ADEQ
Arizona Department of Environmental Quality

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# Streambank Stabilization Management Measures

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# Introduction

Streambank and shoreline protection consists of restoring and protecting banks of streams, lakes, estuaries, and excavated channels against scour and erosion by using vegetative plantings, soil bioengineering, and structural systems.

Streambank erosion is a process that occurs when the forces exerted by flowing water exceed the resisting forces of bank materials and vegetation. Stream erosion refers to the active erosion within a stream channel or adjacent floodplain. The erosion can be the result of lateral instability (bank erosion) or vertical instability (gullying). Underlying causes for streambank erosion are often a result of the removal of riparian vegetation or mechanical channel alterations. Eroding stream banks can be a primary contributor of excessive sediment and other pollutants in rivers, lakes, and streams.

The principal causes of streambank erosion may be classed as geologic, climatic, vegetative, hydrologic/hydraulic, or human induced. These causes may act independently but normally work in an interrelated manner. Direct human activities, such as channel confinement, realignment, and damage or removal of vegetation, are major factors in streambank erosion.

Erosion occurs in many natural streams that have vegetated banks. However, land use changes or natural disturbances can cause the frequency and magnitude of water forces to increase. Loss of streamside vegetation can reduce resisting forces, thus streambanks become more susceptible to erosion. Channel realignment often increases stream power and may cause streambeds and banks to erode. In many cases, streambed stabilization is a necessary prerequisite to the placement of streambank protection measures.

Benefits of Streambank Protection (including but not limited to the following):

- Prevent the loss of land, soil, and vegetation adjacent to a watercourse
- Minimize damage to utilities, roads, buildings or other facilities adjacent to a watercourse
- Reduce sediment loads to streams
- Maintain the capacity of the stream channel and control unwanted meander of a river or stream
- Improve the stream for recreational use or as habitat for fish and wildlife

The following should be considered in planning and selecting the appropriate streambank protection measures:

- Watershed data
- Causes and extent of erosion problems
- Hydrologic/hydraulic data
- Stream reach characteristics
- Soils
- Hydrologic, climatic, and vegetative conditions
- Habitat characteristics
- Environmental data
- Social and economic factors

A maintenance plan should be included with all site plans. The maintenance plan should indicate when inspections of the site will be made and who will be responsible for necessary maintenance. Site inspections, conducted to ensure the stream bank structures are staying in place, are particularly important within the first few months of installation and following storm events, which result in bankfull streams.

Since each reach of a watercourse is unique, stream bank protection techniques must be selected on a site-by-site basis; the specifications for each technique differ. Selection of an appropriate, effective, and efficient best management practice(s) (BMP) should have emphasis on "softer," less rigid structures, and soil bioengineering, a combination of biological and ecological concepts to arrest and prevent shallow slope failures and erosion.

## Cost ranges used in the following streambank protection measures:

- Low - 💰 $0 – 500
- Medium Low - 💰💰 $500 – 1,000
- Medium - 💰💰💰 $1,000 – 5,000
- Medium High - 💰💰💰💰 $5,000 – 10,000
- High - 💰💰💰💰💰 $10,000 +

# Brush Layer

**DESCRIPTION:**
This is a form of soil bioengineering which uses live branch cuttings laid flat into small benches excavated in the slope face perpendicular to the slope contour. Cuttings taken from well-suited species, typically willow or cottonwood, and properly installed, secured by live stakes angled into the slope face at intervals, will root and stabilize slopes. The goal is for natural recruitment to follow once slopes are secured. This stabilization method has the advantage of causing relatively little site disturbance. The up-and-down placement is intended to reinforce slopes in terms of mass stability, to protect against mass shearing and slumping. This technique is most applicable to areas subjected to cut or fill operations or areas that are highly disturbed and/or eroded. Layering provides the best technique to achieve soil reinforcement to resist potential shallow-seated landsliding events. Brush layers act as live fences to capture debris moving down the slope.

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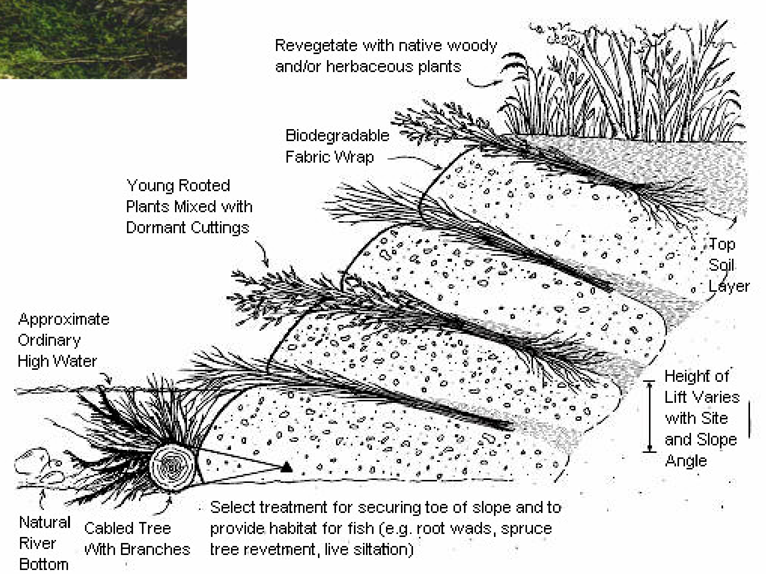

# Brush Mattress

**DESCRIPTION:**
A brush mattress is a layer (mattress) of interlaced live branches placed on a bank face, often with a live fascine and/or rock at the base. The live branches are cut from any adventitiously sprouting woody plant, such as willow, and some species of shrub dogwood or alder. The mattress and the live fascines are held in place with wire or twine, live stakes, and dead stout stakes. A brush mattress is used along the face of an eroding bank and acts principally to armor the bank. The brush mattress has the potential to immediately slow velocities along the bank and accumulate sediment. Together with the sprouting plants, the brush mattress develops a strong network of interlocking roots and plant stems.

**COST:**

# Brush or Tree Revetment

**DESCRIPTION:**
A tree revetment, made by anchoring trees along a streambank, is an inexpensive, effective way of stopping streambank erosion. The trees greatly slow the current along the eroding bank; this decreases erosion and allows silt and sand to be deposited along the bank and within the tree branches. The deposited material forms a good seed bed in which the seeds of river trees such as cottonwood and sycamore can sprout and grow. The resulting trees spread roots throughout the revetment and streambank. By the time the revetment trees have decayed, the bank should be stabilized by the roots of the living trees. As an added benefit, tree revetments provide excellent fish habitat and wildlife cover

This form of soil bioengineering uses uprooted, live trees laid on their sides and secured to the bases of banks along eroded stream segments, tops pointed downstream and overlapped about 30 percent. Species used are those with dense and abundant branching to promote sediment trapping, and those which are decay-resistant. The flexibility of live trees is recommended; limbless trunks should be removed, revetment ends should be anchored at stable points along the bank, and the anchoring system should be chosen according to the bank material to be stabilized and weight of the object to be anchored.

**COST:** $


# Brush Trench

**DESCRIPTION:**
Bundles of willow cuttings are buried in a trench stabilizing the eroding streambank. The sprouting willow cuttings will create a fence to filter sediment and storm runoff eroding into the stream while the roots will develop and stabilize the streambank.

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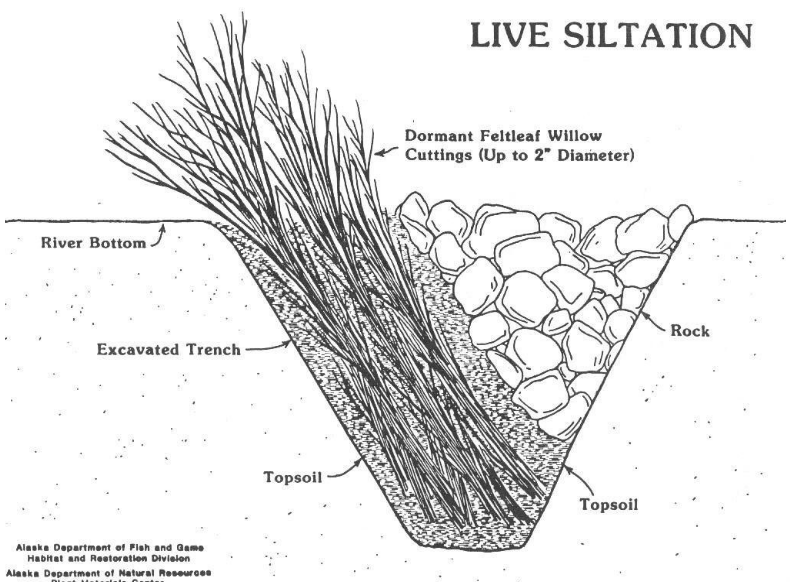


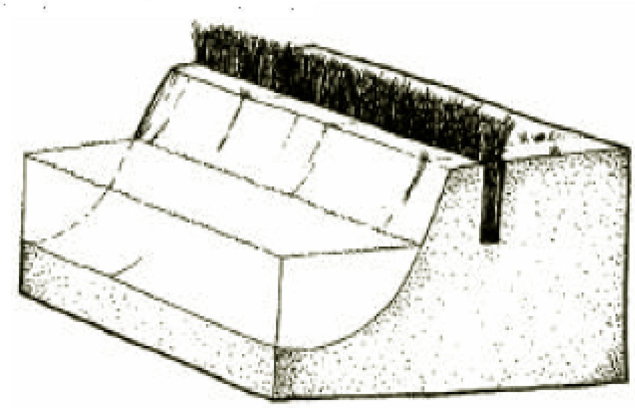

# Cross-Vane Weir Diversion

**DESCRIPTION:**
The V-shaped diversion of this natural weir effectively transports stream flow while maintaining the transport of sediment. The cross-vane is a grade control structure that decreases near-bank shear stress, velocity and stream power, but increases the energy in the center of the channel. The structure will establish grade control, reduce bank erosion, create a stable width/depth ratio, maintain channel capacity, while maintaining sediment transport capacity, and sediment competence. The cross-vane also provides for the proper natural conditions of secondary circulation patterns commensurate with channel pattern, but with high velocity gradients and boundary stress shifted from the near-bank region.

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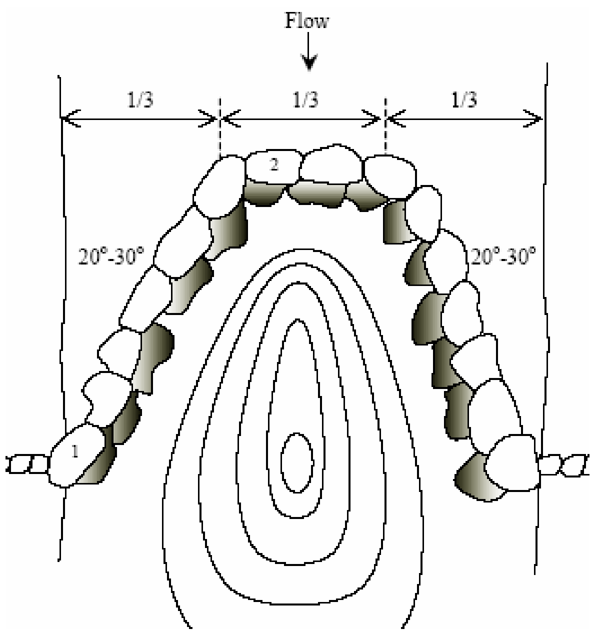


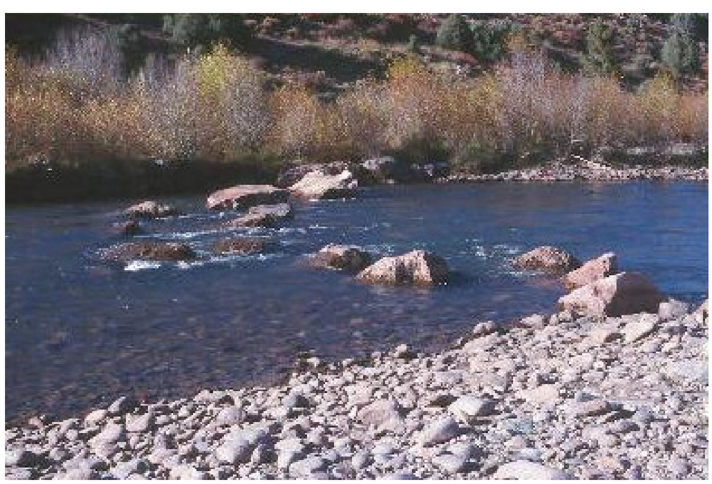

# Erosion Control Fabric

**DESCRIPTION:**
Erosion control fabric will prevent sediment runoff and provide streambank erosion control. During a revegetation project of an eroded streambank, these commercially-available fabrics will allow vegetation to grown into the fabric and seed to be placed underneath the fabric. The mesh fabric allows storm water to penetrate the compost/mulch material readily but holds the material in place to prevent erosion losses, and to facilitate the separation and removal of sediment deposited on the upslope side. It also allows the structure to be moved out of the way and then put back in place readily to let traffic through and to help the structure hold its shape and remain intact if it is run over by trucks or equipment.

**COST:**

# Fascines/Bundles/Wattles

**DESCRIPTION:**
Fascines, or bundles, are groups of dormant branches bound together to create a log-like structure that will root and grow, providing plant cover quickly. The bundle is used to re-vegetate and stabilize slopes, secure the toe of streambanks, or provide a transition from one revegetation technique to another. Bundles are planted in shallow horizontal or vertical trenches and provide immediate physical protection to a site before plant growth begins. Bundles create small shelves that collect native seeds and water

Willows and other softwoods can also be bound together in various ways in order to ensure immediate protection of the streambank. Fascine rolls (also known as wattles) can be constructed with bundles of willow, dogwood or poplar whips and then placed across the slope on the contour. They are set against the bank so that the vegetation, which will take root, touches the ground above the water level and will get sufficient moisture. Covering them with soil improves the contact with the ground and retards their loss of moisture.

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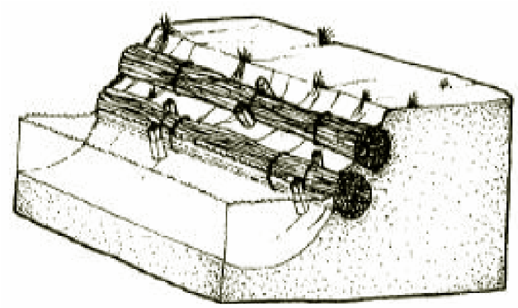

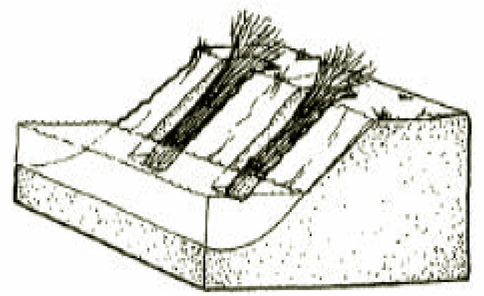

# Fence Barriers

**DESCRIPTION:**
Constructing fences along streambank or strategically placed within watershed will deny access from livestock, people, and wildlife. These fence barriers will reduce gully, rill, and wind. Direct animal contact with surface waters will result in surface water contamination and damage to waterways.

Stream protection with fencing involves the fencing of narrow strips of land along streams to completely exclude livestock. The fenced areas may be planted with trees or grass, but are typically not wide enough to act as streamside buffers. As a result of streamside fencing, remote watering and stream crossings must be provided.

**COST:**

# Filter Strips

**DESCRIPTION:**
Filter Strips are areas of grass or other permanent vegetation that intercept runoff before it enters a water body. Filter strips collect sediment, nutrients and organic materials, and provide wildlife habitat.

The purpose of a filter strip is to provide a buffer between possible contamination sources and water bodies. Herbaceous vegetation will filter runoff water by intercepting or trapping field sediment, organics, nutrients, pesticides and/or other potential pollutants before they are able to reach streams, lakes, or rivers.

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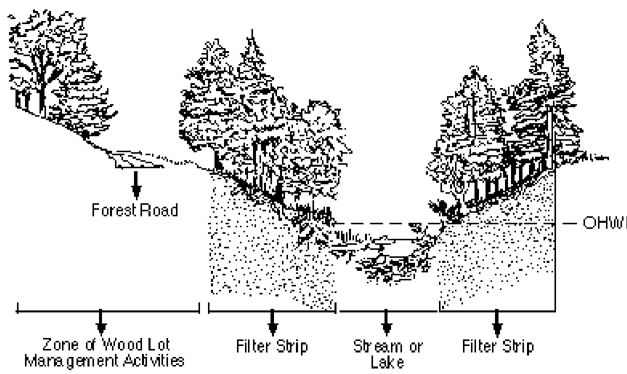


# Grade Stabilization Structures/Biologs

**DESCRIPTION:**
Grade stabilization structures are designed to prevent banks from slumping, reduce the velocity with which water runs off the land, and prevent erosion of a channel that results from excessive grade in the channel bed. Proper grade stabilization, combined with adequately protected outlet structures, can reduce the likelihood that soil will be detached and transported to surface water.

A structure designed to reduce channel grade in natural or constructed watercourses to prevent erosion of the channel from excessive grade or increased channel flows. This practice can prevent head-cutting or stabilize gully erosion. Grade stabilization structures may consist of rock, drop structures, concrete or riprap chutes, gabions, pipe drop structures, diversion ponds, water and sediment control basins, or the use of biologs.

Biologs are made from natural material rolled into structures resembling tree trunks or logs. Biologs can contribute to the protection of the streambank toe or grade by trapping sediment and erosive currents and providing riparian vegetation that may be planted into biolog.

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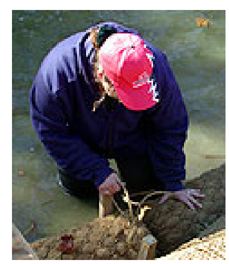
## Grade Stabilization Structures/Biologs (cont.)



# Grazing Management

**DESCRIPTION:**
Grazing management is based on basic scientific knowledge about the interaction of grazing animals and plants. Grazing management that elevates the health status of vegetation on grassland ecosystems will produce healthy plant communities, quality habitat for wildlife, reduce soil erosion, improve soil composition, and produce stronger livestock performance.

One key to improving grassland ecosystem health is implementing grazing management practices that meet the biological requirements of the plants. Meanwhile, coordinating grazing periods with vegetation growth stages will stimulate beneficial processes within plants and the ecosystem.

Proper grazing management techniques include combinations of exclusion, seasonal rotation, rest and/or mechanical treatments

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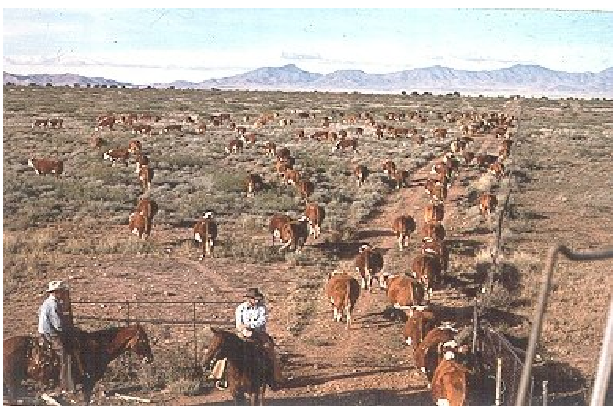

# Invasive Species Removal

**DESCRIPTION:**
Invasive species are non-native, adventitious species capable of moving aggressively into a habitat and monopolizing resources such as light, nutrients, water, and space to the detriment of other native species, or species that reached its location without assistance from humans. Non-native and exotic species spreads rapidly, alter the water table and soil nutrients, exclude native species, and provide a poor food source for native birds, insects, and rodents.

Invasive species can aggressively spread over large areas, effectively out-competing and eliminating native vegetation. Detection and removal of these invasive species is a critical component to manage the destabilization of stream channels, protect soil, improve water quality, enhance stream flow, and restore native habitat.

The non-native limbs and debris can be chipped into mulch, and used to carpet the streambank and/or riparian trails. On the ground, monitoring in the years following removal will identify where additional removal and re-vegetation will be necessary.

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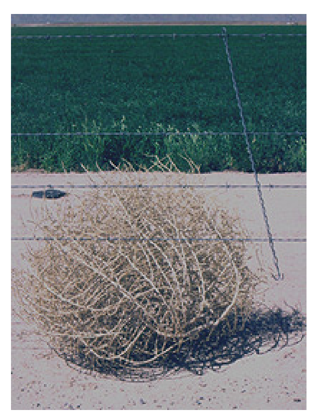

# Live Staking

**DESCRIPTION:**
Live staking is used to reestablish streambank vegetation and help stabilize selected slope areas. This form of soil bioengineering involves the planting of live cuttings from shrubs or trees along the streambank and is also known as woody cuttings, posts, poles or stubs. As cuttings develop, they protect streambanks from erosion while minimizing sediment and associated nutrient impacts downstream. Established cuttings also moderate bank and water temperatures, facilitate colonization of other species, and provide forage.

Stakings provide long-term streambank stabilization with delayed initial onset and are best used as part of a system which includes immediate means of buffering banks from erosive flows (e.g. tree revetments, which can actually accrue sediments), a component to deter undercutting at the bed/bank interface (e.g. riprap or gabions) and a means of reducing the energy of incoming flows at their source.

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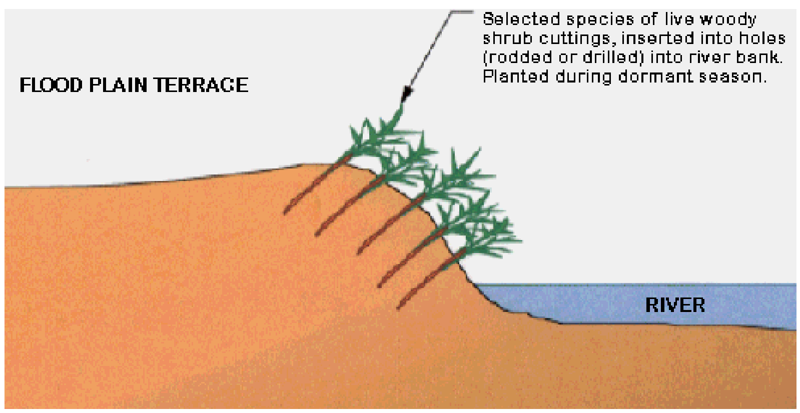


# Riprap

**DESCRIPTION:**
Riprap consists of a layer of angular stone designed to protect and stabilize areas subject to erosion, slopes subject to seepage, or areas with poor soil structure. Riprap is used on streambanks where stream velocities are too great to successfully establish vegetative cover, on channel bottoms and slopes, stormwater structure inlets and outlets, slope drains, and shorelines.

Stones should be of sufficient size to resist washing downstream. Larger rock should be placed at the bank bottom below the baseflow elevation. Rock should be underlain by a filter blanket of gravel, sand and gravel, or synthetic material to prevent soil movement into or through the riprap. It is most effective when used as part of a system which includes a means of reducing the erosive potential of incoming flows at their source, despite the fact that riprap is detrimental to wildlife and their habitat.

**COST:** $ $ $ $

# Road Stabilization

**DESCRIPTION:**
This management practices requires the use of rock, vegetation, and/or geotextiles to enhance the stabilization of roads and other embankments. Stabilizing embankments reduces sediment inputs from erosion and protects infrastructure while preventing excessive stormwater from entering the embankment and encompassing stream.

Traditional stabilization relies on the use of expensive rock treatments. Other options are available that include the use of erosion control fabric, toe rock, and revegetation to stabilize banks.

Planning considerations include the height and slope of the bank, the climate, and value of the road or infrastructure. In general, hardening the bank with rock riprap is the most costly approach. Often the installation of native plant materials can reduce erosion runoff and stabilize the soils. Erosion control cloth can be used to temporarily stabilize the bank until vegetation is established.

**COST:** 💰 💰

# Rock Vane/Barb

**DESCRIPTION:**
Rock vanes and barbs are constructed rock structures (or logs) created to slow flood waters near the banks and increase flood velocities in the channel center. Vanes and barbs convey flow away streambank reducing the channel slope and stream velocity. This protects stream banks from erosion and helps the stream scour the center channel for better sediment transport.

**COST:**

# Rootwad Revetments

**DESCRIPTION:**
Tree rootwad revetments are created from uprooted live hardwood trees. These are cut into segments, the bottom segment containing the root mass is placed into an excavated hole in the bank trunk-first and protruding perpendicular to stream flow, the hole is backfilled, and remaining segments are used as footer logs to protect the base.

A rootwad is the lower trunk and root fan of a large tree. Individual rootwads are placed in series and utilized to protect stream banks along meander bends.  A revetment can consist of just one or two rootwads or up to 20 or more on larger streams and rivers.

Rootwad revetments have the potential to greatly enhance in-stream habitat and protect the streambank from erosion. Rootwad revetments promote the formation of pool habitat along the outside of meander bends and the root fan portion of the rootwads provides overhead cover for the pools

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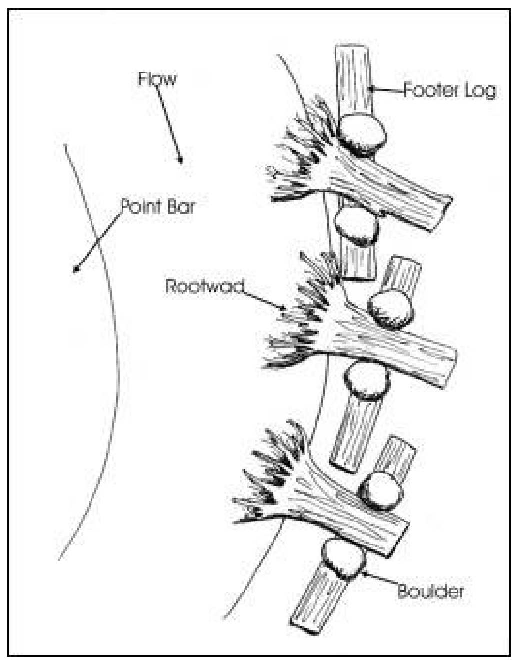


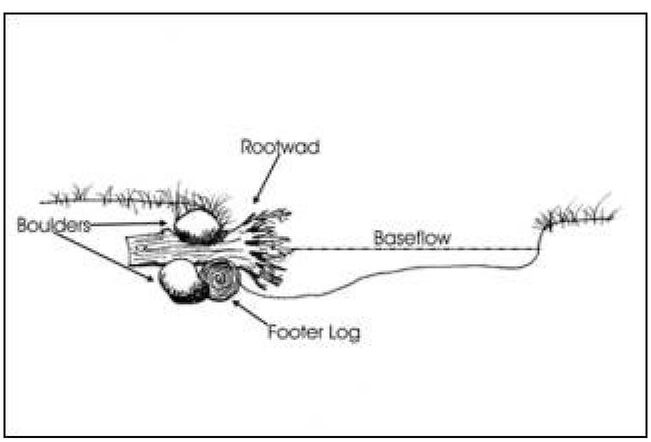


# Sediment Barrier/Silt Fence

**DESCRIPTION:**
A sediment barrier consists of a permeable barrier designed to detain sheet flow of stormwater runoff from disturbed soil along a slope. This barrier contributes to settling some suspended solids from the detained water above the structure while allowing slow passage of the water through a filtering material. All sediment barriers should be installed along the contour, perpendicular to runoff flow, with each end curving gently up-slope enough to capture and pool the design volume of runoff during a storm event. Typical sediment barriers used for streambank protection are silt fences, brush, hay, straw bales, filter berm, and dikes.

A silt fence is a temporary sediment barrier consisting of geotextile filter fabric buried at the bottom, stretched, and supported by metal posts, designed to retain sediment from small disturbed areas by reducing the velocity of sheet flows. Like all sediment barriers, silt fences also should be installed along the contour, perpendicular to runoff flow, with each end curving gently up-slope enough to capture and pool the design volume of runoff. They should not be used on steep slopes or in channels or swales. Silt fencing is pre-fabricated and ready for immediate installation. It has numerous unique features and when installed correctly, the sediment control structures in silt fence functions both as a filter and checks velocity of run-off flow.

**COST:**


# Sloped Drain

**DESCRIPTION:**
A sloped drain will divert drainage from the top to the bottom of a cut or fill slope for the purpose of conveying concentrated runoff down the slope face without causing erosion. Stormwater runoff flowing over steep slopes can be very erosive, in addition to, destabilizing streambanks. A sloped drain will decrease riparian sediment erosion by using pipes or conduits designed to transport water from one elevation to a lower one without erosion. These are generally used in conjunction with diversions or tailwater recovery systems to convey runoff down a slope until permanent water disposal measures can be installed.

**COST:**

## Stream Channel Stabilization

**DESCRIPTION:**
Stream channel instability is commonly a result of increased flows due to runoff from storms, roads, upland disturbances, and human interferences. This practice potentially includes realignment of stream channels, as well as, widening floodplains, and stabilizing grades. The reconstruction or restoration of a stream reach and/or channel re-alignment can also be accomplished using fill materials (riprap), concrete, fabricated structures, or a variety of bioengineering practices. This practice significantly reduces sediment input to a system and jump starts the riparian recovery process. All sources contributing to channel instability should be identified before considering channel treatment.

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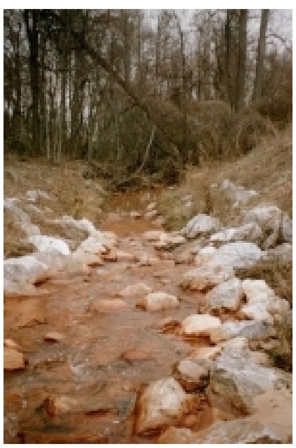

# Tailwater Recovery

**DESCRIPTION:**
Tailwater recovery is a conservation management action that collects, stores, and transports surface water runoff (tailwater) for reuse. This practice decreases irrigation consumption and surface water contamination due to pesticides, nutrient loading, and suspended sediment. Additionally, tailwater recovery can reduce channel erosion and destabilization of stream morphology.

The most common type of tailwater recovery system is the “sequential use system” that collects tailwater for use on lands at lower elevations. “Sequential use systems” usually flow by gravity into and out of a pond, canal, or farm delivery ditch and are reused as needed.

The size, capacity, selection and location of equipment, and facilities for these systems depend on the type of irrigation system, irrigation practices and goals, and topography.

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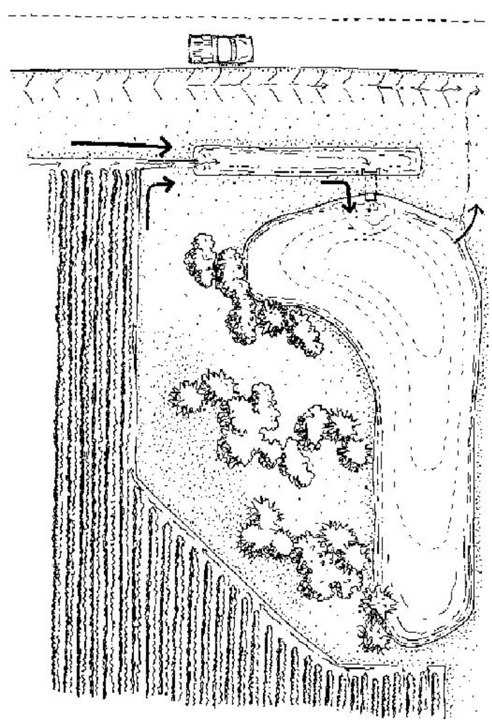

# Toe Rock

**DESCRIPTION:**
Rock (riprap) can be layered at the toe of the stream as an armoring technique to provide additional strength to stream banks. This will reduce the scouring of the toe and banks in high velocity flows. Layers of rock should be placed from the toe extending up to bankfull elevation. Toe rock can be even more effective when combined with bioengineering practices such as brush trench, live staking, planting, and seeding.

By using a trench extending below the stream scour level, variety of rocks sizes layered upward will withstand stream forces, reduce erosion, and stabilize the streambank. Fabric can be installed behind the rock to keep stream flows from washing out soils behind the structure.

**COST:** 💰 💰

# Vegetation/Seeding

**DESCRIPTION:**
Vegetation is probably the most commonly used tool for streambank protection. Vegetation has the advantage of being self-propagating and self-repairing. Emergent vegetation provides two levels of protection. First, the root system helps to hold the bank soil together and increase overall bank stability by forming an interweaving network. Second, the stalks, stems, branches and foliage provide resistance to streamflow, absorbing flow energy rather than deflecting it as hardened structures do or allowing it to erode soil particles. Vegetative cover above the waterline protects the banks from rainfall, runoff, and trampling forces.

Vegetation also provides water quality benefits by causing settling of particulates and absorbed pollutants, removing nutrients directly from the water column, and assimilating nutrients from the soil. Native species should be used and their water requirements should be matched to the zones in which they are placed.

Vegetation seeded above the waterline should typically be spread in a matrix such as a hydro-mulch, or sprigged. The range of successful applications can be expanded by using vegetation in conjunction with other streambank protection measures, such as geo-grid pavers, riprap, geotextile or biodegradable mats and rolls, or the use of other bioengineering methods.

Seeding can be used where appropriate. Seeding and mulching are not appropriate in areas of flooding, high water flow or rapid changes in water depth, as the mulch and seed will be washed away. Proper seedbed preparation, fertilization and irrigation may be needed to assure seedling survival. Two types:

- Permanent - Establishment of perennial vegetative cover with seed to minimize runoff, erosion, and sediment yield on disturbed areas. Disturbed soils typically require roughening and amendment with a nutrient source. Seeding should be done together with mulching. Seed mixtures are typically most effective, and species vary with preferences, site conditions, climate, and season.

- Temporary - Planting rapid-growing annual grasses, small grains, or legumes to provide initial, temporary stabilization for erosion control on disturbed soils that will not be brought to final grade for more than approximately one month. Seeding is facilitated by nutrient addition and surface roughening. Broadcast seeds must be covered by raking or chain dragging, preferably after mulching; hydroseed mixtures are spread in a mulch matrix.

**COST:** 

## Vegetation/Seeding (cont.)

# Watering Facilities

**DESCRIPTION:**
Providing adequate access to watering facilities rather than directly from streams will greatly reduce erosion to streambanks. Watering facilities such as tanks, troughs, watertight containers, or concrete perimeter retention ponds provide low impact access to water. Livestock/Wildlife watering facilities in selected areas that do not disturb riparian habitat protect and enhance vegetative cover, provide erosion control through better grassland management, protect water quality and water supplies from contamination.

**COST:**

# Weir

**DESCRIPTION:**
Built from rocks, logs, or other sturdy material, weirs reduce stream velocity and prevent gully erosion due to channelization. This is done by concentrating flows in the center of the channel. Weirs can provide improvements to water quality, as well as, habitat enhancement. Weirs are most successful in streams with lower discharge.

Benefits of weirs include formation of pool habitat, collection and holding of spawning gravels, promotion of gravel bar/riffle formation, trapping suspended sediments, re-oxygenating water, allowing organic debris deposition, promotion of invertebrate production, and can distribute water for off channel watering facilities.

**COST:**

# References


## Documents:

Engineering Field Handbook, Chapter 16, Streambank and Shoreline Protection. 1996. NRCS.

Engineering Field Handbook, Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction. 1996. NRCS.

Bioengineering for Streambank Erosion Control, Appendix B.

Handbook of Best Management Practices. State of Nevada Conservation Commission and Department of Conservation and Natural Resources.

A Manual of Conservation Practices to Reduce Pollution Loads Generated from Nonpoint Sources. 2004. Tetra Tech.

Biotechnical Streambank Protection. 2002. USDA.

## Websites:

Alternative Stream Research
http://www.tostreams.org/

Pickaway SWCD
http://pickaway.oh.nacdnet.org/photo_gallery/streambank.htm

TTI: Environmental Management
http://tti.tamu.edu/enviro_mgmt/projects/1836/demonstration_project.stm

1997 Conservation/Restoration Projects Completed
http://www.portup.com/~lindq/1997proj.html

Agroecology Issue Team of the Leopold Center for Sustainable Agriculture
http://www.buffer.forestry.iastate.edu/HTML/bankstabilization.html

Practical Stream Management
http://riverwatch.missouri.org/practical.html#value

http://www.michigandnr.com/publications/pdfs/huntingwildlifehabitat/Landowners_Guide/Habitat_Mgmt/Wetland/Streams_Rivers.htm

http://www.buffer.forestry.iastate.edu/Virtual_Risdal_Tour/Site_11/stop_11.htm

http://www.co.fairfax.va.us/nvswcd/snakedenbranch.htm

http://www.watershedrestoration.org/news/happen.htm