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Tracing disturbance impacts on water quantity and quality through a stream network

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By dismantling and redistributing 100s of meters of bedrock to mine coal from the surface, mountaintop mining with valley fills has dramatically changed catchment hydrology and biogeochemistry over more than 5,000 km2 in Central Appalachia. Throughout this expansive coal region, mining operators deposit tens of millions of m3 of crushed bedrock into headwater valleys, creating valley fills, which have substantial subsurface water storage potential. Streams draining mines have reduced peakflows, elevated baseflows, and lower event runoff ratios on average. The water stored in and percolating through valley fills drives the dissolution and oxidation of pyrite into sulfuric acid which reacts with carbonate-rich materials to rapidly weather out a suite of elements including Ca2+, Mg2+, K+, SO42-, HCO_3-, and the pollutant Selenium. Together these ions increase the average specific conductance of mined streams from $\sim$60 to $\sim$ 1,500 μS/cm, 25-times higher than unmined streams, exporting 45-times more total dissolved solids. Together, the increased catchment storage, consequent elevated baseflow, and elevated weathering rates from mining have the potential to lower water quality throughout river networks in Central Appalachia, especially during the summer low flow period. To better understand the water quality impacts of mining at the river network scale, we used the paired catchment approach. Working in the Mud River, West Virginia, we instrumented a 4th order catchment $\sim$35 km2, that was 46% mined. Within the large catchment we instrumented 8 additional 1st-3rd order sub-catchments that varied in catchment size, mining cover, mine size, and mine age. At each site we measured stream discharge and specific conductance (SC). Using SC as a trace for mining we did simple hydrograph separations at our largest catchments, partitioning the hydrograph between mined and unmined water. Our results suggest that on an annual scale, mine water contributes a disproportionate percentage of the water (53% mine-water vs 47% unmined water). This difference is exaggerated during low-flow periods in the summer when all mining catchments had consistently elevated baseflow, even when streamflow in the reference catchments ceased. Cumulatively this lead to long periods during the summer, when nearly 100% of the Mud River baseflow was generated in the mined portion of the catchment. At a larger scale we show that SC can remain elevated 30 km downstream of mining, despite the overall mining coverage dropping to less than 5%.