

The Schwartzwalder deposit is the largest known vein type uranium deposit in the United States. Located about eight miles northwest of Golden, Colorado it occurs in Proterozoic metamorphic rocks and was formed by hydrothermal fluid flow, mineralization, and deformation during the Laramide Orogeny. A complex brittle fault zone hosts the deposit comprising locally brecciated carbonate, oxide, and sulfide minerals. Mining of pitchblende, the primary ore mineral, began in 1953 and an extensive network of underground workings was developed. Mine dewatering, treatment of the effluent and its discharge into the adjacent Ralston Creek was done under State permit from about 1990 through about 2008. Mining and dewatering ceased in 2000 and natural groundwater rebound has filled the mine workings to a current elevation that is above Ralston Creek but that is still below the lowest ground level adit. Water in the "mine pool" has concentrations of dissolved uranium in excess of 1,000 times the U.S. Environmental Protection Agency drinking-water standard of 30 micrograms per liter. Other dissolved constituents such as molybdenum, radium, and sulfate are also present in anomalously high concentrations.

Ralston Creek flows in a narrow valley containing Quaternary alluvium predominantly derived from weathering of crystalline bedrock including local mineralized rock. Just upstream of the mine site, two capped and unsaturated waste rock piles with high radioactivity sit on an alluvial terrace. As Ralston Creek flows past the mine site, a host of dissolved metal concentrations increase. Ralston Creek eventually discharges into Ralston Reservoir about 2.5 miles downstream. Because of highly elevated uranium concentrations, the State of Colorado issued an enforcement action against the mine permit holder requiring renewed collection and treatment of alluvial groundwater.

As part of planned mine reclamation, abundant data were collected and compiled into a report by Wyman and Effner (2007), which was to be used as a basis for eventual mine site closure. In 2010 the U.S. Geological Survey was asked by the State of Colorado to provide an objective and independent review of the Wyman and Effner (2007) report and to identify gaps in knowledge regarding the hydrogeology of the mine site.

Key findings from the U.S. Geological Survey assessment include geological structural analysis indicating that although the primary uranium-hosting fault likely does not cross under Ralston Creek, many complex subsidiary faults do cross under Ralston Creek. It is unknown if any of these faults act as conduits for mine pool water to enter Ralston Creek. Reported bedrock permeabilities are low, but local hydraulic gradients are sufficient to potentially drive groundwater flow from the mine pool to the creek. Estimated average linear velocities for the full range of reported hydraulic conductivities indicate groundwater transit times from the mine pool to the creek on the order of a few months to about 3,800 years or 11 to 65 years using mean reported input values. These estimates do not account for geochemical reactions along any given flow path that may differentially enhance or retard movement of individual dissolved constituents. New reconnaissance data including 34S isotope and 234U/238U isotopic activity ratios show potentially distinctive signatures for the mine pool compared to local groundwater and Ralston Creek water above the mine site.

Although the mine pool may be near an equilibrium elevation, evidence for groundwater recharge transients indicates inflow to the workings that are greater than outflow. There is not enough hydraulic head data adjacent to the mine workings to adequately constrain a final equilibrium elevation or to predict how several wet years in succession might affect variations in mine pool elevation. Although ground level adits are sealed with bulkheads, if the mine pool elevation were to rise slightly to the elevation of or above these adits, there is additional potential for seepage into the environment. The mine workings, mine pool water, the mineralized fault zone, and parts of the alluvial aquifer contaminated by mine waste are all potential sources of dissolved metals to Ralston Creek. The waste rock piles are not a major contaminant source at this time based on data in Wyman and Effner (2007) and new U.S. Geological Survey data. However, questions regarding the long-term integrity of the cap rock seal, possible leaching processes between the unsaturated and saturated zone, groundwater flow in the alluvial aquifer and a 100-year-plus flood make the waste rock piles a potential source in the future.

Recent geochemical data from Ralston Creek shows dissolved uranium concentrations that remain above drinking-water standards in spite of treatment operations. The mine pool water is now hydraulically above the creek, and the pathway(s) for mine pool water flowing into the alluvial aquifer and Ralston Creek through the bedrock should be investigated further.

Established monitoring wells at the mine site are not adequate to characterize local hydraulic head and to contrast the geochemistry of bedrock and alluvial groundwater because many of them are screened in both the bedrock and alluvium. The bedrock is particularly underrepresented in existing wells. This report suggests the drilling and completion of appropriately sited and nested bedrock and alluvial well pairs. These wells should be sampled in conjunction with a series of stream tracer dilution studies in Ralston Creek with the sumps operational as well as shut down. An expanded program of water sampling could include high precision uranium and sulfur isotope analyses and other analyses of potentially diagnostic trace elements and their ratios. This approach may permit the identification of mine pool and/or other mixed contaminated water entering Ralston Creek. It will be critical to determine if the hydraulic heads in the bedrock wells are higher than in the alluvial wells. Although Ralston Creek delivers a relatively small proportion of water flowing to Ralston Reservoir, continued monitoring of the mine pool elevation and dissolved uranium concentrations in all water samples is essential.

