STREAM BANK STABILIZATION

4.1 Introduction

Many waterfront developments feature roads, bridges, and buildings constructed along areas that are particularly susceptible to erosion over time, such as rivers and streams. The pace of the natural erosion is often accelerated by human activities that increase stormwater runoff and remove essential riparian vegetation from the banks. Due to the potential loss of property and structures bordering waterways, stabilization and/or protective measures are often necessary for the long-term preservation of these areas. (Figure 4.1)

Figure 4.1 Developed Coastal Area
Photo Courtesy of: Roger Houston

Previous chapters highlighted low impact development strategies and their effectiveness in reducing land disturbance and impervious cover - both of which significantly degrade downstream water quality. The following practices help to ensure downstream stability by slowing stormwater water before it reaches the waterway. In addition to these conservation mechanisms, various natural techniques in this Chapter can be used to stabilize areas already experiencing erosion. This Chapter recommends low impact practices to stabilize stream banks while protecting the natural integrity of the stream and riparian forest system.

4.2 Erosion

Erosion in this region is most often due to the natural forces of water – waves erode streams and beaches, and tidal rivers are subject to the ebb and flow of the daily tides. Human activities such as land disturbances that alter or destroy natural topographic and hydrologic features and create impervious surfaces accelerate the natural erosion process. In the coastal region, development is likely the greatest contributing factor to the acceleration of streambank erosion.

Figure 4.2a Bank Erosion

Photo Courtesy of: Matt Renault

Figure 4.2b Transportation of Eroded Material

Photo Courtesy of: Tara Merrill

4.2.1 Overland and Stream Channel Erosion

Stormwater runoff can cause significant damage to a stream and contributes to stream bank erosion. The force of the stormwater as it enters the stream creates rills or gullies the compromise the stability of the side banks, leading to eventual bank slide or total collapse. This type of erosion, commonly referred to as overland erosion, can carry soils from unstable banks into the stream, degrading downstream water quality and aquatic habitat. (Figure 4.2.1.a)

Figure 4.2.1a Vegetated Slope vs. Non-vegetated Slope with Rills and Gullies

Photo courtesy of: Doug Lowry, Armtec Construction Products

Channel erosion often occurs when the fast introduction of rainwater increases the flow rate of the stream, which deepens the channel and undermines the side slopes causing the bank to "slump" under its own weight. Ultimately, this can lead to bank failure if left uncorrected.

4.2.2 Stream Characteristics Affecting Erosion

To understand stream channel erosion, it is helpful to understand flow activity within the stream itself. There are two basic types of stream water flow: laminar (slow), or flow in a single direction, and turbulent (fast) or multidirectional flow. Both flow types can contribute to erosion, but turbulent flow is often strongest and most destructive in terms of stream channel erosion.

Turbulent flow contributes to the degradation of the toe of a slope through scouring or *undercutting*. Once the base erodes, the unsupported upper portions of the bank fracture and collapse or slump into the channel. The portion of the collapsed bank is picked up by the current and carried downstream. (Figure 4.2.2.a)

Figure 4.2.2a Photo of Rotational Slump of Stream Bank

Courtesy of: Tellusnews.com

4.3 Types of Channels

There are four classifications of river channels that impact the potential for streambank erosion. (Figure 4.3.a) *Straight* channels are formed as the channel encounters a steep gradient and are characteristic of mountain streams. *Braided* channels develop on broad flat floodplains where the river fills its banks and flows with little sinuosity despite its winding appearance at low

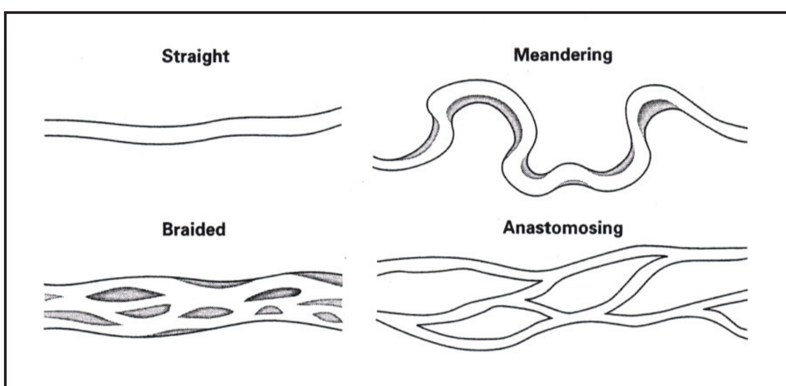


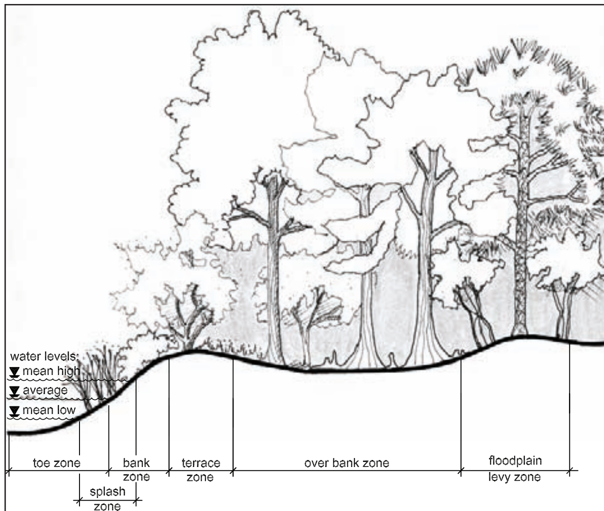
Figure 4.3a Four Classifications of River Channels

Courtesy of: Nichols, Gary. 1999. Sedimentology and Stratigraphy. Blackwell Sciences, Ltd.

flow conditions. *Meandering* and *anastomosing* channels are common to the coastal plain of Georgia. The meandering river redefines itself by eroding the sediment on its outside curves and depositing the sediment on its inside curves, while the anastomosing river contains many separate channels that part and join again along its course.

4.4 Stream Bank Zones

Understanding of the different zones of the stream bank is important to prescribing appropriate stabilization or protective measures against erosion. (Figure 4.4.a) There are four principal stream bank zones (USACE, 1997):



Bank Zones Section
Figure 4.4.a - nts

- Toe Zone – The toe zone is the portion of the bank between the streambed and the average normal water stage. This is a high stress area that typically has little or no aquatic vegetation. Moderate to high flow currents may erode the center and sides of the channel and undermine, or undercut, the base of the bank slope. Undercutting in the toe zone is likely to result in bank failure if appropriate preventive or corrective measures are not taken.
- Splash Zone – The splash zone is the portion of the bank between normal low- and normal high water levels. Located just above the toe zone, the splash zone is frequently exposed to wave wash, currents, and debris movement. This zone is typically vegetated with hardy grasses and other submergent vegetation capable of withstanding periodic inundation and possible saline conditions in tidal areas.
- Bank Zone – The bank zone refers only to that portion of the bank normally above the high-water level. This area is exposed periodically to wave wash, erosive river currents, debris movement, and frequent human and animal traffic. The water table is frequently close to the soil surface due to proximity

to the stream. Small trees, shrubs, and ground vegetation cover this area in optimal conditions.

- Terrace Zone – The portion of the bank inland from the bank zone is called the terrace zone. It may be a sharply sloping bank or simple the level area at the crest of a high bank. Though only occasionally flooded, this zone can be easily eroded when vegetation is not present. This area is dominated by mature trees, shrubs, and herbaceous species.

4.5 Low Impact Bank Stabilization Practices

Low impact bank stabilization practices dissipate excess stream energy, solving erosion problems without placing costly concrete "armor" along the banks. This conventional practice of hard-armoring streambanks with rock revetments and concrete bulkheads tends to degrade the quality of aquatic habitat and add to downstream erosion over time. (Figure 4.5.a) For the most part, low impact practices make use of bioengineering techniques that use natural materials and are based the natural behavior of the stream.

Figure 4.5a Hard Armoring of Bank Which Prohibits Native Vegetation,

Degrades Wildlife Habitat, and Deters Infiltration of Stormwater

Photo Courtesy of: Tara Merrill

The practices discussed in this Chapter place a great deal of emphasis on physical, structural, and vegetative stabilization of the stream bank and were formulated based on the underlying philosophy of low impact development (LID), that is, the employment of natural functions and features to lessen the impact on the environment. These practices can be used individually, or in conjunction with conventional methods depending on stream velocity and other bank conditions. While the primary focus here is streams, these techniques can also be applied to ponds and lakes, tidal lagoons, drainage canals and ditches.

These low impact strategies for stream bank stabilization promote:

- Reducing runoff at the source by introducing runoff water into the soils,
- Using native vegetation to slow runoff and divert flow across the land surface to allow for infiltration and treatment of potentially polluted stormwater,
- Using vegetation to stabilize the surface, lessening the likelihood of erosion by raising the energy required for surface breakdown and leading to the deposition of already collected sediment,
- Bank shaping and sloping practices that achieve stable banks,
- Using structural and vegetative stabilization measures to preserve the stream under normal flow conditions and withstand the impact of substantially increased flows,
- Control soil movement through the use of biodegradable materials that disintegrate into humus, a media that allows for infiltration and air exchange which promotes the growth of plants,
- Using biodegradable materials or environmentally-sensitive synthetics as an alternate to permanent materials, and
- Using vegetation to shade the water, which lowers the water temperature and increases its capacity to hold oxygen needed by aquatic animals to breathe.

The following twelve practices are illustrated and discussed along with instruction for their implementation. While these practices are simple in nature and are encouraged for use in coastal areas, all streams are unique and often have specific conditions to evaluate before recommending a design solution. It is important to consult with the Georgia Department of Natural Resources or other stream bank experts who can identify the actual source and cause of the erosion problem and design appropriate stabilization and protection measures specifically adapted to local conditions.

4.5.1 Practice 1 - Bioengineering: Shaping and Planting Banks[1]

Bioengineering refers to the process of adjusting bank slope by grading or sloping to achieve a stable shape, then establishing appropriate plant species to maintain the new bank shape. This practice essentially uses the natural strength of riparian vegetation, rather than structural measures, to provide long-term bank stability. Many factors must be considered when determining proposed slope dimensions and vegetation types including characteristics of available soils, the influence of high groundwater, and the flow velocity in the area of erosion.

Installation

There are three basic steps to this method: (Figures 4.5.1.a and 4.5.1.b)

1. Grade the existing banks to achieve a stable angle of the slope.
2. Install a biodegradable or synthetic fabric to hold soil in place.
3. Plant slope with native vegetation for added long-term stability.

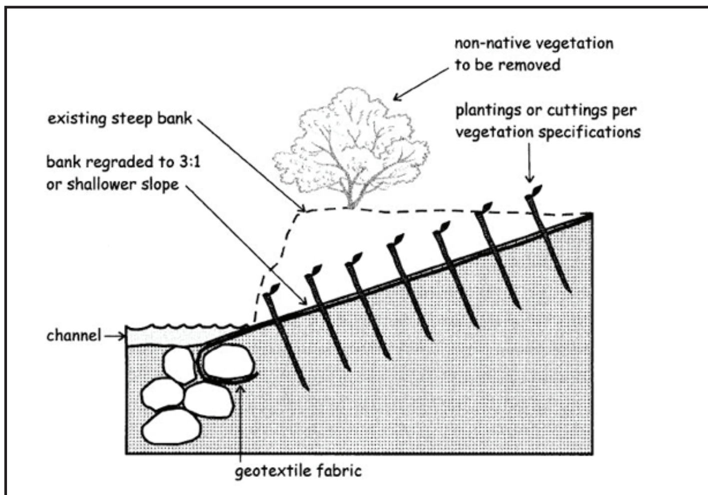


Figure 4.5.1a Regrading and Replanting of Bank Slope

Illustration Courtesy of: EPA.gov

Figure 4.5.1b Replanting of Stream Bank

Photo Courtesy of: Elliott Smith, Sausalcreek.org

- For most coastal streams, vertical or near-vertical banks should be graded to a moderate 3:1 angle. In some cases, such as along especially steep sandy bluffs (>1.5:1 angle) or areas subject to rapid stream flows, structural reinforcement may be necessary to control slumping or undercutting. Although grading activities may disturb some existing vegetation, it will provide a more stable long-term riparian setting and will improve local hydraulic conveyance.

- Once the desired angle is achieved, biodegradable filter fabric is placed and fastened or "toed in" a minimum of 12" into the side slope to hold lose sediments in place.
- Plants can be installed by simply cutting openings in the fabric and placing the plant directly in the bank substrate beneath. (See Practice 2 for Suggested Bank Plantings.)
- The other means of disrupting runoff and increasing contact time is to plant a line of native shrubs, four to five feet back from the top of the bank. By simply raising the profile of the top of the bank and contouring it on the back (away from the water), a vegetated swale will mitigate runoff if added. However, careful attention must be given to this design so not to create a secondary "stream" or drainage pattern that can undermine the top of the slope.

4.5.2 Practice 2 - Natural Vegetation Establishment

Vegetation establishment is an inexpensive and effective method to minimize erosion. Native plants are particularly effective against erosion because they feature two levels of protection. The top layer of growth serves to deflect stream flows away from the banks and an extensive underground system of roots binds the soils to the slope. This practice can be applied to all four of the primary bank zones. Beyond initial earthworks and plantings, this practice is considered relatively maintenance free if left alone. (Figure 4.5.2.a)

4.5.2a Stream Bank Before and After Stabilization with Vegetation

Photo Courtesy of: Nagreen.com

For areas of mild current and wave action with somewhat stable existing slopes, sodding and vegetating with flood tolerant plants can provide sufficient protection against erosion. For areas of moderate to high water velocities, this practice can be used in combination with structural methods to achieve the desired level of protection. For optimal protection, natural vegetation re-establishment is a recommended application for all of the practices introduced in this chapter.

Installation

- If suitable, existing soils are used. If soil must be added, suitable material must be used, and appropriate soil erosion control practices must be in place during construction to avoid sedimentation of the stream. The soil is generally held in place by biodegradable material, often coir fabric, wire mesh and/or stakes. (Figure 4.5.2.b)

4.5.2b Hydroseeding for Slope Stabilization

Photo Courtesy of: EcoSystems, Inc.

- The re-establishment of vegetation can be accomplished by seeding, either by manual or mechanical application or by installing plant cuttings, rootwads, bareroot or containerized specimens. Hardy, fast-growing native species should be selected and planted close together for dense coverage once mature. The entire exposed area of the bank should be planted to promote the spreading and interweaving of fibrous root systems to hold the soil in place. The most important consideration is the ability of the plants to withstand flooded conditions all or most of the time.
- It is important to avoid introduction of non-native species. These species can become invasive and out-compete existing vegetation. In addition, invasive plants are not familiar nesting or feeding habitat for fish and wildlife using these areas.

- A good rule of thumb is to look at the natural system and attempt to duplicate the native vegetation. The following plants, separated by freshwater and salt-tolerant species, can be used along banks in coastal Georgia:

Recommended Plantings for Coastal Stream Banks

Salt-Tolerant Species

Live Oak *(Quercus virginiana)*
Red Cedar *(Juniperus virginiana)*
Slash Pine *(Pinus elliottii)*
Wax Myrtle *(Myrica cerifera)*
Cabbage Palm *(Sabal minor)*
Inkberry Holly *(Ilex glabra)*
Palmetto *(Serenoa ripens)*
Sea Oats *(Uniola paniculata)*
Silverling *(Baccharis halmifolia)*
False Willow *(Baccharis angustifolia)*
Marsh Elder *(Iva frutescens)*
Tall Goldenrod *(Solidago canadensis)*
Needle Rush *(Juncus roemerianus)*
Smooth Cordgrass *(Spartina alterniflora)*
Big Cordgrass *(Spartina cynosuroides)*
Salt Meadow Cordgrass *(Spartina patens)*
Salt Grass *(Distichilis spicata)*
Sea Lavendar *(Limonium carolinianum)*
Sea Oxeye *(Borrichia frutescens)*
Sea Purslane *(Sesuvium portulacastrum)*
Marsh Bulrush *(Scirpus cyperinus)*
Spike Rush *(Eleocharis flavescens)*
Ladies Tresses *(Spiranthes vernalis)*
Broomsedge *(Andropogon glomeratus)*
Indian Blanket *(Gaillardia pulchella)*
Red Rattlebox *(Sesbania punicea)*
Coral Bean *(Erythrinia herbacea)*
Smartweed *(Polygonum punctatum)*
Sand Vetch *(Vicia acutifolia)*
Coastal Dropseed *(Sporobulus virginicus)*
Swamp Loosestrife *(Decodon verticullatus)*
Common Marsh Pink *(Sabatia stellaris)*

Freshwater Species

Water Oak *(Quercus virginiana)*
Red Maple *(Acer rubrum)*
Bald Cypress *(Taxodium distichum)*
Slash Pine *(Pinus elliottii)*
Black Willow *(Salix nigra)*
American Holly *(Ilex opaca)*
Sweetgum *(Liquidambar styraciflua)*Black
Tupelo *(Nyssa sylvatica)*
Black Titi *(Cyrilla racemiflora)*
Buttonbush *(Cephalanthus occidentalis)*
Fetterbush *(Lyonia lucida)*
Wild Blueberry *(Vaccinium elliotti)*
Virginia Willow *(Itea virginica)*
Oak leaf Hydrangea *(Hydrangea quercifolia)*
Stinkbush *(Illicium floridanum)*
Swamp Azalea *(Rhododendron viscosum)*
Winged Sumac *(Rhus copallina)*
Meadow Beauty *(Rhexia mariana)*
Lizard's Tail *(Saururus cernuus)*
Pickerel Weed *(Pontedaria cordata)*
Spiderwort *(Tradescantia virginiana)*
St. John's Wort *(Hypericum hypericoides)*
Soft Rush *(Juncus effusus)*
Cinnamon Fern *(Osmunda cinnamomea)*
Royal Fern *(Osmunda regalis)*
Golden Club *(Orontium aquaticum)*
Virginia Creeper *(Parthenocissus quinquefolia)*
Common Purslane *(Portulaca pilosa)*

4.5.3 Practice 3 - Temporary Reinforcement Coir Rolls/Mats

Made of rope fashioned from coconut husk fibers, coir rolls and mats are high- tensile solutions for toe and bank reinforcement. (Figures 4.5.3.a-b) In addition to coir, several natural fabrics including jute, straw, and cotton also have high lignin content making them durable and versatile. (Figure 4.5.3.c) Fibrous rolls or mats are held together by organic netting with biodegradable stitching. These materials slow and deflect water flows, hold the soils in place, and serve as growing medium for the establishment of vegetation along banks. These materials are inexpensive solutions easily transported and installed at the project site. Lightweight bank coverings and vegetative establishment practices are typically applied to low flow streams or canals experiencing low to moderate effects of erosion. Because of their flexibility, they can be placed along the natural contour of the channel and banks relatively easy. Following installation, the material is seeded or planted with cuttings or root wads. Once vegetation is established, little or no maintenance is required. (Figure 4.5.3.d)

Figure 4.5.3a Coconut Mat on Stream Bank

Photo Courtesy of: Chere Peterson

Figure 4.5.3b Biodegrading Coconut Mat Along Bank

Photo Courtesy of: Chere Peterson

Figure 4.5.3c Jute Mesh Covering Slope

Photo Courtesy of: Matt Renault

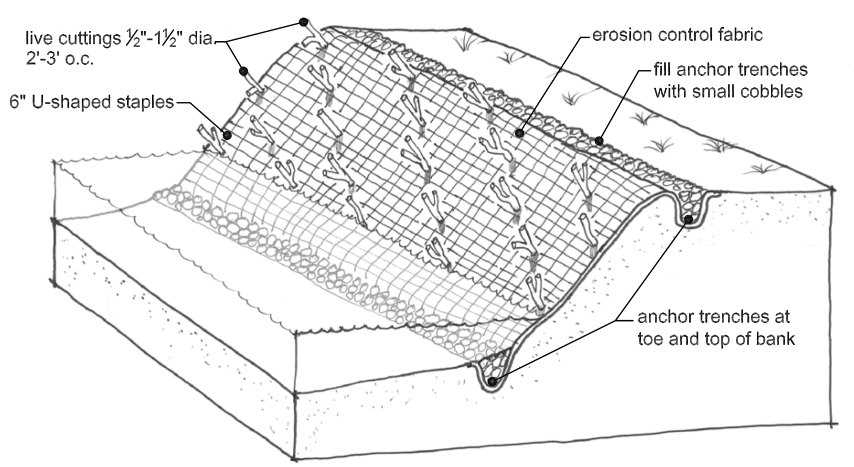
Figure 4.5.3d Installation of Straw and Coir Log Along Stream Bank at Low Tide

Photo Courtesy of: Tellusnews.com

Coir rolls or "bio-logs" are arranged in cylindrical bundles of fiber while mats are intertwined coir fibers held together by mesh. Both rolls and mats are available in varying thickness, width, and lengths depending on the shape and size of area to be covered. They can be ordered as pre-seeded media or planted following installation.

Installation

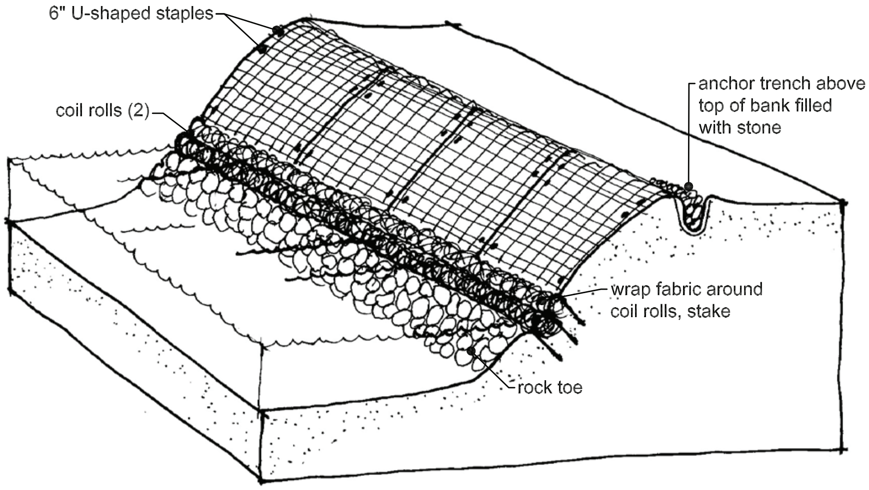
- The rolls or mats are laid parallel to the stream within the splash and bank zones of the stream. Several rolls or mats are overlapped a minimum of 12" and laid between hardwood wooden stakes that are driven through the coir (or other material) and into the substrate beneath a minimum of 3'.
- The coir is fastened to the staking by wire or string. The edges can also be "keyed" into the side slope a minimum of 1' by whatever is used as toe reinforcement.
- Once in place, semi-aquatic plants or seeds are planted directly into the fiber. (Figure 4.5.3.e)



Live Cuttings with Erosion Control Fabric

Figure 4.5.3.e - nts

◆ Over time the coir accumulates sediment and biodegrades as plant roots develop, creating vegetated protective bank covering. (Figure 4.5.3.f)



Coil Rolls with Erosion Control Fabric
Figure 4.5.3.f - nts

4.5.4 Practice 4 - Permanent Reinforcement Synthetic Solutions

While biodegradable materials are preferred, several ecologically-sensitive, cost- effective alternatives can be used to retain the soils on stream banks (moderate flow conditions) that allow for drainage through the structure. These products, also known commonly as geotextiles, can be used in lieu of riprap or in combination with rock if necessary. Some toe reinforcement, rock or log revetments, or stone gabions are still required, but only up to the average annual high water line**.**

These three-dimensional, vegetated erosion reinforcement fabrics offer structural stability equivalent to a minimum of 12 inches of rock at approximately half the cost. These materials can have an effective lifespan of 4 to 50 years, depending on whether they are heavy weight and UV stabilized products. These high-density (often plastic) materials can be used to line streams, drainage swales and canals, and ponds to protect against erosion, with the added benefits of permeability, which improves wildlife habitat and increases species diversity. Most of these methods can be manually seeded or hydroseeded for rapid vegetation establishment. Geotextiles are available in various shapes, sizes, and strengths to fit almost any channel or bank configuration.

First, selected grasses are grown on a geo-membrane, which is then laid over a prepared bank. The geo-membrane holds the soils back, while the grasses penetrate through the membrane into the bank providing strength and stability.

There are three basic types of geotextiles:

- Filter fabrics are woven, non-woven or knitted, permeable sheets used for soil reinforcement. These reinforced, high tensile strength mats are usually applied to the natural contour of the slope. They can be used alone or beneath other structures such as gabions and log revetments. The fabric is usually covered with soil and planted for optimal stability. (Figure 4.5.4.a)

Figure 4.5.4a Filter Fabric Applied to a Moderate Slope

Photo Courtesy of: US Fabrics, Inc.

- Geo-grids are tough, non-woven (webbed) synthetic sheets with large rectangular holes that can be applied to steep slopes and vegetated with grasses for additional support. (Figures 4.5.4.b and 4.5.4.c)

Figure 4.5.4b Geo-grid

Photo Courtesy of: Pavingexpert.com

- Geo-matrices are three-dimensional geo-grids (high density plastic webs with pockets), or sections of cells that can be filled with soil and planted to control erodible banks, especially banks that contain granular sands. Geogrids and matrices are usually rings on a flexible grid with horizontal bars connecting every few rows that increase contact time for infiltration.

Figure 4.5.4c Hexagonal Cells Filled with Turf for Bank Reinforccement

Photo Courtesy of: Pavingexpert.com

The flexible grid permits a good, custom fit against the natural bank contours. (Figure 4.5.4.d)

Figure 4.5.4d Slope Tame on the Banks of the Chattahoochee River

Photo Courtesy of: Chere Peterson

Installation

Filter Fabric

- Up-slope ends or edges should be buried in the bank, covered with soil, and pressed securely in place.
- Up-slope sections are placed over down-slope sections and ends are overlapped a minimum of 12 inches and pinned securely. The edges of each sheet should have a minimum of 4 inches of overlap.
- Securely anchor mats to the bank surface with stakes, pins, and/or staples spaced approximately 12 inches apart.
- Spread suitable soil over the mats and seed or insert cuttings for vegetation establishment.

Geo-Grids and Matrices

- The material is applied to eroded portions of the bank much the same as filter fabric but entails a more intensive anchoring technique.
- The anchoring system is positioned a minimum three feet back from the bank's crest. Split duck-billed anchors (resembling old-fashioned button-topped clothespins) of cast aluminum, with a loop located mid point between top and bottom, through which a threaded stainless steel wire, about 30 inches long is inserted.
- A piece of 3/8 inch rebar is placed in the grooved anchor and driven to a depth at least 12 inches into the ground, more, if soil stability demands it. A loop on the other end of the wire slips freely over a three-foot piece of rebar, which is placed between one of the upper rows of the geo-grid or matrix, perpendicular to the slope.

- Rings may be filled with sand and vegetated, or actual sod cut an inch thick may be placed on top of the rings, soaked, then rolled into the rings using a rope-and-winch system for the roller on very steep banks.

4.5.5 Practice 5 - Pole Plantings

Pole plantings are an inexpensive, easy-to-install method for re-vegetating and stabilizing bank slopes. Sometimes known as "live stakes", these rootable cuttings can be inserted directly in the bank substrate or into a bank covering such as coir or geotextile fabric. For cuttings to be used alone in the splash zone, the toe must be hardened (rock toe rolls) and water velocity must not exceed 5 feet per second. When stream velocities are in excess of 5 fps, this method is generally used in the splash zone in combination with brush mattresses.

Pole plantings provide habitat when used with such stabilization techniques as riprap, gabions, and log revetments. The poles have tremendous tensile strength, which can enhance the strength and shear resistance of the soil. When incorporated into structural practices, the poles can increase the strength and longevity of the structures. The dormant cuttings can replace wooden construction stakes for securing the matrix pad to the bank slope. Once the pad disintegrates, it serves as additional growing media facilitating root growth. The establishment of durable hardwood shrubbery with a dense fibrous matrix of roots is the desired end result. (Figure 4.5.5.a)

Figure 4.5.5.a Biodegrading Coconut Mat Along Bank
Photo Courtesy of: Chere Peterson

Installation

- Successful planting is from early spring through the summer and fall, most of the growing season. An alternative to cuttings with established roots are dormant cuttings. However, when the plant is dormant, the planting period is usually limited to the winter season.
- Cutting can either be ordered or selected from a natural stand. Either type should be inspected for disease, splitting and insect damage.

- ◆ Although there can be considerable size variance, cuttings typically range from 0.5 to 3 inches in diameter. Larger sizes may be necessary in some situations for greater survivability.
- ◆ Live brush cuttings 3 to 5 foot long or stakes 2 to 3 feet long' long should be selected. Cuttings and stakes should have side branches removed and bark left intact. If dormant stakes are used, they must be soaked in water prior to installation to stimulate root growth. (Figure 4.5.5.b)

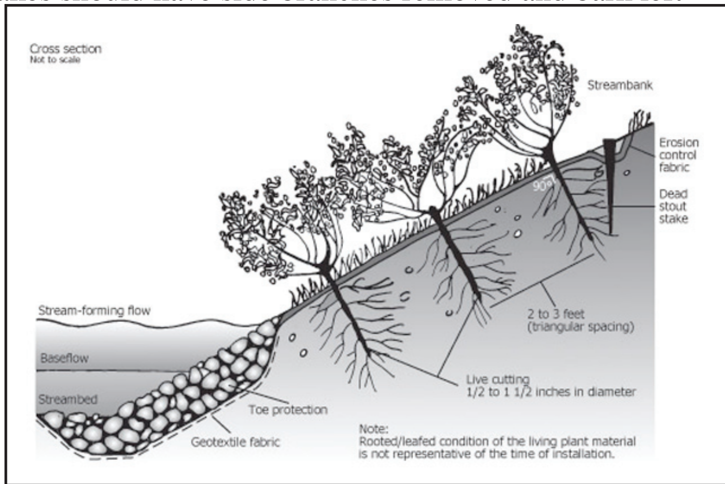
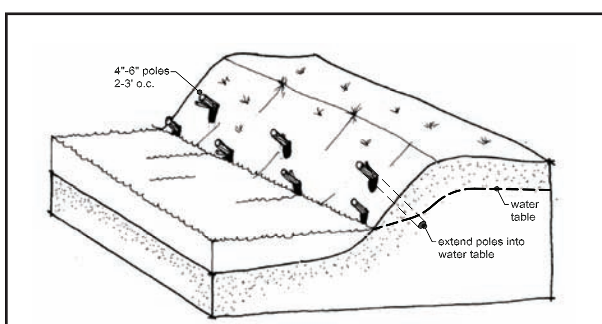


Figure 4.5.5b Installation of Pole Plantings

Illustration Courtesy of: USDA

- ◆ The distance to the water table effectively determines planting depth although erosive force of the stream at the planting site should be taken into account as well. The appropriate depth is generally 3 to 4 feet in most coastal areas. At least two buds should be left above ground after planting.
- ◆ Poles (hardwood cuttings or stakes), and have the advantage of being easier to install using a dibble stick. Dibble bars or sticks are soil augers used to "punch" holes for plant insertion. Manual or machine-assisted excavation may be necessary depending on the size of the poles, substrate type, and bank condition.
- ◆ Poles can be installed from the low water line up to, and into the terrace zone, even in relatively dry soil, so long as the cutting is long enough to reach the water table.
- ◆ Tops are normally cut square for easy tamping and basal ends should be cut at an angle to ease soil insertion. Cuttings should only be used in cohesive soil. Air pockets must be removed by adding soil and pressing firmly. (Figure 4.5.5.c)



Pole Planting

Figure 4.5.5.c - nts

4.5.6 Practice 6 - Brushlayering

Brushlayering is a technique where bundles of live tree branches are buried in parallel trenches excavated in constructed terraces or along existing contours of an eroding stream bank. When sprouted and rooted, the trees will stabilize the stream bank with a dense matrix of roots. This practice is usually applied to the splash and bank zones of a stream. Typically, a brush trench (see Practice 8) is installed at the top to filter overland flows. For severely eroded stream banks, toe protection such as log or rock revetment (see Practice 9) may be necessary. (Figure 4.5.6.a)

Figure 4.5.6a Initial Installation of Brush Layering
Photo Courtesy of: Phillip Williams and Associates

Installation

- Tree cuttings (most often Willow or Alder) should be harvested from a healthy, native stand of trees with no more than two-thirds taken from each plant. Cuttings should be ½ inch or larger in diameter to ensure enough stored energy for rooting.
- Cuttings are tied in bundles to ease transport to the project. The terminal bud should be removed to route stem energy to lateral buds for more effective root and stem sprouting.
- Soak the bundles for four to five days before planting.
- Dig a horizontal trench into the stream bank between the annual low and high water levels, about two to three feet deep with the back of the trench extending to the normal water table. The surface of the trench should be sloped 10 to 20 degrees so the outside is higher than the inside. (Figure 4.5.6.b)
- Cut the twine holding the bundles and place the cuttings in the trench. Be certain the cut ends reach the bottom of the trench. Spread the cuttings through the trench, keeping in mind that as a rule the thicker and denser the cuttings are, the better the treatment will work. (Figure 4.5.6.c)

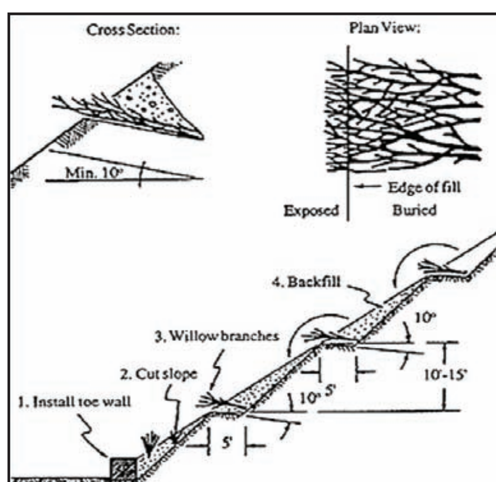
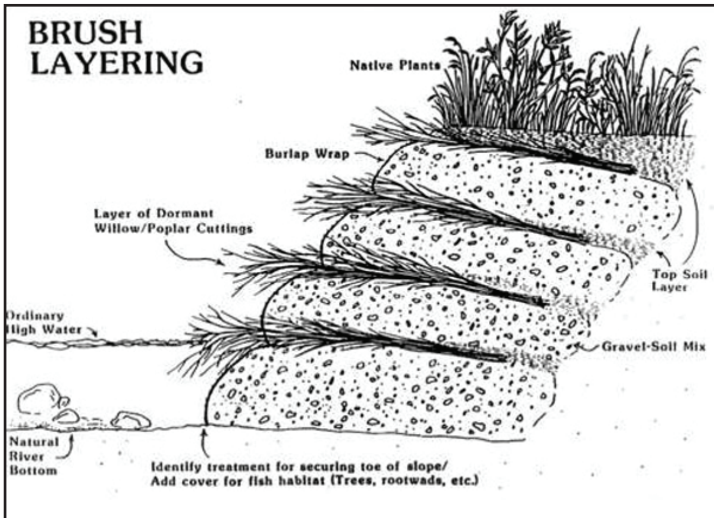


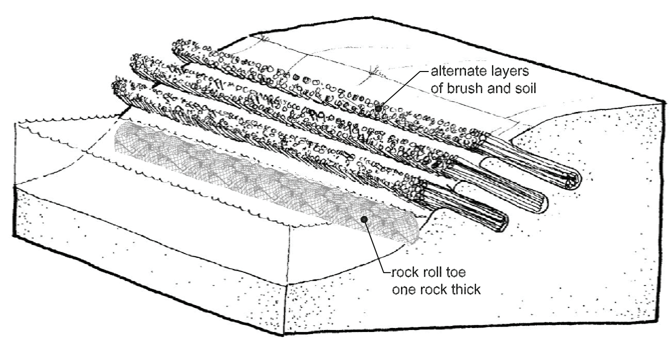
Figure 4.5.6b Installation of Brush Layering 1
Illustration Courtesy of: ianrpubs.unl.edu

- Create another terrace for cuttings behind the first layer. Repeat the layering and trenching process until the stream bank is sufficiently covered. (Figure 4.5.6.d)

4.5.7 Practice 7 - Contour Wattling/Brush Mattresses



Wattles and mattresses are thick layers of live branches that serve as barriers



Brush Layering with Rock Roll Toe
Figure 4.5.6.d - nts

against erosion. Sometimes referred to as fascines, wattles and brush mattresses, this practice can be applied along existing bank contours. The bundles are buried across the slope, parallel or nearly parallel to the stream and supported by stakes driven through the bundles and placed on the down slope. (Figure 4.5.7.a)

The interconnected stake structure when used on slopes provides protection from erosion due to downward water flow, wind action, and trampling by livestock and humans. Contour wattles and brush mattresses are also installed in combination with a coir fiber mats

Figure 4.5.7a Brush Mattresses Being Installed

Photo Courtesy of: NRCS

or rolls (see Practice 3). This holds slopes between the wattles in place without the development of rills or gulleys from overland flow. This practice is typically applied to the eroding bank and splash zones of the stream.

Installation

- Branches to be used are cut from live trees and kept moist until installation. The branches should be acquired and planted while dormant – either fall or early spring.
- The branches should be two
to three years old and 3 to 6 feet long. Basal ends are usually no more than 3.5 cm
in diameter.
- The branches are compacted into layers 10 to 15 cm thick held in place by woven or tie-wire.
- Planted perpendicular to the bank, the basal ends are set in a ditch at the bottom of the splash zone slope just above any toe protection. (Figure 4.5.7.b)
- Wedge shaped stakes up to 3 feet long are used to hold the bundles in place. The bundles are laid in the trench and the

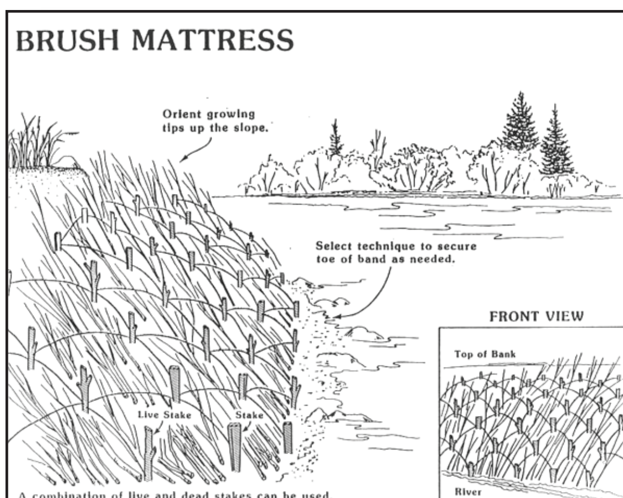


Figure 4.5.7b Installation of Brush Mattresses

Illustration Courtesy of: Tara? Matt?

stakes are driven into place and held down by a grid or web of galvanized annealed tie wire connecting the stakes. If the bundles are secured with woven wire mesh, the stakes can simply be driven through the mesh. Woven wire if used should be strong, welded, two to four inch mesh. (Figures 4.5.7.c-e)

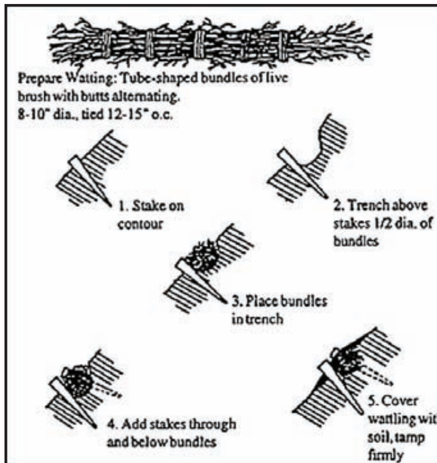
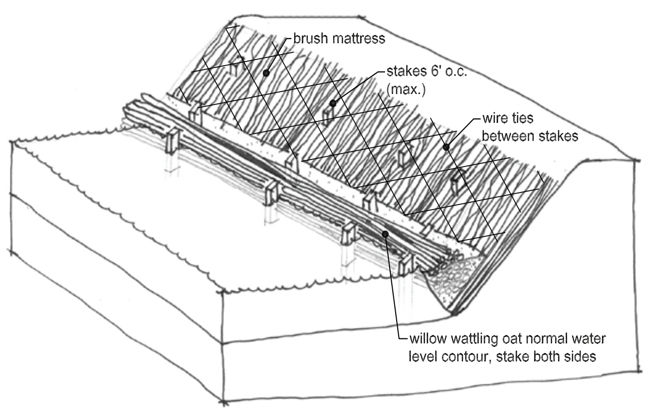
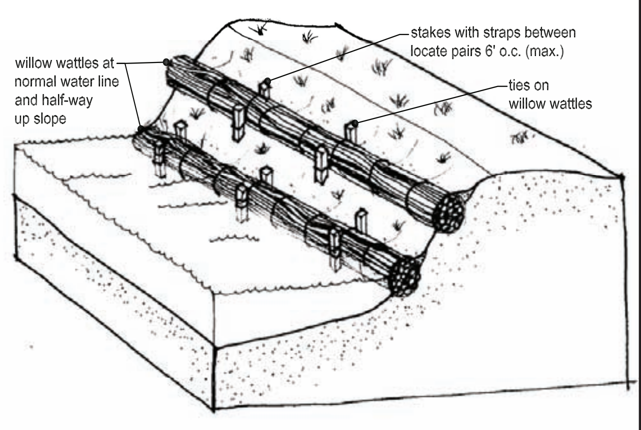


Figure 4.5.7c Installation of Contour Wattling

Illustration Courtesy of: ianrpubs.unl.edu



Brush Mattress with Contour Wattle
Figure 4.5.7.d - nts



Willow Wattles
Figure 4.5.7.e - nts

4.5.8 Practice 8 - Brush Trench

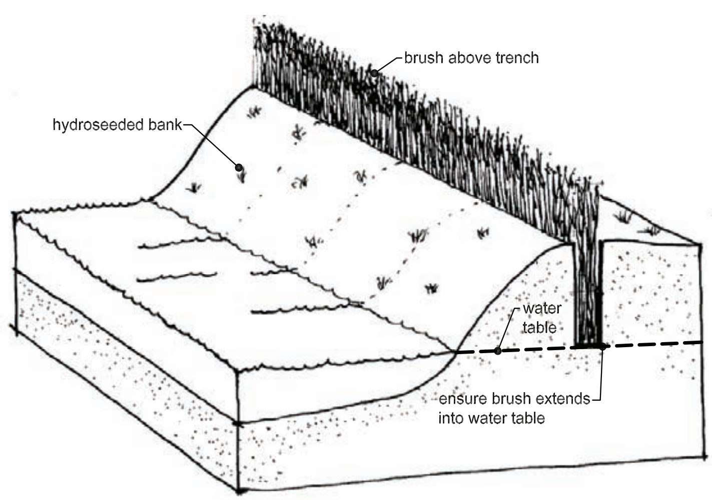
The brush fence is an effective method that filters runoff before it enters the stream. Essentially, a fence made of tree branches is installed along the top margin of the eroding stream bank, which intercepts incoming runoff. When sprouted and rooted, the wall of trees stabilizes the bank with a dense matrix of roots. This technique should be used in combination with toe and mid-bank protection such as wattles (see Practice 5) or log revetments (see Practice 9). (Figure 4.5.8.a)

Figure 4.5.8a Brush Trench with Willow Cuttings During and After Construction

Photo Courtesy of: DOT.state. mn.us

Installation

- Cuttings should be harvested from a healthy, native stand of mature trees with no more than two-thirds taken from each plant. Cuttings should be ½ inch or larger in diameter to ensure enough stored energy for rooting.
- Cuttings may be tied in bundles to ease transport to the project. The terminal bud should be removed to reroute stem energy to lateral buds for more effective root and stem sprouting.
- Soak the bundles for five to seven days before planting.
- Dig an 18 inch deep trench three to four inches wide and set back 12 inches from the top of the stream bank. Place the excavated material on the upslope side of the trench. (Figure 4.5.8.b)
- The depth of the trench should reach the capillary fringe of the water table for sufficient water to sustain planted cuttings.



Brush Trench

Figure 4.5.8.b - nts

- Cut the twine holding the bundles and place the cuttings in the trench. Be certain the cut ends reach the bottom of the trench. Spread the cuttings through the trench, keeping in mind that as a rule the thicker and denser the cuttings are, the better the treatment will work. A rule of thumb is that a bundle 8 to 12 inches in diameter will fill 1 linear foot of trench.
- Backfill the trenches with the excavated soil. To remove air pockets, water while backfilling the plants.

4.5.9 Practice 9 - Rock Rolls/Vegetated Gabions

This practice places rocks contained within wire mesh containers along the toe and splash zones to prevent bank washout and toe scour by diverting and dissipating high velocity flows. Small to medium size rocks are enclosed within rectangular or cylindrical wire-mesh baskets to form a structural toe or sidewall, which is embedded into the eroded (undercut) areas of the bank to create a stable stream profile. Live branch cuttings can be placed between each consecutive layer of baskets to consolidate the structure and bind it to the bank (see Practice 7). The baskets can be planted with native vegetation. Once mature, the vegetation will grow over the water providing a shady habitat for fish. (Figures 4.5.9.a and 4.5.9.b)

Figure 4.5.9a Tiered Installation of Rock Gabions

Photo Courtesy Of: Tostreams.org

Figure 4.5.9b Vegetated Tiered Gabions

Photo Courtesy Of: Tostreams.org

This method is usually combined with bioengineering techniques (see Practice 1) such as the re-grading of the slope and re-vegetation within and above the affected area. Where the bank is steep and needs moderate structural support, the treatment is quite effective. (Figures 4.5.9.c and 4.5.9.d)

Figure 4.5.9c Vegetation Taking Hold on Rock Gabion

Photo Courtesy Of: Tostreams.org

Figure 4.5.9d Willow Tree Growing from Gabion

Photo Courtesy Of: Tostreams.org

Installation

- Excavate to a depth of half the size of the gabion basket. In the case of severely undercut banks, the baskets may fit without excavation.
- Gabions can be ordered pre-assembled or they can be prepared and transported to the project site. To assemble a gabion, unfold hinged panels and form a rectangular basket which is then filled with rock and soil in proportion with stability requirements, generally increased rock for increased stability. The sides of the basket are connected with corkscrew spiral binders that securely stitch the panels together and form the corners of the basket. Preformed binders are used to connect adjacent vertical basket panels together. (Figure 4.5.9.e)
- Place gabions side by side along the eroded area of the banks while placing soil behind and between the baskets.
- Insert branch cuttings into and through the baskets into the bank substrate beneath, if possible. Add and compact

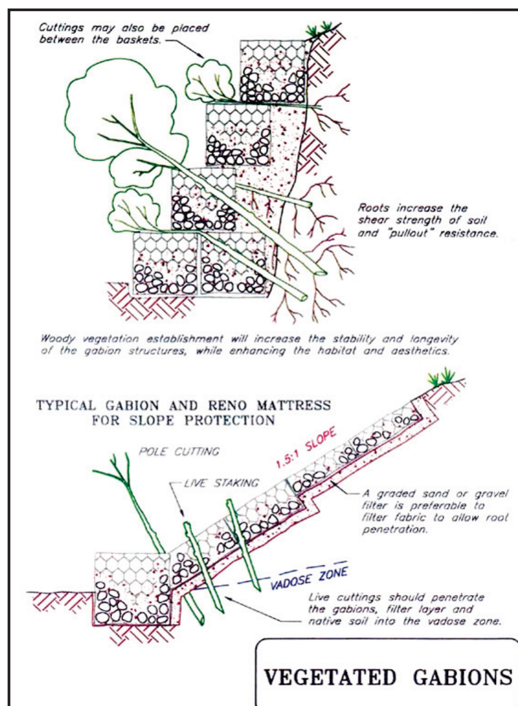
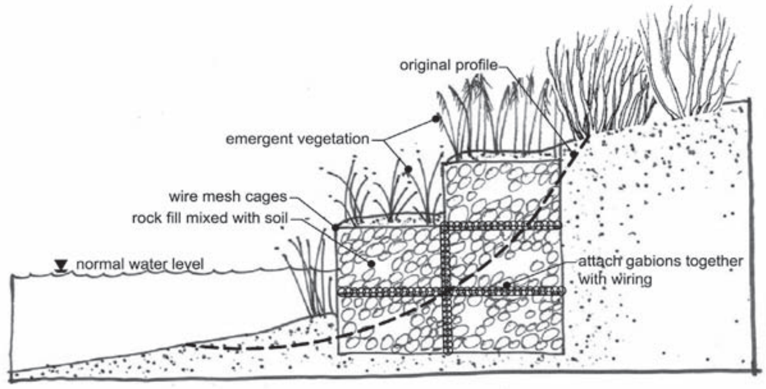


Figure 4.5.9e Installation of Vegetated Rock Gabions

Illustration Courtesy of: Salix Applied Earthware soil over cuttings to remove excess air pockets and secure cuttings in place. (Figure 4.5.9.f)



Vegetated Gabions
Figure 4.5.9.f - nts

- Starting at the toe zone, this method is repeated in layers until the desired height is achieved.
- Tiebacks must be installed at both upstream and downstream ends to ensure proper placement.

4.5.10 Practice 10 - Vegetated Cribwalls

With a natural appearance and effective protection, cribwalls are a useful practice in areas with near vertical banks where other options would be construction-intensive. The opportunity for quick establishment of bank vegetation is another positive benefit for the use of this practice. (Figure 4.5.10.a)

Made of untreated wood or timber, these hollow box-like structures are placed within eroded banks and filled with alternating layers of soil and live branch cuttings. The cuttings root and eventually replace the wood as a structural element.

Figure 4.5.10a Vegetated Cribwall
Photo Courtesy of: Phillip Williams and Associates

The treatment is resistant to high flow velocities and is effective on the outer perimeters of bends. The cribwalls are typically applied to the toe and splash zones of the banks where a low wall might be required to stabilize the toe and reduce steepness of the slope. Where stable streambeds exist, the treatment may be used above or below water level. Cribwalls can be used in conjunction with soil bioengineering methods that stabilize the upper bank and ensure a regenerative source of streambank vegetation. In moderate to high velocity conditions, a rock toe may be necessary to stabilize the crib structure. (Figure 4.5.10.b)

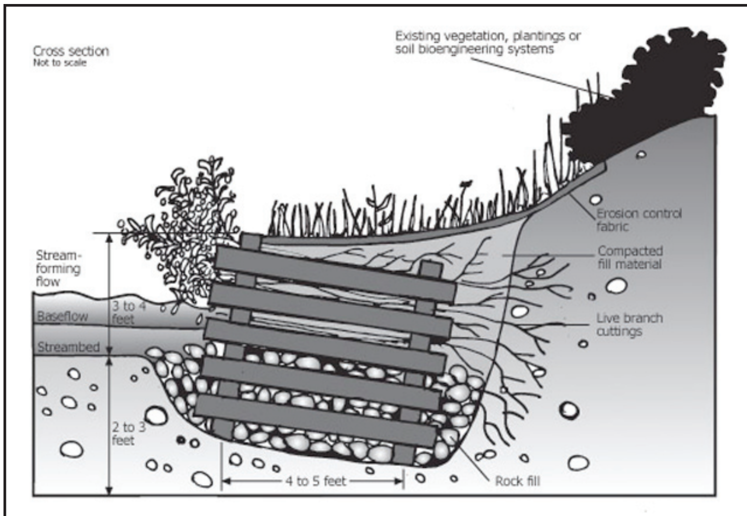


Figure 4.5.10b Installation of Vegetated Cribwalls

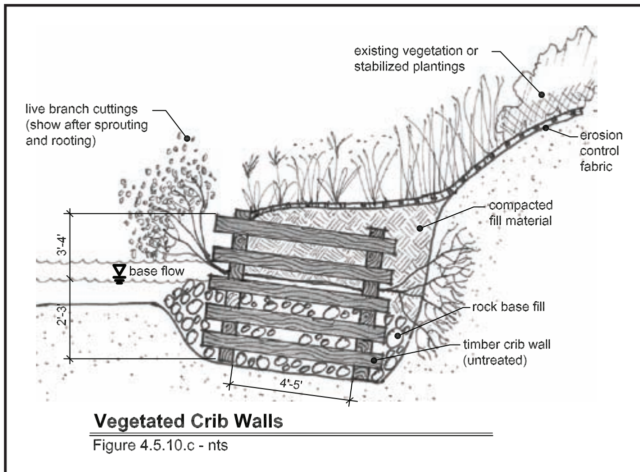
Illustration Courtesy of: USDA

Installation

- For best results, wooden timbers are placed parallel to and embedded in the streambank. The base timbers are placed within this toe trench below stream grade to prevent undercutting of the structure.
- Base logs should be as long as possible while conforming to the contour of the stream bank. The next series of logs ("tieback logs") is placed at right angles to the first log. The ends of each log overlap the right angle log below.
- Each log is secured in place by cutting notches in the wood. Holes can be drilled through the overlapping logs, and steel pins are used to hold them securely.
- Tieback logs, at least two per base log, are embedded into the slope 4 to 6 feet, at grade with the base log. Tiebacks can be secured to the base log using threaded rebar. Approximately halfway up the backside of the base log, geo-textile fabric is fastened to seal the bedding of the structure. Once the first row of logs has had tiebacks and geo-textile fabric installed, and has been backfilled to the top of the log, a second face log is placed on top of the tiebacks. This log is set back

approximately 6 inches from the previous. The same procedure is repeated until desired height is reached.

- The openings are then filled with live plant cuttings and soil for long-term bank support until the cribwall has degraded. (Figure 4.5.10.c)



4.5.11 Practice 11 - Revetments

For unstable, especially steep banks, more intensive structural measures may be necessary for adequate stabilization. Similar to cribwalls, log revetments are usually placed along the bank instead of inside of it and are often used as a load-bearing solution. Better than vertical concrete bulkheads, log revetments are placed along the natural contour of the bank providing periodic level areas for vegetation establishment. Essentially, revetments reinforce granular soils by confinement via a wall or "fascia" that can be an oversteepened and still facilitate the growth of vegetation. The logs themselves provide terraces that accumulate sediment and can support vegetation in the bank and terrace zones. In addition, the vegetated terraces provide overhang essential for fish habitat. This practice is used for unstable slopes with poor soils along medium to high velocity streams. (Figures 4.5.11.a and 4.5.11.b)

Figure 4.5.11a Stream Channel Before Log Revetment

Photo Courtesy of: rrnw.org

Figure 4.5.11b Stream Channel After Log Revetment

Photo Courtesy of: rrnw.org

In addition, various geo-synthetic options (high density polyethylene products) are available for supplemental use. These expandable honeycomb like structures give additional structural integrity and provide protection from future channel and bank erosion. This multi-layered technique is typically applied to steep bluffs (nearly vertical) with little or no vegetation. The sections of cells are placed in layers or terraces along the natural contours of the bank. These cells are filled with soil and planted for added stability. The web fascia is available in different colors, shapes, and sizes depending on the natural conditions of the site. (Figures 4.5.11.c and 4.5.11.d) These soil retention techniques are typically used on already eroded banks. In cases of limited space, backfilling may be necessary for installation.

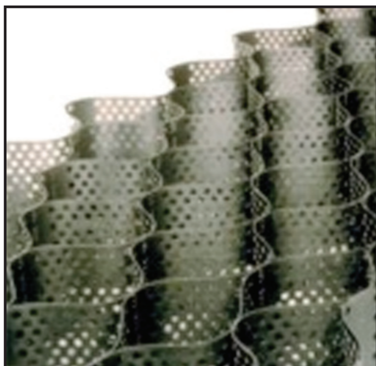


Figure 4.5.11c GeoWeb Material

Photo Courtesy of: Geocheminc.com

Figure 4.5.11d Installation of GeoWeb

Photo Courtesy of: Geocheminc.com

Both of these techniques, unlike concrete, do not impede the interaction of water with the banks (water moving freely through the structure's face). This permeability allows for crabs, insects, and fish to use these areas for breeding, feeding, and reproduction. (Figure 4.5.11.e and 4.5.11.f)

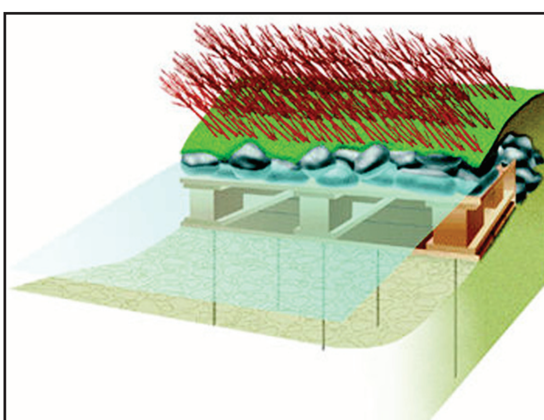


Figure 4.5.11e Fish Lunker Structure Installed

Photo Courtesy of: Collections.ic.gc.ca

Figure 4.5.11f Fish Lunker Structure

Photo Courtesy of: fmr.org

Installation

- Grade bank to stable slope and install coir mats for temporary stabilization. (Figure 4.5.11.g)
- Cut wooden timbers to the length of the eroded bank. Fallen trees can be de-limbed and used provided they are of sufficient length and in sturdy condition.
- Logs are stacked up the bank in an overlapped shingle-style with their ends facing upstream. The logs are kept in place by cables looped around the logs and fastened to “dead men” or helical anchors depending on the bank substrate.

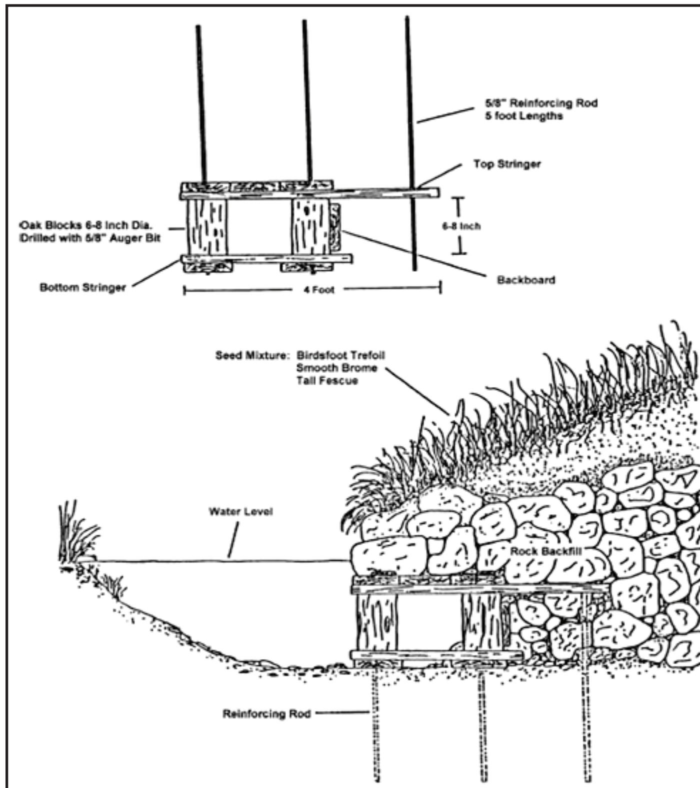


Figure 4.5.11g Installation of Fish Lunker Structure

Photo Courtesy of: Vetrano, 1988 Chesapeakebay.net

- Flood tolerant plants are then planted from the revetment shoreward.

4.5.12 Practice 12 - Bendway Weirs & Low Sills

In some cases, it may be necessary to slow or even divert the flow of a stream in order protect the banks from erosion, especially the outer banks along channel bends. Weirs and sills are basically obstructions that change the flow pattern and reduce the concentration of currents on the outer bank. Essentially, this practice creates an area of soil deposition before the weir and deeper pools found after the structure.

Built of logs, boulders or quarried stones placed across the channel and firmly anchored into the stream banks and bed if necessary, these structures can control erosion, accrete sediments, and create aquatic habitat in the form of permanent pools. (Figures 4.5.12.a and 4.5.12.b) Weirs are designed to intercept a large percentage of the flow and move the thalwag (the deepest section of the channel) away from the toe of the eroding bank. Once the high velocity flow vectors have been deflected away from the bank, less intensive practices such as coir mats and can be used on the streambank areas between weirs.

Figure 4.5.12a Wooden Weirs Stream Channel

Photo Courtesy of: Zeitlow.com

Figure 4.5.12b Stone Weirs in Channel

Photo Courtesy of: David Derrick, Landandwater.com

Installation

- Determine the stream channel geometry and velocity of flow at this location. Design the weir's cross shape and size to achieve the targeted flow pattern, sediment accretion rate, and velocity.
- Orientate the weir almost perpendicular (angled 10-20 degrees) to outgoing stream flow.
- The weir should be set level crested at an elevation low enough to allow normal unimpeded boat traffic over the structure.
- Weir ends should be keyed into the bank to ensure the stream does not migrate or scour around the structure.
- Resulting areas of sediment accretion along the banks should be planted as soon as formed. The plants, once established will further facilitate bank formation by slowing water causing more sediment to drop out and collect around the vegetation itself.

(Footnotes)

[1] The Practices described in this Chapter were derived in concept from *The Practical Streambank Bioengineering Guide, U.S. Department of Agriculture, Bentrup, Gary; Hoag, J. Chris, May 1998* and *Bioengineering for Streambank Erosion Control Manual, drafted by the U.S. Army Corps of Engineers, Waterways Experiment Station, 1977,* and adapted to fit representative stream bank conditions in the coastal region of Georgia.