STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid in Securing Favorable Conditions of Water Flows

October 1996

Applied River Morphology

Luna Leopold best describes Dave Rosgen's new book, *Applied River Morphology*, as "a generous and detailed explanation of the classification system and how it might be used to incorporate the observed processes of river mechanics into restoration design."

Applied River Morphology is the product of Dave Rosgen, a former hydrologist with the U.S. Forest Service and now Principal Hydrologist of Wildland Hydrology Consultants. The book is illustrated by Dave's long-time collaborator and former Forest Service Regional Hydrologist, Lee Silvey. Most of the volume describes in pictures and words the Rosgen stream classification system and lays out Rosgen's "natural stability" approach to stream restoration.

The classification system is based on Rosgen's 31 years of experience and observation of hundreds of natural, stable streams and rivers in North America. Building on geomorphological principles established by Luna Leopold and others, Rosgen observed a consistent pattern of natural river geometry and published a prototype classification system in 1985, followed by a revised and modified treatment of the subject in the geomorphological journal, **Catena**, in 1994. The book is essentially an expansion of the article, "A Classification of Natural Rivers," published in **Catena**.

Rosgen's system is based on the notion that the most effective classification system is one based on objective, quantifiable criteria that are readily observable and measurable in the field. The objective of classifying streams on the basis of channel morphology is to set categories of discrete stream types so that consistent, reproducible descriptions and assessments of condition and potential can be developed. Since the procedure relies on morphology, it is not readily apparent that the system is process based. However, the classification system is grounded in the basic morphological-process relations of fluvial systems.

The book begins with a brief discussion of fundamental principles of river systems followed by a discussion of stream classification and the hierarchy of river morphology. It then describes a four level hierarchy of river inventory and assessment including:

Level 1 - Geomorphic Characterization
Level 2 - Morphological Description
Level 3 - Assessment of Stream Condition and Departure from Potential
Level 4 - Field Data Verification.

STREAM 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 wildland 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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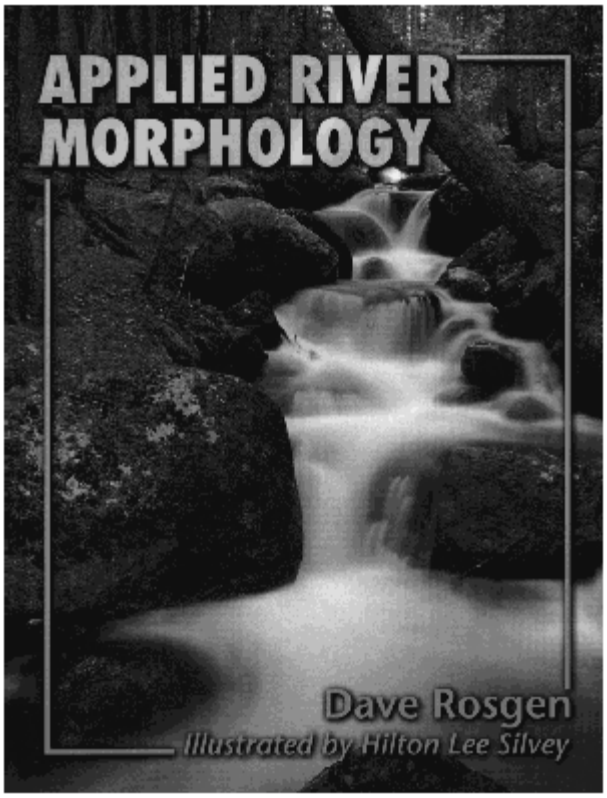
IN THIS ISSUE

- **Applied River Morphology**
- **Use and Misuse of Channel Classification**
- **Hydrology Workshop Proceedings**
- **Ask Doc Hydro: Armor/Pavement**



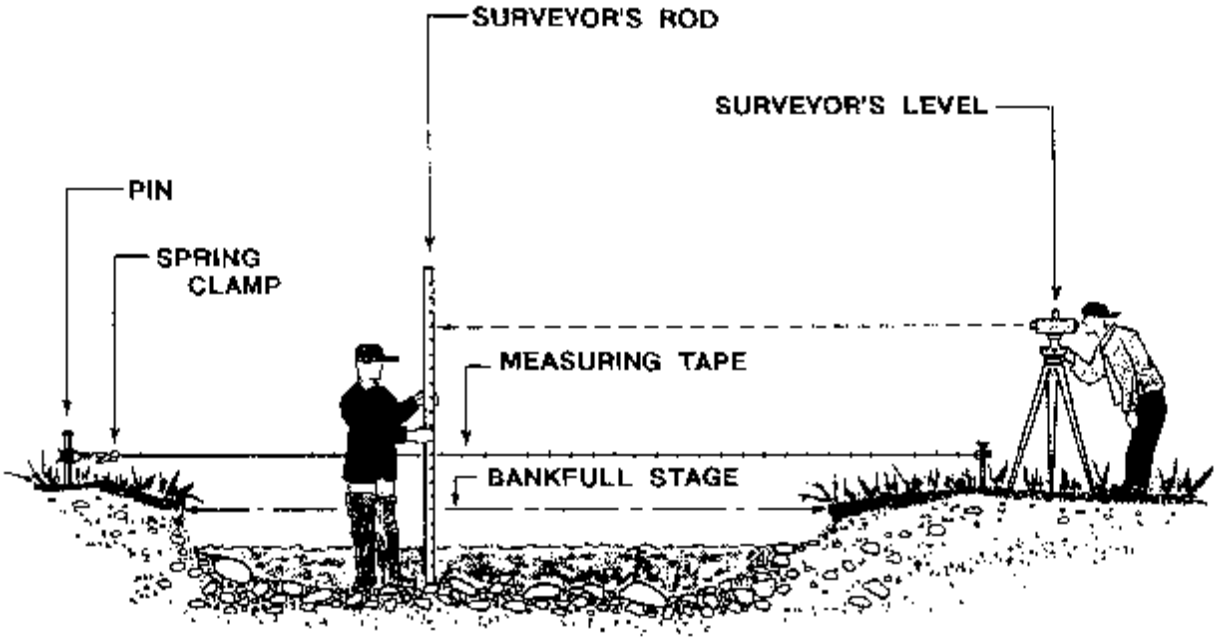
Reprinted from the book **Applied River Morphology**, written by David L. Rosgen and illustrated by Hilton Lee Silvey; published by Wildland Hydrology Books, 157649 US Hwy 160, Pagosa Springs, CO 81147; phone 970-264-7100.

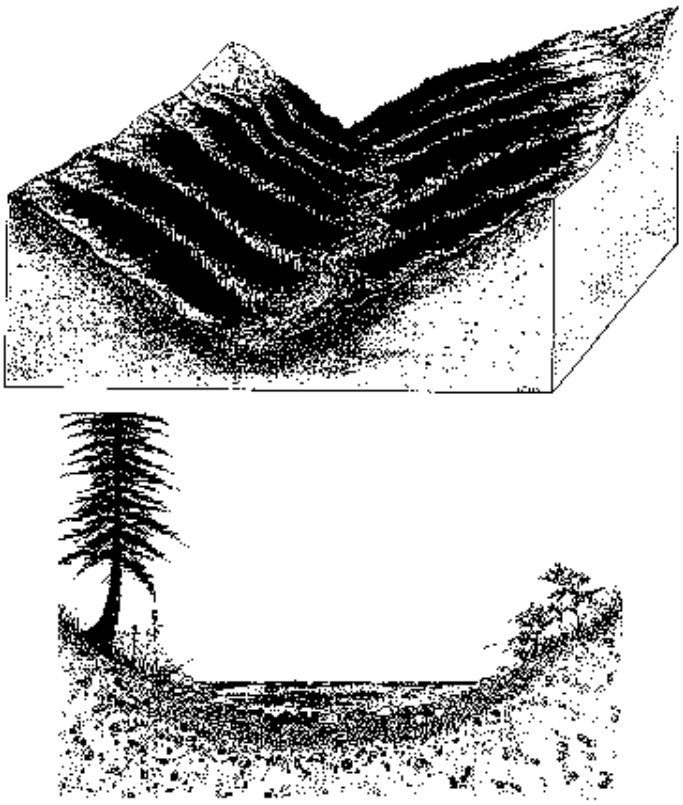
Each of the levels is covered in detail with colorful illustrations, photographs, and examples fully explaining office and field methods (see example below).

The chapter on geomorphic characterization (Level 1) introduces some new concepts to the stream classification system by discussing the association between landforms and stream types. Eleven valley types describing valley morphology and their delineation criteria are introduced.

The largest part of the book is spent on morphological descriptions (Level 2), field methods for stream type delineation, and examples of stream types. Extensive photographs and illustrations of typical stream types (see opposite page) are used to help the reader visualize the range of stream types (A, B, C, D, DA, E, F, and G) found in nature. Example field data forms to facilitate the process are included in the book.

The chapter on assessing stream condition and departure from potential (Level 3) will probably be the most controversial part of the book. Applying the classification describes only the existing morphologic condition. A given classification does not necessarily mean that the river is in a "stable" condition or functioning close to its "potential." Rosgen argues that the self-stabilization tendencies of a stream system and the natural tendency to evolve into a





DELINEATIVE CRITERIA (B3)

Landform/soils: Narrow, moderately steep colluvial valleys with gentle side slopes. Soils are colluvium and/or alluvium. Often in high line valleys or on well vegetated alluvial fans.

Channel materials: Predominantly cobble with lesser amounts of boulders, gravel and sand. Streambeds are stable due to coarse material.

Slope Range: .02 - .04 (B3c, < .02) Entrenchment Ratio: 1.4 - 2.2

Width/depth Ratio: > 12 Sinuosity: > 1.2

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particular morphological form needs to be understood to provide a blueprint for the river's future. Several examples of evolutionary sequences are presented; however, the author cautions that these are only a few of many potential scenarios of stream type shifts that may occur.

The book ends with a discussion of applications of the classification system to solving real world problems. Field users of the classification system will find this book to be a constant and useful reference guide. Those looking for a scientific treatment of fluvial processes, stream classification and exposition of the data collected to derive the delineation parameters will be disappointed. The author presents summary frequency distribution data for the delineative criteria that make up the classification system, but not the raw data he measured over the years from the hundreds of channels observed throughout North America.

The book is primarily designed to permit interested users to understand the basis of the morphological hierarchy and to apply it in the field. The book fulfills this objective and will be a valuable addition to the library of anyone who needs to classify streams as part of their work on rivers.

Applied River Morphology *is published by Wildland hydrology Books,157649 US HWY 160, Pagosa Spring, CO 81147; Phone: 970 264- 7100. The 390 page hard-cover book with 770 color illustrations and photographs sells for $89.95.*

Use and Misuse of Channel Classification Schemes

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Though channel classification schemes have been a part of geomorphic investigation for decades, only in the last several years have they become a central feature of many channel investigations by public agencies. Specifically, the classification scheme proposed by Rosgen (1994) has gained dominance across the country. While a common classification scheme has been welcomed, concerns are emerging about some end-uses of this channel classification.

"It is not the author's intent to suggest that Rosgen's channel classification scheme is without utility. Rather, it is suggested that individual interpretations of its utility is frequently extended beyond its credible use."

The advantages of a common classification are clear; it provides a common language for describing streams. Further, it provides potentially interesting ways to stratify and group geomorphic and channel-related data in the pursuit of more accurate empirical descriptions of stream behavior. However, with increasing regularity, channel classification schemes are used to justify or guide channel restoration, reclamation and enhancement project design, instream flow decisions, and regulations concerning appropriate watershed uses. While channel classification may be a useful tool in the inventory of a watershed or a particular site, the scientific basis for extending its use beyond channel typology is frequently unclear.

The concerns surrounding the use of channel classification to guide stream management decisions is perhaps best illustrated through example. Mechanical restoration of channels in severely degraded environments is increasingly common. In one case, an entire watershed experiencing dramatic instability was classified using the Rosgen methodology. Many "non-classifiable" channel segments were identified in the surveys, though the evaluators felt compelled to assign them a pre-established place in the scheme. The "pristine" channel characteristics, as derived from 60-year old aerial photographs, were then compared to existing conditions and found to be in a different classification. The apparent objective of the resulting restoration plan was to re-create a channel with classification attributes of the pristine channel.

While the foregoing logic may appear initially sound, a broader examination of the watershed's current condition suggested otherwise. Dramatic changes in base level, sediment supply, watershed use, hydrologic regime, and vegetative condition, marked a radical basin-wide departure from pristine conditions. With these drainage-wide changes, is it logical to assume that an "unstable channel type" can be made stable simply by imposing a range of classified historic "stable" channel geometry attributes on it? Rosgen's (1994) channel classification scheme does not provide a mechanism for predicting new stable channel forms in disturbed watersheds.

The most recent review of rapidly changing channel morphology (Petts and Gurnell, 1995) suggest that the dynamics of unstable systems are more poorly understood than even stable systems. Simply classifying a disturbed channel does not suggest what the channel is "changing to" or what it "should be" if restored. Though it is possible that stream classification may be useful in clarifying knowledge that has eluded geomorphic researchers for decades, it has not yet evolved to such a state.

In another example of misuse of channel classification, some resource agencies have developed land management strategies based on channel classification. In one case, grazing was deemed allowable or prohibited based on

whether a grazing allotment's streams fit a specific Rosgen channel type. The logic used was that if a channel failed to meet an identified class, it was unstable and prone to greater instability with continued grazing pressure. As a colleague has noted, there is more to ornithology than field guides describing species, distribution, and habitat, just as there is more to stream behavior than stratifying channels into types. While it is recognized that grazing can have negative impacts on channel health, is a failure to fall into a specific category an accurate indicator of stream health and resilience?

A final observation relating to public agencies' reliance on channel classification systems to guide stream management decisions is warranted. In the private sector, with increasing regularity, professionally trained geomorphologists, hydrologists, and engineers are encountering resistance to their findings if they are not directly interpretable within the Rosgen classification scheme. As a further aggravation, it is assumed by some that any finding or plan absent of channel classification language is suspect and probably wrong. It is dangerous to assume that stream behavior can be grouped into "right" and "wrong" observations and paradigms, as decades of debate within the fluvial geomorphic academic community can attest. Perhaps a more productive approach will be to reconcile the interpretations drawn from the classification system with observations falling outside of it.

It is not the author's intent to suggest that Rosgen's channel classification scheme is without utility. Rather, it is suggested that individual interpretations of its utility is frequently extended beyond its credible use. In the field of applied geomorphology, perhaps the recognition of the unknowns in a given system's behavior are as critical for appropriate management decision making as is the assumption of total understanding.

References

Gurnell, A. and G.E. Petts (eds.) 1995. Changing River Channels. John Wiley & Sons, New York. 442 pg.

Rosgen, D.L. 1994. A classification of natural rivers. Catena Vol. 22., pp. 169-199.

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Doctor Hydro invites you to send in written questions via the mail, on the Data General, FAX, or E-mail to: "Ask Doctor Hydro."
With each issue of STREAM NOTES, we will select at least one question of widespread interest and provide an answer.

Ask DOCTOR Hydro

Dear Doc Hydro: I see the term "armor" and "pavement" used to describe the coarse surface layer in gravel-bed streams. What is the difference between these terms?

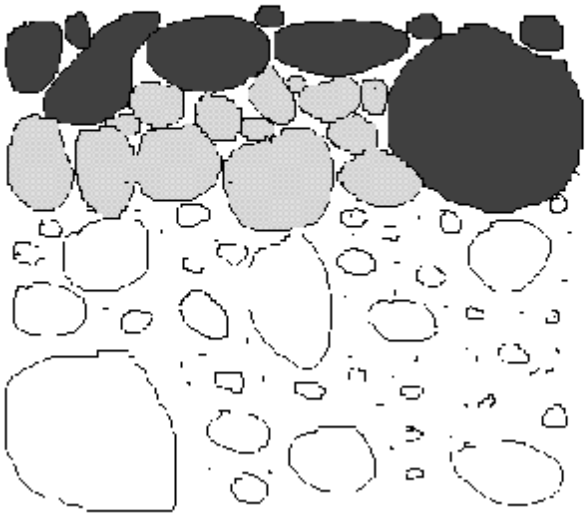
The lack of generally accepted terms to describe the surface of gravel-bed channels causes much confusion. Unfortunately, the terminology, as well as the definitions of terms such as surface layer, armor layer and pavement has not been consistently applied in various studies or in the literature and the terms are often used interchangeably by various authors. Consequently, authors generally define the terms to suit their particular purposes.

There is wide agreement that streams with mostly gravel or coarser bed material usually possess a surface coarser than the underlying material (substrate). This feature appears to occur in a wide variety of mountain and alluvial streams having a large range of different flows, sediment transport rates, and size distribution of bed materials. Some argue that this coarse surface layer is due to selective erosion of the transportable gravel and sands, leaving behind untransportable coarse particles. Others argue that the spatial concentration of coarse particles on the surface is part of bedload trasnport under the equal mobility concept. In both cases, the surface layer acts to contrl the movement of temporarily stored sediment and protects the finer materals below from excessive scour during floods.

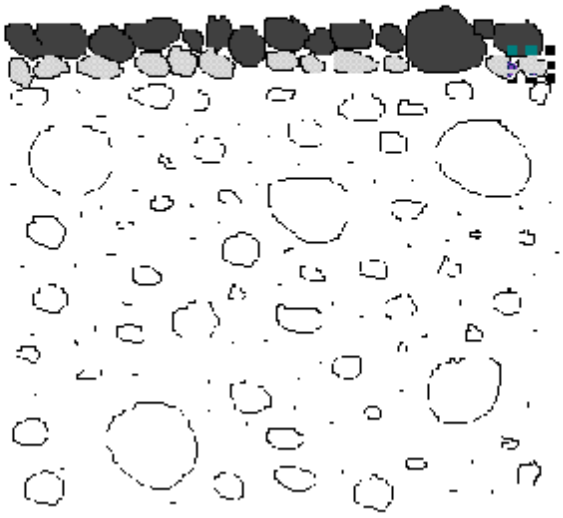
The surface layer is comprised of those particles that are exposed at the stream bottom surface (particles shaded in black in the figures). The surface layer is by definition only one grain diameter thick, but since the particles making up the surface are of different sizes, the thickness of the surface
layer varies from particle to particle. The above definition is however, not universally accepted.

The armor or pavement layer is usually defined to reach a thickness of the Dmax particle size, and consists of the

Mountain streams



Alluvial streams



surface particles plus those subsurface particles that are at a depth less then the Dmax of the surface layer (black and gray particles in the figures). However, some researchers consider only the particles at the surface to define the armor layer. Numerical modelers typically call the layer that exchange sediment with the water column a surface layer and assign a thickness to it. Consequently, variations in definition are common in the literature.

The frequency of bed particle motion and the supply of upstream sediment are sometimes used to differentiate between armor and pavement. Where there is no supply of bed-sized sediment from upstream, for example, in stream reaches immediately below reservoirs, the bed surface is immobile at all discharges less than than the historical maximum discharge. The immobile surface in these channels is commonly called "armor." In contrast, when bed-sized sediment is supplied from upstream and the channel remains in equilibrium, particles in the bed surface will be transported frequently within a span of several years. The term "pavement" has been used to describe a bed surface where particle motion occurs at least occasionally.

The most common usage in America is to call the coarse surface layer an armor layer. The layer can be static or mobile. The term pavement is typically not used although it can be found in older literature. The terminology "static armor" and "mobile armor" have been proposed but this has not received widespread acceptance. In summary, distinct, commonly accepted definitions are lacking. Therefore, when reading the literature, pay careful attention to what the author says when referring to the surface of gravel-bed rivers.

National Hydrology Workshop Proceedings

In 1992 the Forest Service held a National Hydrology Workshop in Phoenix, Arizona, with the theme, "Watershed in the Nineties." The focus of the workshop was to help hydrologists working on the National Forests become more effective in these changing times. Toward that end, papers were presented with the objective of strengthening and improving technology transfer, increasing the technical skills of hydrologists, and sharing ideas and developing strategies for moving water resource management into the 1990s and beyond. The papers presented at this workshop are contained in the publication: ***National Hydrology Workshop Proceedings***, Phoenix, Arizona, April 27-May 1, 1992. Dan Neary, Kim Ross, Sandra Coleman (editors), General Technical Report RM-GTR-279, Rocky Mountain Forest and Range Experiment Station, 210 pages. Copies have been mailed to Forest Service hydrologists.

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IN THIS ISSUE

- **Applied River Morphology**
- **Use and Misuse of Channel Classification**
- **Hydrology Workshop Proceedings**
- **Ask Doc Hydro: Armor/Pavement**