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ABSTRACT

The beach and sand dunes are the first line of defense protecting the land from the sea. The effectiveness of the beach is caused by its sloping surface which dissipates the energy of waves and by the flexibility of the slope which changes as the waves change. The process and rate of accretion and erosion are dependent on the size and frequency of waves, the formation of sand bars, and the tidal cycle. Littoral drift occurs when waves approach the beach at an angle. This can affect the beach when a barrier is put across the littoral zone causing sand to collect on one side and erode on the other. Sand dunes protect the land by acting as a dike during exceptionally high tide and as a reserve supply of sand in times of severe erosion. Their effectiveness can be destroyed by pedestrians, vehicles, or housing construction, but these problems can be overcome. If the unique features of the beach are recognized, it can be enjoyed without interfering with its job of protecting the land. (DC)

SEA GRANT

MAP-19

The Beach— A Natural Protection From the Sea

William M. Sensabaugh

The beach is a great place for an outing. A place to swim, sunbathe, surf, picnic, and fish. These are the things that most people think of when they think of the beach. However, the beach and the dunes that buttress it are much more than just a place for recreation. It is the first line of defense which protects the land from the sea. With an understanding of how the beach performs its protective role, man can use and enjoy the beach with a minimum of interference with this protection.

There are two principal features of the beach which make it particularly effective in protecting the upland. First, it has a sloping surface which gradually dissipates the energy of a wave as the wave flows up the slope. Second, since it is made of sand, the beach is flexible and the slope can change as the waves change.

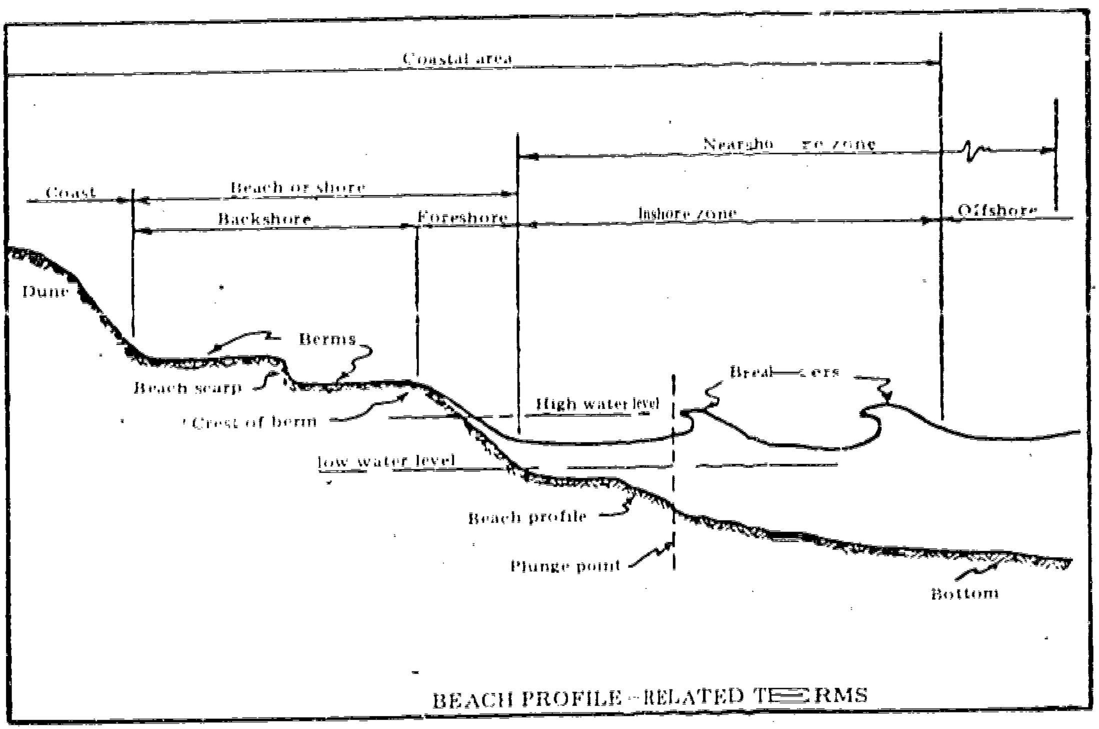


Figure 1

HOW THE BEACH "WORKS"

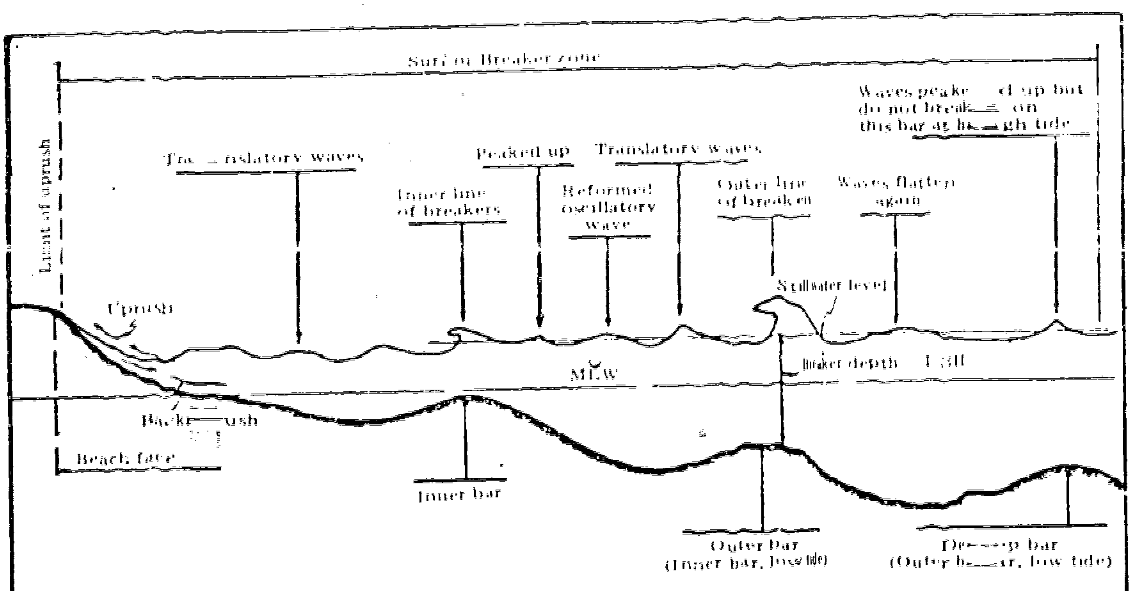
For purposes of discussion, consider a beach on the east coast of Florida sometime in the spring or early summer. The waves are of moderate size and not very close together. Each wave in its turn follows the same sequence of events. The wave breaks and in so doing stirs up the sand on the bottom. Part of this sand remains temporarily in suspension as the wave flows up the beach face. Now three things are happening to dissipate the energy of the wave. First, the water is flowing up a slope and everybody knows that water would rather flow downhill than up-hill, so the water slows down. Second, the sandy beach face is rough and this also helps to slow down the water. Third, some of the water from the wave soaks into the sand. The effect of the slowing down and soaking in is that some of the grains of sand that went into suspension when the wave broke are left up on the beach face. Each succeeding wave leaves a few more grains of sand and the beach builds up, usually with the beach face becoming steeper in the process.

As the beach building process continues, the dry sand area or berm becomes wider and the typical "summer beach" develops.

In the fall the stormy weather brings with it bigger waves which are frequently closer together. The waves hit the beach in rapid succession and the beach is not able to soak up as much of the water of each wave. There is more water left on the beach face to wash back down after each wave and each wave carries a little sand with it as it recedes. The beach erodes. The sand, however, doesn't travel very far before it settles to the bottom to form a sand bar. This sand bar is important because it changes the depth of the water.

As a wave approaches the beach, the water becomes shallower and shallower. When the wave reaches water which is about 1.3 times as deep as the wave is high, the wave will break. As a sand bar builds up, the water over the bar becomes more shallow and the waves break sooner. This means that by the time the wave reaches the beach it has less energy to be dissipated on the beach.

Assume for a moment that the water level does not change (i.e., no tides), that the waves do not change, and that there is plenty of sand on the beach. The storm waves begin to hit the beach and the beach starts to erode. The sand is carried offshore and builds a sand bar. As the waves erode the beach, the beach face becomes less and less steep. This means that the waves can run up further and dissipate their energy over a larger area. When this happens, each wave carries a little bit less sand off of the beach to the offshore bar. Of course while this is happening the bar is building and causing the waves to break a little bit further from the beach and therefore to have a little less energy when they reach the beach. When the slope of the beach and height of the bar and the amount of wave energy divided between the bar and the beach reach a certain point, the system is balanced. Little or no sand is carried off of the beach, the bar does not get any higher and the waves can keep coming in without causing additional significant changes in the beaches.



SCHEMATIC DIAGRAM OF WAVES IN THE BREAKER ZONE

Figure 2

Now, if we go back to the beginning and keep the waves and the beach the same but let the water level change (i.e., the rise and fall of the tide) what will happen? If we start at high tide when the beach starts to erode and the bar starts to build, the water level will start to go down. As far as the waves are concerned, the falling water level will make the sand bar seem to build up faster than the beach is eroding. This is because the important thing is the depth of water over the bar. Therefore, with a falling tide we would expect less erosion. With a rising tide we would expect more erosion of the beach since the bar would seem to build at a slower rate.

If we let the waves change as well as the tide, the situation becomes more complex. If a storm should extend over one or more tidal cycles the rise and fall of the water level adds additional complexities. However, the general idea remains the same. The storm waves erode the beach, the sand forms a bar (or several bars) which cause the waves to break further from shore and thereby reduces the rate of erosion of the beach. This activity leads to what is called a typical winter beach profile: a narrower beach with a flatter slope and one or more fairly well-defined sand bars.

LITTORAL DRIFT

If the waves are coming straight to the beach (Fig. 3) the movement of sand caused by the waves will be onshore--offshore, with very little sand moving parallel to the water's edge. However, if the waves approach the beach at an angle (Fig. 4), the sand which is stirred up by the waves will tend to move parallel to the water's edge. This sand movement parallel to the water's edge is called littoral drift. "Littoral" means of, or pertaining to a shore, especially of the sea.

How does littoral drift affect accretion and erosion and the sand bars? If you stand in the middle of a long, fairly straight stretch of natural beach and look for the effects of littoral drift you will not find much. This is because for every grain of sand that moves away from you to the right, another grain moves toward you from the left. To say it another way, the input of sand (from the left) into your area of observation is equal to the output of sand (to the right) from your area of observation. This means that the amount of sand in your area of observation remains constant but the grains of sand that make up that amount are changing. The situation is similar to the amount of water under a bridge. If you know the width and length of the bridge and the depth of the water, you can determine the amount of water under the bridge. If the river is flowing the amount of water under the bridge will remain constant but a particular drop of water in the river will be under the bridge for only a short time. To go one step further, if you put a dam up-stream of the bridge, the amount of water under the bridge decreases because you have stopped the input. If you put the dam downstream the amount of water increases because you have cut off the output. The same thing can happen to the sand on the beach.

If you put a barrier across the littoral zone, the sand will collect on the updrift side and the beach will erode on the downdrift side. Jetties and groins are two kinds of barriers that block the drift of sand in the littoral zone.

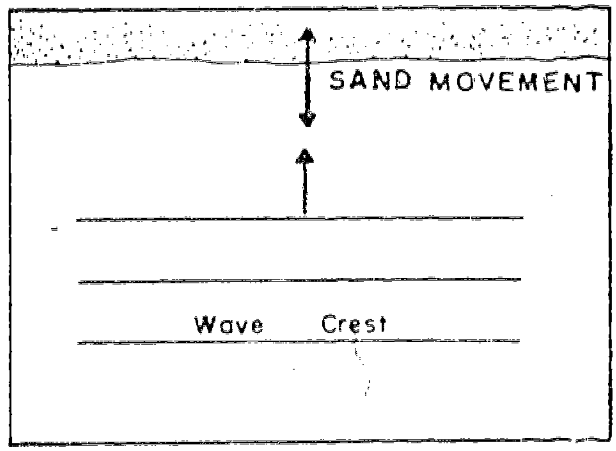


Figure 3 Waves Approaching Beach Straight On

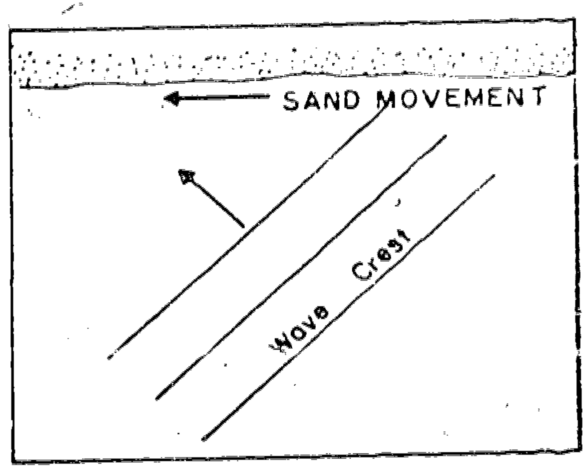


Figure 4 Waves Approaching Beach At An Angle

SAND DUNES

Sand dunes are the second line of defense which protects the land from the sea. This is done in two ways. First, the dune acts as a dike which prevents the exceptionally high tides of some storms from flooding the land. Second, the dunes are a reserve supply of sand with a replenish the beach in times of severe erosion. As was pointed out earlier, it is important that the beach have an adequate supply of sand in order that it may make the adjustments necessary to dissipate the energy of the waves. Since the dunes protect the land during unusual conditions such as extremely high water or high waves, they are not called on every day to serve their protective role. In fact, if the beach is in good condition and the weather is fairly calm, several years may pass between the times when there is a storm severe enough for the water to reach the dunes. For this reason, some people fail to realize, or they forget, that the sand dunes are really a part of the beach and as such they are part of nature's way of protecting the land from the sea.

Dunes are built by the wind which blows the sand into the vegetated area behind the beach. The vegetation traps the sand and the dune builds up. Vegetation is important because not only does it trap new sand to build the dune, but it also prevents the sand which is already in the dune from blowing away.

There are two main problems, caused by man, which can partially or completely destroy the effectiveness of the dunes as a part of the beach.

The first problem is the destruction of the vegetation which holds the dune in place. Pedestrian traffic kills the vegetation in the foot paths and [illegible]. This makes weak points in the dune line which can be rapidly eroded by storm waters and can result in the flooding of the area behind the dunes. Simple, inexpensive foot bridges over the dunes can prevent these weak points. Dune buggies driven over the dunes also kill the vegetation, which leads to wind erosion and generally lower the height of the dunes thereby reducing their protection.

The second problem is construction too close to the water. In some beach areas, the dunes have been flattened off for building sites or houses have been built on the seaward side of the dune. Sea walls have been bu[illegible] seaward of the dunes to "protect the land" [illegible] in fact the dune is much better protection [illegible] the wall. Where dunes are well developed, it [illegible]ually possible to build houses on stilts, behind the center line of the dune and enjoy the advantages of an ocean-front home without interfering with the natural functioning of the beach.

It is the unique features of the beach which make it a desirable place to live or to play. If you recognize and work with these unique features, such as shifting sand and constantly changing water level and waves, rather than ignore or work against them, the beaches can be used and e[illegible]oyed without interfering with their job of protec[illegible]g the land from the sea.

Figures 1 & 2: From Technical Report No. 4, *Shore Protection, Planning and Design*, U.S. Army Coastal Engineering Research Center (formerly Beach Erosion Board).

*First printed January 1975. At that time, the author, William M. Sensabaugh, was the Coastal Engineering Specialist, Florida Sea Grant Program.

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