The Massachusetts

Unpaved Roads BMP Manual

A Guidebook on How to Improve Water Quality While Addressing Common Problems

Prepared by:

Berkshire Regional Planning Commission
33 Dunham Mall, Pittsfield, MA 01201

Prepared for:

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and

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Region 1

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Forward

This manual was prepared by the Berkshire Regional Planning Commission for the Massachusetts Department of Environmental Protection and the U.S. Environmental Protection Agency. This manual has been adapted from the Vermont Better Backroads Program Manual *Clean Water You Can Afford,* a publication of the George D. Aiken and Northern Vermont Resource Conservation and Development Councils, originally prepared by the Windham Regional Commission. Illustrations throughout this manual are credited to Melissa M. Reichert, Senior Planner/Landscape Architect with the Windham Regional Commission and have been reprinted here with permission.

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Important!

All road projects that occur within and near areas subject to Massachusetts and Federal environmental regulations cannot be "design-built" in the field; they must be designed and permitted prior to commencement of any work.

Limited copies of this report are available at no cost by written request to:

Massachusetts Department of Environmental Protection
Arthur Screpetis, Division of Municipal Services 627 Main Street
Worcester, MA 01608

Disclaimer: The information contained within this manual has been compiled from various reputable sources and reviewed, but has not been verified for engineering integrity. This manual is meant to be a guidance document on unpaved road management, not a set of definitive design specifications. Individual site conditions (i.e. soils, grades, proximity to water bodies, rates of flow, peak discharges, etc.) must be considered when projects are designed. The services of a professional engineer may be required in some instances.

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INTRODUCTION

The Importance of Local Unpaved Roads

Unpaved roads are common across the Massachusetts landscape. A familiar sight in rural communities, unpaved roads offer a sense of timelessness, helping residents connect with the days of cart paths and carriage roads. Often narrow and bordered by stone walls and mature shade trees, and often following an alignment parallel to streams and brooks, unpaved roads offer a scenic escape from the realities of concrete and pavement. The preservation of unpaved roads is important to the character of the Massachusetts landscape.

Aside from their value as a scenic and often historic resource, unpaved roads have the advantage of lower construction costs than paved roads, require less equipment and skilled operators, and generate lower speeds than their paved counterparts. Yet, like paved roadways, dirt and gravel roads require regular maintenance to keep them passable and safe. Well-maintained dirt and gravel roads can serve traffic very satisfactorily, and should be considered as a legitimate road surfacing option, not just something a community grudgingly maintains while it waits for paving.

Purpose of this Manual

The purpose of this guidance manual is to help local road officials gain a better understanding of:

- ® Typical problems that can result from improper maintenance of unpaved roads
- ® How to prevent unpaved road problems from contributing to water quality problems using low-tech, common sense strategies

To do this, this manual presents guidelines on **Best Management Practices (BMP's)** that can be used to improve water quality in the Commonwealth of Massachusetts while enhancing the quality of unpaved roads. *These guidelines should not be considered definitive design specifications for BMP's, as individual site conditions will always determine the level of design necessary for success at any given site.*

This manual is designed for those who supervise highway departments, work in road crews, or are otherwise involved in maintaining public or private roadways. The information contained within is meant to help road maintenance decision-makers understand that unpaved roads can be managed in such a way so as to not be contributors to water quality problems.

The Need for BMP's

Unpaved roads, by nature of their topography and design, can, if not properly managed, contribute heavily to water quality problems. Erosion from unpaved roads and road related projects could contribute to polluted runoff, or nonpoint source pollution. This nonpoint source pollution is a major contributor to water quality problems throughout Massachusetts. Using structural BMP's and inexpensive routine and preventative maintenance practices outlined in this manual can improve overall water quality while potentially reducing the cost of maintaining unpaved roads.

Nonpoint Source (NPS) Pollution

Pollution of surface or ground water supplies originating from land-use activities and/or the atmosphere, having no well-defined point of entry.

Best Management Practice (BMP)

Structural, nonstructural and managerial techniques that are recognized to be the most effective and practical means to prevent and reduce nonpoint source pollutants.

BMP Selection

This manual covers many aspects of BMP's as they relate to unpaved roadways. But how does one arrive at the point of knowing which BMP is best for any particular circumstance? Each BMP technology has certain limitations. Efforts to solve a road related problem without sufficiently evaluating the cause and properly designing a solution can result in failure and the waste of already limited funding. A systematic approach to BMP selection should be followed.

This manual, as well as other state manuals such as the *MA Erosion and Sediment Control Guidelines for Urban and Suburban Areas,* covers numerous structural BMP's. However, the most cost-effective means of maintaining unpaved roads are often through nonstructural BMP approaches such as good site planning, frequent inspections and routine maintenance. Nonstructural measures are highly effective pollution prevention measures which can reduce or even eliminate the need to use structural BMP's. These nonstructural approaches, in most cases, will result in a road project that suits the land constraints and minimizes unforeseen costs.

Each BMP has certain limitations. When considering the most appropriate method to solving an unpaved roadway problem, the following questions should be asked:

- Are there important natural resources such as, but not limited to, endangered species habitat areas, rivers, wetlands, floodplains, and drinking water wells adjacent to the project site that might make one rethink a design?
- Are there physical site constraints such as steep slopes, ledge, or property boundaries that may influence the design?
- Is future required maintenance reasonable and acceptable for this type of BMP?

- Can maintenance be done with the available personnel, equipment, or financial resources?
- Is the BMP cost effective when compared with other options?
- Are there opportunities to utilize comprehensive site planning or nonstructural BMP's in order to minimize the need for structural controls?

BMP Selection Involves A Three-Step Process

Identify Problem

Identify Required Strategy to Solve Problem

Select Appropriate BMP

This manual is meant to be a starting point when considering the use of BMP's for unpaved roadways. The chapters and tables that follow each chapter provide guidance for choosing the most appropriate structural BMP for a site and given condition by explaining the basic considerations for their design and use. Nonstructural BMP's are explained below. The practices chosen will often vary from one site to another and from one individual to another, depending on individual judgment and preference and past experience with a particular practice.

Nonstructural BMP's

The use of nonstructural approaches should precede the use of structural BMP controls for unpaved road management. Nonstructural BMP's are generally less expensive than structural practices, since they require comparatively less capital. Several nonstructural BMP's are explained below and throughout this guidance document. Nonstructural BMP's that minimize the creation of new runoff, limit erosion, and protect the health of water resources are highlighted below.

Plan projects carefully: Good planning and site design is critical to managing unpaved roadways and nonpoint source pollution. It can decrease existing runoff, eliminate unnecessary increases in runoff, and reduce erosion and sedimentation problems. In addition, a well thought out site design will minimize the size and related material, construction, and maintenance costs of structural BMP's. More importantly, *how* and *where* one proposes work strongly affects its "permitability". That is, the project's design often drives the permitting process. Understanding this in advance can often save time and money up front. See the *Permits and Regulations* section for more information on site design and permitting.

Maintain structural BMP's: BMP's must be maintained in order to function properly. Too often, BMP's are constructed without plans or obligations for long-term maintenance. The maintenance requirements for unpaved roadway BMP structures must be considered during the selection process. For this reason, BMP's should be designed to minimize maintenance needs, wherever possible, and should take into consideration available personnel, equipment, and financial resources needed for proper maintenance.

Maintain natural buffers and drainageways: Road runoff generally takes the path of least resistance. If these drainageways are stable and well vegetated, they should be preserved. The natural buffer located between the road and waterbody or wetland will help infiltrate runoff, reduce the velocity of the runoff, and help remove some of the sediments in the runoff.

Minimize the creation of steep slopes: Steep slopes have a significant potential for erosion. Slopes steeper than 2H:1V should be avoided unless stabilization methods are employed.

Maintain as much of the natural vegetation as possible: Vegetation absorbs water, which will reduce the amount of stormwater runoff the road drainage system needs to handle. Large trees are especially important because their roots help to hold soil in place, and should be protected from damage during any planned roadwork.

What About Drainage?

It is often said that the three most important factors affecting the life of any roadway are "drainage, drainage, drainage", and this is certainly true of unpaved roads. Without good drainage, even the best of construction methods and materials could be wasted. Understanding the fundamentals of drainage, or runoff, is imperative to maintaining good unpaved roads.

Runoff

The portion of precipitation or snow melt that flows over and through the soil, eventually making its way to surface waters (such as streams, rivers, ponds.) Also commonly referred to as stormwater.

Water is the enemy of unpaved roads, and much of the work local road crews do involves controlling drainage. The importance of providing good drainage should be obvious. Too much surface water can weaken a roadbed resulting in rutting, potholes, shoulder erosion, ditch washouts, and clogged culverts. Water flowing too slowly deposits sediments and clogs channels and culverts. Standing water can weaken the sub-base and lead to surface failure. More important, erosion of unpaved roads can degrade water quality in streams and rivers. It almost seems as if it's a "no-win" situation.

Basic to any good road, especially unpaved roads, is proper design, construction, and maintenance. Yet, few unpaved roads were designed correctly in the first place. With an adequate knowledge and understanding of the forces that act upon unpaved roads, local road managers can arm themselves with the necessary tools to enhance these roads while protecting the quality of water within the Commonwealth. This is where drainage and proper use of BMP's comes into the picture!

Although this manual covers many aspects of unpaved roadway maintenance and repair, the underlying theme is that it deals with *drainage, or runoff.* If communities can learn to control runoff using good drainage practices, the life of the supervisor and road crew can be simplified. If drainage problems are ignored, they won't go away. Instead, they will become a continuing and expensive headache. Good roadwork, done carefully, is expensive enough; but reacting to one crisis after another can destroy an already tight road budget in a hurry.

It is important to note that the principles of good drainage are the same for paved roads as they are for unpaved roads. There may need to be a shift in emphasis or change of procedures a bit to fit local conditions but the goal remains the same…keeping water out of the road system!! ***Proper roadway drainage is critical if unpaved roads are to stand up to the damaging effects of weather and traffic.***

Factors Affecting the Life of an Unpaved Road

There are five major factors that affect the ability of an unpaved (as well as paved) roadway to survive and serve the needs of the traveling public over a long and useful life.

Traffic Loads. Road damage typically depends on the number and weight of heavy trucks using a road, not the number of lighter vehicles.

Subgrade Quality. Unpaved roads need a good subgrade to help carry heavy loads and support the surface. A properly constructed subgrade can greatly influence road performance and life.

Workmanship and Construction Practices. Using quality materials and following proper construction practices can greatly increase the life of an unpaved road.

Maintenance Program. Unpaved roads require routine and preventative maintenance on a regular basis. The idea is to spot the "possible" problem before it gets to be a "real" problem. Spend a few dollars *now* to prevent major repair costs *later.*

Water. It is said that 80% of existing roadway problems can be traced to the presence of water from poor drainage either in or on the roadway. However, not all water is bad for a road.

POSITIVE EFFECTS OF WATER

- aids in unpaved road surface compaction
- assists in establishing and maintaining vegetation for erosion control
- allows unpaved road surfaces to be graded more easily

NEGATIVE EFFECTS OF WATER

- increases the disintegration of unpaved and gravel surfaces
- softens and reduces the load carrying ability of sub-grades and shoulders
- erodes roadside surfaces
- deposits sediment and debris in roadside ditches and culvert

The negative effects of water are clearly illustrated in this photograph. The erosive forces of the flowing water have "blown out" this sloping unpaved road, rendering it virtually impassable.

ROAD SURFACES

Unpaved roads generally carry local traffic between rural lands and villages, and provide connecting links between paved collector roads. In many rural Massachusetts towns much of the local road system has an unpaved/gravel surface that requires routine maintenance to keep it open. The top layer of gravel on these roads must be shaped, compacted, and smoothed to ensure a good riding surface and to allow runoff to move quickly from the road surface to established drainageways.

Importance to Water Quality

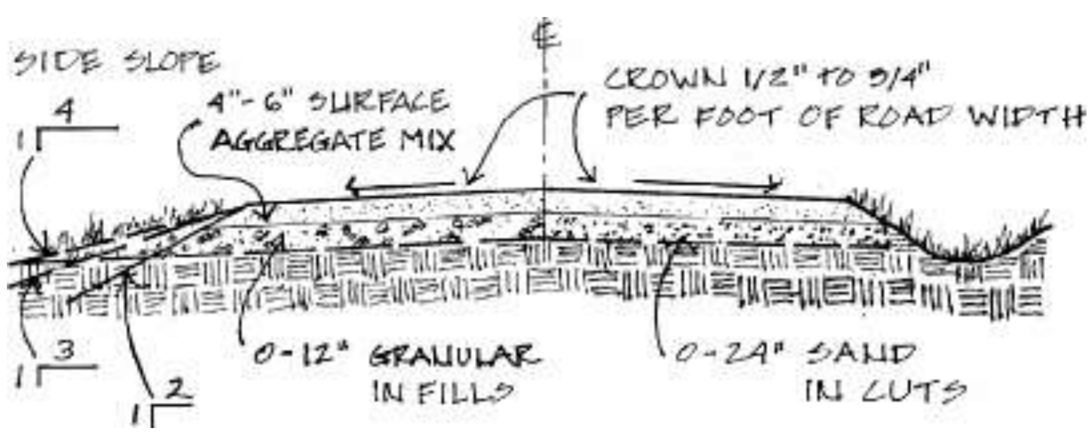
Surface water that is not effectively conveyed from the road surface to a drainage channel can result in deterioration of the road surface, safety problems resulting from ice build up, and various erosion problems. Immediate removal of runoff from the road surface will prevent many of the problems associated with surface deterioration. This will lengthen the life of the road surface, as well as lessen maintenance frequency and costs. It will also decrease the amount of sediment carried by road runoff into waterways.

General Road Surface Principles

þ 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.)

þ Keep the road surface tight and impervious.

þ Perform regular drainage maintenance and grading.



Typical crown and road profile (1 inch=8 feet)

Surface Profile & Grading

The most important aspect of maintaining a gravel road surface is to preserve and maintain a proper road crown for good drainage, accomplished through grading. Equally important is good compaction of the road surface which quickens the removal of runoff and protects the road surface from erosion.

Grading, or reshaping, cuts through the road surface crust. Grade when reshaping or when the correction of major surface defects is necessary.

- Perform grading operation with the moldboard tilted backward and with sufficient down pressure on the blade to produce a cutting action; the outer edge of the moldboard should be at the road surface's edge.
- Ensure a minimum of one foot from the ditch line so that vegetation or rock stabilization is not disturbed.
- Crown the old surface before regraveling.

Blading, or dragging, is a smoothing operation that pulls loose material from the sides of the road or spreads windrowed aggregate to fill surface irregularities. When blading is completed, spread the aggregate back over the road and restore the road crown.

- Perform blading/dragging with the moldboard tilted forward with light down 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.
- Avoid blading as a measure to correct severe corrugations or other extensive surface and subgrade failures (consider reconstruction of roadbed.)

Thinking About Paving an "Old" Gravel Road?

If you finally decide to pave what has always been a gravel road, you should remember this. The surface of a gravel road which is to be paved should have far fewer "fines" than a road that is to remain gravel. Why? Without a paved surface, the moisture in the road that is drawn up due to the wicking action of the fines is free to evaporate. Once the road is paved, the moisture will continue to be drawn up but its evaporation will be blocked. This can lead to frost heaving and other pavement problems. In short, you will be wasting money if you pave a gravel road that does not have the proper road base.

Surface Materials

For an unpaved road to shed water properly, it should have a tight, impervious surface. This requirement calls for a higher percentage of "fines" than the base gravel under asphalt pavement. Unpaved surfaces with a small amount of fines do not have enough of this "binder" to hold the surface together when the weather is dry. As the surface falls apart, the loose material is thrown to the shoulders and ditches by traffic, and into the air as dust. Ruts, corrugations, and potholes then appear.

Adding aggregates, or road surface material, to the road base is usually accompanied by blading and dragging, although light applications of medium-sized and fine aggregates may be made occasionally to correct slippery conditions. When increasing the depth of the surface, filling depressions, restoring crown and profile, or correcting other problems that require coarse aggregates, an aggregate mix (with a maximum size of 1 inch) should be dumped in windrows and spread with a grader.

Guidelines for Grading

- Grade roads in the spring as soon as the frost leaves the ground, or as soon as possible after a rain while the surface materials are still moist but not wet.
- Limit the amount of road surface disturbed to that which can be stabilized by the end of the workday.
- Grade when gravel is moist after or during a light rain (do not grade if heavy rain is in the forecast.)
- Crown roads 1/2 to 3/4 inch for each foot of road width, measured from the center of the roadway to the outside edge, to ensure good drainage.
- Outslope roads with over-the-bank drainage problems entirely toward the ditched side of the road.
- When possible, compact the entire width of the newly graded roadway with a steel wheel roller by end of day.
- Scarify the existing surface to blend the soils and improve compaction.
- Add approximately 2 to 3 inches of new material to correct any faults.
- 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; this should be built into the regular operations budget rather than a capital expenditure.
- A recommended aggregate mix 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.)
- Be sure not to leave a gravel or sod berm between the road and the ditch slope.

Shoulders

Road shoulders serve a number of useful functions. They transfer water accumulated on the traveled portion of the road to the sideslope and ditch; serve as a safety zone and parking area for motorists; help to support the road surface; and help separate the traveled way from the sideslopes and ditches. They also act as collectors of winter sand and debris removed from the traveled way.

Shoulders must be shaped to allow water to drain. Unpaved shoulders are sloped at about twice the rate of the traveled way and often consist of less suitable material than the traveled way. This happens over a period of time as winter sand and debris accumulate, or as ditches are maintained.

For shoulder maintenance, blading is recommended. Adjust the blade so the inside edge of the shoulder is at the same elevation as the outside edge of the road surface. This will allow the water to drain and eliminate the possibility of secondary, or false, ditches. The shoulder should be bladed to recover loose aggregates and fines and at the same time remove unwanted vegetation. The loose fines and aggregate should be spread on the road surface to help build the crown and stabilize the road surface. Shoulder drop minimum is 1 ½ to 2 inches for a 2-foot shoulder and 3 to 4 inches for a 4-foot shoulder.

Proper shoulder maintenance will prevent false ditches

General Shoulder Maintenance

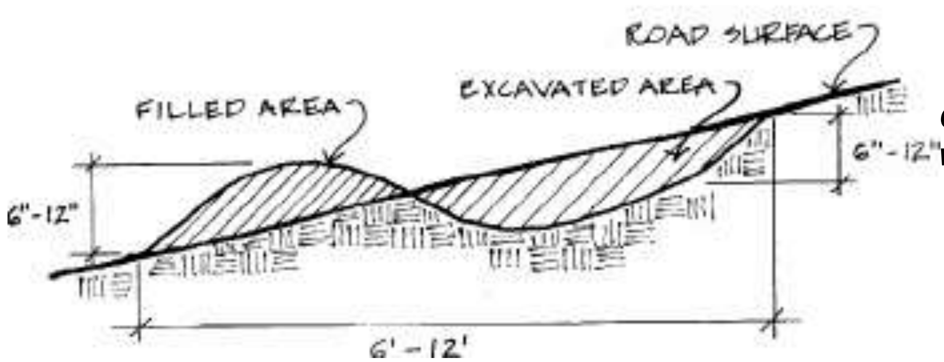
- Remove woody roadside vegetation (not grass) from the edge of the shoulder. A growth of thick vegetation can prevent water from flowing off the traveled lanes, allowing it to pool at the edge of the shoulder. Mow and remove brush, weeds and other debris frequently before they grow large enough to create “large” problems.
- Remove winter sand and debris from the road shoulder to prevent stormwater flow from being disrupted. When grading the road, blade the edge of the shoulder to eliminate any build-up of sand and gravel.

- Ensure that the shoulder is flush with the road surface to prevent erosion at the road edge.

Waterbars

Waterbars are an inexpensive way to control and divert water from a road surface at selected intervals. These narrow bermed structures are constructed by forming a ridge or a ridge and channel diagonally across the sloping roadway, and may be shallow or deep depending on the need and anticipated runoff volumes. They can be used to divert water and prevent erosion on long, sloping roads. Waterbars work well for low volume roads and woods roads, but may not be suitable for the typical unpaved roadway where speeds are greater. Tips for success include:

- Construct low enough for traffic to pass over but high enough to direct runoff flow off the road.
- Install at about a 30-degree angle down slope.
- Ensure adequate drainage at the outflow, protected with stone, grass, sod, or anything that will reduce velocity of water.
- Inspect regularly and rebuild periodically.



Cross section of a waterbar

Spacing Needed Between Water Bars	
Slope	*Diversion Spacing (feet)*
< 5%	125
5 –10%	100
10 –20%	75
20 – 35%	50
> 35%	25

Unpaved Road Distress Conditions

Surface Deteriorations

Common types of surface deteriorations include dust and ravelling:

Dust in the air results from the loss of fine, binder aggregates from road surfaces and leads to other types of road distress.

- Sprinkling water on the road surface is only a very short-term solution.
- Applying calcium chloride is a common treatment 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. Apply at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage.
- Spray-on adhesives such as latex emulsions or resin in water are not recommended, as a potential exists for water quality impacts from the practice.

Ravelling is the loss of coarse aggregate from the road surface.

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

Surface Deformations

Surface deformation problems can be reduced with proper road surface drainage. Common surface deformations include:

Potholes are caused by excessive moisture content, poor drainage, and poorly graded aggregates.

· Repair with spot grading (undercut potholes with grader blade—don't just fill them in!)

Pothole on an unpaved roadway

Rutting occurs when there is high moisture content in the road subsurface soil, resulting in longitudinal depressions left in the wheel paths.

- 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 with roadbed material is preferred.
- For severe ruts, a layer of geotextile material may be required under at least six inches of crushed gravel (see section titled *Other Considerations.)*

Depressions are 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 sorted aggregate, grading, and compacting.

Soft Spots are caused by lack of proper drainage from the road surface.

- Correct by replacing the soft spot area with a suitable material such as well-sorted stone or gravel.

Corrugations, also called washboards, are a series of ridges and depressions across the road surface caused by lack of surface cohesion and excessive vehicle speeds.

- Correct by improving the cohesive qualities of the road surface: remix with a good percentage of fines, scarify the road surface while damp, regrade, re-crown, and roll the surface.
- Blading is not recommended when considering repair of extreme corrugations.

Corrugations on an unpaved roadway

Matrix of Road Surface BMP's For Maintenance Work		
What you observe…	*How bad is the problem…*	*How to fix it…*
Improper drainage	Minor	þ Grade shoulders and ditches þ Clean ditches þ Install waterbars if appropriate
Improper drainage	Major	þ Clean ditches þ Reconstruct surface, base, and drainage þ Install waterbars if appropriate
Dust	Minor	þ Apply liquid/solid dust control
Dust	Major	þ Add minor gravel, regrade, compact
Improper Cross Section	Minor	þ Reshape (blading or dragging), þ Reshape with minor added material
Improper Cross Section	Major	þ Regrade þ Add major gravel, regrade, compact
Potholes	Minor	þ Spot regravelling
Potholes	Major	þ Regrade þ Add major gravel, regrade, compact
Rutting	Minor	þ Reshape (blading or dragging) þ Reshape with minor added material
Rutting	Major	þ Regrade þ Add major gravel, regrade, compact
Loose Aggregates *or* Ravelling	Minor	þ Reshape (blading or dragging) þ Reshape with minor added material
Loose Aggregates *or* Ravelling	Major	þ Regrade þ Add major gravel, regrade, compact
Corrugations	Minor	þ Reshape (blading or dragging) þ Reshape with minor added material
Corrugations	Major	þ Regrade þ Add major gravel, regrade, compact
Soft Spots	Minor	þ Reshape (blading or dragging) þ Reshape with minor added material
Soft Spots	Major	þ Regrade þ Add major gravel, regrade, compact
Depressions	Minor	þ Reshape (blading or dragging) þ Reshape with minor added material
Depressions	Major	þ Regrade þ Add major gravel, regrade, compact

DITCHES

Ditches are used to convey water from storm runoff to an adequate outlet without causing erosion or sedimentation. They are ideal for collecting and dispersing surface water in a controlled manner. A good ditch requires shaping and lining (using the appropriate vegetative or structural material) and maintenance. Constructed properly, ditches will remove runoff quickly and reduce seepage into the road subgrade.

Importance to Water Quality

Well-designed ditches provide an opportunity for sediments and other pollutants to be removed from runoff water before it enters surface waters or groundwater. Ditches work by controlling, slowing and filtering road runoff through vegetation or rock lining. Efficient removal of runoff from the roadway will help preserve the roadbed and banks. In addition, a stable ditch will not become an erosion problem itself.

General Ditch Principles

þ Ensure that the ditch is properly lined to prevent erosion.

þ Perform regular maintenance to keep ditch clear and stable, and to maintain capacity of channel.

Ditch Profile and Lining

Using the correct ditch profile and lining techniques will help remove water from the road and through the ditch more quickly. This will help to decrease erosion and increase the length of time between cleaning and regrading, cutting maintenance costs. Use an articulated bucket to create most ditches.

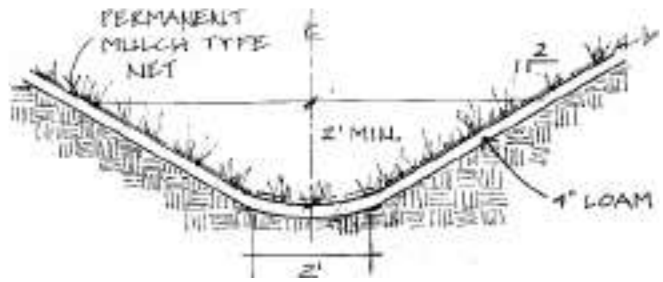
- Locate ditches on the up slope side of the road to prevent water from flowing onto the road from uphill.
- Design and grade ditch and bank side slopes at a maximum 2H: 1V ratio.
- Excavate a ditch deep enough to drain the road base, generally 1.5 to 2 feet deep.
- Shape the ditch bottom so that it is rounded or parabolic-shaped and at least 2 feet wide to help slow and disperse water.

A few words about Slope

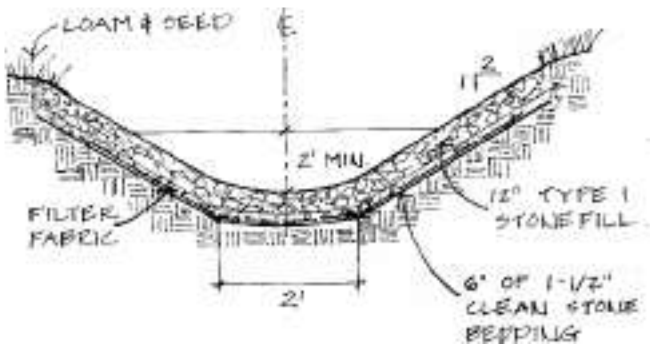
Slope, or grade, is an important factor to be considered as part of a site suitability assessment when designing and selecting a BMP. Refer to the graphic on page 17 for more information on how to quickly and easily determine a slope.

- Line ditches that have a less than 5% slope with grass in order to filter sediments.
- Line ditches that have a greater than 5% slope with riprap stone.
- Line ditches as soon as possible to prevent erosion and to maintain the ditch profile.
- Prevent water from standing in a ditch—standing water weakens roads.

Ditch Types



Grass lined ditch

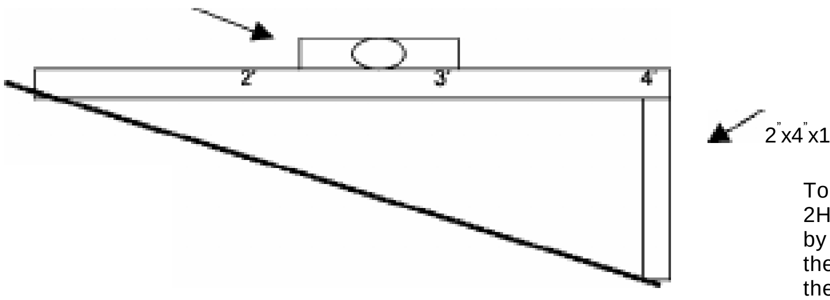


Stone lined ditch

Ditch Lining		
Channel Slope	*Lining Material*	*Lining Thickness*
0-5%	Erosion control blanket and seeding	
5-10%	2-6 inch diameter rock	7.5”
> 10%	3-12 inch diameter rock	12”

Use a 2"x4"x4' with common carpenter's level taped to top. Mark off at 2, 3, and 4 feet. Move vertical length up or down slope until level to determine slope ratio.

A simple slope gauge you can carry in the truck



To convert a ratio such as 2H:1V to a slope %, divide 1 by 2 (the second number by the first number) to get .5 then multiply by 100% to get 50%. Remember, slopes can be greater than 100%…a 1H:2V slope is 200%!

Ditch Maintenance

Ditch cleaning and maintenance is one of the most important elements to maintaining good drainage along any type of road. For unpaved roadways, a well-designed ditch can be cleaned with either a grader or a backhoe with a grading bucket, but production under normal conditions is generally higher with a grader.

- Inspect ditches regularly and schedule cleaning every few years. The bottom of the ditch should remain compact and rounded.
- Clean ditches when they become clogged with sediments or debris to prevent overflows and washouts.
- Check ditches after major storm events as fast moving water may have developed obstructions, erosion, or bank collapse.
- Regrade ditches only when absolutely necessary and line with grass (or stone) as soon as possible. Seed, mulch, and use fiber mats to assist revegetation.

Obstructions in this ditch have led to standing water

Can You Answer These Questions About Your Ditches?

þ Are ditches deep enough to drain subgrade and/or cut off subsurface water?

þ Are ditches broad enough?

þ Is there adequate slope to the ditch line to prevent ponding?

þ Is the ditch free of obstructions?

þ Has erosion started at spot locations in the ditch?

þ Is the ditch lining (stone or vegetation) holding up?

þ Could velocity dissipaters be used to slow down the water?

þ Does the ditch have a stable outlet?

Routine Maintenance and Inspection Checklist

Spring and Summer

- Clean and remove fallen brush, leaves, trash, sediment and other debris from the ditch.
- Reshape the ditch to improve flow capacity.
- Re-establish and/or improve the cover type:
  - ® Earth – Seed, mulch, and apply erosion control matting to prevent erosion
  - ® Grass – Reseed, mulch and apply erosion control matting. Mow and trim out brush
  - ® Stone – Add stone to slopes and low spots, if necessary. Place or form stones to fit ditch shape. Patch broken or washed out areas to prevent further damage and erosion

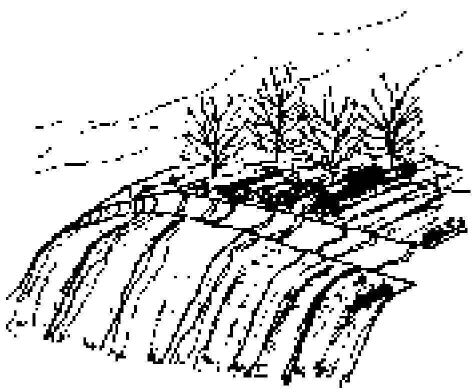
Fall and Winter

- Remove accumulated debris.
- Keep critical sections free from snow and ice to prevent spring flooding.

Diversion Ditches and Berms

Diversion ditches and berms (earth dikes) are used to re-direct stormwater runoff. They may be located above steep slopes, across long slopes, or below steep grades. Their purpose is to intercept surface runoff from the slope and carry it away. This not only reduces the volume of water that has to be carried to the roadside drainage system but also protects the slope from excessive runoff and greater erosion problems.

- Use a diversion ditch 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.
- Use in combination with 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 ditch

Typical diversion berm

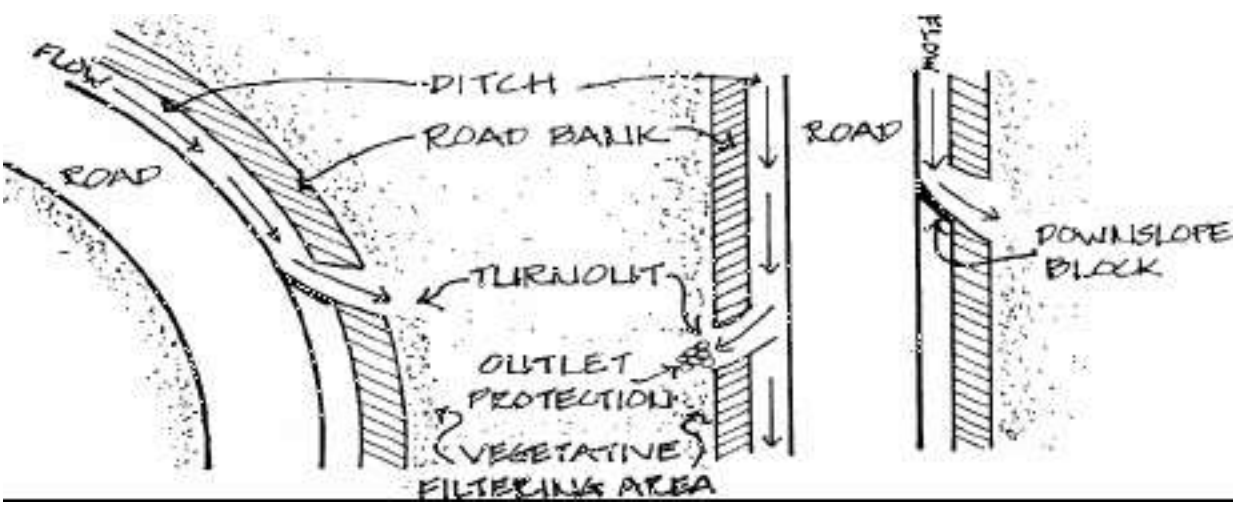
Turnouts

Turnouts are extensions of ditches that direct water to filtering areas. There must be adequate outlet protection at the end of the turnout area, either a structural (rock) or vegetative filtering area. See the section on *Outlet Protection* for details on the construction of proper outlet areas.

- Follow culvert requirements for spacing *(see next section.)*
- Use only in areas where the water will flow positively in a filtering area well away from the road and adjacent surface waters.

Spacing Needed Between Turnouts

Road Grade (percent)	*Distance (feet)*
2	250
5	135
10	80
15	60
20	45
25	40

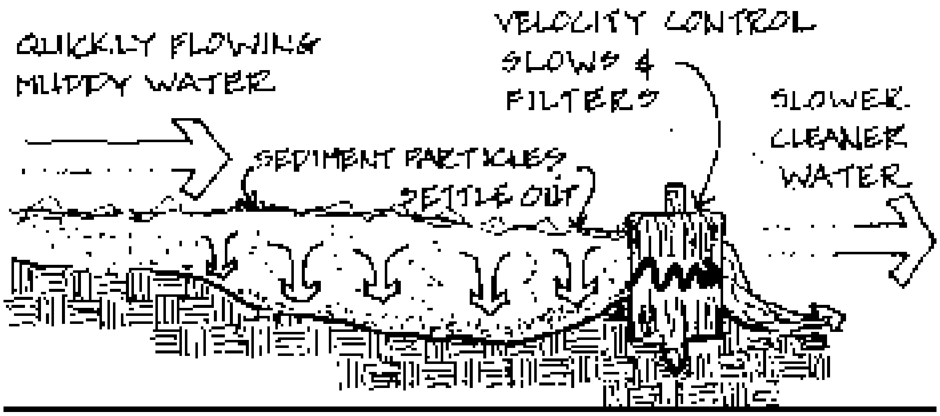


Two types of turnouts

Velocity Controls and Energy Dissipaters

Velocity controls and energy dissipaters, also called check dams, are used to slow the water flowing through ditches and swales. The reduced water speed reduces erosion and gullying in the channel and allows sediments to settle out behind the check dam. They may be built from stone, silt fencing, or haybales. They are effective at keeping brush, trash, sediment and other debris from reaching and plugging culverts. Where temporary channels or permanent channels are not yet stabilized, velocity controls must be used. Use only in drainage areas of less than 2 acres.

- Locate in ditch channel or near culvert outlet.
- Construct dams and dikes no higher than 2 feet.
- Clear sediment out from behind dams when half full.
- Monitor all check dams for performance and clean sediments and debris regularly, especially after rainstorms.



A check dam works by slowing water and allowing sediments to settle out

Types of velocity controls and energy dissipaters include:

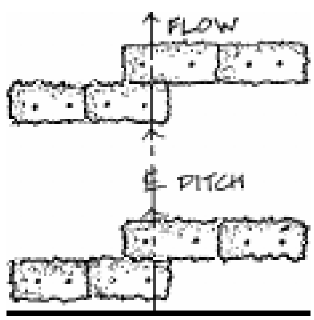
Hay Bale Dikes

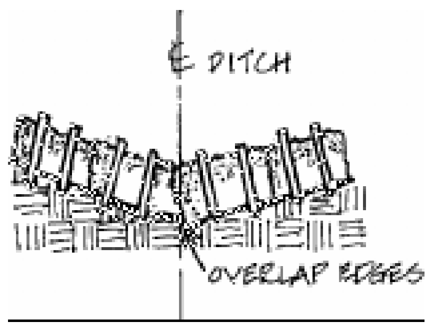
Hay bale dikes are temporary sediment barriers constructed of a row of hay, or straw, bales tightly butted together, embedded 4 inches into the ground and anchored. Properly sited, they decrease the velocity of sheet flows and low-to-moderate level channel flows. The ends of hay bales should be higher than centers such that water will spill over the top of the bales, not around the sides. Hay bale dikes are an inexpensive, temporary dike structure since hay bales will rot; use where effectiveness is required for less than three months.

- Use in smaller ditches to slow water flow and at the toe of a slope to trap sediment.
- Installation technique is critical to proper functioning of a dike: bales must be entrenched and backfilled, first stake in each bale driven toward previous bale to force them together, and gaps between bales should be filled with loose hay.
- Remove sediment from behind bales when it reaches one-half the height of the bale.
- Inspect after each rainfall and replace damaged bales promptly.

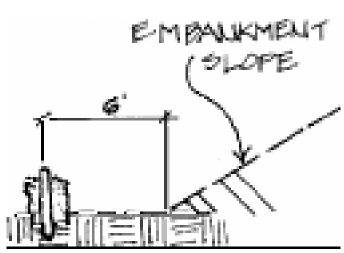
Note: *Hay bale dikes can be easily damaged by heavy runoff and high water velocities and, therefore, must be checked and maintained frequently to remove sediment buildup. They should also be removed before winter to allow spring runoff to flow freely through the ditch, preventing it from flowing across the road surface and creating a potential washout.*

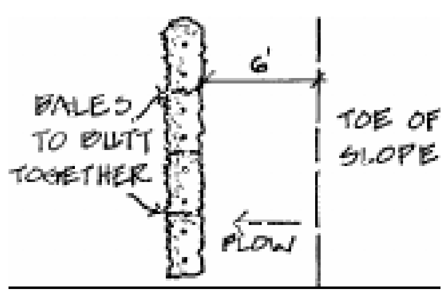
Type A – Use in ditches or in areas where the existing ground slopes in toward the filled embankment.





Type B – Use at the base of a slope or where the existing ground slopes away from the toe of the filled embankment.

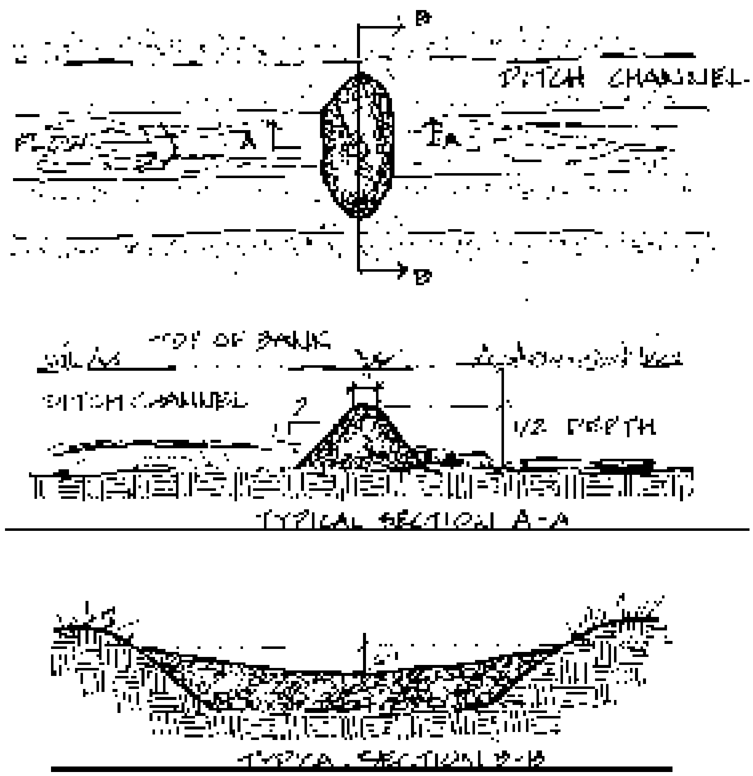




Stonedikes

Stonedikes are more expensive than other types of check dams, but provide a more permanent structure. They are good at preventing rill and gully erosion in ditches, and create volume for settling out sediments.

- Construct with stone large enough to handle the expected velocity of water, generally 2 to 4-inches in size; the smaller the stone size the more sediment removed, but the rock must be large enough to stay in place given the expected design flow through the channel.
- Place the rock by hand or with mechanical placement to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges; do not dump rock to form dam.
- The dams should be spaced so that the toe of the upstream dam is at the same elevation as the top of the downstream dam.
- Inspect once a week and following rainfall, and remove sediment from behind dams when half-full.

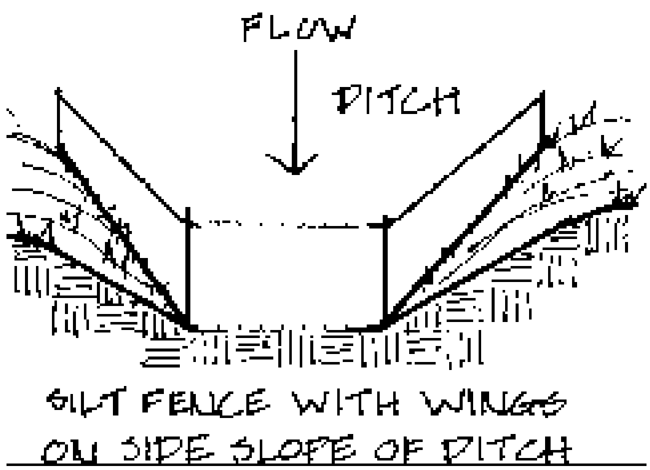


Stone Dike

Silt Fence Dikes

A silt fence dike is a temporary type of velocity control and sediment barrier constructed of a pervious geotextile fabric stretched across and attached to supporting posts and entrenched, or dug into the soil. Silt fence dikes offer temporary velocity control and have the advantage of being lightweight, portable, and often reusable; the expected life of a sediment fence is generally six months. Silt fence typically detains a much higher percentage of suspended sediments than hay bales. Installation and maintenance tips can be found in the section titled *Erosion and Sediment Control.*

- Use in ditches to slow water flow and at the toe of a slope to trap sediment; not practical where large, concentrated flows are involved.
- Allow for safe bypass of storm flow to prevent overtopping failure of fence.
- Remove trapped sediment periodically for optimum performance.
- Inspect after each rainfall and repair damaged fencing promptly.
- Remove when the project is finished.



Silt fence dike installed in a ditch

Matrix of Ditch BMP's for Maintenance		
What you observe …	*How bad is the problem…*	*How to fix It…*
Erosion in Ditch	Minor	þ Perform regular maintenance þ Line ditch appropriately þ Install velocity controls*
Erosion in Ditch	Major	þ Perform regular maintenance þ Regrade ditch þ Line ditch appropriately þ Install velocity controls*
Ditch can't handle volume	Minor	þ Install ditch turnouts þ Increase ditch width/depth
Ditch can't handle volume	Major	þ Install ditch turnouts þ Construct diversion itches/berms þ Increase width/depth

** When making decisions about the use of velocity controls, keep in mind that the size of the ditch and amount and velocity of the water will determine the type and the design. The use of velocity controls in anything but a small shallow ditch should generally be referred to an engineer to ensure appropriate design.*

CULVERTS

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. Culverts preserve the road base by draining water from ditches along the road, keeping the sub-base dry. Culvert installation is a simple operation, yet it is a process that is notorious for being done incorrectly and haphazardly. Proper installation and routine maintenance are necessary to ensure the safety of the roadway.

Importance to Water Quality

Properly placed culverts along paved or unpaved roads will help alleviate ditch maintenance problems by outleting water in a timely manner. Significant erosion problems can develop at the outlets of culverts if they have not been properly designed or installed. Placing culverts and other outlets based upon road slope will control volume and velocity of discharges, reducing erosion and undermining and preventing sediment from entering surface waters.

General Culvert Principles

þ Inspect on a regular basis.

þ Protect inlets and outlets by marking their location, stabilizing entry and exit zones, and maintaining ditch linings to prevent erosion.

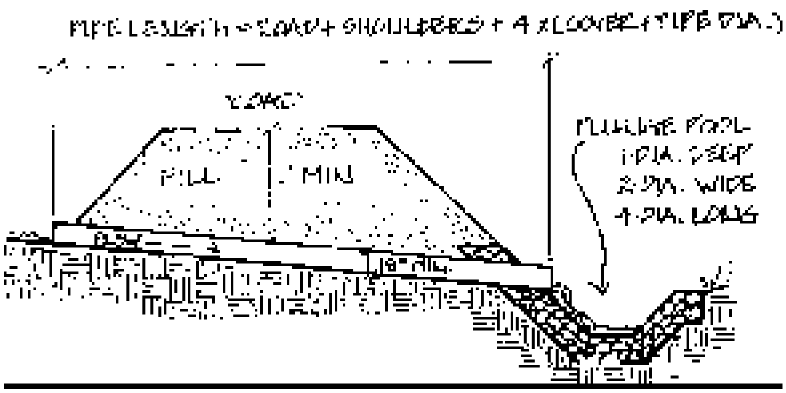
þ Practice preventative maintenance to avoid clogging, washouts, and settlement.

General Specifications for Installation

- Install culverts during periods of low water flow; (note: it is best to pump flowing water over the road while a culvert is being installed to avoid sedimentation of the waterway.)
- 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 (see spacing chart.)
- Outlet the culvert to a vegetated area, never directly into a stream.
- The upslope/inlet end must always be higher in elevation than the down slope/outlet end.
- Ensure a slope of 0.5% or greater to allow for positive drainage flow.

- Culvert pipe length = road and shoulder width at angle across road + 4 times the culvert diameter; extra length will need to be added to accommodate for headwalls.

- Ideally, culverts should be placed below frost depth to avoid problems caused by frost heaving.
- A minimum of one foot of fill over a steel culvert and 1.5 feet over a plastic 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.
- Protect all culvert outlets from erosion and undermining by use of rock aprons, plunge pools, or slope drain/sediment basins.



Culvert profile and cross-section

Installation/Replacement

Proper installation is an important component to ensuring success of a culvert. Significant erosion problems can develop at the outlets of culverts if they have not been properly designed or installed. Improperly sized culverts can cause upstream flood problems from water backing up at the road crossing. In addition, water quality problems can be created from improper grade and poor erosion controls during installation of culverts. *Remember, what follows are purely "rule of thumb" guidelines. Pro fessional engineers may need to be consulted in some instances. Permits may be required prior to the commencement of work. Contact your conservation commission or DEP for assistance and information.*

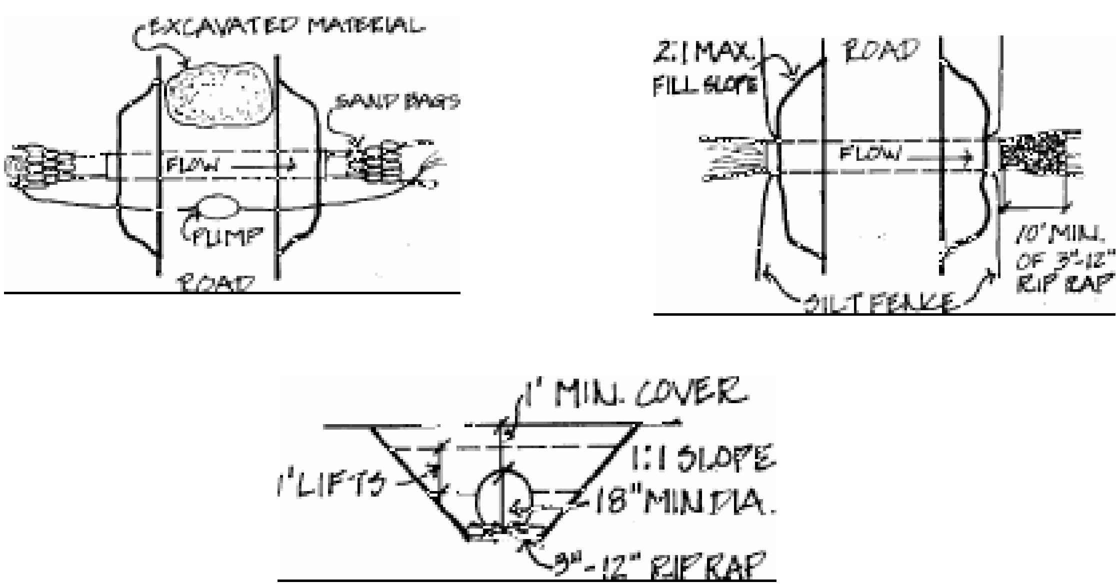
<u>Sizing Culverts</u>

- For small drainage areas (less than 20 acres) culverts may be sized by adding the acreage of the watershed to "8". For example, a 15 acre watershed would use a 24 inch culvert: 15 + 8 = 23", then rounded to the nearest even inch = 24".
- Design culverts to handle at least a ten-year-frequency storm.
- Drainage areas of larger than 20 acres should be referred to an engineer for the sizing and design of the culvert.

Drainage Area	Culvert Diameter Needed
0-5 acres	12”
5-10 acres	18”
10-15 acres	24”
15-20 acres	30”
>20 acres	Detail design: consult a professional

<u>Installation</u>

- Install erosion controls prior to any disturbance; if dewatering is necessary, place 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, removing old culvert if it is a replacement.
- Ensure that a stable, uniform foundation is provided, regardless of the type of pipe being used. The foundation should be strong enough to carry the load of the backfill or embankment material placed on the pipe and still maintain the established grade.



Culvert installation details

- Lay pipe up slope, starting at outlet end; place culvert level with the streambed and backfill in 6'" to 8" lifts, tamping the fill in place (poor compaction has led to more trouble with culvert installation for both flexible and rigid pipe than all other factors combined.) To prevent frost heaving, install below frost depth.
- Place 3 – 12 inch diameter riprap in the excavated outfall area, tamping it level with the stream bottom.
- Prevent frost-heaving problems by installing culverts below frost depth where appropriate, and backfilling with the excavated material.
- Seed and mulch all disturbed areas immediately.

Advantages and Disadvantages of Various Pipe Types

Steel Culvert

® Advantages – strong, relatively lightweight, easy to place, moderate service life (estimate 30 years), readily available.

® Disadvantages – subject to corrosion, subject to abrasion, shorter life than concrete.

Aluminum Culvert

® Advantages – very light weight, long life, resists corrosion, available in 20' sections.

® Disadvantages – requires special care when backfilling, easily damaged, subject to abrasion

Concrete Culvert

® Advantages – strong, resistant to corrosion, resistant to abrasion, long life (estimate 75 years).

® Disadvantages – requires special handling, requires careful placing, not readily available in all areas, maximum 8' sections.

Plastic Culvert

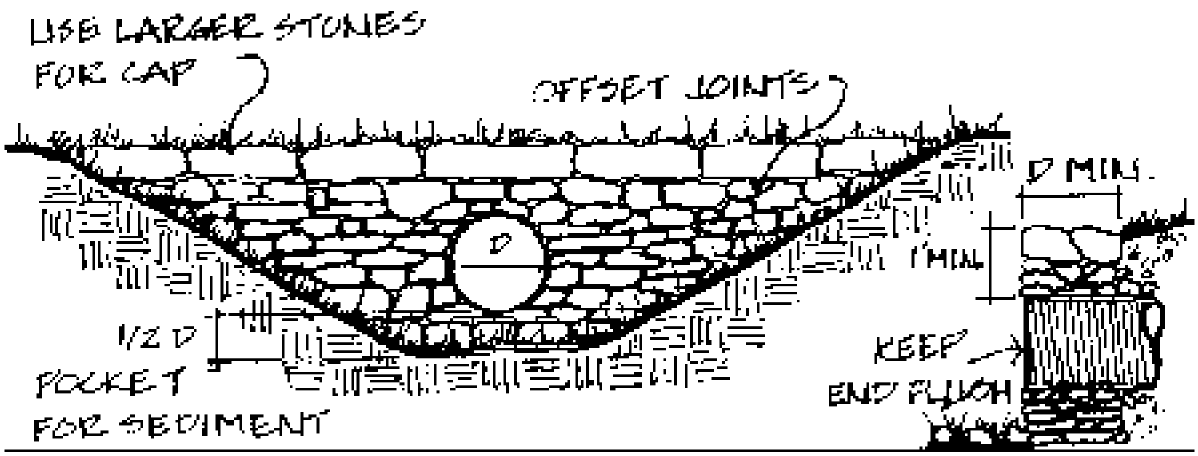
® Advantages – lightweight, available in 20' sections, resistant to corrosion, long life.

® Disadvantages – requires special care when backfilling, possible ultraviolet light degradation, may be subject to damage at low temperatures or high heat.

Headers and Endwalls

Headers direct flow into the culvert, mark the location of a culvert, and protect the culvert from damage during grading and ditch cleaning. Endwalls direct flow back to the regular channel as water leaves the pipe. Both protect the embankment from scour and erosion.

- Headers and endwalls should be flush with the ends of the culvert.
- Flared header extensions help direct the flow of runoff into the culvert, preventing water from flowing in undesirable directions.
- Dry laid field stone headers are in keeping with Massachusetts' character and are aesthetically attractive. They have historically been used in many areas lasting over 100 years.



Header and endwall detail

Reasons to Replace or Repair a Culvert

- end crushing due to errant vehicles
- corrosion from salt water or acid soils
- erosion due to high flow velocities carrying sand and gravel
- pipe capacity insufficient for runoff needs
- poor headwall or slope treatment resulting in embankment loss
- poor culvert bedding resulting in settlement, or structural failure

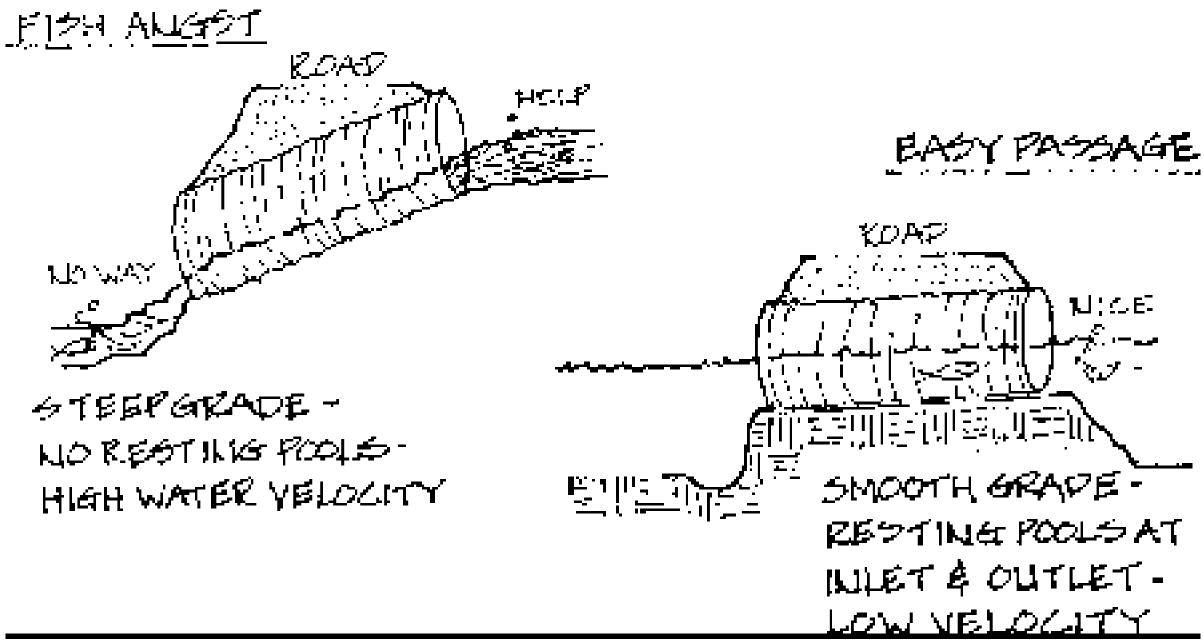
Fish Friendly Culverts

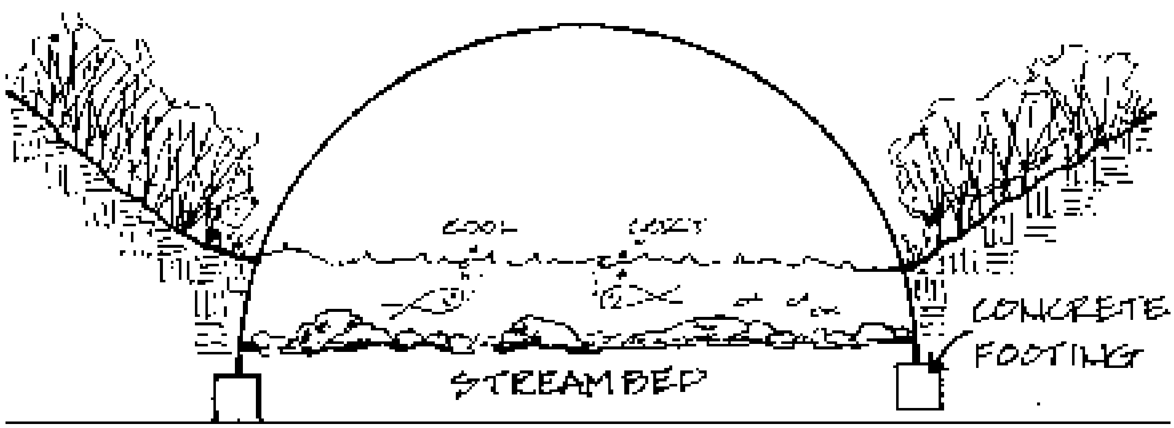
A culvert installation should not reduce fish passage effectiveness in the stream from that which existed prior to the installation. Special attention to culvert grade is necessary if fish passage is to be accommodated. Culverts can impede fish passage by creating the following conditions:

- ® Excessive water velocity which exceeds fishes' swimming speed and duration.
- ® Vertical barrier created by improper setting of the culvert grade (called "perching".)
- ® Inadequate water depth caused by culvert's design requirements to pass a major storm flow, resulting in sheet flow through culvert.
- ® Debris problems caused by oversized culverts which actually lowers stream velocity and depth allowing debris to settle out.

Remember, you can always contact the local/state fisheries biologist early in the design process for assistance with stream crossings or other stream related projects. Other tips for successful fish friendly culvert installation include:

- When crossing a stream, select the culvert site so there is no sudden increase or decrease in gradient and there is a 50 feet straight alignment of the stream channel directly above the crossing.
- Use bridges, bottomless arches (see graphic on next page) or partially buried culverts in areas where fish passage is an important consideration.
- Corrugated steel culverts decrease water velocities and supply resting areas for migrating fish.
- Make culvert diameters adequate to pass maximum expected design flows, but provide sufficient depths to allow passage in minimal flow conditions.
- Design culverts so that water velocity and depth passing through the pipe are equal to water velocities and depths in the stream.
- Provide resting pools at culvert inlet and outlet for culverts installed across streams.
- Place riprap securely at upstream culvert end 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.





Bottomless arch culvert to accommodate fish passage

Culvert Maintenance and Inspection

Despite the best efforts to keep culverts free and clear, they may become clogged with eroded soil, sticks, and leaves. The best way to keep culverts working properly is to inspect them every chance you get, and at a minimum every spring and fall. During a rainstorm is a good time to check all of the road drainage systems. You can often spot small problems before they turn into large ones.

General Maintenance and Inspection

- Avoid clogging, collapsing, washouts, and settlement by practicing preventative maintenance.
- Replace culverts with the same size pipe if it has been handling flow sa tisfactorily.
- Pay special attention to water action at the culvert inlet.
- Use high pressure flushing to effectively clear most plugged culverts.
- Flush culverts from the outlet end.
- Be sure to clean the outlet ditch after flushing.
- Thaw frozen culverts using steam, high-pressure water, ice auger s , or calcium chloride. and fall and
- Inspect culverts every chance you get, but at least every spring following heavy storms.
- Mark all drainage culverts to insure that they are not skipped during ins pections.
- Monitor culverts with running water during freezing weather and take action if they start to freeze.

Routine Seasonal Maintenance

Spring

- Inspect culverts for winter damage.
- Remove obvious blockage (trash, fallen brush, etc.)

Summer

- Clean/flush inside pipe.
- Repair/improve/install headwalls, end sections, and splash pads.
- Mow, trim and remove brush from around the culvert ends.
- Reestablish vegetation around culvert ends to prevent erosion.

- Add cover material if necessary.
- Remove obvious blockages.

Fall

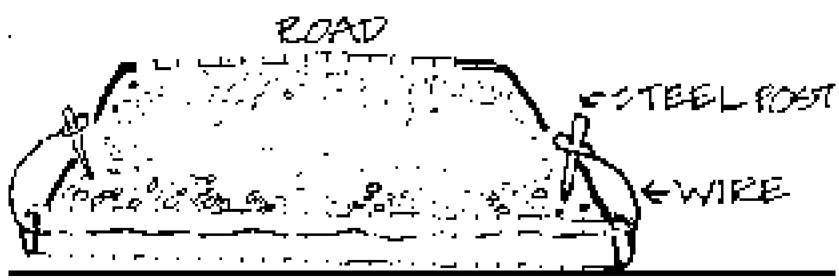
- Mark culvert ends for winter.
- Remove obvious blockages.

Winter

- Thaw culverts as necessary to maintain flow during warm spells.

Culverts must be kept free of snow and ice buildup. Free flowing culverts prevent roadways from becoming flooded during winter thaws and freezing over when the temperatures drop. Open culvert ends by shoveling the snow and chipping away the ice as necessary. If snow and ice buildup extends into the pipe, remove it using augers and chisels. Steam and high-pressure water can also be used to melt ice and force snow out of difficult culverts.

The **"John's Welder"** method, extracted from a Maine road drainage manual, is detailed below. This method is typically reserved for culverts that experience recurring ice blockage. Suspend a ¼ 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.



Matrix of Culvert BMP's

What you observe…	*What the Reasons Might Be…*	*How to fix it…*
Scouring/erosion at the inlet	• Ditch too steeply graded • Poor location/alignment • Clogged pipe	þ Line the inlet with stone þ Properly align the culvert þ Clean/flush the culvert
Scouring/erosion at the outlet	• Pipe sloped too much • Pipe is too small	þ Build a stone splash pad þ Check size and replace with larger pipe if necessary
Ponded or puddled water	• Invert is too high • Ditch grade is too flat	þ Reset the pipe to match the invert to the channel bottom þ Regrade ditch to maintain correct flow
Dented/crushed ends	• Traffic/snow plows are hitting the ends	þ Fix pipe ends; mark and protect
Heavy corrosion	• Water flowing through the culvert is acidic	þ Install a sleeve of PVC in the existing pipe or replace the steel pipe with a non-corrosive pipe (PVC, aluminum, concrete)
Piping around the outlet	• Pipe is incorrectly installed, resulting in water flowing outside the pipe	þ Reinstall pipe with proper bedding and compaction þ Install a headwall
Sediment build-up	• Not enough slope	þ Reinstall pipe with a slope of at least ¼" per foot
Objects blocking the pipe	• Debris traveling from the ditch to the culvert	þ Remove blockage þ Install check dams upstream
Sagging bottom	• Foundation material has settled on or has low bearing capacity	þ Reinstall pipe with suitable and properly compacted foundation material
Crushed top	• Not enough cover • Soil around walls not compacted • Traffic loads are too heavy	þ Add cover þ Reinstall pipe deeper and/or with suitable and properly compacted bedding material þ Install multiple smaller pipes or pipe with different shape þ Replace with stronger pipe

OUTLET PROTECTION

Outlet protection is important for controlling erosion at the outlet of a channel or culvert. Outlet protection works by reducing the velocity of water and dissipating the energy. It should be installed at all pipe, culvert, swale, diversions, or other water conveyances where the velocity of flow may cause erosion at the pipe outlet and in the receiving channel. There are a number of outlet structures that can be used in a variety of situations. Several types of outlet protection techniques are detailed below.

Importance to Water Quality

Outlet structures reduce the velocity of water carried by road ditches and culverts, therefore helping to control erosion and limit sedimentation. After passing through an outlet structure, water should outlet to areas with moderate slopes and vegetative filter zone before entering surface waters. 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. If these structures discharge to surface waters, a Notice of Intent filing will be required. See *Permits and Regulations* section for more information.

General Outlet Protection Principles

þ Install at all pipe, culvert, swales, or other water diversions where water velocity may cause erosion.

þ Design and size outlet protection for anticipated water velocities.

þ Perform regular maintenance and inspect periodically.

Structural Outlet Protection

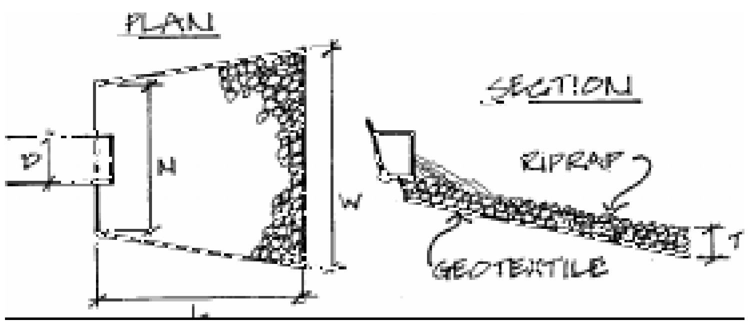
Rock Aprons

Rock aprons are designed to control erosion at the outlet of a channel or conduit by reducing the velocity of the flow and dissipating the energy through sheet flow. They can be installed at any pipe, culvert, swale, or diversion outlet where the velocity of the flow may cause erosion. Riprap is commonly used to construct rock aprons.

- Use only where there is an adequate vegetative filter strip (minimum of 50’) between culvert and water body.
- 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 Design Specifications					
Culvert Diameter (in.)	*Riprap Size – R#*	*T (in.)*	*N (ft.)*	*W (ft.)*	*L (ft.)*
18	R#3 or R#4*	18	4.5	14.5	10.0
24	R#3 or R#4*	18	6.0	20.0	14.0

*Use R-3 sized riprap when slope of outfall is less than 10%, and use R-4 when slope outfall is greater than 10%. (R-# is a National Crushed Stone Association specification. For example, R-4 specifies that the riprap will be between 3 and 12 inches in size, with an average size of 6 inches, and that 50% of tonnage will be greater than 6 inches and 50% less than 6 inches.)



Typical rock apron

Riprap Conveyance Channel

Use riprap conveyance channels to remove sediments while carrying runoff from a culvert or ditch.

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

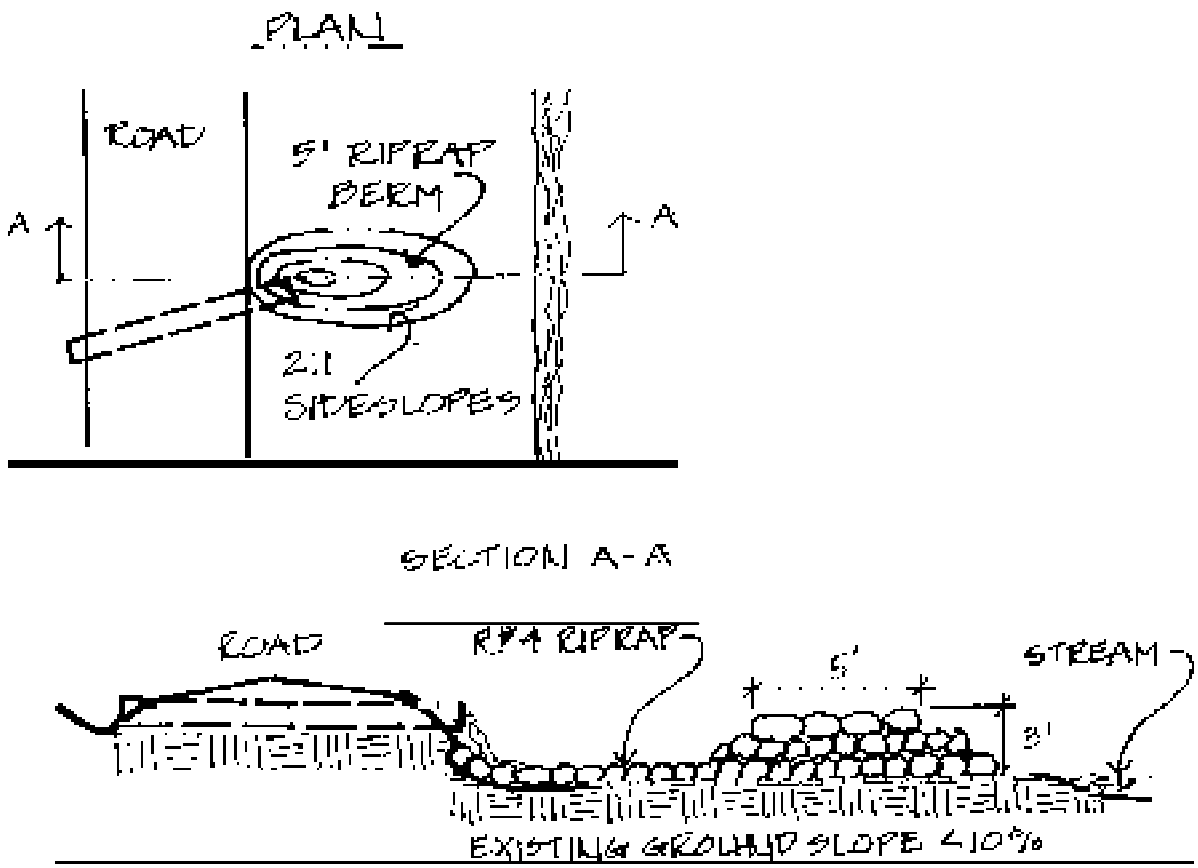
Riprap conveyance channel

Riprap conveyance channel profile

Splash/Plunge Pools

Splash or plunge pools are designed to control erosion at the outlet of a channel or conduit, detaining water, and allowing sediment to settle out. They work by reducing energy and velocity by providing storage of runoff. They should be installed at all pipes, culverts, swales, or diversions and in the receiving channel where the velocity of the flow may cause erosion at the outlet. Riprap is the preferred material. Splash pools are good for removing sediments (by absorbing energy from flowing water and allowing sediments to settle out) from areas with concentrated flows and areas without adequate vegetative filter zones.

- Limited to areas with less than 10% slope to consolidate sediment for easier removal.
- Clean when pool area is one third filled with sediment.
- Should be located and constructed so that mechanized cleaning is possible.



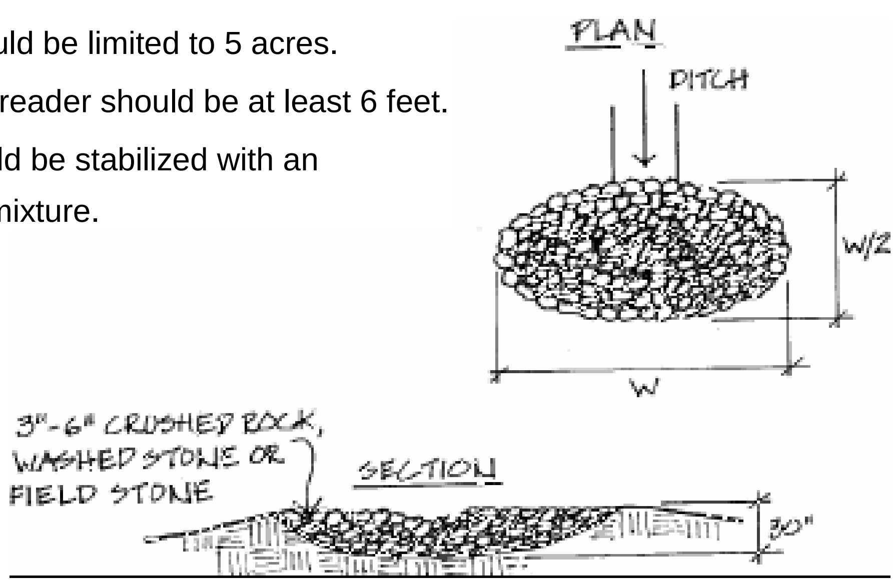
Cross section of a splash/plunge pool

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

Level Spreaders

A level spreader is an excavated depression constructed at "zero percent" grade across a slope. The level spreader changes concentrated flow into sheet flow and then outlets it onto stable areas, reducing erosion potential and encouraging sedimentation. Level spreaders are relatively low cost structures designed to release small volumes of water safely.

- The level spreader should be flat ("0 percent" grade) to ensure uniform spreading of runoff.
- Drainage area should be limited to 5 acres.
- The width of the spreader should be at least 6 feet.
- The spreader should be stabilized with an appropriate grass mixture.



Nonstructural Outlet Protection

Filter Zones

Filter zones, or natural “buffer” zones, are undisturbed vegetated areas that slow water by overland flow through vegetation and reduce erosion and runoff velocities. They are often used to separate roads, development, or construction sites from sensitive areas such as streams, wetlands, and lakes. Natural buffer zones provide critical wildlife habitat adjacent to streams and wetlands, as well as assist in controlling erosion, especially on unstable steep slopes. Excessive runoff or sediment may damage the filtering area and require other types of structural controls.

- Filter zones act as a natural sediment traps, as well as a visibility and noise screen.
- Filter zones have low maintenance requirements and are low cost when using existing vegetation.
- Filter zones are the preferred method of slowing and filtering water before it enters surface waters.
- If there is little or no vegetation between the road and stream, consider *creating* or *enhancing* a filter zone by planting a diversity of native grasses, shrubs, and trees. This will enhance filtration of road runoff before it reaches the waterbody.

Tips for filter zones:

þ Fence or flag clearing limits and keep all construction equipment and debris out of the natural area.

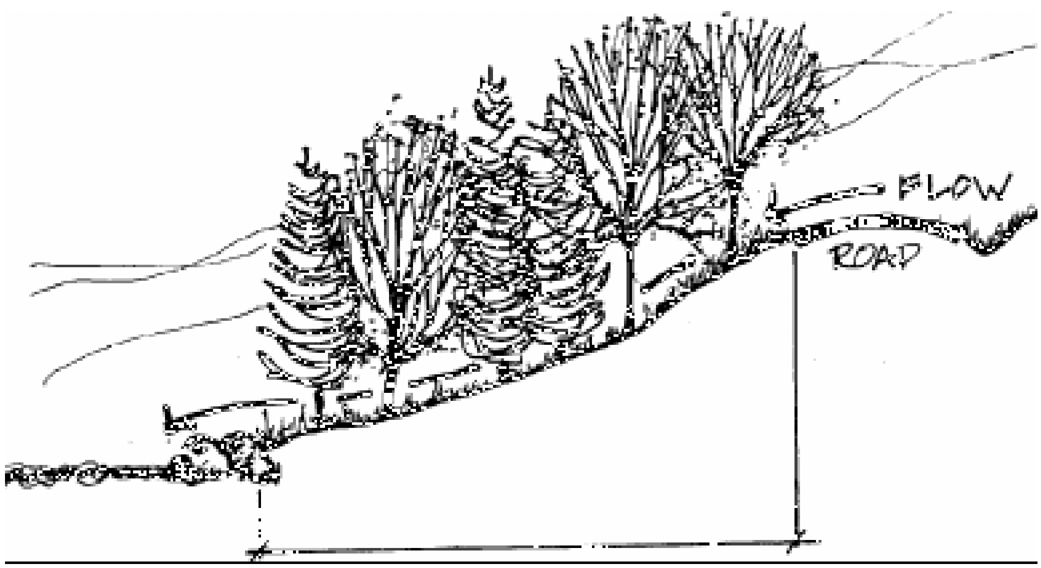
þ Keep all excavations outside the drip line of trees and shrubs.

þ Routine and careful maintenance such as mowing, fertilizing, and pruning is important to ensure healthy vegetation. Appropriate maintenance methods will be dependent on the species of plants and trees involved, soil types, and climatic conditions.

þ Establish new filter zones using appropriate native species for the site.

NOTE: *In Massachusetts, the area extending 200 feet out on either side of a perennial river (one that flows year round) is a regulated resource called the Riverfront Area. The Massachusetts Wetlands Protection Act strictly regulates all work within this important area. See the Permits/Regulations section for more information on Riverfront Areas and applicable laws and regulations.*

Recommended Filter Zone Widths	
Slope of land between road and water	*Recommended Filter Zone Widths, in Feet*
0-10%	50’
11-20%	51’-70’
21-40%	71’-110’
41-70%	111’-150’



Cross section of a filter zone

Matrix of Outlet Protection BMP's

What you are trying to achieve…	*How to achieve it…*	*Consideration for use…*
Natural sediment filter Improved appearance	· Natural filter zones · Enhanced or created filter zones	þ Little maintenance required, low cost.
Slow velocity of water at outlet Control or reduce erosion at outlet Settle out sediments	· Rock apron	þ Use only where there is an adequate filter strip between outlet and waterbody.
	· Rip rap conveyance channel*	þ Use on fill slopes, steep slopes where outlet flows close to surface waters.
	· Splash/plunge pool*	þ Use where storage of runoff is necessary before discharge.
	· Level spreader*	þ Changes concentrated flow into sheet flow.

*****May require site-specific engineering assistance.

BANK STABILIZATION

Bank stabilization is the vegetative or structural means used to prevent erosion or failure of any slope. Erosion occurs when soil particles at the bank's surface are carried away by wind, water, ice, and gravity. It can also be caused by such things as stream currents and waves, obstacles in a stream, overbank drainage, heavy rainfall on unprotected land, freeze-thaw and dry cycles, seepage, and changes in land use. Bank failure occurs when an entire section of the bank slides to the toe of the slope. It can be caused by an 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, and changes in stream channel shape.

> ***Note:*** *The bank stabilization techniques outlined in this chapter are generally appropriate for immediate protection of slopes against surface erosion, cut and fill slope stabilization, and small gully repair treatment. Large-scale slope stabilization projects should be referred to professional engineers or the Natural Resources Conservation Service (NRCS). Streambank stabilization is a much more complex project that will require specialized engineering and environmental review. Consult your conservation commission or DEP before undertaking a streambank stabilization project.*

Importance to 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 caused by these problems. The following chapter will highlight some of the more common techniques used for slope stabilization.

Because such work may involve anything from vegetative plantings to complex construction of stonewalls and riprap slopes, it is often difficult to determine what, if anything, needs to be done. When in doubt, contact your local conservation commission, DEP, or other professional organization for assistance.

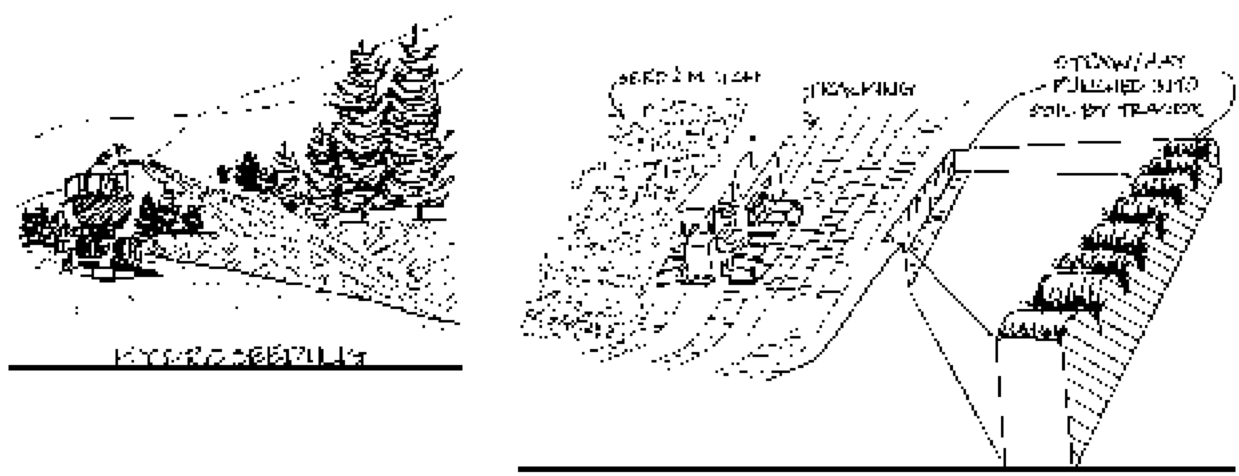
General Bank Stabilization Principles

- þ Carefully evaluate the site and follow design considerations when selecting appropriate stabilization techniques.
- þ Use living plants adapted to the site whenever possible.
- þ Perform regular maintenance and inspect new stabilization projects frequently.

Vegetation - Seeding

Seeding is the most efficient and inexpensive method to stabilize a bank or any bare area, and should be used wherever possible. Grass and legumes will slow the movement of water, allowing more water to seep into the ground and minimizing the impact of runoff.

- Areas to be seeded should have a maximum 2H: 1V slope.
- Seed areas as soon as possible after disturbance; this may even need to be done on a temporary basis.
- Spread at least 3 inches of topsoil over the area to be seeded.
- Finish grading should 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, preferably a native mix.
- Broadcast seed evenly over the prepared area by either hand broadcasting or hydroseeding with a truck mounted sprayer.
- Mulch after seeding with hay or straw to a depth of 3 inches. This can be done by blowing on from a truck or 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 or sheepsfoot roller.



Hydroseeding and surface roughening, two low cost ways to stabilize a slope

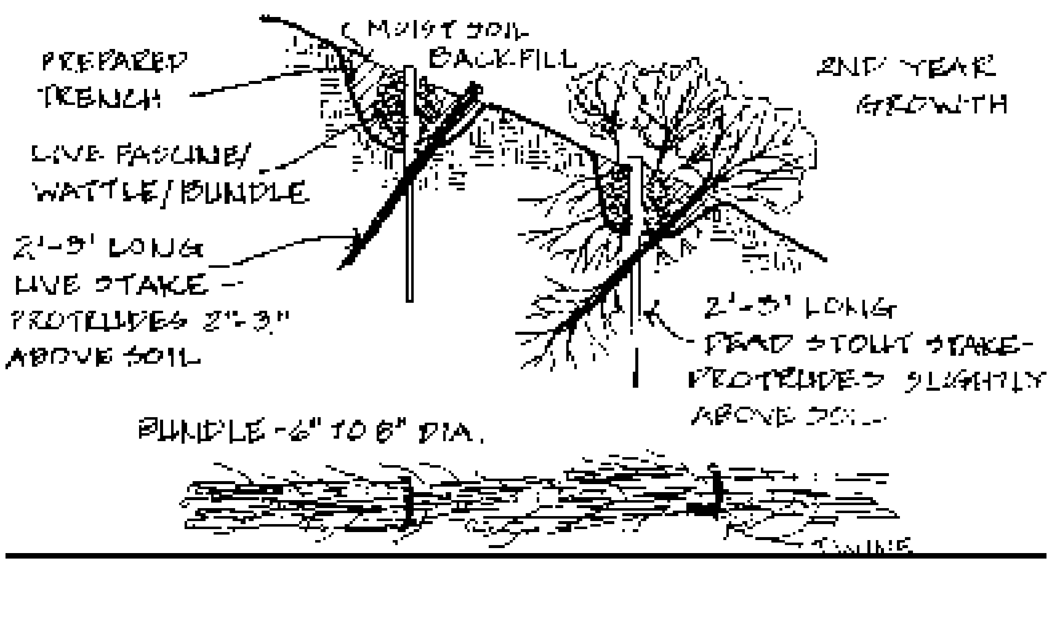
Vegetation – Shrubs and Trees

The use of shrubs and trees to control erosion and stabilize slopes is commonly referred to as *bioengineering,* or the use of live plant materials to aid in stabilization and erosion control. These techniques can be used to stabilize steep slopes and stream banks, and create a good vegetative filter zone. Take cues from other plants in the area to determine the most suitable plants to use for stabilization. For streambank stabilization, specialized design and rigorous environmental permitting will be required. Consult your conservation commission or DEP.

Live Fascines

Fascines, also called wattles or bundles, are long bundles of live branches installed in shallow trenches, 5 to 30 feet in length and 6 to 8 inches in diameter. They are generally tied together with growing tips oriented the same direction and tops evenly distributed through the length of the bundle. Fascines can be used on steep slopes (1H:1V) and to protect slopes from shallow slides. Commonly used plants for live fascines include willows, alders, and dogwoods.

- 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 (November to early March.)

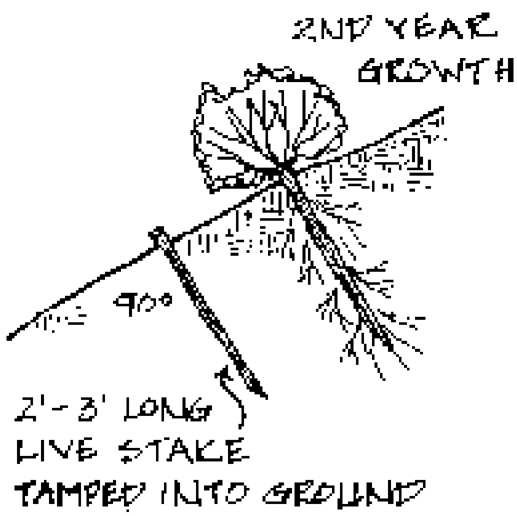


Live fascines/wattles/bundles

Live Stakes

Live stakes are cuttings of live branches, usually ½ to 1-½ inches in diameter and 2 to 3 feet long, taken from living, woody plants capable of quickly and easily taking root. This is an inexpensive method that can be used when time is limited and the site is relatively uncomplicated. Live stakes are usually used on moderate slopes (4H:1V or less) of original bank soil (not fill) and where there is little active erosion or chance of bank washout. Dogwood and alder species are capable of rooting, but willow species work best. Live stakes must be used when the plant is dormant.

- Branches should be cleanly removed from the stakes, and basal ends of stakes should be 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 (spring, winter, or fall.)



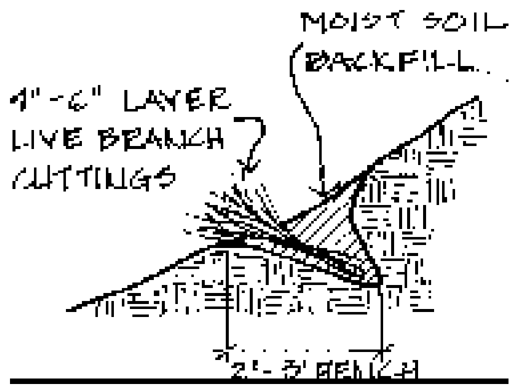
Live stakes

Brushlayeri ng

Brushlayering is a technique whereby live branches, ½ to 2 inches in diameter and 3 to 4 feet long, are placed perpendicular to the slope with growing tips outward. Brushlayering is used to break up slopes into a series of shorter slopes.

- 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 with cut end into bank perpendicular to slope.
- Backfill on top of branches and compact.
- Plant branches the same day as cut during dormant periods (spring, winter, or fall.)

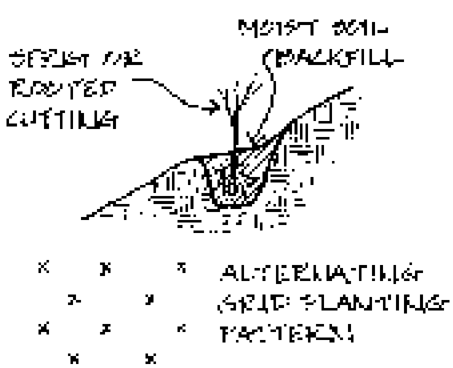


Brushlayering

Sprigs/Plugs

Sprigs or plugs are individual plant stems with roots; they can be seedlings or rooted cuttings. Sprigs and plugs are a low cost, quick growing option that can be planted anytime of year.

- 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 apart.
- Often used on filled slopes in conjunction with special fiber rolls.
- Rooted shrubs from a nursery may also be planted. These 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 2H:1V slope will help to stabilize the bank.

Cut and/or Fill

- The removal or addition of soil to the bank to create the desired 2H:1V or smoother slope, often times removing less stable soils and replacing them in the process of regrading the slope.

Notching or Keying

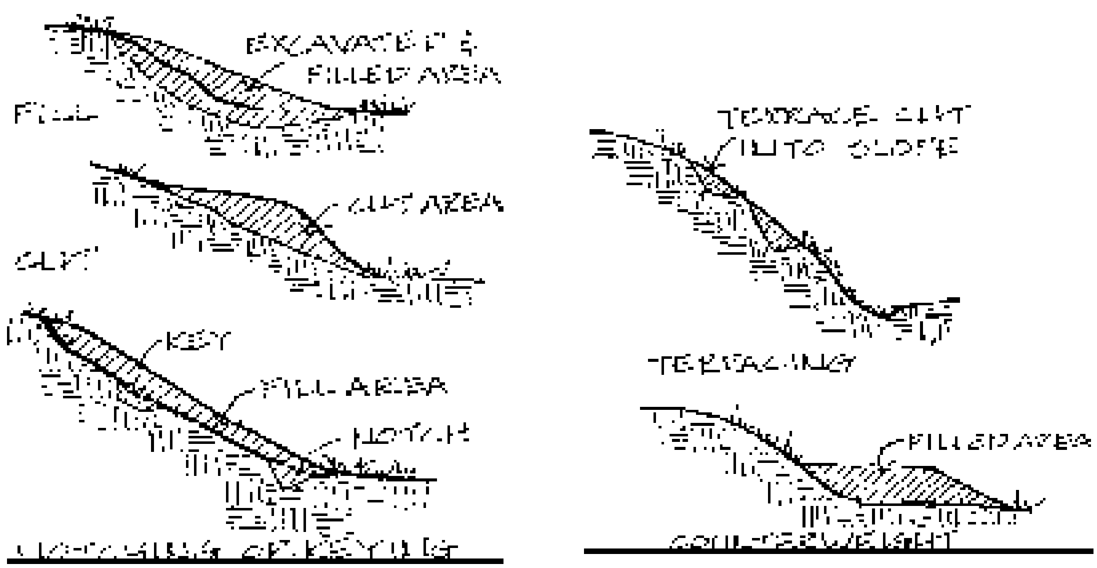
- A V or trapezoid shaped cut is made in the existing ground to help further stabilize fill added to smooth the slope.

Terracing

- Benches can be constructed on slopes that are excessively steep and long to provide near level areas that intercept and divert water.
- Angle terraces toward the slope to intercept water and prevent erosion of terrace.

Counterweights

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



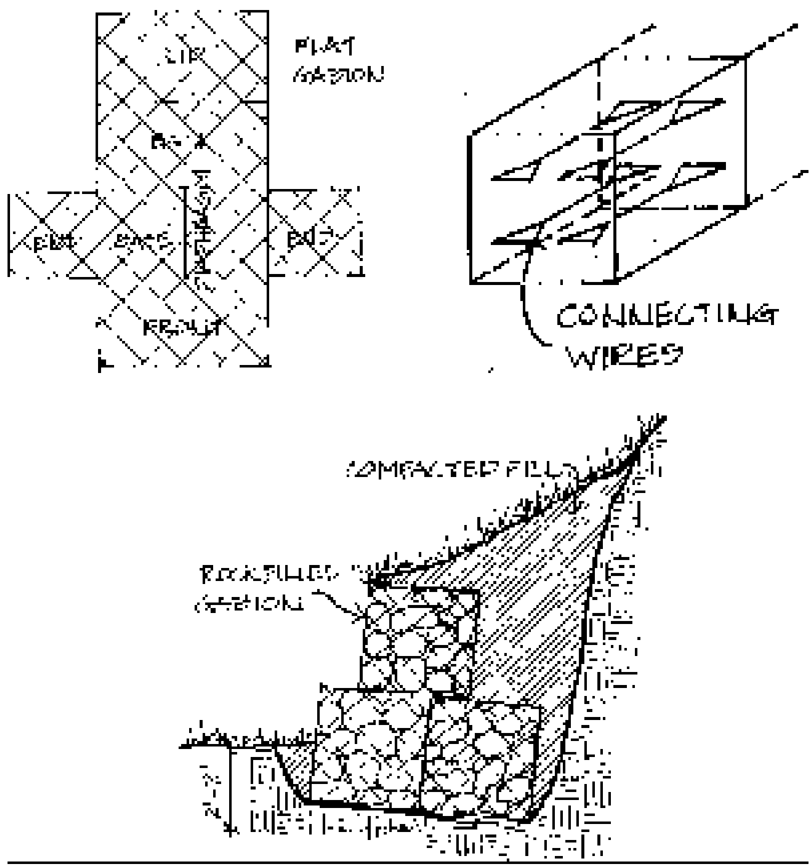
Examples of grading techniques

Structures - Walls

Gabions

Gabions are rectangular wire mesh baskets filled with stone, stacked atop one another to form a gravity-type wall. Gabions depend on the interlocking of the individual stones and rocks within the basket for internal stability. They are an easy-to-use method for slowing the velocity of runoff and protecting slopes from erosion.

- Gabions are permeable and allow water to seep through and aid in the removal of sediments.
- Gabions can be combined with woody vegetative stabilizers.
- Gabions are more expensive than either vegetated slopes or riprap.
- One disadvantage is that they are unnatural looking; they can be made more attractive by use of attractive facing stone toward the front of the wall and by establishing vegetation in the spaces between the rocks *(see page 54, vegetated gabion.)*



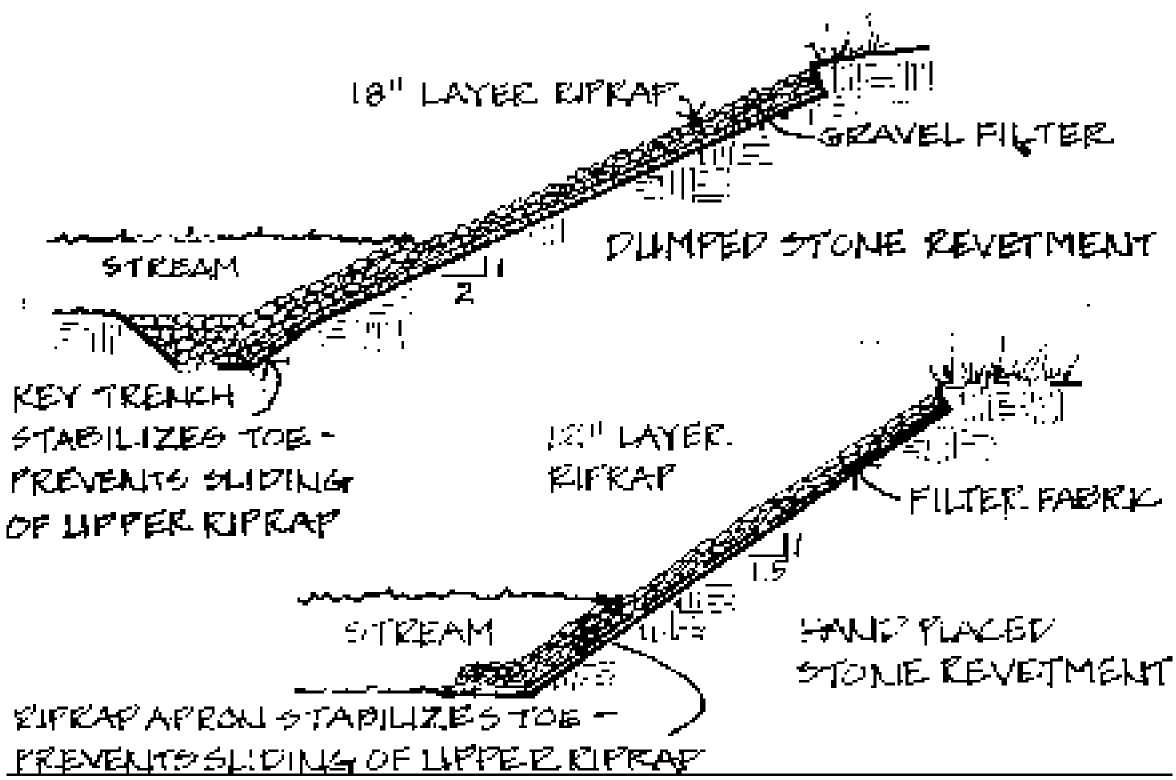
Gabion wall

Structures - Revetment Systems

Ri prap

Riprap can be placed on roadside slopes and stream banks where vegetation does not adequately check erosion and filter sediment. *Note: Specialized design and wetland permits will be required when using riprap on stream banks.*

- Size of riprap is dependent on quantity and velocity of water flow; generally, top of riprap (min. thickness=max. rock size), bottom of riprap (min. thickness=2 x max. rock size.)
- Used on very steep slopes, at sharp turns in streams (especially those with widely fluctuating flows), and where a bridge or culvert restricts water flow.
- Habitat and aesthetic value relatively low unless enhanced with vegetation.



Riprap revetment on a stream bank

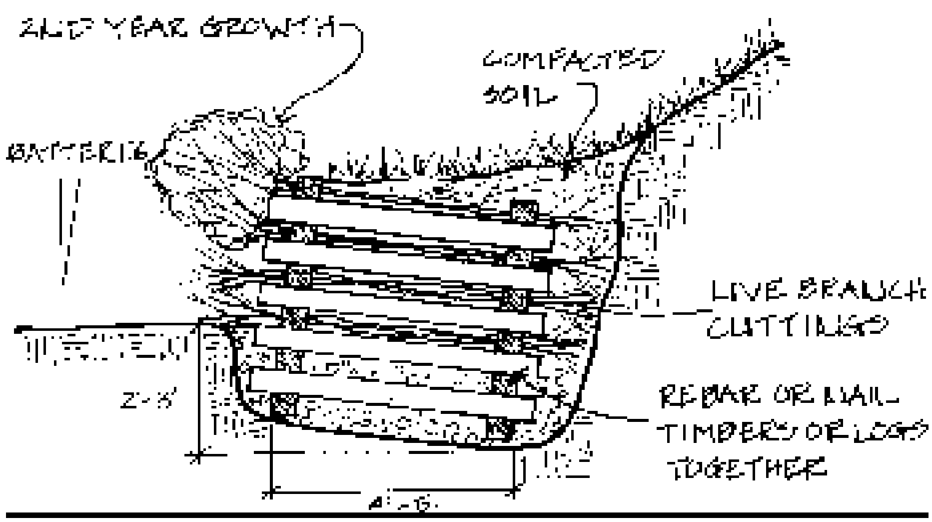
Combinations

Combinations utilize vegetative and structural components to stabilize steep banks in an integrated and complementary manner. Combinations can be used when one component will not provide the necessary slope protection and stabilization. Techniques include:

Live Cribwall

A live cribwall is a rectangular framework made of logs or timbers, rock, or woody cuttings. This technique can be used on roadside slopes and streambanks. Use at the base of the slope where a low wall, not higher than 6 feet, is required.

- 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.
- If used to repair streambank, place two to three feet below streambed on gravel base and ensure cribs are uniform with existing bank, not projecting into stream.
- Timbers provide structural support while plants take root. Use half as much wood as in a timber or log crib, making it less expensive and more natural looking after it has begun to grow.
- May also be constructed in a step fashion, creating planting areas.

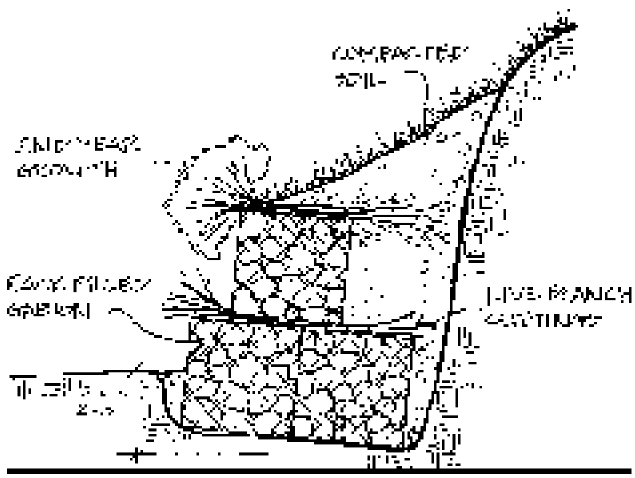


Live cribwall

Vegetated Gabion

A gabion wall can be combined with live branches, as used in brushlayering. “Greening” a gabion wall in this way will provide aesthetic and habitat enhancement to the wall.

- Backfill between each layer of gabions and place live branch cuttings on backfill.
- Place cuttings at an angle of at least 10% so they can survive and root.
- Live branches root in gabions and slope, binding the gabions to the slope.

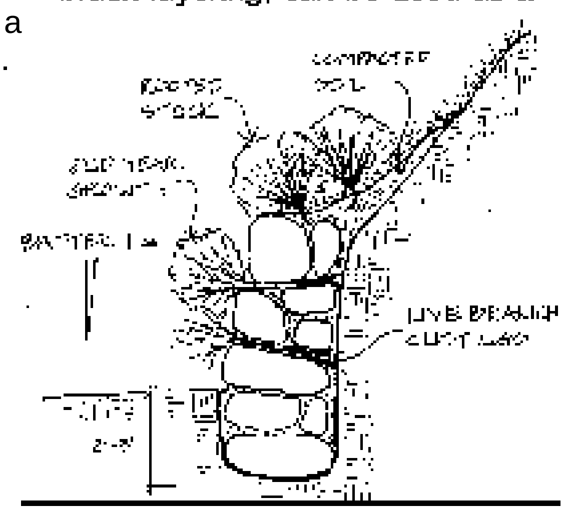


Vegetated gabion

Vegetated Rock Wall

A combination of rocks and live branches, as used in brush layering, can be used as a retaining wall along a slope. Use at the base of a slope where a low wall, not higher 5 feet, is required.

- Provide a well-drained base for the wall.
- Excavate a minimum amount of slope behind the wall.
- Place rocks with long axis slanting, or battered, inward toward the slope.
- Backfill between each layer of rocks and place live branch cuttings and backfill.
- Cover with soil and compact.

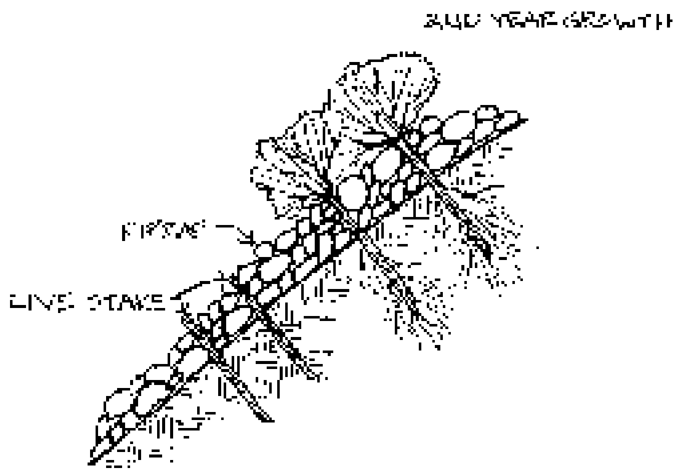


Vegetated rock wall

Vegetated Riprap/Joint Planting

This technique combines riprap revetment with the tamping of live stakes between the joints or open spaces in the rocks. Joint planting with riprap increases the effectiveness of the rock system by forming a living root mat in the base upon which the riprap has been placed.

- 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.
- When used on streambanks, this method promotes deposition of silts and provides shade that will reduce water temperatures in the stream.



Vegetated riprap

Mats & Blankets

Mulch mats and blankets are materials that have been formed into sheets of mulch that are more stable than normal mulch. Mats and blankets are used to provide bank stabilization and prevent erosion on a temporary basis on steep slopes. They can also be used in ditches with high water velocities, and in other areas prone to erosion. Types of mats and blankets include:

Jute Matting

Jute matting is made from undyed jute yarn, woven into an open 1-inch square weave mesh. It is very effective when spread over seeded and mulched areas to hold soil and seed in place.

- Bury up slope end of each section in a 6-inch vertical slot, and then backfill.

- Overlap each up slope section with 12 inches of mat.
- Overlap side-by-side sections by 4 inches.
- Securely anchor mat with stakes, staples, or rocks.

Wood Excelsior Blankets

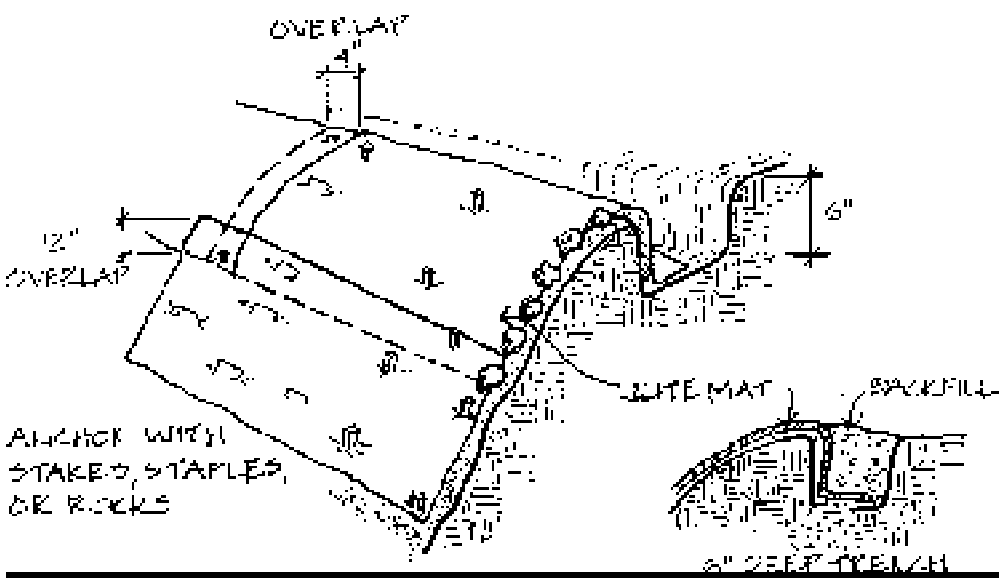
These blankets are a machine-produced mat of 6-inch long curled wood excelsior entwined with a photodegradable plastic mesh. There is no need to mulch when using a wood excelsior blanket.

- Ends of section should be tightly butted but not overlapped
- Installation is otherwise similar to jute mat.

Mulch Blanket

Mulch blankets are typically straw, coconut, or wood fibers sandwiched between photodegradable plastic. They are used 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.



Mat and blanket installation

Matrix of Bank Stabilization BMP’s			
Bank Stabilization Technique	*Examples*	*Appropriate Uses*	*Role of Vegetation*
Grading Techniques	-Cut and fill -Notching -Terracing -Counterweights	On slopes no greater than 2H:1V and where structural stabilization techniques not needed	Once re-established, will act as adequate stabilizer
Vegetative	-Seeding of grass -Hydroseeding	Use on slopes where slight to moderate stabilization is needed to control water and wind erosion and minimize frost effects	Control weeds, bind and retain soil, filter soil from runoff, intercept raindrops, and maintain infiltration
Bioengineering Techniques* (trees & shrubs)	-Live Fascine -Live Stakes -Brushlayering -Sprigs and plugs	Control rills and gullies Control movement of soil Filter sediment	Same as above, but also reinforce soil, minimize downslope movement of soil, improve appearance
Combinations*	-Live cribwall -Vegetated gabion -Vegetated rock wall -Joint planting	Same as above, but also control erosion on cut and fill slopes subject to scour and erosion	Same as above, but also reinforce soil, minimize downslope movement of soil, improve appearance
Structural*	-Rock wall -Gabion baskets -Rip rap -Geotextiles, mats and blankets	Use on eroding slopes with seepage problems and/or slopes with non-cohesive soils	Not applicable

* May require site-specific engineering assistance.

EROSION AND SEDIMENT CONTROL

Erosion occurs when individual soil particles are carried away from the road surface, ditch, or road base by water, wind, ice, or gravity. These soil particles are often transported by runoff to streams, ponds and lakes where they can alter the water chemistry, affecting the quality of water and fish habitat. Sediments can impact surface water ecosystems by adding excess nutrients that deplete oxygen supplies, smothering spawning and feeding habitat of fish, and contaminating drinking water supplies. By using the BMPs outlined in this manual and following the accepted guidelines found below,

General Erosion Control Principles

þ Keep disturbed areas small. As you increase the amount of disturbed earth, you increase the likelihood of soil erosion.

þ Stabilize disturbed areas ASAP. Bare, disturbed soil is likely to erode, especially during a rainstorm. Use grass seed, hay mulch, erosion control matting, silt fence, etc. to minimize the loss of soil from the site.

þ Keep water velocities low by retaining vegetation on site. Water that moves slowly is less likely to cause erosion. Removing grass, vegetation, and topsoil increases the amount and speed of runoff.

þ Protect disturbed areas from stormwater runoff. Use the BMPs outlined in this manual (e.g. diversion ditches) to prevent water from entering and running over disturbed areas.

þ Keep sediment within work boundaries. Retain sediment at the work site by filtering water as it flows and detaining “dirty” water for a period so that soil particles and nutrients settle out.

þ Follow up and inspect recent work. At the end of the workday, check to make sure all erosion controls are in place and working properly. Make repairs if necessary.

þ Visit recently completed jobs as often as possible, but especially after a rainstorm, to check on stabilization efforts and potential problems.

erosion from roadways and road related projects can be controlled.

There are four principal factors that influence the potential for erosion: soils, surface cover, topography, and climate. These factors are interrelated in their effect on erosion potential.

Soils

Soils vary in their erosion potential. Soils that are least subject to erosion from rainfall and runoff are those with high permeability rates, such as gravel and gravel-sand mixtures. Generally, though, all soils should be treated as if their erosion potential is high.

Vegetative Cover

Vegetation is a principal component of effective erosion control that performs functions such as shielding soil surface from falling rain, holding soil particles in place, and slowing the velocity of runoff. Soil erosion and sedimentation can be significantly reduced by scheduling road maintenance or other construction activities to minimize the area of exposed soil and the length of exposure time. Special consideration should be given to the maintenance of existing vegetative cover, especially on steep slopes, drainageways, and streambanks. Other cover such as mulch, erosion control blankets, and stone riprap also protect soil from erosion.

As a Rule of Thumb….

1. *The more fine-grained material there is in soil, the greater the amount of material that will be picked up by water flowing across its surface.*
2. *The steeper the slope, the faster the water will move, thus enabling it to carry more soil.*
3. *The larger the unprotected surface, the larger the potential for problems.*

Topography

Topographic features influence erosion potential. Drainage area (watershed) size and shape affect runoff rates and volumes, which are directly related to slope length and steepness. As slope length and steepness increase, the potential for erosion is magnified. The proper use of BMP's and other drainage and erosion controls must consider the effects of the existing topography.

Climate

The frequency, intensity, timing, and duration of rainfall are fundamental in determining the amount of erosive runoff produced. In Massachusetts, soil erosion is caused primarily by runoff water from rainfall or snowmelt. Erosion hazard is high in spring when most plants are dormant and when the ground is still partially frozen. Areas where soil is exposed should be well stabilized in the fall, before the period of high erosion risk in spring. October is too late to seed and establish a good vegetative cover for the winter. Where cover has not been established, structural stabilization methods, such as hay bales, silt fence or anchored mulch must be used.

Sediment Controls & Traps

The following tools are useful for temporary erosion control and for the removal of sediments. Types of sediment controls and traps include:

Straw or Hay Bale Barriers

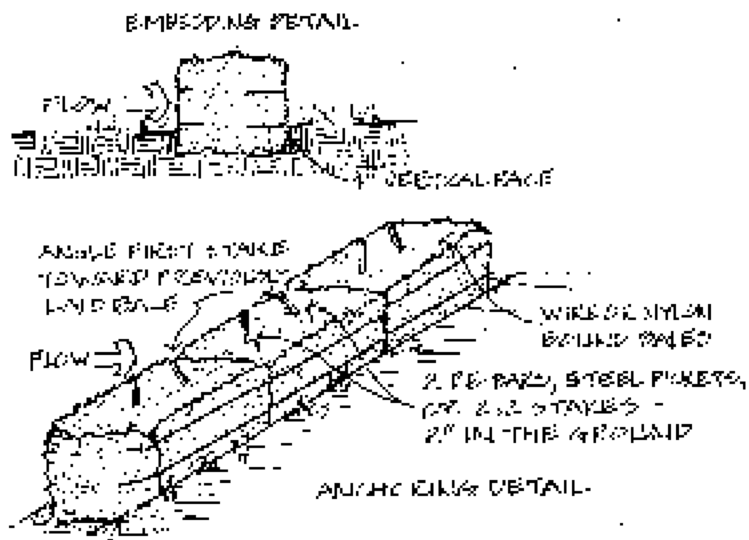
Haybales are used to intercept and detain small amounts of sediment downslope from disturbed areas to prevent sediment from leaving the site. Haybales are an inexpensive method of sediment control where effectiveness is required for less than three months. Proper installation and maintenance is critical to performance.

Installation Tips:

- þ Excavate a trench the width of a bale to a minimum depth of four inches.
- þ Place bales in a single row, lengthwise along the contour, with ends of adjacent bales tightly abutting each other.
- þ Bales should be resting on a cut-stem side of the bale, not the string.
- þ Securely anchor each bale with at least two stakes or re-bars driven through the bale, with the first stake driven toward the previously laid bale.
- þ Fill gaps between bales with straw to prevent water from escaping through the barrier.

Maintenance Tips:

- þ Inspect immediately after each rainfall for accumulated sediments, and repair or replace damaged bales promptly.
- þ Remove sediments when the level of deposition reaches one-half the height of the barrier.
- þ Incorporate any remaining sediment deposits after the barrier is no longer needed with the existing grade and seed immediately.
- þ Remove once the temporary sediment control is no longer necessary.

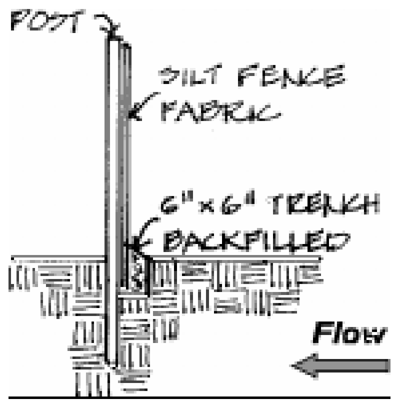


Hay bale installation

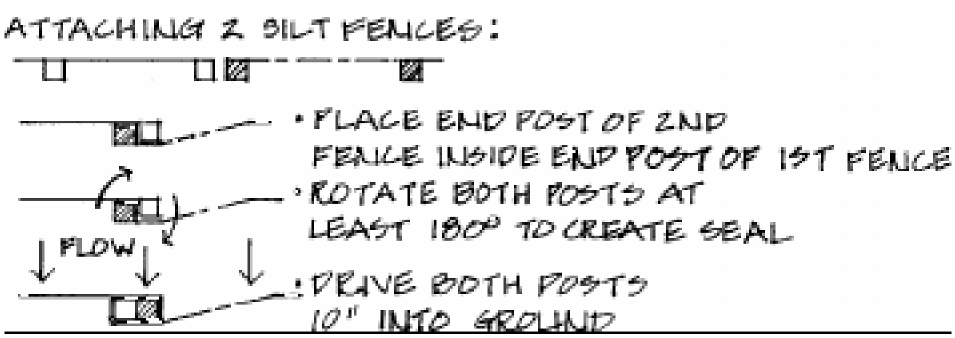
Sediment Fence

Sediment fencing (or silt fencing) is a temporary barrier consisting of filter fabric stretched across and attached to supporting posts and entrenched. A sediment fence intercepts and detains small amounts of sediment from disturbed areas during construction operations and reduces runoff velocity down a slope. See *silt fence dikes* in *Ditches* section for additional information on the use of silt fencing.

Installation Tips:



- þ Dig a trench approximately 6 inches deep and 6 inches wide, or a V-trench, along the line of the fence.
- þ Attach continuous length of fabric to upslope side of posts, avoiding joints particularly at low points in the fence line. Where two sections need to be joined, follow the detail below.
- þ Place the bottom one foot of fabric in the trench and backfill with earth or gravel.



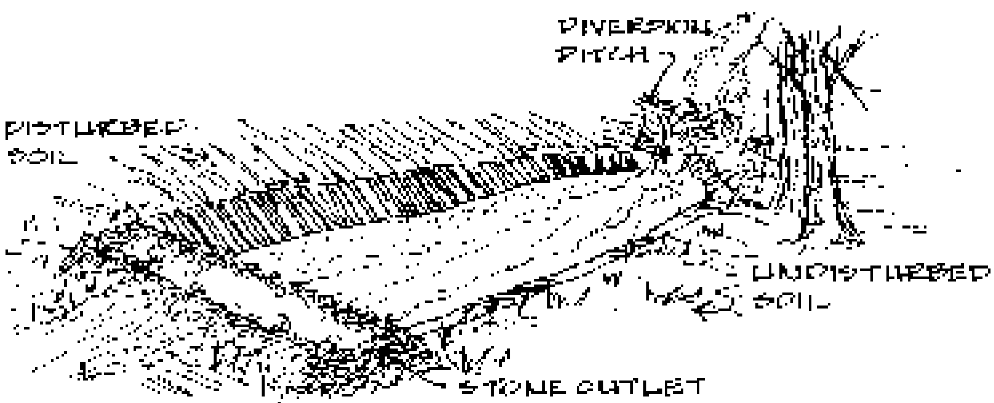
Maintenance Tips:

- þ Inspect immediately after each rainfall for accumulated sediments, and repair as necessary.
- þ Remove sediment deposits promptly to reduce pressure on the fence.
- þ If fabric tears, decomposes, or in any way becomes ineffective, replace it immediately.
- þ Incorporate any remaining sediment deposits after the barrier is no longer needed with the existing grade and seed immediately.
- þ Remove when no longer necessary.

Sediment Trap

A sediment trap intercepts sediment-laden runoff from small, disturbed areas and detains it long enough for the majority of sediment to settle out. A sediment trap is formed by excavating a depression or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway constructed of large stones allows a slow release of runoff. Usually installed in drainage ways with small watersheds, they may also be used at a storm drain inlet or outlet.

NOTE: *Although inexpensive and relatively simple to install, sediment traps of any significant size should be referred to an engineer for detailed design.*



Sediment trap

Geotexti les

A geotextile is a synthetic permeable material that can be used for a variety of road related projects. There are many types and uses of geotextiles, and a geotextile manufacturer can provide help in selecting the correct material for your specific need. Not all functions are provided by each type of geotextile, so check before you buy.

This manual covers four uses that are closely associated with unpaved roads and the use of previously outlined BMP's: separation, reinforcement, filtration/drainage, and erosion control.

Separation or Stabilization

- Geotextiles can be used to permanently separate two distinct layers of soil in a roadway, such as new gravel from the underlying roadbed.

Drainage/Filtration

- Geotextile acts as a filter through which water passes while restricting "fines."

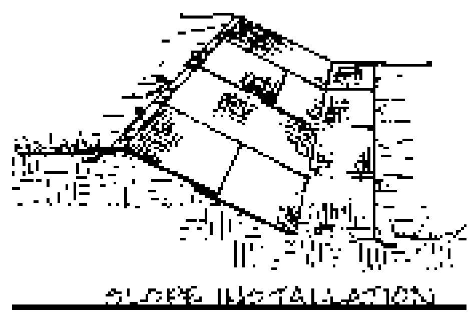
- Typically, non-woven geotextiles are used because of small pore size and high flow capacity. “Slit-tape” woven fabric should not be used for drainage applications because of its poor capacity to pass water.

Reinforcement

- Use geotextile when construction is proposed in “soft” areas where the foundation soils are too weak to support a road or structure.

Erosion control

- Geotextile is used in “silt fencing,“ see installation detail under *Silt Fence Dikes.*
- Use where a layer of heavy stone or riprap is placed to provide erosion protection in ditches, culverts, and streambanks. Place geotextile between rock layer and underlying soil surface.



Proper installation of geotextiles is very important; follow the manufacturer’s advice for handling and installation. The effectiveness of the material could be severely reduced if it is torn or punctured during placement. The geotextile should be placed with the machine (long) direction in the direction of water flow in the drainage system, loosely but with no wrinkles, and in intimate contact with the soil so that no void spaces occur behind it. Overlap the ends 1 to 2 feet. Place aggregates immediately following placement of fabric.

Geotextiles in Roadways – Three Practical Uses

Problem 1: Culverts

Every few years, some of your culverts seem to erode or washout during spring runoff, flash floods, or days of heavy rains. You’d like to “floodproof” these pipes so that you can avoid these frequent headaches.

Solution: A geotextile could be used to protect both ends of the culvert from the scouring effects of flowing water. At each end, a piece of geotextile (woven or non-woven) could be placed against the surrounding gravel and then covered with 12” to 18” large stones (riprap.) The fabric should also be placed over the top of the culvert end and tucked in or anchored into a six-inch deep trench and backfilled. The fabric will then prevent water from washing away the gravel which is around or above the pipe ends. As long as the water cannot get behind or under the fabric, the gravel will be protected from the eroding effects of flowing water.

Problem 2: Underdrains

Several of your roads always seem to hold water under the surface. In gravel roads, this creates an unstable and muddy mess. On paved roads, the surface develops cracks and ruts and eventually gets potholed.

Solution: Assuming there is an adequate depth of roadway base gravel and/or the pavement is thick enough to carry the traffic loads, an “underdrain” could be built with geotextile to drain this subsurface water. Typically, an underdrain is a 3’ to 5’ deep vertical-sided trench under the shoulder which provides “underground” drainage for the road base. This trench is filled with a slotted or perforated drainpipe and backfilled with free-draining gravel. A typical problem is that water carries “fines” into the gravel and pipe and clogs it. Using a thin non-woven or a woven monofilament can eliminate this problem. First, line the pipe with the fabric, install the bedding gravel and pipe, backfill with gravel, and close the fabric flaps on the top to prevent contamination with fines. Then add the surface gravel to cover it over.

Problem 3: Unstable Roads

Every spring, some of your roads become impassable because of mud conditions. The typical cure is to 1) close the road, or 2) add more gravel to get up out of the mud. The only problem, though, is it happens again the next year, and the next year, and…

Solution: Eliminate this annual headache with a geotextile. After the road has dried out, re-establish the proper crown of the road and do any necessary ditch or shoulder work to get the water off the road. Unroll a layer of geotextile (any woven product or a heavier non-woven) lengthwise down the road. Subsequent lengths should be properly overlapped at the sides and ends by 2 to 3 feet. Backfill the fabric with a minimum of 8” (compacted) surface gravel, shape to the proper crown and compact. On local roads, which carry a significant percentage of trucks, it is probably wise to consider 12” or more of gravel.

OTHER CONSIDERATIONS

Additional Steps to Protect Water Quality

Planning for erosion control and integrating it into the each project is an essential component to good road maintenance. Some helpful pointers on project management are included below:

- **Do not wait until the last minute.** Work all of the erosion control decisions and designs into initial project planning and think of all the necessary details. Estimate labor and materials, locate your material sources, and prepare your crew for the task at hand.
- **If permits or land easements are needed, build this into the project timeline.** Although most necessary permits are simple and relatively quick to obtain, the process still takes time. An understanding of the regulations and permitting process is essential. Consult your conservation commission to learn what permits you'll need and secure them early. Obtaining easements from landowners is often necessary for a project; do not rely on a verbal agreement when it comes to obtaining easements! Get something in writing.
- **Do the job right!** Use the appropriate BMPs, follow maintenance and inspection schedules associated with structural BMP's, obtain the necessary permits, and know when to ask for help. Skipping corners often leads to additional expenses and headaches down the road.
- **Know what materials are needed.** Knowing where and when to get the best materials, and how much the materials cost, can save time down the road. Planning out a whole season's worth of projects may reveal that materials can be purchased in bulk to save money. Keep a log of products and materials used in projects, and evaluate their success to determine what works best. Consider sharing resources with neighboring towns.
- **Consider the time of year.** Activities that take place near water should be performed during periods of low flow, such as mid to late summer. Grass planting is most effective in spring and summer. When ditching and road grading, keep an eye on the weather to avoid heavy rains. Minimize late fall work as it is expensive to put extra controls down to last over the winter.
- **Know your crew.** Understanding the strengths and limitations of your crew can save time and money. It doesn't make sense to put them to a task they may not be able to complete.

Operation and Maintenance Plans

> *Crisis work is nearly always more expensive in terms of labor and equipment, and often more expensive in material costs. Add that to the public's perception that the highway crew is not in control and the potential for disaster is evident!*

BMP's have specific maintenance requirements to ensure long-term effectiveness. Operation and maintenance (O&M) plans should be developed for all structural BMP's, and not only because many conservation commissions are requiring them. O&M plans outline the regular inspection and cleaning schedule necessary to keep a structural BMP in good repair and operating as designed. O&M plans should include information such as:

® BMP system owner and party responsible for maintenance

® schedule for inspection and maintenance

® routine and infrequent maintenance tasks

The basic maintenance requirements for each BMP have been included in their description throughout this manual. Unless maintenance requirements are specified, it is recommended that the plan provide for routine inspections conducted on a monthly basis during the first six months of operation and thorough investigations conducted twice a year.

For most BMP's, the maintenance requirements include visual tasks (e.g., inspection of sediment build up) and physical upkeep tasks (e.g., sediment removal and disposal, and mowing of grassed swales.) To promote proper O&M, BMP's for unpaved roads should be relatively easy to inspect and offer low frequency maintenance.

Too often, BMP's are constructed without plans or obligations for long-term maintenance. The maintenance requirements for unpaved roadway BMP structures must be considered during the selection process. For this reason, BMP's should be designed to minimize maintenance needs, wherever possible. Future maintenance problems should be anticipated and O&M plans should be developed to alleviate them as much as possible.

The point to remember regarding O&M plans is that with one in place crisis work may be avoided altogether. For most types of problems, there are solutions that might be scheduled with a systematic plan in place that gave maintenance work its rightful priority.

Aesthetics/Vegetative Management

The vaulting tree canopies over Massachusetts' back roads are one the state's important scenic resources for residents and visitors alike; but there are times when aesthetics and good road maintenance and sound erosion control practices may seem to conflict. Good maintenance and erosion control practices make backroads 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. Tips on aesthetic and vegetation management are included below.

> *The road crew has the important job of balancing the need for proper road maintenance and erosion control that will keep sediment from reaching surface waters with the need to maintain the wonderful aesthetic qualities of Massachusetts' backroads.*

- MGL Chapter 41§1 places all shade and ornamental trees within the limits of public roads under the control of the tree warden – consult your town's tree warden regarding issues and problems with roadside trees.

- Removal of large, healthy trees along the road should only be done when absolutely necessary and only with the tree warden and/or landowner's permission.
- Grading too close to trees, closer to the trunk than the drip line of the leaf canopy, will harm the tree and may eventually kill the tree.
- Any damaged tree roots should be cut clean.
- Grading that exposes roots, especially on slopes or along deep ditches, may cause a hazard by making trees more easily uprooted, as well as look unsightly.
- Cover exposed tree roots as quickly as possible to avoid damaging the tree.
- Any tree limbs broken during maintenance should be pruned back close to the main trunk or branch.
- Replant areas where trees are removed with native trees to provide for new canopy and revegetation.
- Rebuild any stonewalls that must be removed for road construction or ditching.
- Cleaning ditches does not mean clearing all of the vegetation around them, only enough to ensure adequate flow.

Aesthetics are important in gaining acceptance of BMP's. BMP's can either enhance or degrade the amenities of the natural environment and the adjacent community. Careful planning, landscaping and maintenance can make a structural BMP an asset to a site.

Beavers

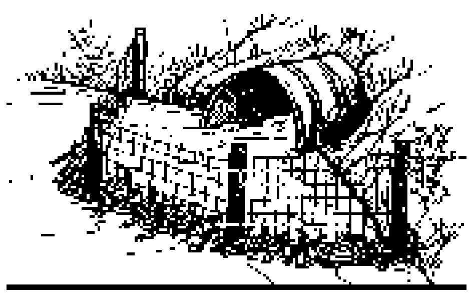
Beavers can create problems for road crews by building dams that block culverts and impounding water that can be released during a flood, washing out roads and bridges. Beavers like to build dams at culverts because the stream flow is narrowed and the road makes up the rest of the dam. This creates a recurring problem for road crews since beavers have a tendency to keep rebuilding dam after dam in the same spot. However, beavers also create significant wildlife habitats and scenic areas.

In Massachusetts, beaver management is the jurisdiction of local boards of health and local conservation commissions. Depending upon the type of damage one is incurring and/or the techniques employed to mitigate the damage, permits may be required from one or both local agencies before any action may be taken.

Avoiding and Resolving Conflicts

An assortment of techniques are used to mitigate the flooding damage caused by beavers including breaching of beaver dams, protecting road culverts with fences or guards, and controlling water levels with water flow devices. All of these techniques require a certain degree of effort and regular maintenance to insure water levels that can be tolerated. The initial costs to install and maintain culvert guards/meshes or water flow devices are usually less than the costs to repair roads, property or buildings damaged by flooding. Recognizing chronic or potential problem sites and taking proactive preventative measures may be more cost effective in the long run.

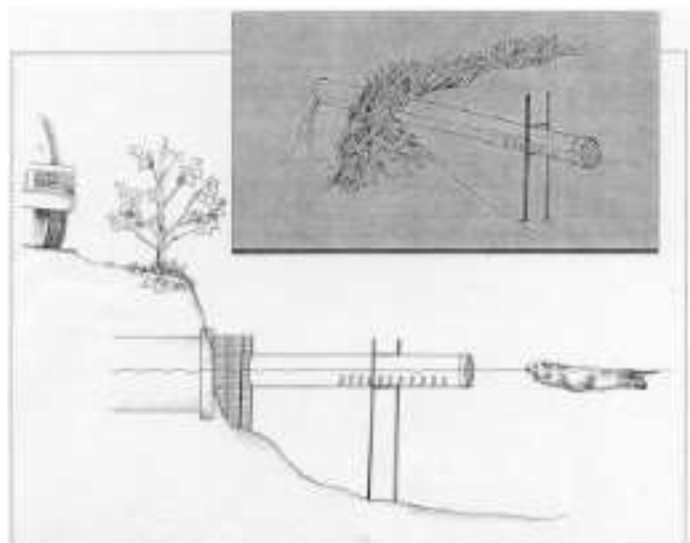
Beaver fencing is used to physically exclude beavers from plugging the intakes of road culverts and prevent them from detecting the flow of water into the culvert. The beavers will build up debris along the fence but not inside the culvert. Maintenance will still be necessary, but will not be as difficult. If beavers do begin to construct a dam against a fence installed to protect a culvert, it may be necessary to install a water level control device to regulate the water level.



Source: “Beaver Damage Control”, Wisconsin Dept. of Nat. Res., Bureau of Wildlife Management

Water level control device (WLCD) installation is worth considering if some degree of elevated water is tolerable. The best devices keep beavers away from the intakes and regulate the water level in the pond by muffling the sound of escaping water, making the sensation of flow undetectable. Some devices only delay the beavers from getting to the intake of the device and merely slow them from plugging it. All of the techniques have advantages and disadvantages associated with their use, and they vary in terms of expense, maintenance requirements and performance. None are 100% effective. The use of WLCDs does not eliminate the need to control beaver populations, but may increase tolerance for beaver activity in a specific area. It is usually the application and modification of a few techniques, used in combination, which is most beneficial at a specific site.

An example of a Water Level Control Device



Source: *Beavers in Massachusetts,* a publication of U MASS Cooperative Extension

Water leveling control devices can be used to maintain flows in road culverts that are repeatedly blocked by beavers. They should only be used where appropriate conditions exist. Depth of water behind the dam, stream flow, and size of the wetland upstream are among the considerations. Proper installation of the pipe is also important if flooding is to be controlled.

Building roads and structures to accommodate beaver activity is the wisest investment. Also, it is much easier to identify and rectify potential problems before they become costly and difficult to correct. **Remember: alteration of beaver dams and draining wetlands is regulated by the Massachusetts Wetlands Protection Act.** You will need to obtain a permit before any maintenance of beaver dams is performed. For more information contact the Massachusetts Division of Fisheries and Wildlife, the Massachusetts Department of Environmental Protection, or your local conservation commission or board of health.

Disposal of Excess Materials

Often, highway departments find it necessary to dispose of excess materials from work sites or ditch cleaning. The improper disposal of excess material may increase the amount of sediment that enters surface waters and could damage sensitive areas, particularly wetlands and floodplains.

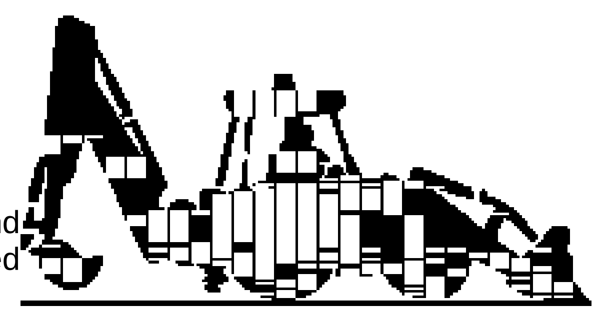
- Never dispose of excess materials in wetlands, drainage ditches and swales, areas within 200 feet of (and drain into) a perennial waterway, or on slopes that are more than 2H:1V.
- Ensure the area down slope of the disposal area has an adequate undisturbed vegetated filter strip to trap sediments.
- Seed or vegetate any fill areas as soon as possible to stabilize soil.
- Plan possible disposal areas ahead of time, giving the opportunity to utilize excess materials if possible.

Catchbasin cleanings cannot be used for daily cover or grading material. Massachusetts regulations mandate that they be landfilled. See *Permits/Regulations* section for more information on this topic.

Storage and Borrow Areas

Storage and borrow areas are areas where soil used in road construction or maintenance is either taken from or stored for future use. These areas usually contain stockpiles of exposed dirt, sand, or other road materials. Follow the simple steps below to ensure that your storage/borrow area is not contributing to erosion and sedimentation problems.

- Develop an erosion and sediment control plan for the specific site.
- Divert runoff from the face of exposed slopes.
- Leave unvegetated only those areas in current use.
- Stabilize exposed areas immediately after use.
- Locate storage areas away from surface waters.
- Control any sediment from storage and borrow areas with previously described temporary controls.



PERMITS AND REGULATIONS

There are a variety of local, state, and federal laws and regulations that could affect projects involving the management and/or maintenance of unpaved roads in the Commonwealth of Massachusetts. A working knowledge of the laws that may apply to your road projects is essential. Remember, *local highway departments are not exempt from local, state, or federal laws and regulations.*

Important!!

All road projects that occur within and near areas subject to Massachusetts and Federal environmental regulations cannot be "design-built" in the field; they must be designed and permitted prior to commencement of any work.

Depending on the nature and complexity of the roadwork proposed, various permits or approvals may be required by federal, state, and local agencies, boards, and commissions prior to beginning construction. They need to be applied for early in the planning process.

Start by establishing a relationship with your local conservation commission. Often, the commission will be happy to help you review problems, evaluate planning alternatives and obtain the necessary permits. This should always be your first contact when undertaking a corrective problem for any natural resource issue.

It is important to emphasize that all projects, whether new or maintenance, should be designed so that they avoid, minimize, and mitigate impacts to wetlands and waterbodies. What follows are some "Frequently Asked Questions" to help you determine if your road project might require permitting.

State and Local Permit Requirements

Massachusetts Wetlands Protection Act and Stormwater Policy

What is the scope of the Conservation Commission's and the DEP's authority?

Local conservation commissions and DEP (Department of Environmental Protection) are charged with the administration of the Wetlands Protection Act (MGL Chapter 131, §40), hereafter called the Act. Under the Act and its associated regulations (310 CMR 10.00), the scope or "reach" of their authority extends to wetlands, brooks, streams, creeks, rivers and other "wetland resource areas". In some cases their "reach" also extends to the 100-foot buffer zones around the resource areas. These areas subject to protection are explicitly defined and characterized within the regulations. Work proposed within or near these wetland resource areas is likely to be subject to the local conservation commission's formal review. During the review, DEP may provide written comment or other guidance to the commission or the applicant.

The regulations do not extend the conservation commission's or DEP's jurisdiction to work done outside of these areas, unless and until an activity actually results in an alteration of wetland resource areas. *In short, how and where public works officials propose work strongly affects the degree to which the conservation commission or DEP could be involved in permitting.*

What kinds of questions should you ask the Conservation Commission?

Many conservation commissions are willing to provide time for informal discussions with potential applicants; these discussions are usually held during regularly scheduled conservation commission meetings, and any type of question is usually met with interest. Commissions can answer general questions about how the permit process works, where permit applications can be obtained and what is required to file a complete permit application. Commissions may also be willing to look at an individual site, listen to specific ideas and provide basic guidance to help avoid the designing of a project that cannot be permitted under the regulations. Early discussions with the commission are extremely important and can help a project proceed in a time and cost-efficient manner.

What kinds of permits must be applied for, and when?

If a permit is required, the type of review the conservation commission will undertake will depend on three things: the type of work being proposed, whether or not the work will affect areas subject to protection, and how much alteration is proposed in these areas. If it is unclear if a project will actually affect areas subject to the commission's jurisdiction, the commission may be requested to determine if proposed work will or will not be subject to their formal permit review; this can be done through a *Request for Determination of Applicability,* which is the simplest type of review.

Projects that will actually take place within areas subject to commission jurisdiction usually require the filing of a *Notice of Intent,* and a formal public hearing of the case is required. Planning a project to avoid and minimize impacts to wetland resource areas, and submitting a complete application in advance of work scheduling, will positively affect the type and length of review required by the commission.

Request for Determination of Applicability

A written request filed to the conservation commission or DEP by any person as to whether a site or work therein is subject to the Wetlands Protection Act.

Notice of Intent

The written notice filed to the conservation commission or DEP by any person intending to remove, fill, dredge, or alter an "area subject to protection" under the Wetlands Protection Act.

The required forms for submitting a *Request* or *Notice* are available through your local conservation commission or online at:

www.magnet.state.ma.us/dep/appkits/forms.htm

Who can provide assistance to a DPW that is seeking a permit?

Some cities and towns maintain professional full- or part-time staff that can provide assistance to individuals seeking to do work within the conservation commission's jurisdiction. Environmental professionals and many professional engineers can provide permit assistance at an hourly rate. DEP Wetlands Program staff can provide assistance before and during the processing of a permit; DEP may, in some cases, provide pre-permitting guidance.

What is the difference between maintenance work and projects that expand or enlarge the road?

Both dirt road maintenance and expansion projects are subject to the same scrutiny…will they and how much will they alter wetland resource areas? Local public works departments that wish to follow a comprehensive road maintenance plan can work with their conservation commission to permit their routine road maintenance activities in a comprehensive or "generic" permit; this requires the filing of a Notice of Intent. The types of individual projects that can be considered maintenance are quite limited: no expansion of road structures can be undertaken and work within certain wetland resource areas is not allowed. The types of projects that are permitted as maintenance will depend on the quality of the proposal. This comprehensive approach to permitting maintenance projects allows public works departments to spend less time on the paper work associated with wetlands permitting, but requires a commitment to following standard road design and engineering practices when conducting activities in or near wetland resource areas. Alternatively, when dirt road maintenance is proposed within <u>some</u> areas subject to protection under the Act, a review under a *Request for Determination of Applicability* may be adequate.

Most road projects that occur within or near wetland resource areas will require the filing of a *Notice of Intent* for that specific project. Special provisions for the permitting of a limited group of roadway-related projects are contained in the regulations (see 310 CMR 10.53(3)(d), (f) and (k)). These projects include the construction, reconstruction, operation and maintenance of public utilities; maintenance and improvement of existing public roads, and road drainage structures. These provisions allow the conservation commission to use their discretion in allowing alterations to wetland resource areas that exceed standard regulatory thresholds.

MA Stormwater Policy

A state policy implemented to improve water quality and address water quantity problems through the implementation of performance standards for storm water management. It is intended to be applied during routine project review by local Conservation Commissions or DEP.

How does the MA Storm water Policy affect what and where you plan to do roadwork?

The MA Stormwater Policy applies to both dirt road maintenance and expansion projects when these projects must also be reviewed under the Wetlands Protection Act. Under the Policy, maintenance and improvement of existing roadways (including widening less than a single lane), adding shoulders, correcting substandard intersections, and drainage and re-paving of roads are considered “redevelopment projects”. When redevelopment projects are conducted within areas subject to the Commission’s jurisdiction, a *Notice of Intent* will likely be required.

For these redevelopment projects, applicants must meet the Policy’s standards to the “extent practicable”, rather than to the full extent required for new development. Road projects that are truly maintenance in their character (e.g. are not interpreted by the conservation commission to be expansions of existing structures) will likely be able to meet each of the nine standards to the extent practicable. If the project can’t meet the Standards to the extent practicable, retrofitted or expanded stormwater management systems must be designed to <u>improve existing conditions.</u>

Do I need a permit every time I grade a dirt road?

You may not need an *Order of Conditions,* or permit, every time a road is graded. However, the conservation commission should decide if the proposed work requires some kind of formal review that may include the filing of a *Notice of Intent.* For example, annual road grading on a level, stable dirt road that is located within the buffer zone might be allowed under a negative *Determination of Applicability,* and no *Notice of Intent* would be required. However, grading of a steep dirt road that chronically erodes into a brook will likely require the filing of a *Notice of Intent.* The conservation commission will use their interpretation of the regulations, the site-specific conditions and the scope of work proposed to determine what kind of review, if any, is required.

What about emergency work?

Sometimes situations arise where it is necessary to perform emergency roadwork. Such emergency projects, generally required to repair damages caused by a major storm, are rare and of short-term duration. The Wetlands Protection Act has emergency provisions that allow for a quick response to emergency conditions. Emergency projects may include repairing a collapsed culvert or repair or a washed out section of roadway—projects necessary for the protection of public health and safety. In these emergency situations, it is not feasible to wait for the permit process—but this does not mean you can proceed without authorization! Such projects must still be brought before the conservation commission (or DEP on appeal of the commission’s action or inaction) who will certify if the project qualifies as an emergency. Once an emergency certification has been issued to remove or remedy the immediate hazard, emergency permits are obtained and short-term measures installed to immediately correct the problem. A site inspection must be done prior to the issuance of an emergency certificate. Emergency certification is good for 30 days unless the time is extended by the Commissioner of DEP.

Emergency work must consist of only the work required to lessen the threat and not effect a more permanent solution. Implementation of any long-term measures to completely solve or improve the problem, however, will require that all appropriate permits be obtained and needed measures installed at a later time.

Solid Waste Disposal

Solid waste can be in the form of catch basin cleanings, road sweepings, or other construction debris. The Massachusetts solid waste disposal regulations (310 CMR 19.0), as they apply to road maintenance and management, govern the handling and disposal of catch basin cleanings and street sweepings. Street sweepings will not be discussed here. More information can be found in the DEP's *Final Policy on Reuse and Disposal of Street Sweepings: BWP-94-092.*

Catch basin cleanings are classified as a solid waste and must be handled and disposed of in accordance with all DEP regulations, policies, and guidance at a landfill that is permitted by the State of Massachusetts to accept solid waste. Catch basin cleanings cannot be used for any purpose, such as road grading material or as fill for any project without a special "beneficial use determination" from DEP. If it is suspected that the catch basin cleanings are contaminated from a spill, or if the catch basins are connected to a sanitary sewer system, the cleanings should be treated as hazardous waste. In these situations, DEP may require testing prior to disposal.

If you have further questions regarding handling and disposal of solid waste, call the regional office of the Massachusetts DEP and ask for the Bureau of Waste Management.

Public Shade Trees

Any tree within or touching a city or town way is public property, according to MGL Chapter 87. No public shade tree may be cut, trimmed, or removed without the permission of the city or town tree warden, by any person, "even if he be the owner of fee in the land in which the tree is situated". The tree warden must hold a public hearing, notice of which is to be posted on the affected tree(s), and if there is written objection, the selectboard or mayor must approve the work. This law does not apply to dangerous or diseased trees or to tree cutting for widening of the paved way. If you have questions regarding public shade trees that may be impacted because of proposed roadwork, contact your local tree warden

Scenic Roads

Another law that limits the cutting of trees along roadsides is the MGL Chapter 40, §1 5C. If a town meeting or city council has voted to designate any road, other than a state or numbered road, as a "scenic" road, then any repair, maintenance, construction or paving work "shall not involve or include the cutting or removal of trees, or the tearing down or destruction of stone walls or portions thereof, except with the prior written consent of the planning board". A public hearing must be held, but no hearing is required if the proposed work does not involve trees or stonewalls. Check with your local planning board or community development office to determine if any roads in your community have been designated scenic.

Federal Permit Requirements

Under Section 404 of the federal Clean Water Act, the US Army Corps of Engineers is authorized to regulate projects that may have an impact on waters of the US (including land under water and wetland areas.) Examples of such projects include filling wetlands, rivers and streams, and the discharge of dredged or fill material in these areas. In Massachusetts, the Corps has issued a "Programmatic General Permit" that expedites review of minimal impact work in coastal and inland waters and wetlands within the Commonwealth of Massachusetts. These minor projects usually will not need an individual review and permit from the Corps, as local review is presumed to be sufficient. Typically, road projects will not need an individual permit from the Corps unless there is filling of greater than 5000 square feet of wetlands. However, all projects involving placement of fill or excavation of wetland areas must contain provisions for mitigation of impacts, including wetland replacement.

The Army Corps of Engineers defines three levels of Section 404 projects: Category I, II, and III. In an effort to efficiently administer federal permit procedures, local Conservation Commission review and approval covers "non-reporting" Category I projects such as minor fill in wetlands (up to 5000 square feet with mitigation), streambank stabilization projects filling less than 500 linear feet of bank (with no other provisions), and dredging less than 100 cubic yards of material. There is no need to file with the Corps for Category I projects.

Category II projects must be filed with the Corps for review. Road projects that may fall into Category II include coastal and inland wetland fill greater than 5000 square feet, and activities within one-quarter mile upstream or downstream of National Wild and Scenic Rivers. The Corps will review such projects and determine if they require an individual permit. The filing of Category II projects can be achieved with submittal of the Notice of Intent upon completion of its review at the local level.

Category III projects require individual permit review, which often takes considerable time and effort. Typically, road projects won't require individual permits unless there is significant wetland filling (greater than one acre or fill in a salt marsh.)

In addition to 404 permits, 401 Water Quality Certification is required for work in Corps jurisdiction if the project involves a discharge to waters of the US. The 401 State Water Quality Certificate is required under s. 401 of the Federal Clean Water Act, which basically requires that the state certify that state water quality standards will be met by the proposed work. If a project does require a 401 Water Quality Certificate, it must be issued by the Massachusetts DEP on behalf of the Army Corps of Engineers before work can proceed. The 401 review process is conducted by the DEP simultaneously with their review of local permits.

If you have questions about 404 permits or 401 Water Quality Certification, call the wetlands program of your regional DEP office. Their contact information is found in the Resource List of this manual.

BMP's IN ACTION: Selected Case Studies

The following examples of actual projects from Vermont and Massachusetts prove that common sense techniques can be applied to save roads and protect the environment at the same time. The road crews that implemented these BMP's used available technology and local ingenuity to protect their roads, while protecting water quality and saving money on future maintenance.

***Remember…** careful site analysis, planning, and scheduling can reduce the need to utilize stabilization and control practices, and, thereby, reduce the cost of implementing structural measures.*

<u>Wolcott, Vermont</u>

The road crew in Wolcott, Vermont used to spend a considerable amount of time maintaining the ditches and culverts along a steep, sandy section of road. The steep slopes and ditches continually eroded and, even after minor storms, the crew would need to clean out sand that had accumulated in the culverts and ditches. The solution was found in improving the ditch. The crew reshaped the ditch and laid 6-foot wide geotextile strips along its length. On top of this, they laid 4-inch riprap about 8 to 12 inches thick. The construction resulted in excellent soil stabilization and a ditch that properly conveys water.

<u>Cost Analysis:</u>

Total project cost for materials, labor and equipment:	$4,500
Estimated cost of maintenance (materials, labor, and equipment) before project: $1,200 per year X 10-years	$12,000
Estimated savings over 10 years	$7,500

Source: Vermont Local Roads Program

Tyring ham Road, Becket, MA

Tyringham Road in Becket is a steep, low volume unpaved road that has been experiencing increasing traffic over the years. The road crew used to spend a considerable amount of time in that area even after minor storms, patching washouts and regraveling. The road was often closed in the spring because it was impassable. The town had considered upgrading the road to improve safety for a number of years.

Problem

The lack of adequate ditches and runoff outlet areas along the road led to washouts and road closings. Erosion from heavy rains threatened the road itself. Heavy sediment loads of gravel and sand were reaching the river at the bottom of the hill. Frequent maintenance was required, often taking the road crews away from other important work. It was not unusual for the road crew to reapply gravel every four weeks to this section of road. Something had to be done, not only for environmental reasons but also because the road was becoming very costly to maintain.

Solution

Bill Elovirta, Highway Superintendent, utilized a number of the BMP's outlined in this manual to solve the problems he was experiencing on Tyringham Road. After obtaining the necessary permits, his crew widened the road, graded back the roadside banks, and improved the ditches along both sides of the road using 4 to 6 inch irregularly shaped stone, laid 10 to 12 inches thick. Culverts were laid at appropriate intervals to get the runoff from one side of the road to the other were it could be outleted properly. These outlet areas were designed to slow down the runoff and settle out sediments before the runoff reached the river. The road surface itself was improved using recycled asphalt giving the road a hard surface that sheds water easily.

Now, the road is easy to grade and shape, but still has the look and feel of gravel. The highway department is pleased with the results of the BMP applications, as are the residents who use the road. Bill and his crew are applying the same solutions to other areas in town.

1. Before the project, Tyringham Road was narrow with steep banks and no formal ditches.

2. Erosion from the road surface and roadside bank were accumulating near and washing into the river.

3. To improve the drainage, ditches were constructed on both sides of the road and culverts were used to direct water to stable outlets.

4. Completed road project.

Cost Analysis:

Total project cost for materials, labor and equipment:	$32,000

Estimated cost of maintenance (materials, labor and equipment):

before project:	*$1,000/yr*
after project:	*$400/yr*

Estimated maintenance savings over ten years:	$6,000

Gibbs Road, Otis, MA

Gibbs Road was a narrow unpaved road in Otis that the highway department widened in 1995 to improve safety. Following the widening project, a section of steep roadside bank that was cut back was never adequately stabilized. As a result, the bank began to erode, plugging up ditches and culverts and causing ice dams that would freeze over the road in winter. This stretch of road became a maintenance nightmare in all seasons.

Problem

The lack of adequate stabilization for this 400-foot stretch of roadside bank was an issue for a number of reasons. Not only would water seeping out of the bank freeze over the road causing winter safety concerns, but the lack of vegetation on the bank caused large amounts of silt and sediments to be carried toward the nearby river. The highway department would often spend time cleaning the ditch at the toe of the slope only to find it filled the next day with sediment from the eroding bank. In addition, the culverts would plug up easily and needed continuous maintenance. The highway department decided to use a combination of BMP's to stop the bank from eroding and direct runoff to stable outlets.

Solution

Ray Strickland, Highway Superintendent, was open to exploring a variety of options for stabilizing the eroding bank. Several non-structural options were investigated, including conventional bank stabilization techniques such as brush layering and hydroseeding. It was determined that these techniques would not be practical for several reasons, including the excessive amount of seepage from the bank which created constant wet conditions and the orientation of the bank (entirely north facing, surrounded by tall trees) which severely limited adequate exposure to sunlight necessary for plant growth.

Structural techniques investigated included gabion baskets and hard armoring, or facing the bank with rock. Ultimately, after considering a number of options, it was decided to utilize the hard armoring technique. Of concern to Ray and the town was how the bank would look after it was stabilized and whether the project would be in keeping with the rural character of this backroad. To address these concerns, native stone was used to face the bank and vegetation, where it was adequately stabilizing the bank, was kept and encouraged to grow.

Once the necessary permits were secured, the bank was graded to a uniform slope, and 1-inch irregularly shaped stone was placed on the bank to a depth of 12 inches. Over the top of this, large, flat native stone was placed, beginning at the toe of the bank and working up the slope. The spaces between the large rocks were filled with the smaller rock. A proper ditch was created along the bottom of the bank and new culverts were installed which outlet to rock aprons.

1. Before the project, the roadside bank was severely eroding which led to continual maintenance.

2. Erosion of the soil from the bank plugged up culverts and accumulated very close to the river (in the background).

3. A Work in Progress: To stabilize the bank, the town used a combination of small and large rocks on the face of the bank. A ditch was constructed along the toe of the slope and culverts were used to direct runoff to stable outlets before it reached the river.

Cost Analysis:

Total project cost for materials, labor and equipment: $18,000

Estimated cost of maintenance (materials, labor and equipment):

before project: *$1,000/yr*
after project: *$200/yr*

Estimated maintenance savings over ten years: $8,000

Norfolk Road, Sandisfield, MA

Several years ago, heavy rains in Sandisfield caused a large beaver dam to break, sending a wave of water down the river toward unpaved Norfolk Road. The culvert that carried the river under the road was overtopped and much of the road washed out, leading to a major reconstruction project at the river crossing. At the same time the road was rebuilt, the highway crew widened a several hundred-foot stretch of roadway near the river crossing. Limited funds and manpower prevented the town from properly stabilizing the cleared roadsides and addressing drainage issues associated with the reconstruction and widening project.

Problem

When the road crossing was reconstructed following the break of the beaver dam, the old culvert was replaced with one the same size. Although this seemed like the proper thing to do at the time, Ed Riiska, Highway Superintendent, soon began to question the sizing of the culvert. If the beaver dam were to break again, the road would be lost as it had several years ago. In addition, Ed was concerned about the lack of vegetation in the area of the road widening and the lack of ditches to control runoff. Without ditches and adequate outlets, runoff was moving toward the river uncontrolled and laden with sediment.

Solution

The Sandisfield Highway Department installed two new culverts on each side of the existing arch culvert under Norfolk Road. These new culverts were set higher than the center arch culvert and were designed to begin to accept water at the point where the arch culvert would near the point of being overtopped. New headwalls and endwalls were also constructed using rock from the site. As this project involved work directly associated with a river, permits were necessary. Working closely with the local conservation commission, Ed received the go ahead with the condition that no work could take place from within the river.

To address road runoff in the area of the previous road widening, ditches were constructed on the sides of the road. These rock-lined ditches were designed based on the size of the contributing watershed. Rock lined turnouts were constructed to slow down runoff leaving the ditches and settle out sediments before the water reached the river. As much of the work was taking place within the regulated Riverfront Area, the roadsides were stabilized using native grasses, a condition required by the conservation commission.

1. During the site visit with the conservation commission, members discussed with the highway superintendent ways to reduce potential impacts to the river during installation of the new culverts.

2. Construction began after the permits were obtained. One condition placed on the project was that no work was to take place from inside the river.

3. Headwalls and endwalls were constructed using stone found on site. The new culverts are expected to adequately handle heavy flows, thereby improving the protection of the road.

Cost Analysis:

Estimated cost of reconstructing roadway (materials, labor and equipment) after beaver dam broke in 1995:	$20,000
Total new project cost for materials, labor and equipment (installation of culverts only):	$8,000

Potential cost savings over time are difficult to determine, but could be significant especially if the beaver dam breaks again.

RESOURCE LIST

The following organizations may be able to provide technical assistance with road maintenance, project design, and erosion and sedimentation control problems:

FEDERAL

USDA Natural Resources Conservation Service
MA State Office, Amherst: (413) 256-6290

U.S. Army Corps of Engineers, New England District
696 Virginia Road
Concord, MA 01742
(978) 318-8111

U.S. Army Corps of Engineers, New York District
26 Federal Plaza
New York, NY 10278
(212) 264-0100

STATE

Massachusetts Highway Department
State Office: Boston, MA (617) 973-7800
District 1 (Lenox): (413) 637-1750
District 2 (Northampton): (413) 584-1611
District 3 (Worcester): (508) 754-7204
District 4 (Arlington): (781) 641-8300
District 5 (Taunton): (508) 824-6633

Massachusetts Department of Environmental Protection
State Office: Boston, MA (617) 292-5500
Northeast (Woburn): (617) 932-7677
Southeast (Lakeville): (508) 946-2714
Central (Worcester): (508) 792-7683
Western (Springfield): (413) 784-1100

Massachusetts Department of Fisheries, Wildlife, and Environmental law Enforcement, Division of Fisheries and Wildlife
Western District, Pittsfield: (413) 447-9789
Connecticut Valley District, Belchertown: (413) 323-7632
Central District, West Boylston: (508) 835-3607
Northeast District, Acton: (978) 263-4347
Southeast District, Buzzards Bay: (508) 759-3406

Bay State Roads Program, UMASS, Amherst
Phone: (413) 545-2604

REGIONAL

Regional Planning Agencies
Berkshire Regional Planning Commission (Pittsfield): (413) 442-1521
Cape Cod Commission (Barnstable): (508) 362-3828
Central Massachusetts Regional Planning Commission (Worcester): (508) 756-7717
Franklin Regional Council of Governments (Greenfield): (413) 774-3168 Martha's Vineyard Commission: (508) 693-3453
Merrimack Valley Planning Commission (Haverill): (978) 374-0519
Metropolitan Area Planning Council (Boston): (617) 451-2770
Montachusett Regional Planning Commission (Fitchburg): (978) 345-7376
Nantucket Planning and Economic Development Commission: (508) 228-7233
Northern Middlesex Council of Governments (Lowell): (978) 454-8021
Old Colony Planning Council (Brockton): (508) 583-1833
Pioneer Valley Planning Commission (West Springfield): (413) 781-6045
S.E. Regional Planning & Economic Development District (Taunton): (508) 824-1367

LOCAL

Town or City Conservation Commissions
Contact your city or town hall

GLOSSARY

Aggregate: Any of various loose, particulate materials such as sand, gravel, or pebbles, used in a road sub-base or upper base.

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 operation of filling an excavation after it has once been made.

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.

Berm: A narrow shelf or flat area that breaks the continuity of a slope.

Best Management Practice (BMP): Structural, non-structural, and managerial techniques that are recognized to be the most effective and practical means to prevent and reduce nonpoint sources of pollution. Best management practices should be compatible with the productive use of the resource to which they are applied and should be cost effective.

Binder: A material for holding loose material together, as in a macadamized road.

Bioengineering: See *soil bioengineering.*

Brushlayering: Live branch cuttings laid in a crisscross fashion on benches between successive lifts of soil.

Channel: A natural stream that conveys water; a ditch excavated for the flow of water.

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

Crown: A convex road surface that allows runoff to drain to either side of the road.

Culvert: A metal, plastic, or concrete conduit through which surface water can flow under or across roads.

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 streamflow 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 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 soil and land by water, gravity, wind, or ice.

Filter zone: A vegetative planting area used to retard or collect sediment for the protection of watercourses, diversions, drainage basins, or adjacent properties. Also called a buffer zone, or vegetated filter zone.

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

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

Grade: (1) The inclination or slope of a channel, conduit, etc., or natural ground surface, usually expressed in terms of the percentage of number of units of vertical rise (or fall) per unit of horizontal distance. (2) To finish the soil surface, a roadbed, top of embankment, bottom of excavation, etc.

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

Header/Headwall: A structure built at the inlet of a culvert to protect the inlet from erosion.

Hydroseeding: Sowing of seed by distribution in a stream of water propelled through a hose.

Intermittent stream: A watercourse that flows in a well-defined channel only in direct response to a precipitation event. It is dry for a large part of the year. The opposite of *Perennial Stream,* or *River.*

Joint planting: The insertion of live branch cutting 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 fascine: A 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.

Nonpoint source pollution: Pollution of surface or ground water supplies originating from land-use activities and/or the atmosphere, having no well-defined point of entry.

Outslope: A transverse gradient on a road surface where the road slopes only in one direction. Opposite of a crowned road, where water is allowed to shed in two directions.

Perennial stream: A watercourse that flows throughout a majority of the year in a well-defined channel. Synonymous with *River.*

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

Plunge pool: A device located at the outlet of a culvert designed to dissipate the energy of flowing water.

Pollutant: Any substance of such character and in such quantities that upon reaching the environment (soil, water, or air) is degrading in effect so as to impair the environment's usefulness or render it offensive.

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

Riprap: 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 runoff and wave action.

River: Any naturally flowing body of water that empties to any ocean, lake, pond, or other river and which flows throughout the year. Perennial streams are rivers; intermittent streams are not rivers.

Road crown: The highpoint of the road surface, usually the centerline of the roadway. Road crown helps shed water from the road surface.

Rock apron: Erosion protection placed below streambed in an area of high velocity flow such as a culvert inlet.

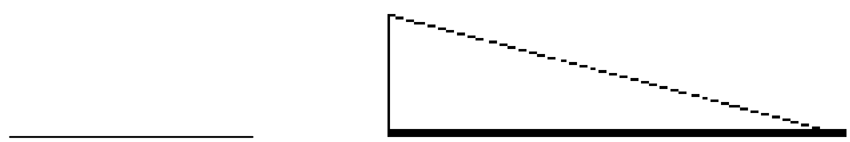
Runoff: The portion of the precipitation or snowmelt that flows over and through the soil, eventually making its way to surface water supplies (such as streams, rivers, and ponds); runoff includes surface runoff, interflow and groundwater flow.

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

Sediment: The deposition of transported soil particles due to a reduction in the rate of flow of water carrying these particles.

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 2H:1V, 50 percent, or 30 degrees. *In formation on how to calculate a slope can be found in the section on Ditches.*



1H:1V, or 100% **2H:1V, or 50%** **4H:1V, or 25%**

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.

Swale: An elongated depression in the land that is at least seasonally wet, is usually vegetated, and is normally without flowing water. Swales are used to temporarily store, route, or filter runoff. Also called a ditch.

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 road.

Vegetated filter: See filter zone.

Vegetated structure: 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 of land that contributes runoff to the supply of a stream or lake. Often times called drainage area, drainage basin or a catchment area.

Wetland: Any of a number of tidal and non-tidal areas characterized by saturated or nearly saturated soils most of the year. Wetlands form an interface between terrestrial and aquatic environments. Wetlands include freshwater marshes around ponds and channels (rivers and streams); other common wetlands include swamps and bogs. Refer to *Permits and Regulations* section for state specific definitions of wetland.

REFERENCES

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Massachusetts Department of Environmental Protection, *Massachusetts Nonpoint Source Management Manual "The MegaManual": A Guidance Document for Municipal Officials,* June 1993. **Contact the Massachusetts Statehouse Bookstore at (617) 727-2834 for information on how to receive this guidebook.**

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Metropolitan District Commission, *Erosion and Sediment Control Manual,* December 1994. Contact the Environmental Quality Section of the MDC at (617) 727-1300 for information on how to receive this manual.

United States Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, *Unsurfaced Road Maintenance Manual,* December 1992. **Contact the Army Corps of Engineers, New England Division at (978) 318-8111 for information on how to receive this manual.**

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Vermont Local Roads Program, *Developing a Highway Access Policy,* May 1997. **Contact the Vermont Local Roads Program at (800) 462-6555 for information on how to receive this policy.**

Windham Regional Commission, *Vermont Better Backroads Manual: Clean Water You Can Afford,* a publication of the George D. Aiken Northern Vermont Resource Conservation and Development Councils, November 1995. **Contact the Vermont Local Roads Program at (800) 462-6555 for information on how to receive this manual.**

Further Reading

Connecticut Department of Transportation/Office of Environmental Planning in Cooperation with the United States Department of Transportation/Federal Highway Administration, *On-site Erosion and Sedimentation Control for Construction Activities,* January 1985.

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