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Landscape and hydrologic controls on solute dynamics in non-perennial headwater streams

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Non-perennial streams are critical terrestrial-aquatic interface (TAI) ecosystems that influence the exchanges of solutes between land, surface water, and groundwater as streams fluctuate between dry, pooled, and flowing states. However, constraining the landscape and hydrological controls on biogeochemical processes in non-perennial streams remains challenging in watersheds containing heterogeneous and/or rapidly changing land covers. This work focused on a series of stream channels within a fourth-order watershed (77 km^2) in East Tennessee that drains catchments representing a gradient of land cover, from majority urban/industrial to primarily forested. Stream channels contained both perennial reaches and non-perennial reaches that flowed seasonally and/or in response to rain events. We coupled bi-monthly synoptic surveys of stream solute concentrations with continuous monitoring of the presence of surface water to investigate how land cover and stream permanence impact spatial patterns of stream solute concentrations. Within individual tributaries, a general downstream progression from non-perennial to perennial flow was associated with an increase in the concentrations of most major solutes (e.g., Ca, Mg, SO_4^{2-}, Cl^-) and trace metals (e.g., Cr, Sr, Mo, U) but a decrease in dissolved organic carbon, suggesting a shift from surface runoff or shallow interflow sources in non-perennial reaches to groundwater-derived flow in perennial reaches. Across the entire watershed, solute concentrations within streams were positively correlated to both the presence of developed and impervious land cover and the extent of stream flow permanence. In addition, solute concentrations were generally higher in perennial reaches in developed areas compared to forested areas, indicating potential influences of urban development on groundwater that feeds these reaches from sources such as road surface runoff and industrial discharges. Ongoing efforts will implement high spatial and temporal resolution surface water and groundwater monitoring and statistical clustering analyses to better constrain the drivers of water and solute exchange at the TAI and understand the potential implications for biogeochemical processes in the perennial stream network.