D6.1 SURFACE WATER

The Appendix D6 Hydrology pages, table, figure and exhibits are sequentially numbered in this section, such as D6-1. The addendums are numbered by the sub-section, such as Figure D6B.

D6.1.1 DRAINAGE BASIN DESCRIPTION

The Nichols Ranch ISR Project areas exist in the Cottonwood and Willow Creek drainage areas. The Nichols Ranch Unit is located in the Cottonwood Creek drainage while the Hank Unit is located in the Willow Creek drainage.

The Nichols Ranch Unit is located near the confluence of the Cottonwood Creek drainage with the Dry Fork of the Powder River. Figure D6-1 shows the Cottonwood drainage area. The majority of the Nichols Unit drains directly to Cottonwood Creek while a portion of the northern part of the area drains to Tex Draw which is a tributary to the Dry Fork of the Powder River. Cottonwood Creek is a tributary to the Dry Fork of the Powder River and its confluence is located approximately v2 mile downstream of the project area. Tex Draw also enters the Dry Fork of the Powder River approximately 2 miles downstream of the project area.

Area of the Cottonwood Creek drainage basin is 80.2 square miles. Dry Fork of the Powder River is a tributary to Powder River which is a tributary to the Yellowstone River, which is a part of the Missouri River drainage basin. Land surface elevation in Cottonwood Creek drainage varies from 5,974 to 4,590 ft-msl at the mouth. The channel elevation varies from 4,622 to 4,660 ft-msl in the project area. Cottonwood Creek channel is flat at a gradient of approximately 0.003 fl/ft.

The Tex Draw drainage area is 5.2 square miles and its elevation varies from a peak of 5,085 to an elevation of 4,540 ft-msl at its confluence with the Dry Fork of the Powder River. None of the Tex Draw channel exists within the Nichols Ranch Unit area but the northwestern portion of the project area drains to Tex Draw. Tex Draw has a much steeper gradient due to being a smaller ephemeral channel and has an approximate gradient of 0.01 **ft/ft** just north of the project area.

The Hank Unit is located in the Dry Willow and Willow Creek drainages. Dry Willow is a tributary to Willow Creek which is a tributary of the Powder River. Dry Willow and a portion of Willow Creek drainage upstream of the Dry Willow confluence are shown in Figure D6-1. The Hank Unit is roughly 16 miles upstream of the confluence of Willow Creek and the Powder River. Willow Creek is oriented in a westerly direction through the northern end of the unit.

The area of the Willow Creek drainage basin above the Dry Willow Creek confluence is approximately 13.2 square miles. Elevation in the Willow Creek drainage varies from 6,052 to 4,795 ft-msl at the confluence of Dry Willow Creek. The short reach of the Willow Creek channel within the unit boundary ranges in elevation from 5,015 to 5,040 ft-msl. The gradient of the stream channel within the Hank Unit is about 0.008 **ft/ft,** and

the active stream channel width varies from a few feet to several tens of feet.
The drainage area of Dry Willow Creek is 12.2 square miles. The maximum elevation in this drainage basin is 6,018 **ft** and the elevation at the confluence is 4,795 ft. The elevation of the channel in the Hank Unit area of Dry Willow Creek varies from 4,995 ft to 5,085 ft-msl. The stream channel in this area has a gradient slightly greater than 0.01 **ft/ft.**

D6.1.2 SURFACE-WATER FLOW

Dry Willow, Willow and Cottonwood Creeks and Tex Draw are classified as ephemeral streams in the project area. Stream flows only occur in response to heavy snow melt and to large rainstorms. Runoff flows are typically intermittent in the spring and early summer and the stream channels are dry the remainder of the year except during major thunderstorms in the area.

The estimated peak flows for various recurrence intervals for Cottonwood, Tex, Dry Willow and Willow Creek drainages are presented in Table D6-1. The technique that was used to estimate the peak flows is presented in Lowham (1976).
The predicted peak flows in Table D6-1 vary from 454 cubic feet per second (csf) for a two-year recurrence interval to 7,500 csf for a hundred year recurrence interval for Cottonwood Creek drainage. 'The peak flows for Tex Draw vary from 170 to 2,720 csf for the 2 and 100 year recurrence intervals.

The predicted peak flows for the Dry Willow Creek and Willow Creek above Dry Willow Creek vary from a low of 231 csf for the 2 year recurrence interval for Dry Willow up to a peak of 3,840 for the 100 year recurrence interval. The estimates for Dry Willow and Willow Creak are very similar due to similarity in drainage area.

The flow velocities for the 1 0-year peak discharges are calculated to present an estimate of the channel velocities during a significant runoff event. The bottom half of Table D6-1 presents the calculation of the flow velocities based on typical channel slope and the 10-yr peak discharge. The 10-year peak discharge was selected as representing a reasonable design period for the life of this operation. These 10-year peaks are calculated for the confluence of the drainages and therefore are a very conservative representation of the peak at the project location. The peak velocities for Cottonwood Creek are smaller due to the wide flood plane and the milder channel slope. Cottonwood Creek does have an incised pilot channel which has been dammed and, therefore, runoff flow during any significant event will be spread over a very significant width of the flood plane. The velocities in Tex Draw, Dry Willow and Willow Creek will be much greater due to the steeper channel slope and are near 10 ft/sec.

D6.1.3 SURFACE-WATER QUALITY

The surface water quality from the Cottonwood, Tex, **Dry** Willow and Willow Creek drainages is generally very good in the upper channel reaches of these areas. A typical TDS is 200 mg/i. Water quality generally deteriorates as the surface water flows further

down stream and is in contact with the streambed for longer periods of time.
The U. S. Geological Survey has monitored the Dead Horse Creek drainage which is approximately 30 miles north of the confluence of the Dry Fork with the Powder River and roughly 20 miles north of the confluence of Willow Creek with the Powder River. Dead Horse Creek drainage area is 151 square miles, which is significantly greater than the local drainages of the mining area. Limited water quality data from this gauging station shows that ion concentrations are significant with conductivity of greater than 2,000 umhos/cm.

Table D6A.i-1 in Addendum D6A presents water quality data available from surface water samples within the drainages in the project. The Dry Willow Reservoir which is upstream of the Hank Unit had a TDS of 174 mg/l. The Brown Water Pond also had a very low TDS due to the pond proximity to the drainage divide. This pond captures water after it has moved only a relatively short distance. The Dry Willow Reservoir and Brown Water Pond were dry in September of 2007. Additional samples on Dry Willow Creek and Cottonwood Creek show that the TDS can exceed 2,000 mg/l in the surface runoff. Surface runoff water quality is generally dominated by bicarbonate concentrates but increase concentrations of calcium and sulfate are observed with increasing exposure time in channels.

D6.2 GROUND-WATER HYDROLOGY

The regional ground-water setting has been defined by Hodson and others, 1973. The aquifers of interest in this area are sands within the Wasatch Formation. The confining units between the aquifers are also within the Wasatch Formation.

D6.2.1 GEOLOGIC SETTING AND WELL CONSTRUCTION

The Nichols Ranch ISR Project is located in the outcrop of the Wasatch Formation. The stratigraphy of the Wasatch at this site consists of alternating layers of sand and shale with lignite marker beds. The mineable ore exists in two sand members, designated as the A Sand at the Nichols Ranch Unit and F Sand at the Hank Unit. These two sand members are typically separated by the B and C Sands and adjacent aquitards.
The aquifer and aquitard sequence at the project area is shown in Figure D6-2. This shows labeled sands from the 1, A, B, C, F, G, and H Sands. This figure also shows the aquitards that exist between the different sands and those aquitards are labeled as by the combination of labels for the two adjacent sands. These sands are the same names that are used at Power Resources North Butte permit which exists just north of the Hank Unit site.

The majority of the wells completed in the Nichols Ranch Unit are completed in the A Sand because this is the ore bearing sand in this area. Figure D6-3 shows the locations of the Nichols Ranch Unit wells and Exhibit D6-1 shows the locations of wells within three miles of the Nichols Ranch Unit. Table D6-2 presents the tabulation of the well data for the Nichols Unit wells. This table shows that eleven of the wells have been completed in the A Sand with one well completed in each of the 1, B and C sands while two wells have been completed in the F Sand and one well in the Cottonwood alluvium. Wells MN- 1, MN-2, URZNB-1 and URZNl-2 are completed as open-hole completions while the remainder of the wells have well screens in their completion interval.

Table D6-3 presents the basic well data for the Hank Unit wells while Figure D6-4 shows the location of the Hank Unit wells. Exhibit D6-2 shows the locations of wells within three miles of the Hank Unit. Eleven of these wells are completed in the F Sand because this is the ore bearing sand in this area. Four of the wells are completed in the overlying G Sand while one of the wells is completed in the underlying C Sand. In areas where the C Sand does not exist, the B Sand is the underlying aquifer and seven of the wells in this area are completed in the B Sand. Additionally, four existing stock wells are completed across a combination of the sands.

D6.2.2 SUMMARY OF AQUIFER AND AQUITARD PROPERTIES

Numerous single-well pump tests and multi-well pump tests were conducted at the Nichols Ranch and Hank Units to define the aquifer properties. The detailed hydrologic analyses and supporting data are contained in Addendums D6B and D6C for Nichols Ranch Unit and Hank Unit respectively. Three multi-well pump tests were conducted at the Nichols Unit site and are referred to in this report as the MN-1, MN-2 and MN-6 tests. Three multi-well tests were performed at the Hank Unit site. These tests are referred to as the URZHF-1, URZHF-5 and SS1F tests. Tables D6-3 and D6-4 present the basic well data for wells used to define the aquifer properties for the Nichols Ranch and Hank Units respectively. Addendum D6J presents the aquifer test theory used to analyze the pump tests.

D6.2.2.1 AQUIFER PROPERTIES

In addition to determining the aquifer properties from the multi-well test, numerous single-well tests were conducted to define the aquifer properties. Several pump tests were previously conducted by Cleveland-Cliffs and Uranerz and the results of these tests were analyzed and included in the general hydrologic analysis.

Table D6-4 presents a summary of the aquifer properties for the Nichols Ranch Unit. This table shows a summary of the aquifer properties for the A, B, C, F and 1 Sands for the Nichols Ranch Unit. For the A Sand, the single-well pump tests are presented first and then the results for the three multi-well pump tests are presented. Transmissivities for the A Sand aquifer vary from a low of 101 to a high of 460 gal/day/ft. A value of 350 gal/day/ft is thought to best represent the **A** Sand in the Nichols Unit area. The hydraulic conductivity (horizontal permeability) varies from 0.18 to slightly greater than 0.7 ft/day (0.08 to 0.36 Darcy), and a value of 0.5 ft/day is thought to best represent the A Sand. Average storage coefficient for the A Sand was 1.8E-4.

The one single-well pump test in the B Sand produced a transmissivity of 174 gal/day/ft and a horizontal permeability of 0.37 ft/day. The single-well pump tests for the 1 Sand produced a transmissivity of 88 and 101 gal/day/ft for the 1 Sand. A significantly higher transmissivity was obtained from the single-well test for the F Sand well at 1,410 gal/day/ft and a hydraulic conductivity of 3.6 ft/day. A small transmissivity of 45 gal/day/ft and hydraulic conductivity of 0.099 ft/day were determined for the C Sand. Table D6-5 presents the summary of aquifer properties for the Hank Unit. This table presents results of aquifer properties testing for the F, A, B, C and G aquifers in the Hank Unit area.

The properties in the F Sand vary greatly in the Hank Unit area. The transmissivities vary from a low of 18 to a high of 6,670 gal/day/ft. Hydraulic conductivity varies from a low of 0.14 ft/day to a high of 9.4 ft/day (0.07 to 4.5 Darcy). A transmissivity of 400 gal/day/ft is thought to best represent the majority of the F Sand in the Hank Unit and the hydraulic conductivity of 0.6 ft/day is also thought to best represent the F Sand. A storage coefficient of 6.8E-5 was determined for the F Sand at the SS1-F site. The water level in the ore zone of the Hank Unit is near the top of the sand and therefore the F Sand is not fully saturated and is therefore an unconfined aquifer at the Hank Unit The primary storage property for an unconfined aquifer is specific yield and a specific yield of 0.05 is thought to best represent the F Sand in this area.

Similar tests were conducted on two G Sand wells. The transmissivities of this G Sand varied from 0.4 to 2.9 gal/day/ft with hydraulic conductivities varying from 0.005 to 0.022 fl/day.

The aquifer properties for the underlying sands were determined for the C, B and A Sands. The aquifer properties for the C Sand were a low transmissivity of 1.9 gal/day/ft and a hydraulic conductivity of 0.025 ft/day. The transmissivities for the B and A Sand varied over a much larger range from 264 to 1,300 gal/day/ft. Hydraulic conductivities for the B and A Sand varied from 0.38 to 2.2 ft/day.

D6.2.2.2 AQUITARD PROPERTIES

The vertical permeabilities of the aquitard in the Powder River Basin have been defined at numerous locations. These permeabilities have been measured in multi-well pump tests with the Neuman-Witherspoon (1972) method, determined from the results from the leaky aquifer pump test analysis with the modified Hantush (1960) method, and from laboratory measurements. This data has shown that the vertical permeability of these aquitards is low enough that site specific measurements of the aquitard permeabilities are not necessary. Aquitard permeabilities were measured in the area just north of the Hank Unit in Power Resources North Butte permit. This permit presents aquitards evaluated with the Neuman-Witherspoon field test for the aquitard between the F and C Sands. The vertical permeability of this material was 3.8E-8 cm/sec (3.5E-2 ft/yr). A second multiwell test at the North Butte site defined the aquitard permeability between the A Sand and the 1 Sand. The results of this test were 4.1E-8 cm/sec (4.2E-2 ft/yr). Additional field tests were evaluated using the modified Hantush method to define the vertical permeability of the aquitard. These calculated permeabilities varied from a low of 6.7E-9 to a high of 6.9E-8 cm/sec. Laboratory permeabilities were also measured on two samples of the aquitards at the North Butte permit and these permeabilities varied from

6.4E-9 to 1.3E-8 cm/sec. This data shows that the aquitards in this area have sufficiently small vertical permeabilities to restrict the movement of ground water from one aquifer to the next. Aquifer confinement will be further defined for each of the wellfields during the wellfield multi-well pump test.

D6.2.3 GROUND-WATER FLOW

Water levels have been measured in the wells in the Nichols Ranch ISR Project area to define the direction and gradient of the ground water movement and define water-level changes in the aquifers in this area. Addendum **D6D** presents the water-level plots and tabulation of ground-water levels.

The water level elevation for the A Sand, which is the production sand at the Nichols Ranch Unit, is presented in Figure D6-5. This water-level elevation map shows that the ground water in the A Sand is flowing to the northwest with an average gradient of 0.0033 ft/ft. This gradient, an effective porosity of 0.05 and an average hydraulic conductivity of 0.5 ft/day indicates that the ground water in the A Sand is flowing at an average rate of 0.033 ft/day (12 ft/yr).

A F Sand well was added at the Nichols Ranch Unit to define the shallow ground water at this site. Figure D6-6 shows the water-level elevation for F Sand well URZNF-3. The water-level elevation of this shallow sand is roughly 25 feet higher than the water-level elevation than the A Sand at this location. An additional shallow monitoring well was installed at the Nichols Ranch Unit in the Cottonwood alluviumn This monitoring well is located on the downstream edge of the Nichols Ranch Unit area (see Figure D6-3 for location). Completion information for this well is presented in Table D6-3 and the well has a water-level elevation of 4,629 ft-msl. This water-level elevation is approximately 35 feet below the water-level elevation of the A Sand in this area.

Figure D6-6 shows the water-level elevation for the F Sand for the Nichols Ranch ISR Project area. This map includes wells in both the Nichols Ranch and Hank Units. The ground water elevation show that the water in the F Sand is flowing west with an average gradient of 0.005 ft/ft. This gradient, along with an average hydraulic conductivity of 0.6 ft/day and an effective porosity of 0.05, indicates that the ground water velocity is moving at 0.06 ft/day (22 fl/yr). Ground water in the F Sand flows into the Cottonwood alluvium in the area of the Nichols Ranch Unit.

Figure D6-7 presents the water-level elevations for wells that are completed in the B and C Sands. The water-level elevations in these sands indicate that the gradient is to the west in the Nichols Ranch ISR Project area for both the Nichols Ranch and Hank Units (see Figure D6-7). The piezometric gradient in the ground-water systems has a northnorthwest gradient further to the north of the Hank Unit. Similar gradients are observed in the B and C Sand aquifers as in the A and F Sand aquifers.

The shallow sands in the Hank Unit area are more likely to be affected by local topography changes than the deeper sands. Figure D6-8 presents a water-level elevation map for the G and H Sands which are the overlying sands for the F Sand in the Hank Unit. These piezometric contours are for the G Sand and show a much steeper gradient of 0.014 ft/ft to the west. This gradient, an average hydraulic conductivity of 0.005 fl/day and an effective porosity of 0.05 indicate that the ground water in these sands is moving at an average rate of 0.0014 ft/day (0.5 ft/year).

The head in H Sand well URZHH-7 is shown on Figure D6-8 with a water-level elevation of 5,072.9 ft-msl. H Sand well URZHH-7 was installed to define the shallow groundwater at the Hank Site. This well is completed in the H Sand which is above the G Sand. The H Sand has a water-level elevation approximately 150 feet higher than the G Sand in this area of the Hank Unit.

D6.2.3.1 NICHOLS RANCH UNIT WATER LEVEL CHANGES

The water-level elevations have been measured on the Nichols Ranch ISR Project wells and are presented in Addendum D6D. Table D6D.1-1 in Addendum D6D presents the water-level data tabulation for the Nichols Ranch Unit wells while Table D6D.2-1 presents the water-level data collected for the Hank Unit wells. Figures D6D. 1-1 through D6D.1-3 in Addendum D6D present the water-level elevations versus time for the Nichols Ranch Unit wells. Water levels for the A Sand wells for the last year have been fairly steady.
Water-level elevations for the B Sand well URZNB-1 and the 1 Sand well URZNl-2 are slightly less than the water level elevation in adjacent A Sand well MN-1. The vertical head difference between these two aquifers and the A Sand is approximately 10 feet. Water levels have been fairly steady in the B Sand and 1 Sand in the Nichols Ranch Unit area.

Water-level changes in the DW-4 cluster of wells to the northeast of the Nichols Ranch Unit have also been fairly steady. These water levels were also measured in 1978 and 1979 and were slightly lower than the recent water levels. The comparison in head between the F Sand, C Sand and A Sand and a comparison of the historical 1978 and 1979 data to the recent data are presented for the DW-4 site. Water levels are about 55 feet higher in the F Sand than those observed in the C and A sands.

D6.2.3.2 HANK UNIT WATER LEVEL CHANGES

The water-level changes for the Hank Unit wells are presented in Figure D6A.2-1 through D6D.2-5 in Addendum D6D, while Table D6D.2-1 in Addendum D6D lists the water levels. The water-level changes for the Hank 1, Dry Willow #1, URZHF-1, URZHC-2, and URZHG-3 wells are presented in Figure D6A.2-1 Addendum D6D. The recent water levels in the F Sand in Hank 1 and Dry Willow #1 wells have been fairly steady. The recent water levels in the Hank 1 well are approximately 14 feet higher than the 1979 measurement Water levels in the Dry Willow well are approximately five feet higher than they were in 1979.

Figure D6D.2-2 in Addendum D6D presents the water levels measured for the second new well cluster including, G Sand well URZHG-4, F Sand well URZHF-5 and B Sand well URZHB-6. The head in the G Sand in this area is approximately 35 feet higher than the head in the F Sand while the F Sand head is similarly higher than the B Sand head. The BR wells are presented in Figure D6D.2-3 in Addendum D6D and these wells are located on the northern side of the Hank Unit. These wells were monitored in the early 1980s for a period of slightly more than two years. Recent water levels in F Sand wells BR-B and BR-G are similar to those that were measured in the early 1980s. Figure D6D.2-4 in Addendum D6D presents the plot of water levels for F Sand well WCMN1. This well is monitored continuously by the BLM in conjunction with to their coal bed methane monitoring program. A plot of data for this well shows that in 1999 through early 2000 the water level was rising in this well and then gradually declined for the next 6-7 years. During the last several months of monitoring, the water levels in well WCWNI have declined at a faster rate than the previous years. Monitoring in March and April in 2007 shows a gradual water-level rise. This plot also shows one data point that was measured in 1979 which is a slightly lower water level than the present level. The BLM has also monitored three alluvial wells in the Dry Willow alluvial system. The water levels for these wells are shown in Figure D6D.2-5 in Addendum D6D with alluvial wells DRYMW1 showing saturation in portions of 2000 through 2001 and well DRYMW3 having some saturation in late 2003. Both of these wells were dry in August of 2007 and through the majority of the monitoring period.

D6.2.3.3 COAL BED WATER LEVEL CHANGES

Exhibit D6-5 shows the spacing from the base with the A Sand at the Nichols Ranch Unit to the top of the coal which is 765 feet. The base of the F Sand to the top of the coal of the Hank Unit is 1160 Feet (see Exhibit D6-5). The BLM has monitored water levels in the coal aquifers and sand aquifers above the coal for the last several years. The network of monitoring wells is used to define the effects of water extraction from the coal bed production zone. The nearest monitoring site to the Hank Unit is a coal well approximately 5 miles due north of the northern boundary of the Hank Unit. Figure D6D.3-1 of Addendum D6D presents the water-level elevations of the Pistol Coal Well. This coal aquifer well has water levels that varied over a range of slightly greater than 10 feet for the past ten years. This well did not show a significant effect from the production of water from the coal aquifer.

The Bullwacker sand and coal wells, which are located approximately 6 miles southwest of the Nichols Ranch Unit, have been monitored since 2002. Figure D6D.3-2 in Addendum D6D presents the water level changes for the 2 Bullwacker wells. The sand well, which is completed 100 feet above the coal, has had approximately 140 feet of water level decline through early 2007. The coal well, which has also been monitored over this same period of time, shows a decline in water level starting in 2002 with a drop of approximately 600 feet by early 2007. This indicates that, at the Bullwacker site, the coal has had a large amount of drawdown and the sand water level appears to be declining steadily with the coal. This sand unit must be hydraulically connected with the coal or some well completion is allowing connection between the coal and this sand. The coal and sand are monitored by the BLM at a location 12 miles west of Nichols

Ranch Unit at the Streeter site. Figure D6D.3-3 in Addendum D6D presents the waterlevel elevation for the Streeter sand and coal wells. These figures show that the Streeter sand well has declined by about 9 feet from late 2004 to late 2005. Water levels in most of 2006 were fairly steady. This sand is 624 feet above the top of the coal. The water levels from the Streeter coal well were fairly steady from late 2004 through mid 2005 when water levels started to gradually decline. Water levels from this well have declined approximately 22 feet from mid 2005 through late 2006. The change in the water level from the Streeter sand well is unusual because the water level initially declined and then became steady. Additional water level monitoring will be neccessary to determine whether the observed water level decline should be attributed to the water production from the coal aquifer.

The sand well in the All Night Creek area is completed 124 feet above the coal. These two wells (completed in the sand and coal) are approximately 11 miles to the southwest of the Hank Unit. Figure D6D.3-4 in Addendum D6D presents the water level changes for the All Night Creek wells. The water level changes in the coal are nearly 500 feet while the water levels have not changed significantly in the sand well.
The Beaver Federal sand and coal wells are located approximately 20 miles northnortheast of the Hank Unit. Figure D6D.3-5 of Addendum D6D presents the water levels for the Beaver Federal sand and coal wells. The water level has not changed appreciably in the Beaver Federal sand well, while the coal's water level has declined greater than 200 feet. This sand is 541 feet above the coal, similar to the A Sand completion above the coal. The response of the ore sand water levels in the Nichols Ranch project to coal bed production should be similar to the response in this well.

D6.2.4 GROUND-WATER QUALITY

The ground-water quality at the Nichols Ranch ISR Project areas has been defined by sampling numerous wells in several aquifers in this area. Addendum D6E contains a tabulation of all ground-water quality. Some of the older water quality results were deemed not representative of the aquifer and are not used in the summary calculations of water quality. A criterium was established whereby the largest measured constituent concentration was deemed an outlier if it was greater than five times the next highest value in the data set. These outlier water quality results are highlighted in the water quality table in Addendum D6E.

Table D6-6 presents the summary of the ground-water quality. These summaries are grouped for the A Sand, F Sand, B and C Sands together, then the G and H Sands and finally the 1 Sand. The values in Addendum D6E that are highlighted are not included in Table D6-6 calculations. Three sets of parameters are listed in the upper half of the first page in Table D6-6. The A Sand wells MN-1, MN-2, MN-3, MN-4, MN-5, MN-6 and DW-4L were used to calculate the average concentrations for the A Sand. The first row presents the number of samples followed by the average of those samples for that particular constituent. The maximum, mean and standard deviation are also given in the summary tabulations. The A Sand water typically has very low TDS, (less than 500 mg/1), with its major components being sodium, sulfate and bicarbonate.

For the twenty-nine samples, the TDS varies from a minimum of 289 to 370 mg/l with a standard deviation of 23 mg/l. The sulfate concentrations for the twenty-nine samples vary from 85 to 183 mg/I while the chloride concentrations vary from 4 to 16 mg/I. Variations are 84 to 130 mg/I for sodium and 5.3 to 11 mg/I for calcium. The variation of uranium concentrations are over a small range from less than detection values to a maximum 0.027 mg/I. These A Sand wells are fully penetrating wells and therefore the uranium and radium concentrations will be significantly less for the average of the aquifer than within the ore zone. Radium concentrations from the A Sand vary from less than detection to 36.3 pCi/l. The radium-226 concentrations would likely be in a few hundred pCi/l for a partially penetrating well completed only in the ore zone.

The second group of three sets of summary parameters is for the F Sand wells DW-4U, Hank 1, Dry Willow #1, WC-MN1, BR-B, C #1, SS1F, URZHF-1, URZHF-5 and URZNF-3. F Sand wells BR-G and OW43756 were not included in summary calculations because their water level elevations indicate that they are receiving water from an aquifer with a higher head. Thirty-six samples have been collected from the F Sand wells, with the average TDS concentration greater than 1,000 mg/I. The range in TDS concentration is from 710 to 1,860 mg/l. Sodium, calcium, bicarbonate and sulfate are the major dissolved constituents in this water.

The sulfate concentrations varied over a large range from 418 to 981 mg/I while the chloride concentrations are low in the F Sand water with a variation of less than detection to 33 mg/l. The cations with the largest concentrations are sodium with a variation from 94 to 245 mg/l and calcium which varies from 44 to 293 mg/l. Uranium concentrations varied from less than detection to a high of 5.25 mg/l in this ore bearing sand. Radium concentrations have varied from less than detection to 562 pCi/l.

The two sands that are typically between the A and F production sands are the B and C Sands. The water quality data for these two sands were grouped together in water quality tabulations, and these two sands are connected in some areas. The second page of Table D6-6 presents the summary of the water quality for the B and C Sands. This analysis includes wells BR-Q, BR-T, NBHW-13, DW-4M, F. Brown #1, Brown #5, SS1-M, SS1-U, URZNB-1, URZHC-2 and URZHB-6. TDS concentrations for these aquifers are typically above 600 mg/1 with the larger major constituent concentrations being those of sodium, bicarbonate and sulfate.

The TDS of this water ranges from 278 to 966 mg/l. Sodium is the major cation in this water with concentration variations of 85 to 250 mg/l. Sulfate is a major anion with concentrated variation from 121 to 620 mg/l. These sands do show low concentrations of uranium in some areas that is attributed to limited mineralization. The radium concentrations in the B and C aquifers vary from less than detection to a maximum of 128 pCi/1.

The second group of parameters on the second page of Table D6-6 is for the **G** and H Sands which are the overlying sands for the F Sand in the Hank Unit area. This summary was made from water quality from BR-I, BR-F and BR-H wells. This tabulation shows that, on average, the TDS is near 500 mg/1 with a range of 225 to 696 mg/I. The major constituents with the highest concentrations are sodium, sulfate and bicarbonate. Well BR-I could not be located and there is no recent sample.

The uranium concentrations in the G and H Sands varied from less than detection to 0.018 mg/l for uranium and from less than detection up to 1.9 pCi/1 for radium-226. This data indicates that the wells completed in the G and H Sands are not near mineralized areas.

The third page of Table D6-6 presents the summary of water quality for the 1 Sand well URZN1-2 in the Nichols Ranch Unit area. This data shows that the TDS is slightly greater than 200 mg/I with sodium and bicarbonate being the major components of this water quality. The sulfate and chloride concentrations for the 1 Sand vary over a very small range. Sodium concentrations vary from 92 to 104 mg/I. Bicarbonate is the major anion in this water with very low levels of uranium and radium indicating no mineralization near this 1 Sand well. No other constituent concentrations are significant in the water from the 1 Sand.

D6.3 WATER RIGHTS

Surface and ground-water rights on, adjacent to, and within 3 miles of the Nichols Ranch ISR Project are listed in Table D6F.I-1 in Addendum F and Table D6F.2-1 for the surface water and Tables D6G.1-1, D6G.1-2, D6G.2-1 and D6G.2-2 for the Nichols Ranch Unit and Hank Unit permitted water wells. Table D6G.1-1 lists the wells within the Nichols Ranch Unit while Table D6G. 1-2 in Addendum D6G list wells in and within three miles of the Nichols Ranch Unit. Table D6F.1-2 in Addendum D6F lists the abbreviations used by the State Engineers Office for both the surface and ground-water rights. Figures D6-9 and D6-10 present the locations of the Nichols Ranch Unit and Hank Unit surface rights respectively. Exhibits D6-1 and D6-2 show the locations of the permitted wells within three miles of the Nichols Ranch Unit and Hank Unit respectively. No adjudicated surface water rights are located in or adjacent to (within 2 mile of the project unit) the Nichols Ranch ISR Project. The surface water rights that do exist within the proposed mining project area are limited to stock/storage ponds and ephemeral creeks. Ground-water rights in the Nichols Ranch ISR Project area are mainly associated with the old monitoring wells and stock wells. No other adjudicated water rights are in the project area and lands adjacent to the project area according to the Wyoming State Engineers Office. Uranerz Energy Corporation also does not hold any adjudicated water rights in the project area. Most wells that are located within the Nichols Ranch ISR Project area were previously installed by uranium exploration companies, the T-Chair Livestock Company, or coal bed methane companies. Several additional wells have been completed in the project areas by Uranerz Energy Corporation for use in collecting base line ground water quality data.

Wells in the area of the proposed project area are uniformly distributed over the area excluding monitoring/sampling wells that are permitted by Uranerz Energy Corporation. Most of the wells are used for livestock watering through the use of windmills or electric well pumps. Well depths vary from 180 feet to 1,000 feet in depth, and most wells are completed in sands other than the ore bearing sands. Those wells that are completed in the ore bearing sand will be abandoned using acceptable WDEQ methods or will be used as monitoring wells if not completed in multiple sands. No wells in or adjacent to the project area are used for domestic water consumption. A domestic water supply well is found on the Pfister Ranch (BR-T), located approximately 0.6 miles north of the northern boundary of the Hank Unit. This well is completed at a depth that is stratigraphically below the zones planned for the ISR mining at the Hank Unit. Additionally, the well is located at a large distance from any Hank planned wellfield areas and in the B Sand. It is unlikely that any mining activities that take place in the Hank area will affect this well because of the physical separation of the well from the ore zone. The extensive groundwater monitoring program utilized during the mining project will detect any problems prior to this well being adversely affected by mining activity.

Six permitted wells exist within 2 mile of the Hank Unit area. These wells consist of the Connie #2 well which is nearly ½2 mile east of the project area. This well is used to supply water for stock and has a depth of 350 ft. This well is thought to be in the top portion of the F Sand. The Paden #1 and North Dry Willow #1 wells are very near the mineralized areas near the Hank Unit. The North Dry Willow #1 well is completed in the F Sand through sands down below the 1 Sand and will have to be abandoned before a wellfield pump test in this area. The Paden #1 well is also very near the ore zone in this area and is completed in the C, B and A Sands. This well will have to be monitored during pump testing to determine if it has any connection with the F Sand. If the Paden #1 well has connection with the F Sand it will also need to be replaced. The Brown-WS well is completed in the C, B and A Sands. It is located greater than 1,000 feet west of the mineralized area in Hank Unit. The Brown #5 stock well is located just north of the northern edge of the Hank Unit area. This well has a depth of 540 feet and is completed in the B Sand. The distance of the ISR operation from this well makes it unlikely that mining operations will affect its water level or water quality. The sixth permitted well at the Hank Unit is the Means #1 well, which is used for stock watering and is 700 feet deep and also likely extends down to the A Sand.

Six permitted wells that are not related to the mining operations also exist within 2 mile of Nichols Ranch Unit. The Red Spring Artesian #1 well is located just north of the northwest comer of the project area. This well is completed to 740 feet deep and was a flowing well. The well was not flowing in August of 2007. This well likely extends to sands below the A Sand.

The other five wells are in the southern portion of the project area. The Brown 20-9 well is within the Nichols Ranch Unit. This well is thought to be completed in the A Sand and has a total depth of 740 feet with perforations from 495 to 695 feet.
The Dry Fork #3 well is completed to a depth of 360 feet. With this depth, the well completion interval should be significantly shallower than the A sand.
The N *1,* 11894 well, which is located in Section 19, is completed down to a depth of 310 feet. This well is likely completed in the C Sand.

D6.4 **COAL** BED **METHANE** WELLS **AND OIL/GAS** WELLS

Wells permitted for coal bed methane production are presented on Exhibits D6-3 and D6-4 for the Nichols Ranch Unit and Hank Unit respectively. The tabulation of the coal bed methane wells is presented in Addendum D6H. Exhibit D6-5 shows the footage between the base of the ore sand for each of the two sites and the top of the coal bed methane coal. Oil/Gas wells are shown on Exhibit D6-6 for the combined Nichols Ranch Project. Tabulation of the oil/gas wells is presented in Addendum D6H.

D6.5 EXPLORATION DRILL **HOLES**

A search of the drill hole database maintained by Uranerz Energy Corporation resulted in a total of 546 abandoned exploration drill holes located within the Nichols Ranch ISR Project boundaries. Hole drilled from 1997 through 2007 have been plugged in accordance with current State of Wyoming regulations. A reasonable inspection of the project area showed that these abandoned holes were marked with a stake or pin flag after plugging was completed. To the best of Uranerz Energy Corporations knowledge all holes drilled prior to 1997 were sealed and surface plugged in compliance with the State of Wyoming regulations in effect at the time of drilling. No problems are anticipated with past abandoned drill holes.

All known abandoned drill holes are listed in Tables **D61.I-1,** D61.1-2, D61.2-1 and D61.2-2 and the location and density is shown on Exhibits D6-7 and D6-8.

D6.6 REFERENCES

Hantush, M.S., 1960, Modification of the Theory of Leaky Aquifers. Journal of Geophysical Research, Vol. 65, No. 11, pp. 3713-3725.
Hodson, W.G., R.H. Pearl and S.A. Druse, 1973. Water Resource of the Powder River Basin and Adjacent Areas, Northeastern Wyoming. U.S.G.S. Hydrologic Atlas HA-465.
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TABLE D6-2. BASIC WELL **DATA** FOR **NICHOLS** RANCH **UNIT** WELLS.

WELL NAME	NORTH. COORD.	EAST. COORD.	MP ELEV. (ft-msi)	CASING DIA. (in)	STICK-UP ABOVE LSD	WELL DEPTH (ft-mp)	WATER LEVEL DATE	DEPTH (ft-mp)	ELEVATION (ft-m.)	SCREEN INTERVAL (ft-tsd)	AQUIFER
20-9	1102911	275410	4664.08	5.0	0.9	740			--	495-615	A
	1102911	275410	4664.08	5.0	0.9	740			--	635-655	A
CALVING #1	1100015	289109	4824.00	5.0	1.6	560			--	390 - 420	A
	1100015	289109	4824.00	5.0	1.6	560			--	440-500	A
Dry Fork #3	1100675	273123	4720.00			360					C
DW-4L	1112331	276856	4969.73	5.0	0.4	795	12/20/2006	311.48	4658.25	726 - 795	A
DW-4M	1112331	276769	4970.17	5.0	0.3	441	10/4/2007	286.14	4684.03	389-441	C
DW-4U	1111406	276812	4966.75	5.0	0.3	310	10/4/2007	230.24	4736.51	256 - 309	F
GARDEN											A

MN-1	1105710	273118	4715.14	4.5	1.3	556	10/4/2007	49.83	4665.31	#	479-556	A
MN-2	1108147	273844	4771.00	4.5	0.7	670	10/4/2007	179.00	4592.00	#	560-670	A
MN-3	1106960	275167	4764.64	4.5	0.7	585	10/4/2007	96.65	4667.99		479 - 585	A
MN-4	1109835	272220	4800.36	4.5	2.2	623	10/4/2007	146.75	4653.61		520 - 623	A
MN-5	1108755	272120	4883.28	4.5	2.3	727	10/4/2007	228.10	4655.18		628-727	A
MN-6	1107478	272220	4761.18	4.5	2.2	593	10/4/2007	103.85	46.57.33		485-593	A
1 11894	1102532	269925	4622.33	2.0	0.0	310					191-310	F
ichols #1	1107430	272265	4758.88	5.0	1.2	620	10/4/2007	101.25	57.6346		550 - 565	A
Pats #1	1102872	279812	4690.00		---	405			-		375-405	B
Pug #1	1102383	275338	4685.00		--	370			--		340-370	C
Red Spring A#1	1111694	269021	4710.00	6.0	2.9	740						A
URZN1-2	1105691	273081	4714.31	4.5	1.1	645	10/4/2007	63.78	4650.53	#	600-645	1
URZNB-1	1105725	273149	4716.36	4.5	1.3	375	10/4/2007	62.14	4654.22	#	330-375	B
URZNF-3	1105992	273707	4728.87	4.0	2.3	173	10/4/2007	89.20	4639.67		153 -173	F
URZNQ-4	1103219	272397	4638.44	4.0	1.5	35	10/4/2007	9.33	4629.11		15 -35	ALL
W. Of **WW1**	1116674	286130	5080.00	6.0	2.3	720	9/26/2007	372.30	4707.70		340 -370	C
1116674		286130	5080.00	6.0	2.3	720	9/26/2007	372.30	4707.70		540 - 720	A

NOTE: * = Abandoned
#= Open Hole Completion
ALL = Alluvial
W. of WW1 = West of Wdow Women

Project boundaries. Hole drilled from 1997 through 2007 have been plugged in accordance with current State of Wyoming regulations. A reasonable inspection of the project area showed that these abandoned holes were marked with a stake or pin flag after plugging was completed. To the best of Uranerz Energy Corporations knowledge all holes drilled prior to 1997 were sealed and surface plugged in compliance with the State of Wyoming regulations in effect at the time of drilling. No problems are anticipated with past abandoned drill holes.

All known abandoned drill holes are listed in Tables **D61.I-1,** D61.1-2, D61.2-1 and D61.2-2 and the location and density is shown on Exhibits D6-7 and D6-8.

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Lowham, H.W., 1976. Techniques for Estimating Flow Characteristics of Wyoming streams. U.S.G.S.. Water Resource Investigation 76-112.

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