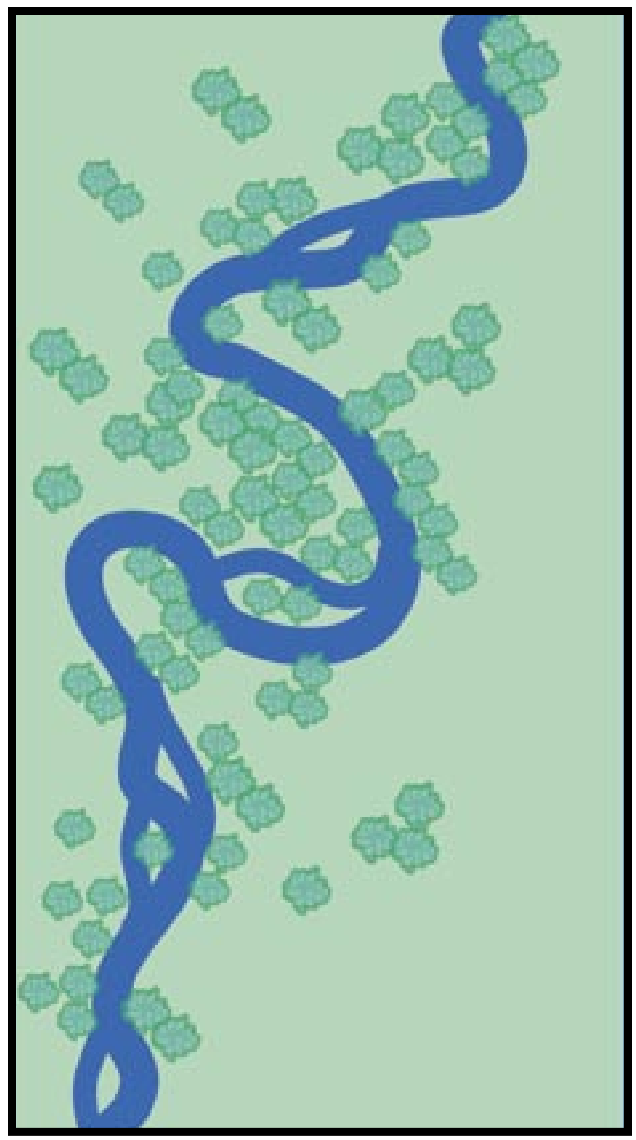
Learning to Go with the Flow

Streams and Bank Stabilization

Spring 2002

One of the key ways that people impact Montana's rivers and streams is by stabilizing their banks—more and more weirs, riprap, barbs, and other structures are lining our riverbanks. This publication is a quick guide to the most common bank stabilization structures being used in Montana. It describes what the structures look like, how they work, and lists their possible impacts on natural stream processes. Finally, it offers a series of practical actions that can help to preserve and, in some cases, improve the health of Montana's precious waterways.



Streams and Rivers Need Room to Move

In order to understand how bank stabilization structures impact our rivers and streams, it is important to know the basics about how streams function. They are dynamic systems that are meant to flood—and they must have room to move. Stream corridors are a complex network of water, land, plants, and animals.

Many rivers and streams found in Montana's valleys and plains meander, sweeping and snaking across the landscape. If given space, the bends in meandering streams naturally and slowly migrate. This meandering tends to create a pattern in which outside bends are dominated by cut banks (caused by erosion), and inside bends are dominated by gravel bars (where sediment is deposited). This process, in combination with the moist, often wet soils and high water table found next to streams, creates a corridor called a riparian area.

A river's floodplain is often defined by riparian vegetation, which is adapted to growing in this dynamic system. Plants associated with riparian areas include cottonwoods, willows, dogwood, alder, sedges, forbs, and cattails. Healthy, functioning floodplains, with their full complex of riparian vegetation, serve many useful purposes, including:

- Reducing flood heights by soaking up, storing, and slowly releasing floodwaters;
- Decreasing stream velocities and soil erosion;
- Improving water quality by filtering and reducing nutrients, pesticides, salts, sediments, organic wastes, and other pollutants running into our streams and, ultimately, our drinking water; and
- Providing the most diverse fish and wildlife habitat found in Montana.

Riprap, Rootwads, Revetments, and More

When someone buys a piece of land, they usually expect their property line to stay in the same place it was on the day the land was purchased. If the piece of land is located on a stream or river, this principle does not work—because streams and rivers are dynamic: banks erode and material is deposited elsewhere, new channels are cut, and old channels dry up. Although erosion is natural, erosion levels can be accelerated above natural rates because of human-caused activities, such as removal of riparian vegetation, bank stabilization, or upstream manipulation of stream channels. Increasingly, landowners are turning to bank stabilization in an attempt to control streams to protect their property from both natural and human-caused erosion. Measures used to stabilize banks are generally classified into three categories: **armor**, **channel structures,** and **vegetative methods.**

Armor comes in two forms: bank armor and levees. **Bank armor** is a blanket of resistant material that is placed along the streambank, extending into the stream. Riprap is a common form of bank armor. When water hits the hard surface of riprap, the water cannot scour the riverbank, thus erosion is reduced. **Levees** are structures composed of rock or fill material constructed within the floodplain. They constrict and concentrate the erosive force of flood flows.

Channel structures are walls built into the active channel of a stream. Their purpose is to steer the fastest portion of a stream's current away from the eroding bank. Barbs, jetties, vanes, and weirs are in this category. These structures are sometimes favored over bank armor because they use less rock, can be less disruptive to natural stream functions and riparian habitat, and can allow a stream to use more of its floodplain. Though channel structures can be less damaging than bank armor, they can contribute to a more serious problem because of the cumulative effects of channelization, discussed below.

Vegetative methods generally involve tree trunks fixed into banks at angles so that they redirect the swiftest portion of a stream's current away from the bank. They also stabilize banks. Rootwads, tree revetments, and live vegetation are included in this category. Although rootwads and tree revetments are "softer" than riprap or channel structures, they fundamentally do the same thing: disrupt natural stream functions to reduce erosion of banks. Planting native riparian vegetation is the measure most in harmony with the natural functions of a stream.

The number, location, spacing, angle, size, and height of all of these structures vary, depending on the stream type and conditions, the landowner, and the consultant/engineer involved. The most common material used for bank armor and channel structures is large rock. In addition, gabions (*defined below*), concrete, logs, and (rarely) sand bags are used. Broken concrete is discouraged because it often contains toxic paint, petroleum products, rebar, and similar contaminants that are illegal to place in Montana's streams and rivers. In the past, car bodies and tires were used.

One Thing Leads to Another

Landowners use barbs, riprap, and other structures to prevent rivers and streams from using their floodplains and changing their courses. While this may sound reasonable and harmless, the consequences for our rivers can be serious. While a few barbs or a short stretch of riprap will not significantly impact a stream, ten barbs in a row can turn a river to hit the opposite bank, a long stretch of riprap can cause serious erosion downstream, and the combination of many projects can cause channelization.

Currently there is increasing public attention focused on the way government agencies are allowing more and more bank structures to armor our riverbanks. In 2000, a study done in Billings on the Yellowstone River concluded that bank stabilization structures now cover 41% of the 30-mile research area, double the amount found in 1957. A similar study performed in 1998 on the Yellowstone River in Park County (Livingston area), found that 21% or 22.2 miles of this portion of the river was lined by bank stabilization structures.

As more bank stabilization structures are built, both short-term and long-term consequences arise. In the short-term, stabilization measures tend to physically stabilize one local stretch of riverbank or divert flows away from one bank to another. This can trigger increases in river flow velocities, exacerbate downstream bank erosion, and lead to further instabilities downstream. In other words, preventing natural erosion at one location can significantly increase erosion downstream of the project. Therefore the "problem" is neither controlled nor solved, but merely relocated from one spot to another, negatively impacting downstream landowners. Increased downstream erosion often causes affected landowners to put in structures to protect their property—and the cycle repeats itself over and over again.

Over the long-term, bank stabilization can cause the channelization of our rivers and streams as floodplains narrow or disappear, natural stream migration is prevented, and, ultimately, riparian vegetation does not regenerate. Channelization also impacts the health of rivers and streams by: exacerbating the severity, duration, and frequency of local flooding events and erosion downstream; preventing the maintenance and formation of sandbars and backwater areas; and degrading critical fish and other habitat required in aquatic systems. At a time when government agencies and the private sector are spending billions of dollars each year to address these issues, it seems "a penny wise and a pound foolish" to eliminate the natural features that provide these same services at practically no cost.

What's a Person to Do?

As property values increase along our streams, the demand for bank stabilization projects is increasing. The solutions to reverse this trend are complicated and not always obvious:

- Set buildings back away from streams—and support land-use planning that requires all structures to be built a set distance from a stream. Setbacks should incorporate floodplains, as well as non-floodplain areas: a common problem arises when homes are built overlooking a river, then landowners stabilize the bank below to prevent their homes from eventually falling into the water.
- When bridges are built or reconstructed, advocate increasing their span or relocating them so that bank stabilization is not needed to protect either end of the bridge. (When bridges are constructed too narrowly, streambanks are lined with riprap.)
- Avoid projects that remove native shrubs and other woody plants from the streambank and adjacent floodplain. If vegetation is disturbed by a project, insist that native riparian plants are planted (and established) when the project is complete. Don't plant lawns or other non-native vegetation along stream banks.
- Support programs that restore the ability for natural stream processes to function, including easements purchased that allow flooding and stream meandering, and programs that remove old bank stabilization structures.
- If bank stabilization is deemed necessary, confine it to the shortest possible length of stream and use techniques that fit the stream type and have the least impact.

The Definitions

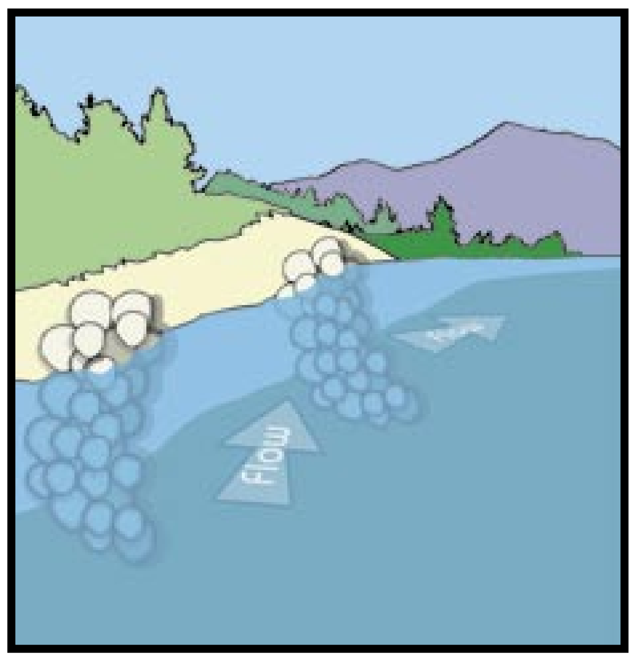
The following section describes the most common bank stabilization structures used in Montana. In addition, definitions are included for a few additional important terms: channelization, floodplain, ordinary high-water mark, and riparian. All definitions are guidelines, because the terms are not standardized and different people (including engineers) may call the same structure different things. For more technical publications, contact the U.S. Army Corps of Engineers or the Montana Association of Conservation Districts.

Barbs and Vanes

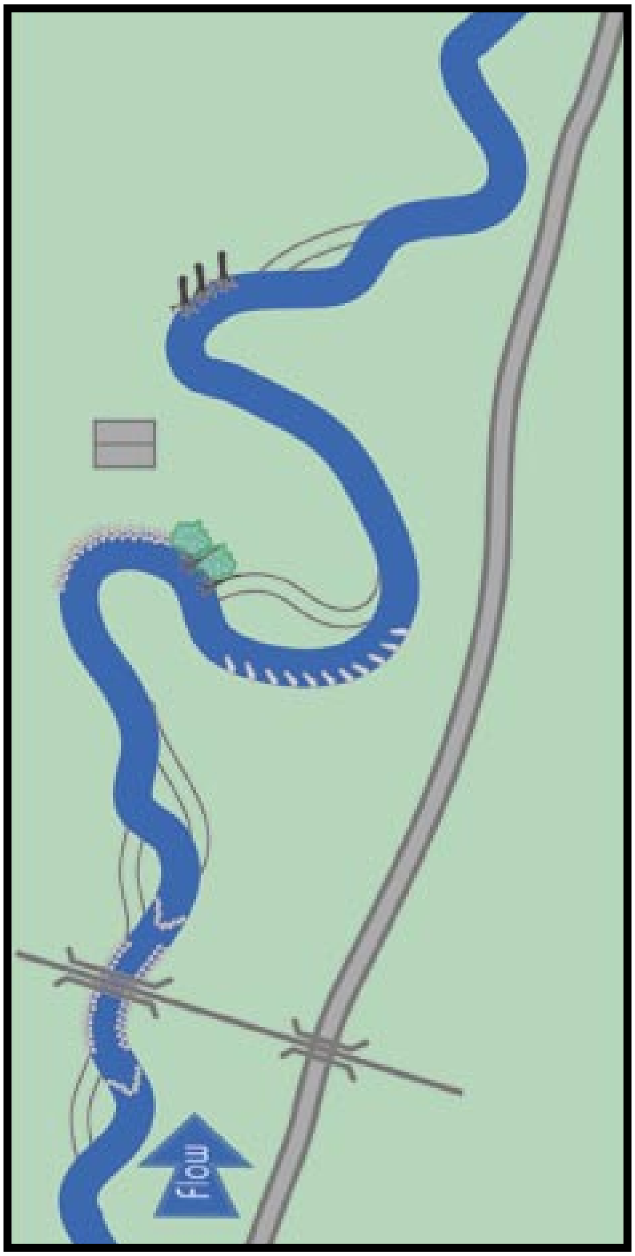
Description: Narrow structures, usually constructed of rock, that are attached to the eroding side of the riverbank. Barbs are anchored into the bank and can extend to the far side of the main channel of the river. They are always angled upstream, usually at a 20˚ to 30˚ angle. At the bank, barbs are usually built as high as the river's ordinary high-water mark; from there they angle downward to the bottom of the river. On major Montana rivers, barbs are usually constructed in a series, typically spaced 75 to 150 feet apart. Sometimes a J-shaped hook is built on the end of the barb.

Relationship to Similar Structures: The term "barb" can be interchangeable with the terms vane and bendway weir. A short barb can be called a "hard point." Barbs are lower in construction, require less rock, and cause less stream disturbance than jetties. A barb is sometimes referred to as a dike.

How It Works: Water flows over a barb and is then directed away from the eroding shoreline.



Impacts: Barbs contribute to the channelization of rivers. They can cause problems for other landowners by deflecting the current against opposite or downstream banks and initiating new erosion. Located in sequence, they can "turn" a river to hit the opposite riverbank. Barbs can also cause increased scouring, channel shifts, scalloping of the bank, and destructive eddies. During low water, barbs may be a hazard for boaters to navigate.



Channelization

Description: Straightening of a stream by eliminating or shortening the stream's natural meanders. Bank stabilization structures and/or the dredging of a stream channel can result in channelization. Today, channelization occurs most often as a result of the cumulative effects of multiple bank stabilization structures built along a river.

How It Works: Meandering serves to slow down the river's current. Removing meanders causes an increase in the speed of water, which causes down-cutting of the channel and an increase in the stream's slope.

Impacts: Because of faster water speeds, down-cutting, and increased slope, channelization: increases erosion downstream as faster moving water hits downstream banks; reduces the size of the stream's natural floodplain, because the down-cut channel holds more of the flood flows—so less water overflows the banks; increases the intensity of flooding downstream, because the channel is holding more water moving at faster speeds; reduces the storage capacity of the riparian areas surrounding the stream, which in turn can reduce the recharging of ground water from the floodplain; lowers streamside groundwater tables, thus affecting the ability of riparian vegetation to reach water; degrades fish habitat because of lost riffles, pools, and other habitat needs; and more. Finally, because of all of the above-described consequences, channelization creates expensive restoration projects—as people try to correct the problems they have created.

Multiple bank stabilization structures built on a stream can lead to channelization.

Dikes

Description: The term "dike" has two meanings in the world of bank stabilization. In the first definition, which is more commonly used by the layperson, the term describes an earthen wall constructed on the riverbank to control or confine water, such as a levee. This type of dike can be constructed directly on the riverbank or set back from the river. In the second definition, which is more commonly used by engineers, the term describes a structure that extends from the bank into the river to redirect water flows, such as a barb or jetty.

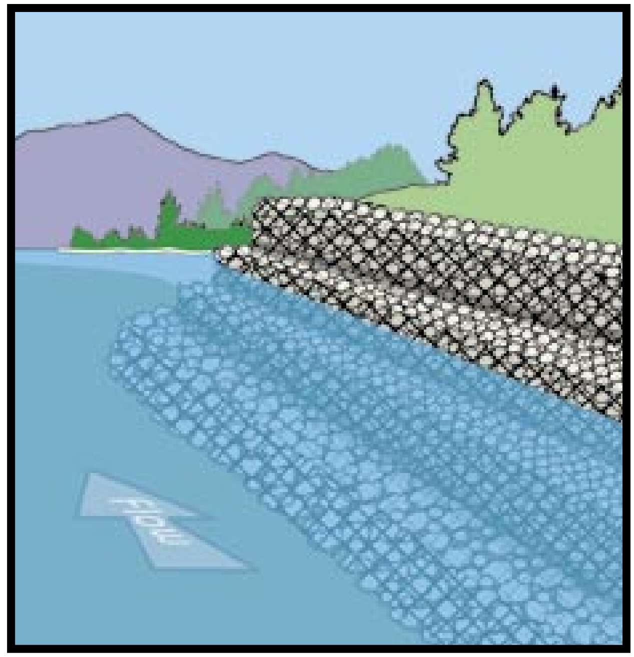
How It Works/Impacts: *Because of differences in definition, see specific definitions of levees, barbs, and jetties.*

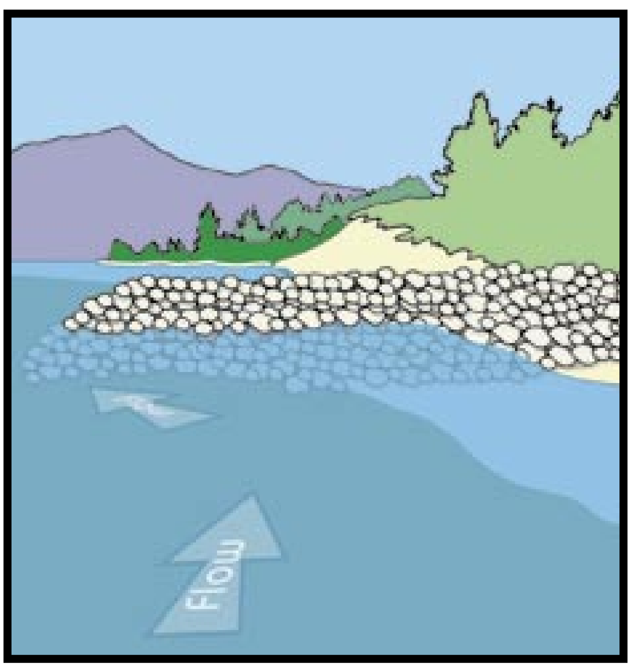
Floodplain

Floodplains are the low land adjacent to a stream or river that is covered with water when the river overflows its banks at flood stages. The 100-year floodplain is defined as the area adjoining a stream that is likely to flood on the average of every 100 years; or more precisely, the area of land that has a 1% chance of being flooded in any given year.

Gabions

Gabions are rectangular rock-filled wire baskets. Gabions, themselves, are not bank stabilization structures, but they are used to construct them. They can be used to construct riprap, retaining walls, and sometimes a structure like a jetty. Gabions are often used in locations where larger rock is not readily available. They are susceptible to failure due to natural corrosion of the wire basket, or abrasion by river sediments or ice. Gabions are more commonly used to protect lakeshore property than riverfront property.





Jetties

Description: Narrow structures, usually constructed of rock, that are attached to the eroding side of the riverbank. Jetties are anchored into the bank and can extend into the main channel of the river. They are built so they extend above the river's ordinary high-water mark for a distance, before angling downward to the river bottom. Jetties are oriented upstream, downstream, or perpendicular to the bank (with perpendicular the most common orientation). They can be constructed in a series.

Relationship to Similar Structures: Jetties are taller, require more rock, and cause more stream disturbance than barbs, vanes, or bendway weirs. A jetty can also be referred to as a dike.

How It Works: Flowing water hits the jetty and is then forced to go around the structure and away from the eroding bank.

Impacts: Jetties contribute to the channelization of rivers. They can also cause problems for other landowners by deflecting the current against opposite or downstream banks and initiating new erosion. Located in sequence, they can "turn" a river to hit the opposite riverbank. They can also create large scour holes on the downstream side of the jetty that can erode large reaches of stream banks. Jetties may be a hazard for boaters to navigate.

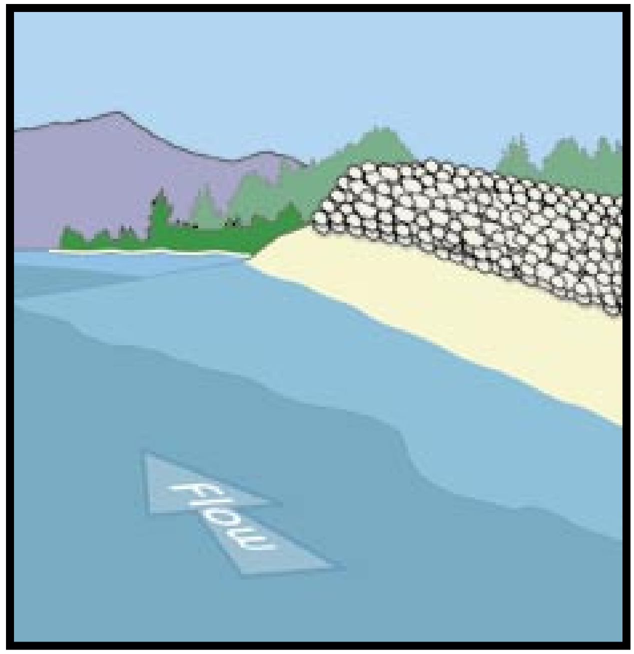
Levees

Description: Long, narrow earthen walls built in the floodplain above the ordinary high water mark. If set back from the river channel, levees allow the river to access a portion of the natural floodplain. They are often built as barriers to protect buildings, other structures, or agricultural property.

Relationship to Similar Structures: A levee is sometimes referred to as a dike. If built of concrete or masonry, the structure is referred to as a floodwall.

How It Works: Levees are used to restrict a river to a narrow area during a flood.

Impacts: Levees contribute to the channelization of rivers. They can increase water speed during flooding; reduce or eliminate storage of water on the floodplain; increase erosion and flooding downstream; deprive the floodplain of water and sediment; and, by giving a false sense that the flood hazard is alleviated, encourage development directly behind them. They also reduce the area in which sediment and water-transported seeds are deposited, thus reducing the size and richness of riparian areas.

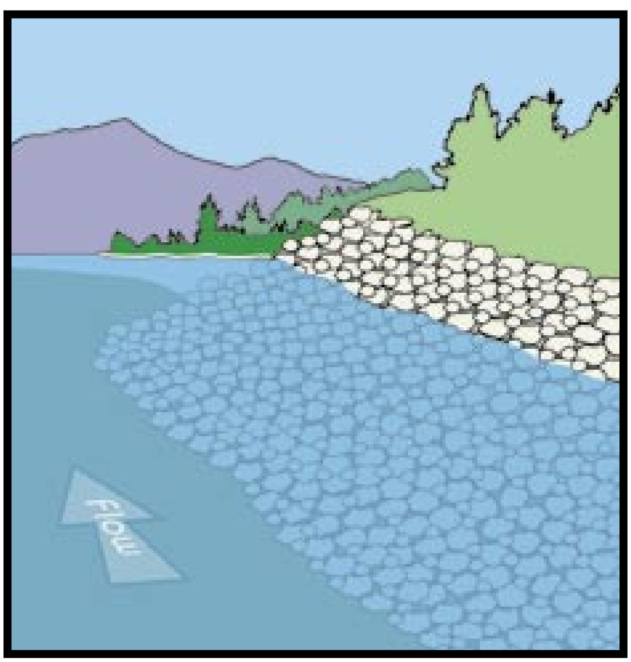


Ordinary High-Water Mark

"The line that water impresses on land by covering it for sufficient periods to cause physical characteristics that distinguish the area below the line from the area above it." A lack of most terrestrial plants is a "characteristic of the area below the line." "A flood plain adjacent to surface waters is not considered to lie within the surface water's high-water marks." (Source: Title 23, Chapter 2, Part 3, Montana Code Annotated.)

Riparian

This term means "related to, living on, or located on" the bank of a stream or lake. Riparian areas occur along the shorelines of streams, rivers, lakes, and reservoirs. Some are narrow bands stretching along mountain streams, others stretch thousands of feet beyond the water's edge across broad floodplains. Plants associated with riparian areas include cottonwoods, willows, dogwood, alder, sedges, forbs, cattails, and more.



Riprap

Description: Riprap is a blanket of durable material, usually rock, placed along the bank of a stream and extending below the ordinary high water mark.

Relationship to Similar Structures: Riprap is a type of revetment; it is sometimes called a rock revetment (*see Tree Revetment below*).

How It Works: Riprap prevents erosion because the force of the stream's water hits the riprap and cannot scour the soil along the bank. It is durable and resistant to scouring from water and ice.

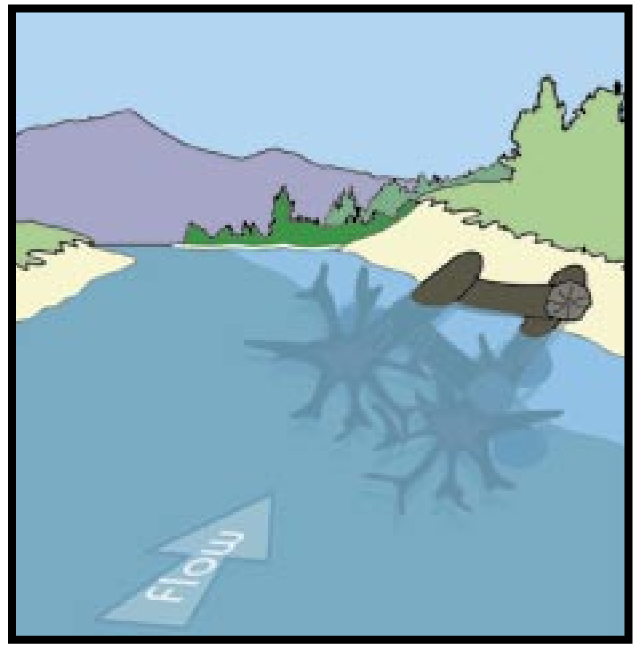
Impacts: Riprap contributes to the channelization of rivers by reducing the ability of a stream to dissipate its energy laterally through erosion, thus increasing stream velocity. This transfers the energy of the stream vertically and downstream, causing streams to dig deeper channels (or "entrench") and increase bank erosion downstream where there is no bank stabilization structure. Riprap can also decrease water quality because pollutants entering the stream from runoff cannot be absorbed; destroy or replace natural vegetation on the bank; significantly degrade fish habitat along the channel; and prevent the natural meandering of rivers. In some instances, however, large angular rock can provide pockets of water for adult fish.

Rootwads

Description: Eight- to 20-foot lengths of tree trunks with good-sized root systems placed on streams and smaller rivers. Each trunk is buried into the bank and the root mass extends out into the water. Rootwads are usually placed in a series. The trees are buried low enough in the stream so that the root systems remain covered during low water. Rootwads are often used with logs and boulders to line a bank.

How It Works: When the water hits the root system, it slows down, lessening erosion.

Impacts: Rootwads contribute to the channelization of streams. They are less damaging to streams than riprap. Although rootwads discourage bank erosion, they encourage the water to scour the streambed instead. When installing rootwads, it is important that riparian vegetation and their root systems are not destroyed. If incorrectly designed, a rootwad system can increase erosion and scouring rates, resulting in the eventual loss of the system.

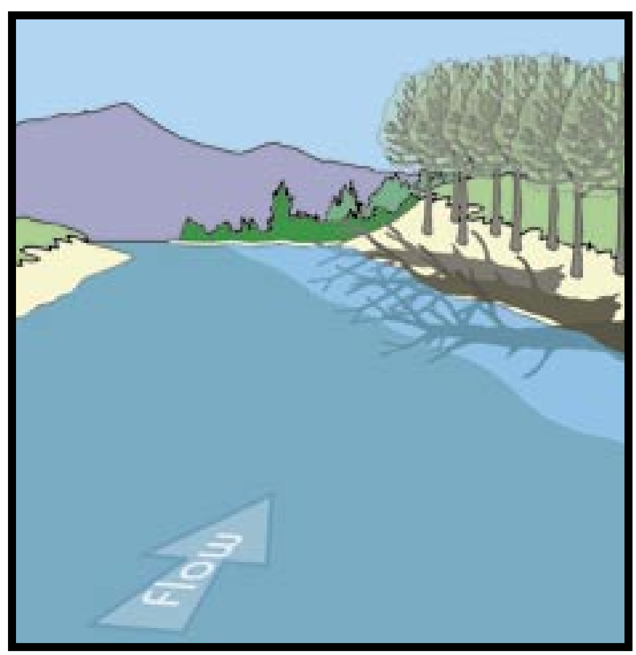


Tree Revetments

Description: Revetments are blankets of material covering a streambank to prevent erosion. Riprap is a type of revetment made of rock (*see Riprap above*). In Montana the term "revetment" is usually associated with using native materials, such as trees, rootwads (*see Rootwads above*), or brush. **Tree revetments** line the streambank with trees, including the trunk, limbs, and branches, but not the root systems. The trees are anchored into the bank and are usually cabled together.

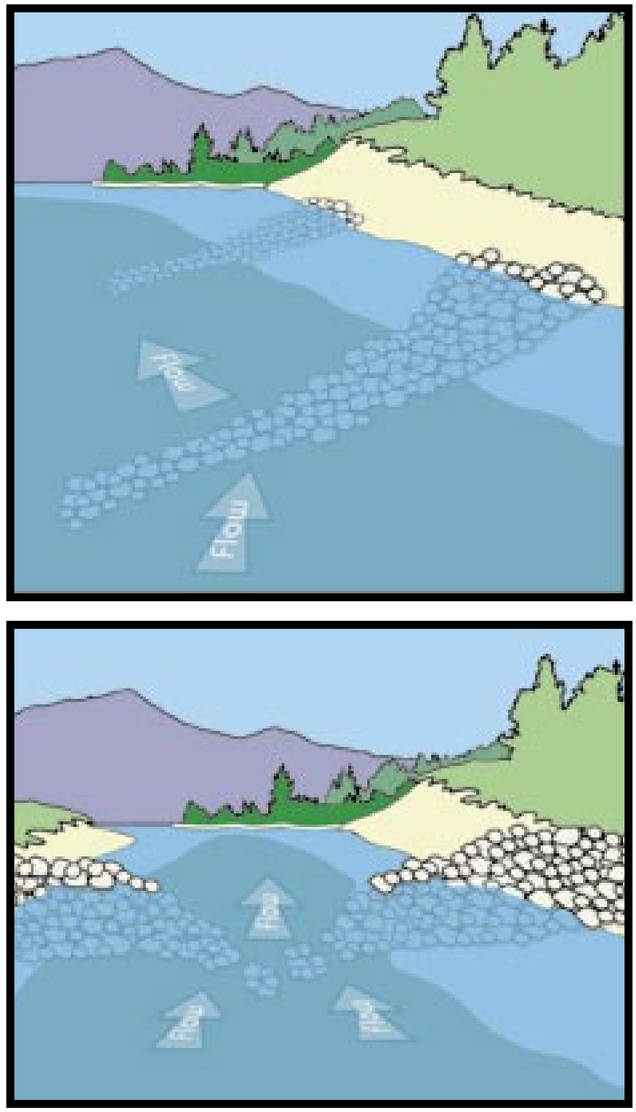
How It Works: When the water hits the tree branches, it slows down, lessening erosion.

Impacts: Tree revetments contribute to the channelization of streams. They are less damaging to streams than riprap. Although tree revetments discourage bank erosion, they encourage the water to scour the streambed instead. When installing tree revetments, it is important that riparian vegetation and their root systems not be destroyed. If incorrectly designed, tree revetments can increase erosion and scouring rates, resulting in the eventual loss of the structure.



Weirs

Weirs are low barriers built across a stream or river. Most of the weirs used in Montana are either anchored into one bank (with bendway weirs the most common) or span the entire river (with vortex weirs the most common).



Top: Bendway Weir Bottom: Vortex Weir

Bendway Weirs

Description: Narrow structures, usually constructed of rock, that are attached to the eroding side of the riverbank. Bendway weirs are anchored into the bank and can extend to the far side of the main channel of the river. They are always angled upstream. At the bank, these weirs usually begin at the river's ordinary high-water mark; from there they can angle steeply downward toward the river bottom, and then continue into the stream channel as a low wall; or they can angle downward to the bottom of the river like a barb. They are usually constructed in a series.

Relationship to Similar Structures: The term "bendway weir" can be interchangeable with the terms vane and barb. These weirs are lower in construction, require less rock, and cause less stream disturbance than jetties. A bendway weir can also be referred to as a dike.

How It Works: Water flows over bendway weirs and is then directed away from the eroding shoreline.

Impacts: Bendway weirs contribute to the channelization of rivers. They can cause problems for other landowners by deflecting the current against opposite or downstream banks and initiating new erosion. Located in sequence, they can "turn" a river to hit the opposite riverbank. These weirs can also cause increased scouring, channel shifts, scalloping of the bank, and destructive eddies. During low water, bendway weirs may be a hazard for boaters to navigate.

Vortex Weirs

Description: Low walls built from bank-to-bank across a stream. The common vortex weirs found in Montana are shaped like a "V" or a "W." Vortex weirs that point upstream are designed for bank stabilization. If they face downstream, they are generally designed to divert irrigation water. They are frequently built in series, with each weir only a few feet high or less, so that they do not create a dam across a stream during low water. In the middle of the river, gaps are left to allow sediment to move through the structure.

Relationship to Similar Structures: Also called drop structures, barrages, or check dams.

How It Works: Water that goes over vortex weirs is drawn away from the eroding bank and into the center of the stream.

Impacts: Vortex weirs contribute to the channelization of rivers. During low water, these weirs may be a hazard for boaters to navigate. They can also cause increased scouring, channel shifts, scalloping of the bank, barriers for fish passage in low water, and destructive eddies.

Montana Audubon

Montana Audubon, P.O. Box 595, Helena, MT 59624, (406) 443-3949, www.mtaudubon.org, produced this publication. Our members, located in ten chapters around the state, work to protect birds, other wildlife, and their habitats through conservation, education, and advocacy.

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