Introduction:
We performed two conservative tracer injections in a mountain stream in order to access the relationship between storage parameters on the short sub-reach scale to the longer reach which they comprise.

Site Description:
Data was collected at Spring Park Creek (SPC), which is located in the Tenderfoot Creek Experimental Forest in the Little Belt Mountain Range, Montana. SPC is one of four first order flumed tributaries to Tenderfoot Creek which join the main stem above the confluence. These sub-reaches were then grouped to form six combination reaches (C) of increasing length.

Methods:
Conservative NaCl was injected over two six-hour periods during consecutive days (8/16/06, 8/17/06) and empirical EC data was collected for all sub and combination reaches. For every conductivity probe of known strength were used to convert the stream EC readings to stream NaCl concentration (Gosseff and McGlynn, 2005). The following TSMS OTIS was used to simulate this observed data:

\[
\frac{\partial C}{\partial t} = \frac{Q}{A} \frac{\partial}{\partial x} \left( \frac{\partial}{\partial x} \left( A \frac{\partial C}{\partial x} \right) + \alpha \left( C_x - C \right) \right) + \frac{Q}{A} C_x
\]

\[
\frac{d C_x}{dt} = A \frac{C_x}{A_c} (C_x - C)
\]

Where, \(C\) is the solute concentration in the stream (mol L\(^{-1}\)), \(Q\) is the volumetric flow rate (m\(^3\) s\(^{-1}\)), \(D\) is the dispersion coefficient (m\(^2\) s\(^{-1}\)), \(A\) is the cross-sectional area of the storage zone (m\(^2\)), \(A_c\) is the cross-sectional area of the storage exchange coefficient (s\(^{-1}\)), \(Q\) is the lateral inflow rate (m\(^3\) m\(^{-1}\) length of stream, or m\(^3\) s\(^{-1}\)), \(C_x\) is the lateral inflow solute concentration, \(r\) is time (s), \(x\) is distance downstream (m).

After a reasonable fit was determined using OTIS, OTIS-P was used to calculate parameters that minimized the squared differences from observed data. This technique allowed us to specify a 95% confidence interval for most values, and an overall residual sum of squares (RSS) for each reach.

Once solute transport parameters were estimated for each SR and C reach the Damkohler Number (DaI) and the New Metric \(F_{med200}\) were determined. This DaI is a method of accessing the reliability of parameters, and should fall within one order of magnitude of 1x10\(^5\). The \(F_{med200}\) describes the fraction of median travel time which is due to storage normalized to a 200 m reach.

\[
DaI = \left( \frac{A}{A_c} \right) L
\]

\[
F_{med200} = 1 - \exp \left( - \frac{\text{median travel time}}{200} \right)
\]

Discussion & Conclusions:
• The weighted average of a combination reach’s components was not a consistent predictor of that C reach value for any parameter.

• D and A increase with reach length, which is to be expected.

• According to DaI calculations, the majority of our sub-reach lengths may have been too short to facilitate enough interaction between the tracer and the storage zone to provide reliable parameter estimates.

• The \(F_{med200}\) metric suggests that storage does not play a major role in median mass transport times in this stream, even over the longer reach lengths.

• A logical next step would be to use UCODE to perform a parameter sensitivity analysis.

References:
Scaling of Transient Storage Parameter Estimates with Increasing Reach Length in a Mountain Headwater Stream
Briggs, M (mabriggs@mines.edu), MN Gooseff, and B. McGlynn

Abstract. Numerous studies have used the methods of stream tracer experiments and subsequent solute transport modeling to determine transient storage characteristics of streams. Experimental reach length is often determined by site logistics, morphology, specific study goals, etc. Harvey et al. [1996] provided guidance for optimal study reach lengths, based on the Dahmkoeler number, as a balance between timescales of advective transport and transient storage. In this study, we investigate the scaling of parameters in a solute transport model (OTIS) with increasing spatial scale of investigation. We conducted 2 6-hour constant rate injections of dissolved NaCl in Spring Park Creek, a headwater stream in the Tenderfoot Creek Experimental Forest, Montana. Below the first injection we sampled 4 reaches ~200m in length, we then moved upstream 640m for the second injection and sampled 3 more ~200 m reaches. Solute transport simulations were conducted for each of these sub-reaches and for combinations of these sub-reaches, from which we assessed estimates of solute velocity, dispersion, transient storage exchange, storage zone size, and Fmed (proportion of median transport time due to storage). Dahmkoeler values calculated for each simulation (sub-reaches as well as longer combined reach) were within an order of magnitude of 1, suggesting that our study reach lengths were appropriate. Length-weighted average solute transport and transient storage parameters for the sub-reaches were found to be comparable to their counterparts in the longer reach simulation. In particular the average dispersion found for the sub-reaches (0.43 m²/s) compared very favorably with the value for dispersion calculated for the larger reach (0.40 m²/s). In contrast the weighted average of storage zone size for the sub-reaches was much greater (1.17 m²) than those calculated for the injection reach as a whole (0.09 m²) by a factor of ~13. Weighted average values for transient storage exchange and size for the sub-reaches were both found to be higher than that of the reach as a whole, but only by factors of ~2.5 and 3 respectively. This study indicates that some values of solute transport and transient storage for a particular reach can be reasonably extrapolated from its corresponding component reach values.

AGU Fall Meeting 2006
Additional information at:
http://www.mines.edu/~mgooseff/web_research/hydroscapes.html