

### Understanding How Recharge Cycles and Dissolved Nitrate Affect Selenium

*Using geochemical modeling and laboratory testing to track selenium and salinity*

#### Bottom Line

This research project investigated the processes controlling selenium loading in the lower part of the Uncompahgre River Basin in western Colorado.

#### Better, Faster, Cheaper

These results identify recharge conditions and nitrate concentrations that promote and/or deter selenium and salinity mobilization, which will assist Reclamation in implementing best management practices for irrigation in the Western United States (U.S.). As the project evaluated generic geochemical processes rather than site-specific processes, results are directly transferrable to other locations in the Western U.S. where selenium-bearing shales lurk under waterways.

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#### Problem

Selenium concentrations can lead to serious environmental problems. Selenium is a major contaminant of concern in surface water in many Western States where Cretaceous marine shales naturally contain selenium. Selenium is leached to ground water and surface water by limited natural runoff, agricultural and domestic irrigation, and leakage from irrigation canals. In some areas, concentrations exceed levels that are deemed safe for sensitive aquatic life, including endangered fish. In the early 1980s, selenium contamination from irrigation wastewater caused deaths and severe deformations in waterfowl at the Kesterson National Wildlife Refuge in central California. Resource managers and policy makers have been addressing the potential for widespread selenium contamination at other sites since then.

However, to implement the best practices for managing selenium depends on understanding how selenium moves from the shale into and through water systems—and these processes are not fully understood. This is apparent in the Gunnison River Basin, Colorado. In the 2009 Programmatic Biological Opinion for the Gunnison River Basin, the U.S. Fish and Wildlife Service determined that “Colorado pikeminnow, humpback chub, bonytail, and razorback sucker are being harmed from continued discharge of selenium related to the Uncompahgre Project and other water uses in the Gunnison Basin. . .” The Gunnison Basin Selenium Management Program was developed as part of a broad-based cooperative effort to provide water security, environmental compliance, and regulatory certainty for water users in the Gunnison Basin.

#### Solution

This Reclamation Science and Technology Program research project investigated two ways that selenium can leach from shales and be transported through water systems:

- 1. Recharge and Water Table Fluctuations (Wetting and Drying).** As stream and ground water levels fluctuate throughout the year, selenium can cycle between dissolved and solid phases. When water levels rise, selenium-bearing salts can be dissolved, mobilized, and flushed to streams. When water levels fall, salts can be left behind in deposits as water evaporates.
- 2. Dissolved Nitrate in Ground Water.** In irrigated agricultural areas, dissolved nitrates in recharge and ground water have been statistically related to elevated ground water selenium concentrations.



*Drillers and the rig obtaining core samples.*

## Application and Results

Reclamation and the U.S. Geological Survey (USGS) worked together to quantify the effects of selenium on water quality, aquatic wildlife, and birds in the Upper Colorado River Basin. The processes influencing selenium mobilization were examined with laboratory studies to determine geochemical mass balance and develop conceptual models using field data collected from the Lower Uncompahgre River Basin. Work included:

- Testing soil and sediment samples from the study area using sequential extractions to identify the forms of selenium present in solid phases
- Characterizing the form of selenium in non-irrigated and irrigated soils from agricultural sites and sediments from a wetland formed by a leaking canal
- Conducting laboratory leaching experiments and geochemical modeling
- Developing a conceptual model of selenium weathering to explain seasonal variations in the surface water chemistry of Loutzenhizer Arroyo, a major tributary contributor of selenium to the lower Uncompahgre River

The technical results of this study were published in the Applied Geochemistry Journal in August 2014.

## Future Plans

A phase II investigation has been funded by the State of Colorado and USGS to characterize the occurrence, distribution, and spatial variability of selenium in soils in shallow aquifer sediments derived from Mancos Shale and associated soils. Ultimately, this information will assist in making land- and water-use decisions to decrease effects of selenium contamination.

## Implications for Best Management Practices

During the irrigation season, most of the irrigation water is contacting soils that have been leached by decades of irrigation and have a relatively low capacity to release selenium. Deep percolation of irrigation water and leakage from canals promotes ground water flow through shallow bedrock along bedding planes and weathering fractures, dissolving selenium and nitrates from secondary salts.

Dissolved nitrates from the dissolution of soluble salts plays an important role in keeping ground water selenium concentrations elevated by inhibiting selenate reduction.

Nitrates in winter baseflow can be derived from naturally occurring salts in the Mancos Shale rather than leaching from fertilizers, although nitrate loading from irrigated fields is another potential source in surface water.

## More Information

[www.usbr.gov/research/projects/detail.cfm?id=6623](http://www.usbr.gov/research/projects/detail.cfm?id=6623)

Mast, M.A., T.J. Mills, S.S. Paschke, G. Keith, J.I. Linard. 2014. *Mobilization of Selenium From the Mancos Shale and Associated Soils in the Lower Uncompahgre River Basin, Colorado*. Applied Geochemistry Journal, 48 16-17.

***“These research results will provide important tools to assist in our understanding of selenium mobilization leading to more efficient, targeted approaches to control selenium loading in the basin.”***

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## Collaborators

- U.S. Geological Survey
- Colorado River Water Conservation District
- Gunnison Basin Selenium Management Program



**Analyzing core samples.**