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Supplement 2

Environmental Impact Statement for the Nichols Ranch ISR Project in Campbell and Johnson Counties, 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/62

3.5.2 Groundwater

3.5.2.1 Regional Groundwater Resources

As discussed in Section 3.3.4.3 of the GEIS, the Northern Great Plains aquifer system is the major regional aquifer system in the Wyoming East Uranium Milling Region. This regional aquifer system has been subdivided into five major aquifers (Whitehead, 1996). These aquifers, from the shallowest to the deepest, are the Lower Tertiary, Upper Cretaceous, Lower Cretaceous, Upper Paleozoic, and Lower Paleozoic aquifers. The Lower Tertiary aquifers consist of the sandstone beds with the Wasatch Formation and the Fort Union Formation. Both formations consist of alternating sandstone, siltstone, and claystone beds and containing lignite and subbituminous coal. Most water is stored in and flows through the more permeable sandstone beds. In the Lower Tertiary aquifers, which include the ore horizons as described below, the regional flow direction is northward and northeastward from the recharge area in northeastern Wyoming. In Wyoming, the potentiometric surface of the Lower Tertiary aquifers is higher than the underlying Upper Cretaceous aquifers; consequently, groundwater moves vertically downward from the Lower Tertiary aquifers to the Upper Cretaceous units through the confining layer separating the two aquifers. (NRC, 2009b)

The Upper Cretaceous aquifer consists of sandstone beds interbedded with siltstone and claystone in the Lance and Hell Creek Formations and the Fox Hill Sandstone. The Fox Hills Sandstone is one of the most continuous water-yielding formations in the Northern Great Plains aquifer system. The Upper Cretaceous aquifers are separated from the Lower Cretaceous aquifers by several thick confining units. The Pierre Shale, the Lewis Shale, and the Steele Shale are the regionally thickest and most extensive confining units. The lower Cretaceous aquifers are the most widespread aquifers in the Northern Great Plain aquifer system and contain several sandstones. However, the lower Cretaceous aquifers contain little freshwater. The water becomes saline in the deep parts of the Powder River Basin. The Paleozoic aquifers cover a larger area, but they are deeply buried in most places and contain little freshwater.

As previously discussed in Section 3.4 of this supplemental environmental impact statement (SEIS), the Wasatch Formation outcrops in the study area and represents most of the surficial deposits in the area except for limited Quaternary deposits within surface drainages. Extensive alluvial deposits are present in the proposed project area along Cottonwood Creek. The sandstone beds within the Wasatch Formation comprise the shallowest aquifers within the proposed project area. There are commonly multiple water-bearing sands within the Wasatch Formation. Due to their higher permeability, these water- bearing sands provide the primary sources for groundwater withdrawal. Groundwater within the Wasatch Formation aquifers is typically under confined (artesian) conditions, although locally unconfined conditions exist. Well yields from the Wasatch Formation in the southern part of the Powder River Basin where the proposed site is located are reported to be as high as 1,900 liters per minute (Lpm) (500 gallons per minute [gpm]). In the vicinity of the Pumpkin Buttes, the Wasatch Formation is known to be 480 m (1,575 ft) thick (Sharp and Gibbons, 1964).

3.5.2.2 Local Groundwater Resources

As discussed in Section 3.4 of this SEIS, Uranerz has identified a series of sand layers in the upper portion of Wasatch Formation present in the proposed project area and have labeled these layers from the shallowest to the deepest as the H, G, F, C, B, A, and 1 Sands. The sands are considered aquifers in the proposed project area. The intervening shales that separate these sands are considered aquitards due to their hydraulic properties (i.e., low permeability) and have been identified by the overlying and underlying sands. For example, the shale separating the H and G Sands has been labeled the HG Aquitard. A schematic of the typical aquifer and aquitard sequence in the proposed project area is shown in Figure 3-4. While generally present throughout the proposed project area, the nature and extent of these sands differ somewhat across the proposed project area from the Nichols Ranch Unit to the Hank Unit. In addition, depth and expression of these sands at the ground surface is influenced by the topographical relief of the proposed project area. The production aquifer at the Nichols Ranch Unit is the A Sand, while the production aquifer at the Hank Unit is the F Sand. The geologic nature and extent of the specific sands and aquitards identified in the proposed project area is discussed further in Section 3.4.

The depth at which groundwater is first encountered across the site varies and depends on surface topography. The specific sand that acts as the surficial aquifer similarly varies across the proposed project area depending on the outcropping of these sands and the surface topography. Limited groundwater level data are available to define depth to shallow groundwater across the Nichols Ranch Unit and additional wells are planned to better define shallow groundwater levels in this area. In the southern portion of the Nichols Ranch Unit, 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, the G sand is likely to be the shallow aquifer, with depth to groundwater ranging between 30 to 50 m (100 to 150 ft). Groundwater flow in the F and G Sands is projected to be in a westerly direction, most likely a result of the local topography.

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

Groundwater in the surficial aquifers is likely unconfined, although there may be portions of these aquifers that are locally confined. Those sands that underlie the surficial aquifer, particularly at depth, are generally confined.

3.5.2.3 Uranium-Bearing Aquifers

The principal uranium bearing aquifer at the Nichols Ranch Unit is the A Sand (Figure 3-4). As indicated in Section 3.4.1, the A Sand is 18 to 30 m (60 to 100 ft) thick and is located 91 m to 213 m (300 to 700 ft) below the surface at the Nichols Ranch Unit. The A Sand is thickest to the northeast and thins to the southwest and is fine- to coarse-grained. Groundwater in the A Sand is confined. The A Sand is underlain by the A1 Aquitard and the 1 Sand. The 1 Sand has been identified as the production aquifer. The A1 Aquitard is comprised of mudstones and carbonaceous shale with occasional thin lenses of poorly developed coal. This unit ranges in thickness from 6 to 11 m (20 to 35 ft). The underlying 1 Sand is variable in thickness, ranging from 3 to 26 m (10 to 85 ft) in thickness, and occurs at depths of 171 to 216 m (560 to 710 ft) bgs. The sand is very fine to coarse grained.

The A Sand is overlain by the BA Aquitard and the B Sand. The B Sand has been identified as the aquifer overlying the production aquifer. The BA Aquitard varies from 7.6 to 27 m (25 to 90 ft) in this area, thickening to the northwest and thinning to the southeast. This unit consists of mudstones and thin discontinuous light gray siltstones. The BA Aquitard has been shown to extend across the site from the Nichols Ranch Unit to the Hank Unit, where it is 24 m (80 ft) thick and is composed mainly of mudstones. The B Sand ranges in thickness from 30 to 183 m (100 to 600 ft) at the Nichols Ranch Unit. This unit is fine- to coarse-grained. The body of the B sand is occasionally separated by lenses of mudstone, siltstone, and carbonaceous shale. Some of these mudstone splits exceed 8 m (25 ft) in thickness and may extend for thousands of feet. The B Sand is very extensive and has been correlated across the gap between the Nichols Ranch and Hank Units.

The principal uranium ore zone sand member at the Hank Unit is the F Sand, which is approximately 23 m (75 ft) thick and 61 to 183 m (200 to 600 ft) bgs in this portion of the proposed project area. The water levels in the F sand fall below the base of the overlying GF Aquitard in the northern portion of the Hank Unit and slightly above in the southern portion. The F sand is therefore both an unconfined and slightly confined aquifer across the Hank Unit. The F Sand is underlain by the FC Aquitard and the C Sand. The C Sand has been designated the aquifer underlying the production zone in areas where it is present. The C Sand at the Hank Unit is 1.5 to 6.1 m (5 to 20 ft) thick, discontinuous, and is composed of fine- and very fine-grained sand. The C sand is not always present below the F Sand at the Hank Unit. At these locations, the B Sand is the sand unit underlying the production sand. The FC Aquitard is composed of mudstones, siltstones, gray carbonaceous shale, and poorly developed coal. The aquitard ranges in thickness from 14 to 24 m (45 to 110 ft), depending on the presence of the C Sand. Where the C Sand is not present, it merges with the CB Aquitard overlying the B Sand.

Water levels have been measured in wells installed in the proposed project area to define the direction and gradient of groundwater movement. The location of wells installed at the Nichols Ranch and Hank Units are shown in Figures 3-6 and 3-7, respectively. While wells have been installed in many of the identified sand aquifers, these wells have been concentrated in the production zones at the Nichols Ranch and Hank Units. Based on these water level measurements, a potentiometric map has been presented for the A Sand at the Nichols Ranch Unit (Figure 2-19 of the Technical Report [TR]) (Uranerz, 2007). This potentiometric map indicates that groundwater in the A Sand is flowing to the northwest with an average gradient of 0.0033. Based on this gradient, an effective porosity of 0.05, and an average hydraulic conductivity of 0.15 m/day (0.5 ft/day), the average rate of groundwater flow is estimated to be 0.01 m/day (0.033 ft/day). A similar potentiometric map has been presented for the F Sand across both the Nichols Ranch and Hank Units (Figure 2-20 of the TR) (Uranerz, 2007). This map indicates that water in the F Sand is flowing west with an average gradient of 0.005. Based on this gradient, an effective porosity of 0.005, and an average hydraulic conductivity of 0.18 m/day (0.6 ft/day), the average rate of groundwater flow in the F Sand aquifer across the proposed project area is estimated to be 0.018 m/day (0.06 ft/day). Similar gradients and flow directions have been observed in the B and C Sand aquifers as in the A and F Sand aquifers. The shallow sands in the Hank Unit are more likely to be affected by local topographical changes than the deeper sands. Water level data for the G Sand in the Hank Unit show a much steeper groundwater gradient.

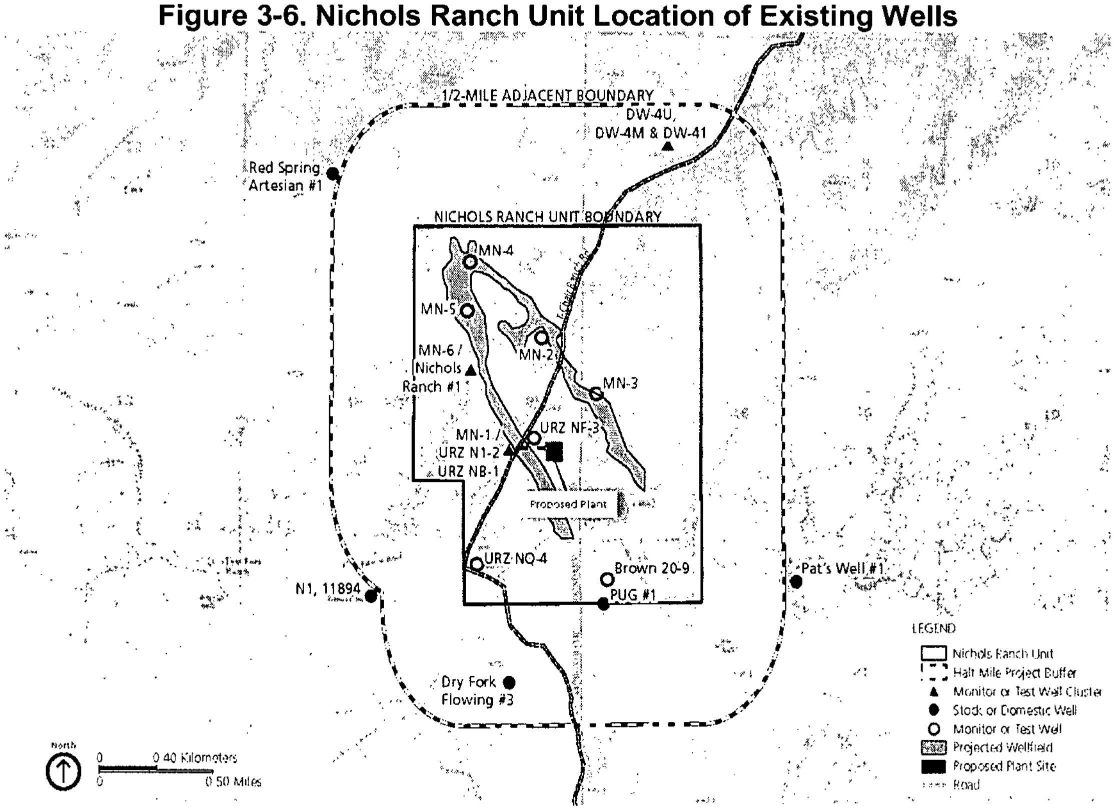
3.5.2.3.1 Hydrogeologic characteristics

The hydraulic properties of the production aquifers as well as the associated underlying and overlying aquifers have been evaluated in the project area using both multi-well pumping tests and single tests. Aquifer testing was previously conducted between 1978 and 1979 by Cleveland-Cliffs and Uranerz. Additional aquifer testing was conducted by Uranerz in 2006 and 2007. The hydraulic conductivity of the A Sand at the Nichols Ranch Unit was found to vary from approximately 0.55 to 21.3 cm/day (0.018 to 0.7 ft/day). Uranerz estimated that 15.2 cm/day (0.5 ft/day) for hydraulic conductivity best represents the A Sand in this area. A single-well test for the B Sand aquifer indicated that the hydraulic conductivity of 11.3 cm/day (0.37

ft/day) for this sand. Two single-well tests for the 1 Sand resulted in hydraulic conductivities of 5.5 and 7.9 cm/day (0.18 and 0.26 ft/day) for this sand. A single-well test in the F sand yielded a higher hydraulic conductivity of 110 cm/day (3.6 ft/day).

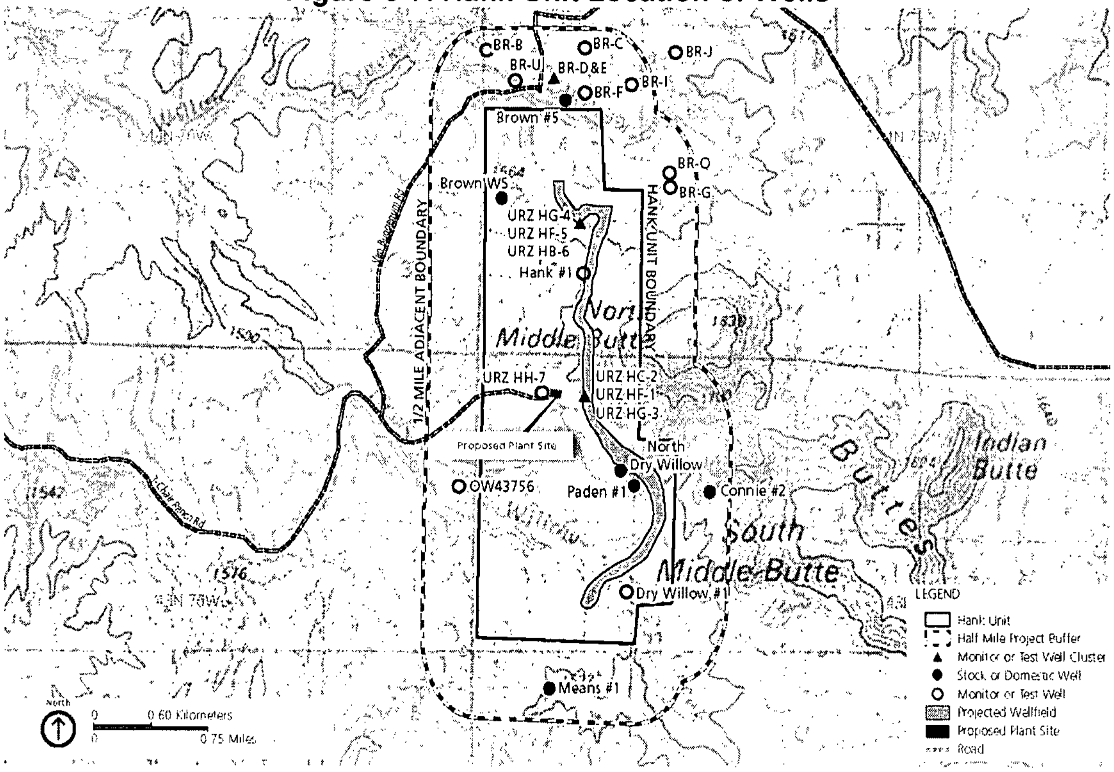
The hydraulic properties of the F Sand at the Hank Unit were found to vary greatly. The hydraulic conductivities of this unit were found to vary from 4.3 cm/day to 287 cm/day (0.14 to 9.4 ft/day). Uranerz estimated that 18.3 cm/day (0.6 ft/day) for hydraulic conductivity best represents the majority of the F sand in this area. The water-level in the ore zone at the Hank Unit is near the top of the sand and therefore the F Sand is not fully saturated. Accordingly, the F Sand aquifer is an unconfined aquifer. The primary storage property for an unconfined aquifer is specific yield. Uranerz has estimated that a specific yield of 0.05 best represents the F Sand in this area. Test results from two G Sand wells yielded hydraulic conductivity measurements for this sand of 0.15 and 0.67 cm/day (0.005 and 0.022 ft/day). A single measurement in the C Sand indicated a hydraulic conductivity value of 0.76 cm/day (0.025 ft/day). Two single well tests in the B Sand yielded hydraulic conductivity measurements of 11.6 and 67.1 cm/day (0.38 and 2.2 ft/day).

Figure 3-6. Nichols Ranch Unit Location of Existing Wells



Source: modified from Uranerz, 2007

Figure 3-7. Hank Unit Location of Wells



Source: modified from Uranerz, 2007

3.5.2.3.2 Level of confinement

Vertical permeabilities of the aquitards in the Powder River Basin have been defined at numerous locations, including just north of the Hank Unit during the permitting of the PRI North Butte ISR Project. These permeabilities have been measured using multi-well pumping tests and a variety of analytical methods. These permeabilities have also been determined using laboratory measurements. Uranerz reported that data and analysis presented in the PRI North Butte ISR Project application indicate that the vertical permeability for the aquitard separating the F and C Sands was 0.004 cm/day (1.1 x 10^{-4} ft/day). A second multi-well test at the PRI North Butte ISR Project site indicated that the aquitard permeability between the A Sand and the 1 Sand was 0.004 cm/day (1.2 x 10^{-4} ft/day). Laboratory measurements of permeabilities of samples from two aquitards were submitted for the PRI North Butte ISR Project site. These permeabilities varied from 54.9 to 0.001 cm/day (1.8 ft/day to 3.7 x 10^{-5} ft/day). These data were considered sufficient to demonstrate the confinement of the uranium-bearing sands at the project area. Aquifer confinement would be further verified at each of the well fields during the required well field multi-well pumping tests. These data would be submitted as part of the well field data packages and would be reviewed and approved by the NRC before each well field would begin operation.

3.5.2.3.3 Groundwater Quality

In Wyoming, the quality of groundwater is measured against either 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 Groundwater Quality standards. The Wyoming standards are based on ambient water quality and are divided into three classes (WDEQ, 2005):

- Class I 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.

Groundwater quality in the proposed project area has been defined by sampling numerous wells in many of the aquifers identified in the area. The resulting groundwater quality data are presented below in Table 3-4. The data in this summary have been grouped for the A Sand, the F Sand, the B and C Sands, the G and H Sands, and the 1 Sand. Included in this summary table are EPA Drinking Water Standards (40 CFR Part 142 and 40 CFR Part 143) and Wyoming Class I, Domestic Ground Water Quality standards.

The groundwater quality summary data indicate that the A Sand water has very low TDS (less than 500 mg/L), with major components being sodium, sulfate, and bicarbonate. Uranium concentrations in A Sand groundwater varied between detection and 0.027 mg/L. Radium-226 concentrations varied between detection and 36.3 pCi/L. Typically, uranium-bearing aquifers, particularly in the ore zone, exhibit uranium and radium-226 levels exceeding their respective EPA MCLs (NRC, 2009b). The relatively low concentrations found in the A Sand in the area of Nichols Ranch and Hank Units appear to be related to the length of the well screens (ranging from 21 to 34 m [69 to 110 ft] in length) which extend over the entire A Sand and are not limited to the ore zone. This would lead to dilution of the samples with water from outside the ore zone.

Groundwater quality data for the F Sand indicate that average TDS concentrations were greater than 1,000 mg/L. Sodium, calcium, bicarbonate, and sulfate are the major dissolved constituents in this water. Uranium concentrations were measured in this ore-bearing sand at an average of 0.16 mg/L, with a maximum concentration of 5.25 mg/L. Radium concentrations as high as 562 pCi/L were also measured, with an average value of 43 pCi/L. Consequently, the F Sand does not meet the Wyoming Class I, II, or III groundwater quality standards and exceeds the EPA MCL for uranium.

Water quality for the B and C Sands were grouped together by Uranerz. These sands lie between the two production zones and are connected in some areas. TDS in these aquifers averaged 793 mg/L with the major constituents being sodium, bicarbonate, and sulfate. Uranium concentrations in these aquifers averaged 0.059 mg/L, with a maximum of 2.16 mg/L. Radium concentrations in the B and C aquifers average 16 pCi/L with a maximum measured concentration of 128 pCi/L. Consequently, the B and C Sands do not meet the Wyoming Class I, II, or III groundwater quality standards and exceed the EPA MCL for uranium.

Water quality for the H and G Sands were grouped together by Uranerz. TDS in these aquifers averaged 427 mg/L with the major constituents being sodium, bicarbonate, and sulfate. Uranium concentrations in these aquifers were generally low, averaging 0.004 mg/L. Radium concentrations in the H and G aquifers average 0.44 pCi/L with a maximum measured concentration of 1.9 pCi/L. Uranium concentrations averaged 0.059 mg/L. As a result, the H and G Sands meet the Wyoming Class II groundwater quality standards and are suitable for agriculture.

Water quality for the 1 Sand is also good. TDS in this aquifer averaged 232 mg/L with the major constituents being sodium, bicarbonate, and sulfate. Uranium concentrations in this aquifer were very low, averaging 0.00015 mg/L. Radium concentrations were on average 0.1 pCi/L. Consequently, the 1 Sand meets the Wyoming Class I groundwater quality standards.

Table 3-4. Water Quality of Specific Aquifers in the Nichols Ranch Unit

Water Quality Parameter	Nichols Ranch Unit			
	"B and C sand" Overlying Aquifer	"A sand" Ore zone Aquifer	"1 sand" Underlying Aquifer	Water Quality Standards[a]
Bicarbonates as HCO_3 (mg/L)	120.65	138.86	233.75	
Carbonates as CO_3 (mg/L)	3.43	4.41	15.75	
Chloride (mg/L)	53.22	8.06	5.00	250
Conductivity (umhos/cm)	1162.68	564.13	411.5	
Fluoride (mg/L)	0.174	0.24	0.65	2.0 – 4.0
pH (s.u.)	8.15	8.48	8.63	6.5 – 8.5
Total Dissolved Solids (mg/L)	**797.11**[b]	333.14	232.0	500
Sulfate (mg/L)	**466.24**[b]	135.05	1.5	250
Radium-226 (pCi/L)	**15.44**[b]	**5.02**[b]	0.1	5.0
Nitrogen, Ammonia as N (mg/L)	**0.627**[b]	0.09	0.07	0.5
Nitrogen, Nitrate+Nitrite as N (mg/L)	0.069	0.05	0.05	10
Aluminum (mg/L)	0.095	0.05	0.05	0.05 to 0.2
Arsenic (mg/L)	0.002	0.0	0.0005	0.01
Barium (mg/L)	0.052	0.05	0.05	2.0
Boron (mg/L)	0.110	0.08	0.05	
Cadmium (mg/L)	0.004	0.0	0.0025	0.005
Calcium (mg/L)	53.22	7.61	3.75	
Chromium (mg/L)	0.016	0.02	0.025	0.1 (total)
Copper (mg/L)	0.012	0.01	0.005	1.0
Iron (mg/L)	0.109	0.07	0.015	0.3
Lead (mg/L)	0.01	0.01	0.005	0.015
Magnesium (mg/L)	10.94	0.57	0.50	
Manganese (mg/L)	0.025	0.01	0.005	0.05
Mercury (mg/L)	0.001	0.0	0.0005	0.002
Molybdenum (mg/L)	0.069	0.07	0.05	
Nickel (mg/L)	0.02	0.02	0.025	0.1
Potassium (mg/L)	6.89	2.23	2.25	
Selenium (mg/l)	0.0	0.0	0.0005	0.05
Sodium (mg/l)	189.49	113.62	99.5	
Uranium (mg/L)	**0.06**[b]	0.01	0.00015	0.03

Water Quality Parameter	Nichols Ranch Unit			
	"B and C sand" Overlying Aquifer	"A sand" Ore zone Aquifer	"1 sand" Underlying Aquifer	Water Quality Standards[a]
Vanadium (mg/L)	0.05	0.05	0.05	
Zinc (mg/L)	0.23	0.01	0.005	5.0

[a] EPA Drinking Water Standards - 40 CFR Part 142 and 40 CFR Part 143, *Wyoming Water Quality, Rules and Regulations, Chapter 8, Class I, Domestic Ground Water*

[b] Bolded values exceed either EPA or Wyoming Class I Groundwater Standards

Table 3-5. Water Quality of Specific Aquifers in the Hank Unit

Water Quality Parameters	Hank Unit			
	"G sand" Overlying Aquifer	"F sand" Ore Zone Aquifer	"B and C sand" Underlying Aquifer	Water Quality Standards[a]
Bicarbonates as HCO_3 (mg/L)	151.1	171.43	120.65	
Carbonates as CO_3(mg/L)	8.8	0.63	3.43	
Chloride (mg/L)	7.6	5.53	53.22	250
Conductivity (umhos/cm)	804.9	1426.96	1162.68	
Fluoride (mg/L)	0.2486	0.15	0.174	2.0 – 4.0
pH (s.u.)	8.4	7.82	8.15	6.5 – 8.5
Total Dissolved Solids (mg/L)	**504.4**[b]	**1020.95**[b]	**797.11**[b]	500
Sulfate (mg/L)	243.1	**597.33**[b]	**466.24**[b]	250
Radium-226 (pCi/L)	0.73	**44.6**[b]	**15.44**[b]	5.0
Nitrogen, Ammonia as N (mg/L)	0.103	0.05	**0.627**[b]	0.5
Nitrogen, Nitrate+Nitrite as N (mg/L)	0.05	0.05	0.069	10
Aluminum (mg/L)	**0.425**[b]	**0.05**[b]	0.095	0.05 to 0.2
Arsenic (mg/L)	0.0033	0.0068	0.002	0.01
Barium (mg/L)	0.055357	0.05	0.052	2.0
Boron (mg/L)	0.24643	0.08	0.110	
Cadmium (mg/L)	0.00329	0.0034	0.004	0.005
Calcium (mg/L)	48.6	99.77	53.22	
Chromium (mg/L)	0.0221	0.02	0.016	0.1 (total)
Copper (mg/L)	0.00714	0.02	0.012	1.0
Iron (mg/L)	**0.499**[b]	**0.30**[b]	0.109	0.3
Lead (mg/L)	**0.0231**[b]	0.01	0.01	0.015

Water Quality Parameters	Hank Unit			
	"G sand" Overlying Aquifer	"F sand" Ore Zone Aquifer	"B and C sand" Underlying Aquifer	Water Quality Standards[a]
Magnesium (mg/L)	9.8	24.37	10.94	
Manganese (mg/L)	**0.051**[b]	**0.07**[b]	0.025	0.05
Mercury (mg/L)	0.00047	0.0005	0.001	0.002
Molybdenum (mg/L)	0.05	0.05	0.069	
Nickel (mg/L)	0.0232	0.02	0.02	0.1
Potassium (mg/L)	6.0	7.12	6.89	
Selenium (mg/L)	0.0026	0.02	0.00	0.05
Sodium (mg/L)	110.9	185.73	189.49	
Uranium (mg/L)	0.009475	**0.15**[b]	**0.06**[b]	0.03
Vanadium (mg/L)	0.0363	0.05	0.05	
Zinc (mg/L)	0.021	0.02	0.23	5.0

[a] EPA Drinking Water Standards - 40 CFR Part 142 and 40 CFR Part 143, *Wyoming Water Quality, Rules and Regulations, Chapter 8, Class I, Domestic Ground Water*

[b] Bolded values exceed either EPA or Wyoming Class I Groundwater Standards

3.5.2.3.4 Current Groundwater Uses

Uranerz contacted the Wyoming State Engineer's Office (WSEO) to identify all permitted wells within each unit and within a 4.8-km (3-mi) radius of each unit. Numerous wells have been identified in these surveys, including wells associated with mining and aquifer monitoring, stock watering wells, and domestic wells. The survey indicates that excluding the monitoring and mining-related wells, most wells are used for livestock watering through the use of windmills or electric well pumps. The depth of these wells generally ranges between 30 and 305 m (100 and 1,000 ft). A number of the identified wells are noted to have sufficient hydraulic heads to allow the wells to discharge to the surface without pumping (flowing wells). In the proposed project area, wells that are completed in the ore-bearing zone will be abandoned per Wyoming regulations/guidance or will be used as monitoring wells if deemed appropriate (i.e., proper screen interval).

Inspection of these data for wells identified within the Nichols Ranch Unit and within a 4.8-km (3-mi) radius of the unit with depths of between 91 to 210 m (300 to 700 ft) bgs (i.e., potentially screened within the A Sand) indicates available ground water head averages around 136 m (446 ft). The survey has identified nine existing wells within the Nichols Ranch Unit excluding aquifer testing or monitoring wells. All of these wells are used for stock watering. The review of these wells conducted by Uranerz indicates that several of these wells are completed in the ore-bearing sands and would need to be abandoned or converted to monitoring wells. The survey also indicates three domestic wells within 4.8 km (3 mi) of the Nichols Ranch Unit well fields. Two of the wells (Doughstick and Garden Well) are approximately 3.62 km (2.25 mi) southeast and upgradient of the proposed well fields, while Dry Fork #1 is about 2.01 km (1.25 mi) southwest and crossgradient from the proposed well fields.

Inspection of these data for wells identified within the Hank Unit and within a 4.8-km (3-mi) radius of the unit with depths of between 61 to 180 m (200 to 600 ft) bgs (i.e., potentially screened within the F Sand) indicates available groundwater head averages around 75 m (246 ft). Six permitted wells were identified within 0.8 km (0.5 mi) of the Hank Unit. All of these are used for stock watering. Several of these wells appear to be completed in the F Sand, while other wells are screened through multiple sands including the C, B, and A Sands. Several of these wells would need to be abandoned or converted to monitoring wells. The survey also indicates three domestic wells within 4.8 km (3 mi) of the Hank Unit. A domestic well was identified 1 km (0.6 mi) north of the northern boundary of the Hank Unit. This well (BR-T) is reported to be completed in the B Sand below the westward flowing production zone (F Sand) at the Hank Unit. The other two domestic wells (Doughstick and Garden Well) are approximately 4.8 km (3 mi) southwest and crossgradient from the proposed well fields.

3.5.2.4 Surrounding Aquifers

As indicated in Section 3.3.4.3.4 of the GEIS, the Wasatch and Fort Union Formations are important aquifers for water supplies on a regional scale. The Fox Hill Sandstone is one of the most continuous water-yielding formations in the Northern Great Plans aquifer system. Except at outcrop areas, the Paleozoic aquifers are not usually used for water production because they are either deeply buried or contain saline water.

Based on the survey of water wells within a 4.8-km (3-mi) radius of the proposed site, water supply wells are generally completed within 300 m (1,000 ft) of the ground surface in the sands of the Wasatch Formation. The Fort Union Formation is not extensively used because sufficient yields of groundwater are available from the overlying Wasatch Formation.

Deep well injection has been proposed for the disposal of liquid effluent wastes. Typically, deep well injection in the Powder River Basin occurs in the Upper Cretaceous Lance Formation (e.g., Irigaray/Christensen Ranch) several thousand feet below the Lower Tertiary production zones. Uranerz has indicated that it will apply for an Underground Injection Control (UIC) permit through WDEQ. As required, the disposal well will be completed (i.e., screened) in an approved subsurface formation and will be operated according to permit requirements.

4.5.2 Groundwater Impacts

Potential environmental impacts to groundwater at the proposed Nichols Ranch ISR Project 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 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 <u>Construction Impacts to Groundwater</u>

Section 4.3.4.2.1 of the GEIS (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 mud from well drilling, and spills of fuels and lubricants from construction equipment. The GEIS further stated that groundwater use during the construction phase would be limited and would be expected to be protected by implementing BMPs such as spill prevention and cleanup. The volume of drilling fluids and muds introduced into the environment during well installation would be limited. Thus, the construction impacts to groundwater would be SMALL based on the limited nature of construction activities and the implementation of BMPs to protect shallow groundwater (NRC, 2009a).

The consumptive water use during construction would be generally limited to dust control, drilling support, and cement mixing. Most water used for construction at the proposed Nichols Ranch ISR Project would be extracted from wells completed in surficial aquifers. The consumptive water use during construction is expected to be SMALL and temporary relative to the water supply available in these aquifers.

The volume of drilling fluids and muds used during well installation is expected to be limited and BMPs would be applied to prevent, identify, and correct impacts to soils and the surficial aquifer at the proposed Nichols Ranch ISR Project. 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. Therefore, any small amount of leakage from the mud pits or spills from drilling activities should result in only a small amount of infiltration and not cause any changes in the surficial aquifer water quality. The introduction of drilling fluids to the surficial aquifers may occur during drilling of production and monitoring wells, but is expected to be small, since drilling muds are designed to seal the hole so the casing may be set.

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

During all construction operations at the proposed Nichols Ranch ISR Project, the groundwater quality of near surface aquifers would be protected by BMPs during facility construction and well field installation including implementation of a spill prevention and cleanup program to prevent soil contamination from fuels and lubricants from construction equipment. The volume of fuels and lubricants to be kept in the proposed project area is expected to be small and any leaks or spills would result in an immediate cleanup response to prevent soil contamination or infiltration to groundwater.

Based on this analysis, consumptive groundwater use during the construction phase would be limited and would be 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 BMPs to protect soils and shallow groundwater consistent with the GEIS conclusions (NRC, 2009a).

In conclusion, 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 proposed Nichols Ranch ISR Project. Even in instances where the water-table aquifer is shallow (e.g., See Section 4.5.2.1.2.1), groundwater quality of near-surface aquifers during construction would be protected by BMPs such as implementation of a spill prevention and cleanup plan to minimize soil contamination. Uranerz has committed to an aggressive program to clean up spills (Uranerz, 2007). Additionally, the amount of drilling fluids and mud 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 BMPs to protect shallow groundwater.

Additionally, after its independent review of the Uranerz's ER; the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions are comparable to those described in the GEIS for groundwater and incorporates by reference the GEIS's conclusions that the impacts to groundwater during construction are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed in the GEIS.

4.5.2.1.2 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. 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).

4.5.2.1.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

Section 4.3.4.2.2.1 of the GEIS (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 facility or central processing plant and also to connect injection and extraction wells to manifolds inside the 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 environmental 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 indicated in the GEIS, potential environmental impacts could be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydraulically separated from other locally and regionally important aquifers.

As previously discussed in Section 3.4.1 and 3.5.2 of this SEIS, the Wasatch Formation outcrops in the proposed 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. Uranerz identified a series of sand layers in the upper portion of Wasatch Formation present in the proposed 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, the depth and expression of these sands at the ground surface is influenced by the topographical relief of the proposed project area.

The depth at which groundwater is first encountered in aquifers across the Nichols Ranch Unit varies and depends on surface topography. The specific sand that acts as the surficial aquifer similarly varies across the proposed project area depending on the outcropping of these sands and the surface topography. Limited groundwater level data are available to define depth to shallow groundwater across the Nichols Ranch Unit, and additional wells are planned to better define shallow groundwater levels in this area (Uranerz, 2007). In the southern portion of the Nichols Ranch Unit, shallow groundwater is first encountered in the Cottonwood alluvium and is within 3 m (10 ft) of the ground surface (Uranerz, 2007). Moving north from the Cottonwood alluvium, shallow groundwater is first encountered in the F Sand aquifer at depths ranging from 15 to 30 m (50 to 100 ft). However, in the northernmost portion of the Nichols Ranch Unit, 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 central processing plant is approximately 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, the 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 total dissolved solids (TDS), but appears suitable for stock watering in many areas (Wyoming Class III groundwater). The well survey provided by Uranerz indicates that there are a number of stock watering wells within a

0.8-km (0.5-mi) radius of the proposed project area. 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 is similarly uncertain and the installation of additional wells are planned to identify shallow water levels in the Hank Unit (Uranerz, 2007). However, Uranerz indicated that the H Sand should be the surficial aquifer in this area, with depth to groundwater ranging between 15 m (50 ft) in the low lying areas to the west of the Hank Unit to 61 m (200 ft) along the eastern border of the Hank Unit. 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 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 at 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 indicate that this unit is suitable for livestock use (Wyoming Class III groundwater). The well survey provided by Uranerz indicates that there are six of stock watering wells within a 0.8-km (0.5-mi) radius of the proposed 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. Uranerz has planned an aggressive leak detection and spill cleanup program (Uranerz, 2007). In addition, preventative measures such as well mechanical integrity testing (Uranerz, 2007) would limit the likelihood of well integrity failure during operations.

As discussed previously for the Nichols Ranch Unit, the surficial aquifer is close to the ground surface in several areas, but these shallow aquifers do not appear hydraulically connected with more significant supplies of water from other local and regional aquifers. In one case though, the water is used by ranchers to water their stock. Therefore, the resultant impact to the shallow aquifer could potentially be MODERATE. However, the implementation of the leak detection program and mechanical integrity testing should mitigate the potential impact (i.e., early detection and cleanup) and result in SMALL potential operational impacts to shallow (near surface) aquifers for the Nichols Ranch and Hank Units.

Additionally, after its independent review of the Uranerz's ER; the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions are comparable to those described in the GEIS. The GEIS concludes that impacts to shallow aquifers during operations would be SMALL to LARGE. The staff concludes that site-specific impacts for the proposed Nichols Ranch ISR Project are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed 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 Section 4.3.4.2.2.2 of the GEIS, 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 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 the U.S. Environmental Protection Agency (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 ISR Project, portions of the A Sand at the Nichols Ranch Unit and F Sand at the 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. Water consumptive use is discussed in more detail in Section 4.3.4.2.2.2 of the GEIS.

Uranerz provided predicted drawdowns created by production bleed during operations (Uranerz, 2007). These predictions were 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 liters per minute (Lpm) (3,500 gallons per minute [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 1.8×10^{-4}. Simulations were conducted to evaluate the drawdowns resulting from concentrated drawdowns distributed at various locations in the projected well fields. These predictions show that 9 m (30 ft) of the drawdown will extend approximately 2,100 m (7,000 ft) outward from the center of the well fields. The 1.5 m (5 ft) contour is projected to extend out approximately 6,860 m (22,500 ft) or approximately 6.4 km (4 mi) from the proposed Nichols Ranch ISR Project area.

Uranerz indicated that the primary effect of the drawdowns caused by the Nichols Ranch Unit bleed should be limited to those wells that are located in the ore zone (A Sand) unit (Uranerz, 2007). 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. Uranerz 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 3.5.2.3.5, inspection of Wyoming State Engineer's Office (WSEO) well data for wells within 4.8 km (3 mi) of the Nichols Ranch Unit indicates an average of about

136m (446 ft) 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. Uranerz indicated 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 (Uranerz, 2007). A pump or other supplement may have to be installed in a flowing well if the drawdowns cause it to cease flowing. Uranerz 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 proposed Nichols Ranch ISR Project (Uranerz, 2007).

In addition to the drawdown, 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 Unit has not indicated leakage from either the overlying B Sand or the underlying 1 Sand. Specifically, Uranerz 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, 2007). Neither test indicated a hydraulic connection (drawdown) between the A Sand and the B Sand or 1 Sand. Even if leakage from underlying or overlying units were to occur in offsite areas, these drawdowns are expected to be 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 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.

As previously discussed in Section 3.5.2, the F Sand production zone at the Hank Unit is not completely saturated. 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 4-1, 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 flow rate, whereas the pressure drawdown to produce water from a confined aquifer must occur over a larger area to meet the well flow rate.

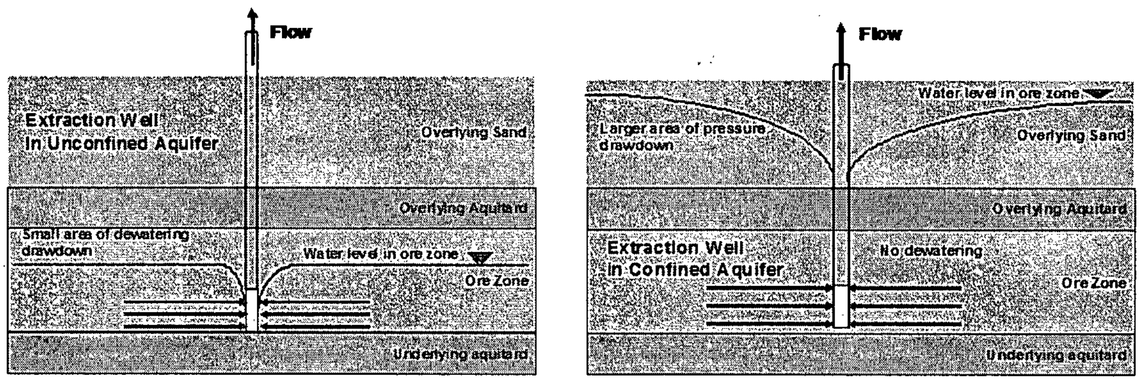


Figure 4-1. Drawdowns in an Unconfined Aquifer and Confined Aquifer from an Extraction Well Operating at Same Rate

Uranerz 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 withdrawals in the southern well field 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 well field, while the drawdowns of 1.5 m (5 ft) will extent out approximately 270 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, Uranerz 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, 2007). 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, Uranerz stated that any wells screened in the F Sand in the area immediately adjacent to the Hank Unit 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). 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.

<u>Excursions and Groundwater Quality</u>.

As discussed in Section 4.3.4.2.2.2 of 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 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 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 Part 40 Appendix A or to Alternate Concentrations Limits (ACLs) approved by the NRC. For proposed ACLs to be approved, they must be shown to be protective of public health at the site.

In Section 2.11.4 of the GEIS, 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).

Current groundwater compositions at the Nichols Ranch and Hank Units affect the use of the groundwater resource. In the Nichols Ranch Unit, the A, B, and C Sand aquifers contain water whose compositions (primarily for radium-226) exceed the Wyoming Ground Water Quality Class I (domestic use), Class II (agriculture use), and Class III (suitable for livestock) standards. In contrast, the deeper 1 Sand aquifer meets Wyoming's Class I standard. Based on cross-sections, Uranerz 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 the Hank Unit, the G and H Sands, 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 pre-existing water quality in both the Nichols Ranch and Hank Units, and the expected restoration of the production zones at both units, and due to the confinement of the Nichols Ranch Unit 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 (Uranerz, 2007).

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. Uranerz's groundwater monitoring program is detailed in Chapter 6 of this SEIS. 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 chloride 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 aquifers 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 completed wells, or to a loss of mechanical integrity of ISR injection and extraction wells. To ensure the detection of vertical excursions, the NRC also requires monitoring in the overlying and underlying aquifers (Uranerz, 2007). A program of mechanical integrity testing of all ISR wells is also required (Uranerz, 2007). Corrective action is required if any vertical excursions are detected (Uranerz, 2007).

Groundwater in the A Sand (the production zone) at the Nichols Ranch Unit is confined and there is sufficient hydraulic conductivity for ISR operations. The drawdown created by pumping in the production zone should facilitate containment of the lixiviant in the ore 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 production area will undergo further extensive testing required before initiating ISR operations. The results of this further testing will be provided in the 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, 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 the Hank Unit can affect the methods applied in the restoration stage of the ISR project (see Section 4.5.2.1.3). However, given the generally poor water quality and the evidence suggesting insignificant connections between the production zone and the overlying and underlying aquifers, the potential environmental impact to groundwater quality from excursions at the Hank Unit is considered SMALL.

Additionally, after its independent review of the Uranerz's ER; the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions are comparable to those described in the GEIS. The GEIS concludes that impacts to production and surrounding aquifers during operations would be SMALL to LARGE. The staff concludes that site-specific impacts for the proposed Nichols Ranch ISR Project are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed 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 *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 proposed Nichols Ranch ISR Project site.

The GEIS also indicates that the potential environmental impact of injecting a 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 if 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.

Section 4.3.4.2.2.3 of the GEIS indicates that in the Wyoming East Uranium Milling Region, where the proposed 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, Fort Union Formation, Lance Formation, and Fox Hills Formation by thick low permeability confining layers that include the Pierre Shale, Lewis Shale, and Steele Shale (Whitehead, 1996). Hence, the 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 East Uranium Milling Region, considering the relatively low water quality in and the reduced water yields from the nonkarstic Paleozoic Aquifers and the presence of thick and regionally continuous aquitards confining them from above, the potential environmental impacts due to deep well injection of leaching solution into the nonkarstic Paleozoic aquifers could be SMALL.

Uranerz plans to dispose of waste fluids using deep well injection and is seeking a permit for Class I injection wells from the WDEQ. Each of the units would 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.

Additionally, after its independent review of the Uranerz's ER; the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions are comparable to those described in the GEIS. The GEIS concludes that impacts to deep aquifers during operations would be SMALL to MODERATE. The staff concludes that site-specific impacts for the proposed Nichols Ranch ISR Project are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed in the GEIS.

4.5.2.1.3 <u>Aquifer Restoration Impacts to Groundwater</u>

As indicated in Section 4.3.4.2.3 of the GEIS, the potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including 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.

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 4.5.2.1.2.2). 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 re-injected into the production aquifer and all withdrawals should be considered consumptive.

Uranerz is planning three phases of restoration: groundwater sweep, groundwater transfer, and groundwater treatment. The sequence of the restoration methods would be determined based on operating conditions (Uranerz, 2007). Uranerz indicated that restoration will be sequenced with production at the facility. Thus, initially only production will be occurring. However, as production moves from one well field to another, restoration and production will be occurring. Eventually, after production is complete, only restoration will be undertaken. Uranerz indicated that restoration will consume 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 disposal well. Based on liquid disposal rates predicted for the deep injection wells, net withdrawals may approach 380 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 analysis of the predictions of drawdown during production (see Section 4.5.2.1.2.2) 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 (136 m [446 ft] on average) of available hydraulic head in the Nichols Ranch Unit, 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 Unit 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 the Nichols Ranch Unit will be SMALL.

For the Hank Unit, the analysis of the predictions of drawdown during production (see Section 4.5.2.1.2.2) has indicated that at 284 Lpm (75 gpm), production withdrawals should result in limited, localized drawdowns. The limited drawdowns are 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 this phase for transporting restoration fluids between the pump house and the satellite facility or central processing plant and also to connect injection and extraction wells to manifolds inside the 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 in shallow aquifers. However, as discussed in Section 4.5.2.1.2.1, Uranerz has committed to an aggressive leak detection and spill cleanup program (Uranerz, 2007), as well as preventative measures such as well mechanical integrity testing. Consequently, the implementation of these measures should result in SMALL potential-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 aquifer restoration in much the same manner as during the operational phase. As previously indicated in Section 4.5.2.1.2.3, it is assumed that the potential environmental impact to deep aquifers below the production aquifers of deep well injection of waste will be SMALL.

Additionally, after its independent review of the Uranerz's ER; the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions are comparable to those described in the GEIS. The GEIS concludes that impacts to groundwater during aquifer restoration would be SMALL to MODERATE. The staff concludes that site-specific impacts for the proposed Nichols Ranch ISR Project are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed in the GEIS.

4.5.2.1.4 Decommissioning Impacts to Groundwater

As indicated in Section 4.3.4.2.4 of the GEIS, 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.

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 well field restoration at the site would have determined that the restoration standards that had been met were protective of public health and safety.

After ISR operations are completed at the proposed Nichols Ranch ISR Project, 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 (Uranerz, 2007). If this process is properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be SMALL (NRC, 2009a).

Additionally, after its independent review of the Uranerz's ER; the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions are comparable to those described in the GEIS for groundwater and incorporates by reference the GEIS's conclusions that the impacts to groundwater during decommissioning are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed in the GEIS.

4.5.2.2 No-Action (Alternative 2)

The No-Action Alternative would result in no construction or operational activities onsite 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. Impacts on the groundwater from other activities in the area such as CBM extraction are possible but not as a result of the No-Action Alternative.

4.5.2.3 Modified Action – No Hank Unit (Alternative 3)

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 4.5.2.1), while removing those impacts identified for the Hank Unit.

4.5.2.3.1 <u>Construction Impacts</u>

As indicated during the evaluation of the potential environmental impacts at the Nichols Ranch Unit in Section 4.5.2.1.1, the potential environmental impacts to groundwater resources during construction of the Nichols Ranch Unit would be SMALL based on the limited nature of construction activities and implementation of BMPs to protect shallow groundwater.

4.5.2.3.2 <u>Operation Impacts</u>

As discussed previously in Section 4.5.2.1.2, during operation, the potential environmental impact to shallow groundwater quality at the Nichols Ranch Unit appears to be SMALL. 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 be 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.

4.5.2.3.3 <u>Aquifer Restoration Impacts</u>

As discussed previously in Section 4.5.2.1.3, 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 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 SMALL. During aquifer restoration, the potential environmental impact to deep aquifers below the production aquifers of deep well injection of waste will be SMALL.

4.5.2.3.4 Decommissioning Impacts

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, 2009a). As described in 4.5.2.1.4, 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 well field restoration at the site would have determined that the restoration standards that had been met were protective of public health and safety.

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 proposed Nichols Ranch 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 deep well injection. Onsite groundwater-related impacts from the proposed Nichols Ranch ISR Project are anticipated to vary from SMALL to MODERATE, depending on the specific issue, and are discussed in detail in Chapter 4 of this SEIS. After uranium production and restoration ceases, groundwater levels will recover and groundwater restoration will restore all impacted aquifers to acceptable water quality levels.

Future ISR activities and present and future CBM activities in the vicinity of the proposed project area may cumulatively affect groundwater resources. Two licensed operations, PRI's North Butte ISR Project and Cogema's Irigaray/Christensen Ranch ISR Project, in the vicinity of the proposed project are not currently in operation. However, when operations do begin, they could potentially be extracting ore from the same aquifer as the proposed Nichols Ranch ISR Project. The resulting effects may include temporary impacts on groundwater levels in the ore zone aquifer and a geochemical change in the chemistry of the ore zone aquifer at those sites (Uranerz, 2007).

Cumulative impacts on groundwater resulting from the interaction between ISR activities and CBM activities may occur but are not likely since the CBM production and the ISR activities are conducted in stratigraphically separate aquifers. For the proposed Nichols Ranch ISR Project, the ISR activities would take place in sandstone aquifers at depths of 90 to 180 m (300 to 600 ft). In comparison, the CBM production from coal seams occurs at depths equal to or greater than 300 m (1,000 ft). Communication between the uranium ore zone aquifer and CBM coal seam is possible if the CBM wells happen to be located near any of the ISR well fields and if the CBM well was not completed properly. However, like the mechanical integrity tests conducted by ISR companies, CBM producers use a similar procedure to test the integrity of each CBM well. CBM wells in the proposed project area would be in place prior to Uranerz beginning operations at the proposed Nichols Ranch ISR Project. Uranerz would monitor ore zone aquifers to see if potential impacts resulting from unanticipated aquifer communication are taking place between the CBM well and the ISR ore zone aquifer. Uranerz would address these problems and resolve them before ISR operations began on the proposed site (Uranerz, 2007). The Final Environmental Impact Statement (EIS) Powder River Basin Oil and Gas Project states that the areal extent and magnitude of drawdown effects on coal zone aquifers and overlying or underlying sand units in the Wasatch Formation would be limited by the discontinuous nature of different coal zones within the Fort Union Formation and sandstone layers within the Wasatch Formation (BLM, 2003).

Cumulatively, the MODERATE impacts to groundwater from the proposed Nichols Ranch ISR Project discussed in Chapter 4 are not expected to contribute to a perceptible increase in the MODERATE to LARGE impacts to groundwater in the affected aquifer when added to past, present, and reasonably foreseeable future actions.

6.2.5 Groundwater Monitoring

Private wells within 1 km (0.6 mi) of the well field area boundary would be sampled on a quarterly basis. These samples would be analyzed for natural uranium and radium-226.

6.3 Physiochemical Monitoring

This section describes Uranerz's proposed physiochemical monitoring program as described in its license application (Uranerz, 2007). The purpose of this monitoring program is to provide data on operational and environmental conditions so that prompt corrective actions can be taken when adverse conditions are detected and to comply with environmental requirements or license conditions. In this regard, this monitoring program helps to limit potential environmental impacts at an ISR facility. The physiochemical monitoring program proposed by Uranerz includes groundwater monitoring and well field and pipeline flow and pressure monitoring.

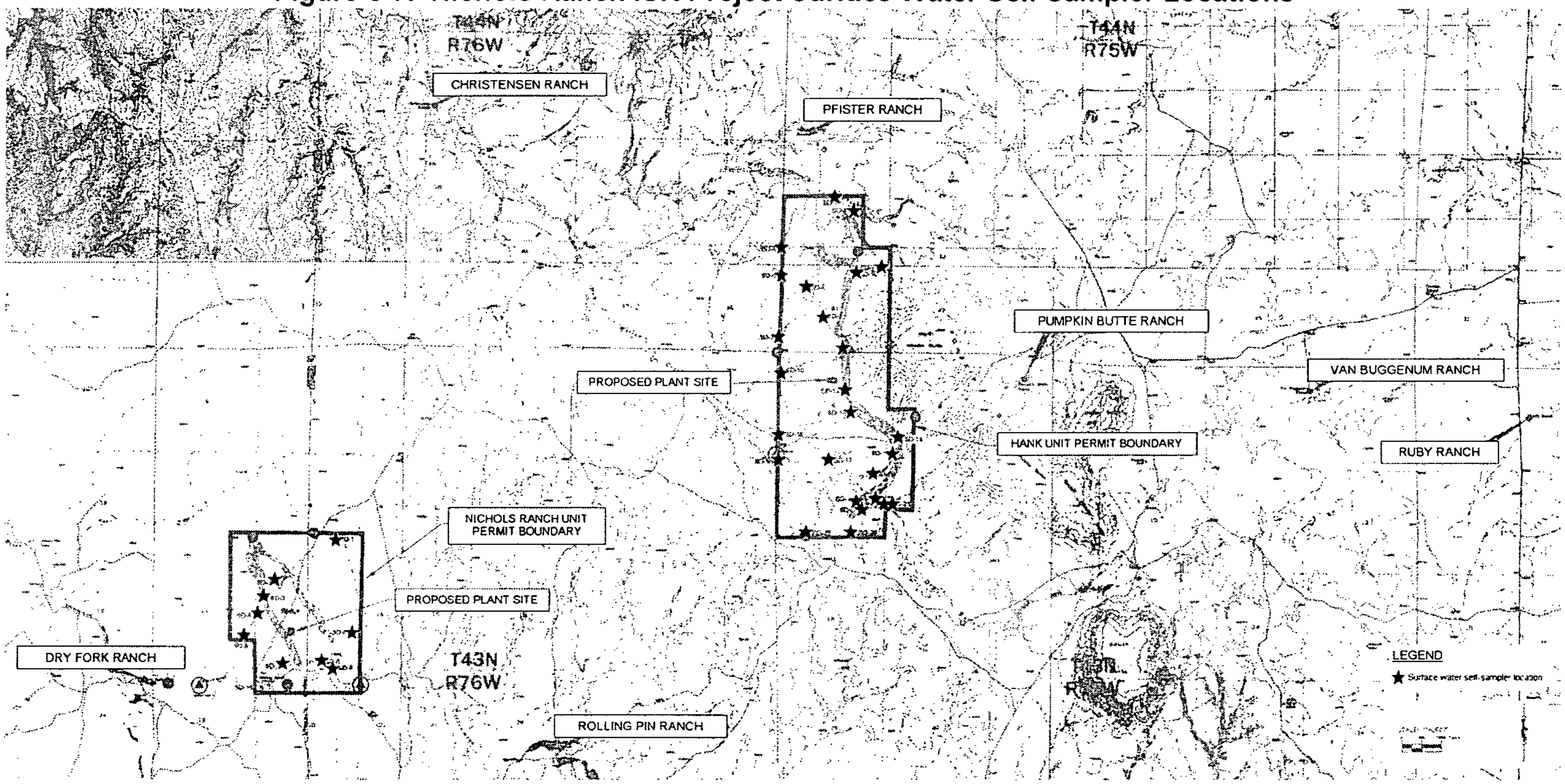
6.3.1 Well Field Groundwater Monitoring

As discussed in Section 8.3 of the GEIS, the ISR production process directly affects the groundwater near the operating well field. For this reason, groundwater conditions are extensively monitored both before and during operations. The pre-operational groundwater monitoring that would occur as part of the proposed Nichols Ranch ISR Project is discussed below in Section 6.3.1.1. The groundwater quality monitoring that would occur during operation is discussed in Section 6.3.1.2.

6.3.1.1 Pre-Operational Groundwater Sampling

As indicated in the Section 8.3.1.1 of the GEIS, a licensee must establish baseline groundwater quality before beginning uranium production in a well field. This is done to characterize the water quality in monitoring wells that are used to detect lixiviant excursions from the productions 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.

Figure 6-7. Nichols Ranch ISR Project Surface Water Self Sampler Locations



Source: modified from Uranerz, 2007

Uranerz would install monitoring wells in the ore zone (A Sand at the Nichols Ranch Unit; F Sand at the Hank Unit) at a density of 1 well per 1.6 ha (4 ac). During operation, these ore zone monitoring wells would be sampled twice per month at intervals of approximately two weeks. Horizontal monitoring wells would be installed on the edge of the well field, approximately 150 m (500 ft) from the well field and spaced 150 m (500 ft) apart, in the same zone as the ore zone. This distance takes into consideration that if an excursion were to occur, processing fluids could be controlled within 60 days as required by the Wyoming Department of Environmental Quality (WDEQ). Vertical monitoring wells would also be installed in the overlying (B Sand at the Nichols Ranch Unit; G Sand at the Hank Unit) and underlying (1 Sand at the Nichols Ranch Unit; B or C Sand at the Hank Unit) aquifers at a density of one underlying and one overlying well per every 1.6 ha (4 ac). The density and spacing of these wells is dependent on the presence and thickness of the confining units above and below the ore zone and Uranerz would consult with NRC and WDEQ to determine the appropriate well density and spacing in these instances. The locations of these monitoring wells are shown in Figures 6-8 and 6-9.

During the pre-operational baseline water quality assessment, the ore zone monitoring wells would be sampled four times with a minimum of two weeks between sampling. The first and second sampling events would be analyzed for all parameters found in WDEQ-Land Quality Division (WDEQ-LQD) Guideline No. 8 (WDEQ, 2005), including uranium parameters. Those parameters are as follows:

- Ammonia nitrogen as N
- Nitrate + nitrite as N
- Bicarbonate
- Boron
- Carbonate
- Fluoride
- Sulfate
- Total Dissolved Solids (TDS) @ 82 °C (180 °F)
- Radium-226 (pCi/L)
- Radium-228 (pCi/L)
- Dissolved arsenic
- Dissolved cadmium
- Dissolved calcium
- Dissolved chloride
- Dissolved chromium
- Total and dissolved iron
- Dissolved magnesium
- Dissolved manganese
- Dissolved molybdenum
- Dissolved potassium
- Dissolved selenium
- Dissolved sodium
- Dissolved zinc
- Gross Alpha (pCi/L)
- Gross Beta (pCi/L)
- Uranium
- Vanadium

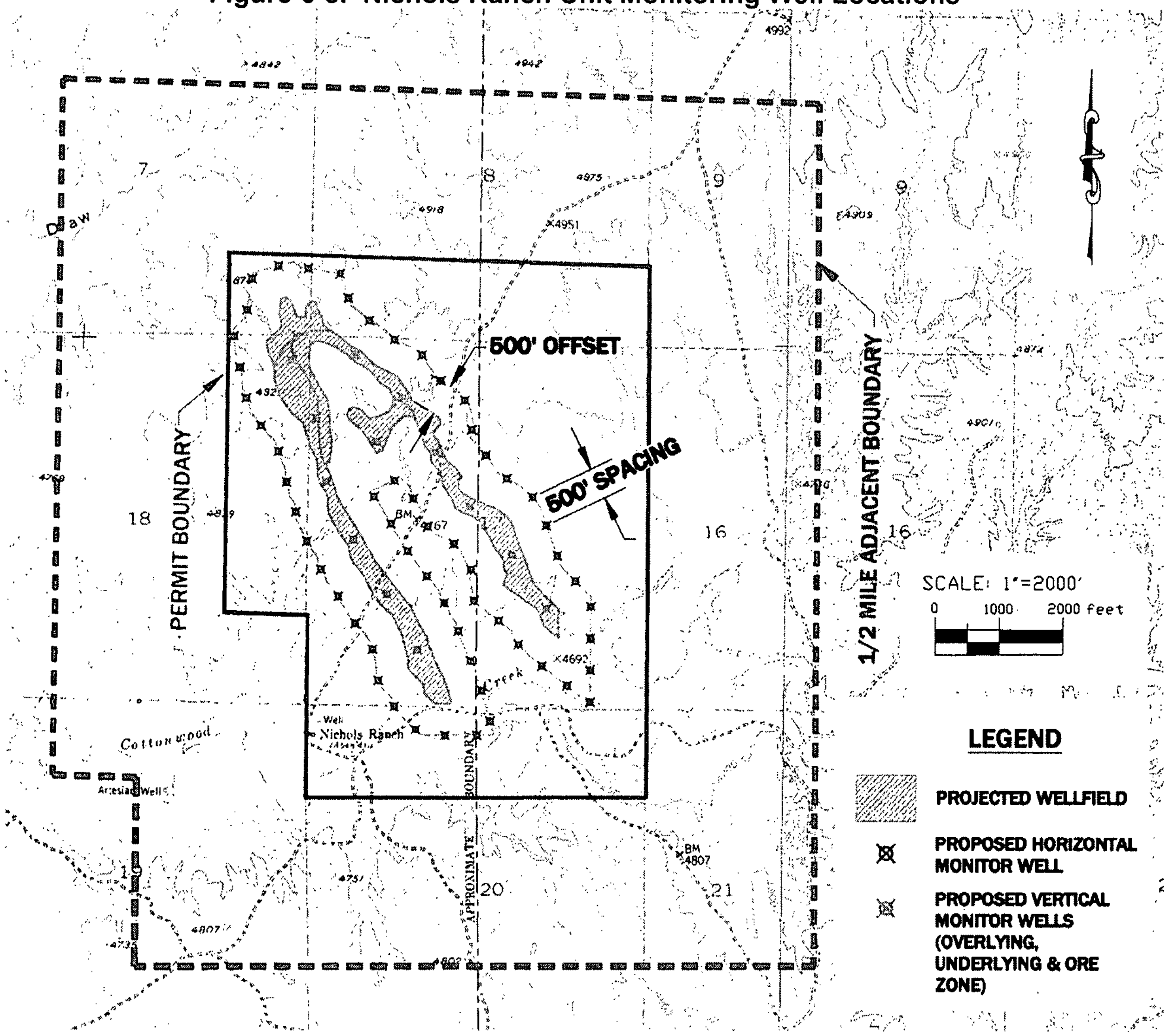
Those parameters that were not detected during the first and second sampling events could be eliminated from the third and fourth sampling events. The ore zone monitoring ring wells would be sampled four times with at least two weeks between sampling. The first sampling event would include the analyses for the parameters found in WDEQ-LQD Guideline No. 8 (WDEQ, 2005) including uranium parameters. The remaining three sampling events would be tested for the potential Upper Control Limit (UCL) parameters of chloride, total alkalinity, and conductivity. Overlying and underlying aquifer wells would be sampled four times with at least two weeks between sampling events. The first and second sampling events would be analyzed for the following parameters:

- Alkalinity
- Ammonium
- Arsenic
- Barium
- Copper
- Electrical conductivity @ 25 °C (77 °F)
- Fluoride
- Iron
- Nitrate
- pH
- Potassium
- Radium-226

- Bicarbonate
- Boron
- Cadmium
- Calcium
- Carbonate
- Chloride
- Chromium
- Lead
- Magnesium
- Manganese
- Mercury
- Molybdenum
- Nickel
- Selenium
- Sodium
- Sulfate
- Total dissolved solids
- Uranium
- Vanadium

The third and fourth sampling events would be analyzed only for the possible UCL parameters of chloride, total alkalinity, and conductivity.

Figure 6-8. Nichols Ranch Unit Monitoring Well Locations

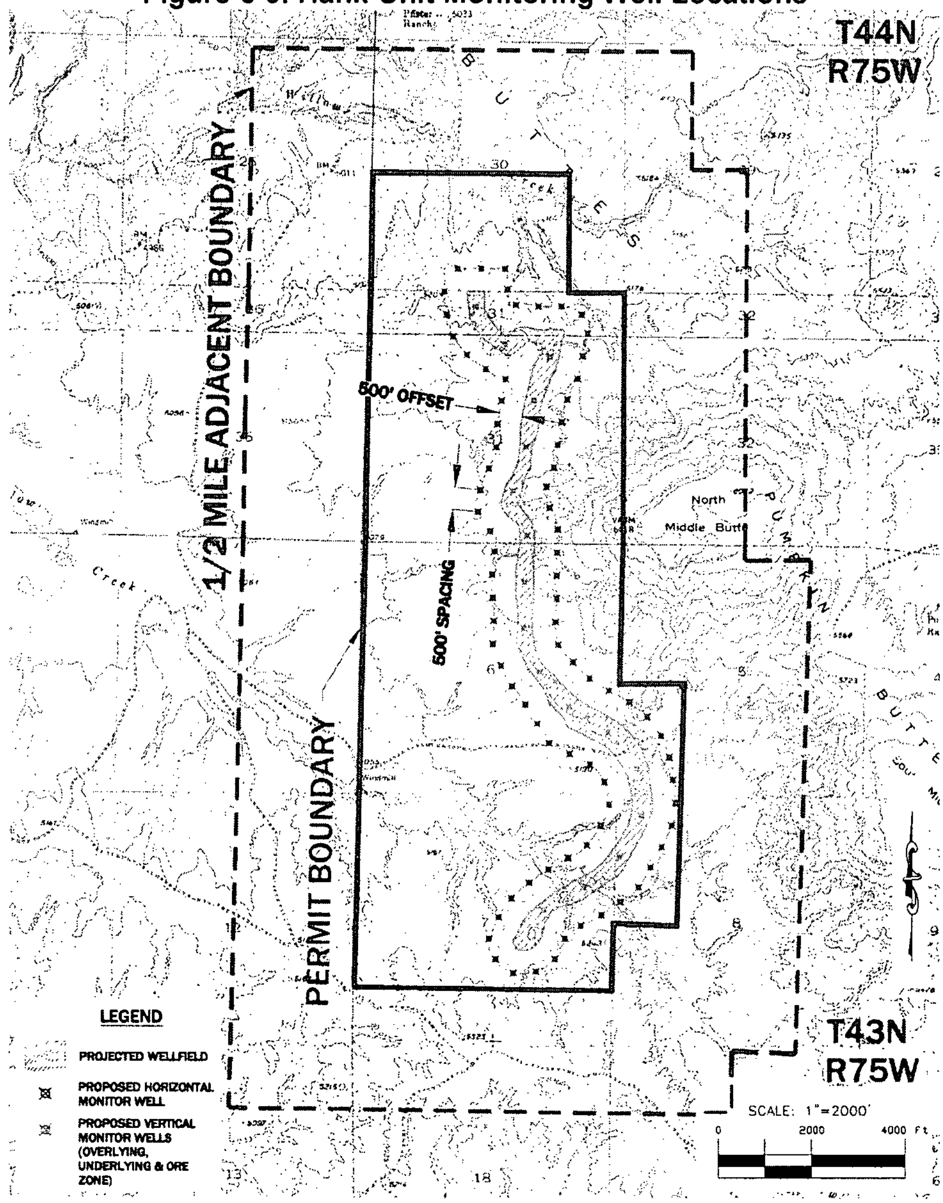


Source: modified from Uranerz, 2007

6.3.1.2 Groundwater Quality Monitoring

As discussed in Section 8.3.1.2 of the GEIS, monitoring wells are situated around the well fields, in the aquifers overlying and underlying the ore-bearing production aquifers, and within the well fields for the early detection of potential horizontal and vertical excursions of lixiviants. 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 of 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

Figure 6-9. Hank Unit Monitoring Well Locations



Source: modified from Uranerz, 2007

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 discussed in greater detail in Section 8.3.1.2 of the GEIS.

During operation, the ore zone monitoring wells and the overlying and underlying aquifer monitoring wells would be sampled twice per month at intervals of approximately two weeks. These samples would be analyzed for and compared against the UCL parameters of chloride, total alkalinity, and conductivity. Static water levels would also be noted. 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.

Uranerz's operational groundwater monitoring program would detect and correct for any condition that could lead to an excursion affecting groundwater quality near the well fields. These excursions can be caused by improper water balance between injection and recovery rates, undetected high permeability strata or geological faults, improperly abandoned exploration of drill holes, discontinuity within the confining layers, poor well integrity, or hydrofracturing of the ore zone or surrounding units. The program would include monitoring process variable such as flow rates and operating pressures of operating wells (injection, production, and monitoring) and the main pipelines going to and from the central processing plant and satellite facility. The monitoring program is required per 10 CFR Part 40 Appendix A, Criterion 7.

Uranerz would adequately maintain all of the analytical data from the monitoring wells and submit the data to the WDEQ quarterly. In addition, Uranerz would maintain copies onsite of all of the analytical data from the monitoring wells in case of an NRC inspection. If an excursion is detected, Uranerz would notify the NRC and WDEQ verbally within 24 hours and in writing within 7 days of a verified excursion. Additional and more frequent sampling may be warranted to confirm that an excursion occurred. Corrective actions such as adjusting the injection and recovery flow rates in the affected area would be implemented as soon as practical and as long as it takes the excursion to be mitigated. Within 60 days of the confirmed excursion, Uranerz would have to file a written report to the NRC describing the event and corrective actions taken.

The final number of monitoring wells and production pattern would be determined during final well field planning and submitted to the WDEQ in the well field package. Uranerz must demonstrate the hydraulic interconnection between the monitoring wells and production pattern, in both the Nichols Ranch and Hank Units, before ISR activities begin. Such a demonstration would be particularly important at the Hank Unit where limited drawdowns due to the unconfined nature of the F Sands may limit the spacing between the production well pattern and the outer monitoring ring. After a proposed well field is found feasible for ISR activities, a Production Area Pump Test is developed and conducted to determine information on the hydrologic characteristics of the production area and the underlying and overlying aquifers within the production zone. Uranerz would submit the test plan to the WDEQ prior to conducting the test. After the test, Uranerz would compile a summary report to submit to the WDEQ and NRC for review and approval.