Using novel geophysical techniques to relate surface coal mining fill characteristics to effluent stream water quality[1]

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Abstract: Surface coal mining has altered Appalachian landscapes, affecting water quality and aquatic ecology. Valley fills created from excess overburden are prominent features of many mined landscapes. Increased total dissolved solids (TDS), as measured by its surrogate specific conductance (SC), is a significant water quality concern related to the exposure of fresh mineral surfaces to weathering in valley fills. Specific conductance levels in waters draining Appalachian mined areas are highly variable, yet the causes for this variability are not well known. Here we sought to improve understanding of such variability by connecting it to valley fill characteristics such as age and construction method. We used electrical resistivity imaging (ERI) to investigate the geologic structure of four valley fills in two dimensions. We combined ERI with artificial rainfall to investigate the location and residence time of hydrologic preferential flowpaths through the fills. Finally, we used borings, tracer tests, and SC measurements in effluent streams to corroborate the ERI results and improve understanding of relationships between fill characteristics and SC. We found that ERI is able to successfully distinguish fills constructed using conventional loose-dump and experimental controlled-material compacted-lift construction methods. Conventional fills had greater ranges of resistivity in the subsurface indicating a wider range of substrate types. Conventional fills also showed more accumulation of water within the fill during artificial rainfall, possibly indicating greater quick/deep preferential flowpaths than in the experimental fill. Bore logs confirm the ERI structural interpretations. Tracer tests indicate that accumulations of water within the fills during rainfall may only flush out later during larger storm events. ERI results indicate that flow within valley fills is highly preferential with most infiltrating water interacting with only a small subset of the fill volume. ERI appears to be a robust non-invasive technique that provides reliable information on valley fill structure and hydrology, and experimental compacted-lift valley fill construction produces significantly altered hydrologic response, which in turn affects downstream SC.

Additional Key Words: Geophysical Inverse Modeling, Stormflow, Preferential Flow, Conductivity

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