4.5.2 Groundwater Impacts

Potential environmental impacts to groundwater at the Nichols Ranch and Hank site may occur during all phases of the ISR facility's lifecycle, but primarily during operations and aquifer restoration.

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 or near-surface activities that can introduce contaminants into soils are more likely to impact shallow aquifers while ISR operations and aquifer restoration will likely impact the deeper uranium-bearing aquifer, and potentially impact any aquifers above and below, and adjacent surrounding aquifers.

ISR facility impacts to groundwater resources can occur from surface spills and leaks, releases from shallow surface piping, 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.

4.5.3.1 Alternative 1 (Proposed Action)

4.5.3.1.1 Construction Impacts to Groundwater

The GEIS (Section 4.3.4.2.1; NRC, 2009a) indicates that during construction of ISR facilities, the potential for groundwater impacts are primarily from consumptive groundwater use, introduction of drilling fluids and muds from well drilling, and spills of fuels and lubricants from construction equipment. During the construction of the wellfields and facility at Nichols Ranch ISR, potential impacts to groundwater could occur from the consumptive use of groundwater, introduction of drilling fluids and muds into the environment during well installation, discharge of pumped water to the surface during hydrologic testing and surface spills of fuels and lubricants.

Groundwater use during construction is expected to be 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 potentially could have a SMALL adverse and temporary impact to groundwater supplies within the Nichols Ranch ISR Project. Even in instances where the water-table aquifer is shallow (e.g., See Section 4.5.3.1.2.1), groundwater quality of near-surface aquifers during construction would be protected by best management practices (BMPs) such as implementation of a spill prevention and cleanup plan to minimize soil contamination. The applicant has committed to an aggressive program to clean up spills (ER, 2009, pp. ER-133, 134). Additionally, the amount of drilling fluids and muds introduced into aquifers during well construction would be limited and have a 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 best management practices to protect shallow groundwater.

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According to the CEQ, the significance of impacts is determined by examining both context and intensity (40 CFR 1508.27). Context is related to the affected region, the affected interests, and the locality, while intensity refers to the severity of the impact, which is based on a number of considerations. 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) would be detectable but would not adversely impact the current or potential future uses of groundwater in the area.¶
LARGE: Chemical, radiological, and/or hydraulic impacts 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.¶

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4.5.3.1.2 Operation Impacts to Groundwater

As indicated in Section 4.3.4.2.2 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, 2009a).

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4.5.3.1.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

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The GEIS (Section 4.3.4.2.2.1; NRC, 2009a) 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. 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 shallow aquifers is close to the ground surface, 2) the shallow aquifers are important sources for local domestic or agricultural water supplies, or 3) shallow aquifers are hydraulically connected to other locally or regionally important aquifers.

As previously discussed in Section 3.4.1 and 3.5.3, the Wasatch Formation outcrops in the project area and is characterized by a series of sand layers separated by mudstones and siltstones. The more permeable sand layers serve as aquifers in this area. The applicant has identified a series of sand layers in the upper portion of Wasatch Formation present in the project area and have labeled these layers from the shallowest to the deepest as the H, G, F, C, B, A, and 1 Sands. In addition, depth and expression of these sands at the ground surface is influenced by the topographical relief of the project area.

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The depth at which groundwater is first encountered across the Nichols Ranch Unit varies and depends on surface topography. The specific sand that acts as the surficial aquifer similarly varies across the project area depending on the outcropping of these sands and the surface topography. Limited groundwater level data is available to define depth to shallow groundwater across the Nichols Ranch Unit area, and additional wells are planned to better define shallow groundwater levels in this area (Uranerz, 2007). However, based on available data and extrapolation of sand units across the site, the applicant has estimated the depth to shallow groundwater and the sand layer acting as the surficial aquifer across the Nichols Ranch Unit

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area (Uranerz, 2007). In the southern portion of the Nichols Unit area, shallow groundwater is first encountered in the Cottonwood alluvium and has been shown to within 3 m (10 ft) of the ground surface. Moving north from the Cottonwood alluvium, shallow groundwater is first encountered in the F aquifer at depths ranging from 15 to 30 m (50 to 100 ft). However, in the northernmost portion of the Nichols Ranch Unit area, the G sand is likely to be the shallow aquifer, with depth to groundwater ranging between 30 to 60 m (100 to 200 ft). Groundwater flow in the F and G Sands is projected to be in a westerly direction (Uranerz, 2007).

Thus, the depth to shallow groundwater in the southern portion of the Nichols Ranch Unit is limited. Data indicate that the depth to groundwater in the general area of the proposed processing plant is about 15 m (50 ft) and portions of the projected production zone extend to the area adjacent to the Cottonwood Creek alluvium, where groundwater may be as shallow as 3 m (10 ft). This limited unsaturated zone offers a limited buffer to absorb and attenuate any releases at the ground surface. Moreover, shallow groundwater likely flows to Cottonwood Creek alluvium, and if left unchecked, shallow groundwater contamination could migrate into and along this alluvial material to the west. The groundwater quality data for the F Sand indicate that groundwater in this unit has relatively high TDS, but appears suitable for stock watering in many areas (Wyoming Class III groundwater). The well survey provided by the applicant indicates that there are four stock watering wells within a half-mile radius of the project area. From Table D6-2 (Uranerz, 2007), only one of these wells (N1, 11849) is screened in the F Sand shallow aquifer and could be potentially impacted by releases at the ground surface that migrate downgradient to the west.

Depth to shallow groundwater at the Hank Unit Area is similarly uncertain, and the installation of additional wells are planned to identify shallow water levels in the Hank Unit area (Uranerz, 2007). However, the applicant has indicated that the H Sand should be the surficial aquifer in this area, with depth to groundwater ranging between 15m (50 ft) in the low lying areas to the west of the Hank Unit area to 61 m (200 ft) along the eastern border of the Hank Unit area. Groundwater flow in the H Sand at the Hank Unit is expected to flow in a westerly direction. The Willow and Dry Willow Creek alluvial materials in the Hank Unit area are not expected to contain water except during short periods of time after runoff events.

The depth to shallow groundwater appears somewhat greater at the Hank Unit than the Nichols Ranch Unit. There is generally a 30 m (100 ft) or more separation from the ground surface to shallow water beneath most of the production zone and planned processing facility. However, the southern portion of the ore body extends into an area where shallow water is projected to be within 15 m (50 ft) of the surface. Water quality data from the H sand indicates that this unit is suitable for livestock use (Wyoming Class III groundwater). The well survey provided by the applicant indicates that there are six stock watering wells within a half-mile radius of the project area. None of these wells are screened in the shallow aquifer. Monitoring wells, however, are screened in the surficial H Sand aquifer (e.g., BR-I, BR-K, URZHH-7), (Uranerz, 2007).

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 (Section 7.5.3.1 of the TR, Uranerz 2008b) and spill cleanup program (Section 4.4 of the TR, Uranerz 2008b). In addition, preventative

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Deleted: lies over the shallow F Sand which is the production zone in the Hank Unit. Those wells in close vicinity to the site that are screened in the H Sand are also likely screened in the F Sand as well. The applicant has indicated that wells screened across the F Sand in the vicinity of the Hank will be abandoned (Uranerz,2007 Appendix D6 p.D6-12). Thus, wells using shallow groundwater from the H Sand will likely be abandoned and will not be directly impacted by releases at the surface.

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measures such as well mechanical integrity testing (Section 3.4.6 of the TR, Uranerz 2008b) would limit the likelihood of well integrity failure during operations. Without these mitigating measures, the resultant impact to the shallow aquifer could potentially be LARGE; however, the implementation of these measures should mitigate the potential impact (i.e., early detection and cleanup) and result in MODERATE potential operational impacts to shallow (near surface) aquifers for the Nichols Ranch and Hank Units. This evaluation is consistent with the GEIS analysis, which predicated its MODERATE to LARGE groundwater impacts rating on (1) the groundwater in shallow aquifers is close to the ground surface, (2) the shallow aquifers are important sources for local domestic or agricultural water supplies, or (3) shallow aquifers are hydraulically connected to other locally or regionally important aquifers. For the Nichols Ranch ISR, the surficial aquifer is close to the ground surface in several areas. In one case, the water is used by ranchers to water their stock. However, these shallow aquifers do not appear hydraulically connected with more significant supplies of water from other local and regional aquifers.

4.5.3.1.2.2 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 well field to minimize the potential movement of lixiviant and its associated contaminants out of the well field.

The portion of an aquifer where the production occurs must be designated as an exempt aquifer by EPA pursuant to the Federal underground injection control (UIC) regulations before any production begins. An exempt aquifer designation means the aquifer is not, nor would it ever be a source of drinking water in the location covered by the exemption. At the proposed Nichols Ranch Project, portions of the A Sand at Nichols Ranch Unit and F Sand at Hank Unit in which production operations would occur and typically a buffer zone would be sought to be declared as exempt by EPA. Groundwater in the aquifer outside the designated exempt zone would still be considered a possible source of drinking water.

Consumptive water use during ISR operations could potentially impact a local water user who uses water from the production aquifer outside the exempted zone. This potential impact would result from lowering the water levels in nearby wells, thereby 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 potentially impact the water levels in these overlying and underlying aquifers and reduce the yield in any nearby wells withdrawing water from these aquifers.

The applicant has provided predicted drawdowns created by production bleed during mine operation (Addendum 7A of the TR, Uranerz, 2008b). These predictions are based on a simple analytical model and relied on aquifer properties determined during aquifer testing or assumed based on local conditions. Based on an assumed production rate of 13,250 Lpm (3,500 gpm) and a 1 percent bleed rate, a groundwater withdrawal rate of 133 Lpm (35 gpm) was used to predict drawdowns at the Nichols Ranch Unit. The drawdowns resulting from this pumping rate were predicted using the aquifer properties of 4,350 L/day/m (350 gal/day/ft) for transmissivity and a storage coefficient of 1.8 x 10^{-4}. Simulations were conducted to evaluate the drawdowns resulting from concentrated drawdowns distributed at various locations in the projected wellfields. These predictions show that 9 m (30 ft) of the drawdown will extend 2,134 m (7,000 ft) outward from the center of the wellfields. The 1.5 m (5 ft) contour is projected to extend out 6,858 m (22,500 ft) or approximately 6.4 km (4 mi) from the Nichols Ranch ISR Project area.

The applicant has indicated that the primary effect of the drawdowns caused by the Nichols Ranch bleed should be limited to those wells that are located in the ore zone (A Sand) Unit (May 8, 2009 Response to Environmental RAIs, LU-1 ER Section 3.1.2). This conclusion is based on the assumption that the A Sand is well-confined and there would be little leakage from the underlying or overlying sands into the A Sand. The applicant has further indicated that the predicted drawdowns should not greatly impact production from pumping wells since, in the confined A Sand, there is a large amount of potential drawdown available. As discussed in Section 3.5.3.1.4, inspection of WSEO well data for wells within 3 miles of the Nichols Ranch site indicates an average of about 446 feet in available hydraulic head. Despite the significant amount of available head, flowing wells (i.e., those wells with a potentiometric surface above the ground surface) in the Nichols Ranch Unit area may cease flowing due to the predicted drawdowns. The applicant has indicated in Drawing, Exhibit 4-3 Nichols Ranch ISR Project "A" Sand Drawdown and Free Flowing Wells that flowing wells within the 3 m (10 ft) drawdown contour may be impacted and has identified a total of 10 wells within an 8 km (5 mi) radius that are flowing wells and screened within the A Sand. A pump or other supplement may have to be installed in a flowing well if the drawdowns cause it to cease flowing. The applicant has indicated that "confidential surface use agreements are in place with the landowners" detailing mitigation measures that will be implemented if a free flowing well is impacted by the Nichols Ranch ISR Project. (Uranerz, 2009, Section 4.4.1.3 p. ER-91).

In addition to the drawdown in the A Sand, pumping of the A Sand may induce leakage from the overlying and/or underlying aquifers. Such leakage may occur in areas where the intervening aquitards are not extensive or where they are compromised by wells screened over multiple aquifers or inadequately sealed wells or boreholes are present. The result of such leakage across confining beds would produce drawdowns in these adjacent beds; however, aquifer testing at the Nichols Ranch has not indicated leakage from either the overlying B Sand or the underlying 1 Sand. Specifically, the applicant has presented the results of two multi-well pumping tests (MN-1 and MN-2 multi-well tests) that included pumping of the A Sand coupled with monitoring of the A Sand, the overlying B Sand aquifer, and the underlying 1 Sand aquifer (Uranerz, 2009, Addendum D6B). Neither test indicated a hydraulic connection (drawdown) between the A Sand and the B Sand or 1 Sand. Even if leakage from under- or overlying units were to occur in off-site areas, these drawdowns are expected to a fraction of the drawdowns experienced in the A Sand. Consequently, given the abundant hydraulic head in the A Sand, the in-place mitigation measures in the event of impact to free flowing wells, and the absence of the evidence indicating leakage from overlying and underlying aquifers, the potential short-term

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impact due to consumptive use at the Nichols Ranch Unit during the production phase is considered SMALL.

The net consumptive use of water at the Nichols Ranch Unit during the operational phase (production and restoration) is a small fraction of the water currently stored in the A Sand in the Powder River Basin. After production and restoration are complete and groundwater withdrawals are terminated at the Nichols Ranch Unit, groundwater levels will tend to recover with time. Thus, the potential long-term (approximately 10 years) environmental impact from consumptive use during the operational phase at Nichols Ranch Unit is considered SMALL.

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As previously discussed in Section 3.5.3, the F Sand production zone at Hank is not completely saturated over much of the proposed license area. Therefore, it is an unconfined aquifer. The unconfined conditions in the production zone help to reduce the potential impact of the consumptive use anticipated during ISR operations. For a given net withdrawal, an unconfined aquifer exhibits substantially less drawdown in water level over a smaller area relative to that exhibited in a confined aquifer. As shown in Figure 4-x, the water produced from a well in an unconfined aquifer (water level below overlying aquitard) comes from dewatering of the aquifer pore space in the production zone. However, the water moving to a well in a confined aquifer (water level above overlying aquitard) comes from the compression of the sediments and expansion of water from the pressure drawdown in the production zone, but does not drain the pore spaces. Therefore, much more water is produced from dewatering drawdown over a small area of an unconfined aquifer to meet the well rate, whereas the pressure drawdown to produce water from a confined aquifer must occur over a larger area to meet the well rate.

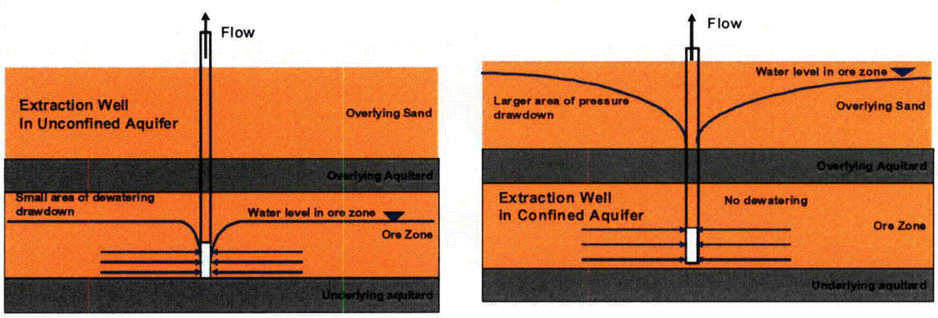

Figure 4-x. Difference in size and type of drawdown in an unconfined aquifer and confined aquifer from an extraction well operating a same rate.

The applicant has provided predictions of drawdowns created by production bleed in the F Sand at the Hank Unit. Based on an assumed production rate of 9,470 Lpm (2,500 gpm) and a 3 percent bleed rate, a groundwater withdrawal rate of 284 Lpm (75 gpm) was used to predict drawdowns at the Hank Unit. The drawdowns resulting from this pumping rate were predicted using the aquifer properties of 400 gal/day/ft for transmissivity and a storage value of 0.05 for the unconfined F Sand. Simulations were conducted by assuming 284 Lpm (75 gpm) distributed over 6 locations in the northern well field for 1.5 years followed by a second set of six

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withdrawals in the southern wellfield for the remaining 1.5 years. The predictions indicate that drawdowns of 3 m (10 ft) will extend out only to the area immediately adjacent to the southern wellfield, while the drawdowns of 1.5 m (5 ft) will extent out approximately 274 m (900 ft) from the well field. The reduced drawdowns observed in the F Sand at the Hank unit are due to the unconfined nature of the aquifer. Aquifer testing at the Hank unit has not indicated leakage from either the overlying G Sand or the underlying B Sand. Specifically, the applicant has presented the results of two multi-well pumping tests (URZHF-1 and URZHF-5 multi-well tests) that included pumping of the F Sand coupled with monitoring of the F Sand, the overlying G Sand aquifer, and the underlying B Sand aquifer (Uranerz, 2009, Addendum D6C). Neither test indicated a hydraulic connection (drawdown) between the F Sand and the G Sand or B Sand. No flowing wells have been identified in the F Sand in this area. In addition, the applicant states that any wells screened in the F Sand in the area immediately adjacent to the Hank unit area will need to be abandoned due to their close proximity to the production zone using acceptable WDEQ methods or will be used as monitoring wells if not completed in multiple sands (Uranerz, 2007 Appendix D6 pD6-12). Thus, the potential environmental impact due to consumptive use of groundwater at the Hank Unit during the production phase is likely to be SMALL.

The net consumptive use of water at the Hank Unit during the operational phase (production and restoration) is a small fraction of the water currently stored in the F Sand in the Powder River Basin. After production and restoration are complete and groundwater withdrawals are terminated at the Hank Unit, groundwater levels will tend to recover with time. Thus, the potential long-term (approximately 10 years) environmental impact from consumptive use during the operational phase at Hank Unit is considered SMALL.

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 maximum contaminant levels (MCLs) provided in Table 5C of 10 CFR 40 Appendix A or to Alternate Concentrations Limits (ACL) approved by NRC. For proposed ACLs to be approved, they must be shown to be protective of public health at the site.

In the GEIS (Section 2.11.4), the NRC staff documented that, based on historical information at operating ISR facilities, excursions have occurred at these facilities. Separately, the NRC staff analyzed the environmental impacts from both horizontal and vertical excursions at three NRC-licensed ISR facilities (NRC, 2009b). In that analysis, which involved 60 events at the three facilities, the NRC staff found that, for most of the events, the licensees were able to control and reverse the excursions through pumping and extraction at nearby wells. Most excursions were short-lived, although a few continued for several years. In all cases, none resulted in environmental impacts (NRC, 2009b).

Groundwater compositions at Nichols Ranch and Hank affect the use of the groundwater resource. In the Nichols Ranch area, the A, B, and C Sand aquifers contain water whose compositions (primarily for Ra226) exceed the Wyoming Ground Water Quality Class 1 (domestic use), Class II (agriculture use), and Class III (suitable for livestock) standards. In

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contrast, the deeper 1 Sand aquifer meets Wyoming's Class I standard. Based on cross-sections, the applicant shows the 1 Sand to be very discontinuous and thin. Consequently, due to the significant depth, and limited extent of this aquifer, the 1 Sand is not expected to be used as source of drinking water. At Hank unit, the G H Sand, which lie above the F Sand production zone, are considered the shallow (near surface) aquifers and meet Wyoming's Class III standard (suitable for livestock), while both the F Sand and underlying B and C Sands exceed Wyoming's standards for drinking water, agriculture or livestock use. Based on the generally poor preexisting water quality in both the Nichols Ranch and Hank unit areas, and the expected restoration of the production zones at both units, and due to confinement of the Nichols ranch production aquifer, 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 (Section 3.4.8; Uranerz, 2008b).

Besides hydraulic control of the well field to limit the potential for excursions, geochemical aspects of the aquifer(s) can provide mechanisms that attenuate the plume of reactive constituents of the lixiviant and and/or mobilized reactive constituents of the aquifer. The roll front ore deposits formed millions of years ago. (ref) However, their continued presence today suggests these features are relatively stable and processes that would tend to disperse the accumulation of uranium ore are less effective than those that concentrate the uranium. Sorption and precipitation are processes that tend to attenuate the movement of uranium and other reactive constituents. These processes are active at the Nichols Ranch and Hank and are expected to limit the potential for excursions of reactive constituents.

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. The applicant's groundwater monitoring program is detailed in Section 5.7.8 of the TR (Uranerz 2008b). If excursions are detected, corrective actions are required outside of the exempted portion of the production aquifer. Chemical indicators of horizontal excursions will use conservative (nonreactive or unretarded) constituents of the lixiviant such as chloride. An elevated Cl concentration in a monitoring well could provide an early signal suggesting the approach of a plume of reactive contaminants. Corrective action can be implemented to stop or reverse the progress of the plume.

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. Steep hydraulic gradients in which the hydraulic head of the production zone exceeds that of the overlying or underlying aquifers also can lead to vertical excursions. Vertical excursions can also occur due to improperly sealed boreholes, to poorly

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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 (Section 5.7.1.3.1; Uranerz 2008b). A program of mechanical integrity testing of all ISL wells is also required (Section 3.4.6; Uranerz 2008b). Corrective action is required if any vertical excursions are detected (Section 5.7.8.10.3; Uranerz 2008b).

Groundwater in the A Sand (the production zone) at the Nichols Ranch Unit is confined and there is sufficient hydraulic conductivity to allow ISR 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. The overlying BA Aquitard and underlying A1 Aquitard are thick and extensive and are expected to confine the lixiviant to the A Sand. Pumping tests conducted to date indicate no potential hydraulic connection between the A Sand and the overlying or underlying sands. Each mine unit will undergo further extensive testing during the Mine Unit Test required before initiating solution mine in each mine unit. The results of this further testing will be provided in the Mine Unit Data Packages, which will be reviewed and approved by the NRC. Therefore, the potential environmental impact to groundwater quality is considered SMALL at the Nichols Ranch Unit.

The occurrence of unconfined conditions in the production zone at the Hank Unit presents special considerations when evaluating the maintenance of the necessary inward hydraulic gradient, the reliability of monitoring around the periphery of the well field, and the capability of reversing any potential horizontal excursion by drawing the lixiviant back into the producing well. Although the unconfined condition of the production zone at the Hank Unit does not necessarily indicate that leakage will occur from the overlying G Sand aquifer, as the overlying aquifer could be perched and separated from the production zone by an aquitard, it does result in limited drawdown. However, as in ISR operations in confined aquifers, Mine Unit Data Packages containing the results of aquifer testing throughout the production zone will be required to verify that hydraulic control of the production zone can be maintained with the planned production bleed. These tests must also demonstrate that hydraulic control reaches out to the proposed monitoring ring and that sufficient drawdown is available to pull back any horizontal or vertical excursion that might occur. The unconfined conditions of the F Sand at Hank can affect the methods applied in the restoration stage of the ISR project (See Section 4.5.3.1.3). However, an approved decommissioning plan is required which demonstrates that NRC clean up requirements can be met before NRC will terminate the license. Therefore, the potential environmental impact to groundwater quality from excursions at the Hank Unit is considered SMALL.

4.5.3.1.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

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

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Comment [a13]: Two pages before, first paragraph, you indicate that aquifer testing has not indicated leakage from the overlying or underlying sand. Clarify whether the hank unit is confined or unconfined. Done JWB

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Comment [A14]: Is there any independent information from NRC on this unconfined aquifer issue? Talk to Elise about her evaluation and input any information she has

Comment [a15]: Also indicat ... [7]

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The GEIS also indicates that the potential environmental impact of injection 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 4.3.4.2.2.3) indicates that in the Wyoming East Uranium Milling Region, where the Nichols Ranch ISR Project is located, the Paleozoic aquifers are hydraulically separated from the aquifer sequence that includes, from the shallowest to the deepest, the Wasatch Formation, the Fort Union Formation, the Lance Formation, and the Fox Hills Formation by thick low permeability confining layers that include the Pierre Shale, the Lewis Shale, and the Steele Shale (Whitehead, 1996). Hence, nonkarstic Paleozoic aquifers (e.g., Tensleep Sandstone) can be investigated further for suitability of disposal of leaching solutions. The GEIS has concluded that in the Wyoming West Uranium Milling Region, considering the relatively low water quality in and the reduced water yields from nonkarstic Paleozoic Aquifers and the presence of thick and regionally continuous aquitards confining them from above, the potential environmental impacts due to deep injection of leaching solution into nonkarstic Paleozoic aquifers could be SMALL.

Nichols Ranch ISR plans to dispose of waste fluids using deep well injection and is seeking a permit for Class 1 injection wells from the WDEQ. Each of the mine units will have a deep injection well. The WDEQ will evaluate the suitability of the proposed deep injection wells. The WDEQ will 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 will be SMALL.

4.5.3.1.3 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 waste 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.

Nichols Ranch is planning three phases of restoration: groundwater sweep, groundwater transfer, and groundwater treatment. The sequence of the restoration methods used will be determined based on operating conditions (Uranerz, 2007).

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.

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Deleted: Depending on the progress of restoration, it is possible that not all phases of restoration will be utilized. 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. During the groundwater transfer phase, water may be transferred between a production area beginning restoration and a production area beginning mining operations. Also a groundwater transfer may occur within the same production area, if one section of the production area is in a more advanced state of restoration than another. The direct transfer of water will act to lower the TDS in the production aquifer being restored by displacing affected groundwater with pre-mining baseline quality. This water can then be used in other restoration or production areas without withdrawing additional groundwater from the production aquifer. During the treatment phase water from the restoration zone is sent for treatment by ion exchange and reverse osmosis. After treatment the water can be reinjected into the restoration zone to continue flushing of the production zone.¶

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As discussed in Section 4.5.3.2.2.2 of this EA, the applicant has presented predictions of drawdown during production at both the Nichols Ranch Unit and the Hank Unit. Based on an assumed production rate of 13,250 Lpm (3,500 gpm) and a 1 percent bleed rate, the applicant has provided predictions of drawdown at the Nichols Ranch Unit based on a bleed of 133 Lpm (35 gpm). Based on an assumed production rate of 9,470 Lpm (2,500 gpm) and a 3 perce ... [9]

The applicant has indicated that restoration will be sequenced with production at the facility. Thus, initially only production will occur at each mine unit. However, as production moves from one wellfield to another, restoration and production will occur simultaneously. Eventually, after production is complete, only restoration will be undertaken. The applicant has indicated that restoration will consumed additional water, particularly during the groundwater sweep phase. Also, during restoration, approximately 20 to 25 percent of the groundwater treatment flow through the reverse osmosis unit is disposed of as brine that is sent to the deep well disposal. Based on liquid disposal rates predicted for the deep injection wells, net withdrawals may approach 379 Lpm (100 gpm) at both the Nichols Ranch and Hank Units during the combined production and restoration phase and during the restoration phase alone. The applicant has not, as yet, provided predictions of the drawdowns that such withdrawals would create or an evaluation of the impact of these drawdowns.

The analysis of the predictions of drawdown during production (see Section 4.5.3.2.2.2) has already indicated that at 133 Lpm (35 gpm), production drawdown from the Nichols Ranch Unit will likely reach a 8 km (5 mi) radius from the unit. The additional consumptive used of groundwater that will accompany aquifer restoration would accentuate these drawdown effects. Given the ample amount (446 feet on average) of available hydraulic head in the Nichols Ranch area, the temporary environmental impact due to consumptive use during restoration at the Nichols Ranch Unit has the potential to be moderate, particularly for wells located just outside the Nichols Ranch boundary. After production and restoration are complete and groundwater withdrawals are terminated at the Nichols Ranch Unit, groundwater levels will tend to recover with time. Thus, the potential long-term environmental impact from consumptive use during the restoration phase at Nichols Ranch Unit will be SMALL.

For the Hank Unit, the analysis of the predictions of drawdown during production (see Section 4.5.3.2.2.2) has indicated that at 284 Lpm (75 gpm), production withdrawals should result in limited, localized drawdowns. The limited drawdowns were due to the unconfined nature of the production aquifer (F-Sand) at the Hank Unit. The additional pumping amounts that may occur during restoration are not likely to increase these drawdowns significantly. Thus, the potential environmental impact due to consumptive use of groundwater during aquifer restoration at the Hank Unit is likely to be SMALL.

The unconfined condition of the F Sand at the Hank Unit will result in cones of depression around pumping wells. Consequently, portions of the aquifer will be drained by the pumping process. The restoration of the aquifer will require methods that return water to those drained portions of the aquifer to remove lixiviant and contaminants that are retained in the vadose zone.

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. However, the fluids transported in these pipes during restoration are generally less potent than during production. 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

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in shallow aquifers. However, as discussed in Section 4.5.3.2.2.1, the applicant has commited to an aggressive leak detection (Section 7.5.3.1 of the TR, Uranerz 2008b) and spill cleanup program (Section 4.4 of the TR, Uranerz 2008b), as well as preventative measures such as well mechanical integrity testing. Consequently, the implementation of these measures should result in MODERATE potential restoration-related impacts to shallow (near surface) aquifers for the Nichols Ranch and Hank Units because these aquifers are close to the surface and are used for watering livestock.

The disposal of waste fluids via deep well injection of waste is planned during mine restoration in much the same manner as during mine 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 will be SMALL.

4.5.3.1.4 Decommissioning Impacts to Groundwater

As indicated in the GEIS (Section 4.3.4.2.4), 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. The applicant plans an aggressive leak detection (Section 7.5.3.1 of the TR, Uranerz 2008b) and spill cleanup program (Section 4.4 of the TR, Uranerz 2008b). Without these mitigating measures, the resultant impact to the shallow aquifer could potentially be LARGE; however, the implementation of these measures should mitigate the potential impact (i.e., early detection and cleanup) and result in MODERATE potential operational impacts to shallow (near surface) aquifers for the Nichols Ranch and Hank Units.

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 will be plugged and abandoned in accordance with the Wyoming UIC program requirements. The wells would be filled with cement and clay and then cut off below plough depth to ensure that groundwater does not flow through the abandoned wells (Stout and Stover, 1997), (Uranerz, 2007,TR). 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, 2009a).

Furthermore, prior to NRC's termination of the ISR source material license, the licensee must demonstrate that there would be no long-term impacts to underground sources of drinking water. Earlier NRC approvals of the completion of wellfield restoration at the site would have

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Comment [a16]: If we do not have confirmation that the applicant will commit to the BMPs call the impact moderate but indicate if it was mitigated to BMPs it would be small.Done JWB

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4.5.3.2 Alternative 2 (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. Wells that have already been constructed would be plugged to prevent the degradation of aquifers with better water by aquifers with poor water. With the plugging effort complete, Alternative 2 would result in no impacts to groundwater from an ISR. Impacts on the groundwater from other activities in the area such as Coal Bed Methane (CBM) extraction are possible but not as a result of the No-Action alternative.

4.5.3.3 Alternative 3 (No Hank Unit)

Alternative 3 would include issuing Uranerz a license for the construction, operation, aquifer restoration, and decommissioning of facilities for ISR uranium milling and processing as proposed by Uranerz, but only for the Nichols Ranch Unit and not the Hank Unit. This would result in the same environmental impact as identified for the Nichols Ranch Unit for Alternative 1 (see Section 4.5.3.1), while removing those impacts identified for the Hank Unit.

4.5.3.3.1 Construction Impacts to Groundwater

As indicated during the evaluation of the potential environmental impacts at the Nichols Ranch Unit, the potential environmental impacts to groundwater resources during construction of the Nichols Unit would be SMALL based on the limited nature of construction activities and implementation of management practices to protect shallow groundwater.

4.5.3.3.2 Operation Impacts to Groundwater

As discussed previously, during operation, the potential environmental impact to shallow groundwater quality at the Nichols Ranch Unit appears to be MODERATE. Additionally, the potential short-term environmental impact due to consumptive use during operation at the Nichols Ranch Unit is SMALL. After production and restoration are complete and groundwater withdrawals are terminated at the Nichols Ranch Unit, groundwater levels will tend to recover with time. Thus, the potential long-term impact from consumptive use during the operational phase at Nichols Ranch Unit remains SMALL. The potential environmental impact to groundwater quality in the production zone during operations is likely to SMALL at the Nichols Ranch Unit. During operations, the potential environmental impact to deep aquifers below the production aquifers of deep well injection of waste is assumed to be SMALL.

4.5.3.3.3 Aquifer Restoration Impacts to Groundwater

During aquifer restoration, the short-term environmental impact due to consumptive use during restoration at the Nichols Ranch Unit has the potential to be MODERATE. After production and restoration are complete and groundwater withdrawals are terminated at the Nichols Ranch

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Comment [A17]: Can we summarize the impacts under this alternative to say they are small except for drawdown due to the same processes described above?

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Unit, groundwater levels will tend to recover with time. Thus, the potential long-term environmental impact from consumptive use during the restoration phase at Nichols Ranch Unit is likely to be SMALL. The potential impact to shallow groundwater during restoration at the Nichols Ranch Unit appears to be MODERATE. During aquifer restoration, the potential environmental impact to deep aquifers below the production aquifers of deep well injection of waste will be SMALL.

4.5.3.3.4 Decommissioning Impacts to Groundwater

During decommissioning, the potential environmental impacts to the groundwater resources in shallow aquifers at the Nichols Ranch Unit would be expected to be SMALL. The potential environmental impacts due to well abandonment at the Nichols Ranch Unit would also be expected to be SMALL (NRC, 2008). As described in 4.5.3.1.4, prior to NRC's termination of the ISR source material license, the licensee must demonstrate that there would be no long-term impacts to underground sources of drinking water. Earlier NRC approvals of the completion of wellfield restoration at the site would have determined that the restoration standards that had been met were protective of public health and safety.

References

NRC, 2009. Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities. NUREG-1910. Vol. 1 and 2. June 2009.

NRC, 2009b. "Staff Assessment of Groundwater Impacts from Previously Licensed In-Situ Uranium Recovery Facilities." Memorandum from C.Miller to Chairman Jaczko, et al. July 10, 2009. ADAMS Accession Number ML091770402]

Uranerz, 2007. Nichols Ranch ISR project U.S.N.R.C. Source Material License Application, Volume III, Environmental Report. November 2007. Casper, Wyoming. Accession No. ML080090338.

Uranerz, 2007. Nichols Ranch ISR project U.S.N.R.C. Source Material License Application, Volume I, Technical Report. November 2007. Casper, Wyoming. Accession No. ML080080609.

Uranerz, 2009, ML091610137

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Deleted: 4.5.3.3 Alternative B (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. Wells that have already been constructed would be plugged to prevent the degradation of aquifers with better water by aquifers with poor water. With the plugging effort complete, Alternative B would result in no impacts to groundwater. ¶
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Alternative D would include issuing Uranerz a license for the construction, operation, aquifer restoration, and decommissioning of facilities for ISR uranium milling and processing as proposed by Uranerz, but using evaporation ponds rather than deep well injection as an alternative liquid waste disposal method. The primary potential environmental impact of evaporation ponds to groundwater would be through leakage from the ponds to shallow (near surface) groundwater. All other potential environmental impacts to ... [10]

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Page 8: [1] Deleted **Paul Michalak** **10/02/2009 12:34:00 AM**

If the aquifer cannot be returned to preoperational conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels (MCLs) provided in Table 5C of 10 CFR 40 Appendix A or to Alternate Concentrations Limits (ACL) approved by NRC. For these reasons,

Page 8: [2] Comment [A10] **alk** **10/16/2009 6:09:00 PM**

Clarify this, Why are impacts small if there could be impacts to water that can be sued for agricultural purposes. Still need to clarify the risk associated with the well that is suitable for agricultural use The impacts in this section are directed to the production zone aquifer. The impacts to G and H Sands is large or moderate depending on the effectiveness of mitigative efforts. JWB

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As described in the GEIS, it is thought that the original ore front deposit was formed by the intrusion of an oxidized groundwater solution into an aquifer whose conditions were generally more reducing. The porous medium of the aquifer contained dispersed minerals with redox-sensitive elements in lower oxidation states. Uranium in its IV oxidation state (reduced) is relatively insoluble. On oxidation to the VI state, the uranium solubility increased significantly. As a result, reduced uranium in the solid was converted to oxidized uranium that dissolved in the groundwater. The dissolved uranium was transported in the oxidized groundwater. As the oxidizing solution advanced through the aquifer, it reacted with reducing minerals, including those that contained uranium. However, gradually the intruding solution's oxidizing capacity was depleted. Eventually that capacity reached a state at which the intruding solution could no longer efficiently mobilize uranium. It is at this location where the uranium minerals were concentrated as a result of the precipitation of dissolved uranium.

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are sorption and precipitation

Page 8: [5] Comment [A12] **alk** **10/12/2009 6:54:00 PM**

Shorten and clarify this discussion. Simply state that the chemical conditions at the site reduce the mobility of the uranium

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The introduction of lixiviant containing unnaturally high concentrations of oxygen and carbonate is an effort to remobilize the front. The processes that contribute to the remobilization of the uranium are competing with the natural processes that would tend to immobilize the ore. The processes that control the fate of the system depend, in part on the balance of mass of the competing reactants. The applicant can control the amount of oxygen injected into the aquifer. The natural amount of sorbing and/or reducing minerals in the aquifer constrain the movement of uranium and other reactive constituents found in the ore[A1].

Page 9: [7] Comment [a15] **alk** **10/16/2009 5:11:00 PM**

Also indicate that Done JWB unconfined conditions create restoration issues. However, an approved decommissioning plan is required which demonstrates that NRC clean up requirements can be met before NRC will terminate the license

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The unsaturated conditions overlying the ore-bearing deposits also present special concerns. Normally, the production zone in an ISR project remains fully saturated and under pressure. However, in unconfined conditions such as those found at the Hank Unit, there is the potential that the oxidants injected into the production zone may volatilize and create a vapor lock. These issues are still being evaluated as part of the concurrent safety review and are the subject of ongoing discussions with the applicant. Pending the resolution of these issues, potential environmental impact due to changes in water quality and potential horizontal or vertical excursions at the Hank Unit cannot be evaluated.

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As discussed in Section 4.5.3.2.2.2 of this EA, the applicant has presented predictions of drawdown during production at both the Nichols Ranch Unit and the Hank Unit. Based on an assumed production rate of 13,250 Lpm (3,500 gpm) and a 1 percent bleed rate, the applicant has provided predictions of drawdown at the Nichols Ranch Unit based on a bleed of 133 Lpm (35 gpm). Based on an assumed production rate of 9,470 Lpm (2,500 gpm) and a 3 percent bleed rate, the applicant has provided predictions of drawdown at the Hank Unit based on a bleed of 284 Lpm (75 gpm).

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4.5.3.4 Alternative D (Alternate Liquid Waste Disposal Method)

Alternative D would include issuing Uranerz a license for the construction, operation, aquifer restoration, and decommissioning of facilities for ISR uranium milling and processing as proposed by Uranerz, but using evaporation ponds rather than deep well injection as an alternative liquid waste disposal method. The primary potential environmental impact of evaporation ponds to groundwater would be through leakage from the ponds to shallow (near surface) groundwater. All other potential environmental impacts to groundwater identified in the evaluation of Alternative B would remain the same.

As indicated in the GEIS (Section 2.7.2), evaporation ponds would be constructed, operated, and monitored for leakage in accordance with NRC regulations at 10 CFR Part 40, Appendix A. Evaporation ponds at NRC-licensed ISR facilities are designed with leak detection systems to detect liner failures. The licensee also must maintain sufficient reserve capacity in the retention pond system so the contents of a pond can be transferred to other ponds in the event of a leak and the subsequent corrective action and liner repair. Licensees can minimize the likelihood of impoundment failure by designing the pond embankments in accordance with the criteria found in NRC Regulatory Guide 3.11. Sufficient freeboard height above the liquid level ensures containment during wind and rain events. As indicated in the GEIS (Section 4.3.12.2), leaks may occur over the operational life of a pond; however, the pond design helps to contain leaks and the monitoring would detect leaks before a significant release of material to the environment occurs. Based on these considerations, the potential environmental impact from the use of a pond is generally considered to be SMALL.

The potential environmental impact at the Nichlols Ranch ISR Project to shallow groundwater due to releases at the surface from piping or value failures has already been evaluated for Alternative B (Section 4.5.3.2.2.1). As indicated in that evaluation, the potential environmental impacts to shallow water due to leaks from 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. The evaluation of Alternative B indicates that the depth to shallow groundwater in the southern portion of the Nichols Ranch Unit is limited. Data indicate that the depth to groundwater in the general area of the proposed processing plant is only 15.2 m (50 ft) and portions of the projected production zone extend to the area adjacent to the Cottonwood Creek alluvium, where groundwater may be as shallow as 3 m (10 ft). This limited unsaturated zone offers a limited buffer to absorb and attenuate any releases at the ground surface. Moreover, shallow groundwater likely flows to Cottonwood Creek alluvium, and if left unchecked, shallow groundwater contamination could migrate into and along this alluvial material to the west. The groundwater quality data for the F Sand indicate that groundwater in this unit has relatively high TDS, but appears suitable for stock watering in many areas. The well survey provided by the applicant indicates that there are a number of stock watering wells within a half-mile radius of the project area. While it is uncertain how many of these wells are screened in the shallow aquifer, some of these wells may be potentially impacted by releases at the ground surface that migrate downgradient to the west. Thus, potential impact to shallow groundwater during operation at the Nichols Ranch Unit was found to be MODERATE

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add to this potential environmental impact to shallow groundwater.

The evaluation of Alternative B indicates that the depth to shallow groundwater appears somewhat greater at the Hank Unit than the Nichols Ranch Unit. There is generally a 30.5 m (100 ft) or more separation from the ground surface to shallow water beneath most of the production zone and planned processing facility. However, the southern portion of the ore body extends into an area where shallow water is projected to be within 15.2 m (50 ft) of the surface. Water quality data from the H Sand (the shallow aquifer) indicates that groundwater quality in this unit is relatively good and suitable for multiple purposes. The well survey provided by the applicant indicates that there are a number of stock watering wells within a half-mile radius of the project area. It is uncertain how many of these wells are screened in the shallow aquifer. However, the H Sand lies over the shallow F Sand which is the production zone in the Hank Unit. Those wells in close vicinity to the site that are screened in the H Sand are also likely screened in the F Sand as well. The applicant has indicated that wells screened across the F Sand in the vicinity of the Hank will be abandoned. Thus, wells using shallow groundwater from the H Sand will likely be abandoned and will not be directly impacted by releases at the surface. Regardless, due to the shallow depth to groundwater in the southern portion of the Hank Unit area and relatively good groundwater quality in the shallow aquifer, the potential impact to shallow groundwater at the Hank Unit is likely MODERATE under Alternative B. The addition of evaporation ponds under Alternative D would not likely change this potential impact. Consequently, potential environmental impact to shallow groundwater under Alternative D is likely MODERATE.