SOME USEFUL PHYSICAL MEASUREMENTS

Several useful and "doable" physical hydrologic measurements that we might make in Sixmile Creek are flow, channel elevation and suspended sediment load.

FLOW (Q)

(Stream)Flow is defined as the quantity of water passing a given channel cross-section per unit time. It is commonly expressed in either cubic feet per second (cfs) or cubic meters per second. Flow is one of the most important measurements made in streams but also rather difficult.

Why Measure Flow?

Flow and changes in flow are measures of the behavior of a stream over space and time. Flow measured at a point over time determines the size and character of flood events as well as the nature of base flow. Such measurements require continuous recording gauging stations, as the USGS station at German Crossroad. This is not a task for our group.

Flow is a necessary component to measurements of total fluxes of water quality parameters. We measure these parameters (various chemical, biological and sedimentological "entities" in concentrations (e.g mg/liter) but to calculate total fluxes, these concentrations have to be multiplied by the flow (e.g. m^3/sec) to get values in mg or grams per second. We must therefore measure flow at every station where we measure concentrations of parameters.

How Do We Measure Flow?

There are several methods, most of which use the equation $Q=Av$, where A is the cross sectional area of the wetted channel and v is the water velocity. We must therefore make 2 discrete sets of measurements, neither of which is simple. The velocity varies over the cross section because the stream bed creates friction and slows the water, and the rougher the bed the greater the effect.

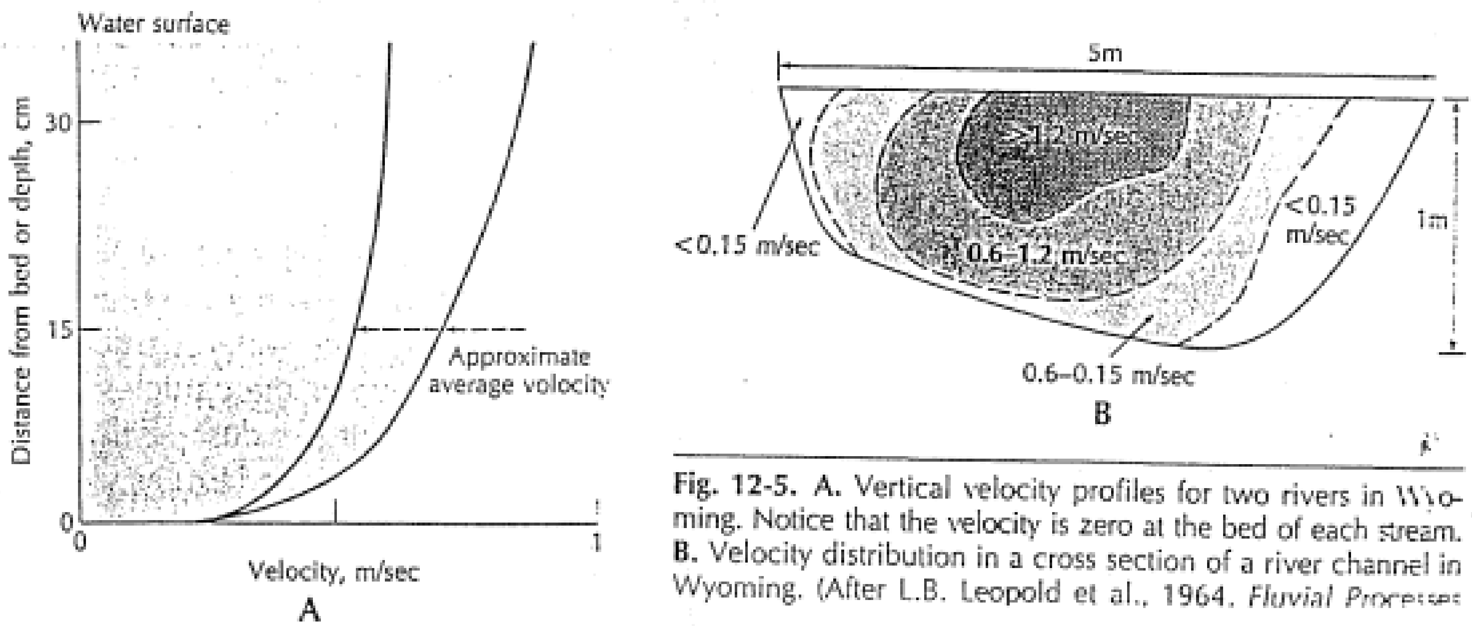


Fig. 12-5. A. Vertical velocity profiles for two rivers in Wyoming. Notice that the velocity is zero at the bed of each stream. B. Velocity distribution in a cross section of a river channel in Wyoming. (After L.B. Leopold et al., 1964, *Fluvial Processes*

The average velocity occurs about 0.6 of the depth (from the surface). Another generality is that the average velocity is roughly 0.8 of the surface velocity, which is the fastest.

The channel cross section is not a simple geometry either, with depth varying across the channel, and roughness creates "noise".

The easiest way to proceed is to measure channel depths at intervals across the channel (e.g. every 5 or 10 ft). Make several adjacent measurements to get a good average. Sketch the cross section to see where the main flow is.

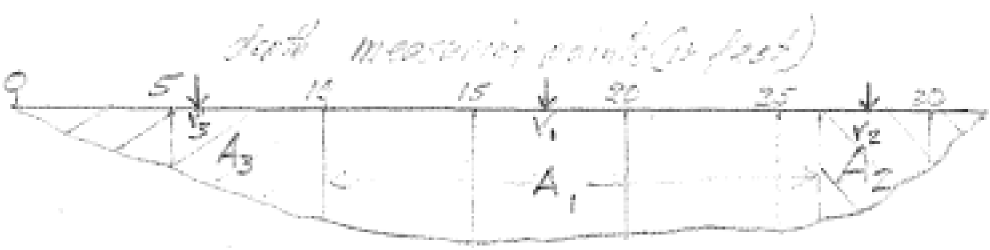
Next we must measure velocity. This can be done either with a current meter or by measuring surface velocity with a floating object. If we use a current meter, it should be put at 0.6 the depth so that it measures average velocity.

Timing a float seems simpler but maybe not. Use a floating object that is highly visible , disposable if it's high water, and not too "fluffy"(like a piece of paper, which will be wind affected). Measure and mark a length of 15-40 feet(5 to 15m) that is as uniform as possible. Throw the float in above the upper mark and time its passage to the lower mark. Divide the distance by the time to get velocity in ft/sec(or meters/sec).

Make several velocity measurements across the channel, at known positions within the cross section. Pick places that seem representative of a section of the channel (e.g. one in the fastest deepest water and ones in sections that have uniform depth. All these surface velocities must be multiplied by 0.8 or so to get average velocities. The shallower and rougher the channel, the lower this number should be.

When both the cross sectional shape and the velocities have been measured, plot a cross section with the average velocities in the correct positions and divide the channel up into "representative" segments, as shown below.

Calculate the total flow(Q) as $Q = A_1 v_1 + A_2 v_2 + A_3 v_3 \dots A_n v_n$



Flow might be more easily approximated by using the ratio of watershed area above the measuring site with that above a gaging station with continuous readings:

$$Q_{site} = [(Area_{site})/(Area_{gage})]\, Q_{gage}$$

This assumes steady state flow and uniform water input (rain, melting snow or ground water seepage. For high water events this assumption is very poor because rainfall or snowmelt usually varies over the total watershed and flood event peaks migrate downstream with time. For base (low) flow periods, when many of our measurements will be made, these assumptions are better, but still assumes uniform seepage.

I suggest that several rounds of actual low flow measurements be made, and that these be compared with the values of the approximation method. This comparison will allow and "adjusted" ratio to be determined for subsequent use-with much higher confidence.

CHANNEL ELEVATION

The change in channel elevation over time is a measure of channel aggradation (filling) or degradation (downward erosion). This in term reflects the balance between the amount of sediment available for transport and the capacity of the stream to move it. These elevation changes result from changes in watershed land use and in channel geometry , most of which are deleterious. The subject is too complex to cover here, but the measurement is quite easy and very well worth making.

How Do We Measure Channel Elevation?

Absolute channel elevation (in ft above sea level) doesn't need to be known, but only changes over time. Therefore all we need is an unchanging and relocatable reference point from which we can repeatedly measure the distance to the channel bed. Bridge decks are very good reference elevations because they seldom change and because they allow us to measure to distance to the channel bed very easily.

Things to be taken into consideration : 1. make annual measurements about the same time of each year-summer is best. High water events can temporarily change channel depth

2. A channel is composed of pools and riffles with very different depths. If possible, measure in a riffle, as they vary less, but if a pool exists under a bridge, note that. Even better, measure the depth to the water surface and then measure the WATER depth of the channel and the bottom on the pool, where it becomes a riffleThe elevation of the channel at that point is a reliable elevation.

SUSPENDED SEDIMENT LOAD

Suspended sediment load is a parameter that is very useful to make for several reasons. It, like flow is rather difficult and/or time consuming, but unlike flow, is not absolutely necessary. However, most of the perceived problems related to Sixmile Creek are associated with sediment transport and it seems logical to include these measurements in our program.

Sediment transport is another very complex topic, only a tiny bit of which can be covered here. The solid sediment load is carried wither in suspension (the clay, silt and fine sand) or as bed load (larger stuff that slides, bounces and rolls along the bottom). Although it is very important, the measurement of bed load is beyond our capability, but we can learn much from the measurement of suspended sediment.

Suspended sediment is collected automatically and continuously at the USGS gaging stations, but they represent only 2 points along the channel and give very little information as to how the watershed is supplying suspended sediment to the main stream. Suspended and bed loads in Sxmile Creek probably have significantly different source distributions, with the bed load dominantly derived from the bed and banks of the larger channels and the suspended sediments dominantly or largely derived fro tributaries draining the glacial lake clays. It would be important to docum,ent this second assumption and also to see how the source distribution of suspended sediments changes over time-both short and long term.

Sixmile Creek transports almost no sediment during periods of low (base) flow. As the flow increases during a storm event, suspended sediment load rises rapidly but not until the channel is almost full does significant bed load transport occur. Thus, we could measure suspended sediment during several of the many storm events from spring through fall.

How Do We Measure Suspended Sediment?

Our goal would be to collect sediment samples at "equivalent" times throughout the watershed during a storm event. This is quite difficult to do early in an event because flow at this stage is highly transient and sediment loads vary widely for many reasons. It is also difficult to mobilize the troops early during an event. For these reasons it would be better to make measurements during the falling stages of a storm event, when the rate of change is slower and people have time to organize.

Samples would be collected with a USGS suspended sediment sampler, which we will have on loan. This sampler can only be employed from a bridge or aerial tramway, but collects representative and well-calibrated samples. It is far superior to stream edge sampling or even other bridge sampling methods and can produce data acceptable to the USGS.

We will demonstrate its use later but suffice it to be said that this is also a concentration measurement that must be coupled with a measurement of flow to produce a value of the total flux (in grams/second, Tons/year, etc). The actual fluxes are not as important as the variations in fluxes at various sites along the stream. Sites should be chosen to sample major tributaries as well as sections of the main channel with different hydrologic and geologic characteristics. This will require no little thought. Although it seems redundant, we should sample at the German Crossroad USGS gaging station to establish a comparison between the two quite different sampling methods.