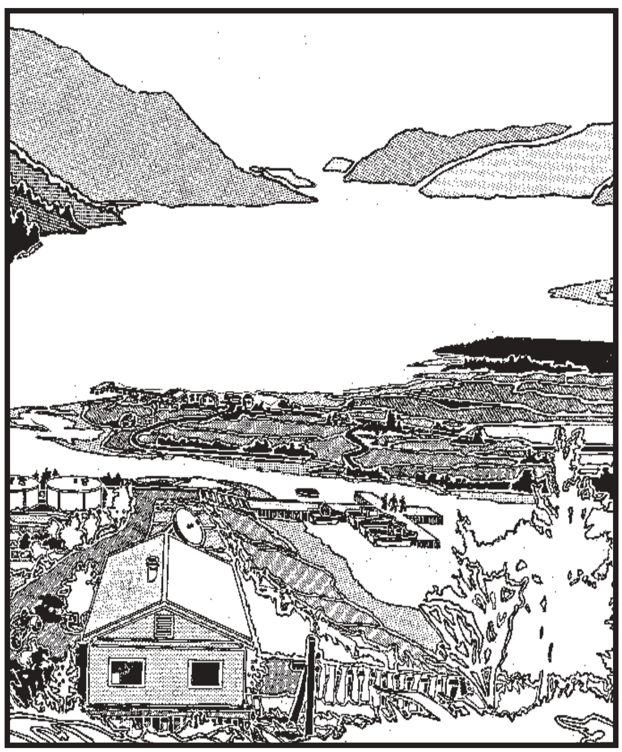
Alaska Floodplain Management

Understanding and Evaluating Erosion Problems



Prepared for:
Department of Community and Regional Affairs
by
Woodward-Clyde Consultants, Anchorage, Alaska
Printed September 1982   Reprinted June 1989 with revisions

Revised & Reprinted: March 1998

Credits & Acknowledgments

Credits - 1989

Woodward-Clyde Consultants
Project Staff
Joseph M. Colonell
Janet K. Hearn
Larry A. Rundquist

Alaska Department of Community and Regional Affairs
David Hoffman, Commissioner
Municipal and Regional Assistance Division
Marty Rutherford, Director
Christy Miller, Planner and Floodplain Management Program Coordinator

Graphics by Fineline Graphics
Chris Hitchcock
Jane Stinson

The work that provided the basis for this publication (in 1982 & 1989) was supported by funding under a Cooperative Agreement with the Federal Emergency Management Agency. The substance and findings of that work are dedicated to the public. The author and publisher are solely responsible for the accuracy of the statements and interpretations contained in this publication. Such interpretations do not necessarily reflect the view of the Government.

Acknowledgments - 1998

Prepared by:
Department of Community and Regional Affairs
Municipal and Regional Assistance Division
Patrick K. Poland, Director

Project Manager:
Christy Miller, Planner

Layout, Production & Cover Design:
Judy Hargis, Publication Technician

Additional Graphics by:
Bud Root, Bud Root Commercial Art and Design

This is an educational manual for small communities and private and public landowners to assist them in Understanding and Evaluating Erosion Problems and alternative solutions. The two primary components of the erosion process are an erodible material and an energy source acting on the material. These components are explained to help the users understand the source of their own erosion problem. Characteristic profiles of eroding shorelines and typical energy sources are presented thereby allowing users to identify the characteristics of their erosion problem. The fundamental principles and means of controlling erosion are presented to enable users to understand potential solutions to their erosion problem. Sources of additional guidance for evaluation, design, and implementation of alternative solutions are also presented.

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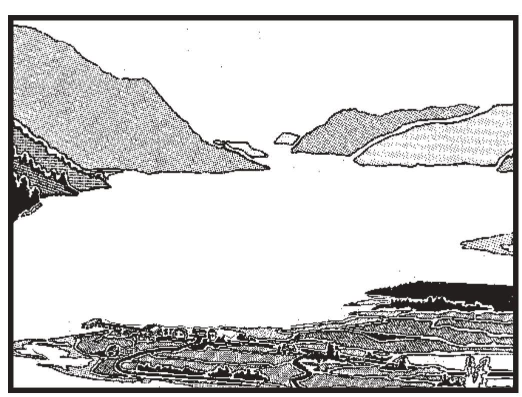


Introduction

The purposes of this manual are to provide:
- ✓ explanations of various erosion processes,
- ✓ means of describing and evaluating individual erosion problems,
- ✓ criteria for selecting appropriate solutions to erosion problems, and
- ✓ guidance for seeking assistance.

The manual is designed to be used in conjunction with U.S. Army Corps of Engineers publications that include:

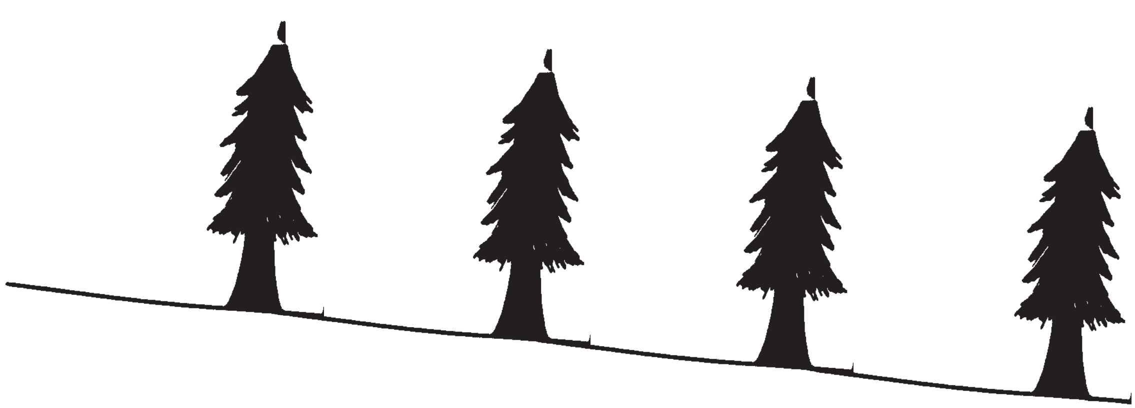
Help Yourself — A brochure with a discussion of the critical erosion problems and alternative methods of shore protection.

Low Cost Shore Protection — A brochure that presents low cost ways for the shoreline property owner to control or slow down erosion.

Low Cost Shore Protection: Property Owner's Guide — A report that gives detailed information on low cost shore protection.

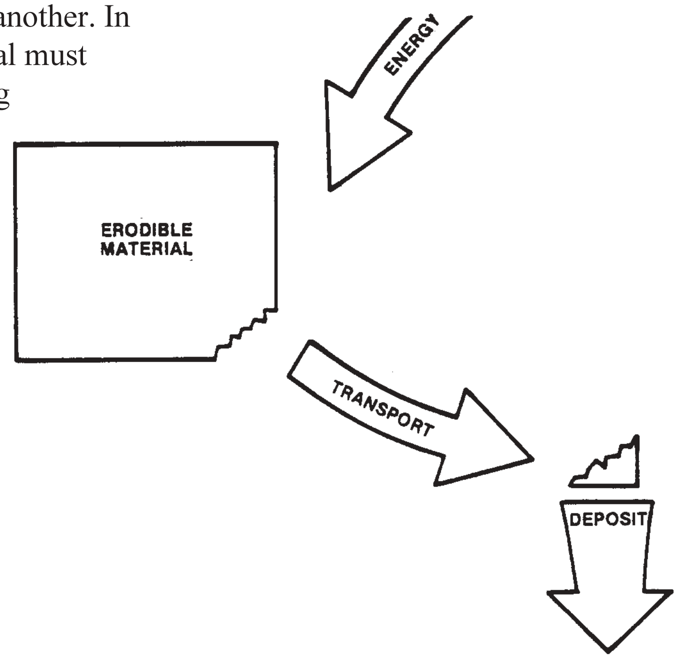
These publications can be obtained from the Corps of Engineers or the Department of Community and Regional Affairs.

In general, erosion should not be classified according to location, i.e.; coastal or riverine, because the fundamentals of erosion and erosion control are the same regardless of where they occur. Each environment has, however, unique problems and features that merit special attention. The discussions in this manual address both the general and site specific aspects of erosion.



Understanding Erosion

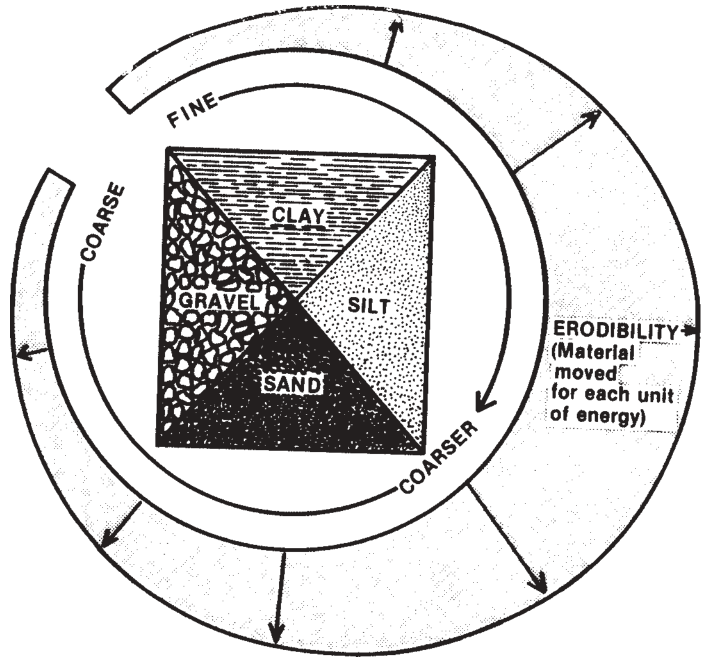
Erosion is any process, natural or man-made, by which material is removed from one location and deposited in another. In order for erosion to occur, an erodible material must be exposed to some form of energy or eroding force.



In this section 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, and also the erosive characteristics of some different shoreline and river configurations.

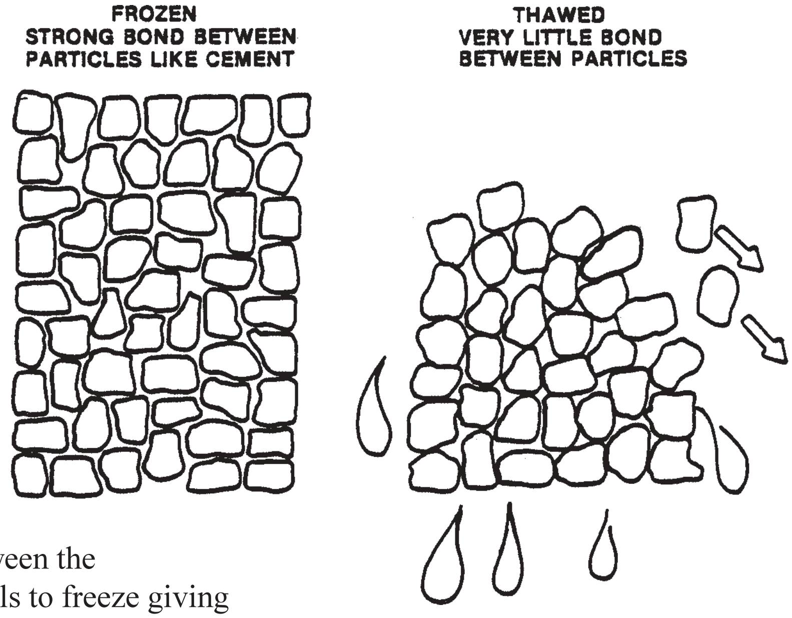
Erodible Materials

The types of erosion we must cope with daily 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 remove the gravel or sand particle from the shoreline.

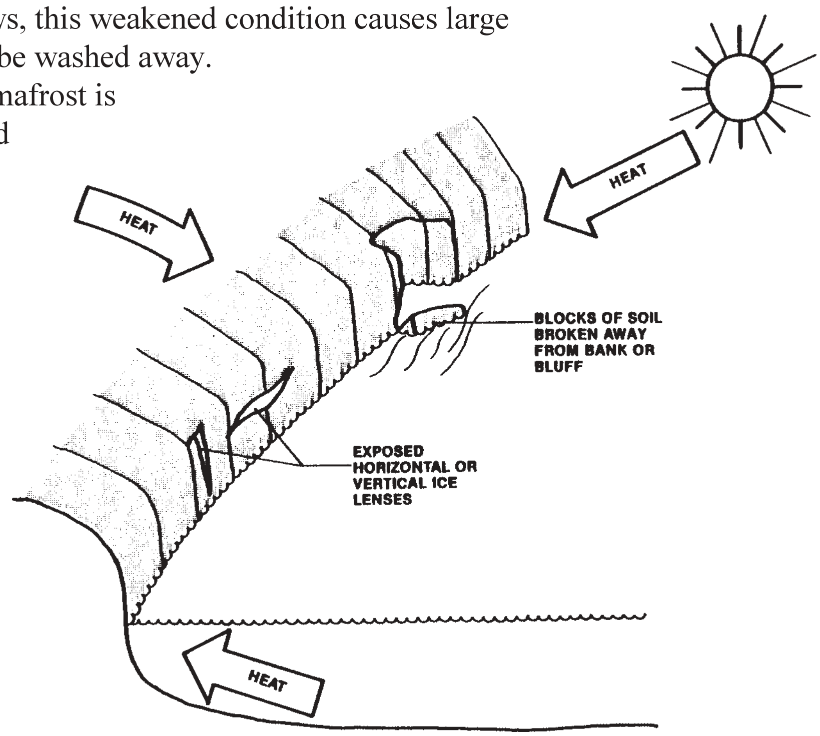


Clay and silt soils are more commonly called mud. They differ from sand and gravel in that they are made up of microscopic particles which stick together when wet. Clay soils are more difficult to erode because they have a stronger bond than silt. Clay will not fall apart when dried, but silt will. Many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

Frozen soils are an important part of the erosion problem 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 contain 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.

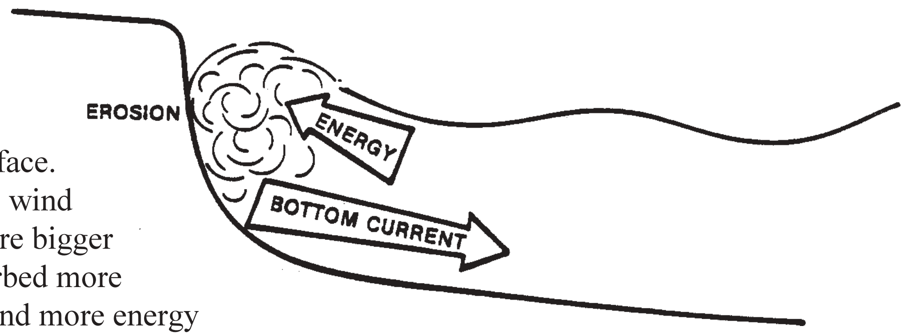


Sources of Energy

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

Waves

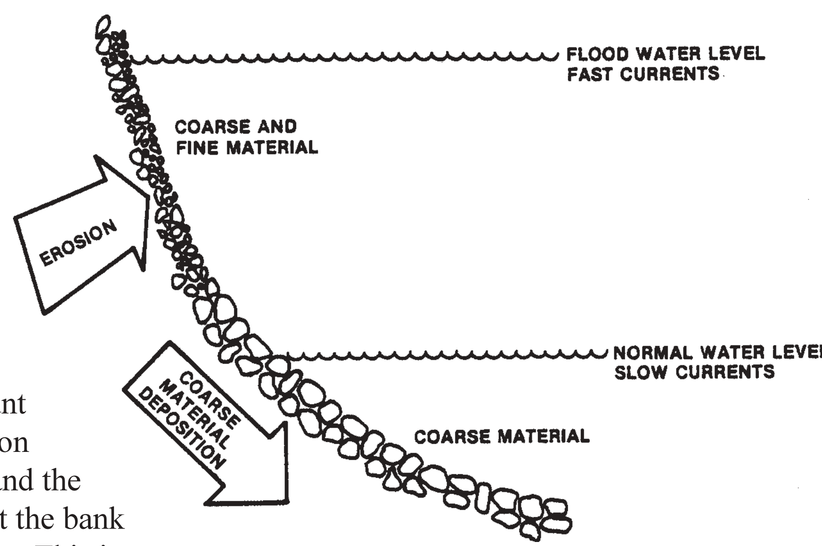
Natural waves can occur on any body of water, and generally develop from wind disturbing the water surface. During storms when the wind blows hard, the waves are bigger because they have absorbed more energy from the wind, and more energy means the waves have a greater ability to erode the shoreline.



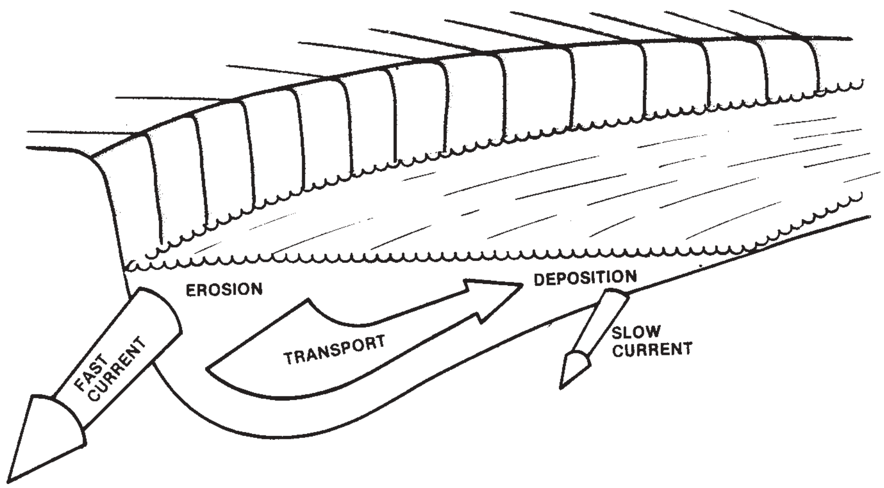
Sometimes people cause waves that lead to shoreline erosion. The most common man-caused waves are from power boats. The faster the boat is going, the bigger the waves are, because more energy is being transferred to the water. Sometimes the energy from boat wakes can be greater than from natural wind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

Currents

Currents are most commonly thought of in conjunction 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 how fast the water is moving, and the speed at which it moves against the 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.

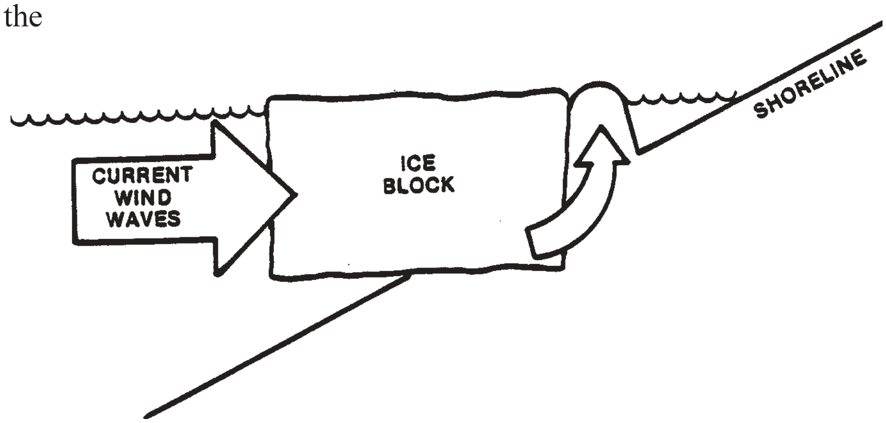


At bends in a river, the water flows faster against the outside bank causing it to erode faster at those locations than at other places along the river.



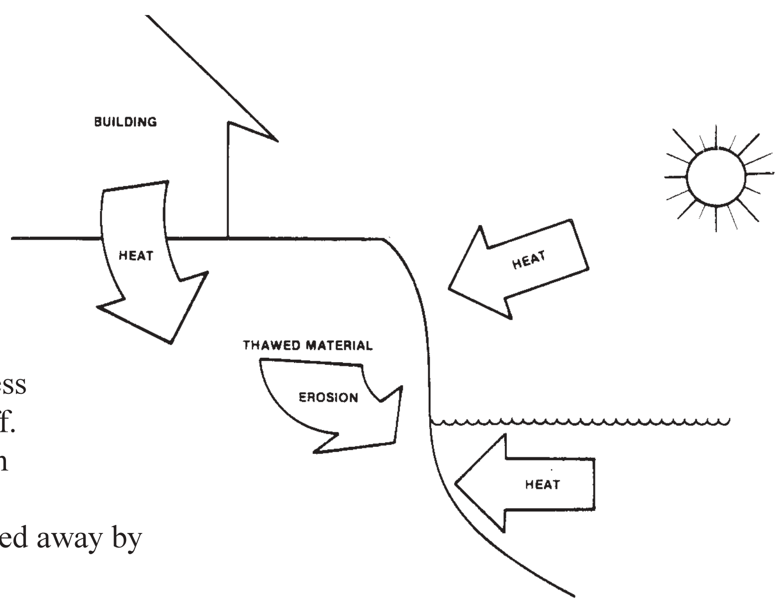
Ice

When ice is forced onto a shoreline by currents, wind, and waves, it erodes the shoreline by pushing the sediments around or loosening them so they can be washed away by the current, waves, or wind. 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.



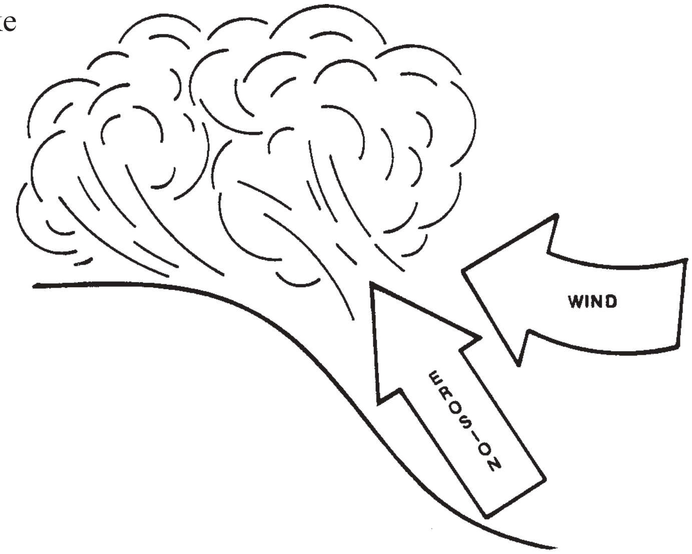
Heat

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. Warm water can also thaw frozen soil. Soils loosened by thermal processes are subsequently washed away by currents, waves, or wind.



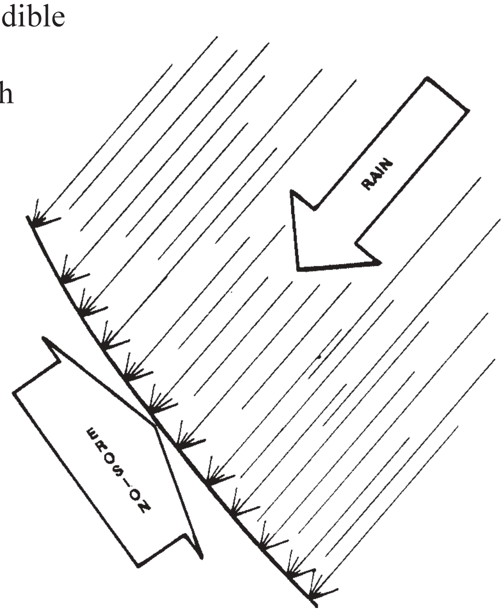
Wind

Wind is essentially a current in the air. Like currents in water, the energy in an air current increases as its 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.



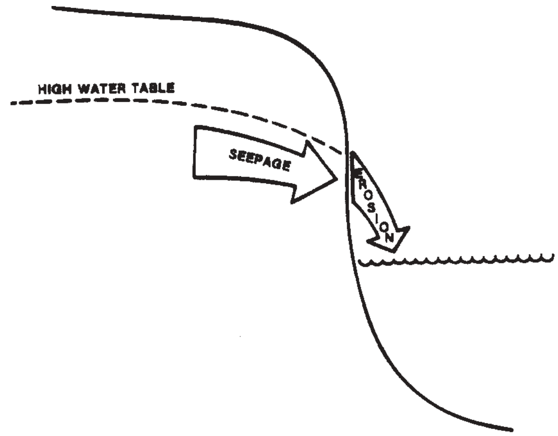
Precipitation

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.



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.



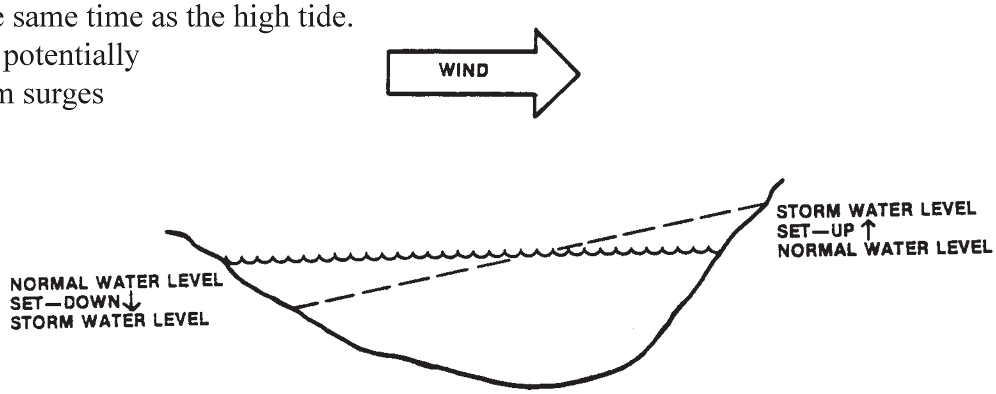
Factors that can Increase or Accelerate Erosion

Tides, Storm Surge, and Flooding

Storm surges, tides, 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, 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. 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 ft with currents exceeding 6.5 knots.

"Storm surge" is the term used to describe the change in sea level caused by 1) winds blowing towards or away from shore, or 2) winds blowing alongshore. An onshore wind causes an increase in water level known as "set-up" or positive surge, while an offshore wind decreases the water level ("set-down" or negative surge). An alongshore wind results in a positive surge to the shoreline to the right of the wind's path and a negative surge to the left. For example, if the wind blows from the south it causes a set-up to the east and a set-down to the west. Surges can be particularly harmful if they occur at the same time as the high tide. In Alaska, most potentially destructive storm surges occur along the northern and western coasts where the offshore water depths are relatively shallow.



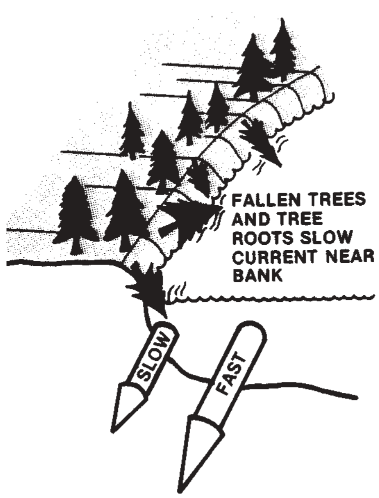
Riverine water levels increase in response to precipitation or melting snow and ice entering the river. The mouths of rivers are often very responsive to the changes in water level that accompany tides and surges.

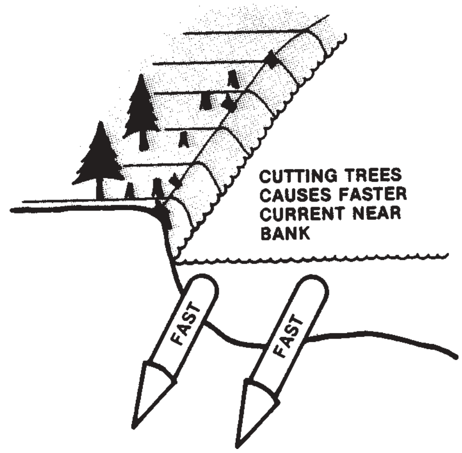
Problems Created by People

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.
- ☞ Creating waves with power motors.

A dam on a stream traps sediments and causes 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 that the bank is eroding, but may also provide protection to the bank by reducing current speed. Where wind erosion is a problem, vegetation will often help to hold the blown material.





Symptoms of Erosion

A variety of erosion symptoms will help to determine the nature of any particular problem. Among these symptoms are:

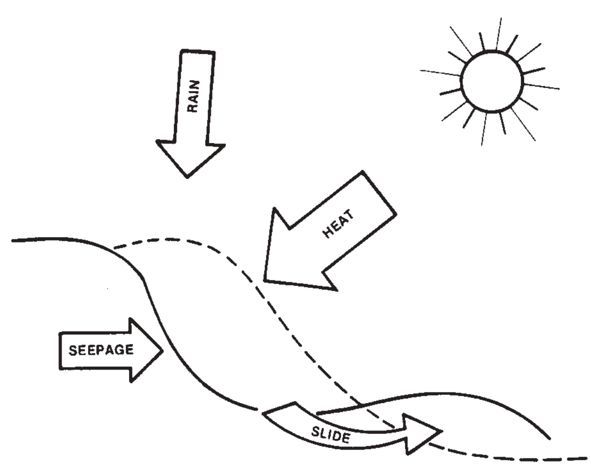
- slides,
- undercutting,
- scarps,
- exposed permafrost,
- root exposure and fallen trees, and
- ice gouging.

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

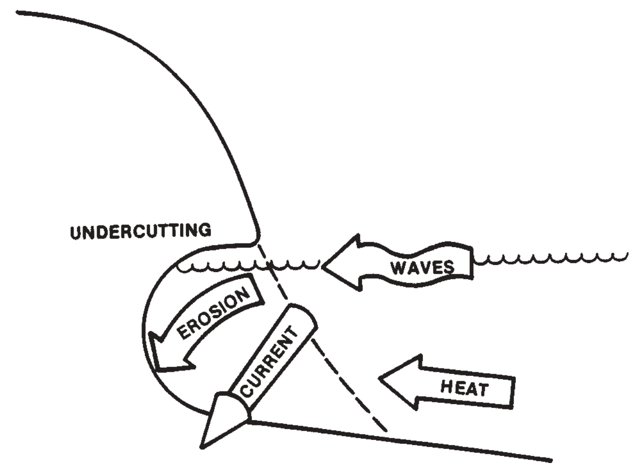
Table 1. Erosion Symptoms and Causes

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

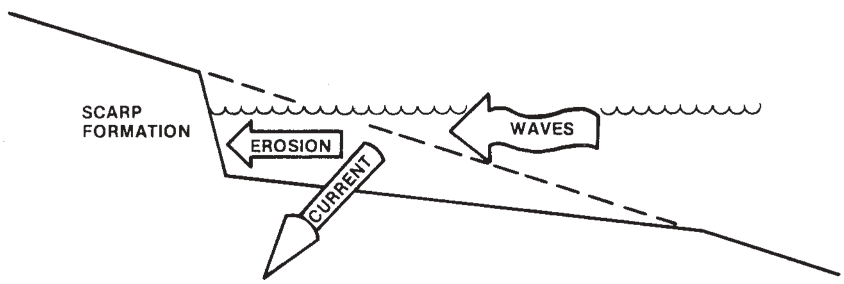
Slides



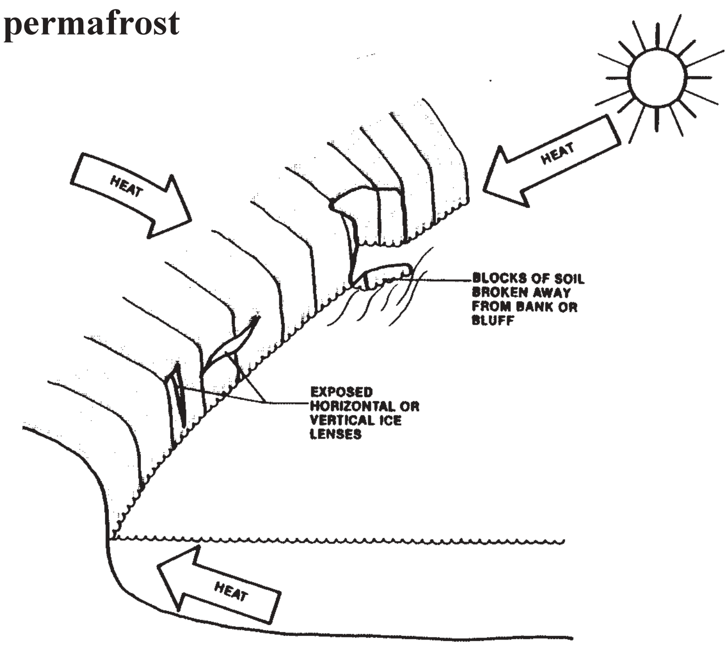
Undercutting



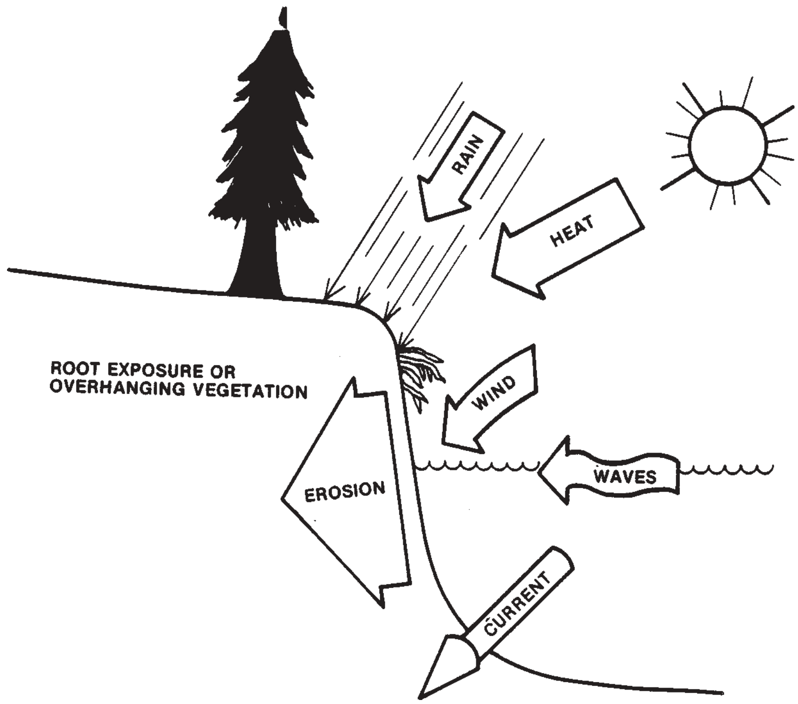
Scarps



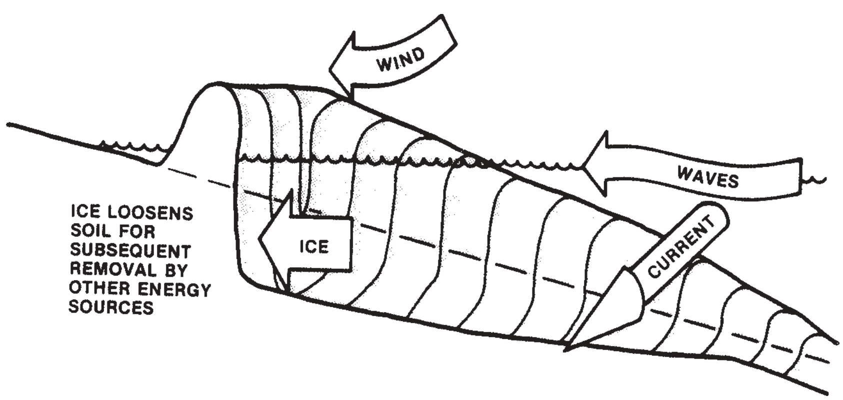
Exposed permafrost



Root exposure and fallen trees



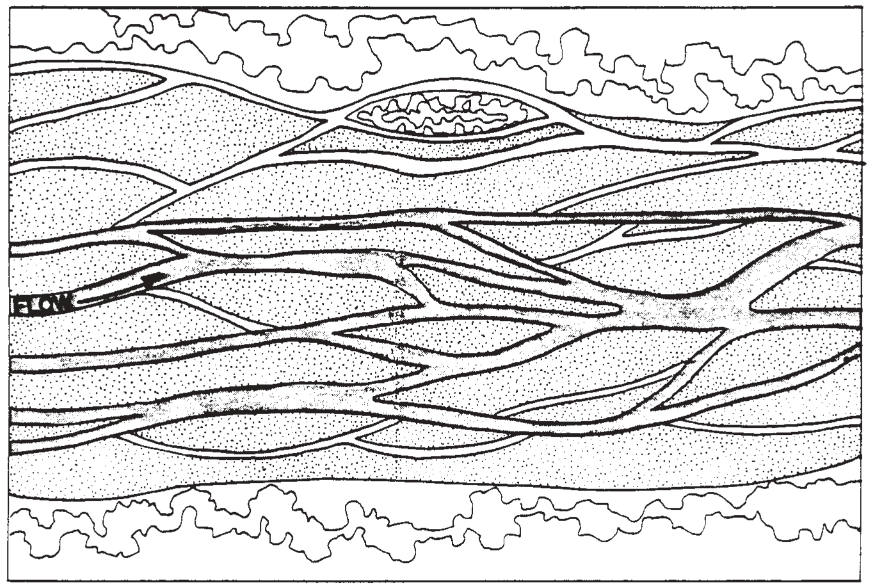
Ice gouging



River and Shoreline Configurations

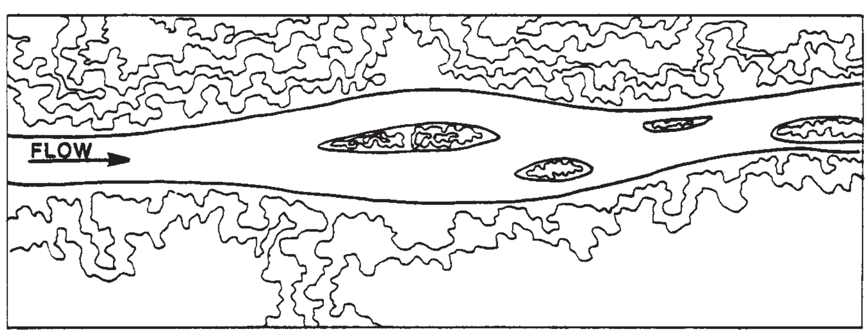
The configuration of a river or shoreline often has an effect on the rate of erosion of the bank or beach. Following is a discussion of various configurations and their impact on erosion patterns and rates.

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 and/or by channel diversion into what was previously a flood channel.



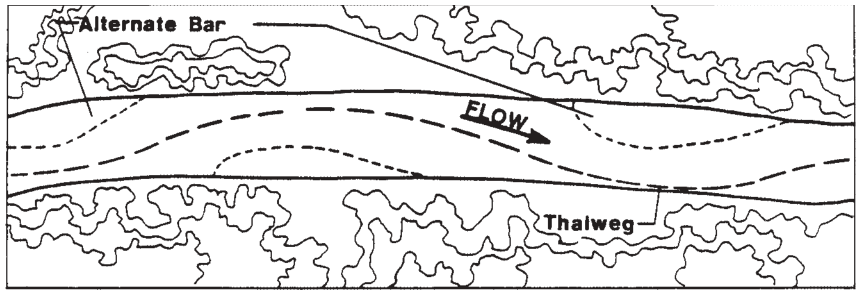
Braided River

A split channel 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.



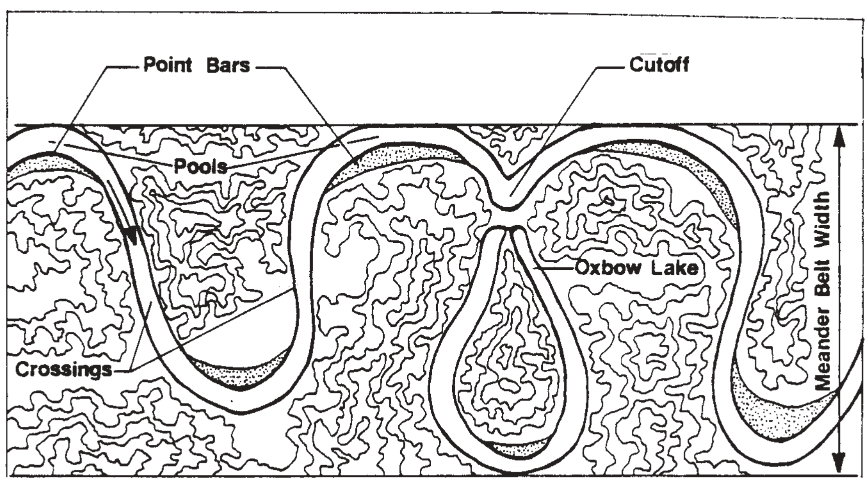
Split Channel River

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. Banks of straight channels are expected to be relatively stable.



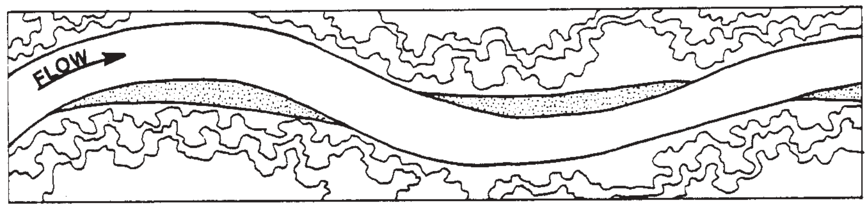
Straight River

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.



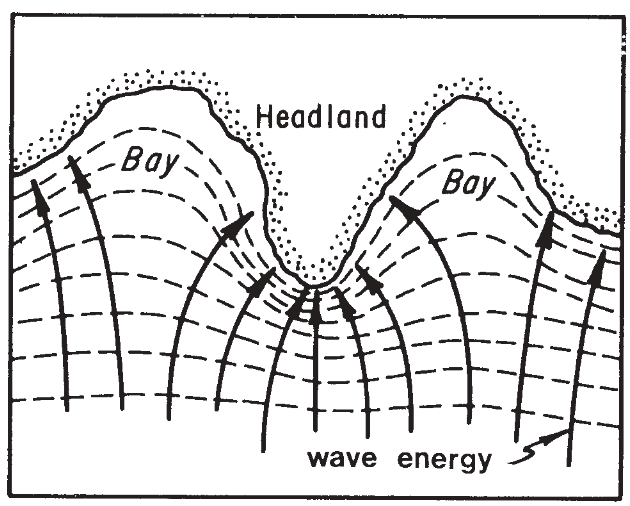
Meandering River

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.



Sinuous River

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 the bay, thus decreasing wave height and the energy available for beach erosion.



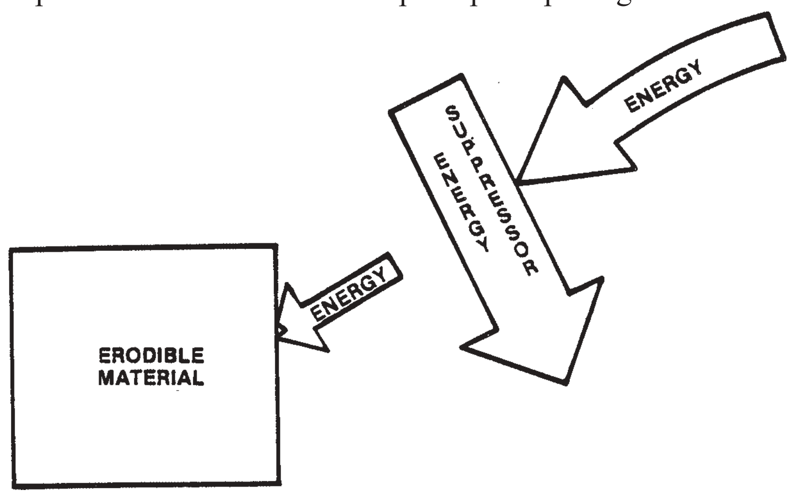
Headland

Some Principles and Means of Controlling Erosion

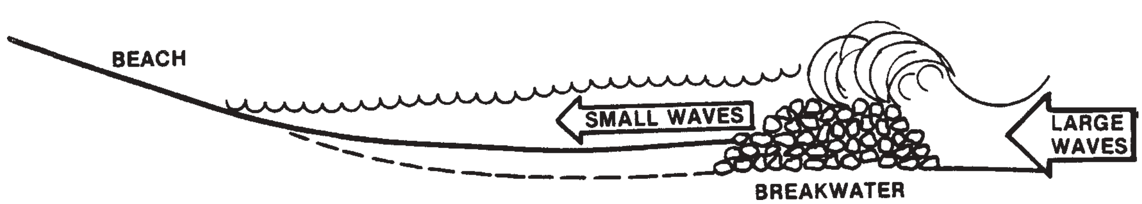
One of five basic principles lies behind any solution to an erosion problem. Each of these principles and some possible solutions are discussed below.

Suppress or diminish the energy source.

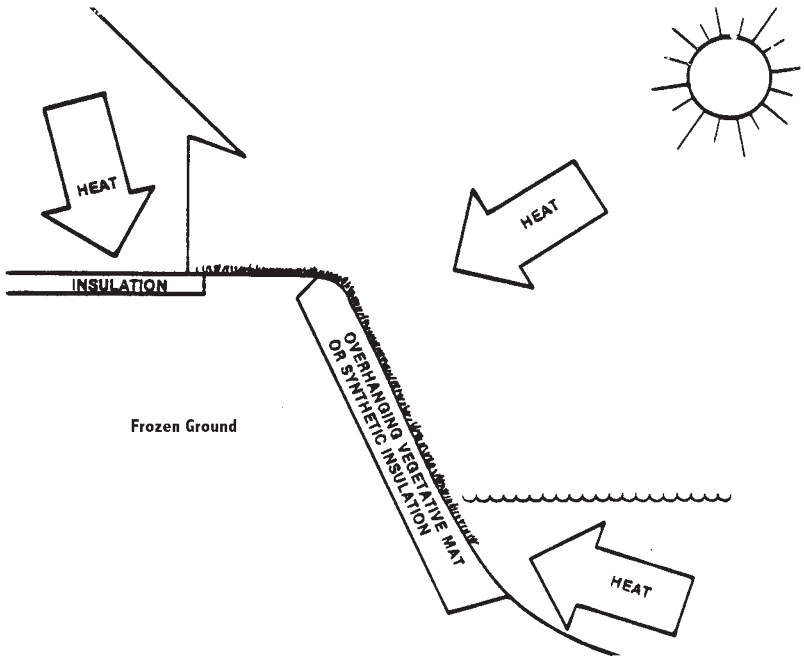
If you can do something that will decrease the energy in the erosive force, then the erosion process will slow down and perhaps stop altogether.



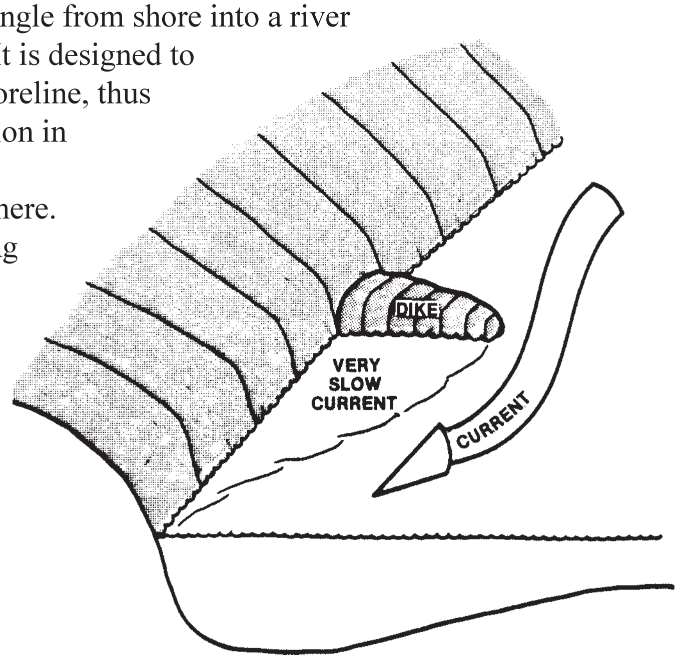
A breakwater is an offshore structure or partition that protects the shoreline against damaging wave action by causing the wave to break at the wall instead of on the shore. After the wave breaks, it is not so high and thus contains less energy. Because of their expense and potential for creating additional problems, breakwaters are **not** often justifiable as a means of erosion control.



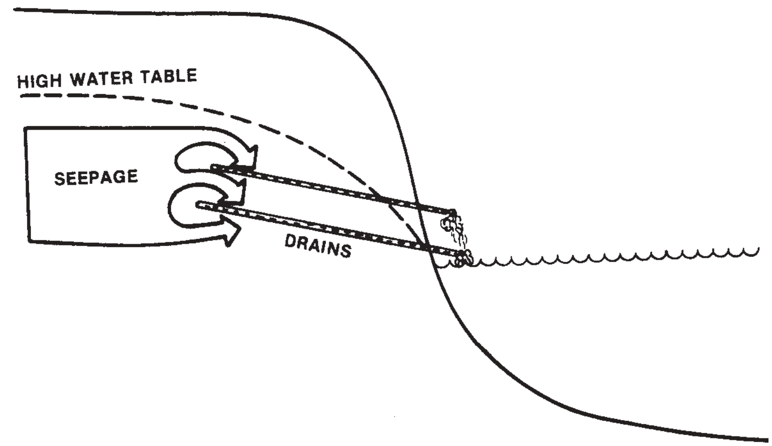
Insulation of frozen ground helps to diminish the amount of heat that is absorbed by the soil, thus preventing thaw. This is already a standard practice for construction of buildings and roads in many arctic areas. Banks can also be insulated, but if the insulating material is exposed to any other stresses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



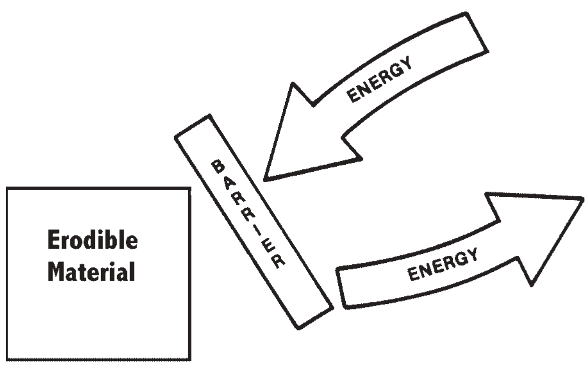
A spur dike is a structure that extends at an angle from shore into a river and is placed upstream of the problem area. It is designed to deflect the current away from the eroding shoreline, thus slowing the current at this point. This reduction in energy slows the erosion process, but, if not carefully 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.



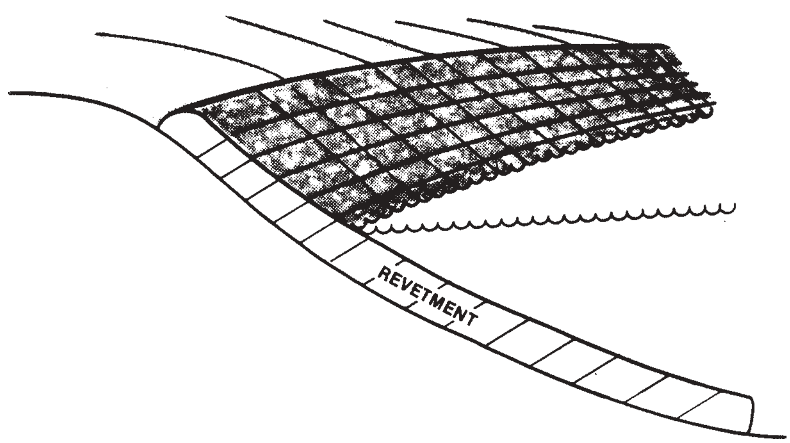
Tile drains help to control seepage forces by removing water from the soil. Lowering the water content decreases the weight and increases the strength of the soil, thus stabilizing the bank or bluff. Additional protection should be placed at the toe of the slope to protect against waves, currents, and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



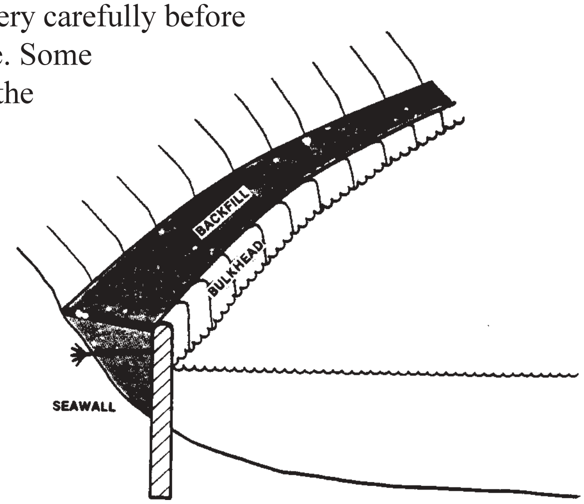
Protect or shield the erodible material by making a barrier between the erodible material and the energy source.



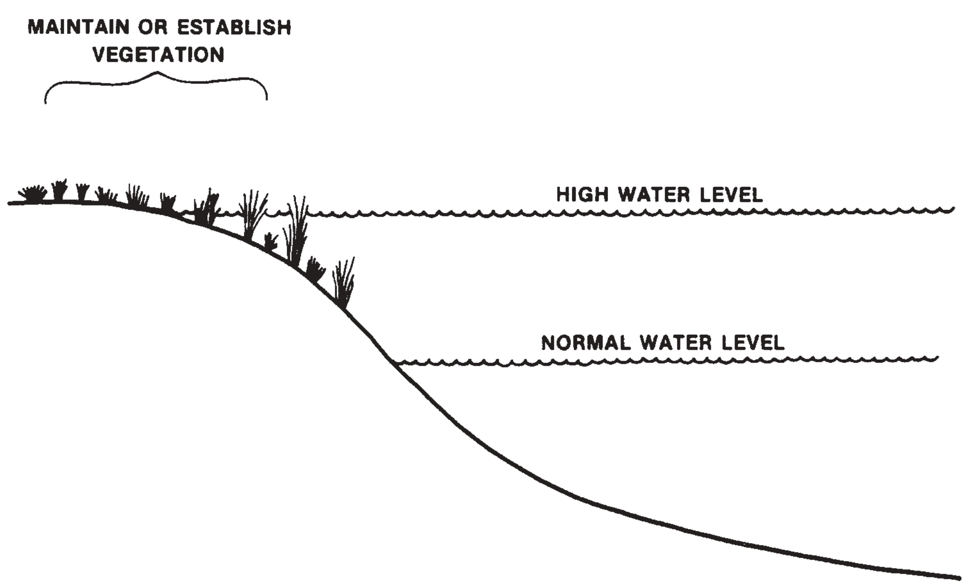
A revetment is a facing of stone or other resistant material that is placed against an eroding bank. Because there are many materials that can be used in the construction of revetments, they are one of the least expensive and most viable means of erosion control. The use of local materials, such as used fuel oil drums or large boulders, simplifies the planning and construction process. Revetments must be constructed according to strict guidelines, or they will fail. See Corps of Engineers publications for further details.



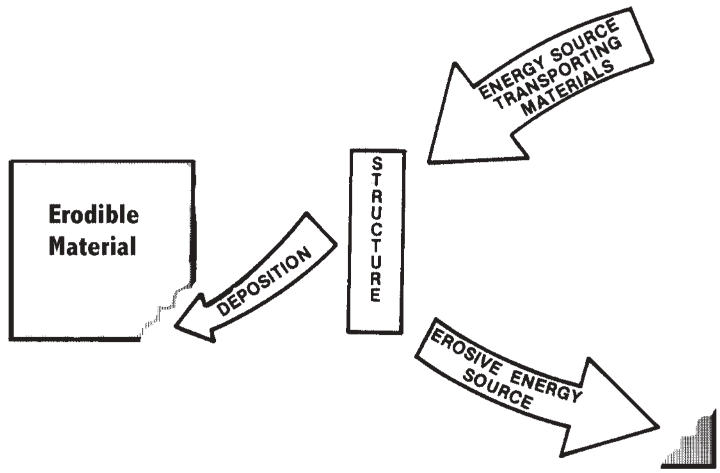
A seawall is a structure that separates a water body and an eroding bank and thus protects the bank from wave erosion and damage. Seawalls are more complicated and expensive to construct than revetments. Other solutions should be examined very carefully before the decision to build a seawall is made. Some details about seawalls are included in the Corps publications.



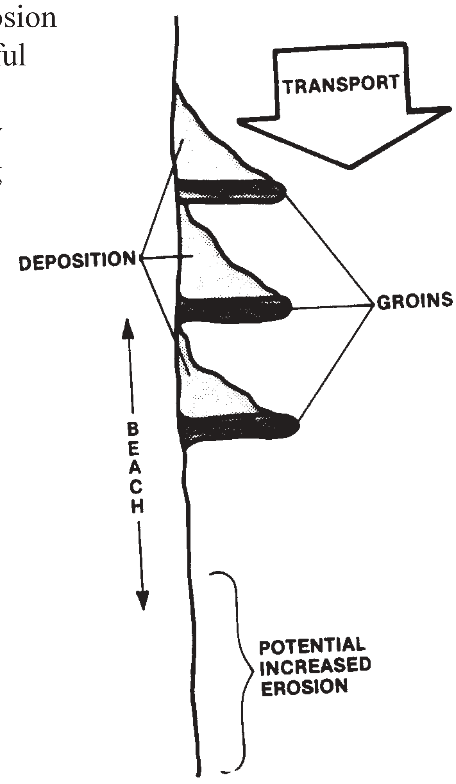
Maintaining or establishing a vegetative cover for trapping and holding eroding material is a natural, practical, and relatively inexpensive means of erosion control and can be used in conjunction with other erosion controls. Maintenance may be more frequent than other alternatives in areas where the vegetation is subjected to occasional wave activity. The easiest way to utilize vegetation as erosion control is to **maintain** existing vegetation, which may mean avoiding access through the vegetated area.



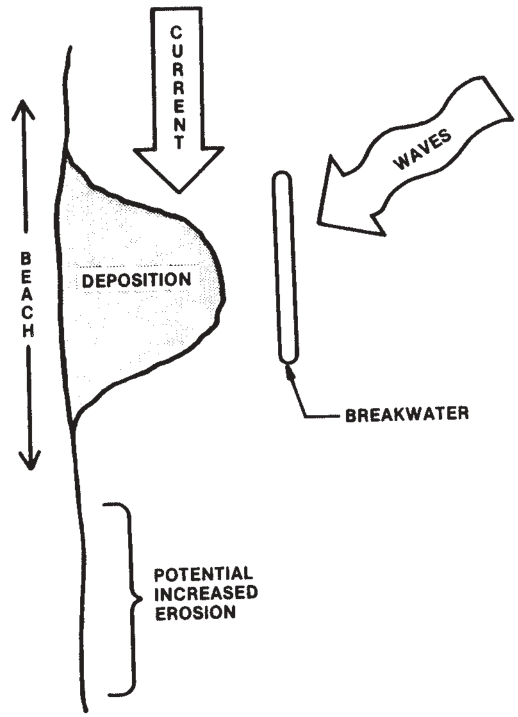
Cause a new beach to be formed by initiating deposition instead of erosion.



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 may have serious impacts to adjacent beaches by depriving them of sediment.

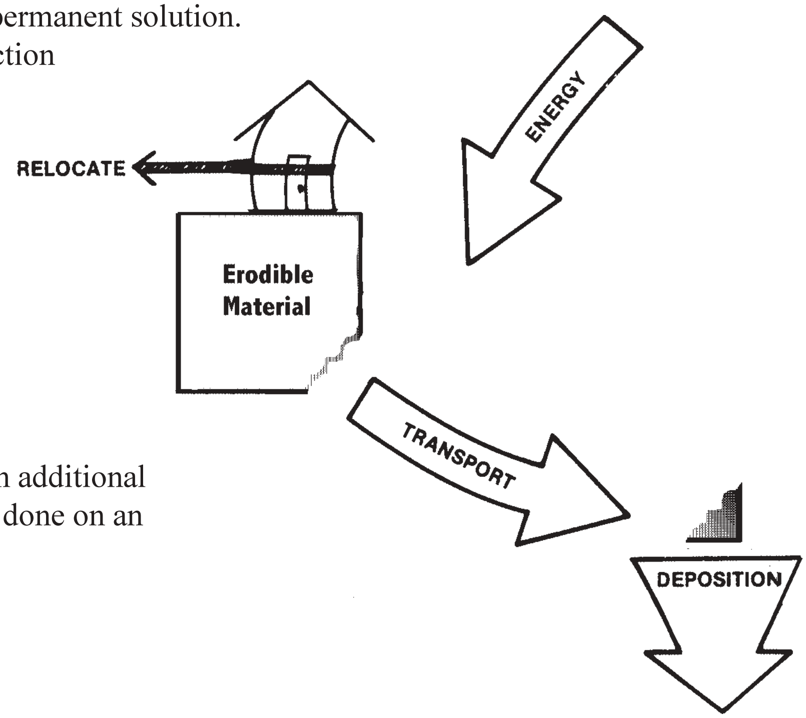


Offshore breakwaters can also be useful in helping to form new beaches. However, because they interfere with natural transport they can damage adjacent beaches through sediment deprivation. Unlike groins, which trap moving sediment, breakwaters restrict sediment movement and encourage sediment deposition by decreasing the wave energy that is available to move the sediment along the beach.



Move endangered property to a safer location.

Stopping natural erosion processes is extremely difficult and often costly. Structural alternatives may not be effective or only transfer the problem to adjacent shorelines. Although relocation is often an unpopular solution to an erosion problem, it can be a permanent solution. 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, relocation may be the least-cost alternative because maintenance costs and the risk of structural failure are eliminated. An additional advantage is that relocation can be done on an individual **or** group basis.



Stop 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, and
- try to reduce shoreline traffic.

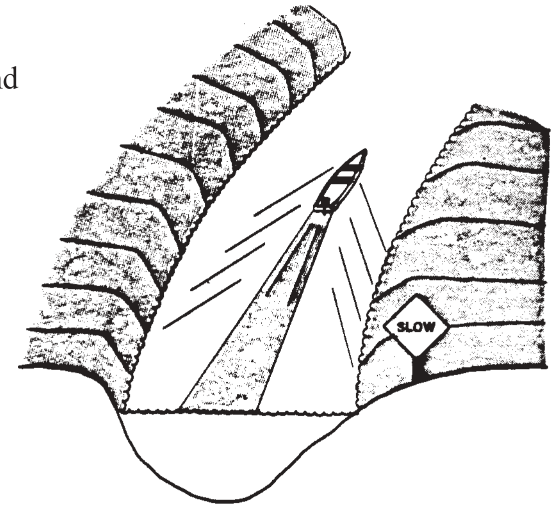


Table 2 presents erosion control alternatives and the types of energy they protect against.

Table 2.

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

Understanding and Defining Your Problem

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

- ❖ Describing the affected area and erosional symptoms.
- ❖ Identifying the energy sources acting against the affected area.
- ❖ Identifying alternatives that are compatible with your problem and location.
- ❖ Evaluating the potential alternatives.

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

- ❍ It helps you to identify environmental factors, e.g. shoreline configuration and energy sources, that may be contributing to the erosion problem.
- ❍ 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 10) and *River and Shoreline Configurations* (page 13) 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?). The second page of the form is directed toward identifying the main energy sources acting against the eroding area and eliminating 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.

Once you know what type of problem you are trying to solve, you are ready to identify the alternatives that will be appropriate to dealing with your specific problem and area. An important part of this process is to <u>eliminate</u> 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.

(continued on page 26)

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 of flooding
  Happens ___ times in ___ years
- ☐ Location of side view sketch
  shown on the other sheet.
- ■ River shape as seen from the air
  - ☐ Braided
  - ☐ Split
  - ☐ Meandering
  - ☐ Sinuous
  - ☐ Straight

Sketch of Overhead View

See example of completed Overhead View on page 32.

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 blocks

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 usually has:

- ⭘ Strong wind driven rain or hail
- ◌ Heavy rain or hail
- ❒ Light to moderate rain

Seepage - Eroding shoreline is exposed to:

- ⭘ Water seeping out of bank or bluff
- ◌ Wet bank or bluff
- ❒ Dry bank or bluff

Sketch Checklist

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

Sketch of View from Side

See example of completed View from Side on page 33.

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 symbols on the other page of this form. Then transfer the check marks in the ⦿ and ɞ symbols to the symbols in the table on the right. → → →
- **Identification of symptoms** is accomplished by comparing your eroding shoreline shape with the erosion symptom shapes illustrated in the text. Check **all symbols** on the line or lines of the appropriate symptoms.
- Compare the horizontal rows and vertical columns for each energy source.
- The probable energy sources causing your eroding shoreline are those with the ❄'s checked in both rows and columns.
- Possible energy sources are those with ❄'s in rows and ✞'s in columns or ✞'s in rows and ❄'s in columns.
- Unlikely energy sources are those with ✞'s in both rows and columns.

Energy Sources Identified by Erosion Symptoms

Symptoms of Erosion	Waves	Current	Ice	Heat	Wind	Precipitation	Seepage
Slides	ɞ	ɞ		⦿		ɞ	ɞ
Undercutting	⦿	⦿		ɞ			ɞ
Scarps	⦿	⦿					
Ice Exposure	ɞ	ɞ		⦿		ɞ	
Root Exposure	⦿	⦿		ɞ	ɞ	ɞ	ɞ
Ice Gouging			⦿				

Energy Sources Identified Directly

Waves	⦿	ɞ	ɞ
Current	⦿	ɞ	ɞ
Ice			ɞ
Heat	⦿	⦿	ɞ
Wind		⦿	ɞ
Precipitation		⦿	ɞ
Seepage		⦿	ɞ

2. The size of the affected area or area 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 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:

1. You want to get the most for your money. Several factors will influence the cost-effectiveness of the selected alternative. Many inexpensive methods will be adequate and meet your needs as effectively as high-priced protection. This is particularly true in areas with ice problems, because the chances of your structure being destroyed are high. In such cases, it may be easier and cheaper to rebuild an inexpensive structure frequently, than to risk having a costly structure destroyed and quite possibly never rebuilt. 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.
2. Construction and maintenance should be as simple as possible. Structures that are difficult to construct and expensive to maintain should be avoided.
3. Whenever possible, materials that are locally available, either through purchasing or scavenging, should be used. This not only simplifies installation and maintenance, but eliminates expensive shipping charges and material costs.
4. 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 also further guidance in evaluating alternatives, refer to the Corps publications.

Seeking Assistance

Communities and private landowners who are in need of erosion protection can obtain three types of assistance:

- technical,
- monetary, and
- guidance in applying for permits.

The best sources of technical assistance are a private consultant and the U.S. Army Corps of Engineers. A private consultant will help with all phases of the project including problem assessment, detailed design, and construction. The Corps will help you to utilize their publications and develop preliminary designs. They will only help with construction if you qualify for federal funding.

Depending on the situation, other agencies that may assist you are:

- Department of Military Affairs, Alaska Division of Emergency Services (ADES)
- Department of Transportation and Public Facilities (DOT/PF)
- Department of Community and Regional Affairs, Municipal and Regional Assistance Division (MRAD)
- Department of Natural Resources (DNR)

ADES will only assist if the situation is a life-threatening, immediate problem. DOT/PF will help when a road, airport or other public transportation facility is in danger. MRAD will provide planning assistance related to relocation. DNR will help to assess hazardous conditions related to severe erosion problems.

Monetary assistance may be available from the federal government under the 1962 River and Harbor Act and the 1946 Flood Protection Act. Unfortunately, most of the communities in Alaska do not qualify for this money because the monetary benefits of the proposed protection must be greater than the project cost in order for funding to be approved.

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

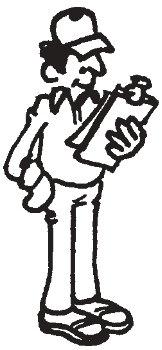
- Division of Land and Water Management, DNR
- Corps of Engineers
- Alaska Department of Fish and Game

Appendix - Example Problem

Background Information

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

Erosion Rate Estimate



Concerned about how much time he has before his meat shed is threatened, he decides to monitor the speed at which the bank is eroding. His carpenters tape is only 18 ft 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 ft. Dividing 18 ft by 6 steps tells him that each step is about 3 ft 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 two more times and counts 49 and 51 steps. The average number of steps for the three times is 50 steps. With each step measuring about 3 ft, the distance is about 50 steps times 3 ft/step = 150 ft. 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 ft distance.

Over the next two months, Solomon studies the Erosion Control Manual, writes to the Corps of Engineers for copies of their pamphlets, and discusses his study with his neighbors, asking them to watch their shorelines for clues to the energy sources causing the erosion. He pays particular attention to the 4 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 ft (45 steps times 3 ft/step). He calculates that he lost 15 ft (150 ft - 135 ft) of bank in that two month period. He observed that most of the bank erosion took place during the 4 rainstorms during that time. Knowing that they normally get about 12 rainstorms per year, Solomon figures that he may get three times as much erosion in a one year period, or about 45 ft (15 ft for 4 rainstorms times 3 is 45 ft for 12 rainstorms). Since there is 135 ft from the bank to his meat shed, he figures that it will take 3 years before his shed is threatened. All his neighbors property is farther back from the bank than that. Solomon 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, Solomon walked the distance from his shed to the bank. At the end of the next July, he counted 35 steps, which is 105 ft (35 steps times 3 ft/step). Subtracting from his original distance of 150 ft a year earlier, gave an erosion rate of 45 ft during that year. Solomon 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, Solomon and his neighbors got together to evaluate their problem and discuss potential solutions. They filled out the 2 page form in the Erosion Control Manual to help them identify the energy source or sources causing their bank erosion. They completed the form based on their observations (see pages 32 & 33):

- ☒ 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.
- ☒ 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

Solomon and his friends then used Table 2 to identify alternative solutions to their erosion problem.

Table 2.

	Suppress or Diminish Energy				Shield Erodible Material			Form a New Beach		
	Breakwater	Insulation	Spur Dike	Tile Drain	Revetment	Seawall	Vegetation	Groin	Breakwater	Relocation
◆ Waves	(x)				(x)	(x)			x	(x)
● Currents			(x)		(x)	(x)	(x)	(x)		(x)
Ice										x
Heat		x					x			x
Wind					x		x			x
■ Precipitation					(x)		(x)			(x)
Seepage				x			x			x

- ◆ 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. Solomon and his neighbors summarized their evaluation in a table.

Alternative Solutions	Effectiveness	Relative Cost	Maintenance	Readily Available Materials	Effects 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
Seawall	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	Waves, precipitation, and current	Med	Low	Land available	No

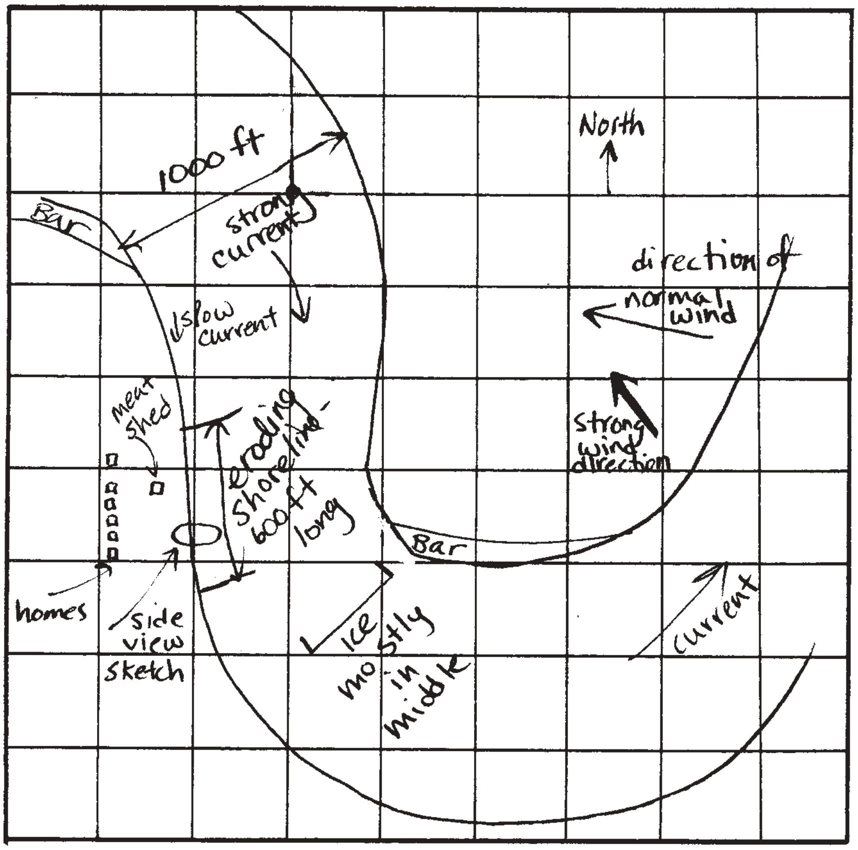
Solomon and his neighbors selected revetment as the best solution, but considered relocation as an alternative.

Seeking Assistance

Solomon wrote a letter to the Corps of Engineers telling them what he and his neighbors had observed and concluded. He included the completed 2 page form and the table evaluating alternatives. The Corps evaluated the materials and sent an engineer to the site to review the problem with Solomon. After further analysis of information gathered during the site visit, the Corps told Solomon that his assessment of the problem and solutions was well done. The Corps 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. The Corps also concluded that revetment or relocation would be the best alternative solutions. They advised Solomon that the cost of installing revetment or that of moving exceeded the value of Solomon's and his neighbor's properties and thus could not be federally funded. The Corps enclosed additional publications and pointed out that the use of fuel drums, if properly installed, should be an effective revetment.

Solution

Solomon relocated his meat shed farther from the bank. Solomon and his neighbors collected fuel drums from neighboring communities and a nearby sawmill. They hired a consultant to review their design. The consultant recommended some minor revisions be made to the design. Solomon and his neighbors built the revetment structure themselves.



Sketch of Overhead View

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

Wind - Eroding shoreline is exposed to:

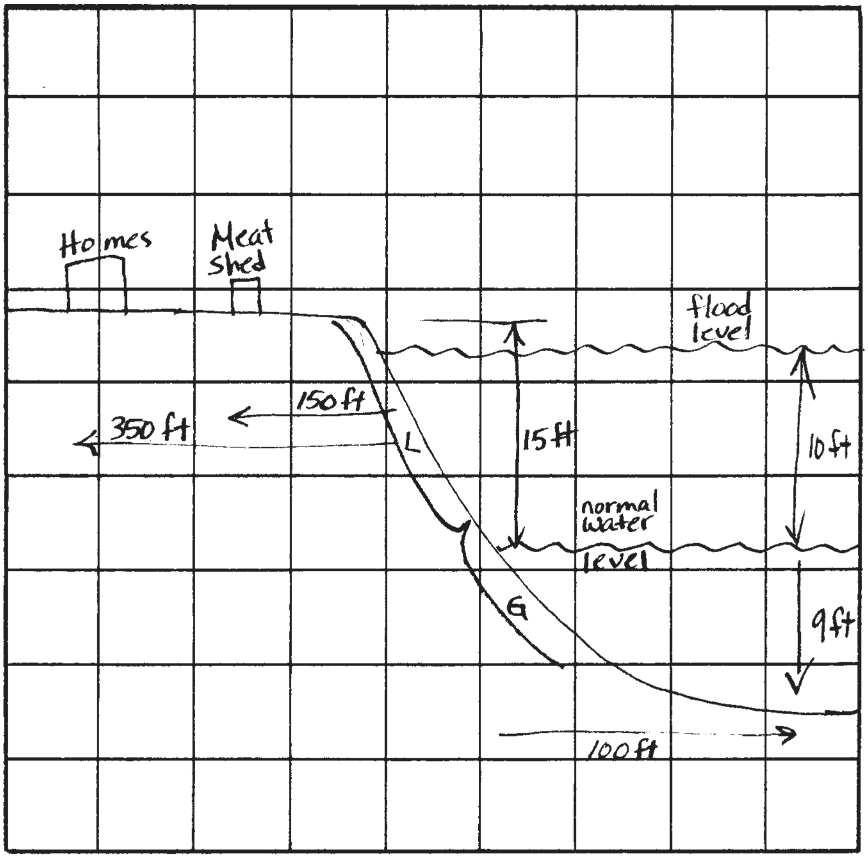
- ⦿ Strong winds that make air dusty
- ✞ Strong winds that are not dusty
- ❐ No wind or light winds

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 shoreline
- ☑ Properties to be protected
- ☑ Measured or estimated distances
- ☑ Height of bank or bluff
- ☑ Normal water level
- ☑ Floodwater level
- ☐ ~~Beach, if any~~ **None**
- ☑ Bottom slope below water
- ■ Soil Types
  - ☐ Frozen
  - ☑ Unfrozen
  - ☑ Gravel sized (G)
  - ☐ Sand sized (S)
  - ☑ Silt sized (L)
  - ☐ Clay sized (C)
  - ☐ Mixed sizes (show mix)

Sketch of View from Side

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 symbols on the other page of this form. Then transfer the check marks in the ⭘ and ☙ symbols to the symbols in the table on the right. → → →
- **Identification of symptoms** is accomplished by comparing your eroding shoreline shape with the erosion symptom shapes illustrated in the text. Check **all symbols** on the line or lines of the appropriate symptoms.
- Compare the horizontal rows and vertical columns for each energy source.
- The probable energy sources causing your eroding shoreline are those with the ❄'s checked in both rows and columns.
- Possible energy sources are those with ❄'s in rows and ✞'s in columns or ✞'s in rows and ❄'s in columns.
- Unlikely energy sources are those with ✞'s in both rows and columns.

Energy Sources Identified by Erosion Symptoms

Symptoms of Erosion	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		⭘	✞

Information Sources

Alaska Division of Emergency Services (ADES)
Department of Military Affairs
P. O. Box 5750
Ft. Rishardson, AK 99505-5750
Phone: 907-428-7000 FAX: 907-428-7009

Department of Transportation and Public Facilities (DOT/PF)
Division of Statewide Planning
3132 Channel Drive
Juneau, AK 99801-7898
Phone: 907-465-4070 FAX: 907-465-6984

Municipal and Regional Assistance Division (MRAD)
Department of Community and Regional Affairs
Christy Miller, Planner
333 West 4th Avenue, Suite 220
Anchorage, AK 99501-2341
Phone: 907-269-4500 FAX: 907-269-4539

Department of Natural Resources (DNR)
Division of Mining and Water Management
3601 C Street, Suite 800
Anchorage, AK 99503-5935
Phone: 907-269-8600 FAX: 907-563-1853

Corps of Engineers

Anchorage, AK 99________
Phone: 907-____________ FAX: 907-_____________