Houston's Flood Is a Design Problem

It’s not because the water comes in. It’s because it is forced to leave again.

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Floods cause greater property damage and more deaths than tornadoes or hurricanes. And Houston’s flood is truly a disaster of biblical proportions: The sky unloaded 9 trillion gallons of water on the city within two days, and much more might fall before Harvey dissipates, producing as much as 60 inches of rain.

Pictures of Harvey’s runoff are harrowing, with interstates turned to sturdy and mature rivers. From Katrina to Sandy, Rita to Tōhoku, it’s easier to imagine the flooding caused by storm surges wrought by hurricanes and tsunamis. In these cases, the flooding problem appears to be caused by water breaching shores, seawalls, or levees. Those examples reinforce the idea that flooding is a problem of keeping water out—either through fortunate avoidance or engineering foresight.

But the impact of flooding, particularly in densely developed areas like cities, is far more constant than a massive, natural disaster like Harvey exposes. The reason cities flood isn’t

because the water comes in, not exactly. It's because the pavement of civilization forces the water to get back out again.

There are different kinds of floods. There's the storm surge from hurricanes, the runoff from snowmelt, the inundation of riverbanks. But all these examples cast flooding as an occasional foe out to damage human civilization. In truth, flooding happens constantly, in small and large quantities, every time precipitation falls to earth. People just don't tend to notice it until it reaches the proportions of disaster.

Under normal circumstances, rain or snowfall soaks back into the earth after falling. It gets absorbed by grasslands, by parks, by residential lawns, by anywhere the soil is exposed. Two factors can impede that absorption. One is large quantities of rain in a short period of time. The ground becomes inundated, and the water spreads out in accordance with the topography. The second is covering over the ground so it cannot soak up water in the first place. And that's exactly what cities do—they transform the land into developed civilization.

Roads, parking lots, sidewalks, and other pavements, along with asphalt, concrete, brick, stone, and other building materials, combine to create impervious surfaces that resist the natural absorption of water. In most of the United States, about 75 percent of its land area, less than 1 percent of the land is hardscape. In cities, up to 40 percent is impervious.

The natural system is very good at accepting rainfall. But when water hits pavement, it creates runoff immediately. That water has to go somewhere. So it flows wherever the grade takes it. To account for that runoff, people engineer systems to move the water away from where it is originally deposited, or to house it in situ, or even to reuse it. This process—the policy, planning, engineering, implementation, and maintenance of urban water systems—is called stormwater management.

The combination of climate change and aggressive development made an event like this almost inevitable.

According to my Georgia Institute of Technology colleague Bruce Stiftel, who is chair of the school of city and regional planning and an expert in environmental and water policy governance, storm water management usually entails channeling water away from impervious surfaces and the structures built atop them. In other words, cities are built on the assumption that the water that would have been absorbed back into the land they occupy can be transported away instead.

Like bridges or skyscrapers designed to bear certain loads, storm water management systems are conceived within the limits of expected behavior—such as rainfall or riverbank overrun events that might happen every 10 or 25 years. When these intervals are exceeded, and the infrastructure can't handle the rate and volume of water, flooding is the result.

Houston poses both a typical and an unusual situation for stormwater management. The city is enormous, stretching out over 600 square miles. It's an epitome of the urban sprawl characterized by American exurbanism, where available land made development easy at the edges. Unlike New Orleans, Houston is well above sea level, so flooding risk from storm surge inundation is low. Instead, it's rainfall that poses the biggest threat.

A series of slow-moving rivers, called bayous, provide natural drainage for the area. To account for the certainty of flooding, Houston has built drainage channels, sewers, outfalls, on- and off-road ditches, and detention ponds to hold or move water away from local areas. When they fill, the roadways provide overrun. The dramatic images from Houston that show wide, interstate freeways transformed into rivers look like the cause of the disaster, but they are also its solution, if not an ideal one. This is also why evacuating Houston, a metropolitan area of 6.5 million people, would have been a terrible idea. This is a city run by cars, and sending its residents to sit in gridlock on the thoroughfares and freeways designed to become rivers during flooding would have doomed them to death by water.

Accounting for a 100-year, 500-year, or "million-year" flood, as some are calling Harvey's aftermath, is difficult and costly. Stiftel confirms that it's almost impossible to design for these "maximal probable flood events," as planners call them. Instead, the hope is to design communities such that when they flood, they can withstand the ill effects and support effective evacuations to keep people safe. "The Houston event seems like an illustration that we haven't figured it out," Stiftel says.

Many planners contend that impervious surface itself is the problem. The more of it there is, the less absorption takes place and the more runoff has to be managed.

Reducing development, then, is one of the best ways to manage urban flooding. The problem is, urban development hasn't slowed in the last half-century. Cities have only become more desirable, spreading outward over the plentiful land available in the United States.

The National Flood Insurance Program, established in 1968, offered one attempt at a compromise. It was meant to protect and indemnify people without creating economic catastrophe. Instead of avoiding the floodplain, insurance allowed people to build within it, within management constraints recommended by FEMA. In theory, flood-hazard mitigation hoped to direct development away from flood- prone areas through the disincentives of risk insurance and regulatory complexity.

Sometimes "living with water" means sidestepping the consequences.

Since then, attitudes have changed. For one part, initial avoidance of floodplains created desirable targets for development, especially in the middle of cities. But for another, Stiftel tells me that attitudes about development in floodplains have changed, too. "It's more about living

with water than it is about discouraging development in areas prone to risk."

Sometimes "living with water" means sidestepping the consequences. Developers working in flood zones might not care what happens after they sell a property.

That's where governmental oversight is supposed to take over. Some are more strict than others. After the global financial crisis of 2008, for example, degraded local economies sometimes spurred relaxed land-use policy in exchange for new tax bases, particularly commercial ones.

In other cases, floodplains have been managed through redevelopment that reduces impervious surfaces. Natural ground cover, permeable or semi-permeable pavers, and vegetation that supports the movement of water offer examples. These efforts dovetail with urban redevelopment efforts that privilege mixed-use and green space, associated with both new urbanism and gentrification. Recreation lands, conservation lands and easements, dry washes, and other approaches attempt to counterbalance pavement when possible. Stiftel cites China's "sponge cities" as a dramatic example—a government-funded effort to engineer new, permeable materials to anticipate and mitigate the flooding common to that nation.

But Thomas Debo, an emeritus professor of city planning at Georgia Tech who also wrote a popular textbook on stormwater management, takes issue with pavement reduction as a viable cure for urban flooding. "We focus too much on impervious surface and not enough on the conveyance of water," he tells me. Even when reduced in quantity, the water still ends up in in pipes and concrete channels, speeding fast toward larger channels. "It's like taking an aspirin to cure an ailment," he scoffs. Houston's flooding demonstrates the impact. Instead, Debo advocates that urban design mimic rural hydrology as much as possible. Reducing impervious surface and improving water conveyance has a role to play, but the most important step in sparing cities from flooding is to reduce the velocity of water when it is channelized, so that it doesn't deluge other sites. And then to stop moving water away from buildings and structures entirely, and to start finding new uses for it in place.

That can be done by collecting water into cisterns for processing and reuse—in some cases, Debo explains, the result can even save money by reducing the need to rely on utility-provided water. Adding vegetation, reclaiming stormwater, and building local conveyance systems for delivery of this water offer more promising solutions.

Though retired from Georgia Tech, Debo still consults on the campus's local stormwater management efforts. In one case, the institute took a soccer field and made it into an infiltration basin. Water permeates the field, where it is channeled into pipes and then into local cisterns.

A centralized approach to stormwater management is a pipe dream.

In Houston's case, catastrophic floods have been anticipated for some time. The combination of

climate change, which produces more intense and unpredictable storms, and aggressive development made an event like this week's almost inevitable. The Association of State Floodplain Managers has called for a national flood risk-management strategy, and the Houston Chronicle has called flood control the city's "most pressing infrastructure need." A lack of funding is often blamed, and relaxed FEMA regulations under the Trump Administration won't help either.

But for Debo and others, waiting for a holistic, centralized approach to stormwater management is a pipe dream anyway. Just as limiting impervious surface is not the solution to urban stormwater management, so government-run, singular infrastructure might not be either. "It's much more difficult, and a much bigger picture," Debo insists to me. "There is no silver bullet for stormwater management."

One problem is that people care about flooding, because it's dramatic and catastrophic. They don't care about stormwater management, which is where the real issue lies. Even if it takes weeks or months, after Harvey subsides, public interest will decay too. Debo notes that traffic policy is an easier urban planning problem for ordinary folk, because it happens every day.

So does stormwater—it just isn't treated that way. Instead of looking for holistic answers, site-specific ones must be pursued instead. Rather than putting a straight channel through a subdivision, for example, Debo suggests designing one to meander through it, to decrease the velocity of the water as it exits.

The hardest part of managing urban flooding is reconciling it with Americans' insistence that they can and should be able to live, work, and play anywhere. Waterborne transit was a key driver of urban development, and it's inevitable that cities have grown where flooding is prevalent. But there are some regions that just shouldn't become cities. "Parts of Houston in the floodway, parts of New Orleans submerged during Katrina, parts of Florida—these places never should have been developed in the first place," Debo concludes. Add sea-level rise and climate-change superstorms, and something has to give.

Debo is not optimistic about resisting the urge toward development. "I don't think any of its going to happen," he concedes. "Until we get people in Congress and in the White House who care about the environment, it's just going to get worse and worse."

Even so, there's reason for optimism. If good stormwater management means good, site-specific design, then ordinary people have a role to play, too. Residential

homeowners who install a new cement patio or driveway might not even realize that they are channeling water down-grade to their neighbors, or overwhelming a local storm drain. Citizens can also influence stormwater issues within their municipalities. Many folks know that they have a local city council and school board, but local planning, zoning, and urban design agencies also

hold regular public meetings—unfortunately, most people only participate in this aspect of local governance when they have an axe to grind. For the average American concerned with the deluge, the best answer is to replace an occasional, morbid curiosity with flooding with a more sophisticated, long-term interest in stormwater management.

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