5.6.3 Groundwater

5.6.3.1 Potential Groundwater Impacts

Potential groundwater impacts include groundwater consumption, drawdown in nearby water supply wells, and potential groundwater quality impacts. Each of these is discussed below.

5.6.3.1.1 Potential Groundwater Consumption

Inyan Kara Aquifer

ISR circulates significant quantities of water through the ore zone, but only a small fraction of that water is a net withdrawal because most water is reinjected into the deposit. During ISR operations (including both production and restoration), a small portion of the solution extracted from the aquifer will be "bled" from the system. Bleed is defined as excess production or restoration solution withdrawn to maintain a cone of depression so native groundwater continually flows toward the center of the production zone. This bleed constitutes the net water withdrawal from the Inyan Kara aquifer. Nominal bleed rates of 0.5 to 1% are planned over the life of the project, with a design average bleed rate of 0.875%. Instantaneous production bleed may vary in the range of 0.5 to 3% for short durations, from days to months. If necessary, additional aquifer restoration bleed (up to 17%) will be used briefly during aquifer restoration to recover additional solutions and draw a greater influx of water into the ore zone from the surrounding Inyan Kara aquifer. This is known as groundwater sweep.

Table 5.6-1 summarizes the typical Inyan Kara water usage for the Dewey-Burdock Project. During uranium recovery (production), Powertech (USA) proposes to pump up to 8,000 gpm from the Inyan Kara aquifer. The typical production bleed rate will be 0.875%. Therefore, the net production withdrawal will typically be up to 70 gpm. During aquifer restoration, Powertech (USA) proposes to pump up to 500 gpm from the Inyan Kara aquifer. The restoration bleed will vary from about 1% to 17%. Therefore, the net aquifer restoration withdrawal will be up to 85 gpm. During concurrent production and restoration, the anticipated maximum gross and net usage from the Inyan Kara (on an annual average basis) will be 8,500 gpm and 155 gpm, respectively.

Madison Limestone

Table 5.6-2 summarizes the anticipated typical water consumption from the Madison Limestone. This includes approximately 12 gpm usage at the CPP plus aquifer restoration water. In the DDW option, the water withdrawn from the well fields will be treated with RO, and resulting permeate will be reinjected along with Madison Limestone water into the well fields. Based on an estimated permeate recovery rate of 70%, the Madison Limestone requirement will be 65 to 145 gpm at 17% and 1% aquifer restoration bleed, respectively.

Table 5.6-1: Typical Inyan Kara Water Usage

Usage	Amount
Production Only	
Gross Inyan Kara Pumping, gpm	8,000
Net Inyan Kara Usage (0.875% bleed), gpm	70
Aquifer Restoration Only	
Gross Inyan Kara Pumping, gpm	500
Net Inyan Kara Usage (1% bleed), gpm	5
Net Inyan Kara Usage (17% bleed), gpm	85
Concurrent Production and Restoration	
Gross Inyan Kara Pumping, gpm	8,500
Net Inyan Kara Usage (1% aquifer restoration bleed), gpm	75
Net Inyan Kara Usage (17% aquifer restoration bleed), gpm	155

Table 5.6-2: Typical Madison Water Usage

Usage	Amount
Production Only	
CPP usage, gpm	12
Aquifer Restoration Only	
Deep Disposal Well Option	
CPP usage, gpm	12
Madison Usage (1% bleed), gpm	145
Madison Usage (17% bleed), gpm	65
Land Application Option	
CPP usage, gpm	12
Madison Usage (1% bleed), gpm	495
Madison Usage (17% bleed), gpm	415
Concurrent Production and Restoration	
Maximum Anticipated Madison Usage (DDW option), gpm	157
Maximum Anticipated Madison Usage (land application option), gpm	507

In the land application option, all of the water withdrawn during aquifer restoration will be treated and disposed. The water will be replaced with water from the Madison Limestone or another suitable aquifer except for the restoration bleed, which will vary from 1% to 17%. Since the aquifer restoration pumping rate will be up to 500 gpm, between 415 and 495 gpm from the Madison Limestone will be reinjected into well fields undergoing aquifer restoration.

5.6.3.1.2 Potential Drawdown

Inyan Kara Aquifer

Petrotek Engineering Corporation (Petrotek) prepared a numerical groundwater flow model using site-specific data to predict hydraulic responses of the Fall River and Chilson aquifers to ISR production and restoration operations at the Dewey-Burdock Project. A primary model objective was to predict drawdown on a local and regional scale.

The numerical groundwater model domain encompasses nearly 360 square miles with north-south and east-west dimensions of 100,000 ft (18.9 miles). The northern and eastern boundaries of the model domain represent the updip limits of saturated conditions within the Inyan Kara aquifer system. The southern and western boundaries of the model extend at least 10 miles beyond the permit area. The Dewey Fault forms a no-flow boundary along the northwestern and northern boundaries of the model domain. Four layers were modeled. From shallowest to deepest these include the Graneros Group, Fall River Formation, Fuson Shale, and the Chilson Member of the Lakota Formation.

The model was calibrated to average 2010-2011 water level data by varying recharge to the Fall River and Chilson aquifers. Transient calibrations also were performed by simulating results of the 2008 aquifer tests conducted in support of the NRC license application. The calibrated model was then verified through simulation of aquifer tests conducted in 1982 by TVA.

Operational simulations were performed for gross Inyan Kara production rates ranging from 4,000 to 8,000 gpm. Restoration was simulated as a 1% bleed for a 500 gpm, gross restoration flow rate (5 gpm net extraction). Additional restoration bleed also was simulated for the groundwater sweep option. The results of the numerical groundwater modeling are presented in Appendix 5.6-A. Figures 6-38 and 6-39 in Appendix 5.6-A depict the modeled maximum drawdown for the Fall River and Chilson, respectively, at an 8,000 gpm gross production rate with a 1% production bleed and 1% aquifer restoration bleed applied to a 500 gpm gross restoration rate plus groundwater sweep. This represents a maximum net Inyan Kara water usage rate of 147.2 gpm, or an amount approximately equal to the typical net Inyan Kara usage during concurrent production and restoration in Table 5.6-1.

Figure 6-38 in Appendix 5.6-A shows the maximum predicted drawdown in the Fall River Formation, and Figure 6-39 in Appendix 5.6-A shows the maximum predicted drawdown in the Chilson. Maximum drawdown outside the permit area during the simulation was slightly greater than 12 feet within the Fall River and approximately 10 feet in the Chilson. The groundwater model report in Appendix 5.6-A shows that potential drawdown impacts will be short-lived, with recovery to within 1 to 2 feet of pre-ISR levels within one year after the end of ISR operations.

The potential to unlawfully impair existing water rights or domestic wells will be addressed in Inyan Kara aquifer water appropriation permits obtained through the DENR Water Rights Program. The Inyan Kara water rights applications demonstrate that Inyan Kara water is available for the proposed use and the proposed diversions can be developed without unlawful impairment of existing rights.

Madison Limestone

Powertech (USA) has developed a conceptual groundwater flow model of the Madison Limestone in the vicinity of the permit area. The model results are provided with the water appropriation permit application for the Madison that has been submitted to the DENR Water Rights Program. The conceptual model demonstrates that Madison water is available for the proposed use and the proposed diversions can be developed without unlawful impairment of existing rights.

5.6.3.1.3 Potential Groundwater Quality Impacts

Potential groundwater quality impacts include potential impacts to the ore zone, potential impacts to aquifers surrounding the ore zone, potential impacts to overlying and underlying aquifers, and potential impacts to the alluvium. Each of these is addressed below.

5.6.3.1.3.1 Potential Impacts to Ore Zone Groundwater Quality

A potential environmental impact to groundwater as a result of ISR is the degradation of water quality in the ore zone within the well field areas. The interaction of the lixiviant with the mineral and chemical constituents of the aquifer will result in an increase in trace elements and salinity during uranium recovery operations. This will result from oxidation of uranium and other trace constituents and through the IX process, which will exchange dissolved uranium for chloride or bicarbonate ions.

During aquifer restoration, Powertech (USA) will restore groundwater quality consistent with NRC license conditions, the primary restoration goals being baseline water quality or an EPA-established maximum contaminant level (MCL) on a parameter-by-parameter basis. Therefore, the potential impacts to ore zone groundwater quality will be temporary and will end with NRC approval of successful aquifer restoration in each well field.

5.6.3.1.3.2 Potential Impacts to Inyan Kara Groundwater Quality Outside of the Ore Zone
Horizontal excursions have the potential to contaminate groundwater horizontally outside of the ore zone. Horizontal excursions could be caused by a temporary well field imbalance, in which the inward hydraulic gradient normally maintained by production and restoration bleed is temporarily altered. Horizontal excursions, if left uncontrolled, would have the potential to impact the groundwater quality of USDWs surrounding the ore zone. However, as described in Section 5.6.3.2, an extensive monitoring system will be implemented to ensure that potential excursions are rapidly detected and corrected. Therefore, potential impacts to Inyan Kara groundwater quality outside of the ore zone would be brief and localized.

By properly designing, pump testing, and operating each well field and its associated monitor well network, Powertech (USA) will minimize the risk of excursions and the potential impacts resulting from excursions. By routinely sampling monitor wells for changes in water level and concentrations of highly mobile and conservative excursion parameters, Powertech (USA) will ensure that any potential excursions are identified and corrected quickly. As described by NUREG-1910, Supplement 1 (NRC, 2010), "An excursion is defined as an event where a monitoring well in overlying, underlying, or perimeter well ring detects an increase in specific water quality indicators, usually chloride, alkalinity and conductivity, which may signal that fluids are moving out from the wellfield … The perimeter monitoring wells are located in a buffer region surrounding the wellfield within the exempted portion of the aquifer. These wells are specifically located in this buffer zone to detect and correct an excursion before it reaches a USDW … To date, no excursion from an NRC-licensed ISR facility has contaminated a USDW."

5.6.3.1.3.3 Potential Impacts to Overlying or Underlying Aquifers
Potential impacts to overlying or underlying aquifers could occur from a vertical excursion of ISR solutions into an overlying or underlying aquifer. This could be caused by vertical hydraulic head gradients between the production aquifer and the underlying or overlying aquifers. A vertical hydraulic head gradient could be caused by pumping from either the underlying or overlying aquifers for water supply in the vicinity of the ISR facility. Discontinuities in the thickness and spatial heterogeneities in the vertical hydraulic conductivity of confining units could also lead to vertical movement of solutions and excursions.

Another potential source of vertical excursions is potential well integrity failures during ISR operations. Inadequate construction, degradation, or accidental rupture of well casings above or below the uranium-bearing aquifer could allow lixiviant to travel from the well bore into the surrounding aquifer. Deep monitor wells drilled through the production aquifer and confining units that penetrate aquitards could potentially create pathways for vertical excursions as well.

Section 5.6.3.2 describes how an extensive monitoring system and MIT program will be implemented to prevent vertical excursions and to provide rapid detection and corrective action in the event of a vertical excursion. Potential impacts to overlying or underlying aquifers would be brief and localized.

5.6.3.1.3.4 Potential Impacts to Alluvium

The primary potential to impact alluvial water quality would be a pipeline leak or spill. Potential impacts and mitigation measures for leaks and spills are addressed in Sections 5.6.4.1 and 5.6.4.2.
If land application is used for liquid waste disposal, the alluvial groundwater quality could be impacted in the vicinity of the land application areas. The GDP and Section 5.6.3.2 describe mitigation measures that will protect alluvial groundwater quality during land application.

5.6.3.1.4 Potential Impacts to Groundwater Hydrologic Balance
Any disturbance to the prevailing hydrologic balance of the affected land and of the surrounding area and to the quantity of groundwater both during and after ISR operations and during reclamation will be minimized in accordance with SDCL 45-6B-41. Powertech (USA) will be required to demonstrate that water is available for the proposed diversions in the Inyan Kara and Madison in order to obtain water appropriation permits from the DENR Water Rights Program. The water appropriation permit applications will demonstrate limited potential impacts to the groundwater hydrologic balance due to limited drawdown.

5.6.3.1.5 Potential Subsidence in ISR Well Fields
There is no potential for subsidence in the ISR well fields due to limited drawdown in the ore zone and other aquifers and due to the nature of uranium ISR, which does not affect the structural integrity of the ore zone sands. Refer to Section 5.6.3.1.2 and Appendix 5.6-A, which describe how potential drawdown in the Inyan Kara aquifer will be limited, and the potentiometric water level is anticipated to recover to pre-ISR levels rapidly after the end of ISR activities. Section 5.6.3.1.2 also describes how potential drawdown in the Madison Limestone will be only a small portion of the confining pressure above the top of the Madison.
The following information from the ISR GEIS addresses subsidence potential in ISR well fields in the Nebraska-South Dakota-Wyoming Uranium Milling Region, which includes the proposed permit area (NRC, 2009, Section 4.4.3.2):

"The removal of uranium mineral coatings on sediment grains in the target sandstones during the uranium mobilization and recovery process will result in a change to the mineralogical composition of uranium-producing formations. However, the uranium mobilization and recovery process in the target sandstones does not result in the removal of rock matrix or structure, and therefore no significant matrix compression or ground subsidence is expected. In addition, the source formations for uranium in the Nebraska-South Dakota-Wyoming Milling Region occur at depths of tens to hundreds of meters [hundreds of feet] … and individual mineralization fronts are typically 0.6 to 7.5 m [2 to 25 ft] thick … At these depths and thicknesses and considering that rock matrix is not removed during the uranium mobilization and recovery process, it is unlikely that collapse in the target sandstones would be translated to the ground surface. Therefore, impacts to geology from ground subsidence would be expected to be SMALL."

5.6.3.2 Mitigation of Potential Groundwater Impacts Following is a list of mitigation measures for potential impacts to groundwater. Specific mitigation measures for potential impacts to water supply wells, corrective actions for excursions, and protection of groundwater quality in and around land application areas are provided below. • Perform MIT on all wells prior to use and repeat every 5 years. • Minimize groundwater use during operations by limiting production and restoration bleed to the minimum amount needed to ensure hydraulic well field control. • Monitor well pressures to detect leaks. • Install and operate an extensive monitoring system to detect potential horizontal or vertical excursions of ISR solutions. • Plug and abandon or mitigate any of the following should they pose the potential to impact the control and containment of well field solutions within the permit area: o Historical wells and exploration holes o Holes drilled by Powertech (USA) for delineation and exploration o Any well failing MIT • Maintain pumping and injection rates (well field balance) to ensure radial hydraulic flow into and through the production zone. • Monitor to detect and define unanticipated surface spills, releases, or similar events that may infiltrate into the groundwater system. • Implement a spill prevention and cleanup plan to minimize potential impacts to groundwater, including rapid response cleanup and remediation capability, techniques, procedures, and training. • Monitor nearby domestic, livestock, irrigation, and designated monitor wells as appropriate during operations. • Select restoration method to minimize water consumption during groundwater restoration. • During groundwater restoration, monitor groundwater using standard industry practices to determine the progression and effectiveness of restoration. • Implement an extensive land application monitoring system that includes compliance wells, intermediate wells, and vadose zone monitoring. • Site land application areas at locations where natural conditions make it highly unlikely that the land application water will reach the alluvium. • Apply land application water at agronomic rates. • Treat the land application water and/or DDW water to remove radionuclides.

Mitigation of Potential Impacts to Water Supply Wells

The following procedures will be followed to evaluate and mitigate potential impacts to water supply wells. During the design of each well field, all nearby water supply wells will be evaluated for the potential to be impacted by ISR operations or the potential to interfere with ISR operations. If needed, this evaluation also will include groundwater modeling. The results of the evaluation will be contained within a well replacement plan described in the hydrogeologic data package for each well field (refer to Section 5.3.3.4).

At a minimum, all domestic wells within the permit area will be removed from drinking water use and all stock wells within ¼ mile of well fields will be removed from private use. Depending on the well construction, location and screen depth, Powertech (USA) may continue to use the well for monitoring or plug and abandon the well.

The well owner will be notified in writing prior to removing any well from private use. Powertech (USA) will work with the well owner to determine whether a replacement well or alternate water supply is needed.

Section 5.5.2 describes the operational groundwater monitoring plan that will be used to assess potential impacts to domestic, livestock and irrigation wells. The monitor well ring will provide advance warning before any wells outside the ring have potential to be impacted. If routine monitoring of a water supply well indicates diminished water quantity or quality, the well owner will be notified in writing and the well will be removed from use. Powertech (USA) will work with the well owner to determine if well replacement is necessary. Well replacement procedures are described below. The monitoring and well replacement or abandonment procedures to be implemented by Powertech (USA) will assure that there will be no effects on anyone or any water well outside the monitor well ring.

Water Supply Well Replacement Procedures

Replacement wells will be located an appropriate distance from the well fields and will target an aquifer outside of the ore zone that provides water in a quantity equal to that of the original well and of a quality which is suitable for the same uses as the original well, subject to the lease agreement and South Dakota water law.

Lease agreements for the entire permit area currently allow Powertech (USA) to remove and replace the water supply wells as needed. The following is an excerpt from the lease agreements with each landowner. (Note: all lease agreements formerly held by Denver Uranium have been assigned to Powertech (USA).)

DENVER URANIUM shall compensate LESSOR for water wells owned by LESSOR at the execution of this lease, as follows: Any such water which falls within an area to be mined by DENVER URANIUM, shall be removed from LESSOR's use. Prior to removal, DENVER URANIUM shall arrange for the drilling of a replacement water well or wells, outside of the mining area, in locations mutually agreed upon between LESSOR and DENVER URANIUM, as may be necessary to provide water in a quantity equal to the original well and of a quality which is suitable for all uses the original water well served at the time such well was removed from LESSOR's use.

An example of a replacement well is provided in Figure 5.6-1, which shows use of the project Madison well to supply water by pipeline to local stock tanks.

Excursion Control

The following mitigation measures will be used to prevent potential horizontal or vertical excursions of ISR solutions.

Pre-operational excursion preventative measures will include, but will not be limited to:

1. Proper well construction and MIT of each well before use;

2. Monitor well design schema based upon delineation drilling to further characterize the zones of mineralization and to identify the target completion zones for all monitor wells; and

3. Pre-operational pumping tests with monitoring systems in place to obtain a detailed understanding of the local hydrogeology and to demonstrate the adequacy of the monitoring system.

Operational excursion preventative measures will include but will not be limited to:

1. Regular monitoring of flow and pressure on each production and injection well;

2. Regular flow balancing and adjustment of all production and injection flows appropriate for each production pattern;

3. Operation of bleed, and continuous measurement of bleed rate;

4. Monitoring hydrostatic water levels in monitor wells to verify the cone of depression; and

5. Regular collection of samples from all monitor wells to determine the presence of any indicators of the migration of ISR solutions horizontally or vertically from the production zone.

6. Perform MIT on all wells prior to use and repeat every 5 years.

Monitor wells will be positioned to detect any ISR solutions that may potentially migrate away from the production zone due to an imbalance in well field pressure. The monitoring well detection system described in Section 5.3.3.1.2 is a proven method used at historically and currently operated ISR facilities. Prior to injecting chemicals into each well field, pre-operational pump testing will be conducted to demonstrate hydraulic connection between the production and injection wells and all perimeter monitor wells (see Section 5.3.3.3). The results of the pump testing will be included within the hydrogeologic data packages prepared for each well field as described in Section 5.3.3.4. Additional monitor wells will be installed within overlying and underlying hydrogeologic units. The pre-operational pump testing will demonstrate vertical confinement and hydraulic isolation between the production zone and overlying and underlying units. The monitoring system and operational procedures have proven effective in early detection of potential excursions of ISR solutions for a number of reasons:

• Regular sampling for indicator parameters (such as chloride) that are highly mobile can detect ISR solutions at low levels well before an excursion is created.

• Monitoring hydrostatic water levels in perimeter monitor wells will provide immediate verification of the cone of depression, draw rapid attention in the event of a change, and provide the ability for measurement and implementation of corrective response.

• Bleed will create a cone of depression that will maintain an inward hydraulic gradient toward the well field area.

• The natural groundwater gradient and slow rate of natural groundwater flow is small relative to ISR activities and the induced gradient caused by the production and restoration bleed.

Controls for preventing migration of ISR solutions to overlying and underlying aquifers consist of:

• Regular monitoring of hydrostatic water levels and sampling for analysis of indicator species;

• Routine MIT of all wells on a regular basis (at least every 5 years) to reduce any possibility of casing leakage;

• Completion of MIT on all wells before putting them into service or after work which involves drilling equipment inside of the casing;

• Proper plugging and abandonment of all wells which do not pass MIT or that become unnecessary for use; • Proper plugging and abandonment of exploration holes with potential to impact ISR operations; and • Sampling monitor wells located within the overlying and underlying hydrogeologic units on a frequent schedule. These controls work together to prevent and detect ISR solution migration. Plugging any exploration holes that pose the potential to impact the control and containment of ISR solutions prevents connection of the production zone to overlying and underlying units. The EPA UIC requirements for MIT assure proper well construction, which is the first line of defence for maintaining appropriate pressure without leakage. Sampling the monitor wells will enable early detection of any ISR solutions should an excursion occur.

Excursion Corrective Actions Powertech (USA) will implement the following corrective action plan for excursions occurring during production or restoration operations. Corrective actions to correct and retrieve an excursion may include but will not be limited to: • Adjusting the flow rates of the production and injection wells to increase the aquifer bleed in the area of the excursion; • Terminating injection into the portion of the well field affected by the excursion; • Installing pumps in injection wells in the portion of the well field affected by the excursion to retrieve ISR solutions; • Replacing injection or production wells; and • Installing new pumping wells adjacent to the well on excursion status to recover ISR solutions.

In the event of an excursion, the sampling frequency will be increased to weekly. NRC will be notified within 24 hours by telephone or email and within 7 days in writing from the time an excursion is verified. DENR will be notified in writing within 7 days from the time an excursion is verified. In addition, if the excursion has potential to affect a USDW, EPA will be notified verbally within 24 hours and in writing within 5 days. A written report describing the excursion event, corrective actions taken and the corrective action results will be submitted to all involved regulatory agencies within 60 days of the excursion confirmation. If wells are still on excursion status when the report is submitted, the report also will contain a schedule for submittal of future reports describing the excursion event, corrective actions taken, and results obtained. If an excursion is not corrected within 60 days of confirmation, Powertech (USA) will terminate injection into the affected portion of the well field until the excursion is retrieved, or provide an increase to the reclamation financial assurance obligation in an amount that is agreeable to NRC and that would cover the expected full cost of correcting and cleaning up the excursion. The financial assurance increase will remain in force until the excursion is corrected. The written 60-day excursion report will state and justify which course of action will be followed. If wells are still on excursion status at the time the 60-day report is submitted to NRC, and the financial assurance option is chosen, the well field restoration financial assurance obligation will be adjusted upward. When the excursion is corrected, the additional financial assurance obligations resulting from the excursion will be removed.

Protection of Groundwater Quality in and around Land Application Areas

Powertech (USA) will operate the proposed land application systems in accordance with an approved GDP, the primary purpose of which is to protect groundwater quality in accordance with State standards. Mitigation measures to protect groundwater quality in the land application areas are described above and include implementing an extensive land application monitoring system that includes compliance wells, intermediate wells and vadose zone monitoring; siting land application areas at locations where natural conditions make it unlikely that land application water will reach alluvial groundwater; applying land application water at agronomic rates; and treating land application water to remove radionuclides. These mitigation measures will ensure compliance with groundwater quality standards in and around the land application areas during and after ISR operations and during reclamation.