A Tale of Two Breakwaters

Editor's note: *This pair of articles highlights two parts of VIMS' multi-faceted role in helping to guide shoreline management in Chesapeake Bay.*

Shoreline Program Aids Yorktown Revitalization

It might be the last thing on their minds as they relax on the beach, shop in nearby stores, or enjoy an evening concert, but visitors to Yorktown's new Riverwalk Landing are direct beneficiaries of a long-term collaboration between York County officials and scientists at VIMS.

The collaboration, which began with the construction of a small breakwater in 1985, has helped the historic riverfront community stem shoreline erosion, weather Hurricane Isabel and several powerful nor'easters, and maintain a popular swimming beach.

VIMS' lead in the project is Scott Hardaway, head of the Shoreline Studies Program at the Institute and a recent electee to the National Research Council's *Study Committee on Mitigating Shore Erosion Along Sheltered Coasts*.

Hardaway says that VIMS' primary role in the revitalization project has been to provide technical advice concerning the size, shape, and placement of the 12 breakwaters that now line the York River waterfront.

Two floating breakwaters, which serve as piers for commercial and recreational vessels, were designed by the Williamsburg office of civil engineering firm VHB Inc. VHB prepared the final design and plans for all phases of the Yorktown project.

The Yorktown work is part of VIMS' larger Chesapeake Bay Breakwater Database Project, a partnership with the U.S. Army Corps of Engineers to develop guidelines and track breakwater performance at 40 sites around the Bay.

In its first year of operation, the $10 million Riverwalk Landing drew more than 65,000 visitors to special events in Yorktown and countless more on an everyday basis. The development pumped millions of dollars into the local economy.

Breakwaters are elongate structures, typically of stone, that are emplaced just seaward of the shoreline to be protected. They work by damping, bending, and otherwise disrupting waves before they reach land.

To ensure that a breakwater system will perform most effectively, Hardaway's group uses a combination of field measurements, mathematical equations, and computer models to identify the particular conditions under which the system will operate. They characterize the prevailing wind and wave direction, predicted wave heights and water levels for 50- or 100-year storms, the seafloor bathymetry, and the shoreline profile.

They then use this information to specify the many interacting factors that govern a breakwater's shape and placement (see figure). "While we try to consider all of these factors, they rarely carry equal weight," notes Hardaway. "In fact, satisfying all objectives for any given project is unlikely, as some may be mutually exclusive."

The magnitude of the sand supply is another important design factor. Historically, Yorktown Beach was fed by erosion of sandy banks nearby. However, the beach began to narrow as the natu-

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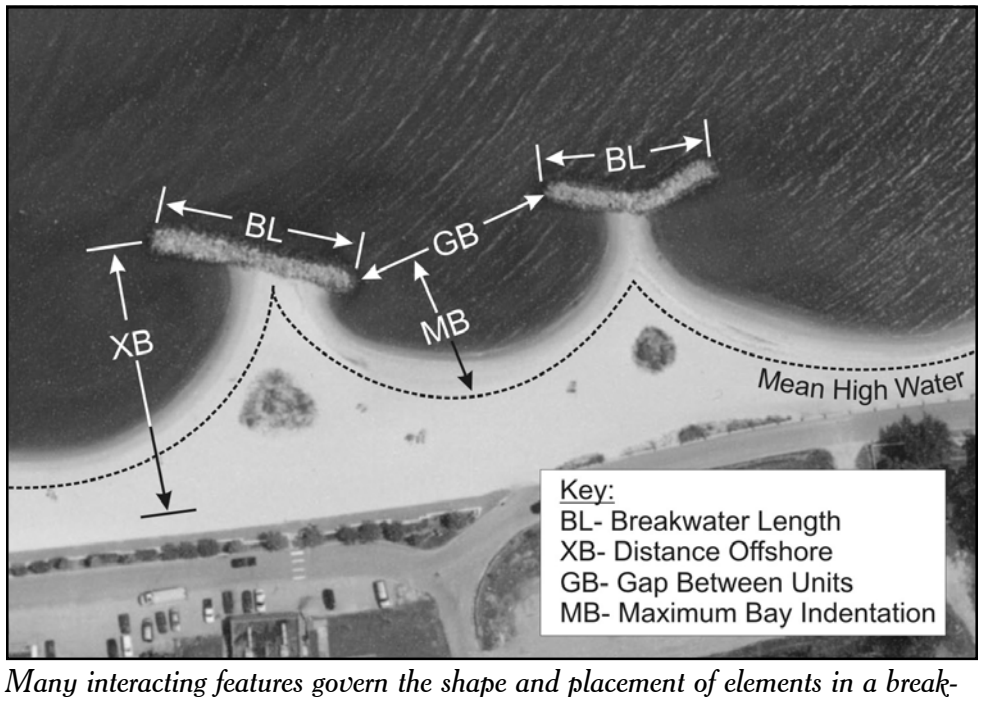

Many interacting features govern the shape and placement of elements in a breakwater system. These include orientation, length, and height of individual breakwaters; the gap between adjacent breakwaters; the distance between a breakwater and the shore; the width and elevation of the beach; and the system's possible effects on other shorelines up- and downriver.

Maa Works with Local Business to Test Breakwater

VIMS researcher Dr. Jerome Maa has been funded by a local company to test the efficiency of floating breakwaters in protecting marinas and other coastal structures from wave action.

The company, Coastal Design and Construction, Inc. (CDCI) of Gloucester County, recently awarded Maa a 4-month contract to study the efficiency of a floating breakwater they've emplaced outside the Hyatt Hotel's River Marsh Marina. The marina abuts the Choptank River near Cambridge, Maryland.

Test results will help the company provide its customers with more realistic estimates of breakwater performance—and help explain a discrepancy between observations of breakwater performance in the laboratory and the real world.

"The marina had asked for a floating breakwater that could reduce wave height by 75%," says Maa. "Lab studies done by a Spanish institute several years ago showed that a floating breakwater would be unable to meet this requirement, but CDCI's experience with real world breakwaters suggests otherwise."

To help the company test breakwater performance in the field, Maa will deploy three separate wave gauges in the vicinity of the Hyatt Hotel's River Marsh Marina—one outside the structure and two in the protected waters within. The gauges, built by VIMS instrument maker Wayne Reisner, employ a bottom-mounted sensor that records the rise and fall of water pressure as wave crests and troughs pass above. In addition to measuring wave height, the external sensor employs a trio of pressure gauges that together provide data on wave direction.

Maa, along with team members Bob Gammisch and Ho Kyung Ha, will travel to the site once a month between December and March to download the wave data for analysis. The four-month study was scheduled for winter in order to sample the larger waves that typically roil Chesapeake Bay and its tributaries during that time.

Maa suspects that his study will confirm that the Choptank breakwater meets the performance requirements requested by the marina. Concerns about breakwater performance, he thinks, are likely a result of the methods used in the original laboratory tests of breakwater efficiency.

"The original experiments with the floating breakwater didn't distinguish between wave diffraction and transmission," explains Maa. "They thus probably underestimated the effectiveness of the device." Results of Maa's study will be provided in a report to CDCI this spring, just after the wintertime experiment ends.

Floating breakwaters are a relatively recent innovation in wave-management technology. Because they float on the surface, they are more environmentally friendly, and typically cheaper, than more traditional designs that require the costly and oftentimes destructive emplacement of stonework on the seafloor.

Floating breakwaters function best in protected coastal areas where wave heights are generally low and the distance between wave crests is short. Shorelines exposed to massive, long-period swells still require the use of solid breakwaters that sit on the seafloor.

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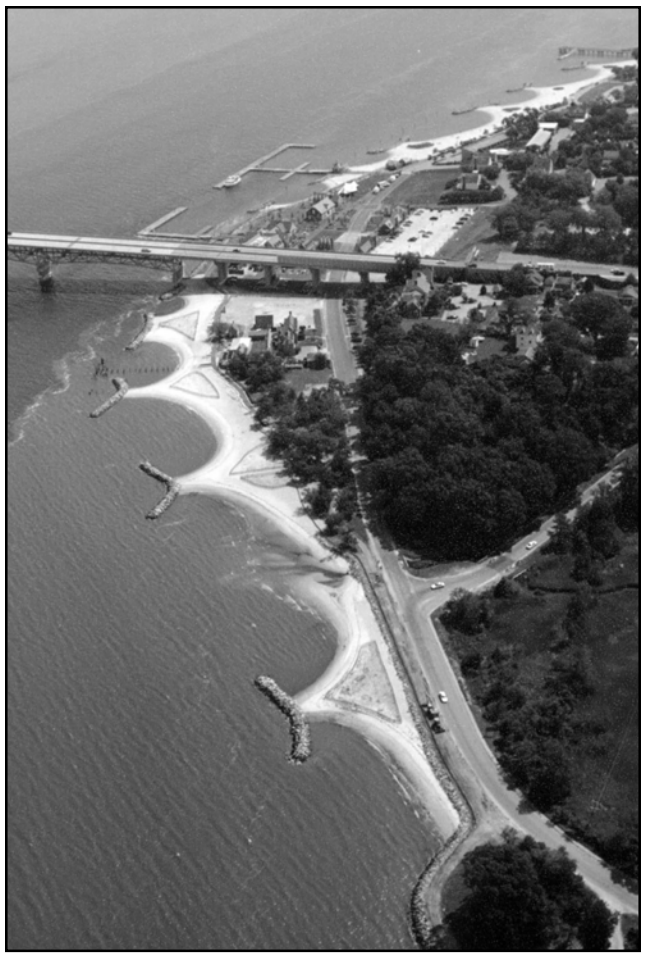
ral sediment supply was depleted by "hardening" of the shoreline upstream due to emplacement of riprap and bulkheads.



An aerial view of the Yorktown waterfront shows the breakwaters that protect the new Riverwalk development.

"By the 1970s and 80s, the Yorktown beach was easily overwashed during storms, and continued to erode," says Hardaway.

VIMS scientists entered the picture in 1985 after a particularly damaging nor'easter, when they were asked to become technical advisors to York County's Public Beach board. Hardaway and colleagues have partnered with the County ever since, helping to design and monitor all four phases of Yorktown's current system, which now features 12 separate breakwaters that range from 80-150 feet long.

VIMS has also advised on nourishing and stabilizing the Yorktown beach. A common misconception, explains Hardaway, is that breakwaters trap sand to form the adjacent beaches. Instead, he says, the beaches are created by sand brought in from upland sources. In Yorktown, some of the beach sands were obtained during dredging for Coleman Bridge widening in 1996.

Once created, the beaches are stabilized by planting cord grasses in the sandy ridge, or tombolo, that connects the breakwater to the shore.

Breakwater systems at Yorktown and elsewhere around the Bay weathered a severe test when Hurricane Isabel blew ashore in 2003. At Yorktown, Isabel produced a 7-foot storm tide topped by 6-foot waves. During the height of the storm, waves of 4 feet or higher were breaking across Yorktown's breakwater system and into the adjacent walkway, road, and buildings.

Although Yorktown's waterfront suffered considerable damage from Isabel, Hardaway notes that the breakwaters did provide an important service, by preventing even worse damage.

"The breakwater system significantly reduced wave action, which likely ensured the structural integrity of the buildings on Water Street," says Hardaway. "The system experienced sand losses and local scour but maintained its overall integrity and performed above expectations. It was designed for a 50-year event and sustained what many consider a 100-year event in this part of the Bay."

Hardaway notes that trade-offs between protection and cost are an integral part of any breakwater design. "The Yorktown breakwater system minimized Isabel's damage, hastened post-storm recovery, and provides the benefits of beach and dune habitat. Higher breakwaters and more sand would give more protection, but at what cost?"

Local officials will continue to grapple with that question during the coming years, as many hurricane experts predict that the current period of enhanced hurricane activity in the Atlantic will continue for a decade or more.

In addition to breakwaters, the Shoreline Studies group at VIMS can choose from several other alternatives when advising localities on shoreline protection.

Bulkheads are vertical wooden structures parallel to shore that reflect the energy of breaking waves. They commonly promote scour on the seaward side.

Revetments are inclined piles of stone riprap that protect the base of eroding banks. The slope of a revetment minimizes wave reflection and seaward scour.

Groins are built perpendicular to the shore to trap sand for beaches. In areas with insufficient sand supply, they can starve existing beaches "downdrift."

Sills are elongate, wedge-shaped piles of rock built near-shore to help establish a marsh fringe or "living shoreline."

During the last few decades, there has been a move from traditional "hardened" structures like bulkheads and revetments toward breakwaters and sills, as shoreline managers promote the benefits of a living shoreline.