RESTORATION AND MONITORING OF AQUATIC QUALITY IN A COAL-MINED WATERSHED, SWATARA CREEK AT RAVINE, PENNSYLVANIA[1]

C. A. Cravotta III[2], M. D. Bilger, R. A. Brightbill, and D. Bogar

Extended Abstract

Streamflow, chemical, and biological data for the northern part of Swatara Creek, which drains a 112-km^2 area in the Southern Anthracite Field of eastern Pennsylvania, indicate progressive improvement in water quality since 1959, after which most mines in the watershed had been flooded. Drainage from the flooded mines contributes substantially to baseflow in Swatara Creek. Beginning in 1995, a variety of treatment systems and surface reclamation were implemented at some of the abandoned mines (Cravotta and Weitzel, 2001). At Ravine, Pa., immediately downstream of the mined area, median SO_4 concentration declined from about 150 mg/L in 1959 to 75 mg/L in 2000 while pH increased from acidic to near-neutral values (medians: pH~4 before 1975; pH~6 after 1975). As a consequence of the improved water quality at Ravine, the fish community has rebounded. No fish were present during ecological surveys in 1985 and 1990; however, in 1994 and 1996 six species of fish were found. Increasing numbers of fish species have been found annually since 1996. In 2000, twenty-four species of fish were documented. Although the majority of the fish species are considered to have moderate tolerance to pollution, several intolerant species including river chub, cutlips minnow, and longnose dace, have been reported since 1997. An increased abundance of benthic macroinvertebrate taxa that are considered intolerant of pollution indicates water quality improved from fair in 1994 to very good in 1999 and 2000. Nevertheless, Hydropsychidae (caddisflies) and Chironomidae (midges), which are known to tolerate acidic conditions, were dominant. Although subordinate, the appearance of Ephemeroptera (mayflies) in 1997 and later years is significant in that these animals are sensitive to acidic conditions and considered intolerant to pollution. Nevertheless, recent monitoring indicates elevated concentrations and transport of Fe, Al, Mn, and trace metals during stormflow and elevated concentrations of Fe, Mn, Co, Cu, Pb, Ni, and Zn in streambed sediments relative to unmined areas and to toxicity guidelines for aquatic invertebrates and fish (Cravotta, 2000; Cravotta and Bilger, 2001). The metals are ubiquitous in the fine fraction (<0.063 mm) of bed

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sediment in mining-affected tributaries and Swatara Creek and represent a long-term source of contamination.

Selected References

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Restoration and Monitoring of Aquatic Quality in a Coal-Mined Watershed

Swatara Creek at Ravine, Pennsylvania

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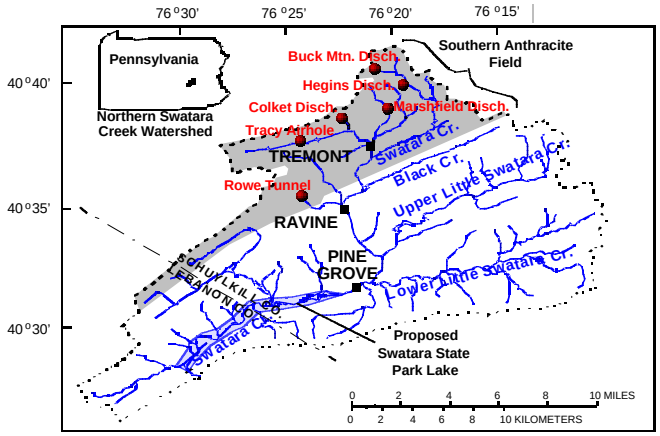
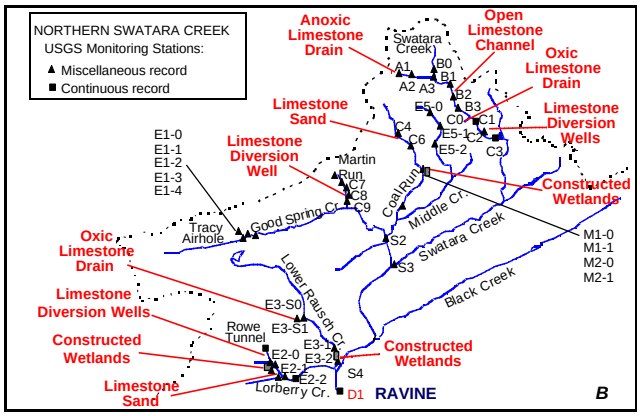
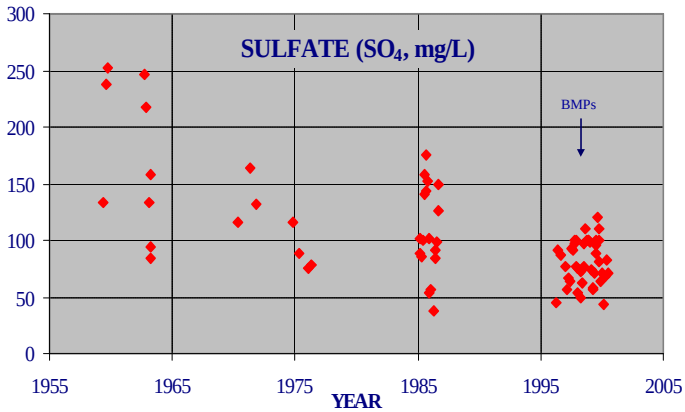
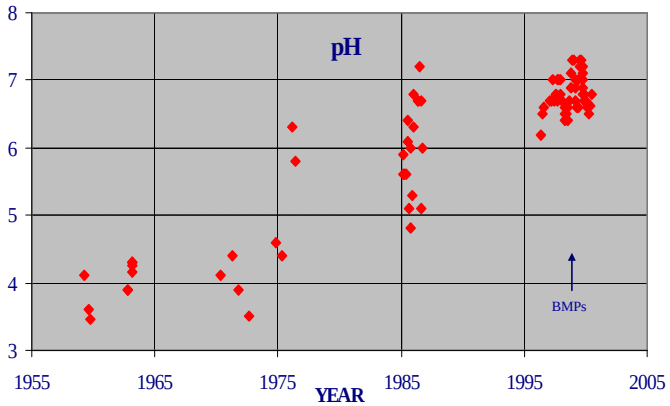


Swatara Creek drains an area of 577 mi² within the Ridge and Valley Province in east-central Pennsylvania. The upper 43-mi² area above Ravine is underlain by the Southern Anthracite Field. Although several surface and underground anthracite mines presently are active, most mines in the Swatara Creek Basin were abandoned before 1960. Once abandoned, the underground mines flooded producing numerous large discharges that are contaminated with acidity, sulfate, and metals. The polluted drainage from these abandoned mines affects water quality miles downstream. Construction of the proposed Swatara State Park Reservoir has been delayed until the AMD is remediated.

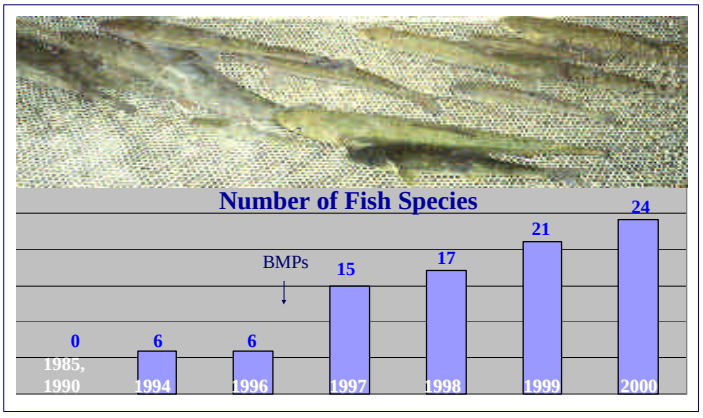


To neutralize AMD in the Swatara Creek Basin above Ravine, a variety of treatment systems were installed in 1995 through 1998 including limestone-sand dosing, open limestone channels, anoxic and oxic limestone drains, limestone diversion wells, and wetlands. To characterize untreated mine drainage and treatment-system performance, data on flow rate and water quality throughout the basin were collected during baseflow and stormflow conditions in 1995-2001. Data for two stations on Swatara Creek, near Ravine and Pine Grove, indicate cumulative effects of AMD remediation and transport of pollutants from the mined part of the basin to a proposed reservoir at Swatara State Park.

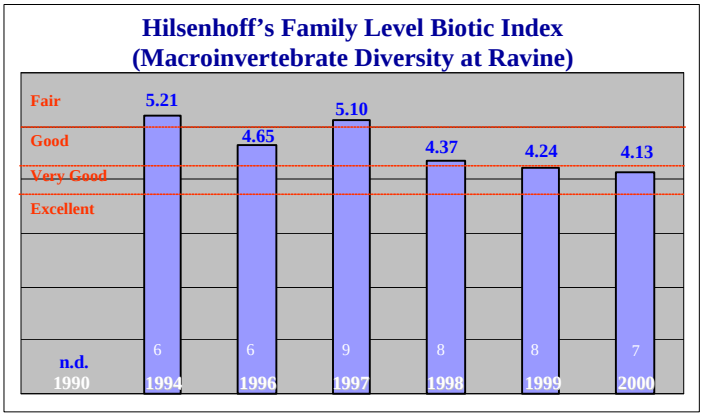




Baseflow data collected periodically since 1959 at Ravine indicate significant improvement in water quality. For example, sulfate declined while pH increased sharply after 1975 from 3.5-4.4 (median ~4) to 4.6-7.0 (median ~6). The decline in SO_4 concentration probably was caused by a decline in pyrite oxidation after flooding of the abandoned mines had minimized inflows of oxygenated air and water. The associated increase in pH was caused by the onset of carbonate buffering that occurred when the rate of alkalinity production equaled or exceeded acid production. Although a variety of environmental factors could affect pH and SO_4 concentrations, consistently near-neutral pH with variable SO_4 concentration at Ravine during 1998-2000 imply that the recently implemented limestone treatments have neutralized acid, further improving water quality. At near-neutral pH, the transport of dissolved metals typically is attenuated owing to precipitation and adsorption. Nevertheless, recent monitoring indicates elevated concentrations and transport of Fe, Al, Mn, and trace metals during stormflow and elevated concentrations of Fe, Mn, Co, Cu, Pb, Ni, and Zn in streambed sediments relative to unmined areas and to toxicity guidelines for aquatic invertebrates and fish. The metals are ubiquitous in the fine fraction (<0.063 mm) of bed sediment in mining-affected tributaries and the main stem of Swatara Creek and represent a long-term source of contamination.



As a consequence of the improved water quality in Swatara Creek at Ravine, the fish community has rebounded. No fish were present during ecological surveys in 1985 and 1990; however, in 1994 and 1996 six species of fish were found. Increasing numbers of fish species have been found annually since 1996. In 2000, twenty-four species of fish were documented, including cold-water species such as brook trout and sculpin and warm-water species such as sunfish, pickerel, and bullhead catfish. Although the majority of the fish species are considered to have moderate tolerance to pollution, several intolerant species including river chub, cutlips minnow, and longnose dace, have been reported since 1997.



An increased abundance of benthic macroinvertebrate taxa that are considered intolerant of pollution indicates water quality improved from fair in 1994 to very good in 2000. Nevertheless, Hydropsychidae (caddisflies) and Chironomidae (midges), which are known to tolerate acidic conditions, were dominant. Although subordinate, the appearance of Ephemeroptera (mayflies) in 1997 and later years is significant in that these animals are sensitive to acidic conditions and considered intolerant to pollution. The benthic macroinvertebrate community recorded for 1999 and 2000 can be characterized as moderately impacted based on total taxa and slightly impacted based on total mayfly, stonefly, and caddisfly taxa.

REFERENCES:

Cravotta, C.A., III, and Bilger, M.D., 2001, Water-quality trends for a coal-mined watershed in Eastern Pennsylvania: Geochemistry--Exploration, Environment, Analysis, vol. 1, p. 33-50.

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