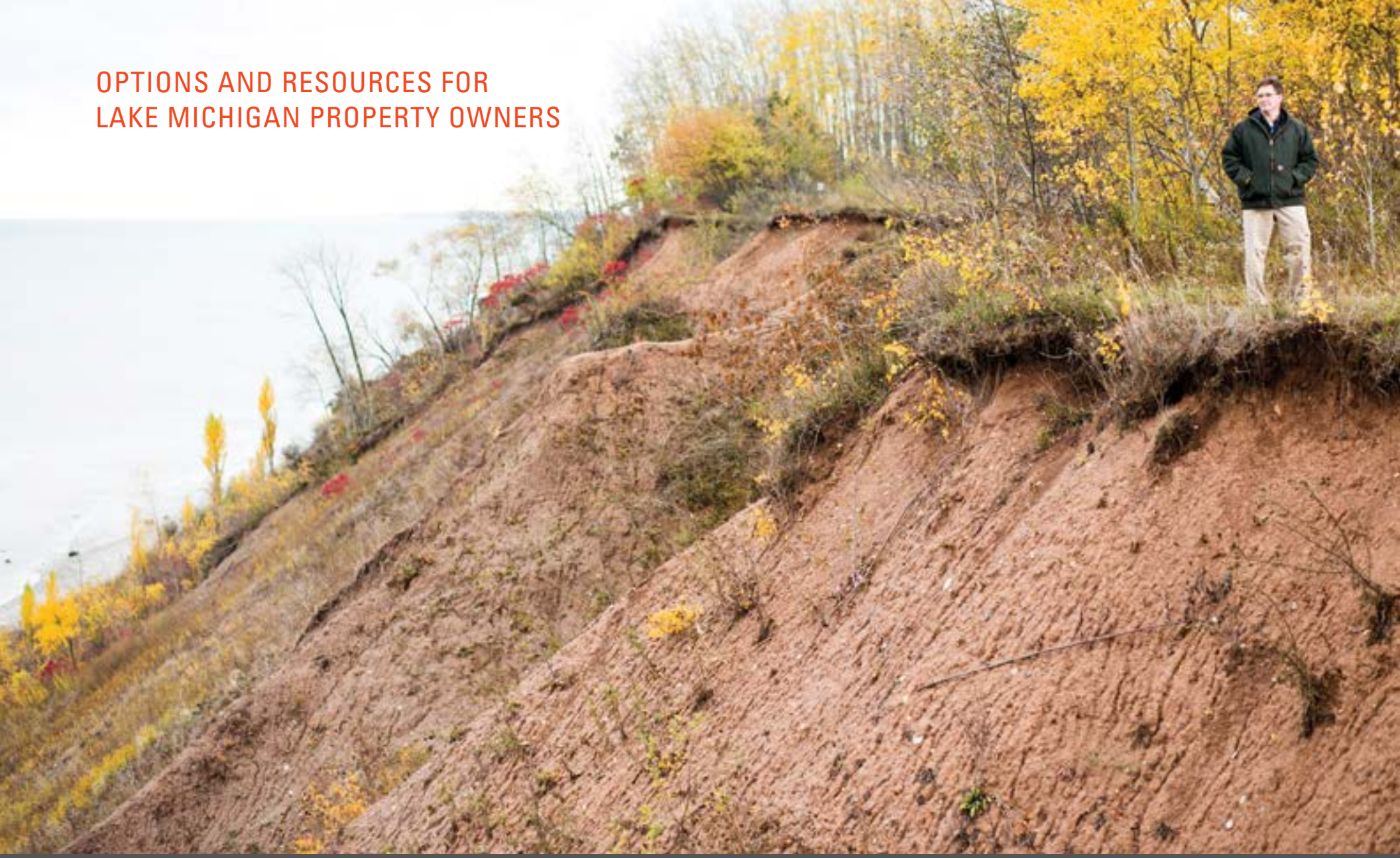
OPTIONS AND RESOURCES FOR
LAKE MICHIGAN PROPERTY OWNERS



Adapting to a Changing Coast

UNIVERSITY OF WISCONSIN SEA GRANT INSTITUTE

Cover: Lake Michigan Bluff in Lion's Den Gorge Nature Preserve, Narayan Mahon

Adapting to a Changing Coast

OPTIONS AND RESOURCES FOR LAKE MICHIGAN PROPERTY OWNERS IN SOUTHEASTERN WISCONSIN

Andrew Mangham, David Hart, Adam Bechle, Gene Clark,
Deidre Peroff, Julia Noordyk, Bert Stitt and Linda Stitt

UNIVERSITY OF WISCONSIN SEA GRANT INSTITUTE

August 2017

CONTENTS

Introduction IV

THEME 1: LOW-IMPACT PRACTICES 1
Building Relocation 2
Mobile Construction 4
Green Infrastructure / Low-Impact Development 6

THEME 2: BLUFF STABILITY PRACTICES 9
Bluff Top Practices for Stormwater and Wastewater Management 10
Bluff Dewatering 12
Bluff Vegetation and Green Infrastructure 14
Bluff Re-Grading and Terracing 16

THEME 3: STRUCTURAL SHORE PROTECTION 19
Revetment 20
Seawall 22
Groin 24

THEME 4: NATURE-BASED SHORE PROTECTION 27
Living Revetment / Seawall 28
Artificial Beaches and Beach Nourishment 30

THEME 5: COLLABORATION AND FACILITATION 33
Non-Binding Collaboration With Neighbors 34
Visioning and Facilitated Collaboration 36
Dynamic Concept Mapping / VCAPS 38
Neighborhood Associations 40

Acknowledgements 43
Credits 44

INTRODUCTION

One of the unique challenges of living on the shores of the Great Lakes is the variability of their water levels. Since the record low monthly average water level on lakes Michigan and Huron in January 2013, heavy rainfall and low evaporation have driven a rapid rise. This includes a 2.9-foot increase above the record low by July 2014, moving levels back above the long-term average recorded over the past 100 years. Water levels as of July 2017 have increased an additional 1.8 feet but are still 1.6 feet short of the record high monthly average of October 1986. In some sections of the Lake Michigan coast, rising water levels have submerged beaches and brought high-energy waves right up to the toe of lakeside bluffs.

In 2015, a team of investigators representing disciplines including coastal engineering, geology, urban and regional planning, law, policy studies, ecology, landscape architecture and social science led by the University of Wisconsin Sea Grant Institute received funding from the Graham Sustainability Institute at the University of Michigan to explore the impacts of changing water levels on coastal bluffs in northern Milwaukee County and southern Ozaukee County. This Great Lakes Water Levels Integrated Assessment identified, reviewed and synthesized existing data and reports and developed more than 60 possible options to help local officials and property owners adapt to a changing coast.

This document presents 16 options in five themes that address changing coastal bluffs and beaches.

One of the key elements of University of Wisconsin Sea Grant Institute's approach to the integrated assessment was the community engagement used to identify and assess response options. This engagement was led by a pair of experienced community facilitators and the social science outreach specialist at Wisconsin Sea Grant. It included three community conversations attended by more than 140 people during the summer of 2016 to provide background on water levels and coastal bluff processes and resources to address coastal erosion, as well as listening to hopes, wishes, concerns and issues for a healthy and vital future for coastal bluffs and shores.

This document presents 16 options in five themes that address changing coastal bluffs and beaches. We've selected these 16 options from the more than 60 total options because they represent practices that coastal property owners in southeastern Wisconsin could consider to address coastal hazards. Though we drew on the experience and insights of experts in an array of fields ranging from public engagement to regional planning to coastal engineering, our intention was always to provide a set of options rather than a set of prescriptions. Ultimately, the decisions about what to do in the face of variable lake levels, eroding beaches and unstable bluffs belong to the people that live with those issues.

Keeping that in mind, we present a diversity of options that respond to the issues, concerns and hopes that came out of our community engagement meetings and reflect a range of priorities and perspectives. There are structural options for preventing erosion and stabilizing bluffs that rely on armoring shorelines and reshaping the landscape. There are also options that rely on living with natural processes and retreating from the coast. To help guide homeowners' decisions we also provide some of the main benefits and challenges associated with these options. We are hopeful that these options will help homeowners and community officials build resilience to coastal hazards that result from variable Great Lakes water levels and storms.

THEME 1: LOW-IMPACT PRACTICES

- BUILDING RELOCATION
- MOBILE CONSTRUCTION
- GREEN INFRASTRUCTURE / LOW-IMPACT DEVELOPMENT

BUILDING RELOCATION

Who?
Homeowner

Purpose?
Move home to safe location without altering coastline

Challenges?
Relocation cost may exceed value of home

Cost?
$-$$$

Adding shore protection or re-grading a bluff can be extremely costly and requires appropriate techniques to be effective. Even when done properly, armoring the shore and altering the bluffs can have significant impacts on the coastal ecosystem and sediment budget within the lakes. In many cases, physically relocating an at-risk house away from the bluff top to a safe location can be a less expensive and more effective solution. For developers working in potentially high-risk coastal areas, consider using modular or mobile construction techniques and zoning practices that ease relocation.

Benefits	Challenges
Avoids damaging coastal ecosystem	Relocation cost can exceed value of home
Preserves sediment input to lake	Loss of homes could reduce tax base
Avoids impacts to neighbors from shore protection structures	Loss of homes could impact adjacent property values
Can be much less expensive than shore protection/bluff stabilization	
Can be most effective option for safeguarding homes	

Resources

"House Relocation-County Hwy LS-Sheboygan County" a summary of a relocation by a resident on the border of Sheboygan and Manitowoc counties by Alan Lulloff, Association of State Floodplain Managers (ASFPM).
uwmadison.box.com/v/lulloff-bluff-relocation

A news story about the relocation of musician Paul Simon's Hamptons Cottage in response to bluff erosion, featuring Gene Clark of Wisconsin Sea Grant.
realtor.com/news/celebrity-real-estate/paul-simon-hamptons-cottage-physically-moved/

"A Case Study on Adapting to Erosion and Sea Level Rise," a summary of the relocation of the town of Longboat Key in response to sea level rise in Florida by the Florida Sea Grant College Program.
flseagrant.org/wp-content/uploads/2011/08/Longboat-Key-Case-Study_web-version.pdf

"Move Back to Avoid the Hazard," an informational site from the Maine Sea Grant Program giving advice about relocation in the face of coastal hazards.
seagrant.umaine.edu/coastal-hazards-guide/beaches-and-dunes/move-back

"Relocation Engineering Principles and Practices," a factsheet produced by the Federal Emergency Management Agency (FEMA) for homeowners to help plan a relocation.
fema.gov/media-library-data/20130726-1506-20490-8344/fema259_ch5r.pdf

Building relocation images: This Sheboygan, Wis., home had to relocate across the highway after a bluff collapse (left).

One strategy for living on a dynamic coastline is to use construction techniques that ease relocation, as is the case with this home (right).

Related Option

Mobile Construction

MOBILE CONSTRUCTION

Who?
Homeowner

Purpose?
Ease relocation of homes in event of retreat from the coast

Challenges?
Requires specialized construction

Cost?
$-$$$

Relocating a home can be a less expensive and more effective solution to addressing risks from eroding shorelines and collapsing bluffs. However, some homes are easier to relocate than others. Citizens and communities considering new construction near bluffs might consider using modular building techniques to make buildings easier to relocate in the event that it becomes necessary.

Benefits	Challenges
Eases relocation of homes in event of retreat from coastline	Requires specialized construction that may limit aesthetics/value
Could ease protection of coastal ecosystem	
Could ease preservation of sediment input to lake	
Can be less expensive than adding shore protection/bluff stabilization	
Eases most effective option for safeguarding homes	

Resources

Modular building techniques have come a long way from mobile homes in trailer parks. The Modular Building Institute, a non-profit trade association for modular construction, provides information about advantages of modern modular construction practices, including a discussion of relocatable buildings.
modular.org/htmlPage.aspx?name=why_modular

In New Zealand, coastal communities face serious threats from erosion and rising sea levels. In many communities the idea of a managed retreat, the planned relocation of a community away from the coastline, is gaining popularity. A key component of incorporating this strategy is making buildings easily relocatable. This presentation from the New Zealand Planning Institute discusses some of the challenges associated with adopting a policy of building relocatable homes as part of a long-term strategy for resilience.
planning.org.nz/Folder?Action=View%20File&Folder_id=255&File=BARRY-PICENO_Kate.pdf

This report from Environment Waikato, a local government agency in New Zealand, discusses the feasibility of implementing a long-term managed retreat strategy and specifically recommends relocatable construction as a component of the plan.
waikatoregion.govt.nz/assets/PageFiles/5405/tr06-48.pdf

Related Options

Building Relocation

Green Infrastructure / Low-Impact Development

Mobile construction images: The use of mobile construction techniques makes building relocation easier. Mobile construction techniques include modular construction and prefabricated housing but also include simple approaches, such as building a home that is elevated over a pad and easier to load onto a trailer (top left).

Many companies produce beautiful, efficient homes that are also relatively simple to move if necessary (top right).

In some areas, the use of mobile construction is being discussed as a requirement for all new housing, as those areas embrace the idea of a managed retreat rather than sinking millions into armoring the shore (bottom).

GREEN INFRASTRUCTURE / LOW-IMPACT DEVELOPMENT

Who?
Homeowner/local or state government

Purpose?
Mitigate impacts on coastal erosion due to human development

Challenges?
Requires appropriate location and construction practices

Cost?
$-$$$

Green infrastructure refers to techniques for development that protects, restores, or mimics natural processes. Other terms that come up to describe certain green infrastructure practices are low-impact development and living shorelines. In this context, we are talking about using green infrastructure techniques to improve the stability of bluffs. Using bluff vegetation to slow the erosion of the bluff top and bluff face caused by runoff is an example of green infrastructure. Other examples include using rain barrels to catch roof runoff before it can infiltrate into the bluff or using appropriately located rain gardens or bioswales to direct, capture and infiltrate stormwater runoff away from the bluff.

Benefits	Challenges
Reduces development impacts that can aggravate bluff/shore erosion	Requires appropriate location and construction practices to be effective
Can improve aesthetics/value of new development	Reduces development impacts, but may not completely mitigate them
Can be lower cost than shore protection/bluff stabilization	Reduces impact from development, but may not impact natural erosion processes

Resources

"Vegetative Best Management Practices: A Manual for Pennsylvania and Lake Erie Bluff Landowners," a free publication made available by Pennsylvania Sea Grant.
seagrant.psu.edu/sites/default/files/BluffBook2017_0.pdf

"Reducing Stormwater Costs Through Low Impact Development (LID) Strategies and Practices," an overview of green infrastructure/low-impact development techniques for managing stormwater published by the Environmental Protection Agency.
epa.gov/green-infrastructure/stormwater-costs

"Design Guidelines for Stormwater Bioretention Facilities," a free publication from the University of Wisconsin Water Resources Institute.
publications.aqua.wisc.edu/product/design-guidelines-for-stormwater-bioretention-facilities/

"Stabilizing Coastal Slopes," a free publication available on the University of Wisconsin Sea Grant Institute website.
publications.aqua.wisc.edu/product/stabilizing-coastal-slopes-on-the-great-lakes/

"Minimizing Bluff Top Development Risk," a case study about bluff development in Ozaukee County, Wis., on the National Oceanic and Atmospheric Administration's Great Lakes Coastal Resilience Planning Guide.
greatlakesresilience.org/case-studies/land-use-zoning/minimizing-bluff-top-development-risk

Related Options

Bluff Top Practices for Stormwater and Wastewater Management

Bluff Vegetation and Green Infrastructure

Artificial Beaches and Beach Nourishment

Green infrastructure images: Green infrastructure techniques are not always strong enough to resist erosion by incoming waves, but they can help with erosion of fine sand and sediment. Here (left) a combination of planting and windscreens helps mitigate erosion of a beach in Kenosha, Wis.

This bioswale in Mequon, Wis., (right) is another form of green infrastructure designed to capture, direct and infiltrate stormwater. Bioswales can be used to direct stormwater off a bluff, improving stability.

NOTES

THEME 2: BLUFF STABILITY PRACTICES

- BLUFF TOP PRACTICES FOR STORMWATER AND WASTEWATER MANAGEMENT
- BLUFF DEWATERING
- BLUFF VEGETATION AND GREEN INFRASTRUCTURE
- BLUFF RE-GRADING AND TERRACING

BLUFF TOP PRACTICES FOR STORMWATER AND WASTEWATER MANAGEMENT

Who?
Homeowner/local or state government

Purpose?
Reduce bluff erosion from stormwater runoff flow

Challenges?
Requires appropriate location and construction practices

Cost?
$-$$

When allowed to flow over the top of a bluff, stormwater runoff from snowmelt and rain can erode the top and face of the bluff, significantly decreasing bluff stability. The addition of impervious surfaces, such as rooftops, driveways, streets and sidewalks, will increase stormwater runoff volume and can lead to faster rates of erosion of the bluff. Bluff top stormwater runoff best practices consist of a range of actions that can be taken by homeowners and municipalities to direct the flow of runoff away from the edge of the bluff, reducing erosion rates and the risk of collapse. Examples include appropriately positioning stormwater ditches and roof gutters to direct flow away from the bluff, using rain barrels to capture roof runoff and routing water into existing storm sewer systems.

Benefits	Challenges
Reduces bluff top/face erosion from stormwater	Requires appropriate location and construction practices to be effective
Improves long-term bluff stability	Requires homeowner education
Can be very cost-effective approach to addressing bluff erosion issues	Does not address other bluff stability issues such as slope angle/natural groundwater drainage

Resources

"Pine Creek Conservancy," a case study by Alan Lulloff of the Association of State Floodplain Managers (ASFPM) about a development in Manitowoc, Wis., that was threatened by poor choices that were made when choosing a location for a septic system.
uwmadison.box.com/v/lulloff-pinecreek

"Protecting Coastal Investments," a free publication pulling together examples of regulations for Wisconsin's coastal communities by University of Wisconsin–Madison Professor Brian Ohm. For a discussion of stormwater and wastewater management go to page 32 of the publication.
nsgl.gso.uri.edu/wiscu/wiscuh08001.pdf

"Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices," an overview of green infrastructure/low-impact development techniques for managing stormwater published by the EPA.
bit.ly/2vlQKhT

Bluff top stormwater practices images: This home (left) was well constructed at a very safe distance from the bluff. However, the developer installed a mound system for wastewater disposal between the house and the bluff. The added water and weight from the system caused the bluff to collapse after a severe storm. Moving the mound system to the landward side of the development could have prevented the collapse.

A rain barrel set up to collect runoff from the roof (top right). Along with directing roof drain downspouts away from the bluff, collecting the water in barrels rather than allowing it to infiltrate into the bluff is an excellent strategy for managing bluff top stormwater runoff.

Stormwater infiltration system installed in a parking lot constructed on a bluff top (bottom right). Runoff from the parking lot is diverted away from the bluff and collected in this system, which allows it to drain into the soil. The system is designed so that the added groundwater flows away from the bluff, improving its stability.

"Stabilizing Coastal Slopes," a free publication available on the University of Wisconsin Sea Grant Institute website.
publications.aqua.wisc.edu/product/stabilizing-coastal-slopes-on-the-great-lakes/

"Minimizing Bluff Top Development Risk," a case study about bluff development in Ozaukee County, Wis., on the National Oceanic and Atmospheric Administration's Great Lakes Coastal Resilience Planning Guide.
greatlakesresilience.org/case-studies/land-use-zoning/minimizing-bluff-top-development-risk

Related Options

Bluff Re-grading and Terracing

Bluff Vegetation and Green Infrastructure

Bluff Dewatering

Building Relocation

BLUFF DEWATERING

Who?
Homeowner/local or state government

Purpose?
Improve bluff stability

Challenges?
Requires frequent maintenance

Cost?
$-$$$

Groundwater seeping out of the face of a bluff can increase instability and the chance of bluff collapse. Dewatering is the practice of using drainage systems to reduce the groundwater level in a bluff and improve its stability.

Benefits	Challenges
Improves bluff stability by reducing/rerouting groundwater flow through the bluff	Requires appropriate location and construction practices to be effective
Lower cost than bluff re-grading/terracing	Can require frequent maintenance to clear/repair blocked or damaged drains
Lower impact on coastal ecosystem than more aggressive bluff stabilization practices	Does not address other bluff stability issues such as slope angle or stormwater erosion

Resources

"Stabilizing Coastal Slopes," a free publication available on the University of Wisconsin Sea Grant Institute website.
publications.aqua.wisc.edu/product/stabilizing-coastal-slopes-on-the-great-lakes/

Coastal bluff failure information on the University of Wisconsin Sea Grant Institute website.
seagrant.wisc.edu/Home/Topics/CoastalEngineering/Details.aspx?PostID=698

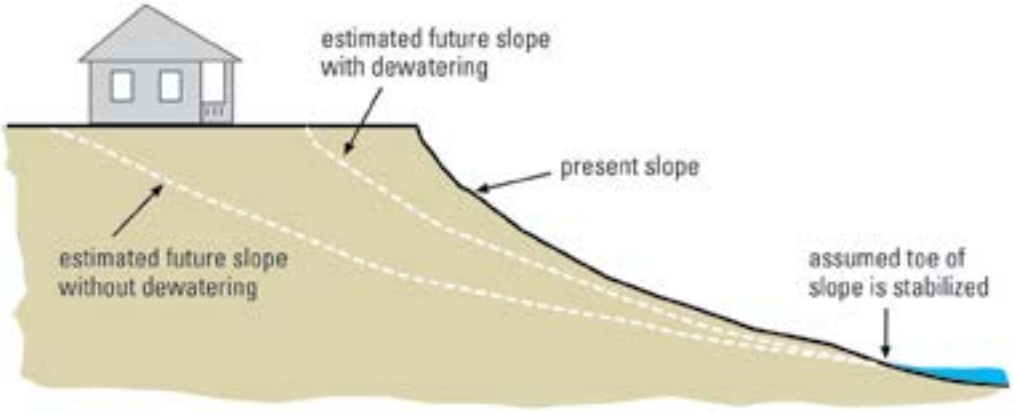
Construction setbacks information on the University of Wisconsin Sea Grant Institute website.
seagrant.wisc.edu/Home/Topics/CoastalEngineering/Details.aspx?PostID=703

"Great Lakes Bluff Failures," a publication by Dave Mickelson, emeritus professor of the University of Wisconsin-Madison Department of Geoscience.
readywisconsin.wi.gov/CoastalErosion/DM_bluff_processes_racine_co.pdf

"A Primer on Coastal Bluff Erosion," a free publication from the California Coastal Commission.
coastal.ca.gov/publiced/waves/coastal-erosion.pdf

"Living on the Coast: Protecting Investments in Shore Property on the Great Lakes," a joint publication from University of Wisconsin Sea Grant Institute and the U.S. Army Corps of Engineers.
seagrant.umn.edu/downloads/ch002.pdf

"Minimizing Bluff Top Development Risk," a case study about bluff development in Ozaukee County, Wis., on the National Oceanic and Atmospheric Administration's Great Lakes Coastal Resilience Planning Guide.
greatlakesresilience.org/case-studies/land-use-zoning/minimizing-bluff-top-development-risk



Related Options

Bluff Re-grading and Terracing

Bluff Vegetation and Green Infrastructure

Bluff Top Practices for Stormwater/ Wastewater Management

Building Relocation

Bluff dewatering images: Dewatering a bluff can have a profound impact on bluff stability (top). Note how different the future slopes are with and without dewatering. Dewatering can be accomplished using various draining techniques.

Groundwater seeping out of the face of a bluff (bottom left).

The black pipe coming out of the bluff (bottom right) is the mouth of a wick drain, a common type of drain used to dewater bluffs.

BLUFF VEGETATION AND GREEN INFRASTRUCTURE

Who?
Homeowner/local or state government

Purpose?
Improve bluff stability

Challenges?
Choosing/establishing appropriate vegetation

Cost?
$-$$

"Green infrastructure" refers to a set of practices that mimic natural systems and promote a healthy ecosystem. In this case, appropriate planting on the top and face of the bluff can slow erosion caused by stormwater runoff and improve bluff stability with developed root systems.

Benefits	Challenges
Reduces erosion rate on bluff top/face by spreading and slowing runoff and groundwater flow	Choosing appropriate native vegetation requires knowledge or guidance
Improves aesthetics of bluff	Establishing healthy, stable plant population can be difficult in early stages
Can improve quantity/quality of coastal habitat and ecosystem	Does not address other bluff stability issues such as slope angle
Can be a cost-effective method for reducing bluff erosion	

Resources

"Stabilizing Coastal Slopes," a free publication available on the University of Wisconsin Sea Grant Institute website.
publications.aqua.wisc.edu/product/stabilizing-coastal-slopes-on-the-great-lakes/

"Stabilizing Very Steep Slopes & Coastal Bluffs," a free publication made available by the Safe Harbor Environmental Consulting Group.
safeharborenv.com/free-publications/

"Vegetative Best Management Practices: A Manual for Pennsylvania and Lake Erie Bluff Landowners," a free publication made available by the Pennsylvania Sea Grant Institute.
seagrant.psu.edu/sites/default/files/BluffBook2017_0.pdf

"Minimizing Bluff Top Development Risk," a case study about bluff development in Ozaukee County, Wis., on the National Oceanic and Atmospheric Administration's Great Lakes Coastal Resilience Planning Guide.
greatlakesresilience.org/case-studies/land-use-zoning/minimizing-bluff-top-development-risk

Related Options

Bluff Dewatering

Bluff Re-grading and Terracing

Bluff Top Practices for Stormwater/ Wastewater Management

Bluff vegetation images: This bluff (top left) has been recently regraded and is currently being planted with grasses to help stabilize the soils and slow erosion.

Use of appropriate vegetation on the face of a bluff is important. Certain species of trees add weight to a bluff and have broad, shallow root systems that tear out soils when the tree falls over (top right).

Vegetation can also be used to help stabilize dune and beach areas (bottom).

BLUFF RE-GRADING AND TERRACING

Who?
Homeowner/local or state government

Purpose?
Improve bluff stability

Challenges?
Expensive, can be limited by existing infrastructure

Cost?
$-$$

This technique involves increasing the stability of a bluff by physically altering the shape, moving the bluff top away from the shore and creating a gentle slope between the top and toe of the bluff. In some cases, terraces can be cut into the bluff.

Benefits	Challenges
Provides long-term bluff stability by creating new slope angle	Can be very expensive
Can provide increased area for natural vegetation and habitat	Extent of grading/terracing can be limited by existing infrastructure
	Might reduce sediment input to lake and lead to loss of beaches

Resources

"Stabilizing Coastal Slopes," a free publication available on the University of Wisconsin Sea Grant Institute website.
publications.aqua.wisc.edu/product/stabilizing-coastal-slopes-on-the-great-lakes/

Coastal bluff failure information on the University of Wisconsin Sea Grant Institute website.
seagrant.wisc.edu/Home/Topics/CoastalEngineering/Details.aspx?PostID=698

Construction setbacks information on the University of Wisconsin Sea Grant Institute website.
seagrant.wisc.edu/Home/Topics/CoastalEngineering/Details.aspx?PostID=703

"Great Lakes Bluff Failures," a publication by Dave Mickelson, emeritus professor of the University of Wisconsin-Madison Department of Geoscience.
readywisconsin.wi.gov/CoastalErosion/DM_bluff_processes_racine_co.pdf

"A Primer on Coastal Bluff Erosion," a free publication from the California Coastal Commission.
coastal.ca.gov/publiced/waves/coastal-erosion.pdf

"Living on the Coast: Protecting Investments in Shore Property on the Great Lakes," a joint publication from University of Wisconsin Sea Grant Institute and the U.S. Army Corps of Engineers (USACE).
seagrant.umn.edu/downloads/ch002.pdf

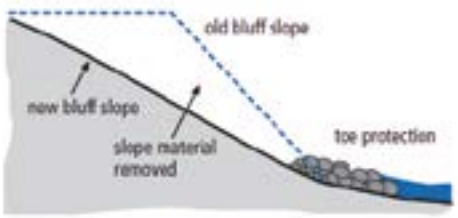


Figure 8: Cutback Slope Stabilization Method

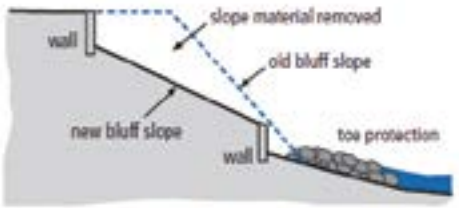


Figure 10: Terraced Bluff Stabilization Method

Figure 9: Cut and Fill Slope Stabilization Method

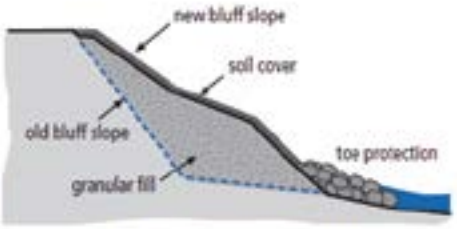


Figure 11: Fill Slope Stabilization Method

"Stabilizing Concordia University's Bluff," a summary of the issues associated with a bluff stabilization project on the campus of Concordia University in Mequon, Wis., published on the National Oceanic and Atmospheric Administration's Great Lakes Coastal Resilience Planning Guide.
greatlakesresilience.org/stories/wisconsin/stabilizing-concordia-university%E2%80%99s-bluff-0

"Minimizing Bluff Top Development Risk," a case study about bluff development in Ozaukee County, Wis., on NOAA's Great Lakes Coastal Resilience Planning Guide.
greatlakesresilience.org/case-studies/land-use-zoning/minimizing-bluff-top-development-risk

Related Options

Bluff Dewatering

Bluff Vegetation and Green Infrastructure

Bluff Top Practices for Stormwater/ Wastewater Management

Building Relocation

Bluff re-grading and terracing images: Different approaches to bluff regrading (top left).

This bluff is in the process of being regraded using the terracing method (top right).

A view from the bottom of a bluff that has been regraded using a terracing method (bottom left).

Rather than using terraces, this bluff has been reshaped to have a smooth, gentle slope to the shore (bottom right).

NOTES

THEME 3: STRUCTURAL SHORE PROTECTION

- REVETMENT
- SEAWALL
- GROIN

REVETMENT

Who?
Homeowner/local or state government

Purpose?
Reduce shore erosion

Challenges?
Can accelerate erosion of adjacent properties

Cost?
$$-$$$$

Similar to a seawall, this is a hard protective structure, often made of stone, concrete or sandbags parallel to the shore with a sloping face designed to protect against wave erosion.

Benefits	Challenges
Resists bluff toe and shore erosion from strong waves	Can accelerate shore erosion of adjacent properties
Can provide some protection from storm surge	Can accelerate erosion of lakebed along bottom edge of revetment
Can be durable, long-term technique for reducing shore erosion	Requires appropriate materials/practices to be effective
	Reduces sediment input to lake and leads to loss of beaches
	Damages shoreline habitat
	Can limit pedestrian access to shoreline
	Can be difficult to access site for construction

Resources

"Natural and Structural Measures for Shoreline Stabilization," a publication by the Systems Approach to Geomorphic Engineering.
sagecoast.org/docs/SAGE_LivingShorelineBrochure_Print.pdf

"Living on the Coast: Protecting Investments in Shore Property on the Great Lakes," a joint publication from the University of Wisconsin Sea Grant Institute and the U.S. Army Corps of Engineers.
seagrant.umn.edu/downloads/ch002.pdf

"Great Lakes Coastal Shore Protection Structures and Their Effects on Coastal Processes," a publication by Wisconsin Sea Grant.
ready.wi.gov/CoastalErosion/GLCoastalShoreProtectctionStructures.pdf

Related Options

Seawall

Groin

Living Revetment/Seawall

Artificial Beaches and Beach Nourishment

Revetment images: Revetments are often made of interlocking stones and should slope down into the water (top left).

The Southport Park revetment in Kenosha, Wis., provides simple shore protection (top right).

Revetments can be paired with other coastal erosion techniques. Bender Park in Oak Creek, Wis., is an example of a revetment paired with bluff re-grading. The bluff is at a stable angle, and the revetment protects the bluff toe from further erosion (bottom).

SEAWALL

Who?
Homeowner/local or state government

Purpose?
Reduce shore erosion

Challenges?
Can accelerate erosion of adjacent properties

Cost?
$$$-$$$$$

Similar to a revetment, this is a hard structure running parallel to the shoreline that resists erosion by incoming waves. Seawalls can be vertical or sloping and can allow for access by including walkways along the top.

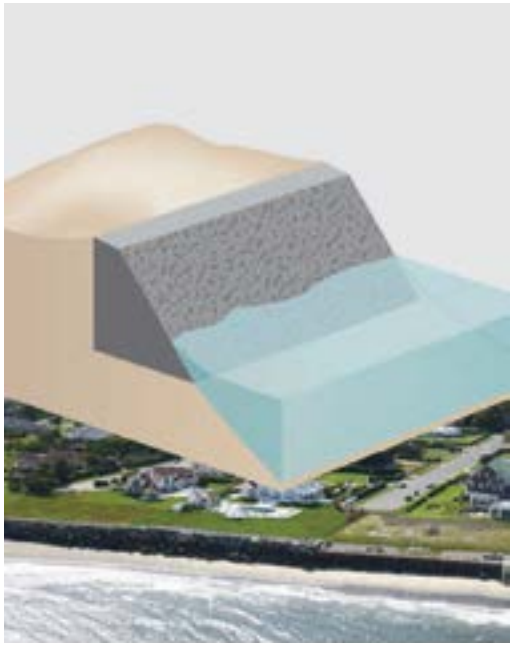
Benefits	Challenges
Resists bluff toe and shore erosion from strong waves	Can accelerate shore erosion of adjacent properties
Can be durable, long-term technique for reducing shore erosion	Can accelerate erosion of lakebed along bottom edge of seawall
Can maintain shoreline access by adding pathway along top of seawall	Requires appropriate materials/practices to be effective
	Reduces sediment input to lake and leads to loss of beaches
	Damages shoreline habitat
	Can be difficult to access site for construction
	May present higher costs than revetment

Resources

"Natural and Structural Measures for Shoreline Stabilization," a publication by the Systems Approach to Geomorphic Engineering.
sagecoast.org/docs/SAGE_LivingShorelineBrochure_Print.pdf

"Living on the Coast: Protecting Investments in Shore Property on the Great Lakes," a joint publication from the University of Wisconsin Sea Grant Institute and the U.S. Army Corps of Engineers.
seagrant.umn.edu/downloads/ch002.pdf

"Great Lakes Coastal Shore Protection Structures and Their Effects on Coastal Processes," a publication by Wisconsin Sea Grant.
ready.wi.gov/CoastalErosion/GLCoastalShoreProtectctionStructures.pdf



Related Options

Revetment

Groin

Living Revetment/Seawall

Artificial Beaches and Beach Nourishment

Seawall images: While revetments are often made of interlocking stones, seawalls tend to be constructed out of continuous materials like concrete or sheet metal (top left).

Some seawalls are sloped towards the water (top right), but most are vertical like this seawall in Kenosha, Wis. (bottom).

GROIN

Who?
Homeowner/local or state government

Purpose?
Reduce shore erosion

Challenges?
Accelerates erosion of adjacent shoreline

Cost?
$$-$$$

A structure built out into the water perpendicular to the shore. Designed to intercept water and sediment flow running parallel to the shore to either capture sediment or prevent loss of sediment. The beaches created by these groins can protect the toe of a bluff by allowing waves to break over a gentle slope rather than slam into the toe of a bluff. Groins that extend further into the water and rise higher from the lake bed will capture more sediment. In Illinois, shorter groins are combined with added sand to create pocket beaches. When used in this way, groins can have less of an impact on the sediment budget within the lake.

Benefits	Challenges
Preserves beach by trapping incoming sediment and resisting erosion by parallel currents	Accelerates erosion of adjacent properties
Includes a wide variety of construction options	Presents increasing difficulty in getting permit approval due to adjacent erosion impacts
Has lower construction and maintenance costs than other practices	Reduces sediment input to lake and can lead to beach loss in other locations

Resources

"Natural and Structural Measures for Shoreline Stabilization," a publication by the Systems Approach to Geomorphic Engineering.
sagecoast.org/docs/SAGE_LivingShorelineBrochure_Print.pdf

"Living on the Coast: Protecting Investments in Shore Property on the Great Lakes," a joint publication from the University of Wisconsin Sea Grant Institute and the U.S. Army Corps of Engineers.
seagrant.umn.edu/downloads/ch002.pdf

"Great Lakes Coastal Shore Protection Structures and Their Effects on Coastal Processes," a publication by Wisconsin Sea Grant.
ready.wi.gov/CoastalErosion/GLCoastalShoreProtectctionStructures.pdf

Related Options

Revetment

Seawall

Living Revetment/Seawall

Artificial Beaches and Beach Nourishment

Groin images: Groins can be made from a variety of materials, ranging from stone (top left) to concrete slabs (top right) to sheet metal (bottom).

Groins can also be paired with other practices, as in Klode Park in Whitefish Bay, Wis. (bottom). Small breakwaters have been placed perpendicular to the groins to provide added protection to shore.

NOTES

THEME 4: NATURE-BASED SHORE PROTECTION

- LIVING REVETMENT/SEAWALL
- ARTIFICIAL BEACHES AND BEACH NOURISHMENT

LIVING REVETMENT / SEAWALL

Who?
Homeowner/local or state government

Purpose?
Reduce shore erosion

Challenges?
Accelerates erosion of adjacent shoreline

Cost?
$$$-$$$$

These structures are very similar to traditional revetments and seawalls in that they are structures running parallel to the shore with either a sloping (in the case of revetments) or vertical (in the case of seawalls) facing the lake. However, they also include the use of vegetation and stones on the land immediately behind the structure.

Benefits	Challenges
Resists bluff toe and shore erosion from strong waves	Can accelerate shore erosion of adjacent properties
Adds/preserves near-shore habitat	Can accelerate erosion of lakebed along bottom edge of structure
Can be durable, long-term technique for reducing shore erosion	Requires appropriate materials/practices to be effective
Improves appearance over traditional seawall or revetment structures	Reduces sediment input to lake and leads to loss of beaches
	Can be difficult to access site for construction

Resources

"Natural and Structural Measures for Shoreline Stabilization," a publication by the Systems Approach to Geomorphic Engineering.
sagecoast.org/docs/SAGE_LivingShorelineBrochure_Print.pdf

"Guidance for Considering the Use of Living Shorelines," a publication by the National Oceanic and Atmospheric Administration.
habitat.noaa.gov/pdf/noaa_guidance_for_considering_the_use_of_living_shorelines_2015.pdf

"Living Shoreline Design Guidelines for Shore Protection in Virginia's Estuarine Environments," a more in-depth discussion of living shoreline techniques, including hybrid techniques such as a living revetment, published by the Virginia Institute of Marine Science.
vims.edu/research/departments/physical/programs/ssp/_docs/living_shorelines_guidelines.pdf

Related Option

Artificial Beaches and Beach Nourishment

Living revetment images: A hybrid structure that combines elements of hard shore protection and living shorelines can take many forms. It can enhance the living shoreline when a marsh that protects the shoreline is protected by a low-profile form of a revetment called a sill (left).

It can also enhance the hard structure and simply include planting along the top of a revetment or seawall (right).

ARTIFICIAL BEACHES AND BEACH NOURISHMENT

Who?
Homeowner /local or state government

Purpose?
Reduce shore erosion

Challenges?
Requires periodic renewal of sediment

Cost?
$-$$$

Depositing sand on the shoreline to either replenish sediment washed away from an existing beach or to create a new beach that slopes into the lake can reduce wave energy or increase resistance to flooding. In some cases, such as with artificial pocket beaches, natural erosion can be slowed by using short groins filled to the design height with sand to create the beach and breakwater structures to reduce the energy of incoming waves.

Benefits	Challenges
Preserves/adds beach area along shore	Requires constant maintenance
Adds sediment to lake, feeding other beaches	
Can recycle sediment removed during lakebed/ inland development	
Provides additional shoreline habitat	

Resources

"Living on the Coast: Protecting Investments in Shore Property on the Great Lakes," a joint publication from the University of Wisconsin Sea Grant Institute and the U.S. Army Corps of Engineers.
seagrant.umn.edu/downloads/ch002.pdf

"Natural and Structural Measures for Shoreline Stabilization," a publication by the Systems Approach to Geomorphic Engineering.
sagecoast.org/docs/SAGE_LivingShorelineBrochure_Print.pdf

"Explore Beaches," an informational site from the University of Southern California Sea Grant Institute.
explorebeaches.msi.ucsb.edu/beach-health/beach-nourishment

Beach Nourishment informational website from the University of Maine Sea Grant Institute.
seagrant.umaine.edu/coastal-hazards-guide/beaches-and-dunes/beach-scraping-and-nourishment

Related Option

Groin

2

Artificial beach images: Beach nourishment can be used to construct an artificial beach, and it can be combined with structural approaches. This pocket beach on the Concordia University campus in Wisconsin (top left) is set back from the shoreline and protected by extensions of a revetment that act like breakwaters and reduce the energy of incoming waves.

While beach nourishment is often a small-scale practice, it can be applied to large-scale projects such as the restoration of the New Jersey shoreline after Hurricane Sandy (bottom left).

The sand can be from inland sources or dredged material from a lake bed (right).

NOTES

THEME 5: COLLABORATION AND FACILITATION

- NON-BINDING COLLABORATION WITH NEIGHBORS
- VISIONING AND FACILITATED COLLABORATION
- DYNAMIC CONCEPT MAPPING / VCAPS
- NEIGHBORHOOD ASSOCIATIONS

NON-BINDING COLLABORATION WITH NEIGHBORS

Who?
Homeowner

Purpose?
Share costs, improve planning

Challenges?
Requires communication and cooperation

Cost?
$

Individual citizens can join together in informal groups to address risks from coastal erosion. These group collaborations can help to share costs, implement larger and more effective measures and avoid unanticipated repercussions from certain structures, such as enhanced erosion of neighboring shorelines resulting from the construction of a revetment.

Benefits	Challenges
Can spread out costs of projects	Requires clear communication and cooperation
Can lead to larger scale, better coordinated projects	
Reduces unanticipated impacts on neighbors	

Resources

"Working with Engineers and Contractors on Shore Protection Projects," is a University of Wisconsin Sea Grant Institute resource for homeowners.
readywisconsin.wi.gov/CoastalErosion/WorkingWithEngineersWISCUG12007.pdf

The Wisconsin Coastal Management Program provides a guide for communities who want to address coastal hazards.
doa.wi.gov/Documents/DIR/Coastal%20Management/CoastalPlanoptimized.pdf

The University of Wisconsin-Stevens Point has a guide to starting a lake association. While it focuses on inland lakes, many of the strategies discussed here would work for groups of neighbors working together on the Great Lakes coastline.
uwsp.edu/cnr-ap/UWEXLakes/Pages/organizations/associations/starting-la.aspx

The Wisconsin Great Lakes Chronicle, a publication by the Wisconsin Coastal Management Program, has many stories of citizen involvement in coastal projects.
doa.state.wi.us/Documents/DIR/Coastal%20Management/Program%20Docs/Chronicle13-web.pdf

Related Options

Visioning and Facilitated Collaboration

Dynamic Concept Mapping / VCAPS

Neighborhood Associations

Non-binding collaboration images: Local citizens work together to clean up South Shore Beach in Milwaukee (left).

Volunteers staff a boat wash to prevent the spread of aquatic invasive species (top right).

Citizen groups work together to protect natural resources, like this coastal ravine in Lion's Den Gorge Nature Preserve in Ozaukee County, Wis. (bottom right).

VISIONING AND FACILITATED COLLABORATION

Who?
Homeowner/municipal government

Purpose?
Share costs, improve planning

Challenges?
Requires communication and cooperation

Cost
$-$$

Individual citizens can join together in informal groups to address risks from coastal erosion, sharing costs, implementing larger scale measures and avoiding unanticipated repercussions. While informal collaborations between neighbors can be extremely effective, some groups find it useful to have a meeting facilitated by a community engagement specialist and go through a visioning exercise in which multiple ideas are laid out and discussed within the context of the agreed-upon values of the group. This often leads to clearer, more effective planning with greater consensus.

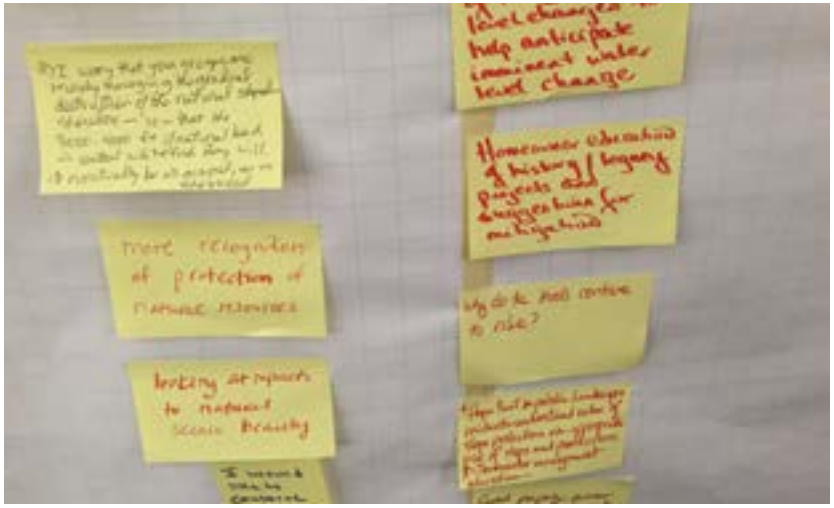
Benefits	Challenges
Can spread out costs of projects	Requires clear communication and cooperation
Can lead to larger scale, better coordinated projects	Requires an experienced community facilitator
Reduces unanticipated impacts on neighbors	
Improves long-range planning	
Can ease cooperation and communication with local government	

Resources

The American Planning Association discusses visioning in the context of community planning.
planning.org/research/postdisaster/briefingpapers/visioning.htm

The University of Wisconsin-Stevens Point and the University of Wisconsin-Extension provide a publication that discusses visioning in a variety of contexts.
uwsp.edu/cnr-ap/clue/Documents/publicProcesses/Using_Visioning_in_Comprehensive_Planning_Process.pdf

This website from Dane County and the University of Wisconsin-Extension gives an overview of visioning and provides extra resources.
fyi.uwex.edu/danecountycommunitydevelopment/organizational-development/strategic-visioning-resources/



Visioning and facilitated collaboration images: Visioning and facilitated collaboration can take many forms. Meetings that include a visioning component often have exercises that help generate ideas, express concerns and find common ground among the members before specific plans or goals begin to be developed.

NOAA's Office for Coastal Management provides a training manual for planning and facilitating collaborative meetings.
coast.noaa.gov/data/digitalcoast/pdf/planning-and-facilitating-collaborative-meetings.pdf

Related Options

Dynamic Concept Mapping / VCAPS

Non-Binding Collaboration With Neighbors

Neighborhood Associations

DYNAMIC CONCEPT MAPPING / VCAPS

Who?
Homeowner/municipal government

Purpose?
Share costs, improve planning

Challenges?
Requires communication and cooperation

Cost
$-$$

VCAPS stands for vulnerability, consequences and adaptation planning scenarios. This is an approach to planning that identifies immediate long-term and short-term vulnerabilities and then evaluates the consequences of various planning scenarios that could be implemented to address those vulnerabilities. Facilitated use of this approach at the neighborhood/community level aids in prioritizing and refining plans and leads to a more resilient approach to planning for coastal erosion.

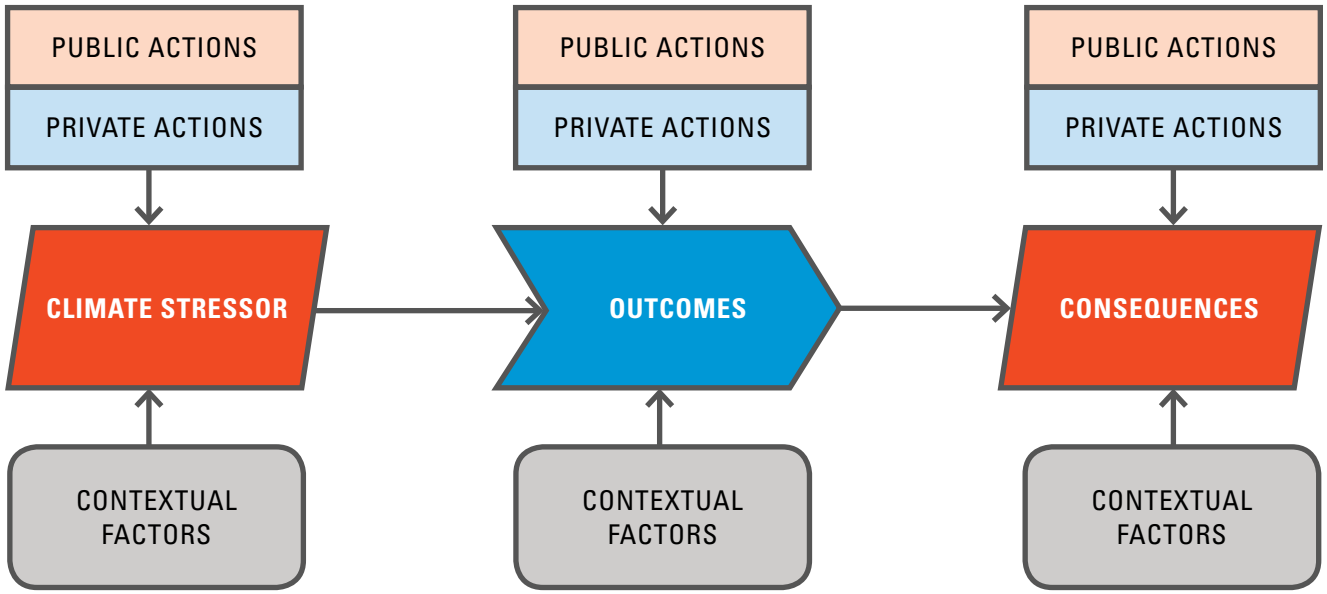
Benefits	Challenges
Can spread out costs of projects	Requires clear communication and cooperation
Can lead to larger scale, better coordinated projects	Requires an experienced meeting facilitator
Improves long-range planning	
Can ease cooperation and communication with local government	
Provides framework for evaluating multiple scenarios	

Resources

This website gives a thorough overview of the VCAPS idea, the process used in VCAPS and specific case studies where VCAPS has been used for coastal planning in the U.S. There is also a user guide.
vcapsforplanning.org/

The South Carolina Sea Grant Institute provides several examples of VCAPS being used by coastal communities in the Carolinas.
scseagrant.org/Content/?cid=251

Similarly, the North Carolina Sea Grant program provides a detailed case study of VCAPS in use for the town of Plymouth, N.C.
ncseagrant.ncsu.edu/program-areas/coastal-hazards/community-assessment/



VCAPS images: VCAPS (left) is a planning framework that provides a simple and effective format for community planning. The first step is to consider an event or process that could be aggravated by climate change, called a climate stressor. The public and private actions and context are laid out to see what current conditions affect that stressor. Then additional events or processes that could occur as a result of that climate stressor, called outcomes, are discussed. Finally, the consequences of those outcomes are carefully described.

Communities can use the VCAPS framework to consider the actions that they can take at each step of that process to mitigate potential consequences and clarify planning priorities (bottom left). The VCAPS process has been used effectively in a number of locations including Plymouth, N.C. (bottom right).

Related Option

Visioning and Facilitated Collaboration

NEIGHBORHOOD ASSOCIATIONS

Who?
Homeowner

Purpose?
Share costs, improve planning

Challenges?
Requires communication and cooperation

Cost
$-$$

While informal collaborations between neighbors can be very effective, sometimes it is preferable to have clearer guidelines about responsibilities and expectations. Several models exist to clarify these questions. One tried-and-true model is the neighborhood association. These can be very informal or can involve elected officials and voluntary dues. Neighborhood associations are often confused with homeowners associations. Homeowners associations are even more structured than most neighborhood associations and include agreed-upon rules and regulations focused more on building and safety issues. Both types of associations are models that could be considered when a group of citizens works together to address coastal erosion issues.

Benefits	Challenges
Can spread out costs of projects	Requires clear communication and cooperation
Can lead to larger scale, better coordinated projects	Can limit development options of property owners
Improves long-range planning	
Can ease cooperation and communication with local government	
Provides avenue for preventing undesirable practices	

Resources

The city of Madison, Wis., provides a description of the pros and cons of neighborhood associations, and how to go about forming them.
cityofmadison.com/dpced/planning/neighborhood-associations/1606/

Madison Neighborhood Association websites, a list of neighborhood associations found throughout Madison, Wis. These follow a variety of structures from formal to informal.
cityofmadison.com/neighborhoods/profile/websites.html

A common form of non-binding collaboration is the formation of environmental groups, such as the Alliance for the Great Lakes. Their website discusses projects they are involved with around the Great Lakes, including areas in Wisconsin.
greatlakes.org/

Neighborhood associations images: Various neighborhood associations can often serve as important groups when coordinating with government agencies. Here the Breezy Point, N.Y., (left) homeowners association talks with an official from the U.S. Army Corps of Engineers about recovery plans following Hurricane Sandy.

There are different models for neighborhood associations, ranging from informal groups to improvement districts to homeowners associations. All provide a framework for residents to come together to create a plan for addressing local concerns.

The Great Lakes Information Network is a website that pulls together links to various organizations and resources concerned with a wide range of environmental issues in the Great Lakes Region. Their "watersheds" section provides links to a large range of non-governmental citizens groups that are excellent examples of people coming together to address environmental challenges.
great-lakes.net/links/envt/orgs_water.html#sheds

Related Options

Visioning and Facilitated Collaboration

Dynamic Concept Mapping / VCAPS

NOTES

ACKNOWLEDGEMENTS

Options for "Adapting to a Changing Coast" associated with the Great Lakes Water Levels Integrated Assessment in Wisconsin were generated through a series of interviews with project investigators and partners from September 2016 to January 2017. The authors thank the experts listed below for sharing their ideas for promoting a healthy and resilient coast.

John Janssen, professor, School of Freshwater Sciences, University of Wisconsin-Milwaukee

Jenny Kehl, associate professor, University of Wisconsin-Milwaukee

Jim LaGro, professor, Department of Planning and Landscape Architecture, University of Wisconsin-Madison

David Mickelson, emeritus professor and senior scientist, Department of Geoscience, University of Wisconsin-Madison

Brian Ohm, professor, Department of Planning and Landscape Architecture, University of Wisconsin-Madison

Chin Wu, professor, Department of Civil and Environmental Engineering, University of Wisconsin-Madison

Alan Lulloff, science services program director, Association of State Floodplain Managers

Mike Hahn, director, Southeastern Wisconsin Regional Planning Commission

Kate Angel, federal consistency and coastal hazards coordinator, Wisconsin Coastal Management Program

Kathi Kramasz, water regulations and zoning specialist, Wisconsin Department of Natural Resources

Roxanne Gray, mitigation section supervisor, Wisconsin Emergency Management

Katie Sommers, state hazard mitigation officer, Wisconsin Emergency Management

Caitlin Shanahan, disaster response and recovery planner, Wisconsin Emergency Management

CREDITS

PHOTOGRAPHY
Cover, Narayan Mahon

Contents, opposite, Wisconsin Sea Grant and the Wisconsin Coastal Management Program.

Introduction, Kevin J. Miyazaki.

Page 3, left, Alan Lulloff, Association of State Floodplain Managers; right, Gene Clark, Wisconsin Sea Grant.

Page 5, top left, Gene Clark, Wisconsin Sea Grant; top right, Koma Modular Construction, Creative Commons; bottom, Wisconsin Sea Grant and the Wisconsin Coastal Management Program.

Page 7, left, Wisconsin Sea Grant and the Wisconsin Coastal Management Program; right, Aaron Volkening, Creative Commons.

Page 11, left, Alan Lulloff, Association of State Floodplain Managers; top right, Gene Clark, Wisconsin Sea Grant; bottom right, Gene Clark, Wisconsin Sea Grant.

Page 13, top, Wisconsin Sea Grant; bottom left, Wisconsin Sea Grant and the Wisconsin Coastal Management Program; bottom right, Wisconsin Sea Grant and the Wisconsin Coastal Management Program.

Page 15, all photos Wisconsin Sea Grant and the Wisconsin Coastal Management Program.

Page 17, top left, Wisconsin Sea Grant; top right, Gene Clark, Wisconsin Sea Grant; bottom left, Wisconsin Sea Grant and the Wisconsin Coastal Management Program; bottom right, Gene Clark, Wisconsin Sea Grant.

Page 21, top left, Systems Approach to Geomorphic Engineering; top right, Wisconsin Sea Grant and the Wisconsin Coastal Management Program; bottom, Wisconsin Sea Grant and the Wisconsin Coastal Management Program.

Page 23, top left, Systems Approach to Geomorphic Engineering; top right, Ron Noble, Creative Commons; bottom, Wisconsin Sea Grant and the Wisconsin Coastal Management Program.

Page 25, top left, Systems Approach to Geographic Engineering; top right, Southeastern Wisconsin Regional Planning Commission; bottom, Wisconsin Sea Grant and the Wisconsin Coastal Management Program.

Page 29, left, National Oceanic and Atmospheric Administration; right, Gene Clark, Wisconsin Sea Grant.

Page 31, top left, Wisconsin Sea Grant and the Wisconsin Coastal Management Program; bottom left, U.S. Army Corps of Engineers; right, Wisconsin Sea Grant.

Page 35, left, Jane Harrison, Wisconsin Sea Grant; top right, Wisconsin Sea Grant; bottom right, Kenneth Caspar, Creative Commons.

Page 37, top, Creative Commons; bottom, Wisconsin Sea Grant.

Page 39, both photos, South Carolina Sea Grant Institute.

Page 41, left, U.S. Army Corps of Engineers, New York; top right, City of Milwaukee Neighborhood Associations; bottom right, Norm Tyler, Creative Commons.

WRITERS
Andrew Mangham and David Hart

with Adam Bechle, Gene Clark, Deidre Peroff, Julia Noordyk, Bert Stitt and Linda Stitt

EDITORS
Moira Harrington and Elizabeth White

DESIGNER
Yael Gen

Printed locally using Wisconsin-manufactured, FSC® certified paper containing 10% post-consumer recycled content

AUGUST 2017 WISCU-H-17-002

seagrant.wisc.edu