CHARACTERIZING SURFACE-GROUND WATER EXCHANGE RATES AND HYDRAULIC TRANSPORT PROCESSES IN A CASCADING STREAM

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ABSTRACT Cascading streams in mountain areas are the source for drinking water in many Honduran villages, and source water capture may dewater the stream and diminish ecologically important surface-ground water exchange. Our study quantified the rates and hydraulic transport processes of surface-ground water exchange for several flow rates, from 1 to 15 Litres per second, in Prieta Creek, a cascading stream in northern Honduras. Surface-ground water exchange was monitored within a 40 m reach with chloride tracer tests and piezometer pressure measurements, and analyzed using models for transient storage, hydro-static and hydro-dynamic flux. Transient storage analysis of the tracer data indicated a reach wide decrease in exchange with decreasing flow rate, but did not provide spatial information on the key locations or transport processes affected by dewatering. Piezometer data and the hydro-static MODFLOW model simulation showed decreasing downwelling strength with decreasing flows, but the model accuracy was compromised in steeper sloped sections of the channel. The MODFLOW model failed to represent dynamic velocity head and turbulent based momentum transfer identified as active in the channel based on effective diffusion analysis. We addressed this limitation by applying the Reynolds averaged Navier Stokes based computational fluid dynamic (CFD) Flow3D model with the k-e renormalization grouping turbulence algorithm. The CFD model allowed for spatially detailed analysis of transport processes involved in surface-ground water exchange. These CFD simulations demonstrated for the steeper cascades a strong spatial correlation between in channel turbulence and areas of rapid oscillation between downwelling and upwelling flux. Pressure head analysis confirmed the CFD model was able to resolve important pumping head transfer mechanisms in addition to the turbulent momentum transfer. During dewatering, these transport processes diminished in magnitude, yet remained active throughout the channel.

Keywords: Drinking water systems, Hyporheic exchange