STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station **July 2001**

Let Rivers Teach Us

by Luna B. Leopold

River channels are being altered on a massive scale for many purposes, including flood control, road engineering, fishery improvement and erosion control. Geomorphic principles of river form and process are known to few of the designers of such works. It is proposed that that there be established a center for case study storage and dissemination so that knowledge of successes and failures adds to our ability to maintain and improve river environments.

Only a few weeks ago I received notice from one of the federal resource agencies that they plan to do fisheries habitat improvement work in local wetlands. The improvement will consist of five log drop structures and ten log-and-rock revetments in a reach of 220 feet of channel. This, they say, will reduce erosion and the impacts of sediment deposition.

Unfortunately, many fisheries specialists, federal engineers and consulting firms have made no attempt to absorb our rapidly increasing fund of knowledge of river process and channel behavior.

Rivers do not construct drop structures. Rivers construct and maintain, by process of erosion and deposition, channels of particular characteristics including dimensions, planforms, cross sections, gradients, and distributions of sediment materials. These morphologic parameters are scaled to the size of the drainage basin and the nature of the rocks of the area. But they are scaled appropriately to maintain quasi-equilibrium.

The idea of check dams or drop structures became a widespread practice in the western United States in the 1930's, when the newly formed Soil Erosion Service faced the formidable gullies dissecting alluvial valleys. I remember very well the philosophy of those erosion engineers who stated flatly that a check dam in a gully would cause aggradation all the way to the watershed divide and the gully would be filled its entire length.

That this was not happening, they attributed to the limited time of observation. In time, they said, the gully would fill its entire length. It is clear that the experience over a thousand years in Palestine, in Mexico and elsewhere was quite unknown to the erosion engineers.

It is obvious to most of us today that a grade control structure flattens the channel gradient upstream for only a short distance and intrudes an unnatural-anomaly into the fluvial system. Such an anomaly will be attacked by the flow and, given time, will be eliminated. It will ultimately be destroyed by undercutting, by lateral erosion of the abutments, by scour hole erosion at the toe, or by some combination of these.

If a reach of channel is suffering unusual bank erosion, downcutting of the bed, aggradation, change of channel pattern, or

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Larry Schmidt, Program Manager

The PRIMARY AIM *is to exchange technical ideas and transfer technology among scientists working with wildland stream systems.*

CONTRIBUTIONS *are voluntary and will be accepted at any time. They should be typewritten, single-spaced, and limited to two pages. Graphics and tables are encouraged.*
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IN THIS ISSUE

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other evidence of disequilibrium, a realistic approach to amelioration of these problems should be based on restoring the natural combination of dimension and form characteristics of similar channels in quasi-equilibrium. These characteristics include appropriate values of width, gradient, pool and riffle sequence, length, radius, amplitude of curves and meanders, and hydraulic roughness.

A procedure might, in principle, include the following steps. Inspect the channel upstream and downstream of the reach exhibiting problems. Inspect nearby or similar valleys that appear more natural. Choose a reach of a natural river, which appears to represent the condition of the problem channel before it was disturbed or disrupted.

At this point it is useful to remind ourselves what are the principal morphologic features of the river channel that must be retained or restored. First, the slope or gradient of the channel must be the same as it is in the natural or undisturbed reach of the river. The deviation from this natural slope is the clearest reason that drop structures cannot be permanent and should be avoided.

The second imperative is the channel width. The width must represent the bankfull dimension such that when the normal bankfull discharge is exceeded, the water will overflow onto a flood plain of much greater width. This means that both width and depth at bankfull must be considered and an overflow area provided for greater discharges.

If the river curves or meanders present in the undisturbed reaches have been eliminated or importantly changed in the disturbed area, they must be reinstalled by physically constructing them. The layout of curves is the principal way the desired gradient is maintained or restored. No natural channel is straight, so the reconstruction of curves of appropriate size and shape is a main element in river restoration. The bed elevation should vary, in that pools occur in the curved reach and shallower zones in crossovers.

The dimension of width, depth, meander length, radius of curvature, slope, and other features have been published for many regions in the United States. These dimensions can be used as a rough check on those measured in undisturbed reaches of the river in question.

To give a few examples of such dimensions, the channel width tends to increase downstream as the square root of the bankfull discharge. The mean velocity at bankfull is, for small to medium size rivers, about five feet per second. A single sequence of a pool and a riffle usually has a length along the stream of five to seven channel widths. The radius of curvature for most channel bends is about two to three times the channel width. The bankfull level closely corresponds to the mean height or mean elevations of the point bar that commonly extends streamward from the convex bank of a channel bend.

There are a few generalizations drawn from scientific studies of channel form that can be useful in practical problems of river restoration or maintenance. Width is the morphologic parameter most easily altered by the river. If the river is deprived of some of its natural discharge, it will narrow its channel. Bank erosion usually will follow unusual or unnatural alteration in sediment supply or a change in water-sediment relation. An alteration in channel gradient (slope) is the most disruptive to the natural equilibrium. The increase in gradient is the main reason channel straightening or channelization is so destructive to river systems. Also, river curves provide an essential source of hydraulic resistance necessary for equilibrium.

Paucity of field data is a major roadblock to river work. To approach any of these matters quantitatively one must have some data measured in the field. The value of river parameters can be estimated, but with no assurance of verity.

Unfortunately, too many professionals approach such problems with the supposition that computer can do all. In river work, computer modeling is an insidious procedure in which an air of surety hides questionable assumptions. A computer gives numerical answers, but the basis on which the computation rests are hidden.

Some of the most important parameters are measured at gaging stations of the U.S. Geological Survey, but the number of measuring stations has been reduced in recent years. Moreover, some of the needed values are not measured at gaging stations at all, especially slope, a carefully selected representative cross section, and the size distribution of bed material. No field determination of bankfull stage is part of gaging station procedure. Suspended load is measured at about one station of ten, and bedload at only a few of the suspended load stations. But more important than the small number of locations, the number of days on which sediment is measured is only 10 to 15 days per year, often too few to span a range of discharge values. The number of days bedload is measured is even fewer, 2 to 10 per year.

Some consultants who are involved in river restoration are gradually beginning to collect field observations as part of their regular practice, but this is not yet common. There is too much reliance on computer models with no field measurements to support the computations. Indeed, even the Corps of Engineers tends to rely on computers and estimates rather than engaging in actual measurement in the development of a design for river improvement. In fact, with the increase in river improvement work, there is even less data being collected than in previous decades.

With the reduction of data collected at gaging stations and the increase in work to be done, other agencies of federal and state government will have to start collecting data themselves. This will be an unfortunate direction because there will be no standard of excellence of the process and the results will not be published as has been the case under the Geological Survey.

There are a lot of people harming rivers. There are also people who are improving them. But we do not know who is doing what. We are all trying as best we know how to do effective maintenance and improvement work. But there is no attempt to learn from each other. No doubt mistakes are repeated. No doubt success goes unnoticed.

We have a problem in river restoration that presently is leading to serious consequences but is also possible of solution. The problem is lack of communications and trading of experience. As a result, successes in field restoration are little known, while mistakes are repeated indefinitely.

There are many handbooks, instruction manuals, and how-to-do-it pamphlets on channel improvement. There are none I have seen that makes an evaluation of different techniques with explanation of the initial condition, the recommended solution, and the result of the treatment. What is needed is a gradually accumulating file of case studies, describing with text the illustration of the original condition, an assessment of the basic cause of the problem, the techniques and construction details of treatment, and an objective analysis of the result.

If such a file was initiated and all operatives urged to contribute, it is certain that we would learn from each other and our techniques would become more closely tailored to the type of river and the type of problem.

I propose an expanded effort that hopefully would involve federal and state personnel, consultants, and academics. Who or what organization should take the lead is not specified. But one thing seems clear. We must let the river teach us. Not just a few of us. Let the river teach all of us.

The above article is excerpted from a November 18, 1997 oral presentation by **Dr. Luna Leopold,** Professor Emeritus, University of California, Berkeley, at a Natural Resources Conservation Service Symposium in Berkeley, California entitled "Understanding River and Stream Systems." A complete copy of the paper is available from the NRCS Watershed Science Institute Web page (http://www.wcc.nrcs.usda.gov/watershed/pdffiles/leopold.pdf).

Sampling Surface and Subsurface Particle-Size Distributions in Wadable Gravel-Bed Streams

by Kristin Bunte and Steven R. Abt

Rocky Mountain Research Station General Technical Report RMRS-GTR-74, ***Sampling Surface and Subsurface Particle-Size Distributions in Wadable Gravel– and Cobble-Bed Streams for Analyses in Sediment Transport, Hydraulics, and Streambed Monitoring***, by Kristin Bunte and Steven Abt is a 428 page compilation and detailed discussion of the literature pertaining to bed-material sampling in these types of stream channels.

The Stream Systems Technology Center initiated the generation of this compendium of methods because National Forest System streams are dominated by gravel caliber material and sound guidelines for characterizing the bed material of gravel- and cobble-bed streams are needed by hydrologists, fisheries and aquatic biologists, and geomorphologists. The publication was made possible through a partnership between STREAM and the Colorado State University, Engineering Research Center.

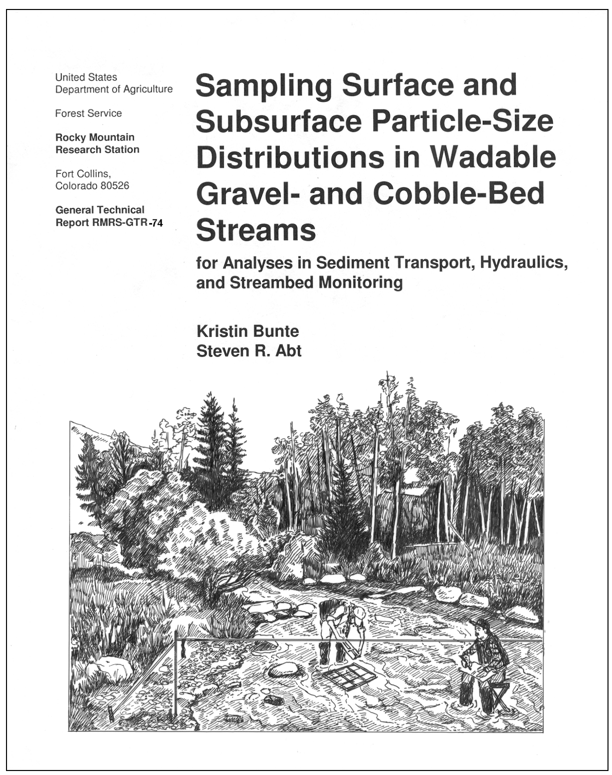
Purpose of Bed-Material Sampling

The majority of bed-material sampling work is undertaken to obtain information on the particle-size distribution of the riverbed. Information on bed-material particle size is needed for a variety of purposes that can be grouped into three major areas:

1. Streambed monitoring for detecting watershed impacts, analyzing stream habitat, and evaluating the success of mitigation efforts,
2. Computations of flow hydraulics and bedload transport rates or transport capacities to analyze and predict stream behavior, and
3. Advancement in the understanding of stream processes.

Attributes of Gravel– and Cobble-Bed Rivers

Sampling bed-material in gravel– and cobble-bed streams is more complicated than sampling sand-bed streams because these channels have unique characteristics. For example, gravel– and cobble-bed streams usually have a surface pavement or armor layer that is coarser than the sediment below the surface. Consequently, the user first needs to identify the appropriate bed-material strata to sample for a given study objective. Particles on the surface, in the subsurface, and in the armor layer are also sampled by different techniques. Particles may be picked off the stream surface (pebble count), or the subsurface sediment may be excavated (volumetric sample) after surface particles or the armor layer has been removed. Equipment and techniques employed for sampling subsurface sediment depend on sampling objectives, the size of the bed material in the stream, and on whether the streambed is dry or inundated. In addition, these types of streams are typically composed of many areas with different particle size-distributions. As a result, the user needs to select a spatial sampling strategy that coordinates study objective with stream conditions.


United States Department of Agriculture

Forest Service

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General Technical Report RMRS-GTR-74

Sampling Surface and Subsurface Particle-Size Distributions in Wadable Gravel- and Cobble-Bed Streams

for Analyses in Sediment Transport, Hydraulics, and Streambed Monitoring

Kristin Bunte
Steven R. Abt

Finally, the physical act of collecting representative samples is often challenging. Individual fine particles located between large clasts on the bed may be difficult to pick up, while cobbles and boulders may be too heavy or too wedged in the bed surface to dislodge. Flow may be fast or deep in mountain streams and the cold water makes it difficult to work bare-handed. The number of sample needed for statistical accuracy is usually large, sampling sites may lack vehicle access, and investigators are frequently surprised by the large sample sizes or volumes necessary for the desired statistical accuracy.

Purpose and Intent of Guidelines

There is an abundance of literature that demonstrates sampling equipment, compares and suggests sampling procedures, recommends sample sizes, proposes sampling schemes, presents alternative particle-size parameters or computational methods, and describes the findings of specific bed-material studies. This methodological diversity, and the ongoing debates on the general appropriateness of methods or their applicability in specific situations, leaves the field person with a variety of techniques from which to choose. However, there is little guidance for deciding if a particular method is suitable for a given study and a given stream.

Faced with this diversity, stream studies tend to resort to so-called "standard methods." For example, the 100-particle Wolman pebble count is often considered a standard method for surface particles and the McNeil sampler is commonly used for volumetric bed-material samples in submerged conditions. These methods have attained "standard" status, and are described and applied on numerous occasions, primarily because they are relatively quick and easy to use.

This compendium strives to inform field personnel about sampling bed-material by explaining the various aspects of bed-material sampling in gravel– and cobble-bed streams and discussing the proper application, scope, and limitations of sampling methods. Included are an explanation of bed-material strata, the procedures and equipment used for sampling, a discussion of the spatial scheme to be employed, the relation between sample size and accuracy, and methods of particle-size analysis. These guidelines provide the user with a wide range of information as a basis for selecting methods and approaches suitable for a particular study in the selected fluvial setting.

Complex physical processes act in mountain streams. In-stream fluvial processes and near-stream and off-stream sedimentary processes influence stream morphology and the spatial variability of bed-material sizes. Such complex, multi-process environments require professional experience for meaningful field work. Unfortunately, government agencies and consulting firms frequently desire simple guidelines that advocate methods requiring little field time and that can be followed by inexperienced field personnel. However, an inexperienced crew will be unable to determine sampling locations and sample sizes if these decisions depend on recognizing geomorphic, hydraulic, and sedimentary processes of various scales and magnitude. Such assessments require knowledge and familiarity with fluvial processes. This document provides some of this knowledge.

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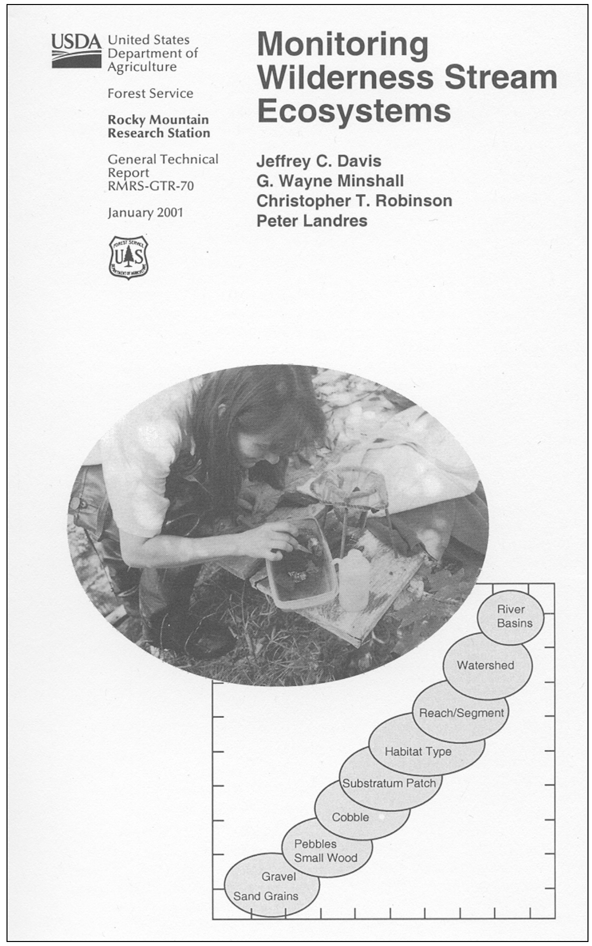
E-mail: rschneider@fs.fed.us
Mail: Publications Distribution, Rocky Mountain Research Station, 240 West Prospect Road, Fort Collins, CO 80526-2098.

The document may be viewed and downloaded from the STREAM web-page at www.stream.fs.fed.us by navigating to the "Download Area (FTP)" section or by going directly to http://www.stream.fs.fed.us/ftparea.html and look for file: "rmrs_gtr_74.pdf".

Monitoring Wilderness Stream Ecosystems

Rocky Mountain Research Station General Technical Report RMRS-GTR-70, ***Monitoring Wilderness Stream Ecosystems***, by Jeffrey C. Davis, G. Wayne Minshall, Christopher T. Robinson, and Peter Landres presents protocols and methods for monitoring the major physical, chemical, and biological components of stream ecosystems.



The 5½ x 8½ inch 137 page manual provides information to overcome most or all of the sampling difficulties associated with remote sites by demonstrating how to monitor streams in the backcountry wilderness using equipment that is lightweight, portable, and rugged. Most of the methods described were developed and refined for wilderness use over the past 17 years by the Stream Ecology Center at Idaho State University.

Parameters covered in the manual include:

- Temperature
- Discharge
- Stream and Substratum Morphology
- Water Quality
- Macroinvertebrates and Fish
- Algae/Periphyton
- Large Woody Debris
- Organic Matter
- Primary Production, and
- Nutrient Dynamics

The Stream Systems Technology Center partially funded publication of these monitoring protocols in the spirit of furthering the use of common measurement protocols among physical and biological scientists. Unfortunately, this publication falls short of fully meeting this objective. For example, the manual supports measurement of channel slope using clinometers, cautioning only that users may find this difficult due to limited visibility, ignoring the widely accepted view that clinometers should be avoided due to large errors in their readings (frequently ± 0.5%). Use of inaccurate slope readings of this magnitude can produce large errors in predicted flows.

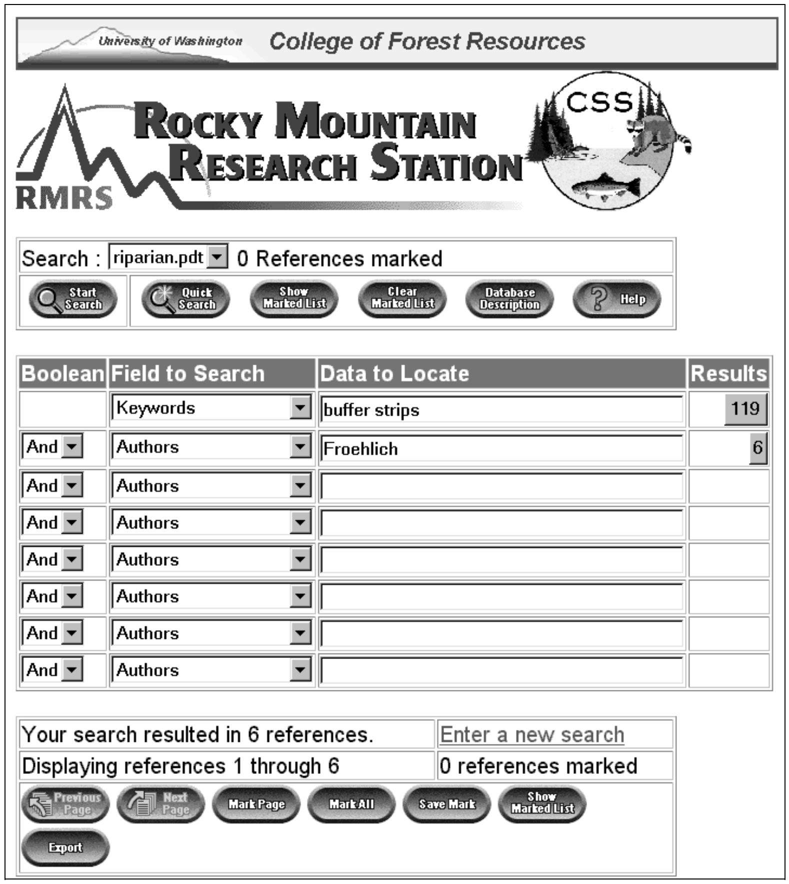
We believe users can overcome some of this shortfall in measurement of physical properties by using this publication in conjunction with the 1994 Rocky Mountain Research Station publication, ***Stream Channel Reference Sites: An Illustrated Guide to Field Techniques*** by Harrelson, Rawlins, and Potyondy (GTR-RM-245). The Stream Channel Reference Sites publication provides greater detail on techniques for measuring the physical characteristics of streams.

Readers may order copies of RMRS-GTR-70 and GTR-RM-245 by sending mailing information in label form along with the publication title and number to one of the following media:
Phone: (970) 498-1392; FAX: (970) 498-1396;
E-mail: rschneider@fs.fed.us
Mail: Publications Distribution, Rocky Mountain Research Station, 240 West Prospect Road, Fort Collins, CO 80526-2098.

Comprehensive Annotated Riparian Bibliography

(wwwdev.cfr.washington.edu/ris/html/Intro.htm)

A joint partnership between the National Stream Systems Technology Center at the Rocky Mountain Research Station and Dr. Susan Bolton of the University of Washington's Center for Streamside Studies (CSS) produced this comprehensive searchable Web-based riparian bibliography. The bibliography includes over 11,000 citations and was developed through an extensive search of literature and electronic databases. Sources of information include journals, government documents, books, monographs, and conference proceedings.



The site is primarily for the use of university students, faculty, Forest Service employees, federal land management agencies, and cooperators to assist in identifying publications that might be relevant to a given study. Users are encouraged to read the literature rather than relying on the abstracts alone. The Web-based bibliography is made available to the public as a convenience. The site is updated frequently and users can help by noting and reporting any errors they encounter.

The electronic database can be searched using Internet Explorer or Netscape. The database can be searched by author, title, keyword, dates, or publications. Quick and Advanced search options are available. A typical search is shown in the figure on this page. The example shows a search combining the keywords "buffer strips" with the author "Froehlich" which resulted in 119 and 6 hits, respectively. Selected documents are listed and can be marked for retrieval of the citation along with its abstract. Marked documents may be exported in a variety of formats.

FishXing Software Update

FishXing, software to facilitate the analysis of fish passage through culverts, has been updated to fix a few bugs. If you use or intend to use FishXing, please download the new version. If you have FishXing installed, use the "Add/Remove Programs" Control Panel in Windows to remove the current version before installing the new one. Any FishXing data files you have will remain intact. The new version is available at the FishXing website at: http://www.stream.fs.fed.us/fishxing or if you would like to bypass the homepage go to the download page at: http://www.stream.fs.fed.us/fishxing/downloadpage.html.

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