ABSTRACT

A simple field technique for measuring streamflow and some examples from NSW and Tasmania

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Mostly cavers are at a loss when it comes to making an estimate of streamflow volume. Yet the phenomenon of the hydraulic jump makes it possible to get a fix on flow velocity, simply by 'stopping' the flow so that its kinetic energy becomes potential energy. The velocity-head rod is an accepted device in hydrology but used in larger streams than are common in caving situations.

The writer is used to the imperial units where a jump of 3/8" = 1 ft/sec, 3/4" = 32ft/sec, 3/2" = 3ft/sec and 3" = 4ft/sec. It is normally possible to find appropriate cross-sections to apply these rules and one can memorise hand parts to simply use the fingers. Metric conversion is 1 cu.ft/sec = 28 litres/sec. Applications at Windy Gap, Kempsey hinterland, NSW, and Mole Creek, Tasmania, are given as illustrations of what can be discovered using this method. It was also used in work at Jenolan and Mt Arthur, New Zealand.

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The method of measuring a flow volume that first comes to mind is the "floating stick" method, which requires a regular section channel going for enough of a distance to work; and this normally can't be done in caving situations. Not so well known are methods utilizing the hydraulic jump effect. This happens at an obstruction to flow which forces movement in the horizontal to go vertical; a transfer from kinetic to potential energy. The v you need to get is proportional to the square root of h. For a measuring point all that is required is a clean cross section or ideally a group where different cross sections and velocities can be compared in the hope of getting converging flow measurements. The point is that such conditions usually can be met in caving situations.

The basic instrument used by those primarily interested in stream gauging is the velocity head rod, a device you can look up on Google though an earlier version in a textbook, *Meinzer's Hydrology*, is the basis for my adaptation. I started using the method before metrification and since I find the old units convenient I use them in the field and convert to metric later on. Anyway the basic rod is rectangular cross-section modified to make a sharp edge out of one of the narrow sides and with measuring scales up the long axis. Then the rod is placed in the stream sharp edge upstream so as to get a depth measurement — the sharp edge is to prevent the hydraulic jump occurring — then the rod is turned 180 degrees to measure the hydraulic jump itself. The observer then does a traverse across the stream taking repeated measurements for slices of a cross-section of the stream. The method assumes something firm on the bottom and depth and velocity the observer can survive but overall, streams bigger than cavers normally deal with. A professional hydrologist would be using a rod of say 5 to 6 ft which is a bit much for a caver to be carrying around. Very small streams can in principle be measured with a v-notch weir but this is often impractical as a field device when the bed materials won't cooperate. The device is cumbersome and can't be bedded in properly in stony ground. The common situation is to be wanting to measure streams mostly of intermediate size and with no device on hand, or perhaps with say a photograph of a party wading across a stream as the only data. In this case you can make a depth estimate from the degree the various people are sunk in the water and flow velocity from the bow wave induced by their bodies.

The typical situation is to be dealing with flows of the order of 1/12 to 20 cusecs in imperial units and flow velocities that can be shoehorned into 1, 2, 3, 4 ft/sec using hydraulic jumps that correspond: 3/8" = 1ft/sec, 3/4" = 2ft/sec, 1 1/2" = 3ft/sec, 3" = 4ft/sec. Higher flow velocities, up to 12" = 8ft/sec become hard to read because the pile up jumps around a lot. In principle some velocities lower than 1 ft/sec could be reckoned from another phenomenon; the little wave that appears out from an obstruction, moves closer with increasing velocity and merges into the regular head jump a bit before 1 ft/sec.

I find it easier to work in the old imperial units, then convert to litres/sec. Conversion factor is 1 foot/sec = 28.3 litres/sec.

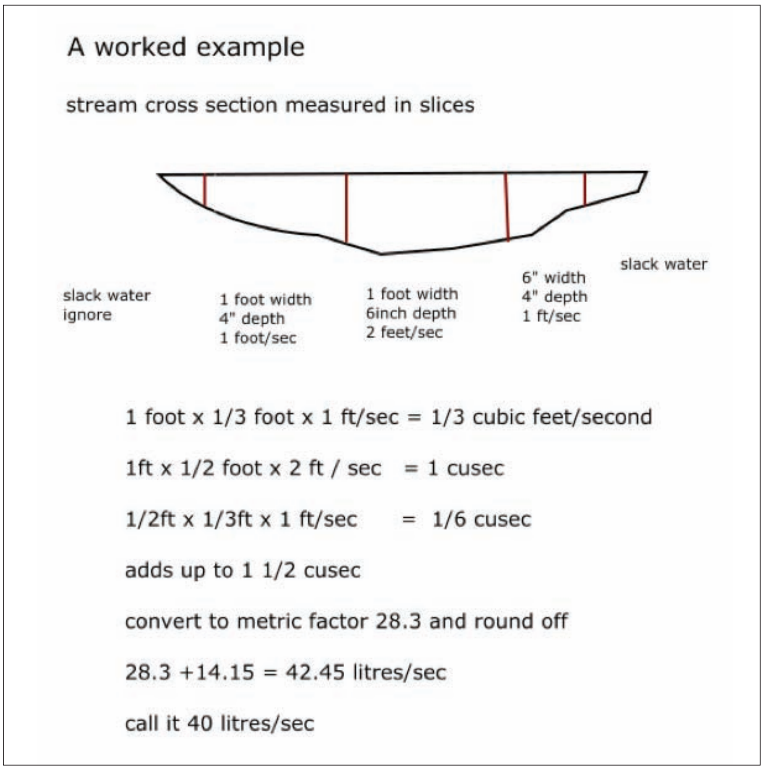
The usual situation is to have no device with you when you want to take a flow measurement. To cope with this situation I have memorized enough hand/body parts features to do the head jumps and channel sections. And to allow for drag effects I prune the section a bit. To do the flat bit of the velocity head rod I use two fingers. It's a good idea to take more than one measurement and do different combinations of cross-section and flow velocity. Also slice up the cross-section if there is enough velocity variation. The critical value of the technique is in coping with far from optimum sites for measurement. Some examples from Jenolan: Lower River in Mammoth Cave, Jenolan emerges from two holes in a wall, crosses the floor into a gutter then into deep water. Back in the days when Central Lake was normally present normal flow was 6 cusecs it could be measured by combining readings from both holes. At that time the gutter overflowed too much for measurement. In recent years the flow is confined to the gutter and can be measured there. It is only necessary to get a cross-section of the stream. Another difficult but fudge-able measuring point used to be the outlet weir for the Jenolan underground river with the complicating factor being discharge under the weir. But the way the water moved into Blue Lake meant that the flow under the weir could be estimated as a quarter of the whole and the remainder could be measured. But it's worse now.

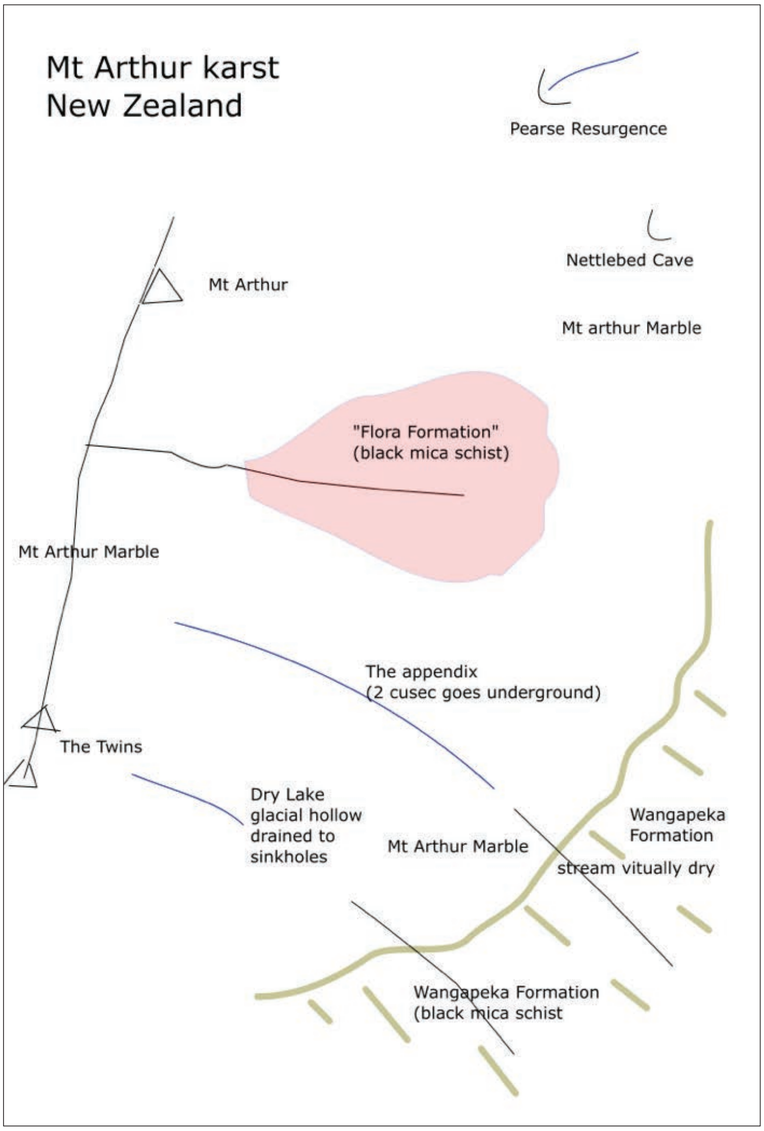
Right: Slicing a cross section since velocity is likely greater in the middle.

Some examples

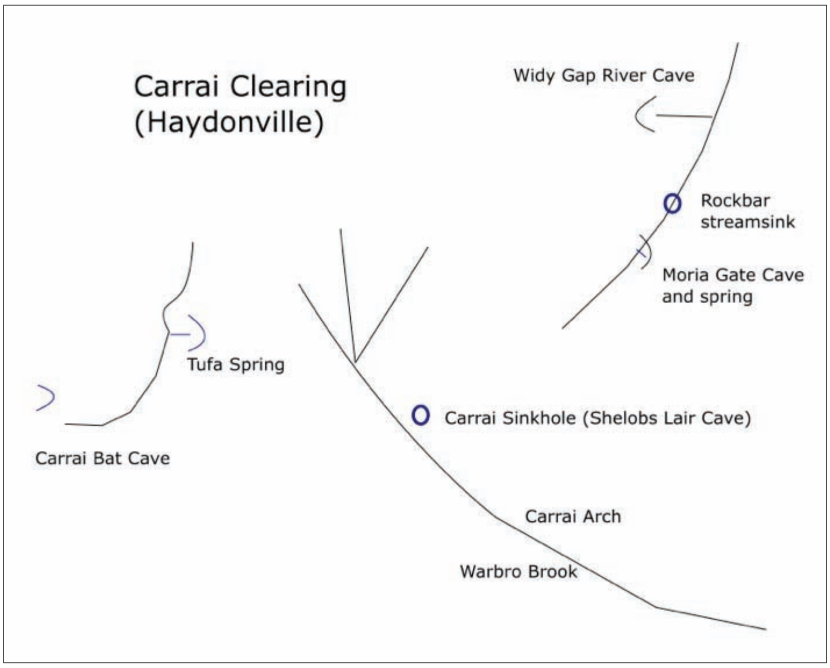
MT ARTHUR KARST, NZ SOUTH ISLAND: The camp on the 1966 expedition was at Dry Lake, a glacial basin drained by small swallets. The ground accessed from this camp is remote from the Pearse Resurgence; the known large spring for the area, and going on the published geology map the local underground drainage appeared to be blocked off by a schist formation supposedly coming to the surface from below the marble. But on the walk in I noticed a group of sinkholes near the contact that were in the schist itself, showing that the marble must be underneath. The new version of the geology coming from this observation meant there was no impediment to the local drainage heading underground to the Pearse Resurgence and Nettlebed Cave. It remained to check out the possibility of resurgences at low points on the marble contact in the local area and to see how they matched up with measurable stream sinks, which I could do with velocity head measurements to prove that at least 2 cusecs were going under in the next valley. The creeks just off the marble were mere trickles so the 'it all goes to the Pearse' model was proven.

CARRAI-WINDY GAP, NSW MACLEAY VALLEY KARST: The limestone belt here can direct underground drainage along strike and though obscured with superficial cover much of the time it does seem that the belt can contain more than a single bed. Because of the cover situation inflow points can't be located generally but in Carrai Clearing, at a highish point on the belt, Warbro Brook crosses on an alluvial flat that is assumed to be leaking. At the margin of the flat adjacent to limestone outcrop there is an open sinkhole so situated that water from the creek can be diverted into it, and this was done as part of a water tracing experiment with home-made





fluorescein. The questions to consider were whether the extra water would go West to Tufa Spring near Carrai Bat Cave (not likely but checked with a charcoal bag) or East to River Cave, Windy Gap (likely) but with an extra complication: the cave is not just over the divide but on the opposite side of the next valley. A bar of limestone crosses this creek and water sinks into it which is then expected to go to River Cave (proved later with rhodamine) and this water comes from a spring in what appears to be a different limestone bed near Moria Gate Cave. This spring is on the expected side of the valley but isn't as big as River Cave. So, would the water go directly to River Cave, or take the indirect route by first coming to the surface at Moria Gate Spring then sinking again at the rockbar? This is where flow measurement would help and as it happened, the extra water appeared at River Cave and the situation at the rockbar was as before. Ergo the connection is direct.



MOLE CREEK — FEEDERS TO TAILENDER SPRING: There was a dye test run (published in Forestry) in which rhodamine was placed in Aqueduct Swallet and fluorescein was placed in the outlet of Blue Lake. The rhodamine was never seen again except in a fancy fluorimeter but the green stuff was seen in Rat Hole and in Tailender Spring. (It was measurable at the time, but no more since 'environmental flow' is now released from the Hydro dams.) Tailender Spring flow was as expected from the sum of the two identified sources but where did the join occur with respect to Rat Hole? The strong fluorescein response could have been masking a rhodamine positive if the join was upstream. But the flow in Rat Hole made perfect sense if Blue Lake was the only feeder.