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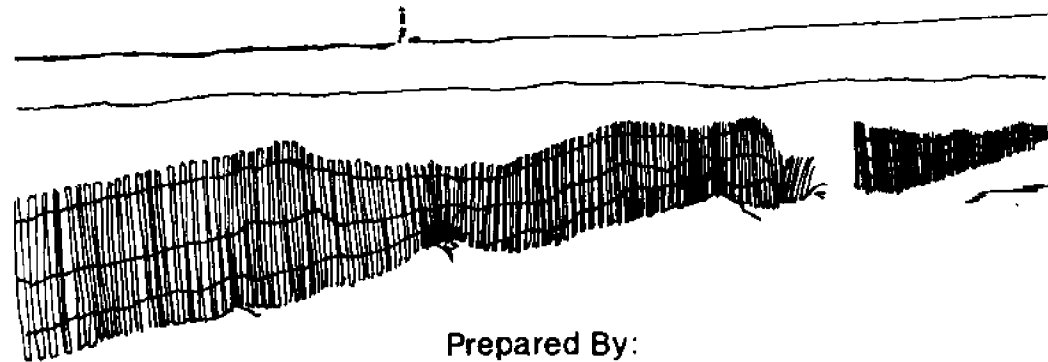


SHORELINE PROTECTION  
GUIDE FOR PROPERTY OWNERS

# SHORELINE PROTECTION GUIDE FOR PROPERTY OWNERS

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"Shoreline Protection Guide" is for all persons who own property bordering on Great Lakes or saltwater coastlines. It is aimed at giving a clear understanding of:

- the basic physical processes of erosion/deposition
- how some common shore protection structures work and
- their limitations and possible side effects.

This guide is not a do-it-yourself blueprint to shore protection, nor a substitute for professional engineering advice and design. Therefore we've made no attempt to discuss design principles and construction procedures. But, when you're faced with an erosion problem, this information will help you make better decisions.

The first step in solving a shore protection problem is to decide why the erosion is taking place and whether you really need shore protection. The "Coastal Processes" section of this booklet will help you determine some of this, but you should also have some assistance from a professional, such as an engineer.

Next, work with the engineer to decide how much protection you need. Examine the range of solutions available to you and study all of them for secondary functions, side effects, aesthetics, and the combined costs of construction and maintenance over the life expectancy of the structure. (Many of these things are discussed in the "Shore Protection Methods" section.) It might be cheaper in the long run to move the house or building you're trying to protect.

Some of the simple methods, such as riprap revetments may seem made to order for the do-it-yourselfer. But building a simple riprap or stone revetment is not just a matter of laying rocks or boulders in place. Any structure subject to water action must have special foundation design and construction to fit the job it was intended for, and may even be eroded away itself. Many revetments and even groins have been built by individuals or groups of property owners, but it is always best to get advice on materials and construction methods from a professional in the field.

## COASTAL PROCESSES

The natural forces affecting the shoreline are wind, tides, waves and currents. These forces both wear away and build up a shoreline. We can modify these forces and redirect them, but we'll never totally control them.

### WIND AND WAVES

The wind acts upon the shore in two ways. First, it physically moves sand from one place to another, causing erosion in one area and deposition in another. This process, although it forms sand dunes, is not considered a major factor in coastal erosion.

Principally, the wind is a generator of waves. The longer and stronger the wind blows and the greater the distance over which it blows, the larger and more powerful the waves will be. And waves do have significant effect on shorelines. During storms their energy can carry beach sands seaward, erode cliffs and banks and damage or carry away man-made structures. During calm periods, waves move offshore sand onto the beaches, building them up.

### CURRENTS

Currents—the movement of water from one place to another—are another major force affecting the shoreline. Most currents are caused by differences in elevation of the water surface from one place to another. Some, like the Gulf Stream are caused by temperature differences.

Perhaps the most important current affecting shoreline change is the **longshore current**, generated by waves as they strike the coast at an angle. It runs parallel to the shoreline and varies in velocity and direction with wave angle and energy. It often transports large quantities of sand along the coast.

### LITTORAL DRIFT

This movement of sand parallel to the coast, through the combined forces of the longshore current and wave action on the beach is known as **littoral drift** (see Figure 1). Since the wind and waves determine the direction and magnitude of the littoral drift, it

may move sand along the shore in one direction, equally in both directions, or as is most common, unequally in both directions but with the overall or net sand movement in one direction over a period of a year or more. If there is an abundant supply of sediment, as from eroding cliffs or sediment-laden streams flowing into the sea, the littoral drift will deposit sediment whenever its speed—and carrying capacity—is reduced. When sediment is scarce, the littoral drift will carry sand away from the beaches, thus causing erosion. This sand may eventually be deposited on beaches downdrift, but it may also be carried seaward and deposited offshore.

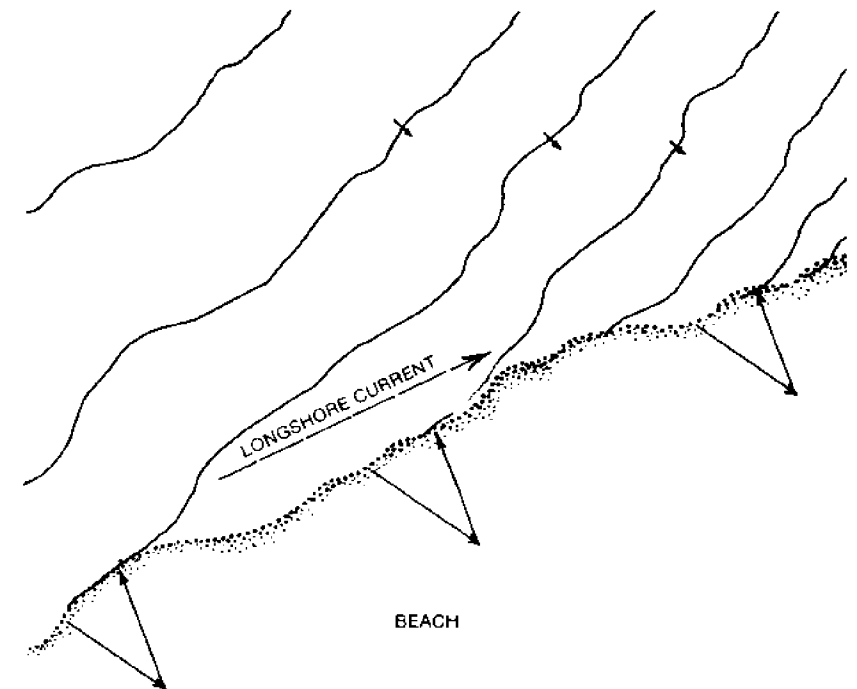


FIGURE 1: LITTORAL DRIFT

## TIDES

The periodic rising and falling water levels caused by the gravitational attraction of the moon and sun are not a big factor in shoreline change except when storms pile up tide levels and low places begin to flood. Tides produce currents, especially at harbor entrances or at inlets to lagoons and bays. A strong inflowing or flood tide at an inlet can sweep sediments from the littoral drift into the bay, or carry them seaward on an outflowing or ebb tide. Tides also determine the level at which waves hit a beach. During hurricanes and storms, upland areas normally out of reach of the waves may bear the full brunt of the attack if it comes at high tide.

### A Special Note for the Great Lakes...\*

The shore area of the Great Lakes is subject to the attack of winds, waves, long-shore currents, ice, and floating debris. Winds having an average velocity of more than 25 miles per hour and lasting from 6 to 10 hours are capable of creating waves from 8 to 10 feet high on many portions of the Great Lakes. Some shoreline areas suffer damage from smaller waves as well as from the larger ones described above.

The various erosive factors are always at work to a greater or lesser degree. During low lake levels, the waves break on the relatively flat portion of the beach shown as B-C in Figure 2. Thus, the breaking waves use up most of their energy on the more stable part of the beach and do little or no damage to the steeper banks lying farther back. The ice also piles up on the flat portion of the beach during low water and, while it causes some scouring (wearing) and rearrangement of the beach material, it does little permanent damage. Under such conditions some sections of shoreline may be stable for long intervals.

However, during periods of high lake levels, the waves and ice are able to make direct attacks on the more vulnerable steep banks such as A-B in Figure 2. The material in these steep banks is unstable and becomes easy prey to the erosive forces. Large quantities of the beach material slide into the lake, causing the bank to recede rapidly to positions such as D-E and F-G. The eroded bank material is carried away along the shore by the currents, which are able to roll the coarser sand along the bottom while carrying the finer materials in suspension. The carrying capacity of the water is greatly increased by the turbulence resulting from the breaking waves. The

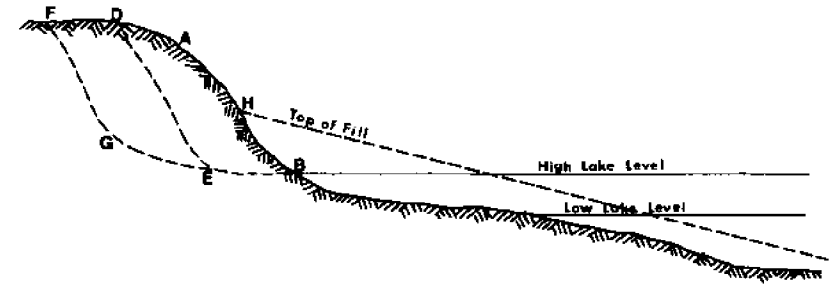


FIGURE 2: BEACH PROFILE

coarse sand is transported along the shore until it reaches a barrier of some kind, while the finer material is carried along in suspension until a relatively quiescent area is reached, where the lack of turbulence permits the material to be deposited.

\*From "Low Cost Shore Protection for the Great Lakes" Research Publication No. 3, University of Michigan Lake Hydraulics Laboratory and Michigan Water Resources Commission. pp. 4-5

## SHORE PROTECTION METHODS

### BULKHEADS, REVETMENTS, SEAWALLS

**Bulkheads, revetments and seawalls** are similar in that they are built directly against and parallel to the shoreline. They may also be shaped alike and constructed of the same materials, such as concrete, wood or steel, but they are used in different situations.

**Bulkheads** help keep land from sliding into the water; they act as retaining walls (Figure 3). Bulkheads may also protect the backshore from wave and current attack, and may serve as a docking or mooring facility. Docks constructed in pilings, however, are much less expensive and more practical for this purpose than bulkheads.

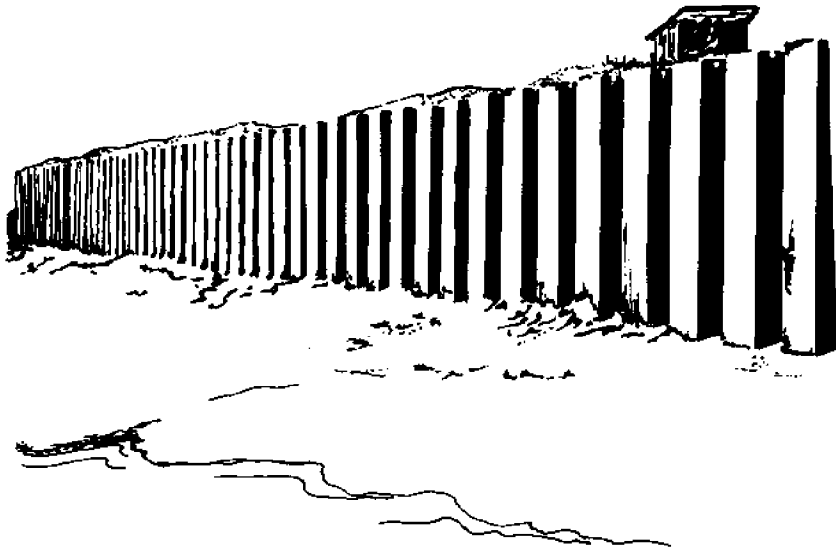


FIGURE 3: STEEL PILE BULKHEAD

**Revetments** are usually the lightest of the three structures; they are not intended to retain land or fill, but just to protect the shoreline from currents and light waves. They may be constructed of concrete, interlocking blocks, rocks, boulders or demolition materials, such as broken slabs of concrete (Figure 4). Another form of the revetment is the gabion, usually nothing more than wire or plastic mesh baskets filled with rocks or other heavy materials (Figure 5).



FIGURE 4: CONCRETE REVETMENT

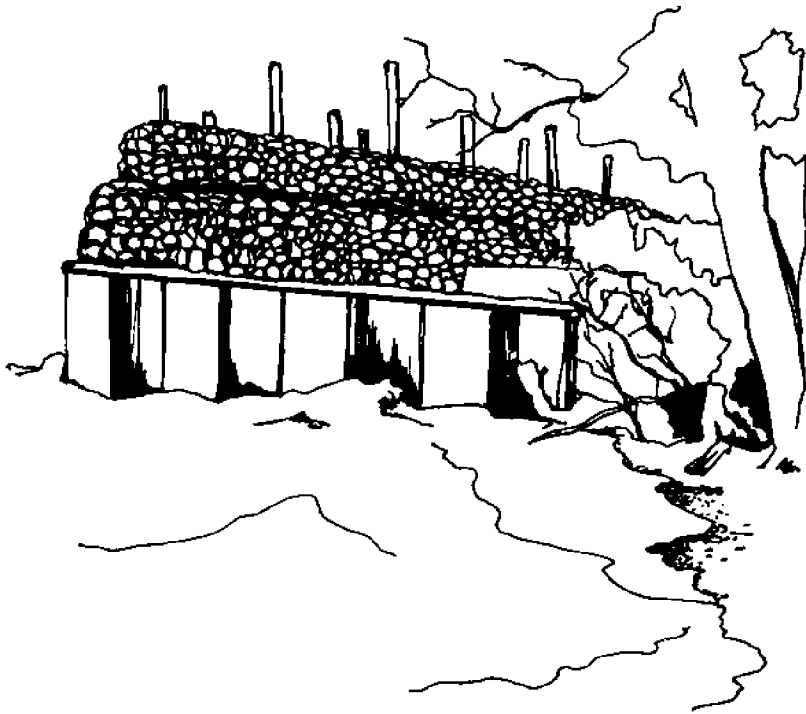


FIGURE 5: GABION REVETMENT

**Seawalls**, the strongest and most massive of the three, are specifically designed to withstand the full force of heavy wave attack. They may also serve as retaining walls and, in some locations, as docking facilities (Figure 6).

The details of differences among these three structures may not always be clear—but it's the purpose, not the name, that's the important thing. Once it's clear what the structure is supposed to do, the engineer can calculate length, height, shape, surface texture (roughness), and permeability. His design also has to consider potential side effects.

Length is dictated by the stretch of shoreline to be protected. If erosion is taking place adjacent to the property to be protected, it will continue in areas left unprotected. Erosion can also be accelerated



FIGURE 6: SEAWALL

in downdrift or downcurrent areas due to the lack of sediment formerly coming from the now protected shoreline. In such situations, the engineer must also take into account the possibility that the structure itself may be attacked by erosion.

Strength and massiveness are determined almost entirely by degree of erosion and prevailing physical conditions. A seawall designed to withstand the full force of ocean storm waves will be more massive and possess more structural integrity than a revetment designed to protect the banks of an embayment from currents and light wave action.

Shape, or more properly, the "cross-sectional profile of the face of the structure," is influenced by both degree of erosion and side effects. The face may be vertical, sloping, convex, concave, or stepped. Each has a different purpose, and each brings side effects in varying degrees, particularly wave runup and over-topping (waves washing up and over the top of the structure) and scouring (wearing action) in front of the structure.

A concave structure is the most effective against wave over-topping, but it also causes considerable scouring. As waves hit the face, they are deflected back towards the water and downward (Figure 7). Wave energy is concentrated in front of the structure,

increasing the scouring action of the waves on the bottom sediments. This may lead to undercutting or attack on the toe or base of the structure. Since undercutting is a well-known phenomenon, engineers offset it by placing the toe at a calculated depth below the bottom and protect or armor it with large stones or other means. However, protecting the base from undercutting will not alter scouring in front of the base. For this reason, the concave shape should be used only where reducing wave overtopping is urgent.

Concave seawalls are most often used to protect roads or developed areas along the ocean front. In situations where it is important not to accelerate erosion in front of a structure—for example, where protection from high tide storm waves is needed landward of a beach or wetland—other profiles or other protections should be considered. When both protecting the upland from wave overtopping and at the same time lessening the erosion effect on a beach is imperative, a combination of concave and stepped profiles is sometimes used.

The vertical shape is most often found in bulkheads and docking structures. It may be the easiest and perhaps the cheapest to construct but it has some drawbacks where shore protection is a prime consideration. A vertical wall, like a concave wall, concentrates wave energy in front of it, thereby accelerating erosion (Figure 8). The vertical profile is less effective than the concave in reducing wave overtopping and causes scouring just as severe.

Convex and sloping profiles are least effective in stopping overtopping, but they do tend to reduce scouring. This is a distinct advantage where protecting the toe of a cliff from wave erosion and minimizing scour-induced erosion on the beach in front of the cliff is necessary (Figure 9).

A stepped wall reduces scouring action and also provides easy access to the beach in front of it. Because it is more complicated to construct, it is also more expensive than a simple vertical or sloped structure (Figure 10).

Surface texture and permeability also make a difference. Sloped, rough, and permeable surfaces, such as those found on riprap or stone revetments, reduce wave runup and dissipate wave energy more than do revetment surfaces of smooth concrete. The design engineer should figure maximum height according to wave runup calculations.

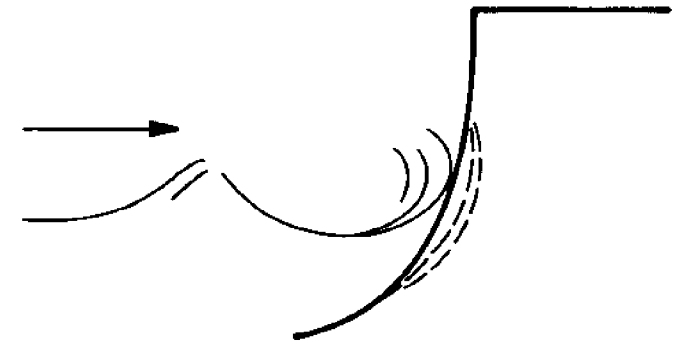


FIGURE 7: CONCAVE STRUCTURE

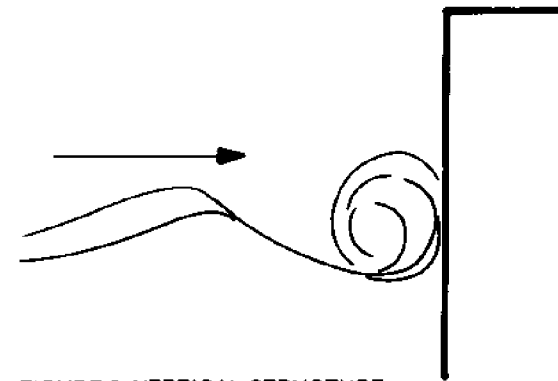


FIGURE 8: VERTICAL STRUCTURE

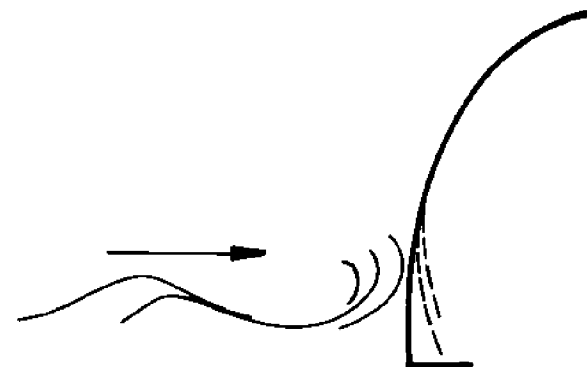


FIGURE 9: CONVEX STRUCTURE



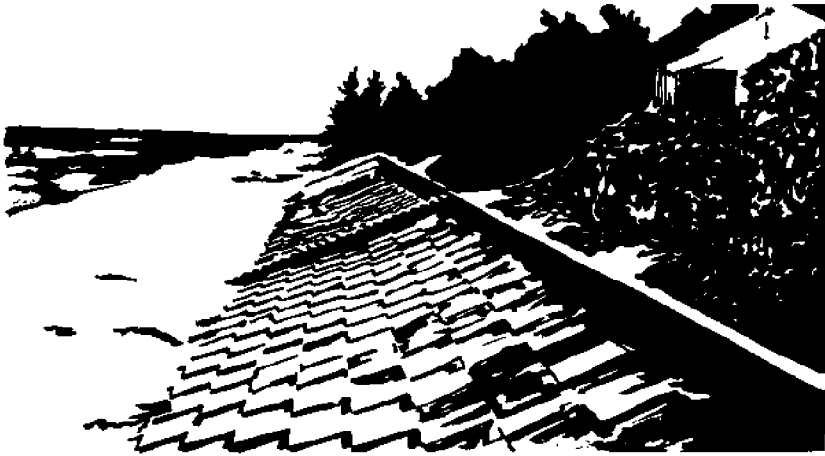


FIGURE 10: STEPPED, INTERLOCKING CONCRETE REVETMENT

## GROINS

Groins are beach protection devices perpendicular to the shore and connected to it. Their purpose is to build or maintain beaches by trapping sand coming down in the littoral drift (Figure 11).

A groin is effective only when one direction predominates in the littoral drift and there is a sufficient supply of sand. Where the littoral drift is balanced in both directions, or where erosion buildup of beaches is mostly from onshore-offshore movement of sand, groins will be of little value. Moreover, if insufficient quantities of sand are being transported by the littoral drift, beaches downcurrent of the groin may become starved for sand and erode badly.

Even with an adequate supply of sand in the system, downdrift beaches may erode while the updrift side of the groin is filling with sand. This effect can be mitigated slightly by artificially filling the updrift side of the groin immediately after construction. Once it is filled, sand bypasses, going around the end of the structure. Nevertheless, some shoreline recession will probably still occur immediately downdrift of the groin.

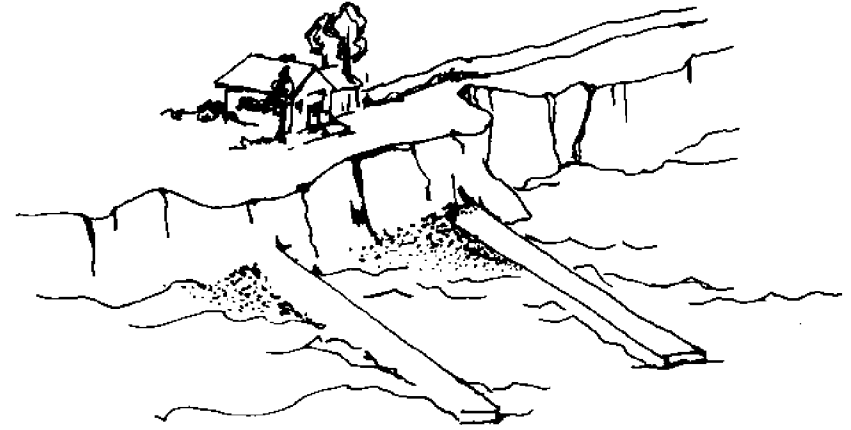


FIGURE 11: GROINS

The decision to use groins should be carefully weighed. If conditions are not right or if the groin is improperly designed for existing conditions, the erosion problem that prompted the groin in the first place may not be solved, and erosion may be induced or accelerated in adjacent areas.

Groin costs vary widely, depending on location, size, material, and so forth. They're generally considered one of the expensive methods of protection for the individual property owner.

## BREAKWATERS

Breakwaters are constructed offshore and parallel to the coastline (Figure 12). They are used to reduce or eliminate wave action on the shore. In doing so, they may almost completely block littoral drift—in some cases so completely that the area landward of the breakwater fills in and eventually connects the breakwater to the shore. A breakwater may seem an attractive solution to erosion problems, but the effect on downdrift beaches can be disastrous; the cutoff of sediment supply may greatly accelerate their erosion.

Breakwaters are more expensive to construct than shore-connected structures and are not a common method of private property protection.

## PROTECTIVE BEACHES

Beaches are part of nature's own line of defense against erosion and flooding of the backshore; they dissipate wave energy and block high water. In cost per foot of shoreline protected, they are one of the most economical forms of shore protection and should be considered whenever possible. Costs do vary considerably, depending upon prevailing conditions, availability of suitable materials, length of shoreline, and periodic maintenance required.

When he's beginning to consider whether a protective beach is advisable, the engineer looks first at direction and strength of littoral drift, deficiency of natural sediment supply, offshore profile, and particle size characteristics of existing beach materials. Based on his findings, he designs a beach of proper height, width, slope, and sand size and estimates future requirements for periodic replenishment.

It may become apparent at the outset that a protective beach would need groins to hold the sand in place and lessen replenishment. Over a period of many years initial and maintenance costs

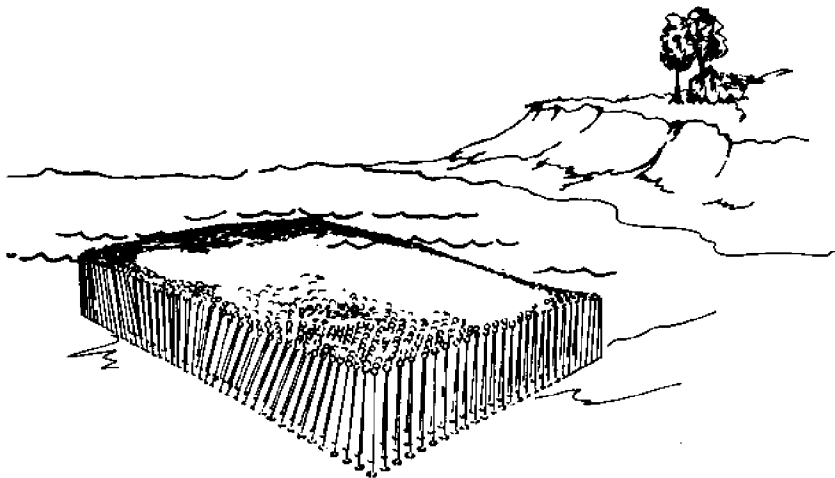


FIGURE 12: BREAKWATER SYSTEM

may be less for a beach with groins than without, but their possible adverse effects on adjacent areas should always be considered in the overall shore protection plan.

## DUNES

Sand dunes primarily protect low interior and backshore areas from floods and wave damage during hurricanes and severe storms. They also are an additional source of sand for the littoral drift. Dunes can be established or built up artificially or seminaturally. Where dunes do not already exist, they can be built by trucking additional sand to the site and bulldozing into the right shape. Snow fences, dead Christmas trees, and other entrapment objects are commonly used to assist in the natural formation of sand dunes (Figure 13).



FIGURE 13: SAND DUNES

Whether dunes are artificial or natural, they should be stabilized by plantings of suitable beachgrass and salt-tolerant vegetation. Along with this, the dunes and their vegetation should be protected from any vehicle traffic and from pedestrian damage by providing dune crossing boardwalks or similar structures.

Although it is desirable to maintain and protect sand dunes, they are no guarantee against hurricane and storm damage. Systems of high, unbroken, and artificially stabilized sand dunes, particularly on exposed ocean beaches which are narrow and low, may accelerate erosion by concentrating wave energy in front of the dunes. In other words, sand dunes should be strengthened and maintained to protect all existing structures, but they shouldn't be built to protect a planned structure. It is not advisable to build a house on a beach and try to protect it with sand dunes.

## VEGETATIVE AND OTHER METHODS

Other than stabilizing sand dunes with beachgrass plantings, there are few, if any proven and guaranteed vegetative shore protection techniques. Combining vegetative and mechanical techniques to stabilize cliffs and bluffs, though, should certainly be considered. Recommendations for planting will vary with location and climate.

Wetlands are effective buffers between water and uplands by dissipating wave energy and trapping sediment. Currently many research and development projects on creating "wetland fringes" for shore protection are being carried out in every U.S. coastal region. Researchers haven't yet entirely overcome some difficulties in establishing these artificially created wetlands, but results thus far look promising. Along this same line, thriving communities of eelgrass can control erosion by absorbing wave energy, slowing down currents, and causing sediment to deposit, but techniques of establishing these communities have not been perfected. Vegetation and wetland shore protection will be attractive possibilities for waterfront property owners when techniques to get good growth are improved and made reliable.

## One Final Word.....

In recent years there has been growing concern about the uncontrolled construction of shore protection works such as groins, seawalls, revetments and bulkheads. Many people interested in maintaining and improving a natural and healthy environment are concerned about bulkheads going up one after another, along more and more stretches of shoreline. Although the data are not conclusive, evidence strongly suggests that groins accelerate erosion in adjacent areas and that bulkheads cause shore loss and water turbidity through increased scouring, thus isolating the land from direct contact with the water and halting the interacting, dynamic sea-land ecology. Some argue, "What harm does a single 50 foot or 100 foot bulkhead do to the environment?" What about the many miles of bulkheads, seawalls and other protective works added to our shoreline every year? What about the cumulative effect?

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