STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid In Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station **July 2004**

An Approach for Quantifying Channel Maintenance Instream Flows in Gravel-Bed Streams

by Larry Schmidt and John Potyondy

The Stream Systems Technology Center has been working on stream channel maintenance issues for over 10 years. Channel maintenance instream flows in the Forest Service context are narrowly defined and necessarily constrained to those flows necessary to achieve the Forest Service Organic Act purpose of "securing favorable conditions of waters flows." This constraint arises from the legislative history of the Organic Act and the Agency's subsequent interpretation of the phrase "favorable conditions of water flows in legal proceeding throughout the West.

General Technical Report RMRS-GTR-128, ***Quantifying Channel Maintenance Instream Flows: An Approach for Gravel-Bed Streams in the Western United States***, by Larry Schmidt and John Potyondy discusses one approach for quantifying these instream flows flows for gravel-bed streams and lays out the scientific basis for and provides a quantification approach for estimating the necessary channel maintenance flow regime.

We hypothesize that channel maintenance flows, coupled with proper management of upland watersheds, will provide for favorable conditions of water flows. Favorable flows occur when the stream channel is able to pass sediment in equilibrium so that aggradation doesn't significantly increase flood peaks. To provide for favorable flows, essential portions of the natural streamflow in National Forest streams may need to be legally or administratively protected.

Simply stated, channel maintenance instream flows are designed to maintain the physical characteristics of the stream channel. The approach in RMRS-GTR-128 describes one way to estimate the <u>minimum essential regime of streamflows</u> necessary for the channel and its floodplain to remain fully functioning with respect to sediment and flow conveyance. A fully functioning channel conveys water and sediment without aggradation or degradation, dissipates energy, reduces flood peaks, sustains flows, and acts as a natural stream.

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John Potyondy, 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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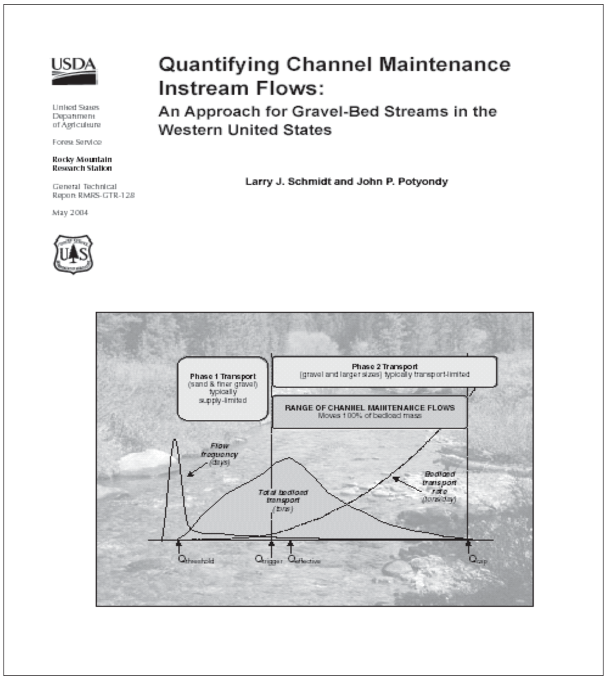


The published approach is appropriate for quantifying channel maintenance flows on perennial, unregulated, snowmelt-dominated, gravel-bed streams with alluvial reaches and is primarily intended to evaluate run-of-the-river projects that pass most or all bedload sediment in the natural stream channel. Many of the concepts and principles presented have potential application to rain-dominated and other systems, but must be extrapolated carefully. The approach is unlikely to work in arid environments with ephemeral channels where hydrographs are flashy.

Channel maintenance in gravel-bed streams typically requires a range of instream flows that transport bedload sediments through the channel network. Our analysis indicates that in the coarse-grained gravel-bed streams of the Rocky Mountains, low flows that occur most of the year transport insignificant bedload sediment. However, when higher flows begin to fill the channel near its capacity, coarse bedload transport and scour of vegetation within the channel combine to help maintain channel morphology. In addition, these high flows periodically inundate the floodplain, helping to sustain and regenerate streambank and floodplain vegetation. Consequently, a range of intermediate to high flows that typically occurs for a limited time during the year provides for the necessary stream channel maintenance.

In gravel-bed streams these flows range from intermediate flows associated with initial coarse sediment movement from the coarse surface layer of gravel-bed streams (Phase 2 transport) up to the 25-year flow event. A typical sediment-transporting channel maintenance hydrograph therefore includes a range of discharges making up a portion of the rising and falling limbs of the annual hydrograph, excluding discharges in excess of the 25-year event. Conceptually, the required maintenance flow regime begins at a discharge at which transport-limited gravels making up the bed of the channel begin to move ($Q_{trigger}$ or the beginning of Phase 2 transport) and includes all flows up to and including the instantaneous 25-year flow (Q_{cap}) (Figure 2). This range of flows moves all bedload sediment, scours vegetation from the channel, partially inundates the floodplain, and provides high flow functions needed to sustain streamside vegetation.

Precise estimation of the lower starting point of the channel maintenance flow regime is challenging. While the existence of different phases of transport in gravel-bed rivers is widely acknowledged, the threshold between phases often lacks a precise value due to the nature of bedload transport phenomena, sampling difficulties, and the fact that all estimations requires some degree of professional judgment.

We believe the starting point is best estimated from a combination of considering the particle size distributions of the bedload, the size distribution of the bed material, and bedload transport rates. In our judgment, the starting point is best estimated by examining direct empirical bedload measurements or arithmetic plots of bedload data. Direct measurement provides tangible evidence of the particle sizes and the amount of material moving at different discharges without reliance on computational techniques or theoretical constructs of sediment transport. However, indirect extrapolation approaches based on research studies may be necessary where data are unavailable.

We propose use of the piecewise regression technique developed by Ryan et al. (2002) as an objective way to estimate threshold discharges. Where field data are lacking, sufficient research information exists at this time for selected regions to predict a generic starting point.

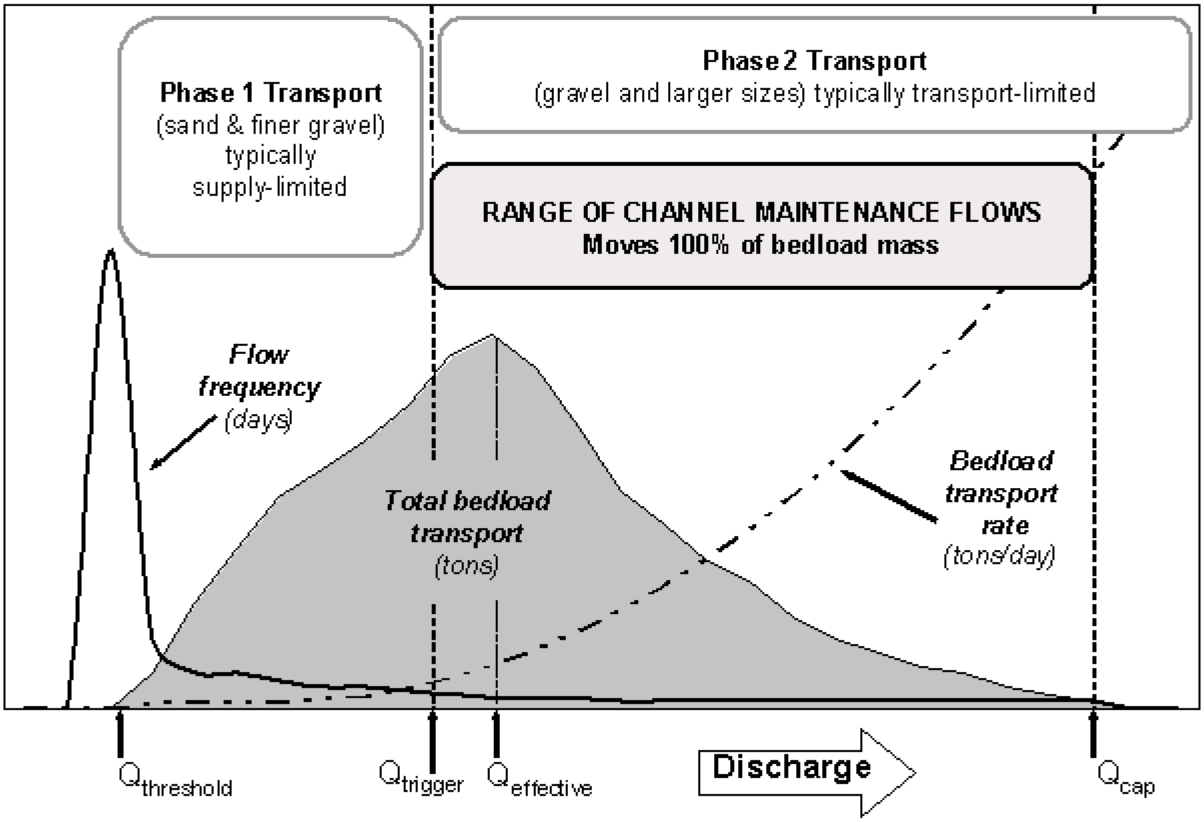


Figure 1. Schematic of long-term total bedload transport model for gravel-bed rivers based on Wolman and Miller's magnitude-frequency concepts. Bedload movement begins at $Q_{threshold}$, flows between $Q_{threshold}$ and $Q_{trigger}$ are Phase 1 transport, $Q_{trigger}$ is the beginning of Phase 2 transport, flows between $Q_{trigger}$ and Q_{cap} are Phase 2 and move the majority of the coarse sizes, and Q_{cap} is the upper limit of the required channel maintenance flow regime.

For example, studies of coarse-grained channels in Colorado and Wyoming concluded that the transition from Phase 1 transport to Phase 2 transport occurs between 60 to 100 percent of the 1.5-year discharge, with an average of 80 percent. An average starting point of 80 percent of the 1.5-year discharge, a surrogate value for bankfull discharge, provides a good first approximation for general application while a selection of 60 percent of bankfull discharge or the 1.5-year discharge provides a more conservative estimate for mobile systems with higher sand loads. In all cases, best application of the approach occurs at sites having long-term bedload data and streamflow records.

RMRS-GTR-128 also provides suggestions for analyzing and displaying results, implementing studies at the watershed scale, determining data needs, and post-project management and evaluation.

Larry Schmidt and **John Potyondy** are hydrologists and former and current Program Managers, respectively, of the Stream Systems Technology Center in Fort Collins, CO. Direct questions to John Potyondy at (970) 295-5986 or jpotyondy@fs.fed.us.

Copies of RMRS-GTR-128 are available by sending your mailing information in label form through one of the following media. Please specify the publication title and series number. Telephone (970) 498-1392; FAX (970) 498-1396; E-mail rschneider@fs.fed.us. An electronic version of the publication can be downloaded from: http://www.fs.fed.us/rm/pubs/rmrs_gtr128.html

The Geomorphic Response of Rivers to Dams: An Electronic Short Course on CD-ROM

by Mike Furniss

A new form of publishing is being used to provide a short course on the geomorphic response of rivers to dams. A set of 2 CD-ROMs and an Internet site fully capture a 3-day Forest Service short course (Figure 1) that was given in March of 2003 at the University of Reno.

The course was designed for the scientific staffs of the National Forest System responsible for the analysis of hydropower facilities on national forest lands. The electronic presentation of the course is intended to be used either as a stand-alone course for people who could not attend the workshop but wish to learn about this topic, or as detailed notes and references for those who attended.

Sponsored by STREAM, the Washington Office Lands Staff, and the Pacific Northwest Research Station, the product delivers a rich combination of video, audio, high-resolution images and hyperlinks (Figure 2).

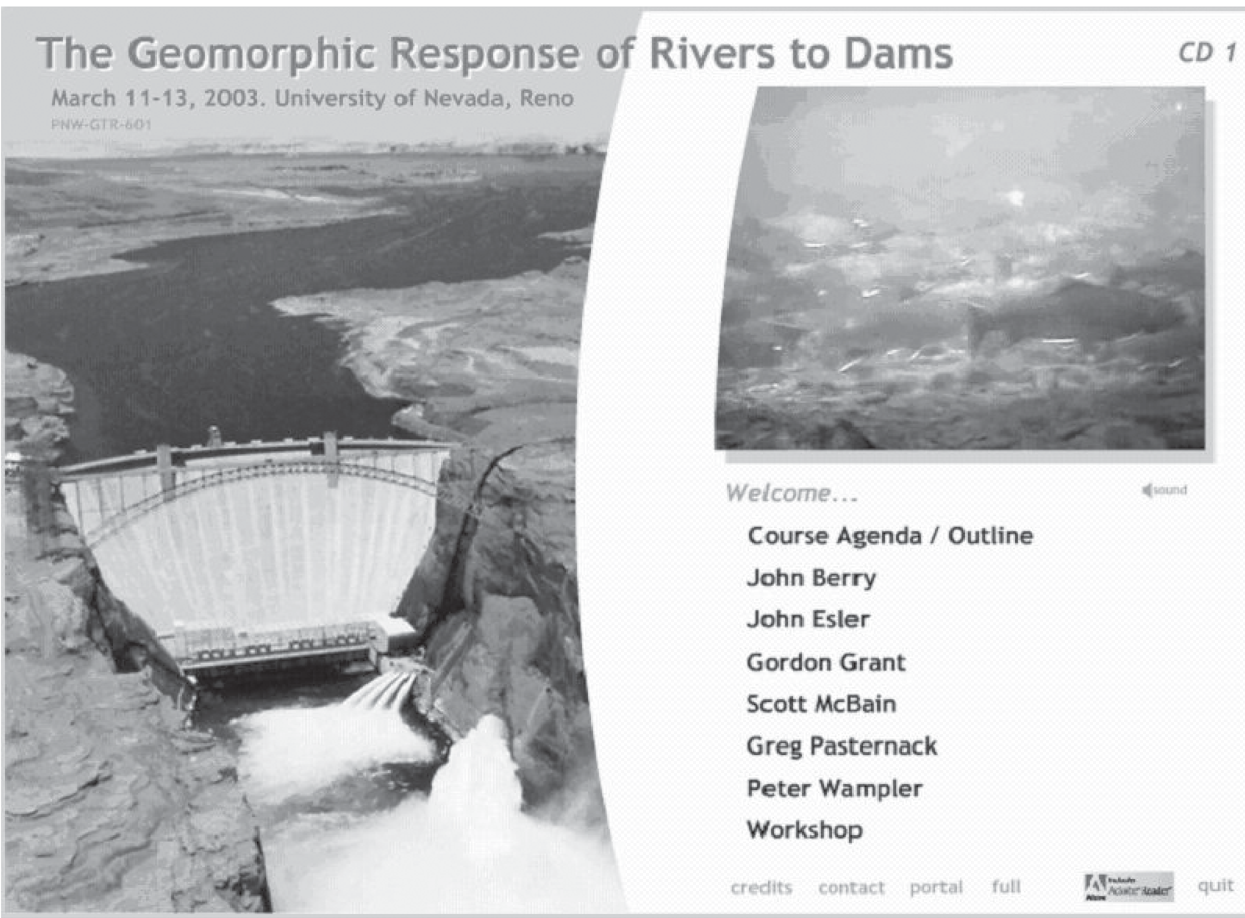


Figure 1. The home screen of the short course presents an index of the presentations by the name of each of the lecturers. Opening the "Course Agenda/Outline" provides a clickable index based on the agenda and the topics and subtopics covered by each talk. A workshop module reproduces the class exercise for the Clackamas River.

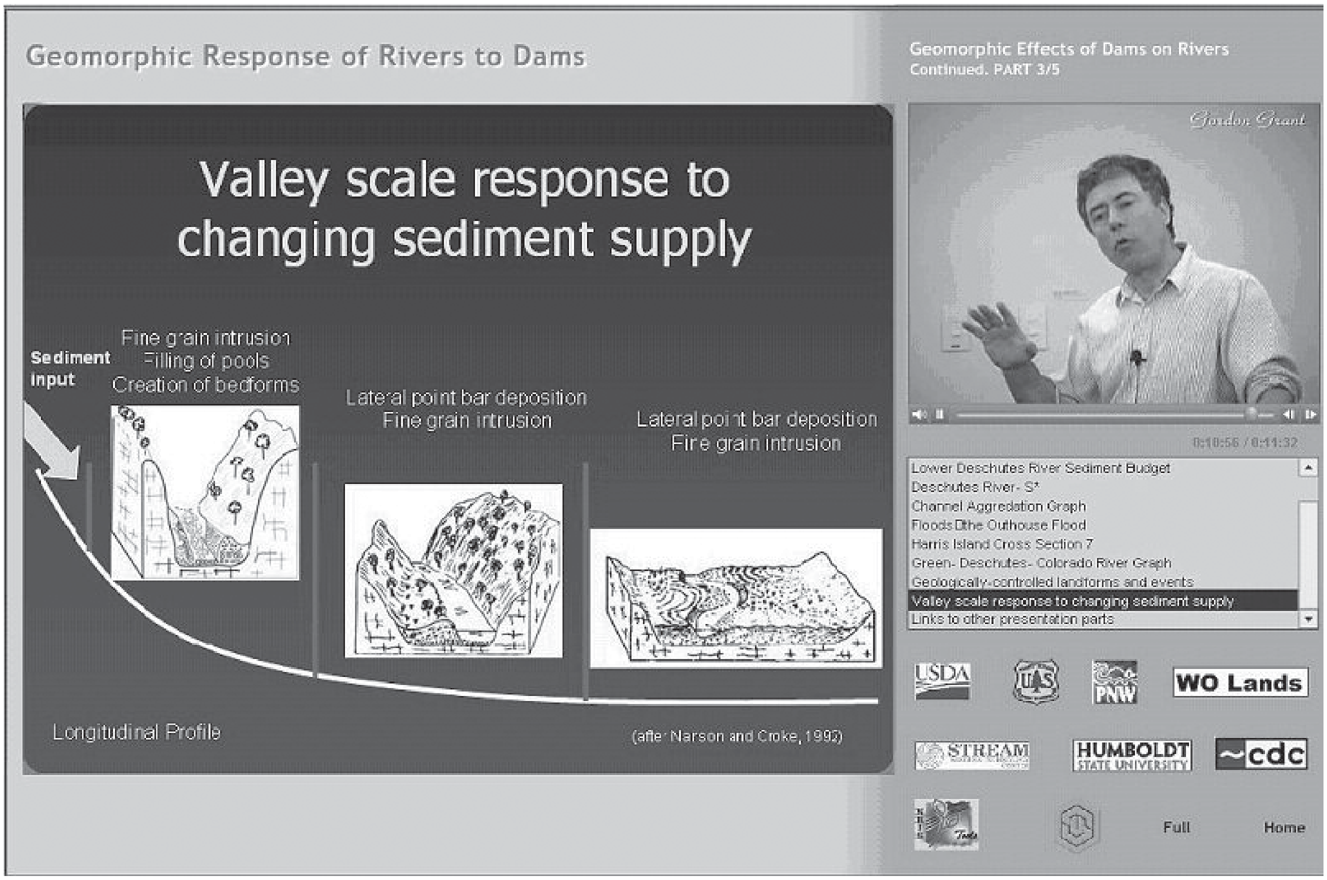


Figure 2. Each lecture contains a small video of the presenter, high-quality audio of the talk, the slides the presenter used, an interactive Table of Contents based on the slides, and web links. Users can watch the presentation as it was given, or access it non-linearly using the Table of Contents. Shown here is Gordon Grant of the PNW Research Station discussing the basics of how dams affect river morphology.

Bob Deibel of the WO Lands Hydropower Program asks: "Have you even been to a training session, and recalled that a topic was discussed, but don't quite recall the specifics and can't find it in your notes? We purposely told students to listen attentively to the presentations as this product will serve as their "notes" for the course."

The video and production work was accomplished by Mike Furniss and Jeff Guntle of the Pacific Northwest Research Station in Corvallis. With this medium, they combine the narrative form of teaching that happens in live lectures with a "matrix of resources" found on the web and in books. One can simply sit back and listen to the lessons, or interactively access those parts of interest, repeating sections as needed, to comprehend the material. Since almost no one learns from hearing things just once, this kind of presentation enables students to repeat material until they really get it and can apply it.

The product also includes a web "portal" that provides additional resources on the subject of dams and river morphology.

You can request the ***Geomorphic Response of Rivers to Dams*** CD set from the Pacific Northwest Research Station by contacting PNW Publications at (503) 808-2138, or emailing pnw_pnwpubs@fs.fed.us and requesting GTR-PNW-601. If you have a fast Internet connection, you can get a stream of the course via the Internet at http://www.fsl.orst.edu/geowater/morphology.

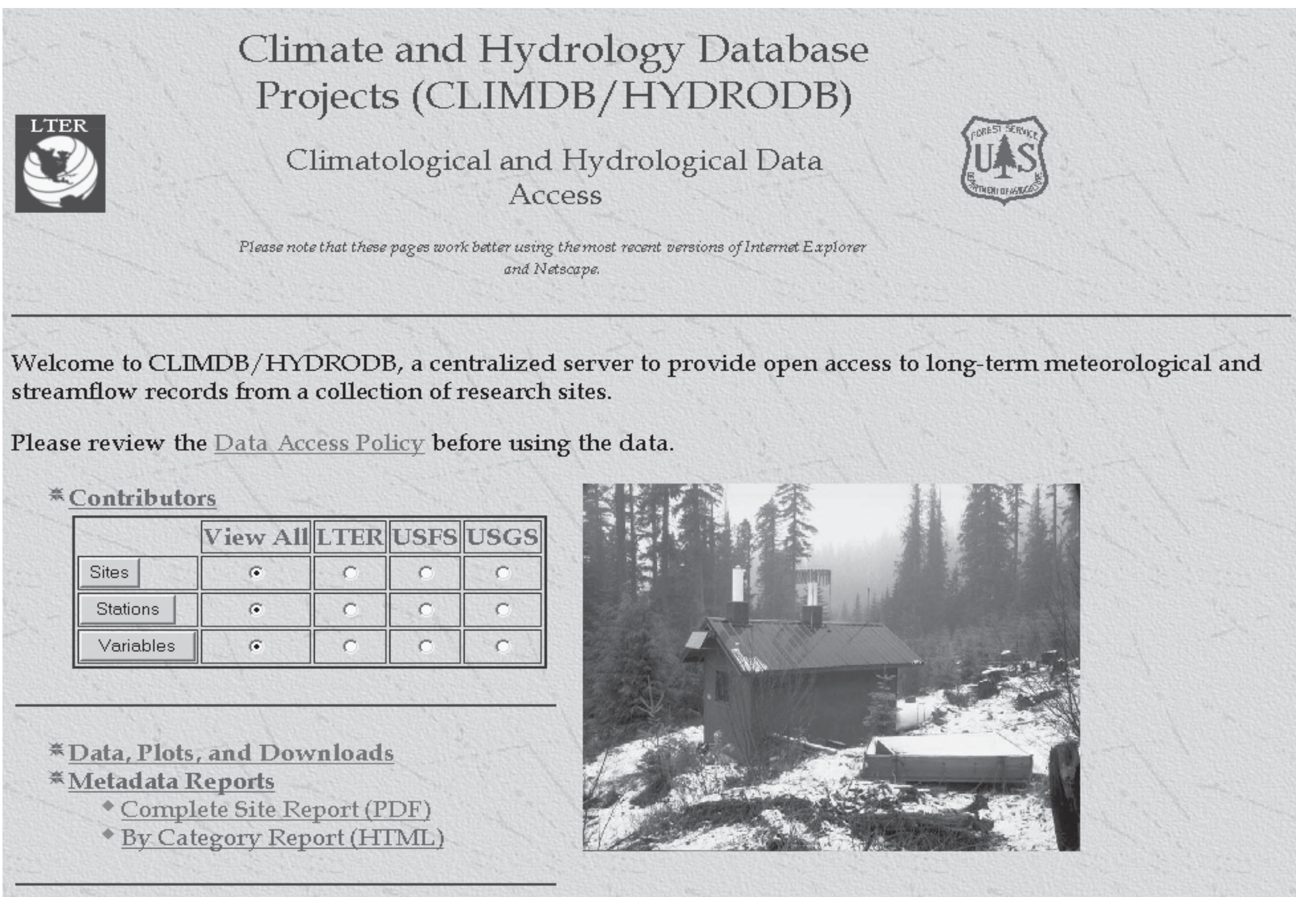
Web Harvester:
Access to Long-term Streamflow and Weather Data from Research Watersheds

by Douglas Ryan

Detailed, long-term streamflow and weather data from a collection of research watersheds from across the US are now available at a "one-stop-shopping" web site. The data, along with information to aid in their interpretation and use (called "metadata"), have many potential applications for research, synthesis, education, and practical purposes such as building and testing models used in land management.

Don Henshaw, Information Manager at H.J. Andrews Experimental Forest in Corvallis, OR, has overseen designing this web site to use new technology, called "Web Harvesting,"that makes it easier for the public to use these data and reduces the effort for individual study sites to make them publicly available. The data and metadata can now be viewed, graphically displayed, and downloaded from the web (see figure below) at: http://www.fsl.orst.edu/climhy/hydrodb/

Data can be retrieved using the applications ClimDB and HydroDB. ClimDB/HydroDB allows the public to visit the site and to trigger a harvest of the site's climate and streamflow data from the central site webpage.



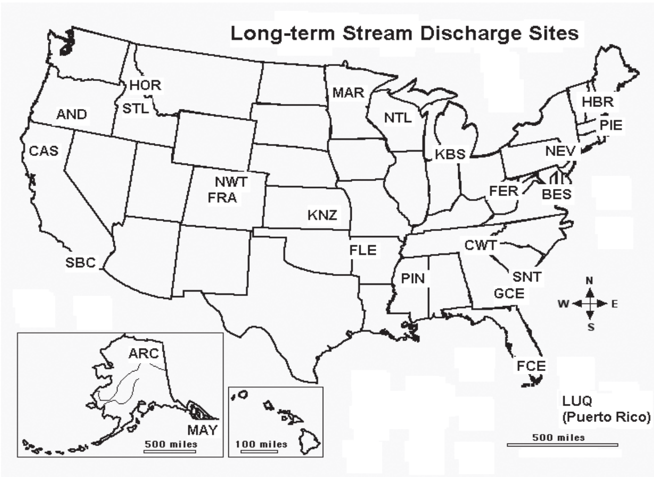


Figure 1. Long-term stream discharge sites from which data can be retrieved using HydroDB.

Most of the sites contributing data are intensively-studied, small watersheds on Forest Service Experimental Forests and/or participants in the National Science Foundation's Long Term Ecological Research (LTER) Network (Figure 1 & Table 1). Some of the data are from paired-watershed studies that compare effects of land-use treatments to reference conditions. Although the web site currently contains hydrologic and meteorological data, many other aspects of these sites have been studied and references to these other studies are contained within the metadata. Expansion of the web site to include long-term water chemistry and sediment data is planned for the near future.

Currently available data parameters include air temperature, dewpoint temperature, atmospheric pressure, solar radiation, precipitation, relative humidity, snow depth, soil moisture, soil temperature, stream discharge, water temperature, wind direction, and wind speed.

Practitioners with a need for detailed, long-term streamflow and weather records from intensively studies sites are encouraged to visit this web site. Any study site with long-term, site-specific stream discharge and weather data is welcome to make their data publicly available using this application by following directions on the web site. Creation of this web site is jointly supported by USDA Forest Service Research and Development and the Long-Term Ecological Research (LTER) Program of the National Science Foundation.

Table 1. Site ID and name of long-term study sites with stream discharge data.

ID	Name and Location
AND	H.J. Andrews Experimental Forest, OR
ARC	Arctic Long Term Ecological Research , AK
BES	Baltimore Ecosystem Study, MD
CAS	Caspar Creek, CA
CWT	Coweeta Creek, NC
FCE	Florida Coastal Everglades, FL
FLE	Fleming Creek, AR
FER	Fernow EF, WV
FRA	Fraser EF, CO
GCE	Georgia Coastal Ecosystem, GA
HBR	Hubbard Brook, NH
HOR	Horse Creek, ID
KBS	Kellogg Biological Station, MI
KNZ	Konza Prairie, KS
LUQ	Luquillo Experimental Forest, PR
MAR	Marcell Experimental Forest, MN
MAY	Maybeso Creek, AK
NEV	Neversink Watershed, NY
NTL	Northern Lakes, WI
NWT	Niwot Ridge, CO
PIE	Plum Island Ecosystem, MA
SBC	Santa Barbara Coastal, CA
PIN	Pine Watershed, MS
SIL	Silver Creek, ID
SNT	Santee Experimental Forest, SC

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IN THIS ISSUE

STREAM NOTES

Larry Schmidt, STREAM Program Manager Retires

Larry Schmidt, Program Manager of the Stream Systems Technology Center since 1992 has retired after a 40-year Forest Service career. Larry began his career in 1961 as a seasonal employee on the Kaibab National Forest in Arizona and subsequently served as Forest Hydrologist on the Toiyabe National Forest , Regional Hydrologist of the Intermountain Region, Regional Water Resources Program Manager of the Southwest Region, and Riparian and Watershed Improvement Program Manager in the Washington Office prior to coming to the newly formed STREAM TEAM in 1992.

"I'm most grateful to RMRS employees and leadership, and other Stations and Regions, for helping make us successful as a unit," says Larry. "Our biggest success has been the ability to highlight the importance of gravel bed rivers to National Forest System lands, and to engage Forest Service, academics and others in managing these important waterways." Larry and his wife, Phyllis, have moved to the Carson Valley in western Nevada, where they are building a home.