Solutions for Shoreline Erosion

A Basic Guide to Bioengineering

Ontario

CATARAQUI REGION CONSERVATION AUTHORITY

Mississippi Valley Conservation

Quinte CONSERVATION

Raisin Region Conservation Authority
Office de protection de la nature de la région Raisin

RIDEAU VALLEY CONSERVATION AUTHORITY

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Partners:

Ontario Ministry of Natural Resources

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What is Shoreline Erosion?

Soils along the shorelines of lakes, rivers and streams are gradually weathered, displaced and deposited by various forces including wind, water, ice, and gravity.

Although erosion is a natural process, it can be dramatically accelerated by changes in land use, such as removal of shoreline vegetation. Without the presence of a healthy vegetated buffer, shorelines have reduced resistance against erosion, potentially resulting in a loss of habitat, soil stability and land.

What is Bioengineering?

Bioengineering is the combination of engineering techniques using natural materials and structures to stabilize soils. It is often used as a means of repairing/remediating shorelines from the effects of erosion with the intent of minimizing the overall impact to the environment. The end goal is a self-repairing shoreline that stabilizes soils, minimizes erosion and contributes to healthy habitat. Various bioengineering solutions are available depending on site specific conditions (slope, wave/water energy and soil composition).

Planting material

Coir fabric installation

Why Consider Bioengineering?

Conventional methods, while potentially effective, may offer only a temporary fix to a dynamic problem.
Bioengineering:

- is low maintenance and self-repairing
- is cost-effective compared to conventional methods that need regular maintenance
- addresses a variety of contributing causes of erosion
- promotes good habitat value for fish and wildlife, while still addressing the issue of shoreline erosion
- can be less invasive compared to conventional erosion control methods

While the use of bioengineering methods to remediate shoreline erosion is beneficial, it may not always be an appropriate course of action if site-specific conditions limit the potential for this approach.

Eroded shoreline with exposed roots and soil

Bioengineering & Your Shoreline: Planning Considerations

A shoreline is a dynamic system, with complex ties to both the terrestrial and aquatic environment.

Each property's shoreline is unique. Site conditions such as waterfront access, erosion type/source, soil type, existing vegetation, prevailing winds, wave action, fluctuating water levels and growing conditions need to be considered in your bioengineering project planning.

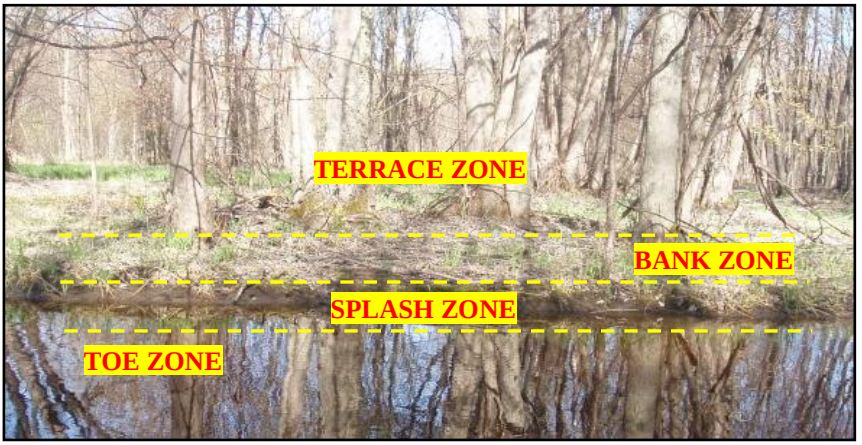
1. Shoreline Dynamics

Shorelines are made up of four zones that are subject to a number of natural and human-made erosive forces.

Table 1. Bioengineering by shoreline zones

Zone Type	Description	Erosion Source Example
Toe Zone	The bank portion between the lake/stream and the average water height	Boat wakes
Splash Zone	The bank portion which falls between the average range in high and low water levels	Ice movement/scour
Bank Zone	The section above the normal high water level	Mowing to water's edge/removal of vegetated buffer
Terrace Zone	Inland portion from the bank zone	Lack of upland vegetation

Allen, H & Leech, J.R. – Bioengineering for Stream Bank Erosion Control *U.S. Army Corps of Eng.*



Various bank zones

2. Causes and Types of Erosion:

Table 2.Common sources and causes of shoreline erosion

Erosion Type	Description
 **Sheet**	• The impact of rain or runoff from upland areas moves and displaces soil
 **Wave Action**	• The wearing away of bank materials due to the impact of wave action along the shoreline • May be natural or human-influenced (i.e., boat wakes)
 **Undercutting**	• The displacement of shoreline material within the toe/splash zones in which the bank is cut out from underneath, leaving an open gap. • Can be scoured out by ice movement
 **Slope Failure**	• Once bank stability has been compromised through loading and/or undercutting, the bank may collapse/slump, washing sediment and debris into the waterway
 **Rill/Gully**	• Periodic drainage paths which extend from inland to the shoreline, cutting into banks and washing sediment into the waterway

3. High Water Mark (HWM):

- The usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land.
- Shoreline alterations below the HWM have the potential to damage aquatic habitat.
- Identifying the HWM allows for a reasonable determination of where special precaution must be taken when modifying the shoreline (e.g., sediment control measures and extent of work needed).

4. Accessing the Site for your Project:

- Steep slopes and/or weak soil stability may not allow for the use of heavy machinery, regardless of the initial design plan.
- Precautions must be taken to prepare the site against possible environmental damage, and ultimately minimize the impacts to adjacent lands and the waterway (i.e., siltation).
- Site preparation will often require the selective removal of vegetation, but should be done in a manner which permits for rapid restoration.
- When removing vegetation, it is best to leave the root systems intact, removing only the portions which may impede the work environment.
- By preventing disturbances to larger vegetation (i.e., trees, large shrubs) and utilizing a single point access route, damage to the site can be minimized.

5. Soil Types:

Soil characteristics (i.e., drainage) determine the types of trees and shrubs that are suitable for your shoreline.

- Silts and sands are generally considered easily erodible, while finer clay soils are more resistant to erosive forces.
- Soils such as leda clays are well known for their rapid transition between seemingly solid to liquid states, potentially resulting in slope failure.
- In general, soils with high organic matter content are less erodible.

Table 3. Common soil classifications and their related properties

Soil Type/Class	Description	Bioengineering Considerations
	Granular soil structure that drains quickly	Sand is easily erodible and displaced and its sole use in projects should be avoided
	Moderate sized soil particle	Is highly erodible and well known for its impact on waterways (siltation)
	Smallest soil particles	Erosion rate varies based on the soil structure. Some clays have high resistance against erosion and others have low resistance (i.e., leda clay)
	Mixture of silt, clay, sand and organics	Most ideal soil composition for use in bioengineering as it offers a suitable growth medium and relatively strong soil cohesion

6. Slope:

- The stability of a slope is related to its steepness and soil type, which will ultimately determine the bioengineering options/methods used on your site.
- If the bank profile has been highly eroded, grading must take place to ensure that vegetation remains rooted.
- Sand will remain stable up to an angle of approximately 30º, whereas clay and silt can resist movement at much steeper angles.
- Based on the compositions of the soils present, the overall slope characteristics will need to be adjusted to complement the soil properties.

In order to depict bank steepness, the banks can be classified into two steepness profiles:

- High bank (1:1 slope ratio / ~ 45 º)
- Low bank (3:1 slope ratio / ~ 18 º)

Low Bank Example

High Bank Example

7. Aquatic/Terrestrial Transition – Ribbon of Life:

The goal of shoreline erosion protection is to ensure that an appropriate undisturbed buffer is maintained or incorporated into your design.

- The naturalized portion of the shoreline, which closely borders the waterway, is referred to as the buffer zone.
- This zone represents the transition between aquatic and terrestrial habitat.
- The buffer provides habitat to local plant and animal communities, protects sensitive organisms from sunlight and heat and protects water quality by filtering out contaminants.
- This portion of the shoreline provides habitat for fish and wildlife for feeding, reproducing and resting.

- Shoreline vegetation provides natural resistance against erosion, reinforcing soils stability through complex root structures.
- Larger buffer zones have a greater ability to protect the shoreline from degradation.
- With periodic maintenance and monitoring, bioengineering techniques have been shown to successfully promote the reintroduction/maintenance of these self-sustaining environments.

8. Landowner Goals

- Aesthetics

- Waterfronts are sometimes altered for aesthetic purposes, despite the resulting negative implications to the natural environment.

- Access/Use

- Removal of natural vegetation degrades the shoreline and waterway making it more susceptible to erosion.

- Reducing Erosion

- Loss of the upland buffer typically leads to the loss of soils and sediment in the water and can negatively impact fish and wildlife.

- Maintaining a Healthy Shoreline

- The use of fertilizers has the potential to reach the waterway and harm aquatic species and habitat

Habitat friendly approaches:

- Allow for a healthy vegetated buffer between upland mowed lawn and waterbody.
- Allow for a moderate access area (15 meters or 25 percent of the waterfront, whichever is less)
- Utilize floating/seasonal docks or walkways that use a single point of water access to minimize shoreline disturbance.

9. Vegetation/Plant Selection

- Choose native plant varieties which promote biodiversity and are suitable to the shoreline environment.
- Herbaceous plants (grasses and wildflowers) increase the overall fertility of the soil.
- Woody shrubs (dogwoods/willows) possess complex root structures that work to stabilize soils.
- In general, projects with the greatest diversity of plants tend to be the most successful (i.e. using both herbaceous and woody shrubs).
- Plants are typically cut fresh and installed during their dormancy. When dormant, plants are more resistant to the stresses associated with transplanting.

Differences in root structure between natural shrubs with long roots (left) and ornamental grasses with short roots (right).

Bioengineering Approaches/Techniques

Method: Live Crib Wall

Log walls with live vegetation placed between the seams of each layer and often utilized when bank grading is not possible.

Slope Type: low or high bank profiles
Erosion Type: undercut, sheet, rill/gully, slope failure
Pro: protection for both toe and bank zones
Con: higher development and labour cost over other bioengineering approaches

Method: Brush Mattress

Layers of live cuttings staked into upper banks as a means of stabilizing soils and establishing riparian vegetation.

Slope Type: low or high bank profiles
Erosion Type: undercut, sheet, rill/gully, slope failure
Pro: provides immediate protection
Con: effective on upper slopes but not as effective on lower banks

Method: Coir Logs

Coconut/synthetic fibers bound together into a cylindrical structure and placed along the shoreline to absorb wave energy and allow vegetation to establish.

Slope Type: low bank profile
Erosion Type: undercut
Pro: bundles are flexible and capable of molding to the shoreline
Con: not suitable for high flow or shear stress areas

Method: Planting

Planting of riparian vegetation along the shoreline to promote soil structure.

Slope Type: low or high bank profiles
Erosion Type: undercut, sheet, rill/gully
Pro: relatively low cost with little environmental disturbance
Con: can not be used in all situations (i.e., soil type, extreme shade)

Method: Planting/Riprap Combination

Planting of riparian vegetation along shoreline with stone/rock placed on lower banks for stabilization.

Slope Type: low bank profile
Erosion Type: undercut, sheet, rill/gully, toe
Pro: protection for both the toe and upper bank zones
Con: typically requires heavy machinery for re-grading purposes with moderate disturbance to the environment

Method: Live Staking

Live cuttings are staked into the bank to stabilize the shoreline, allowing for the re-establishment of riparian vegetation.

Slope Type: low or high bank profiles
Erosion Type: undercut, slope failure
Pro: versatile technique, little environmental disturbance, low cost, good early stage solution
Con: does not provide immediate protection (ie., Requires about two years to establish)

Method: Soil Wraps

Live cuttings divided between layers of staked soil wraps, graded to create a stable bank and re-establish vegetation growth.

Slope Type: low or high bank profiles
Erosion Type: undercut, slope failure
Pro: capable of stabilizing steep slopes
Con: complex and relatively expensive technique compared to other bioengineering approaches

Method: Fascine / Brush Mattress

Bundles of live cuttings staked and secured into the bank to create a stable platform for vegetation growth and stable soils.

Slope Type: low or high bank profiles
Erosion Type: undercut, sheet, rill/gully
Pro: offers both sediment and erosion control with minimal disturbance to the environment
Con: may be restrictions on in-water work

Costs of Bioengineering

In general, shoreline work carried out using naturalized approaches and concepts can have an overall economic benefit over more traditional erosion control methods (ie., rip-rap, armour stone).

Some of the costs associated with bioengineering include:

- Specific site attributes (i.e., slope, access)
- Scope of project
- Availability/source of materials
- Equipment needs/available access
- Labour costs

While there is an initial cost for establishing this naturalized approach, the costs of bioengineering can be minimized by:

- Using native plants/vegetation
- Recruiting volunteers for labour
- Carrying out work at times when other construction activities are not as prevalent
- Applying for financial assistance through stewardship programs
- Long term sustainability and therefore reduced maintenance costs

Contacts & Approvals

Before starting your project, ensure that you contact the following agencies to gain the necessary permits and approvals. It is the responsibility of the proponent to secure any other permits/ permissions from other Federal, Provincial, and Municipal agencies.

Conservation Authority – Provincial Legislation

If you are planning to do any work near a lake, river, stream or wetland, you may require approval from a Conservation Authority (CA). Through the direction of your local conservation authority, the project may undergo review and refinement, with specific consideration made for minimizing damage to the natural environment, promoting habitat and protecting the public from flooding. Pre-consultation can identify potential conflicts related to the project design at a site specific level. Consult CA staff early in the design process, as they may offer valuable advice, while helping to expedite the approval process. CA staff will help to implement a design and work strategy which eliminates major physical disturbance, maintains a healthy vegetated buffer, sustains stream flow and minimizes sedimentation to the waterway. CAs have agreements with Fisheries and Oceans Canada whereby they review the impacts to fish and fish habitat on their behalf.

Ontario Ministry of Natural Resources Provincial Legislation

In Ontario, the beds of most lakes and rivers are public lands. A work permit is a document issued by the Ministry of Natural Resources under authority of Section 14 of the *Public Lands Act*, to authorize specific activities and works on public lands and shore lands. A Work Permit is required to provide for effective stewardship of public lands and to ensure that specific activities undertaken on shore lands have regard for the environment, other users and neighbouring landowners. Requirements and considerations under the provincial *Endangered Species Act (2007)* must also be addressed. If in doubt as to whether a permit is required or not, applicants are encouraged to contact their local Ministry of Natural Resources office well in advance and make an appointment to speak with a Ministry staff person.

Parks Canada – Federal Legislation

Parks Canada Agency, Rideau Canal Office administers the Federal Crown's jurisdiction over the beds of the rivers and lakes which comprise the Rideau Canal system and is responsible for granting approval to dredge, fill, or perform other works in the waters or bed of the Canal. All in-water and shoreline works or structures on, in, over, under, or adjoining bodies of water under the jurisdiction of Parks Canada must receive written authorization prior to the commencement of any work. Applicants may also be required to obtain written permission of the adjoining landowner should your proposal have the potential to interfere with that owner's riparian rights.

Parks Canada – **Rideau Canal Office**
34A Beckwith St. S – Smith Falls, ON
K7A 2A8 Tel: 613-860-1251
http://www.pc.gc.ca

Fisheries and Oceans Canada – Federal Legislation

Any development along a shoreline has the potential to damage the environment, and may be harmful to fish and fish habitat. The federal *Fisheries Act* protects the welfare of fish and habitat against harmful alterations, disruption and destruction (HADD). The Act also states that no one is permitted to deposit a deleterious (harmful) substance into water containing fish. Violations to the *Fisheries Act* may result in substantial fines, and/or the risk of imprisonment. If found guilty, the violator may also be required to cover the costs of restoring the habitat at the site and/or be required to fulfill other court ordered remedies.

Bioengineering projects must first meet the criteria of an Operational Statement, incorporating conditions intended to protect the habitat. If the project design meets these criteria, a formal review from Fisheries and Oceans will not be required. Projects and designs which do not fall into the contexts of these conditions may require review under alternate legislation.

References & Resources

Publications:

- Allen, H.H. Leech, J.R. (1997) ***Bioengineering for Streambank Erosion Control.*** U.S. Army Corps of Engineers

- ***Bioengineering Techniques for Erosion Prevention.*** Capital Region District – British Columbia http://www.crd.bc.ca/watersheds/protection/howtohelp/bioengineering.htm

- ***Bioengineering Techniques.*** Drainage Management Guide (2004). Ministry of Agriculture, Food and Fisheries. BC

- Extension Notes:
  - ***Buffers Protect the Environment (2000)***
  - ***Protecting Fish Habitat From Sediment (2000)***

- ***Fish Habitat and Determining the High Water Mark on Lakes*** (T-6) Fisheries and Oceans Canada Factsheet

- ***Fish Habitat and Shoreline Stabilization*** (C-4) Fisheries and Oceans Canada Factsheet

- ***Native Plant Resource Guide***. 2000. Society for Ecological Restoration, Ontario Chapter, Second Edition.

- ***The Shore Primer – A Cottager's Guide to a Healthy Waterfront***. Fisheries and Oceans Canada (2008)

Potential Financial Assistance Programs

- **Community Fisheries and Wildlife Involvement Program**
  Ministry of Natural Resources (MNR) funding for projects that benefit biodiversity, involve the public and benefit the community. http://www.mnr.gov.on.ca

- **Ontario Drinking Water Stewardship Program (ODWSP)**
  Potential funds available for projects that protect surface and ground water on lands located near municipal wells and surface water intakes. Approved projects may include runoff and erosion control protection. Contact your local Conservation Authority.

- **Rural Clean Water Programs**
  Incentive grants to assist farmers and rural property owners with projects that protect surface and ground water. Projects may include erosion control and shoreline planting.

- **Shoreline Naturalization Programs**
  Provide information about the value and benefits of naturally vegetated, healthy shorelines. The program also offers simple, cost-effective advice and hands on guidance to waterfront property owners interested in enhancing or naturalizing their shorelines. The program provides technical and financial assistance for approved shoreline naturalization projects.

Ontario Stewardship Councils

- **Ontario Stewardship**
  Ontario Stewardship's purpose is to link landowners with funding, information and expertise to ensure that good management practices flourish. (Shoreline protection, trees/shrubs planting, wildlife habitat protection projects, project funding support)
  www.ontariostewardship.org

Native Plant Sources

- **Ferguson Forest Centre**
  Quality tree seedlings for today and tomorrow
  275 County Road 44, Kemptville, ON K0G 1J0
  (613) 258-0110
  ffc@storm.ca, www.seedlingnursery.com

- **Trees Ontario**
  www.treesontario.on.ca

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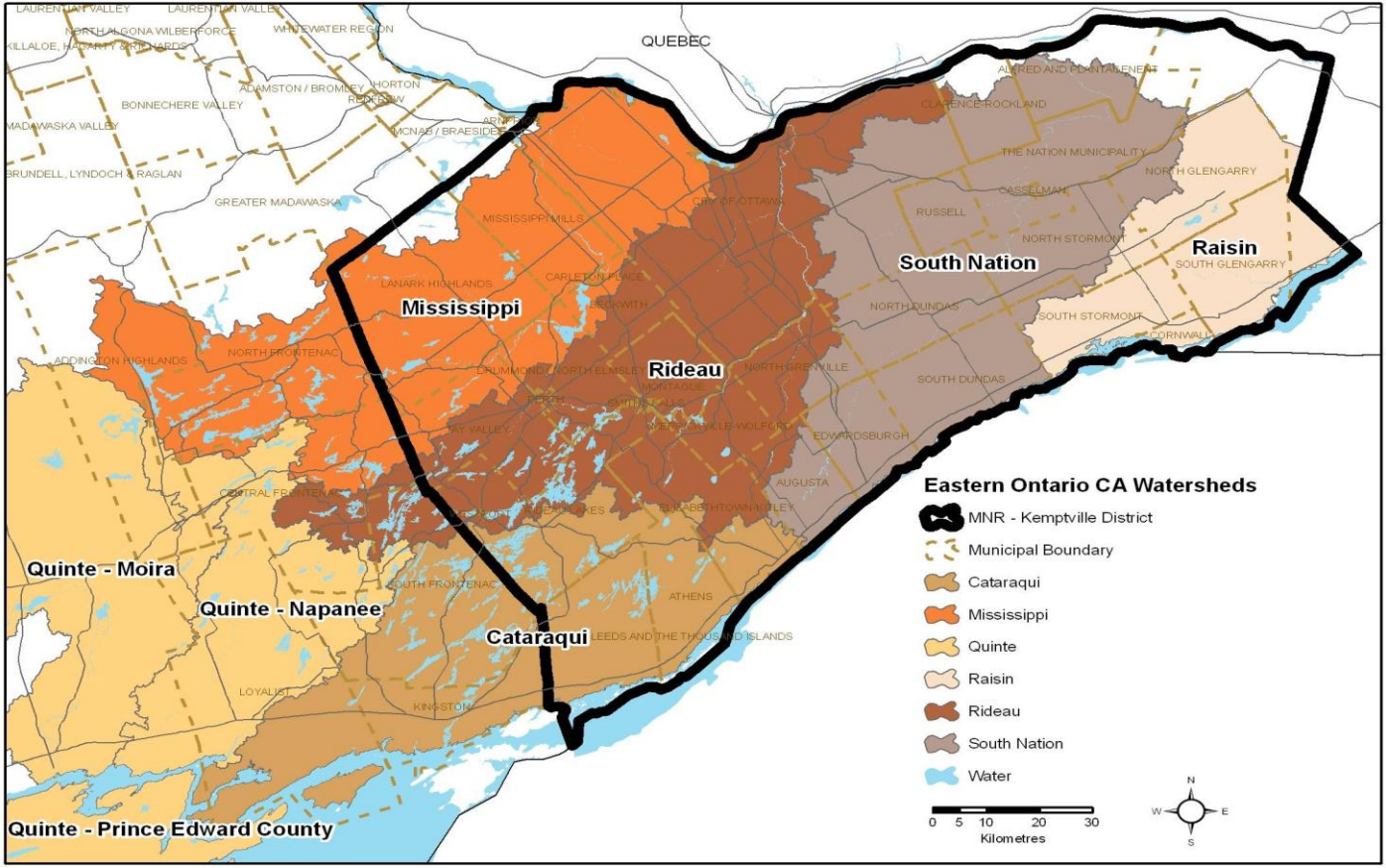
Eastern Ontario Watersheds / MNR Kemptville District



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