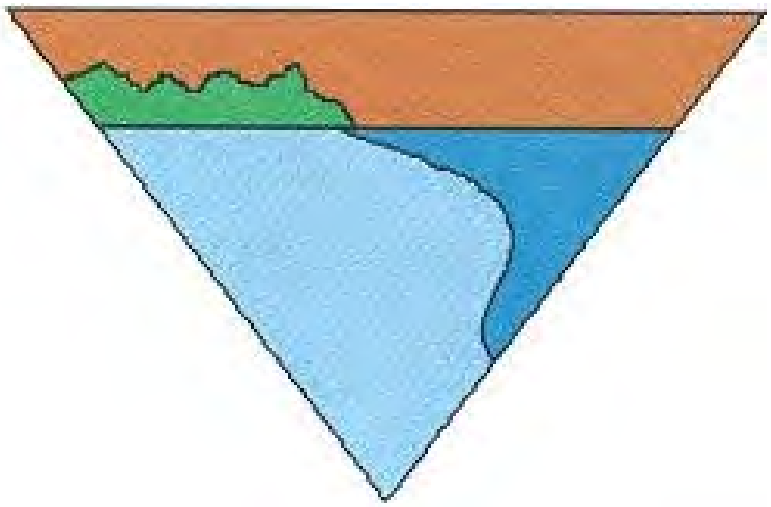
Vermont Better Backroads Manual

Clean Water You Can Afford



A publication of the
Northern Vermont &
George D. Aiken
Resource Conservation and
Development (RC&D) Councils

November 1995
Updated 2002, 2009

PRINCIPLES OF BETTER BACKROADS

1. Get water off the road quickly and avoid having water run lengthwise down the road.

2. Stabilize and revegetate disturbed areas in and/or near ditches, culverts, banks, inlets and outlets immediately.

3. Divert as much runoff as possible away from surface waters into vegetated areas.

4. Good maintenance saves $$$ by decreasing road problems and preventing untimely repairs.

5. Good maintenance and infrastructure reduces susceptibility to flash flood damage.

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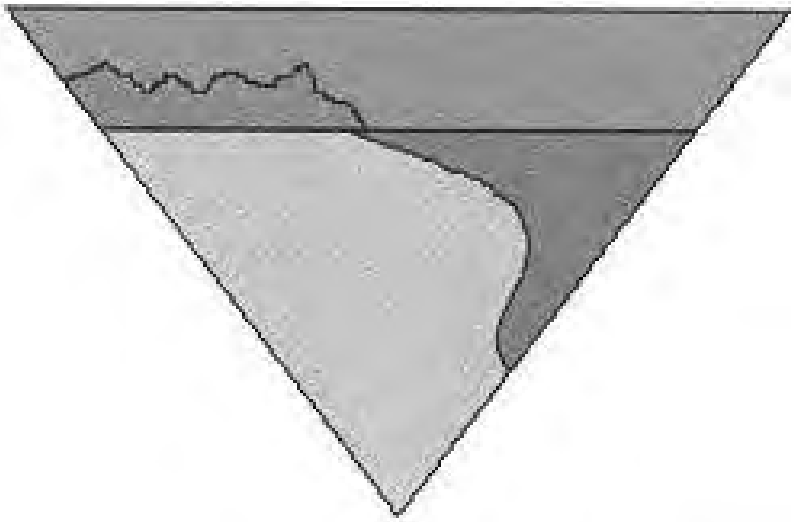

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2009 editing by Linda Boudette and the Better Backroads Steering Committee

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Vermont Agency of Natural Resources
George D. Aiken & Northern Vermont Resource Conservation and Development Councils
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* Diagram included with the description of technique

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Manual History:
Funding for this manual was originally provided by a grant from the U.S. Environmental Protection Agency (EPA) through the Clean Water Act, Section 319, Nonpoint Source Pollution funds to the Vermont Agency of Natural Resources. The grant was administered through the George D. Aiken Resource Conservation and Development (RC&D) Council. Since 1997, most program administration has been provided by the Northern Vermont RC&D Council.

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Participants:
The following organizations have participated in the development of this program and manual:
Vermont Local Roads
Vermont Agency of Transportation
Vermont Agency of Natural Resources, Department of Environmental Conservation
George D. Aiken RC&D Council
Northern Vermont RC&D Council
United States Natural Resources Conservation Service
Vermont Association of Conservation Districts
Southern Windsor County Regional Planning Commission
Two Rivers-Ottauquechee Regional Commission
Windham Regional Commission
Lake Associations
Many local road managers and crews

Purpose:
The purpose of this program is to provide cost effective techniques and actions that can be used to enhance maintenance of gravel backroads while improving the water quality in Vermont. Town road managers and crews, private road maintenance and construction companies, selectboards, lake, river and watershed associations, and the citizens of Vermont can effectively use this manual. This manual provides many hands-on action techniques that can be used in a variety of situations.

This program is designed to help road maintenance decision makers understand that using appropriate erosion and sediment control techniques is cost-effective. Value and quality doesn't mean cheap in the short run. It often means wisely investing limited local revenues in a systematic way in order to realize long-term savings.

Additional Publications Available from the Better Backroads Program:
Cost-Effective Solutions to Protect Water Quality Near Vermont Town Roads

Developing a Highway Access Policy: Guidelines and a Model Ordinance

Road Drainage and Erosion Control: Two Models for Developing a Town Inventory and Capital Budget

More Information:
For further assistance, including information on erosion assessment and planning grants, additional publications, and on-site assistance, please contact any of the Better Backroads Program partners, listed in the Resources section starting on page 57.

INTRODUCTION

Need:
Soil erosion occurs when soil particles are carried away from the road bank, surface, ditches, or road base by water, wind, ice, or gravity. Exposed soil, rapid water velocity, and the presence of fine sands and silts all increase the potential for soil erosion. Other pollutants such as oil and grease can also be washed from gravel roads.

These sediments and pollutants are then carried away into nearby streams and ponds. Gravel roads, by nature of their topography and design, can, if not property managed, contribute heavily to this significant water pollution problem. Excess sediment is a major cause of water quality problems in both lakes and streams.

Large quantities of sediments and other pollutants can impact surface water ecosystems by:

- smothering spawning and feeding habitat (fish eggs need a clean, sediment-free gravel-cobble-boulder stream bottom for incubation),
- disturbing the reproductive cycle of many aquatic organisms,
- disrupting the food chain,
- adding excess nutrients that may result in algae blooms and reduce the clarity of the water,
- killing small bottom-dwelling stream animals which provide food for fish,
- destroying fish habitats and irritating the gills of fish making them more prone to disease,
- smothering fish eggs and larvae,
- increasing the frequency of flooding by filling river channels,
- changing the chemical balance of the waters,
- diminishing recreational uses.

- The checklist on the next page outlines cost-effective ways to manage drainage on a road system while also protecting the quality of Vermont's surface waters.
- Use this checklist to guide your road maintenance operations.

Better Backroads Best Practices Checklist

☐ Crown roads to allow water to move quickly from the surface into the ditches (approximately ½ to ¾ inch per linear foot).

☐ Stabilize all exposed soil with seed and mulch, erosion contol blankets or hydroseeding as soon as possible.

☐ Line ditches with slopes greater than or equal to 5% with stone.

☐ Line ditches with slopes less than 5% with vegetation (seed and mulch).

☐ Direct runoff into vegetated areas, where possible.

☐ Avoid concentrating runoff and keep runoff velocities as low as possible.

☐ Install culverts with a minimum diameter of 18 inches.

☐ Install stone aprons at culvert outlets where erosion is occurring.

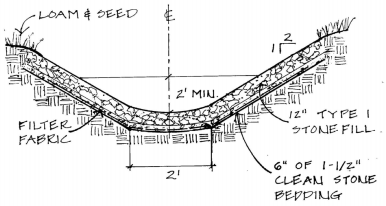
☐ Install headers and/or wingwalls on culverts where erosion is occurring.

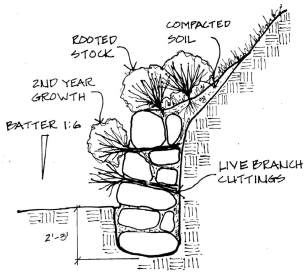
☐ Schedule and perform regular inspection and maintenance on culverts and ditches.

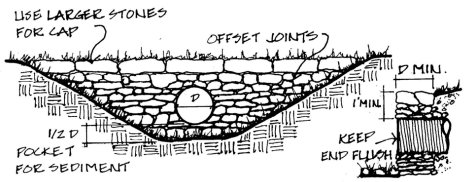
☐ Stabilize eroding banks with vegetation or stone.

☐ Disturb in a day only an area that can be stablized that same day.

☐ After September 15th, stabilize soils by hydroseeding or covering with erosion control blankets, not just seed and mulch.







Description:
Unpaved roads carry local traffic between rural lands and villages, and provide connecting links between paved collector roads. In Vermont, more than 55% of the local town roads have an unpaved/gravel surface. The top layer of gravel on these roads is shaped, compacted, and smoothed so that surface water runoff will move quickly from the road surface into established ditches.

Importance to Maintenance & Water Quality:
Failure to direct surface water from the road surface to a drainage channel can result in deterioration of the road surface, safety problems (ice) and assorted erosion problems. Immediate removal of runoff from the road surface will prevent erosion and road surface deterioration. This will lessen the frequency and cost of maintenance, thereby lengthening the life of the road surface. It will also decrease the amount of sediment carried into surface waters.

Surface Profile & Grading:

- Grade roads in the spring as soon as the frost leaves the ground, or as soon as possible after rain while the surface materials are still moist but not wet.
- Remove any berm left on the road from winter sanding so that stormwater can get into the ditches and not erode the road surface.
- The amount of road surface disturbed should be limited to that which can be stabilized by the end of the work day.
- Do not grade if rain is in the forecast (*after* rain is best).
- Proper crowning and compacting of the road surface quickens the removal of runoff, which will reduce road surface erosion.
- Crown roads ½ to ¾ inch for each foot of road width, measured from the center of the roadway to the outside edge to ensure good drainage.
- Slope roads with over-the-bank drainage problems entirely toward the ditched side of the road.
- Proper equipment for surface maintenance includes: grader (shaping and restoring), rake (smoothing before compaction), steel wheel roller (compaction), and slope board (slope confirmation).

Blading/Dragging: a smoothing operation which pulls loose material from the sides of the road or spreads windrowed aggregate to fill surface irregularities and restore the road crown.

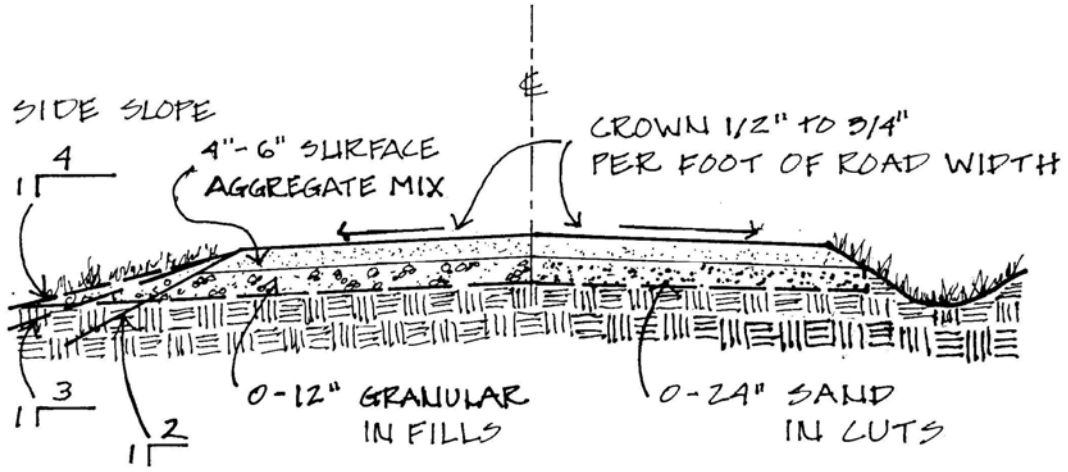
- Perform blading/dragging with the moldboard tilted forward with light downward pressure on the grader blade; adjust the angle of the moldboard to between 30 and 45 degrees; in most cases, tilt the front wheels slightly 10 to 15 degrees toward the direction the aggregate should roll.
- Avoid blading during dry periods to minimize the loss of fine aggregates.

Grading: cuts through the road surface crust; used when reshaping or when the correction of major surface defects is necessary.

- Perform grading operation with the moldboard tilted backward and with sufficient downward pressure on the blade to produce a cutting action; outer edge of the moldboard should be at the road surface's edge.
- Keep a minimum of one foot from the ditch line so that vegetation or rock stabilization is not disturbed.
- Grade roads in the spring or after rain. Avoid grading during dry periods to minimize material loss as dust.

General Road Surface Principles

- ☑ Preserve and maintain a proper road crown for good drainage (free water cannot be allowed to stand in ruts or potholes or it will soak into the surface.)
- ☑ Keep the road surface tight and impervious.
- ☑ Perform regular drainage maintenance and grading.



ROAD CROWN & PROFILE

- When possible, the entire width of the roadway disturbed by grading should be compacted with a steel wheel roller by the end of the day.
- For a gravel road to shed water properly, it should have a tight, impervious surface.
- Construct the surface layer with well-graded soils and crushed rock.
- An aggregate mix recommended by the Vermont AOT would be uniformly graded from coarse to fine. Approximate sizes for surface composition are: soil (<.074 mm), sand (.074-2.0 mm) and aggregate (>2.0 mm.).
- Add approximately 2 to 3 inches of new material to correct any faults.
- Scarifying the existing surface blends the soils and improves compaction.
- Add new material by running a truck down the center of the roadway and dumping; then blend the old material with the new using a grader, followed by compaction using a steel wheel roller.
- Regravel road surface every 4 to 5 years with 2-3 inches of new gravel.

Distress Conditions – Surface Deteriorations
Common types of surface deteriorations include:

Dust: the loss of fine, binder aggregates from road surface into the air.

- Dust can leads to other types of road distress.
- Sprinkling water on the road surface is only a very short-term solution.
- Dust can be minimized by applying calcium chloride which draws moisture from the air to improve fine aggregate cohesion. It is most effective if applied before roads become too dry and dusty and after any grading actions.
- Liquid calcium chloride is typically applied at a rate of 0.5 gallons per square yard in the spring followed by 0.3-0.4 gallons per square yard in the summer. Dry calcium chloride is typically applied at 2.5 pounds per square yard in the spring and 1.5-2.0 pounds per square yard in the summer.
- Note: Calcium chloride should be used in moderation adjacent to surface waters as its long term, extensive use can cause water quality problems in some areas.

Raveling: loss of coarse aggregate.

- Correct by grading or blading with the addition of a binder to improve surface composition.

Slipperiness: excessive amounts of fine aggregates or soil on the road surface can cause the road to become slippery during wet weather.

- To correct, add coarse aggregate by grading, blading and compacting.

Distress Conditions – Surface Deformations

Surface deformation problems are reduced with proper road surface drainage and include:

Rutting: longitudinal depressions in the wheel paths caused by high moisture content in the subsurface soil, inadequate surface course thickness, and/or heavy traffic loads.

- Grade, add suitable material, and roll road surface to correct ruts.
- Adding stone is a temporary solution and is not recommended; draining the ruts and filling them with roadbed material is preferred.
- For severe ruts, a layer of geotextile material may be required under at least six inches of crushed gravel.

Corrugations/Washboard: series of ridges and depressions across the road surface caused by lack of surface cohesion and excessive vehicle speeds.

- Blading is not recommended.
- Improve the cohesive qualities of the road surface by remixing with good fine percentage, scarify the road surface while damp, regrade, re-crown, and roll the surface.

Depressions: localized low areas one or more inches below the surrounding road surfaces caused by settlement, excessive moisture content, and improper drainage.

- Correct depressions by filling with well graded aggregate, grading, and compacting.

Potholes: depressions or "holes" in the road surface caused by excessive moisture content, poor drainage, and poorly graded aggregates.

- Spot grading or patching with crushed aggregate will repair potholes.

Soft Spots: caused by lack of proper drainage; part of "mud season".

- To correct, replace soft spot area with a suitable material such as well-sorted stone or gravel.
- Deepening the ditches may alleviate soft spots by helping to drain the subsurface.
- Chronic and severe locations may need to have road material right down to and including bed material.

Regular road regravelling every 5 to 6 years on a rotating basis will save maintenance costs over the long term. This should be built into the regular operations budget rather than a capital expenditure.

- Jerry Remillard
Director of Public Works
Brattleboro, VT

Disposal of Excess Materials:

- Improper disposal of excess material can increase the amount of sediment that enters streams and damages sensitive areas, particularly wetlands.

- Excess material should not be disposed of in wetlands, drainage ditches and swales, streambanks, areas within 50 feet of (and drain into) a waterway, slopes that are more than 2 horizontal: 1 vertical or other locations that may potentially cause pollution.

- Be sure that the area downhill of the disposal area has an adequate vegetated filter strip to trap sediments.

- Seed or vegetate any fill areas as soon as possible.

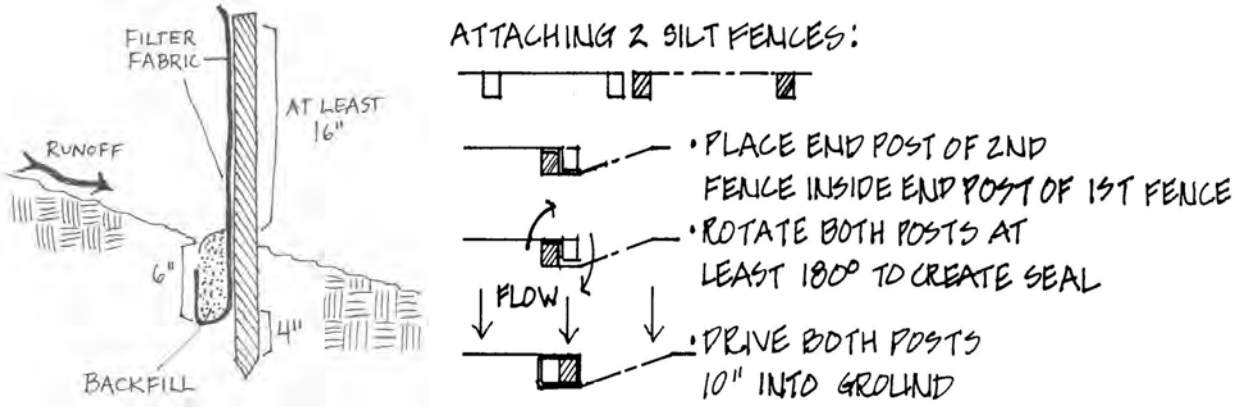
- Plan possible disposal areas ahead of time, giving the opportunity to utilize excess materials if possible.

Temporary Erosion Control:
It might be necessary to implement some temporary erosion control measures to reduce surface water pollution during the installation of your project or for a short period after the project is completed.

Sediment Controls:
Used as a temporary means of erosion control for the removal of sediments. Types of sediment controls include silt fence, hay bales, rock filters and a sediment trap.

Silt Fence:
Constructed of a pervious geotextile fabric and steel or wood posts. Used to remove sediments from sheet flows.

- A temporary control that has the advantage of being lightweight, portable and often reusable.
- Use at the base of a slope to intercept overland flow and hold sediment.
- Can last up to a year or longer.
- Use a “j-hook” at the ends to catch water trying to get around it.
- Periodic removal of trapped sediment is necessary for optimum performance.
- Silt fences are no longer recommended for use across ditches as flowing water can easily overwhelm them.
- Install a silt fence in the water around a work area on a lake bank. Be sure to anchor the bottom of the silt fence tightly to the lake bottom. Silt fence may also be recommended for work on streambanks.
- Permits should be obtained for both of the above activities (see *Resources* section of this Manual for permit info, p. 61)

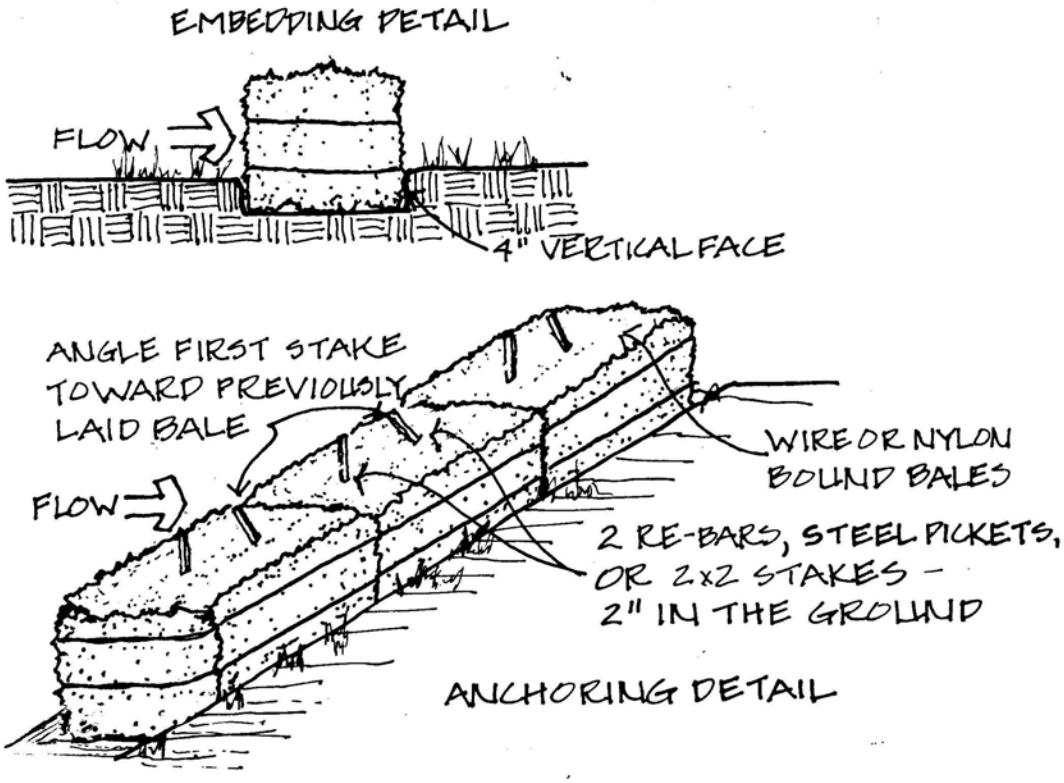


SILT FENCE

Hay Bale Check Dams: Hay bales are no longer a recommended erosion control device. They disintegrate rapidly and should never be counted on to provide more than one or two weeks of effective sediment control. If you do choose to use them, be sure to install them keeping the following recommendations in mind.

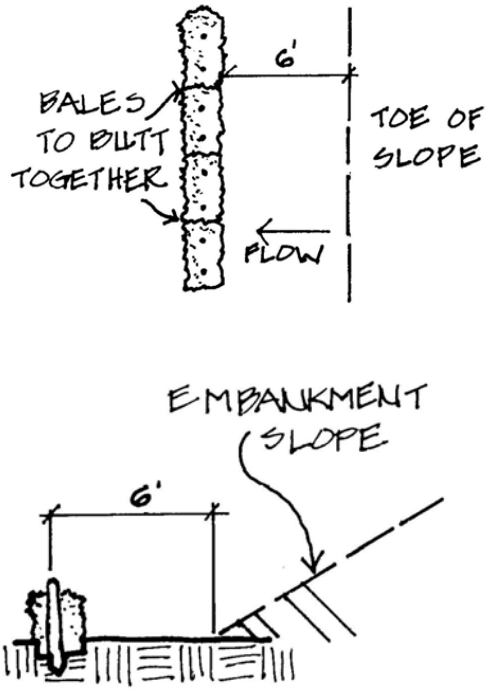
Hay bales should only be used to remove sediments from sheet flows. They are often used at the toe of a slope and can also be used at culvert outlets or around drains to remove sediments.

- Bury bales at least 4 inches into the soil.
- Never install in running water.



HAY BALE CHECK DAMS

Toe of Slope Installation: At the base of a slope or where the existing ground slopes away from the toe of the filled embankment.



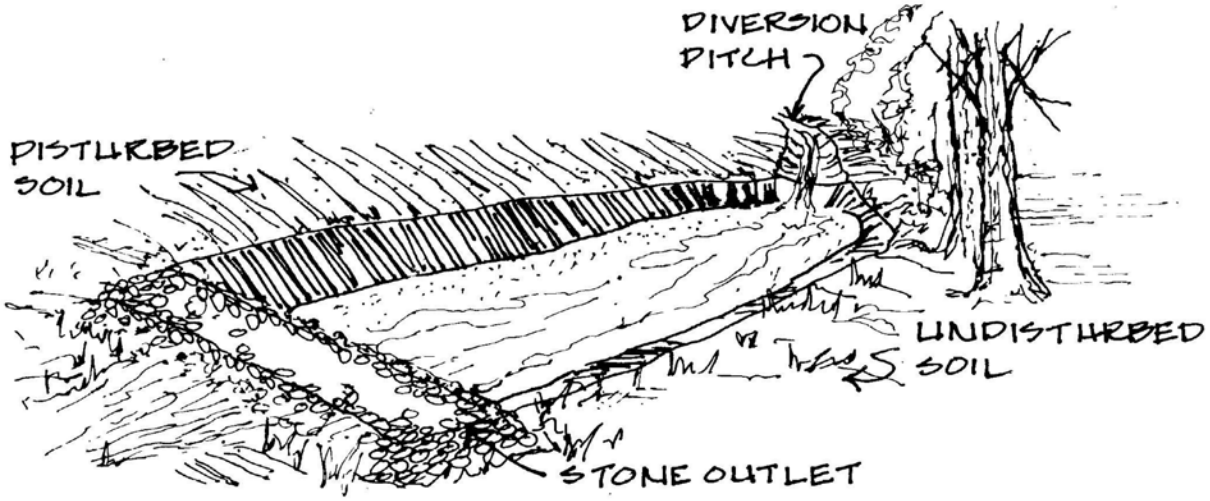
HAY BALE INSTALLATION

Rock Filters:

- Use in conveyance channels to remove sediments.
- Require periodic maintenance to remove accumulated sediment to prevent clogging.
- Need to be removed and replaced if filter becomes clogged.

Sediment Trap:

- Small temporary excavation or embankment designed to intercept, trap, and retain sediment.
- Handles flows larger than other controls.
- Should be at least twice as long as it is wide.



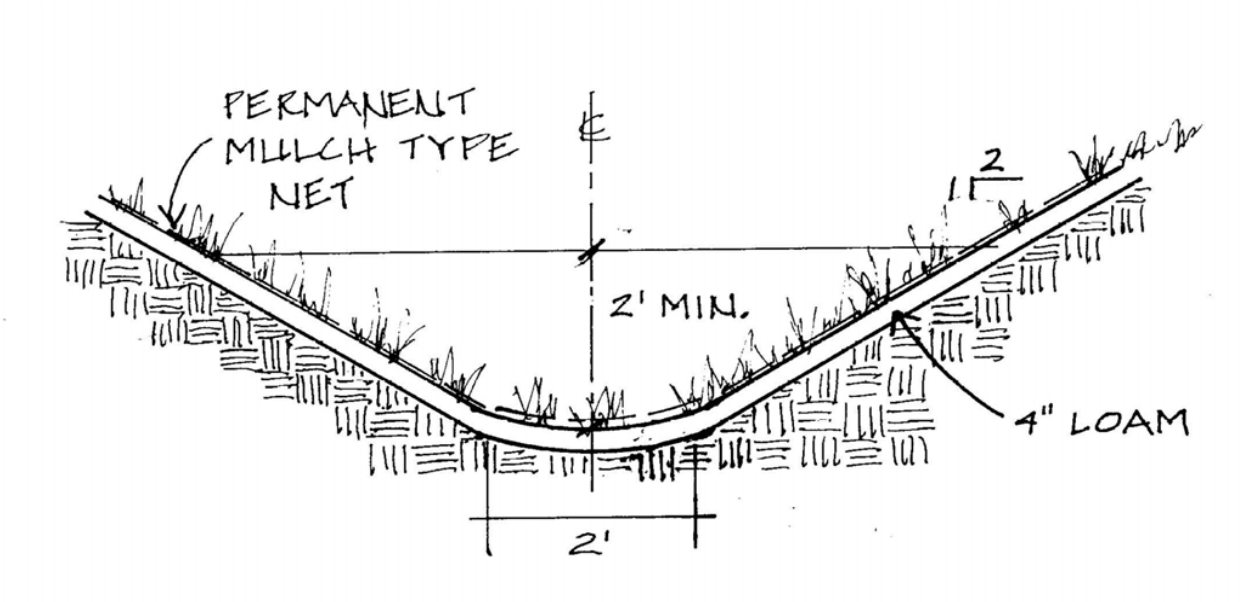
SEDIMENT TRAP

Description:
Ditches are constructed to convey water from storm runoff away from roads to an adequate outlet without causing erosion or sedimentation. They are ideal for collecting and dispersing runoff water in a controlled manner. A stable ditch needs to be shaped and lined using the appropriate vegetative or structural material.

Importance to Maintenance & Water Quality:
Efficient removal of runoff from the roadway will help preserve the road bed and banks. Well designed ditches provide an opportunity for sediments and other pollutants to be removed from runoff water before it enters surface waters. This can be achieved by controlling, slowing and filtering the water through vegetation, stone, or other structures. In addition, a stable ditch will not become an erosion problem itself.

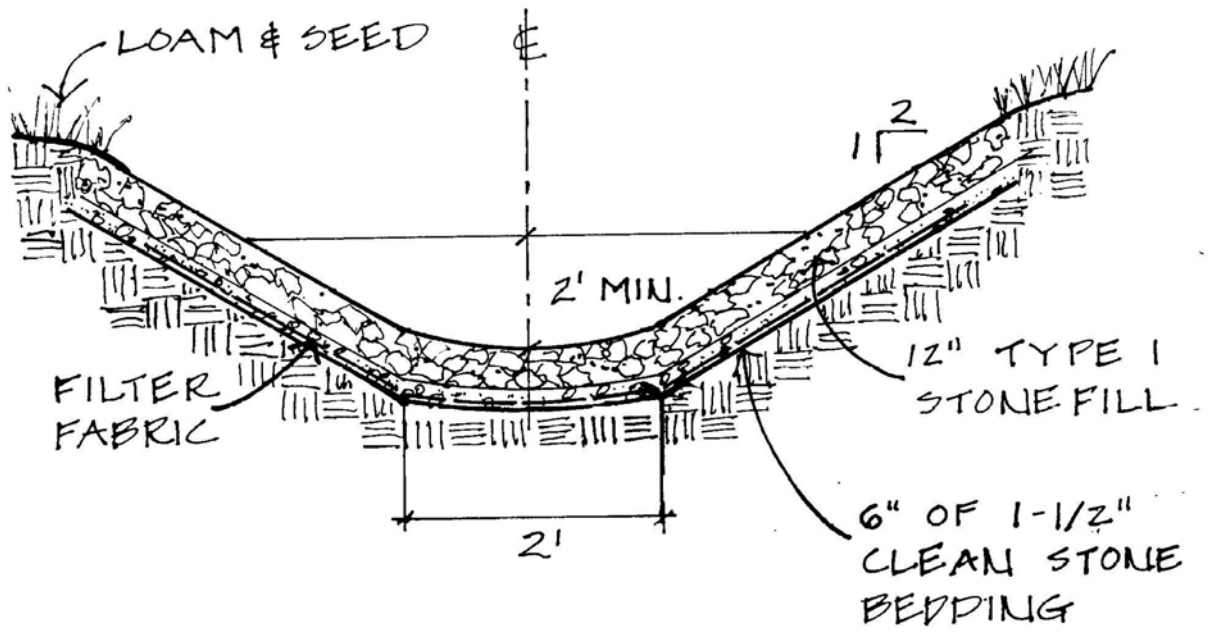
Ditch Profile and Grading: Proper ditch profile and grading techniques will remove water efficiently, decrease erosion, and increase the length of time between cleaning and regrading, thereby cutting maintenance costs.

- Locate ditches on the up slope side of the road to prevent water from flowing onto the road from uphill.
- Design and grade ditch and bank side slopes at a maximum 2 horizontal: 1 vertical ratio.
- Excavate a ditch deep enough to drain the road base and handle expected runoff - 1.5 to 2 feet deep.
- The ditch should be *slightly* rounded (parabolic shape preferred) or trapezoidal and at least 2 feet wide to help slow and disperse water.



GRASS LINED DITCH

- Size ditches so they are large enough to handle runoff from the drainage area.
- The preferred equipment for creating ditches is a rubber-tired excavator with an articulated bucket.
- Line ditches which have a less than 5% slope with grass in order to filter sediments. Use mulch or erosion control blankets to hold seed in place and allow it to become established.
- Line ditches which have a greater than 5% slope with riprap.
- Line ditches as soon as possible to prevent erosion and to maintain the ditch profile.
- Ditches should deposit water away from the road and prevent standing water, which can weaken the road.
- Outlet ditches into vegetated areas, where possible.
- Vegetated ditches installed after September 15th should be stabilized with either erosion control blankets or hydroseeding to provide adequate protection for winter.



STONE LINED DITCH

TABLE 1: DITCH LININGS		
Channel Slope	**Lining**	**Thickness**
0-5%	grass	
5-10%	R#3 (2 - 6 inch) diameter rock	7.5”
> 10%	R#4 (3-12 inch) diameter rock	12”

Cleaning & Maintenance:

- Clean ditches when they become clogged with sediments or debris to prevent overflows and washouts.
- Check ditches after major storm events as they may have obstructions, erosion, or collapsed banks.
- Regrade ditches only when absolutely necessary and line with vegetation or stone as soon as possible.
- Preventing erosion from uphill or on backslopes can lengthen the time needed between ditch cleanings.

Economic advantages of maintaining a properly constructed ditch estimated over a 20 year period are:

$36,000/mile/20 years for an improperly constructed ditch
$26,000/mile/20 years for a properly constructed ditch

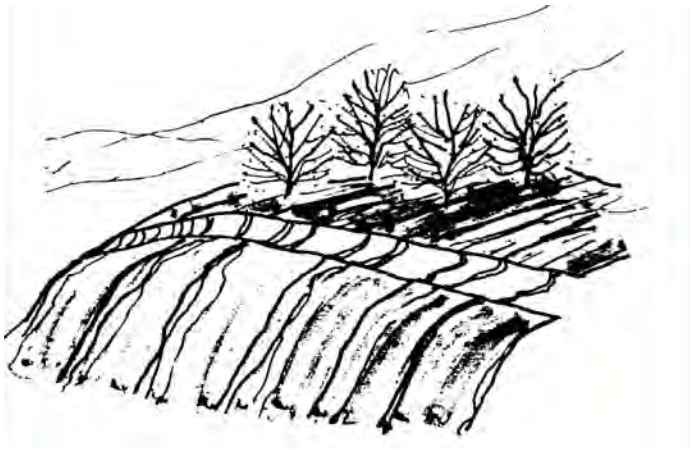
$10,000/mile/20 years
SAVINGS FOR INSTALLING A PROPER DITCH

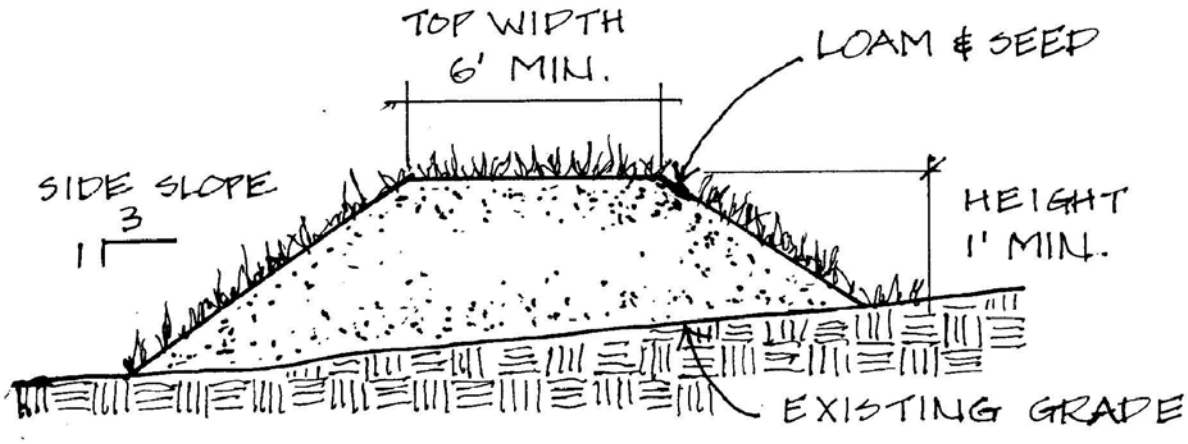
This amount can be increased by $5,000/mile/20 years if an excavator is used instead of a backhoe

Everett Hammond
Director of Public Works
Rockingham, VT

Diversion Ditches and Berms: Use to intercept, consolidate and direct runoff.

- Locate at the top of a slope to prevent erosion such as gullies and rills on the slope; may also be used across a slope to break up the length of the slope or to redirect water flow.
- May use a combination of a ditch and a berm or mound of earth or stone in areas where runoff is hard to control or when constructed on a slope.
- Locate diversion ditches and berms where they will empty into stable disposal areas to collect sediments.
- Design and line diversion ditches the same as other ditches.

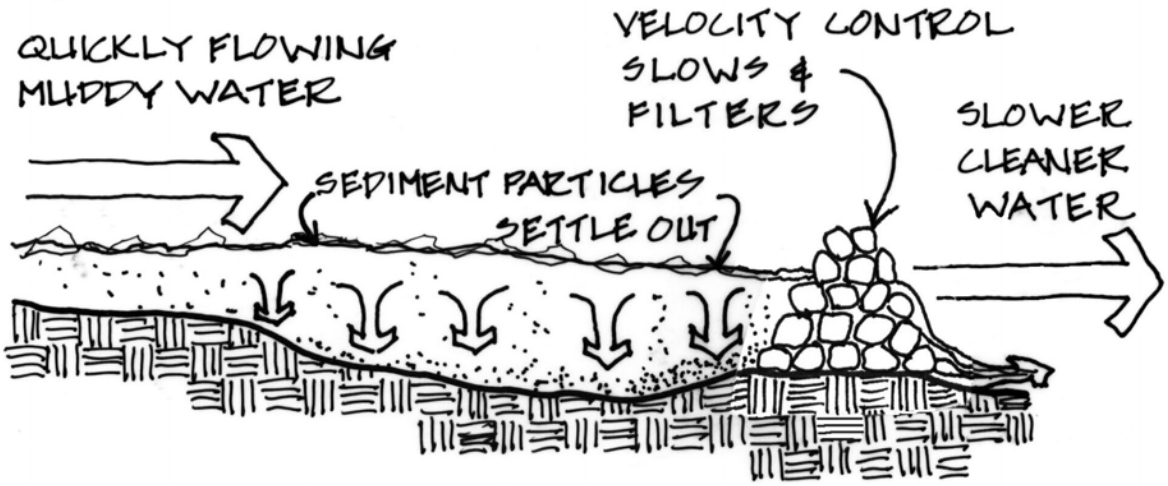




DIVERSION BERM

Velocity Controls and Energy Dissipaters: Locate in ditch channel or near culvert outlet.

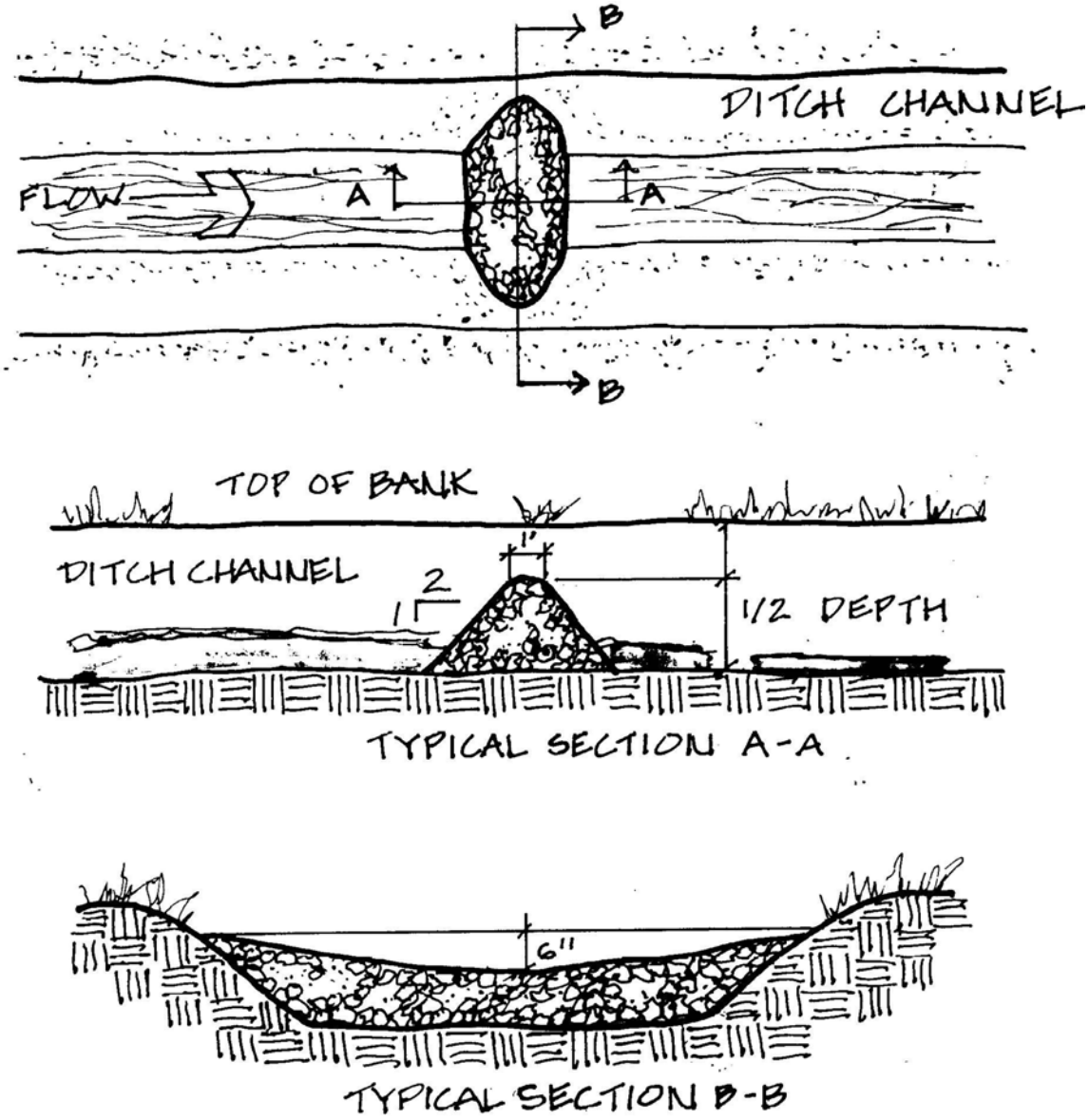
- Used to slow the water flowing through ditches and culverts.
- Means of keeping brush, trash, and other debris from reaching culverts and becoming lodged inside.
- Reduce erosion by preventing scouring of ditches and culvert beds and outlets.
- Collect sediment and help ground water recharge.
- Types of velocity controls and energy dissipaters include check dams made from stone or logs and brush.
- Clean sediment out as needed.



VELOCITY CONTROL

Stone Check Dams: constructed of stone large enough to handle the expected velocity of water.

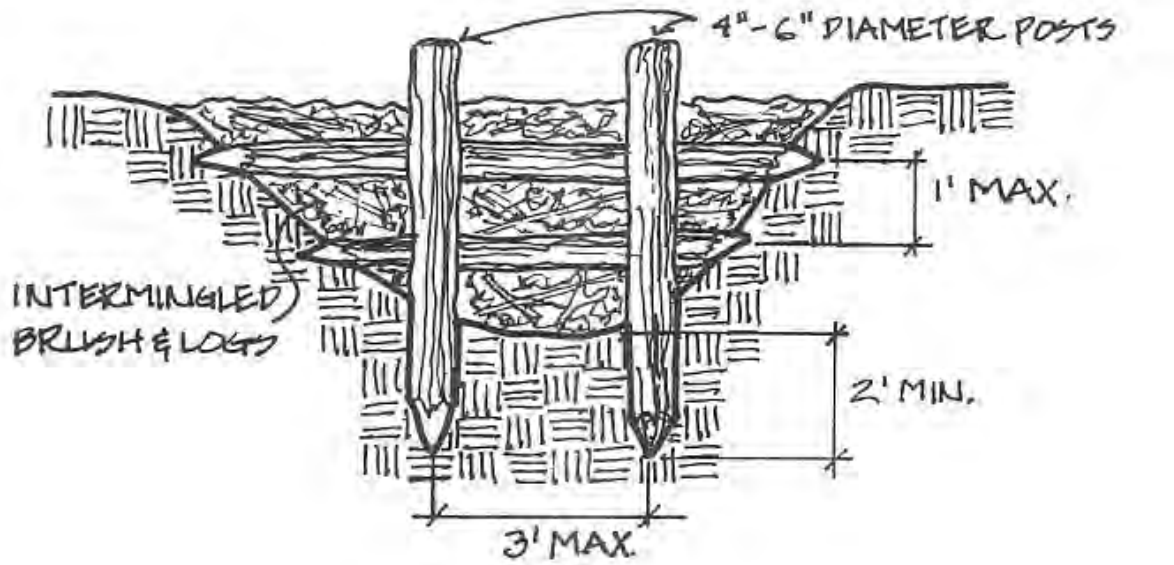
- More permanent than most other types of controls.
- Can be easily expanded if necessary.
- The smaller the stone size, the more sediment that is removed.
- Easy installation.

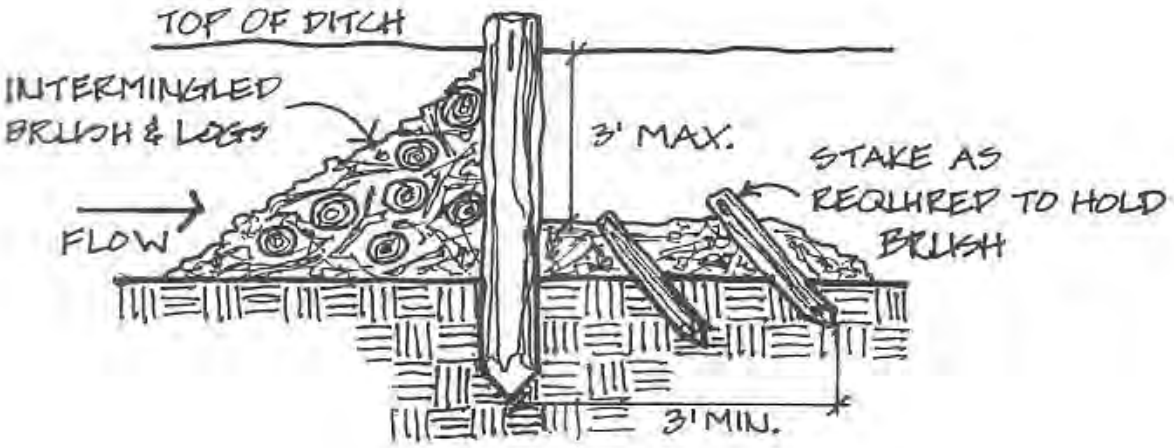


STONE CHECK DAMS

Log and Brush Check Dams:
Constructed brush intermeshed with logs staked into the ground.

- Materials for these dams can be gathered on site making them convenient and inexpensive.
- Good emergency control.
- Installation technique is critical to performance.
- Difficult to remove and repair.





LOG & BRUSH CHECK DAMS

Description:
A culvert is a closed conduit used to convey water from one area to another, usually from one side of a road to the other side. A very wide or long culvert may be considered a bridge.

Importance to Maintenance & Water Quality:
Properly placed culverts will help alleviate ditch maintenance problems by outleting water in a timely manner. Sizing and maintaining culverts correctly will prevent flooding problems that can lead to erosion and repairs. Placing culverts and other outlets based upon road slope will control the volume and velocity of discharges and reduce the amount of sediment entering surface waters. Culverts preserve the road base by draining water from ditches along the road, keeping the sub-base dry.

In-Stream Culvert Considerations:
Culvert installation should occur during periods of low stream flow (Note: it is best to divert the stream while culvert is being installed to avoid sedimentation of the stream) or during dry periods. *Any time a culvert is being installed in a stream, a Stream Alteration Engineer at the Agency of Natural Resources must be contacted to determine requirements for a permit* (see p. 61).

- Disturb the natural system and land as little as possible.
- Always attempt to align the culvert and set the grade to match the existing stream channel.
- Incorporate aquatic organism passage into the design. Contact Vermont Department of Fish & Wildlife for assistance (see p. 60).
- Geomorphic assessment data (information about changes and adjustments in a stream and what changes may be anticipated in the future) is available for many streams in Vermont. Contact the Department of Environmental Conservation River Management section (see p. 60) to find out if this information is available before changing or installing stream culverts.

Non-Stream Culvert Considerations:
- Place culverts no more than 500 feet apart, where there are existing water channels crossing the road, and wherever needed to control the volume and velocity of water. Steep slopes will need more culverts to control water flow.
- Outlet the culvert to a vegetated area - never directly into a stream.
- A 0.5% slope is the minimum to allow for positive drainage flow and should be used in all culvert designs except equalizers.
- Set grade to where the outlet can discharge to the existing ground; if this is not possible, use a flexible slope drain and a sediment basin.
- Design culverts to handle at least a ten year frequency storm.
- Ideally, culverts should be placed below frost depth to avoid problems caused by frost heaving.

- Culverts for small watersheds (less than 20 acres) maybe be sized by adding the acreage of the watershed to “8” (example: a 15 acre watershed would use a 24 inch culvert : 15 + 8 = 23, then rounded up to the nearest even inch = 24”).

- Watersheds of larger than 20 acres or culverts larger than 36 inches in diameter should be referred to a hydrology professional for the sizing and design of the culvert. VTrans will do hydraulics studies to size large culverts at no cost to municipalities. See the *Resources* section for VTrans contact information (p. 58).

- The recommendation for culvert diameter at stream crossings is the width of the stream channel (bank to bank) measured upstream of the culvert crossing, at a minimum.

- The recommended minimum size for all culverts is 18 inches.

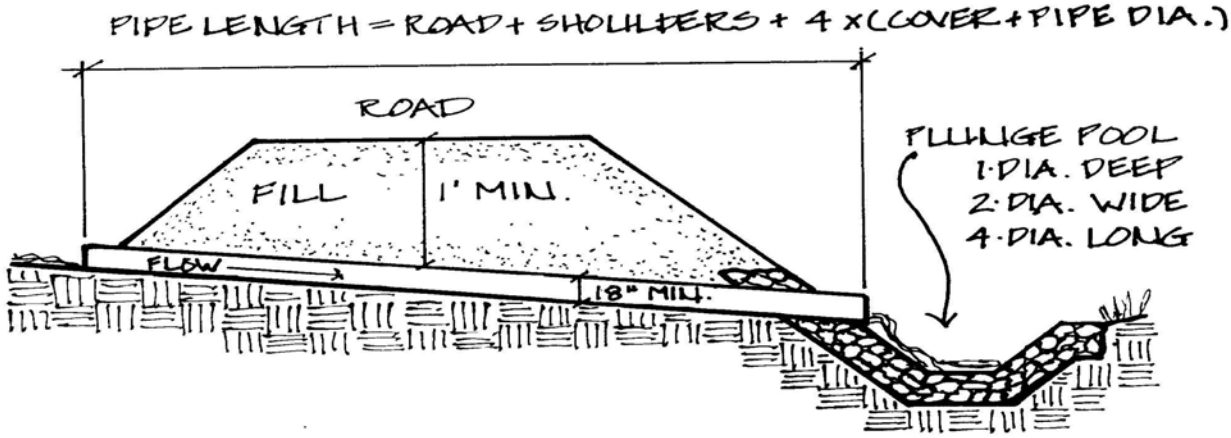
- Culvert pipe length = road and shoulder width at angle across road + 4 x (cover + diameter). Extra length will need to be added to accommodate for headwalls (see below for example calculation).

- A minimum of one foot of fill over a culvert is recommended.

- The bottom width of the culvert trench should be twice the width of the culvert, with sidewalls no steeper than 1:1.

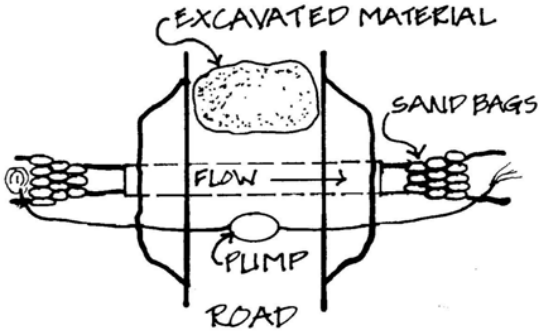
- Consider protecting culvert outlets from erosion and undermining by use of rock aprons, headwalls and wingwalls, and/or plunge pools.

Culvert length example calculation:
Using 18 inch (1.5 ft.) culvert with 1.5 ft. of cover and 28 ft. road + shoulder width.
Step 1: Pipe length = 28 + 4 (1.5 + 1.5) **Step 2: Pipe length = 28 + 4 (3)**
Step 3: Pipe length = 28 + 12 **Step 4: Pipe length= 40**

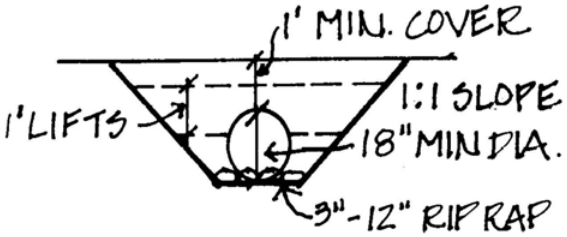


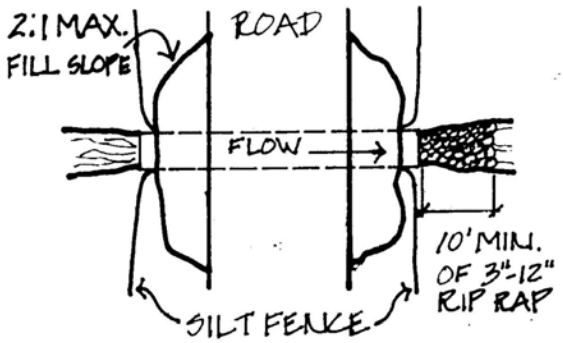
CULVERT PROFILE & CROSS SECTION

Installation/Replacement:
Install sandbag dams in the stream and use a pump with riprap placed at the discharge to convey water around the excavation.



- Excavate the culvert area; remove the old culvert if doing a replacement.
- Excavate 10 feet downstream of the culvert discharge to a depth of 18" for riprap. Use erosion control precautions; permit may be required.
- Lay pipe up slope, starting at outlet end.
- Place culvert level with the streambed and backfill in one foot lifts, tamping the fill in place.
- Place 3 – 12 inch diameter riprap in the excavated outfall area tamping it level with the stream bottom.
- Place silt fence at the base of the bank slope and remove sandbag dam.
- Seed and mulch all disturbed areas.





Fish Friendly Culverts:
A culvert installation should not change the conditions in the stream that existed prior to the installation.

- Trout and other species move upstream and downstream to spawn and meet other habitat needs.

- Culverts can impede fish passage by the following conditions:
  - vertical barrier – fish must jump too high if culvert is perched,
  - water velocity too fast over the given length of the culvert in relation to fish capabilities,
  - inadequate water depth in culvert,
  - icing and debris problems,
  - culvert design does not accommodate the size and species of fish passing through the structure.

- When selecting a new stream crossing site to install a culvert, the ideal site will have no sudden increase or decrease in gradient and not be located at or near a bend in the stream. This will minimize the potential for frequent or difficult maintenance.

- Use bridges, bottomless arches or partially buried culverts in areas where fish passage is an important consideration.

- Corrugated steel or plastic culverts decrease water velocities and supply resting areas for migrating fish.

- Make sure culvert diameters are adequate to pass maximum expected design flows.

- Design culverts so that water velocities passing through the pipe are equal to water velocities in the stream.

- Provide resting pools at culvert inlet and outlet for culverts installed across streams with high gradients.

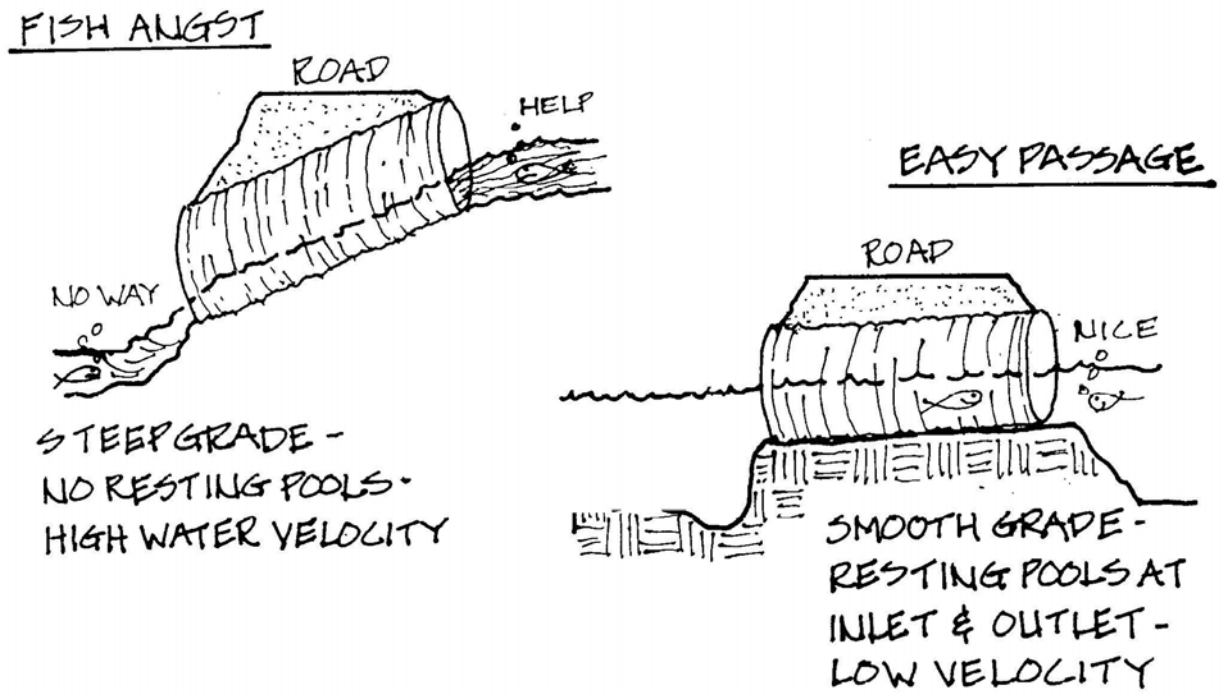
- Place riprap at upstream culvert end securely to avoid dislodging that may result in lower culvert capacity, higher velocity flows, and reduced inlet efficiency.

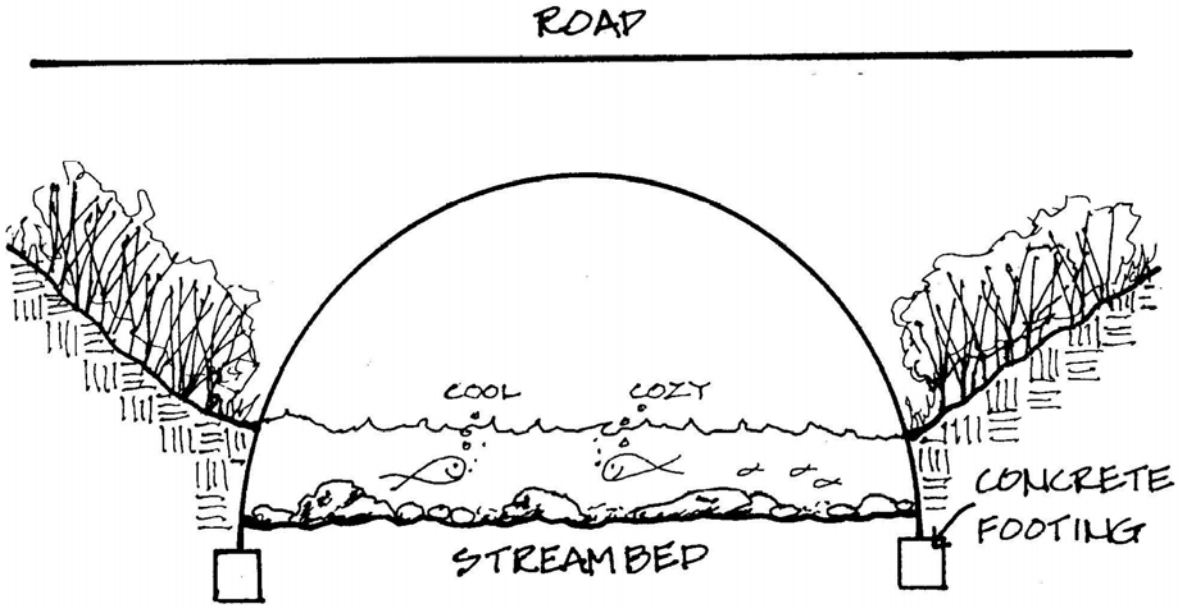
- Minimize disturbance of soil and vegetation.

- Complete all work on culvert installation before diverting the stream back to the stream channel and through the culvert.

- Contact the Vermont Department of Fish & Wildlife for assistance with stream crossings (see p. 60 for contact information).

- Contact a Stream Alteration Engineer for possible permit requirements (see p. 61 for contact information).





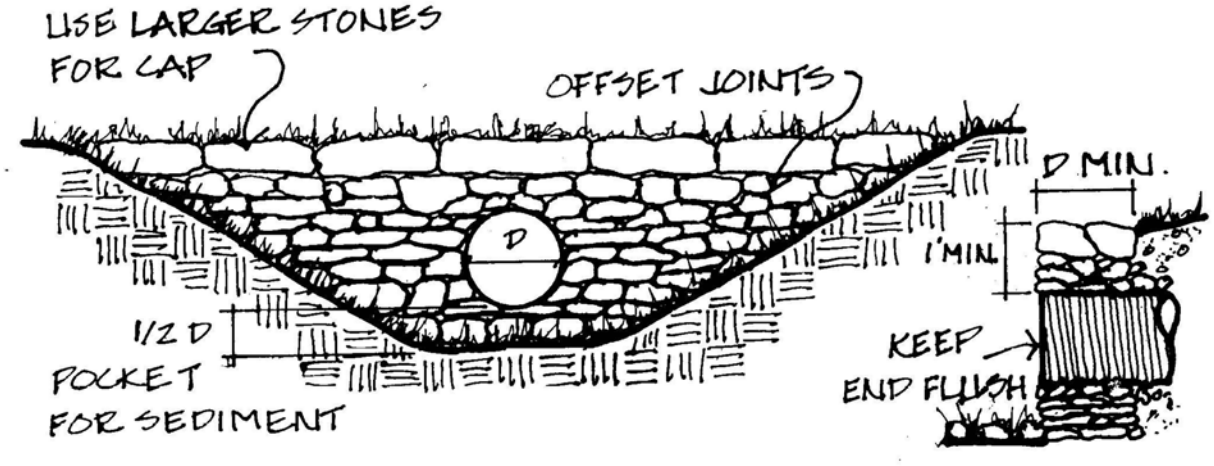
BOTTOMLESS ARCH CULVERT

Intersection of Public Roads with Private Roads/Drives:
To ensure the integrity of roads and ditches it may be necessary to provide culverts or other structures where private roads or drives intersect with public roads.

- Culverts on private roads/drives should follow the same criteria in placement and sizing as described for public roads.
- An open top culvert may be used when drainage is entering a public road by way of the private road surface. This open top culvert can be used to divert the drainage into the existing ditch.
- It is recommended for towns to have adopted a policy and standards for installing and maintaining driveway culverts. See page 56 for more information.

Headers:
Headers mark the location of a culvert, protect the culvert from damage during grading, plowing and ditch cleaning, increase the hydraulic efficiency, and prevent erosion around the culvert inlet.

- Headers can be used when hydraulic efficiency needs to be increased by 10% or less if installing a header will be easier than replacing the culvert.
- Headers should be flush with the end of the culvert.
- Dry laid field stone headers have historically been used in many areas for over 100 years, are in keeping with Vermont's character, and are aesthetically attractive.
- Header extensions (wings) help direct the flow of runoff into the culvert, preventing water from flowing in undesirable directions.

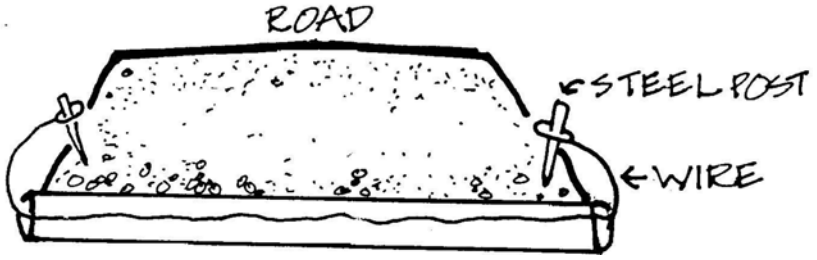


HEADER

Cleaning and Maintenance:
Avoid clogging, collapsing, washouts, and settlement by practicing preventative maintenance.

- Inspect culverts as often as possible, but at least in the spring, fall and after major storms.
- Mark or inventory culverts so they do not get missed during inspections.
- Inspect underdrains and keep outlets of underdrains clear.
- Check culverts during freezing weather and take action if the culverts start to freeze.
- Use a high pressure hose to flush most plugged culverts (with water).
- Flush culverts from the outlet end.
- Clean the outlet ditch after flushing.
- Thaw frozen culverts by using steam, high-pressure water, ice augers, calcium chloride and/or the "John's Welder" method below.
- Check culvert inlet for erosion and to ensure water is flowing in the pipe and not around it; if some water goes around the culvert it can undermine the bedding and the culvert will fail (e.g. "piping").
- Replace culverts with the same size pipe if it is handling the flow adequately.
- Increase culvert size as development along a road increases or if the culvert is more than half full during high flows.

The "John's Welder" method for removing ice build up, extracted from a Maine drainage manual, is detailed below. This method is typically reserved for culverts that experience recurring ice blockage. Suspend a 1/4 inch diameter wire through the pipes that freeze most often. When ice blocks the pipe, hook up a portable welder to the wire and melt the ice around it enough to start the water flowing again. The moving water continues to increase the flow opening. The ends of the wire are attached to steel posts in the embankment at each end of the culvert. The wire remains suspended in the pipe permanently until a freeze-up calls for removing the wire from the posts and hooking up the welder again.



Culverts should be inspected as often as possible, but at least in the spring, fall and after major storms. Increasingly, road foremen need to fix culverts or replace culverts with larger ones when they are routinely upgraded or if they are known to be substantially undersized. Use the following chart to help you recognize the signs that maintenance or replacement of a culvert is required and to prioritize your culvert projects.

CULVERT MAINTENANCE & INSPECTION CHART

What you observe...	What may be the reason	How to fix it...
Scouring/ erosion at the inlet	-ditch too steeply graded -poor location/alignment -culvert is plugged -culvert too small	-line the inlet with stone -properly align the culvert -clean/flush the culvert -replace with larger culvert -install headwalls
Scouring/ erosion at the outlet	-culvert is sloped too much -culvert is too small -culvert is too high above ground (perched)	-decrease slope of culvert -check size and replace with larger pipe if necessary - build a stone splash pad
Ponded/puddled water	-inlet is too high -ditch grade is too flat -culvert is too small	-reset the culvert to match the inlet to the channel bottom -regrade ditch to maintain correct flow -install a larger culvert
Dented/crushed ends	-traffic/snow plows are hitting the ends	-fix culvert ends and mark them -install stone header to protect from damage -add extension to lengthen culvert
Heavy corrosion	-water flowing through the culvert is acidic	-install a sleeve of PVC in the existing culvert or replace the steel culvert with a non-corrosive material (PVC, aluminum, concrete)
Water piping around the culvert	-culvert is incorrectly installed, resulting in water flowing outside the culvert	-reinstall pipe with proper bedding and compaction -install a headwall
Sediment build-up in culvert	-not enough slope -an erosion source exists uphill from culvert	-reinstall culvert with a slope of at least 1/4” per foot -locate and stabilize uphill erosion site
Sediment build-up above culvert inlet	-culvert too small -an erosion source exists uphill from culvert	-replace existing culvert with a larger one -locate and stabilize uphill erosion site

What you observe...	What may be the reason	How to fix it...
Objects blocking the culvert	-debris traveling from the ditch to the culvert	-remove blockage -install check dams uphill of the culvert
Sagging bottom	-foundation material has settled or has low bearing capacity -bottom of culvert has rotted out	-reinstall culvert with suitable and properly compacted foundation material -replace culvert
Crushed top	-not enough cover -soil around the walls not compacted -traffic loads are too heavy	-add cover -reinstall culvert deeper and/or with suitable and properly compacted bedding material -replace with stronger culvert
Eroding side banks at culvert inlet and outlet	-culvert improperly aligned with water flow -culvert too small	-realign culvert to match flow of water -replace existing culvert with a larger one -install headers and wing walls
Water backed up at culvert inlet	-culvert too small	-replace existing culvert with a larger one
Culvert is narrower than “bank full” width of live stream	-culvert too small	-measure the “bank full” or channel width about 50 feet upstream of the culvert and install a new culvert at least as wide in diameter
Culvert has washed out	-culvert too small, at the wrong angle to the road, has unstable or nonexistent headers	-replace existing culvert with a larger one -install headers on new culvert -do not reinstall the same culvert or a new one that is the same size as the one that washed out

As mentioned earlier, when considering an in-stream culvert replacement or upgrade, it may be helpful to check with the River Management Section at the Agency of Natural Resources to see if geomorphic assessment data (information about changes and adjustments a stream is undergoing) exists for that particular stream. Utilizing this information in conjunction with the hydraulic analysis (structure sizing recommendations, taking into account topography and expected flows from storm events) from a VTrans District Technician can help towns select a cost-effective structure that will be compatible with the stream channel now and in the future.

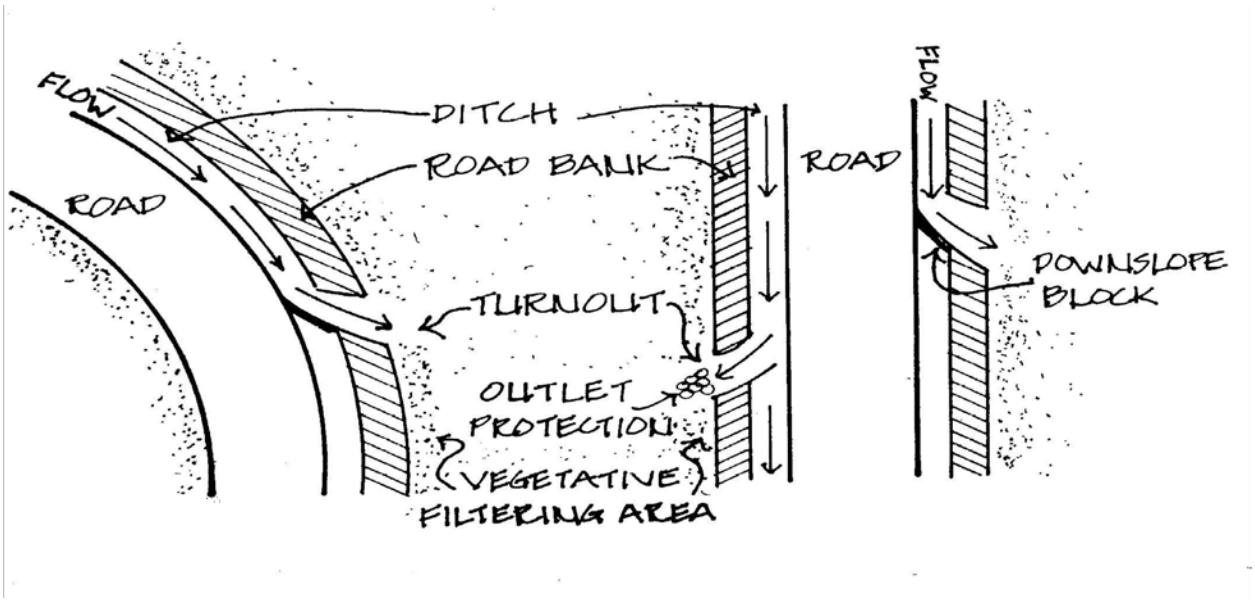
OUTLET STRUCTURES

Description:
Outlet structures are used to discharge water from a ditch or culvert. There are a variety of types of outlet structures.

Importance to Maintenance & Water Quality:
Outlet structures reduce the velocity of water carried by road ditches and culverts, therefore helping to control sedimentation. Water should outlet to areas with a moderate slope and vegetative filter zone before entering surface water. This type of outlet, often referred to as ***daylighting***, will allow for most of the sediments and other pollutants to be removed before runoff enters surface waters.

Turnouts:
Extensions of ditches which direct water away from the road edge to filtering areas whenever possible. Use of turnouts will not only protect water quality, but will also collect gravel for reuse.

- Follow culvert recommendations for spacing of turnouts (see p. 19).
- Use only in areas where the water will flow to a filtering area well away from the road and surface waters.



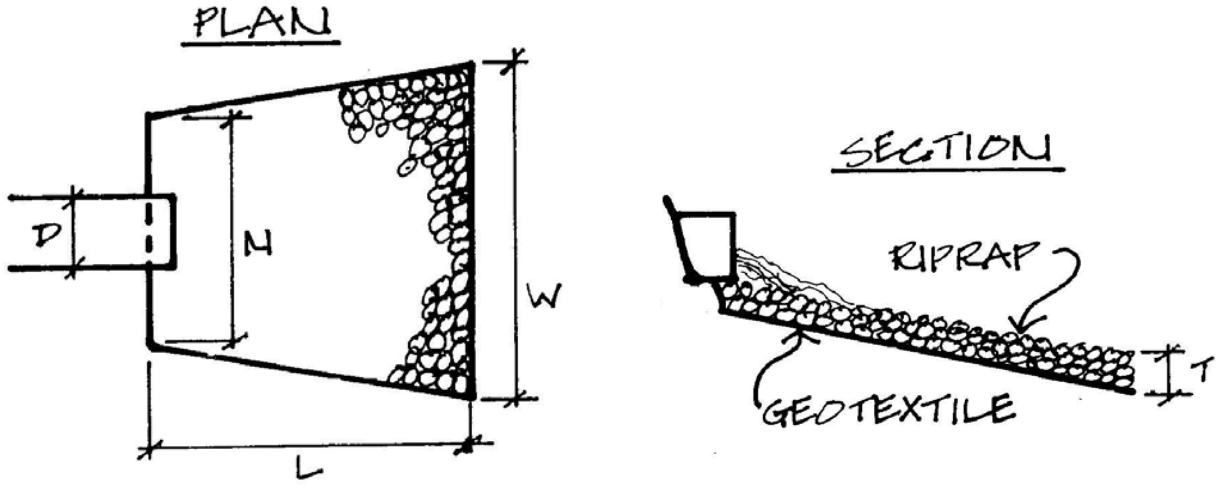
TURNOUTS

Rock Apron:
An area lined with riprap used to discharge water from culverts to existing ground.

- Provide culvert outlet protection by reducing water velocity and promoting sheet flow.
- Use only where there is an adequate vegetative filter strip.
- Discharging of a culvert to a fill slope will require a conveyance channel before the water reaches the rock apron.
- Size and placement of riprap in the apron is dependent upon the diameter of the culvert as well as on expected water flow through it.

Rock Apron Specifications					
Culvert Diameter (D)	Riprap Size	T (in.)	N (ft.)	W (ft.)	L (ft.)
18 inches	(3-12 inch)	18	4.5	14.5	10.0
24 inches	(3-12 inch)	18	6.0	20.0	14.0

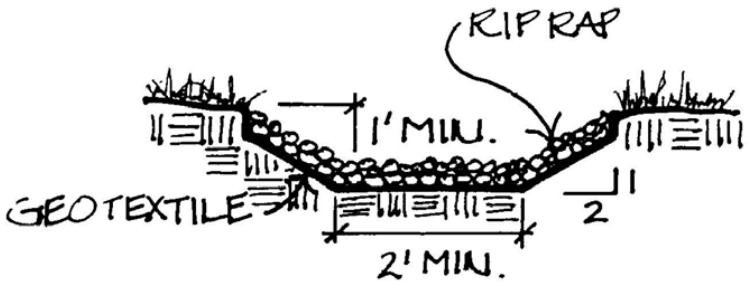
D= diameter of culvert
T= depth of stone in apron
N= width of apron near culvert
W= width at downhill end of apron
L= length of apron

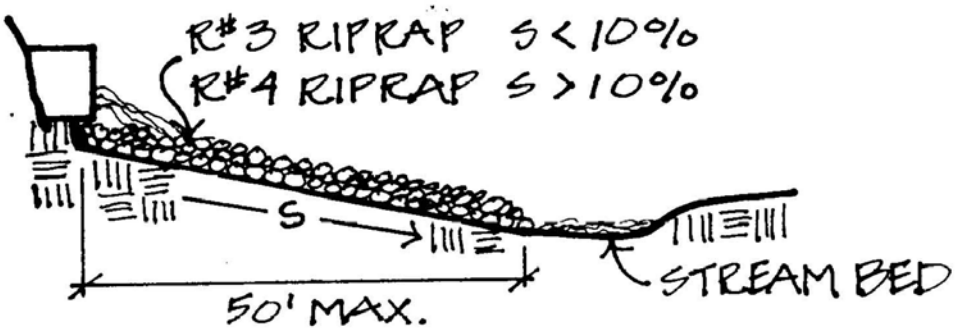


ROCK APRON

Riprap Conveyance Channel:
A riprap channel is used to remove sediments and to keep the channel itself from eroding while carrying runoff from a culvert or ditch.

- Use in areas with fill slopes or with steep slopes where erosion would otherwise occur.
- Use in areas without adequate vegetative filter strips, and where an outlet must go directly into surface waters.

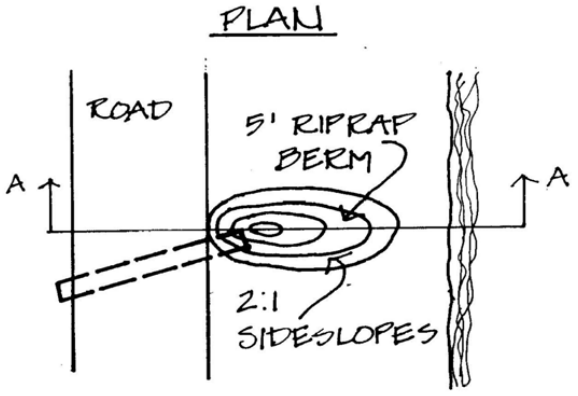


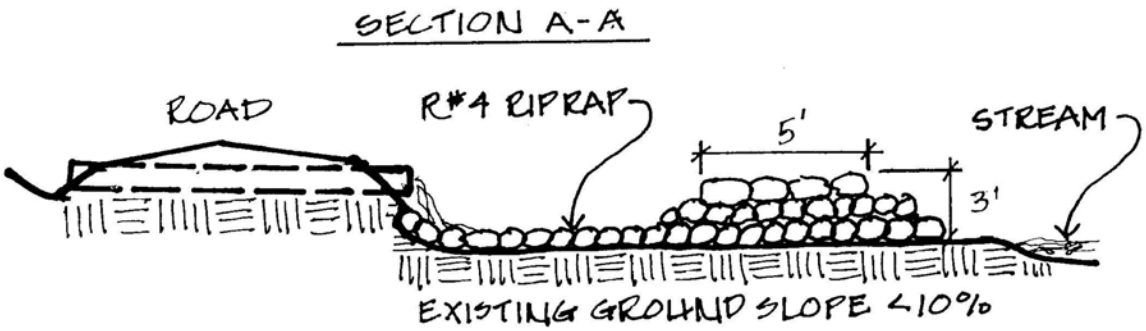


RIPRAP CONVEYANCE CHANNEL

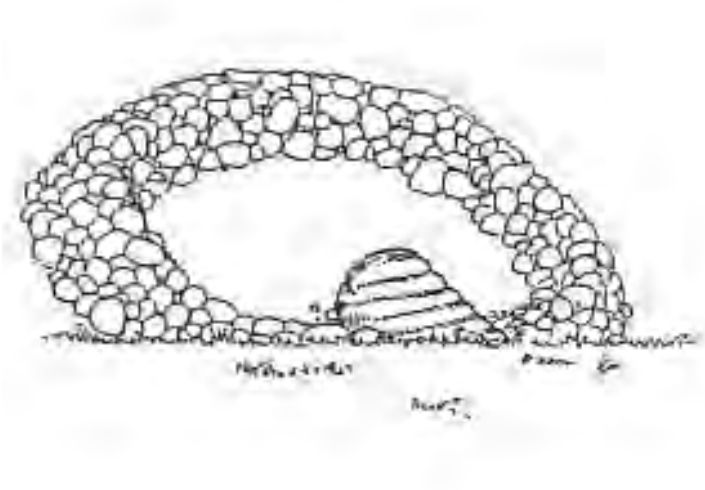
Splash/Plunge Pools:
Riprap basin located at outlet of a culvert pipe.

- Used to remove sediments (by absorbing energy from flowing water and allowing sediments to settle out) from areas with concentrated flows and areas without adequate vegetative filter strips.
- Limited to areas with less than 10% slope.
- Consolidates sediment for easier removal.
- Reduces energy and velocity of flows by providing storage of runoff.
- Can allow for ground water recharge.
- Clean when pool area is one third filled with sediment.
- Locate the pool so that mechanized cleaning is possible.
- See pool capacity requirements chart on next page for sizing.





SPLASH/PLUNGE POOL



Splash/Plunge Pool Capacity Requirements		
Distance Between Culverts (ft.)	Pool Capacity (cu. ft.)	
	Crowned road	Banked road
500	230	460
400	180	360
350	160	320
300	140	280
250	120	240
200	100	200

Description:
Bank stabilization is the vegetative or structural means used to prevent erosion or failure of any slope. These terms have different definitions as well as different causes. Erosion occurs when soil particles are carried away. It is directly caused by: wind, water, ice, and gravity. It is indirectly caused by such things as: obstacles in a stream, overbank drainage, heavy rainfall on exposed soil, freeze-thaw and dry cycles, seepage, and changes in land use. Failure of a bank occurs when a section of the bank slides. Bank failure is caused by: increase of load on top of the bank, swelling of clays due to absorption of water, pressure of ground water from within the bank, minor movements of the soil or creep, and changes in stream channel shape.

Importance to Maintenance & Water Quality:
Stabilization of banks along roads and streams will prevent bank erosion and failure, both of which may contribute considerable amounts of sediment to surface waters. Preventing erosion and bank failure can also alleviate the need for expensive road repairs that can be the result of these problems.

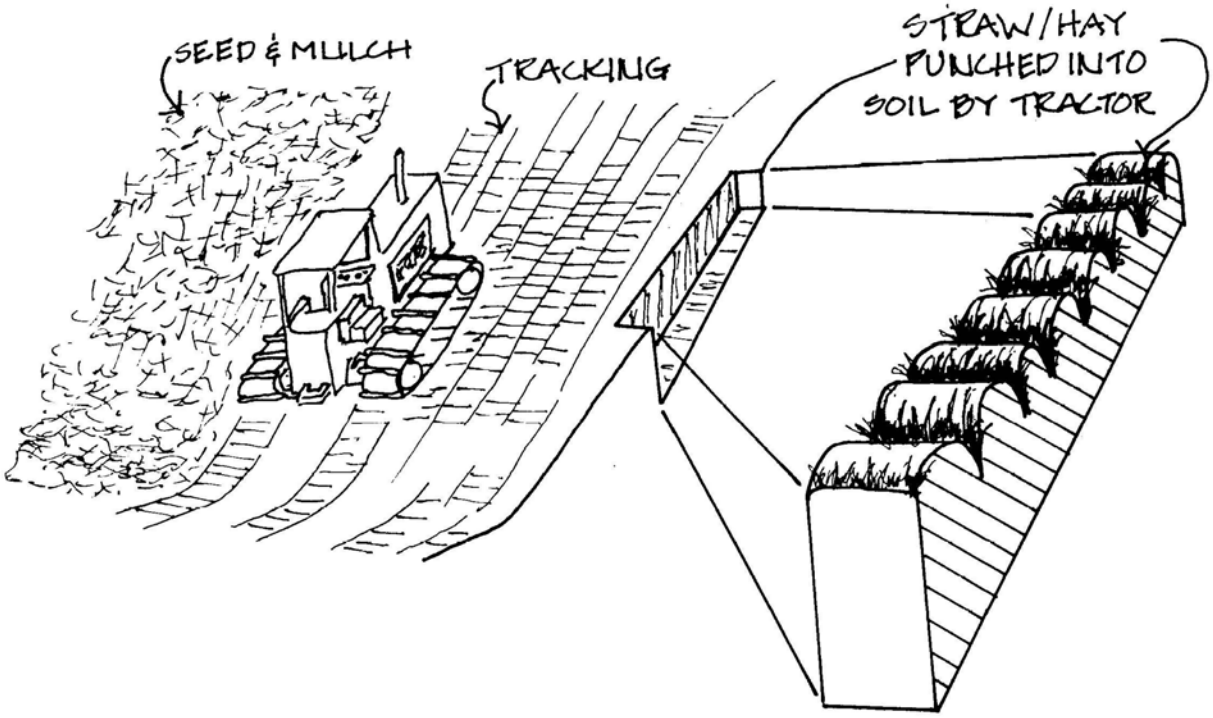
Vegetation – Seeding:

- Seeding is the most efficient and inexpensive method to stabilize a bank and should be used wherever possible.
- Grass will slow the movement of water, allowing more water to seep into the ground and minimizing the impact of runoff to surface waters.
- Seed areas **as soon as possible** after disturbance - this may even need to be done on a temporary basis.
- Place sod in areas with unstable soil immediately.
- Areas to be seeded should have a maximum 2 horizontal : 1 vertical slope.
- Erosion control blankets (rolls of degradable netting embedded with hay or straw) can be used on steep slopes to better hold seed and soil in place.
- Spread at least 3 inches of topsoil over the area to be seeded.
- Finished grading should be done after topsoil is spread.
- Fertilize and lime the area as needed according to the soil conditions.
- Harrow or rake fertilizer and lime into soil to a depth of two inches.
- The surface should be left rough to reduce water velocity and to help hold seed and mulch.
- Select a seed mixture appropriate for site soil and drainage, (“conservation mix” is suitable for most areas).
- Broadcast seed evenly over the prepared area by either hand broadcasting or hydroseeding.
- Hydroseeding is done using a truck with a mounted sprayer that broadcasts a mixture of seed, mulch and tackifier.

- Mulch after seeding with hay or straw to a depth of 3 inches. This can be done by blowing it on from a truck or by hand spreading. If no mulch is to be applied, roll, rake or brush to lightly cover the seed.

- Anchor mulch into soil by using a disk harrow, sheepsfoot roller or tractor.

HYDROSEEDING



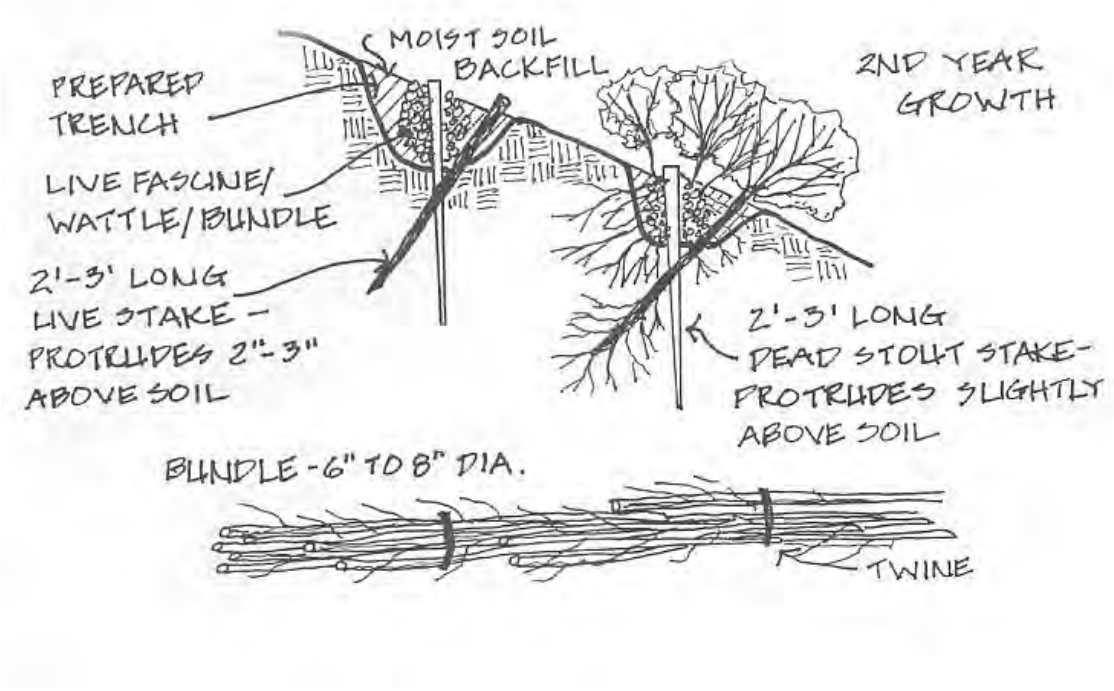
SURFACE ROUGHENING

Vegetation – Shrubs and Trees:
Shrubs and trees can be used to stabilize steep slopes and stream banks, and create a good vegetative filter strip.

- Deeply rooted woody species provide greater protection against bank erosion problems.
- Identify other plants in the area to determine the most suitable plants to use for stabilization.
- Commonly used stabilization plants include: willows, alders, and dogwoods.
- Techniques for stabilizing banks with **woody plants** include live fascines/wattles/bundles, live stakes, brushlayering, and sprigs/ plugs.

Live Fascines/Wattles/Bundles:
Long bundles, 5 to 30 feet in length and 6 to 8 inches in diameter, of live branches tied together with growing tips oriented the same direction and tops evenly distributed through length of bundle.

- Place in 12 to 18 inch deep trench dug along the contour of the slope, working from the base of the slope upwards.
- Secure with live stakes and dead stout stakes.
- Install bundles the same day as cut during dormant periods (spring, winter or fall).
- Can be used on steep slopes (1:1) and to protect slopes from shallow slides.



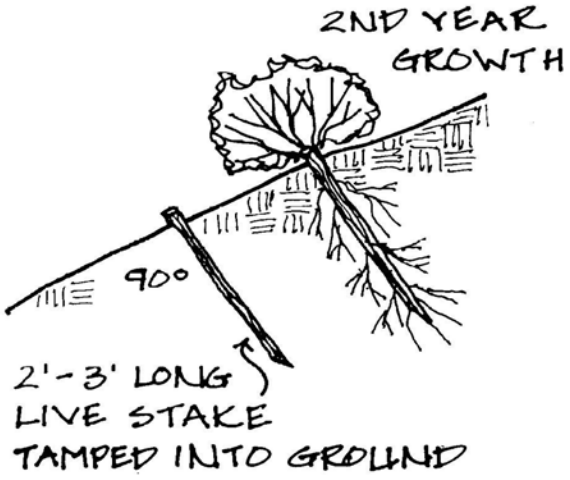
LIVE FASCINES/WATTLES/BUNDLES

Live Stakes:
Cuttings of live branches, usually ½ to 1-½ inches in diameter and 2 to 3 feet long.

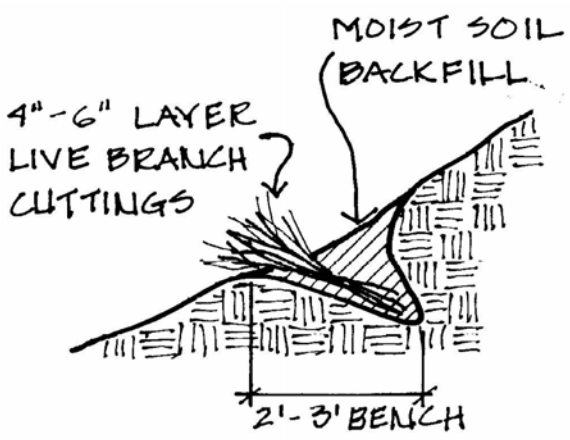
- Branches should be cleanly removed from the stake and basal ends of stake cut at an angle for easy insertion into the soil.
- Stakes are tamped into the ground at right angles to the slope along the contour with buds oriented up.
- Plant in alternating grids with 2 to 4 stakes per square yard.
- Plant stakes the same day as cut during dormant periods (spring, winter, or fall.).
- Inexpensive method that can be used when time is limited and the site is relatively uncomplicated.

Brush layering:
Live branches, ½ to 2 inches in diameter and 3 to 4 feet long, are placed perpendicular to the slope with growing tips outward.

- Small 2 to 3 feet wide benches, angled slightly higher at the outside, are excavated along the contour starting at the toe of the slope and working upward.
- Branch cuttings are placed on the bench in a crisscross or overlapping manner.
- Backfill on top of branches and compact.
- Plant branches the same day as cut during dormant periods (spring, winter, or fall.).
- Used to break up slopes into a series of shorter slopes.



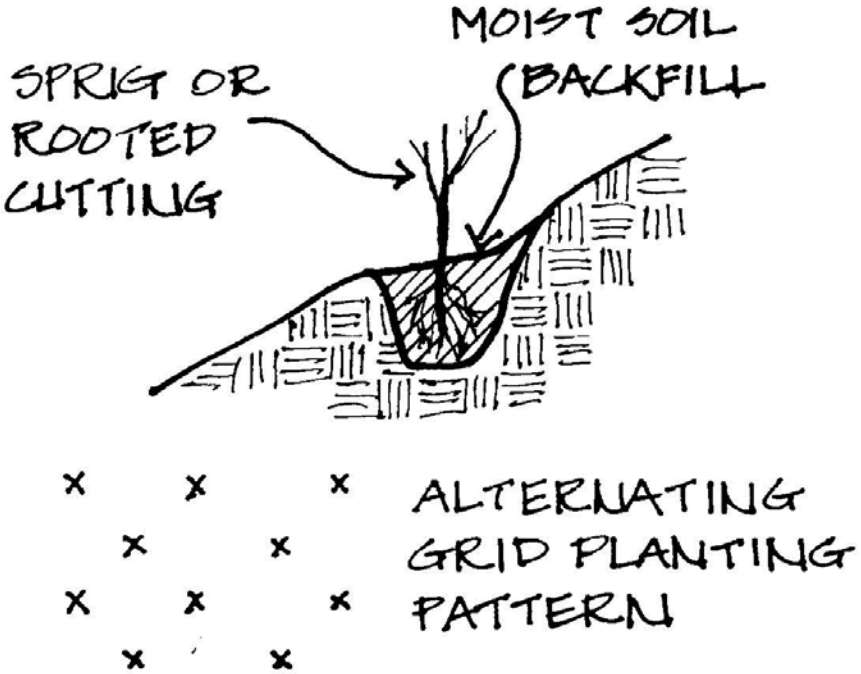
LIVE STAKES



BRUSHLAYERING

Sprigs/Plugs:
Individual plant stems with roots –can be seedlings or rooted cuttings.

- Place in hole that is dug large enough to accommodate the roots and tamp soil down around the plant.
- Plant in alternating grids with plants ½ to 1 yard or meter apart.
- Often used on filled slopes in conjunction with special fiber rolls.
- Rooted shrubs from a nursery may also be planted and are more reliable, but more expensive.



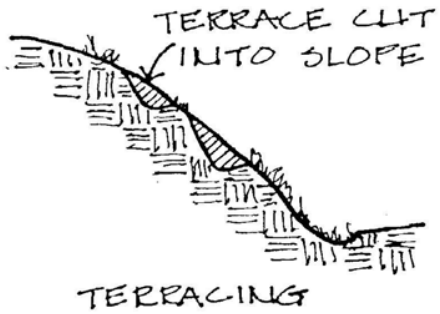
SPRIGS/PLUGS

Grading Techniques:
Proper grading or regrading of slopes can often stabilize banks without the use of structures.

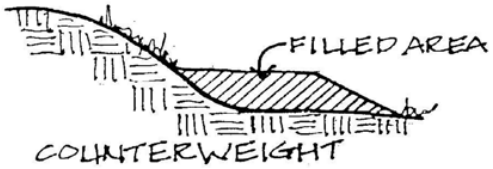
- Grading or regrading slopes to a maximum 2:1 slope will help to stabilize the bank.

Terracing:
Benches can be constructed on slopes that are excessively steep and long to provide near level areas that intercept and divert water.

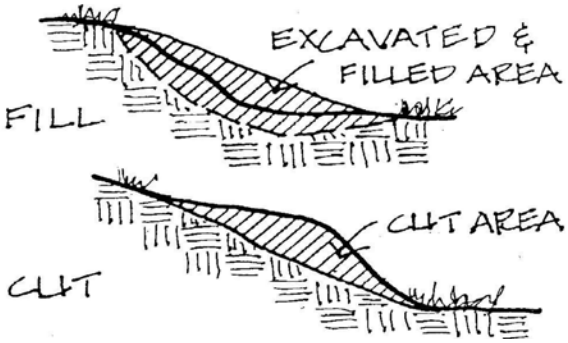
- Backslope terraces inwards toward the slope to intercept water and prevent erosion of terrace.



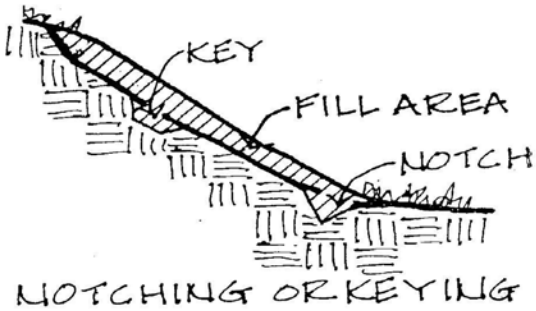
Counterweight:
A one level bench and slope that can be added next to a steep failing bank to hold the bank up and prevent continued sliding.



Cut and/or Fill:
The removal or addition of soil to the bank to create the desired 2:1 or flatter slope, often times removing less stable soils and replacing them in the process of regrading the slope.

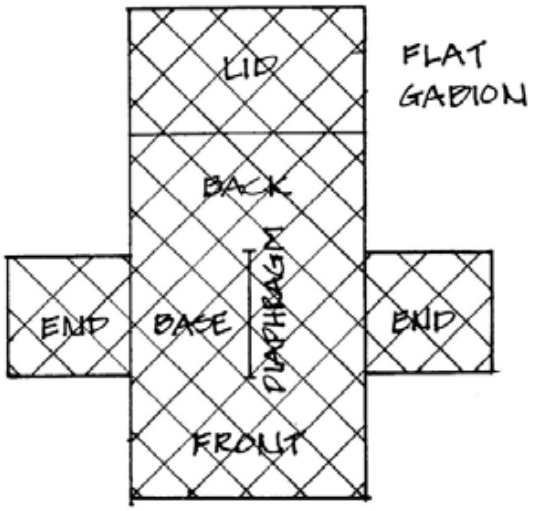


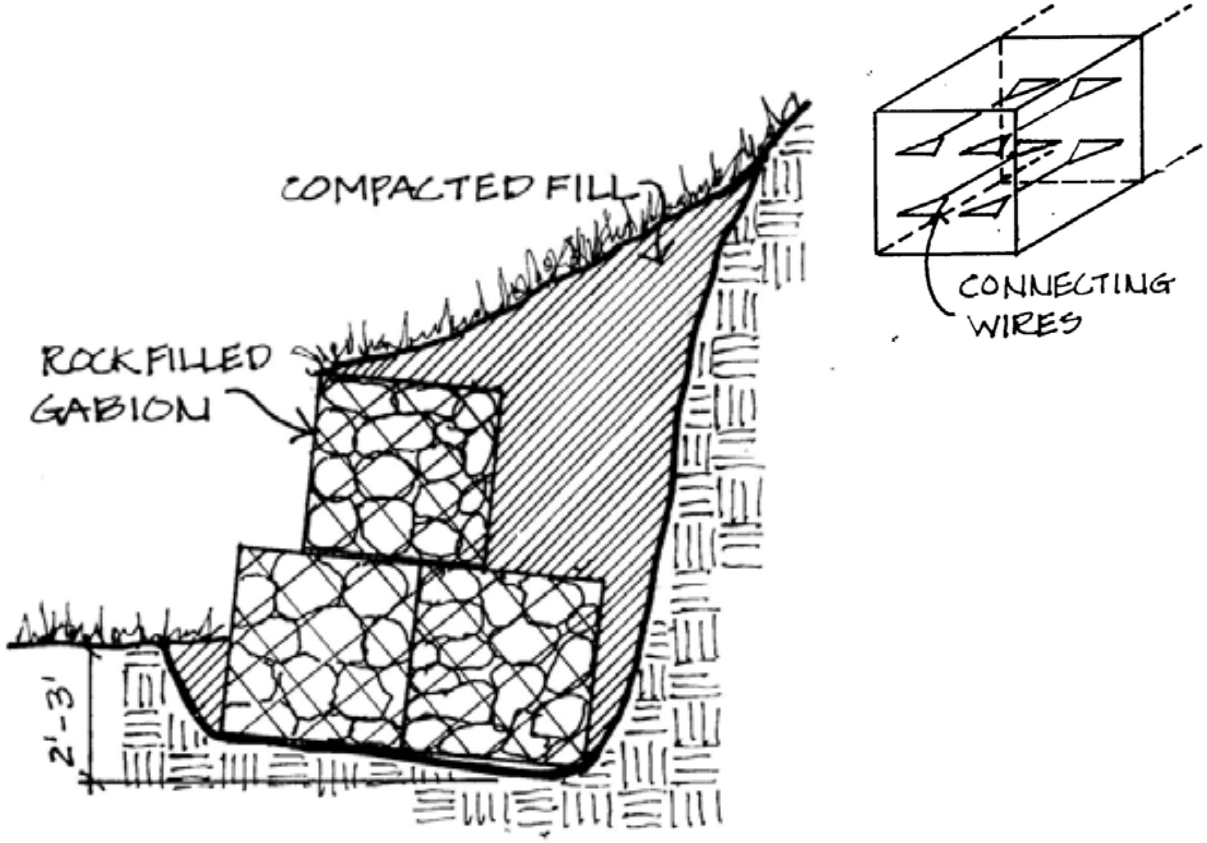
Notching or Keying:
A "V" or trapezoid shaped cut made in the existing ground to help further stabilize the slope.



Gabion Wall:
Wire mesh rectangular boxes filled with stone and used as a retaining wall.

- Gabions are permeable allowing water to seep through and aiding in the removal of sediments.
- Gabions can be stacked or terraced.
- Gabions can be combined with woody vegetation for stabilization and aesthetics (see page 43).
- Use filter fabric between soil and gabions to prevent soil from washing out.

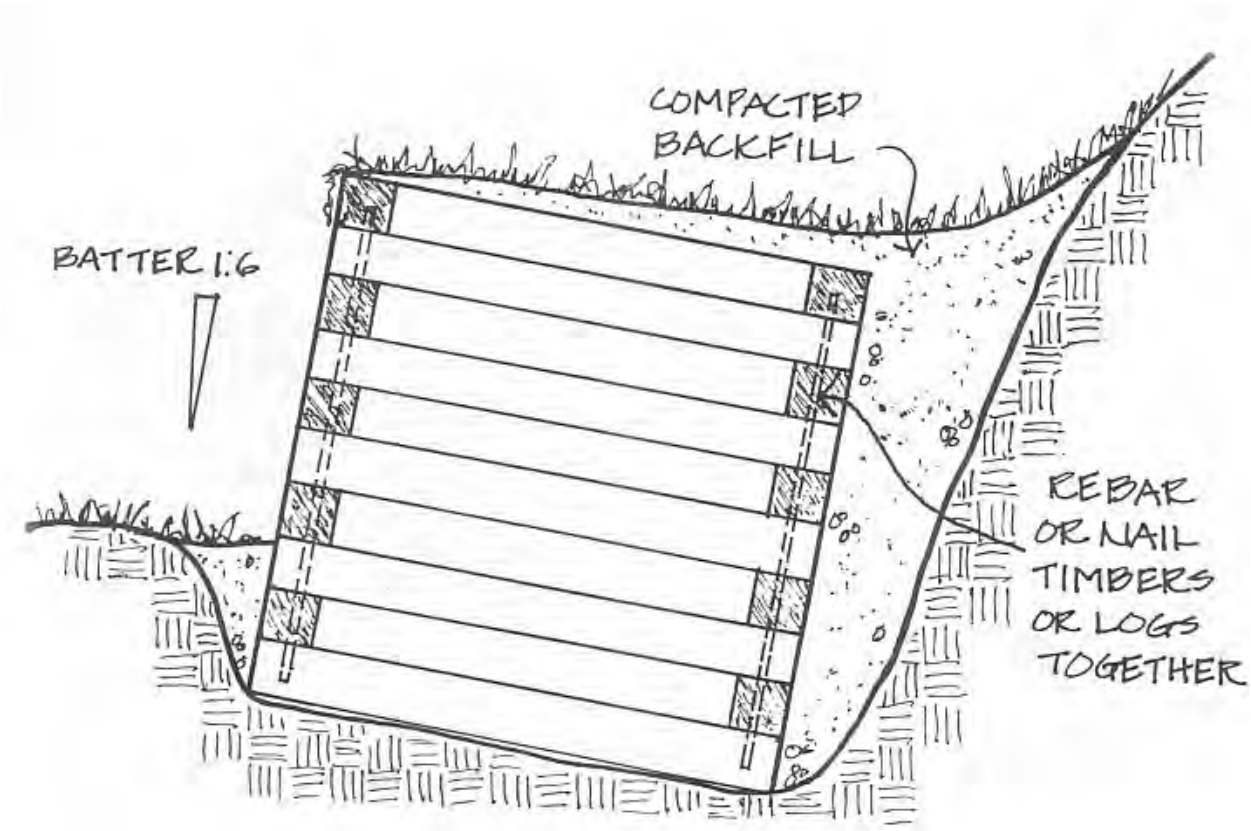




GABION WALL

Log or Timber Cribs:
A structure made of logs or treated timber and filled with soil used as a retaining wall.

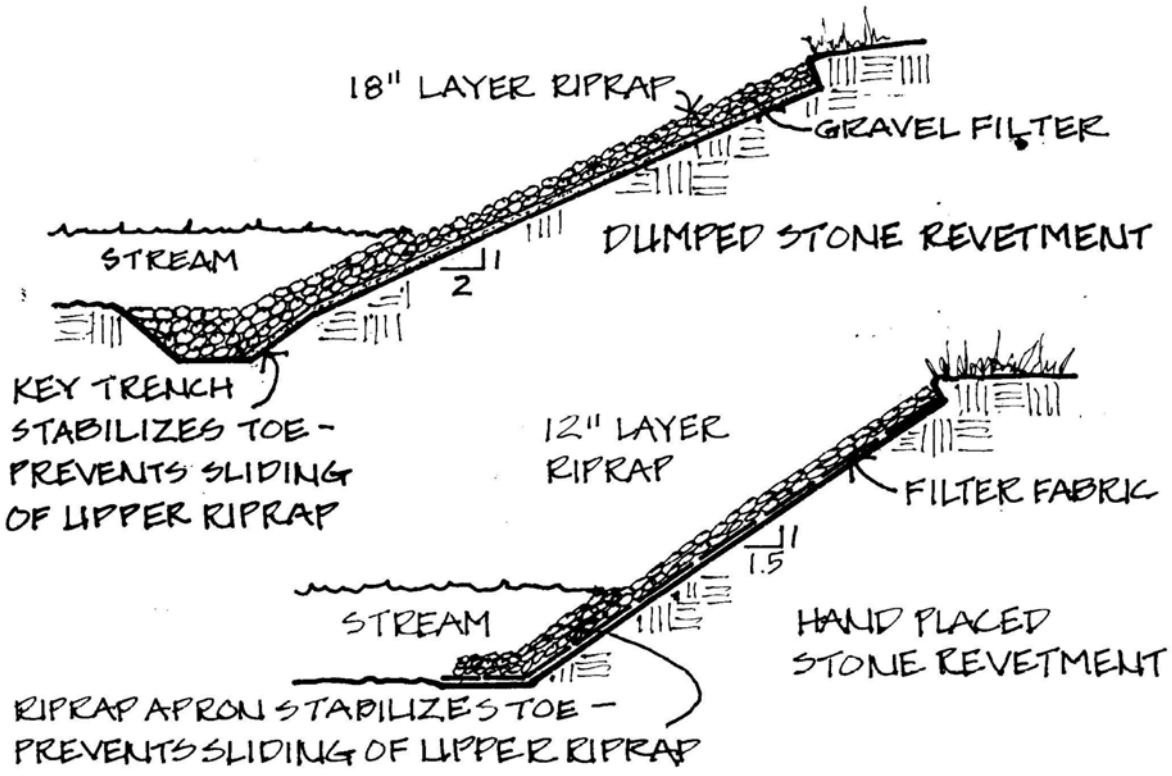
- Live branches can be planted in the crib to assist with stabilization (see page 42).



LOG OR TIMBER CRIB

Riprap Revetment System:
Riprap can be carefully placed on bank slopes and stream edges where vegetation does not adequately prevent soil loss to reduce erosion and filter sediment.

- Size of riprap is dependent on quantity and velocity of water.
- Used on very steep slopes, at sharp turns in streams and where a bridge or culvert restricts water flow.
- Always contact a Stream Alteration Engineer at the Agency of Natural Resources before installing riprap on a streambank (see page 61).
- Use angular riprap stone. Slate or round stone will slide too easily.
- Install filter fabric under riprap to prevent soil from washing out unless advised otherwise by the Stream Alteration Engineer.
- Consider planting among the riprap to add stability, attractiveness and habitat value to the job (see page 45).
- Consider planting vegetation at the top of the bank- above the high water level- and stabilizing with riprap at the toe of the slope where moving water will flow.



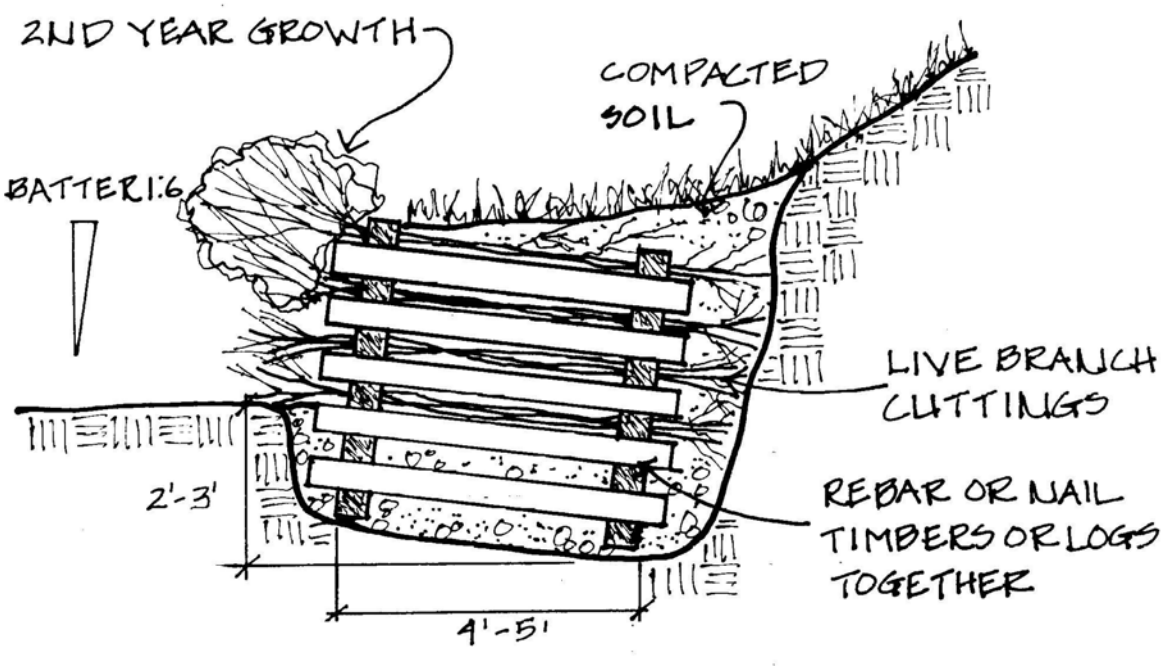
RIPRAP REVETMENT

Bioengineering:
The combination of vegetative and structural components to form a system used to stabilize steep banks.

- Used when one component will not provide the necessary slope protection and stabilization.
- Combination or bioengineering techniques include live crib wall, vegetated gabion, vegetated rock wall and vegetated riprap/joint planting.

Live Crib Wall:
A log or timber crib combined with live branches, as used in brush layering.

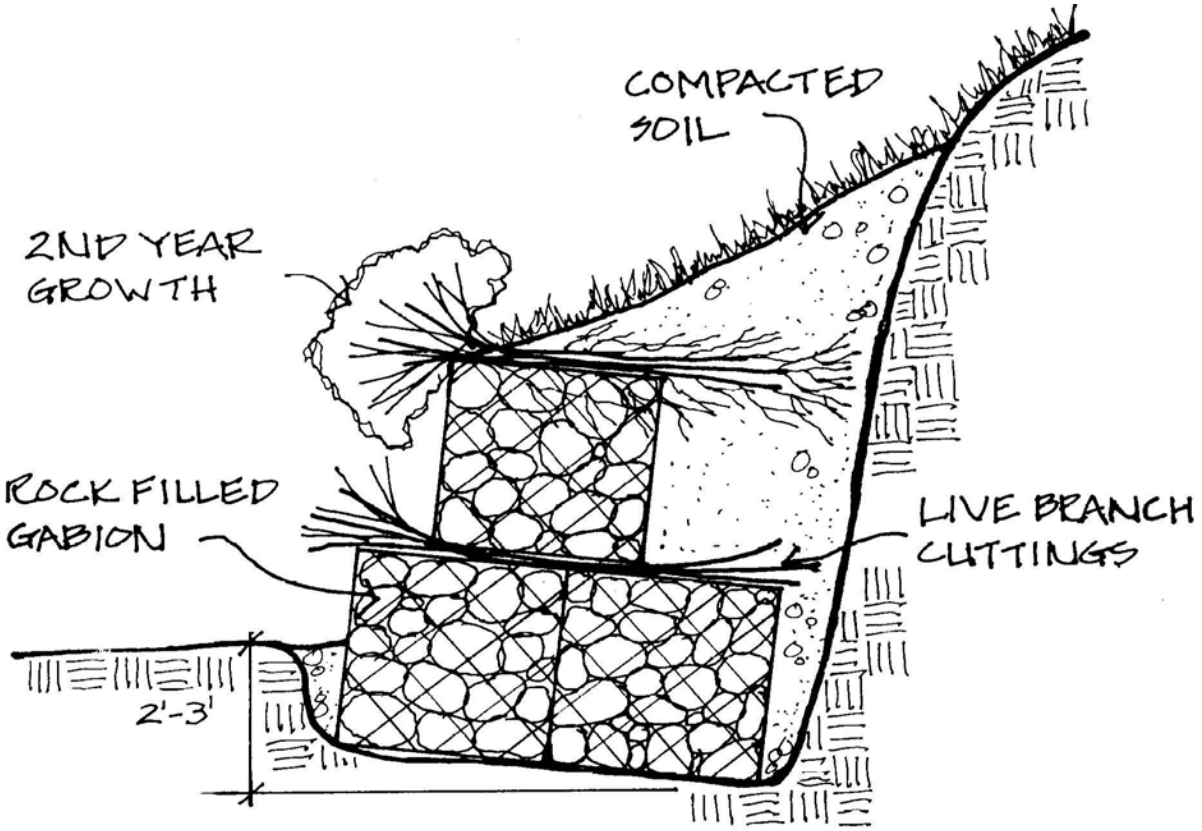
- Place logs or timbers in an alternating manner, leaving space for live branch cuttings.
- Branch cuttings should be long enough to reach the undisturbed soil at the back of the crib.
- Cover each layer of branches with a layer of compacted soil.
- Use at the base of a slope where a low wall (not higher than 6 feet) is required.
- May also be constructed in a step fashion, creating additional planting areas.
- Timbers provide structural support while plants take root, but use half as much wood as in a timber or log crib, making it less expensive.



LIVE CRIBWALL

Vegetated Gabion:
A gabion wall combined with live branches, as used in brush layering.

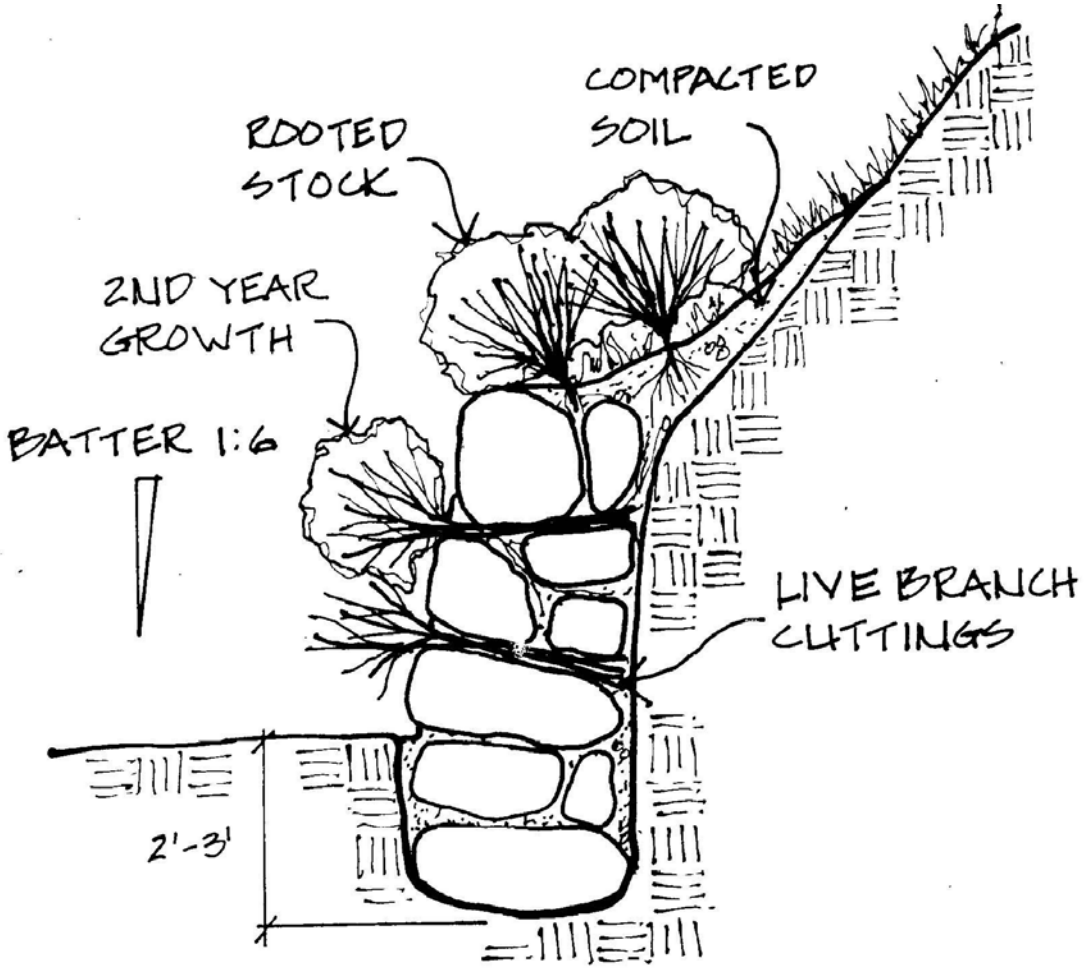
- Backfill between each layer of gabions and place live branch cuttings on backfill.
- Cover with soil and compact.
- Use at the base of a slope where a low wall, not higher than 5 feet is required.
- Live branches root in gabions and slope, binding the gabions to the slope.
- Aesthetic enhancement to gabion wall.



VEGETATED GABION

Vegetated Rock Wall:
A combination of rocks and live branches, as used in brush layering.

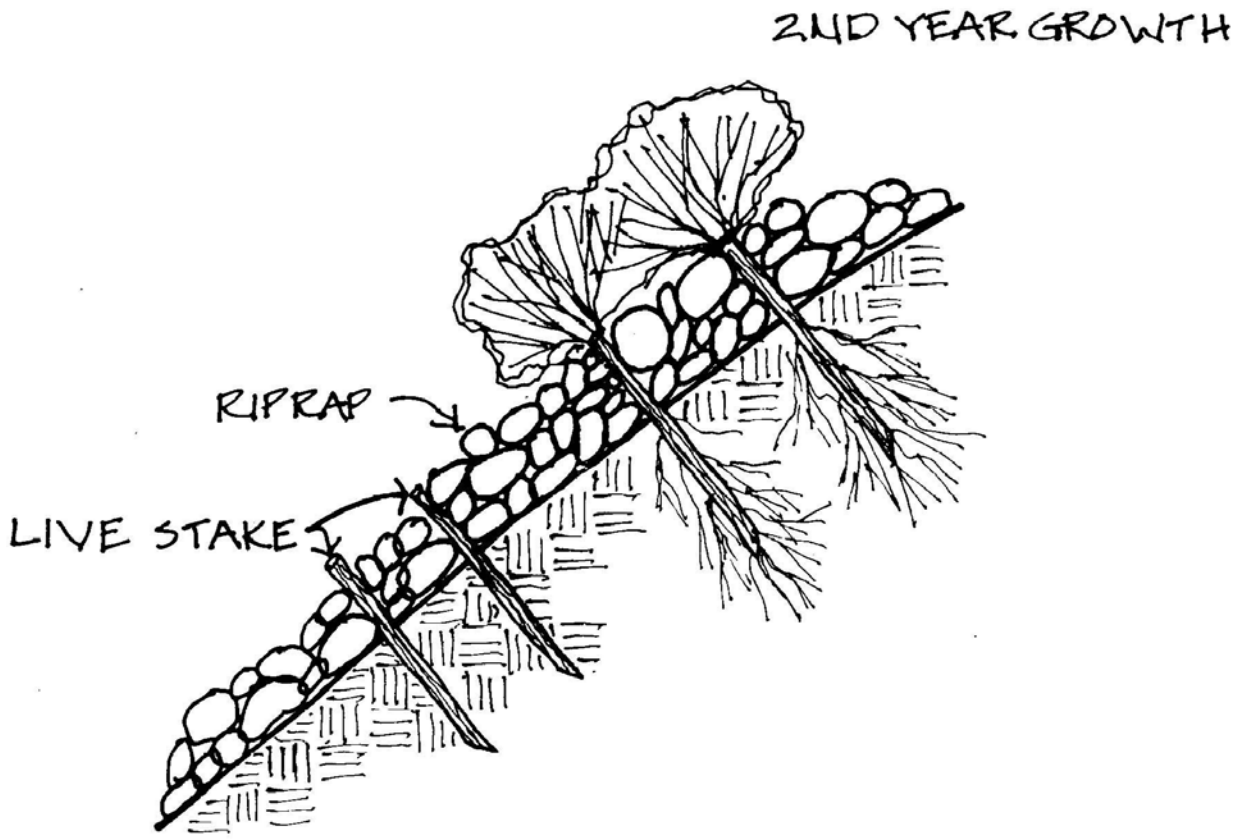
- Provide a well-drained base for the wall.
- Excavate a minimum amount of slope behind the wall.
- Place rocks with long axis slanting inward toward the slope.
- Backfill between each layer of rocks and place live branch cuttings on backfill.
- Cover with soil and compact.
- Use at the base of a slope where a low wall, not higher than 5 feet is required.



VEGETATED ROCK WALL

<u>Vegetated Riprap/Joint Planting</u>:
Combines a riprap revetment with the tamping of live stakes between the joints or open spaces in the rocks.

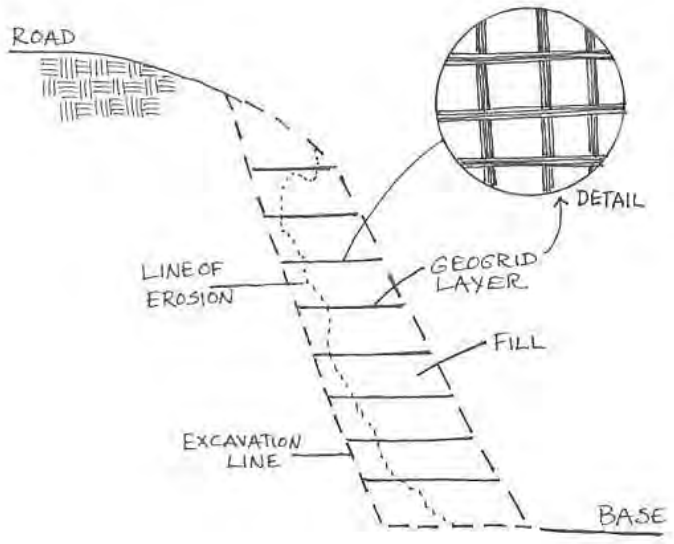
- Live stakes must be long enough to extend well into soil below rock surface.
- Roots improve drainage and create a mat that binds and reinforces the soil, preventing washouts and loss of fines between and below the rocks.



VEGETATED RIPRAP

Geogrids:
Geogrids are extremely durable woven materials with a polymer coating that can be used for soil reinforcement. Geogrids have a high tensile strength and are ideal for use on steep slopes and in areas with a narrow right-of-way or where finished slopes will be steeper than 2:1.

- Can be used as an alternative to riprap or a concrete retaining wall.
- Can be planted over with vegetation for additional strength and aesthetics.
- Resists degradation by water and chemicals normally found in soils.
- Check with product manufacturer for specific installation details.

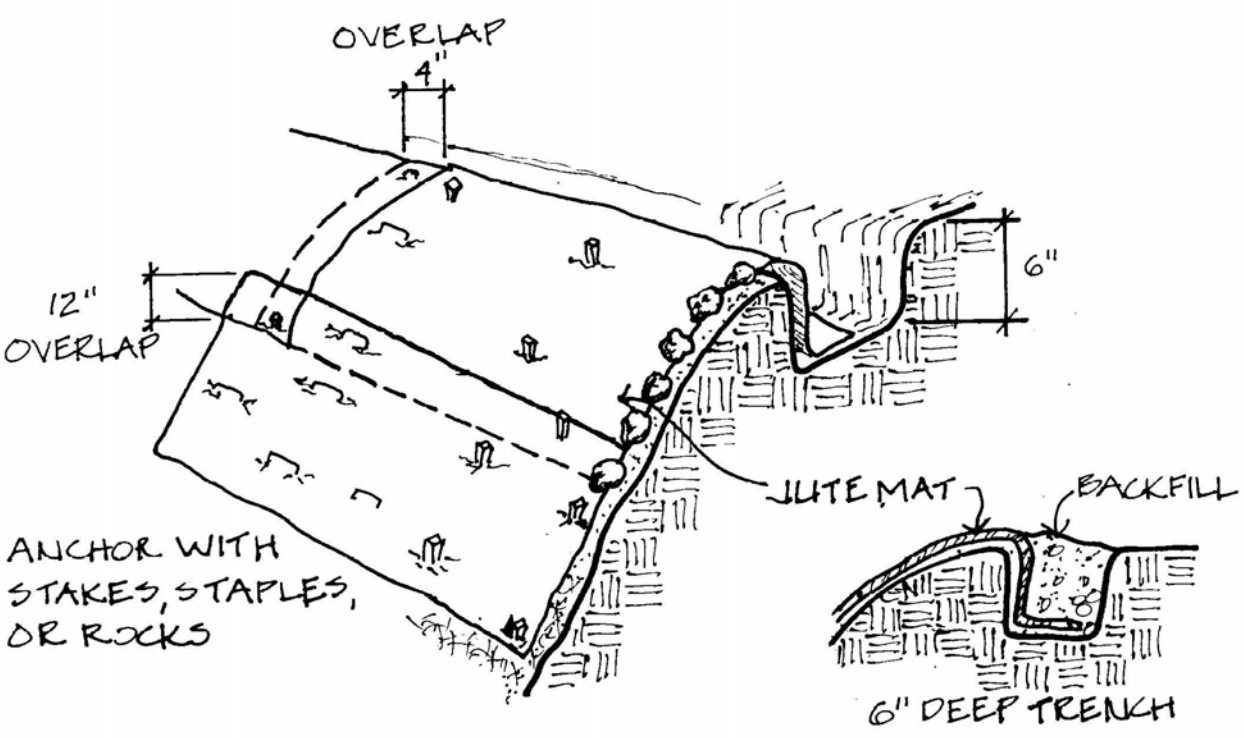


GEOGRID

Erosion Control Mats & Blankets:
Erosion control mats and blankets are used to prevent erosion on steep slopes, in ditches with high water velocities, and other areas prone to erosion. Types of mats and blankets include jute matting, wood excelsior mat, mulch blanket, and geotextiles.

Jute Matting:
Undyed jute yarn, woven into an open 1-inch square weave mesh.

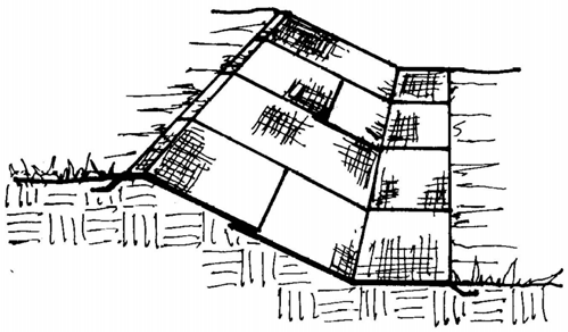
- Spread over seeded and mulched areas to hold in place.
- Bury up slope end of each section in a 6-inch vertical slot, backfill and tamp.
- Overlap each up slope section with 12 inches of mat.
- Overlap side-by-side sections by 4 inches.
- Securely anchor mat with stakes and/or staples.
- Use only matting with non-fixed net joints near water so animals can't become trapped in the matting.



JUTE MATTING

Wood Excelsior Mat:
Machine produced mat of 6-inch long curled wood excelsior entwined with a photodegradable plastic mesh.

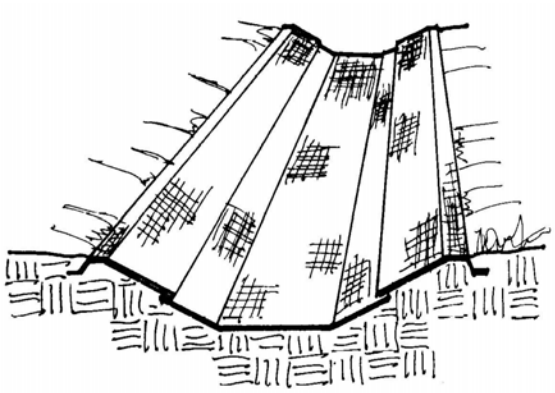
- No need to mulch when using a wood excelsior blanket.
- Ends of sections should be tightly butted but not overlapped.
- Installation is otherwise similar to jute mat.



SLOPE INSTALLATION

Mulch Blankets:
Straw, coconut, or wood fibers sandwiched between photodegradable plastic.

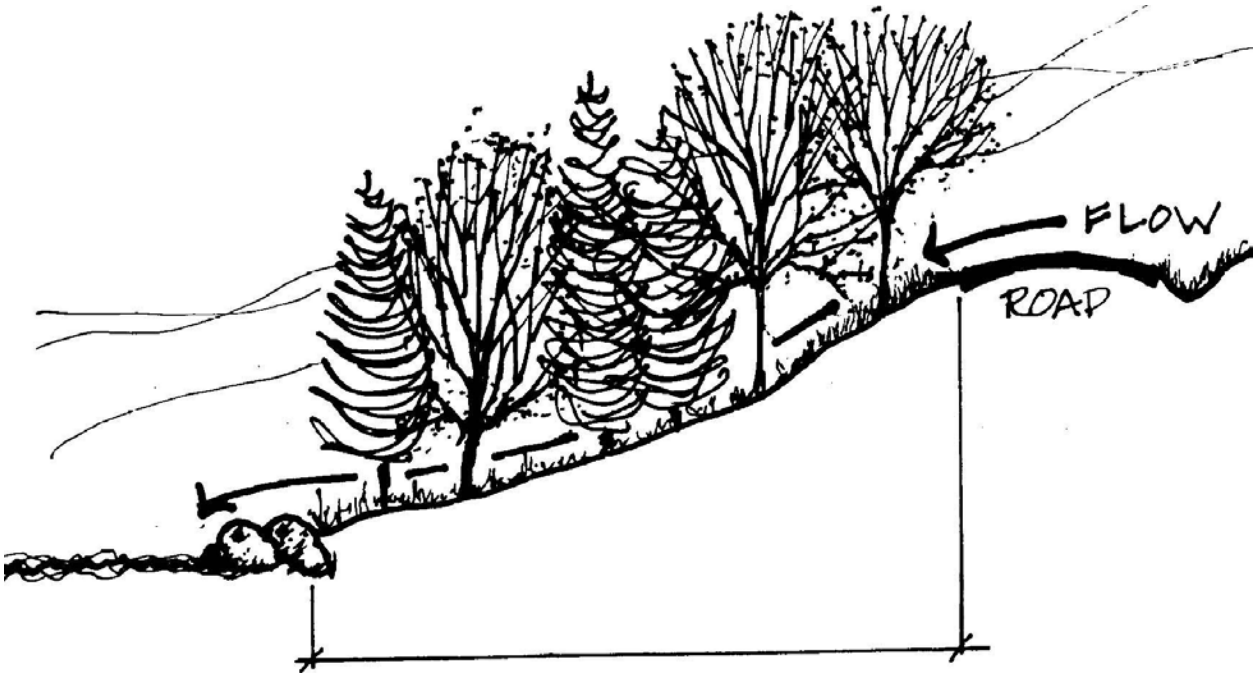
- Use in areas where it is difficult to hold mulch in place and there is erosion potential until vegetation is established.
- Place after area has been seeded.
- Place lengthwise along direction of the slope and secure with staples.



DITCH INSTALLATION

Buffer Zone: Undisturbed vegetated areas that separate roads, development, or construction sites from sensitive areas such as streams, wetlands and lakes.

- Roughness of the vegetation slows stormwater flow and reduces its erosive power.
- Vegetation acts as a natural filter by intercepting sediments, nutrients and other pollutants that may be in stormwater .
- Does not require any maintenance.
- Preferred method of slowing and filtering stormwater before it enters surface waters.
- Buffer zones are not intended and should not be used for treatment of channelized flow.
- Provides shade and habitat for birds and other wildlife.
- Can help stabilize banks and absorb floodwaters.



50' MINIMUM FOR STREAMBANKS
100' MINIMUM FOR LAKE SHORES

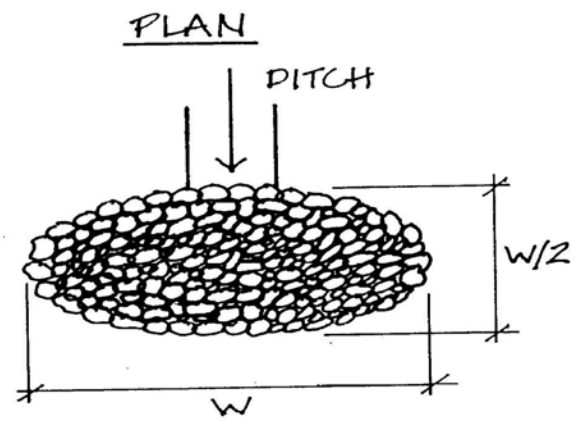
BUFFER ZONE

Storage & Borrow Areas:
Areas where soil for use in road construction or maintenance is either kept for future use or taken from, as in a sand pit.

- Develop an erosion and sediment control plan for the specific site.
- Divert runoff from the face of exposed slopes.
- Only leave areas in current use unvegetated.
- Stabilize exposed areas immediately after use.
- Locate storage areas on the uphill side of a disturbed area so they can act as a diversion for runoff.
- Locate these areas away from surface waters.
- Control any sediment from storage and borrow areas with previously described temporary control techniques (see pages 9-11).

Level Spreader:
Bermed trench used to intercept and discharge water flow over a wide linear area.

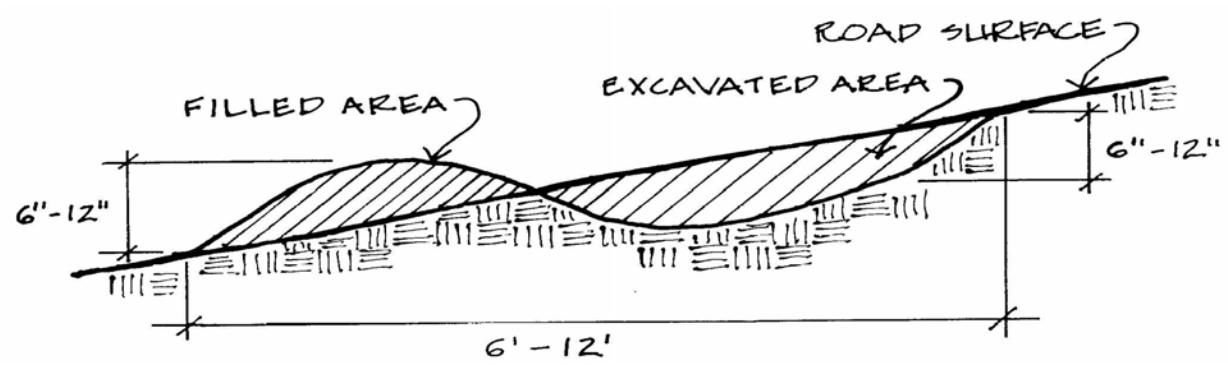
- Prevent gullies by discharging over a wide linear area.
- Generally used at the toe of a slope.
- Construct a long, level bermed trench. Water will discharge evenly over the berm when trench is full.



LEVEL SPREADER

Waterbar:
Berm or open culvert constructed across a road or driveway used to divert water flowing down the road.

- Use only on very low traffic volume roads.
- Prevents gullies in the road.
- Eliminates concentrated sediment deposits.
- Construct low enough for traffic to pass over and angle at approximately 30° across road (not perpendicular).
- Spacing of waterbars is dependent upon road slope.
- Need to be cleaned out and/or rebuilt periodically.
- Inexpensive means for controlling and diverting water.



WATERBAR CROSS-SECTION

Vegetation Management:
The overarching tree canopies along Vermont's Backroads are an important intrinsic natural resource to both residents and visitors. Roadside trees not only help hold soil and stabilize banks with their roots, but also provide cooling shade in the summer, act as living snow fences in winter and provide beautiful foliage in the fall. Roadside trees also encourage traffic calming to slow motorists down and contribute to the community by instilling a sense of pride in the residents.

Trees growing alongside the road are exposed to many more stresses than forested trees. Root and trunk injuries are common during ditch work, plowing and grading and roadside trees have an increased exposure to salt from winter road maintenance. The road crew has the important job of balancing the need for the proper road maintenance and erosion control that will keep sediment from reaching surface waters with the need to maintain the wonderful aesthetic qualities of Vermont's backroads.

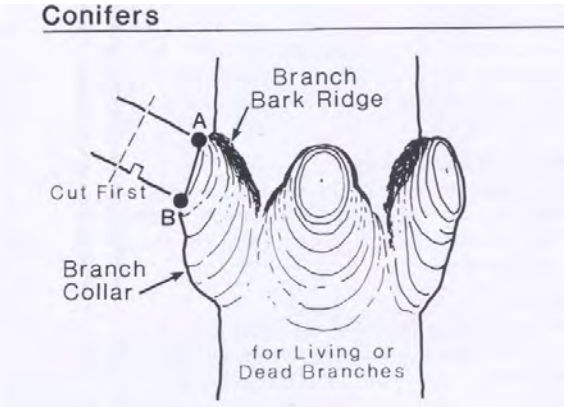
Following a few simple best management practices and working with your town's tree warden make it possible to accomplish both.

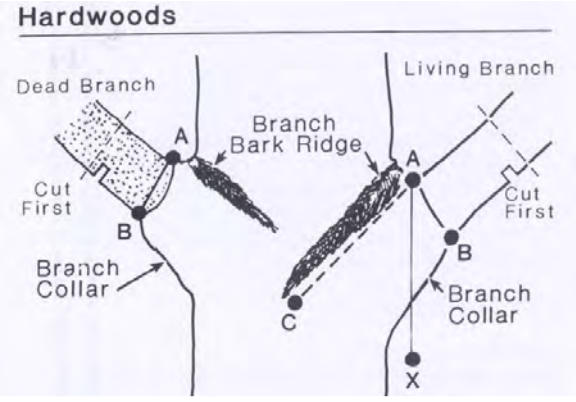
Roles and Responsibilities
Vermont Statutes Title 24 Chapter 67 V.S.A. §871 places all shade and ornamental trees within the limits of public ways under the control of the tree warden.

- Only the tree warden, deputy tree warden, or someone with his or her permission may cut a public shade tree. They may remove diseased, dying or dead trees which create a hazard to public safety or threaten the effectiveness of disease or insect control programs at any time.

- Healthy public shade trees in the residential part of town shall not be felled without a public hearing by the tree warden.

- The tree warden may also plan and implement a town shade tree preservation program by planting new trees and shrubs and maintaining healthy ones.





Prune limb along the A-B line

From: Shigo, Alex L. 1984. Homeowners guide for beautiful, safe, and healthy trees. USDA Forest Service NE-INF-58-84.

Roadside Tree Best Management Practices

- Road crews should work with the tree warden to identify and remove hazard trees.
- Avoid grading near tree trunks and under the tree canopy, if possible, to prevent damaging root systems.
- Roots that are exposed during grading or excavating should be cut cleanly to promote quick wound closure and covered with soil, mulch or burlap as soon as possible.
- Prune trees during the dormant season when possible. When pruning limbs, do not leave a stub or cut limbs flush with the stem. See images (at left) for guidance on proper pruning.
- Do not prune trees with a flail mower or boom arm mower.
- In heavily wooded areas, consider thinning the roadside trees by selecting the best trees to retain and cutting competing trees.
- Replant areas where trees are removed for construction purposes to provide for a new canopy and revegetation.
- For more information or questions regarding roadside trees, please contact the Vermont Urban and Community Forestry Program (see page 60).

Aesthetics

Road maintenance can sometimes appear messy and unsightly to the town residents. Performing maintenance with this in mind and practicing good erosion control techniques during and after construction can help alleviate these concerns, make the scenery more attractive and make the public happy about the care their roads are receiving. This in turn makes the public more supportive of the needs of the road crew in maintaining town roads properly. Respect and attention to the historic and aesthetic characteristics of the road can also help keep town residents happy.

- Rebuild any stonewalls that must be removed for road construction or ditching.
- Using stone culvert headers is aesthetically pleasing and in keeping with the rural character of Vermont's road system.

Beavers:
Beavers play an important role in Vermont's natural landscape by creating pond and wetland habitat. But beavers can create problems for road crews by building dams that block culverts and impounding water that can be released during a flood, washing out roads and bridges and releasing massive amounts of sediment. Beavers particularly like to build dams at culverts. This creates a recurring problem for road crews since beavers tend to rebuild dam after dam at the same spot. In recent years, many inventive people have developed methods to deal with the beavers other than dismantling dams or extermination. Here are some options:

- **Ignore the problem.** Evaluate the real threat to the road. Perhaps a "live and let live" approach would be easiest on all involved.

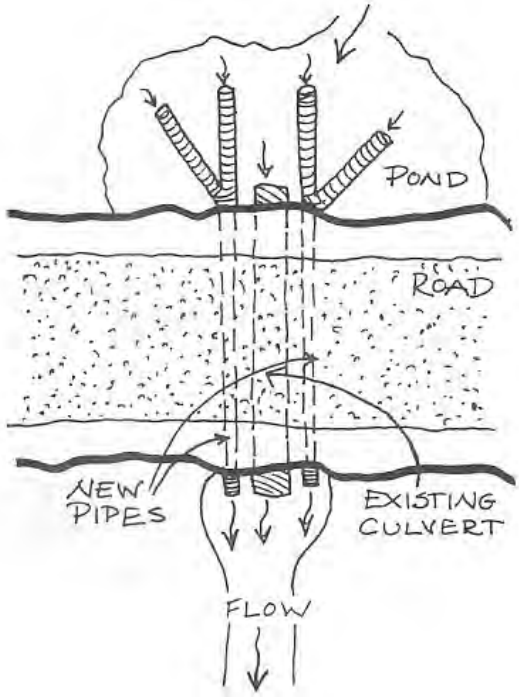
- Hang a 36"x36" **white flag** attached to two poles near the culvert when beavers begin to construct a new dam. The color and motion may cause the beavers to leave and not come back.

- **Weld an elbow onto the culvert.** A 90 degree angle pointing downward below water level results in continual drainage, and the beavers won't be able to plug the inverted culvert end.

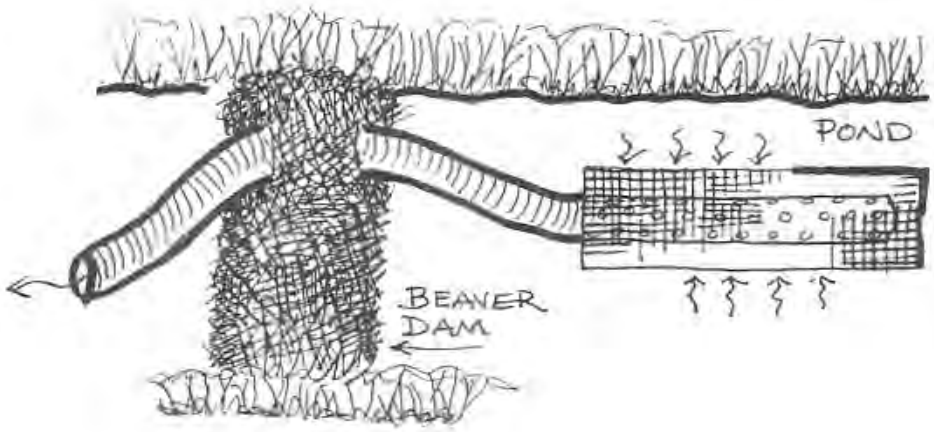
- **Avoid sudden destruction** of a dam. The resulting release of water and accumulated sediment from behind the dam can cause massive turbidity and flooding problems downstream and may result in a violation of Vermont Water Quality Standards. If a dam must be removed, do so gradually.

Try some of these new water level control ideas. These designs have been used around the country. These designs seek to limit the depth of the water behind a dam, but do not remove the dam itself. More details can be obtained from your district Fish and Wildlife office, the Vermont Local Roads Program, USDA Wildlife Services, or the Wetlands office of the Department of Environmental Conservation.

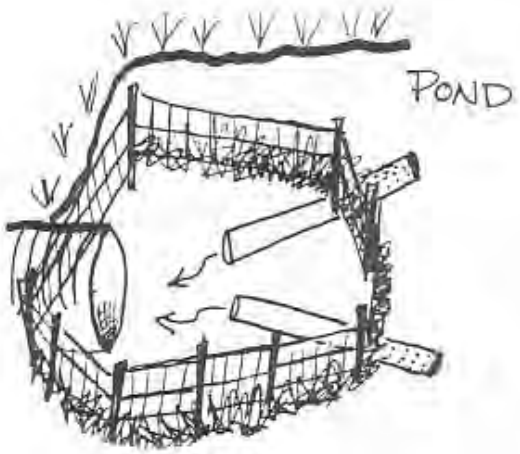
"Beaver Reliever" Designed by the US Forest Service, this installation features additional perforated pipes parallel to the culvert. These extra perforated pipes help maintain the water level in the pond below the level of a culvert.

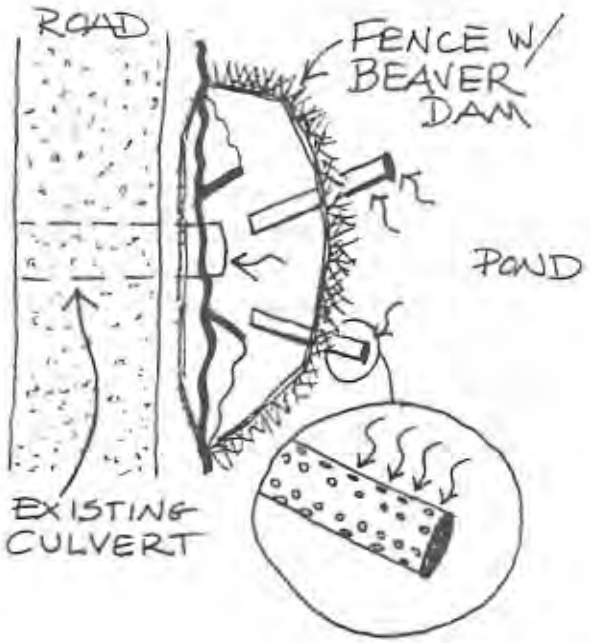


Beaver Baffle. A baffle system is a drain for the dam itself, creating an outlet for water straight through the dam. It requires only shallow digging into the dam. There are several versions of this involving perforated pipe intakes and inserting the discharge pipe through the dam.



Build a Fence. Build a horseshoe shaped fence with heavy gauge wire around the upstream side of a culvert to keep beavers from plugging the culvert. You can more easily remove dam material from the fence, or for persistent problems, install perforated pipes through the fence into the pond.





Erosion Assessment and Capital Budget Planning

It is costly and time consuming to repair damage caused by excess water or poor drainage, especially when damage is caused over and over in the same location. The environmental and recreational impacts of silt and gravel settling in streams, rivers and lakes are high. Most road managers appreciate the need for adequate funds to fix a problem correctly the first time, yet may be having difficulty securing the funds.

Towns with an up-to-date inventory of road conditions with respect to erosion and a capital budget plan for fixing problems can tackle these issues in a systematic and justifiable manner. The basic premises are:

1. People make the best decisions when they know how extensive the problems are.

2. Fixing a problem site once and for all, although it may be more costly up front, actually pays for itself in a short period of time by reducing recurring "band-aid" maintenance.

The Vermont Better Backroads Program has published "Road Drainage and Erosion Control: Two Models for Developing a Town Inventory and Capital Budget" that describes such a process. In addition, grants are available to help with this work through the annual Better Backroads grant program. To request a copy of this document, contact the Northern Vermont Resource Conservation and Development Council (see page 57).

Highway Access Policy

Town road managers recognize that driveways can have a significant negative impact on town roads. A town highway access policy establishes minimum standards for the design, construction and maintenance of driveways, and driveway structures. It is a useful management tool to reduce maintenance and save the town time and money.

A good highway access policy can:

- Reduce flood damage
- Reduce erosion
- Reduce costs
- Reduce accidents

"Developing a Highway Access Policy: Guidelines and a Model Ordinance" is available from the Northern Vermont Resource Conservation & Development Council and Vermont Local Roads. This document provides examples and model language to create or update a town policy. Technical assistance is available through the Vermont Local Roads program; see page 57 for contact information.

The Vermont Better Backroads program has been offering grants to towns and organizations to address road erosion problems and improve water quality since 1997. Grants are awarded in two categories.

A. **Erosion Assessment and Capital Budget Planning**
   In many cases, reduction of road erosion requires planning and budgeting to realize cost savings and road improvements. This grant category offers towns a proactive and long term approach to road maintenance.

B. **Correction of a Road Related Erosion Problem**
   This category is for site-specific erosion fixes using such methods as rock-lined ditches, bank stabilization, culvert headers and turnouts.

Grant applications are made available in the fall each year. Contact the Northern Vermont Resource Conservation & Development Council at (802) 828-4595 for more information.

The following organizations may be able to provide assistance with road maintenance and erosion control projects and/or applying for Better Backroads grants.

Better Backroads Program
www.vt.nrcs.usda.gov/rc&d/bbcoverpage.html
617 Comstock Road, Suite 2
Berlin, VT 05602-8498
(802) 828-4595

Northern Vermont Resource Conservation & Development (RC&D) Council
www.vt.nrcs.usda.gov/rc&d/NoVT
617 Comstock Road, Suite 2
Berlin, VT 05602-8498
(802) 828-4595

George D. Aiken Resource Conservation and Development (RC&D) Council
www.vt.nrcs.usda.gov/rc&d/GDA/index.html
22 North Main Street, Suite 2
Randolph, VT 05060
(802) 728-9526

Vermont Local Roads
www.vermontlocalroads.org
Saint Michael's College
One Winooski Park
PO Box 260
Colchester, VT 05439
(802) 654-2652 or (800) 462-6555

Vermont Department of Environmental Conservation (DEC) Water Quality Division
www.vtwaterquality.org
103 South Main Street, 10 North
Waterbury, VT 05671-0408
(802) 241-3777 or (802) 241-3770

Vermont Agency of Transportation (VTrans) State office
www.aot.state.vt.us
One National Life Drive
Montpelier, VT 05633-5001

VTrans District 1: Bennington
359 Bowen Road
Bennington, VT 05201
(802) 447-2790

VTrans District 2: Dummerston
870 US Route 5
Dummerston, VT 05301
(802) 254-5011

VTrans District 3: Rutland
122 State Place
Rutland, Vermont 05701
(802) 786-5826

VTrans District 4: White River Junction
221 Beswick Drive
White River Junction, Vermont 05001
(802) 295-8888

VTrans District 5: Colchester
5 Barnes Ave
Colchester, Vermont 05446
(802) 655-1580

Mailing address
P.O. Box 168
Essex Junction, VT 05453

VTrans District 6: Berlin
186 Industrial Lane Rd. Berlin
Barre, Vermont 05641
(802) 828-2691

VTrans District 7: St. Johnsbury
1068 US Route 5, Suite 2
St. Johnsbury, Vermont 05819
(802) 748-6670

VTrans District 8: St. Albans
680 Lower Newton Rd.
St. Albans, Vermont 05478
802-524-5926

VTrans District 9: Derby
4611 US Route 5
Newport, Vermont 05855
(802) 334-7934

Federal Highway Administration
www.fhwa.dot.gov/vtdiv/index.htm
87 State Street
PO Box 568, Room 216
Montpelier, VT 05601
(802) 828-4423

Vermont League of Cities and Towns
www.vlct.org
89 Main Street, Suite 4
Montpelier, VT 05602
(802) 229-9111

Addison County Regional Planning Commission
www.acrpc.org
14 Seminary Street
Middlebury, VT 05753
(802) 388-3141

Bennington County Regional Commission
www.rpc.bennington.vt.us
111 South Street, Suite 203
Bennington, VT 05201
(802) 442-0713

Central Vermont Regional Planning Commission
www.centralvtplanning.com
29 Main Street, Suite 4
Montpelier, VT 05602
(802) 229-0389

Chittenden County Regional Planning Commission
www.ccrpcvt.org
110 West Canal Street, Suite 202
Winiooski, VT 05404
(802) 846-4490

Lamoille County Planning Commission
www.lcpcvt.org
632 Laporte Road
Morrisville, VT 05661
(802) 888-4548

Northwest Regional Planning Commission
www.nrpcvt.com
155 Lake Street
St. Albans, VT 05478
(802) 524-5958

Northeastern Vermont Development Association
www.nvda.net
St. Johnsbury office
36 Eastern Ave.
PO Box 630
St. Johnsbury, VT 05819
(802) 748-5181

Newport office
55 Seymour Lane, Unit 3
Newport, VT 05855
(802) 334-5861

Rutland County Regional Planning Commission
www.rutlandrpc.org
The Opera House
67 Merchant's Row
PO Box 965
Rutland, VT 05702
(802) 775-0871

Southern Windsor County Regional Planning Commission
www.swcrpc.org
PO Box 320
Ascutney Professional Building
Route 5
Ascutney, VT 05030
(802) 674-9201

Two Rivers-Ottauquechee Regional Commission
www.trorc.org
3117 Rose Hill
Woodstock, VT 05091
(802) 457-3188

Windham Regional Commission
www.rpc.windham.vt.us
139 Main Street, Suite 505
Brattleboro, VT 05301
(802) 257-4547

Vermont Natural Resource Conservation Districts (NRCDs)
www.vacd.org

Bennington County NRCD
www.bccdvt.org
310 West Main St.
Bennington, VT 05201
(802) 442-2275

Caledonia County NRCD
www.caledoniadistrict.org
481 Summer Street, Suite 202
St. Johnsbury, VT 05819
(802) 748-3885 x110

Essex County NRCD
481 Summer Street, Suite 202
St Johnsbury, VT 05819
(802) 748-3885 x114

Franklin County NRCD
27 Fisher Pond Road, Suite 1
St Albans, VT 05478
(802) 524-6505

Grand Isle NRCD
317 West Shore Road
North Hero, VT 05474
(802) 864-0223

Lamoille County NRCD
www.lcnrcd.com
109 Professional Drive, Suite 2
Morrisville, VT 05661
(802) 888-9218

Orleans County NRCD
59 Waterfront Plaza
Newport, VT 05855
(802) 334-8325 x18

Ottauquechee NRCD
www.vacd.org/onrcd/index.html
28 Farmvu Drive
White River Junction, VT 05001
(802) 295-7942 x11

Otter Creek NRCD
68 Catamount Park, Suite B
Middlebury, VT 05753
(802) 388-6746

Poultney-Mettowee NRCD
P.O. Box 209
Poultney, VT 05764
(802) 287-8339

Rutland NRCD
www.vacd.org/rcd/index.html
170 South Main Street
Rutland, VT 05701
(802) 775-7192 x17

White River NRCD
www.vacd.org/white_river/index.html
617 Comstock Road, Suite 1
Berlin, VT 05602
(802) 828-4493 x110

Windham County NRCD
www.vermontconservation.org
28 Vernon Street, Suite 2
Brattleboro, VT 05301
(802) 254-5323 x104

Winooski NRCD
Berlin office
www.vacd.org/winooski
617 Comstock Road, Suite 1
Berlin, VT 05602
(802) 828-4493 x110

Williston office
1193 South Brownell Road, Suite 35
Williston, VT 05495
(802) 865-7947 x104

Vermont Department of Fish & Wildlife
www.vtfishandwildlife.com
103 South Main Street, 10 South
Waterbury, VT 05671-0501
(802) 241-3700

Vermont Department of Environmental Conservation, River Management Section
www.vtwaterquality.org/rivers.htm
103 South Main Street, 10 North
Waterbury, VT 05671-0408
(802) 241-3770

Vermont Urban & Community Forestry Program
www.vtcommunityforestry.org
103 South Main Street 10 South
Waterbury, VT 05671-0601
(802) 241-3673

For some erosion control projects, it may be necessary to obtain a permit for your activities. See below for information on permits that may be required and contact information.

Lakes and Ponds Shoreland Encroachment Permits
A permit is required to encroach beyond the shoreline of any lake or pond which is a public body of water. Common activities requiring a permit include installation of retaining walls or riprap and dredging or filling activities. Some repairs to existing encroachments or replacements also require a permit.

Information:
www.vtwaterquality.org/permits/htm/pm_encroachment.htm
Contact:
Vermont Water Quality Division
Shoreland Encroachment Program
103 South Main Street, 10 North
Waterbury, Vermont 05671-0408
(802) 241-3777

Stream Alteration Permits
This permit program regulates the alteration of streams and is intended to prevent creation of flood hazards, protect against damaging aquatic habitat and protect the rights of neighboring landowners.

Information:
www.vtwaterquality.org/permits/htm/pm_streamalt.htm
Contact:
Vermont Water Quality Division
Western Vermont
111 West Street
Essex Junction, VT 05452
(802) 879-5631

Central and Southeastern Vermont
Vermont Water Quality Division
5 Perry St., Suite 80
Barre, VT 05641-4268
(802) 476-2679

Northeastern Vermont
Vermont Water Quality Division
1229 Portland Street Suite 201
St. Johnsbury, VT 05819-2099
(802) 751-0130

Wetlands Permits
The purpose of this program is to protect the future of significant wetlands in Vermont. Class One and Class Two wetlands are considered significant wetlands. All uses which are not allowed uses are conditional uses and require a Conditional Use Determination (CUD). If an individual is unsure whether a permit is required, the Wetlands Coordinator should be contacted.

Information:
www.vtwaterquality.org/permits/htm/pm_cud.htm
Contact:
Vermont Water Quality Division
Wetlands Section
103 South Main Street, 10 North
Waterbury, Vermont 05671-0408
(802) 241-3777 or (802) 241-3770

Stormwater Permits
The stormwater program issues permits for runoff from impervious (i.e., hard) surfaces, construction sites and industrial facilities. If your project will disturb one or more acres of land, a Construction Stormwater Discharge Permit is required.

Information:
www.vtwaterquality.org/permits/htm/pm_stormwater.htm
Contact:
Vermont Water Quality Division
Stormwater Section
103 South Main Street, 10 North
Waterbury, Vermont 05671-0408
(802) 241-3777 or (802) 241-3770

Water Quality Certification
Section 401 (a)(1) of the Clean Water Act specifies that any applicant for a federal license or permit to conduct any activity including, but not limited to, the construction or operation of facilities, which result in any discharge into the navigable waters, shall provide the licensing or permitting agency a certification from the State.

Information:
www.vtwaterquality.org/permits/htm/pm_401.htm
Contact:
Water Quality Division
103 South Main Street, 10 North
Waterbury, VT 05671-0408
(802) 241-3777 or (802) 241-3770

Federal Permit Requirements for Work in Rivers, Streams, Lakes and Ponds
Permits are required for all structures or work beyond the ordinary high water mark under Section 10 of the Rivers and Harbors Act. Permits are required for the excavation, or mechanized land clearing in all waters of the United States under Section 404 of the Clean Water Act.

Information:
www.nae.usace.army.mil/reg/vtpgp.pdf
Contact:
U.S. Army Corps of Engineers
8 Carmichael Street, Suite 205
Essex, VT 05452
(802) 872-2893

The following online publications and resources may help you with planning Better Backroads projects and/or other road projects.

VTrans Orange Book for Local Officials
www.aot.state.vt.us/maint/OrangeBook.htm

VTrans Culvert and Ditching Program
www.aot.state.vt.us/techservices/EnvPermit/CulvertDitching.htm

VTrans Structures Manual
www.aot.state.vt.us/Progdev/Documents/Structures/2004_Structures_Manual.pdf

VTrans Town Highway Maps
www.aot.state.vt.us/Planning/MapGIS/Town_Maps1.htm

Vermont Better Backroads Pocket Guide
ftp://ftp-fc.sc.egov.usda.gov/VT/RCD/BBR%202008/pocket_guide.pdf

Aggregate - Any of various loose, particulate materials such as sand, gravel, or pebbles, added to a cementing agent to make concrete, plaster, etc.

Backhoe - A hydraulic excavating machine consisting of a tractor having an attached hinged boom, with a bucket with movable jaws on the end of the boom.

Backfill - The material used to refill a ditch or other excavation, or the process of doing so.

Batter - The angle of the front of a retaining structure with respect to a vertical plane.

Bench - A horizontal surface or a step in a slope that breaks the continuity of the slope.

Berm - A linear mound of earth or other material.

Binder - A substance that holds loose material together.

Brush layering - Live branch cuttings laid in a crisscross fashion on benches between successive lifts of soil.

Channel - A natural stream that conveys water or a ditch excavated for the flow of water.

Crib Structure - A hollow structure constructed of mutually perpendicular, interlocking beams or elements.

Culvert – Usually a factory assembled round-shaped conduit connected together with couplers or bands; it differs from a bridge in that it is usually constructed entirely below the road surface.

Cutting - A branch or stem pruned from a living plant.

Dead Stout Stake - A 2x4 timber that has been cut into a specific shape and length.

Detention Structure - A basin or pond used in managing stormwater runoff through temporary holding and controlled release of storm water.

Detention Dam - A dam constructed for the purpose of temporary storage of stream flow or surface runoff and for releasing the stored water at controlled rates.

Disk Harrow - An agricultural implement with spike like teeth or upright disks, drawn chiefly over plowed land to level it, break up clods, root up weeds, etc.

Diversion - A channel, often with a supporting berm on the lower side, constructed across or at the bottom of a slope for the purpose of intercepting surface runoff; to minimize erosion; or to prevent excess runoff from flowing onto lower lying areas.

Diversion Dam - A barrier built to divert part or all of the water from a stream into a different course.

Embankment - A structure of soil, aggregate, or rock material constructed above the natural ground surface.

Energy Dissipater - A device used to reduce the energy of flowing water.

Erosion - The wearing away of the land surface by running water, wind, ice or other geological agents, including such processes as gravitational creep; detachment and movement of soil or rock fragments by water, wind, ice or gravity.

Filter Strip - A long vegetative planting area used to retard or collect sediment for the protection of watercourses, diversions, drainage basins, or adjacent properties.

Fish Habitat – Resources and conditions essential for the production of fish including sufficient water quality and quantity, spawning, nursery, rearing and food supply areas – all of which fish depend on directly or indirectly for their processes.

Gabion - A patented woven wire basket filled with rocks of such size that they do not pass through the openings in the basket; individual baskets are stacked in place like building blocks and filled with rock to form erosion resistant structures.

Geotextile - Synthetic polyethylene fibers manufactured in a woven or loose non-woven pattern to form a blanket-like product.

Habitat - The environment in which the life needs of a plant or animal are supplied.

Header/Headwall - Structure built at the inlet or outlet of a culvert to protect the inlet/outlet from erosion.

Hydroseeding - Sowing of seed by distribution in a stream of water, mulch and tackifier propelled through a hose.

Joint Planting - The insertion of live branch cuttings between openings of rocks, blocks, or other inert materials into the natural ground.

Live Cribwall - A hollow, structural wall formed out of mutually perpendicular and interlocking members, usually timber, in which live branch cuttings are inserted through the front face of the wall into the crib fill and/or natural soil behind the wall.

Live Branch Cuttings – Living, freshly cut branches of woody shrub and tree species that propagate from cuttings embedded in the soil.

Live Fascine - Bound, elongated sausage-like bundles of live cut branches that are placed in shallow trenches, partly covered with soil, and staked in place to arrest erosion.

Live Stake - Cuttings from branches that are tamped or inserted into the earth.

Mulch - A natural or artificial layer of plant residue or other materials covering the land surface which conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

Permeability - The capacity of a porous rock or sediment to permit the flow of fluids through its pore spaces.

Plunge Pool - A depressed area used to dissipate the energy of flowing water that may be constructed or naturally created by flowing water. These pools may be protected by various lining materials.

Pollutant – Dredged soil, solid waste incinerator residue, sewage, garbage, sewage sludge, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water.

Retention Structure - A natural or artificial basin that functions similar to a detention structure except that it may maintain a permanent water supply.

Riprap Revetment - Broken rock, cobbles or boulders placed on earth surfaces, such as the face of a dam or the bank of a stream for protection against the action of water.

Road Crown – Convex section or outline of the road surface.

Rock Apron - Erosion protection placed in an area of high velocity flow such as a culvert outlet.

Runoff - The portion of the precipitation on a drainage area that does not infiltrate and is discharged from the area.

Scarify - To abrade, scratch, or modify the surface; for example, to break the surface of a road with a narrow-bladed implement.

Sediment – Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity or ice and has come to rest on the earth's surface either above or below sea level.

Sheet Flow – Water, usually storm runoff, flowing in a thin layer over the ground surface.

Slope - The degree of deviation of a surface from horizontal, measured in a numerical ratio, percent, or degrees; expressed as a ratio or percentage, the first number is the horizontal distance (run) and the second number is the vertical distance (rise) as 2:1, 50 percent, or 30 degrees.

Slope Board - A device, usually of wood, created to confirm the cross slope of a road, ditch, or bank.

Soil Bioengineering - Use of live, woody vegetative cuttings to repair slope failures and increase slope stability, often combined with inert structures and materials.

Sub-base - The drainage layer of a road between the surface and the existing ground.

Surface Water – all water the surface of which is exposed to the atmosphere.

Swale - An elongated depression in the land surface that is at least seasonally wet, is usually vegetated, and is normally without flowing water. Swales conduct stormwater into primary drainage channels and provide some groundwater recharge.

Tamp - To force in or down by repeated, rather light, strokes.

Ten-year Frequency Storm - Maximum quantity of water flow per second expected at a particular water crossing, on a statistical average, once every ten years; it has a ten percent probability of occurring in any given year.

Terrace - An embankment or combination of an embankment and channel across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope.

Toe of the Slope - Base of the slope.

Underdrain - A drain placed beneath the surface of a road.

Vegetated Structures - A retaining structure in which living plant materials, cuttings, or transplants have been integrated into the structure.

Water Quality - A term used to describe the chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Watershed - The area contained within a divide above a specified point on a stream contributing to the supply of a stream or lake. Often times called drainage area, drainage basin or a catchment area.

Wetland – Land that is inundated by surface or ground water with a frequency sufficient to support plants and animals that depend on saturated or seasonally saturated soil conditions for growth and reproduction. These areas are commonly known as bogs, fens, marshes, wet meadows, shrub swamps and wooded swamps.