Understanding and Evaluating Erosion Problems

State of Alaska

Department of Commerce, Community, and Economic Development

Division of Community and Regional Affairs

Cover: Erosion of the Arctic Alaska coastline causing a cabin to be washed into the ocean. ***Photo: Benjamin Jones, USGS.***

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Introduction

This handbook is intended to assist Alaskan property owners and communities in understanding and evaluating erosion problems and alternative solutions. The more local officials and community residents understand about the factors contributing to community erosion problems, the better able they will be to monitor, describe, seek assistance for, and make decisions about local erosion issues.

These components, along with the characteristic profiles of eroding shorelines and typical energy sources, are explained in this handbook to help users understand the source of their community erosion problems. The fundamental principles and means of controlling erosion are presented to enable users to understand potential solutions. Sources of additional guidance for evaluation, design, and implementation of alternative solutions are also presented.

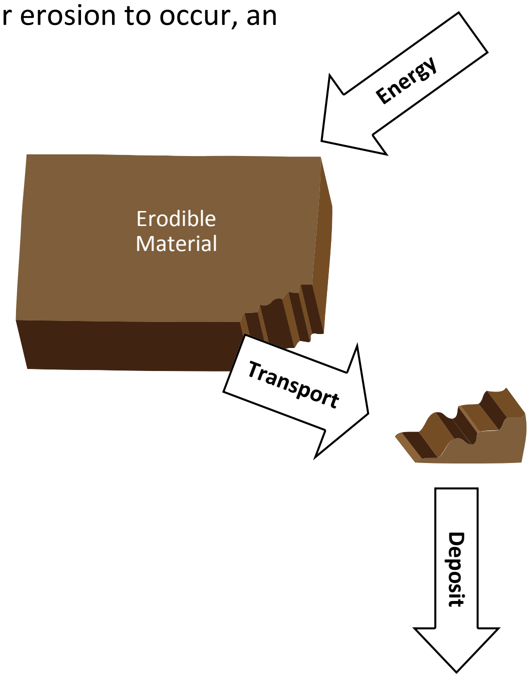
In this handbook, erosion has not been classified according to location, such as coastal or riverine, because the fundamentals of erosion and erosion control are the same regardless of where they occur. Each community and its environment has, however, unique problems and features that merit special attention. The discussions in this handbook address both the general and site-specific aspects of erosion.

An eroding bluff on the Ninglick River in Newtok. *Photo: Stanley Tom, Native Village of Newtok.*

Heavily eroded bank of the Yukon River after severe 2013 flooding in the community of Alakanuk, Alaska.
Photo: Federal Emergency Management Agency (FEMA).

Chapter 1: Understanding Erosion

Erosion is any process, natural or man-made, by which material is removed from one location and deposited in another. In order for erosion to occur, an erodible material must be exposed to some form of energy or eroding force.

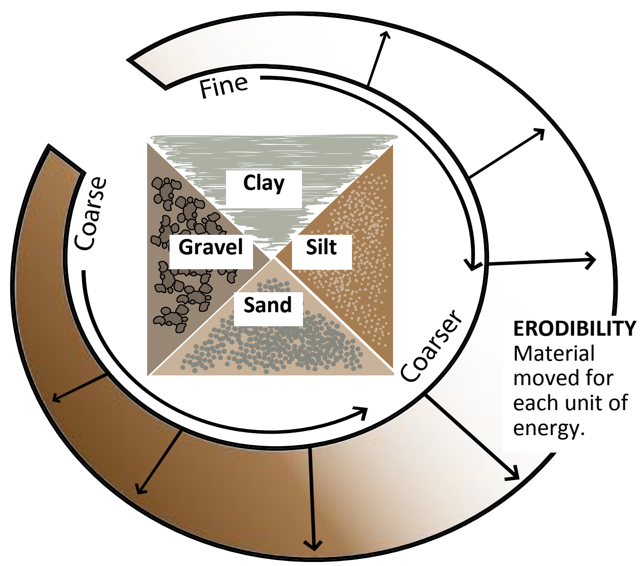


In this section of the handbook, we discuss:

- Different types of erodible material
- Energy sources that promote erosion
- Natural and human-induced events that can lead to erosion in an area
- The symptoms of erosion
- The erosive characteristics of some different shoreline and river configurations

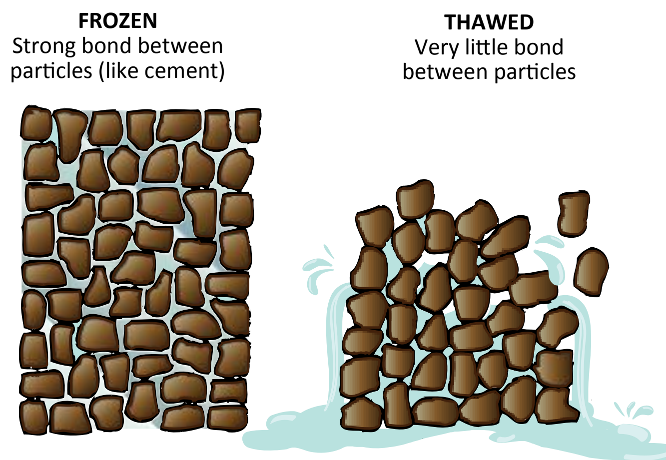
Erodible Materials

The types of erosion generally involve soil, typically clay, silt, sand, or gravel. Sand and gravel are essentially the same except that gravel particles are larger. This fact becomes important because the heavier or larger the particle, the more energy must be applied to transport or move the gravel or sand particle from the shoreline.



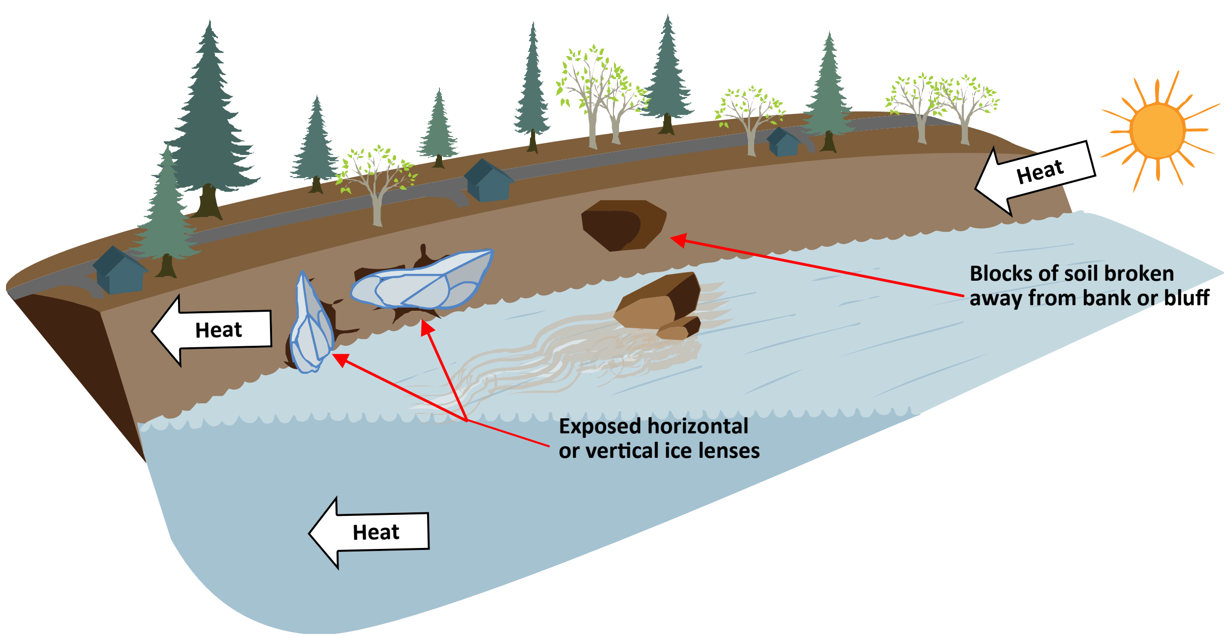
Clay and silt soils are more commonly called mud. They differ from sand and gravel in that they are made up of microscopic particles that stick together when wet. Clay soils are more difficult to erode because they have a stronger bond than silt. Clay will not fall apart when dried, but silt will. Many of the bluffs along rivers and oceans are made of clay and silt, or contain clay and silt mixed with other particle sizes.

Frozen soils are an important part of the erosion process in Alaska. Permanently frozen soils are called "permafrost" and usually begin a few feet below the surface where the warmth from the sun cannot thaw them. Permafrost often contains large layers of ice called ice lenses.



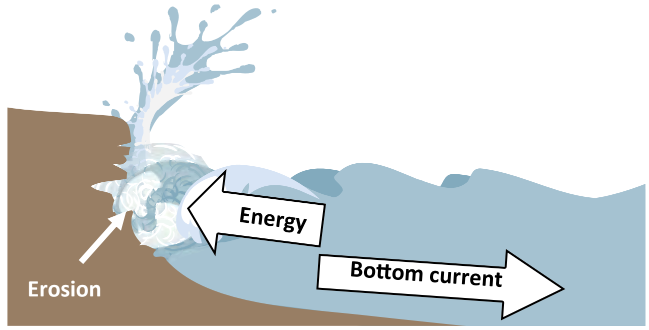
Other soils freeze and thaw in response to changing temperatures and sunlight exposure. During the winter, severe cold causes the water between the individual particles of thawed soils to freeze giving them properties similar to permafrost. The ice forms a strong bond that holds the soil together. In the summer, when days are long and the weather is warm, the ice melts in soils that are exposed to the sun. The soils lose strength as they lose the bond provided by the ice.

When the face of a bluff thaws, this weakened condition causes large chunks of soil to fall off and be washed away. Additional frozen soil or permafrost is exposed by the loss of thawed material, causing it to thaw. This process is called "thermal erosion" and can have significant impacts in areas where the soil is either permanently or seasonally frozen.



Sources of Energy

The energy necessary for erosion to occur can come from many different sources. Energy sources typically act together rather than separately in creating an erosion problem. Sources of energy are discussed below.



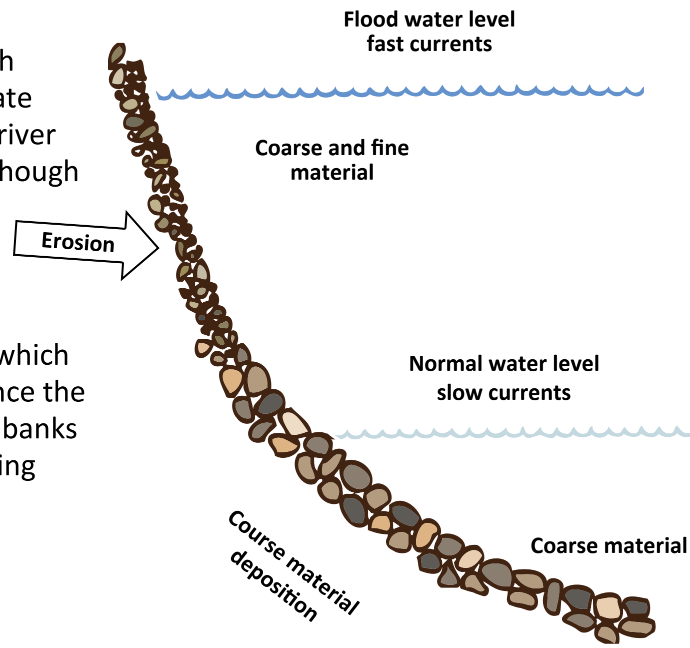
Waves

Natural waves can occur on any body of water, including ocean, lakes, and wide rivers, and generally develop from wind disturbing the water surface. During storms when the wind blows hard, the waves are larger because they have absorbed more energy from the wind, and more energy means the waves have a greater ability to erode the shoreline. In open ocean areas, large waves that develop offshore (we call these swells) can move towards the coast. In this way, large waves can arrive to the coastline even in places where high winds are not present.

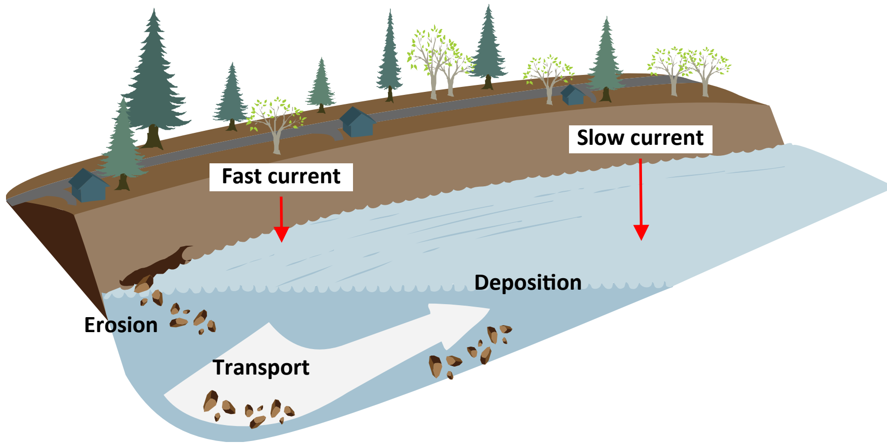
Sometimes people cause waves that lead to shoreline erosion. The most common man-caused waves are from power boats (wakes). The faster the boat is travelling, the larger the waves, because more energy is being transferred to the water. Sometimes the energy from boat wakes can be greater than from natural wind waves. A reduction in speed will decrease the amount of wave energy and help to decrease the risk of shoreline erosion.

Currents

Currents are most commonly associated with oceans and rivers, although wind can generate currents on the surface of lakes. In general, river currents are not dependent on the wind, although surface currents will change speed and direction in response to changes in the wind. The amount of energy in a current depends on water surface elevation, and how fast the water is moving. The speed at which water moves against a river bank will influence the rate of erosion. This is one reason why river banks erode during a flood when the water is flowing very fast.

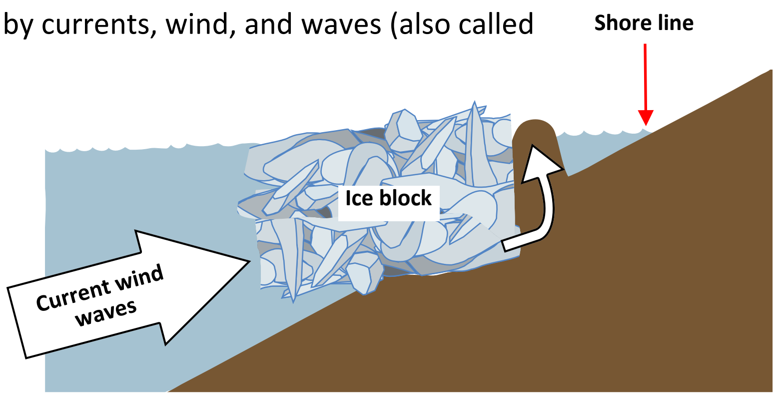


At bends in a river, the water flows faster against the outside bank. Erosion is caused by an acceleration, or an increase in speed or direction of the water and/or wind. As a result, the outside banks of a river tend to erode faster than at other places along the river.



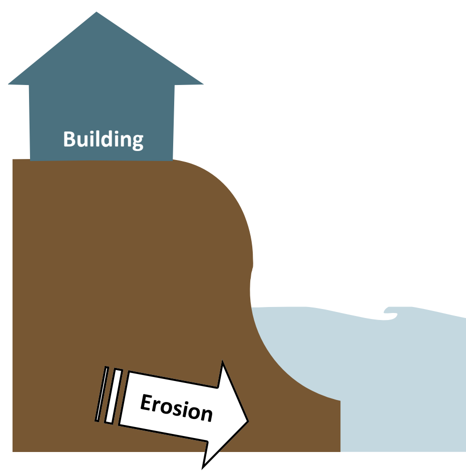
Ice

When ice is forced onto a shoreline by currents, wind, and waves (also called "Ivu"), it can erode the shoreline by pushing the sediments around or loosening them so they can be washed away by the current or waves. The amount of energy delivered to the shoreline depends on the size of the ice block and the speed at which it hits the beach.

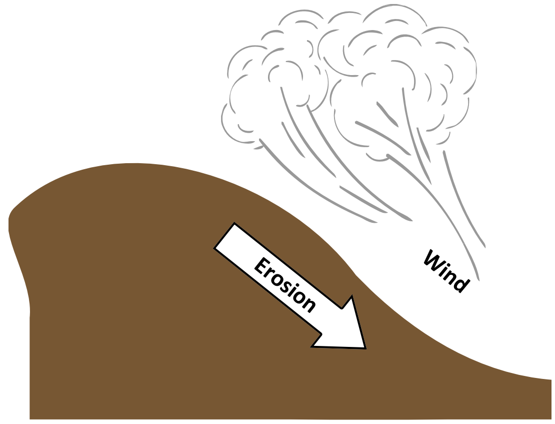


Heat

The role of heat in accelerating the erosion process was discussed in *Erodible Materials* (page 3). The sun is the most common source of heat energy, but heat transferred from buildings to the ground can also cause soil to thaw. If buildings are located near the edge of a bluff, this can speed up the process of thermal erosion along the bluff. Ocean water, or water warmer than the coast line or river bluff can also thaw frozen soil. Soils loosened by thermal processes are subsequently washed away by currents, waves, or wind.

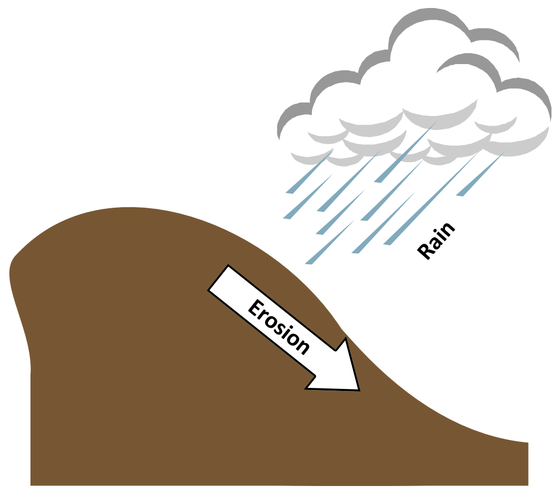


Wind



Wind is essentially a current in the air. Like currents in water, the energy in an air current increases as air pressure and speed increases, but in general wind is not as powerful an eroding force as water. Dried sediments are eroded more easily by wind than moist sediments because the water acts to hold the soil particles together.

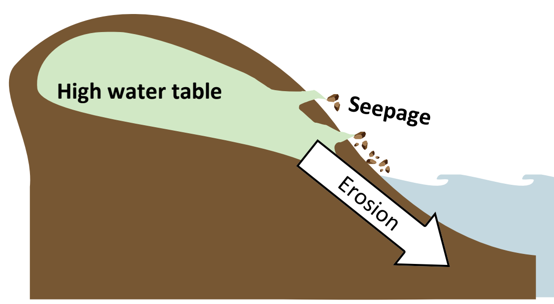
Precipitation



Rain, sleet, and hail can be significant eroding forces. The amount of energy they exert on the erodible surface depends on the weight of the individual drops and the speed at which they hit. When the wind blows, it increases the energy of the precipitation by increasing the speed. The flow of water along the surface (runoff or sheetflow) can also transport particles along the surface.

Seepage

Seepage problems are common in clay bluffs. Water moves fairly easily through the top layer until it reaches the hard, underlying layer which is difficult for the water to flow through. As water collects, the saturated upper layer can become unstable and slide off. Additional seepage can occur along sand layers within the bluff. When this water runs off it can weaken the base of the slope. Seepage can be exacerbated or triggered by construction or development that channels water.



Factors that can Increase or Accelerate Erosion

Tides, Storm Surge, and Flooding

Tides, storm surges, and floods can increase the intensity of the energy source and the level of the shoreline at which the energy is applied. Increased water levels in oceans or rivers result in flooding of areas that are not normally exposed to direct wave, current, or ice action. This increased contact with infrequently exposed parts of the coast, in conjunction with high energy levels typical of storm and flooding events, leads to increased potential for erosion of the shoreline.

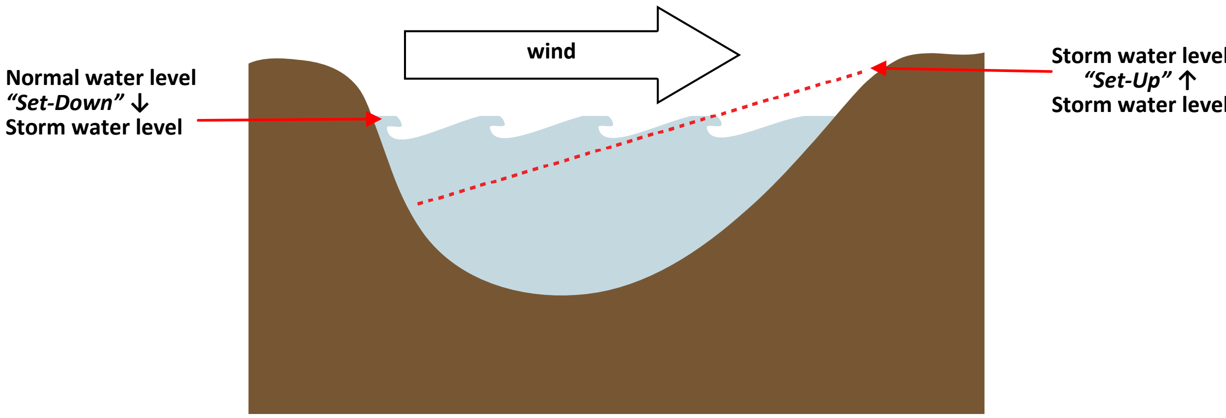
Tides are the natural, periodic variations in water levels of oceans, bays, gulfs, and inlets. If a high tide and a low tide each occur once during the day, the tide is called diurnal. If they each occur twice daily, the tide is semi-diurnal. Most of the tides in Alaska are a combination of the two (mixed). In addition to causing changes in water levels, incoming and outgoing tides generate currents. The speeds of these currents, as well as the tidal elevations, are influenced by coastal and underwater features such as bays, gulfs, inlets, channels, canyons, and bottom slope. Inlets often have extreme tides and develop swift tidal currents because of the way they are shaped. Cook Inlet in south-central Alaska can have tidal fluctuations of over 37 feet with currents exceeding 6.5 knots.

Total elevated coastal waters during storms are the result of several combined processes:

- Tides (discussed above.)
- Storm surge, which is an onshore rise of water associated with a low pressure weather system. Storm surges are caused primarily by high winds pushing on the ocean's surface. The wind causes the water to pile up higher than the ordinary sea level.
- Breaking waves lead to the 'pile-up' of a water bulge along the coast - "set-up" (pictured in figure, next page). Breaking waves on the beach also propel water inland - we call this "runup".
- Freshwater input from rivers and streams is impeded from flowing into the ocean during large storms by elevated ocean levels. This can lead to additional increases in the total water level around estuaries and river mouths as water flowing downstream is trapped at the coast.

In Alaska, most potentially destructive storm surges occur in fall and early winter along the northern and western coasts where the offshore water depths are relatively shallow.

Riverine water levels increase in response to precipitation or melting snow and ice entering the river. The mouths of rivers are often very responsive to the changes in water levels that accompany tides and surges. Winter storms can also cause untimely ice breakup on rivers that can form ice jams and cause flooding.


wind
Normal water level
"Set-Down" ↓
Storm water level
Storm water level
"Set-Up" ↑
Storm water level

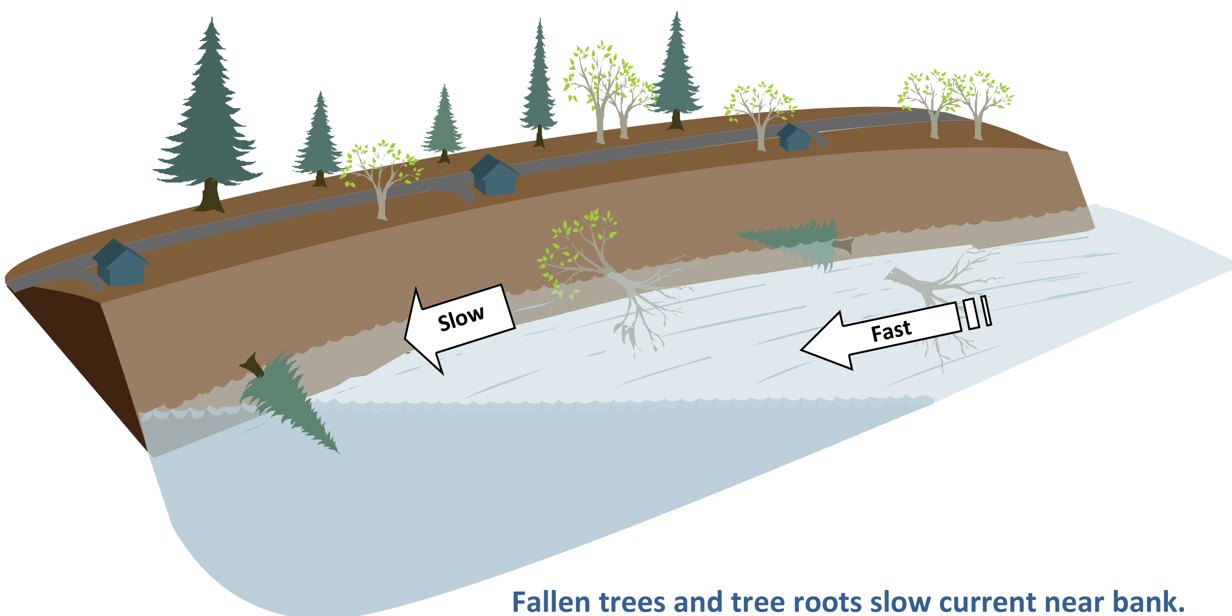
NOTES

Problems Created by People

Sometimes erosion is a direct result of human activities. Among these are:

- Accelerating or instigating erosion by removing sand or other shoreline materials.
- Preventing new sediments from being deposited to replace eroded material.
- Removing shoreline vegetation that anchors sediments.
- Creating waves with power motors.
- Modifying the condition of the beach surface with activities such as all-terrain vehicle (ATV) use.

A dam on a stream traps sediments and can cause increased bed scour and bank erosion downstream. Maintaining shoreline vegetation is important because the root systems help to hold the dirt in place and stabilize eroding banks. Trees leaning into the water indicate the bank is eroding, but may also provide protection by reducing current speed. Where wind erosion is a problem, vegetation will often help to anchor the sediment.



Fallen trees and tree roots slow current near bank.

Symptoms of Erosion

The primary symptom of erosion is that once dry property is washed away as the shoreline moves inland. A variety of specific erosion symptoms will help to determine the possible cause or energy source(s) that are triggering a particular problem. Among these symptoms are:

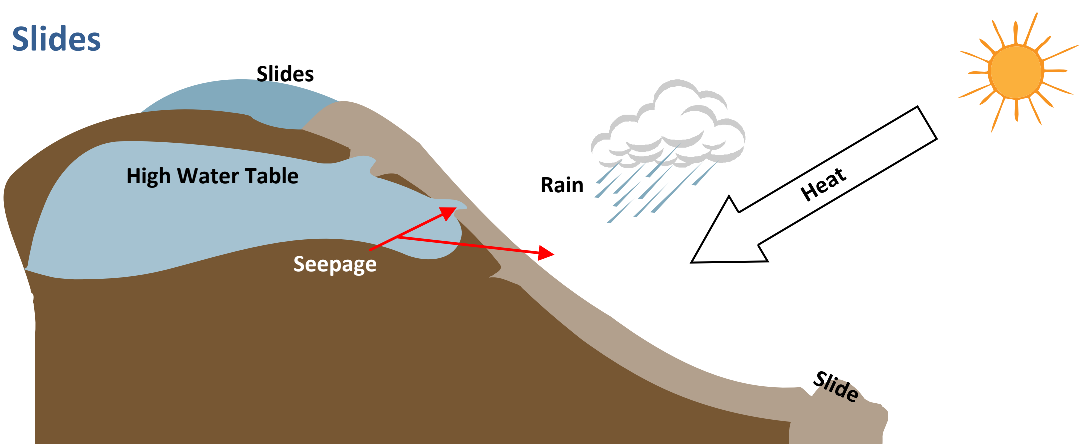
- slides
- undercutting
- scarps
- exposed permafrost
- root exposure and fallen trees
- ice gouging

Table 1. is a summary of erosion symptoms and causes, and following are sketches of each of these symptoms, along with the most common energy sources that can cause them.

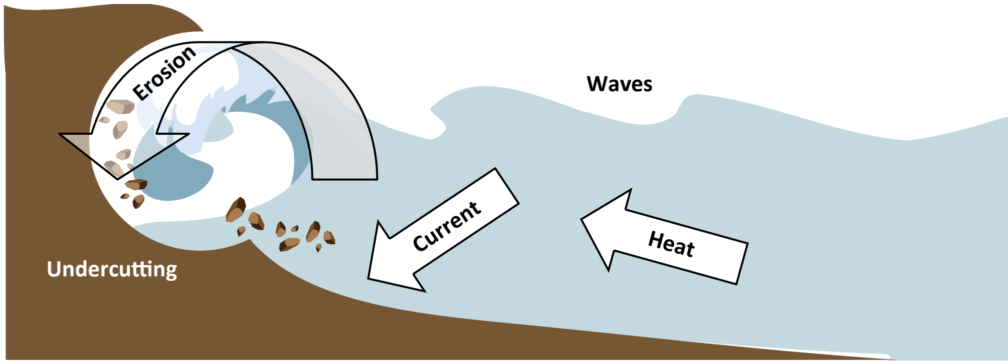
Table 1. Erosion Symptoms and Causes

	Waves	Currents	Ice	Heat	Wind	Precipitation	Seepage
Slides							
Undercutting							
Scarps							
Exposed permafrost							
Root exposure & fallen trees							
Ice gouging							

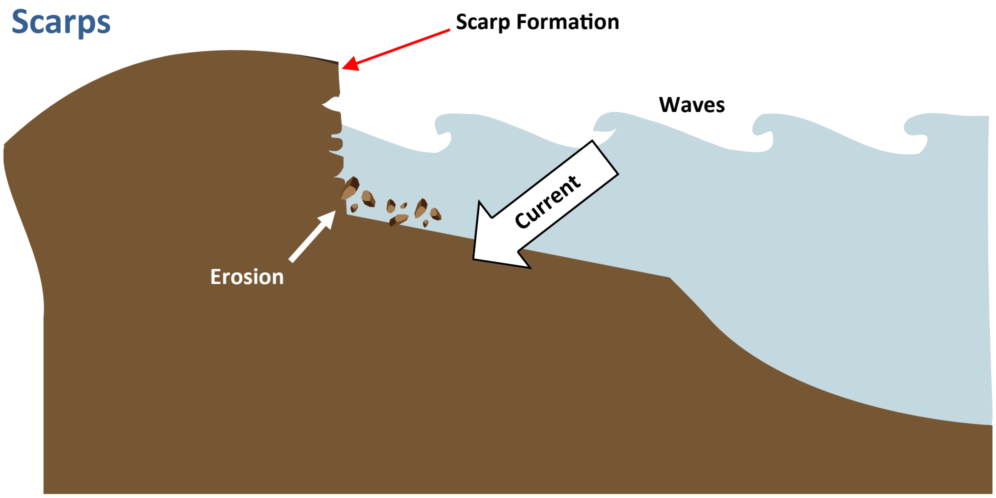
Slides



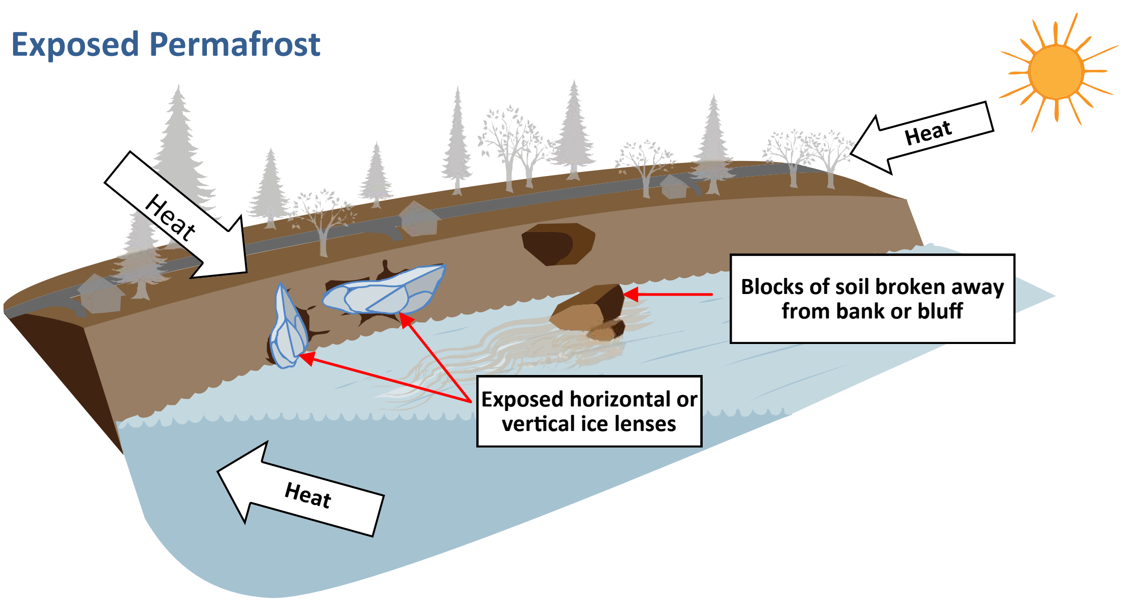
Undercutting



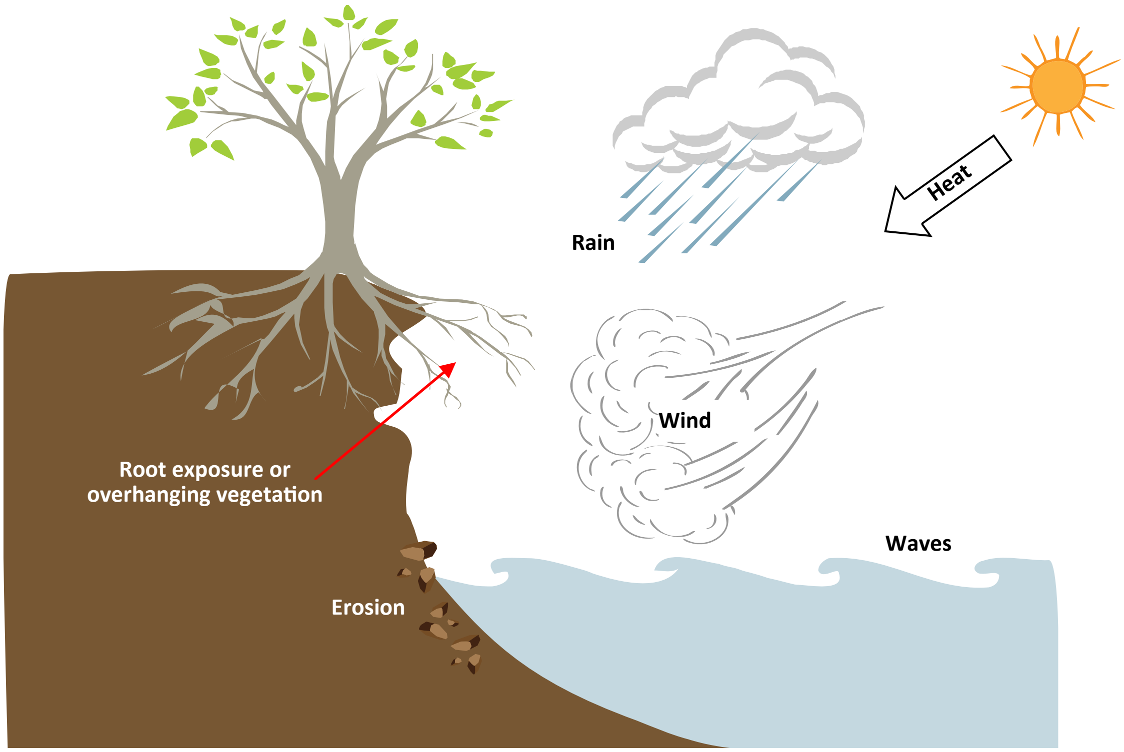
Scarps



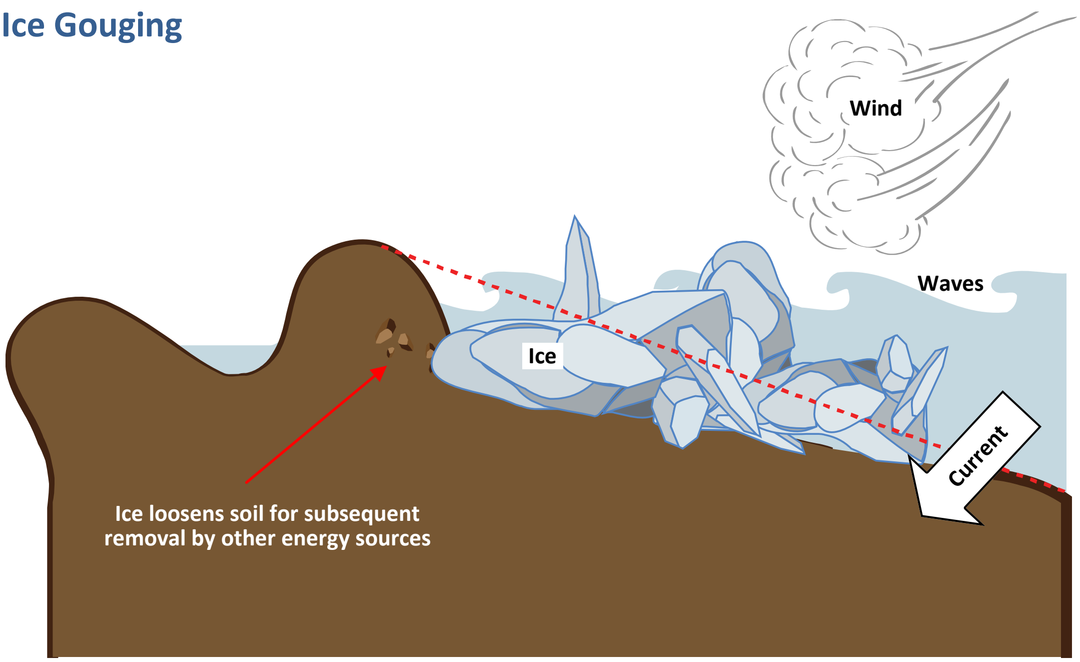
Exposed Permafrost



Root Exposure and Fallen Trees



Ice Gouging

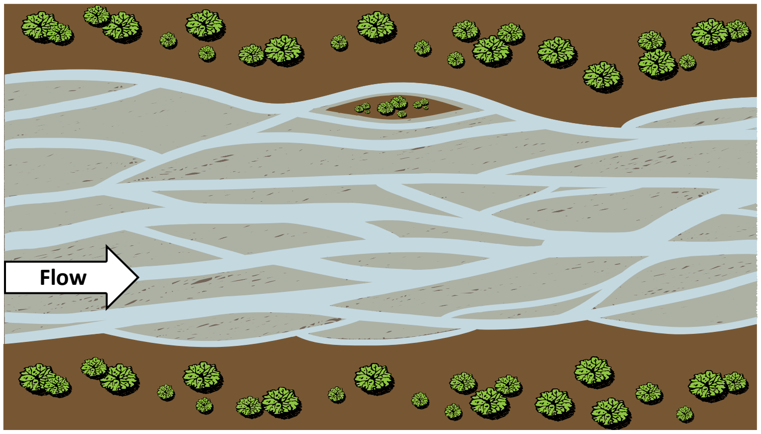


River and Shoreline Configurations

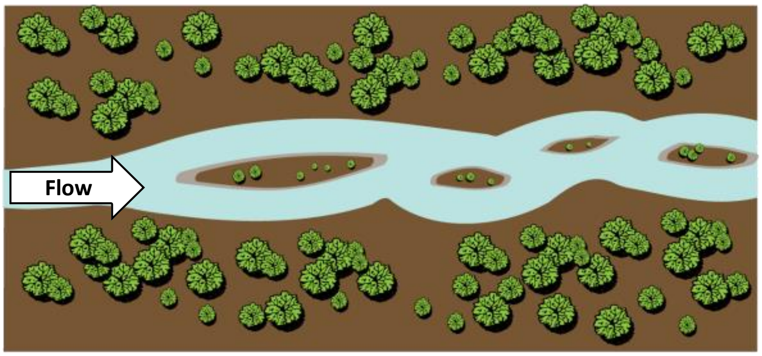
The configuration of a river or shoreline often has an effect on the rate of erosion of the bank or beach. Following is a discussion of various configurations and their impact on erosion patterns and rates.

Braided River

A braided river typically contains two or more connecting channels separated by gravel bars. A number of channels may only have water in them during floods, while others, called active channels, carry flow most of the time. Channels shift by bank erosion, the deposit of eroded sediment on the bed and banks of individual channels, and by channel diversion into what was previously a flood channel.



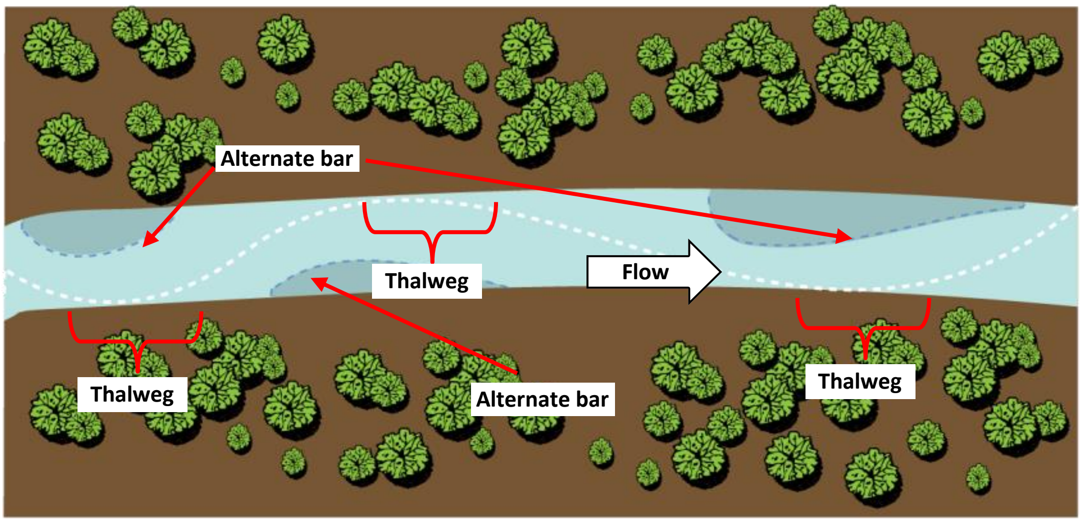
Split Channel River



A split channel (or anabranching) river has numerous stable islands which divide the flow into two channels. The banks of the channels are typically vegetated and stable. There are usually no more than two channels in a given section of river and other sections are single channel. One of the two channels in a split reach may be dry during periods of low flow. Gravel bars along the sides or in the middle of the channels are typically more erodible than the banks. The bars, rather than the banks, are eroded during floods, resulting in a channel that does not shift or move its banks.

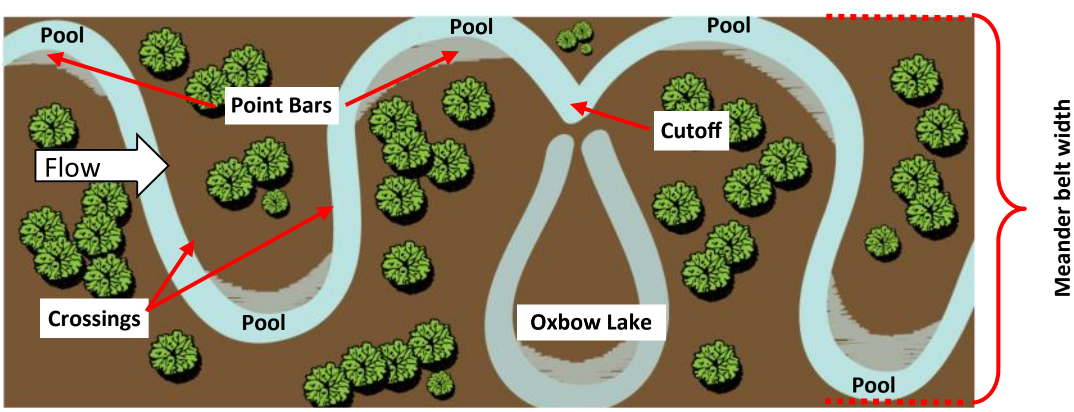
Straight River

A straight river flows in a single channel. The deepest part of the channel, or thalweg, typically wanders back and forth within the channel with alternate ground bars formed by sediment deposition opposite those locations where thalweg is near the site. The alternate bars may or may not be exposed at low flows.



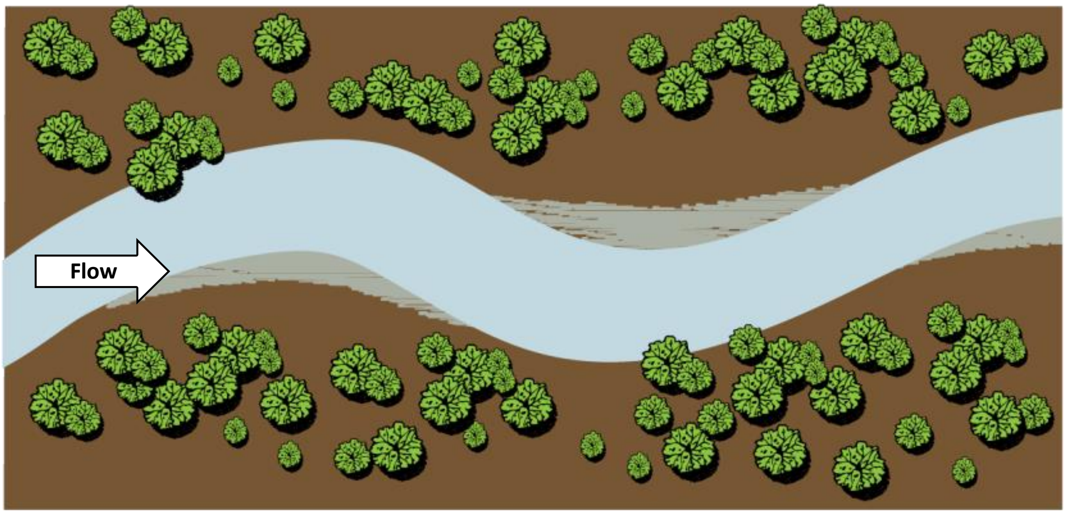
Meandering River

A meandering river winds back and forth within the floodplain. Flow is contained in a single channel, with very few islands. At each bend, the typical cross section contains a point bar on the inside of the bend and a pool on the outside of the bend. Point bars are the primary area of sediment deposition in a meandering river, while the greatest erosion occurs at outside bends. A meandering river shifts in the downstream (down valley) direction by a continuous process of erosion and deposition. Erosion takes place on the outside bank, downstream from the middle of the meander bend. Deposition occurs on the downstream end of the next point bar downstream. A result of the channel shifting at different rates in different locations is channel cutoffs and the formation of "oxbow lakes" in the area.



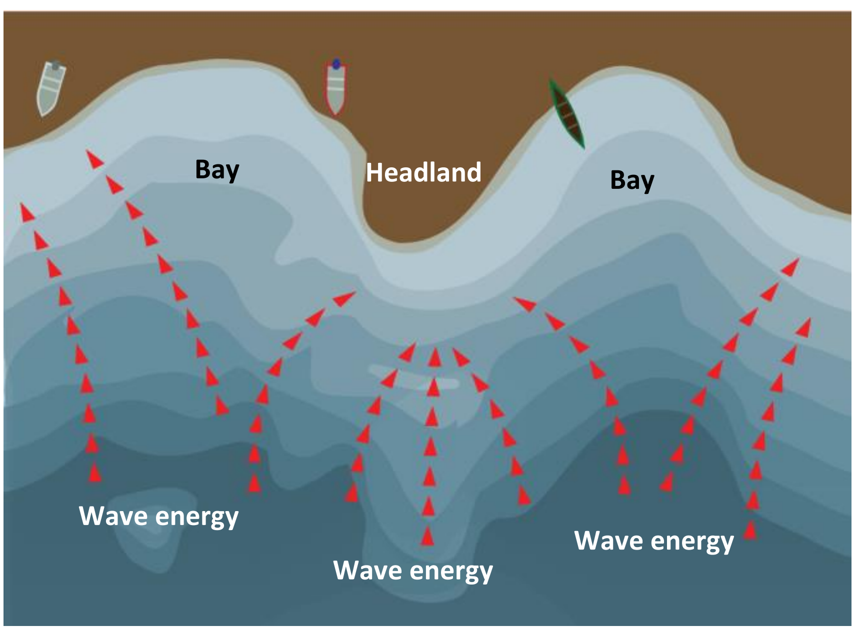
Sinuous River

A sinuous river is similar to a meandering river except that it does not bend as sharply. In sinuous rivers, point bars are smaller and channel shifting is generally less than that of a similar-size meandering river.



Headland

A headland is a point of land that extends into a body of water and is an important feature with respect to wave erosion. As waves move toward headlands they increase in height, and wave energy is concentrated at the headland, thus increasing the potential for erosion. The reverse occurs at bays or indentations in the shoreline. Waves spread as they enter a shallow bay, thus decreasing wave height and the energy available for beach erosion.



Chapter 2: Principles and Means of Controlling Erosion

There are several different ways in which communities can address erosion problems. The options for adapting to erosion fall along a spectrum, and frequently, communities will select measures which fall into one of more of the following adaptation categories:

- Do Nothing: In other words, let nature take its course. Property is allowed to wash away. This response requires no investment, unless buildings or other infrastructure must be removed to prevent water pollution.
- Protect-in-Place: This category refers to the use of shoreline protection measures and other erosion controls to prevent or minimize erosion. Most of the principles and means of addressing erosion problems in this handbook are protect-in-place measures. Individual property owners must take care that their shore protection measures do not adversely impact their neighbors. Special permits with assessment of environmental impacts are required for most shore protection measures, which can cause problems farther along the shore.
- Migration[1] - involves the community gradually moving development away from erosion prone areas. In order to migrate, a community needs suitable, developable land nearby. A community may decide that migrating some structures away from erosion-prone areas in combination with protect-in-place measures will adequately address the community erosion problems.
- Relocation - involves moving the entire community to an entirely different location that is not vulnerable to erosion. Because relocation requires the acquisition of a new community site and moving or rebuilding community facilities and infrastructure, it's usually the most costly and time-consuming way to address erosion problems. Relocation is usually considered only as a last resort, after it has been determined that other methods of dealing with the erosion problem would not be feasible. In some cases, a community may wish to use protect-in-place or migration strategies as temporary measures while planning for permanent relocation of the community.

Protect-in-Place Strategies for Controlling Erosion

All strategies should be designed by a qualified licensed engineer

In general, there are 3 basic principles underlying Protect-in-Place erosion strategies :

- Suppresses or diminish the energy source
- Shield by making a barrier
- Cause a new beach to be formed by deposition

Two additional principals that underlie solutions to erosion problems include:

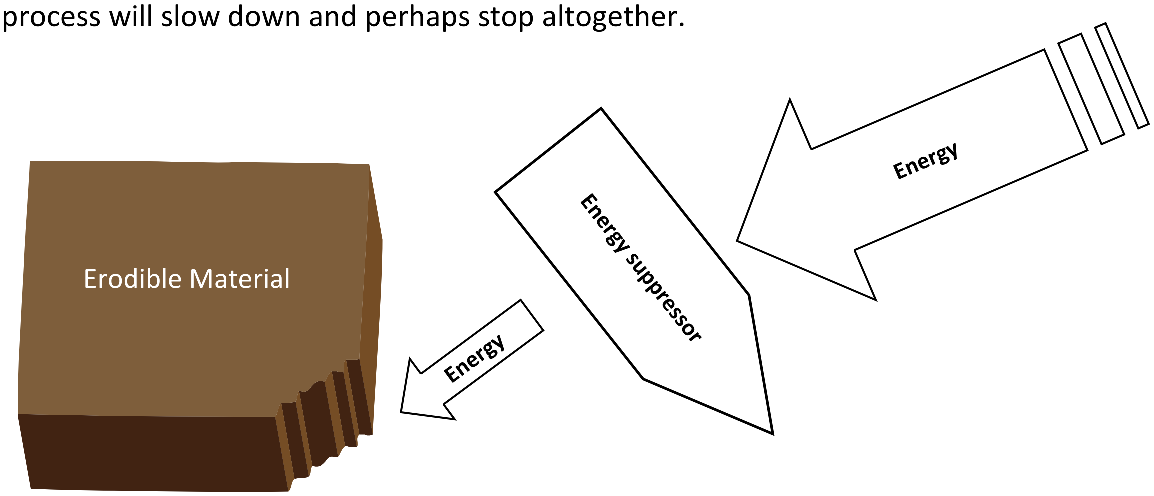
- Move endangered property to a safer location
- Reduce erosion-causing activities

These principles and some possible solutions are discussed on the following pages.

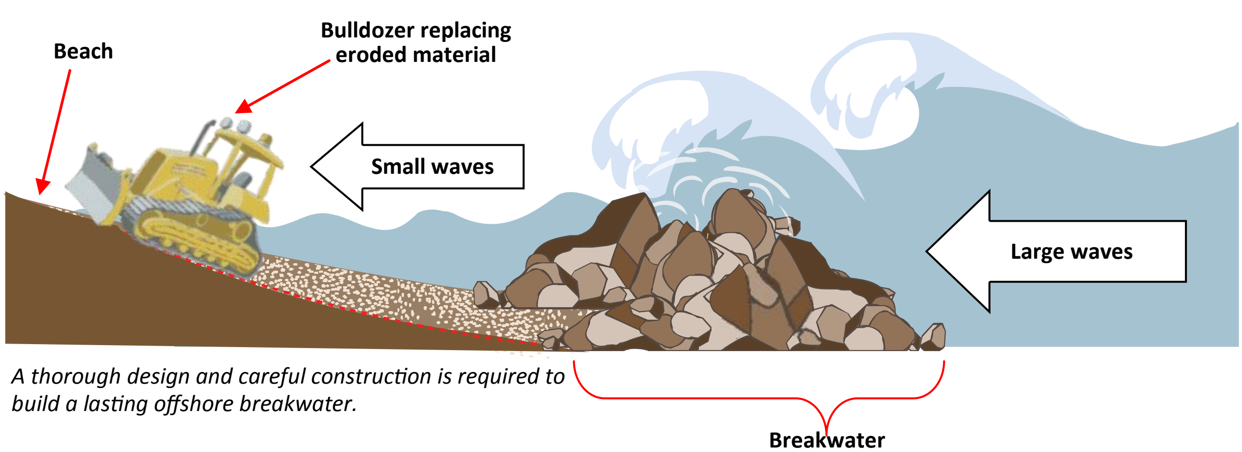
[1] Setbacks are a commonly used means for preventing development close to erosion-prone areas. As a planning tool, setbacks could be used in conjunction with the migration of development away from erosion-prone areas to ensure future development doesn't take place in areas from which structures were moved. Setbacks are generally set in municipal ordinances or zoning.

SUPPRESS OR DIMINISH THE ENERGY SOURCE[2]

If you can do something that will decrease the energy in the erosive force, then the erosion process will slow down and perhaps stop altogether.



Beach fill involves placing material from a local source on the shore to replace what erosion took away. The fill will erode, as did the original material and will eventually have to be replaced. While in place, the fill will insulate the natural material that it covers. Fill material similar to the original beach material will reduce disruptions to local habitat and will supply nearby beaches with material as it erodes. Coarser material will erode more slowly with little effect on shoreline habitat and human uses.

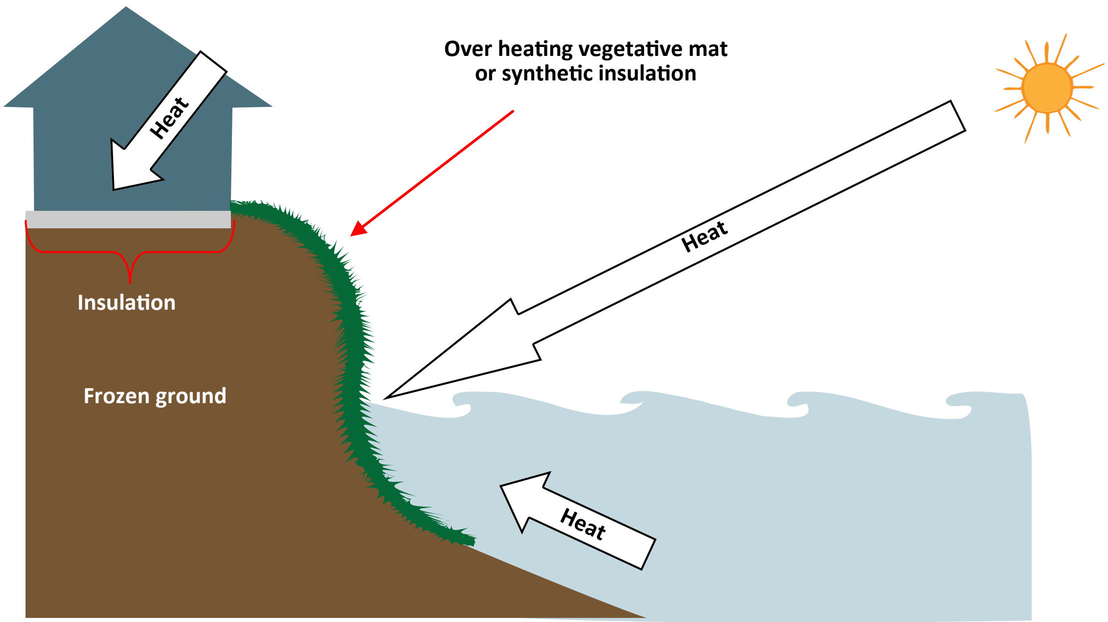


A thorough design and careful construction is required to build a lasting offshore breakwater.

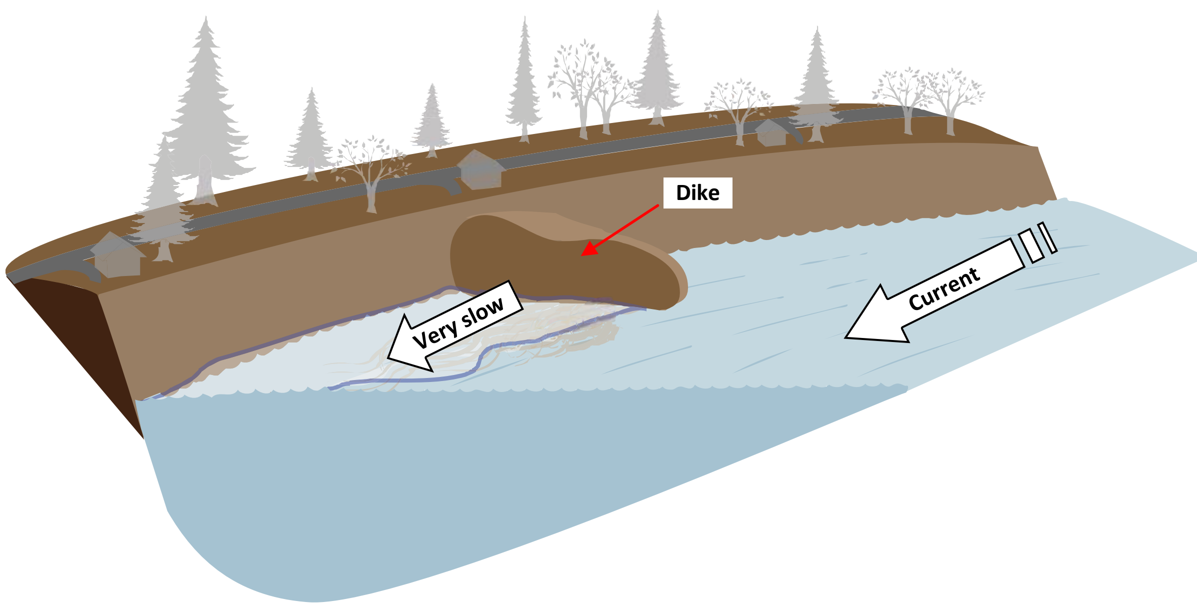
A breakwater is an offshore structure or partition that protects the shoreline against damaging wave action by causing the wave to break at the structure instead of on the shore. After the wave breaks, it is not so high and thus contains less energy. In Alaska, breakwaters can be difficult to maintain in areas of near shore ice.

[2]All erosion protection measures should be designed by a licensed professional engineer who specializes in river or coastal engineering

Insulation of frozen ground helps to diminish the amount of heat that is absorbed by the soil, thus preventing thaw. This is already a standard practice for construction of buildings and roads in many arctic areas. Banks can also be insulated, but if the insulating material is exposed to waves or ice, it probably won't last. Vegetation is an example of a natural insulating material.

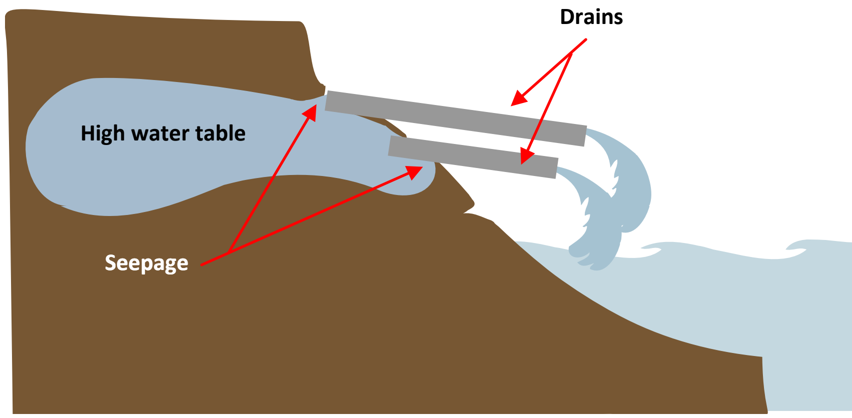


A spur dike is a structure that extends at an angle from shore into a river and is placed upstream of the problem area. It is designed to deflect the current away from the eroding shoreline, thus slowing the current at this point. This reduction in energy slows the erosion process, but, if not carefully designed, can hasten erosion elsewhere. Dikes are often used in series to protect a long section of shoreline. High costs may limit the use of dikes.

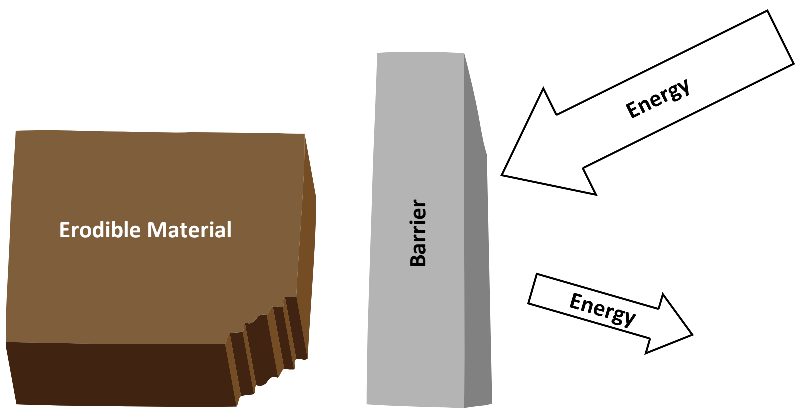


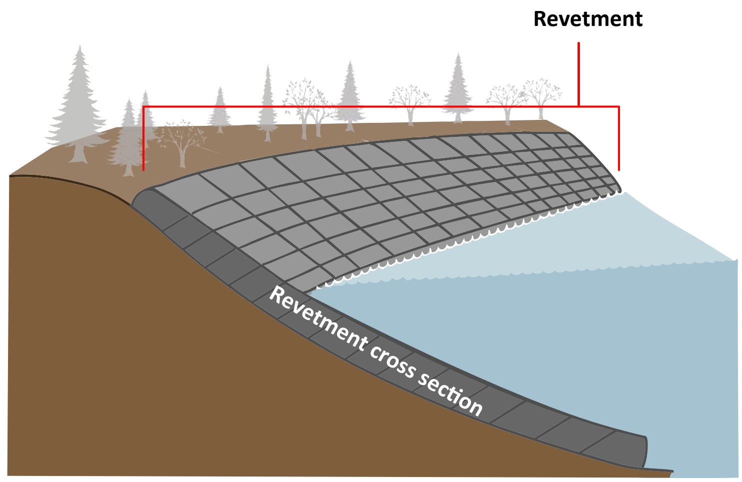
Spur dikes on the Matanuska River. *Photos: U.S. Geological Survey (USGS)*

Tile drains help to control seepage forces by removing water from the soil. Lowering the water content decreases the weight and increases the strength of the soil, thus stabilizing the bank or bluff. Additional protection should be placed at the toe of the slope to protect against waves, currents, and ice.



Protect or shield the erodible material by making a barrier between the erodible material and the energy source.

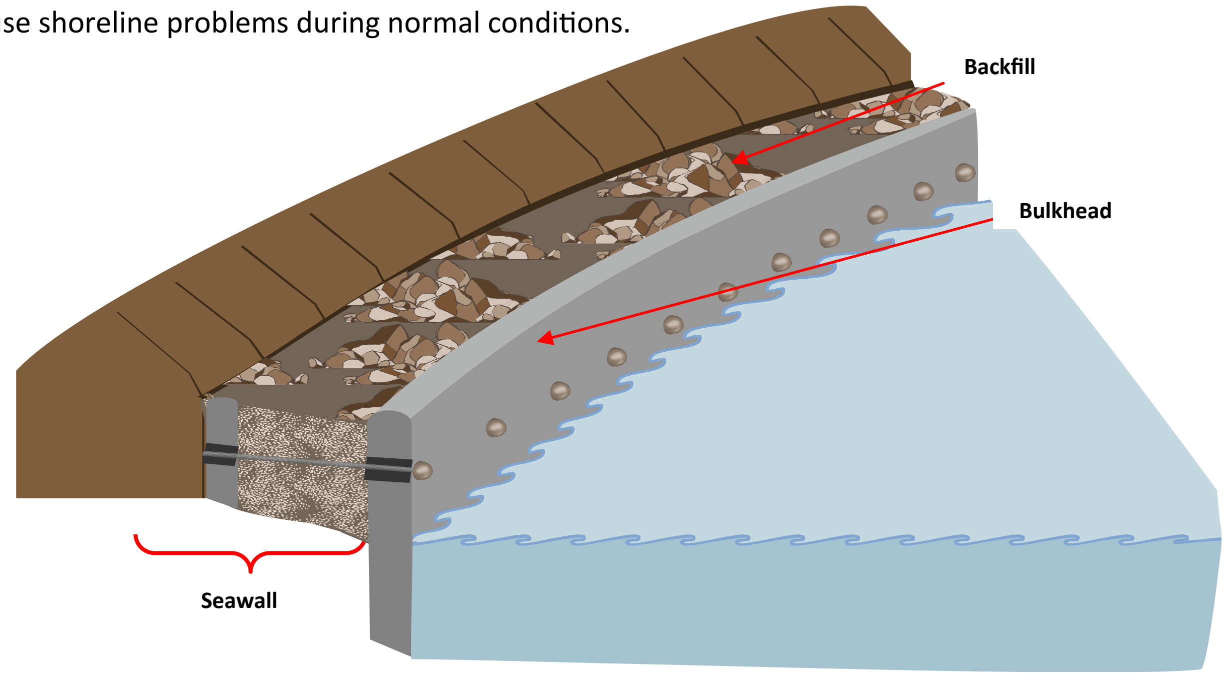




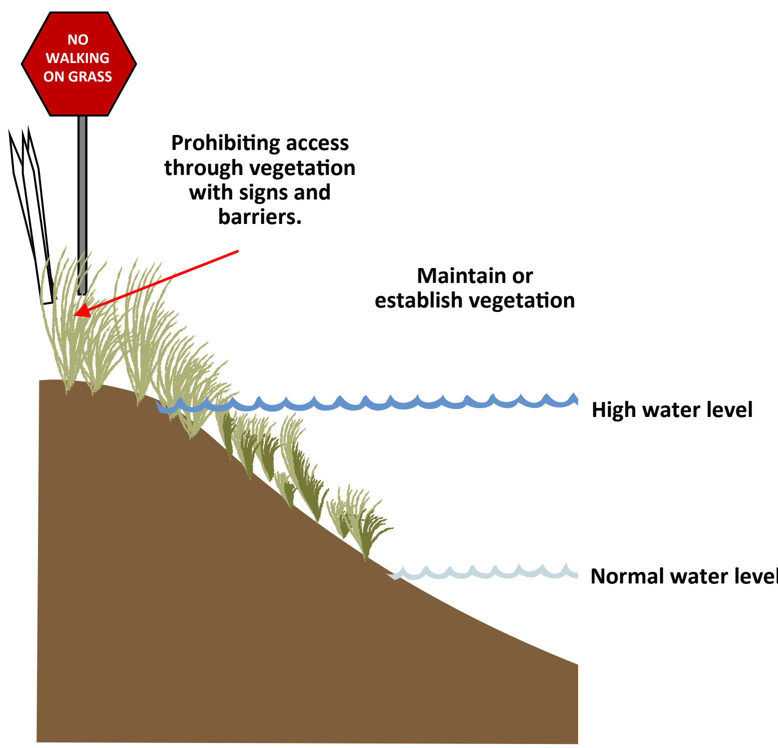
A revetment is a facing of stone (armor rock) or other resistant material that is placed against an eroding bank. Revetments are a good means of erosion control because there are many materials that can be used to build one. The use of local materials, such as large boulders, simplifies the planning and construction process. Revetments must be constructed according to strict guidelines, or they may fail due to removal by waves or settling into the sand.

Rock revetment at Shishmaref, Alaska. *Photo: Orson Smith, PE, Ph.D., University of Alaska Anchorage*

A seawall is a structure that separates a water body and an eroding bank and thus protects the bank from wave erosion and damage. Seawalls are more complicated and expensive to construct than revetments. Seawalls can be controversial since they change the balance of wave energy near the shore and induce sediment loss along the front of the wall. Seawalls built above the normal reach of the sea as a defense against high water during storms do not cause shoreline problems during normal conditions.



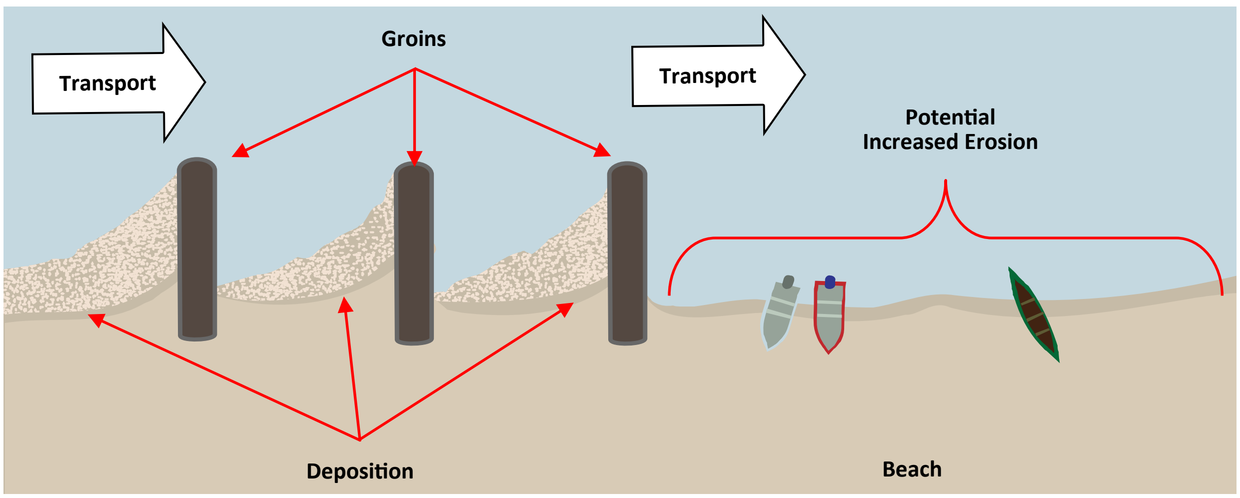
Maintaining or establishing a vegetative cover for trapping and anchoring eroding material is a natural, practical, and relatively inexpensive means of erosion control and can be used in conjunction with other erosion controls. Vegetative cover will not prevent erosion from storm waves or strong currents. The easiest way to utilize vegetation as erosion control is to maintain existing vegetation, which may mean avoiding access through the vegetated area.



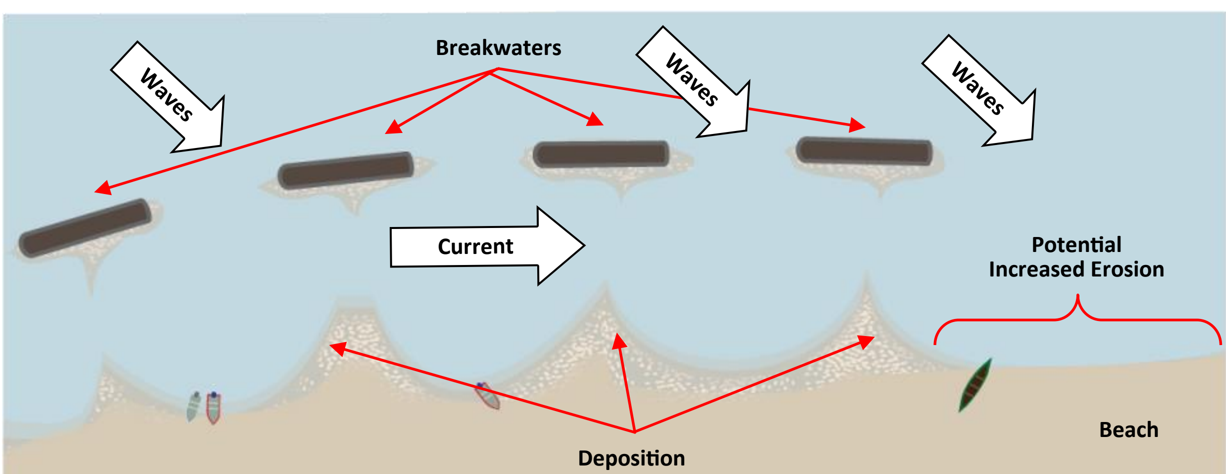
Sea wall at Dillingham, Alaska. *Photo: Orson Smith, PE, Ph.D., University of Alaska Anchorage*

CAUSE A NEW BEACH TO BE FORMED BY INITIATING DEPOSITION INSTEAD OF EROSION[1]

A groin is a structure built approximately perpendicular to the shoreline that traps sediment as it is transported along the beach, thus helping to expand existing shorelines and slow the erosion process. The use of groins assumes that sand is plentiful and moving along the shoreline. Groins are costly, require careful study and engineering design, and all these options can cause impacts to adjacent beaches. by depriving them of sediment if not properly installed.



Like groins, offshore breakwaters can also be useful in helping to form new beaches. Unlike groins, which block moving sediment, breakwaters trap sediment by creating low wave energy environments that encourage the deposition of sediments moving along the shore while limiting the opportunity for these sediments to be re-transported. Because breakwaters interfere with natural transport, they can damage adjacent beaches through sediment deprivation.



[1]Beach nourishment (not covered in this handbook) involves the restoration of eroded shoreline with fill. Beach nourishment can also be used to create a new beach.

Groins at Ninilchik, Alaska. *Photo: Orson Smith, PE, Ph.D., University of Alaska Anchorage*

Move endangered property to a safer location

Stopping natural erosion processes is extremely difficult and often costly. Structural alternatives may require ongoing maintenance that is not cost effective or may transfer the problem to adjacent shorelines.

Migrating property away from erosion-prone areas can be the most effective way to mitigate erosion problems, because moving endangered property to a new location is usually a permanent solution. Suitable, developable land nearby is necessary to migrate property.

The importance of proper site selection cannot be overemphasized. Extreme care and planning should go into the site selection so that existing problems will not reoccur, and new problems are not created. Depending upon the severity of the erosion problem, migrating structures may be the least-cost alternative because maintenance costs and the risk of structural failure are eliminated. An additional advantage is that property migration can be done on an individual or group basis.

In cases where there is no suitable, developable land nearby, the most effective way to mitigate erosion problems may be to move the entire community to an entirely different location that is not vulnerable to erosion. As discussed on page 17, because relocation requires the acquisition of a new community site and moving or rebuilding community facilities and infrastructure, it's usually the most costly and time-consuming way to mitigate erosion problems. Relocation is usually considered only as a last resort, after it has been determined that other mitigation measures are infeasible.

Newtok barge landing, erosion damage. *Photo: Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs (DCCED/DCRA)*

Minimize and Reduce Erosion-Causing Activities

If you are doing something that you recognize is causing an erosion problem, the simplest solution is to stop the activity. In some cases, human-induced erosion may be only a part of the problem, but avoiding the erosive activity can reduce shoreline degradation so that additional control measures can be minimized. Examples of things you can do to slow erosion are:

- decrease boat speeds
- maintain shoreline vegetation
- try to reduce shoreline traffic.

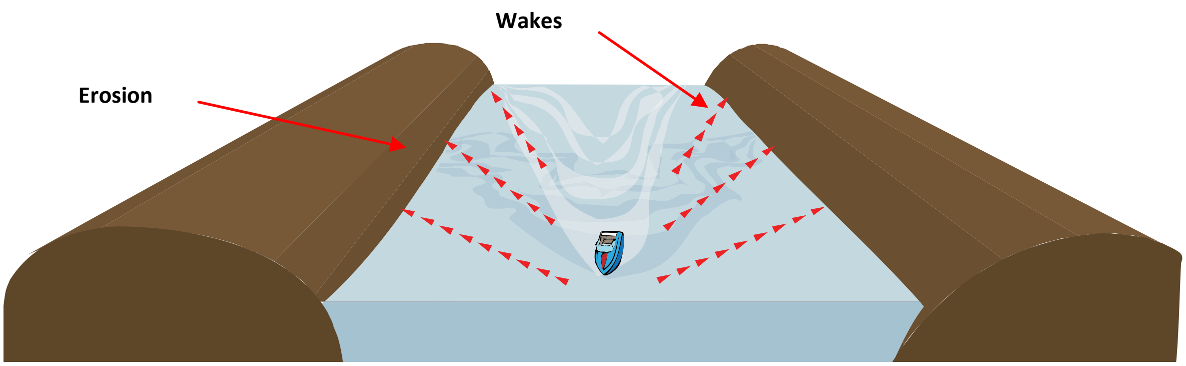


Table 2.
Erosion Alternatives and the types of energy they protect against.

	Suppress or Diminish Energy				Shield Erodible Material			Form a New Beach			
	Break Water	Insulation	Spur Dike	Tile Drain	Revetment	Seawall	Vegetation	Groin	Breakwater	Beach Fill*	Relocation
Waves	■				■	■			■	■	■
Currents			■		■	■	■	■		■	■
Ice										■	■
Heat		■					■			■	■
Wind					■		■			■	■
Precipitation					■		■			■	■
Seepage				■			■			■	■

* *Beach fill temporarily addresses all erosive factors.*

Chapter 3: Understanding and Defining Your Problem

The four basic steps toward understanding and defining the nature of your erosion problem are:

1. Describing the affected area and erosional symptoms.
2. Identifying the energy sources acting against the affected area.
3. Identifying alternatives that are compatible with your problem and location.
4. Evaluating the potential alternatives.

The process of describing the affected area and erosional symptoms accomplishes two objectives:

1. It helps you to identify environmental factors, e.g. shoreline configuration and energy sources, that may be contributing to the erosion problem.
2. It provides important information to those assisting you with devising and implementing a solution.

The forms on the following two pages are intended to help you make your description as complete and informative as possible. When completing the sketches of overhead and side views of the shoreline, you may find it helpful to refer to *Symptoms of Erosion* (page 11) and *River and Shoreline Configurations* (page 14) describing different symptoms of erosion and shoreline and river configurations. Try to include in your sketch all the items listed under "Sketch Checklist" which is located next to the sketch area. It is also helpful to try to indicate how fast the shoreline is eroding (how many feet per year, or per large storm event?).

The second page of the form focuses on the identification of energy sources acting against the eroding area and the elimination of unlikely energy sources. The identification procedure is approached in two different ways. First, you are asked to describe the types of energy you have seen acting on your shoreline. Second, you are asked to list the symptoms that characterize the eroding area. By combining these two sets of observations, the major eroding forces are identified. An example of a completed set of forms is included in the Appendix. ***Whenever possible, take photos of the eroded area you've sketched, as this will provide additional valuable information to accompany your completed forms.***

Once you know what type of problem you're trying to solve, you're ready to identify the alternatives for dealing with your specific problem. An important part of this process is to eliminate alternatives that do not specifically address your problem. To do this, you will need to consider:

1. The compatibility of the alternative with the configuration of the shoreline. Some methods of shore protection will not be effective for all shorelines. For example, offshore breakwaters are not a good alternative if the water depth changes quickly as you move away from shore. Consult the Corps publications for guidance.
2. The size of the affected area or areas you wish to protect. For example, it would be unwise to select a high maintenance alternative if you need to protect a long length of beach.
3. The types of erosive forces involved. The selected alternative should be one that is designed to

protect against the erosion-causing force. Refer to Table 2, page 28, for guidance.

4. Whether or not reasonable shoreline access can be maintained.

5. Whether this is a temporary or long-term, permanent stabilization project.

The final, and probably the most difficult step in this process, is to **evaluate** each of the potential alternatives. In doing so, you should remember that:

- You want to get the most for your money. Several factors will influence the cost-effectiveness of the selected alternative. In general, a structural solution is not a good investment of your funds if the costs, both construction and maintenance, are greater than the value of the property you are trying to protect.
- It is advantageous to work with your neighbors or other members of your community when planning shoreline protection. In doing so you can provide better, more extensive protection for less money than you could through several individual efforts. In addition, cooperative planning helps you to identify potential impacts on adjacent shorelines and landowners that sometimes accompany structural shore protection. Such problems can be avoided through community organization.

The design and construction of shore protection is beyond the scope of this manual. For this information and additional guidance in evaluating alternatives, please contact the US Army Corps of Engineers.

Ninglick River bluff undercut by thermal erosion at Newtok, Alaska. *Photo: Stanley Tom, Native Village of Newtok.*

River bank erosion at Kongiganak, Alaska. *Photo: DCRA/DCCED*

COMMUNITY EROSION OBSERVATION RECORD

Sketch Checklist

- ☐ Eroding shoreline
- ☐ Properties to be protected
- ☐ Measured or estimated distances
- ☐ Islands, bars, opposite bank
- ☐ Direction of current
- ☐ Direction of ice movement
- ☐ North direction indicated
- ☐ Normal wind direction
- ☐ Strong wind direction
- ☐ Happens _____ times in _____ years
- ☐ Known limits offloading
- ☐ Happens _____ times in _____ years
- ☐ Location of side view sketch shown on other sheet
- ■ River shape as seen from the air:
  - ☐ *Braided*
  - ☐ *Split*
  - ☐ *Meandering*
  - ☐ *Sinuous*
  - ☐ *Straight*

Sketch of Overhead View

Energy Source Identification

WAVES - *Eroding shoreline is exposed to:*

- □ Big waves → How often? ____ times per year. How big? ____ feet.
- ○ Boat waves → How often? ____ times per week. How big? ____ feet.
- ○ Small waves
- △ No waves

CURRENT- *Eroding shoreline is exposed to:*

- □ Fast current → ____ feet in ____ seconds
- ○ Slow current → feet in seconds
- ○ Current direction changes with wind direction
- △ No current

ICE - *Eroding shoreline is exposed to:*

- ○ Ice blocks → How big? ____ feet thick x ___ feet wide x _____ feet long
- △ No ice frozen

HEAT - *Eroding shoreline is:*

- □ Always frozen with lenses of ice
- □ Always Frozen with no ice visible
- ○ Frozen in winter but not summer
- △ Never frozen

WIND - *Eroding shoreline is exposed to:*

- □ Strong winds that make air dusty
- ○ Strong winds that are not dusty
- △ No wind or light winds

PRECIPITATION - *Eroding shoreline is exposed to:*

- □ Strong wind-driven rain or hail
- ○ Heavy rain or hail
- △ Light to moderate rain

SEEPAGE - *Eroding shoreline usually has:*

- □ Water seeping out of bank or bluff
- ○ Wet bank or bluff
- △ Dry bank or bluff

Sketch Checklist

- ☐ Shape of eroding
- ☐ Properties to be protected
- ☐ Measured or estimated distances
- ☐ Height of bluff or bank
- ☐ Normal water level
- ☐ Floodwater level
- ☐ Beach, if any
- ☐ Bottom slope below
- ■ Soil types:
    - ☐ *Frozen*
    - ☐ *Unfrozen*
    - ☐ *Gravel sized (G)*
    - ☐ *Sand sized (S)*
    - ☐ *Silt sized (L)*
    - ☐ *Clay sized (C)*
    - ☐ *Mixed sizes (show mix)*

Assessment of Energy Sources

- The probable energy source(s) causing your eroding shoreline are identified in two ways:

    1. Direct identification of the energy that you have seen acting on your shoreline.
    2. Identification of the symptoms of erosion and the energy sources that cause those symptoms.

- The direct identification of energy sources is accomplished by checking the appropriate shapes on the first page of this form. Then transfer the check marks in ☐ and ○ shapes in the table on the right (*Symptoms of Erosion*).

- Identification of symptoms is accomplished by comparing your eroding shoreline shapes with the erosion symptom shapes illustrated in the text. Check all shapes on the line or lines of the appropriate symptom(s).
- Compare the horizontal rows and vertical columns for each energy source.
- The probable energy sources causing your eroding shoreline are those with the ☐ shape in both rows and columns.
- Possible energy sources are those with ☐ shapes in rows and ○ shapes in columns, or ☐ shapes in rows and ○ shapes in columns.
- Unlikely energy sources are those with ○ shapes in both rows and columns.

Energy Sources Identified by Erosion Symptoms

	Waves	Current	Ice	Heat	Wind	Precipitation	Seepage
Slides	○	○		☐		○	○
Undercutting	☐	☐		○			
Scarps	☐	☐					
Ice Exposure	○	○		☐		○	
Root Exposure	☐	☐		○	○	○	○
Ice Gouging			☐				

Energy Sources Identified Directly

Waves	☐	○	○
Current	☐	○	○
Ice			○
Heat	☐	☐	○
Wind		☐	○
Precipitation		☐	○
Seepage		☐	○

Notes

Chapter 4: Seeking Assistance

Communities and private landowners in need of erosion protection can obtain three types of assistance; technical, funding, and guidance in applying for permits. Assistance resources are provided on the following pages.

Technical Assistance

Depending on the situation, several agencies may assist you with your erosion problem:

Alaska Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs (DCRA): DCRA helps communities reduce losses and damage from flooding and erosion. DCRA can provide technical assistance on community planning, floodplain management, hazard impact assessments, community migration and relocation, and grant opportunities. DCRA's funding assistance for erosion issues is summarized in the section on Funding Assistance.

Alaska Department of Military and Veterans Affairs, Division of Homeland Security and Emergency Management (DHS&EM): DHS&EM responds to state disaster declarations dealing with erosion and flooding when local communities request assistance. The situation must be a life-threatening, immediate problem. DHS&EM's funding assistance for erosion issues is summarized in the section on Funding Assistance.

Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys (DGGS): DGGS conducts geological and geophysical studies to determine potential geologic hazards to buildings, roads, bridges, and other installations and structures, and maintains quick response capability to deploy geological field teams in the immediate aftermath of major geohazard events to describe and document the nature, extent and severity of geologic impacts such as significant erosion.

Alaska Department of Transportation and Public Facilities (DOT&PF): DOT&PF will help when a road, airport, or other public transportation facility is in danger.

US Army Corps of Engineers (USACE): USACE can help you utilize their publications to develop preliminary designs. They can help with construction if you qualify for federal funding. Several of the USACE funding programs are summarized in the section on Funding Assistance.

US Department of Agriculture, Natural Resources Conservation Service (NRCS): NRCS can provide technical assistance on improving private lands and their management, and maintaining and improving wildlife and fish habitat. NRCS's funding assistance for erosion issues is summarized in the section on Funding Assistance.

US Environmental Protection Program, Indian Environmental General Assistance Program (IGAP): EPA Tribal Coordinators can provide technical assistance with grant writing and grant opportunities for addressing erosion issues. EPA's IGAP funding assistance for erosion issues is summarized in the section on Funding Assistance.

National Oceanic and Atmospheric Administration (NOAA) especially for storm surges and open ocean erosion (they are not just oceans and flooding). National Ocean Service: http://oceanservice.noaa.gov/hazards/natural-hazards/

Ocean and Coastal Resource Management :
http://coastalmanagement.noaa.gov/initiatives/shoreline_resources.html

In addition to the agencies listed above, a private consultant can help with all phases of the project including problem assessment, detailed design, and construction.

Funding Assistance

Some potential sources of funding to address your erosion problem are as follows:

USACE

Section 103 of the 1962 River and Harbor Act: allows for the study, adoption, and construction of small shoreline erosion protection projects without specific authorization by Congress. A project is accepted for construction only after detailed study clearly shows its engineering feasibility, environmental acceptability, and economic justification. This program requires a 35% non-federal match.

Section 14 of the 1946 Flood Control Act: allows the USACE to plan and construct emergency streambank and shoreline protection projects to protect highways, highway bridge approaches, and public facilities. This program also requires a 35% non-federal match.

Section 22 of the Water Resources Development Act of 1974 (Planning Assistance to States Program): allows the USACE to assist the states, local governments, and other non-federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources. This program requires a 50% non-federal match.

Section 111 of the River and Harbor Act of 1968: Allows the USACE to mitigate shoreline erosion damage caused by federal navigation projects.

DHS&EM

Hazard Mitigation Grant Program (HGMP): Funds provided by the Federal Emergency Management Agency (FEMA) and administered by DHS&EM to states and Indian tribal governments to assist communities in implementing long-term measures that substantially

reduce the risks of future damage, hardship, loss, or suffering in an area devastated by a disaster.

Requirements for HGMP funding are that the community has a Local Hazard Mitigation Plan, there is a Federal Disaster Declaration in Alaska, the project is shown to be cost-effective, and the state or local government provides a 25% non-federal match.

Pre-Disaster Mitigation (PDM) Program: Funds provided by FEMA and administered by DHS&EM to states, territories, Indian tribal governments, and communities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. Requirements for PDM funding are that the community has a Local Hazard Mitigation Plan, the project meets cost-benefit analysis and cost- effective requirements; and that the state or local government provide a 25% match (10 % or more for a small and impoverished community.)

DCRA

Flood Mitigation Assistance (FMA) Program: Funds provided by FEMA and administered by DCRA to communities for (1) development of flood risk mitigation plans or (2) activities described in approved plans to reduce the risk of flood damage to structures covered under the National Flood Insurance Program, such as elevation, acquisition, and relocation of buildings. Erosion related to flooding can be addressed through this funding. Requirements for FMA funding are that the community participates in the National Flood Insurance Program (NFIP); has a FEMA-approved Flood Risk Mitigation Plan (unless grant is for development of such a plan); the project meets cost-effectiveness requirements; and the state or community provides a non-federal match.

Repetitive Flood Claims (RFC) Program: Funds provided by FEMA and administered by DCRA to reduce flood damage to individual properties for which one or more claim payments for losses have been made under flood insurance coverage and that will result in the greatest savings to the NFIP in the shortest period of time. Some erosion issues related to flooding may be addressed through RFC funding. Requirements for RFC funding are that the community participates in the National Flood Insurance Program (NFIP), has a FEMA-approved Flood Risk Mitigation Plan (at the discretion of the FEMA director), the project meets cost-effectiveness requirements, and that there is a lack of capacity by the community to manage FMA grant activity or an inability to meet FMA match requirements,

Severe Repetitive Loss (SRL) Program: Funds provided by FEMA and administered by DCRA to mitigate flood damage to residential properties covered under a National Flood Insurance Program flood insurance policy that have had either (1) four or more flood-related insurance claims payments that each exceeded $5,000 and cumulatively exceeded $20,000 or (2) at least two flood-related insurance claims payments that cumulatively exceed the value of the property. In both instances, at least two of the claims must be within 10 years of each other. Requirements for SRL funding are that the community participates in the NFIP, has a FEMA-approved Flood Risk Mitigation Plan; the project meets cost-effectiveness requirements, and the state or community provide a non-federal match.

Alaska Climate Change Impact Mitigation Program (ACCIMP): The ACCIMP provides grants for Hazard Impact Assessments and Community Adaptation to address the impacts of erosion, flooding, thawing permafrost, and other impacts of climate change.

- Hazard Impact Assessment (HIA) Grants provide funding to communities to hire a contractor to identify, define, assess impacts to the community. The HIA provides recommendations to the community for the next steps to be taken to address the hazard impacts.

- Community Planning Grants are provided to communities who have undergone HIA's. The Community Planning grant is intended to help the community address one or more of the recommendations from the HIA, such as protest-in-place, migration, or relocation strategies.

NRCS

Watershed Surveys and Planning Program: Depending upon federal appropriations, this program can provide funding for surveys and plans to protect watersheds from damage caused by erosion, floodwater, sediment, and to conserve and develop water and land resources. Types of surveys and plans include watershed plans, river basin surveys and studies, flood hazard analyses, and flood plain management assistance. The focus of these plans is to identify solutions that use land treatment and nonstructural measures to solve resource problems.

Watershed Protection and Flood Prevention Program: Provides funding for projects that control erosion and prevent flooding. Limited to watersheds that are less than 250,000 acres.

Emergency Watershed Protection Program: Provides assistance where there is some imminent threat—usually from erosion caused by river flooding.

Conservation Technical Assistance Program: Provides technical assistance to communities and individuals to solve natural resource problems, including reducing erosion, improving air and water quality, and maintaining or restoring wetlands and habitat.

FEMA

***(See DHS&EM and DCRA for additional FEMA-funded programs administered through the State of Alaska Public Assistance Program*)** Provides aid to state government agencies; local governments; Indian tribes, authorized tribal organizations, and Alaska Native villages; and private nonprofit organizations or institutions that provide certain services otherwise performed by a government agency. Assistance is provided for projects such as debris removal; emergency protective measures to preserve life and property; and the repair and replacement of damaged structures, such as buildings, utilities, roads and bridges, recreational facilities, and water-control facilities (e.g., dikes and levees). This funding requires that there be a Federal Disaster Declaration and cost share (match) from the State or applicant.

Individuals and Households Program: This program provides for the necessary expenses and serious needs of disaster victims that cannot be met through insurance or low-interest Small Business Administration loans. FEMA provides temporary housing assistance to individuals whose homes are unlivable because of a disaster. Other available services include unemployment compensation and crisis counseling to help relieve any grieving, stress, or mental health problems caused or aggravated by the disaster or its aftermath. FEMA can cover a percentage of the medical, dental, and funeral expenses that are incurred as a result of a disaster. This funding requires that there be a Federal Disaster Declaration. Funding provides temporary assistance for primary residences only.

IGAP

General Assistance Program (GAP) Grant: GAP grants are available to Tribes or Intertribal consortiums and can address erosion issues related to solid or hazardous waste.

US Department of Housing and Urban Development

Community Development Block Grant Program: Administered by the State of Alaska Department of Commerce, Community, and Economic Development (*see above*).

Indian Community Development Block Grant (ICBDG) Program: The ICDBG program can provide funding for recipients that may be able to address erosion issues for housing rehabilitation, land acquisition to support new housing construction, and under limited circumstances, new housing construction.

Community Facilities: Infrastructure construction, e.g., roads, water and sewer facilities; and, single or multipurpose community buildings.

Native American Housing Assistance Self-Determination Act of 1996: Provides grants and technical assistance to Indian tribes and Alaska Native villages to develop affordable housing for low-income families. The funds may also be used to move homes that are threatened by flooding and erosion.

Imminent Threats Grants Program: Provides funding to alleviate or remove imminent threats to health or safety for nonrecurring events.

Native American Housing Assistance Self-Determination Act of 1996: Provides grants and technical assistance to Indian tribes and Alaska Native villages to develop affordable housing for low-income families. The funds may also be used to move homes that are threatened by flooding and erosion.

Imminent Threats Grants Program: Provides funding to alleviate or remove imminent threats to health or safety for nonrecurring events.

US Department of Commerce, Economic Development Administration

Economic Adjustment Program: Provides assistance to protect and develop the economies of communities. This assistance could involve building erosion or flood control structures to protect village commercial structures, such as canneries.

US Department of the Interior, Bureau of Indian Affairs

Road Maintenance Program: Provides funding for maintaining and repairing roads, culverts, and airstrips to provide a foundation for economic development.

Housing Improvement Program: Provides grants and technical assistance to replace substandard housing, including housing that is threatened, damaged, or lost due to erosion or flooding.

US Department of Transportation

Federal Aviation Administration, Alaska Region Airports Division: Provides funding to improve airport infrastructure—including those threatened by flooding and erosion. May fund relocation of an airport if necessitated by community relocation, provided the airport is in the National Plan of Integrated Airport System and meets agency design standards. However, the community must be relocated before the new airport is built.

Federal Highway Administration: Provides funding through the State of Alaska for roads, pedestrian facilities, and snowmobile trails. Funding may be available to assist villages with improving or repairing roads and boardwalks impacted by flooding and erosion.

Permitting Assistance

Finally, you should be aware of permits that may be required before project construction can begin. Agencies to consult include:

- Alaska Department of Environmental Conservation
- Alaska Department of Fish and Game
- Alaska Department of Natural Resources, Division of Mining, Land, and Water
- US Army Corps of Engineers

Appendices 1-3

Teacher housing threatened by erosion in Shishmaref. *Photo: Kawerak*

NOTES

Appendix 1: Example Problem

Background Information

Assume that Michael Adams and his family live on the Kuskokwim River in western Alaska. Michael and his five neighbors have noticed that the river is much closer to their homes than it used to be. Concerned about their property, Michael asks an official of a nearby village where he can get assistance. He is provided a copy of the DCRA erosion handbook. He reviews the handbook and proceeds as described below.

View of Lower Kalskag and Kuskokwim River. ***Photo: DCRA***

Erosion Rate Estimate

Concerned about how much time he has before his meat shed is impacted by erosion, he decides to monitor the speed at which the bank is eroding. His carpenters tape is only 18 feet long, so he stretches it out on the ground and walks along the tape length to find out that 6 steps is equal to 18 feet. Dividing 18 feet by 6 steps tells him that each step is about 3 feet long. He walks along a line that looks like the most direct line to the river bank and counts 50 steps. He repeats the walking 2 more times and counts 49 and 51 steps. The average number of steps for the 3 times is 50 steps. With each step measuring about 3 feet, the distance is about 50 steps times 3 feet/step = 150 feet. He marks the corner of the meat shed and a tree that he walked right beside so that he would remember to walk the same line later for comparison with his 150 feet distance. He also takes photos of the path he followed.

Over the next two months, Michael studies the erosion handbook and discusses his observations with his neighbors, asking them to watch their shorelines for clues to the energy sources causing the erosion. He pays particular attention to the four rainstorms with heavy wind that happened during the typically rainy months of August and September. In late September, he walks the distance to the bank again along the same line to get an average of 45 steps which equals 135 feet (45 steps times 3 feet/step). He calculates that he lost 15 feet (150 feet - 135 feet) of bank in that two month period. He observed that most of the bank erosion took place during the four rainstorms during that time. Knowing that they normally get about 12 rainstorms per year, Michael figures that he may get three times as much erosion in a one year period, or about 45 feet (15 feet for 4 rainstorms times 3 is 45 feet for 12 rainstorms). Since there is 135 feet from the bank to his meat shed, he figures that it will take about 3 years before his shed is threatened, if the same conditions continue.

His neighbors' properties are farther back from the bank than that. Michael and his neighbors decide to watch the bank and the erosion process until the next summer when they would decide what they wanted to do.

Several times during the year, Michael walked the distance from his shed to the bank. At the end of the next July, he counted 35 steps, which is 105 feet (35 steps times 3 feet/step). Subtracting from his original distance of 150 feet a year earlier, gave an erosion rate of 45 feet during that year. Michael thought that the weather was pretty typical that year, so the erosion rate of 45 ft per year was a good estimate.

Identification of Energy Source

One evening, Michael and his neighbors got together to evaluate their problem and discuss potential solutions. They filled out the Community Erosion Observation Form in the Erosion Handbook to help them identify the energy source or sources causing their bank erosion.

They completed the form based on their observations (see pages 48-49):

- The overhead view was sketched and included consideration of everything on the Sketch Checklist; distances were estimated by walking.
- They checked the appropriate symbols in the energy source identification section and transferred the marks in the squares and circles to the right place on the form.
- They sketched the side view of a typical bank, using the checklist to make sure the sketch was complete.
- They identified that root exposure was the only symptom similar to their bank shape and marked the symbols on that line of the form.
- To assess which energy sources were the most likely to be important, they looked for all the sources with squares checked in both the rows and columns. Only waves had squares checked in both rows and columns.

Erosion of the bluff of the Ninglick River in Newtok, Alaska. *Photo: Stanley Tom.*

- Precipitation was the only energy source with a square checked in the row and a circle checked in the column. Current had a square checked in the column and a circle checked in the row. Thus, precipitation and current are possible energy sources acting on their bank.
- Energy sources unlikely to be significant include heat, wind, and seepage which have only circles checked.

Identify the Alternative Solutions

Michael and his neighbors then used Table 2, below, to identify alternative solutions to their erosion problem.

They found that a breakwater, revetment, a seawall, and relocation were anticipated to be potential protection against forces due to wave energy, the most likely energy source. Spur dikes, revetment, a seawall, vegetation, groins, and relocation were noted to be protection measures against current. Revetment, vegetation, and relocation were identified to be protection measures for precipitation.

Evaluate Alternative Solutions

Each of the alternative solutions was evaluated for effectiveness, relative cost, maintenance, available materials, and effects on adjacent shorelines. Michael and his neighbors summarized their evaluation in a table (next page). Michael and his neighbors selected revetment as the best solution, but considered relocation as an alternative.

Table 2. Erosion Alternatives	Suppress or Diminish Energy				Shield Erodible Material			Form a New Beach		
	Break Water	Insulation	Spur Dike	Tile Drain	Revetment	Seawall	Vegetation	Groin	Breakwater	Relocation/ Migration
Waves	X				X	X				X
Currents			X		X	X	X	X		X
Ice										
Heat										
Wind										
Precipitation					X		X			X
Seepage										

Table 3. Evaluation					
Alternative Solutions	**Effectiveness**	**Relative Cost**	**Maintenance**	**Readily Available Materials**	**Effect Elsewhere**
Breakwater	Waves only	High	High-ice forces	No	Minimal
Spur Dike	Current only	High	High-ice forces	No	Some
Revetment	Waves, precipitation, and current	Med-High	Low	Maybe	Minimal
Sea Wall	Waves and current	High	Low	No	Minimal
Vegetation	Precipitation and current	Low	High-wave action	Yes	No
Groins	Current only	High	High-ice forces	No	Some
Relocation	Wave, precipitation, and current	Med	Low	Land Available	No

Seeking Assistance

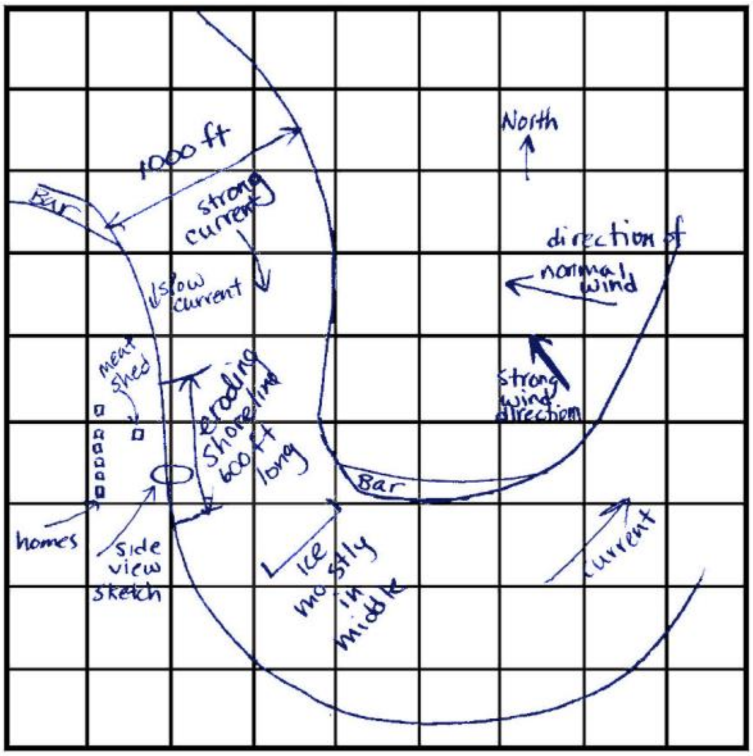
Michael wrote a letter to the state and federal agencies listed on pages 35-36 of the Erosion Handbook, telling them what he and his neighbors had observed and concluded. He included photos of the eroded area, the completed Community Erosion Observation Form and the table evaluating alternatives. The agencies reviewed the materials. One of the federal agencies, the US Army Corps of Engineers (USACE), sent an engineer to the site to evaluate the erosion problem with Michael. After further analysis of information gathered during the site visit, the USACE told Michael that his assessment of the problem and solutions was well done. They concluded that wind-driven rain and waves were the main energy sources, with currents being sufficient to carry away the sediments eroded by the rain and waves. They also concluded that revetment or relocation would be the best alternative solutions and provided Michael with USACE programs that might provide funding for the project. Several of the other agencies Michael wrote to provided him with information on grant opportunities to fund the non-federal match for the design and construction of a revetment. Some of the agencies also offered to provide technical assistance to Michael in completing the grant applications.

Solution

Michael moved his meat shed farther from the river bank. With the documentation Michael had compiled on his community's erosion problem, Michael completed several grant applications to provide a non-federal match for a community revetment project. With his thorough documentation, he was awarded a grant which was used as local match for USACE funding for the design and construction of a riverbank revetment .

River bank erosion at Kotlik, Alaska. *Photo: Lawrence Blood, DCCED/DCRA*

COMMUNITY EROSION OBSERVATION RECORD



Sketch Checklist

- ☒ Eroding shoreline
- ☒ Properties to be protected
- ☒ Measured or estimated distances
- ☒ Islands, bars, opposite bank
- ☒ Direction of current
- ☒ Direction of ice movement
- ☒ North direction indicated
- ☒ Normal wind direction
- ☒ Strong wind direction
- ☐ Happens 12 times in 1 years
- ☐ ~~Known limits of flooding~~ none
  ~~Happens ___ times in ___ years~~
- ☒ Location of side view sketch shown on other sheet
- ■ River shape as seen from the air:
  - ☐ Braided
  - ☐ Split
  - ☒ Meandering
  - ☐ Sinuous
  - ☐ Straight

Energy Source Identification

WAVES - *Eroding shoreline is exposed to:*

- ☒ Big waves → How often? 12 times per year. How big? 2 feet.
- ○ Boat waves → How often? ___ times per week. How big? ___ feet.
- ○ Small waves
- △ No waves

CURRENT - *Eroding shoreline is exposed to:*

- ☐ Fast current → ___ feet in ___ seconds
- ⊗ Slow current → 10 feet in 5 seconds
- ○ Current direction changes with wind direction
- △ No current

ICE - *Eroding shoreline is exposed to:*

- ○ Ice blocks → How big? ___ feet thick x ___ feet wide x ___ feet long
- ☒ △ No ice blocks. The ice is far from shore when it moves

HEAT - *Eroding shoreline is:*

- ☐ Always frozen with lenses of ice
- ☐ Always frozen with no ice visible
- ⊗ Frozen in winter but not summer
- △ Never frozen

PRECIPITATION - *Eroding shoreline is exposed to:*

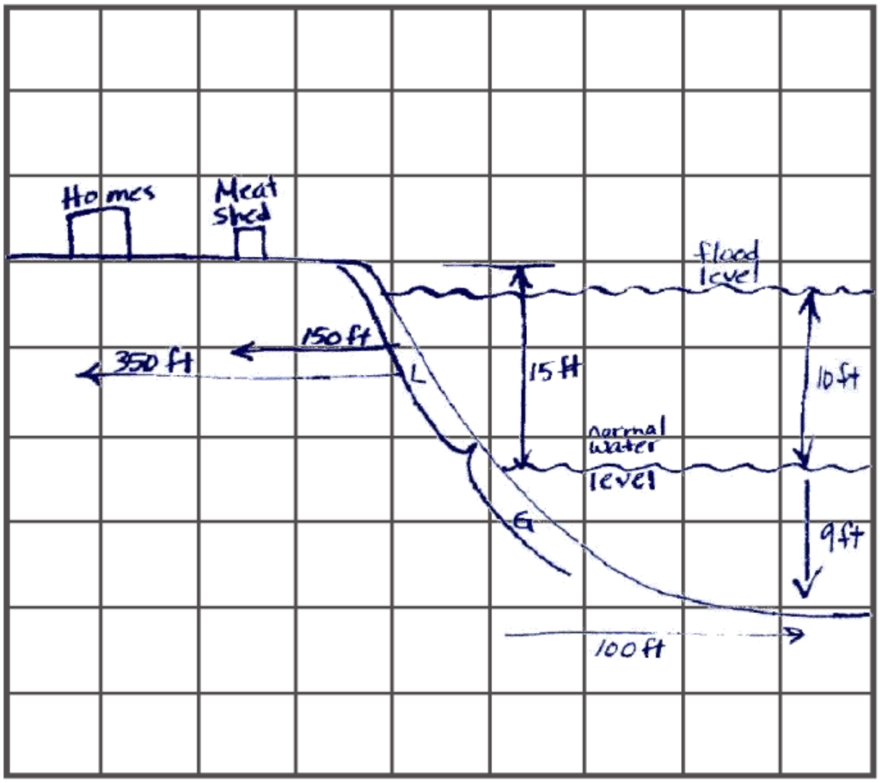
- ☒ Strong wind-driven rain or hail
- ○ Heavy rain or hail
- △ Light to moderate rain

WIND - *Eroding shoreline is exposed to:*

- ☐ Strong winds that make air dusty
- ⊗ Strong winds that are not dusty
- △ No wind or light winds

SEEPAGE - *Eroding shoreline usually has:*

- ☐ Water seeping out of bank or bluff
- ⊗ Wet bank or bluff
- △ Dry bank or bluff

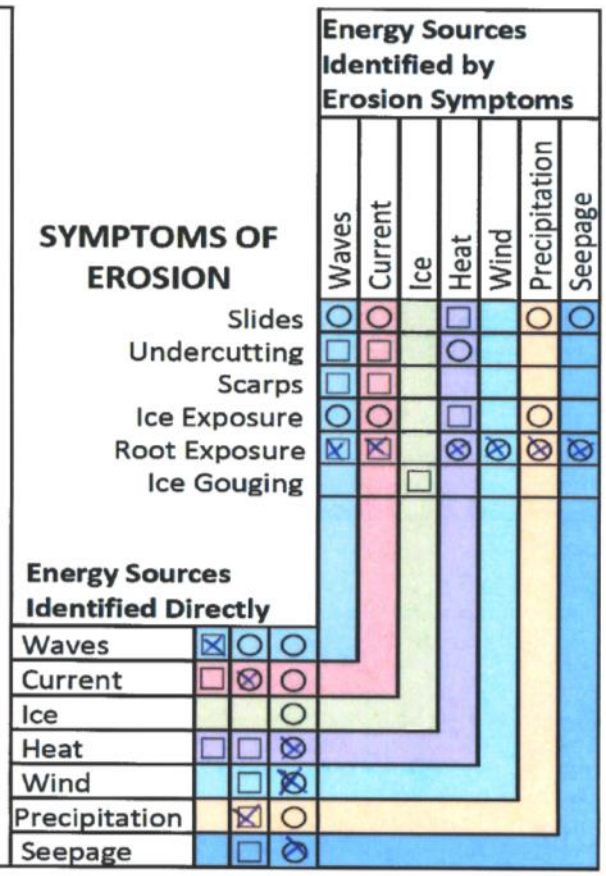


Sketch Checklist

- [x] Shape of eroding
- [x] Properties to be
- [x] Measured or estimated
- [x] Height of bank or bluff
- [x] Normal water level
- [x] Floodwater level
- [ ] Beach, if any none
- [x] Bottom slope below
- Soil types
  - [ ] Frozen
  - [x] Unfrozen
  - [x] Gravel sized (G)
  - [ ] Sand sized (S)
  - [x] Silt sized (L)
  - [ ] Clay sized (C)
  - [ ] Mixed sizes (show mix)

Assessment of Energy Sources

- The probable energy source(s) causing your eroding shoreline are identified in two ways:
  1. Direct identification of the energy that you have seen acting on your shoreline.
  2. Identification of the symptoms of erosion and the energy sources that cause those symptoms.
- **The direct identification** of energy sources is accomplished by checking the appropriate shapes on the first page of this form. Then transfer the check marks in ☐ and ○ shapes to the ☐ and ○ shapes in the table on the right *(Symptoms of Erosion).*
- **Identification of symptoms** is accomplished by comparing your eroding shoreline shapes with the erosion symptom shapes illustrated in the text. Check all shapes on the line or lines of the appropriate symptom(s).
- Compare the horizontal rows and vertical columns for each energy source.
- The probable energy sources causing your eroding shoreline are those with the ☐ shape in both rows and columns.
- Possible energy sources are those with ☐ shapes in rows and ○ shapes in columns, or ☐ shapes in rows and ○ shapes in columns.
- Unlikely energy sources are those with ○ shapes in both rows and columns.



NOTES

Appendix 2: Information Sources

Alaska Department of Commerce, Community, and Economic Development
Division of Community and Regional Affairs
550 West 7th Avenue, Suite 1770
Anchorage, AK 99501
Phone: 907-269-4501
http://commerce.alaska.gov/dcra/

Alaska Department of Military and Veterans Affairs
Division of Homeland Security and Emergency Management
P. O. Box 5750
Ft. Richardson, AK 99505-5750
Phone: 907-428-7000 FAX: 907-428-7009
http://ready.alaska.gov/

Alaska Department of Natural Resources
Division of Geological & Geophysical Surveys
3354 College Road, Fairbanks, AK 99709
Phone: 907-451-5000 Fax: 907-451-5050
http://www.dggs.dnr.state.ak.us/

Alaska Department of Transportation and Public Facilities
Statewide Design & Engineering Services
3132 Channel Dr.
P.O. Box 112500
Juneau, AK 99811-2500
Phone: 907-465-2960 Fax: 907-465-2460
http://www.dot.state.ak.us/stwddes/

U.S. Army Corps of Engineers, Alaska District
Alaska Baseline Erosion Assessment
P.O. Box 6898
Anchorage, AK 99506-0898
Phone: 907-753-5694
Alaska.Erosion.POA@usace.army.mil
http://www.poa.usace.army.mil

U. S. Department of Agriculture
Natural Resources Conservation Service (NRCS)
Alaska State Office
800 West Evergreen Avenue, Suite 100
Palmer, Alaska 99645-6539
Phone: 907-761-7760
http://www.ak.nrcs.usda.gov/

U.S. Department of Commerce
Economic Development Administration
Alaska Regional Office
510 L Street, Suite 444
Anchorage, AK 99501
Phone: 907-271-2271
http://www.eda.gov/

U.S. Environmental Protection Agency
Alaska Operations Office
222 W. Seventh Avenue, #19
Anchorage, AK 99513-7588
Phone: 907-271-5083
http://www.epa.gov/aboutepa/states/ak.html

Appendix 3: Helpful Publications

Help Yourself: A brochure prepared by the USACE in 1978 with a discussion of the critical erosion problems and alternative methods of shore protection. Available on the U.S. Government Printing Office's website at:
http://goo.gl/yPQyq

Low Cost Shore Protection: A brochure prepared by the USACE in 1981 that presents low cost ways for the shoreline property owner to control or slow down erosion. Available on the USACE Coastal and Hydraulics Laboratory website at:
http://goo.gl/6kpVs

Low Cost Shore Protection: Property Owner's Guide: A report prepared by the USACE hat gives detailed information on low cost shore protection. Available on the USACE Coastal and Hydraulics Laboratory website at:
http://goo.gl/2fVfh

Promoting Generations of Self-Reliance: Stories and Examples of Tribal Adaptation to Change: This new publication by EPA Region X's IGAP Program suggests three components for communities to consider when planning for, implementing, and evaluating long-term climate change adaptation goals. Available on the Alaska Center for Climate Assessment & Policy's website at:
http://goo.gl/ViIk9

Soil Erosion Fact Sheets: A series of 7 factsheets prepared by the New South Wales, Australia Department of Primary Industries to help property owners address erosion issues. The factsheets include: Types of Erosion, Indicators of Erosion, Monitoring Erosion, Groundcover, Gully Erosion, Roads and Tracks, and Planning your Erosion Project.
http://goo.gl/gx3OI

Erosion Control Technical Guide: A technical guide prepared by the California Department of Transportation that offers tools to aid the decision-making process in designing sustainable erosion controls on project sites. Soil, water and vegetation must all be considered to achieve successful, self-sufficient erosion control at a project site.
http://goo.gl/SZL7p

Citizen's Guide to Erosion and Sediment Control: Prepared by the Loudoun County, Virginia Department of Building and Development, this brochure provides general information about erosion and sediment control and how it can affect water quality, wetlands, wildlife and natural vegetation.
http://goo.gl/LyHkj

On the Coast: A guide promoting an understanding of coastal processes and good stewardship of coastal property on the Kenai Peninsula: *River Center, Soldotna 2010, Coastal Erosion Responses for Alaska in a Changing Climate, Alaska Sea Grant 2011*

Eroding bluff near the Naknek River, Alaska. *Photo: Sally Russell Cox, DCCED/DCRA*

Glossary

Alternate Ground Bars - Sediment deposition formed opposite of wandering *thalwegs.*

Anabranching (or Split Channel) River - A channel type with numerous stable islands which divide the flow of the river into two channels.

Bluff - A steep *headland*, promontory, riverbank, or cliff.

Breakwater - An offshore structure or partition that protects the shoreline against damaging wave action by causing the wave to break at the structure instead of on the shore.

Braided River - A channel type that contains two or a network of connecting channels separated by gravel bars.

Currents - A body of water or air moving in a definite direction, especially through a surrounding body of water or air in which there is less movement.

Diurnal Tide - A high tide and a low tide that each occur once during the day.

Erodible Materials - Particles which vary in texture, size, and susceptibility to *erosion* based on their resistance to energy.

Erosion - Any process, natural or man-made, by which material is removed from one location and deposited in another.

Floodplain - An area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge.

Groin - A structure built approximately perpendicular to the shoreline that traps sediment as it is transported along the beach, thus helping to expand existing shorelines and slow the *erosion process*.

Headland - A point of land that extends into a body of water and is an important feature with respect to wave erosion.

Ice Lenses - Large layers of ice in *permafrost.* They are formed when moisture, diffused within soil or rock, accumulates in a localized zone.

Insulation – A natural or man-made material used on frozen ground to help diminish the amount of heat that is absorbed by the soil, thus preventing thaw.

Meandering River - A channel type that typically contains only one channel, and winds back and forth within the *floodplain*.

Migration - Gradually moving property and development away from erosion prone areas. In order to successfully migrate, a community needs suitable, developable land nearby.

Glossary

Negative Surge - A decreased water level that is caused in the presence of offshore wind and/ or high atmospheric pressure.

Offshore Breakwaters - Man made structures that restrict sediment movement and encourage sediment deposition by decreasing the wave energy that is available to move the sediment along the beach

Permafrost - Permanently frozen soils located a few feet below the surface where the warmth of the sun cannot thaw them.

Point Bars - The primary area of sediment deposition in a *meandering river*.

Positive Surge (see storm surge)

Protect-in-Place - The use of shoreline protection measures and other erosion controls to prevent or minimize erosion.

Relocation - Moving the entire community to an entirely different location that is not vulnerable to erosion. Relocation is usually considered only after it has been determined that other methods of dealing with an erosion problem would not be feasible.

Revetment - A facing of stone or other resistant material that is placed against an eroding bank.

Runup - When breaking waves on the beach propel water inland.

Scarp - A steep slope or long rock that occurs from *erosion* or faulting and separates two relatively level areas of differing elevations.

Seawall - A structure that separates a water body and an eroding bank and thus protects the bank from wave erosion and damage.

Seepage - Water escaping out of a bank or *bluff*.

Semi-Diurnal Tide - A high tide and a low tide that each occur twice during the day.

Set Down - The drop in water level caused by wind stress acting on the surface of a body of water for an extended period of time. As the wind blows, water recedes from the upwind shore and exposes terrain that was formerly underwater.

Set Up - The tendency for water levels to increase at the downwind shore, and to decrease at the upwind shore.

Sinuous River - Similar to a *meandering river* except that it does not bend as sharply.

Slides - Geological phenomenon which includes a wide range of ground movement, such as rockfalls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and onshore environments.

Split Channel (or Anabranching) River - A channel type with numerous stable islands which divide the flow of the river into two channels.

Spur Dike - A structure that extends at an angle from shore into a river and is placed upstream of the problem area.

Storm Surge (or Positive Surge) - An onshore rise of water associated with a low pressure weather system. Storm surges are caused primarily by high winds pushing on the ocean's surface.

Straight River - A channel type with a single flowing channel.

Thalweg - The line along a channel that connects the lowest elevations of the channel bed. The deepest part of a channel of water.

Thermal Erosion - The result of melting and weakening permafrost due to moving water.

Tides - The natural, periodic variations in water levels of oceans, bays, gulfs, and inlets.

Tile Drains - Used to control seepage forces by removing water from the soil.

Undercutting - Erosion of material at the base of a steep slope, cliff, or other exposed rock.

Vegetative Cover- Plants used for trapping and holding eroding material.

Waves - A form of energy created in water usually from wind distributing the water surface.