efforts to restore the aquifer.

In addition to the Fault, the extent of confinement provided by the overlying Lost Creek Shale and the underlying Sage Brush Shale is uncertain (See Sections 3.4 and 3.5.3.1 of this EA). While these shales are really extensive, large sections of the Sage Brush Shale are less than 3.4 m (10 ft) thick in the proposed project area, and several areas of the Lost Creek Shale are less than 3.4 m (10 ft) thick in the proposed project area. Data presented by the applicant indicate that in some locations within the mining units these confining units are only 1.5 m (5 ft) thick. These areas of thinning in the overlying and underlying confining layers suggest that there may be some hydraulic connection between the production aquifer and the overlying and underlying aquifers. These concerns are supported by the results of the 2007 pumping tests. Minor responses in the overlying and underlying aquifer were observed during these tests. A number of potential causes for these responses have been suggested in addition to leakage across the confining layers, including potential impacts from off-site pumping, leakage through abandoned boreholes, or communication across the Fault. However, the cause of these responses observed in the overlying and underlying aquifers during the 2007 pumping test have not been clearly identified.

The applicant indicates that each mine unit would be subject to further extensive testing during the Mine Unit Test required before initiating solution mine in each mine unit. This addition testing would employ a greater density of monitoring well within the production zone aquifer and overlying aquifer on both sides of the fault. This additional hydrologic testing would provide better information regarding the cause of the drawdown response in overlying and underlying wells. These results would be provided in the Mine Unit Data Packages, which would be reviewed and approved by the NRC. The applicant indicates that engineering practices are available to isolate the lixiviant form overlying and underlying aquifers.

The special technical issues presented by the presence of the Fault relative to control, monitoring, and recovering any horizontal and/or vertical excursions in the area adjacent to the Fault are currently being evaluated as part of the safety review. Similarly, the technical issues presented by the potential lack of vertical confinement of the HJ production aquifer are currently being evaluated as part of the safety review. Pending this review, these issues remain unresolved and the impact due to changes in water quality and vertical excursions cannot be assessed.

4.5.3.2.2.3 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 SDWA, and the Clean Air Act, the EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from the EPA or from an authorized state UIC program. The WDEQ has been authorized to administer the UIC program in Wyoming and is responsible for issuing any permits for deep well disposal at the Lost Creek site.

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

The GEIS (Section 4.2.4.2.2.3) indicates that in the Wyoming West Uranium Milling Region, where the Lost Creek ISR Project is located, the Paleozoic aquifers included in the Upper Colorado River Basin aquifer system are typically deeply buried, contain saline water and are not commonly tapped for water supply (Whitehead, 1996). The Paleozoic aquifers are separated from the overlying aquifers (including the ore-bearing aquifer) by the regionally extensive Lewis Shale. Hence, the Paleozoic aquifers (*e.g.*, Tensleep Sandstone) could be suitable for disposal of leaching solutions.

Lost Creek plans to dispose of waste fluids using deep well injection and is seeking a permit for a Class 1 injection well from the WDEQ. The WDEQ would evaluate the suitability of the proposed deep injection wells. The WDEQ would only grant such a permit if the waste fluids can be suitably isolated in a deep aquifer. Consequently, it is assumed that the potential environmental impact to deep aquifers below the production aquifers of deep well injection of waste would be SMALL.

4.5.3.2.3 Aquifer Restoration Impacts to Groundwater

As indicated in GEIS (Section 4.2.4.2.3), the potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including discharge of wastes storage ponds, 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.

Lost Creek is planning three phases of restoration: groundwater sweep, groundwater treatment, and recirculation. A reductant may be added anytime to the fluids circulated during restoration to lower the oxidation potential of the production zone. During groundwater sweep, water is pumped from the mine unit, without re-injection, resulting in an influx of baseline quality water from the perimeter of the mine unit. This baseline quality water effectively sweeps the affected portion of the aquifer. Following the sweep phase, water would be pumped from the mine unit to treatment equipment and then re-injected into the mine unit. Ion exchange and reverse osmosis circuits are used during this phase to treat the groundwater. At completion of the groundwater treatment phase in a mine unit, recirculation would be initiated. Recirculation consists of pumping from the mine unit and re-injecting the recovered solution to recirculate solutions and homogenize the groundwater conditions.

Regardless of the process, hydraulic control of the former production zone must be maintained during restoration. This is accomplished by maintaining an inward hydraulic gradient through a production bleed (see Section 4.5.3.2.2.2). As discussed in the GEIS, the impacts of consumptive use during aquifer restoration are generally greater than during ISR operations. This is particularly true during the sweep phase when a greater amount of groundwater is generally withdrawn from the production aquifer. During the sweep phase, groundwater is not reinjected into the production aquifer and all withdrawals should be considered consumptive.

As discussed in Section 4.5.3.2.2.2 of this EA, the applicant has provided predictions of drawdown based on and average consumptive use of 656 Lpm (175 gpm) during the project period. The applicant plans to concurrently restore individual wellfields while moving on to ISR operations at other areas. Thus, it is anticipated that only a limited portion of the proposed wellfields would be in restoration phase at any particular time. This mix of wellfields in production and restoration was considered when developing the above estimate of average consumptive use. As discussed in Section 4.5.3.2.2.2, significant drawdowns in hydraulic head have been predicted. The drawdown at the end of production/restoration operations is predicted to be 53 m (177 ft) at 3.2 km (2 mi) from the centroid of production and 45 m (147 ft) at 4.8 km (3 mi). Although the prediction is for drawdowns in the HJ Horizon based on the assumption that the HJ Horizon is fully confined above and below, there may be potentially significant drawdowns in sands overlying and underlying the HJ Horizon which can impact water levels and groundwater usage in a number of nearby groundwater wells. Consequently, the temporary impact of consumptive groundwater use during aquifer restoration is likely to be MODERATE to LARGE. These temporary effects could span many years, however, the final impact would likely be SMALL since water levels should recover after aquifer restoration is complete.

As previously discussed, the above predictions are based on conservative assumptions and may overestimate the impact of consumptive use during the restoration phase. In addition, the applicant has committed to a program of water-leveling monitoring in nearby wells and to the provision of additional pumping capacity, as necessary.

A network of buried pipelines is used during ISR restoration for transporting restoration fluids between the pump house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside the pumping header houses. Although the liquids carried in these pipes during restoration are less potent, the failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers could result in leaks and spills of these fluids which could impact water quality in shallow aquifers. Similarly, the waste storage ponds would operate and could result in leakage to shallow groundwater. These potential impacts to shallow groundwater have previously been evaluated in Section 4.5.3.2.2.1. As this evaluation indicated, the potential environmental impact to shallow aquifer during the restoration phase from releases from the surface would be SMALL.

The disposal of waste fluids via deep well injection of waste is planned during aquifer restoration in much the same manner as during aquifer operation. As previously indicated in Section 4.5.3.2.2.3, it is assumed that the potential environmental impact to deep aquifers below the production aquifers of deep well injection of waste would be SMALL.

4.5.3.2.4 Decommissioning Impacts to Groundwater

The environmental impacts to groundwater during dismantling and decommissioning ISR 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. 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 ISR operation and groundwater restoration activities. Spills of fuels and lubricants during decommissioning activities could impact shallow aquifers. Implementation of BMPs during decommissioning can help to reduce the likelihood and magnitude of such spills and facilitate cleanup. Based on consideration of BMPs to minimize water use and spills, potential environmental impacts to the groundwater resources in shallow aquifers from decommissioning would be expected to be SMALL.

After ISR operations are completed, improperly abandoned wells could impact aquifers above the production aquifer by providing hydrologic connections between aquifers. As part of the restoration and reclamation activities, all monitoring, injection, and production wells would be plugged and abandoned in accordance with the Wyoming UIC program requirements. The wells would be filled with cement and clay and then cut off below plough depth to ensure that groundwater does not flow through the abandoned wells (Stout and Stover, 1997). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be expected to be SMALL (NRC, 2008).

4.5.3.3 Alternative C (Dry Yellowcake)

Alternative C would include issuing LCI a license for the construction, operation, aquifer restoration, and decommissioning of facilities for ISR uranium milling, but processing the recovered uranium into a dry powder instead of a yellowcake slurry. The potential environmental impacts to groundwater for this alternative would not differ from those identified for Alternative B. Consequently, the potential environmental impacts to groundwater for Alternative C are identical to those identified for the Alternative B.

4.5.3.4 Alternative D (Alternate Plant Site)

Alternative D would include issuing LCI a license for the construction, operation, aquifer restoration, and decommissioning of facilities for ISR uranium milling and processing, but using an alternative facility layout, as originally proposed by LCI. The potential environmental impacts to groundwater for Alternative D would not differ from those identified for the Alternative B. Consequently, the potential environmental impacts to groundwater for Alternative D are identical to those identified for the Alternative B.