

Environmental Effects of Historical Mining in the Boulder River Watershed, Southwestern Montana

The U.S. Geological Survey recently completed an environmental study of historical mining in the Boulder River watershed. Results of the study have been used by State and Federal agencies to plan and implement cleanup.

The Watershed Approach provides an effective means to evaluate the environmental impacts of historical mining and helps to focus cleanup efforts at sites where the most benefit will be gained in the watershed. The watershed approach is based on the premise that contaminated sites that have the most profound effect on water and ecosystem quality within an entire watershed can be identified, characterized, and ranked for cleanup.

The Boulder River watershed in Montana is one of many watersheds in the western United States where historical mining has left a legacy of acid mine drainage and elevated concentrations of potentially toxic trace elements in surface streams. U.S. Geological Survey (USGS) scientists recently completed a major assessment of the environmental effects of historical mining in the Boulder River watershed. The study demonstrated how the watershed approach can be used to assess and rank mining-affected sites for possible cleanup. The study was conducted in collaboration with State and Federal land-management agencies, which have the responsibility to clean up many historical mine sites.

Results of the study have been published in USGS Professional Paper 1652. This report describes the geology and geochemistry of rocks and sediment, the hydrology and water chemistry of streams and ground water, and the diversity and health of aquatic organisms. Most importantly, the report defines the major sources of trace elements in the watershed and describes many techniques that can be used to identify these sources and determine their environmental effects. Maps and data collected for the study are included on a CD that accompanies the report.

The Historical Mining Era

The Boulder River watershed study area encompasses the Boulder and Basin mining districts. Mining of ore deposits containing copper, lead, and zinc, as well as silver and some gold, started in the early 1860s and ended in the 1970s. The main period of mining was from about 1880 to 1907, and peak production occurred during 1895–1903.

During the mining era, mine waste and mill tailings were discharged with little regard for potential effect on the landscape or streams. Although most mining in the watershed occurred nearly a century or more ago, effects on the environment are still present today. Physical manifestations of these effects are evident as land disturbances, unvegetated areas, and colorful mine drainage near mine and mill sites (fig. 1). Ecological impairment is reflected

through reduced abundance and diversity of aquatic organisms and, in some stream reaches, total absence of a viable fish community.

In some mining districts, trace-element concentrations in streambed sediment and water were elevated long before any mining occurred because mineralized rocks were weathering and contributing acid and trace elements to streams. This was not the case in the Boulder River watershed. Acidic and trace-element-rich water in the study area is associated with

- mine adits that opened and exposed vein deposits and channeled ground water to the land surface, or
- dumps containing mineralized mine waste or mill tailings.

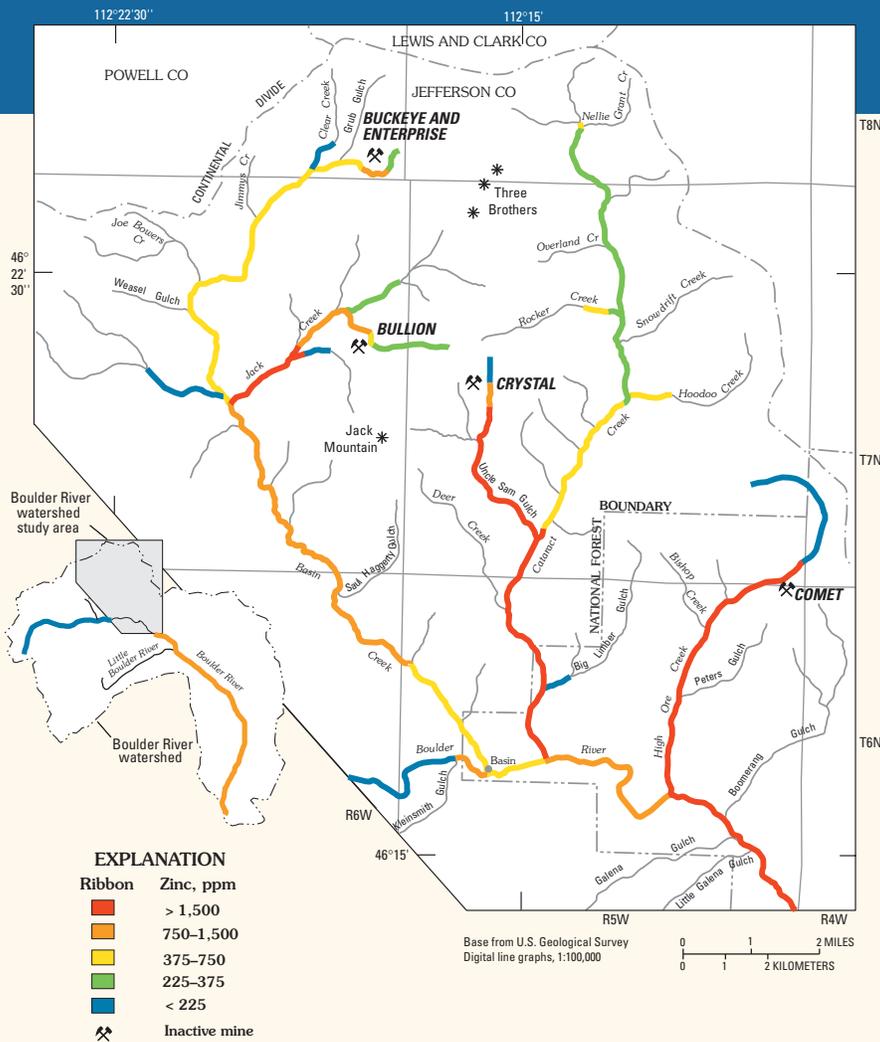
Environmental Effects

Environmental effects from historical mining in the Boulder River watershed are most noticeable in streams. In many stream reaches, concentrations of toxic trace elements were elevated in the stream water, in the sediment forming the streambed, and in the aquatic organisms that inhabit the streams. The major tributaries of the Boulder River as well as the Boulder River downstream from Basin Creek had elevated concentrations of copper, lead, and zinc (fig. 2). These effects were observed for a distance of 55 miles downstream to the confluence of the Boulder River with the Jefferson River.

The major environmental effect of historical mining in the watershed has been impairment of aquatic life in streams. All species of fish were absent in stream reaches downstream from a few large mines because of the high trace-element concentrations caused by acid mine drainage. Farther downstream, trout were found in less contaminated reaches, but exposure to high trace-element concentrations affected the health of these fish. The effects on the fish were shown to result from the trace elements in water through exposure of the gills and in diet through the consumption of aquatic insects.



Figure 1. Mill tailings in the High Ore Creek valley before large-scale cleanup activities at the Comet mine site, October 1996.



Mine Cleanup and Monitoring

Many of the historical mine sites identified as contributors of trace elements in the watershed have been targeted for cleanup. Large-scale cleanup efforts have been undertaken at the Comet mine in High Ore Creek (fig. 1), the Buckeye and Enterprise mine site (fig. 3), and the Bullion mine, both of which are in the Basin Creek drainage.

Monitoring is an important tool for evaluating the effectiveness of cleanup efforts and assessing the extent of ecological restoration. When comprehensive monitoring data have been collected and analyzed, land managers can more objectively evaluate the success of a cleanup action and whether cleanup goals have been met. Monitoring data for water, streambed sediment, and biology have been collected downstream from each cleanup project.

◀ **Figure 2.** Map showing concentration of zinc in streambed sediment. The highest concentrations of zinc were in stream reaches downstream from the Comet, Crystal, Bullion, and, to a lesser extent, the Buckeye and Enterprise mines. This pattern of concentrations indicates that these five mines are the main sources of zinc in the Boulder River watershed.



Figure 3. Buckeye mill site, upper Basin Creek, before (left) and after (right) cleanup.

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For the complete report see: Nimick, D.A., Church, S.E., and Finger, S.E., eds., 2004, Integrated investigations of environmental effects of historical mining in the Basin and Boulder mining districts, Boulder River watershed, Jefferson County, Montana: U.S. Geological Survey Professional Paper 1652, 524 p. URL: <http://pubs.usgs.gov/pp/2004/1652/>.

This Fact Sheet is available online at: <http://pubs.usgs.gov/fs/2005/3148/>