



In the wake of catastrophic loss of life and property, industry and Member Firm leaders assess the ad

# HIGH WAT

BY BOB WOODS

In the span of three weeks, from late August to mid-September 2017, three major hurricanes hit the United States. First came Harvey, a Category 4 storm that dropped 5 feet of rain on Houston. Then Category 4 Irma ravaged several Caribbean islands and forced the evacuation of more than 3 million people from south Florida before flooding most of the state. Finally, Category 5 Maria devastated Puerto Rico, already hit hard by Irma, and left the entire island without power and dropped enough precipitation that stormwater punched through a dam designed to protect tens of thousands of people downstream.

In what has become a familiar aftermath, amid repairing the destruction and waiting for the floodwaters to recede, another practice began: evaluating the impacted flood protection systems and how well they performed, or didn't. Simultaneously, in the spirit of never letting a serious crisis go to



A segment of I-10 in Houston, Texas following Hurricane Harvey. The storm dropped nearly 50 inches of rain resulting in massive flooding.

## erty from hurricanes Harvey, Irma and Maria, equacy of U.S. flood protection systems

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waste, the entire nation's vulnerability to flooding is being scrutinized, similar to what occurred after Hurricane Katrina in 2005 and Superstorm Sandy in 2012.

Following those cataclysms, billions were spent to repair failed infrastructure, and bold new flood protection projects were proposed. But once again, many of the same questions remain. What's the physical condition of our dams, levees and similar infrastructure? Is nonstructural floodplain management, including a slew of laws and regulations, among federal, state and local authorities adequate? What, if any, changes should be considered to better protect against future loss of life and property from flooding? And, of course, who's going to pay billions and billions of dollars for all this?

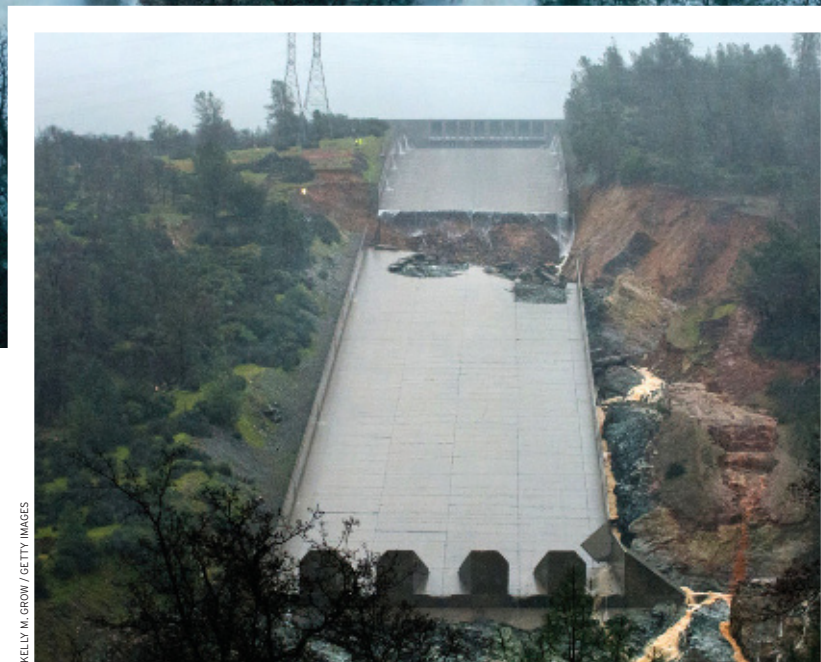
These questions were posed to a cross-section of flood protection experts, officials at various national agencies and organizations as well as executives at ACEC Member Firms with whom they collaborate. Collectively they provided an insightful compilation of assessments, statistics, suggestions and opinions. The upshot is the U.S. needs not only to upgrade infrastructure and nonstructural administration but also to address critical issues such as urban development and funding.

It's helpful to start by looking at the mind-boggling network of hard infrastructure that comprises flood protection in virtually every community throughout the country. The U.S. Army Corps of Engineers (USACE), a Department of Defense unit, maintains a comprehensive national inventory of dams and a



In February 2017, the emergency spillway in the Oroville Dam failed, causing the evacuation of almost 200,000 people from Oroville, California. Inset: Once the stormwater overflow halted, a 45-foot-deep, 300-foot-wide and 500-foot-long crater in the spillway was revealed.

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partial accounting of levees, plus evaluations of their condition.

As of October 2016, USACE listed 90,580 dams, with an average age of 56 years old, though around 4,400 are more than 100 years old. Each dam is classified in one of three categories based on its hazard potential, or anticipated consequences in the case of failure, mainly fatalities and economic losses. More than 15,000 dams are deemed high-hazard potential, up from 10,213 in 2005. Another 11,882 are classified as significant-hazard and 60,705 as low-hazard, with 2,495 undetermined.

Just 16,179 dams are designed exclusively for flood control while the vast majority hold back and contain water for recreation, hydropower, navigation, drinking water, irrigation and other beneficial purposes. USACE may be the most visible entity aligned with dams, yet it owns and operates only 715. Other federal agencies own an additional 2,666 dams, state and local governments and public utilities own 28,599, and 58,148 are privately owned. USACE and 15 other federal agencies regulate about 10 percent of dams; states regulate the remaining 90 percent.

The far-flung ownership and regulatory authority of dams make their safe operation a multilayered task. “Part of the challenge is you have responsibilities laid out across many federal agencies and states, without department-level oversight of it all,” says Eric Halpin, who as USACE’s deputy dam and levee safety officer oversees more than 3,000 infrastructure systems.

The labyrinth of levees found in every state—usually earthen embankments or concrete floodwalls all designated for flood

risk management—demand a different type of herculean effort. Nationwide there are an estimated 100,000 miles of levees, yet only around 30,000 miles are documented, according to USACE’s National Levee Database. The Army Corps owns and operates a small percentage but has regulatory authority over about 14,000 miles of levees across nearly 2,000 systems. State, local and private entities manage the rest. Unlike the hazard potential assigned to dams, the condition of the nation’s levees is largely unknown.

The Association of State Dam Safety Officials (ASDSO) estimates that it will cost more than \$64 billion to rehabilitate nonfederal and federal dams—and nearly \$22 billion to bring just the high-hazard ones up to current standards. Yet only \$5.6 billion in funding has been provided. Repairing levees will cost another \$80 billion over 10 years, though only \$10 billion is in the pipeline.

The federal standard for gauging the protection level of a dam or levee is whether it can withstand a 100-year flood or a 1-in-100 chance of failure in any given year. That standard was established 1973 when the National Flood Insurance Program (NFIP) was mandated by the Federal Emergency Management Agency (FEMA) to map all the floodplains in the U.S.

Yet there's an important nuance that goes beyond the physical integrity of dams and levees and takes into account factors over the lifespan of aging structures, especially increased development downstream and improved data predicting natural disasters such as hurricanes, floods and earthquakes, as well as national security threats.

"Many dams were designed for low-hazard or significant-hazard potential," says Mark Ogden, a technical specialist for ASDSO, "but development has occurred downstream since and now they're high-hazard potential and need to be upgraded to a different standard."

The same situation exists with many levee systems, says Steve Verigin, a senior principal at GEI Consultants, Inc. "It only takes one point of weakness for a levee to fail," he says. "Many started out as low structures that protected agricultural land and, over time, have become higher structures that protect greater lives and property and have not been reassessed to structurally meet those demands."

The historic flooding in Houston from Hurricane Harvey is a poignant, and painful, example of expanding urban development. The Buffalo Bayou is a 52-mile river that flows east through the city and surrounding Harris County. The bayou's flood control system is highlighted by the Addicks and Barker dams. The reservoirs they created were cresting during Harvey, forcing USACE to release water, which inundated surrounding neighborhoods. And even though the dams held up then, a 2009 report by the *Houston Press* found that Addicks and Barker are the most dangerous dams in the U.S.

"There are 1 million people in the floodplain below the Addicks and Barker dams," Halpin says. "When we built those dams 70 years ago, there were about 10,000 people so that has to be part of the discussion moving forward."

Much of that discussion will be spearheaded by Houston's Storm Water Action Team, reports Steve Costello, an engineer who retired from Costello, Inc., in 2015 and is now the city's chief resilience officer, or "flood czar," as he's often called.

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"The city has been experiencing stress-related redevelopment," says Costello. "We advocate for densification of the city, and when you densify an existing area, you strain the infrastructure."

That infrastructure has required updating for years, and though several initiatives have addressed needs, more needs remain, raising vital questions around ongoing development. "Should developers participate in improving the existing drainage problem, over and above just the mitigating of this project?" Costello says. "Ideally, the city would have money in advance to invest in infrastructure for redevelopment, and we wouldn't have this issue." But the public funds aren't there, he says, and developers balk at footing the bill. "We hope the redevelopment task force will address some of these issues moving forward," Costello says.

A similar situation confronts communities around Sacramento, California, where a 42-mile levee system controls the confluence of the Sacramento and American rivers. New Orleans used to top the list of U.S. cities most at risk from river flooding, but it's been replaced by Sacramento, as noted in a recent news report from National Public Radio (NPR). The risk in the region is so great that in 2008, federal officials mandated a building moratorium until the city worked on its levees. "It's pretty scary when you think about it," Rick Johnson, director of the Sacramento Area Flood Control Agency, tells NPR. "We have more than 100,000 people living out there."

The cost of upgrading Sacramento's levees has been estimated at \$4.4 billion and would take nearly a decade more. Instead of waiting on federal funds, the city tapped into state coffers and raised local taxes. So far, 18 miles of the levees have been improved, and the building moratorium has been lifted.

That solution exemplifies what's become a bizarre incentive to continue urban development in flood-risk areas throughout the country. This points to a basic problem the nation faces, says Jim Murphy, a water resource project director for AECOM. "It may appear that we reduce risk, but we do not eliminate it. By allowing development, it actually increases risk. Thus, we still build where we shouldn't build," he says.

The reality, however, is that development is going to continue, so efforts must continue to mitigate the risks of inevitable future floods not only by investing to improve dams and levees but also by addressing non-structural floodplain management. For instance, FEMA has only mapped about a third of the floodplains in the country, which means that many people aren't aware they live in a flood zone and thus don't purchase policies from NFIP.

Communities and individuals need to better understand their risk and what they can do to reduce the chance of flooding, says Jeff Sparrow, senior vice president at Michael

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Baker International. “That’s founded in how we communicate risk awareness [to the public] but also in ensuring that FEMA maps and data are current and making that information available for people to use and make good decisions,” Sparrow says.



Steve Fitzgerald, president of the National Association of Flood and Stormwater Management Agencies (NAFSMA), agrees that public awareness is paramount. “Over the last 10 years, we’ve focused on including preparedness, resiliency, evacuation procedures and communications to ensure that constituents know their risks. It’s all part of the broader flood risk management effort.”

The Association of State Floodplain Managers (ASFPM) focuses on helping local officials manage their flood risk by advocating for stronger infrastructure and smarter floodplain management regulations. Yet Larry Larson, director emeritus and senior policy advisor at ASFPM, contends that engineers also have a key role to play, especially in mapping. “Up until now, we in the engineering community have not been real positive about this,” he says. “We’ve kind of done what the

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MARIO FINIS | STANTEC

decision-makers wanted us to do, rather than saying what we should do. The engineering community needs to stand up and have a voice in these kinds of decisions.”

That sentiment is echoed by Mario Finis, senior vice president of the waterpower and dams group for Stantec. “We as engineers have the science and technology behind us,” he says. “We understand what’s happening, so it’s incumbent upon us to share that information with policymakers and politicians who don’t have that background to fully understand things. We need to make our voices heard and make sure people can make risk-informed decisions.” ■

**Bob Woods** is a technology and business writer based in Madison, Connecticut.

The repaired levee in New Orleans’ Lower 9th Ward. The levee was breached during Hurricane Katrina, causing massive flooding.

