STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

October 1993

STREAM Activities

Exactly one year ago, the first issue of STREAM NOTES introduced the Stream Systems Technology Center, also known as STREAM. Located in Fort Collins, Colorado, at the Rocky Mountain Forest and Range Experiment Station, the center is a joint effort between Forest Service Research and National Forest Systems. The stated mission of STREAM is to improve knowledge about stream ecosystems and physical processes, identify research needs, develop operational tools, and provide training and technical support to forest officers. The Center operates under a team concept and adds people through details, contracts, and agreements to help the three-person permanent staff achieve objectives.

STREAM is involved in many activities. The following listing highlights some of the more significant projects undertaken by the team and its cooperators during the past year.

Channel Dynamics in Forested Mountain Watersheds.

This project will produce a series of Status of our knowledge papers dealing with the channel dynamics of steep gradient, forested mountain watersheds typically found on National Forest System lands. Stream channel dynamics, channel forming processes, and channel response to disturbance in these systems are but a few of the topics to be covered by this series of publications. Authors are primarily Forest Service researchers working in the western United States including Gordon Grant, Tom Lisle, Leslie Reid, Jack King, and Chuck Troendle. Papers will be available for distribution beginning in 1994.

An Approach for Quantifying Channel Maintenance Flows.

The intent of this effort is to develop an improved methodology for quantifying channel maintenance flows building on lessons learned as a result of the Water Division 1 litigation. Consultation with a broad spectrum of technical experts from research, academia, and governmental agencies over the past year has increased our awareness of the diversity of opinions about channel forming processes. Several alternative approaches for determining the amount

S TREAM NOTES *is produced quarterly by the Stream Systems Technology Center, Fort Collins, Colorado.*

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

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

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of flow needed to maintain channels have been proposed and are under evaluation. Due to the complexity of the physical processes involved, site specific analysis to determine channel maintenance flow needs are often suggested. A review draft of the new approach should be available within a few months. Resolving the numerous technical and legal issues surrounding channel maintenance flow quantifications may take up to a year.

Guide to Establishing Permanent Stream Channel Reference Sites.

This project will result in an illustrated guide for establishing permanent stream channel reference sites. Permanent reference sites document the existing physical characteristics of the channel (longitudinal profile, cross-section, bed material) and provide a baseline for evaluating change over time. The how-to, illustrated guide will describe procedures for creating permanent sites, collecting field data, and managing data including archiving data with the Vigil Network. Cheryl Harrelson of the Forest Service and Bill Emmett of the U.S. Geological Survey are part of the team working on this document. The guide will be available in the spring of 1994.

Video On Identifying Bankfull Stage in Western Streams

Consistent identification of bankfull features can be especially difficult for the large variety of different stream types found on National Forest System lands. Bill Putnam is leading an effort to develop a training video to demonstrate in a variety of field settings the indicators to look for to properly and consistently identify bankfull stage. The aim is to assure uniformity of application among Forest Service technical specialists who may need to identify bankfull stage for a variety of applications. Field demonstrations will be limited to perennial streams in the Rocky Mountains. Technical director for this project is Lee Silvey, consulting hydrologist. The video should be available by the summer of 1994.

Parker Equation Sediment Transport Program and User's Guide.

This project will result in a user-friendly PC-based computer program of the Parker sediment transport equation to allow National Forest hydrologists to calculate sediment transport for high gradient streams. A user's manual will also be produced that will contain a brief overview of the conceptual underpinnings of the model, its proper application, data requirements, field data collection procedures, and complete information on how to run the model. Work on this project is being done under contract by David Dawdy, consulting hydrologist. The program and user's guide will be completed this fall.

Improved Method for Calculating Flow and Bed-material Transport.

This project will develop a method for computing the stage-discharge relationship and the discharge-bed-material transport rate relation for gravel bed streams with large relative roughness using a detailed description of channel morphology and bed-material size distribution. The model will allow Forest Service hydrologists to estimate sediment transport under alternative flow scenarios at instream flow quantification sites. Data required to run the PC-based model will require about one day of field effort. Principal investigators are Ned Andrews and Jon Nelson of the U.S. Geological Survey in Boulder, Colorado. A preliminary user's guide and a prototype of the model suitable for testing will be ready this fall.

Assess Channel Maintenance Concepts for Spring-fed Streams.

This project will review the status of our knowledge about spring-fed systems and develop recommendations about how to assess channel maintenance flow needs. The effort is being conducted in partnership with Peter Whiting, Department of Geological Sciences, Case Western Reserve University.

Assess Changes Due to Long-term Diversions.

The objective of this project is to develop a protocol for assessing changes due to long-term water diversion and evaluate the consequences of the changes to resource values. The effort is being conducted in partnership with Jack Schmidt, Utah State University.

Technical Summary of the Water Division 1 Court Case.

This project will provide a scientifically oriented brief of the technical testimony about channel maintenance flows made during Colorado's Water Division 1 court case. Parties disagreed about the nature of streams and presented technical testimony pertaining to the science of fluvial geomorphology and instream flows. The synthesis document should be useful to managers and technical specialists alike. The project is under contract to Nancy Gordon, consulting hydrologist and author.

Watershed Continuing Education Training Opportunities Notebook.

In cooperation with Jim Fogg of the Bureau of Land Management, Shelly Witt of the National Fish Habitat Relationships Group, and a variety of Forest Service Regional representatives, we are developing a notebook of continuing education opportunities for hydrologists and watershed managers. A major goal of this effort is to maintain a technical and professional cadre of hydrologists to meet the evolving and expanding needs of the Forest Service's mission. The notebook, a compilation of courses available from a wide variety of vendors, addresses the maintenance and development of technical and program management skills. The notebook will be updated continually and will be distributed to the field later this fall.

Additional projects and collaborations not discussed in this brief summary will be highlighted in future editions of STREAM NOTES.

STATISTICALLY TESTING WOLMAN PEBBLE COUNTS: Changes in Percent Fines

The pebble count technique (Wolman, 1954) has long been used by geomorphologists, hydrologists, and river engineers to characterize rivers which flow on coarse material and are wadable during low flows. The procedure has recently been recognized by fishery biologists as a better alternative to characterize substrate than the visual estimation techniques commonly used in fisheries and instream flow studies. In addition, pebble counts are used on many National Forests as monitoring tools to evaluate entry of fine sediment into stream. The thrust of this article is to present a methodology for statistically analyzing pebble count data to see if statistically significant changes have occurred.

The Pebble Count Technique

A pebble count consists of a random selection of at least 100 particles from the streambed. Individual pebbles can be selected from a grid system, but more commonly pebbles are selected from the toe of the boot along a toe-to-heel transect which traverses the stream from bankfull to bankfull stage. The intermediate axis of each pebble, defined as neither the longest nor the shortest of three mutually perpendicular axis of a particle, is measured. The intermediate axis can be visualized as that dimension of the pebble which controls whether or not it would pass through a soil sieve.

Transects are run across selected habitat features, such as pools or riffles, depending on the objectives of the study. If the objective is stream characterization, it is appropriate to collect a composite sample of pools and riffles in the proportion with which they occur in the stream.

The greatest source of bias in pebble counting is associated with the manner in which observers pick up particles. The natural tendency is to select larger rocks. To avoid this, observers need to consistently use a fixed reference point, such as a mark on the tip of a boot, and a fixed point on the tip of the finger that descends into the water to select the particle for measurement. The first particle touched by the tip of the finger is the one to measure. Because the technique requires physically picking up particles, it is commonly limited to wadable streams.

Pebbles are tallied and placed into classes using the Wentworth size classes illustrated below.

Size Class	Size Range (mm)
Silt/Clay	<0.062
Very Fine Sand	0.062-0.125
Fine Sand	0.125-0.25
Medium Sand	0.25-0.5
Coarse Sand	0.5-1
Very Coarse Sand	1-2
Very Fine Gravel	2-4
Fine Gravel	4-8
Medium Gravel	8-16
Coarse Gravel	16-32
Very Coarse Gravel	32-64
Small Cobble	64-128
Large Cobble	128-256
Small Boulder	256-512
Medium Boulder	512-1024
Large Boulder	1024-2048
Very Large Boulder	2048-4096

Pebbles down to 2 mm in size (very coarse sand) can be directly measured. Sand, silt, and clay particles smaller than this size can be tallied as "less than 2 mm" or placed into classes using "texture by feel" techniques employed in soil surveys.

The number of pebbles in each size class are tabulated and converted into percentages. Data are plotted as a cumulative size distribution curve. Cumulative percent finer is plotted on the y-axis and particle size expressed as the endpoint of each size range is plotted on the x-axis. A set of four pebble count datasets is show in the figure on the next page.

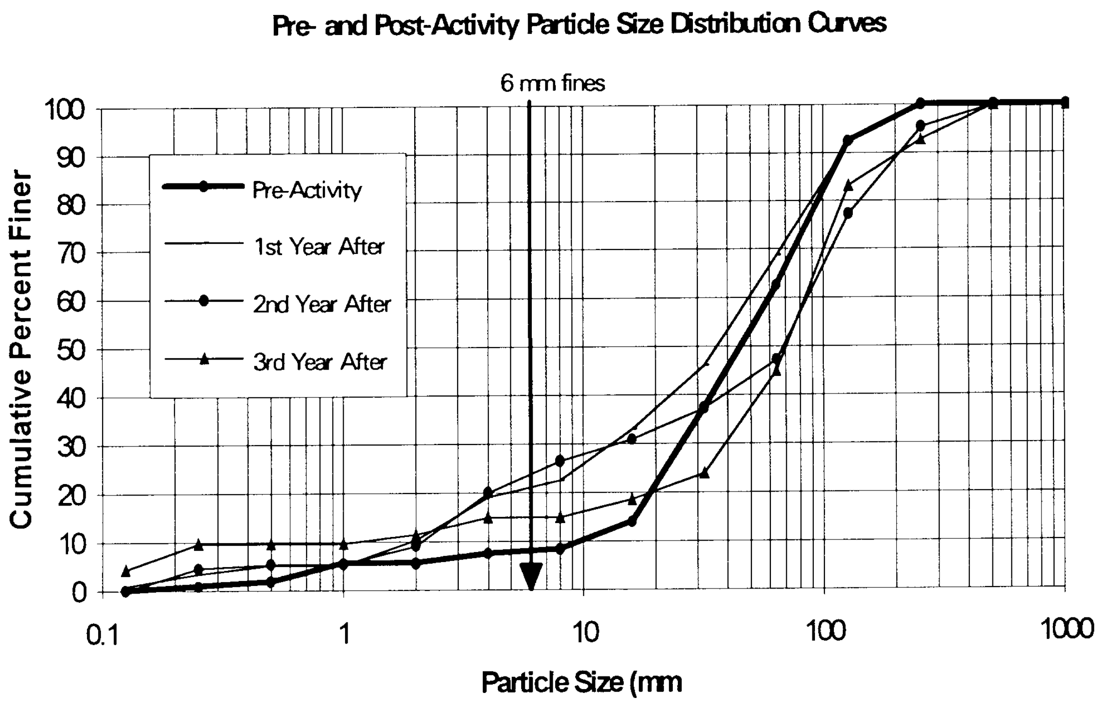
The frequency distribution represents the percent of the stream bed covered by particles of a certain size since each pebble represents a portion of the bed surface. Results are theoretically equivalent to size distributions obtained from bulk samples.

For monitoring purposes, a selected site is often measured for several years. Generally, individuals are interested in measuring changes to surface fines due to management activities such as timber harvest, fire, or road construction. It is widely accepted that increase are fines in stream channels are detrimental to fisheries.

Statistical Analysis

Two general approaches have been used to analyze pebble count data. One looks at changes to some measure of central tendency, such as the median particle size, or the d_{50} size. Decrease in the d_{50} size is generally interpreted as an adverse effect. The other looks at the data with respect to changes in the percent of the bed material for a selected size fraction which is defined as fines. Increases in fines are interpreted as adverse effects. The second approach is of greatest interest for water quality monitoring applications since it specifically looks at changes to the size fraction thought to be most detrimental to fish.

Although opinions among fishery biologists differ on the exact size of fine sediment, particles less than 6.3 mm in diameter are generally defined as



fine sediment. Increases in particle sizes less than 6 mm are used in this article as the size class judged to have the greatest adverse impact to fish habitat. Alternatively, changes in the 2 mm or 4 mm size classes can be used.

An example is presented illustrating analysis of pebble count data using contingency tables and the likelihood ratio Chi-square statistic. The four frequency distributions shown in Figure 1 are used for the example. Pebbles were counted in a stream for 4 consecutive years; one immediately before a land-disturbing activity with measurements repeated for three years after the disturbance.

A 2 x 2 contingency table (number of pebbles less than 6 mm versus number of pebbles greater than or equal to 6 mm) can be used to statistically compare one frequency distribution with another. The major assumption of this analysis is that the pebble counts are statistically independent from one another. Differences between post-treatment years and the pre-treatment year are evaluated based on the statistical significance of the contingency table likelihood ratio Chi-square statistic. Most general statistics texts describe this test, and a comprehensive treatment is contained in Fleiss (1981). Standard computer analysis software such as SAS, SPSS, and (NCSS) Number Cruncher Statistical Systems, generally have the capability to perform this analysis. An example of data input for the SAS computer analysis is shown at the end of this article.

Input data and results of the statistical analysis are shown in the table on the next page.

Evaluating the results for individual years using a Type I error of alpha = 0.05 indicates statistically significant increases in 6 mm fines for the first two years following the land-

TABLE 1

Year	Number of Pebbles <6mm	>6mm	Total	Chi-Square Statistic	Chi-square Probability Prob. Larger	3x Larger
1987 (Pre-Activity)	8	99	107			
1988 (1 Year After)	22	93	115	6.7	0.010*	0.030*
1989 (2 Year After)	22	88	110	7.4	0.007*	0.021*
1990 (3 Year After)	17	96	113	3.2	0.074	0.222

disturbing activity. The changes from 7.5% fines to 19.1% and 20.0% are statistically significant, while the change to 15% in year three is no longer statistically significant.

For other than a simple two year before-after comparison, a Bonferroni correction (Miller, 1981) should generally be applied to significance levels for a group of comparisons to maintain an overall Type I error rate. The simplest form of the Bonferroni correction is to multiply individual significance levels by the total number of tests computed. In this example, with three years of post-treatment data, significance levels were multiplied by three and the resultant probabilities compared to the alpha level of 0.05. In this instance, there were no differences between interpretation of individual and corrected significance levels, but this is not always the case.

The sensitivity of this analysis increases as the number of pebbles counted increases. For instance, in this example increases in 6 mm fines of 11.6% and 12.5% were statistically significant, but 7.5% was not. If the number of pebbles counted in each year had been 150, the individual significance level of the 7.5% difference would have been 0.038, 0.017 with 200 counts, and 0.003 with 300 counts. If provision for detecting small differences is needed, consider increasing numbers of counts beyond the usual 100. Fleiss (1981, Chapter 3) presents calculations for estimating the number of counts that would be needed for a particular situation.

References:

Fleiss, Joseph L. 1981. Statistical methods for rates and proportions, 2nd ed. Wiley, 321p.

Miller, Rupert G. 1981. Simultaneous statistical inference, 2nd ed. Springer-Verlag.

Wolman, M. G. 1954. A method of sampling coarse river-bed material. Transactions of the American Geophysical Union 35(6): 951-956.

SAS Data Input Example:

```
TITLE1 'Pebble Count Analysis Example';

DATA PEBBLE;
        INPUT YEAR SIZE COUNT;

        LABEL SIZE='Pebble size category'
        COUNT='Number in size category';

CARDS;
1987 1  8
1987 2 99
1988 1 22
1988 2 93
1989 1 22
1989 2 88
1990 1 17
1990 2 96


PROC FORMAT;
        VALUE SIZE 1='< 6MM' 2='> 6MM';

TITLE2 '1987 versus 1988';
PROC FREQ;
        WHERE YEAR=1987 OR YEAR=1988;
        TABLES YEAR * SIZE / CHISQ DEVIATION;
        WEIGHT COUNT;
RUN;

TITLE2 '1987 versus 1989';
PROC FREQ;
        WHERE YEAR=1987 OR YEAR=1989;
        TABLES YEAR * SIZE / CHISQ DEVIATION;
        WEIGHT COUNT;
RUN;

TITLE2 '1987 versus 1990';
PROC FREQ;
        WHERE YEAR=1987 OR YEAR=1990;
        TABLES YEAR * SIZE / CHISQ DEVIATION;
        WEIGHT COUNT;
RUN;
```


Prepared by Rudy King, Station Biometrician, Rocky Mountain Research Station and John Potyondy, Hydrologist, Stream Systems Technology Center.

Ask DOCTOR Hydro

Dear Doc Hydro: I've often noticed horizontal lines on large boulders and rocks in stream channels. Where do they come from and are they of any significance?

The horizontal lines you speak of are combinations of lichens and moss which attach themselves to the sides of rocks. The lower end of these growths of lichens and moss have been shown to define the level in the stream referred to as bankfull stage. The use of lichens and moss as indicators of bankfull stage is thought to be most useful in those river channels which are largely or exclusively cut in bedrock. Since "a rolling stone gathers no moss," river banks must contain stable rock material to support moss or lichen flora.

The most comprehensive work on this subject has been done in England by Ken Gregory (1976). Although some lichen species grow under water, the majority grow in sites which are not subject to inundation. Normally, the colonization of rocks by aquatic lichens is slow requiring tens of years. Gregory observed that the types of lichen varied with the nature of the local bedrock. He noted that mosses were associated with lichen at some sites although they did not often provide similarly sharp, easily recognized limits.

Rosentreter (1984) identified conditions required for the survival of aquatic mosses and lichen communities. These include: (1) Stable substrate or a channel composed of solid stable bedrock or large stable boulders; (2) Lack of strong abrasive forces which can come from the current or suspended materials carried by it; (3) Fluctuating water levels which are generally found in natural systems; and (4) High dissolved carbon dioxide levels needed by mosses for photosynthesis.

Gregory correlated well-marked horizontal lichen limits with flood frequency data. He found that the lichen limit is maintained by peak discharges which occur on average at least once or twice each year. There were no lichens below bankfull stage. The flows he observed had recurrence intervals based on the annual series which varied from 1.1 to 1.4 years. He speculated that the abrasive action of suspended sediment particles together with the impact of bedload, may be responsible for producing the lichen limit rather than the frequency of inundation by water alone. He observed that one peak discharge is insufficient to remove lichen cover and postulated that perhaps four or five inundations may be necessary. Gregory's work suggests that lichen limits can be used to identify bankfull channel capacity in bedrock river channels.

For additional detail, see:

Gregory, K.J. 1976. Lichens and determination of river channel capacity. Earth Surface Process 1:273-285.

Rosentreter, R.. 1984. The zonation of mosses and lichens along the Salmon River in Idaho. Northwest Science, 58 (2):108-117.

Rosentreter, R.. 1991. High-water indicator plants along Idaho waterways. Proc. Symp. on Ecology & Management of Riparian Shrub Communities, Gen. Tech. Report INT-289, Ogden, Utah: USDA Forest Service, Intermountain Research Station:18-24.

Questions for Doctor Hydro should be sent in written form, on the Data General if possible, to STREAM:S28A, addressed to subject "Ask Doctor hydro". With each issue of STREAM NOTES, we will select at least one question of widespread interest and provide an answer.

Editorial Policy

To make this newsletter a success, we need **voluntary contributions** of relevant articles or items of general interest. YOU can help by taking the time to share innovative approaches to problem solving that you have developed.

Please submit typed, single-spaced contributions limited to two pages. Include graphics and photos that help explain ideas.

We reserve editorial judgments regarding appropriate relevance, style, and content to meet our objectives of improving scientific knowledge. Send all contributions to: Stream Systems Technology Center, Attention: STREAM NOTES Editor.

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Anyone wishing to be added to our mailing list or requiring a change of address should send their name and street mailing address via DG to STREAM:S28A or write to our mailing address at USDA Forest Service, Stream Systems Technology Center, Rocky Mountain Station, 240 West Prospect, Fort Collins, CO 80525.

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