Report for 2002NV5B: Assessment of Ground Water Recharge in Mine Altered Regions of Nevada

- Conference Proceedings:
  - Turrentine, J. A., T. Halihan and T. Fenstemaker, Vadose Zone Fluid Migration in a Heap-Leach Site using Transient Electrical Resistivity Surveys. Paper No. 7-21. Geological Society of America Annual Meeting, Abstracts with Program. October 26-31, 2002, Denver, CO.
- Other Publications:
  - Webb, G. and S. Tyler. Leaching and draindown experiments conducted at the Gold Acres Facility. Presented at the 2003 Heap Leach Closure Workshop, Elko, Nevada, March 2003 sponsored by UNR Mining Life Cycle Center and the Nevada Mining Association.

Report Follows:

Research Objectives:

This research utilized the unique geometry and construction practices of heap leach gold mining presently used in Nevada to estimate ground water recharge contributions through mining waste material and to quantify the mechanisms of fluid transport through mining waste material. It is well known that it is extremely difficult to accurately measure ground water recharge in arid and semi arid environments. However, heap leach mining structures allow for the collection of all recharge passing through these large (100-500 acre) structures. Following cessation of the mining operation, long term drainage from the heap leach structures can be used to directly estimate the recharge rates (and percentage of recharge to precipitation). Transport through the mining waste material has been investigated in this study through the use of a unique field experiment designed to directly quantify the rates and flow mechanisms (matrix flow, preferential flow, etc.) through actual mining waste material at the Cortez facility in eastern Nevada. Information gathered from a series of leaching and draindown experiments carried out in 2002 and 2003 have shown that fluid flow through the material is highly variable and controlled by heterogeneities in the waste material. These data gathered from this study can be used to assess various waste containment methods for closure of mines as well as rural sanitary landfills.

This project proposes to determine the rate of ground water recharge beneath disturbed mine lands in Nevada, with particular attention to heap leach piles, waste rock dumps and the associated issues of water quality with these areas. In the first year of the project, we have focused on sampling known closed mine sites and designing a field monitoring laboratory to investigate the flow and transport processes in these complex materials. We have and continue to analyze heap leach pile drainage data to determine rates of recharge from these structures. As heap leach piles are lined and drainage can easily be measured, these structures act as very large lysimeters, intercepting ground water recharge before reaching the water table. The integrated fluxes through these structures, long after active leaching and rinsing has stopped represent deep infiltration. Data gathered to date from field investigations shows a complex relationship between surface morphology, precipitation and long-term drainage rate. At several sites, changes in surface cover or management practices have been reflected in declines in drainage rates below that expected for native vegetation at these sites. Water quality from the studies sites shows a wide variation in dissolved constituents, primarily reflecting the mineralogy of the primary ore and waste rock, as well as the rinsing and closure strategies employed. Open pit precious metal mining in Nevada places large volumes of rock, some of which is reactive, at the land surface, both as heap leach piles and waste rock dumps. While the climate of Nevada is generally arid to semi-arid, rainfall and snowmelt can infiltrate following mine closure and become ground water recharge. Given the reactive nature of some of these mining wastes and the almost complete lack of quantitative data on long-term infiltration, it is critical that the rates of water and solute flux through these structures be quantified to determine if a significant potential for ground water degradation may occur and to develop effective management strategies.

As a result of efforts during the first year, we have developed a unique opportunity with Placer Dome Inc., to densely instrument a heap leach pad nearing completion. Currently, there does not exist any detailed, in-place monitoring and sampling facility to study the transport of water and contaminants through gold mining waste at the field scale. The constructed facility represents a partnership between industry and the university of significant benefit to both. At this time, no similar facility exists in the world and will provide tremendous opportunities for future research into contaminant transport from mining waste.

Placer Dome has provided the cost of instrumentation and monitoring as in-kind services, with UNR's activities focused on laboratory analysis, field collection of data, data analysis and experimental design. This site offers a unique opportunity, unavailable to us when the first year proposal was completed, to study in situ, 1) the evolution of wetting and drainage in an active heap leach pile, 2) the geochemical evolution of waters produced during leaching operations, 3) the short term drainage effluent quality following leaching 4) the efficacy of rinsing in reducing toxic species in the effluent waters and 5) to test various cover/closure options to reduce both water flow and toxic element release.

Information on anticipated long-term infiltration through heap leach piles and waste rock dumps at precious metal mines in Nevada is critical for assessing the potential impacts of these structures on ground water quality. Research completed in this project on existing sites (Kampf et al., 2002) and the field investigations in collaboration with Placer Dome Mining have resulted in a much more comprehensive understanding of fluid flow and recharge through mining waste material.

Methodology:

The original proposal had focused on quarterly monitoring of draindown and geochemistry from a bankrupt site in eastern Nevada. With strong industry support, we have revised our original concepts and built a much more detailed instrumentation at Placer Dome's Cortez Gold Acres facility in Crescent Valley, NV. The objectives of this facility are to measure, in space and in time, the fluid flow and contaminant transport processes within a large heap leach structure. The Gold Acres facility was deemed to provide much greater opportunity to study fluid flow in heap facilities, by integrating the sampler design into the construction of the heap leach pile, rather than relying upon a single outflow measurement as we had originally planned in Year 1. In late spring, 2001, UNR was contacted by Placer Dome Mining to develop an in-situ monitoring and research facility at the Cortez Gold Acres heap leach pad in Crescent Valley, Nevada.

This facility, rather than simply monitoring the drainage effluent from the bottom of one heap leach pile, will be constructed such that water quality and flow properties can be monitored at various depths and locations of the heap as well as at the bottom. A large array of samplers were designed and installed in the Cortez Gold Acres heap in January 2002. Figure 1 shows the placement of these lysimeters.

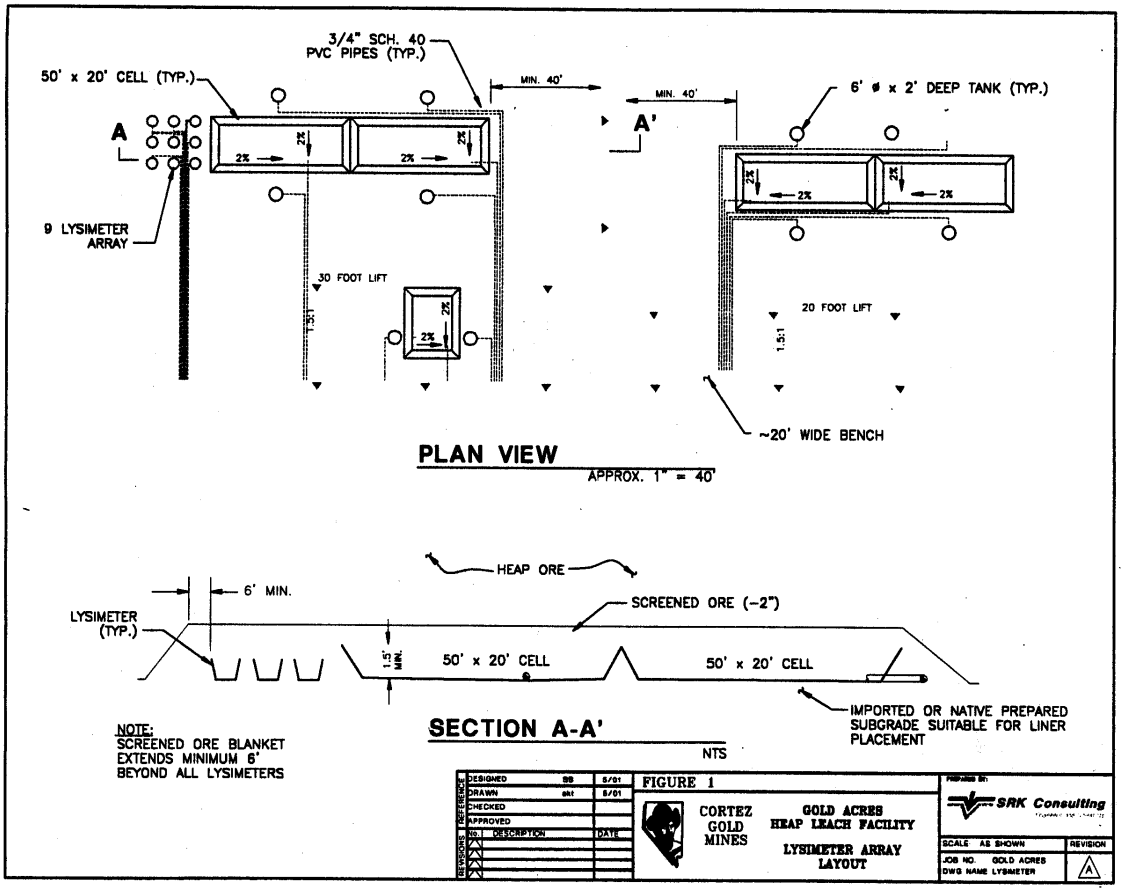

Figure 1. Schematic design of Cortez Gold Acres Facility (CGAF) lysimeter construction and location. Design drawings produced by SRK Consulting Engineers, Inc. for Placer Dome, Inc and the University of Nevada, Reno

Principal Findings and Significance

Due to a series of construction delays and lysimeter failures during construction of the final lift of the Gold Acres facility, the commencement of leaching and rinsing experiments was delayed until Sept-Oct 2002. Lysimeters had to be repaired several times due to accidental bulldozing of the lysimeter drainage lines during construction. As a result, the project has been extended via a no-cost extension through 2004. Several publications and a Master's thesis will be completed by late 2003.

Beginning in September 2002, a 90-day leaching experiment was begun. Field measurement of fluid flow, application rate and geophysical measurements on the top of the heap leach pad were continuously conducted. Lysimeters showed fluid breakthrough in approximately 2 days, close to predicted time based on numerical simulations conducted before the experiments. Fluid flow into the lysimeters was highly variable, showing in the impacts of hydraulic conductivity heterogeneity on the fluid flow field.

Fluxes into the lysimeters were generally between 50 and 60% of the applied flux once steady flow had been achieved. Subsequent numerical simulations, using spatially random generated conductivity field showed that these heterogeneities, combined with reduced permeability of the lysimeter backfill due to compaction are responsible for the reduction in observed flow at the lysimeters.

Draindown was begun in late 2002 and showed predictable results with respect to preferential flow. Those lysimeters that showed evidence of preferential flow during wetting showed rapid draindown (less than 12 hours) and no flows after the initial draindown. However, those lysimeters that showed primarily matrix dominated flow continued to have drainage several weeks after leaching was stopped.

These preliminary results indicate that draindown from closed heap leach mining facilities as well as waste rock materials is dominated by the heterogeneities of the conductivity field. Drainage from large channels will be rapid, however drainage from low conductivity zones will be very slow and may result, if sufficient pyrite is present, in anaerobic conditions dominating in local areas of the material. Such conditions can lead to significant metals transport from the waste material.