LUMPED PARAMETER MODEL FOR BEAR SPRING

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In karst regions, springs provide a focused outflow point for groundwater discharge. A simple lumped parameter model is developed here to approximate the relationship between recharge, spring discharge, and changes in aquifer storage. The conceptual model is shown in Figure 1.

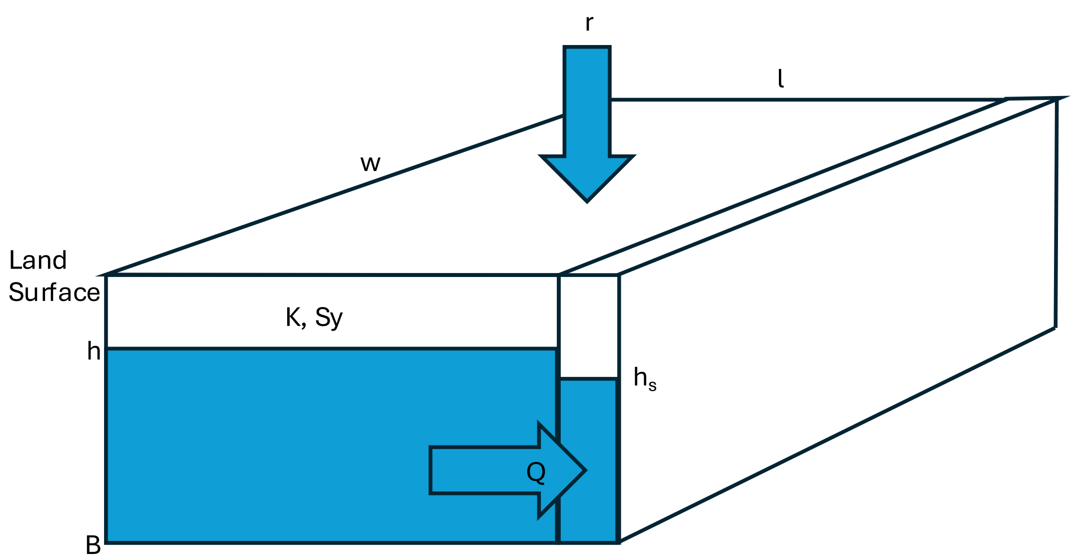

FIGURE 1. text

In this simple conceptual model, a linear spring feature is connected on one side of an unconfined aquifer. The elevation of the spring stage is specified as h_s. The aquifer has dimensions of w by l, giving the plan-view area of the spring shed (A_s) as $l \times w$. The elevation of the water table is given by h, which is assumed to be uniform over the entire area. Land surface bounds the top of the aquifer; the bottom of the aquifer is assumed to be flat at an elevation of B. It would be possible to route any water above land surface to the spring as overland flow, however this is not included yet.

Recharge falls on the spring shed at a uniform rate of r length units per time. Groundwater discharge to spring is denoted by Q and has dimensions of length cubed per time. A simple balance equation for such a system is expressed as,

$$I - O = \Delta S, \tag{1}$$

where I is the sum of all inflow, O is the sum of all outflows, and ΔS is the change in storage. For the case considered here, inflow to the spring shed, in dimensions of length cubed per time, is expressed as rA_s. Outflow occurs through groundwater discharge to the spring (Q_s) , expressed as:

$$Q_s = C\left(h_s - h\right), \tag{2}$$

where C is the conductance in length squared per time. C can be expressed in a variety of different ways. One simple way is assign it as

$$C = \frac{2\overline{K}wb}{l}. \tag{3}$$

which is a Darcy-based approach assuming an average flow distance of half the l value. $\overline{K}$ is used here to denote an average hydraulic conductivity over the height of the aquifer in contact with the spring. It may be possible to use a calculated value for $\overline{K}$ as a function of h to allow it to vary as individual preferential pathways are activated. The b term represents the height of the aquifer in contact with the spring. It can be assigned as a constant, or it could be calculated from the aquifer and spring head using some form of averaging.

The storage term, ΔS can be expressed as

$$\Delta S = A_s S_y \left(\frac{h^{t+\Delta t} - h^t}{\Delta t}\right) \tag{4}$$

From these equations, we can write an explicit solution for $h^{t+\Delta t}$ and march through time to calculate head and spring discharge as a function of recharge, spring shed geometry, and aquifer properties.