SHORELINE STABILIZATION TECHNIQUES

The shoreline is a valuable and important area. It provides a rich, active habitat for fish and wildlife, and cleans stormwater runoff before it enters the water. The shoreline provides structural integrity to the water's edge, protecting it from erosion. The shoreline also gives us a relaxing place to fish, boat and contemplate nature.

Shoreline erosion is a natural process that occurs on lakes, streams, rivers and along the coast. It is the gradual, although sometimes rapid, removal of sediments from the shoreline. It is caused by a number of factors including storms, wave action, rain, ice, winds, runoff, and loss of trees and other vegetation. Although erosion is not intrinsically harmful, when it is augmented to the point where it affects natural resources, water quality, ecosystems, and property loss, it is generally undesirable.

Some commonly practiced shoreline modifications and erosion control methods can actually increase the rate of erosion as well, resulting in costly structural damage as well as property loss. Others may aid in the destruction of the shoreline's natural environment. This guide addresses the problems with some of these common practices and offers alternative methods. The Department encourages the use of "soft" or natural shoreline protection methods over "hard" or structural methods. These methods are much easier on the environment; imitate natural systems, can interact naturally within the ecosystem, as well as save you a significant amount of money. We have included advice and information for various shoreline stabilization methods. Please be aware that permits are necessary for the installation of most of these methods.

Some basic principles of shoreline protection

To best preserve the shoreline environment, stabilization methods should follow these basic principles:

- Imitate nature

  The native vegetation usually found at the shoreline strengthens its structural integrity and prevents the land from breaking apart. The deep roots of these plants bind the earth together while their foliage and branches protect from the erosion caused by rainfall and winds. Removing these plants can cause the shore to weaken and easily crumble into the water.

- Keep slopes gentle

The gradual slope of a natural shoreline absorbs the energy of waves. A steep, eroded slope or retaining wall allows waves to crash into the shore, drastically increasing erosion and causing that wave energy to cause damage on adjacent shorelines.

- Employ “soft armoring” whenever possible.

By “soft armoring” we refer to live plants, logs, root wads, vegetative mats, and other methods that eliminate or reduce the need for “hard armoring”, such as rock rip-rap, stone blocks, sheet-pile or other hard materials. Soft armor is alive and so can adapt to changes in its environment as well as reproduce and multiply. It also provides habitat for fish and wildlife. Vegetation can be kept trimmed so as not to block the view - after all, that’s why many of us choose to live near the water!

- Mix it up

Regardless of the type of natural shoreline encountered, you will undoubtedly see a wide diversity of materials: live trees, dead branches, stumps, rocks of many shapes and sizes, silt, sand, cattails, grasses, flowering plants, etc. By imitating this variety, you can maintain or reproduce the natural value of the shoreline and have an effective, resilient, and eye-pleasing shoreline. Working with these natural and locally available materials can also dramatically cut project costs. In the end, a mix of techniques may yield the best project, uniquely fit for your situation. If your area is already developed, it is a good idea to look to nearby undeveloped shoreline areas for examples of a more natural state.

- Keep it small and simple.

In some instances, only a portion of your shoreline area may be eroding. If this is the case, a small or mixed rip-rap and vegetation project may suffice. Keep in mind that healthy trees are often the cornerstones of a stable shoreline.

How can a natural shoreline protect against erosion?

In its natural state, the shoreline area is perfectly engineered to protect against erosion.

Take the example below:

- The native vegetation usually found in the shoreline area strengthens its structural integrity and prevents the land from breaking apart. The deep roots of these plants bind the earth together, while their foliage and branches reduce erosion caused by rainfall and winds. Clearing these plants causes the shore to weaken and easily crumble into the water.
- The gradual slope of the natural shoreline area has developed to absorb the energy of waves. A steep, eroded slope or retaining wall allows waves to crash into the shore, drastically increasing erosion.

This is the same shoreline, after a considerable amount of erosion:

Although this may not exactly reflect your shoreline, this picture represents the general effects of erosion.

How does the shoreline area provide a habitat for fish and wildlife?

A Natural Shoreline Area:

- Fish and frogs often spawn in the silt at the bottom of the shore and littoral zone. The littoral zone lies just past shoreline area towards the water.
- Vegetation provides nesting spots for birds and food for insects, waterfowl and aquatic mammals.
- Fallen logs and branches provide shelter and hunting areas for fish and mammals, while turtles use them to sunbathe.
- A shoreline's natural vegetation acts as a filter, preventing sediment and unnecessary nutrients from entering the waterbody. This runoff leads to poor water quality and upsets the balance needed for a healthy shoreline habitat. In the case of lawns, this runoff can include fertilizers, pesticides, lawn clippings and pet waste. Geese are attracted to lawns, and their waste can add to this runoff.
- Turtles and amphibians have free access to land, while retaining walls (seen below) block this access, preventing mating and spawning

This is the very same shoreline, after landowner had installed a retaining wall:

The effects are clearly seen, as the lush ecosystem is quickly destroyed.

Harmful Shoreline Alterations

The following types of alterations and shoreline protection lead to increased erosion, structural damage and the destruction of the shoreline ecosystem:

Bulkheads and Retaining walls

Normally a natural, gradual slope will absorb the energy of the wave. Bulkheads and retaining walls cause waves to crash into the shore. Much of the energy of these waves is sent downwards into the water at the base of the wall. The dirt or "substrate" is slowly dug out from under the wall's foundation, eventually causing it to lean and then tumble into the water. Additionally, water draining from upland builds up behind the wall, pushing the wall from behind, especially during freeze-thaw cycles. Construction of a bulkhead or retaining wall can also increase the erosion rates on neighboring properties.

The effect of a bulkhead on adjacent un-bulkheaded property
Courtesy of US Fish and Wildlife Service

From an environmental standpoint, retaining walls are by far the most destructive method of stabilization. With retaining walls, the vegetated area that would normally provide shelter, places to feed, breeding and nesting areas is cleared and built over, quickly and completely destroying the ecosystem.

Not only are retaining walls the most expensive and environmentally harmful option, but when it eventually collapses you'll be left with a staggering repair bill. This is especially troublesome in cases where structures such as houses, garages, etc. are built close to the wall. If the wall fails, you may find the accompanying structure going down with it. No matter how extensive, the collapse of a retaining wall is inevitable.

A retaining wall failure

A very extensive but failed retaining wall

If you already have a retaining wall installed, you may want to completely remove the wall and rework the area using one of our recommended methods. However, in some locations, you may not be able to utilize one of these options. If this is the case, the Department may recommend that you build the wall further back (landward) from the existing wall, rather than building a new wall further out into the water.

Permanent Docks

Docks can interrupt the flow of sediment along the shore and cause unnatural buildups, affecting the rate of erosion. They can also block the sunlight needed for healthy vegetation. For these and other reasons, it is best to minimize the size and number of docks. Temporary and seasonal docks are an optimal tradeoff, requiring a small amount of labor for seasonal installation.

Artificial Sand Beaches

It is important to retain the natural substrate composition. Many people either dump sand to create a beach area, or clear the natural vegetation. Sand beaches are vulnerable to erosion and kill the vegetation underneath. The sand is easily washed away by receding wave action. If a sandy surface is desired, it should be placed well away from the zone affected by wave action, with a wide vegetated buffer strip. Removing the native vegetation, and too many fallen logs and branches both increases the rate of erosion and harms the waterbody's ecosystem. The roots from the vegetation hold the shore together and provide food and shelter for aquatic mammals, birds, turtles and insects.

Lawns and lawn chemicals

Manicured lawns are devoid of the vegetation that normally prevents a shoreline from eroding. The grass used for these lawns lacks a deep root system, which is essential to a stable shoreline. A combination of waves and weather will begin to eat away at the lawn, causing it to break apart and crumble into the water.

Lawn chemicals, such as fertilizers and herbicides, can enter a waterbody and affect its chemical balance, contributing to unsightly and unhealthy algal blooms or in severe cases, fish kills.

To prevent these problems: Either replace the lawn with native vegetation or maintain a "buffer zone" to separate the lawn from the water.

How to create a buffer zone:

A buffer zone is a strip of vegetation at the water's edge. The wider the buffer zone the better, but a buffer extending at least 50 feet back should be enough, although for cold water lakes, at least 100 feet will be necessary. Of course, even the smallest buffer is better than nothing. The simplest way to create a buffer zone is to stop mowing a strip of your lawn at the water's edge. Native vegetation should then begin to return in this area. You may choose to plant certain types of plants for either their look, or their effectiveness in stabilizing the shore. Supplement grass with deeply rooted woody vegetation. Since native species

vary in different areas across the state, we recommend that you check with your local Soil and Water Conservation Service for suggestions.

A manicured lawn eroded by wave action

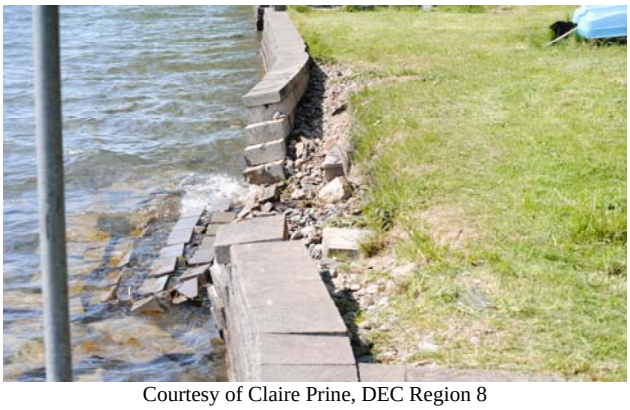
Walkways or Roads

When a walkway or road is built alongside the shore, stormwater runoff will drastically increase, significantly contributing to erosion. Normally, the ground absorbs rainwater. As with lawns, any walkways or roads should be properly buffered from the water as described above.

Recommended Shoreline Protection Methods

We recommend using "softer" approaches for your shoreline protection. These methods can be more cost efficient (having lower maintenance costs), more durable and resilient, aesthetically pleasing, and environmentally friendly to the commonly used "hard" or structural methods. Some landowners also prefer these methods because they help the shoreline blend in with its natural surroundings.

It is common for contractor to recommend installing a concrete retaining wall. Although it may seem like a practical solution, we highly recommend that you consider one of our recommended methods. Retaining walls are not only the most expensive option, but have a tendency to collapse, requiring extensive repairs. They also have a negative impact on the environment.



Courtesy of Claire Prine, DEC Region 8

RE-VEGETATION

Where it works: Re-vegetation works in the case of lawns or bare shorelines with low to moderate erosion. This is not for shorelines with extensive damage or strong wave action.

Basic idea: This method involves re-planting native vegetation that will naturally stabilize the shoreline. The deep roots of these plants bind the earth below tightly, effectively protecting your shoreline from erosion.

Cost: Low
Difficulty: Easy, can be done by landowner

With bare shorelines:
In cases where the shoreline is bare, you will have to plant the vegetation yourself. Plant in late fall or early spring for a greater success rate. This will absorb initial wave action.

LIVE STAKING

Where it works: Slopes with light erosion; can be used in conjunction with other methods for areas with heavier erosion.

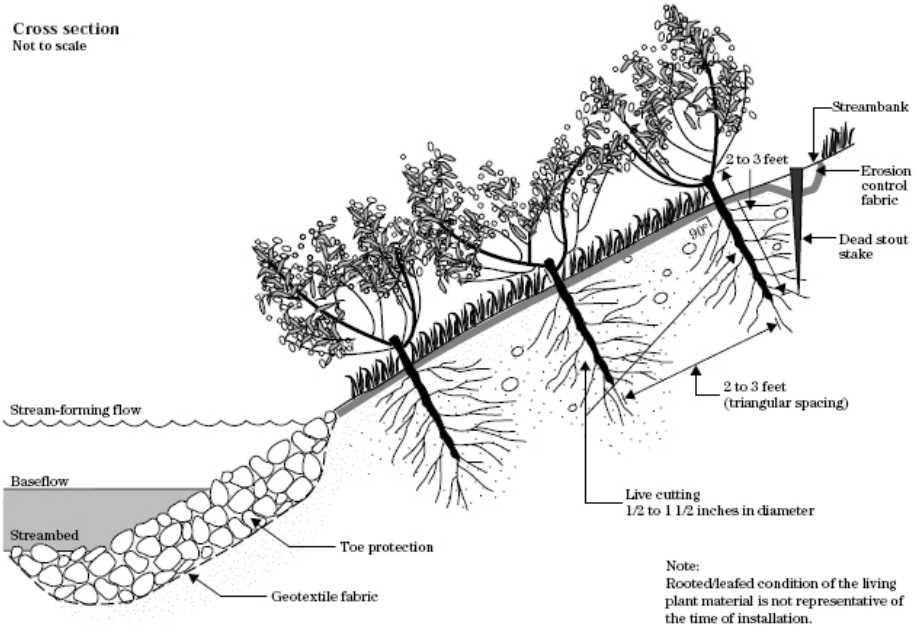
Basic idea: Take cuttings of woody plants (live stakes) like willow and dogwood and drive them into the dirt or substrate of the eroded area. They will sprout roots and grow. Typically this is best to do in early spring or late winter.

Cost: Low.
Difficulty: Easy, can be done by landowner

1. Collect and prepare stakes.
Stakes must be cut (1 foot or more in length) with shears from dormant, mature stems and must be used within 8-10 days. Trim the side branches without damaging the bark, and cut the bottom of the stake at an angle.

Courtesy of USDA - Robbin B. Sotir & Associates

2. Drive stakes.
Using a dead blow hammer, drive the willow or dogwood stakes gently into the ground forming a right angle to the slope (see diagram). If the soil is too packed, pre-form the hole with a steel rod. The stakes should be snugly planted, with about 70% buried and 30% exposed. Place the stakes in a triangular pattern at about 2 to 3 feet apart, with a maximum of 4 stakes per yard. Geotextile fabric or jute mesh is optional but may be needed to hold off further erosion until the live stakes begin to grow. Simply cut and lay the fabric over the area prior to driving any stakes. Anchor the fabric by burying the end in the substrate, behind the live stakes. Rip Rap at the toe is optional.



Courtesy of USDA - NRCS EFH Chapter-16

CONTOUR WATTLING (LIVE FASCINES)

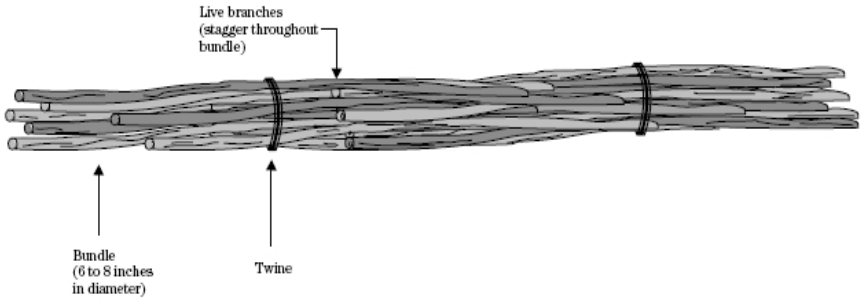
Where it works: Slopes with light erosion

Basic idea: Lay live bundles of stems and branches in trenches on the shoreline, and cover them with soil. They are held in place with both wooden and live stakes. They will sprout roots and grow.

Cost: Low
Difficulty: Easy to moderate depending on level of site prep needed.

1. Collect and prepare bundles

The bundles are made of fresh plant cuttings. They should be straight, 6 to 8 inches in diameter and 5 to 30 feet in length depending on the site conditions. Plant cuttings should range in age, size and species with the growing tips facing the same direction. Willows and dogwoods work particularly well for this application. You do not need to trim the side branches of the cuttings. When tied together, the bundles should be 6 to 8 inches in diameter. You can use hemp or manila binder twine or other degradable fabric to bind the bundles, spacing the ties about a foot apart.



Courtesy of USDA - NRCS EFH Chapter-16

2. Dig trenches and lay bundles

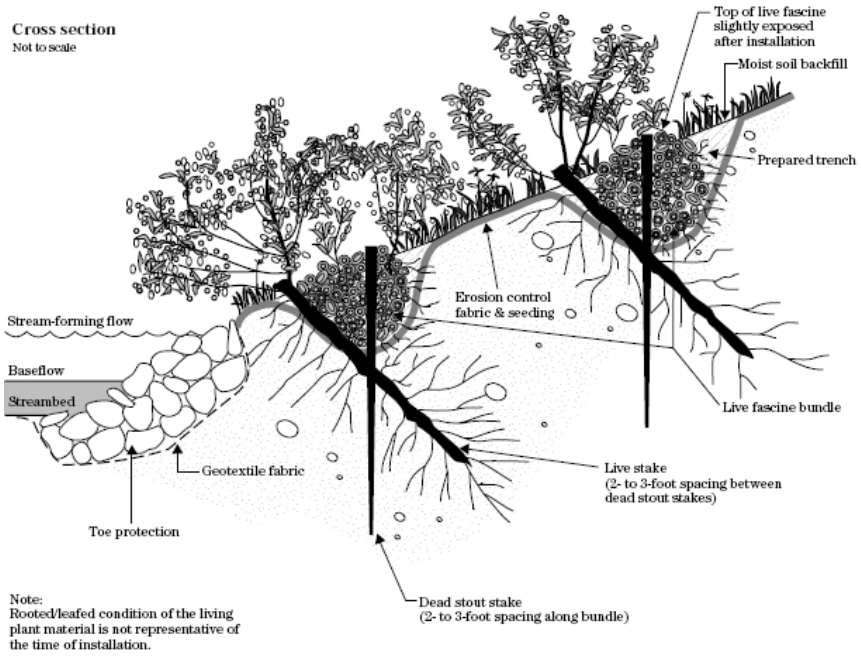
Dig trenches starting at the base of the slope, and continuing up the shoreline, spacing them about 3 feet apart. The trenches should match the width of your bundles and their depth should be about half the diameter of the bundle, ie, 3-4 inches. Lay your bundles in the trenches.

Courtesy of USDA - Robbin B. Sotir & Associates

3. Secure bundles
Secure the bundles into place by driving 2 to 3 foot long wooden stakes through the bundle and into the soil below. Space the stakes 2 to 3 feet apart and make sure there are at least 2 to 3 inches of the stake sticking out of the top of the bundle. Then cover the bundles with soil, but leave a small portion of the top of the bundle exposed. Some large live black willow stakes can be placed along with the dead stakes to secure the bundle, helping to re-vegetate the slope.

Courtesy of USDA - Robbin B. Sotir & Associates

4. (Optional) Lay straw, mulch or fabric
On flatter slopes, lay straw or mulch between the bundles. On steeper slopes, lay a jute or coir (coconut fiber) fabric. The fabric should run under the bundles, with the bundles staked into the fabric. Fabric would need to be installed prior to step 3.



Courtesy of USDA - NRCS EFH Chapter-16

BRUSH LAYERING

Where it works: On badly eroded slopes

Basic idea: Holes are dug into the side of the slope, and plant cuttings are inserted at an angle, and grow outward, while the roots grow into the slope.

Cost: Low

Difficulty: Moderate

Instructions:
1. Cut Branches
Cut fresh, dormant branches (up to 12 feet long and 1/4 to an 1 inch in diameter) from your chosen species, preferably willow or dogwood. Trim off the side branches.
2. Dig the first bench
Dig out the first bench towards the bottom of the slope. The bench should be dug into the slope, about 10 to 25 degrees off horizontal (see diagram)
3. Place the cuttings
There should be several layers of cuttings on each bench, each layer being about an inch thick. Lay the first layer with the bottom ends touching the back of the excavated area and the tips pointing up out of the slope. The cuttings should be crisscrossed. Cover this layer with dirt and start the next. Repeat this process until the desired amount of layers is reached. Then dig the next bench and repeat steps 1-3.
4. Lay mulch or straw
Lay mulch or straw on the exposed soil between the benches.

BRUSH MATTING

Where it works: On badly eroded slopes

Basic idea: This involves creating a "brush mattress" out of live plant cuttings, which lies on the eroded area. It will take root and grow.

Cost: Low
Difficulty: Moderate

1. Choose the plant
Brush mattresses are made of any woody plant that will sprout roots from its stem. Mostly people use the willow, but some species of dogwood and viburnum will work as well. The plants should be 2 to 3 years old, flexible, and about 5 to 10 feet long. The diameter of the branches should be ½ to 1½ inches.
2. Prepare the slope
The slope you will lay the mattress on must be flat to make sure every part of the mattress is in contact with the soil. The area should be about 5 to 18 feet in length. Make sure the soil is loose enough for the mattress to take root.

3. Dig a trench

Dig a trench along the length of the toe of the slope, where your brush mattress will end. The end of the mattress will be tucked in here. OPTIONAL but recommended: Create a live fascine (see "Contour Wattling" section above) and lay it in the trench.

4. Drive the stakes

It is recommended that you use a combination of live and dead stakes. The stakes should be 2 to 4 inches thick and 24 to 36 inches long. Drive them into the slope in rows, spaced 18 inches apart, running from the bottom to the top of the slope (see diagram). If you chose to include a live fascine, the stakes at the bottom of the rows should be staked right through the fascine.

5. Lay the branches

Now lay your branches between the rows of stakes, creating a layer 2 to 4 inches thick.

Brushmattress during installation
(Robbin B. Sotir & Associates photo)

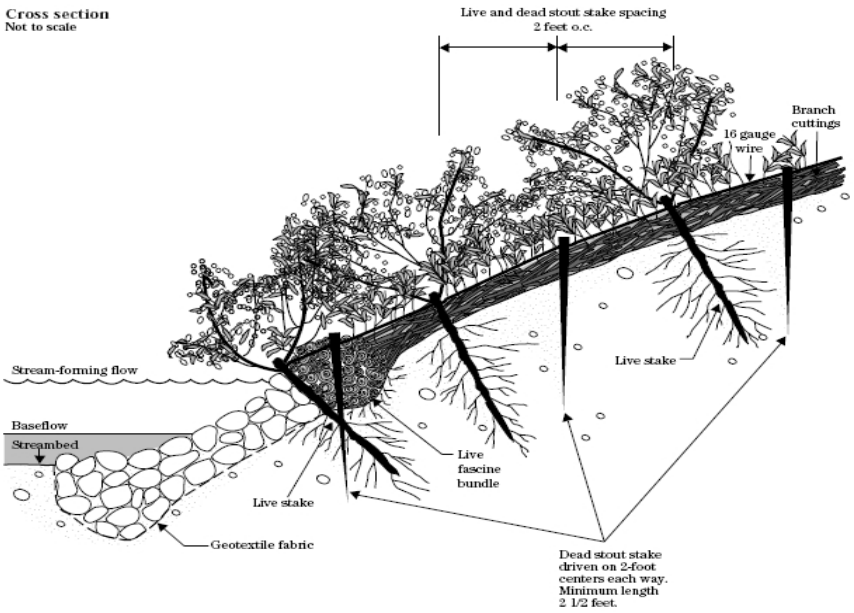
Courtesy of USDA

6. Tie them down

Choose either wire or twine. If using wire, use 16 gauge. With twine, use machine bristle coir that's about 1/5 to ½ inch thick with a breaking strength of 70 to 100 pounds. The wire or twine runs diagonally across the stakes (see diagram) and is tied to each stake in a clove hitch. Rip Rap at the toe is optional.

An installed brushmattress system
(Robbin B. Sotir & Associates photo)

Courtesy of USDA



Courtesy of USDA - NRCS EFH Chapter-16

EROSION CONTROL MATTING

Basic idea: A sheet of special three-dimensional biodegradable erosion-control geotextile fabric is laid down over the exposed slope of the shoreline. Grass seeds are planted throughout the matting and then covered with soil. The grass becomes intertwined with the mat or blanket and stabilizes the shore.

Where it works: Moderate slopes up to 1 vertical to 2 horizontal along roadways or on slopes along waterways.

Cost: Low to moderate depending on area to be covered and site-preparation necessary.
Difficulty: Moderate to difficult, depending on slope preparation necessary and site characteristics.

1. Prepare the slope. Remove all soil clumps and rocks. The prepared area must exactly match the dimensions of project. **Optional** - Spread seeds under the area you will be laying the mat.
2. The erosion-control blankets come in rolls. Lay the blankets.
Each blanket is usually 3 to 4 feet wide. Starting at the top, roll each blanket down the slope. Each blanket should overlap the next by about 3 to 4 inches.
3. Staple the blanket down
Drive special soil staples down the center of each blanket, spaced about 3 to 5 feet apart.
4. Spread soil over the blanket
Thoroughly spread a layer of about 1/2 to 3/4 inches of soil into the mat, this helps the seeds take root.
5. Spread the seeds
Spread the seeds over the mat. Spreading seeds under the mat is another recommended option. Do this prior to laying the mat.

Shoreline Protections Methods recommended under certain conditions

The following methods involve hard armoring, and should only be used if the methods above will not work on your property. The softer methods above are preferred by the Department as they are superior in preventing erosion and maintaining a healthy shoreline environment. If a hard armoring method is indeed required, the sloped rip-rap or rip-rap vegetation combination provide superior protection of the shoreline than vertical cement or block walls and still provide some habitat for wildlife. All these methods will require a permit from the Department.

Figure 16–33 Rock riprap revetment system

Courtesy of USDA - NRCS EFH Chapter-16

STONE RIP-RAP

Where it works: Shorelines where underlying soil is stable.

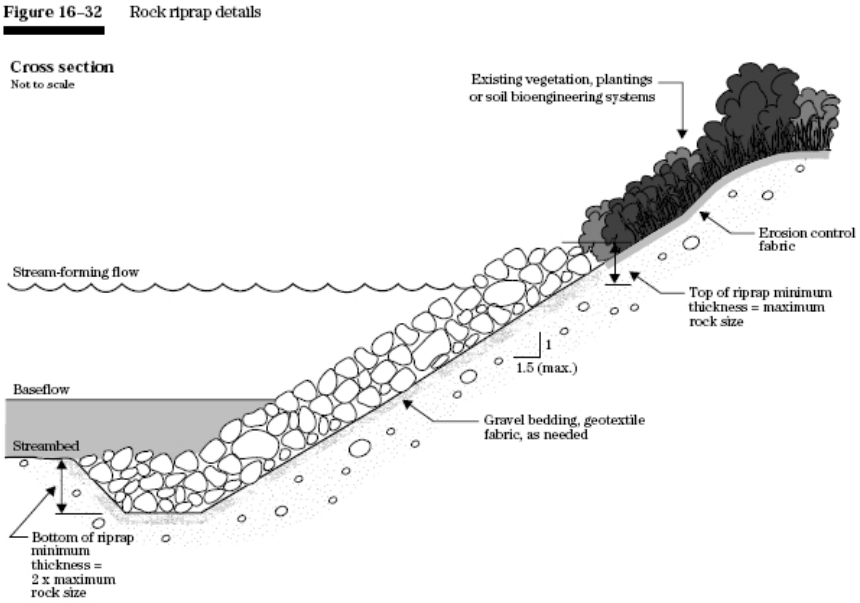
Basic idea: A layer of stones is laid along a slope face or bank and prevents erosion caused by wave action.

Cost: Moderate to high
Difficulty: Moderate

1. Prepare the Slope. Vegetative stabilization methods are preferred on flatter slopes and that the use of stone rip-rap should generally be limited to slopes greater than one vertical to three horizontal, where vegetative stabilization methods are not as effective. The slope must be graded to a maximum of no more than a one foot vertical rise for every 1.5 feet of horizontal distance. (Some DEC regions require a 1:2 slope depending on site conditions.) The soil must be stable. If you need to fill the area, use a fill with stones smaller than 6 inches. Make sure the slope is tightly compacted before placing the Rip-Rap.
2. Lay the rip-rap. Rip rap is hard quarry-cut stone such as limestone or granite chunks, typically 12-18" in length, having at least two fractured faces. These rocks lock in place against each other. Refrain from using rounded field stones because they will slide down the slope. There should be two layers. The first layer is called the "filter layer" The stones should be no larger than 3 inches in diameter. If you choose to use a filter fabric,

place this underneath the filter layer. The top layer or the "armor layer" and takes the initial impact from the waves. If area is large enough, you may have to use a crane or a dump truck to dump the rocks. If the project is small enough you may be able to do this manually.

Note: If there are live trees or other significant native vegetation on the eroded slope, we highly recommend that these be left in place and the rip rap be laid around them taking care not to damage the bark or vegetation.



Courtesy of USDA - NRCS EFH Chapter-16

VEGETATED RIP-RAP (JOINT-PLANTING SYSTEM)

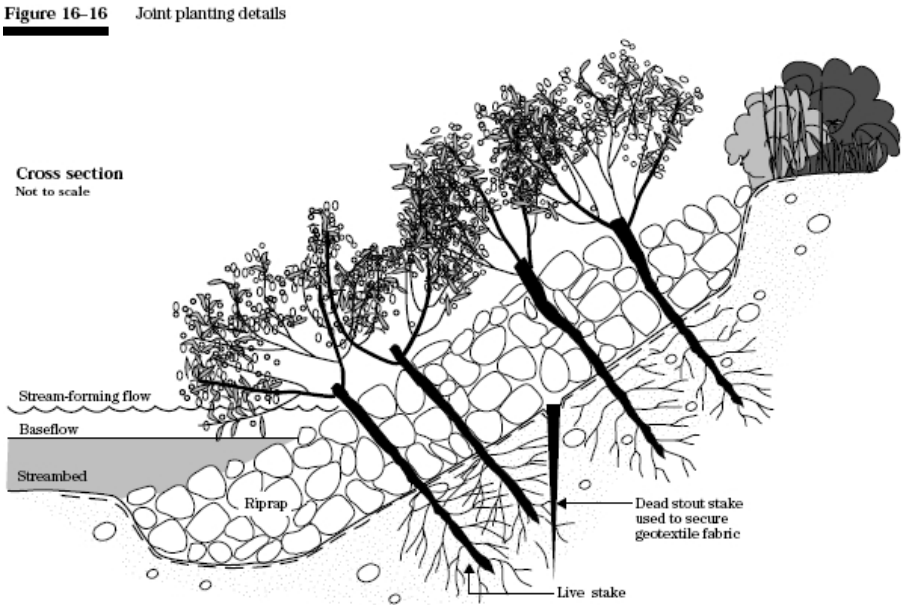
Where it works: Waterways or inland lakes where underlying soil is stable.

Basic idea: This is a combination of live stalking and rip-rap. The rip-rap prevents wave action from eroding the shore while the roots of the plants bind the earth below. The plants cover the rocks, providing shade for fish and wildlife and eventually making for a very nice spot to fish. Some landowners also prefer the look of a more natural shoreline.

Cost: Moderate to High. Much cheaper if rip-rap is already in place.
Difficulty: High

1. Prepare the slope
The slope should be 2 to 1 (Horizontal to Vertical). Cover the area with a filter fabric or jute mesh. Spread the rocks over the fabric, making sure not to damage it.
2. Prepare the live stakes
Stakes must be cut long enough to be able to drive into the dirt below the rocks with the growing tips protruding above the rocks. Cut with shears from dormant, mature stems and must be used within 8-10 days. Trim the side branches without damaging the bark, and cut the bottom of the stake at an angle.

3. Insert the live stakes
They should be inserted perpendicular to the slope. The growing tips should face upward, protruding through and above the rocks. You can use a steel rod (re-bar) to puncture through the fabric and create a hole in the soil below. Use a dead blow hammer to drive the stakes into the soil. There should be two to four stakes per square yard.



NRCS EFH Chapter-16

An installed joint planting system
(Robbin B. Sotir & Associates photo)

Courtesy of USDA

VEGETATED GABION MATTRESS

Basic idea: A gabion mattress is an elongated, mattress shaped cage filled with rocks. Vegetated gabion mattresses involved branches or cuttings inserted through rocks in the cage.

Where it works: Moderate slopes to resist wave action, ice and surface erosion.

Cost: High

Difficulty: High. We recommend that you do not attempt this yourself. A professional contractor, heavy equipment and engineer are required.

VEGETATED CRIBBING (LIVE CRIBBING)

Basic idea: Interlocking planks of wood act as a sort of live retaining wall, but with less of an environmental impact. Vegetation is planted between the planks. This does not work well on high banks with heavy wave action.

Where it works: Unvegetated slopes with a lot of backfill and little wave action

Cost: Moderate to high
Difficulty: Moderate. We recommend that you do not attempt this yourself. A professional contractor, heavy equipment and engineer are required.

Sources

1. "The Shoreline Stabilization Handbook" Northwest Regional Planning Commission. St. Albans, Vermont.

2. USDA NRCS Engineering Field Handbook, Part 650, Chapter 16, Streambank and Shoreline Protection. December 1996.

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