Information Paper 4.8.1.1

Gravelometers: Gravel Templates for Pebble Counting in Gravel-Bed Streams

Particle size frequency distributions are usually obtained by sieving bulk samples of sediment. In the case of surface samples, this is often impractical because particles can be fairly large. Consequently, various particle size axes or dimensions are measured to determine the equivalent sieve size.

The Wolman pebble count is commonly used to sample the surface particle size distribution of gravel-bed rivers. Typically, 100 individual particles are selected from the streambed and the intermediate axis of each particle is measured.

The standard practice is to measure the maximum dimensions of three mutually perpendicular axes, with the largest dimension being the a-axis, the intermediate the b-axis, and the smallest the c-axis. Since most streambed particles approximate ellipsoids, the b-dimension is an acceptable predictor of nominal diameter. The nominal diameter is defined as the diameter of a sphere with the same volume and thus corresponds to sieve size. This in turn makes it possible to determine particle size frequency distribution from the b-axis alone.

Using the b-axis to approximate sieve size equivalents can introduce systematic bias. Sieving has the tendency to produce slightly smaller particle size measurements than b-axis values. This results because certain particles (especially disc-shaped ones) will pass through a sieves square opening diagonally and be tallied in the smaller sieve size class even though the b-axis of the particle is actually slightly larger than the sieve size. Theoretically, bias as large as 1.4 is possible for very flat particles.

To overcome this problem, many investigators use a gravel template, sometimes referred to as a gravelometer or pebblemeter, to classify particles into size classes. Effectively, the gravelometer produces the same results as sieving while minimizing operator error which can arise from measuring the intermediate axis using a ruler. The gravelometer consists of a template with square holes of common sieve sizes (usually 8 to 128 mm) that are used as a hand sieving device to sort particles in the field. Various configurations have been tried. An example of one design is shown in Figure 1, the design used by our testers. Note that the gravelometer has 1/2 phi unit classes, similar to sieve sizes. An alternative template design is shown in Figure 2.

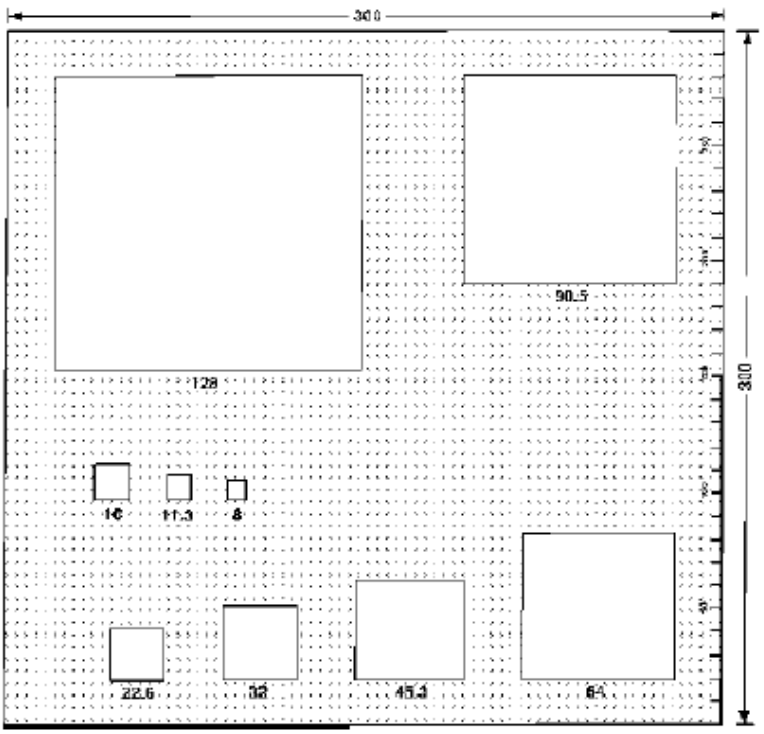

Figure 1. Gravel Template (Gravelometer). Dimensions are in millimeters. Constructed from 4.76 mm aluminum plate.
From: Yuzyk, T.R., 1986. Bed material sampling in gravel-bed streams. Environment Canada, Water Resources Branch, Sediment Survey Section, IWD-HQ-WRB-SS-86-8.

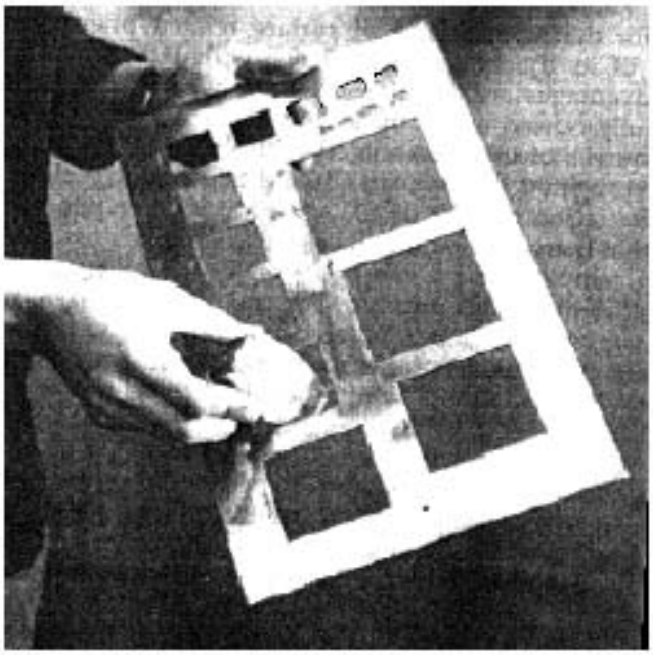

Figure 2. An alternative gravel template design.
From: Hey, R.D. and C.R. Thorne, 1983. Accuracy of surface samples from gravel bed material. Journal of Hydraulic Engineering, Vol. 109, No. 6, p. 844.

Who Uses Gravel Templates

When doing pebble counts, Forest Service research hydrologist, Tom Lisle, in Arcata, California, says, "We always use pebblemeters and I can see no disadvantages. It avoids bias for irregular particles, replicates sieving so you can blend and compare sieved and counted data, and it's faster than a ruler."

Tom's hydrologic technician, Sue Hilton, who actually picks up most of the rocks, agrees and says she wouldn't do it any other way. Sue points out, "The advantages are the obvious ones, you don't have to try to figure out which axis is which or project the end of your ruler to the widest part of the rock or read the tiny marks on the ruler. This eliminates a lot of possible sources of error and it makes the whole process much easier."

How Gravelometer Data Compares with Ruler Measured Data

U.S. Forest Service research geomorphologist, Sandra Ryan, stationed in Laramie, Wyoming, compared gravelometer pebble counts with data obtained using a ruler. Sampling along an established grid, Sandra measured the same 100 particles on several reaches of St. Louis Creek on the Fraser Experimental Forest with a gravelometer and a ruler during 1995. Typical results for a cobble-bed riffle reach are displayed in Figure 3.

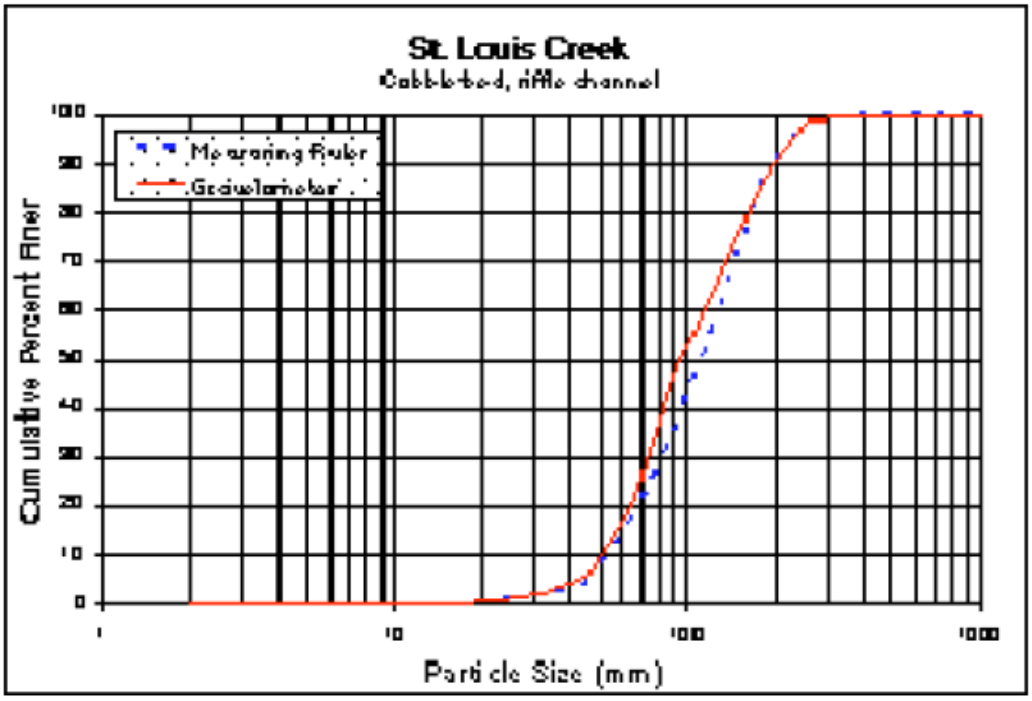

Figure 3. Comparative Pebble Counts

There was little difference in the tails of the particle size distributions, however, in the middle of the distribution, d50 values differed by approximately 10 mm, with the gravelometer systematically producing smaller values than those measured with the ruler primarily because many particles fit diagonally through the squares. Sandra made the general observation that the number of particles tallied (e.g., 400 particles versus 100 particles) is probably more important than the manner of measuring the particles especially if one wishes to define the ends of the distribution. Since particles are tallied by size class, some detail about sizes is lost with the gravelometer. In this experiment where particles were tallied both individually and by size class, there was virtually no difference in percentiles between the two approaches.

Several field hydrologists (Greg Bevenger, Shoshone National Forest; Gary Decker, Bitterroot National Forest; Gary Kappesser, George Washington & Jefferson National Forests) field tested a gravelometer for us this summer in the course of their field work. The gravelometers were generally less well received by field personnel who tended to note that they were cumbersome to carry and use compared to researchers who seem to think that accuracy outweighs these minor inconveniences.

Observations & Improvements

The following is a compilation of comments and suggestions from the field testers, their field crews, and the researchers previously mentioned.

- My impression is that the gravelometer is good for consistency and training
- It's easy to use and accurate.
- In one sense the gravelometer is easier to use than a ruler because no thought is involved. Just shove the rock through the smallest hole!
- The gravelometer provides accurate measurements, no matter who is using it.
- The observer doesn't have to make any judgment calls about how to measure a rock.
- The gravelometer is a little difficult and awkward to carry into remote sites and it is cumbersome to use.
- The gravelometer is best used for training and monitoring purposes, but not reconnaissance level work.
- For reaches with large particles, you need both the gravelometer and a ruler to measure the larger particles. Switching between the ruler and the gravelometer becomes a mid-stream juggling act. When rocks are firmly embedded, it is more difficult to measure them in place than with a ruler.
- When working in cold weather, ice forms in individual squares and decreases the size of the opening.
- Expand the size range of the template. Add a 4 mm and a 180 mm square.
- Make it out of a lighter material and paint or make the surface rough to eliminate blinding reflections from its surface.
- Add a hinge so it can be folded in half.
- Round off the corners and drill a hole near one corner so a cord can be tied to it.

How to Obtain a Gravelometer

Constructing a gravelometer is no easy matter but it can be done with a band saw, a file, and a few hours of labor. You can have one manufactured commercially, but expect to pay over $150 for a single unit. *(NOTE: In 2010 gravelometers could be found for sale at under $50.00)* We believe significant cost reductions are possible if the gravelometer is produced in quantities. The Federal Interagency Sedimentation Committee currently produces a variety of sediment samplers and related measuring equipment. If there is sufficient interest, they may agree to add the gravelometer to their product list.

STREAM would like to make gravelometers more readily available for field use. To do so, we need your support to gauge the extent of interest and the potential market. If you might be interested in purchasing a gravelometer, please send a Data General message, FAX, or E-mail to the STREAM TEAM along with your name, address, and the number of units you may wish to purchase. Doing so is simply an expression of interest and does not imply or make any purchase commitments.

If there is sufficient interest, the Stream Systems Technology Center will bring this matter to the attention of the Federal Interagency Sedimentation Committee in the hopes of having them produce a gravelometer at reasonable prices.

Reference:

Stream Systems Technology Center. (April 1994). Gravelometers: Gravel Templates for Pebble Counting in Gravel-Bed Streams. Stream Notes: To Aid in Securing Favorable Conditions of Water Flows