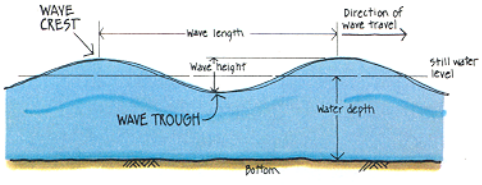
The Erosion Process

The waterfront is the scene of the most dramatic interactions between water, wind, and land. Moving air and water carry material from place to place, eroding and depositing, constantly changing the shoreline. If erosion is not balanced by accretion, the shore will be washed away. Understanding the dynamics of erosion and accretion along the shore is important: to safeguard your property, you need to know how to work with these natural forces, not against them.

Wind and Water

The energy to power the movement of air and water comes partly from the heat of the sun and partly from the gravitational forces of the sun, moon, and earth. Winds—currents in the air—are caused by uneven solar heating, as warm air rises and cooler air rushes in to take its place. Uneven heating also causes currents in the water. Other causes of water currents include streams or rivers entering larger bodies of water, the action of winds moving the water as they might move a raft, and the tides. The range of the tides and the strength of tidal currents are determined by the combined gravitational effects of the sun, moon, and earth. "Spring tides" occur when the sun and moon are approximately in line with each other and their gravitational effects combine to produce the highest high tide and lowest low tide levels. At the times of quarter moons, "neap tides" are produced, with the least range between high and low tide water marks. The tidal currents are strongest at spring tides, when the range is greatest.



Waves are produced by wind blowing across a water surface. The water "moves in place," like stalks of grass bending and rising in the wind. Also like the grass, it does not move very far—this explains how a piece of driftwood, for instance, may stay offshore for a long time, bobbing up and down as waves pass beneath it. Within a wave, water moves in small vertical circles and keeps returning to its starting place, while the form and energy of the wave move forward. The water at the surface moves in the largest circles, forming the crest of the wave at the top of the circle and the trough of the wave at the lowest point of the path. Below the surface, the water moves in smaller and smaller circles, until at a depth greater than half the wave length the water hardly moves at all. As the wave moves toward shore, it begins to drag on the bottom, which eventually causes it to "break" or collapse. This produces a great deal of turbulence, stirring up material from the shore bottom or eroding it from banks and bluffs.

Different Shoreforms

Shorelines are distinguished by certain physical features. Recognizing your shoreform will help you evaluate its resistance to erosion and the measures you can take to diminish or control destruction of your property. Different shoreforms are shown in the photographs on this page and the following page.

Cliffs are usually steep rock formations which erode very slowly, if at all, during a human lifetime. Cliffs do not need the sort of protection described in this brochure, as the natual cliff material is more durable than any of the low cost measures available.

Bluffs are also steep shoreforms, but they are composed of softer erodible material such as clay, sand, or soft rock. Bluffs may be unstable because of the physical characteristics of the bluff materials, seepage of groundwater within the bluff, and erosion by wave action at the base. A drainage system, perhaps combined with a bulkhead, seawall, or revetment, may be an appropriate erosion control measure for a bluff, but due to the complexity of bluff material and the difficulty of analyzing the stability of this shoreform, protection of high bluffs should only be attempted with professional assistance.

Marshes are areas that are saturated with surface water or groundwater and support vegetation adapted for life in such moist conditions. These areas have only recently been appreciated for their contribution to shoreline ecology and for their capacity to protect inland areas by absorbing pollutants, trapping sediments, and buffering some wave action. Previously treated as nuisances to be drained or filled, marshes are now protected by federal and state regulations.

Low bluff

Marsh

Beaches, the most common shoreforms in the United States, are gentle slopes covered with loose sediment. The sediment particles, ranging from fine silt to coarse gravel or cobbles in size, are moved by wind and water to form the typical beach profile shown in the illustration.

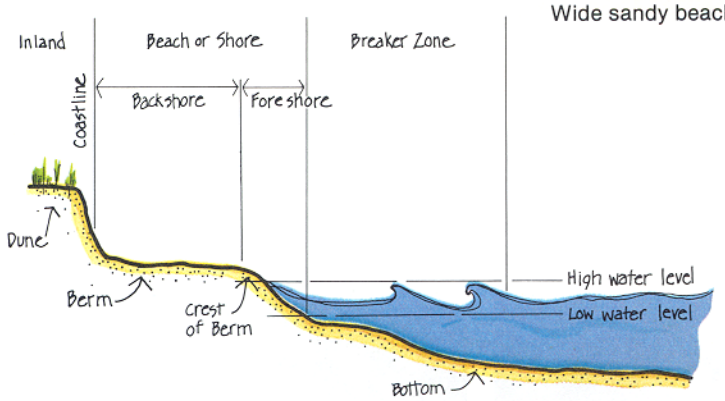
In calm weather, waves at the beach are usually low, long swells. These waves have less energy than choppy storm waves and do not cause as much turbulence when they break. Swells break and run up over the foreshore of the beach until they use up their energy. Then they drop back under the force of gravity. They tend to deposit material on the beach up to the normal high water line. At the high water line, a low ridge or "berm" may be formed by this type of wave action. During storms, water overtops the berm crest and washes over the backshore.

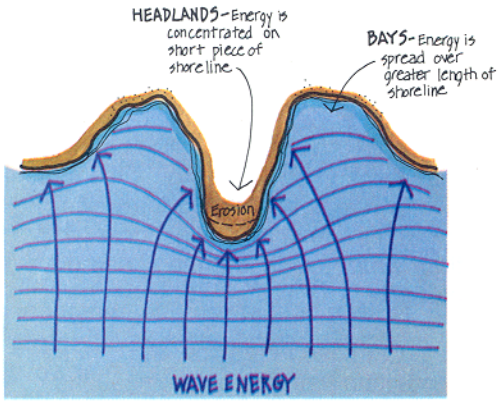
The backshore is bordered on the inland side by dunes, which are formed by the wind blowing sand along the beach until it meets an obstruction. The carrying power of wind is much less than that of water, and even a small obstruction can result in significant deposition. The sizes of the berm and dunes depend on the local wave and wind conditions and may be influenced by some of the erosion control measures you can use to protect the beach.

The shape of the shoreline is also important in the erosion process. The parts of the shore that extend into the water are more vigorously attacked than the shoreline of inlets or bays. As shown in the illustration, incoming waves tend to bend around these peninsulas, headlands, extended beaches, or seawalls, and concentrate their energy on the front and sides of the area. Extra protection or reinforcement is often needed on these exposed parts of the coast.

Wide sandy beach

Narrow cobbly beach

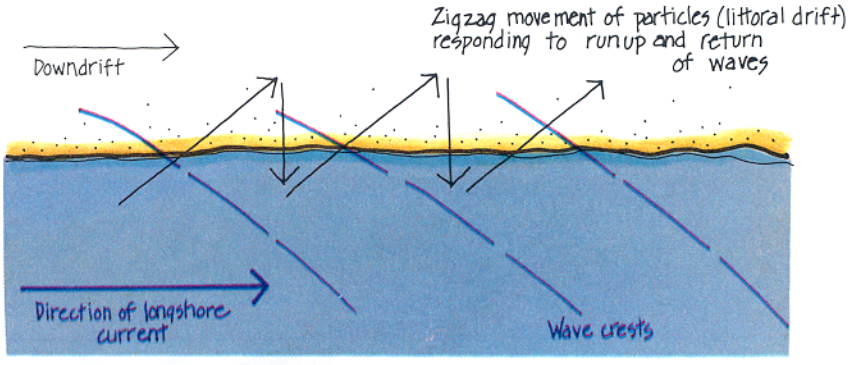




up again when the velocity of the water increases. Growing shores are fed, or "nourished," by material that has been eroded from somewhere else. Often attempts to reduce erosion and build up one area will result in reduced deposition elsewhere, "starving" another shoreline. Erosion and accretion are two faces of the same process, which may either occur at extremely slow rates or make dramatic changes in the shoreline within a human lifetime.

Shorebuilding and erosion

Wave motion, particularly that of breaking waves, is the most important active agent in the building and erosion of the shoreline. The characteristics of waves depend on the speed of the wind, its duration, and the unobstructed water distance, or "fetch," it blows over. As the waves break, run up the shore, and return, they carry sedimentary material onshore and offshore. This sedimentary material is called littoral drift. Most waves arrive at an angle to the shore and set up a longshore current, moving littoral drift in a series of zigzags as successive wave fronts advance and retreat. The illustration shows how this process works. The predominant direction of longshore transport is referred to as "downdrift"; the opposite direction is "updrift."

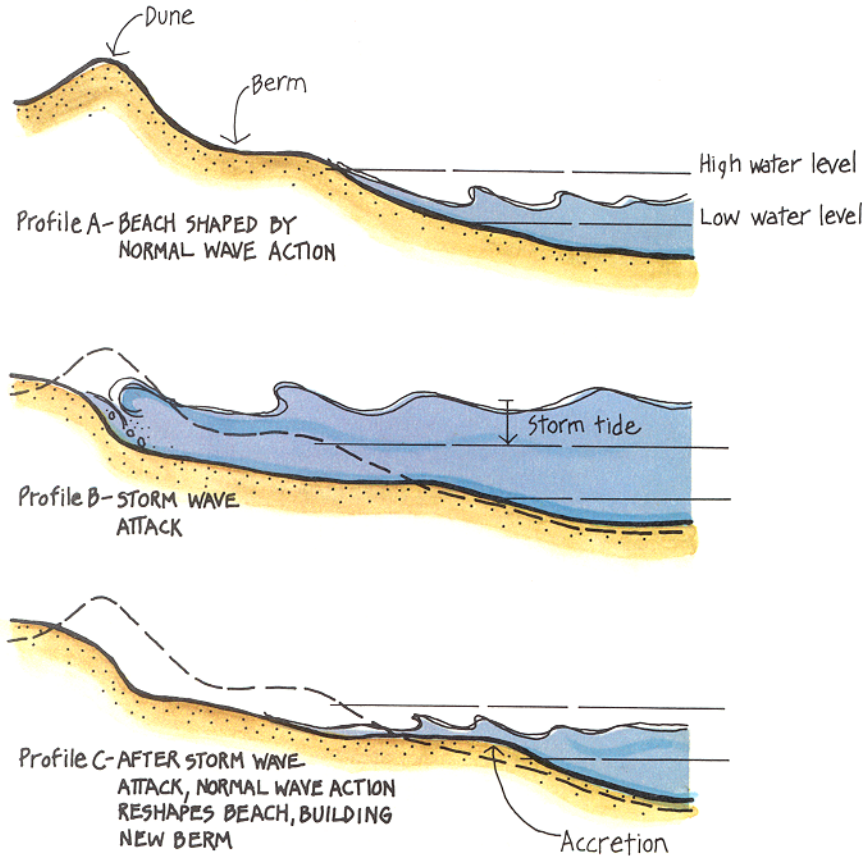


The ability of water to move material depends on its speed. Large waves or fast-moving currents can carry larger quantities and heavier littoral drift. Material picked up from inland heights, from river beds and banks, and from shoreline areas is deposited wherever the water is slowed down, and it may be picked

Water level also influences the erosion process. Changes in high and low water levels due to seasons, tides, storms, droughts, or floods can expose new surfaces to erosion.

Seasons and storms, which affect the movement and level of water and the strength and direction of wind, alter patterns of erosion and deposition. The illustrations on these pages show how storms and seasons act on a beach. Storms whip the water into waves higher than normal, resulting in rapid erosion of vulnerable areas and propelling stones or other debris onto shore with unusual force. As seasons turn, wind strength and direction also change, altering the path of waves and currents and resulting in new areas of erosion or accretion. Where ice forms, it reduces wave action, which may slow erosion, and at the same time it exerts tremendous horizontal and vertical forces that may weaken structures on the shore. Winter freeze and spring thaw affect rivers, streams, and lakes, changing their water levels and the speed of currents.

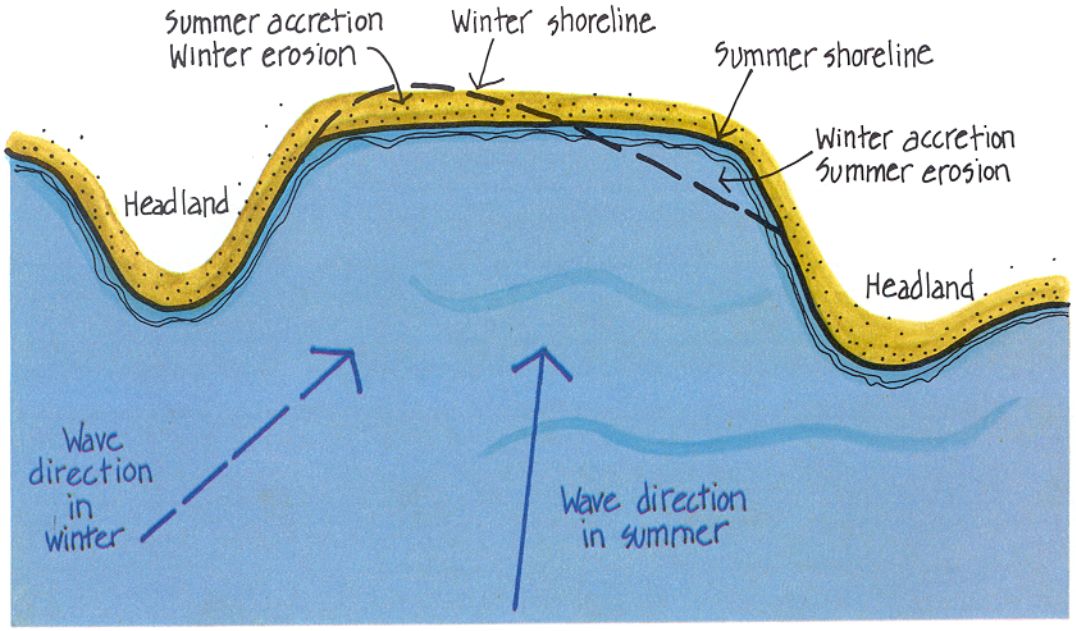
Changes in erosion and deposition patterns due to seasons and storms are often mistaken for overall net loss or gain of shore material. Knowing the direction of net longshore transport is important in designing shore protection, especially for beach fill, groin fields, and breakwaters.



Natural defenses

Gently sloping shores, whether beaches or wetlands, are natural defenses against erosion. The slopes of the foreshore form a first line of defense, dissipating the energy of breaking waves. The berm prevents normal high water from reaching the backshore. Dunes and their vegetation offer protection against storm-driven high water and also provide a reservoir of sand for rebuilding the beach. Wise management of shore areas should include protection of these natural defenses where they exist.

Although erosion is essentially caused by natural shoreline processes, its rate and severity can be intensified by human activity. The shoreline and the water are highly valued for recreational activities, but heavy use and development may accelerate erosion. Those who build "permanent" homes and recreation facilities often ignore the fact that the shoreline is being constantly built up and worn away again. They may also fail to take into account the periodic and unpredictable effects of storms. Dredging for marinas and bulldozing of dunes for improved seascape views remove natural protection against wind and waves. Pedestrian and vehicular traffic also contribute to the destruction of shoreline defenses by destroying vegetation, degrading dunes, and weakening bluffs and banks. Docks, jetties, and other structures interrupt the natural shoreline movement of water and redirect erosive forces in unexpected and possibly undesirable directions. Erosion control should begin with protection of the natural shoreline defenses wherever possible.



Confronted with an erosion problem, you have a variety of choices. They range from doing nothing about the problem, to installing a device or a combination of devices to combat erosion, to relocating or abandoning endangered structures, to selling your property. Your choice will depend on the ways you intend to use the shoreline, the degree of hazard posed by erosion, the existing investment, and the resources you can commit to the undertaking. The frequency, cost, and convenience of maintenance should be considered, as well as the initial costs and availability of labor and materials.

In many cases, the appropriate response to mild erosion is to let it take its course, since natural processes result in a certain amount of unavoidable erosion. Beyond this unavoidable minimum, erosion may be increased by human ignorance or neglect of shoreline processes. You can slow down the rate of erosion, but not eliminate it completely, by such shoreline management techniques as protecting dunes or restricting pedestrian and vehicular access to the waterfront.

Positive measures to control erosion depend on the type of shore in need of protection and the way you want to use the property. Marshes are best served by protecting the existing vegetation and restricting traffic. Beaches may be protected or enhanced by filling or by constructing retaining sills, breakwaters, or groin fields. Accelerated beach erosion usually associated with bulkhead and seawall construction make these measures most suitable for areas where the shore uses (such as boating) require deeper water or where steep bluffs are already severely threatened. Revetments protect sloping backshore areas and have a somewhat less erosive effect on the existing beach. These erosion control measures, as well as the options of relocating and evacuation, are discussed briefly on the following pages.