STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station **April 2001**

Forest Service Stream Classification: Adoption of a First Approximation

Classification of landscapes, soils, forest, and range vegetation is a common and useful tool in natural resource management. Streams offer a significant challenge to classification due to the high variability of flows, conditions, and biogeochemical characteristics. This high variability has made it difficult to define stable attributes that provide a reasonable, meaningful, and measurable framework for classifying streams.

Based on a desire to develop a universal stream classification system that contributes to improving resource management, the Forest Service has adopted the principles, elements, and nomenclature of the stream classification system outlined in the publication,

Rosgen, D.L., 1994. A Classification of Natural Rivers, Catena 22:169-199, Elsevier Sciences, Amsterdam.

The principles, elements, and nomenclature of "A Classification of Natural Rivers" (classification) will serve as a first approximation of a stream classification framework for the agency. This is an important first step in developing a consistent agency wide stream classification system that will enable specialists to communicate more effectively about streams.

Adoption of the stream classification principles, elements, and nomenclature is beneficial for the Forest Service because it:

- Provides a common language for discussing streams and their attributes.
- Focuses communication of management experience with various types of channels.
- Provides a stratification for identifying stream-related research needs and guides appropriate applications of research results.
- Provides a framework for assessing the viability of tools, techniques, and restoration approaches.
- Provides a basis for generalizing and extrapolating data, knowledge, and testing hypotheses about stream systems.

The most important value of a common stream classification system is as a stratification tool and communications framework. The proliferation of local classification approaches is confounding the ability of specialists and resource managers to communicate effectively about streams. A common simplifying and organizing structure will alleviate this problem. Accordingly, it is important to move as quickly as feasible towards adopting and implementing a common system, rigorously testing it, and making necessary modifications. The goal is to use the principles, elements, and nomenclature as a general framework and provide crosswalks to existing classifications, amending them, as necessary, as quickly as possible.

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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

Importance of Measured Data

It is absolutely critical to the credibility and utility of this classification system, and to the Forest Service, to maintain high standards for making needed measurements in applying the classification. Classification and description of the physical attributes must be based on measurable facts as outlined in the ***Catena*** paper, "A Classification of Natural Rivers" (Rosgen 1994) and ***Applied River Morphology*** (Rosgen 1996).

A potential drawback of any classification is the tendency of users to attribute unmeasured facts to the classification. This can definitely be a problem, especially if people fail to maintain an objective approach, or are looking for shortcuts.

An effective classification system must be reproducible. That is to say, the same set of facts should lead to the same classification without regard to the observer. To assure uniform classification, the classification needs to be based on a core set of measured attributes (Figure 1). A "name it/claim it" approach that relies on subjective classification of stream types without data must be avoided because it is the quickest way to destroy the utility or reliability of the system.

Some have suggested that the range of measured variables needed for classification overlaps and that this makes consistent classification difficult. The classification, however, relies on more than a single variable to lead to a classification. In any given case, a specific variable or suite of variables controls the outcome of the classification. This overlap in ranges in individual variables can be accommodated for by the overall robustness of the system.

As the agency gains more experience applying the classification system, it may be possible to refine the ranges or adopt different features or factors that provide more distinctive and unique measurable attributes. For this reason, the approach envisions successive approximations or revisions to the classification system over time.

When using a stream classification system, it is improper to use classification by itself as a basis for land management prescriptions or as a substitute for design data. Users of the system need to adopt an objective approach that avoids unsupported and speculative interpretations. For example, suppose that throughout the country, experience in the use of a given channel treatment technique has consistently resulted in failure. At the same time, other techniques have been very successful in achieving desired and sustainable objectives for the same class of stream. This base of experience provides a basis for cautioning people about the technique and points out opportunities for applying the correct technique to this particular stream type. A specific example of using stream classification to better apply correct techniques to fish habitat structures can be found in Rosgen and Fittante (1996).

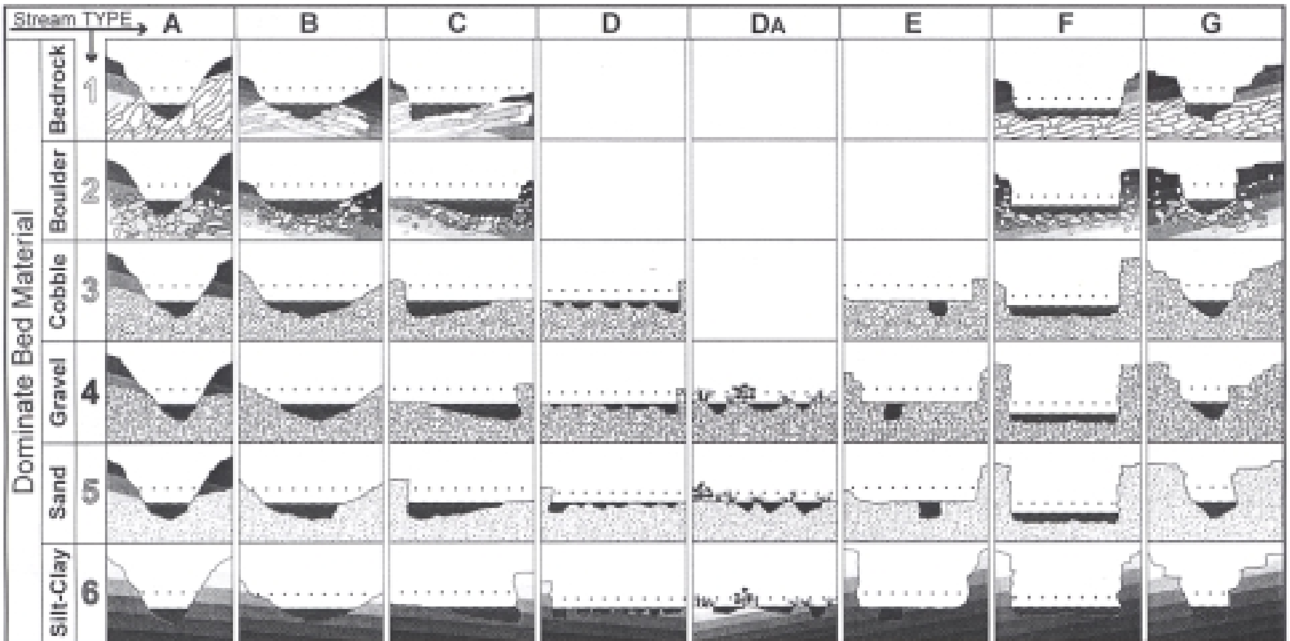
Stream classification provides an opportunity to focus assessments on whether the technique or restoration technique is inherently flawed, or if it is only inappropriate for application in certain stream types. Many current restoration efforts fall into the category of "see it, do it" without regard to whether or not the situations have some commonality. The proposed stream classification systems provides a basis for sharing relevant experiences in the application of techniques to specific stream types.

Future interpretations will need to be developed using a scientific approach relying on hypothesis development and rigorous testing. Without this level of rigor, the use of the classification may be discredited and a potentially useful tool lost.

Other Alternatives Considered

An alternative classification system offered by Montgomery and Buffington (1993) was also considered. While differing in the end product, the approaches proposed by Montgomery and Buffington and Rosgen share the use of geomorphic characteristics and physical processes as a stable base for classification. The Montgomery and Buffington approach focuses primarily on streams in the Pacific Northwest. The Rosgen approach has a broader geographic scope and is applied more widely on National Forests throughout the Nation.

Adopting the principles, elements, and nomencature of the selected classification system provides a delineative framework for a stream



	A	B	C	D	DA	E	F	G
Entrchmnt.	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.4	n/a	variable	>1.5	> 1.4	>1.2
Slope	.04-.099	.02-.039	< .02	< .04	< .005	< .02	< .02	.02-.039

Figure 1. Primary delineative criteria for the major stream types in the Rosgen Stream Classification System. Delineative criteria are based on measured and computed field data from the cross-section (Entrenchment Ratio, Width/Depth Ratio, Dominant Channel Materials) longitudinal profile (Slope, Bed Features), and plan-form (Sinuosity, Meander Width Ratio). Reprinted with permission, Wildland Hydrology Books, 1481 Stevens Lake Road, Pagosa Springs, CO 81147; www.wildlandhydrology.com.

classification system that describes streams in a consistent way nationally. The system will allow the Forest Service to compare streams across different landscapes and geographic areas, and extrapolate experience, data, and information about streams more effectively.

The elements of the selected classification approach are primarily based on physical attributes that have universal applicability. Because physical characteristics are a component part of all ecological systems, biological and chemical characteristics can be addressed in relation to the physical classification on a regional or sub-regional basis, as descriptive factors layered on top of the physical classification.

The physical processes that define the geomorphic character of streams and rivers are universally observable. Climatic and geophysical information, however, varies more widely than physical processes. To be of local value, these more provincial characteristics will need to rely on regionally developed classification and descriptive systems while maintaining the basic physical classification. Forest Service Regions are encouraged to coordinate and collaborate with interagency specialists and scientists that share a given bio-climatic province. In this way, unique areas of the country can have the necessary specificity without creating numerous geographically specific systems that offer little in the way of communication value.

Implementing the Classification System in the Forest Service

The Washington Office Watershed, Fish, Wildlife, Staff is responsible for preparing manual direction during FY2001 to incorporate the use of the stream classification system into the Forest Service Manual Directives System and to develop a strategy for implementing the classification.

The strategy needs to accomplish the following:

- Result in a classification of streams on National Forest System lands.
- Establish a review board to review and adapt the system to incorporate appropriate changes every 3 years (suggested changes would require board review and approval before adaoption).
- Involve other Federal agencies and use an interdisciplinary team to prepare a National Framework for stream condition surveys that includes the physical, biological, and chemical characteristics of streams.
- Crosswalk the new approach with legacy stream classifications.
- Incorporate descriptive information about riparian and aquatic ecosystems and biogeochemical attributes related to the physical attributes of the stream classification.
- Coordinate with the National Resource Information System-Water (NRIS)/Aquatic data system.
- Develop the necessary training and review processes
- Maintain a high level of quality in application.

A frequent concern raised with adopting a single classification system is that this may lock in the existing approach and inhibit the process of refining or improving stream classification approaches. While consistency and stability in the process and approach to classification is essential for a diverse group of users to effectively obtain the benefits of communication and extrapolation of data and information that arise from a common classification system, it is also important to adapt the system in an orderly and careful way as new experience becomes available.

A good model for this exists in the soil classification system. The USDA Natural Resources Conservation Service publication, **Keys to Soil Taxonomy** (1998), provides national taxonomic keys necessary for the classification of soils. Soil taxonomy is presently in it 8th approximation and periodic publication of new approximations in the book, **Keys to Soil Taxonomy,** provides a mechanism for revising and improving soil classification over time.

A similar approach is envisioned with adoption of the stream classification system in its present form as the 1st approximation of a Forest Service stream classification system. Adopting a system at this time and allowing for successive approximations in the future will provide stability and adaptability for the system.

With careful adherence to measurement protocols that include scale, scope, and dimensional units, it should be possible to use measured attributes, or elements of information along with modified criteria, to produce a modified classification. Without measured classification data, it will be impossible to reformulate successive approximations.

The Washington Office will convene a review board made up of scientists and specialists with the responsibility for reviewing recommended changes coming from the field. The board will be responsible for analyzing information coming from field personnel and others and develop and recommend a list of refinements for adoption in subsequent approximations. The first review will occur in about 3 years.

References

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Rosgen, D.L. and B.L. Fittante, 1986. Fish habitat structures: A selection guide using stream classification. Fifth Trout Stream Habitat Improvement Workshop, Lock Haven Univ., Lock Haven, PA, Penn, Fish Comm. Publics, Hamburg, PA.

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Ask DOCTOR Hydro

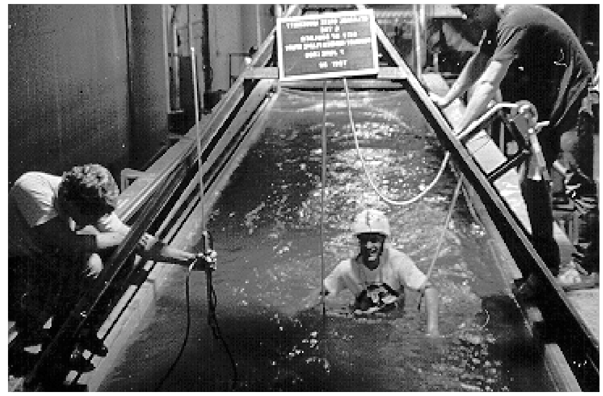

Figure 1. Human subject with safety mechanism in test flume at the Colorado State University Engineering Research Center.

Dear Doc Hydro: A common rule-of-thumb for safe wading says that the product of velocity in feet/second times depth in feet should be less than 10 for safe wading in streams. Is there any scientific basis for this assertion?

Colorado State University conducted a flood hazard study in 1989 to address among other issues the question of when does the velocity and/or depth of flood flow pose a life threatening hazard. Flume tests were performed to identify the approximate depth and velocity of flow at which an idealized, rigid body structure would topple in flood flows and then extended using a series of human subjects to determine when an adult human could not stand or maneuver in a simulated flood flow. Performance of the monolith and the humans was evaluated using the product number of depth times average velocity. Researchers were unable to locate any similar studies in the literature.

A series 20 human subjects (90-201 lbs in weight; 5-6 feet in height) were placed in a recirculating flume and tested to determine when instability occurred (Figure 1). Subjects were exposed to flow velocities ranging from 1.2 to 10.0 fps and flow depths of 1.6 to 4.0 feet. Subjects generally wore jeans or slacks and pull-over shirts. Footwear included tennis shoes, thongs, and light boots. The flume substrate consisted of simulated turf, smooth concrete, steel, and a sand/gravel mixture. Subjects were asked to walk into the flow, walk perpendicular to the flow, and face downstream. The test continued until the subject lost maneuverability and could no longer remain stable in a standing or walking position.

Product numbers at subject instability ranged from approximately 7.5 to 23. Wide variation is attributed to the innate ability of humans to compensate for varying flow conditions by adjusting body stance and body position. Stability was not found to be a function of surface type for the surfaces tested. A semi-logarithmic equation ($r^2 = 0.48$) was developed as a rough guide to predict the product number (subject weight times height) as a means to define the point of human instability. Simply put, bigger is better.

Experimental procedures tended to over-estimate stability due to a number of factors: (1) subjects appeared to be influenced by the presence of safety equipment, (2) they quickly learned to maneuver in the flow, (3) all tests were conducted with comfortable water temperatures, (4) subjects were in good health unencumbered by other equipment, and (5) subjects were exposed to flood flows under good lighting conditions, absent the potential hazard of floating debris.

Given that the experimental tests were conducted under controlled laboratory conditions lacking many of the hazards of outdoor stream gaging work, it's probably wise to err on the conservative side, stay safe, and avoid exceeding the rule of 10.

Reference

Abt, S.R., Wittler, R.J., Taylor, A., and D.J. Love, 1989. Human stability in a high flood hazard zone. American Water Resources Association, Water Resources Bulletin, 25(4) 881-889, August 1989.

Collection and Use of Total Suspended Solids Data

by John R. Gray and G. Doug Glysson

An important measure of water quality is the amount of material suspended in the water. The U.S Geological Survey (USGS) traditionally has used measurements of suspended-sediment concentration (SSC) (USGS parameter code 80154) as the most accurate way to measure the total amount of suspended material in a water sample collected from the flow in open channels. Another commonly used measurement of suspended material is the Total Suspended Solids (TSS) analytical method. The TSS method originally was developed for use on wastewater samples, but has been widely used as a measure of suspended material in stream samples because it is mandated or acceptable for regulatory purposes and is a relatively inexpensive laboratory procedure. The TSS analytical method (USGS parameter code 00530) to determine concentrations of suspended material in open-channel flow is fundamentally unreliable and can result in unacceptably large errors.

Summary of Recent Studies

Studies on the accuracy of the SSC analytical method by ASTM (1999) and the USGS Branch of Quality Systems (Gordon and others 2000) have shown that the SSC analysis represents an accurate measure of the concentration of the suspended sediment in a sample. Data from measurements such as TSS, turbidity, and optical backstatterance are being used with increasing frequency as surrogates for suspended sediment. Collection methods for these data are typically less-expensive than those for traditional data-collection techniques. Additionally, some measurement techniques enable acquisition of suspended-sediment data on a more frequent basis, such as every 15 minutes. However, proper use of these surrogate measurements of suspended material requires that a relation between SSC and the surrogate be defined and documented for each site at which the data are collected.

Differences between the TSS and SSC analysis were investigated using 3,235 paired TSS and SSC samples provided by eight USGS Districts throughout the U.S. (Gray and others 2000), and with 14,446 data pairs from the USGS's National Water Information system (NWIS) data base (Glysson and others 2000). The findings of these studies can be summarized as follows.

1. The TSS analysis normally is performed on an aliquot of the original sample. The difficulty in withdrawing an aliquot from a sample that accurately represents suspended material concentration leads to inherent variability in the measurement. By contrast, the SSC analysis is performed on the entire sediment mass of the sample. If a sample contains a substantial percentage of sand-size material – more than about 25 percent – then stirring, shaking, or otherwise agitating the sample before obtaining a subsample rarely will produce an aliquot representative of the suspended material and particle-size distribution of the original sample.

2. TSS methods and equipment differ among laboratories, whereas SSC methods and equipment used by USGS sediment laboratories are consistent, and are quality assured by the National Sediment Laboratory Quality Assurance Program (OSW Technical Memorandum 98.05; Gordon and others 2000).

3. Results of the TSS analytical method tend to produce data that are negatively biased from 25 to 34 percent with respect to SCC analyses collected at the same time and can vary widely at different flows at a given site (Figure 1). The biased TSS data can result in errors in load computations of several orders of magnitude.

Analysis of paired data for TSS and SSC (Glysson and others 2000) indicates that in some cases, it might be possible to develop a relation between SSC and TSS at a given site. At least 30 paired sample points, evenly distributed over the range of concentrations and flows encountered at the site, would be needed to define such a relation. No reliable, straightforward

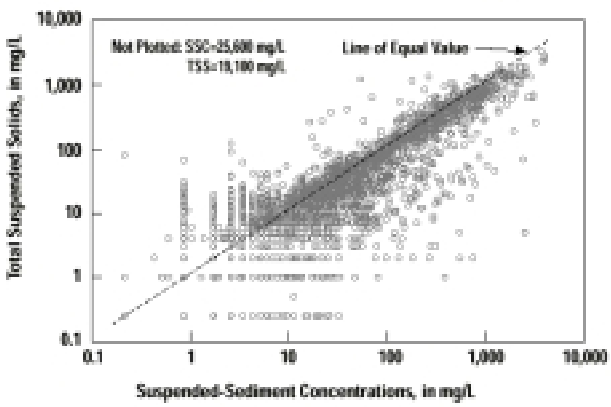

Figure 1. Relation between the base-10 logarithms of suspended-sediment concentration (SSC) and total suspended solids (TSS) for 3,235 data pairs in the scattergram. All SSC and TSS values less than 0.25 mg/L were set equal to 0.25 mg/L to enable plotting the data on logarithmic coordinates.

way presently is available to adjust TSS data to estimate suspended sediment without corresponding SSC data.

Because the TSS analytical method is widely used outside of the USGS for the determination of suspended-material concentrations in water samples for open channel flow, and because the TSS analysis is specified in various States' water-quality criteria standards for sediment, the USGS wishes to share this information with its cooperators. The USGS is passing this information on to the U.S. Environmental Protection Agency's Office of Water, other Federal agencies, and State and local agencies that are involved in collection or use of sediment data.

Summary

It is not appropriate to use TSS data resulting from the analysis of water samples to determine the concentration of suspended material in water samples collected from open-channel flow and calculations of fluxes based on these data. Collection of samples to determine TSS requires concurrent collection of samples for suspended-sediment concentration analysis. Concurrent SSC analysis can only be discontinued after it is conclusively documented in a published report that the TSS data, on a site-by-site basis, can adequately represent SSC data over the entire range of expected flows.

Selected References

ASTM, 1999, D 3977-97, Standard Test Method for Determining Sediment Concentration in Water Samples, Annual Book of Standards, Water and Environmental Technology, 1999, Volume 11.02, p. 389-394.

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Glysson, G.D., J.R. Gray, and G.E. Schwarz, in press, "A Comparison of Load Estimates Using Total Suspended Solids and Suspended-Sediment Concentration Data," in Proceedings of ASCE World Water and Environmental Resources Congress, May 20-24, 2001, Orlando, FL.

Gordon, J. D., Newland, C.A., and Gagliardi, S.T., 2000, Laboratory performance in the Sediment Laboratory Quality-Assurance Project, 1996-98: U.S. Geological Survey Water-Resources Investigations Report 99-4184, 69 p.

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***** The references (Gray et al. 2000 and Glysson et al. 2000) discussing comparability and adjustment of TSS and TSS data are available on-line for downloading at http://water.usgs.gov/osw/techniques/sediment.html.

Direct questions or additional information requests about the USGS policy on the collection and use of total suspended solids data to:
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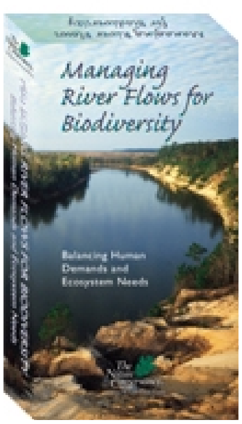
IN THIS ISSUE

STREAM NOTES

Managing River Flows for Biodiversity: Balancing Human Demands and Ecosystem Needs



This video provides information about the water flows needed to sustain the ecological health of river systems, water management strategies that can accommodate human needs while maintaining adequate flows in a river, and some technical tools that help achieve this balance. The video features case studies of the Apalachicola River in Florida and the San Pedro River in Arizona. It also includes interviews with lawyers, water managers, and freshwater ecologists. Hydrologists and aquatic biologists should find the video useful for educating resource specialists, managers, and the general public about the importance of instream flow issues.

The 25 minute video was produced by The Nature Conservancy. Information about obtaining a free copy is available at www.freshwaters.org/ccwp/home.html. You may also order through the National Service Center for Environmental Publications by calling 800-490-9198 or faxing your order to 513-489-8695. Please provide the title of this video (Managing River Flows for Biodiversity) as well as EPA document number EPA 841-V-00-001.