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Land use and stream restoration effects on baseflow stream chemistry and watershed-scale residence time in a 6km^2 urban forest watershed linked to changes to soil-water interaction and instream nutrient processing

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We examined baseflow stream and shallow groundwater chemistry (2014-2021) at 11 nested sites in a 6 km^2 watershed on Piedmont fractured crystalline rocks that underwent whole-watershed stream restoration in 2017-2019 (Reedy Creek, Charlotte, North Carolina, USA). Seasonally cycled δD suggests that significant differences exist in watershed-scale residence time between more and less developed subwatersheds. These results suggest that waters in more developed watersheds take faster pathways through the watershed, on average, to contribute to baseflow (mean residence time ~1 year vs. ~5 years in undeveloped subwatersheds). δD does not suggest that watershed-scale residence time increased post-restoration (instead, a few subwatersheds' residence times decreased modestly). Nitrate, ammonia, and dissolved oxygen concentrations are seasonally cycled, with maxima in early spring and minima in mid to late summer. These trends of baseflow concentrations are consistent with N compounds being mobilized in early spring during transient higher water tables, then increasingly scavenged by biota in the warmer months. At 7 subwatershed sites, nitrate concentrations decreased significantly post-restoration, while total dissolved nitrogen decreased at 6 sites and ammonia increased at 8 sites. Also, increased organic carbon concentrations were observed in 8 subwatersheds post-restoration. Trends in inorganic ions (e.g. declining sulfate, declining K) were also observed in several subwatersheds. Urban land use explains concentration differences among subwatersheds, and urban land uses provide fewer subsurface opportunities for nitrogen to be processed before reaching the stream. In addition, we suggest that restoration induced reach-scale to watershed-scale changes due to: (1) Soil-water interaction in which post-restoration water tables were much higher than pre-restoration, in which water interacted with shallow forest soils and/or (2) Instream processes such as spring algal growth and concomitant decomposition because the post-restoration stream was less shaded than pre-restoration. While the results of this study extend ~2 years post-restoration, a longer-term examination would help us understand if water chemistry changes are permanent or transient effects after watershed-scale stream restoration.