Temporary Stream Crossing

Practice Description

A short term road crossing constructed over a stream for use by construction traffic. Temporary stream crossings can be designed as low water crossings, as an embankment with a culvert, or as a bridge with or without embankment approaches. Properly constructed, they prevent turbidity and streambed disturbance caused by construction traffic. Improperly designed and constructed stream crossings can cause upstream flooding, channel erosion during large flows and failure of temporary crossings.

Temporary stream crossings may be subject to applicable federal, state and local regulations for in-stream modifications. Contact the Corps of Engineers and local authorities for possible permit regulations.

Recommended Minimum Requirements

Prior to start of construction, temporary stream crossings should be designed by a registered design professional. Plans and specifications should be referred to by field personnel throughout the construction process.

- **Drainage Area:** Any size

- **Slopes:**
  - Low Water Crossing:
    - 3:1 or flatter for downstream slope
    - 2:1 or flatter for upstream slope
  - Culvert Crossing:
    - 2:1 or flatter for downstream and upstream slope

- **Low Water Crossings:**
  - Water Flow: Shallow (less than 3 inches deep) or intermittent
  - Traffic Usage: Light
  - Bank Height: Less than 5 feet
  - Approaches: slope of 5:1 or flatter

- **Culverts:**
  - Minimum Diameter: 18 inches or according to design plan; large enough to pass the peak flow from the 2-year 24-hour rainfall event or the design storm

Minimum Height of Fill Over Culvert: 1 foot or 1/2 the pipe diameter, whichever is greater
Culvert Length: Sufficient to extend the full length of the driving surface and the side slopes

Construction

Locate the temporary stream crossing where erosion potential is low. Where practical, locate and construct stream crossings to serve as both temporary and permanent crossings to keep stream disturbance to a minimum.

Site Preparation

Plan stream crossing in advance and attempt to construct them during dry periods to minimize stream disturbance.

Follow all federal, state and local requirements on temporary road crossing.

Ensure that all necessary materials are on the site before any work begins.

Construct a bypass channel before undertaking other work. Refer to plans.

Scarify the creek bed before placing fill.

Dewatering Site

Stabilize the bypass channel with riprap or other suitable material when stream velocity exceeds that allowed for existing soil material.

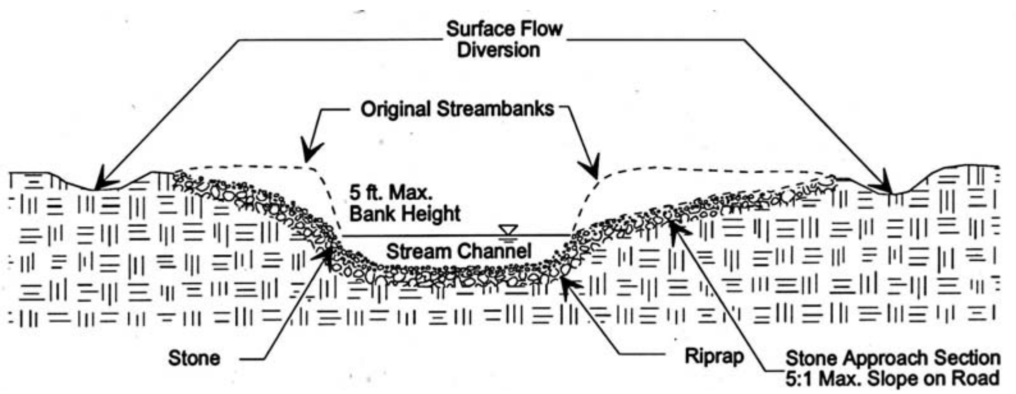


Figure 5.50 Typical Low Water Stream Crossing

Divert the stream to the bypass channel.

Low Water Crossing

Locate low water crossings only where normal flow is shallow (less than 3 inches deep) or intermittent, and where traffic is light. See Figure 5.50.

Excavate the foundation for the temporary crossing. Place crossing straight across or in a slight upstream arc.

Excavate roadways through the abutment approaches (bank) to the crossing according to the design plan.

Place large rock riprap across the channel. Construct a wearing course of gravel or crushed rock over the riprap. Use geotextile between crushed rock and the riprap.

Remove gravel and excess rock riprap as soon as it is no longer needed. Restore original contours to the channel, leaving rock riprap level with the streambed.

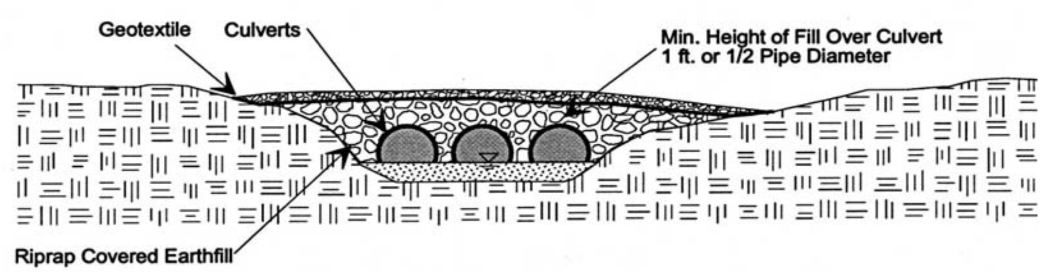


Figure 5.51 Typical Temporary Culvert Stream Crossing

Culvert Crossing

Excavate the foundation for the temporary stream crossing.

Divert the stream flow. Prepare the pipe bedding. Situate the culvert pipe on a firm, even foundation and keep the culvert parallel to the direction of flow. See Figure 5.51.

Place a 4-inch layer of moist, clayey, workable soil (not pervious material such as sand, gravel or silt) around the culvert. Compact by hand to at least the density of the embankment soil. (Don’t raise the culvert from the foundation when compacting under the culvert haunches.)

Extend the end of the culvert beyond the toe of the fill slope or install a riprap apron at least 5 feet wide and 10 feet long to a stable grade.

Remove culvert as soon as its no longer needed. Restore streambed to original contour.

Bridges

Properly designed bridges cause the least disturbance to the streambed, banks and surrounding area. They are the preferred method for temporary stream crossings.

Disadvantages to constructing temporary bridges include the fact that they are the most expensive option to construct, they are the greatest safety hazard if not adequately designed, constructed and maintained, and if washed out they cause a longer construction delay.

Bridges must have stable abutments. It is recommended that a cable be tied to one corner of the bridge frame with the other end fastened to a secure object to prevent flood flows from carrying the bridge downstream where it may cause damage to other property.

Embankment for Bridges and Culverts

Use fill from predetermined borrow areas. It should be clean, stable mineral soil free of roots, woody vegetation, rocks and other debris and must be wet enough to form a ball without crumbling yet not so wet that water can be squeezed out.

Compact the fill material in 6- to 8-inch continuous layers over the length of the embankment. (One way is by routing construction equipment over the embankment so that each layer is traversed by at least one wheel of the equipment.)

Protect the culvert with 2 feet of hand-compacted fill before traversing over the pipe with equipment.

Construct and compact the temporary road crossing embankment to 10% above the design height to allow for settling.

Erosion Control

Unlike permanent stream crossings, temporary stream crossings may be allowed to overtop during peak storm periods. However, the structure and approaches should remain stable. Keep any fill needed in flood plains to a minimum to prevent upstream flooding and reduce erosion potential.

Minimize the size of all disturbed areas and vegetate as soon as each phase of construction is complete. Riprap or establish vegetation on the slopes of the embankment in the temporary stream crossing.

Direct all overland flow to the ditches along the approach roads at low velocity.

Safety

Because temporary stream crossings are potentially hazardous, the following precautions should be taken:

- Construct guardrails or axle berms along the sides of the temporary stream crossing.
- Avoid steep slopes on the embankment; slopes should be kept as flat as possible (3:1 or flatter).
- Approach road slopes should be 5:1 or flatter.

Construction Verification

Check finished grade and size of culvert. Check to see if culverts are free of obstructions.

Troubleshooting

Consult with registered design professional if any of the following occur:

- Variations in topography on site indicate crossing will not function as intended; changes in plan may be needed.
- Design specifications for fill or conduit cannot be met; substitution may be required. Unapproved substitutions could result in the crossing being washed out.

Maintenance

Inspect the temporary stream crossing after each storm event. Pay close attention to the condition of the entrance and exit sections of the culvert pipe, the culvert joints, the abutment supports for bridges, all bridge connections and the amount of erosion on low water crossings.

Add riprap to the culvert entrance and exit as necessary to protect the crossing.

Periodically check the embankment for erosion damage, settling or slumping and repair immediately.

Remove debris, trash and other materials that restrict flow from the culvert or bridge.

Common Problems

Piping failure along culvert; caused by improper compaction, leaking pipe joints or use of unsuitable soil—repair piping damage and install preventative measures to prevent reoccurrence of the problem.

Erosion of embankment slopes; caused by inadequate vegetation or improper grading and sloping—repair erosion damage and reevaluate erosion protection measures.

Slumping and/or settling of embankment; caused by inadequate compaction and/or use of unsuitable soil—return embankment to original configuration using properly compacted soil as specified in the original plans.

Slumping failure; caused by steep slopes—remove slide debris and replace with properly compacted soil.

Erosion and caving below culvert; caused by inadequate outlet protection—repair erosion damage and provide adequate erosion protection.

Culvert not set in direction of flow in stream; results in difficult and costly maintenance—consult registered design professional for other options.

Culvert entrance elevation set too high; results in overtopping of roadway, ponding upstream of the culvert and erosion beneath the culvert—repair erosion damage, and either reevaluate size and elevation of the culvert or raise the roadway elevation.

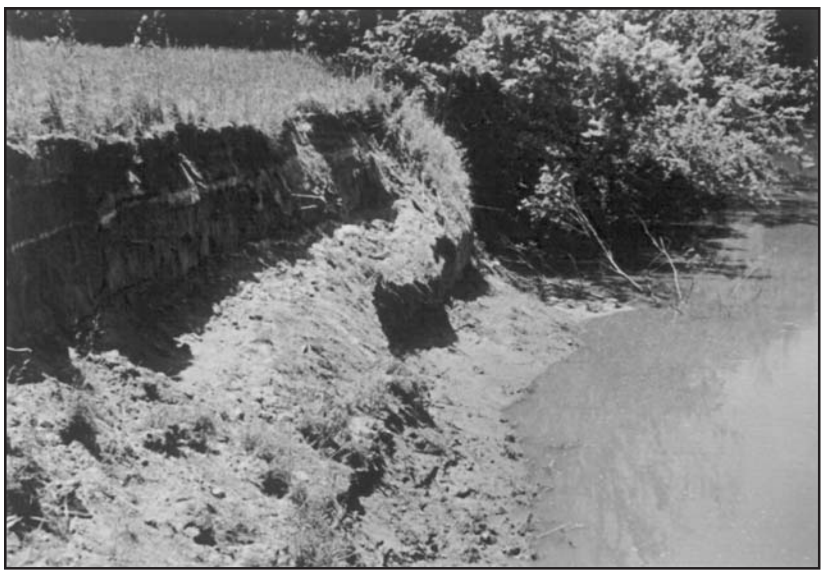
Culvert or bridge opening too small; results in frequent overtopping of roadway and increased erosion potential—repair erosion damage, and either resize the culvert or raise the roadway elevation.

Roadway elevation too high; results in downstream scour and undermining of structure during flooding—repair damage, and resize or lower culvert.

Streambank Protection

Practice Description

The stabilization of the side slopes of a stream to reduce streambank erosion. It is often necessary in areas where development has occurred in the upstream watershed and full channel flow occurs several times a year. Streambank protection can be vegetative, structural or a combined method where live plant material is incorporated into a structure (bioengineering). Vegetative protection is the least costly and the most compatible with natural stream characteristics. Additional protection is required when hydrologic conditions have been greatly altered. Because each reach of channel is unique, measures for streambank protection should be installed according to a plan developed for the specific site and watershed.



Becky Holland, NRCS Earthteam Volunteer. Jackson Co.

Streambanks tend to erode in areas where upstream development has increased water volume and velocity or where vegetation has been removed near the channel.

Considerations in determining which type of streambank protection to use include: current and future watershed conditions, discharge, velocity, sediment load, channel slope, control of bottom scour, soil conditions, present and anticipated channel roughness, compatibility with other improvements, changes in channel alignment, and fish and wildlife habitat.

Recommended Minimum Requirements

Prior to start of construction, streambank protection should be designed by a registered design professional and/or an interdisciplinary team. Protection methods should not affect stream hydraulics; a floodplain study and 404 permit may be required. Plans and specifications should be referred to by field personnel throughout the construction process.

- **Velocities:** Up to 6 feet per second for vegetation alone when stream is stable. Use structural protection for velocities greater than 6 feet per second. Use the velocity associated with the peak discharge of the design storm.

- **Channel Bottom:** Must be stabilized before installing bank protection. Grade control may be needed to prevent downcutting.

- **Vegetative Protection:** Consider the natural zones of a streambank community when placing vegetation.

- **Plant Materials:** Use native plant materials for establishment and long term success. Lists of suitable species may be obtained from the Missouri Department of Conservation (MDC), Kansas Wildlife and Parks, or NRCS.

- **Structural Methods:** May be needed in trouble spots such as bends in the channel or changes in channel slope; or where changes in hydrology, sediment load and channel alignment are occurring.

- **Combined Methods:** Many bioengineering practices are useful to protect streambanks (see *Soil Bioengineering for Slope Protection* Section; also consult with MDC for information on specific practices such as cedar tree revetments).

- **Permits:** Contact the Corps of Engineers and local authorities for permit requirements; permits may be needed if placing fill in wetlands or streams.

Construction

Site Preparation

Follow all local, state and federal government regulations on stream modifications.

Determine exact location of all underground activities.

Stabilize the channel bottom as specified in the design plan before streambank protection measures are installed.

Start and stop bank protection at stable points along the channel.

Vegetative Protection

Provide vegetative protection in zones as indicated on the design plan. The location of each zone depends on the elevations of the mean high water level, the mean water level and the mean low water level as shown in Figure 5.52. Vegetative protection usually works for stabilization only when a channel has become unstable because vegetation has been removed.

Aquatic Zone

The aquatic plant zone includes the stream bed and is normally submerged at all times.

No artificial planting is required in the aquatic plant zone.

Shrub Zone

The shrub zone lies on the bank slopes above the mean water level and is normally dry, except during floods.

Willows, silver maple and poplar can be planted (staked) from top-of-bank to waterline. They are preferred because: They have high root densities, root shear and tensile strength is higher than that of most grasses or forbs, and they can transpire water at high rates.

Upland trees should not be planted in the shrub zone. Refer to plan or consult NRCS, the Missouri Department of Conservation, Kansas Wildlife and Parks, or a forester for appropriate wetland shrub and tree species.

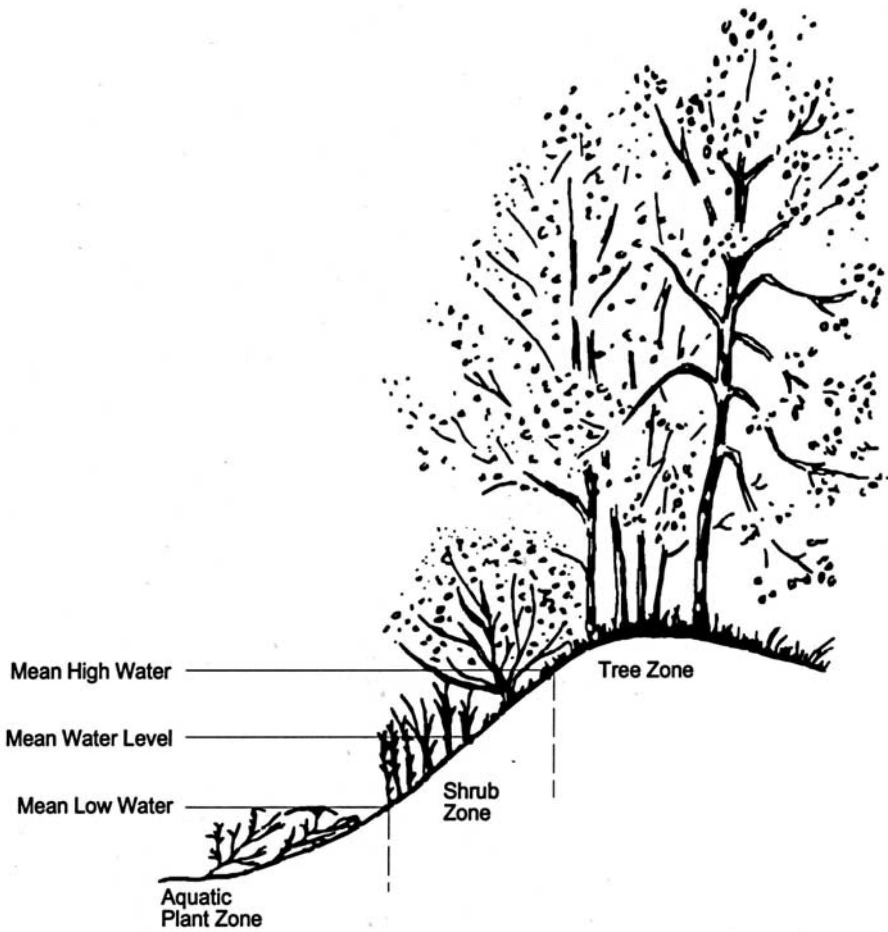


Figure 5.52 Vegetative Zones for Streambank Protection

Some grasses can be planted in the shrub zone if velocities are not too high and plants are not submersed frequently or for long periods of time. Plant grasses in the spring or the fall.

To seed grasses, roughen the seedbed, lime and fertilize according to soil test results. Check with the local Natural Resources Conservation Service or University Extension office for an appropriate seed mixture.

Tree Zone

Plant upland trees along the banks of the stream and not on the slopes.

If trees provide shade to the streambank, grasses should be planted which will thrive in shady conditions.

Riprap is one of the most commonly used methods of protecting streambanks.

Becky Holland, NRCS Volunteer. Jackson Co.

Structural Protection

Structural protection should be provided in locations where velocities exceed 6 feet per second, along bends, in highly erodible soils and in steep channel slopes. Common materials include riprap, gabions, fabric-formed revetments and reinforced concrete. Grouted riprap is not recommended, because grouted rock does not move with freeze/thaw and wetting/drying cycles. Voids quickly form under grouted rock, allowing erosion. The upstream and downstream ends of the structural protection should begin and end along stable reaches of the stream.

Riprap

Riprap is the most commonly used material for streambank protection. Properly sized, graded, bedded and placed riprap rises and settles with soil movement.

Stream banks should be sloped at 2:1 or flatter.

Place filter fabric or a granular filter between the riprap and the natural soil.

Construct the riprap layer with sound, durable rock. Refer to plan for gradation and layering.

Place the toe of the riprap at least 1 foot below the stream channel bottom or below the anticipated scour depth. Install toe walls as specified in plan.

Extend the top of the riprap layer at least up to the 2-year water surface elevation. Vegetate remainder of bank.

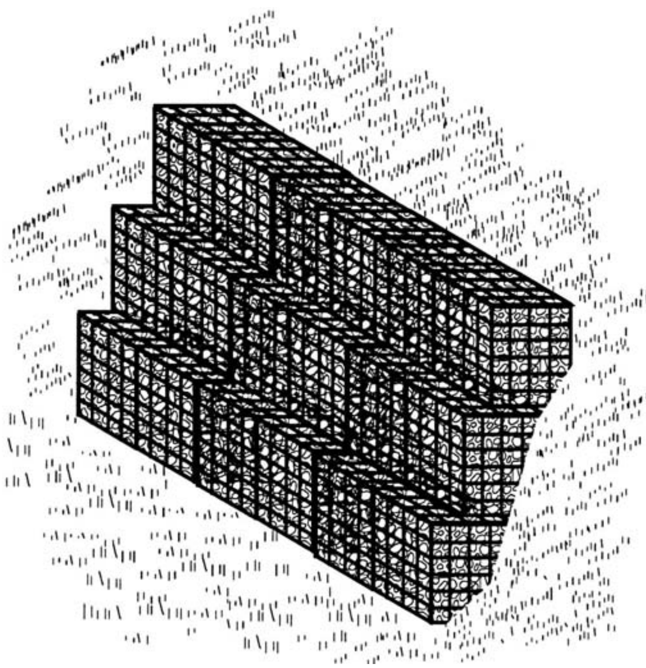


Figure 5.53 Typical Gabion Installation

Gabions

Gabions are rock-filled wire baskets. They are very labor intensive to construct but are semi-flexible, permeable and can be used to line channel bottoms and streambanks.

Construct gabions in accordance with manufacturer's guidelines or as specified in the design plan. Use only durable crushed limestone, dolomite or granitic rock. Shale, siltstone and weathered limestone should not be used.

Place filter fabric or a granular filter between streambank material and gabions.

Install gabions and counterforts as indicated in the design plan.

Fabric Formed Revetments

Fabric formed revetments are manufactured, large, quilted envelopes that can be sewn or zipped together at the site to form continuous coverage. Once the fabric is in place, it is pumped full of grout to form a solid, hard and impervious cover.

Clear, grub and grade the streambank surface to prepare for revetment installation. Install revetments according to manufacturer's recommendations.

Reinforced concrete may be used to stabilize the stream bed or the streambank.

Reinforced Concrete

Reinforced concrete retaining walls and bulkheads provide good erosion protection for streambanks. Anchor the foundation for these structures to a stable, nonerodible base material such as bedrock.

Place filter fabric or a granular filter between streambank material and the retaining wall or bulkhead.

Construct water stops at all joints in concrete retaining walls.

Construct the top of the retaining wall or bulkhead up to the design water surface elevation plus freeboard, and vegetate the rest of the streambank.

Construct weep holes in the retaining wall or bulkhead to provide drainage behind the structure.

There are many manufactured products available for streambank erosion control. Installation of any streambank protection can be labor intensive, as is this installation of interlocking concrete blocks along Two Mile Creek in St. Louis County.

K. Grimes, SWCD. St. Louis Co.

Combined Methods of Protection

Combinations of vegetative and structural protection provide some of the advantages of both. The structures provide immediate erosion, sliding and washout protection. Vegetation provides greater infiltration than some structural methods, increases channel roughness, and filters and slows surface runoff entering the stream. Vegetation also helps maintain fish and wildlife habitat, and a natural appearance along the stream.

Combined methods can be used in areas where velocities exceed 6 feet per second, along bends, in highly erodible soils and on steep channel slopes. Common materials include cellular matrix confinement systems, grid pavers and bioengineering techniques. The upstream and downstream ends of the protection should begin and end along stable reaches of the stream.

Grid Pavers

Grid pavers are modular concrete units with interspaced void areas that can be used to armor a streambank while also establishing vegetation. Grid pavers are typically tied together with cables and come in a variety of shapes and sizes.

Clear, grub and grade smooth the streambank surface to prepare for the installation of the grid paver material.

Grid pavers should be designed and installed in accordance with manufacturer's recommendations. The size and shape of the grid paver will depend on the expected velocity, the shape of the channel and the soil type.

Cellular Confinement Matrices

Cellular confinement matrices are commercial products usually made of heavy-duty polyethylene formed into a honeycomb-type matrix. The cellular confinement matrices are flexible to conform to surface irregularities. The combs may be filled with soil, sand, gravel or cement. If soil is used to fill the combs, vegetation may also be established.

Clear, grub and grade the streambank surface to prepare for installing the matrices. Install systems according to manufacturer's recommendations.

Soil Bioengineering

Soil bioengineering uses live, woody vegetative cuttings to increase slope stability and repair slope failures. Two approaches can be used: woody vegetation systems and woody vegetation systems combined with simple inert structures.

Soil bioengineering is advantageous where there is minimal access for equipment and workers and in environmentally sensitive areas where minimal site disturbance is required. Most techniques can also be used for stream channel or bank protection. Once established, woody vegetation becomes self-repairing and needs little maintenance. (For complete description and installation guide to individual practices see *Soil Bioengineering for Slope Protection* section.)

Design for capacity at rank growth. Design for stability at low or dormant growth.

More information on bioengineering practices can be obtained from your local Natural Resources Conservation Service/Soil and Water Conservation District and the Missouri Department of Conservation. (Also see *Turf Reinforcement Mats* in *Erosion Control Blankets* section.)

Erosion Control

Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete.

Use temporary diversions to prevent lateral surface water from running onto the streambank protection area.

Direct all overland flow to the streambank at low velocities.

Establish vegetation to stabilize all disturbed areas immediately after construction.

Safety

Store all construction materials well away from the stream.

At the completion of each workday, move all construction equipment out of and away from the stream to prevent flooding.

While working in streams with flowing or still water, the following precautions should be taken:

- Avoid steep slopes on the streambank.
- Fence area and post warning signs if trespassing is likely.
- Provide an uncontrolled means of draining the construction site.

Construction Verification

For vegetative protection, check to see that planting and seeding was done in compliance with the design specifications. For structural protection, check cross section of the channel, thickness of protection and confirm the presence of filter cloth between the protection and the streambank.

Troubleshooting

Consult with registered design professional if any of the following occur:

- Variations in topography on site indicate protection will not function as intended; changes in plan may be needed.
- Design specifications for vegetative or structural protection

cannot be met; substitution may be required. Unapproved substitutions could result in erosion damage to the streambank.

Maintenance

Check the streambank after every storm event. Fix gaps in the vegetative cover with structural materials or new plants. Make needed repairs to structural systems with similar material.

Protect new plantings from livestock or wildlife.

Check the streambank for signs of voids beneath gabions, riprap and concrete. Deterioration or erosion of the filter fabric or granular material should be repaired.

Check and repair gabion connections and grid paver connections.

Common Problems

Erosion of streambank; caused by inadequate vegetation, improper structural protection or an increase in stream velocity due to upstream development—repair erosion, establish adequate vegetation or structural protection, and reduce stream velocities.

Slumping failure or slides in streambank; caused by steep slopes—repair slide by excavating failed material and replacing with properly compacted fill. Consider flattening slope.

Sinkholes in riprap; caused by failure of the filter beneath the riprap—remove riprap, repair filter, reinstall riprap.

Reduction in stream capacity; caused by overgrowth of vegetation on the streambank—selectively remove overgrown vegetation at regular intervals.

Streambank Setback

Practice Description

The practice of limiting vegetation removal and grading of the riparian area along flowing waters. This practice is intended to protect the banks of natural streams from damage due to development, lessen the risk of flooding in developed areas and provide a buffer between the developed area and the stream. A properly maintained streambank setback will help maintain channel capacity and stability, reduce the sediment load in the channel and reduce the movement of pollutants into the stream. Setbacks help preserve natural channel meander and protect homes and other buildings from damage due to bank erosion.

Streambank setbacks can also apply to areas adjacent to excavated open channels used for site drainage, drainageways and watercourses that route runoff to streams.

Streams are dynamic, constantly changing systems. Placing homes or other structures too close to a streambank can threaten the structural integrity of the building, or cause the need for expensive protection of the streambank.

K. Grimes, SWCD. St. Charles Co.

Recommended Minimum Requirements

Prior to the start of construction, the 100-year floodplain established by the Federal Emergency Management Agency (FEMA) and the streambank setback area should be shown on the design plan prepared by a registered design professional. Plans should be referred to by field personnel throughout the construction process. The streambank setback should be established according to the planned alignment and grade. Vegetation should be inventoried and flagged for retention.

- **Channel:** Ensure that the channel is stable before determining the width of streambank setback.

- **Streambank Setback in Developed Areas:** The greater of the following is recommended:

  A minimum of 50 feet from the top of the streambanks (larger setbacks will be needed where channels are downcutting, hydrology is shifting and in large drainage areas---if sufficient land is available, a 100-foot setback is encouraged to protect the stream from degradation and to protect property), or

  Beyond the 100-year floodplain.

- **Vegetation:** If possible, preserve desirable natural vegetation within the setback area, especially on steep slopes. Establish vegetation on all areas without sufficient cover (see *Vegetative Protection* in the *Streambank Protection* section). Overall fish and wildlife habitat requirements and landscape character should be considered in determining the scope of streambank setback.

- **Street Setback:** Streets in new developments should be constructed so that they remain usable during runoff from the design storm or according to local requirements.

- **Water Surface Elevation:** A minimum of 1 foot below the ground floor of private dwellings and commercial buildings in a new development during the 100-year frequency, 24-hour duration storm.

- **Permits:** Contact the Corps of Engineers and local authorities for permit requirements; permits may be needed if placing fill in wetlands or streams.

Construction

Site Preparation

Follow all federal, state and local regulations for channel improvements required to increase stream capacity (due to development).

Open channel cross sections should not be reduced in order to increase streambank setback. The use of levees within small watersheds is discouraged.

Locate all underground utilities.

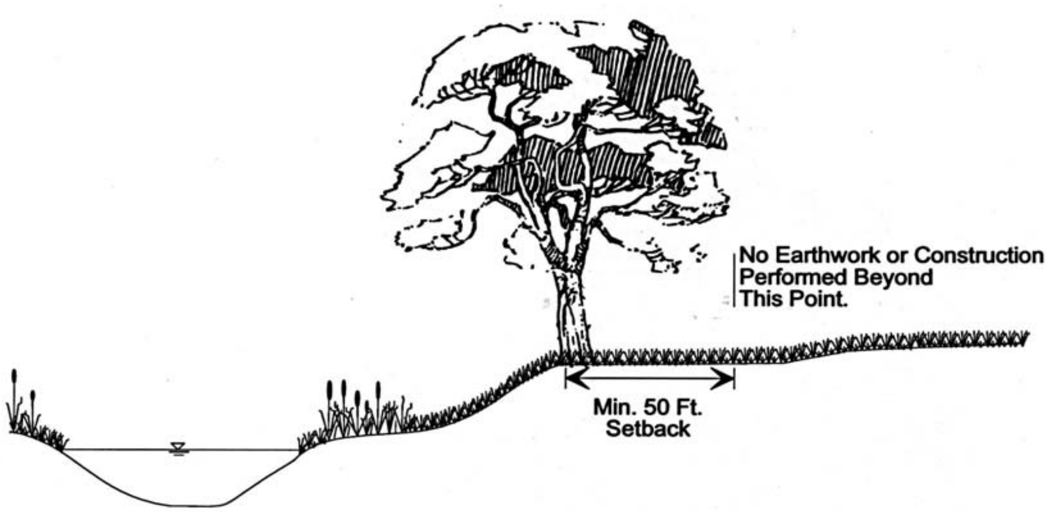


Figure 5.54 Streambank Setback

Natural Channels

Natural channel side slopes should not be disturbed. When disturbance is necessary to develop a site, reestablish vegetation on channel side slopes as soon as possible after excavation or improvement.

Consider the natural zones of a streambank community when placing vegetation. Use native plant materials for establishment and long term success. Lists of suitable species may be obtained from the Missouri

Department of Conservation (MDC) or NRCS. (See *Streambank Protection*.)

Existing woody vegetation adjacent to the stream should not be disturbed.

Leave any right-of-ways in the best condition feasible, consistent with the project purposes and adjacent land uses.

Preserve or plant adapted trees to provide shade to prevent thermal pollution in the stream, help stabilize banks and provide wildlife habitat in those areas of perennial flow or where woody cover exists.

Erosion Control

Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete.

Establish vegetation on all disturbed areas immediately after construction.

The streambank setback area should not be used as a filter strip during construction.

Use temporary diversions to prevent lateral surface water from running onto the streambank setback area.

After construction, direct all overland flow through the streambank setback area at low (5 feet per second or less) velocities.

Safety

- At the completion of each days work, move all construction equipment away from the streambank setback area in anticipation of flooding.
- Temporary stream crossings should be used by construction equipment to prevent destruction of the streambank setback areas.
- Construction materials and waste material should not be stored in the stream channel or streambank setback area.
- Provide temporary fencing and post warning signs until vegetation is established in areas that are disturbed.

- Provide site drainage.

Construction Verification

The alignment and width of the setback should be maintained during all construction activities. The final grades and elevations of the setback area should be checked to insure compliance with plans and specifications.

Troubleshooting

Consult with a qualified design professional if any of the following occur:

- Variations in topography on site indicate setback or channel is inadequate or will not function as intended; changes in the plans may be needed.
- Design specifications for seed variety, trees, mulch and fertilizer cannot be met; substitution may be required. Unapproved substitutions could result in additional flooding and erosion of the streambank.

Maintenance

Check the streambank setback area after every storm event. Fix gaps in the vegetative cover by seeding and mulching or with new plants.

Protect new plantings in the streambank setback area from livestock or wildlife.

Mulch, spray (with an herbicide approved for aquatic use) or chop out undesirable vegetation periodically to prevent its growth.

Keep inlets to side drainage structures open.

Keep subsurface drain outlet pipes open and protected.

Common Problems

Erosion of streambank setback; caused by disturbed land in setback area, inadequate vegetation or concentrated flow—establish adequate vegetation in all areas or install measures to reduce flow concentrations.

Slumping failure or slides in streambank; caused by steep slopes—repair by excavating failed material and replacing with properly compacted fill. Consider reducing slope or installing streambank protection measures.

Reduction in stream capacity; caused by overgrowth of vegetation on the streambank—selectively cut overgrown vegetation.

Channel Clearing and Snagging

Practice Description

The removal of trees and brush; and the removal of sediment bars, drifts, logs, snags, boulders, piling, piers, headwalls, debris and other obstructions from the flow area of a natural or excavated channel. It also applies to selective snagging, which is the selective removal of obstructions from the channel, streambank and floodway. Properly performed, channel clearing and snagging can reduce flooding by improving flow characteristics, prevent bank erosion by eddies, minimize blockages by debris and ice, and improve landscape quality. Improperly done, the practice may result in channel erosion, impairment to the landscape resource quality, and impairment to fish and wildlife habitat.

Recommended Minimum Requirements

Prior to start of construction, channel clearing and snagging should be designed by a registered design professional. Plans and specifications should be referred to by field personnel throughout the construction process.

- **Drainage Area:** Any size
- **Channel Stability:** Determine effect of obstruction removal on channel stability before construction begins.
- **Downstream Reaches:** Determine effect of obstruction removal on downstream reaches before construction begins.
- **Other Resources:** Give special attention to restoring, maintaining or improving landscape resources and habitat for fish and wildlife where applicable.
- **Permits:** Contact the Corps of Engineers and local authorities for possible permit regulations.

Construction

Follow all local, state and federal government regulations on in-stream modifications.

Determine exact location of underground utilities and whether overhead utilities or structures may be affected by the clearing and snagging operation.

Clearly identify trees and features to be saved, using field markings according to the plans and specifications.

Use hand-operated equipment, water-based equipment or small equipment where possible, minimizing disturbance to soil, water and other natural resources.

Cut all trees, stumps and brush to be removed as close to the ground as the cutting tools permit. Leave tree root masses in streambanks to provide stability. Follow label directions for any planned herbicide treatment of stumps.

Fell trees so as to avoid damage to other trees, property and objects outside the limits of clearing.

Remove downed trees, logs, drifts, debris and other obstructions lying wholly or partly in the channel as designated in the drawings.

Perform burning, burying and disposal outside the channel. Conform to all regulations in effect in the area. Dispose of material that is not buried in an approved off-site location or pile so that it does not float away or reenter the channel.

Troubleshooting

Consult with a qualified design professional if any of the following occur:

- Variations in topography, existing channel armor or improvements make effects of clearing and snagging difficult to predict.

Maintenance

Inspect after large stream flows and ice storms for new deposits of channel-blocking material.

Prompt attention to selective snagging needs prevents significant damages and the need for a large-scale operation.

Common Problems

Congestion in urban setting hampers operation—as much as possible, schedule clearing and snagging operations during first development or upon redevelopment of adjacent areas.

Possible downstream flooding—suspend clearing and snagging operation or obtain permits from downstream owners.

Possible effect on bank stability due to changed drawdown—install vegetative or mechanical bank stabilization measures as recommended by a design professional.