











and Verde River water only. NO3- and SO4-2 will not balance with same ratio of water derived above and require additional inputs

locations could never balance because there is a travel associated with the distance separating gaging lischarge data we tested three lag times to see if downstream discharge recorded at Priest Avenue could be explained by flood wave lag along the Verde and Salt downstream and mean discharge upstream 6, 12, & 18 time show that none of the upstream discharges, using



![](_page_0_Picture_27.jpeg)

### Model Approach

We start by attempting to balance major ion concentrations from the Salt and Verde Rivers measured weekly with downstream samples measured daily using minimal components and equations derived for binary or ternary mixing in natural rivers. This method is described by Eqn. (1) where n represents 1) groundwater or baseflow, 2) rainwater or direct flow, or 3) soil water as interflow included with three component mixing models. An underlying assumption is that total discharge is the sum of individual components. This approach often uses a limited number of constituents to solve the mass balance equation such as chloride concentrations or conductivity measurements.

 $\sum (Q_n C_n) = Q_{in-stream} C_{in-stream}$ 

Equation 1

Next, include modifications from research to model managed river system response to storm events; here n represents Verde and Salt River flow, as well as various management components, which include known contributions from evacuated CAP water, Mesa Northwest effluent, possible stormwater drainage, etc. The equations below describe the managed model of stream water chemistry. The continuity, or mass balance equation (2), relates loads of dissolved solutes from individual components and now includes an infiltration component. The equations are iteratively solved using tracer source concentrations (nitrate and sulfate) to converge on potential discharges from various components. Equation 3 assumes water mass loss is equivalent to seepage during storm-related flows derived from reservoir release.

![](_page_0_Figure_33.jpeg)

![](_page_0_Figure_34.jpeg)

Equation 2

Equation 3

## Model Justification

![](_page_0_Figure_38.jpeg)

Component concentrations (shown at left) of chloride on the y-axis and the ratio of nitrate to sulfate on the x-axis show how the flood water composition changed as contributions from various sources mere managed. In addition to the evacuation event of CAP water during event 2, minor inclusions of CAP water are required to balance the continuity equations during non-discharge • Salt R periods as well. We hypothesize that recharge basins BR-MW located just downstream from Granite Reef Diversion Dam that are normally filled with a mixture of CAP, Verde and Salt River waters were flushed during early storm events. This approach allows the resolution of two additional management components (CAP and BR-MW as shown here). The continuity equations in conjunction with the proper lag times then allow us to quantify the composition of seepage required to balance the solutes.

### Model Results

The figure shown at bottom left shows measured concentrations of various major ions on the x-axis and calculated concentrations without seepage or managed inflows on the y-axis. Contrast this with the figure at bottom right which shows calculated concentrations from the seepage mass balance model with nitrate and sulfate concentrations constraining the additional management components.

![](_page_0_Figure_42.jpeg)

![](_page_0_Figure_43.jpeg)

# Model Applications

Shown at left are the responses of Ni, Cr, Cu, and Zn to rain events in the Phoenix metro area. Spikes could indicate input from urban sources. We believe the anagement mixing model we have derived is capable of including trace metal loading from impervious surface runoff through storm drains during first flush conditions. These conditions will result in an urban fingerprint that can be used to study trace metal transport during storm events in a managed environment. The inclusion of a seepage component could have implications for trace metal loading into the shallow quifer and quantification of concentrations within that component. uture goals involve including these trace metals in the interative quantification of oncentrations from various components.

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