Technical Supplement 14S

Sizing Stream Setbacks to Help Maintain Stream Stability

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Cover photo: In some cases, stream restoration may be achieved by allowing the stream to adjust itself within the riparian area and flood plain. What are the migration boundaries, and where should development be restricted to allow this adjustment are questions that need to be tempered by local requirements, land use and ownership, and the community's restoration goals and objectives.

Advisory Note

Techniques and approaches contained in this handbook are not all-inclusive, nor universally applicable. Designing stream restorations requires appropriate training and experience, especially to identify conditions where various approaches, tools, and techniques are most applicable, as well as their limitations for design. Note also that product names are included only to show type and availability and do not constitute endorsement for their specific use.

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Purpose

Many local communities, watershed groups, counties, and states are developing setback ordinances to help protect stream systems. Several guidelines are outlined in this technical supplement. This technical supplement also presents an empirically based equation that calculates the streamway width required to allow a stream to self-adjust its meander pattern. This technical supplement does not cover stream setbacks that are required by local or state laws, nor does it address conservation program requirements.

Introduction

Although many local communities, watershed groups, counties, and states are developing setback ordinances to help protect stream systems, existing guidelines were developed on the basis of different, often nebulous, objectives and are highly variable. In an effort to provide maximum protection or to establish easily understood ordinances, setbacks have ranged from mandating no development in the 100-year flood plain to a fixed setback width (such as 100 ft) that may be unrelated to the stream size or drainage area. As these approaches are only loosely related to stream morphology, if at all, they will provide widely variable levels of effectiveness, underestimating or overestimating the area most vital to maintaining the integrity of streams.

Flood plain function

Flood plains of ecologically healthy streams are characterized by frequent, extensive over-bank flow. Fluvial processes size the main channel to convey the effective (bankfull) discharge, and larger flows spread out onto the flood plain. Abandoned channels or adjacent terraces may have been the active flood plain in the past. Flood plains and adjacent terraces are a complex system of soil, bedrock, vegetation, and subsurface water that affect water quality, wildlife habitat, instream habitat enhancement, recreation, and aesthetics (Large and Petts 1994).

While the flood plain provides important ecologic and pollutant filtration purposes, stream stability depends on the flood plain for the following:

- dissipation of energy of flows exceeding the effective discharge (bankfull)
- sediment transport, storage, and supply—most importantly bedload sediment
- ability of the main channel to adjust its dimension, pattern, and profile, maintaining a dynamic equilibrium

The need for setbacks

Land use change on the landscape often increases the magnitude and volume of discharge, encroaches on the flood plain, and increases stream conveyance by channel lowering, widening, and straightening. The impact of these changes on the stability, ecological function, and general health of the river system is very site specific. Unfortunately, efforts to establish simple, but universal, river corridor protection guidelines or requirements are often arbitrary (table TS14S–1). A useful review of the literature on riparian zone characteristics is presented by Wenger (1999).

Calculating the streamway width

Many empirical equations have been developed to describe bankfull (effective discharge) channel geometry. One such equation by Williams (1986) relates meander belt width (B, ft) and the bankfull width (W, ft) (eq. TS14S–1) (converted from the metric form):

$$B = 5.0\ W^{1.12} \qquad \text{(eq. TS14S–1)}$$

where:
B = belt width (ft)
W = bankfull width (ft)

An equation for the relationship between bankfull channel width and drainage area (DA, square miles) for rivers in the eastern United States (Dunne and Leopold 1978) gives:

$$W = 14.6\ DA^{0.38} \qquad \text{(eq. TS14S–2)}$$

Substituting equation TS14S–2 into equation TS14S–1 provides a relationship for the belt width as a function of drainage area:

$$B = 100\ DA^{0.43} \qquad \text{(eq. TS14S–3)}$$

In developing an equation that might be used to define stream setbacks, it is also important to provide a:

- flood plain that is wide enough to accommodate the existing meander pattern
- flood plain that would accommodate future meander migration that might occur
- factor of safety to account for uncertainty since the equation is based on empirical equations that do not account for all the variability in data used in their development
- minimum level of protection on both banks of the stream

Equation TS14S–1 is based on 153 data points from rivers around the world. The correlation coefficient (r) for the equation is 0.96. Belt width and bankfull width data for 47 of the locations are presented by Williams (1986). The data have been analyzed, and the regression equation that was obtained is very similar to equation TS14S–1. This equation underpredicted the belt width by a mean amount of 24 percent for 24 of the sites and overpredicted the belt width by a mean amount of 36 percent for 23 of the sites.

Overprediction is not a major concern since the method does not attempt to account for meander migration or riparian zone protection. However, without modification, the equation fails the setback requirements at least half the time, so the calculated belt widths have been evaluated in increasing increments of 10 percent. A 10 percent increase reduced the number of sites where the belt width was underpredicted from 24 to 17, while a 20 percent increase reduced the number of sites where the belt width was underpredicted from 24 to 12. Additional increases up to 50 percent only reduced the number of underpredicted sites from 24 to 8. However, an increase of this magnitude resulted in a mean overprediction of 74 percent in the belt width size at the 39 sites where the equation overpredicted the belt width. Based on this analysis, the following equation is obtained that increases the estimated beltway obtained from equation TS14S–4 by 20 percent:

$$\text{Streamway} = 120\ DA^{0.43} \qquad \text{(eq. TS14S–4)}$$

Table TS14S–1 Recommended widths for vegetated riparian zones

Function	Study	Relevant details	Width (ft)
Riparian habitat areas	Washington Department of Fish and Wildlife (2001)	Fish and wildlife-based review of 1,500 articles	150- to 250- or 100-yr flood plain
Wildlife protection	Rabeni (1991)1/	Fish, amphibians, birds	25–200
	Cross (1985)1/	Small mammals	30–60
	Brown, Schafer, and Brandt (1990)1/	Provide food, water, cover	300–600
Water quality	Ahola (1989)1/	General improvements	160
	Pinay and Descamps (1988)1/	As above	3–6
	Correll and Weller (1989)1/	Nitrate control	About 60
Sediment control	Peterjohn and Correll (1984)1/	Nutrient control	About 60
Bank stabilization	Ontario Ministry of Agricultural, Food, and Rural Affairs (1998)	Agricultural ditch bank stabilization	10
Urban stream buffer	Schueler (1995)	Survey of 36 buffer programs	20–200

1/ As cited by Large and Petts (1994)

Equations TS14S–3 and TS14S–4 only apply to the eastern United States. The uncertainty associated with equation TS14S–2 was not evaluated, and it was not possible to evaluate equations TS14S–3 and TS14S–4 with the data published by Williams (1986) because drainage area data were not presented.

Conclusion

Successful stream stewardship requires combining knowledge of natural stream concepts with sound engineering and scientific principles and an understanding and appreciation of the ecology of the stream and its interaction with the landscape. A stream stability protection setback should be based on stream geomorphology concepts and specifically the ability of the stream to self-adjust and maintain itself in a state of dynamic equilibrium.

For the setback to accomplish the goal of the impacted stream to sustain dynamic-equilibrium also requires the incorporation of:

- landscape measures that reduce runoff such as reduction in paved surface area and practices to maintain or enhanced infiltration
- detention/retention management strategies that result in similar post and predevelopment bedload and sediment transport amounts