



## EXPERTS TALK

# Adapting Coastal Infrastructure to Protect Communities with **Brent Moore and Adam Keen**



Brent Moore



Adam Keen

### Designing Safe, Sustainable and Resilient Seawalls and Coastal Structures

Coastal communities today face an array of challenging conditions, including erosion, flooding and recurring severe weather events, all compounded by ongoing sea level rise. Many areas are investigating the need for new or improved coastal structures, such as seawalls. But creating safe, resilient and context-sensitive structures is a complex task involving hydrodynamic modeling, engineering, environmental and social considerations.

The good news is that today's coastal solutions can offer much more than the imposing hardened structures of decades past. They can be made adaptable and attractive parts of a larger holistic coastal protection network.

**Brent Moore, P.E.**, manages HDR's ports and maritime practice on the Gulf Coast and central region of the United States. Experienced in all aspects of marine projects from planning to design to construction administration, he's been involved in federal and state seawall projects across the Gulf and East Coasts, including the ongoing project to rehabilitate the seawalls around prominent and historic national memorials in Washington, D.C.

**Adam Keen, Ph.D.**, leads HDR's coastal services on the West Coast. An expert in coastal modeling, he has worked on coastal zone projects on every continent but Antarctica.

### **Q. How are coastal communities today adapting their infrastructure in response to the risks associated with sea level rise? Where does an owner or agency begin?**

**Keen:** We expect coastal structures to last decades. So during planning and design we must understand where the environment is going long-term. That's no simple task. It requires a deep understanding of existing local conditions and hazards: Where is the water level of today? What do storm patterns look like? What does storm surge look like? How are the drainage networks laid out and where are they vulnerable?

After an analysis of existing issues, we can use sea level rise prediction curves to develop an idea of the future and to determine how flood risks might change over time. These curves look at different scenarios in the coming decades, showing a range of possible outcomes depending on whether median sea level rise is low, high or somewhere in the middle of global predictions. These curves often

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The seawall at Cole Park in Corpus Christi, Texas.

reveal a dramatic change in flooding frequency, even in intermediate to lower scenarios. For example, current 100-year flooding events may occur every five years by 2100. That creates a much bigger risk to any structure, which should guide today's project decisions.

A risk tolerance exercise can help owners determine which scenario to use in planning. If an area will be flooded a few times a year 50 years from now under a high sea level rise scenario, but it will stay dry if sea levels rise to only an intermediate level, is that acceptable? What if the area will be flooded a few times a month? Or if the risk increases in just 25 years? Understanding what level of flooding will be tolerated, when and where, is important to understand as a design team determines which structures and options are feasible.

The key is doing upfront analysis of existing local conditions to help owners understand the risks they are taking on, and to inform detailed design and planning. Otherwise communities are kind of shooting in the dark as they design coastal protection for the future.

**Moore:** Equity considerations also play into these decisions. Whenever a community commits to create infrastructure to protect its valued assets, like seawalls, flood mitigation or avoidance systems, they are making a statement: This area is vital. And if improvements are added or upgraded in one area and not another, it is often clearly stating, or

at least implying, which areas are more important. As communities develop seawall programs, addressing equity is key, requiring a clear understanding of the implications of each solution and the message being communicated by the community regarding priorities.

This process starts with public and stakeholder engagement to determine community needs and expectations. This step is especially important in historic, business or residential areas where structures will have a large impact on neighborhood aesthetics or functionality.

**Q. In the U.S., where can owners and agencies find resources to respond to the needs of today's sea level rise threats?**

**Keen:** The best reference we have for the U.S. is from the National Oceanic and Atmospheric Association. NOAA puts together a document called [Global and Regional Sea Level Rise Scenarios for the United States](#) every couple of years with their most recent update released in 2022. It's a multi-agency, multi-university research initiative, backed up by sound science and policies. The report is the foundation for a lot of the regional and site-specific planning we do. Importantly, FEMA is also beginning to update its flood maps to reflect sea level rise, which should also provide more information in the future.

Taking that regional information and applying it to local communities is where I typically come in to help our

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coastal structures team. I and other coastal experts at HDR provide planning services, numerical modeling, analysis and oceanographic studies. We provide water level estimates and wave loads to designers performing detailed structural design.

If we're working with a team that isn't as familiar with sea level rise and its associated impacts, we'll help them to gather the right guidance documents, develop graphic material and reference information so the team really understands how sea levels will affect these structures in the coming decades.

**Q. How are new engineering solutions and design trends in coastal infrastructure addressing future uncertainties?**

**Moore:** Owners of seawalls and coastal structures are putting a strong emphasis on sustainability and resiliency. They incorporate more resilient project components like pervious pavements to allow increased storage and more rapid dissipation of floodwaters.

For those areas where a hardened structure is needed, there are methods and approaches being implemented that can increase the service life of the structure for the long term. With concrete structures, for example, new concrete mixes, purposeful connection detailing, crack control

design, specific construction finishing requirements, and coatings can provide a 75-year to 100-year lifespan for marine waterfront structures. When possible, projects are also incorporating design elements that don't require or rely upon maintenance and periodic upkeep, which is often not performed long term or lapses over time.

An experienced and forward-thinking design team can also create facility adaptability that meets current needs but allows for future additions. For example, designing a seawall's foundation today for a much higher anticipated load in the future as sea levels rise can accommodate a project's near term budget constraints, while allowing enhancements to be implemented with little additional relative cost in the future.

Our design team used this approach on the Port Everglades Slip 1 Expansion in Fort Lauderdale, Florida. The new bulkhead seawall will be raised 2 feet higher than its current height, but it has been designed with the ability to add another 4 feet in the future. A benefit-cost analysis showed the dramatic difference in cost between preparing for that rise now and putting off changes until later.

A similar approach was used on the seawall renovation project in Corpus Christi, Texas.

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*Bulkhead seawall at the Port of Jacksonville in Florida.*





Ross's Landing in Chattanooga, Tennessee, features a series of benches and seating areas.

**Q. How can seawalls and coastal flooding solutions be designed so they don't become a blight, particularly in areas such as high tourism areas where aesthetics are key?**

**Moore:** Where there's a high interest in aesthetics, engineering solutions are blended with landscape architectural solutions. The holistic seawall solution could include and incorporate a series of raised walls, planter boxes, benches and seating areas to provide additional flood protection.

Landscape architects may also work with coastal designers to create a living shoreline approach with natural materials or a grass-covered earthen berm where appropriate. These soft structures prevent overtopping and erosion but use natural materials such as integrated topography, holding ponds and natural rock-faced retaining walls.

Even these soft structures can be designed with future adaptability in mind, so elevation can be added if needed. As long as the foundation is designed to handle extra weight and increased flood depth and surge, adding more height in the future when needed can often be done cost effectively.

Improving or extending existing seawalls sometimes prompts another aesthetic considerations. As these are often historic structures, it's important for many communities to maintain their look by using the same type of materials, whether rock, stone or timber. Our challenge as designers is to add strength and resiliency with modern techniques while maintaining the look of structures constructed 100 years ago or more.

**Q. As seawalls and new infrastructure are built, how can owners/agencies better manage their assets for long term, sustainable protection?**

**Moore:** Many seawall projects or programs begin with surveying and data acquisition. While this data is key to determining the specifics of a project area and critical to design, it as well as the designed system can also be leveraged for future asset management. This digital data can be incorporated into GIS databases, expanded upon over time and used to track the condition and specifics of these seawall systems.

Having and successfully implementing a master plan for future development is also important. As components are added to, or taken away from the system, modifications and adjustments can be accounted for. These types of adjustments often affect the volume of flooding, and in

turn, the ability of the seawall system to protect the area from flooding.

For owners that want to consider this, it's important to add the design criteria and assumptions to the basis of design document at the beginning of a project and to continue updating the living document throughout the life cycle of the project. By thinking about and planning for this capability as part of the overall strategy from the beginning, it can be used as a valuable tool in the future to manage the entire system. And it in turn aids in the flexibility of the project to deal with changing water levels.

With accurate design data, analyses, record drawing and specification information and the like, adding new features or modifying structures in coming decades will be much easier, potentially without repeated or added studies.

**Keen:** Collecting the right data at the beginning also eases the process of updating site-specific coastal models. The most labor-intensive part of creating a model is at the beginning, when determining the right model grids, boundary conditions and more that drive the numerical model. Once the model is developed, however, it's a much smaller task to adapt it to changes in the environment or in reference guides.

We have quite a few clients who have come back to us five or 10 years after we developed an initial model and asked us to update it to match current conditions. That's not only made much easier by collecting the right data and creating a good initial model, but it's a very powerful tool to help communities continue to assess their risk from sea level rise and ensure they're responding appropriately.



## Inspiration & Advice

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### **Q. How did your career lead you to this specialty?**

**Keen:** I grew up on the ocean, and water has always been a part of my life in one capacity or another. When it came to figuring out what I was going to do with my life, having the ocean as my office for the day seemed a pretty attractive option. I also tend to be creative and artistic, and coastal modeling gives me an outlet in the engineering world to be both because there's no one way to go about coastal modeling. They each have their own characteristic, each section of coast is unique. And seeing how these unique models come together is something that I really enjoy about the process.

**Moore:** I grew up land locked in a rural farming community in northeast Texas. After earning a degree in civil engineering (with a focused structural and geotechnical curriculum), I migrated to the Gulf coast and found a job in the maritime world that matched my engineering skills and interests. From there, water quickly became a primary focus (both business and recreational) and over the last few decades, I've been involved with a large variety of marine-related engineering challenges. The area where the land meets the sea is a unique, challenging environment which requires a special blend of engineering skills. I'm blessed to have been able to work with communities and owners of marine structures all over the world.

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