STREAM SYSTEMS TECHNOLOGY CENTER

STREAM NOTES

To Aid In Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station **July 2003**

Designing Log Contour Basins for Maximum Effectiveness

by Larry J. Schmidt

Various slope treatments are commonly employed after wildfires to reduce surface runoff and sediment transport and to provide for the emergency rehabilitation of burned watersheds.

Slope treatments commonly include log erosion barriers and the contour felling of trees. These practices obstruct flow, reduce slope length, and cause sediment deposition. They consist of an array of logs felled on the contour with enough supplemental work to assure full contact with the ground.

This article is about contour log basins which are slope treatments designed to fully detain water from a given design storm thus eliminating runoff and sediment transport (figure 1). They consist of an array of logs felled on the contour, with constructed basins placed on a spacing governed by the design storm and structure capacity.

Contour log basins work best in areas where short duration, high intensity, low volume storms occur, such as in the Interior West.

Contour log basins:

- Detain surface runoff thus eliminating sediment transport,
- Provide the necessary capacity and spacing to detain runoff,
- Control runoff on-site more effectively than in-channel controls, and
- Are considered to be successful when minimal sediment accumulates behind the structures.

Contour Log Basin Design Process

The design of contour log basins follows a fairly simple, systematic design process.

1. Predict the recovery period in years to achieve satisfactory hydrologic condition.
2. Select an acceptable percent risk over the time required for recovery. See STREAM NOTES, “Calculated Risk: A Tool for Improving Design Decisions”, October 1998.
3. Determine the equivalent return period from the table or formula.
4. Consult state NOAA Atlas II for storm values and adjust rainfall amounts to 30 minute durations.

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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

Figure 1. Important construction features of a well-constructed contour log basins. Photo by Becca Smith

5. Adjust storm using Runoff Curve Number for the site if other than a conservative 100%.
6. Determine the design capacity of the structures (accounting for gaps on the contour between structures as a percentage of full treatment).
7. Use the design runoff and basin structure capacity to determine appropriate spacing between courses (figure 2).
8. If sufficient logs are unavailable to achieve spacing, use wattles, mulching, or hand dug structures to supplement treatment.

Spacing Formula

$$\text{Spacing (feet)} = \frac{\text{Capacity (cubic feet/foot)} \times 12}{\text{Runoff inches}}$$

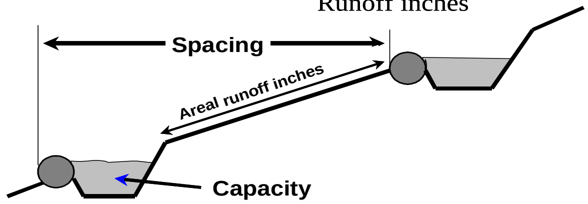

Figure 2. Spacing formula for contour basin design.

9. Implement treatment from the top of slope down so that if a storm occurs during implementation, the existing treatments will function and remain intact to the design standard.
10. If treatment from the ridgeline down is infeasible, consider other options such as mulching.

Effective Application Requirements

- Contour log basins provide an interdependent network of basins to control runoff; accordingly, design and implement treatment from the top of the slope (ridge) down.
- Contour log basins need to be implemented on the contour, in full contact with ground.
- Effective contour log basins require end sills and intermediate equalizer baffles to provide sufficient capacity for runoff detention and to reduce the risk of complete failure.
- Contour log basin spacing and “brick coursing” are critical to effectiveness.
- Infiltration in the basins behind the contour log basins can be enhanced by covering the constructed basin with straw mulch to prevent soil puddling.

Hydrogeological Principles Useful in Predicting the Effects of Streamflow Alterations on Shallow Groundwater and Associated Riparian Vegetation

by Mark Cable Rains

Numerous studies have shown that stream water and shallow groundwater are tightly linked in alluvial settings, and that changes in stream stage are propagated rapidly across alluvial aquifers (Castro and Hornberger 1991, Sophocleous 1991). Thus, many researchers have assumed that stream stages approximate water tables in alluvial aquifers (Auble et al. 1994, Stromberg and Patten 1996). This assumption is valid in some cases but invalid in other cases, particularly in arid basin terrain and more humid mountain terrain. Even when this assumption is valid, this relationship only implies correlation and not causation so the potential effects of stream flow alterations on shallow groundwater and associated riparian vegetation remain unknown.

Stream water and shallow groundwater interactions can be quite complex and can vary spatially on a given river or temporally on a given river segment. Nevertheless, four basic stream water and shallow groundwater interaction conditions can be described: a) shallow groundwater recharged by stream water, with little to no lateral spreading of shallow groundwater outside of the active floodway; b) shallow groundwater recharged by stream water, with extensive lateral spreading of shallow groundwater outside of the active floodway; c) shallow groundwater recharged by regional groundwater; and d) shallow groundwater recharged by mixed stream water and regional groundwater (figure 1). The objectives of this article are to briefly describe each of these conditions, and to briefly discuss how stream flow alterations might affect shallow groundwater and associated riparian vegetation under each of these conditions.

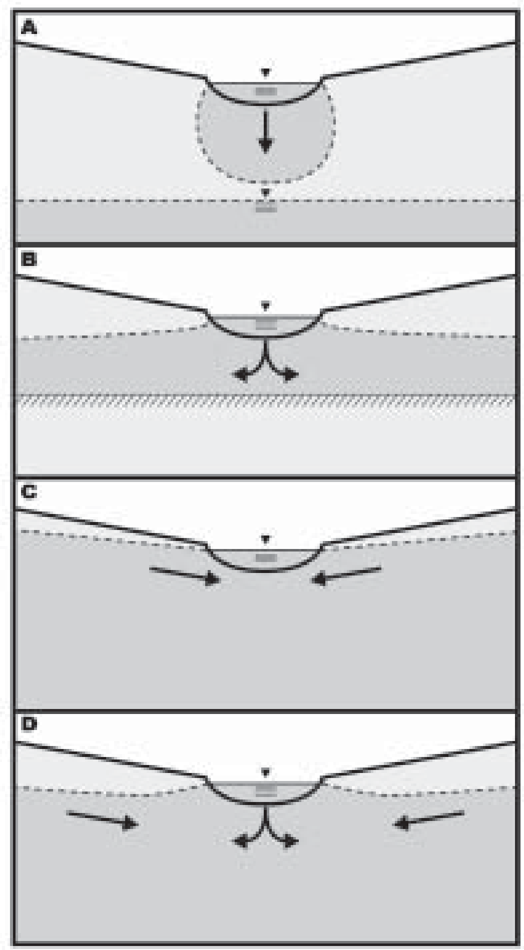

Figure 1. Basic stream water and shallow groundwater interaction conditions: a) shallow groundwater recharged by stream water, with little to no lateral spreading of shallow groundwater outside of the active floodway, b) shallow groundwater recharged by stream water, with extensive lateral spreading of shallow groundwater outside of the active floodway, b) shallow groundwater recharged by regional groundwater, and d) shallow groundwater recharged by mixed stream water and regional groundwater.

Stream Water and Shallow Groundwater Interactions

Shallow Groundwater Recharged by Stream Water

In arid regions, particularly in basin terrain, groundwater recharge occurs largely through infiltration of stream water (Stephens 1996, Izbicki et al. 2000). Where regional water tables are deep and subsurface deposits are permeable, infiltrating stream water flows vertically downward due to gravity drainage and a saturated connection between the stream water and the regional groundwater may or may not be maintained (Figure 1a). Riesenauer (1963) used a numerical groundwater model to study infiltration of canal water to a deep, regional water table. Some saturation did occur, but only directly below the canal and only to a limited depth. The result was a vertical plume of saturation below the canal. Izbicki et al. (2000) used hydrometric and geochemical procedures to study infiltration in the uplands and channels of the western Mojave Desert, California. Infiltration to depths below the rooting zone occurred only beneath the channels. Saturation and high moisture contents did occur, but only directly below the channel and only to approximately 10 m below the land surface. Again, the result was a vertical plume of saturation below the channel.

Where low-permeability deposits or bedrock occur in the shallow subsurface, infiltrating stream water may perch and flow laterally away from the active floodway (Figure 1b). Harvey and Sibray (2001) used hydrometric and geochemical procedures to study infiltration of canal water in western Nebraska. The canal carried water twice a year, once in spring to recharge reservoirs and once in summer to provide water for field irrigation. The canal was dry for the remainder of the year. When the canal carried water, the water table rose rapidly due to infiltration of canal water. The infiltrated canal water perched on low-permeability siltstones and sandstones in the shallow subsurface and flowed laterally to recharge adjacent wetlands and lakes.

Stream flow alterations may have pronounced effects on shallow groundwater and associated riparian vegetation in both of these cases. Depending upon local hydrogeologic conditions, there may be little to no lateral spreading of shallow groundwater and little to no effect on shallow groundwater and associated riparian vegetation outside of the active floodway, or there may be extensive lateral spreading of shallow groundwater and pronounced effects on shallow groundwater and associated riparian vegetation outside of the active floodway.

Shallow Groundwater Recharged by Regional Groundwater

In more humid regions, particularly in mountain terrain, groundwater recharge occurs largely through diffuse infiltration of precipitation in the uplands (Stephens 1996, Flerchinger and Cooley 2000). Water tables often are subdued replicas of land surfaces, with water tables highest under the uplands and lowest under the lowlands. Water flows down gradient, so lowlands typically receive regional groundwater discharge. In some cases, most if not all shallow groundwater may be recharged by regional groundwater discharge (Figure 1c). Gerla (1992) used a numerical groundwater model, analytical particle tracking and geochemical models, and geochemical data to study the source of surface water and shallow groundwater in the Red River Valley, North Dakota. Surface water and shallow groundwater were entirely recharged by regional groundwater, the vast majority of which had flowed more than 100 km through the deep subsurface prior to discharging to the surface and shallow subsurface. This regional groundwater discharge sustained base flows in the Red River.

Stream flow alterations may have little to no effect on shallow groundwater and associated riparian vegetation in these cases. For example, Stromberg and Patten (1996) noted that relationships between stream flow and tree growth were weak in confined canyons, which they suggested was due to the fact that trees in confined canyons were supported by other sources of water such as regional groundwater discharge.

Shallow Groundwater Recharged by Mixed Stream Water and Regional Groundwater

In most circumstances, shallow groundwater is recharged by mixed stream water and regional groundwater and the situation is more complex (figure 1d). Izbicki et al. (1995) used geochemical procedures to study groundwater recharge in the Mojave River basin, California. They identified two aquifers, a shallow alluvial aquifer and a deep regional aquifer. In most of the alluvial aquifer, shallow groundwater was recharged solely by stream water. Where the underlying bedrock shallowed, however, regional groundwater was forced toward the surface and shallow groundwater was recharged by mixed stream water and regional groundwater. The issue was more complicated still since the regional groundwater was recharged partly by stream water farther up gradient and partly by regional groundwater discharge from the surrounding mountain blocks. Thus, the regional groundwater that discharged to the alluvial aquifer was at least in part recharged by the alluvial aquifer itself farther up gradient.

Rains and Mount (2002) used geochemical procedures to study the origin of shallow groundwater in an alluvial aquifer on Little Stony Creek, California. Shallow groundwater was recharged by stream water and regional groundwater, with stream water the more prominent source of shallow groundwater in the wet season and regional groundwater the more prominent source of shallow groundwater in the dry season. In the wet season, continuous stream flows were a relatively large source of shallow groundwater recharge, while in the dry season, intermittent stream flows were a relatively small source of shallow groundwater recharge. Regional groundwater was a relatively constant source of shallow groundwater recharge throughout the year because the alluvial aquifer was a regional low perpendicular to the regional groundwater flow path.

In these circumstances, the effects of stream flow alterations on shallow groundwater and associated riparian vegetation cannot be easily predicted. Aquifers with multiple sources of groundwater recharge respond dynamically to stress, so one cannot predict future shallow groundwater conditions by simply assuming that one source of shallow groundwater recharge will decrease while other sources of shallow groundwater recharge will remain unchanged (Theis 1940). If stream flows are reduced, then shallow groundwater recharge by stream water could be reduced and hydraulic heads in the alluvial aquifer could decline. If hydraulic heads in the alluvial aquifer decline, then hydraulic gradients from the regional aquifer to the alluvial aquifer could increase and regional groundwater discharge to the alluvial aquifer could increase. In an extreme case, total shallow groundwater recharge could remain unchanged, though the relative contributions of stream water and regional groundwater to shallow groundwater recharge could substantially change. In most cases, total shallow groundwater recharge would decrease, though the magnitude of the decrease would depend upon local and regional hydrogeologic conditions.

Concluding Remarks

Stream water and shallow groundwater interactions can be quite complex, and two or more of these stream water and shallow groundwater interaction conditions may occur at different locations on a given river or at different times on a given river segment. Therefore, predicting the effects of stream flow alterations on shallow groundwater and associated riparian vegetation is a daunting task. Numerical modeling can help, but data to adequately model entire river systems typically are lacking. Furthermore, water flows according to governing equations and is relatively well-behaved, while vegetation changes according to a wide variety of physical and biological factors and is relatively ill-behaved. Thus, while it is difficult to predict the effects of stream flow alterations on shallow groundwater, it is more difficult still to predict the effects of stream flow alterations on associated riparian vegetation. However, careful consideration of the hydrogeologic characteristics of the river or river segment of interest can be useful. For example, stream flow alterations may have pronounced effects on shallow groundwater and associated riparian vegetation where shallow groundwater is recharged by stream water, but little to no effect on shallow groundwater and associated riparian vegetation where shallow groundwater is recharged by regional groundwater. Therefore, a basic understanding of the hydrogeologic principles described herein can be used to make first order approximations of the effects of stream flow alterations on shallow groundwater and associated riparian vegetation.

Acknowledgements

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Ask DOCTOR Hydro

Dear Doc Hydro: I've been looking at Bunte and Abt's publication, "Sampling Surface and Subsurface Particle-Size Distributions in Wadable Gravel and Cobble-Bed Streams" (RMRS GTR-74) and reading about the characterization of various particle distribution parameters such as the mean, sorting, skewness, kurtosis, and the various ways of computing size distribution percentiles and statistics. It's all pretty complicated stuff and the equations are pretty formidable. Are there any computer programs that perform these computations and make this task easier?

There's a very nice program called GRADISTAT that should meet your needs. GRADISTAT was developed by Simon Blott and Kenneth Pye of the Department of Geology, Royal Holloway University of London, England to assist the wide-ranging needs of researchers in geomorphology and sedimentology. Soil scientists may also find the program useful to display soil particle size data.

The program, written in Microsoft Visual Basic, is integrated into a Microsoft Excel spreadsheet to allow for both tabular and graphical (frequency and ternary plots) output. A sample of the types of output is shown on this page.

Users are required to input the percentage of sediment present in a number of size fractions. Data can be the weight retained on a series of sieves, or the percentage of sediment detected in size classes derived from a laser granulometer, X-ray sedigraph, or Coulter counter. Input data is limited to an upper size limit of 90 mm, and is therefore best suited for analyzing finer materials.

Blott and Pye also caution that although the GRADISTAT program is extremely flexible in terms of input and output, it remains the responsibility of the user to interpret the results in an appropriate manner. They note that although most sedimentologists have traditionally worked with phi units, in their opinion, statistics expressed in metric units are preferred because the phi scale is seldom used by biologists, soil scientists, and engineers and metric results are easier to visualize because they represent the actual size of the particles.

The GRADISTAT program (GRADISTAT.xls) can be downloaded from the Earth Surface Processes and Landforms software web site (http://www.interscience.wiley.com/jpages/0197-9337/sites.html). Look for: "Software from 'Gradistat: a Grain Size Distribution and Statistics Package for the Analysis of Unconsolidated Sediments' by Simon J. Blott and Kenneth Pye, ***Earth Surface Processes and Landforms,*** Volume 26, Issue 11, pp. 1237–1248."

SAMPLE STATISTICS

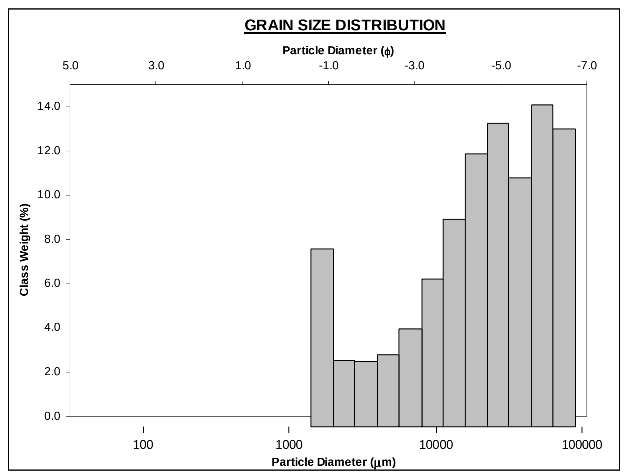
SAMPLE IDENTITY: **Squaw Creek, MT** ANALYST & DATE: S. S. Sampler, August 15, 2000

SAMPLE TYPE: Trimodal, Moderately Sorted TEXTURAL GROUP: Gravel

SEDIMENT NAME: Very Coarse Gravel

	µm	φ	GRAIN SIZE DISTRIBUTION			
MODE 1:	54000.0	-5.735	GRAVEL:	93.5%	COARSE SAND:	0.0%
MODE 2:	26950.0	-4.731	SAND:	6.5%	MEDIUM SAND:	0.0%
MODE 3:	1700.0	-0.743	MUD:	0.0%	FINE SAND:	0.0%
D_{10}:	3351.6	-7.154			V FINE SAND:	0.0%
MEDIAN or D_{50}:	31561.8	-4.980	V COARSE GRAVEL:	49.6%	V COARSE SILT:	0.0%
D_{90}:	142386.9	-1.745	COARSE GRAVEL:	20.4%	COARSE SILT:	0.0%
(D_{90} / D_{10}):	42.48	0.244	MEDIUM GRAVEL:	12.7%	MEDIUM SILT:	0.0%
$(D_{90} - D_{10})$:	139035.3	5.409	FINE GRAVEL:	6.1%	FINE SILT:	0.0%
(D_{75} / D_{25}):	5.833	0.590	V FINE GRAVEL:	4.7%	V FINE SILT:	0.0%
$(D_{75} - D_{25})$:	61227.5	2.544	V COARSE SAND:	6.5%	CLAY:	0.0%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic µm	Geometric µm	Logarithmic φ	Geometric µm	Logarithmic φ	Description
MEAN ($\bar{x}$):	24585.5	2870.1	-3.413	21450.7	-4.423	Coarse Gravel
SORTING (σ):	24945.4	53.97	2.219	1.728	0.789	Moderately Sorted
SKEWNESS (Sk):	0.872	-1.348	0.411	-4.762	4.762	Very Fine Skewed
KURTOSIS (K):	2.546	3.129	1.703	0.133	0.133	Very Platykurtic



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Editorial Policy

For a successful newsletter, we need voluntary contributions of relevant articles or items of general interest. YOU can help by taking the time to share innovative ideas or approaches to problem solving that you may have developed.

Feel free to contact John Potyondy to discuss ideas for contributions (970- 295-5986). Or if you like, submit typed, single-spaced contributions limited to 2 pages to John Potyondy at jpotyondy@fs.fed.us in electronic format. If possible, include graphics and photos that help explain ideas.