U.S.NRC
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NUREG-1910
Supplement 3

Environmental Impact Statement for the Lost Creek ISR Project in Sweetwater County, Wyoming

Supplement to the Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities

Draft Report for Comment

U.S. Nuclear Regulatory Commission
Office of Federal and State Materials and Environmental Management Programs

I/63

3.5.2 Groundwater

3.5.2.1 Regional Groundwater Resources

As indicated in the GEIS (Section 3.2.4.3), the Crooks Gap Uranium District, where the Lost Creek site is located, is part of the Wyoming West Milling Region (NRC, 2009). The Crooks Gap District lies within the Great Divide Basin, an internally closed drainage basin that contains uranium bearing aquifers and encompasses 10,250 km^2 (3,959 mi^2). Hydrologic recharge areas are predominately along the topographically elevated margins of the basin, hence surface and groundwater flow is toward the center of the basin. As the Lost Creek project area is northeast of the basin center, groundwater flow at the site is towards the southwest. Regionally, the Great Divide Basin is part of the regional Upper Colorado River Basin aquifer system, a 51,800 km^2 (20,000 mi^2) system that also includes the Green River and Washakie structural basins of southwestern Wyoming.

The Colorado River Basin aquifer system was subdivided by Whitehead (1996) into five principal aquifers; the Laney aquifer (Tertiary), the Wasatch/Battle Spring-Fort Union aquifer (Lower Tertiary), the Mesa Verde Aquifer (Cretaceous - Mesozoic), and Upper and Lower Paleozoic aquifers. In the project area the stratigraphic units that host the Laney aquifer, the Green River Formation, are not present. As such, at the Lost Creek site, the shallowest Lower Tertiary aquifers consist of sandstone units within the Wasatch/Battle Spring and Fort Union Formations. These formations are up to 3,350 m (11,000 ft) thick in Sublette County; about 2,135 m (7,000 ft) thick near the center of the basin in south-central Wyoming and over 1,890 m (6,200 ft) thick in the project area. These uppermost aquifers serve as regional water supplies for drinking water and livestock, and also host a series of uranium-rich sedimentary units. While these aquifers are identified as the most important and most extensively distributed and accessible groundwater source in the study area by Collentine et al. (1981), the waters typically contain high levels of radionuclides (greater that EPA MCLs) within the basin and locally contain saline water where they are deeply buried. Below these Tertiary units is the Upper Cretaceous Lance/Fox Hills Formation that consists of very fine-grained sandstone, siltstone, and coal beds, which are not considered to be important aquifer units in the project area. Beneath this hydrologic system is a regionally continuous aquitard, the Upper Cretaceous Lewis Shale, which is between about 191 - 381 m (625 -1250 ft) thick in the project area. Due to its low permeability nature and significant thickness, 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 Mesa Verde aquifer system, the top of which is 2286 m (7500 ft) bgs in the project area, consists of interbedded sandstones and shales underlain by Permo-Triasssic confining units approximately 5486 m (18,000 ft) bgs. The Mesa Verde aquifer is generally too deep to economically develop for water supply or have elevated TDS concentration that renders them unsuitable for human consumption. Below the Permo-Triassic confining units the principal aquifers in Paleozoic rocks are the Tensleep Sandstone of Pennsylvanian and Permian age and the Madison Limestone of Devonian and Mississippian age. Sandstone, limestone, and dolomite beds of Pennsylvanian to Cambrian age also are water bearing. Because they are the most deeply buried and contain saline water almost everywhere, the Paleozoic aquifers are rarely used for water supply in southwestern Wyoming. Locally, however, where aquifer units crop out near structural highs along the basin margin (e.g., the Rawlins Uplift and Rock Springs Uplift), water is less saline and contains lower concentrations of radionuclides due to their proximity to the recharge areas and shorter residence time in the formations.

3.5.2.2 Local Groundwater Resources

The Lost Creek Site is directly underlain by the Battle Spring Formation, the upper part of the shallow Lower Teritary aquifer system that extends to a depth of over 1,890 m (6,200 ft). The formation is interpreted to represent a major alluvial system, consisting of thick beds of very fine- to coarse-grained arkosic sandstones separated by various layers of mudstones and siltstones and finer grained beds, with conglomerate beds locally present. The multiple sandstone layers serve as the main water-bearing units and are typically under confined conditions between the finer grained units, but locally unconfined conditions exist. Regionally, the potentiometric surface within shallow aquifer units is usually within 61 m (200 ft) of the ground surface. Most wells drilled for livestock water supply in this unit are less than 305 m (1,000 ft) deep and draw water from the higher permeability sandstone units. Uranium mineralization in the Battle Spring Formation is associated with finer-grained sandstones and siltstones, which may contain minor organic matter in a few areas. This mineralization predominates in several horizons in the upper portion [top 213 m (700 ft)] of the Battle Spring Formation in the project area and its distribution described in more detail below.

3.5.2.3 Uranium-Bearing Aquifers

As discussed in Section 3.4.1, the top 213 m (700 ft) of the Battle Spring Formation was divided by the applicant into at least five horizons denoted from top to bottom as BC, DE, FG, HJ, and KM (see Figure 3-8). 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, which, based on pumping tests, appear to be hydraulically interconnected. As such, the applicant considers the combined HJ Sands as a single aquifer and has designated these sands as the production zone aquifer. The HJ sand units are bounded by areally extensive confining units identified as the Lost Creek Shale and the Sage Brush Shale, which respectively overlie and underlie the proposed production zone. The FG Horizon overlies the Lost Creek Shale and the KM occurs beneath the Sage Brush Shale. The Lower FG (LFG) sand has been designated by the applicant as the aquifer overlying the production zone, and the Upper KM (UKM) sand has been designated as the aquifer underlying the production zone. The UKM, however, is also identified as a potential future production zone. The shallowest occurrence of groundwater within the project area is within the DE Horizon, with the depth to water table varying from approximately 24 to 46 m (80 to 150 ft) below ground surface. The DE Horizon is separated from the FG Horizon below by an unnamed shale layer approximately 9 m (30 ft) thick.

Within the HJ Horizon 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). The top of the HJ Horizon ranges from approximately 91 to 137 m (300 to 450 ft) bgs within the project area. The upper, middle and lower sand units are generally separated by discontinuous thin clayey units that do not act as confining units to prevent groundwater movement vertically between the HJ Sands horizons (LCI, 2008a).

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 is not impervious to groundwater flow. 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 would be the case 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 m/m (ft/ft) (3.4 to 5.6 m/km [18.0 to 29.6 ft/mi]). 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 m/m (ft/ft) (5.3 to 6.3 m/km [28 to 33.3 ft/mile]). 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.

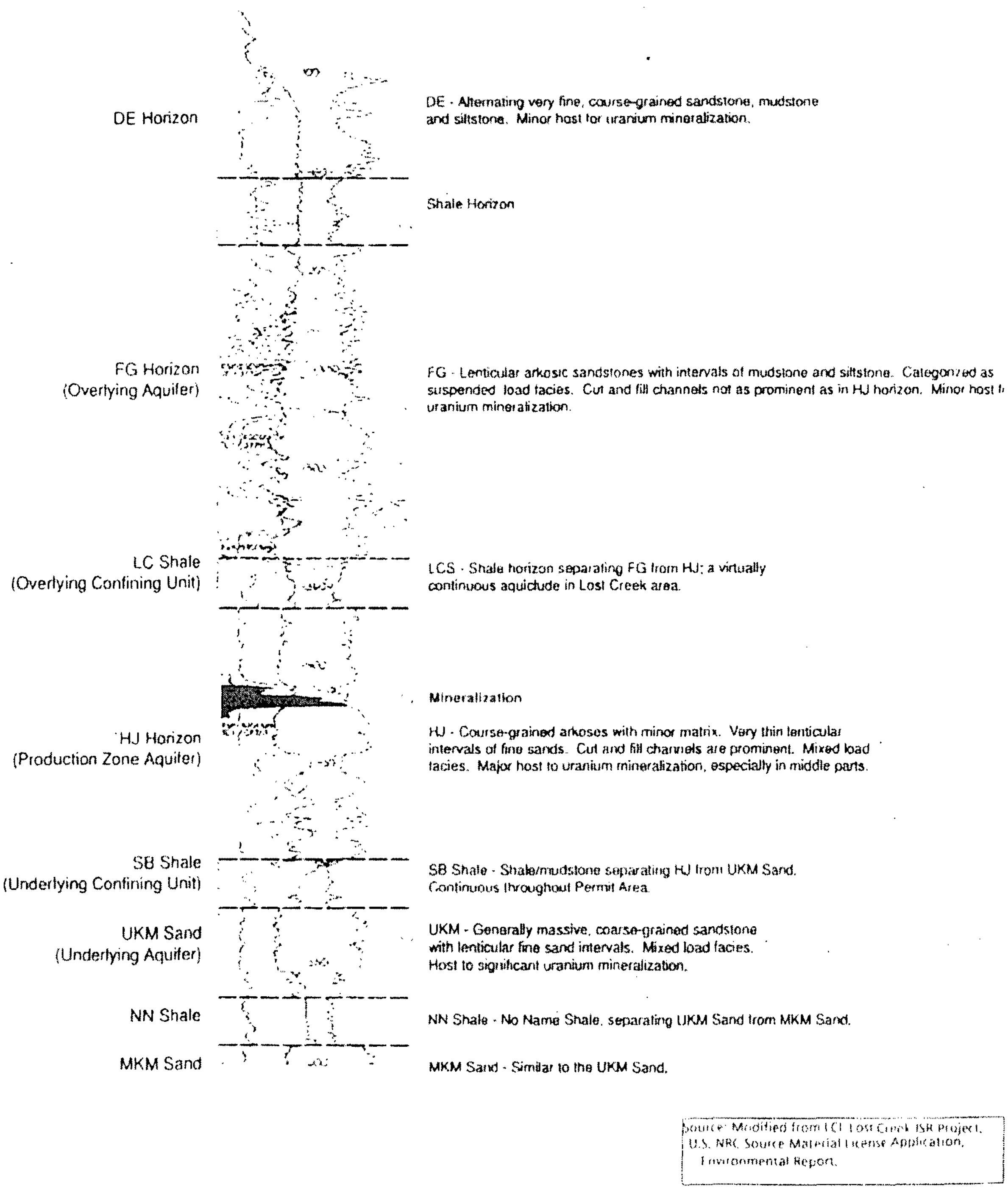

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Figure 3-8 Hydrostratigraphic Units

3.5.2.3.1 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 ore body 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 x 10^{-5} to 1.5 x 10^{-4} and averaged 1.1 x 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 x 10^{-5} to 9.1 x 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 HJ production zone and the overlying FG and underlying UKM aquifers.

3.5.2.3.2 Level of confinement

As discussed in Section 3.4.1, the HJ horizon is bounded above and below by areally 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 extraction 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 will be provided in the Mine Unit Data Packages.

3.5.2.3.3 Groundwater Quality

In Wyoming, the quality of groundwater is measured against either US EPA Drinking Water Standards (40 CFR Part 142 and 40 CFR Part 143) which establish Maximum Contaminant Levels (MCLs) for specific chemical constituents or Wyoming Ground Water Quality standards. The Wyoming standards are based on ambient water quality and are divided into three Classes: Class 1 is defined as suitable for domestic use, Class II is defined as suitable for agriculture, Class III is defined as suitable for livestock, Class IV is defined as suitable for industrial use, and Class Special (A) is defined as suitable for fish and aquatic life (WDEQ, 2005).

Lost Creek ISR, LLC established the site pre-operational groundwater quality in the Lost Creek license area from well data collected by recent sampling in 2006 and 2007 and historical sampling performed by Conoco in the late 1970s and early 1980s. The recent data included four quarters of water sampling in fall and winter 2006 and spring and summer 2007. The groundwater quality was measured in three wells in the DE surficial aquifer, four wells in LFG overlying aquifer, six wells in HJ ore zone aquifer and four wells UKM underlying aquifer. The location of the wells is shown in Figure 3-9. The applicant presented the groundwater quality data for all four quarters for all wells in Table 2.7-13 of the TR. The groundwater quality parameters measured included all suggested analytes in Table 2.7.3-1 of the standard review plan except silver.

NRC staff determined the average ground water quality in the Lost Creek license area from wells in the surficial DE aquifer, overlying LFG aquifer, HJ ore zone aquifer and UKM underlying aquifer from the data. The results are shown in Table 3-2. The table indicates that the average water quality in the surficial DE aquifer exceeded the WDEQ Class I, II and III and EPA primary drinking water standards for gross alpha, uranium, and combined Ra 226 and 228. These standards were exceeded in all wells for all quarters. One well, LC 31M in the far southwest corner of the license area exceeded the WDEQ Class I and EPA primary drinking water standards for sulfate and selenium for all four quarters.

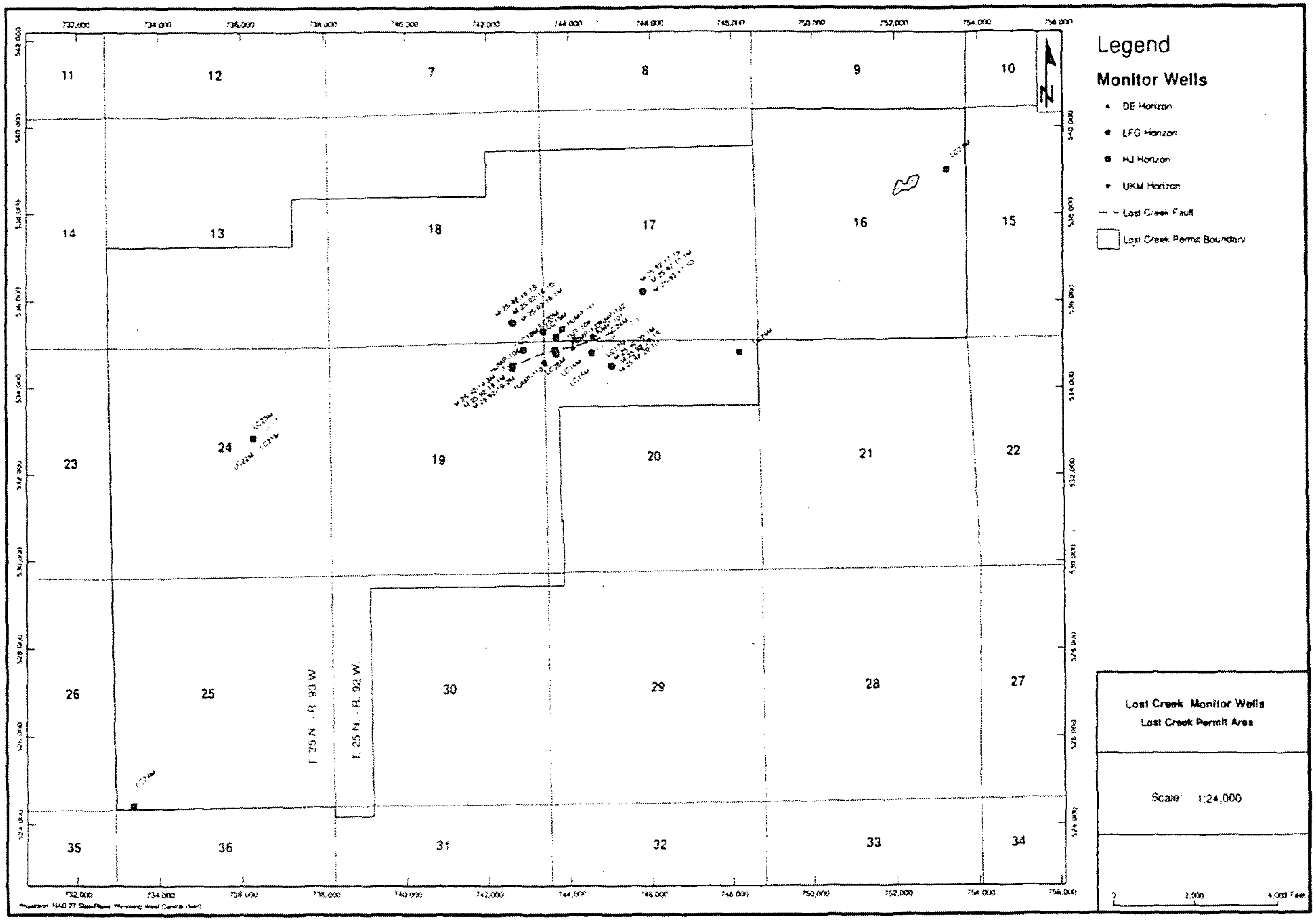

Figure 3-9. Monitoring Wells

Table 1-1. Average Pre-Operational Baseline Groundwater Quality for the Lost Creek License Area Aquifers

Water Quality Parameter	Lost Creek License Area				
	Water Quality Standards*	DE Surficial Aquifer	LFG Overlying Aquifer	HJ Ore zone Aquifer	UKM Underlying Aquifer
Bicarbonates as HCO3 (mg/l)		150	114	111	82
Carbonates as CO3(mg/l)		ND	2.5	3.5	27.8
Alkalinity (mg/l)		104.5	102.2	105.5	84.5
Chloride (mg/l)	250	6.3	5.3	5.5	5.5
Conductivity (umhos/cm)		566.8	463	485.9	558
Fluoride (mg/l)	2.0 - 4.0	0.3	0.21	0.21	0.20
pH (s.u.)	6.5 - 8.5	7.68-8.07	**7.32-8.57**	**7.85-9.51**	**7.66-11.6**
Total Dissolved Solids (mg/l)	500	347	296	311	297
Sulfate (mg/l)	250	135.7	121.5	131.9	117.6
Radium 226 (pCi/l)	*5*	**2.8**	**26.6**	**143.3**	**9.1**
Radium 228 (pCi/l)	*5*	**2.4**	**3.8**	**6.6**	**3.49**
Uranium (mg/l)	0.03	**0.74**	**0.41**	**0.17**	**0.031**
Gross Alpha (pCi/l)	0.01	**495.9**	**356**	**395.4**	**41.3**
Gross Beta (pCi/l)	2.0	157.7	107.9	117.5	23.1
Nitrogen, Ammonia as N (mg/l)	0.5	0.027	0.08	0.015	0.39
Nitrogen, Nitrate+Nitrite as N (mg/l)	10	0.7	0.6	ND	ND
Aluminum (mg/l)	0.05 to 0.2	ND	ND	ND	ND
Arsenic (mg/l)	0.1	0.003	0.003	0.006	0.006
Barium (mg/l)	2.0	ND	ND	ND	ND
Boron (mg/l)		ND	ND	ND	ND
Cadmium (mg/l)	0.005	ND	ND	ND	ND

Table 1-1. Average Pre-Operational Baseline Groundwater Quality for the Lost Creek License Area Aquifers					
Calcium (mg/l)		68.1	58.8	67.7	51.5
Chromium (mg/l)	0.1 (total)	ND	ND	ND	ND
Copper (mg/l)	1.0	ND	ND	ND	ND
Iron (mg/l)	0.3	0.21	**0.37**	0.09	0.12
Lead (mg/l)	0.015	ND	ND	ND	ND
Magnesium (mg/l)		4.3	3.31	3.65	2.45
Manganese (mg/l)	0.05	ND	ND	ND	ND
Mercury (mg/l)	0.002	ND	ND	ND	ND
Molybdenum (mg/l)		ND	ND	ND	ND
Nickel (mg/l)	0.1	ND	ND	ND	ND
Potassium (mg/l)		2.3	3.1	4.4	10.9
Selenium (mg/l)	0.05	**0.079**	0.024	0.002	0.002
Silica (mg/l)		15.6	14.1	14.9	14.4
Sodium (mg/l)		40.3	32.3	31.5	36.2
Vanadium (mg/l)		ND	ND	ND	ND
Zinc (mg/l)	5.0	ND	ND	ND	ND

10 CFR Part 141 and 10 CFR Part 143
Wyoming Water Quality, Rules and Regulations, Chapter 8, Class 1, Domestic Ground Water
Note: Numbers in bold exceeded Wyoming Class I or EPA drinking water standards.

This well also had the highest values of uranium (1.4-2.1mg/l) and gross alpha (967-1430 pCi/L) of all wells at the site. The average water quality in the LFG overlying aquifer also exceeded the WDEQ Class I, II, and III and EPA primary drinking water standards for gross alpha, uranium, and combined Ra 226 and 228 in all of the wells over all four quarters. These standards were exceeded in all wells for all quarters. The four wells across the license ranged from 0.251-0.546 mg/l uranium.

The average water quality in the HJ ore zone aquifer also exceeded the WDEQ Class I, II, and III and EPA primary drinking water standards for gross alpha and combined Ra 226 and 228 in all but two of the wells over all four quarters. The exceptions were wells LCM27M and LCM28M, whose uranium concentrations were below the MCL of 0.03 mg/l; averaging 0.002 mg/l and 0.008 mg/l, respectively. Nonetheless, their gross alpha and combined Ra 226 and 228 values exceeded the aforementioned standards, which is consistent with the presence uranium ore bodies in the aquifer unit. Uranium concentrations in the waters from the other HJ sands monitoring wells had an average range of 0.065 to 0.552 mg/l, which is between 2 and 18 times the MCL for uranium. One well, LC 26M, in the eastern part of the license area, exceeded the WDEQ Class I and EPA secondary drinking water standards for sulfate and TDS.

The average water quality in the UKM underlying ore zone aquifer also exceeded the WDEQ Class I, II, and III and EPA primary drinking water standards for gross alpha and combined Ra 226 and 228 in all of the wells over all four quarters. Two of the wells, LC20M and LC24M, located in the ore zone area, also exceeded these standards for uranium.

The water quality data demonstrate that none of the aquifers tested near and within the ore zone in the Lost Creek license area meet WDEQ Class I, II, III or EPA primary drinking water standards for radionuclides. Nonetheless, for ISR operations to be conducted in an aquifer, it must be declared as an exempt aquifer by the EPA. An exempt aquifer is one that is not nor will ever be used for drinking water given its water quality. The water quality of the HJ sand production zone aquifer in the project area is Class VI under WDEQ standards, which under the State's classification means the groundwater can not be used for drinking, livestock or agricultural use as a consequence of its uranium and radium 226 concentrations. It would therefore be a candidate for an exempt aquifer declaration.

3.5.2.3.4 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 is in standby mode. 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. These aforementioned wells are depicted on Figure 3-10 of the ER and are represented by well numbers 6, 10, 11, and 15 in the table below.

Table 1-2. Existing Wells within 5 Miles of Project Area					
Well No. (Map)	Well Permit Number/Name.	Well Depth (ft.)	Depth (ft.) to Static Water	Projected Aquifer Horizons	Projected Drawdown
1	P6572W	216	60	DE, FG	15 ft
2	P8444P	280	250	FG, HJ	160 ft
3	P8461P	600	-1	DE, FG	16 ft
4	P8462P	600	60	DE, FG	16 ft
5	P10696P	237	-1	DE, FG, HJ	160 ft
6	P13834P/4451	900	104	DE, FG, HJ, KM	40 ft
7	P47137W	unknown	unknown	unknown	unknown
8	P55108W	220	138	DE, FG	15 ft
9	P5111W	300	199	KM	15 ft
10	P5112W/4775	280	155	HJ, KM	199 ft
11	P55113W/4777	220	109	DE, FG	22 ft
12	P55114W	320	237	KM	15 ft
13	P63765W	380	140	DE, FG	15 ft
14	P183470W	unknown	unknown	unknown	unknown
15	Eagle Nest Draw	370	269	DE, FG	15 ft

Source:

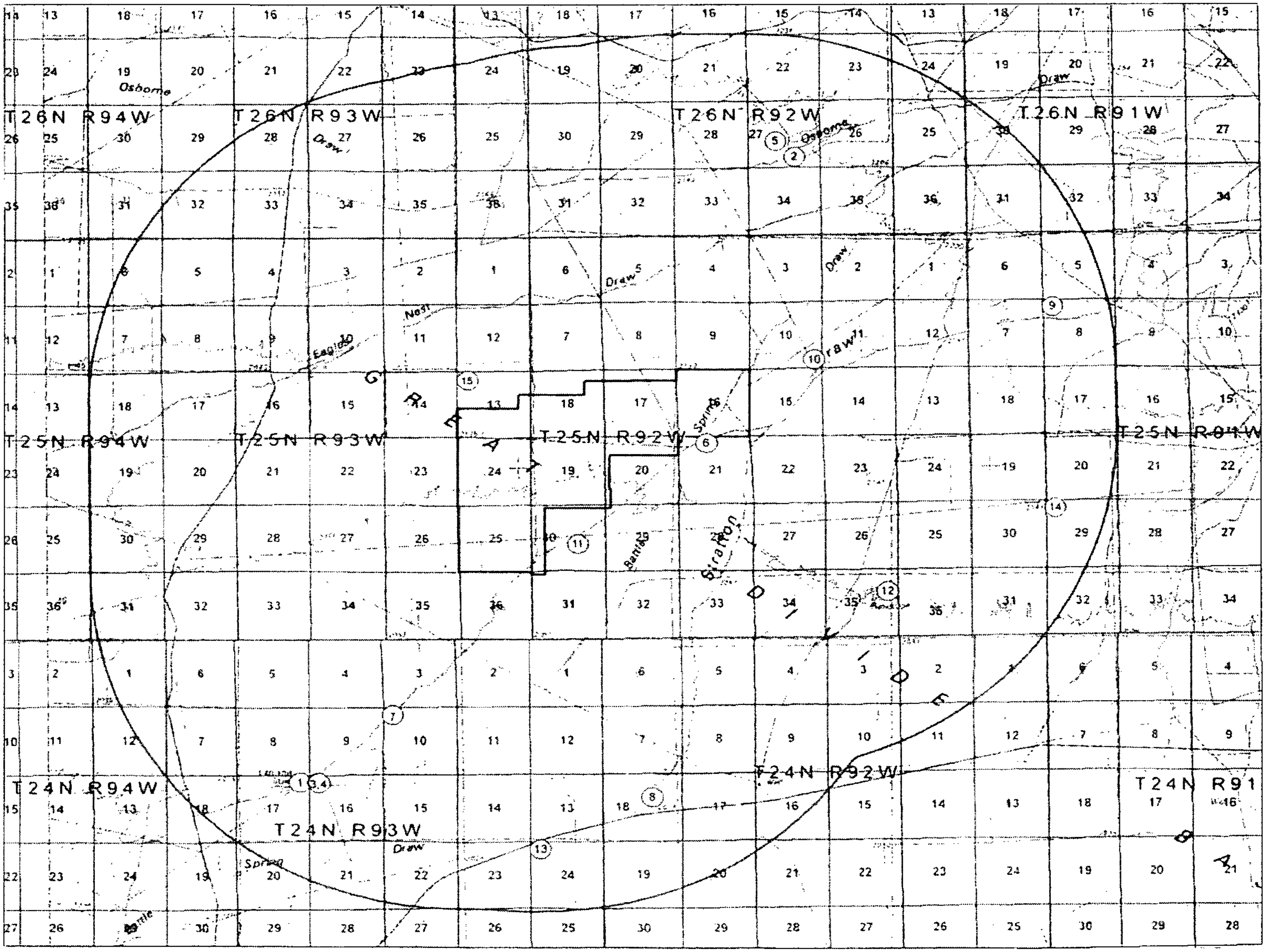

Figure 3-10. Domestic and Stock Wells within 5 Miles of Lost Creek Project Area

Within an 8-km (5-mi) radius, the applicant has identified fifteen active domestic or stock wells (including the four stock wells 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 four other stock wells and one used by Kennecott Uranium within the 8-km (5-mi) radius of the project area. Eight of the BLM wells are at or shallower than the proposed the HJ Horizon production zone (~370 – 500 ft.), however, because the Battle Spring formation is said to dip 3 degrees to the west (Section 2.6.1.2, LCI TR, 2008), the HJ Horizon is expected to be progressively shallower to the east and deeper to the west of the site. As such, a projection of the HJ horizon would place three of the shallower wells to east and northeast (wells 2, 5 and 10) within the production horizon. The applicant has predicted potential drawdowns in the production zone aquifer of 54m (177 ft) at 3.2-km [2-mi] and 45m (148 ft) at 8-km (5-mi) (LCI, 2008c – RAI responses). Consequently, wells 2, 5 and 10 could be potentially be affected out to 8-km (5-mi) by ISR operations at Lost Creek.

3.5.2.4 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. These surrounding aquifers are hydrologically upgradient of the proposed production zone at Lost Creek and are separated stratigraphically as well.

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.

Deep well injection has been proposed for the disposal of RO brines. Typically, deep well injection in the Great Divide Basin occurs in Upper Cretaceous formations several thousand feet below the Lower Tertiary production zones. The applicant has proposed four injection wells 2560m (8400 ft) deep (LCI, 2009); which is at the level of the Mesa Verde formation under the project area. The Mesa Verde formation is beneath the Lewis Shale aquitard. The applicant has indicated that it will apply for the requisite Class I Underground Injection Control (UIC) permits through WDEQ. As required, the disposal well will be completed (i.e., screened) in an approved subsurface formation(s) and will be operated according to the permit requirements.

4.5.2 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 could potentially impact aquifers above and below the uranium-bearing production zone, as well as the uranium-bearing aquifer itself outside of the license area. Surface or near surface activities that can introduce contaminants into soils are more likely to impact shallow (near-surface) 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.

4.5.2.1 Proposed Action (Alternative 1)

4.5.2.1.1 Construction Impacts to Groundwater

As indicated in the GEIS (Section 4.2.4.2.1), potential impacts to groundwater during construction is primarily from consumptive use of groundwater, injection of drilling fluids and muds during well drilling, and spills of fuels and lubricants from construction equipment. During the construction of the well fields and facility at Lost Creek, 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.

The consumptive water use during construction at the Lost Creek site would be generally limited to dust control, drilling support, and cement mixing. Most water used for construction at the Lost Creek project would be extracted from a well completed in the FG horizon. The sands in this horizon constitute an aquifer unit located at depths from 55 to 107 m (180 to 350 ft) below surface, which are hydrologically separated from the HJ production sand and DE surficial aquifer. The consumptive water use during construction is expected to be small and temporary relative to the water supply available in the FG Sands.

The volume of drilling fluids and muds used during well installation is expected to be limited and best management practices would be applied to prevent, identify and correct impacts to soils and the surficial DE aquifer at Lost Creek. Drilling fluids and muds would be placed into mud pits to control the spread of the fluids, to minimize the area of soil contamination and to enhance evaporation. According to the site potentiometric data, the depth to the water table in the surficial DE aquifer at Lost Creek ranges from 24 to 46 m (80 to 150 ft) below ground surface and a low permability BC horizon overlies the DE horizon. Therefore any small amount of leakage from the pits or spills from drilling activities should result in only a small amount of infiltration and not cause noticeable changes in the DE surficial aquifer water quality. The introduction of drilling fluids to the DE, FG, and HJ aquifers may occur during drilling of production wells and monitoring wells, but is expected to be minimal, as drilling muds are designed to seal the hole so that casing may be set.

As wells are installed, some water may be pumped from aquifers for hydrologic tests for pumping tests. This water would be discharged to the surface in accordance with approved permits from the State of Wyoming that the applicant would obtain prior to any release. The surface discharge permits protect near surface aquifers by limiting the discharge volume and prescribing concentration limits to waters that can be discharged.

During all construction operations at Lost Creek, the groundwater quality of near surface aquifers would further be protected if best management practices are employed during facility construction and well field installation. The volume of fuels and lubricants to be kept in the license area during construction is usually small and minor leaks or spills would not be expected to contaminate the groundwater. Such spills would principally be surficial in nature and would have a SMALL impact on surface soils and vegetation.

Based on this analysis, consumptive groundwater use during the construction phase is limited and is expected to have a SMALL and temporary impact. The impacts to soil and groundwater resources during well field and facility construction would be SMALL based on the limited nature of construction activities and implementation of best management practices to protect soils and shallow groundwater. Based on the foregoing analysis, site-specific conditions are consistent with the assumptions stated in the GEIS.

After its independent review of the Lost Creek Environmental Report, the site visit, meetings with the BLM, FWS, WDEQ, SHPO, Sweetwater County, BIA, and other potential stakeholders, and the evaluation of available information, the NRC Staff concludes the site-specific conditions, along with the actions proposed, are comparable to those described in the GEIS for Groundwater and incorporates by reference the GEIS' conclusions that the impacts to Groundwater during construction are expected to be SMALL. Furthermore, while the NRC Staff has identified additional new information during its independent review; it nevertheless, does not change the expected environmental impact beyond what was described in the GEIS.

4.5.2.1.2 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, 2009).

4.5.2.1.2.1 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. 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 EIS, 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 hosts the aquifer directly overlying the production zone (HJ Horizon).

A survey of groundwater wells in the area (see Section 3.5.3 of this EIS) 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 minimal. Any releases would likely be slowed or attenuated by the low permeability beds within the BC Horizon or 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. Based on the foregoing analysis, site-specific conditions are consistent with the assumptions stated in the GEIS for a SMALL impact.

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 a leak detection and spill cleanup program as outlined in section 5.7.8.3 (Storage Pond Leak Detection) and section 4.0 (Effluent Control Systems) of the TR (LCI, 2008). 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 in section 5.3.2 of the TR (LCI, 2008).

After its independent review of the Lost Creek Environmental Report, the site visit, meetings with the BLM, FWS, WDEQ, SHPO, Sweetwater County, BIA, and other potential stakeholders, and the evaluation of available information, the NRC Staff concludes the site-specific conditions, along with the actions proposed, are comparable to those described in the GEIS for Near Surface Aquifers and incorporates by reference the GEIS' conclusions that the impacts to Near Surface Aquifers during operation are expected to be MODERATE, but may be reduced to SMALL, providing monitoring and detection systems function properly, and responses are made quickly. Furthermore, while the NRC Staff has identified additional new information during its independent review; it nevertheless, does not change the expected environmental impact beyond what was described in the GEIS.

4.5.2.1.2.2 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 re-injected 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 (about 1 to 1.5% of groundwater withdrawal) and also includes other smaller losses. The production bleed is the net withdrawal maintained to ensure groundwater gradients toward the center of the production network. This net withdrawal ensures there is an inflow of groundwater into the well field to minimize excursions of lixiviant and its associated contaminants out of the well field.

Consumptive water use during ISR operations could potentially impact local water users who use 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.

Assuming an average withdrawal rate over the life of the Lost Creek 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, 50 m (164 ft) at 4.8 km (3 mi) and 45 m (148 ft) at 8 km (5 mi). Actual drawdown during operations will be dependent on the behavior of the Fault barrier under production conditions and vertical flow from overlying and underlying FG and UKM aquifers. Leakage through these barriers would have the effect of reducing the drawdown relative to those predicted above. Excessive drawdown could also be mitigated by providing pumps to flowing wells that stop flow in response to mine unit 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 (LCI, 2008a).

As discussed in Section 3.5.3.1 of this EIS, fifteen wells have been identified within 8 km (5 mi) of the project area that could be impacted by drawdown. Water levels in any of these wells open to the HJ horizon could be significantly impacted. Although many of these wells are not installed at the same depth as the production wells, the estimated 3-degree dip (west) of the Battle Spring formation may allow potential drawdown to affect several shallower wells to the east and northeast. Because the assumption used in making the predictions that the HJ Horizon is extensive and confined may not be accurate, some groundwater may be drawn from overlying and underlying aquifer units during production as well. This would result in an accompanying reduction in water levels in wells penetrating these sands and could result in drawdowns in the nearby stock wells. Based on the information supplied by the applicant, three of the wells within an 8-km (5-mi) radius, particularly to the east and northeast of the facility, could be significantly impacted 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 many years to occur.

A reduction in water levels in nearby wells could increase the pumping requirements for these wells, with complete dewatering possible in two wells; P5112W/4775 and P8444P. It appears that one of the nearby BLM wells, P10696P, taps a confined aquifer that has sufficient hydraulic head for groundwater to flow to the surface by artesian pressure, negating the need for a pump. Reduction in hydraulic head at this well may stop it from naturally flowing to the surface and require a pump to raise water to the ground surface. Under the conservative drawdown scenario presented by the applicant, only a few (3) of the 15 stock wells would be adversely affected by ISR operations, hence the short-term impact of consumptive groundwater use during mine operation and restoration would expected to be MODERATE. Mitigation of excessive drawdown by the applicant during operation and restoration, using the methods mentioned earlier in this section would change this impact to SMALL. Although there would be potentially slow recovery of water levels to preoperational depths after restoration is complete, the available hydraulic head in the existing wells is great enough that the long-term environmental impact from consumptive use during the operational phase at Lost Creek is expected to be SMALL. Based on the foregoing analysis, site-specific conditions are consistent with the assumptions stated in the GEIS for a MODERATE impact assessment, as local water users near a well field could be affected in the short-term in the same aquifer.

After its independent review of the Lost Creek Environmental Report, the site visit, meetings with the BLM, FWS, WDEQ, SHPO, Sweetwater County, BIA, and other potential stakeholders, and the evaluation of available information, the NRC Staff concludes the site-specific conditions, along with the actions proposed, are comparable to those described in the GEIS for Consumptive Use to Production and Surrounding Aquifers and incorporates by reference the GEIS' conclusions that the impacts to Consumptive Use to Production and Surrounding Aquifers during operation are expected to be MODERATE, but may be reduced to SMALL, providing monitoring and detection systems function properly, and responses are made quickly. Furthermore, while the NRC Staff has identified additional new information during its independent review; it nevertheless, does not change the expected environmental impact beyond what was described in the GEIS.

Excursions and Groundwater Quality: As discussed in the GEIS, groundwater quality in the production zone is degraded as part of ISR operations. In Wyoming, the portion of the production aquifer used for the ISR process must be exempted as an underground source of drinking water by the U.S. Environmental Protection Agency. After production is completed, the licensee is required to initiate aquifer restoration activities to restore the production zone water quality to preoperational baseline levels, MCLs or ACLs. If the aquifer cannot be returned to preoperational baseline conditions, NRC requires that the production aquifer be returned to the MCLs provided in Table 5C of 10 CFR Part 40 Appendix A or to Alternate Concentration Limits (ACLs) approved by NRC. For proposed ACLs to be approved, they must be shown to be protective of public health at the site. 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. Based on the foregoing analysis, site-specific conditions are consistent with the assumptions stated in the GEIS for a SMALL impact determination.

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 of 1 to 1.5%) 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 lixiviant 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 in order to control the excursions.

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 lixiviant 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, 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.

In Section 2.11.4 of the GEIS, the NRC staff documented, that based on historical information, excursions have occurred at operating ISR facilities. Separately, the NRC staff analyzed the environmental impacts from both horizontal and vertical excursions at three NRC-licensed ISR facilities. 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, however, none resulted in environmental impacts (NRC, 2009b).

Many of the hydrogeologic conditions at the proposed Lost Creek ISL facility are similar to those found at other ISL facilities. Groundwater in the HJ production aquifer may be confined locally and the aquifer displays sufficient hydraulic conductivity to minimize excursions during 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. The site-specific hydrogeology, however, has several unique features that present challenges for the Lost Creek site. Foremost among these features is the Fault that runs through the project area (see Section 3.4 of this EIS). Displacement along the fault results in geologic beds that are offset across the Fault. Thus, the production zone, overlying, and underlying aquifers do not appear to be laterally 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 3.5.2.1 of this EIS). While these shales are areally 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 tests 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 require review and approval by the NRC. The applicant indicates that engineering practices are available to isolate the lixiviant from overlying and underlying aquifers, but has not provided supporting information. The applicant, however, must be able to design and install monitoring network that is capable of detecting both horizontal and excursions from the production zone, and must demonstrate that restoration is feasible.

This all being said, the aquifers bounding the proposed HJ production zone, as well as the HJ horizon itself, contain naturally high levels of radionuclides and exceed the WDEQ Class I, II and III and EPA primary drinking water standards for gross alpha, uranium, and combined Ra 226 and 228. Consequently, any impacts to water quality due to excursions, either horizontally in the production zone or vertically into the bounding aquifer units, during operations are expected to be SMALL. Based on the foregoing analysis, site-specific conditions are consistent with the assumptions stated in the GEIS for a potentially SMALL environmental impact, so long as the applicant (LCI) installs and maintains the monitoring well network properly.

After its independent review of the Lost Creek Environmental Report, the site visit, meetings with the BLM, FWS, WDEQ, SHPO, Sweetwater County, BIA, and other potential stakeholders, and the evaluation of available information, the NRC Staff concludes the site-specific conditions, along with the actions proposed, are comparable to those described in the GEIS for Excursions and Groundwater Quality and incorporates by reference the GEIS' conclusions that the impacts to Excursions to Groundwater Quality during operation are expected to be MODERATE, but may be reduced to SMALL, providing monitoring and detection systems function properly, and responses are made quickly. Furthermore, while the NRC Staff has identified additional new information during its independent review; it nevertheless, does not change the expected environmental impact beyond what was described in the GEIS.

4.5.2.1.2.3 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 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 Cretaceous Mesa Verde aquifer included in the Upper Colorado River Basin aquifer system is typically deeply buried, contain saline water and are not commonly tapped for water supply (Whitehead, 1996). The Mesa Verde aquifer is separated from the overlying aquifers (including the ore-bearing aquifer) by the regionally extensive Lewis Shale. Hence, the Mesa Verde aquifer could be suitable for disposal of brine solutions and other liquid wastes.

Lost Creek plans to dispose of waste fluids using deep well injection and is seeking a permit for a Class I 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 and not affect any overlying potable aquifers. 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. Based on the foregoing analysis, site-specific conditions are consistent with the assumptions stated in the GEIS. Therefore, impacts from operation are expected to be SMALL.

After its independent review of the Lost Creek Environmental Report, the site visit, meetings with the BLM, FWS, WDEQ, SHPO, Sweetwater County, BIA, and other potential stakeholders, and the evaluation of available information, the NRC Staff concludes the site-specific conditions, along with the actions proposed, are comparable to those described in the GEIS for Deep Aquifers Below the Production Aquifer and incorporates by reference the GEIS' conclusions that the impacts to Deep Aquifers Below the Production Aquifer during operation are expected to be SMALL. Furthermore, while the NRC Staff has identified additional new information during its independent review; it nevertheless, does not change the expected environmental impact beyond what was described in the GEIS.

4.5.2.1.3 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 to 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 well field 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, in order to render uranium less mobile. 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 4.5.2.1.4). 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 are considered consumptive.

As discussed in Section 4.5.2.1.4 of this SEIS, the applicant has provided predictions of drawdown based on an average consumptive use of 656 Lpm (175 gpm) during the project period. The applicant plans to concurrently restore individual well fields 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 well fields in production and restoration was considered when developing the above estimate of average consumptive use. As discussed in Section 4.5.2.1.4, significant drawdown in hydraulic head have been calculated. 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 50 m (164 ft) at 4.8 km (3 mi), and 45 m (148 ft) at 8 km (5 mi). Although the prediction is for drawdown in the HJ Horizon based on the assumption that the HJ Horizon is fully confined above and below, there may be potential cause drawdown in units overlying and underlying the HJ Horizon which can impact water levels and groundwater usage in a number of nearby stock wells. Consequently, the temporary impact of consumptive groundwater use during aquifer restoration is likely to be MODERATE. These temporary effects could span many years; however, the final impact would likely be SMALL since water levels should eventually recover after aquifer restoration is complete.

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 4.5.2.1.4. 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 ISR operation. As previously indicated in Section 4.5.2.1.4, it is assumed that the potential environmental impact to deep aquifers below the production aquifers of deep well injection of waste would be SMALL. Based on the foregoing analysis, site-specific conditions are consistent with the assumptions stated in the GEIS. Therefore, impacts from aquifer restoration are expected to be SMALL.

After its independent review of the Lost Creek Environmental Report, the site visit, meetings with the BLM, FWS, WDEQ, SHPO, Sweetwater County, BIA, and other potential stakeholders, and the evaluation of available information, the NRC Staff concludes the site-specific conditions, along with the actions proposed, are comparable to those described in the GEIS for Groundwater and incorporates by reference the GEIS' conclusions that the impacts to Groundwater during aquifer restoration are expected to be MODERATE, but may be reduced to SMALL, providing monitoring and detection systems function properly, and responses are made quickly. Furthermore, while the NRC Staff has identified additional new information during its independent review; it nevertheless, does not change the expected environmental impact beyond what was described in the GEIS.

4.5.2.1.4 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. Based on the foregoing analysis, site-specific conditions are consistent with the assumptions stated in the GEIS (NRC, 2009).

After its independent review of the Lost Creek Environmental Report, the site visit, meetings with the BLM, FWS, WDEQ, SHPO, Sweetwater County, BIA, and other potential stakeholders, and the evaluation of available information, the NRC Staff concludes the site-specific conditions, along with the actions proposed, are comparable to those described in the GEIS for Groundwater and incorporates by reference the GEIS' conclusions that the impacts to Groundwater during decommissioning are expected to be SMALL. Furthermore, the NRC Staff has not identified new and significant information during its independent review that would change the expected environmental impact beyond what was described in the GEIS.

4.5.2.2 No-Action (Alternative 2)

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 or affect the functioning of existing BLM stock wells in the affected environment. Consequently, the No-Action alternative would result in no impacts to groundwater.

4.5.2.3 Dry Yellowcake (Alternative 3)

Alternative 3 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 the proposed action. Consequently, the potential environmental impacts to groundwater for Alternative 3 are identical to those identified for the proposed action.

5.5 Water Resources

5.5.1 Surface Water

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5.5.2 Groundwater

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 evaporation ponds or deep well injection

The principal activities that have occurred in the past, that are currently taking place, and that are expected to continue in the future, include grazing, herd management, hunting and mineral extraction. The Rawlins RMP EIS evaluated the potential impacts of past, present, and reasonably foreseeable future actions in the Great Divide Basin on groundwater resources (BLM, 2008b). The primary impacts anticipated were consumptive use and degradation of water quality. Impacts to groundwater quality would depend in large part on the quality and maintenance of oil and gas wells as well as in-situ or other extractive use activities (mostly exploration). Existing levels of mineral extraction activities, combined with the reasonably foreseeable future development, would increase the potential for such impacts. Impacts of drawdown from past, present, and reasonably foreseeable future activities was noted as less of a concern due to the depths of many water formations in the region (305 to 3,050 m; 1,000 to 10,000 ft), and their resulting impracticality for use. Impacts to groundwater from past, present, and reasonably foreseeable future activities in the Lost Creek area of the Great Divide Basin are thus anticipated to be MODERATE. The cumulative effects of the Lost Creek ISR project, when added to these MODERATE impacts of current and future use, are expected to be MODERATE.

6.2.5 Groundwater Monitoring

Groundwater environmental monitoring would be conducted at private and BLM-owned wells within 2 km (1.2 mi). of the permit area on a quarterly basis, with the owners' consent. Samples would be analyzed for uranium and Ra-226. Of the 17 monitoring wells already drilled, and the one private well sampled, more than two-thirds show elevated radionuclide concentrations (Table 3-3). None of these wells, however, are used for drinking or agricultural purposes, and the elevated radionuclide concentrations are consistent with uranium ore within the aquifer.

6.3 Physiochemical Monitoring

This section describes the proposed monitoring program to characterize and evaluate the chemical and physical environment. The purpose is to provide a basis for evaluating changes in the environment resulting from the proposed action. Two aspects must be considered: 1) baseline monitoring, used to support a pre-operational description of the environment; and 2) operational monitoring, used to support potential changes (impacts) to the environment as a result of uranium milling.

6.3.1 Well Field Groundwater Monitoring

As described in Section 8.3 of the GEIS (NRC, 2009), ISR production processes directly affect groundwater in the operating well field. For this reason, groundwater conditions are extensively monitored before, during and after operations. The pre-operational groundwater monitoring that occured at Lost Creek is described below in Section 6.3.1.1. The groundwater quality monitoring that would occur during and after operation is described in Section 6.3.1.2.

6.3.1.1 Pre-Operational Groundwater Sampling

A licensee must establish baseline groundwater quality before beginning uranium production in a well field (NRC, 2009). This is done to characterize the water quality in monitoring wells that would be used to detect lixiviant excursions from the production zone, to recover excursions, and to establish standards for aquifer restoration after uranium recovery is complete. The requirements and details of sampling programs to establish pre-operational groundwater quality are described in Section 8.3.1.1 of the GEIS (NRC, 2009).

LCI installed a monitor well network to provide an evaluation of pre-mining (baseline) conditions within the Lost Creek project area. The baseline groundwater monitoring program is described, in detail, in Section 5.7.8.1 of the applicant's Technical Report (TR), and the results of that monitoring program are described, in detail, in Section 2.7.3 of the TR. To establish baseline groundwater quality, quarterly groundwater samples were collected from 17 monitoring wells and one water supply well. These wells were completed in the production aquifer (designated as the HJ Horizon), the underlying aquifer (designated as the UKM horizon), and in the overlying aquifer (designated as the DE and LFG horizons). Sampling of all the wells began in September 2006, with the exception of four well in which sampling was begun in 2007. This sampling program provided a preliminary baseline analysis of groundwater quality and is intended to describe the overall quality of groundwater that now exists beneath the project area. It should be noted that this does not, necessarily, provide the final basis for establishing restoration criteria for the individual well fields in which uranium milling would be conducted.

6.3.1.2 Groundwater Quality Monitoring

A baseline water quality assessment and restoration goal for each well field would be provided prior to beginning uranium recovery. This assessment would be provided to the WDEQ after being reviewed and approved by the LCI's Safety and Environmental Review Panel (SERP) and the NRC. A detailed description of the monitoring program that would be used to establish baseline water quality is provided in Section 5.7.8.2 of the LCI's TR. Production zone wells (injection and production pattern area) would be sampled four times with a minimum of two weeks between samplings during baseline characterization. The production wells would be selected based on a density of one well per three acres of well fields. During the first two sampling events, each well would be sampled for the full set of constituents required by the WDEQ (Table 6-1). The constituent list may be reduced during subsequent sampling events based on the result of the first two sampling events.

As described in the GEIS (NRC, 2009), monitoring wells would be placed around the perimeter of well fields, in the aquifers both overlying and underlying the ore-bearing (production) aquifers, as well as within the production aquifer for the early detection of potential horizontal and vertical excursions of lixiviants (Figure 2-7). Monitoring well placement is based on what is known about the nature and extent of the confining layer and the presence of drill holes, hydraulic gradient and aquifer transmissivity, and well abandonment procedures used in the region. The ability for a monitoring well to detect groundwater excursions is influenced by several factors, such as the thickness of the aquifer monitored, the distance between the monitoring wells and the well field, the distance between the adjacent monitoring wells, the frequency of groundwater sampling, and the magnitude of changes in chemical indicator parameters that are monitored to determine whether and excursion has occurred. As a result, the spacing, distribution, and number of monitoring wells at a given ISR facility are site-specific and established by license conditions. The factors that control the spacing, distribution and number of monitoring wells are described in greater detail in Section 8.3.1.2 of the GEIS (NRC, 2009).

LCI has documented the groundwater monitoring program that would be implemented at the Lost Creek ISR project in Section 5.7.8 of its TR. Monitoring well locations and spacing are described in Section 3.2.2.2 of LCI's TR. Monitoring wells would be located in a perimeter ring around the well field, with the completion interval of each well targeted to the mineralized zones adjacent to the well. Distances from the perimeter monitor wells to the injection/production patterns in each well field are anticipated to be on the order of 152 m (500 ft). The distance between each of the monitoring wells in the ring is also anticipated to be on the order of 152 m (500 ft). The results of pumping tests indicate that the radius of influence of a single pumping well is much greater than 152 m (500 ft). Consequently, the proposed monitoring well rings should be in hydraulic connection with the production well fields and the proposed monitoring should allow adequate detection so that production fluids could be controlled within 60 days, as required by the NRC. LCI must further demonstrate the hydraulic interconnection between the monitoring wells and production pattern at each well field. The distances between the monitoring ring and the production wells and between each well within the ring would be based on the aquifer characteristics of that well field, and actual distances would be refined at a later time when more data becomes available for that well field.

Monitoring wells would also be completed in the aquifers immediately above and below the uppermost and lowermost mineralized zone, in the UKM and FG horizons, respectively. As previously described in Section 3.5.3 and 4.5.3, aquifer testing conducted in the project area have indicated a potential for hydraulic connection between the production zone (HJ Horizon) and the overlying FG and underlying UKM aquifers. LCI anticipates that the overlying and underlying monitoring wells would be installed at a density of approximately one well for each four acres of mine area. However, they further indicate that the actual density would be based on the aquifer characteristics of the mineralized zone and the overlying or underlying aquifer. Specific locations would be targeted depending on the thickness and continuity of the shale separating the mineralized zone and the underlying and overlying aquifer. LCI is required to demonstrate the adequacy of the monitoring program for the overlying and underlying aquifers at each mine unit.

A fault passing through the project area also complicates the design of an effective monitoring program. As previously described in Section 3.5.3 and 4.5.3, while the fault acts as an impediment to groundwater flow, it does not appear to act as an impermeable barrier. In addition, the strata are displaced across the fault. Monitoring well locations and depths must be specified that adequately represent the existing conditions and ensure adequate operational monitoring in the vicinity of the fault. The location and depth of monitoring wells intended to characterize flow across the fault, but would be determine based on individual mine unit testing.

The constituents chosen for indicators of lixiviant migration and for which UCLs would be set, are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the ion exchange process. Chloride is also a very mobile constituent in groundwater. Conductivity was chosen because it is an indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion as bicarbonate is the major constituent added to the lixiviant during mining.

Operational monitoring would consist of sampling the excursion monitoring wells at least twice monthly and at least ten days apart and analyzing the samples for the excursion indicators chloride, conductivity and total alkalinity. If two of the three UCL values are exceeded in a well during a monitoring event, the well is re-sampled within 24 hours of that determination. If results of the confirmatory sampling are not completed within 30 days of the initial sampling event, the excursion is considered confirmed. If the second sample does not exceed the UCLs, a third sample is taken. If neither second nor third round sample results exceed the UCLs, the first sample is considered in error. If the second or third round samples verify the exceedence, the well in question is place on excursion status. The NRC Project Manager and the WDEQ-LQD are notified by telephone or email within 24 hours and notified in writing within thirty days of a confirmed excursion. Corrective actions are undertaken at this point. A written report describing the excursion event, corrective actions, and corrective action results are to be submitted to the NRC within 60 days of the excursion confirmation.

Following the installation of each production pattern and monitor well network, the Well Field Hydrologic Data Package is assembled and submitted to the WDEQ for review. The contents of the data package would meet the extensive requirements established by the WDEQ. SERP would review the data package to ensure that the results of the hydrologic testing and planned mining activities are consistent with technical requirements and do not conflict with any requirement stated in NRC regulations. The Well Field Hydrologic Data Package would also be reviewed and approved by the NRC to ensure that the specific monitoring program establish for each well field would be adequate to provide a timely indication of any horizontal or vertical excursion that may occur.

Table 6.1 Baseline Water Quality Monitoring Parameters

Parameters Major Ions	Trace Constituents
Calcium	Aluminum

Magnesium	Ammonia
Potassium	Arsenic
Sodium	Barium
Bicarbonate	Boron
Chloride	Cadmium
Carbonate	Chromium
Sulfate	Copper
Nitrate (Total)	Iron
Fluoride	
General Water Chemistry	Manganese
Alkalinity 1	Mercury
Total Dissolved Solids	Molybdenum
pH (field measured)	Nickel
pH (lab measured)	Selenium
Specific Conductance (field measured)	Silica
Temperature (field measured)	Vanadium
Zinc	
Radionuclides	
Gross Alpha 1	
Gross Beta 1	
Radium-226	
Radium-228 1	
Uranium	

[1] The 1982 sampling did not include these parameters Lost Creek October 2007