INT-014

In-situ recovery uranium mining in the United States: Overview of production and remediation issues

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In 2007, in-situ recovery (ISR) methods produced about 95% of U.S. production of 4.53 million pounds. Eleven new and five expansion ISR applications or letters of intent were filed with the U.S. Nuclear Regulatory Commission for the period from 2007-2009. ISR mining can be conducted in water-saturated, permeable, hydrologically confined sandstone beds where the uranium is soluble. Contamination of ground water during and after ISR operations has become a major issue for nearby residents, and for local, county and state governments. Colorado has raised ISR mining requirements and established a burden of proof that operations can return water quality to baseline conditions. Similar concerns are affecting mining plans in Wyoming, Texas, New Mexico, South Dakota, and Nebraska. Major issues affecting restoration at ISR mining operations include the following:

- Baseline water quality: Is the water presently potable or suitable for livestock or irrigation? What parts of the local aquifer should be sampled to establish baseline? What sampling methods are required to establish water quality conditions?

- Control of fluid flow during operations: How much hydrologic understanding of the ore zone is necessary to avoid flow problems?

- Ground-water restoration: To what standard should the ground water be restored? How long should monitoring occur after mining is completed?

- Ground-water restoration: What technologies work or might work?

To date, no remediation of an ISR operation in the United States has successfully returned the aquifer to baseline conditions. Often at the end of monitoring, contaminants continue to increase by reoxidation and resolubilization of species reduced during remediation; slow contaminant movement from low to high permeability zones; and slow desorption of contaminants adsorbed to various mineral phases. New remediation technologies are being examined, including bioremediation and monitored natural attenuation. Bioremediation can occur through addition of a carbon source such as acetate or molasses to augment the natural bacterial population which can induce simultaneous reduction and precipitation of uranium in solution. Bioremediation experiments are presently being conducted at U.S. Department of Energy sites in western states. Monitored natural attenuation suggest that ground-water flow that created the deposit moved from an oxidized zone through the orebody to a reduced zone. Re-establishment of ground-water flow after mining should move contaminants from the mined orebody into the reduced zone where natural processes can reduce the contaminants and remove them from the ground water. Questions: 1) Is current ground-water hydrology suitable? 2) What is the reducing capacity of the reduced zone? 3) Do kinetics of reduction reactions in the reducing zone vs. speed of ground water flow? 4) Effects of heterogeneity in mining zone and reducing zone? 5) Can all analytes of concern be attenuated? 6) Monitored attenuation- can the limited time frame preferred by operators be achieved?