Estimating Flow Rates: Rough methods

In all the following be aware that the velocity varies across the stream (friction at the banks and floor reduces the velocity) - what we are after is the "mean flow" for the whole cross-section. For estimates of mean flow from surface flow - using the quarter points rather than mid-stream gives the best estimate.

For all methods it is advisable to make several estimates in different parts of the stream.
For all methods the channel should be fairly straight and uniform and with minimal turbulence, eddies etc. It also helps if the cross-section is fairly simple (as we have to measure the area of cross-section to get the volume flow, or discharge). Move rocks about to smooth the floor if necessary.

Shannon Fingers.

Henry Shannon was renown for poking his fingers into cave streams and muttering "xxx cusecs" to himself. His method is based on the hydraulic jump that occurs when a flowing stream hits an obstruction (a pair of fingers, or a ruler). Note, it does not work for flows less than about 0.2 m/sec because of difficulty of estimating the height of the small jumps. Even in good conditions the accuracy will not be better than 10%

The procedure is to insert the ruler vertical and initially rotated parallel to the flow (with its end sitting on a solid stone on the floor of the channel) and measure depth for undisturbed flow (we also use this for later cross-sectional area estimates). Then rotate the ruler so it is flat-on to the flow and re-measure to top of the jump. Subtract from first reading to get the actual jump (or better, estimate the difference between the jump in the middle of the ruler and the edges). Repeat in several places across the channel (both to get cross-section shape and as checks on the velocity - but the best velocity is usually 1/4 in from each side).

For a 1.5cm wide ruler:

velocity (as metres / sec) = $0.4436 (\text{jump in cm})^{0.5}$

e.g. a jump of 1.5 cm indicates a velocity of 0.54 m/sec. One of 2mm is 0.63 m/sec.

Multiply the velocity by the cross-section area (in square-metres) to get the discharge flow (m^3/sec).
Multiply m^3/sec by 1000 to convert to litres / sec.

Reference: Pound, M.D. 1972: A simple flow measuring device. *Down Under* **11(5)** 127-129.

Direct measurement with a bucket.

If there is a waterfall where you can get a bucket under the whole flow, then simply measure the time taken (stop-watch) to fill the bucket. Divide the volume of the bucket by the time to get the flow. As always, repeat the measurement several times and average them. If there is some spillage, try to estimate the percent loss and factor that in. A typical bucket is about 9 litres (2 gallons).

Once you have done this a few times, you may be able to make rough guesses of flows by imagining how long a small stream would take to fill a bucket if you could get one under it!

Pooh-sticks, and other floating things

For this you need a stop-watch, a float, and a long, uniform (in cross-section area) portion of the stream with minimal eddies. For slow flows 2-3 m is enough, for fast flows you might want a longer run if there is one that is uniform enough.

Measure a length along the stream - mark start and finish points. Measure the cross-section area at one or more "representative" sections. I usually sit a metal tape across the stream and measure depths with a ruler down from every 10cm mark. Work out the area when you get home, not in the cave!

At the start point, drop your Pooh-stick (twig, leaf, scrap of paper, etc) and start the watch. Follow it down to the finish point - measure the travel time and divide into the length to get velocity. Repeat several times and take the average (ignore any that get obviously stuck in an eddy). Multiply the surface velocity by 0.85 to correct to a mean value for the full stream depth (ignore this for very shallow streams). Measure the average cross-section area for the length of stream used and calculate your flow rate as above.

One problem with pooh-sticks made from leaves or paper is that they can be blown by wind - not usually a problem in caves, but can be annoying in surface streams. A small "super-ball" makes a good pooh-stick; it floats mainly submerged so avoids the wind problem and also gives a better indication of the real velocity. If it touches bottom it will roll without slowing appreciably. For larger streams try an orange - it also floats largely submerged, comes in "visibility orange" for easy observation and will be biodegradable if you loose it!

Reference: Milne, A.A, 1928: *The House at Pooh Corner.* Methuen, London. See Chapter VI.