CH. 4—STREAMBANK & SHORELINE STABILIZATION

Contents

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Introduction

Many waterfront developments feature homes, roads and buildings constructed along rivers, streams, and wetlands that are particularly susceptible to erosion over time.

Due to the potential loss of residences, businesses, and supporting infrastructure, stabilization measures are often necessary for the long-term preservation of the upland portion of the property.

Bank Erosion on St. Catherines Island. Source: Tara Merrill

Previous chapters highlighted land development and stormwater management strategies and their effectiveness in reducing land disturbance and impervious cover - both of which significantly degrade downstream water quality. This chapter provides non-structural and structural practices that stabilize and protect streambanks and shorelines from the negative effects of land erosion. For water quality purposes—bioengineering and non-structural practices using native vegetation are preferred over conventional "hard armoring" such as riprap, seawalls, and bulkheads.

The practices contained in this chapter are most often applied to freshwater streams and wetlands. However, many of the same practices can be customized to work in to tidal waterways as well, especially the upper reaches of tidal creeks that are protected from excessive wind and wave action.

Causes of Erosion

Erosion is a natural process by which soil is removed, transported, and deposited by the forces of wind, rainfall, waves, currents, and the rise and fall of sea levels (tides).

Basic Progression of Erosion from Wave Action

The pace of natural erosion is often accelerated by human activities. Residential, commercial, and recreational developments result in the clearing of vegetation and grading of soils compromising the stability of the land-water interface. Impervious surfaces associated with the built environment also increase the amount and velocity of stormwater runoff which contributes to the erosion of streambanks and shorelines.

A stabilized stream bank or shoreline is dependent on the balance between soil or sand supplied from the bank or transported along the shore, and sediments lost to erosion. The movement of sediments is essential to maintaining shorelines and deterring erosion. The velocity (speed and direction) of water determines the amount of sediment moved. Larger quantities and heavier sediments (sand) can be transported by larger waves or faster moving currents along the shoreline. Fine grained sediments (silts and clays) are generally transported to the deeper waters offshore while larger grained sands are deposited along the shoreline. Stormwater runoff, wave action, and boat wakes contribute to erosion by causing the slumping of unstable shorelines.

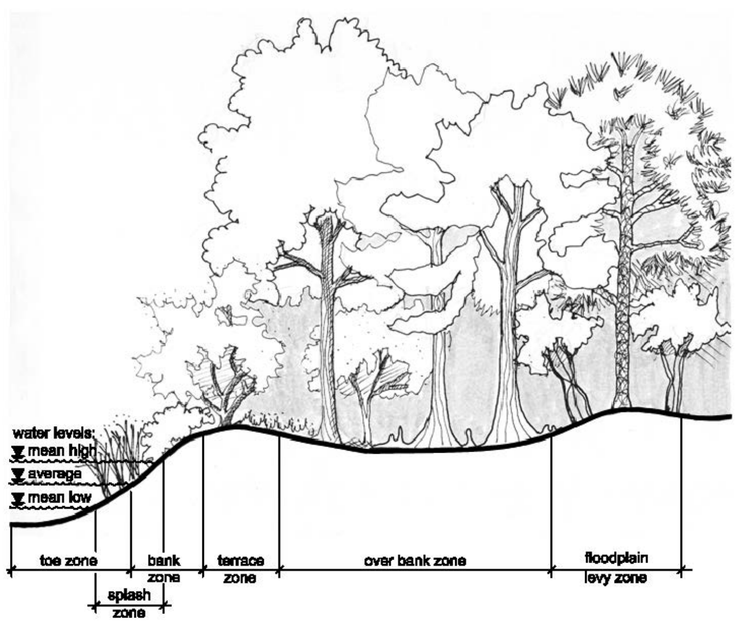
The amount and velocity of the water, the height and slope of a bank, and the amount of vegetation determine the amount of material eroded and deposited along the shoreline.

Stream Bank Zones

It is important to understand the different zones of the stream bank is important before prescribing appropriate stabilization or protective measures against erosion. There are four principal stream bank zones:

Toe Zone—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—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 Zones - Sketch by Matthew Baker, ASLA

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—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.

Streambank and Shoreline Stabilization Practices

Since all stabilization projects are unique—each with their own specific conditions to evaluate—it is important to consult with the Georgia Department of Natural Resources (DNR) and other experienced professionals to identify the actual source and cause of the erosion problem and recommend a solution specifically adapted to local conditions.

Typical Coastal Development with Structural Stabilization Measures (Bulkheads/Rip Rap Revetment). Source: Dr. Clark Alexander

This guidance document presents methods and practices contained in the following engineering manuals and guidance documents:

- *Streambank and Shoreline Stabilization Guidance*, GDNR-EPD, July 2007
- *Streambank and Shoreline Stabilization: Techniques to Control Erosion and Protect Property*, GDNR-EPD, Georgia Soil & Water Conservation Service, April 2011
- *Hydromodification Best Management Practices Manual for Coastal Georgia*, EPA, UGA-MAREX, Ecological Solutions, September 2009
- *Federal Stream Corridor Restoration Handbook*, USDA-NRCS, Revised August 2001
- *Engineering Field Handbook: Streambank & Shoreline Protection*, USDA-NRCS, December 1996
- *A Soil Bioengineering Guide to Streambank & Lakeshore Stabilization*, USDA-Forestry Service, October 2002

While it may be necessary to use structural means to control erosion, techniques which stabilize streambanks and shorelines while protecting the natural integrity of the stream and riparian corridor are strongly encouraged. For this reason, applicable practices are divided into three categories – *preferred*, *acceptable*, and *discouraged*. Preferred and Acceptable practices promote the use of:

- Bioengineering approaches including bank shaping and sloping practices that achieve stable banks,
- Native vegetation which slows runoff and diverts flow across the land surface to allow for infiltration and treatment of potentially polluted stormwater,
- Vegetation to stabilize the soil surface which reduces erosion and promotes sediment deposition/accretion,
- Integrated practices—combination of structural and vegetative stabilization measures—which preserve the stream under normal flow conditions and withstand the impact of substantially increased flows,
- Biodegradable materials that temporarily control soil movement and eventually disintegrate into humus, a media that allows for infiltration and air exchange which promotes the growth of plants,
- Environmentally-sensitive synthetics that provide permanent stabilization with the ecological benefits
- Vegetation to shade the water, which lowers the water temperature and increases its capacity to hold oxygen needed by aquatic animals to breathe.

Stabilization Options

(In order of preference)

Minor erosion with low risk →→ Maintain and/or enhance vegetation

Minor erosion with some risk →→ Non-structural practices including bioengineering

Major erosion with risk, natural buffers present →→Hybrid (combo of vegetative & structural)

Major erosion with high risk, natural buffers absent or not feasible→→Structural controls

Many of the bioengineered and non-structural practices recommended in this chapter can be applied to coastal erosion if adapted to withstand tidal hydrology and saline conditions (See Living Shorelines Section for additional design considerations). General application and installation information are provided for the following practices:

Preferred Practices - Non-Structural & Bioengineered Practices

- Bioengineering: Shaping & Planting Banks
- Natural Vegetation Establishment
- Live Staking
- Live Fascines/Brush Mattresses
- Brush Layering/ Branch Packing
- Temporary Reinforcement: Coir Rolls/Mats
- Permanent Reinforcement: Synthetic Solutions

Acceptable Practices - Integrated Practices

- ✓ Rock Rolls/Vegetated Gabions
- ✓ Vegetated Cribwalls
- ✓ Revetments
- ✓ Joint Plantings

Discouraged Practices - Structural Practices

- Rock Riprap & Rock Gabions
- Bulkheads & Seawalls

Preferred Practices – Non-Structural & Bioengineered Practices

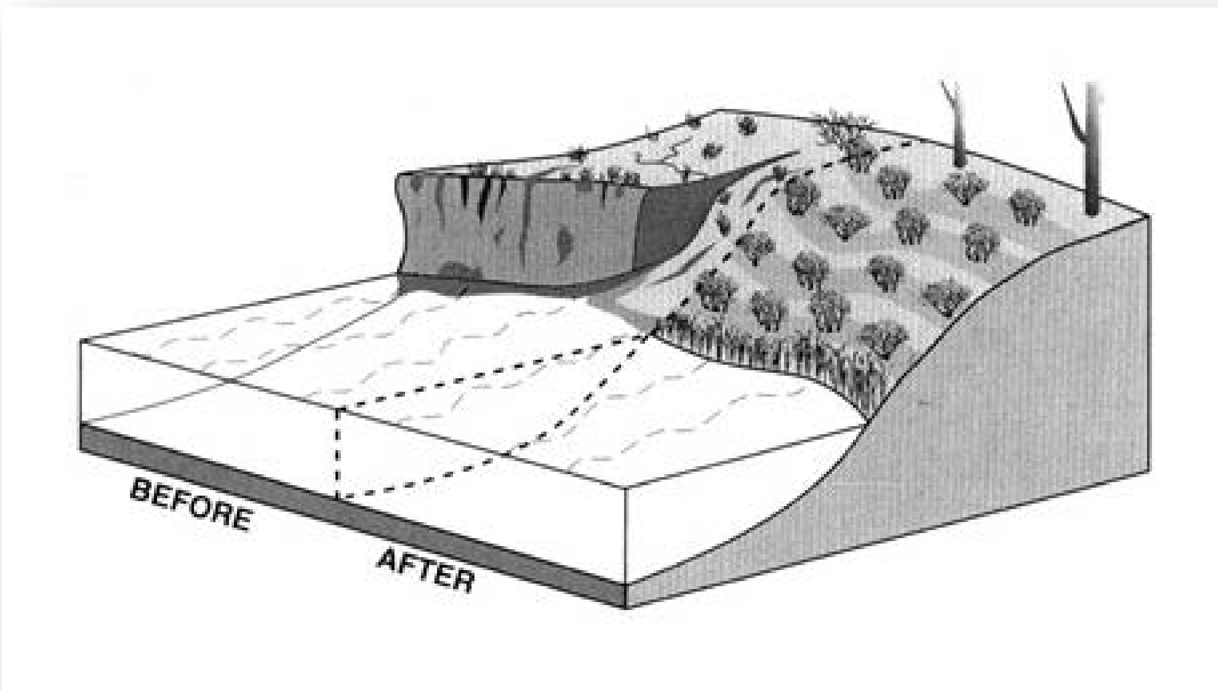
Preferred practices are non-structural techniques that employ bioengineering techniques using native vegetation. The establishment or restoration of native riparian vegetation can prevent erosion caused by rain, wind, or wave action, while preventing or treating against containments or excess nutrients. A healthy riparian corridor also provides food, shade, and cover for fish and wildlife.

Practice 1 - Bioengineering: Shaping & Planting Banks

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.

There are three basic steps to this method:

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



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.

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.

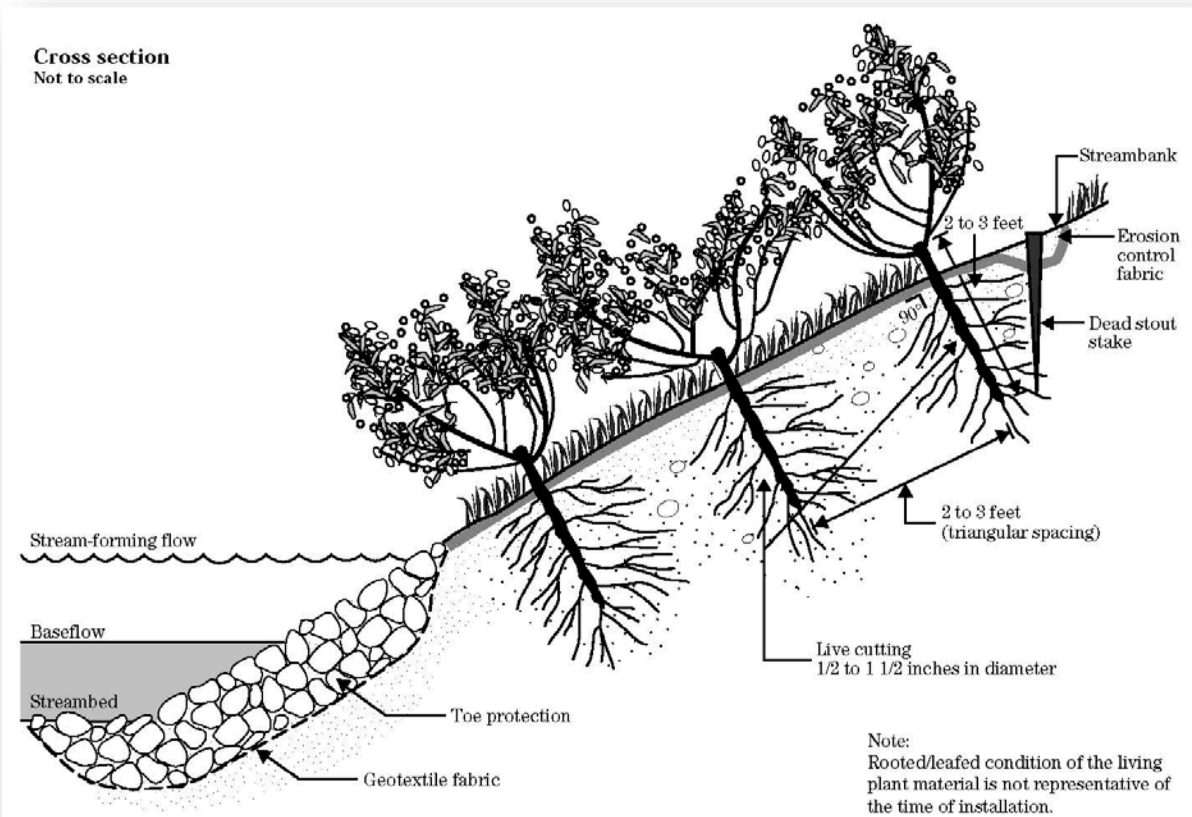
The re-establishment of vegetation can be accomplished by seeding, either by manual or mechanical application or by installing plant cuttings, rootwads, bareroot or containerized specimens. Hardy, fast-growing native species should be selected and planted close together for dense coverage once mature. 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. A list of native trees, shrubs, plants, and grasses can be found at the University of Georgia's Marine Extension website, www.coastscapes.org. Refer to EPD's Streambank & Shoreline Stabilization Guidance for recommended planting densities.

Practice 3 - Live Staking

Live stakes are an inexpensive, easy-to-install method for re-vegetating and stabilizing bank slopes. Sometimes known as “pole plantings”, 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 the water velocity must not exceed 5 feet per second (fps). When stream velocities are in excess of 5 fps, this method is generally used in the splash zone in combination with brush mattresses.

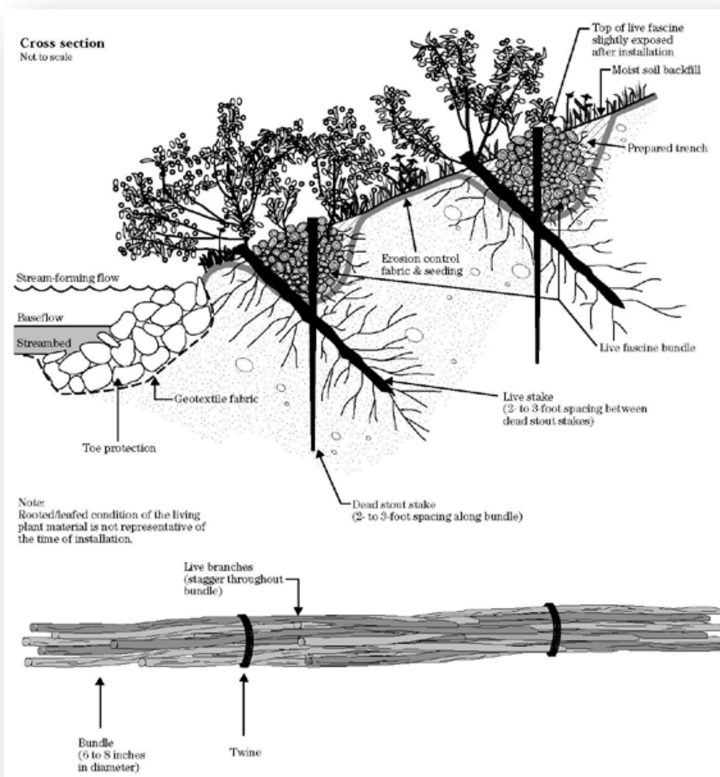
Live stakes provide habitat when used with such stabilization techniques as riprap, gabions, and log revetments. The stakes have tremendous tensile strength, which can enhance the strength and shear resistance of the soil. When incorporated into structural practices, live stakes can increase the strength 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.



Practice 4 – Live Fascines & Brush Mattresses

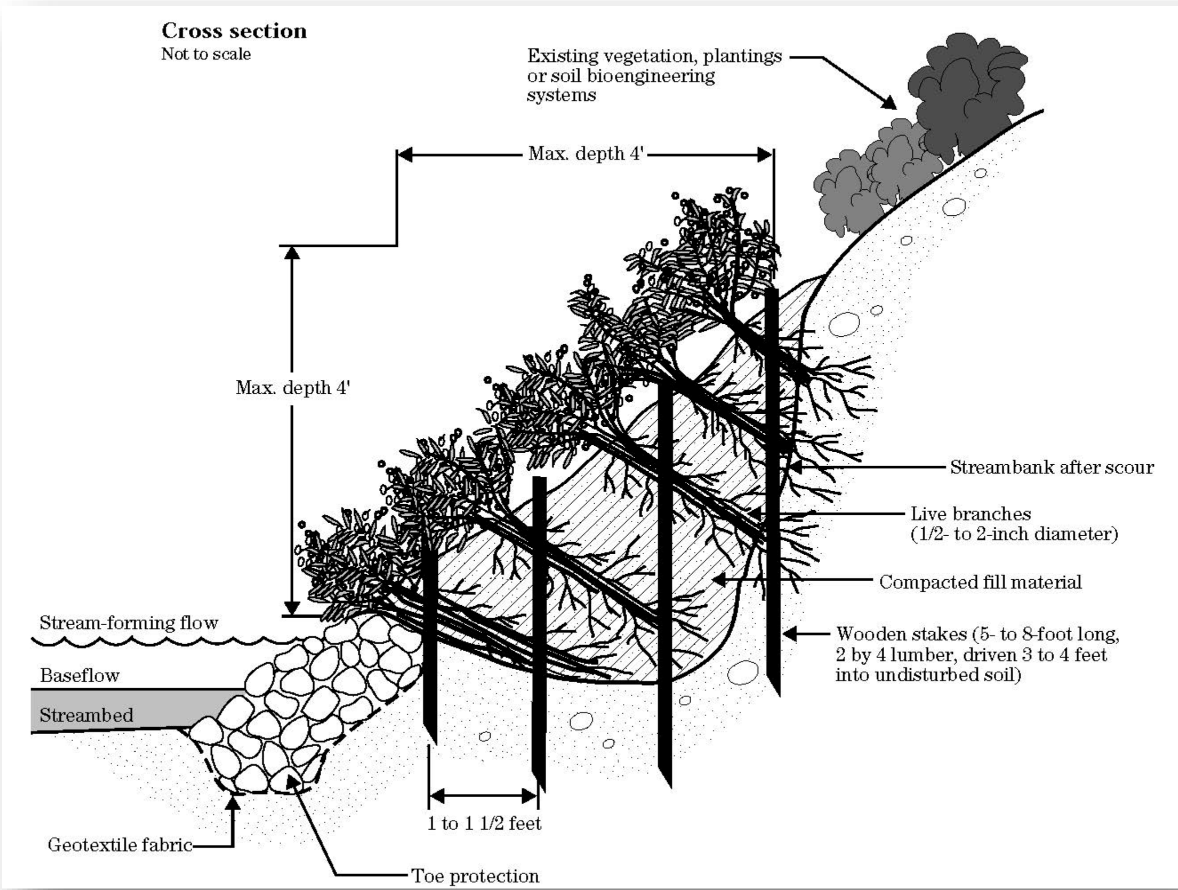
Fascines and mattresses are thick layers of live branches that serve as barriers against erosion. This practice can be applied along existing bank contours. The bundles are buried across the slope, parallel or nearly parallel to the stream and supported by stakes driven through the bundles and placed on the down slope.

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. Live fascines and brush mattresses are also installed in combination with a coir fiber mats or rolls (see Practice 6). 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.



Practice 5 – Brush Layering & Branch Packing

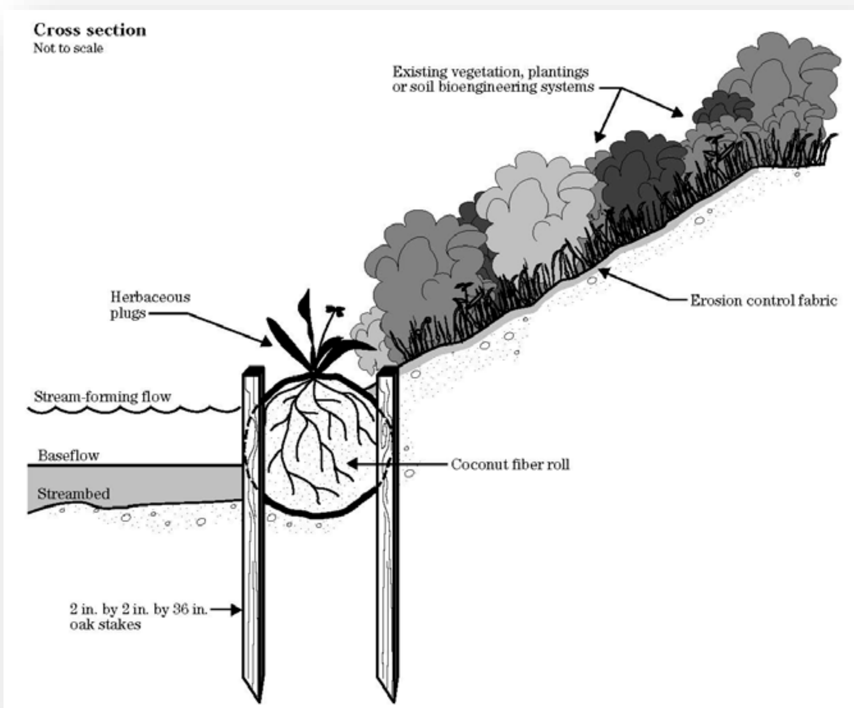
Brush Layering and Branch Packing are techniques where bundles of live tree branches are buried in parallel trenches excavated in constructed terraces or along existing contours of an eroding stream bank. When sprouted and rooted, the trees will stabilize the stream bank with a dense matrix of roots. This practice is usually applied to the splash and bank zones of a stream. For severely eroded stream banks, toe protection such as log or rock revetment (see Practice 10) may be necessary.



Practice 6 - 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. In addition to coir, several natural fabrics including jute, straw, and cotton also have high lignin content making them durable and versatile. 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 that can be 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.

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.



Practice 7 - 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.

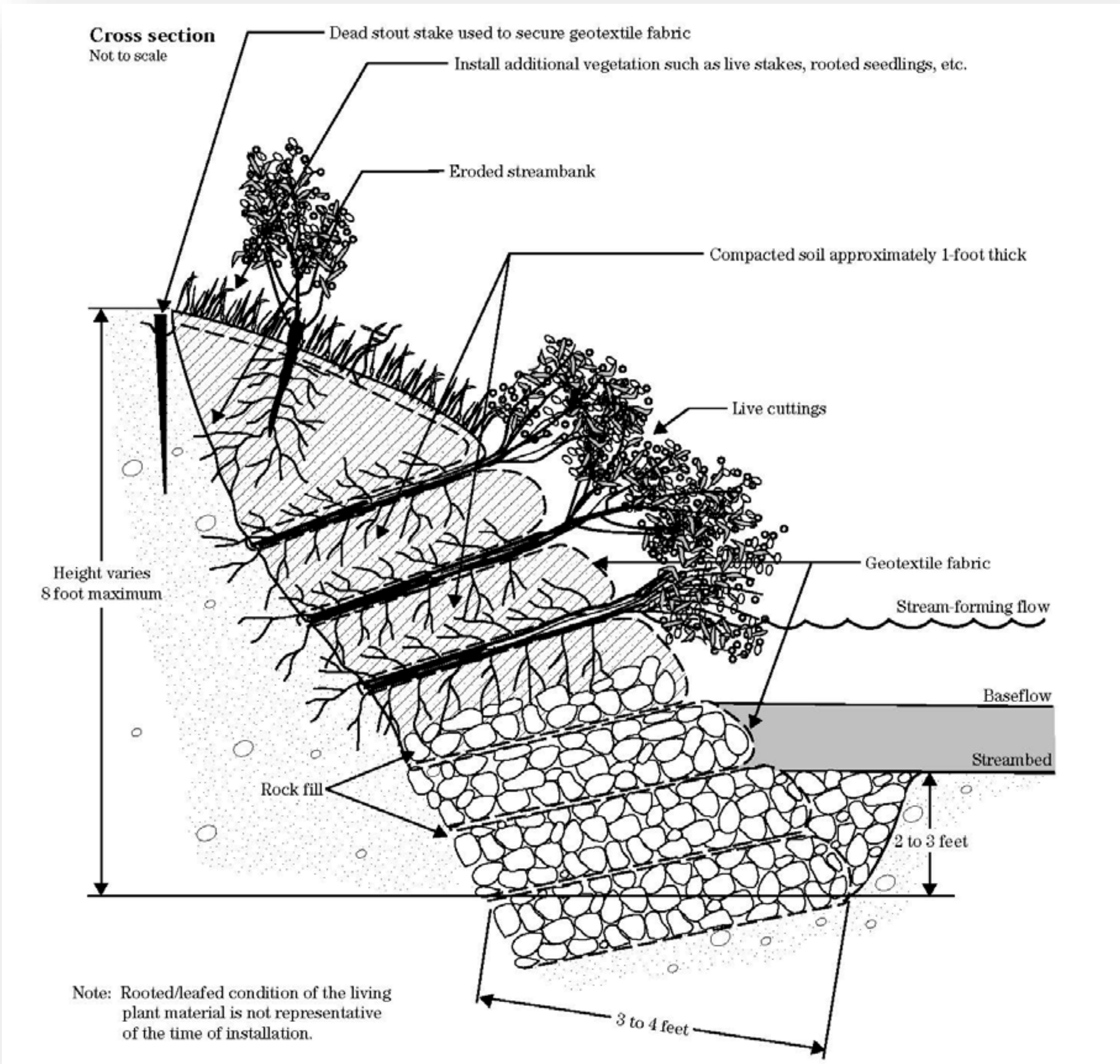
These three-dimensional, vegetated erosion reinforcement fabrics offer structural stability equivalent to a minimum of 12 inches of rock at approximately half the cost. These materials can have an effective lifespan of 4 to 50 years, depending on whether they are heavy weight and UV stabilized products. 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:

1. 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.
2. 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.

3. 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. The flexible grid permits a good, custom fit against the natural bank contours.



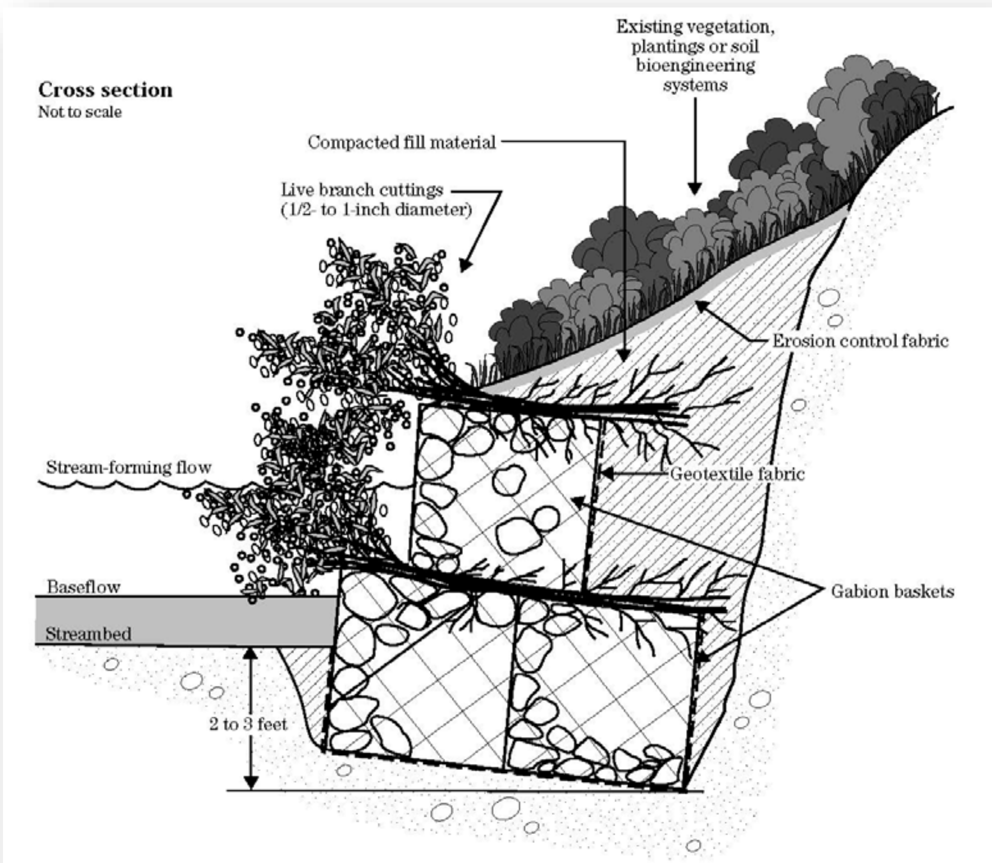
Acceptable Practices – Integrated Practices

These stabilization methods are integrated bioengineering practices combined with one or more structural component useful in areas with higher to moderate velocity flows and/or wave action. This approach is most often appropriate at the toe of the bank or shoreline to prevent additional bank slumping/failure. Structural components should be minimal and only used when necessary to ensure long-term success of stabilization efforts.

Practice 8 - 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 3). The baskets can be planted with native vegetation. Once mature, the vegetation will grow over the water providing a shady habitat for fish and other aquatic organisms.

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. This treatment is quite effective where the bank is steep and needs moderate structural support.

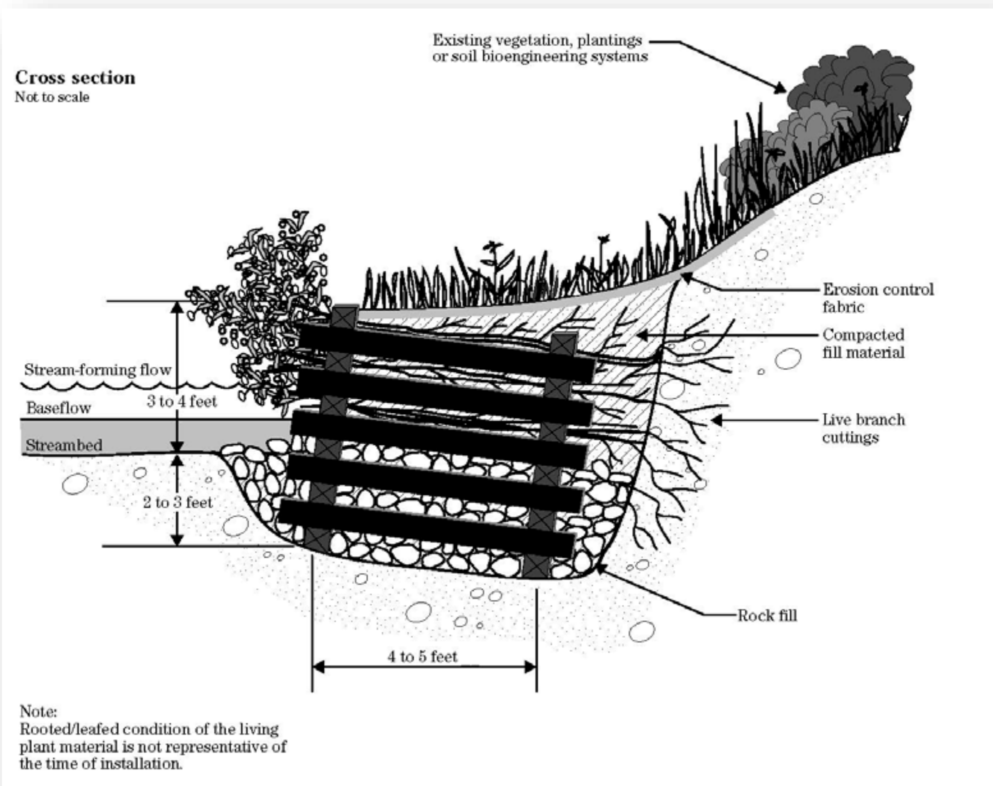


Practice 9 - Vegetated Cribwalls

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

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.

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 near vertical 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.



Practice 10 - Revetments

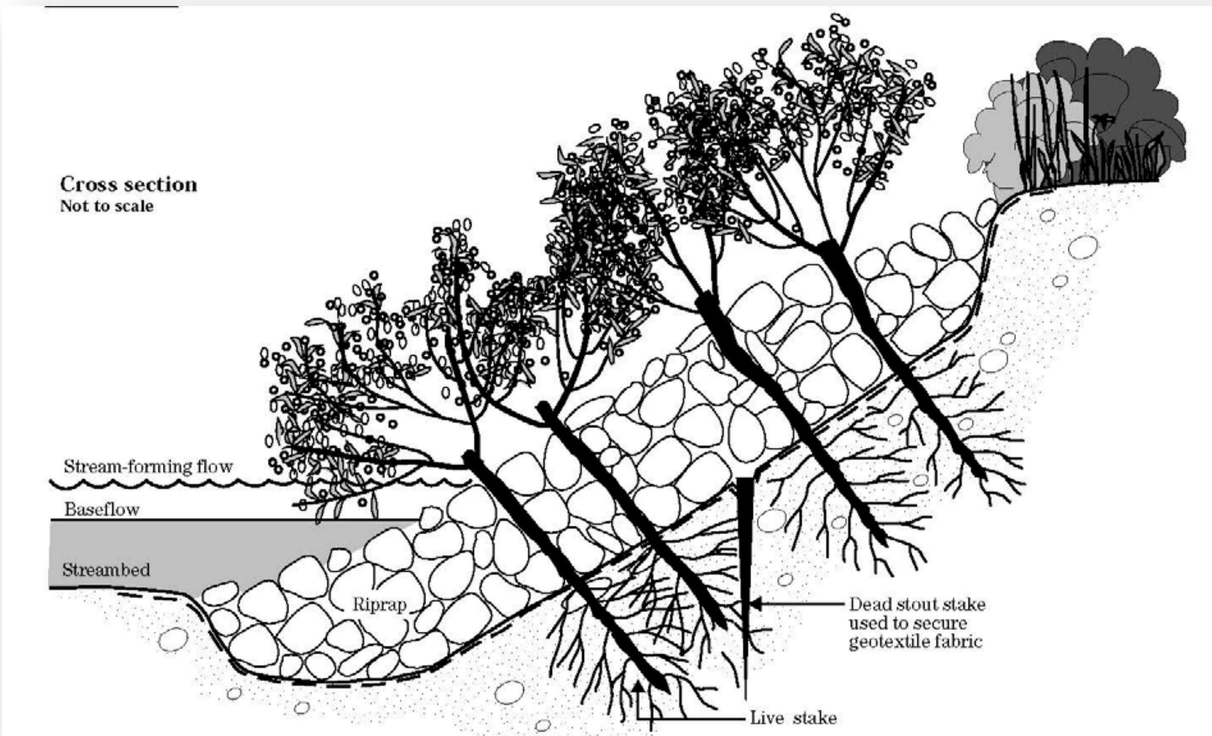
For unstable, especially steep banks, more intensive structural measures may be necessary for adequate stabilization. Similar to cribwalls, log revetments are usually placed along the bank instead of inside of it and are often used as a load-bearing solution. Better than vertical concrete bulkheads, 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.

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. These soil retention techniques are typically used on already eroded banks. In cases of limited space, backfilling may be necessary for installation.

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.

Practice 11 - Joint Plantings

Joint planting or vegetated rip rap involves tamping live stakes into joints or open spaces in rocks placed along the slope. Vegetation, especially deep rooting species planted above and immediately behind the rock will greatly increase the stability of the slope.



Discouraged Practices—Structural Practices

Much of the populated shorelines along the coast are modified with structures to prevent upland and developed property loss. These control structures are built to decrease or halt the erosion process in order to maintain coastal property or to aid in keeping channels or ports open and accessible. Structures are built both parallel and perpendicular to the shore. Structures parallel to the shore are bulkheads or revetments, and those perpendicular to the shore include jetties and groins. The following table shows the results of a survey conducted in 2010 by the University of Georgia Skidaway Institute of Oceanography.

Coastal Structures	Length (meters)	Number of Structures
Hardened Shoreline	212,229	3,161
Bulkhead	74,673	1,425
Revetment	118,375	1,558
Bulkhead and Revetment	7,010	122
Other	7,523	39
Undetermined	4,650	17
Causeway	137,170	494
Field Inspection Route	882,054	--

Over the past decade, there has been a movement to discourage structural practices along Georgia's coastal wetlands, waterways, and shorelines. There is a broad scientific consensus that armoring generally degrades the integrity of the marine ecosystem. Many fish and wildlife species require healthy intertidal habitats for food, migration, cover, and spawning. Structures that run parallel with the streambanks, such as bulkheads, can negatively affect the intertidal habitat by altering sediment composition and supply. Additional impacts (such as the removal of the riparian buffer or vegetation along the banks) can have negative effects on fish spawning habitats and shellfish beds. Additionally, riprap revetments, bulkheads, and seawalls often contribute to erosion in other areas by altering water flow and sediment deposition upstream and downstream of the affected area.

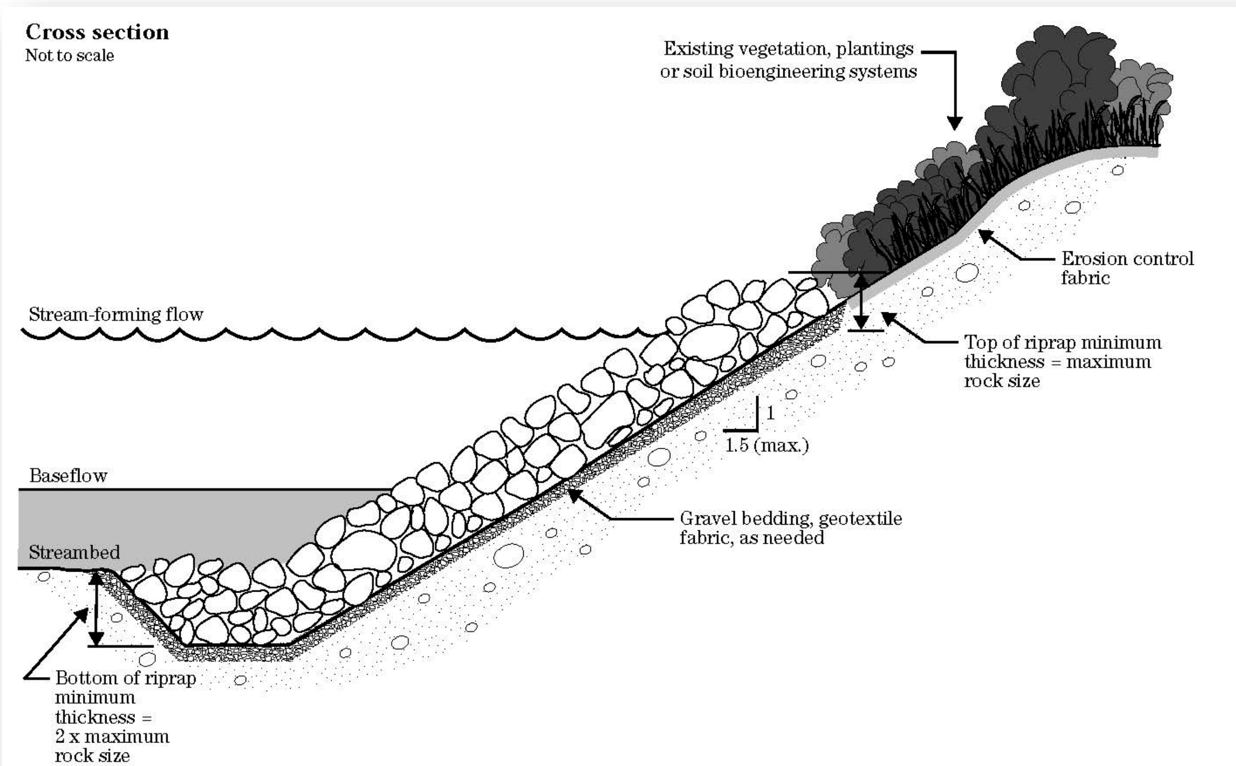
Since alternative practices are available and contractors are more familiar with alternative solutions, the use of hard armoring the streambank to control erosion should be avoided unless there are severe conditions that warrant the need for structural controls.

Practice 12 - Rock Riprap/Rock Gabions

Riprap stabilization designs should include appropriate bank slope and rock size to protect the bank from wave or current action and to prolong the life of the embankment. A final slope ratio of at least 1:2 (vertical to horizontal) is recommended, and a more stable 1:3 slope should be used when possible.

A layer of gravel, small stone, or filter cloth is placed under and/or behind the rock to prevent failure. In many cases, only the toe of the slope may need rock reinforcement; the remainder can be planted with native vegetation.

Rock gabions with vegetation are a more acceptable stabilization practice. See details for Practice 8 - Vegetated Gabions and Practice 11 for Joint Plantings.

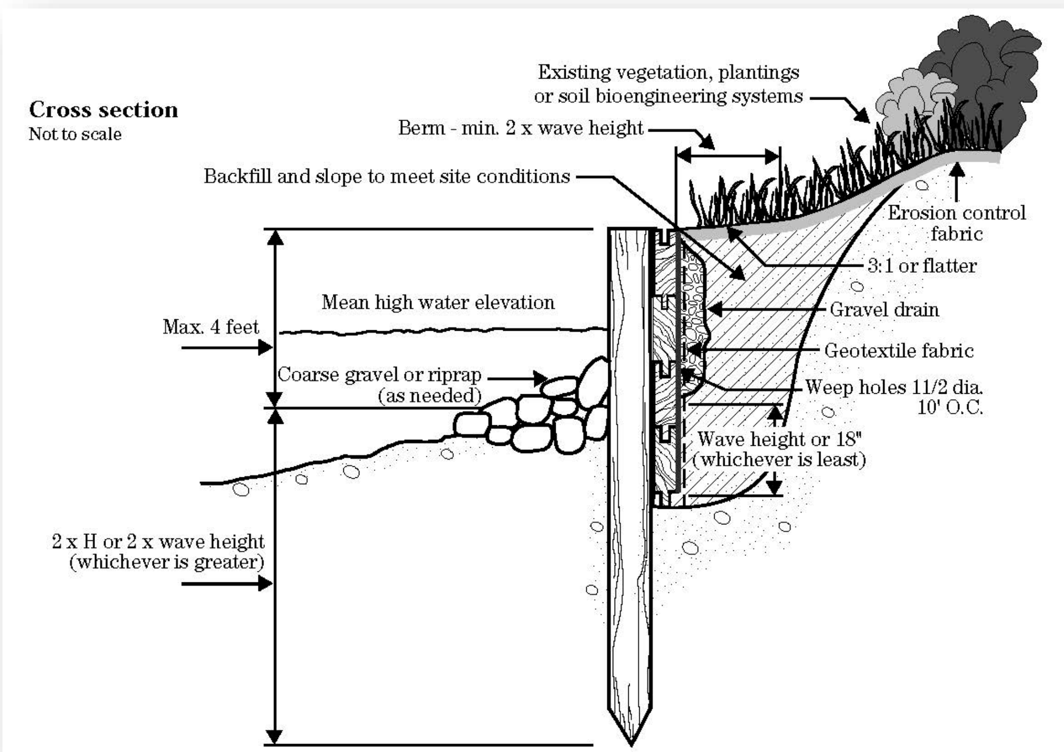


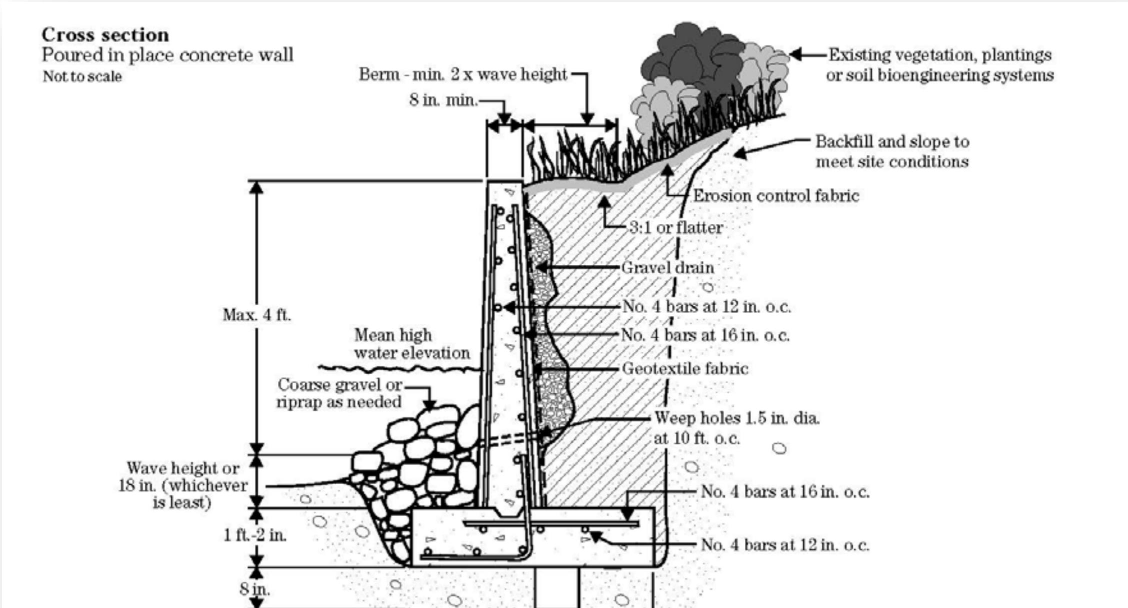
Practice 13 - Bulkheads & Seawalls

Bulkheads and seawalls are generally not encouraged. These structures (typically sheet steel, concrete, or wood) produce a sterile, vertical, flat-faced structure that is of little use to aquatic organisms and other wildlife. They also tend to reflect wave energy rather than dissipate it, usually resulting in erosion problems in front of the structure and elsewhere.

However, when erosive forces are severe and existing building foundations or structures are threatened, and other stabilization approaches would not be effective, a new or replacement retaining wall may be warranted. In these cases, rock should be placed at the toe of the structure to reduce the adverse impacted of reflected wave energy.

Typical Concrete Bulkhead Construction. Source: Dr. Clark Alexander





Typical Concrete Seawall, Source: Dr. Clark Alexander

Living Shorelines—Stabilization Practices in Tidal Waters

Many of the bioengineered and non-structural practices recommended in this chapter can be applied to coastal erosion if adapted to withstand tidal hydrology and saline conditions.

> ***Living Shorelines***
>
> A shoreline management practice that provides erosion control benefits; protects, restores, or enhances natural shoreline habitat; and maintains coastal processes through the strategic placement of plants, stone, sand fill, and other structural organic materials (e.g. coir logs, oyster reefs, etc).

When working in tidally-influenced waters and wetlands, additional factors to consider include:

- Salinity
- Full-sun exposure
- Tidal range
- Substrate type
- Elevation
- Slope
- Landscape position
- Fetch (exposure to wave action)
- Storm surge frequency

With the exception of wave action associated with seasonal storms (nor'easters) and infrequent hurricanes, the tide's twice-daily ebb and flow is by far the dominant physical process along the Georgia coast. Because of the concave shape of the shoreline and a broad, shallow continental shelf, wave energy is low with wave heights averaging from two to less than four feet at the breaking point. The average tidal range is just higher than six feet. Seasonal spring (biweekly) tides range up to ten feet and are the highest along the U.S. South Atlantic coast.

Gently sloping shorelines, beaches, and marshes are nature's best defense against erosion. A shoreline is better protected if there are shoals, tidal flats, offshore bars and/or a marsh near the shore.

Most tidally-influenced vegetation grows beneath mean tide level because the roots must be underwater at high tide but dry at low tide to survive. Source: Dr. Clark Alexander.

Wide, vegetated shorelines can withstand more wave action than narrow shores absent marsh grasses. Sandy beaches and vegetated marshlands prevent average high water from reaching upper areas of the shore. Firmly-anchored plants and stable substrates decrease the rate of erosion by breaking up waves and trapping sediment carried by currents along the shoreline. As this happens, the band of vegetation expands, pushing the mean high tide away from the toe of the bank and provides a dense band of energy-absorbing vegetation. Tidal vegetation also filters pollution from overland runoff in effect improving water quality.

Coastal marshlands serve as a transition zone between open water and land. Salt marshes and estuaries provide excellent habitat for many plant and animal species, several of which are of recreational and commercial importance.

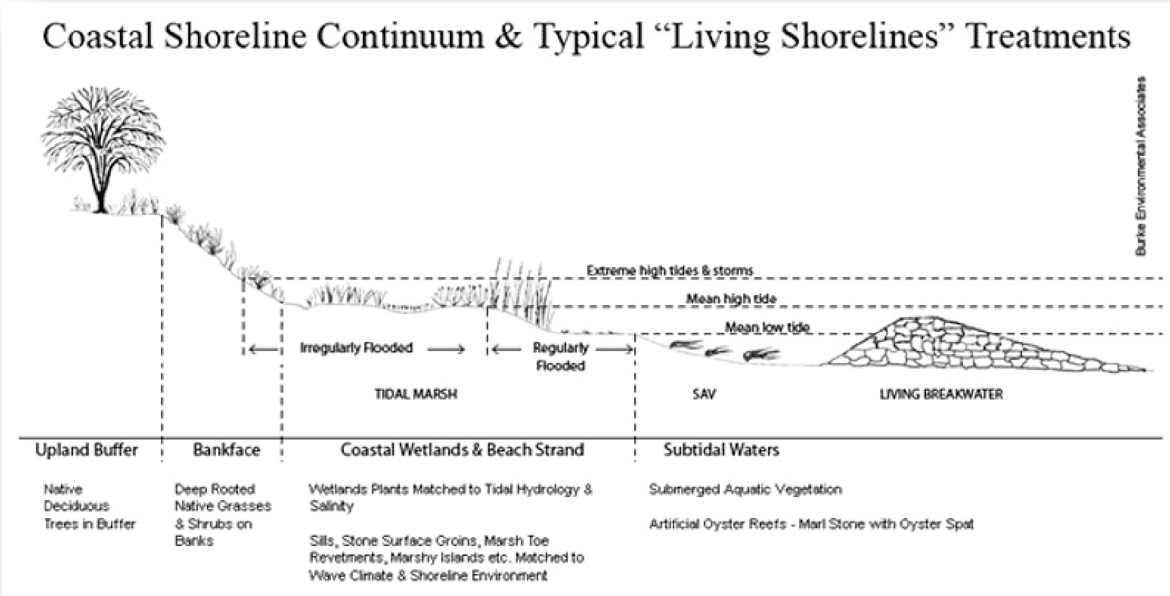
Changes in water level also have an effect on the amount and rate of erosion. Estuarine water levels are influenced by the seasons, tides, storms, droughts, floods and the rise of sea levels. Seasonal storms influence the level and movement of water, the intensity and direction of wind, and the patterns of erosion and deposition. Tidal marshlands also have the ability to protect property from hurricane damage by reducing storm intensity and resulting storm surge, which can be an added benefit for developers and homeowners.

> Living shorelines dissipate and absorb wave energy, promote the building of fringe wetlands and marsh, and provide a structure that is often rapidly colonized by a multitude of marine creatures, including oysters, barnacles, crabs, algae, shrimp, and fish. (Tidal Creek Project, 1997)

Planting a marsh along the shoreline (i.e. constructing a "Living Shoreline") can be an effective way of stabilizing the shoreline and enhancing the ecosystem. Living shorelines work best in areas with low wave action, gentle slope, and low boat traffic. Target areas include the upper reaches of tidal creeks, tidal coves, and other areas protected from excessive wind and wave action. Living shoreline projects utilize a variety of structural and organic materials, such as wetland plants, oyster shells, native substrate, and stone. Vegetative practices can be used in conjunction with bagged oyster shells or rock gabions to build marsh and protect the uplands from wind, wave, and boat actions. In an appropriate setting, this is the most economical procedure to use. Vegetative solutions are often less costly than structural measures and are an attractive way to preserve the coast of Georgia.

The following native plants will be the most successful in or around tidal waters due to their ability to withstand tidal conditions:

- False willow (Baccharis angustifolia)
- Silverling (Baccharis halomifolia)
- Saltwort (Batis maritima)
- Saltmarsh ox-eye (Borrichia frutescens)
- Saltgrass (Distichlis spicata)
- Marsh elder (Iva frutescens)
- Needle rush (Juncus roemerianus)
- Sea lavender (Limonium nashii)
- Annual glasswort (Salicornia bigelovii)
- Perennial glasswort (Salicornia virginica)
- Coastal dropseed (Sporobolus virginicus)
- Smooth marshgrass (Spartina alterniflora)
- Rough marshgrass (Spartina cynosuroides)
- Cord marshgrass (*Spartina patens*)



Living Shorelines Diagram. Source: NOAA Office of Habitat Conservation

The main objective of shoreline stabilization is to reduce the energy of waves striking the eroding bank. Non-structural design options are most suitable in very low energy settings with minor erosion, minor wave action, and good growing conditions. Areas subject to moderate to high wave energy may require a combination of vegetative and structural controls such as stone revetments and bulkheads to provide long-term protection.

Coastal wetlands function as valuable, self-maintaining "horizontal levees" for storm protection, and also provide a host of other ecosystem services that vertical structures do not. Tidal marshlands reduce the need for shoreline armoring through wave energy attenuation and shoreline stabilization that reduces flooding, erosion, and protects the shoreline. Investing in the maintenance and restoration of coastal wetlands can be a cost-effective, multi-beneficial solution to shoreline erosion.

Local Case Study—Sapelo Island, Georgia

Hardened shorelines have been identified as priority threats to marine system habitats in the St. Mary's-Satilla-Cumberland Island Estuarine Complex (DeBlieu *et al.* 2005). Likewise, banks that have been stabilized with riprap or bulkheads can, in certain instances, exacerbate erosion on adjacent properties. Extensive armoring along shorelines prevents wetlands from migrating and river morphology from shifting naturally with climatic changes such as sea level rise.

Volunteer installing bagged oyster shells and marsh plantings. Source: Jan Mackinnon

In 2010, Sapelo Island National Estuarine Research Reserve—with the help of Georgia Department of Natural Resources, University of Georgia Marine Extension, and many private citizen volunteers—applied alternative living shoreline methods along the Ashantilly and Long Tabby Creeks. The practice consisted of a combination of structural controls (bagged oyster shells and rock gabions) and bank re-vegetation (planted *Spartina* marsh grass). The goals of the project are to study the feasibility of alternative techniques and determine the level of effectiveness (shoreline protection and ecosystem function enhancement) of alternative methods.

In order to measure the success or failure of the Sapelo projects, both Ashantilly and Long Tabby sites are monitored on a semi-annual basis. The following information is collected and recorded:

- Aerial Extent of Oyster Reef Habitat
- Fixed Benthic Faunal composition: Oyster, Mussel, Barnacle Density
- Extent of Marsh Vegetation
- Vegetation Composition: # of Plants, Stem Densities/Height
- Basic Water Quality Data: Salinity, Temperature, Dissolved Oxygen


Ashantilly River - Before & After Stabilization. Source: Jan Mackinnon

To date, the alternative techniques have been effective in stabilizing the banks from erosion, filtering upland runoff, and providing marine habitat. Living benthic fauna (oysters, barnacles, and mussels) has colonized a majority of the structure as well as planted and volunteer marsh grasses and other herbaceous vegetation has re-established along the top of banks.

Sea Level Rise

Traditionally, developers, engineers and landowners have focused on practices that address past and present conditions. More recently, they are increasingly faced with planning for future circumstances—namely sea level rise. Since one of the major effects of sea level rise (SLR) is shoreline erosion, many of adaptive responses are aimed at physically protecting the land immediately inland of the tidal creek or shore with what are commonly known as *streambank/shore protection* strategies. There are currently three main categories of strategies being implemented in coastal Georgia—soft and hard engineering practices as well as strategic and/or planned coastal retreat (i.e the process of moving the built infrastructure inland to accommodate for upcoming changes).

Soft practices entail engineered solutions that reshape the landform, but largely allow for natural processes to continue unimpeded by structural controls. Soft engineering strategies include beach renourishment, dune construction, salt marsh and estuarine wetland restoration, and the establishment of living shorelines. Collectively, these strategies can range from relatively simple to extremely complex and highly engineered designs but are based on the principle that the opportunity for long-term streambank or shoreline stabilization is best accomplished through preserving, creating, or enhancing natural systems. Soft stabilization measures include the sloping and shaping of banks and vegetation establishment, both of which promote land accretion. Wetlands created as a result of this process will provide more effective protection against future sea level rise as well as flooding caused by major hurricanes and storms.

By contrast, hard engineering structures (bulkheads, seawalls, and revetments) do not allow for natural migration of streambanks and shorelines and often prohibit the natural establishment of stabilizing vegetation. Since these structures are fixed in place, there is a growing concern that on-going maintenance and future retrofits necessary to keep up with the pace of rising sea levels will render these strategies as impractical from a logistical and economical standpoint. Additionally, once these structures are installed, critical aquatic habitat is often degraded or permanently lost.

For these reasons, G3 encourages soft engineering solutions and/or planned retreat options as preferred alternatives to address long-term sea level rise impacts.

Regulatory Permitting Information

Activities in or near rivers, streams, or wetlands may require permits from local, state and/or federal agencies. A brief summary of different permit types follows; however, you should contact the appropriate agencies before beginning any stabilization activities. Some of the activities associated with stabilizing eroding banks and shorelines along streams, ponds, canals, and other waterbodies may require permitting through the United States Corps of Engineers and the Georgia Department of Natural Resources. Maintenance of existing structures may also require permitting. The following applicable laws and regulations should be considered when applying streambank/shoreline stabilization practices.

- ✓ Section 404 of the Clean Water Act (federal)
- ✓ Section 10 of the Rivers and Harbors Act (federal)
- ✓ Georgia Water Quality Control Act (state)
- ✓ Erosion and Sedimentation Act of 1975 (state)
- ✓ Coastal Marshlands Protection Act (state)
- ✓ Shore Protection Act (state)

Please note that this is not a comprehensive list, and there may be other federal, state, or local laws and regulations that may need to be reviewed prior to undertaking an activity associated with bank stabilization projects.

- Discharge of dredge or fill materials (impacts) within waters of the United States are regulated and require permit authorization by the U.S. Army Corps of Engineers (USACE) under Section 404 of Clean Water Act. Streams (intermittent and perennial), open waters (including canals), ephemeral drainages, and forested wetlands are considered “waters of the United States.”
- Impacts to navigable waters of the United States require authorization under the Section 10 of the Rivers and Harbors Act. Navigable waters of the United States are defined as tidal waters and waters that have been used in the past, are now used, or are susceptible to use as a means to transport interstate or foreign commerce up to the head of navigation.
- Most waters of the State of Georgia require a 25-foot stream buffer and a variance from the Georgia EPD if the 25-foot buffer is encroached upon (unless the activity is specifically exempt). Exceptions to the buffer requirement include warm water ephemeral streams, wetlands, and stream reaches with a bulkhead or seawall. Although it is not mandated by the State, G3 recommends a 100-foot vegetated buffer for all State waters.

- A Coastal Marshlands Protection Act (CMPA) permit is required for any project which involves removing, filling, dredging, draining, or otherwise altering any coastal marshlands.
- A State Revocable License is permission from the State to use publicly owned lands lying below the ordinary high water mark. Required for permanent or temporary activities that would impact tidally influenced waters, salt marshes, intertidal areas, mud flats, or tidal waterbottoms in Effingham, Long, Wayne, Brantley, Chatham, Glynn, Camden**,** McIntosh, Bryan, Liberty, and Charlton Counties**.**
- A State Water Quality Certification is required for most USACE Clean Water Act Permits and Rivers and Harbors Act Permits. This enables the State to review federal permits to ensure the State waters quality standards are met.
- A Shore Protection Act Permit is required for any activities involving shoreline stabilization structures, piers, boardwalks, crosswalks, as well as building structures and supporting infrastructure within the Shore Protection Jurisdictional Area.
- State Buffer Variances and local permits such as Land Disturbance Permits may be required by the local municipality for land-disturbing activities in close proximity to wetlands and waterways.

Federal Regulations

In conducting maintenance/stabilization work around jurisdictional waters and dredging of canals, often the ultimate goal is to reduce erosion, improve water quality, and restore channel function. However, despite the benefit to water quality, resource managers should consider whether the proposed maintenance or enhancement to a jurisdictional area is considered an impact or regulated activity.

The following are generally not considered to be impacts:

- Activities that do not disturb bed and banks of the stream or open water feature.
- Activities that do not result in dredge or discharge of fill materials to that jurisdictional water.
- Regular maintenance of a stormwater management facility.

Regulated impacts will likely occur in the following situation:

- Construction activities that reinforce or protect stream banks with hard materials such as riprap, revetments, and structures.

- Maintenance to a stormwater management pond or facility that has not been maintained and as a result has developed a dominance of wetland vegetation and soils.

**The regulatory line along non-tidal water features (streams, canals, lakes, etc) is referred to as the ordinary high water mark (OHWM). OHWM is defined as the line corresponding to physical indicators of normal flow. Examples include shelving, break in slope, changes in soil texture or substrate size class, destruction of terrestrial vegetation, and a line of debris or wrack.

**The regulatory line (typically the mean high tide) along tidal waters and shorelines must be verified by the Georgia Department of Natural Resource (DNR) Coastal Resources Division (CRD).

The USACE has a variety of permit options to authorize impacts. The size and type of impact typically dictates the type permit that is applied:

- Nationwide Permits,
- Regional Permits,
- Individual Permits, and
- Letters of Permission.
- Minor impacts such as most impacts associated with bank stabilization activities are typically authorized under nationwide or regional permits, which applies to a number of general activities that impact jurisdictional areas. For larger, more complex projects, an Individual Permit may be required.

The Army Corps of Engineers (USACE) has jurisdiction over freshwater wetlands and waterways within all coastal counties. For more information on USACE permitting, visit http://www.sas.usace.army.mil/.

State Regulations

In addition to federal permitting through the Corps of Engineers, there may also be additional permits to obtain from the Georgia Department of Natural Resources (Environmental Protection and Coastal Resource Divisions). The EPD requires a 25-foot buffer on all waters that have wrested or removed vegetation as a result of normal stream flow or wave action resulting in a clear demarcation between the channel and adjacent vegetative growth (GAEPD 2006). Any encroachment into this protected buffer must be approved through the issuance of a Stream Buffer Variance. Preferred and acceptable stabilization methods typically have a shorter regulatory processing period whereas discouraged practices undergo additional agency review and require mitigation for impacts.

Land-disturbing activities one acre or greater are subject to the NPDES State General Permits for Storm Water Discharges associated with Construction Activities. In some counties and municipalities, the local issuing authority has jurisdiction over the issuance of this permit. For more information on EPD permit requirements, please refer to http://www.gaepd.org.

Local Regulations

In addition to the State buffer variance requirements, the local issuing authority may have buffer requirements regarding encroachment or restrictions on percent impervious cover beyond the State-mandated 25-ft buffer. Also, depending upon the County in which the project is located, the Local Issuing Authority may have additional requirements that exceed the NPDES State General Permits for Storm Water Discharges associated with Construction Activities.

Regulatory Contacts

U.S. Army Corps of Engineers Savannah District 100 W. Oglethorpe Avenue Savannah, GA 3140 (912) 652-5279/5770	U.S. Fish and Wildlife Service Southeast Region 1875 Century Blvd, Suite 400 Atlanta, GA 30345 (404) 679-4000	Georgia DNR - Coastal Resources Division One Conservation Way Brunswick, GA 31520 (912) 264-7218
Georgia DNR - Environmental Protection DivisionWatershed Protection Branch 4220 International Parkway, Suite 101 Atlanta, GA 30354 (404) 675-6240	Georgia DNR – Historic Preservation Division 254 Washington Street SW Atlanta, GA 30334 (404) 656-2840	Local Governments (City or County Building Permit/Regulatory Services)