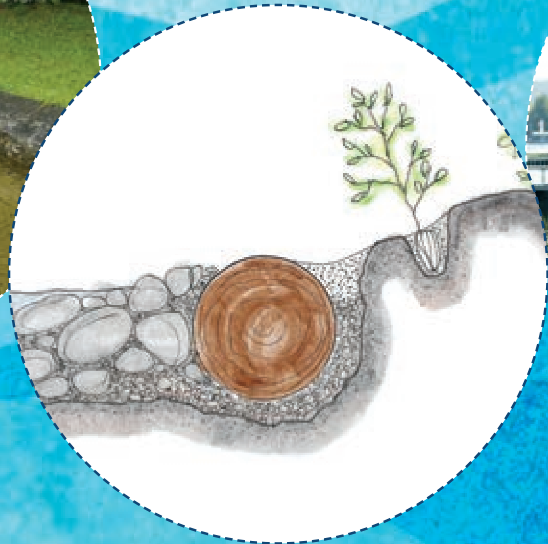


PROTECTING INLAND LAKES THROUGH NATURAL SHORELINES

An Introductory Guide to Bioengineering Techniques

Shoreline erosion is a concern shared by many lakefront property owners. For many years, seawalls have been used to control erosion, however, there are alternative erosion control options that are healthier and more natural for the lake. These alternative options are referred to as bioengineering. Bioengineering techniques use a combination of *native plants with strong, deep rooting, and complex root systems, combined with biodegradable materials like coconut fiber logs* to create a living shoreline that is resilient to erosive forces while also providing habitat.

This document is designed to provide an introduction to:

1. Shoreline Erosion
2. Wave and Ice Energy
3. Erosion Prevention
4. Shoreline Anatomy
5. Signs of Erosion
6. Seawalls vs Bioengineering
7. Types of Materials
8. Basic Bioengineering Concepts
9. Case Studies

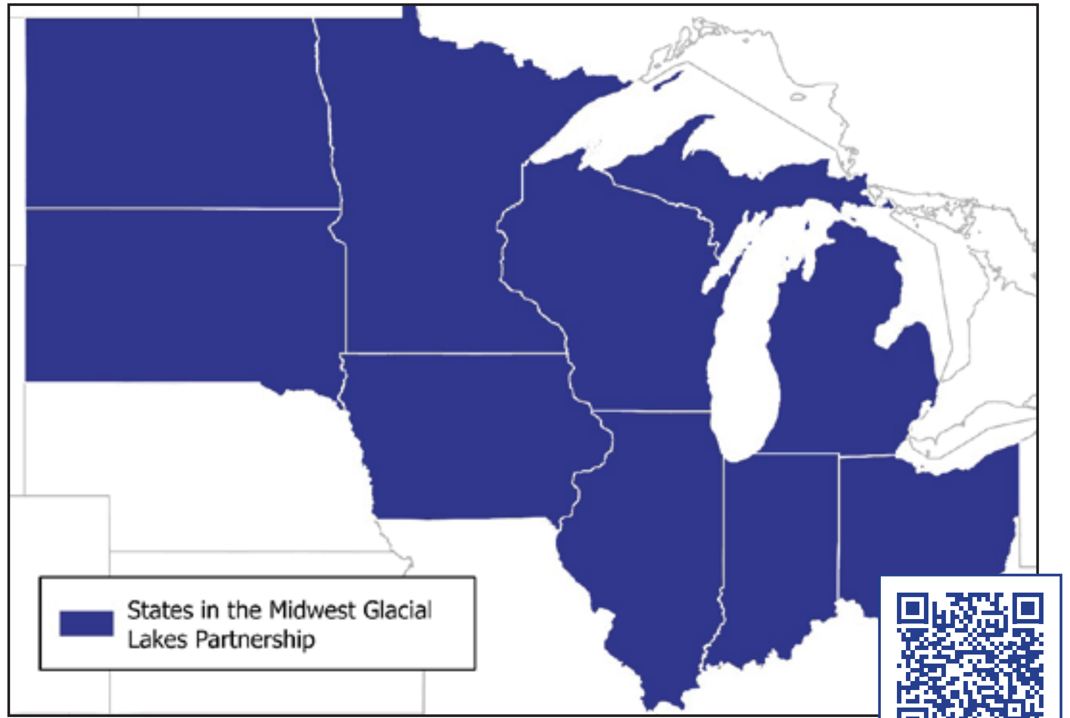
Photo: J. Herbert

RESOURCES

THE MIDWEST GLACIAL LAKES PARTNERSHIP (MGLP)

www.midwestglaciallakes.org

The MGLP works to protect, rehabilitate, and enhance sustainable fish habitats in the glacial lakes of the Midwest covering 9 states and over 80,000 lakes. Explore the website for a variety of resources for each State, the Lake Conservation Planner Tool and Shoreline Living Magazines.



Find out more about natural shorelines in the MIdwest Glacial Lakes Partnership region by visiting the website and connecting with each state's respective contact and program information.

SHORELINE EROSION:
Is it natural or accelerated?

Bioengineering techniques for natural shoreline erosion control are not "one size fits all". They must be tailored to each site based on an assessment of many different factors. A critical first step to resolving shoreline erosion is determining whether it is **naturally** occurring or **accelerated** by human causes and understanding what those causes may be.

Lake shorelines experience some degree of **natural erosion** due to forces such as waves, currents, precipitation, ice movement, the freeze-thaw cycle of groundwater, and seasonal lake level changes. In undeveloped lakes, you may not notice the changes since this is typically a very **slow** process over a long period of time. The plants and animals that live along the shoreline can adjust to these slow changes, maintaining a healthy and productive ecosystem. However, human changes to a lake system such as lake level control structures, boat wakes, aquatic and terrestrial vegetation removal, foot traffic, dredging, filling, or construction along the shoreline create an imbalance in the lake system. This imbalance increases shoreline exposure to erosive forces thus increasing erosion rates—this is called **accelerated erosion.**

ACCELERATED EROSION: Erosion progressing at a rate greater than what would be expected under normal conditions without human influence.

Every site is different. Erosion can be localized or widespread and may be the result of more than one factor. In addition, a property's shape and location on the lake, water level changes, and season are all factors in a shoreline's susceptibility to erosion. Understanding the natural erosive forces and how the consequences of human impacts increase erosion rates will help you better understand your shoreline and how to be a better steward of your shoreline property.

THE INFLUENCE OF WAVES AND ICE ON SHORELINES

Waves and ice influence the extent of erosion and must be considered when designing a bioengineering solution.

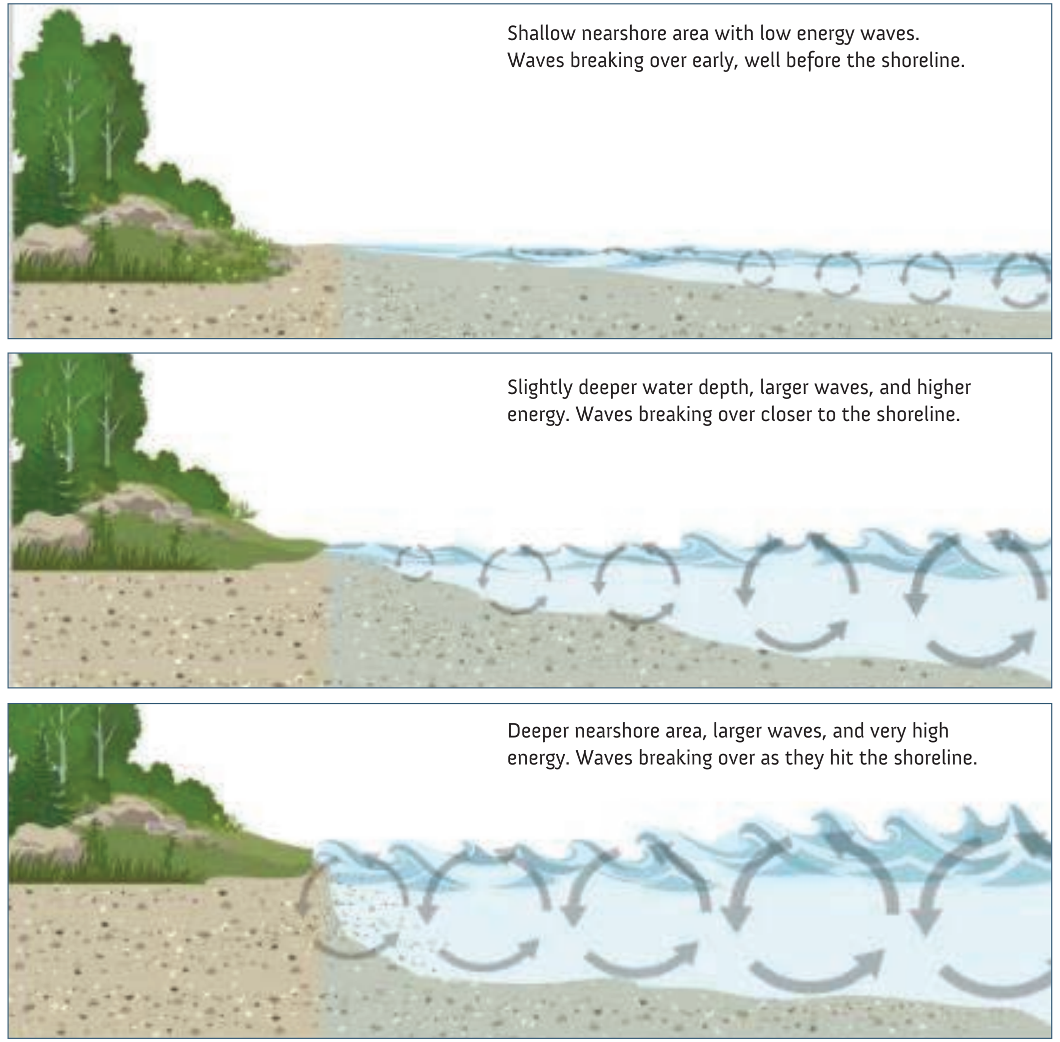


Figure 1: Relationship between run-up, nearshore water depth and wave size.

Wave Action

Waves impacting shorelines are the primary erosive force on lakes. Wave size, speed, and frequency are influenced by both wind and natural lake features such as water depth, bottom and basin shape, and surface area. Human activities like boating also greatly influence the erosive forces of waves.

SIMPLE FACTS OF WAVES

- The bigger the wave, the more energy it has.
- The closer to a shoreline a wave breaks over, the more energy hits the shoreline.
- Boat-generated waves, especially wake boats, can contain much more energy than wind generated waves of equal size.

IMPORTANCE OF LAKE BOTTOM RUN-UP

The shape of a lake bottom is an important factor in determining when a wave will break over. As a wave approaches shallow water, friction from the lake bottom slows the wave.

A long, gentle slope leading up to the shoreline (run-up) allows a wave to break over sooner so the entire wave's force does not hit the shoreline. (See Figure 1)

Ice Push

Ice push is a natural erosive force that is difficult to predict. As lake ice melts it tends to move towards a shoreline and push other objects. Ice push becomes more of a problem with rising water levels, high winds, and on shorelines where shrubs, trees and aquatic vegetation have been removed. The result of ice push is called an "ice ridge". The challenge is to learn to live with ice and minimize the potential for shoreline damage.

WHERE LAKES HAVE ICE THERE IS GOING TO BE ICE PUSH.

Minimizing the damage starts with understanding when the force of ice is the strongest and when it becomes weaker.

SOME BASIC CONCEPTS OF ICE STRENGTH

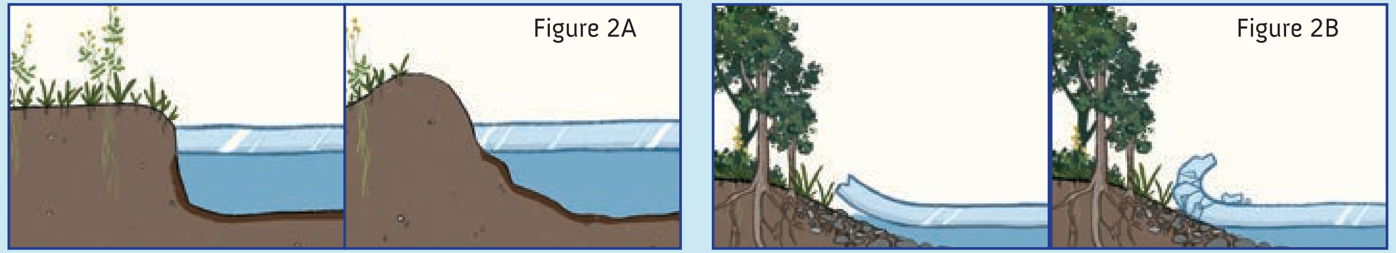
- Ice is the strongest as it moves horizontally toward a shoreline. It can exert 10-12 tons per square foot of pressure on our shorelines. (See Figure 2A)
- Ice becomes weaker as it moves at an angle and even weaker over rough surfaces. (See Figure 2B)

Bioengineering techniques can be used to help weaken ice push through the use of rock and vegetation to provide varying roughness options. The rock must be sized, placed, and sloped correctly in order to provide an appropriate angle and roughness. Vegetation should be native plants, including trees and shrubs, to provide the root structure.

Showing an ice ridge *Tip of the Mitt Watershed Council*

Showing an "ice ramp" utilizing a bioengineered rock revetment *Tip of the Mitt Watershed Council*

DEPICTION OF ICE STRENGTH



Figures 2A and 2B: Showing ice push and break up along a shoreline.

Illustrations: Gwen Marr

THE BEST WAY TO PROTECT IS TO PREVENT

Keeping native vegetation both on the land and in the water provides habitat for fish and wildlife. It is also critical for helping to prevent shoreline erosion. (Figure 3)

SHORELAND VEGETATION BENEFITS

- Reduces erosion and holds soil in place with long, dense roots.
- Filters pollutants, such as sediment and nutrients, before entering the lake.
- Helps to discourage waterfowl, such as geese, from becoming a nuisance on lakefront properties.

WOODY STRUCTURE AND AQUATIC PLANTS

- Absorb wave energy to help reduce impacts on the shoreline.
- Help maintain clear water by stabilizing lake bottom sediments.

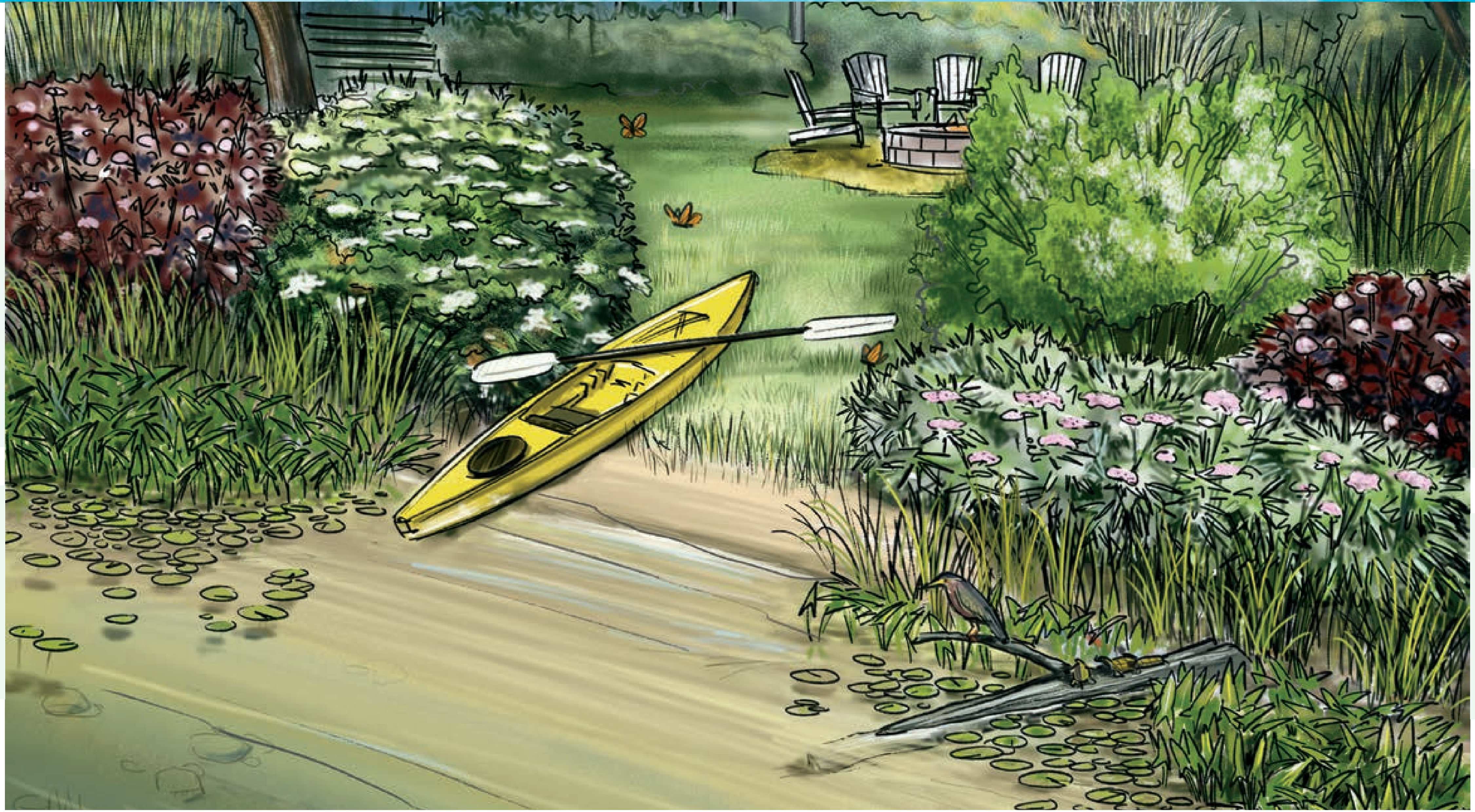


Figure 3: A shoreline balancing recreational access with shoreline habitat and lake health.

Keeping shoreland development to a minimum will help prevent stormwater runoff and shoreline erosion.

IMPERVIOUS SURFACES

(Roofs, driveways, and other hard surfaces.)

- Limit impervious surfaces to allow rainwater to absorb into the ground rather than creating stormwater runoff.
- Maximize distance between impervious surfaces and the lake as much as possible.
- Keep docks, watercraft, and other seasonal equipment storage elevated and away from the shoreline.

ACCESS AND RECREATIONAL AREAS

- Strategically place recreational access points on a shoreline to limit impacts to the shoreline.

ANATOMY OF A SHORELINE

Figure 4: Cross-section of a natural shoreline depicting the location of the bank toe and shoulder.

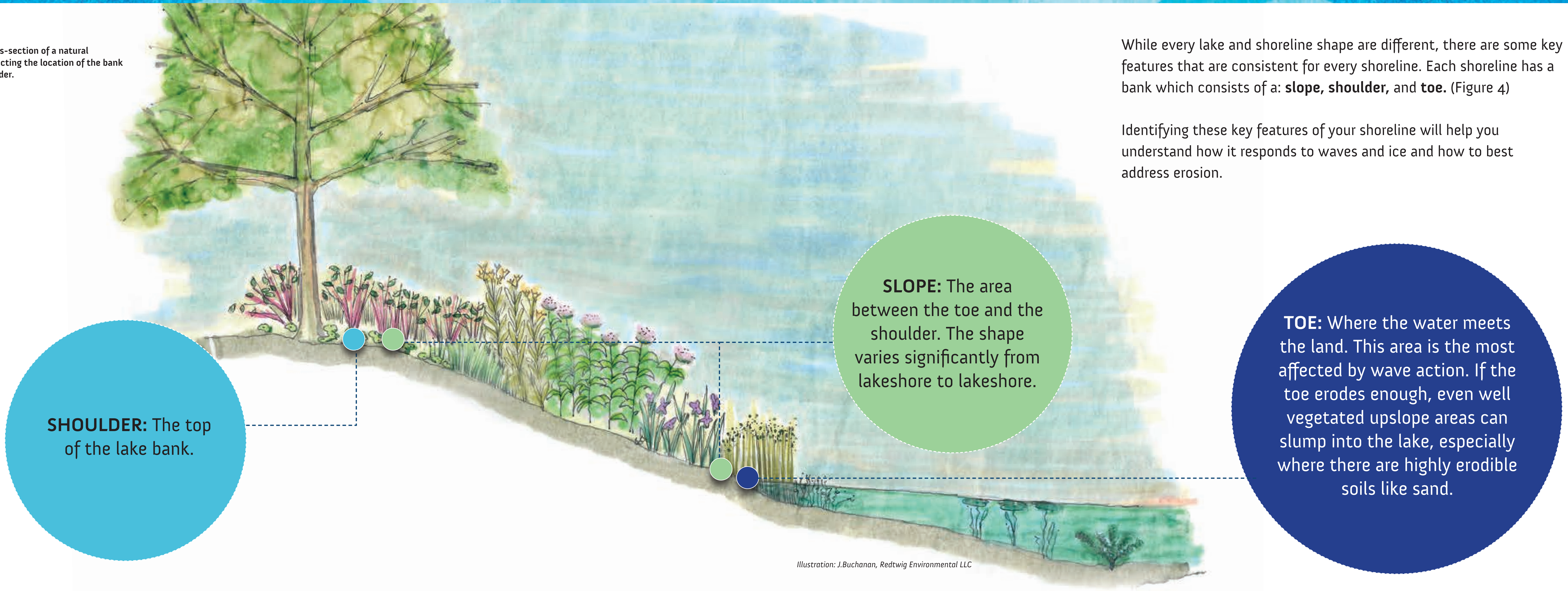


Illustration: J.Buchanan, Redtwig Environmental LLC

While every lake and shoreline shape are different, there are some key features that are consistent for every shoreline. Each shoreline has a bank which consists of a: **slope, shoulder,** and **toe.** (Figure 4)

Identifying these key features of your shoreline will help you understand how it responds to waves and ice and how to best address erosion.

SIGNS OF ACCELERATED EROSION

Each of these photos show different shorelines and the consequences of removing natural shoreline vegetation. Converting shorelines to lawns takes away the natural protection that the original root systems of trees, shrubs, grasses, and sedges provided and leaves the shorelines vulnerable to erosion.

Comparing developed shorelines with neighboring **undeveloped** shorelines or looking at old photos can help highlight impacts of the loss of vegetation.

Indicators of accelerated erosion include: noticeable receding shorelines, large or small gullies caused by overland runoff, excessive bank slumping, excessive root exposure, scalloping of a shoreline, and undercut banks.

Sometimes the solution is very easy, such as adding plants back in. However, restoring stability is more complicated in other situations.

Receding Shoreline:
Shoreline is advancing landward over time.

Receding shoreline:
Example where the addition of rock is ineffective due to improper design and lack of shoreline vegetation.

Rills and Gullies:
Channels form from overland runoff due to exposed soil.

Undercut Bank:
Waves are eroding the soil underneath the bank. Eventually the bank will slump into the lake.

Scalloping:
The irregularities of the shoreline become more pronounced due to exposed shoreline soils. Eventually, the "points" will also erode as residual root structure from the removed vegetation degrades.

Slumping:
The waves undercut the bank. It then became unstable enough for a portion of it to fall (slump) into the lake.

Root Exposure:
It is natural to have some roots exposed along shorelines, however, pronounced root exposure is a sign of accelerated erosion.

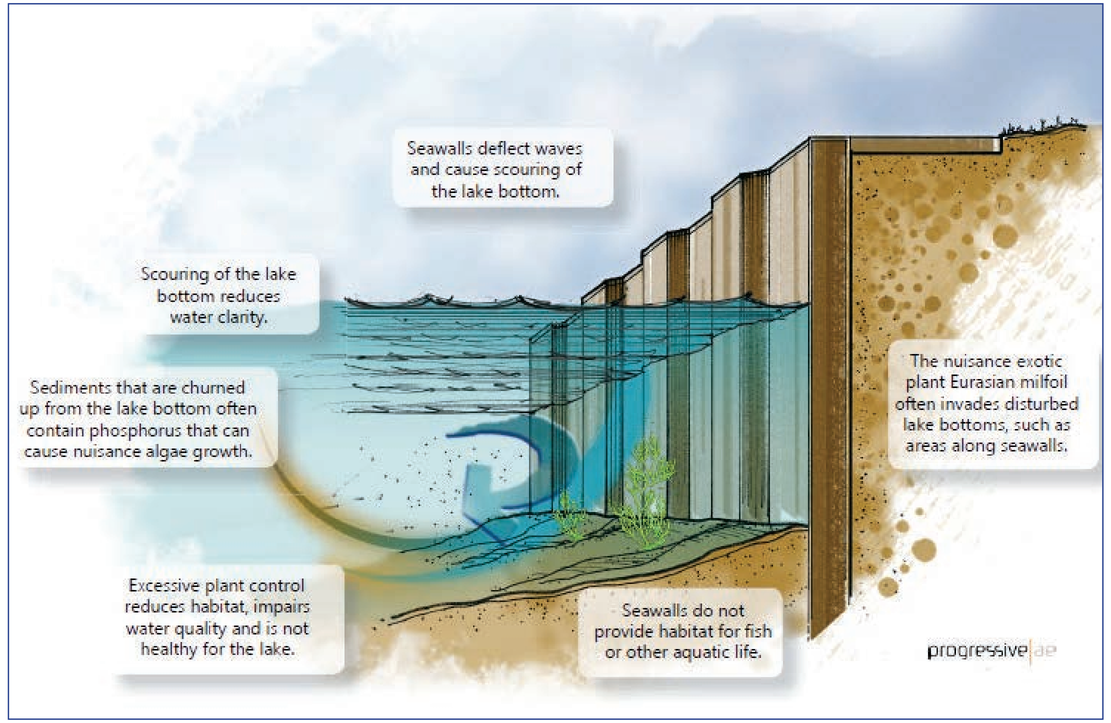
CONTRASTING SHORELINE PROTECTION STRATEGIES

Seawalls: **NOT** Lake-friendly Erosion Control Options

Traditional shoreline erosion control options such as vertical or sloped concrete, wood, steel and rock walls negatively impact the overall health of a lake. Accordingly, these structures are no longer legal to install in some regions. Where allowed, they are discouraged and require a permit from a permitting agency. Seawalls create barriers for animals such as turtles, who need to get out of the lake to lay their eggs. In addition, seawalls cause erosion through scouring and flanking.

Photo: J. Buchanan

PROBLEM: Wave Energy Deflection: Scouring



PROBLEM: Wave Energy Deflection: Flanking

PERMITTING

Learn more about Michigan's Shoreline Permitting.

Bioengineering: **Lake-friendly Erosion Control Options**

While there are some unique situations where seawalls are necessary, there are significantly more sites where more natural techniques for erosion control are appropriate. These more natural techniques are referred to as bioengineering and are healthier for a lake.

A SYSTEM

Bioengineering is not an exact science, and the solutions are very site dependent. Solutions are applied as a system of techniques that provide upland stabilization, bank stabilization and toe protection.

DESIGN GOAL

Every solution should be designed with the intent to recreate natural processes and functions of shorelines to enhance shoreline resiliency. A resilient shoreline does not stay completely unchanged year after year, but can weather the challenges of fluctuating water levels, runoff, ice, wind, waves, and other influential forces. Changes to the shorelines should be expected over time.

DID YOU KNOW?

Bioengineering goes by many terms such as natural shorelines, soft bioengineering, living shorelines and nature-based solutions.

Photo: J. Herbert

WAVE ENERGY AND DESIGN SOLUTION

A FULL SITE EVALUATION AND ASSESSMENT SHOULD BE COMPLETED TO IDENTIFY ALL THE SITE'S COMPLEXITIES.

Wave **Energy**

Wave energy is the most important factor in determining which bioengineering options are appropriate for a given site. Wave energy can be calculated using fetch, the average water depth along the fetch, and sustained wind speed.

Fetch: Longest unobstructed, over-water distance across which wind blows before reaching site. (See Figure 5)

Average Water Depth: Calculated at a minimum of 5 equidistant locations across the fetch.

Wind Speed: For inland lakes within the Great Lakes region the standard design criteria utilizes 35 mph average sustained winds.

Boats: Waves and wakes created by boats can be variable in height and can exceed the height of wind-driven waves on certain water bodies. The type of boat operating within 500 ft. of a site should be factored into the energy or wave height calculation.

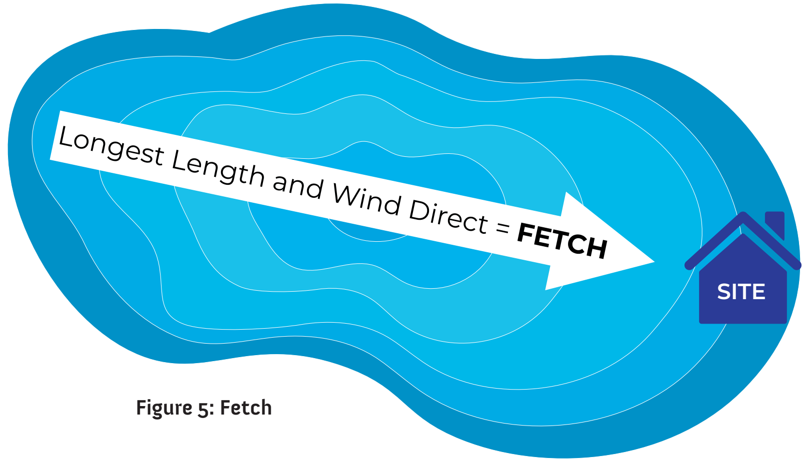


Figure 5: Fetch

Complexities

In addition to wave energy, a given site's physical characteristics (complexities) will influence the design solution. These characteristics may include but are not limited to:

- A site's location on a lake (on a point, in a bay, or proximity to physical structures such as a boat ramp, fishing pier, seawalls).
- Bank shape and height.
- Soil type.
- Proximity to a river mouth.
- Presence/absence of groundwater seeps.
- Ease of access.
- Amount/type of existing vegetation.

WHAT ABOUT YOUR PROPERTY?

1. Is there a long, gentle run up? Or does it get deep fast?
2. Is it on a point? Waves are stronger out on a point.
3. Is it in a protected bay or cove? Waves are fewer and weaker in a cove.
4. Which side of the lake is your site on?
5. Is ice a problem on your site?
6. How close are structures or other infrastructure to the lake? Structures too close to the lake increase design complexities.
7. How easy is it to get construction equipment and materials to your shoreline?
8. What other types of complexities does your property have?

Finding a Solution: **What is best for your shoreline?**

It is important that bioengineering techniques are well-suited for the site and also meet state, federal and local regulations.

The keys to success for any bioengineering technique are:

1. A good design.
2. Proper installation.
3. Follow up maintenance.

There is not a "one size fits all" solution; there are a lot of "depends". Many inland lake shorelines with lower energy can be stabilized by simply planting or allowing native vegetation to grow. The restored root structure fortifies the shoreline against erosive forces.

Sites with higher wave energy and more challenging conditions, typically require more complex design solutions and cost more to restore than simple approaches. (See Figure 6)

Careful consideration of all factors is critical to a successful shoreline design to achieve a resilient shoreline project.

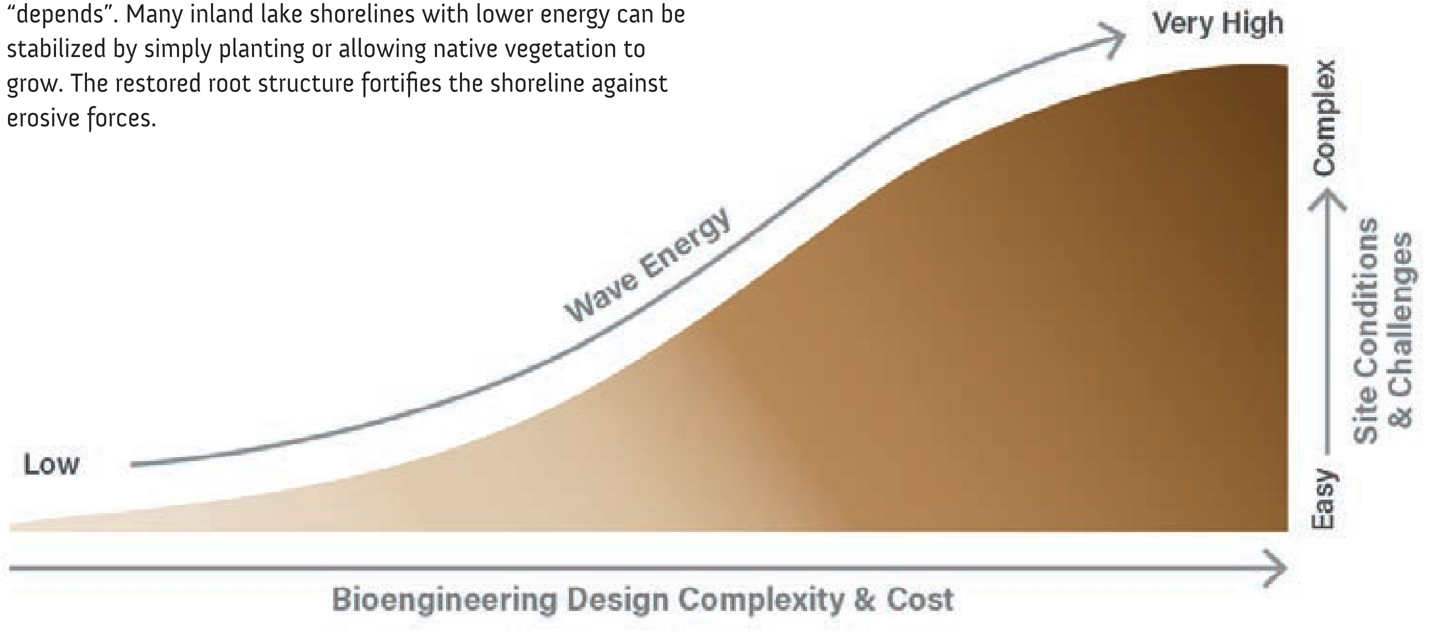
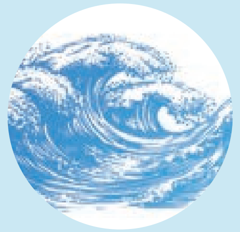


Figure 6: Illustrates the relationships between wave energy, site characteristics and corresponding complexity of bioengineering techniques and costs.



For more detailed information on calculating wave energy on Michigan inland lakes see the Michigan Department of Environment, Great Lakes, and Energy's Inland Lake Shoreline Energy Assessment.

Assessment Instructions

Assessment Tool

www.michigan.gov/shorelineprotection

TYPES OF MATERIALS

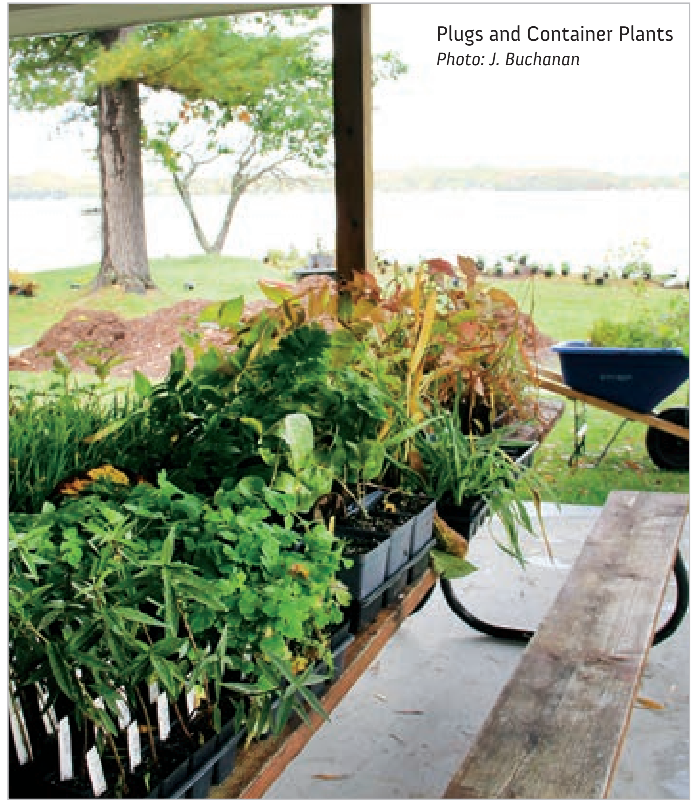
Bioengineering techniques use a combination of native plantings, soils, and other soft or flexible materials that protect shorelines without the negative impacts of traditional erosion control methods (seawalls). In some cases, such as high-energy lakes, fieldstone should be included to provide stabilization.

Live Stakes
Photo: J. Kirkwood

Pre-vegetated Mats
Photo: J. Herbert

Native **Vegetation**

Native vegetation is essential for every bioengineered project. It provides the necessary root structure to hold the shoreline soils in place. A mixture of flowers, grasses, sedges, shrubs, and trees should be used. Depending on the site, either plugs, larger stock, pre-vegetated mats, live stakes or a combination of plant stock types should be used. Live stakes, are cuttings from woody shrubs, such as willow and ninebark, that can root and grow. Seed should only be used in limited situations such as large scale restoration projects.



Plugs and Container Plants
Photo: J. Buchanan

Contractors beginning installation of ECB.
Photo: J. Buchanan

ECB with recently installed plantings
Photo: TOMWC

Erosion Control **Blankets**

Biodegradable erosion control blankets (ECBs) are used to help stabilize shoreline erosion. ECBs should extend landward the distance needed to cover all exposed soils. Ideally, they should also extend the full depth of the planting area to help with weed control and establishment of new plantings. Once they are properly staked, ECBs may be cut to allow installation of plants through the fabric.

Coir **Logs** (Biologs)

Biodegradable coir (coconut fiber) logs are held together with other biodegradable materials such as jute twine, and come in a variety of lengths, sizes, and densities. They are used in many applications, most often at the toe of the shoreline, to provide stabilization and promote the development of vegetation. Coir logs provide long-term, yet temporary, protection. As plant roots grow into and through the logs they biodegrade yielding a more resilient shoreline. When conditions allow, plantings can be installed directly into the coir logs, but extra care is then needed to ensure their survivability.

Coir logs staged along shoreline prior to installation.
Photo: J. Buchanan

Positioning coir logs before finalizing installation.
Photo: J. Kirkwood

Rocks

Many bioengineering projects require the use of rock to help provide stability and resiliency against erosive forces. Whether to use rock or not depends on the site conditions. Rounded fieldstone is recommended over other types of rock, such as angular quarried rock, because it creates a more flexible and resilient system. A mixture of rock sizes is required and the size is determined by the wave height and design. The different sizes of rock act like ball bearings to allow the rock to flex and settle more easily.

Fieldstone, drain stone, and pea gravel staged prior to installation on a high energy lake.
Photo: J. Buchanan

Many eroding shorelines can benefit from a simple, native plant greenbelt, but sites with more challenging conditions will require more complex techniques for long-term stabilization. The following options are not the full list of techniques, but they are some of the most common techniques used for shoreline stabilization. These may be used individually or in conjunction with other techniques for optimal results.

NOTE: Construction of bioengineering erosion control techniques often requires permits. Check with your State's permitting agency.

Greenbelt/**Buffer**

A greenbelt is a strip of vegetation along the shoreline. Ideally, a greenbelt should include a combination of native trees, shrubs, grasses, sedges, and wildflowers. In many cases, restoring/installing a greenbelt is all that is necessary to stabilize the shoreline.

When to use:

- *Alone:* On sites with low wind, wave, and ice action with lawn up to the edge of the lake.
- *Alone:* On sites with a very low bank.
- *Always:* As a component of all bioengineering techniques.

Native plants staged prior to installation.
Photo: J. Buchanan

Basic **Design**

A basic bioengineering design includes coir logs and native plants (See Figure 7). The coir log provides toe protection to allow the plant root systems to become re-established. There may be a need for a minimal amount of rock, such as to provide protection against wave flanking from a neighboring property.

When to use:

- On sites with minimal accelerated erosion with low wind, wave and ice action.
- On sites with a low bank height.
- As a component of other techniques .

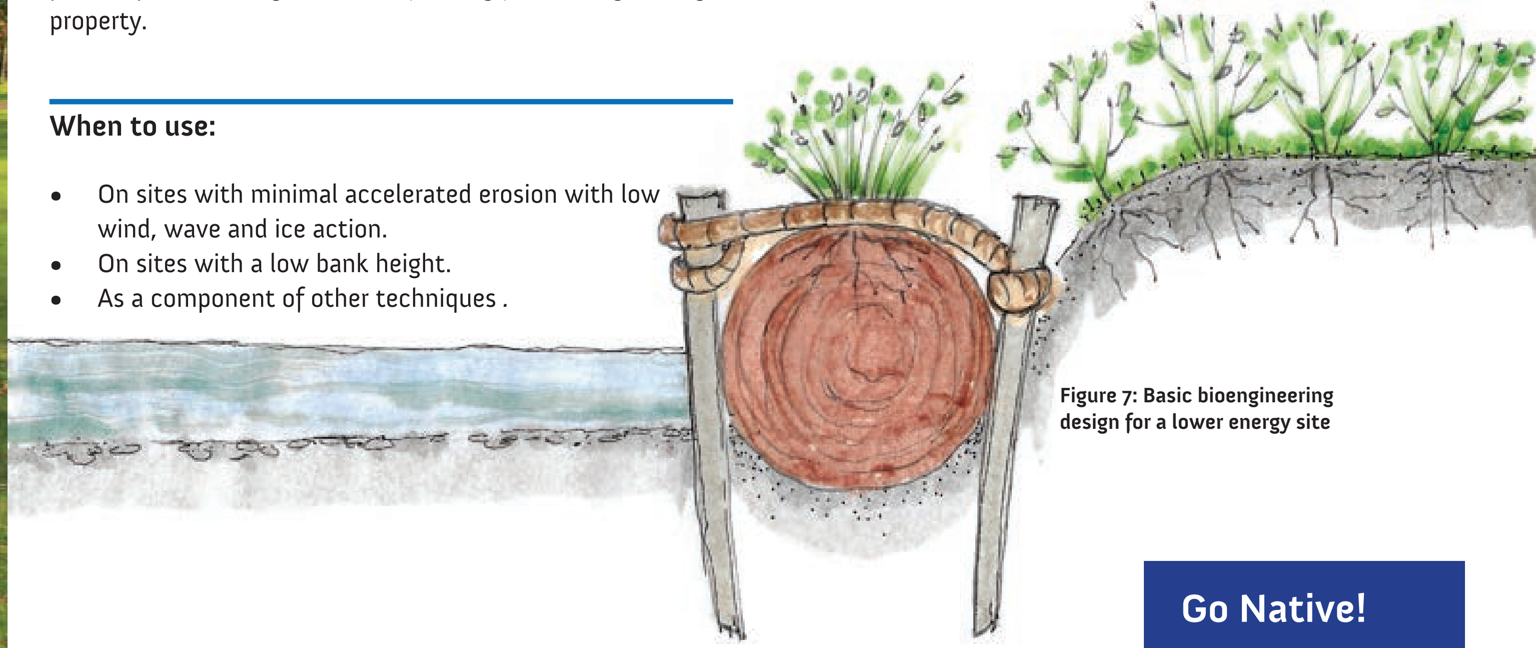


Figure 7: Basic bioengineering design for a lower energy site

Buffer Planting Recommendation

Spacing should be according to species; however, plugs are typically planted 12"- 18" on-center (OC). OC refers to the distance between the center of one structural element to the center of the next.

- Where appropriate, apply mulch and/or erosion control blankets.
- Choose plant stock type that best fits the site design and homeowner goals.
- A minimum of 75% of the first 10 feet should be planted. However, planting a wider area will be more successful and create more shoreline resiliency.

Go Native!

Choose native species (not cultivars) from reputable native plant nurseries within your region.

Fieldstone **Revetment**

A bioengineered fieldstone revetment, also called rip rap (See Figure 8), is different from the traditional use of rip rap. This design uses plants, typically a coir log at the bank toe, and three layers of rock: armoring layer, base apron and filter layer. The rock must be sized correctly based on site conditions and installed at an appropriate slope in order to function correctly. The goal is for sand, silt and organic matter to fill in the spaces to help rebuild the shoreline. (See the Importance of Slope on page 19)

Photo: J. Buchanan

When to use:

- On sites with moderate to high wind, wave and ice action.
- Can be used to replace seawalls in some situations.

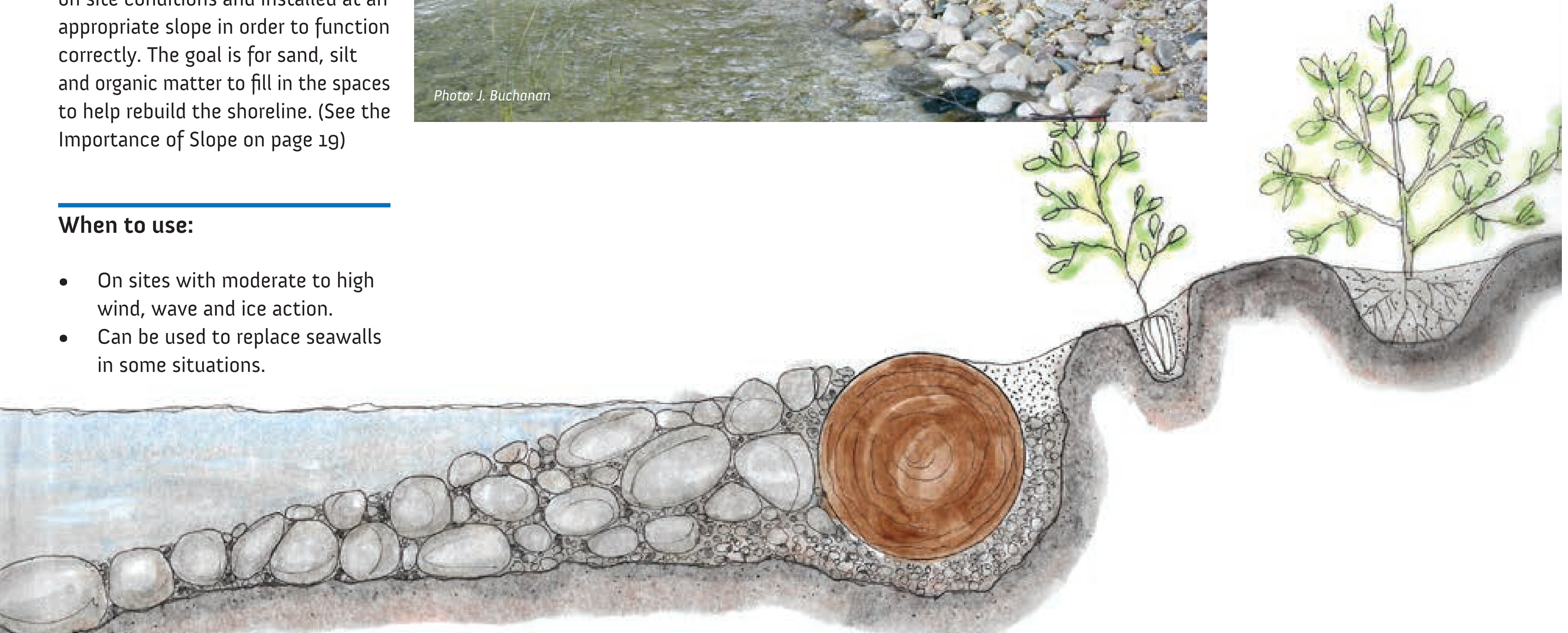


Figure 8: A bioengineering design for a higher energy site.

Encapsulated **Soil Lifts**

Encapsulated soil lifts, sometimes called vegetated geogrids, are layers of soil "encapsulated" inside biodegradable fabric to form the lift and are built on a rock base (See Figure 9). The rock base is sized and sloped correctly per site conditions. Each lift (or layer) is placed on top of the preceding lift, but stepped back to create the desired slope. They are then planted with native plants. Banks typically need to be pulled back to create the desired slope.

When to use:

- On sites with higher banks.
- On sites with low, medium to high energy.
- Can be used to replace seawalls in some situations.

Figure 9: An encapsulated soil lift design and installation.
Photo: TOMWC

Importance of Slope

A properly designed and installed bioengineered fieldstone revetment will have a minimum slope of 4′H (Horizontal):1′V (Vertical) or flatter. Some sites, such as on a Great Lake, may require more gentler slopes like a 20′ H:1′V.

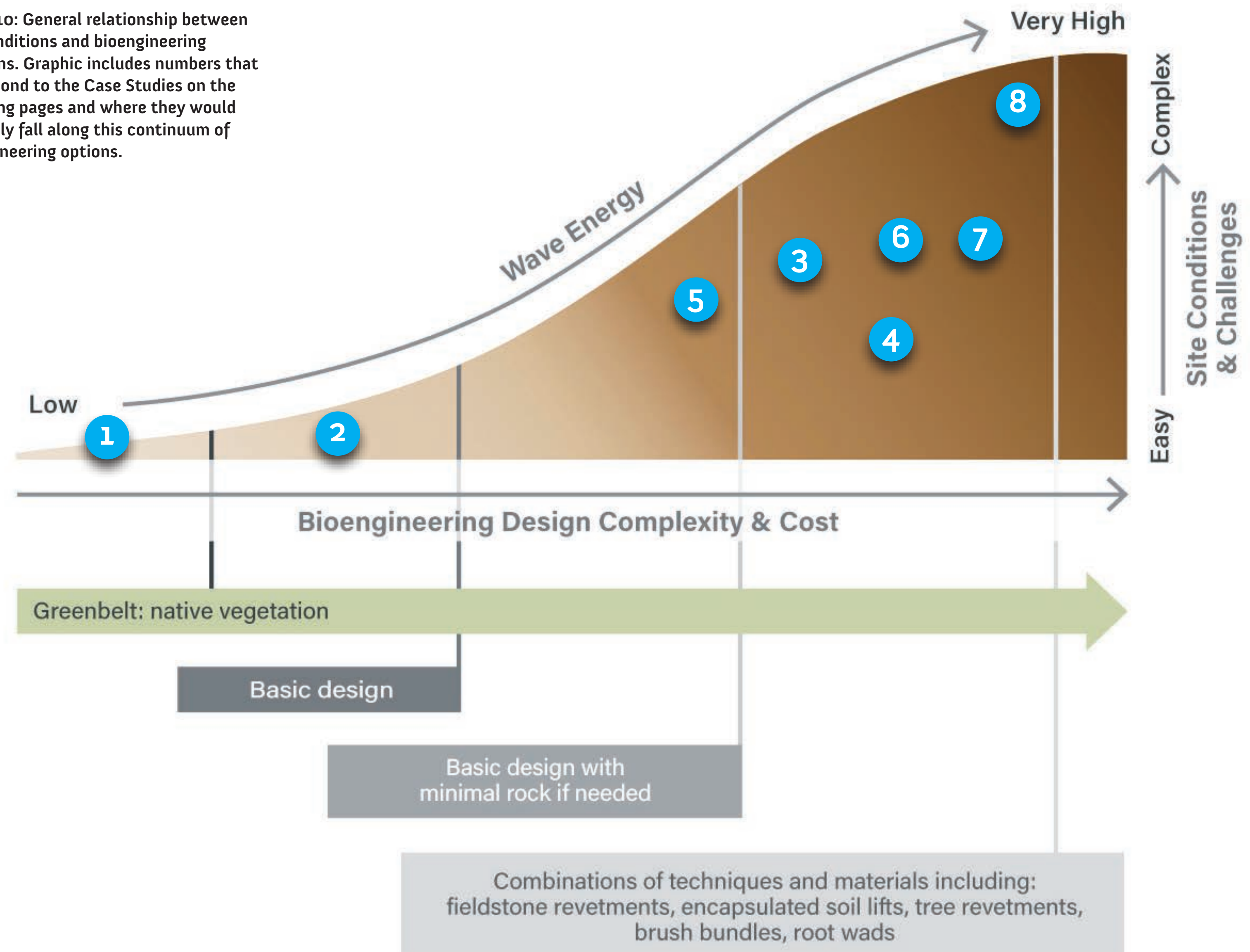
A steeper slope is more vulnerable to ice shove and may also be less stable. Think of the revetment as a wedge that assists ice up and over the shoreline rather than pushing directly into it. The top surface of the revetment, usually a layer of smaller fieldstones top-dressed over the larger fieldstone core, acts like ball bearings, allowing the ice to move freely up the slope without major disruption of the revetment. This roughness also helps to weaken and break up an ice sheet.

CASE STUDIES

The following pages highlight a variety of successful bioengineering projects on sites ranging from very low wave energy with minor site challenges to very high wave energy with highly complex site challenges.

While these bioengineering projects may serve as potential options for your shoreline, remember, every site is different and there is no one size fits all. Often times a combination of these techniques is necessary to achieve a resilient stable shoreline.

Figure 10: General relationship between site conditions and bioengineering solutions. Graphic includes numbers that correspond to the Case Studies on the following pages and where they would generally fall along this continuum of bioengineering options.



SITE 1

TECHNIQUE: Greenbelt/Buffer

Before project, 2001

Photo: J. Kirkwood

After project, 2019

Photo: Mark Bugnaski Photography

After project, 2002

Photo: J. Kirkwood

After project, 2002

Photo: J. Kirkwood

LOCATION:
Private Residence
Little Long Lake

CASE STUDY 1	
FETCH (miles)	**ENERGY**
0.39	Low
VEGETATION	**EROSION CONTROL BLANKET**
Plugs	No
COIR (QTY/diameter)	**ROCKS (diameter)**
No	No
BRUSH BUNDLES	**TREES/WOODY STRUCTURE**
No	No

Site Description

This site's complexity was very low (easy) with a minimal receding shoreline due to mowing to the edge of the lake and foot traffic. A site assessment determined that only plants were needed for this site. The landowner stopped mowing. Then native vegetation was added into the no-mow zone to replace the unwanted species.

SITE 2

TECHNIQUE: Greenbelt/Buffer; Basic Design


Before project, 2012
Photo: J. Herbert


Before project, 2013
Photo: J. Herbert


After project, 2013
Photo: J. Kirkwood


After project, 2015
Photo: J. Kirkwood

LOCATION:
Village of Paw Paw
Maple Island Park
Maple Lake

CASE STUDY 2	
FETCH (miles)	ENERGY
0.28	Low
VEGETATION	EROSION CONTROL BLANKET
Plugs	Yes
COIR (QTY/diameter)	ROCKS (diameter)
10 - 12″	No
BRUSH BUNDLES	TREES/WOODY STRUCTURE
No	No

Site Description

This site is a public park and located on an island. An abundance of geese and swans created a messy and uninviting space for recreation. Shoreline recession was due to lack of native vegetation, mowing to the edge, and foot traffic. Based on a site assessment, coir logs and deep rooting plants were the best option. A goose exclusion fence was used until the plants became established. Access for swimming was also incorporated into the design.

SITE 3

TECHNIQUE: Fieldstone Revetment

Before project, 2009

Photo: TOMWC

Before project, 2009

During project, 2009

After project, 2016

LOCATION:

Private Residence
Elk Lake

CASE STUDY 3	
FETCH (miles)	**ENERGY**
2	High
VEGETATION	**EROSION CONTROL BLANKET**
None added; Landowner no-mow zone	No
COIR (QTY/diameter)	**ROCKS (diameter)**
10 - 16″	8 CY: Peastone 15 CY: 1″ - 3″ Drainstone 34 CY: 6″ - 18″ 4 CY: 6″ and under Fieldstone
BRUSH BUNDLES	**TREES/WOODY STRUCTURE**
No	No

Note: CY = cubic yards

Site Description

This site had a lack of dense root structure. The bank was actively being undercut and would eventually slump. Based on the site assessment a rock revetment was decided. The bank was not pulled back to avoid disturbing remaining root structure. Gravel and the coir log were tucked into the bank cavity to help provide stability. In addition, 5 yards of sand and 5 yards of topsoil were used in this design.

SITE 4

TECHNIQUES: Greenbelt/Buffer; Fieldstone Revetment


Before project, 2013
Photo: J. Herbert


During project, 2014
Photo: TOMWC


After 2014
Photo: J. Kirkwood


Location of coir log.
After project, 2022
Photo: J. Kirkwood

LOCATION:

Emmet County Park
Camp Pet-O-Se-Ga
Pickerel Lake

CASE STUDY 4

FETCH (miles)	ENERGY
2	Moderate
VEGETATION	**EROSION CONTROL BLANKET**
Plugs	Yes
COIR (QTY/diameter)	**ROCKS (diameter)**
3 - 20″ 3 - 16″ 1 - 12″	Drainstone/Peastone 20 - 25 CY Smallest 4″; Median 8″; Largest 12″
BRUSH BUNDLES	**TREES/WOODY STRUCTURE**
No	No

Note: CY = cubic yards

Site Description

This site is at a public park that had a significant goose problem. The shoreline was receding due to mowing to the edge and ice push. In addition, a creek with old wooden pilings in the water was creating a wave flanking problem. The site assessment indicated that a fieldstone revetment would be appropriate. A goose exclusion fence was used until plant establishment. Access to the site was not a problem but the fetch length, ice and the creek created some design challenges.

SITE 5

TECHNIQUES: Greenbelt/Buffer; Fieldstone and Tree Revetment; Brush Bundle

Before project, 2012

Photo: J. Herbert

Photo: J. Herbert

During Construction: June 2012

After project, 2012

Photo: J. Herbert

After project, 2018

Photo: E. Calabro

LOCATION:
Kent County Park
Crockery Lake

CASE STUDY 5	
FETCH (miles)	**ENERGY**
0.84	Moderate
VEGETATION	**EROSION CONTROL BLANKET**
Seed; Plugs; Live Stakes	Yes
COIR (QTY/diameter)	**ROCKS (diameter)**
2 - 16″	10 CY Fieldstone 6 - 12″
BRUSH BUNDLES	**TREES/WOODY STRUCTURE**
Yes	4 dead Ash trees from site

Note: CY = cubic yards

Site Description

This site is at a public park. Erosion was due to frequent boat traffic exacerbated by a nearby boat ramp along with diminished native vegetation. The site assessment also determined that during certain storm events the waves originated from a different direction and were larger than what was typically observed. The design included utilizing the dead ash trees harvested from the site to create woody habitat and a revetment to help abate the boat and storm generated waves. Heavy equipment was not an option at this site due to the sensitivity of the shoreline and limited access.

SITE 6

TECHNIQUES: Greenbelt/Buffer; Fieldstone Revetment

Photo: TOMWC

Before project, 2011

Photo: TOMWC

During project, 2011

Photo: TOMWC

After project, 2019: Notice the shoreline being rebuilt with the sand build up.

After project, 2021
Notice how the waves are running up the bed of the lake and breaking over before they hit the shoreline compared to the waves hitting the neighboring property with rip rap placed at the wrong slope.

Photo: M Bugnaski

LOCATION:

Private Residence
Intermediate Lake

CASE STUDY 6	
FETCH (miles)	**ENERGY**
2.25	High
VEGETATION	**EROSION CONTROL BLANKET**
Plugs	Yes
COIR (QTY/diameter)	**ROCKS (diameter)**
5 - 15″	Drainstone/Peastone/ Fieldstone: 20 - 25 CY; Smallest 4″; Median 8″; Largest 12″
BRUSH BUNDLES	**TREES/WOODY STRUCTURE**
No	No

Note: CY = cubic yards

Site Description

This site was devoid of deep-rooted vegetation and had a failing seawall in between two properties with seawalls. A site assessment showed the site was situated on a long and narrow lake with heavy boat traffic including wake boats. In addition, one neighboring seawall would remain in place and the other adjoining landowner ultimately chose to replace their seawall with non-bioengineered rip rap and no greenbelt.

SITE 7

TECHNIQUES: Greenbelt/Buffer; Encapsulated Soil Lifts; Fieldstone Revetment

Before project, 2022

Photo: TOMWC

During project, 2022

Photo: J. Kirkwood

After project, 2023

Photo: TOMWC

LOCATION:

Emmet County Park
Camp Pet-O-Se-Ga Site 2
Pickeral Lake

CASE STUDY 7	
FETCH (miles)	**ENERGY**
2	Moderately High
VEGETATION	**EROSION CONTROL BLANKET**
Plugs; Live Stakes	Yes
COIR (QTY/diameter)	**ROCKS (diameter)**
Bio-D blocks™ 16 - 400; 2 layers for 60 linear feet	Drain stone/Pea stone; Smallest 2"; Median 8"; Largest 7"
BRUSH BUNDLES	**TREES/WOODY STRUCTURE**
No	Root wads

Note: CY = cubic yards

Site Description

This site is at a public park at a canoe/kayak launch location. The erosion was mainly due to canoes/kayaks being dragged up and down the bank and diminished deep-rooted vegetation. A nearby access road was in jeopardy of being undermined. There was insufficient space to utilize a rock revetment by itself, so a soil lift was used to rebuild and stabilize the bank. Approximately, 30 yards of topsoil was used to construct the soil lifts. A fence was installed to deter people from utilizing the bank to launch their watercraft and a dedicated canoe/kayak slide was installed next to the dock.

SITE 8

TECHNIQUES: Greenbelt/Buffer; Encapsulated soil lifts; Fieldstone and Tree Revetment

Before project, 2008

Photo: Cardno

During project, 2010

Photo: Cardno

After project, 2011

Photo: Cardno

After project, 2013

Photo: Cardno

LOCATION:

Private Residence

Muskegon Lake

CASE STUDY 8	
FETCH (miles)	**ENERGY**
4.2 miles	Very High
VEGETATION	**EROSION CONTROL BLANKET**
Seed; Plugs; Live Stakes; Gallon Pots	Yes
COIR (QTY/diameter)	**ROCKS (diameter)**
Bio-D blocks™ 16 - 400; 2 layers for 100 linear feet	10 CY, 2 - 4″ Cobblestone; 20 CY, 3 - 12″ Round Fieldstone
BRUSH BUNDLES	**TREES/WOODY STRUCTURE**
No	7 Logs

Note: CY = cubic yards

Site Description

This site is located in a very developed area, with infrastructure close to the lake, and a lot of boat traffic including industrial shipping. The site assessment showed the need to remove the concrete slabs which were historical attempts at erosion control before restoration techniques could be installed. In addition, ice and waves were both a significant problem. Ice sheets up to 3′ thick and 8′ waves have been observed at this site.

Monitoring and **Maintenance**

Bioengineered projects do require some degree of maintenance. Some will require more than others. At a minimum, monitoring your bioengineered shoreline, especially within the first 1-5 years, should consist of the following:

SITE PREPARATION

For shoreline sites where turfgrass is the only existing vegetation (no trees, shrubs, or other desirable plants) it is important to properly prepare the site for plantings. It is recommended turf be killed off with a lake-safe herbicide product. Remember to observe all product safety instructions including the rate and frequency of application. Consult a licensed herbicide applicator as necessary. Other options for eliminating turf include cutting and covering, however there are drawbacks that should be taken into consideration. Cut out turf creates bare soil which opens the area up to erosion and seeds already in the soil.

PLANTINGS

When monitoring your newly installed plants keep in mind the 3 W's of maintaining plants: Watch, Water and Weed. It is important to monitor plant growth and health, any signs of potential disease, and damage from insects and other herbivores. Plants will arrive in your shoreline just like any normal garden, so weeding may be necessary. In addition, it is critical that you monitor for any introduction or spread of invasive plant species.

Some common invasive plants to look for include: mint, purple loosestrife, phragmites, reed canary grass, yellow iris, Japanese knotweed, snow on the mountain, periwinkle. Find out more information about invasive species at Midwest Invasive Species Information Network: **www.misin.msu.edu.**

ORGANIC DEBRIS

Once the shoreline restoration project has been installed it is critical to allow "mother nature" to take its course. Over time, leaves, aquatic plants, and other organic material will collect in the near shore areas. The tendency of many lakefront property owners is to keep the newly-installed revetment clean of debris, but this is counter to shoreline restoration. This organic material will help to re-build the shoreline. As sediment, decaying plant matter, and other organic particles settle into the voids and gaps between the fieldstone, land is slowly building and conditions are becoming more receptive to support the critical plant community that will ultimately stabilize the shoreline.

EROSION

Although bioengineering strives to correct erosion in many cases, its success can vary. Some sections of shoreline will become stabilized, while others may continue to experience erosion or even develop new erosion because of inadequate design or installation. Where erosion persists or develops, it is important to address these areas as soon as possible. If this occurs, consider the following questions:

1. **Were the correct plants used?** Having a shoreline of all blooming flowers is pretty, however, they may not provide the necessary root structure. Trees, shrubs, sedges and grasses are critical. Adding some additional deep-rooting plants can provide additional protection.
2. **Are there enough plants?** Installing a few plants along the shoreline is not enough. Ensure the density is appropriate for the species selected and consider expanding the width of the greenbelt for greater benefit.
3. **Are the rocks positioned and sloped correctly?** Sometimes repositioning the fieldstone may be all that is needed, but if it was initially designed incorrectly, it will take more action.
4. **Does the erosion control blanket need to be re-anchored?**
5. **Has the coir log shifted?** Make sure it was tied in correctly initially. Repositioning may be necessary. Additional plants may be necessary to provide stability.

Factors Affecting **Cost**

MATERIALS

The costs of bioengineering vary by what solution is needed. The more complex the project is, the higher the cost. A homeowner can expect to spend an estimated $45 - $80 per linear foot on materials. For example, costs for a 38-cell plug flat of native plants can range from $85 - $110. Planting recommendations are usually about 1 plug per square foot depending on the site and species. A 10' x 100' native planting would cost approximately $2,600 at 1 plug per square foot for the plants. Larger plant stock could be utilized as well. Trees and shrubs should also be considered.

SITE ACCESS

Accessing lakeshore sites can be challenging for contractors and oftentimes access is limited. As a result, contractors may have to access the shoreline via a barge or use wheelbarrows to transport materials to the shoreline. These factors will impact the cost of the project. Regardless, it is important to consider how to best access the shoreline while minimally impacting the adjoining shoreland/ landscape. Shoreline properties are oftentimes low-lying wetland areas that are sensitive to soil compaction from heavy equipment. In this case, devising strategic means to access the shoreline is important. Using wheelbarrows, chutes, and other methods to transport materials to minimize destruction of sensitive plant communities, avoid soil compaction, and reduce risk to septic systems and other utilities is critical. These factors must be weighed beforehand to be sure no further harm is done to the shoreline, the adjoining landscape, and other infrastructure.

Photo depicting a rock chute to transport rocks to reduce impact.
Photo: J. Buchanan

Permitting **Requirements**

BIOENGINEERING SHORELINE PERMITS

Most activities that occur within or along the shoreline of inland lakes and streams are regulated. It is highly likely that your shoreline construction project will require a permit. Start by checking with your State's permitting agency for specific information, and you may need additional permits as well. If a contractor indicates that a permit is not needed, double check with your permitting agency.

Michigan inland lake permit information and resources can be accessed through the Michigan Department of Environment, Great Lakes, and Energy's website: www.michigan.gov/jointpermit

SOIL EROSION AND SEDIMENTATION CONTROL PERMITS

In addition to the shoreline bioengineering permit, a local Soil Erosion and Sedimentation Control Permit will be needed if you will be disturbing soils, removing existing vegetation, or changing topography within 500 feet of a lake or stream in Michigan. Other States have slightly different requirements. In Michigan, this permit is obtained through the local soil erosion inspector or officer in the county in which the project is located. Soil erosion officers review soil erosion and sedimentation control plans, issue permits, and take enforcement actions when necessary to ensure compliance.

Please check with your State's Soil Erosion Control Program or county Soil and Water Conservation District to learn more about applying for a local soil erosion permit.

RESOURCES

FINDING HELP

A list of contractors who have completed the Michigan Natural Shoreline Partnership's Certified Natural Shoreline Professional training is available at **www.shorelinepartnership.org**

It is important, however, that you feel confident they understand shoreline dynamics and will design an appropriate shoreline bioengineering project that meets both your needs and works to maintain the health of your lake.

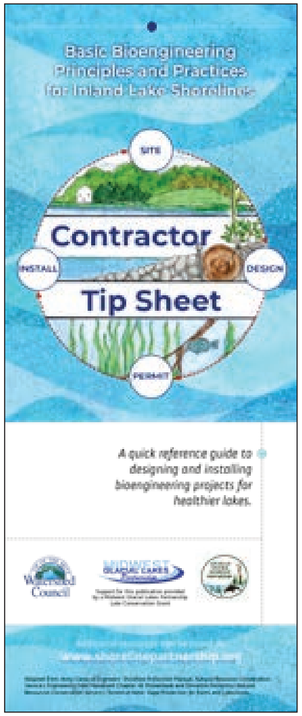
MICHIGAN NATURAL SHORELINE PARTNERSHIP (MNSP)

www.shorelinepartnership.org

The MNSP was formed in 2008 to provide guidance and leadership in changing from high impact shoreline erosion control methods to healthier and more sustainable practices that:

- Restore/Preserve the ecological function of the shoreline.
- Effectively stabilize shoreline erosion.
- Are attractive options to lakefront property owners.

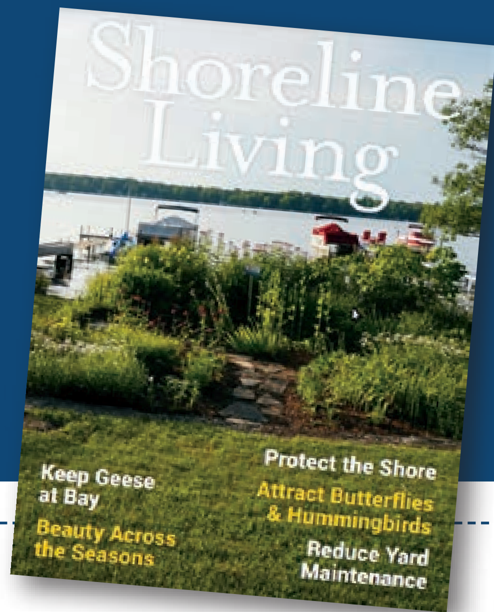
Explore the website for more information on shoreline basics, erosion control, native plants, permitting, contractors, and a resource library.



MICHIGAN SHORELAND STEWARDS PROGRAM (MiSS)

www.mishorelandstewards.org

The Michigan Shoreland Stewards Program is a program of the Michigan Natural Shoreline Partnership (MNSP). MiSS is a free statewide recognition program for lake front property owners. It consists of a web-based questionnaire that is intended to encourage protection of Michigan's inland lakes through best management practices. Property owners have the potential to qualify at three different levels for healthy properties.



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