MEANDER CUTTING

Meanders evolve naturally over time

Highly sinuous, meandering streams often form fairly stable channels. Floodplain and bank vegetation is key in maintaining stability. Natural channel migration occasionally cuts a meander, forming an abandoned oxbow. Meander "cut-offs" are a natural part of stream channel process, but can be accelerated by poor stream management. Extensive rip-rap to constrain the channel may lead to meander cutting up or down stream. Removal of beaver can also increase the probability of meander cutting.

Sediment sources are important

Excess sediment from upstream erosion is a major cause of cutoffs. Many meanders are cut off because stream energy is insufficient to carry incoming sediment through a bend. When a sediment plug forms on the entrance to a meander bend, the stream will cut through the floodplain or point bar.

Restoration is sometimes possible

When a meander is abandoned, the channel responds by increasing its slope, velocity, and ability to carry sediment. This may cause accelerated bank cutting and erosion up or downstream. In some cases, a stable meander pattern can be re-established, but only after first controlling upstream erosion to reduce the stream's sediment load.

Let nature take its course

In many cases (possibly most), allowing natural meander cutoffs to occur without intervention may be the best strategy for ensuring long-term river health. Meanders evolve and "age" as a natural adjustment. Although it is not always easy to determine what "natural" is, it is seldom wise to work against a river's natural process.

As meanders age and the radius becomes tighter, cutoffs become more likely.

Meander abandonment happens frequently in altered stream environments.

Meander abandonment occurs naturally as loops intersect. This site is not suitable for meander reactivation.

BANK AND RIPARIAN VEGETATION

Healthy vegetation promotes healthy river channels

Vegetation serves many functions

Riparian vegetation is an integral and important component of a healthy stream environment. Trees, shrubs, grasses, and other plants help to stabilize banks, regulate water temperature and nutrient levels, filter sediment, and provide cover and food for fish and other organisms.

Vegetation is crucial in stabilizing some channels

Riparian vegetation along otherwise unconfined stream channels is especially significant for maintaining a stable stream corridor. Streams with high bedload transport rates are very sensitive to upstream changes in water and sediment supply. The channel may move laterally, eroding the banks. Floodplain vegetation slows lateral movement and reduces overbank flood velocities.

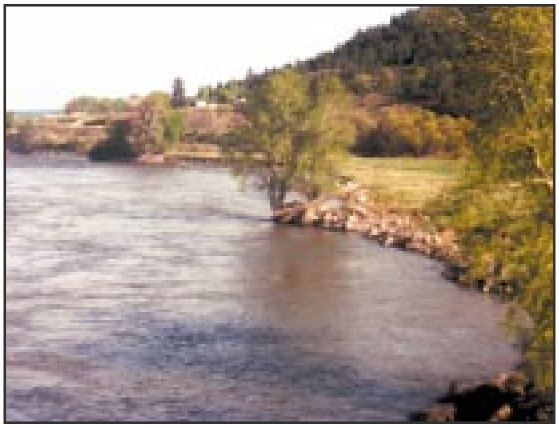
Clearing riparian areas is costly

Land management activities that reduce riparian vegetation (such as home building and livestock grazing) can cause bank erosion even during low flows. When this occurs, a series of channel adjustments may lead to a change in channel type, for example from a single threaded channel to a multiple threaded, over-widened, braided channel. Accelerated bank erosion and channel migration are seen in more sensitive channel types.

Good stream management should include a plan for monitoring and eliminating or reducing noxious weeds, while reseeding with native plants to protect against erosion.

Encouraging the growth of shrubs and trees such as willow, alder, cottonwood, red osier dogwood, chokecherry, spruce, and other riparian species will improve the system health.

Remnant willows are found in many floodplains converted to agricultural uses.



Assisted by rip-rap, a single tree does what it can. Where are the replacements in the floodplain?

Replacement trees are colonizing the expanding point bar floodplain. The channel is moving several feet per year (20+ ft. in 1997), much to the dismay of the landowner.

PONDS (IMPOUNDMENTS)

Instream ponds mean maintenance

Instream ponds fill with sediment

Instream ponds disrupt the flow of sediment through a stream. Gradually, the pond or reservoir will fill with sediment and gravel. In extreme cases, clean water below the impoundment picks up sediment from bed and banks, increasing erosion downstream.

Instream ponds, or impoundments, require engineering

Instream ponds require an engineering design to address sedimentation, outflow structure capacity, dike stability, and fish passage issues. At a minimum, structures should be designed to safely convey the 100-year flood through an emergency spillway. Larger ponds and lakes classified as "high hazard" by the state require additional engineering to ensure structural integrity.

If you must impound, do it off stream

Off-stream ponds avoid many of the complications of instream structures, and may be exempt from most conservation district permitting. Ditches, headgates, or water intakes for the pond located in the perennial channel do, however, require a 310 permit. Diversion designs should ensure adequate control of diverted water to prevent flood damage to pond embankments or outflow structures. Off-stream ponds can adversely affect instream temperatures and, in turn, fisheries.

Hundreds of thousands of cubic yards of sediment have filled much of this reservoir.

This small impoundment has filled with gravel and plants are taking hold.

WOODY DEBRIS REMOVAL

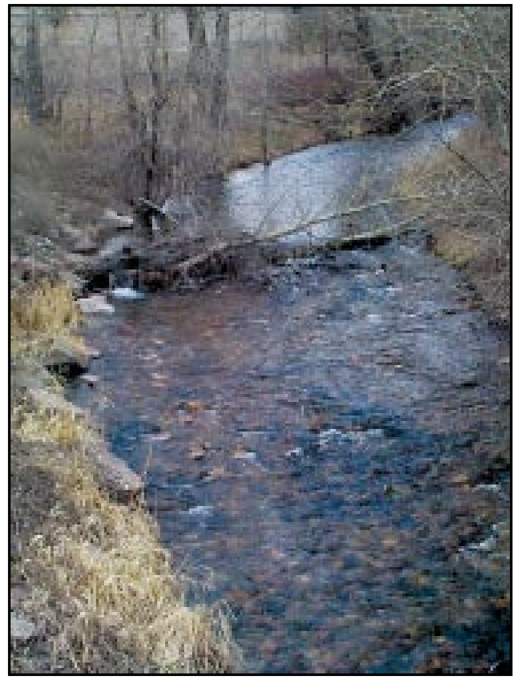
Debris jams typically occur during bankfull or greater floods as natural blowdown or channel migration into floodplain areas delivers trees to downstream reaches. Debris stranded on gravel bars, structures, or channel braids can cause bedload deposition, changes in channel location, and damage to structures. Debris can make a channel more complex, benefitting fish by increasing habitat.

Landowners sometimes remove debris to:

- Reduce erosion due to redirected stream flows.
- Reduce flooding.
- Eliminate new obstructions at culverts, headgates, or bridges.
- Prevent new channels from forming around blockage.
- "Clean up" the stream area.

Undesirable impacts may include:

- Impacts to channel and banks with heavy equipment.
- Sediment release to downstream reaches.
- Diminished bank stability.
- Adverse effects on riparian vegetation and fisheries.



Although it is tempting to remove woody debris, such cleaning should be kept to a minimum.

Debris serves a purpose

Woody debris is an important component of many stream systems, providing fish habitat and channel stability. The following questions should be considered carefully:

- Is debris significant to fish habitat or channel stability?
- Will removal reduce fish habitat or channel stability?
- Will equipment damage the banks or channel?
- Can removal be accomplished without damaging the riparian area?

Guidelines

- Before removing debris, consider the type of stream, amount of debris, and the potential for damage.
- In general, removal should be limited to situations where debris build-up will cause significant property damage.
- Do not remove debris to counter natural changes in channel location or overflow channels.

BEAVER DAMS

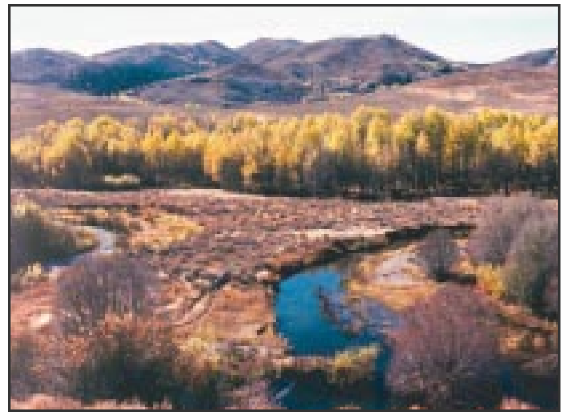
Beaver dams play an important role in stream stability and riparian plant communities. Their effects, however, vary from stream to stream. Before removing beaver dams, weigh the benefits against potentially undesirable channel changes.

Beaver dams are sometimes removed to:

- Reduce flooding.
- Eliminate obstructions at culverts, headgates, or bridges.
- Prevent new channels from forming around dam.
- Drain wetland areas.
- Eliminate beaver damage to mature streambank trees.
- Provide access for migratory fish spawning areas.

Removing beaver dams may cause undesirable side effects, such as:

- Channel down cutting.
- Sediment release to downstream reaches.
- Diminished bank stability.
- Lowering of water table.
- Damage to riparian vegetation and fisheries.



Beaver have enhanced channel stability and riparian conditions at this site.

Subsequent removal of beaver led to channel instability.

The role of beaver

- Many stream systems have evolved with beaver as a natural component of the riparian system.
- Beaver dams maintain high water tables, provide refuge for fish during low flows, and store sediment.
- In some cases, removing beaver dams may have detrimental effects on the health of the stream.

Guidelines

- Generally, beaver dams should not be removed unless flooding upstream will cause significant damage to property.
- Do not remove dams to counter natural changes in channel location, overflow channels, or flooding.
- Consider fencing as an option to protect trees.

LIVESTOCK GRAZING IN RIPARIAN AREAS

Developing off-stream water can improve grazing

Excessive livestock grazing can harm bank stability and riparian health. Impacts are most common on sensitive channel types, for example Rosgen C and E channels. Progressive loss of woody shrubs and bank trampling contribute to channel instability.

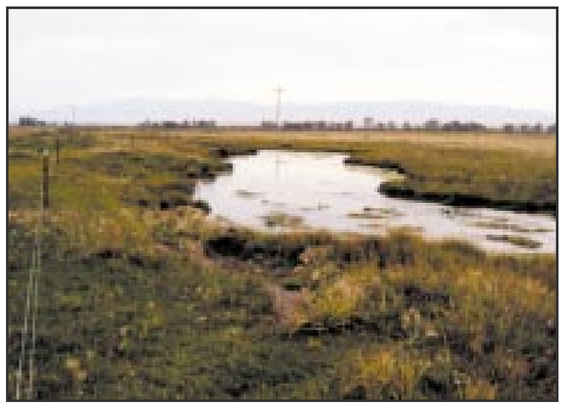
As damaged channels become wider and shallower, fish habitat is lost, and the riparian zone becomes more vulnerable to flood damage, erosion, and channel migration.

Stream projects and livestock grazing

- Streambank stabilization projects that replace and/or enhance riparian vegetation in grazed areas must consider livestock use of the site. Uncontrolled livestock access to the banks may preclude successful revegetation. The project may need to include fencing to protect streambanks.
- Proposed stream improvement projects may involve development of off-stream stock water sources, and fencing off a stream. The off-stream water source may be a pond or tank that draws water from a perennial stream, and returns it to the stream.
- Development of armored livestock watering access points, along with fencing of the stream, is an alternative to developing an off-stream water source.

Careful management of livestock with modified grazing schemes or fencing on damaged streams can dramatically improve riparian health. More information on grazing methods can be obtained in *Best Management Practices for Grazing* (DNRC, 1999) from the Conservation Districts Bureau, Montana Department of Natural Resources and Conservation.

Wide, shallow channels resulting from heavy grazing are poor fish habitat.



Damage from continuous heavy grazing or confined animals can often be reversed while still allowing agricultural practices.

Loss of mature riparian trees and shrubs can result in braiding on sensitive channel types.

ROADS

Roads can contribute significant amounts of sediment to streams

Erosion from roads near streams can be a significant source of sediment, harming water quality and fish habitat.

Some studies suggest that in the mountainous West, forest roads contribute as much as 85 to 90 percent of the sediment reaching streams in disturbed forest land.

Main sources of sediment

- Stream crossings (improperly designed approach grades, poorly armored culvert inlets or outlets).
- Side casting during road maintenance.
- Unstable fill slopes on roads parallel to streams.
- Poorly designed or ineffective drainage features (ditches, cross drains, water bars).
- Erosion from cut slopes, drain ditches, and road surfaces.

To avoid harm to fisheries and water quality, roads and stream crossings should be designed to reduce the potential for sediment delivery. Such projects warrant careful attention to grading and drainage. Road approaches should be kept below six percent grade if possible, and provided with drainage relief every 200 feet on the approach to the crossing. Vegetated swales and filter zones can reduce sediment before runoff reaches the stream.

For more guidance, see *Forestry Best Management Practices*, and the *Sediment and Erosion Control Manual*, available from the Montana Department of Natural Resources and Conservation.

Poor drainage on granitic soils can deliver large amounts of sediment to streams.

Silt fence helps prevent sediment delivery on newly constructed roads, but does not substitute for proper drainage features.

Runoff from heavy rains can deliver large quantities of sediment to stream systems.

STREAM MANAGEMENT

FLOOD CONTROL

What causes flooding? It is essential to identify the causes of flooding before selecting flood control measures.

Causes of flooding

"Normal" stream conditions

Bankfull floods occur approximately every 1.5 to 2 years. Natural overbank flows should be expected frequently in channel types with a well-developed floodplain. Frequent flooding is not necessarily an indication of abnormal stream conditions.

"Abnormal" flooding conditions

Abnormal floods occur when streams experience non-equilibrium conditions, such as aggradation (channel filling), channel constriction (undersized structures), and extreme debris or ice jams.

Aggradation ("filling")

Aggradation is a common cause of "abnormal" flooding conditions due to reduced channel capacity. Aggradation, or channel filling, results when more sediment enters a stream than the channel can carry.

Aggradation is common in depositional areas on alluvial fans, transitions at narrow canyons to wide valleys, and in flat valleys with certain sediment, slope, and discharge characteristics. Aggrading channels have high lateral instability—severe bank erosion—and are often braided with large gravel point bars and medial bars.

The tendency to aggrade or braid is natural in many river systems, but can be accelerated by channel changes (slumps, dewatering, land use, or dikes) that influence sediment supplies and carrying capacity.

Many natural channels overtop the banks every 1.5 to 2 years, on average.

Aggrading "filling" channels result from excess sediment supply or reduced transport capacity.

Attempting to control flooding on aggrading channels with excavation and berms is rarely successful because the channel continues to fill.

FLOOD CONTROL (*continued*)

Channel constriction

Undersized culverts and bridges, extensive diking, debris, or ice jams can cause backwater conditions and increase flooding problems.

Chronic backwater conditions can cause bedload (gravel) to deposit upstream of the obstruction, further exacerbating flooding problems. Designing structures to pass the 100-year flood will help alleviate channel constrictions and associated flooding.

Natural floodplain function

Flows that overtop the bank are common in natural channel types that are not confined (Rosgen C-, D-, and E-types). These channels are typical of broad, lower gradient valleys and have associated floodplain plant and wetland communities that are adapted to recurring flood conditions.

Diking or levees to control floods may adversely affect channel stability and riparian plant communities.

Ice jams are common in some channel types, and can cause flooding to much higher elevations than the 100-year flood (Blackfoot River).

This reach of the Blackfoot River (same location as above) is a moderate risk area for major ice jams. Wider, shallower channels have more frequent icing problems.

Aggradation from a failed culvert crossing has decreased channel capacity and increased flood risk to the road that has encroached on the floodplain.

Levees provide flood control for development in floodplains. Levees require ongoing maintenance, however, and have the potential to severely impair channel function.

FLOOD CONTROL (*continued*)

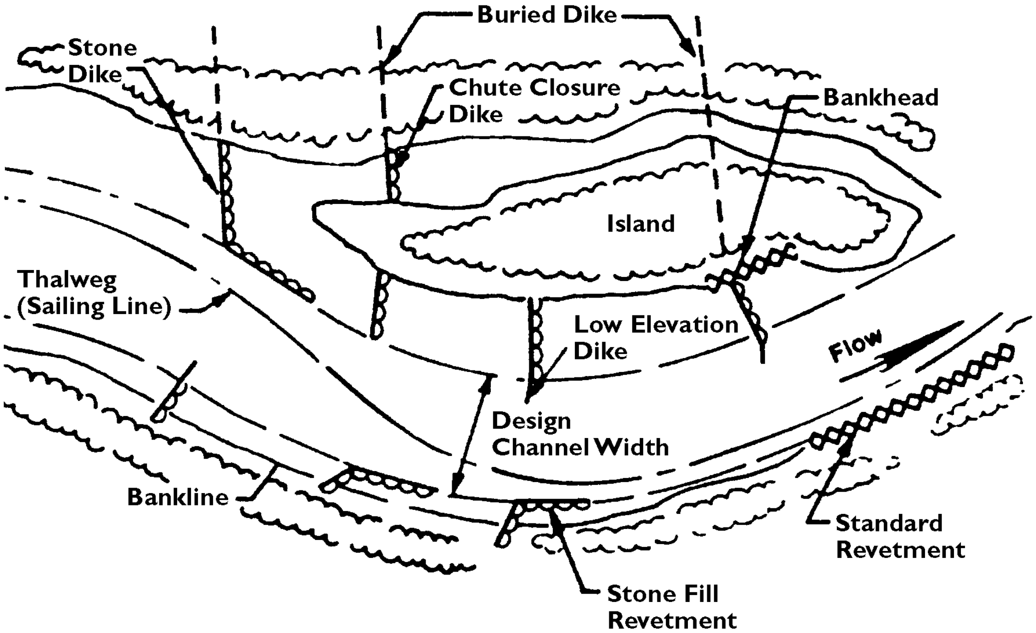
Usually the terms *"dikes"* and *"levees"* are used interchangeably. However, there is a difference as defined by the U.S. Army Corps of Engineers.

Dikes

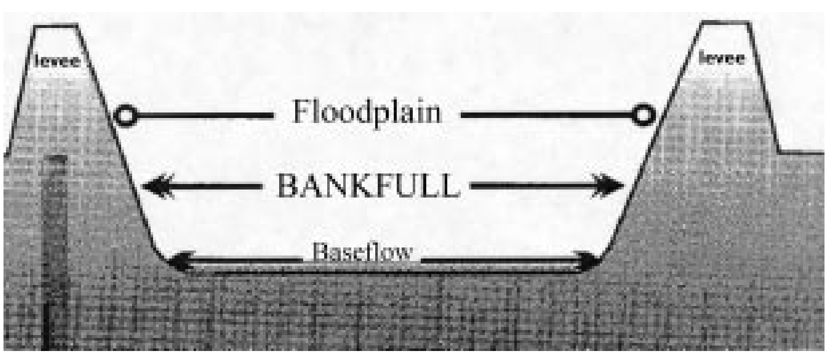
A dike is a *structure placed in the channel*, for the purpose of redirecting flow in the channel. Historically, dikes have been made of stone, concrete rubble, piling, fence materials, tree trunks, etc.

Levees

A levee is a *structure placed on the stream bank or floodplain* and above the channel for the purpose of preventing flood waters from affecting dry land. A levee can be thought of as a long, linear dam that keeps a low area from flooding.



Dikes. Drawing from U.S. Army Corps of Engineers, 1993.



Levee. Diagram adapted from Rosgen, 1996.

SELECTION OF FLOOD CONTROL METHODS

If channel flooding is abnormal due to on-site channel obstruction, the problem can be corrected by removing the blockage or replacing the structure to handle peak flows, ice, or debris.

If the channel is aggrading, cause and effect must be carefully evaluated. Finding a long-term solution may be difficult. The sediment source may be located off site, or the problem may be large scale, even regional. Dikes are of limited use because further aggradation occurs as dike or bank elevation is increased. Channel excavation or dredging is often a temporary solution because channels rapidly refill with sediment. Levees may raise flood water elevations, increasing flood stages upstream or across the river. Always consult your local floodplain administrator before building a dike or levee.

This levee was stabilized to protect downstream development from flooding, although the landowner with the levee did not particularly want to constrain the river.

Channel excavation may be appropriate when:

- Cause and effect are clearly understood (flooding is due to a culvert backwater or hillside slump into the channel).
- Cause can be addressed to prevent recurrence.
- Gravel excavation occurs in a limited area, requires a single entry, and upstream sources are unlikely to rapidly refill the excavated section of the channel.
- Fisheries and channel stability impacts are judged to be minimal.

Dikes and levees may be appropriate when:

- Protection of public infrastructure takes precedence over stream function.
- Dikes can be designed to avoid significant stream and floodplain impacts.
- An engineered design meets all permit requirements.
- Alternatives to dikes are deemed unacceptable (see below).

Alternatives to dikes and levees include:

- Raising the grade of structure(s) threatened by frequent flooding.
- Using berms to deflect flooding from a specific structure, rather than confining the stream channel.
- Relocating threatened structures.
- Restoring the channel to address channel instability issues.

These alternatives to dikes can provide long-term security, and can be cost effective compared to on-going maintenance typical of flood control projects.