

**WATER RESOURCES**

# IMPACT

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**FLOOD  
MANAGEMENT**



**AMERICAN  
WATER RESOURCES  
ASSOCIATION**





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Scott Kudlas, President



**On this page:** **Top:** Hurricane Harvey flooding north of Beaumont, Texas, August 31, 2017. Hurricane Harvey formed in the Gulf of Mexico and made landfall in southeastern Texas, bringing record flooding and destruction to the region. U.S. military assets supported FEMA as well as state and local authorities in rescue and relief efforts. Source: U.S. Army National Guard photo by Sgt. 1st Class Malcolm McClendon. **Bottom:** Hurricane Harvey flooded residential areas of Houston. Source: Citysqwirl, istockphoto.com.

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## ABOUT THIS ISSUE

# Prepare for the Flood of Metaphors

### Guest Editors

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**WHEN I HEAR THE TERM FLOOD USED METAPHORICALLY,** it conjures up images of rapidly moving, potentially overwhelming chaos. If someone is “flooded” or “inundated” with phone calls or requests, they are describing the acute pressure of a force pushing down, or forward, or back upon them. People who are “drowning” in work (a common outcome of actual flooding) are expressing a feeling of despair. They want to bring themselves “up for air” and some sense of control over their situation. From these examples, you might think that floods are bad. Why, then, is flooding also a way to positively describe emotion? A “flood of emotions” comes over a new mother seeing her baby for the first time. This isn’t a bad thing, is it?

Just as metaphorical floods can be both good and bad, so too can actual, physical floods. Floods transport sediment and biota to disperse seeds and foodstuffs for riparian and aquatic species. They clean out stagnant systems and bring new life to areas that may not experience such an abundance of water for many years. They remind us all of the power and beauty of nature, what can happen upstream and downstream of where we live and work, and how we are all connected.

In California, where I currently live, there are at least nine distinct types of flooding, and most of them involve the rapid inundation of an area by a force of water much greater than the typical flow. I arrived in the area after the last major flood (which occurs about every 10 years), coming from a very different geographic region, and I did not appreciate how much the hydrology and topography of the area differed from what I knew about flooding in the East. There aren’t hurricanes here—at least not yet—and the rain doesn’t come as often, but (to use another analogy) when it does rain, it pours! The problem is that most people are unaware of the potential for catastrophic flooding, as evidenced in this [Legislative Analyst’s Office Report](#) from 2017.

As professionals in the field of flood risk management, let’s consider how to connect with the people at risk—the one in five Californians who are living in a floodplain,

for instance—and see if there is even a thought in their heads about this potential reality. Look to communities that flood regularly, and see what they do to bounce back. And risk communication is not enough; besides recognizing that an area can flood, the question then comes (flows) right back to the source (wellspring) of information: what can a person do? Well, for one, make a copy of every important document and keep it in a box in the closet, ready to go into the trunk. Also, home in on the ability to get good-quality information on real-time events, develop an emergency plan for your family, and act on that developed plan. Play a scenario for yourself—if the flood happened at 12 p.m. in my neighborhood, how would I get across town to get my kids from school? How would we get both cars, the camper trailer, and the dog out of harm’s way? The resilience of individuals and families will directly affect (positively or negatively) the work of emergency responders too. It’s simple: don’t be another victim, as it strains an already strained emergency response system. Furthermore, find out how you can become a leader in your own community by becoming a reliable source of information, helping others understand their risk and their ability to reduce it.

As a society, we are recognizing that floods are a reality and that building our way out of risk is not the answer—we have to live with risk, understand it, and adapt to changing circumstances. Much like the willow at the water line, which folds over in the flood and pops back up even stronger when it is over, we need to be flexible in order to stay grounded.

If, as the saying goes, a picture is worth a thousand words, then a good metaphor is worth a thousand pictures. I press you to consider all of the metaphors related to water, and especially the metaphor of flooding. You may be surprised to know that the term is neutral—neither good nor bad—and that the judgment we place on it is subjective.

I hope this reading wasn’t too dry and that your metaphoric meandering begins to flow!—H.M. ■



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# PRESIDENT'S MESSAGE



*Scott Kudlas, AWRA 2021 President*

**IN THE AWRA TRADITION, WE BRING YOU A SERIES OF** thoughtful articles that demonstrate the importance of community, conversation, and connection. Flooding has been with us always, but with climate change it seems more common each year. Ida, Fred, Harvey, and Claudette are names of storms that, depending on where you live, will remind you of torrential rainfall and associated flooding on unprecedented scales. No part of the country is immune. After each event, there is a flurry of media coverage and activity on the ground, but long-term strategic solutions seem to evade us.

Why is that? In my adopted home state of Virginia, the Great Madison County flood and Hurricanes Hazel and Isabel variously conjure memories of death, economic destruction, rebuilding, or loss of power. Memories fade. Costs are staggering, and political will is fleeting. We rebuild only to revisit these tragedies again in the future. Dig deeper into some of these issues by reading Lisa Beutler's article on memories as a tool for accomplishing change and the insightful interview with General Gerald Galloway. My takeaway from his interview is the importance of pragmatism and perseverance in tackling problems like this. What is your takeaway?

You will not be disappointed by the articles on unique community impacts and solutions. Trained as a landscape architect, Josiah Raison Cain presents many concepts that seem new and yet familiar. It is exciting to see the practice of riparian urbanism embraced in metropolitan areas across the country. As we face climate change, we need to actively and consistently look for multipurpose solutions that provide long-lasting benefits to communities. Cain provides some case studies for consideration.

Nature may also provide a tool that can be part of a comprehensive solution to flooding. Beavers, anyone? Beutler notes that in some places near where I grew up, the same beaver ponds have existed for generations, providing flood control and increasing local biodiversity. I can vouch for the accuracy of that report, and I hope you'll attend our October 20 webinar on the benefits of beavers.

Keith Porter reminds us that earthquakes in California

may have consequences for water that we are not fully aware of. He and his colleagues look at the potential effects of a significant earthquake on California's unique water system infrastructure. He notes, "Repairing and dewatering the system could cost over \$5 billion, take six years to complete, and interrupt water conveyance for a quarter million people and the state's prime agricultural areas." Planning for an event like this is a huge task for decision makers and affected communities alike. It will certainly take years.

Last, but certainly not least, this issue features three articles that remind us of the importance of connections to communities in achieving lasting change. As Hunter Merritt points out, the poor and marginalized in our communities are often the most impacted by flooding, given our often inequitable historic legacy. Efforts to improve resilience, Merritt notes, must be led by those very communities. Melissa Weymiller reminds us of the checkered relationship between the government and indigenous peoples and provides some notable suggestions for progress. Kevin Rowell's commentary regarding empathy and reference to four pillars of disaster planning concludes with "It is relationship driven." That says it all.

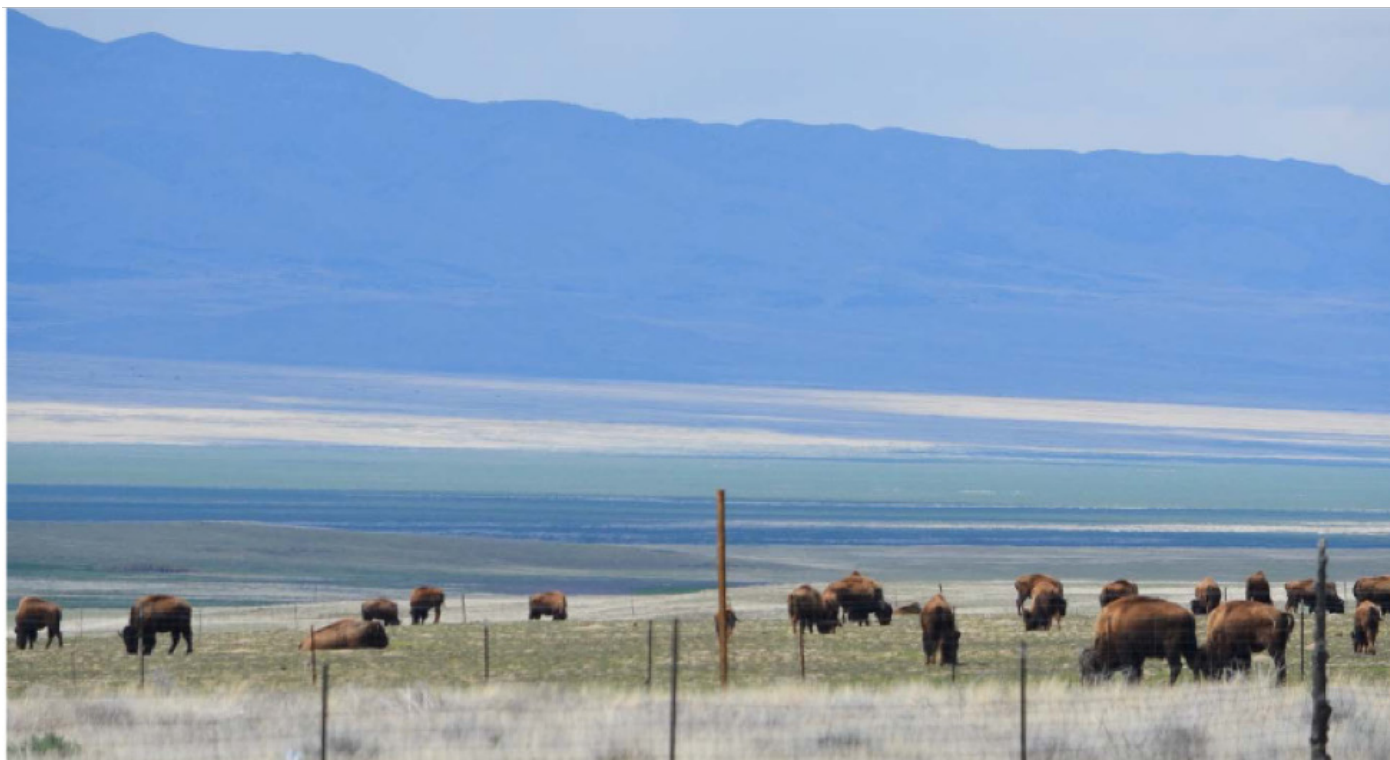
A few updates in closing: as you may have heard, to protect the health and safety of our members and staff, the Board of Directors made the decision for a second straight year to take the AWRA 2021 Annual Water Resources Conference virtual. My heart goes out to all the members of the local planning committee who put forth such a huge effort to host this event. Virtual or not, it will, as always, be a fantastic AWRA event and will take place November 8–10. To find out more about the conference, [click here](#). Please register now, as you will not want to miss it!

Finally, don't miss our AWRA Spring Specialty Conference on April 24–27, 2022. This conference, entitled "Water Risk under a Rapidly Changing World – Evaluation & Adaptation," will be held in Tuscaloosa, Alabama. To find out more, [click here](#). ■



# Working Together to Reduce Flood Risk: Tribal Partnerships and Collaborations

*Melissa Weymiller*



A herd of buffalo grazing on the Skull Valley Reservation. Source: [Skull Valley Band of Goshute Floodplain Management Plan, March 2018](#).

**IT IS NO SECRET THAT STATE AND FEDERAL AUTHORITIES** in the United States have a checkered past when it comes to the treatment of Native American tribes. Today, however, state-led efforts to mitigate flood risk are bringing government agencies and tribal communities into closer cooperation than ever and rebuilding trust along the way. The U.S. Army Corps of Engineers (USACE) support to state-led Silver Jackets teams includes working with tribal governments to develop effective, locally implemented strategies that reduce flood risks.

Federal funds allocated to the USACE help to facilitate cost-sharing and even full federal funding of construction projects designed to protect tribal communities from the economic and human tolls of flooding. Simply throwing federal monies at a problem won't solve it, however. Effective flood risk mitigation requires open lines of

communication and collaboration between government agencies and local organizations and authorities. It is this "secret ingredient" that Silver Jackets teams provide.

### **What Color Is Your Jacket?**

What is the Silver Jackets program? And what's with the name?

Silver Jackets are state-specific, interagency teams who pool their knowledge to identify flood risk solutions that focus on life-cycle risk management (preparedness, response, recovery, and mitigation) and shared responsibility. The name is symbolic and is in reference to the distinctively colored jackets that different U.S. disaster response officials wear: representatives of the Federal Emergency Management Agency (FEMA), for instance, wear blue jackets, while USACE officials wear red. "Silver jackets" signifies many



agencies working together as one team toward a solution. By facilitating cooperation between agencies, Silver Jackets teams help organizations learn from one another to identify appropriate preparedness and mitigation actions that enhance response and recovery efforts when floods occur.

But the efforts of Silver Jackets teams go beyond interagency collaboration. Partnerships with local authorities—such as tribal leaders—are essential to the success of the Silver Jackets. The Utah Silver Jackets team and the Skull Valley Band of Goshute tribe exemplify one such successful partnership. The Goshute, a federally recognized sovereign Indian tribe, are situated on an 18,000-acre reservation located about 70 miles southwest of Salt Lake City. *The Utah Historical Quarterly* ([Summer 1987](#)) noted that the tribe “has since time immemorial lived in northwestern Utah.”

Fewer than 40 people live on the Skull Valley Reservation today, and the tribe is working hard to create economic opportunities to draw tribal members back to the community. However, one peculiar geological feature of the Skull Valley Reservation has proven a major obstacle to the tribe’s efforts at economic and cultural revitalization. Because the tribe lives at the base of an alluvial fan, tribal leaders face significant difficulties in protecting residents from flooding. The problem is not a new one. Written records describe massive flooding in 1878, and tribal members mention large flood events in the 1930s, 1950s, and 1970s.

In recent years, devastating wildfires have compounded the danger already posed by floods. A 2012 blaze on Forest Service and tribal lands in the upper watershed burned a staggering 13,000 acres of forest. As a result of the destruction, floods and debris flows wiped out two roads, a diversion structure, and critical water supply infrastructure. To face this challenge head on, the Utah Silver Jackets brought together governments, agencies, and the

*State-led efforts to mitigate flood risk are bringing government agencies and tribal communities into closer cooperation than ever and rebuilding trust along the way.*

tribal community, who crafted a Floodplain Management Services Interagency Proposal to develop a [Floodplain Management Plan](#) (FMP) in 2017.

Floodplain management plans employ a shared planning methodology to document a community’s approach to driving down flood risks. “Shared planning methodology” may seem like a mouthful, but as the Silver Jackets’ collaboration with the

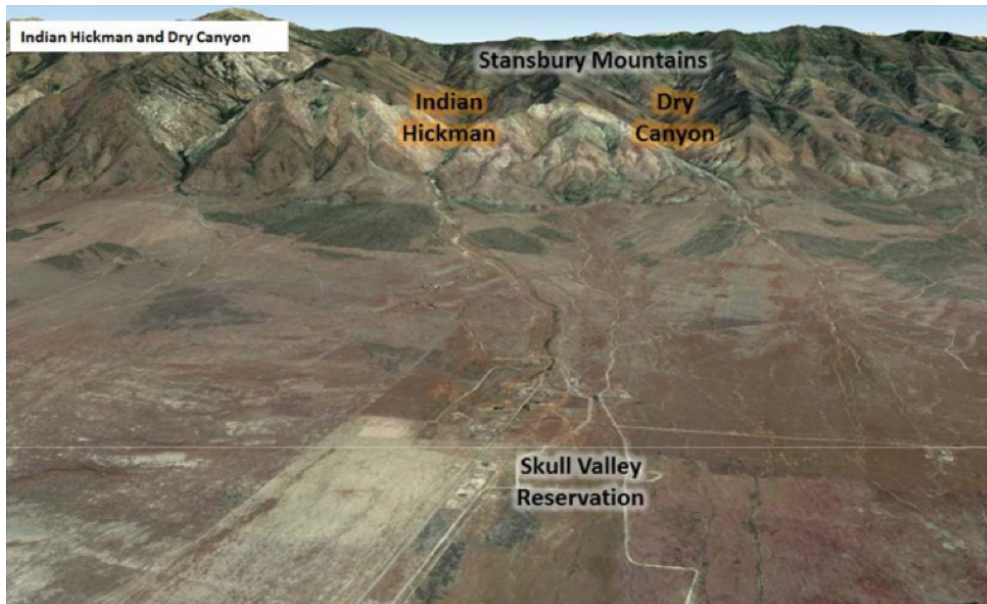
Skull Valley Goshute proves, it is ultimately a practical and empowering collaborative tool for localized flood risk management. The Skull Valley FMP focuses on the future of the floodplain and ways to reduce flood risk by developing goals and concrete measures that the Goshute can actively implement themselves.

In 2018 the Silver Jackets conducted floodplain mapping of the Skull Valley alluvial fan. The map helps tribal members to better understand their flood risk and identifies areas with substantially lower risk that could be developed in the future. The interagency team also helped the tribe develop a Tribal Mitigation Plan, which plans for all the hazards facing the community, not just flooding. It also makes the tribe eligible to apply for mitigation funding through FEMA. Further, the



The destructive effects of flooding on the Skull Valley Reservation—such as the mudflow pictured here, the aftermath of a 2013 flood—have been exacerbated by recent wildfires. Source: [Skull Valley Band of Goshute Floodplain Management Plan](#).





Because the Skull Valley Reservation is located on an alluvial fan, its residents, the Goshute, are particularly vulnerable to dangerous floods. Source: [Skull Valley Band of Goshute Floodplain Management Plan](#).

from one administration to the next. Still, persistence pays off. By continuing to reach out to tribal authorities, government agencies can establish effective links to the tribe and demonstrate a commitment to collaboration that transcends organizational flux and turnover in personnel.

Persistence alone is not enough, however. Respect, honesty, and understanding are crucial. So the [USACE Tribal Nations Center of Expertise](#) provides additional tips for working with tribal communities: Demonstrate empathy when listening to tribal concerns. Do not

team developed a proposal for the Natural Resources Conservation Service (NRCS) Watershed and Flood Prevention Operations Program. The proposal was accepted and will become a multi-million-dollar project to provide flood risk mitigation infrastructure to the tribe.

#### Opening the Lines of Communication—in Both Directions

Many communities, tribal or otherwise, are not fully aware of the full range of state and federal resources at their disposal; likewise, many agencies do not know how best to collaborate with other organizations to support communities. As the Goshute example illustrates, the Silver Jackets help break down these knowledge barriers by developing partnerships through which information and resources can be shared. Indeed, such partnerships provide a critical opportunity for communication between agencies and tribes. It is crucial that these lines of communication remain open in both directions. Silver Jackets teams cannot be effective if the members are not aware of a tribe's water resources problems or concerns. The agencies must work actively with tribal liaisons to identify potential needs.

Getting everyone to the table can be a challenge, however. Tribal leaders who feel that the government has let them down in the past are understandably less inclined to work with federal agencies again. Agencies must work hard to rebuild trusting relationships and set realistic expectations of how their programs can support the tribes. Staff turnover within both federal agencies and tribal governments is one of many pitfalls to building and sustaining such relationships. Trusted individuals may rotate out of key roles, or priorities may change

overextend your authority or make promises you cannot keep. Solicit input from tribes on how to solve complicated resource challenges, and do not mistake kindness, silence, or politeness for consent or agreement. Always meet in a neutral location to make the balance of power as equitable as possible. Finally, pay attention not only to what is said but to what is left unspoken as well.

Ultimately, reducing flood risk is a shared responsibility. One agency, community, or tribe cannot substantially reduce flood risk on its own. To achieve resilience in the face of natural disasters such as floods, effective partnerships—like those forged by the Silver Jackets and the Skull Valley Goshute—are vital. ■

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*This article was adapted from [one](#) published in the February 2020 issue of the USACE flood risk management newsletter, FRM Buzz. For more information, please visit <https://www.usace.army.mil/Missions/Civil-Works/Tribal-Nations/> or contact the director of the USACE Tribal Nations Center for Expertise, Ron Kneebone, at [Ronald.R.Kneebone@usace.army.mil](mailto:Ronald.R.Kneebone@usace.army.mil).*



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## FEATURE

# Is It Time to Add a Beaver to Your Flood Management Team?

*Lisa Beutler*

**IF YOU'RE LOOKING FOR NEW TALENT FOR YOUR NEXT** flood management project, you may have overlooked an entire pool of low-cost, hardworking, extremely experienced workers.

Sometimes called nature's premier construction engineers, they have their detractors, and you may have some qualms after reference checks. They've been in multiple disputes, been called nuisances, and even been ejected from the worksite. But some managers (and governments) are saying it's time to give them a second look.

Beavers, nearly hunted to extinction for their valued coats, are slowly returning to public lands. In his recent book, *Eager*, author Ben Goldfarb calls the semi-aquatic mammals "ecological and hydrological Swiss army knives." Goldfarb believes they are building a new

reputation for positive impacts on landscapes, ecology, and even the economy. "A beaver pond," he explains, "is more than a body of water supporting the needs of a group of beavers, but the epicenter of a whole dynamic ecosystem."

Beaver-built dams and wetlands naturally boost cost-effective climate resilience. Known benefits include habitat creation for endangered species, increased biodiversity, water storage and purification, reduced wildfire damage, accelerated reforestation after fires, and groundwater recharge.

These large rodents are now getting renewed attention for their potential to reduce flooding. For many, this seems counterintuitive. Often considered pests, tens



Management material? Researchers are studying beavers' potential to support ecosystems in the face of a changing climate. Source: Karen Crewe, istockphoto.com.

of thousands of beavers are killed annually when their activities create localized flooding. A return of beavers to Great Britain created enormous controversy as farmers worried about beaver-made alterations to their drainage systems.

### A Cautious Welcome

Prompted by a European Union agreement to bring back extinct species "where feasible," the formal reintroduction of this once-native British mammal was conducted cautiously and studied carefully. Results have been promising. Media headlines such as



[“Dam It! How Beavers Could Save Britain from Flooding”](#) and [“Why Beavers Could be the UK’s Secret Weapon against Flooding”](#) have captured the public’s interest. (Another publication carried a similar banner headline, but, to the horror of beaver enthusiasts, the column included a picture of a nutria.)

In a [five-year study](#) in west Devon, researchers from the University of Exeter measured water flows and water quality above and below beaver dams. As expected, the dams improved water quality. The researchers also found that beaver activity reduced flood events. Monitoring demonstrated that during heavy rain, water volume increased rapidly above the study site. However, floodwater measured again below the site showed reduced peaks and velocity.

In 2019 interviews with the *Guardian*, John Morgan, a retired rancher and owner of the property where the pilot project occurred, reported that before the beavers’ introduction the rural roads in the area used to flood in heavy rain. Since their arrival, road flooding has ceased. Offering a full-throated endorsement of more reintroduction, he said, “I think it’s a good idea. They do a lot of work that these different water companies have to do. If a dam gets washed out, the beavers put it back overnight. They do a 12-hour shift every day of the year. They don’t take holidays.”

*If a dam gets washed out, the beavers put it back overnight. They do a 12-hour shift every day of the year. They don’t take holidays.*

Not everyone shares Morgan’s enthusiasm. Scottish farmers complain about losing farmland to flooding and the costs of clearing ditches blocked by their new co-habitants. Wildlife managers believe most of the issues can be

resolved through a combination of compensation and engineering fixes to circumvent the beavers’ handiwork. In extreme situations, they acknowledge, relocation may be the best option. Importantly, the wildlife managers and beaver advocacy organizations argue that killing should not be used as a management method.

While the beavers may not collect a paycheck, the formal program does have costs. In addition to the potential cost of compensating neighbors for beaver-created losses, there are costs to ensuring the animals remain in appropriate locations. For now, those locations are plentiful, but beavers are territorial, and increased populations would require increased range. Further, without fencing or other barriers, beavers will naturally search for more desirable sites.

#### Putting Beavers to the Test

Beyond Europe, other countries have tried similar programs. In Canada, where the beaver serves as the official emblem, the government has sought to repopulate the once plentiful mammal. A study of beavers in Riding



In some cases beaver dams have been shown to reduce peaks in downstream water flows, reducing flooding. Source: Teacherdad48, istockphoto.com.

Mountain National Park found that they produced significant benefits for biodiversity, water quality, wetland habitat for other species, and water storage during droughts. As in Devon, the beavers also helped reduce downstream flooding.

Still to be studied are the potential impacts on local landowners and neighboring conservation districts if beaver dams break and cause flooding as well as ways to identify and mitigate these risks.

Concerns about dam failure may be misplaced. An [1868 map](#) commissioned by anthropologist and railroad director [Lewis Henry Morgan](#) showed that of 64 beaver dams and ponds across roughly 48 square miles near the city of Ishpeming, Michigan, three-quarters are still standing. A [2012 study](#) conducted on behalf of California's Department of Fish and Wildlife, in cooperation with the Bureau of Indian Affairs and Institute for Historical Ecology, found a beaver dam in Plumas County, California, that was first built around 580 AD, with evidence of repairs around 1730 and in the mid-1800s. It appeared the beavers abandoned the site after the dam suffered a breach around 1850 (coincidentally around the time Europeans began settling in the area). Most engineers would be happy to claim a dam still standing more than a millennium after its initial construction.

Other studies of the efficacy of beaver dams for flood control have been less definitive. In a [2019 study](#), a team of German researchers found benefits similar to those described by others, but "no remarkable effect could be observed for flood events with return periods of more than 2 years." They concluded beaver dams can affect runoff flows but "cannot be counted as a flood mitigation measure."

Back in the United Kingdom, researchers O. Bokhove,

*A 2012 study found a beaver dam in Plumas County, California, first built around AD 580, with evidence of repairs around 1730 and in the mid-1800s.*

M. A. Kelmanson, and T. Kent reported right in the title of their [2020 paper](#) that "upscaling beaver dams for protection against extreme floods proves unrealistic." They modeled flood-excess volume (FEV) for four rivers during five extreme floods

over the past two decades. Reducing FEV by 10% using beaver colonies and beaver dams would require "hundreds of such colonies per river catchment." Given the number of beaver colonies and dams needed, they concluded that "serious flood mitigation by massive introduction of beaver colonies is completely unrealistic."

Still other peer-reviewed studies, as well as multiple anecdotal case studies, throughout the United States and Canada suggest that how effectively beavers' activities are able to control flooding may depend on the physical characteristics of their habitat. In some reviews, one key to success was adjacency to floodplains.

So, in answer to the question, "Is it time to add a beaver to your flood management team?" the answer is, "Maybe." There is broad consensus about the ecological benefits of beaver colonies, and in many cases they appear to offer at least some degree of flood protection. Regardless, the benefits of beavers as a nature-based flood management option are place dependent. Before bringing them on board, managers will need to weigh benefits against potential human conflicts and ongoing programming costs. Meanwhile, they are always an option if you are looking for a team mascot. ■

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Lisa Beutler ([lisa.beutler@stantec.com](mailto:lisa.beutler@stantec.com)), an AWRA past president, started her career as a state park ranger and has always loved the intersection between land and water management. These days she is an executive facilitator at Stantec, working on an extensive water management portfolio.



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## FEATURE

# California's Next Big One: Earthquake-induced Flood Catastrophe

Keith Porter

**STORIES OF CALIFORNIA ON FIRE SEEM TO FILL THE** headlines, and longtime residents can readily share one or more dramatic earthquake stories. Outside of the emergency management community, however, few Californians know of the state's deadliest and most destructive disaster. In the final days of 1861 and the first of 1862, a 25-day storm of almost biblical proportions pounded the state and its neighbors to the north and the east. Unrelenting rain and snow eventually overwhelmed the rivers, and, as UCLA climate scientist Daniel Swain explains, a "significant portion of the state's Central Valley filled with floodwater, creating an inland sea, supposedly 40 miles wide and 150 miles long."

Floodwaters destroyed a quarter of the homes in the Central Valley and one-third of California's taxable land. The economic and human tolls were profound. These losses bankrupted the state, and some researchers estimate that up to 1% of the state's population perished in the floods. But Californians were undeterred. Over the next few decades, Californians responded to flood threats by constructing new levees, forming reclamation districts, and enacting state measures. Floods are an ongoing reality in California, but few understand that disasters like that of 1862 can, and almost certainly will, occur again.

Historically, public awareness of flood risk mitigation measures waxes and wanes. In 2005, after Hurricane Katrina, the nation's levees became a topic of considerable scrutiny. The catastrophic failures of poorly maintained levees led to the devastation of the northern New Orleans metropolitan area. Ray Seed, a renowned geotechnical earthquake engineer investigating the New Orleans levee failures, set off more alarms that hearken to the cataclysms of the 19th century in the Central Valley. Present-day Californians, Seed warned, face similar threats.

Seed was not alone in his assessment. In 2008 and 2009, the Delta Risk Management Strategy (DRMS), prepared for the

California Department of Water Resources, supported his predictions. The 1,500-page study, representing the work of more than 50 authors and 50 reviewers, concluded that "levees in the Delta and Suisun Marsh are at risk of failing due to a variety of factors, including earthquakes and winter storms. Levee failures and the flooding that follow can cause fatalities, destruction of property and infrastructure, interruption of a large portion of California's water supply, environmental damage and statewide economic impacts." The Delta region's complex system of levees, some over a century old, was likely not up to the task of protecting its property, infrastructure, and population.

A few years later, the U.S. Geological Survey (USGS) produced the HayWired Scenario, a detailed account of possible outcomes of a magnitude-7.0 earthquake on the Hayward Fault in the San Francisco Bay area (see sidebar on page 16). I led the engineering aspects of that study and, recalling Seed's warning, wondered what could happen to the Delta in the HayWired Scenario. Seed had used the word "Armageddon" in his warning about California's flood risks. At the time, I thought he was being alarmist. I don't think so now.

### When the Levee Breaks

The Sacramento-San Joaquin River Delta and Suisun Marsh is the largest estuary in the western United States. Home to numerous plant and animal species, and a crucial environment for Bay and Pacific Northwest fisheries, it serves as the hub of California's water supply system. Diversions provide water for approximately

25 million people and 3 million acres of farmland. Key transportation, transmission, and communication lines cross the region. It also hosts recreation and tourism (12% of the state's hunting and 8% of the state's fishing licenses are sold there), and its rich soils support a highly productive farming industry.

Delta islands are home to more than half a million

*The warnings of earthquake-induced levee failures and of the inevitable earthquakes resemble the sound of a freight train barreling toward a car idling on the tracks.*

people, about four times more than the New Orleans neighborhoods affected by levee failures during Katrina. It also exceeds the entire population of California in the early 1860s. Economic studies estimate the region supports 25,000 jobs and \$5.3 billion in annual economic activity statewide, including jobs and activity outside the Delta that directly rely on it. The stakes of earthquake-induced levee damage are high in whatever terms one cares to measure: lives, livelihoods, or the environment.

As part of the HayWired study, my USGS colleague Jamie Jones and I estimated the damage that a Hayward Fault earthquake would cause to the nearby levees. We estimated the failure probabilities of each levee segment and then used a technique called Monte Carlo simulation to combine those individual levee failure probabilities into an estimate of the behavior of the entire system. To understand Monte Carlo simulation, picture a roll of 20 \$1 coins, all flipped once. You get to keep all the ones that come up heads. On average, you will walk away with \$10—half the coins. One way to estimate the chance of different outcomes—walking away with \$5 or \$15 for example—is to flip all the coins over and over again and calculate the likelihood of each outcome. One can do the same thing on a computer to model the probability of levee failure.

Our simulation estimated that thousands of levee failures could realistically occur. An average of 53 islands

*Seed had used the word “Armageddon” in his warning about California’s flood risks. At the time, I thought he was being alarmist. I don’t think so now.*

would experience at least one levee failure in the main shock.

Figure 1 illustrates one of our Monte Carlo simulations. In the first map, the red dots represent failed levee segments, and blue line shows the boundary of mean higher high water.

The map subdivides 1,330 miles of levees into 68,000 segments, 24,000 of which are too weak to resist the peak ground accelerations of the scenario earthquake. In this simulation, 54 of 71 islands are estimated to have at least one levee failure in the scenario earthquake. Of these, 53 are below the average higher high-water mark. The second map shows the resulting flooding.

### A Fast-Moving Train

While some failures might not lead to flooding, the levees would still need repairs. Repairing and dewatering the system could cost over \$5 billion, take six years to complete, and interrupt water conveyance for a quarter million people and the state’s prime agricultural areas. Far graver would be the threat to life, safety, and the economy. The earthquake-induced failure and flooding of 75% of the 71 islands could threaten lives, damage or destroy 400,000 homes, and wipe out tens of billions of dollars of economic activity.

Unless the levees are remediated before the Big One, a catastrophe like the one Seed warned about and we modeled will certainly happen. It is not a matter of if this disaster will occur, but when. A significant earthquake

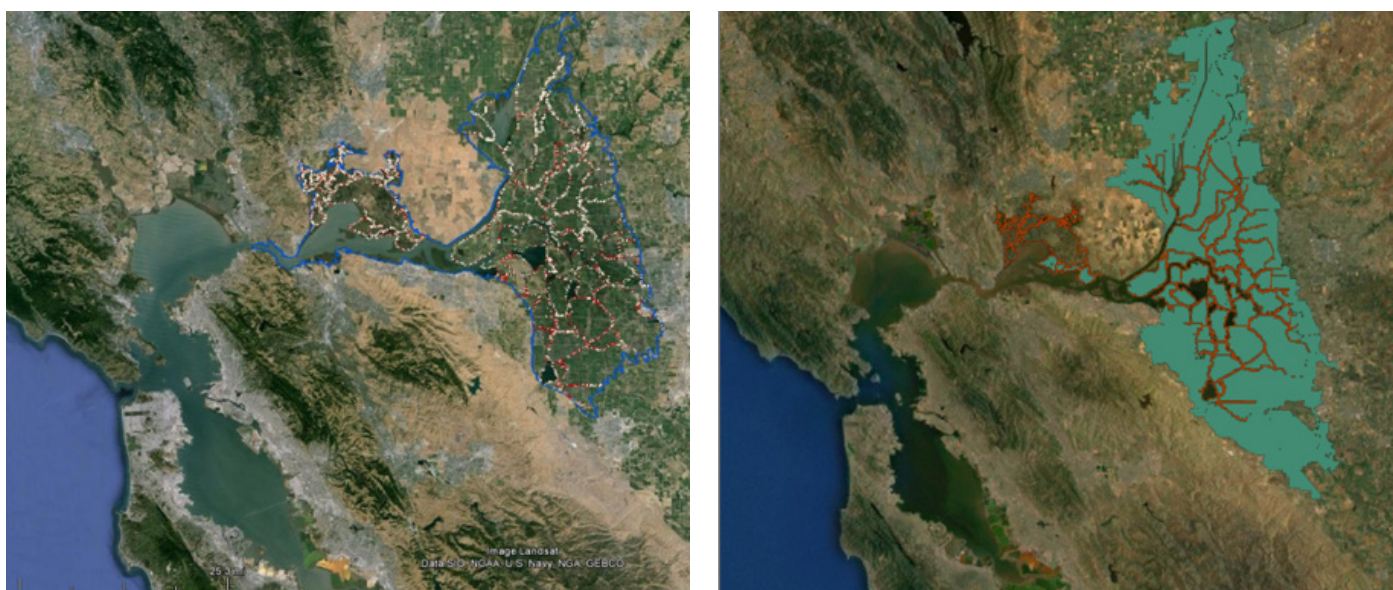


Figure 1. Effects of a potential 7.0-magnitude Hayward Fault earthquake on the California Delta. Left: Red dots are locations with levee failure in the scenario earthquake, and the blue outline is the mean higher high-water level. Right: Resulting flooding.





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## The HayWired Scenario: Quick Facts

1. The scenario assumed a magnitude-7.0 earthquake on the Hayward Fault.
2. The Sacramento and San Joaquin Valley watersheds empty into San Pablo Bay at the north end of San Francisco Bay, 20 miles northeast of the Golden Gate.
  - Flows pass north of Sacramento to approximately 65 miles south to Tracy and west 45 miles from Martinez to the eastern edge of Stockton.
  - There are approximately 1,100 square miles of land in the Sacramento–San Joaquin River Delta and Suisun Marsh.
  - Approximately 41% of the area lies below sea level.
3. Flow activity occurs in an area protected by 1,330 miles of levees.
4. Significant sections of the levee system were built in the late 1800s and early 1900s, before the development of modern geotechnical engineering practices and standards for analysis, design, or construction that consider seismic loading.
5. The flow area includes 57 named islands in the Sacramento and San Joaquin areas and 14 in the Suisun Bay, for a total of 71 named islands.
6. The study methodology used the broadband ground motions modeled by the U.S. Geological Survey (USGS).
  - a. The Delta and the Suisun Marsh experience peak ground acceleration (PGA) shaking between 0.05g and 0.30g in the scenario earthquake, with an average PGA of 0.15g (using the average of levee segments).
  - b. The motions were applied to vulnerability functions provided by the Delta Risk Management Strategy (DRMS) report.
7. Estimated levee failure probabilities ranged between near zero and 80%, with an average failure probability of 36%, with each segment weighted equally.
8. Monte Carlo simulation was used to combine those individual levee failure probabilities into an estimate of the behavior of the entire system.

will almost certainly occur in the 21st century. The USGS estimates a 1 in 40 chance of a magnitude-7 or larger earthquake on the Hayward Fault every year. This adds up to better-than-even odds of such an earthquake within 30 years and about a 90% chance by 2100. And the Hayward Fault is not alone. Several other active faults near the Delta could wreak similar havoc. All of which means predicted losses are less like scary possibilities and more like appalling likelihoods.

The warnings of inevitable earthquakes and of earthquake-induced levee failures resemble the sound of a freight train barreling toward a car idling on the tracks. Even if policymakers take the warnings seriously, debates over whether and how to remediate the levees could take years. Indeed, they already have. Environmental assessments would add more time, then years of

litigation, years to marshal levee remediation resources, and years to perform the actual work. Like the climate crisis that is already upon us, this train is coming fast. Will the state—can the state—move in time? ■

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Keith Porter ([keith@cohen-porter.net](mailto:keith@cohen-porter.net)) serves as chief engineer to the Institute for Catastrophic Loss Reduction. He is a structural engineer, principal of SPA Risk LLC in Denver, and adjunct professor at the University of Colorado Boulder. He does pure and applied research to measure and reduce the adverse effects of natural disasters on the built environment and society. He works with engineers, economists, sociologists, earth scientists, geographers, and anyone else with similar interests.



## FEATURE

# Florida's Most Famous Flood, in Folk Song

Hunter Merritt



The aftermath of the Great Florida Flood in West Palm Beach. Source: [https://commons.wikimedia.org/wiki/File:1928\\_Okeechobee\\_Aftermath\\_10.jpg](https://commons.wikimedia.org/wiki/File:1928_Okeechobee_Aftermath_10.jpg)

**MAJOR FLOODS ARE PART OF OUR HISTORY AND WOVEN** into the cultural fabric of our society. The memories of these floods affect our communities for many years, at a local and highly personal level.

Some of the more [famous](#) floods have become the subject of folk songs. “Hold Back the Waters” by Florida’s own Will McLean presents a cautionary tale about a September 1928 tropical cyclone that inundated South Florida. It pounded the coast of West Palm Beach and overwhelmed a five-foot mud dike around Lake Okeechobee, killing thousands of people, many of them undocumented African American and Afro-Bahamian farmworkers. The song references four thousand

deaths—a [USA Today](#) ranking puts the number at an estimated 2,500–3,000—but many bodies were never found, and the total number will never be known. (A video of McLean performing the song in the late 1970s or early 1980s can be seen on [YouTube](#).)

This catastrophic event has been [named](#) one of the nation’s worst flooding disasters (alongside the 1889 Johnstown Dam failure and the 1900 Galveston hurricane and flood). It prompted the U.S. Army Corps of Engineers to invest in and oversee the construction of a federal system of dams, ditches, dikes, and levees that now reduce—but will never eliminate—the risk of future floods in South Florida.



## Hold Back the Waters

By Will McLean, ©The Will McLean Foundation, all rights reserved

'Twas in the late twenties that there  
come a big flood,

Drowned four thousand, their graves  
was the mud;

'Twas nothing could withstand that  
great tidal wave,

And the ghosts of the vanished still cry  
from the grave.

*(Chorus):*

Lord, hold back the waters of  
Lake Okeechobee

For Lake Okeechobee's blue waters  
are cold;

When wild winds are blowin'  
across Okeechobee

They're calling and seeking for  
other poor souls;

Oh Lake Okeechobee's blue waters  
are cold.

The Seminole left there in haste  
and with speed,

But their wise words of warning  
were given no heed.

When the waters receded, great  
God, what a sight!

Men, women, and children, turned  
black as the night.


Now Lake Okeechobee is calm  
and serene;

The land all around it is fertile  
and green.

But the people get fearful when  
the wild winds do roam,

And they look at the earth dam and  
they think of their home.

**HOLD BACK THE WATERS**



'Twas in the late twenties that there come a big flood,— It drowned four thousand, their graves was the mud.— 'Twas nothing could withstand that great ti-dal wave,— And the ghosts of the vanished — still cry from the grave. — Lord hold back the wa-ters of Lake O- keechobee for Lake O- keechobee's blue wa-ters are cold;— When wild winds are blowin a-cross O- keechobee they're calling and seeking for oth-er poor souls, — Oh Lake O- kee-chobee's blue waters are cold. —

The Seminole left there  
In haste and with speed;  
Their wise words of warning  
Were given no heed.  
When the waters receded,  
Great God, what a sight!  
Men, women and children  
Turned black as the night. Cho.

Now Lake Okeechobee  
Is calm and serene;  
The land all around it  
Is fertile and green;  
But the people get fearful  
When the wild winds do roam;  
They look at the earth dam  
And they think of their home. Cho.

Source: Florida Sand, by Will McLean. Special thanks to the [Will McLean Foundation](https://www.willmcleanfoundation.org/) for permission to publish these lyrics. © Will McLean Foundation, all rights reserved.



A marker in West Palm Beach denotes the location of a mass burial site for victims of the 1928 hurricane and flood. Most of the lives lost in the disaster were undocumented African American and Afro-Bahamian farmworkers. The exact number of deaths will likely never be known. Photo 2010 by Ebyabe. Source: <https://www.blackpast.org/african-american-history/the-okeechobee-hurricane-of-1928/>



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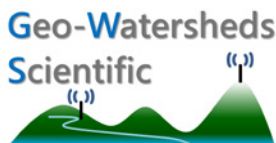
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## FEATURE

# Highlights of an Interview with Gerald Galloway, the Nation's Senior Flood Management Statesman

### Guest Editors

#### WE CAUGHT UP WITH BRIGADIER GENERAL GERALD

E. Galloway Jr. (retired) in late August, just two days after Hurricane Ida made landfall in Louisiana and on the 16th anniversary of Hurricane Katrina. Now 85, he sported a t-shirt emblazoned with the words “Be CIVIL, and Environmental.” As he settled into his office chair, his comfortable demeanor and casual attire belied his stature as one of the world’s top flood-management experts.

Galloway was already well known in the water resources field through his distinguished service in the U.S. Army Corps of Engineers (Corps) when President Reagan appointed him to serve on the seven-member Mississippi River Commission in 1988. Later, President Clinton pressed him into service to lead the task force studying the causes of the Great Flood of 1993 along the Mississippi and Missouri Rivers. The findings and recommendations of that study, now referred to as the Galloway Report, fundamentally altered the national perspective on flood management.

Today Galloway, a former AWRA past president, is professor emeritus of civil and environmental engineering at the University of Maryland. He is still deeply engaged with the Center for Disaster Resilience and continues to influence contemporary thinking about flood management. While his heart remains with the Corps (his sons followed him into this work too), it is clear that he enjoys the freedom of expression afforded to him as an academic.

Not all of Galloway’s accomplishments are in the rearview mirror. As recently as 2018, *Engineering News-Record* named him a top 25 newsmaker for his leadership in water and floodplain management. In July 2021 he addressed the U.S. Senate Committee on Environment and Public Works about incorporating natural and nature-based features (NNBFs) into flood risk management projects. As he explained in the hearing, “The use of natural systems and NNBF in the development and wise use of our nation’s water



Brigadier General Gerald E. Galloway has worked to shape U.S. flood management policy for decades.

resources dates to the earliest inhabitants of this great land.” He continued, “Today they are still important parts of our efforts to ensure the sustainable use of our water resources and to prevent disasters and should be seen as significant elements of the nation’s portfolio to deal with these challenges.”

#### **“It Just Keeps Happening”: Urban Flooding**

Galloway became deeply engaged in the subject of urban flooding during his joint appointment as a Faculty Fellow in Texas A&M’s Hagler Institute for Advanced Study. In collaboration with researchers at the Galveston campus, Galloway published [\*The Growing Threat of Urban Flooding: A National Challenge\*](#) in 2018.

Urban flood management involves organizing



a cityscape so it can handle the water it receives through precipitation and runoff. While this includes stormwater management and flooding from proximity to a floodplain, the central focus of urban flood planning is on how urban populations can manage what the weather dishes out through both their built and natural infrastructure.

In Galloway's view, urban flood management is an issue not just of health and safety but of social equity. As put in the 2018 report, "Urban flooding, which occurs frequently and ubiquitously, is constantly gnawing at the fabric of communities." Because each event rarely results in major dollar damage, losses may not even be reported, but the economic costs to individual flood victims, Galloway explains, may be catastrophic. People living in basements and high-risk neighborhoods may lose all their belongs, including cars and household goods. These are often the most valuable possessions of vulnerable populations, who are also among the populations least likely to have insurance. To make matters worse, residents may not even know that they are at risk. Many states do not require sellers to tell prospective renters or homebuyers if their property has flooded in the past.

Detroit is a poster child for the problem, Galloway

says. He recalls August 11, 2014, when four to six inches of rain fell in a four-hour period over a densely populated portion of the city. Roadways filled with 14 feet of water, and 10,000 storm drains failed to drain. As drivers abandoned their cars, Michigan State Police dispatched dive teams to monitor the freeways. Homes, businesses, and infrastructure were inundated, and direct flood damage totaled \$1.8 billion.

And, Galloway explains, "it just keeps happening." Before the city had fully recovered, massive rainstorms in July and August 2016 struck again, flooding the homes of 3,000 residents. Since 2016 five major rain-to-flood events have occurred, including one this year. Galloway notes that none of these recent Detroit flood events were caused by overflows of the Detroit River (which is also a risk).

The Midwest is not the only place where such floods occur. Indeed, Galloway says that similar events are happening all over the East Coast. No matter where these floods occur, outcomes often depend on socioeconomic status. Affluent neighborhoods can call on officials to assist and implement mitigation measures. Even if a failure occurs, homeowners are insured and can afford repairs. In contrast, less-affluent cities with impervious surfaces, undersized and failed



Detroit, like many cities, has been subject to repeated catastrophic flooding. Urban flooding, argues Galloway, deserves greater attention, major investment, and new approaches that incorporate natural processes. Source: Michigan State Police.

water infrastructure, and ongoing power outages do not recover quickly. Underlying inequities serve to affect the resiliency of people living there even further.

Galloway believes this is a critical, urgent situation the water community should rally to address. Without significant investment, changes in design and policies, and a plan to address historic and ongoing injustices, it may be a grim future for climate-impacted urban landscapes. “Green” or nature-based flood management solutions are particularly promising, says Galloway. And such efforts have already proved fruitful from the Netherlands to Philadelphia and beyond. They are most effective when paired with engineered structural features. “You can’t always just fix a problem by giving a river more room to roam,” he explains.

#### **Sponge Cities and Sediment Diversions**

One example of a hybrid approach is “sponge cities,” a strategy pioneered by Chinese engineers that Galloway saw firsthand before the onset of the COVID-19 shutdowns. Like many U.S. cities, Chinese urban areas are experiencing extreme flood events and water scarcity in the same years. Kongjian Yu of the University of Peking originated the sponge city concept. “Rather than using concrete to channel away rainwater,” Kongjian Yu explains, “you work with nature to absorb, clean, and use the water. Floods are not enemies.”

Sponge city design embraces the integrated urban water management strategies long championed by Galloway. These strategies include designing for microclimates, adapting low-impact development approaches, implementing sustainable drainage systems and rainwater recycling, rehabilitating degraded environments, and constructing multipurpose percolation systems that absorb, purify, and store floodwater. Importantly, sponge cities aim to promote positive interactions across socioeconomic divides to enhance local urban resilience, particularly in the face of ongoing water-related crises. These types of strategies could dramatically improve the future of many U.S. cities, Galloway says.

China’s political culture makes these measures easier to implement, Galloway wryly points out: “When the leader says, ‘I want 70% of the water to stay in your city, do you understand?’ the only answer he hears back is

*Without significant investment, changes in design and policies, and a plan to address historic and ongoing injustice, it may be a grim future for climate-impacted urban landscapes. This is a critical, urgent situation the water community should rally to address.*

“Yes sir!”

Other promising hybrid approaches could benefit U.S. cities, Galloway says. Sediment diversions incorporate structural approaches to allow river water, sediment, and nutrients to flow into degrading wetlands. These diversions mimic the natural processes that restore and replenish wetlands.

Galloway spoke with pragmatism about the need for these types of projects. In the late 1800s people began to levee the Mississippi to reduce flooding and ease navigation. These alterations choked off sediment supply, causing marshlands to sink. This practice, combined with significant channelization of wetlands to support a booming oil industry, led to massive losses of the coastland that had once buffered the inland from severe storms. Although Mississippi River diversions are not new, the concept of using them explicitly to transport sediment is. Galloway is at the forefront of such efforts, assisting in the large-scale coastal restoration sediment diversion project currently underway on the Mississippi River.

Projects of this kind are highly complex and will take decades to complete. Still, Galloway believes this is a direction that holds promise for mitigating flood risk exacerbated by decades of shortsighted development, alteration, and leveeing.

#### **Progress versus Partisanship**

To prepare for the interview, we did some crowdsourcing on social media to discover what people wanted to hear from Galloway. Most were curious about his thoughts on progress. So we put the question to Galloway: Over the course of his career, he and his colleagues have made hundreds of recommendations to reduce the risk and impacts of flooding. To what degree have these recommendations been implemented? Galloway is clearly delighted by this line of questioning. His answer? In a few words, “not near enough.”

Galloway’s discussion of many of his studies and reports resembles an autopsy as he describes various twists and turns that led some of the impetus for action to peter out. Lack of visibility was one major factor: unlike highways, flood risks go largely unnoticed by most people, who thus do not petition their elected officials to take action. In most cases, however, the cause of a report’s demise was politics.



In short, a couple of key factors have hampered progress. One is the loss of congressional champions working to advance flood policy and secure funding for flood-related projects. An even larger concern for Galloway is the shift in political tenor he identifies as beginning with the ascent of Newt Gingrich to the House speakership and continuing today. He stresses that there is nothing inherently partisan about flood management. Rather, the problems created by hyperpartisanship make it difficult to get anything done that doesn't advance a significant political interest.

Galloway describes decades of projects derailed by partisanship in government. Preparation of the landmark 1994 Galloway Report, for instance, was a whole-of-government effort, and upon its delivery the president told the agencies to get to work. But not long after, the president's party lost control of Congress, and most of the report's recommendations were stymied through budget wrangling and other controls. Even so, some good did come from the effort. Many of the lesser recommendations were followed, including important changes to the National Flood Insurance Program. The report was also a catalyst for changes to state and local flood management programs, as well as a call to action for the flood management profession.

Immediately following Hurricane Katrina, many wondered how much of the destruction could have been avoided had the recommendations of the Galloway Report been followed. A lot, Galloway says. In an ironic turn, the federal government sought Galloway's expertise again. He was called to Congress to share his observations about how earlier recommendations could have helped prevent or mitigate the disaster. He was also asked to join the team looking at ways to avoid future catastrophes. In the end, Galloway claims, Congress continued to demonstrate that managing flood risk is simply not a priority. The Senate would have done more had it been important to them, he says.

Still, some changes and improvements recommended after Katrina were implemented. New Orleans adopted a perimeter storm damage risk reduction system as well as interior storm management and pump systems. In the days following Hurricane Ida, it was clear that most of those fixes worked, notwithstanding various other infrastructural problems in the region.

Galloway believes the key to making New Orleans

*His discussion of the fate of many of his studies and task force reports somewhat resembled an autopsy. In most cases the cause of a report's demise was politics.*

more resilient in the future is understanding that, under current climate change scenarios, future storms will eventually overtop the levee system. Bigger levees are not enough, he insists. Strategies that anticipate the realities of climate change will be more effective than those that simply react. Sediment diversion projects are an example of such an anticipatory approach.

We asked about the Principles, Requirements and Guidelines (PR&G), updated in 2013 under the Obama Administration, that laid out broad principles to guide water investments. While Congress had initially supported these updates, Galloway explains, they later added riders to the legislation that prevented the Corps from implementing them.

Galloway is clearly exasperated as he retells these stories. He concludes that powerful interests do not want changes to the status quo. To emphasize, he throws up his hands, exclaiming, "Give me a break. At this point it's impossible to even embarrass the Congress."

#### **One Foot in Front of the Other**

Galloway is frustrated but recovers quickly. It is important, he says, to keep these setbacks in perspective: "You know, a lot of people ask me if I get discouraged after working on this for 60 years and not seeing things get done. I tell them, no, I don't. A lot of good things have happened."

Indeed, he likes to think of his work as "muddling through," to borrow a phrase from political scientist Charles Lindblom. For Galloway, flood risk management is an iterative process rather than a linear one. "As much as you want to just keep moving forward, it is more like two steps forward and a quarter back, then two steps forward and then more back."

As a senior statesman, Galloway continues to provide counsel and bring attention to the nation's flood management needs. He also believes he has an obligation to continue "building the bench" and mentoring and coaching flood management professionals. He sees work to be done and, despite the occasional step backward, intends to keep putting one foot in front of the other. ■

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# FEATURE

## Flood Memories as a Catalyst for Change

*Lisa Beutler*



The Great Flood of 1993 inundated Missouri farmland. Source: Paul Hein, istockphoto.com.

**IT WAS UNEXPECTEDLY WET THAT FALL. THE SOIL IN THE** upper Midwest was moist and the reservoirs were high. Then as winter turned to spring, the rain began again. Voluminous and relentless, it pounded nine states and 400,000 square miles. By late May 1993 some levees along the Mississippi and Missouri Rivers began to fail—and the rain didn't stop. At some locations [National Weather Service records](#) documented flooding lasting for nearly 200 days. The destruction totaled more than anyone at the time could have previously imagined. By count of the [United States Geological Survey](#), flooding led to 47 flood deaths, evacuation of 54,000 people from their homes, and inundation of at least 75 whole towns. In terms of dollars, it was the most severe flood in U.S. history.

The people who once thought their communities were safe from rivers demanded to know how so much could go wrong. The media focused on the flood and then its aftermath, bombarding the nation with pictures of

devastation. Flood and wetlands professionals convened to discuss issues surrounding the flood. All were asking the same basic questions: What was the extent of the flood damage? Why was it so severe and widespread? And what needs to change to keep this from happening again?

In response, President Bill Clinton summoned a team of experts to conduct a postmortem and answer the hard questions. Brigadier General Gerald Galloway, a respected former West Point dean with 30 years of experience with the U.S. Army Corps of Engineers, was tapped to lead the Interagency Floodplain Management Review Committee. The 31-member group included federal engineers and physical, social, and biological scientists, who contributed technical and institutional knowledge on how to reduce flood damage and manage river basin ecosystems.



### A Call to Action Issued ...

The committee delivered its report, [Sharing the Challenge: Floodplain Management into the 21st Century](#), commonly referred to as the Galloway Report, to the White House in 1994. Key recommendations included a call for strict new limits on building in the nation's floodplains and protection of wetlands, which slow flooding and serve as buffers against storms. Unambiguous, it included 60 separate actions, goals, and recommendations for floodplain management and featured statements such as "rainfall and floods like the 1993 event will continue to occur" and "floods are natural repetitive phenomena."

It was a bold call to action, declaring, "Now is the time to organize a national effort to conduct effective and efficient floodplain management and to share responsibility and accountability for accomplishing floodplain management among all levels of government and with the citizens of the nation."

### ... and Disregarded

Fast forward to August 2005. Hurricane Katrina pummeled New Orleans and the surrounding areas, causing more than 1,800 deaths and damage totaling \$125 billion. Once again, the levees failed, new flood

records were set, and General Galloway was summoned to Congress to discuss what had changed since his 1994 report.

By this time, Galloway, in his late sixties, was a professor at the University of Maryland. During the 2006 hearings on Katrina, the general, with the same pragmatism displayed in his namesake 1994 report, replied that the committee's recommendations ended up in the "government's 'too hard' box ... and floated in a bureaucratic malaise over the next years until the memory of the flood faded away." He continued, "And I will tell you that that's the challenge, because the half-life of a memory of a flood is very short. And even with something as disastrous as the Mississippi or New Orleans flood, it won't be long before people have let it slip off their radar screens."

But is it true? Is the half-life memory of floods short? Somewhere in our DNA is a story of a great flood. The stories exist in nearly every culture, and many pre-date biblical accounts of flooding. How do we not remember? What can we learn if we don't remember?

### Measuring the Life Span of Flood Memories

In recent years researchers have considered the impact of flood memories on human behavior.



One way to remember? High water marks on two houses provide evidence of the Great Flood of 1993. Source: Paul Hein, istockphoto.com.



Environmental sciences faculty at the Czech University of Life Sciences considered this topic in their 2019 paper ["How Long Do Floods throughout the Millennium Remain in the Collective Memory?"](#) They hypothesized that communities possess a collective historical memory of extreme phenomena, such as catastrophic floods, which leads community members to live in safer locations. To test their ideas, the researchers cross-referenced information about 1,293 settlements founded over the course of nine centuries with seven extreme flood events.

The historical memory, they found, did not last long: "For a period of one generation after each flood, new settlements appeared in safer places. However, respect for floods waned in the second generation and new settlements were established closer to the water." They concluded, "Flood memory depends on living witnesses and fades away within two generations. Historical memory is not sufficient to protect human settlements from the consequences of rare catastrophic floods."

A 2016 paper, ["Sustainable Flood Memory: Remembering as Resilience,"](#) drew upon research findings on the 2007 floods in the southwest of England. The authors hypothesized that memories of flooding could be used to catalyze action and create resilience in managing for future floods. Through interviews and reviews of official documents, they learned that flood memories were modulated by how the prior flood was perceived—and not all such memories were negative.

Furthermore, they found that memories require maintenance: "Flood memory [is] travelling, across settings as well as through time. The vehicles by which

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it moves (in minds, media or archives) require continued connection and communication." Local communities, academics, and policy makers, they argue, should work proactively preserve flood memories in productive ways. "The extent to which flooded communities can take ownership of their own flood materialization (from hard engineering to storytelling) may have an important function for resilience. . . . Therefore, the role of the social, creative and cultural plays just as significant a part in remembering as defense

systems, barriers and dredging."

#### **Doomed to Repeat?**

The Galloway Report and others since offered straightforward, proven approaches to preparing for and managing catastrophic flood events. Yet for a variety of reasons, change has been difficult to implement. Looking forward, we may do well to consider Winston Churchill's words: "Those that fail to learn from history are doomed to repeat it." The flood community's next course of action may need to include processes to keep the memories of floods and the lessons learned alive. Without these memories, decision makers and those living and working in floodplains are likely to misunderstand the risks they face and be unable to undertake truly informed actions. ■

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## FEATURE

# Riparian Urbanism: New Ways for Cities to Respond to Climate Change

Josiah Raison Cain



Many cities, like San Antonio, have reclaimed waterfront land, but climate change is pushing urban leaders to consider their riparian areas in a broader ecological context. Source: 4kodiak, istockphoto.com.

### DO YOU REMEMBER THE TIME A NATIONAL HOCKEY

League game was rained out? Even if you're a hockey fan, you may not. It's only happened once, in March 1995. As parts of downtown San Jose, California, sat underwater, a San Jose Sharks game had to be canceled. That winter, undersized bridges created bottlenecks as debris and storm flows pulsed through overstressed channels. Water flowed onto city streets. It wasn't the first time San Jose had been under water, nor would it be the last, and San Jose is just one of many cities that have struggled with flooding from their creeks and rivers.

The world's major cities often sprang up alongside rivers and waterways. These vital waterfronts supplied transportation, commerce, and sometimes energy. Less romantically, the same rivers were convenient dumping grounds for sewage and waste. As city dwellers moved to the suburbs, they altered the landscape, removing vegetation and soil, grading land surfaces, and constructing large-scale drainage networks. Because these alterations changed the way water moved, they led to increased water volumes and peak flows and more frequent floods. In many urban zones, rivers were

barricaded to prevent flooding. With the waterways out of sight, proliferating industrialization and development brought unmitigated pollution and degraded urban river ecosystems. For many in power, the resulting decline was just the price of "progress."

Then, something changed. On June 22, 1969, a massive fire on Cleveland's Cuyahoga River captured the attention of *Time* magazine and eventually the nation. *Time's* shocking photos were accompanied by headlines describing a river that "oozes rather than flows" and in which a person "does not drown but decays." The searing images brought home the consequences of abandoning the waterfront. Although it was not the first river fire, the polluted state of the Cuyahoga River mobilized new public concern that helped spur the Clean Water Act and more.

Since then, many cities have reclaimed their waterfronts. With industrial activities moving out of the urban core, cities have leveraged marginal and underutilized public spaces along rivers and waterfronts to create public amenities. Celebrated projects in places as diverse as Brooklyn, San Antonio, Providence,

Greenville, Reno, Tampa, Pittsburgh, Louisville, Denver, and Chicago are breathing new life into their communities.

Urban waterway projects bring their own complications, however. Cities must still manage floods, public access, water quality, and environmental regulation compliance. Climate change presents additional challenges, especially regarding flood management. On the West Coast, dry season flows often degrade water quality and habitat value. Community support for new projects is needed, but it can be notoriously difficult to engage stakeholders, and agencies often have competing responsibilities along rivers. The pressures on urban river corridors to provide open space, habitat, flood protection, and other benefits can overwhelm the people involved, resulting in compromises that produce undesirable outcomes.

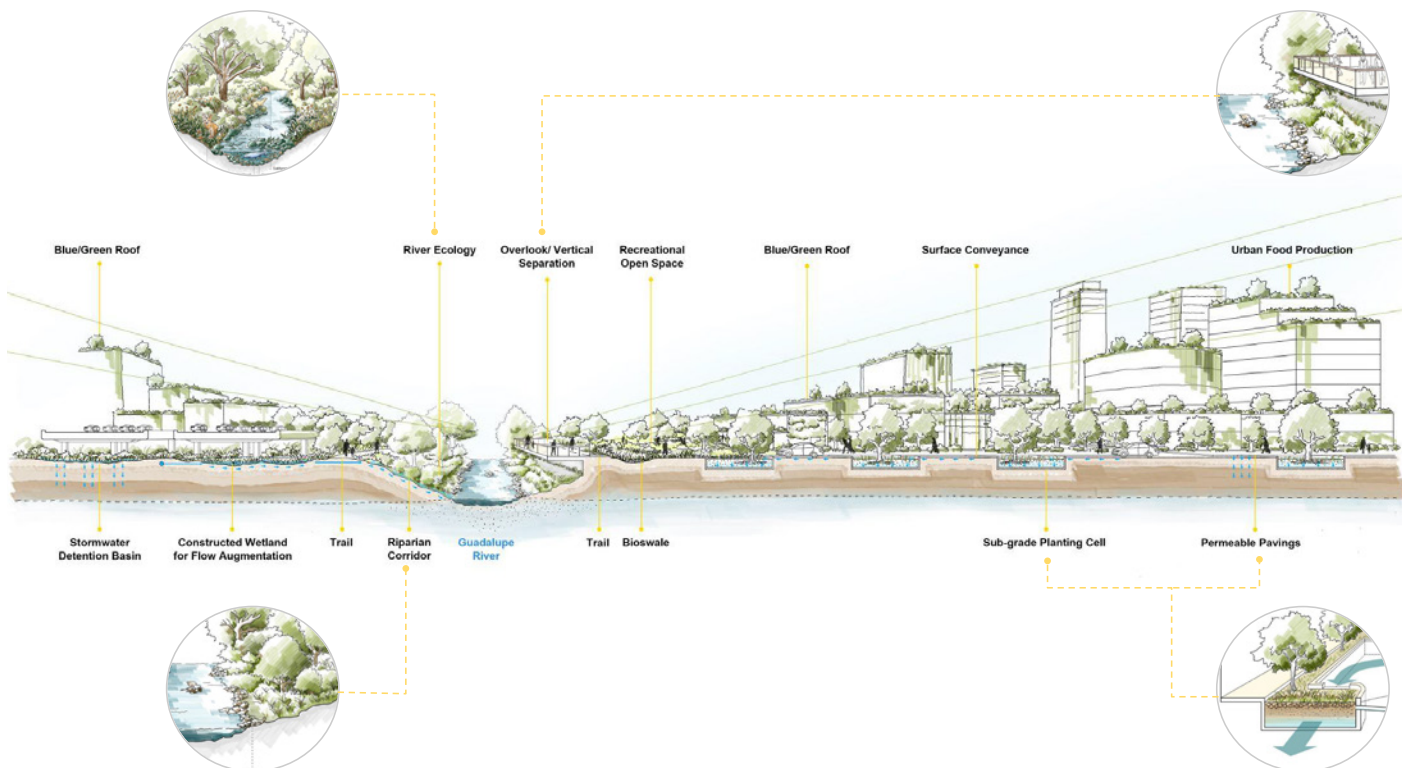
Today, in the face of climate change, San Jose, like other cities, is rethinking its love-hate relationship with

*As rainfall grows more frequent and intense, it exacerbates the problems associated with impervious surfaces, piped stormwater, and other characteristics of urban systems.*

its waterways. Although most such cities have already undertaken waterway projects offering multiple benefits, a paradigm shift is underway that puts water management in the context of a full river system. The new paradigm—riparian urbanism—considers rivers complex and dynamic systems, not limited to just the visible channels.

#### Cities as Part of River Systems

Rivers are the result of design and management decisions within an entire drainage area, including the city itself. In natural systems, rivers typically expand and contract as flows fluctuate in response to upstream precipitation and corresponding groundwater dynamics. It is easy to see the associated changes in the landscape through the unique vegetation patterns on either side of a river, along the riparian corridor. In contrast, most urban rivers are limited to the space within a constricted channel. When problems arise, they are generally addressed within the channel. Although



This schematic of a proposed riparian urbanism approach to San Jose's Guadalupe River shows the wide range of functions and amenities the river and its environs can provide. Source: Sherwood Design Engineers.



advances in green infrastructure, engineering strategy, and corresponding policy have helped improve water quality and flood management regimes, they are rarely implemented at a scale large enough to address watershed problems. Furthermore, pressures from climate change demand a full rethinking of the constrained urban channels that flood

control agencies struggle to maintain safely. As rainfall grows more frequent and intense, it exacerbates the problems associated with impervious surfaces, piped

*Riparian urbanism proposes an expanded approach to urban rivers and tributaries that leverages the many benefits offered by urban river systems.*

stormwater, and other characteristics of urban systems.

Riparian urbanism proposes an expanded approach to urban rivers and tributaries that leverages the many benefits offered by urban floodplains and river systems. Contextualizing the urban fabric as riparian suggests a relationship to water and

ecology that intrinsically connects a stream or river corridor to the city. A corridor of perhaps 1,000 feet adjacent to an urban stream or river can conceivably be

## Case Study: San Jose's Guadalupe River Park

A recent planning study on the expansion of Guadalupe River Park in San Jose offers an example of the potential of riparian urbanism. The goals of the expansion include supporting ecology, improving user experience and public access, and increasing the sustainability and resilience of the downtown district. A "blue-green San Jose" would leverage proposed redevelopment to incorporate riparian urbanism strategies that mimic natural hydrology while benefiting the city through integrated water management and green infrastructure.

When it opened in 2005, Guadalupe River Park was a model for community-friendly flood protection infrastructure and public space design. An innovative design made its flood control features both environmentally sensitive and inviting. With trails for public access, it is San Jose's largest urban park, running along the west side of downtown for 2.6 linear miles. Sadly, even though it still provides flood protection benefits, the park has fallen on hard times. In a region with exceptionally high housing costs, homeless residents have claimed the riverbanks as shelter. The park also suffers from a lack of consistent maintenance and amenities such as vegetation management and sufficient lighting. As a result, a survey of 1,000 San Jose residents (some of whom are regular park goers) reported being less likely to visit Guadalupe River Park than other city parks.

During the past few years, the park has gotten a second look. Plans to bring improved mass transit to a station flanking the park have rekindled interest in the area. Notable corporate entities like Google are planning investments in jobs and housing. And with growing support for urban parks, it may be possible to leverage state funding to improve the park.

I was part of the team that completed preliminary evaluations of underutilized public land, unbuildable lots, and municipal rights-of-way. Our task was to suggest new opportunities to minimize flooding, manage stormwater and hydrology in the context of ecology, support public access, and improve the continuity of open space. In aggregate, these parcels amount to a substantial opportunity to address the runoff that currently discharges directly into the Guadalupe River. Using the spatial framework we developed, we evaluated additional factors, including albedo, shading, evapotranspiration, air flow, and air quality. Our results suggest that stacking functions can significantly improve the likelihood of success for investing in public space in urban settings. We have found similar results evaluating sections of Atlanta and Los Angeles.

Applying a riparian urbanism approach to the areas adjacent to the Guadalupe River can also potentially boost dry season streamflows to support native plants and animals while enhancing the city's long-term resilience. The most consistent source of water available for this purpose is recycled water. Treatment of wastewater, considered a progressive and somewhat novel method, has proven to be an effective strategy for combating seasonal dry flows that can harm local aquatic habitats. Wetlands can be used to treat stormwater, wastewater, or both along the periphery of the river, repurposing marginal areas such as underpasses. These wetland areas can also provide habitats and open space; California already has more than 100 active wetland treatment systems, many of which are open for public recreation.

Future work will be needed, but riparian urbanism offers great promise in building San Jose's resilience and responding to the stressors of climate change.

reimagined to maximize ecosystem services and green infrastructure performance to attenuate groundwater and surface water interactions, while providing a host of additional benefits. When the urban fabric is seen as part of the broader watershed, comprehensive green and blue infrastructure—such as parks, open spaces, ponds, wetlands, and much more—can operate as an extension of the riparian corridor in a way that promotes community and ecological wellness across a range of scales.

Beyond flood management, a whole range of benefits can arise from implementing high-performance green and blue infrastructure outside of the immediate river channel. These can include improved air quality and water quality, shading and cooling, open space access, public health, habitat, pedestrian and bicycle circulation, traffic calming, social equity, and increased real estate value. Focusing approaches to complex urban challenges on river systems, which often lie at the nexus of redevelopment and disparate stakeholder agendas, can offer a framework to galvanize civic efforts around a singular vision.

### Helping Rivers, Helping Cities

The goal of riparian urbanism is to understand, quantify, and implement a framework for an urban environment that performs several functions at once:

1. Accommodates changes in flood dynamics for adaptability and resilience
2. Slows, absorbs, retains, and reuses stormwater for non-potable uses
3. Improves water quality through a combination of pre-filtration and infiltration to groundwater
4. Expands habitat and other ecological functions and processes associated with stream corridors
5. Attenuates climate impacts, including reducing urban heat island effects and improving air quality
6. Provides connectivity and access to open space as a component of the public realm

*When the urban fabric is seen as part of the broader watershed, comprehensive green infrastructure can operate as an extension of the riparian corridor in a way that promotes community and ecological wellness across a range of scales.*

The benefits offered by riparian urbanism can also be modeled to compare scenarios and outcomes, combining results from hydrologic and terrestrial climate software and including public health, equity, and other elements. Such an approach to managing infrastructure in the public realm generates

stacked benefits for both ecology and human experience. In short, this approach helps both the river and the city. ■

Josiah Raison Cain ([jcain@sherwoodengineers.com](mailto:jcain@sherwoodengineers.com)) serves as Sherwood Design Engineers' director of innovation. His deep sustainable design experience and multidisciplinary approach provide insight and opportunities for optimization of the urban fabric through the integration of ecological systems with site and structure.

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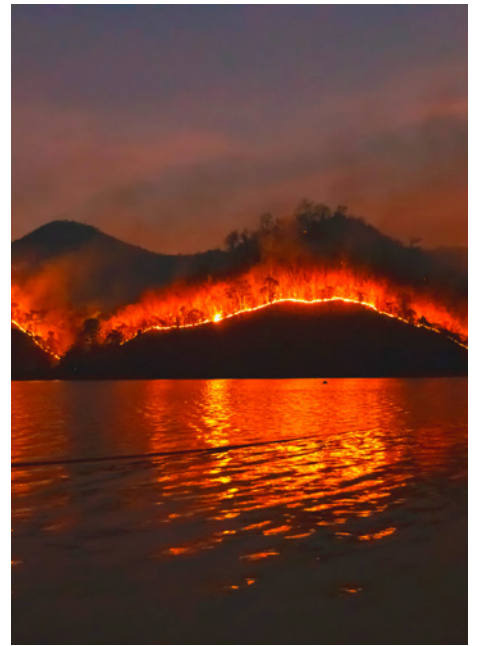
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# FEATURE

## Bridging the Equity Gap in Flood Risk Management

Hunter Merritt

**FLOODS CAN AFFECT EVERY PERSON AND EVERY** community—but not always equally. Some communities, particularly poorer communities that lack access to much-needed resources, struggle harder than others to prepare for and recover from floods. Climate changes are exacerbating these inequalities; tides are rising along coasts, atmospheric storms and river floods are coming harder and faster than ever before, hitting the places that have not been armored against flooding, and emergency response capabilities are feeling the strain.

Across the industry, water resources professionals from a variety of sectors are becoming increasingly aware of disparities in the disaster risk cycle (see Figure 1). Continued effort is needed, on the part of engineers and planners, to better understand the factors that contribute to the inequities facing the less resilient communities. These factors may include the agencies themselves, if they continue to depend upon antiquated policies, processes, and institutional systems that marginalize some individuals and communities.

To that end, the U.S. Army Corps of Engineers' National Flood Risk Management Program hosted the first in a series of virtual engagements titled [“Bridging the Equity Gap in Flood Risk Management”](#) in August 2021. The inaugural webinar, “Environmental Justice, Equity, and Flood Risk Management,” featured panelists who offered valuable insights into how environmental and social justice intersect with flood risk. The panelists also shared perspectives on how everyone—individuals, communities, and agencies—must work together to overcome the equity gap in flood risk management.

### Environmental Justice and Flood Risk Management Policy

Jerica Richardson, a senior policy advisor with the U.S. Army Corps of Engineers (USACE), kicked off the panel with a short history of federal policies centered on environmental justice and an introduction to emergent applications of the principles of environmental justice to contemporary challenges in flood risk management. To evaluate benefits from water resources projects, Richardson explained, USACE and other federal water management agencies apply the “Economic and Environmental Principles and Guidelines for Water

and Related Land Resources Implementation Studies.” These principles and guidelines, first codified in 1983 and recently updated (and renamed) in 2013, assist and direct evaluation of projects from four distinct lenses, often called the “four accounts”: National Economic Development (NED), Regional Economic Development, Environmental Quality, and Other Social Effects. The fourth account includes consideration of social and environmental justice.

Since 1983, NED has been the primary justification for federal water resources investments. However, as Richardson explained, this longstanding approach is beginning to change. Recent directives from the assistant secretary of the Army for civil works underscore the need to balance assessment priorities and place greater emphasis on the other accounts. In justifying projects, Richardson said to “look at all four accounts—that is what they are there for,” and she emphasized the agency’s aspiration toward alignment between existing and changing policy to address environmental justice priorities. Also, Executive Orders 13985 and 14008 call for an increased agency



Figure 1. The disaster risk management cycle illustrates USACE involvement in each quadrant, from response through recovery, mitigation, and preparation. Source: USACE Institute for Water Resources

investment in community engagement to identify equitable flood risk management solutions and collaboratively address water resources concerns.

The next webinar speaker, Dámaris Villalobos-Galindo—an engineer from Valley Water (formerly the Santa Clara Valley Water District) and a member of the Association of State Floodplain Managers' Social Justice Task Force—explored how environmental injustice and inequality can be seen in each quadrant of the disaster risk cycle. “When we talk about flood vulnerability, we often talk about people. In reality, it is the system that is vulnerable—natural, socioeconomic, and institutional.” Low-income and minority communities often lack the resources to adequately prepare for, respond to, recover from, and mitigate against floods. In other words, these communities exhibit a greater degree of flood vulnerability, which Villalobos-Galindo defined as “exposure plus susceptibility, minus resilience.” With this simple formula, Villalobos-Galindo explained how social and economic inequities compound the dangers of flood exposure.

### Preserving a Role for Mutual Aid

Top-down, government-based solutions are not the only way communities can protect themselves from flooding—in certain situations, it can be the least-favored option. Miriam Belblidia, co-founder and director of research and advocacy at Imagine Water Works, presented a history of mutual aid organizations. Mutual aid is as old as community itself: it consists of voluntary associations of individuals providing cooperative, reciprocal assistance. These organizations, such as the award-winning Mutual Aid Response Network, enjoy certain distinct advantages. As Belblidia pointed out, community members themselves are often the first responders in a disaster. Indeed, there is a long history of neighbors helping neighbors before emergency management can arrive, and the concept of self-help and mutual aid is well established in communities such as New Orleans.

Historically, Belblidia explained, mutual aid has been especially valuable in underserved and marginalized communities. Black mutual aid organizations, for example, have existed since at least the 1700s, grounded in the principles of resource sharing that came from the Haitian and French Revolutions. Since that time, associations across the country have formed to share resources and foster a sense of community but have often been eclipsed by government aid programs. “It is interesting to see how these associations, these mutual aid projects, come in response to social upheaval and then are often co-opted by government,” said Belblidia. “One famous example is the Black Panthers’ free breakfast program, which was co-opted by the federal government and then became the Department of

Agriculture’s school breakfast program.”

Grassroots mutual aid is rooted in the community itself. “Mutual aid is about solidarity, not charity,” said Belblidia. The examples she provided demonstrated the resilience that can be cultivated when communities band together and proactively pursue the common good.

### Step One: Empower the Community

All three panelists emphasized that government agencies must earn the trust of historically marginalized communities and involve them in decisions regarding how best to mitigate flood risks and respond to flooding events. Building trust and engaging communities is difficult, but it is also critical, as it provides an opportunity to empower those who are most affected, ensure their perspectives are represented, and engender ownership of the solution. Regional resilience is not a top-down or outside-in initiative. It must be led, owned, and understood by the community, while government plays a supporting role. “Think about what effect your job has. What is the impact on diversity, equity, and inclusion, leveling the playing field?” Villalobos-Galindo enjoined. “You might not think your job, for example in hydraulic modeling, has an impact, but it does.”

In closing, and with gratitude to the coordinators and speakers who participated in this inspirational webinar, the message is clear: community resilience discussions must occur in a variety of settings as we strive to bridge the equity gap in flood risk management. There is no single “owner” of the discussion—everyone has a part in these conversations, and every voice needs to be heard to articulate a shared vision of the future. The information revealed through these discussions must be shared across audiences and agencies so that they can collaborate to identify and holistically address inequities in flood preparedness and resilience. Addressing today’s flood problems, in other words, requires teamwork. These teams must include marginalized and disadvantaged communities, incorporating their perspectives. Working together, communities and government agencies can create a proverbial wave to lift all boats. ■

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## FEATURE

# A New Lens on Disaster Prevention, Response, and Recovery

Kevin Rowell



Hurricane Katrina and the associated flooding have become part of the collective American memory. Source: Imaginewithme, istockphoto.com.

**IN MARCH 2008, DANIEL GOLEMAN, AUTHOR OF THE** bestseller *Emotional Intelligence*, deconstructed the emotional impacts of Hurricane Katrina in an [article](#) in the magazine *Greater Good*. He was highlighting a phenomenon that he, and many of us, witnessed in the wake of the hurricane: “Leaders at the highest levels were weirdly detached, despite the abundant evidence on our TV screens that they needed to snap to action.”

Were leaders trying to remain “cool in a crisis,” as emphasized by traditional models of disaster response? That stance, Goleman noted, can come across as detachment and apathy. In the case of Katrina, he wrote, “The victims’ pain was exacerbated by such indifference to their suffering.”

As we prepare for future floods and other disasters, research on social intelligence—especially empathy—has lessons for policy makers and first responders about the

best way to handle themselves during such a crisis. But disaster professionals then need to go further to build a new way of interacting with communities.

### Understanding Trauma and Empathy

The American Psychological Association explains that trauma is an emotional response to a terrible event. Immediately after the event, shock and denial are typical. In the longer term, reactions include unpredictable emotions, flashbacks, strained relationships, and even physical symptoms like headaches or nausea.

Disaster is a special, collective kind of trauma, and floods are a special kind of disaster. Hurricanes and floods like Katrina, Sandy, and Maria are now part of the collective American memory. In the time that follows a catastrophe, individual survivors experience trauma that can last a lifetime, and collective trauma ripples through



the communities directly affected. As these ripples spread outward, they have physical, social, cultural, environmental, economic, and other kinds of impacts.

After more than two decades of international work as a shelter and building materials specialist, I have my own emotional memories that stick with me. The smell of burning tires and concrete dust

takes me back to the streets of Haiti in the days after the 2010 earthquake. Wiping sweat from my brow in searing heat reminds me of being inside the plastic tarp shelters that house the more than 1.2 million Rohingya refugees who fled genocide in Myanmar for refuge in Bangladesh. While we all respond differently to disaster, these kinds of emotional triggers keep me connected to my own experiences and help arouse the empathy needed to serve others in response to a disaster. It makes me think of the ways our collective human experience requires appreciation for our interdependence.

Not all empathy, however, is created equal. In his article, Goleman cites psychologist Paul Ekman, an expert on the ability to read and respond to others' emotions. Ekman defines three main forms of empathy: Cognitive empathy is knowing how other people feel and what they might be thinking, but because it does not involve internalizing others' emotions, it can leave people so detached that they do nothing to help sufferers. Emotional empathy is feeling what other people feel. This form of empathy also has a downside: if first responders, for instance, become overwhelmed with distressing emotions, they may find themselves paralyzed or emotionally exhausted. In situations of disaster, like floods and hurricanes, a third kind of empathy is more useful: compassionate empathy, which gives us an understanding of a person's predicament, allows us to feel with them, and moves us to help if needed. Compassionate empathy is not innate, says Ekman, but rather a skill, the acquired knowledge "that we're all connected."

### Recalibrating Flood Response

The institutions that oversee flood management prefer to prevent disasters before they happen rather than rely on response and recovery. This rational approach acknowledges that prevention is a less expensive choice. However, the resources necessary to create complete safety from flood events do not exist. So investments in prevention rely on risk assessments and cost-benefit calculations that privilege assets with higher perceived values. As a result, disadvantaged communities, cultural values, and nature itself often

*Disaster planning must be grounded in a genuine relationship that recognizes and engages the knowledge and abilities of a community.*

take a back seat in the decision-making process. In fact, some flood survivors have experienced well-meaning disaster prevention, response, and prevention approaches as re-traumatizing.

We need to recalibrate traditional responses to flood disasters. Of course, immediate assistance, such

as emergency relief and search and rescue, is critical. Even though responders are directed to tailor activities to a community's characteristics, their primary goal is to meet people's basic needs until recovery begins. Then, recovery actions aim to bridge the gap between emergency and normalcy. But what exactly is normal in the context of climate change? Is normal appropriate when the pre-disaster state was already adverse? What gap is being bridged when the trauma is not temporary?

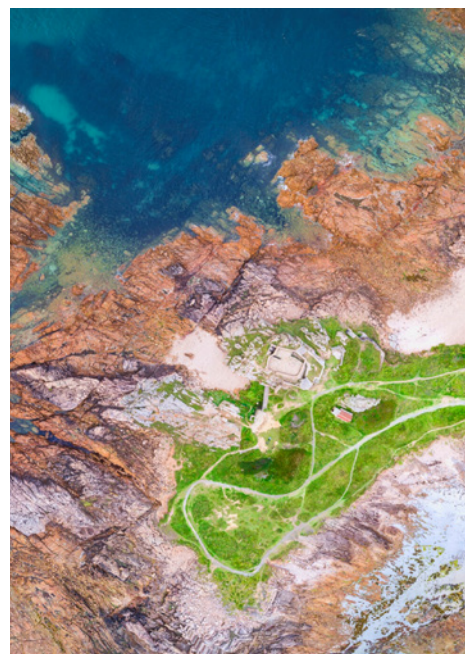
As we try to answer these questions, another principle beyond empathy may serve as a foundation for future action. We know that humans thrive when they exercise their ability—that is, when they have agency—to make decisions about their lives. Disaster planning must therefore incorporate the voices and decision-making capacity of all at-risk communities. It must be grounded in a genuine relationship that recognizes and engages the knowledge and abilities of a community. This [strength-based approach](#), as described by researchers John P. Kretzmann, John L. McKnight, and others, is built on four pillars:

1. It focuses on community assets and strengths rather than problems and needs.
2. It identifies and mobilizes individual and community assets, skills, and passions.
3. It is community driven and builds communities "from the inside out."
4. It is relationship driven.

Disaster professionals face a host of complex issues, especially in a world of climate change, but compassionate empathy and a new kind of relationship with those we serve are the beginning of this unfolding journey. ■

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Kevin Rowell ([kevin@wickedops.com](mailto:kevin@wickedops.com)) is a building technology expert with more than two decades of experience working in international development, community resilience, and disaster recovery. He is passionate about scaling up regional environmental solutions for the housing crisis globally. Previous clients include United Nations agencies, recovery and refugee NGOs, and tech development companies. He is owner and cofounder of Natural Builders ([www.naturalbuilding.com](http://www.naturalbuilding.com)).



## AWRA 2022 SPECIALTY CONFERENCE: GEOSPATIAL WATER TECHNOLOGY

GIS has come a long way and the very term “GIS” doesn’t mean the same thing as it did many years ago. Data, tools, models, and good cartography are still incredibly important. Many of us still perform much of our geospatial work on desktop computers. But we have moved beyond desktops and floodplain mapping to the cloud and to decision-making and web-based applications that are integral to ecology and society. As GIS has changed, our biennial GIS and Water Resources conference is changing too!

This conference is designed around geospatial solutions to water resources-related problems. Innovative water resources scientists, engineers, modelers, and software designers from public/government agencies, academia, and private sector convene to exchange ideas, compare challenges, and identify solutions. If your aquatic research, management, and conservation involves process models, geo-referenced field data, remote sensing, or geostatistical models, then this is the right conference for you.

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October 16, 2021

- Call for Topical Sessions & Workshops

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- David R. Maidment Award Nominations Due

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# JAWRA Featured Collection – June 2023

## Water Risk Under a Rapidly Changing World - Evaluation & Adaptation

The Journal of the American Water Resources Association (JAWRA) is planning this Featured Collection to highlight and build upon contributions from the [AWRA 2022 Spring Conference](#) on Water Risk Under a Rapidly Changing World - Evaluation & Adaptation. This conference is scheduled for April 24-27, 2022 at Tuscaloosa, Alabama, USA.

### Featured Collection Theme:

- Manuscripts will be considered on research related to any of the [conference themes](#).
- Authors who plan to submit a manuscript to the Featured Collection issue of JAWRA are encouraged to present their work at the conference.
- The Featured Collection is planned to be published in June 2023.
- The accepted papers will be accessible immediately on the JAWRA webpage and will be fully citable.

Water risk is an ongoing concern due to rapid population growth, urbanization, increased frequency of extreme climate events, long-term trends in sea-level rise and melting glaciers, degraded landscapes, aging infrastructure, and unequitable access to clean drinking water. For the 2022 Specialty Conference and the Feature Collection, the term “risk” is used in its broadest sense to reflect its multidimensional nature and includes both risks from natural disasters, such as flooding and drought, and the consequent landslide, water scarcity, and further infrastructure failure and public health issues. The COVID-19 pandemic raised public awareness of the importance of universal and equitable access to water, sanitation, and hygiene as a critical public health issue. Wildfires on the West Coast and the dam failure in central Michigan in 2020 are other examples of the urgency of better evaluating and adapting to climate and water risks. It is imperative that water professionals from various sectors collaborate and share cutting-edge solutions to future risks.

**Contact:** To propose a manuscript for inclusion in the JAWRA Water Risk Featured Collection, please contact [jawra-eic@awra.org](mailto:jawra-eic@awra.org) or [jawra@awra.org](mailto:jawra@awra.org) or any guest editors.

## SCHEDULE

### January 15, 2022:

Notice of Intent (NOI) to submit a JAWRA article for consideration.

### May 1- July 31, 2022:

Submission window for full JAWRA manuscripts.

### June 2023:

Publication of Featured Collections in JAWRA.

### Learn more at:

[2022AWRASpringConference](https://2022AWRASpringConference.org)

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