United States Department of the Interior

FISH AND WILDLIFE SERVICE
Mountain-Prairie Region

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Memorandum

To: Project Leaders, Region 6

Through: Regional Chief for National Wildlife Refuge System, Region 6
Assistant Regional Director for Fisheries, Region 6
Assistant Regional Director for Ecological Services, Region 6

From: Deputy Regional Director, Region 6

Subject: Regional Policy Regarding Streambank Stabilization Projects

The attached policy is effective as of the date of this memorandum. The policy was developed during the past year by Ecological Services with help from Water Resources, and input was solicited from all applicable programs and from the field. Comments received from local offices of the Army Corps of Engineers and Environmental Protection Agency, as well as from other regions, also were considered fully before the document was finalized.

You may distribute the document outside of our agency because we hope it will help to educate external entities on the need to give habitat conservation more emphasis when planning, designing, and authorizing streambank stabilization projects. However, when such distributions are made, the recipients should clearly understand that this is internal Region 6, U.S. Fish and Wildlife Service policy that has no authority over the actions of those external parties.

Policy questions should be directed to Dennis Buechler, Regional Section 404 Coordinator, at (303) 236-7400, ext. 231. Technical questions may be directed to Rick Dornfeld, Regional Partners for Fish and Wildlife Coordinator, at ext. 241. Keep us posted on the usefulness of this policy and on changes that should be considered if it is updated in the future.

Attachment

POLICY ON STREAMBANK STABILIZATION PROJECTS

REGION 6
U.S. FISH AND WILDLIFE SERVICE
Denver, Colorado

February 2001

Executive Summary

Actions undertaken or recommended by Region 6 employees in a streambed or on a streambank should support a stream's tendency to adjust towards the most probably natural state. Proposed actions should be evaluated regarding effects on stream dimension, pattern, and profile. They also should be based upon natural stream stability concepts. Bankfull discharge should normally be the basis for planning and evaluating such projects.

This policy focuses on streambank stabilization projects because of the large number of these types of projects that have been constructed and continue to be proposed for construction in Region 6. More importantly, Region 6 has major concerns about the individual and cumulative adverse impacts to fish and wildlife resource that commonly result from such projects. Therefore, the intent of this policy is to encourage proper planning and design of bank stabilization projects. Regional guidelines for planning instream restoration projects can be found at www.r6.fws.gov/pfw.

Introduction

This policy provides direction for U.S. Fish and Wildlife Service, Region 6 employees when they plan or evaluate the impacts of proposed streambank stabilization projects on streams and rivers. It is intended to promote consistency between those who review projects proposed by external entities and those who plan and design projects that will be implemented on USFWS lands.

This document is not intended to provide a comprehensive guide on how to analyze, design, or construct bank stabilization projects. That information is available through appropriately trained personnel and technical publications. Also, this policy was developed mainly for use on flowing streams and rivers in order to emphasize the relevance we place on protection and conservation of riparian and riverine habitats. While the policy does not directly apply to banks on reservoirs, ponds, or lakes, many of the same conservation principles may be applicable for projects in those habitat types.

Background

Rivers evolve and adjust naturally in response to geologic events and climate change. However, human-caused changes at the local or watershed level may disrupt the natural stability of channel equilibrium, and human development frequently occurs in that portion of the valley bottom associated with natural channel movement. The consequences of that development can be substantial changes in hydrology, including altered peak flows, base flows, and timing of flow concentration. These changes may not be reversible and may result in a new human-caused baseline condition for the stream system.

These common human perturbations, which often result in bank erosion, are typically followed by landowner efforts to get Government funding or permits to construct substantial bank stabilization projects that are frequently detrimental to aquatic and riparian fish and wildlife resources. It is a high priority Regional goal to avoid such impacts where possible, to minimize unavoidable impacts whenever practicable, and to attempt to mitigate for all unavoidable habitat losses. That goal formed the framework for the policy contained in this memorandum.

Region 6 endorses the concepts of natural channel stability and bankfull discharge with respect to fluvial geomorphology (Leopold 1994). "A 'naturally stable channel' maintains on the average a constant channel cross section by maintaining an equilibrium between erosion and deposition. Over time, rivers tend to migrate by erosion of one bank balanced by deposition on the opposite bank. While the form of the cross section is 'stable,' meaning constant, position of the channel is not" (Leopold et al. 1964). The most probable natural state, or natural stability, is exhibited by a single-channel stream when over time, in the present climate, the stream adjusts towards dimension, pattern, and profile within stream type limits, without aggrading or degrading, even as the stream may move across its floodplain.

There are two exceptions to this most probable natural state. First, there are naturally occurring braided streams consisting of interconnected distributary channels formed in depositional environments. This stream type is characterized by high sediment supply, excessive deposition occurring as both longitudinal and transverse bars, and annual bed location shifts. There also are anastomosed multichannel streams occurring naturally in broad alluvial valleys in which vertically accreting streambeds are offset by the subsidence effects of tectonically active basins.

Normally, the erosion rate, sediment transport rate, and bar-building deposition are most active in streams when the discharge is near bankfull. Therefore, bankfull discharge is considered to be the channel forming flow. The highest discharges (i.e., high floods) carry the most sediment during their passage, but they are so infrequent that over time they do not usually accomplish as much work as the bankfull flow. Thus, bankfull discharge should be the basis for planning and evaluating instream and streambank projects.

This Region also supports the use of the stream classification system developed by Dave Rosgen and discussed in his book, Applied River Morphology (1996). His classification system is based upon objective, quantitative criteria that can be observed and measured by trained field biologists. The objective of the classification system is to place streams within descriptive or quantitative groups to help us gain an understanding of the stream systems. The classification system is grounded in the basic fluvial geomorphologic processes described by numerous authors (Horton l945, Hack l957, Schumm 1960, Leopold et al. l964, Langbein and Leopold l966, Dunne and Leopold l978, Knighton l984, and Leopold l994). These references can be found in th reference list for Leopold's l994 book, entitled A View of the River.

Rosgen's geomorphic stream classification system summarizes many physical characteristics of stream channels including valley type, stream gradient, stream confinement, floodplain connectivity, roughness, bed and bank material, sediment transport, sinuosity, width to depth ratio, and other significant features. By organizing these attributes into "classes" we are able to organize our data and thoughts regarding similar stream systems. Subsequently, the project designer or evaluator can correlate information, extrapolate to unsurveyed reaches, and predict channel response to various stimuli (e.g., proposed structural, management, and vegetative practices). Additional benefits include improved communications, a consistent and reproducible frame of reference, focused data collection and monitoring, onsite data collections and observations resulting in better input to project design, and development of information that enables assessment of alternatives for stream management within the realm of "natural channel design."

Resource Concerns

Riverine and riparian habitats are among the highest resource priorities in the Mountain-Prairie Region of the USFWS. Riverine wetlands and associated floodplain bottom lands are extensively used by waterfowl, raptors, shorebirds, neotropical migratory birds, furbearers, reptiles, amphibians, and fish for nesting, resting, rearing, and feeding as residents and seasonally as migrants (Stevens et al. 1977, and Knopf et al. 1988). They provide important habitat for many of our listed, proposed, and candidate threatened and endangered species in Region 6.

Measures that stabilize river banks and attempt to train rivers, such as armoring, flow deflection structures, and energy reduction measures, can adversely affect the natural form and function of the river, thus adversely affecting fish and wildlife and their associated habitats in both the aquatic (riverine) and riparian (floodplain) communities. Such measures physically stabilize river banks and may increase river flow velocities, exacerbate downstream bank erosion, and lead to channel narrowing and bed degradation. Associated impacts can include losses of (a) shallow-water riverine habitat, (b) riverine-floodplain connections, (c) backwater chutes, (d) sandbar habitat, and (e) sediment and debris input, which can adversely affect nutrient cycling and creation and maintenance of aquatic habitat features. These physical aspects provide diversity of water depth, velocity, temperature, and sediment size necessary to maintain habitat for fish.

Riparian vegetation is an important source of energy and nutrients to aquatic organisms. Furthermore, trees and other riparian vegetation provide shade which prevents large fluctuations in water temperature. Finally, trees undercut by channel movement provide woody debris for aquatic habitat structure . Large trees that fall into the streams often provide excellent fish habitat. Stabilizing channel banks can pose a threat to "desired" riparian vegetation through direct destruction, impairing normal growth, and precluding re-establishment. "Desired riparian vegetation" refers to the native species of vegetation found in representative riparian areas, which are located landward along the banks of riverine systems.

On many streams in this part of the country, cottonwood trees are considered a "keystone species" upon which a great number of fish and wildlife species depend. Establishment of riparian vegetation, particularly cottonwoods and willows (Family *Salicaceae*), requires creation of bare, moist soil in a location relatively safe from disturbance for several years. Along streams in Region 6, these conditions are created by channel movement (e.g., meander migration), channel narrowing, or overbank flood deposition (Scott et al. 1996).

The longest-lived cottonwoods rarely exceed 200 years in age and many species of willow rarely exceed 50 years in age, so these dynamic channel processes must be maintained to ensure continued recruitment of riparian cottonwoods and willows. Channel stabilization can reduce active channel area and sediment supply. When combined with bed degradation, it also greatly reduces the amount of bare, moist, and safe sites essential to maintain a healthy age structure of riparian vegetation.

On alluvial river systems, another desired habitat is bare sandbars (e.g., nesting habitat for the endangered Interior least tern and threatened piping plover). Hard solutions to bank stabilization such as riprap and jetties may redirect flows in a manner that causes sandbar habitat to be eliminated in a particular location. They also may degrade the channel resulting in less overflows on the bars and establishment of undesired vegetation.

Development pressures have significantly affected these important habitats in river systems throughout the Region 6 States. Traditional engineering concepts of control and containment have been applied to erosion problems associated with flood control, irrigation, highway construction, and land use and management conflicts. Thus, traditional engineers often have become river managers by default. The problem is that the traditional approach typically fails to adequately evaluate and incorporate natural river geometry; floodplain functions; channel processes; riparian functions; aesthetic value; and comparative, long-term financial values of different alternatives. Control and containment engineering concepts, manifested in river alterations throughout the Region, have resulted in significant individual and cumulative adverse impacts to habitat and probably have contributed to major declines in native fish and wildlife populations in some locations.

Rivers in Region 6 are adjusting to human-caused changes in the watersheds and in the channels. As a result, rivers are often overwidened and/or incised as a consequence of land use changes such as overgrazing, construction of impervious surfaces (e.g., roads and parking lots), destruction of riparian vegetation, irrigation diversions, cross-channel dams, bridge crossings, and conversion grasslands into cropland. When they are incised, rivers have reduced access to the floodplain, and the riparian zones may no longer receive the benefits of overbank flooding. Furthermore, in an overwidened or incised state, rivers transport the watershed's flow and sediment in ways that accelerate bank erosion beyond normal ranges.

Unfortunately, many streams have been degraded to the point that they are irreversibly entrenched. Although it would be preferable to restore a channel to its floodplain elevation (i.e., Rosgen Priority I), it may not be practicable or affordable for a landowner to implement the significant measures necessary to reconnect an entrenched channel with the old floodplain, enabling flooding of adjacent wetlands and creating conditions favorable for cottonwood regeneration on the old floodplain. One alternative to bank stabilization in an entrenched channel is to change the stream type to a step-pool stream within the trench. This is Rosgen's Priority III. The riprap solution (i.e., Priority IV) is one that we normally prefer not to see.

The typical result of accelerated bank erosion is landowner alarm, which leads to increased landowner complaints. People with these concerns frequently turn to riprap as a solution. However, Region 6 considers riprap to be a single purpose solution to bank erosion that hardens a riverbank and usually results in adverse effects to riparian and riverine functions and the habitats they provide. Riprap also can (a) transfer erosion problems downstream, (b) be very expensive if properly designed and if proper materials are used (e.g., large rock as opposed to concrete rubble), (c) require expensive maintenance, and (d) cause the thalweg to move directly adjacent to the eroding streambank (where it is not wanted). Riprap failures due to undercutting of the rock toe is common, especially in systems that are incising.

Therefore, unless there is good documentation that streambank erosion is proceeding at a very rapid pace (i.e., loss of several lateral feet) every year (i.e., not just after a 100-year flood), hard solutions (e.g., riprap and flow deflection devices) are not generally considered to be environmentally acceptable from a fish and wildlife standpoint. If bank erosion averages 1 foot per year, significant erosion typically does not occur every year. It is much more common for the bank not to erode for 19 years, and then to erode 20 feet in 1 year. However, landowners need to be informed that this does not mean that the stream will continue to move 20 feet every year. It is wise to ask the landowner how much the bank has eroded during the past 20-30 years, rather than just the last year or two. Such estimates can provide a much more accurate overall view of the stream processes that are occurring at the site.

Basis of Region 6's Policy

Actions Region 6 employees undertake in a streambed or on a streambank, or actions they recommend to others, should support a stream’s central tendency to adjust towards the most probable natural state. Proposed actions should be evaluated as to effects on stream dimension, pattern, and profile; and they should be based on natural stream stability concepts incorporating the bankfull hypothesis.

The first step should always be to evaluate whether passive restoration is possible. The Channel Evolution Model is one effective way to explain why stream bank erosion may be occurring (see description in the attachment to this policy). For example, armoring both stream banks on a Stage III stream, as described by the Model, will only lock the stream into a very unstable state. After identifying the cause of the problem, an analysis should be done to determine if correcting that improper land use or human cause would enable the stream to return to natural stability. For example, in some cases, the exclusion of cattle from the riparian zone may suffice to eventually achieve restoration objectives. Such a solution may be more cost and environmentally effective than implementing construction measures.

However, phased intervention also may be appropriate to address human-caused changes. This concept is discussed in the introduction to Stream Corridor Restoration: Principles, Processes, and Practices, which is a publication that was developed by several agencies at the national headquarters level. In general, it is appropriate to take one of three basic approaches to intervention: (1) nonintervention and undisturbed recovery, (2) partial intervention for assisted recovery, or (3) substantial intervention for managed recovery. The appropriate approach should be determined for each project by conducting an analysis which compares measured values at the project location with a reference reach of the same stream type.

The proposed placement of hard materials in a stream or on the bank should be approached very cautiously. The placement of any materials is not usually recommended if the placement (a) confines the channel so that flows cannot access the floodplain, (b) results in destabilization upstream or downstream of the reach where materials are placed, or (c) has limited habitat value for the desired species guild at the site.

Unconstrained placement of many miles of riprap, jetties, and vanes threatens to cause defacto channelization of many valuable streams in this Region. The results include increased stream velocity, loss of spawning habitat, degradation of the stream channel, loss of proper riffle/pool relationships, removal of desired riparian vegetation, and permanent loss of the ability of the riparian areas to revegetate. However, the placement of materials in combination with restoration of proper dimension, pattern, and profile is supported by this policy if it will restore natural stability and improve habitat for the desired fish and wildlife species guild(s).

In addition, grade control structures, such as "V" weirs or cross-vanes, may be appropriate mechanisms to restore some stream functions that have been completely lost due to channelization, head cutting resulting from downstream perturbations, or encroachment (e.g., in an urban stream that has been straightened or confined by fill, or in areas constricted by bridges or other infrastructure). In this type of setting, grade control structures can be a good option for dissipating energy, reducing bank erosion, improving or providing fish passage, and improving fish habitat where it has been degraded. Grade control structures are most appropriate in streams with gravel or cobble beds.

Region 6 Policy

Bank stabilization projects designed, reviewed, or proposed by Region 6 personnel normally should pass the test of either restoration of natural stream function or the need for immediate protection of highly valuable, permanent infrastructure or cultural resources. Such infrastructures could include human dwellings, schools, hospitals, offices, bridges, etc., that are not practicable to move, but they normally should not include private and unimproved roads, sidewalks, croplands, recreational paths, parks, fences, corrals, etc. When projects are designed by Service personnel to protect infrastructure or cultural resources, the objectives should be to minimize the size and impacts to riparian and stream habitats and, if possible, to improve riparian and riverine habitat functions and values.

Streambank armoring, flow deflection techniques, slope stabilization, and energy reduction methods, especially those placed above bankfull discharge levels, should be last resort options. Armoring, deflection, and energy reduction measures can be successfully employed to protect infrastructure. However, there are no "cookbook" solutions to bank retreat problems. Guiding principles must be applied in a flexible design strategy that ensures that the applied correction measures relate to the cause of the problem and are environmentally sound. Any stabilization methods constructed above bankfull or below bankfull levels should be designed to minimize impacts to river functions, and they should not impair over bank flooding on rivers (i.e., on those rivers that are not already severely entrenched).

For protection of cropland, pasture, parks, and other areas that do not have extensive infrastructure or development, only bank sloping, fencing, riparian planting, and bioengineered techniques will normally be considered ecologically defendable, particularly if the landowner removed the riparian forest which was helping to reduce erosion naturally and/or if the ground is being farmed right up to the edge of the bank.

Region 6 takes a more ecologically defensible view of river projects than traditional engineering approaches have demonstrated. In Region 6, all bank stabilization projects should be subjected to an assessment that links cause and consequence when determining the appropriate corrective action. That assessment should be conducted or required by the Federal agency that is permitting, designing, or constructing the project. Riprap may still be the only possible outcome in some cases. However, proposed projects should be subjected to close scrutiny, and if they do not meet strict environmental criteria, the regulatory agencies should be asked to modify or deny permits for those projects. Furthermore, unavoidable impacts should be fully mitigated.

Mitigation of Impacts

The Federal Section 404 permit program (Clean Water Act) relies on the use of compensatory mitigation to offset unavoidable wetlands impacts by replacing lost wetland functions and values. The Memorandum of Agreement between the Environmental Protection Agency and the Department of the Army (Corps) "Concerning the Determination of Mitigation Under the Clean Water Act Section 404(b)(1) Guidelines" was signed on February 6, 1990. It states that, "the Clean Water Act and the Guidelines set forth a goal of restoring and maintaining existing aquatic resources. Further, the Corps will strive to avoid adverse impacts and offset unavoidable adverse impacts to existing aquatic resources, and for wetlands, will strive to achieve a goal of no overall net loss of values and functions." Given that riverine and riparian habitats are among the highest resource priorities in Region 6, every effort should be made to request mitigation during Section 404 permit reviews to replace unavoidable impacts to those ecosystems.

Examples of mitigation may include, but are not limited to, removal of hard structures in other areas and re-establishing native riparian and natural streambank configurations, fencing to preclude livestock, easements to preclude development near the bank and to preclude removal of woody vegetation, setback zoning for housing, and establishment of buffer strips. We support General Condition 19(c) of the Corps' latest Nationwide Permits (Part III, Federal Register, March 9, 2000). That condition states, "The DE will require restoration, creation, enhancement, or preservation of other aquatic resources in order to offset the authorized impacts to the extent necessary to ensure that the adverse effects on the aquatic environment are minimal. An important element of any compensatory mitigation plan for projects in or near streams or other open waters is the establishment and maintenance, to the maximum extent practicable, of vegetated buffers, next to open waters on the project site. The vegetated buffer should consist of native species . . . ." In riparian ecosystems, those native species should include brush and trees, as well as grasses and forbs.

Review of Proposed Projects

Region 6 supports regulatory agencies that encourage permit applicants to utilize the expertise of engineering consultants that have the necessary level of fluvial geomorphology and stream restoration training and expertise. Training and experience solely with traditional control and containment engineering concepts should not be considered acceptable alternatives unless the consultants have a proven track record of designing and constructing environmentally acceptable projects. Extra caution is appropriate when project planners, designers, and construction companies do not have a record of constructing successful, environmentally sound projects. We also suggest field inspections of some of their past projects and interviews with clients and other knowledgeable parties for the purpose of ensuring the proper expertise is available and will be applied.

Also, regulatory agencies and our field biologists should be wary of practices packaged as "restoration," "soft practices," or "bioengineering." Such approaches can be effective if designed and implemented properly, but improperly designed projects will not pass the test of supporting the streams central tendency to adjust towards the most probable state. Such projects may not properly reduce near bank shear stress; and if they do not, they are likely to fail.

Training Needs

Because of these complex concerns, a USFWS biologist or hydrologist trained in fluvial morphology and stream restoration should review the proposed construction while the project is in the planning stage. This Region supports efforts to train more of our professionals in these subject areas. One appropriate venue for achieving these technical skills is through completion of courses taught by Wildland Hydrology, Inc. Other training options, such as those sponsored by the USFWS' National Conservation Training Center, also should be considered, if they teach principles and techniques that are consistent with this policy. Eventually, all Region 6 instream or streambank projects should be subject to technical approval by staff who have completed the necessary professional training.

Internal Coordination

All bank stabilization projects proposed by Region 6 Project Leaders or supported by USFWS funds (e.g., challenge grants) shall be coordinated early in the planning stages with the applicable State Office of Ecological Services. This direction is consistent with the existing policy stated in the August 29, 1989, memorandum from the Deputy Assistant Regional Director for Refuges and Wildlife, which requires such coordination before Refuge Managers send Section 404 permit applications to the Corps.

Monitoring and Contingency Planning/Funding

Additional information regarding long-term effects to river functions resulting from bank or slope stabilization, streambank armoring, flow deflection, and river energy reduction projects is needed.

Monitoring can provide important information to determine (a) if management objectives are being met; (b) the net impacts on fish, wildlife, and river functions; and (c) means of improving our predictive capabilities for use in reviewing and planning future proposed projects. Furthermore, even well-intended bank stabilization projects sometimes fail because of poor engineering, poor construction, or natural events (e.g., consecutive 100-year floods), and we need to know why.

Therefore, it is essential that the progress of any project that may affect river functions be closely monitored. Region 6 biologists also should recommend monitoring plans as conditions for Section 404 permits where applicable. Reasons for failure and success should be documented and shared with applicable agencies and the public. Permits should be conditioned with habitat objectives and requirements to rectify failures to meet these objectives in a timely manner. Permit applicants should provide assurances that they have the fiscal capability to implement corrective actions shortly after a failure is discovered. Also, field inspections should be conducted to ensure that projects are built according to the authorized specifications. Overbuilt projects need to have the excess materials removed as soon as practicable, and regulatory agencies should fully consider whether enforcement actions are warranted.

Disclaimer

While we hope this policy and the attached guidelines will provide some useful considerations for other agencies and the public, they do not directly apply to anyone but personnel of Region 6 of the USFWS. It does not have any legal standing in and of itself, and it has no legal authority over the actions of external parties.

The U.S. Army Corps of Engineers, Omaha District, in coordination with the States of Montana, North Dakota, and South Dakota, is undergoing cumulative impact studies of bank stabilization on the Yellowstone and Upper Missouri Rivers. Upon completion of the studies and analysis of the information provided, this policy will be updated if appropriate. Also, it is assumed that some field offices may wish to step this policy down into more detailed guidelines for some critical stream reaches. Such efforts should be coordinated early in the development process with the Ecological Services and Water Resources staffs in the Regional Office.

Questions on the policy aspects of this memorandum may be directed to Dennis Buechler, Regional Section 404 Coordinator, at (303) 236-7400, ext. 231, or Dennis_Buechler@fws.gov. Questions on the technical aspects may be directed to Rick Dornfeld at (303) 236-7400, ext. 241, or Rick_Dornfeld@fws.gov. Additional copies may be obtained by contacting Mr. Buechler or writing to the U.S. Fish and Wildlife Service, Ecological Services, P.O. Box 25486, DFC, Denver, Colorado, 80225.

Appendix

Channel Evaluation Model

DEFINITIONS

Anastomose: To connect various stream branches.

Armor: To riprap, bulkhead, or use other rigid methods to contain streams.

Bankfull Discharge: The bankfull stage is the point at which water begins to overflow onto a floodplain. Bankfull may not be at the top of the streambank in incised or entrenched streams. The bankfull discharge is the flow at which channel maintenance is most effective. It is the discharge that is most effective at moving sediment, forming or removing bars, forming or changing bends and meanders, and doing the work that results in the average morphologic characteristics of channels. Commonly (but not necessarily) bankfull discharge can be approximated as the stream discharge having a recurrence interval of 1.5 years, but there is no substitute for field observations.

Bioengineering Techniques: Techniques that utilize live vegetative materials (e.g., root wads, wattling bundles, brush layering, brush mattresses or matting, live stakes and fascine revetments, cedar tree revetments, biologs, and erosion control blankets composed of fiber or plant rolls).

Hard Engineering Techniques: Techniques that employ hard nonliving material such as rock, concrete, soil cement, sand, gravel, and cut timber (e.g., timber bulkhead and dead root wads).

Riparian Buffers: A continuous strip of land that consists of desired native vegetation which is located landward of the stream or river and runs adjacent to a stream or river. A riparian buffer can help stabilize river banks, improve water quality, slow water runoff, and provide habitats for fish and wildlife. In order for riparian buffers to adequately provide the above functions, they should be no less than 50 feet in width.

Soft Engineering Techniques: Techniques that employ a combination of bioengineering techniques and hard engineering techniques in a manner that reduces adverse impacts but provides long-term solutions and re-establishment of at least some of the riparian habitat.

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