SECTION B

Research on Hard-Rock Mining in Mountainous Terrain

The Toxics Program research efforts on hard-rock mining in mountainous terrain has had a change in emphasis in the last several years. The major change has been a concerted effort to work in the pilot watersheds of the USGS Abandoned Mine Lands (AML) Initiative -- the Animas River in Colorado and the Boulder River in Montana. These are mountainous watersheds, with pool-and-riffle streams that receive natural and mine-drainage inflows of surface and ground water. Our role in the AML Initiative has been to adapt and transfer technology developed through field experimentation in St. Kevin Gulch, the Upper Arkansas River watershed, Colorado. This entails adaptation of research methods to the watershed-scale problems faced by Federal land managers in practical field situations.

CHANGING SCALE TO THE WATERSHED

Tracer-injection and synoptic sampling studies in St. Kevin Gulch were on the scale of 2 kilometers (km) or less and at streamflows of less than 1 cubic foot per second (cfs). In this setting, changes in streamflow along the study reach generally were less than an order of magnitude. For the AML Initiative, we have had to adapt methods to a scale of up to 12 km, and streamflow up to 200 cfs, resulting in more than an order of magnitude change in streamflow. This has not meant simply doing a "big" St. Kevin Gulch test by mixing more tracer and injecting it at a greater rate. Transitions from small to large order streams within the basins have required careful evaluation to break the study reach into workable segments. This keeps the tracer concentrations within a reasonable analytical range for each reach, and enables effective interpretation of the tracer-test results.

New sites and different scales have required new thinking and new logistics; each stream has provided new insights. Despite the change in scale, we have found the need to maintain spatially intensive sampling to adequately describe mass balance for inflows to streams. This enables unique identification of various contamination sources and linkage to distinct stream segments within a watershed, information essential for remediation design and monitoring.

UNDERSTANDING INFLOWS

Characterization of the water chemistry of stream inflows has always been an important goal of synoptic sampling. We are able to identify net water-quality changes for stream reaches and to quantify the average concentrations of metals in inflows to these reaches. Characterization of inflows has enabled linkage of the impacts observed in the stream with specific sources of mine drainage. Thus, the goal to understand inflows becomes a goal to understand the pathway of contaminants from a source to the stream. The pathway depends on catchment hydrology as it is influenced by geologic structure. We are expanding our inflow sampling to observe both surface- and ground-water pathways, to make the link between contaminant sources and the streams.

SIMULATING REMEDIATION OPTIONS

Reactive solute-transport models (OTEQ) have been applied to explain the changes in water chemistry downstream, revealing an ability to design and evaluate remediation options. The removal of a mine drainage source is not simply removal of a source term in a contaminant mass-balance exercise. Contaminants are affected by complex reactive processes that occur within the stream. Removal of a metal load can change pH conditions, and in turn, change the overall reaction processes within the stream. Thus, simulation of a remediation option might consider its effect on overall stream chemistry and natural attenuation of metals occurring in the stream. As many options are evaluated with models, we will gain needed understanding of how the many efforts to characterize the watershed fit together to help guide remediation and monitoring efforts.

The papers of this session and two in the session on the USGS Abandoned Mine Lands Initiative reflect progress on these issues.

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