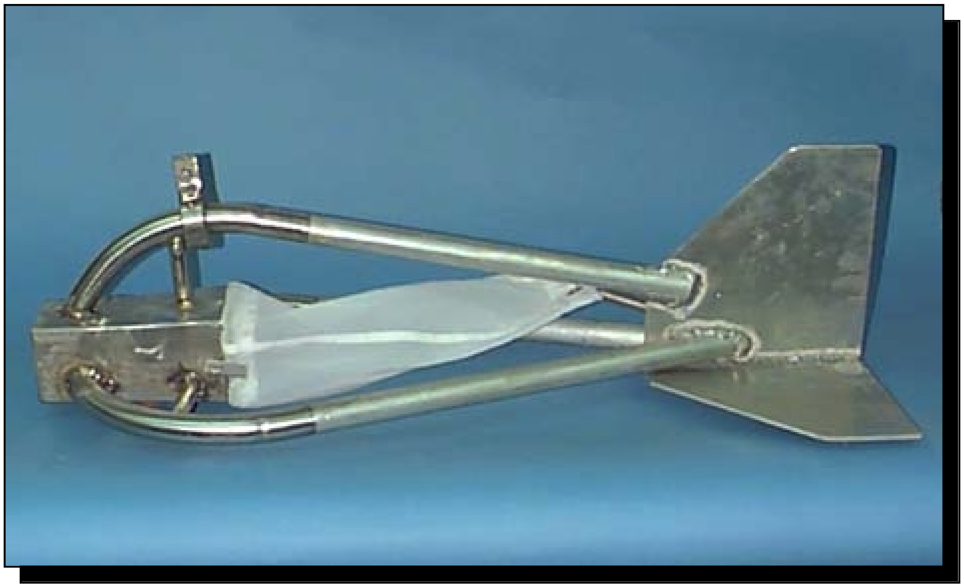
SAMPLING WITH THE US BL-84 BED-LOAD SAMPLER



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Sampling with the US BL-84 Bedload Sampler

Characteristics

Description: The US BL-84 is a cable suspended 32-lb sampler used to collect bedload samples from a stream of any depth (figure 1).

The sampler consists of an expanding nozzle mated to a frame, and a sampler bag (sold separately). The sampler design enables collection of particle sizes up to 1.5 inches at mean velocities up to 10 ft/sec. The sampler has a 3 x 3 inch entrance nozzle and an area expansion ratio (ratio of nozzle exit area to entrance area) of 1.40.

The US BL-84 is constructed of stainless steel and aluminum, is equipped with tail fins, and is 36 inches long by 15 inches wide. The sampler must be supported by a steel cable and reel to be lowered into a river or stream for taking a bedload sample.

Sampling container: The sampler uses a 295 in^2 polyester mesh sample bag that is 18 inches long with mesh openings 0.25 mm. The bag is attached to the rear of the nozzle assembly with a rubber "O" ring.

Sampler function: When the sampler is submerged and sitting on the streambed with the nozzle pointed into the flow, the water sediment mixture flows through the nozzle into the bag. The mesh openings in the bag allow water and fine sediment to flow through the bag while trapping the coarse sediment.

Limitations

Velocity limitations: The US BL-84 samples upper mean velocity limitation is approximately 10 ft/sec.

Depth limitation: The US BL-84 sampler is only limited by the river condition that will allow the sampler to be properly placed on the streambed. A tether line is required to counteract the drag induced by increases in stream velocity (normally above 4 ft/sec). The use of a tether line will allow greater control during lowering and positioning of the sampler (see figure 2).

Instruction for use of the US BL-84 sampler

Sampler preparation: Connect the sampler to a suspension cable and reel that has adequate capacity to raise and lower the sampler with a full sample. All hardware, including clamps and cable, should be as small and streamlined as possible. Suspension cable diameter should not exceed 1/8-inch. Bulky hardware increases drag which will increase the tendency for the sampler to be pulled downstream while is being lowered. To attach the sample bag, loosen the two retaining clips (see figure 1) on either side of the rear of the nozzle. Stretch the "O" ring banded opening of the bag over the rear of the nozzle until it fits in the groove at the rear of the nozzle. Reattach the retaining clips. Attach the retention spring located at the front of the tail to the metal grommet in the rear of the sample bag.

The US BL-84 is shipped with the cable attachment at the proper location for the sampler to be balanced as it is lowered to the streambed. The suspension point is located at a point that balances the submerged sampler with the tail slightly lower than the nozzle. If the sampler is suspended so that its tail is much lower than its nozzle, the tail may touch the streambed before the rest of the sampler makes contact. The tail may then act as a pivot point, causing the sampler to rotate, or "yaw" to one side from the force of the flow impinging on the underside of the sampler. If the sampler is balanced with the nozzle lower than the tail, it may scoop the bed-material as it contacts the streambed.

The use of a tether line is strongly recommended when using the US BL-84. The tether line is used to eliminate downstream drift of the sampler caused by high-velocity and deep depths in open-channel flow. The use of a tether line will also reduce the potential for scooping during sampler placement and retrieval. The tether line is a line connected between an upstream support, such as a transverse cable or stay line and the sampler. A diagram of the use of a tether line with the US BL-84 is shown in figure 2.

Cross-sectional Procedures: The U.S. Geological Survey TWRI "Field Methods for Measurement of Fluvial Sediment" lists three cross-sectional procedures that can be used. They are the Single Equal Width Increment (SEWI) method, the Multiple Equal Width Increment (MEWI) method, and the Unequal Width Increment (UWI) method. The SEWI method actually involves collecting 2 samples at each of 20 verticals and is the most commonly used procedure. Sampling procedures should consider spatial (cross-sectional) variations and temporal (at-a-point) variations. Because knowledge of where bedload has occurred in the past does not necessarily imply where bedload will occur in the future, it is unlikely that pre-judgement will allow an investigator to substitute spatial concerns for temporal concerns, or vice versa.

It is the responsibility of the field personnel to select the procedure that is optimal for the local conditions. Ordinarily, excess samples will have to be collected at a site until enough experience is gained to select the appropriate procedure for the measurement. At some sites it may be possible to define the temporal and spatial variation with 40 samples and other sites may require 100 or more samples to obtain the same information. A plot of the individual bedload transport rates as a function of distance from the bank has often been found to be useful in selecting the appropriate sampling procedure. The optimum sampling procedure should be expected to vary with season and flow conditions.

Sampling Time: The sampling time is the length of time the sampler rests on the bed and accumulates material for each individual sample. Long sampling times tend to average out short-term rate fluctuations and produce rates that vary about the mean rate in accordance with the normal distribution.. Short times, however, tend to reflect instantaneous rate variations and often correspond to asymmetrical distributions (Gomez, Naff, and Hubbell, 1989). Because sampler capacity is relatively small, the range of acceptable sampling times is usually very limited, often 30 to 60 seconds. Although a sampling time of less than 10 seconds should be avoided, the sample bag should never be filled to more than about half full. The sampling time should not be so long that a significant amount of clogging of the bag occurs.

Sample Compositing: A bedload sample is the material collected during one sampling time. The width increment is the width of channel to be represented by the sample vertical (Edwards and Glysson, 1988, p. 98). Individual bedload samples can be analyzed individually, or combined into one or more composite samples for analysis. Only samples collected with equal sampling times and width increments may be composited.

Until sampling variability for the site is understood, it is recommended that all samples should be analyzed individually. The more samples one composites, the less one learns about variability in space and time.

The following data should be recorded on a field note sheet for each cross-section sample:

- Station name/number
- Date
- Cross-section sample starting and ending times
- Gage height at the start and end of sample collection
- Total width of the cross section including stations of both banks
- Width between verticals sampled (SEWI method)
- Station of verticals sampled (UWI or MEWI method)
- Time sampler was on the bottom at each vertical
- Type of sampler used
- Name of person collecting sample

In addition, the following information should be recorded on each sample container:

- Station name
- Date
- Designation of cross-section sample to which the container belongs
  (that is, if two cross-section samples were collected, one would be “A” and the other “B”)
- Number of containers for that cross section (for example, “1 of 2” or “2 of 2”)
- Station(s) of the vertical(s) the sample was collected from
- Time sampler was on the bottom and at the vertical station
- Clock time the sample was collected (start and finish if composite)
- Collector’s initials

Analysis: The usual sampling strategy should be to define the mean transport rate at a series of lateral locations, often equally spaced. For this strategy, samples from different verticals must not be composited. Rather, sample rates should be expressed in units of rate versus width. Rate should be expressed in units of weight per unit time per unit width. For conditions of reasonably constant discharge, the rates at each measurement vertical should be averaged for plotting, and a curve representing the lateral distribution of bedload transport rate across the channel (or channels) should be drawn. This curve should give insight into the true shape of the lateral distribution curve. The area under the curve then represents the total cross-section bedload transport rate, in weight per unit time.

Supplemental Information

Because of spatial and temporal variations in bedload, and the large effort required to obtain even a few samples, the measurement of bedload is substantially different than the measurement of streamflow and suspended-sediment discharge. In particular, it is not possible to establish rigid procedures or accuracy criteria to insure suitable results. Satisfactory measurements can be obtained only by sampling according to an individually planned effort designed to account for the unique situations at a specific measurement site. Optimal schemes require some understanding of the phenomena of bedload transport, particularly with regard to rate variations. Accordingly, it is recommended that anyone who programs, plans, or executes bedload-sampling efforts should seek the wisdom of experienced bedload-sampling personnel and become familiar with literature listed in the references.

Questions and comments regarding sampler operation should be addressed to:

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References

Carey, W.P., 1985, Variability in measured bedload-transport rates: Water Resources Bulletin, American Water Resources Association, v. 21, no. 1, p. 39-48.

Childers, Dallas, 1989, Field Comparison of four pressure-difference bedload samplers in high-energy flow: U. S. Geological Survey Water Resources Investigations.

de Vries, M., 1973, On measuring discharge and sediment transport in rivers: International Seminar of Hydraulics of Alluvial Streams, New Delhi, India, January 15-19, 1973, Delft Hydraulics Laboratory Publication 106, 15 p.

Druffel, L., Emmett, W.W., Schneider, V.R., and Skinner, J.V., 1976, Laboratory hydraulic calibration of the Helley-Smith bedload sediment sampler: U.S. Geological Survey Open-File Report 76-752, 63 p.

Edwards, T.K., and Glysson, G.D., 1998, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, 80 p.

Emmett, W.W., 1980, A field calibration of the sediment-trapping characteristics of the Helley-Smith bedload sampler: U.S. Geological Survey Professional Paper 1139, 44 p.

---- 1981, Bedload sampling in rivers: Beijing, China, Proceedings, International Symposium on River Sedimentation, March 24-28, 1980, Guanghua Press, p. 991-1014.

---- 1981, Measurement of bedload in rivers: Florence Italy, Proceedings, International Symposium on the Measurement of Erosion and Sediment Transport, June 22-25, Publication no. 133, International Association Hydrological Sciences, p. 3-15.

---- 1984, Measurement of bedload in rivers, Chapter 5 *in* Hadley, R.F., and Walling, D.E., (eds.), Erosion and Sediment Yield: Norwich, Geo Books, p. 91-110.

Emmett, W.W., Leopold, L.B., and Myrick, R.M., 1983, Some characteristics of fluvial processes in rivers: Nanjing, China, Proceedings, Second International Symposium on River Sedimentation, October 11-16, Water Resources and Electric Power Press, p. 730-754.

Gomez, Basil, Naff, R.L., and Hubbell, D.W., 1989, Temporal variations in bedload transport rates associated with the migration of bed forms: Earth Surface Processes and Landforms, v. 14, p. 135-156.

Gomez, Bazil; Hubbell, D.W., and Stevens, H.H., November 1990, Water Resources Research, Vol. 26 No. 11, At-a-Point Bed Load Sampling in the Presence of Dunes, p. 2717-2731.

Gomez, Bazil, October 1997, Water Resources Research, Vol. 33 No. 10, Evaluation of process errors in bed load sampling using a dune model, p. 2387-2398.

Leopold, L.B., and Emmett, W.W., 1997, U.S. Geological Survey Professional Paper 1583, Bedload and River Hydraulics-Inferences from the East Fork River. Wyoming, 48 p.

Kuhnle and Willis, 1998, Statistics of Sediment Transport in Goodwin Creek, Journal of Hydraulic Engineering, Vol. 124, No. 11, p. 1109-1114.

Thomas, R.B., and Lewis, Jack, March 1993, Water Resources Research, Vol. 29 No. 3, A New Model for Bed Load Sampler Calibration to Replace the Probability-Matching Method, p. 583-597.

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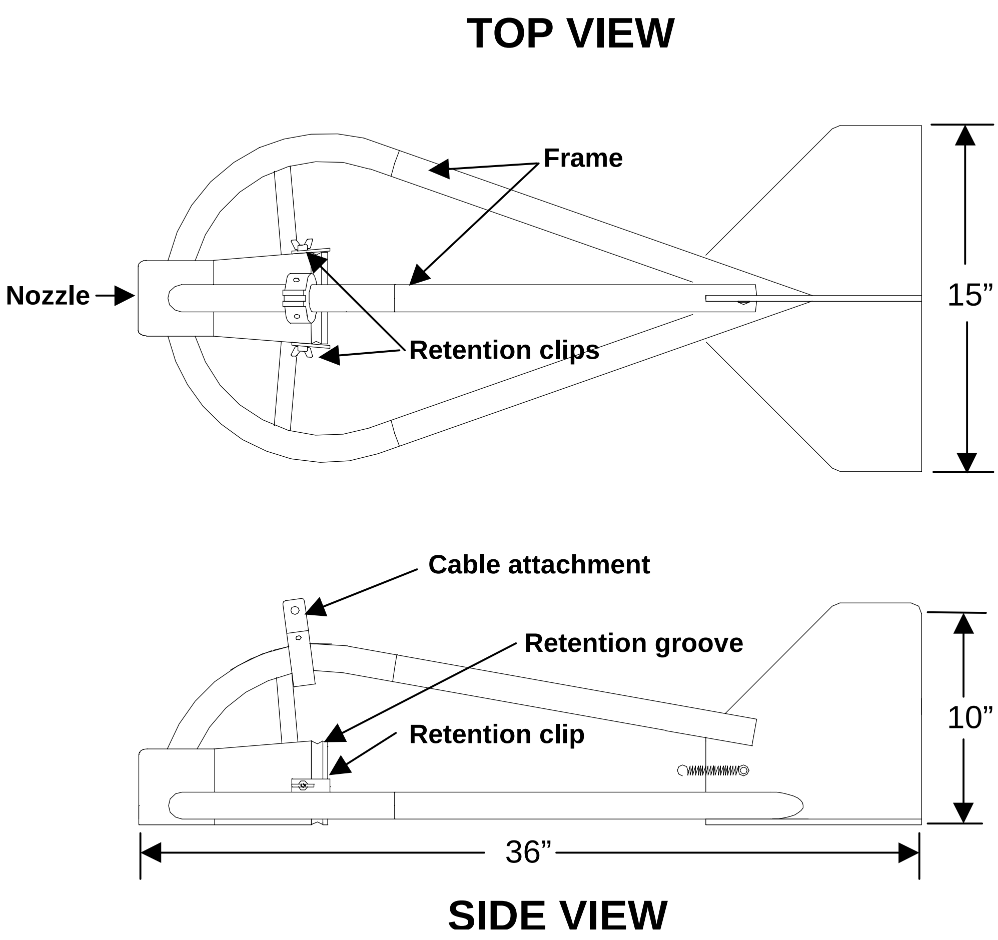

Figure 1. Schematic of the US BL-84.

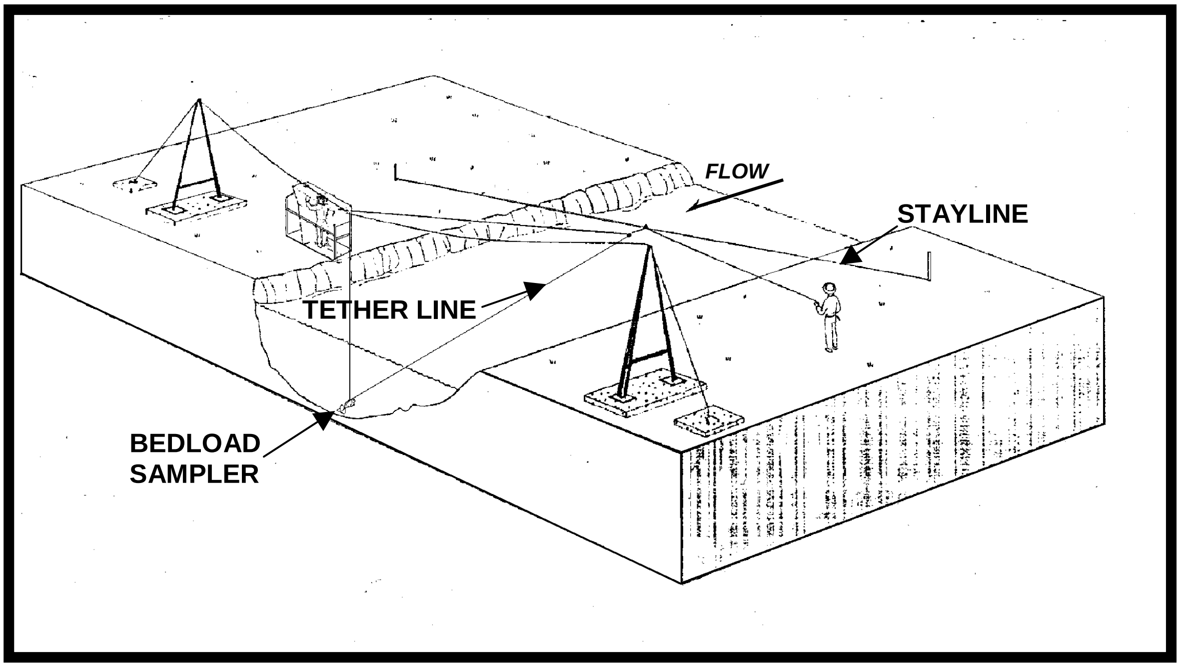

Figure 2. Diagram of US BL-84 with tether line at a cableway.