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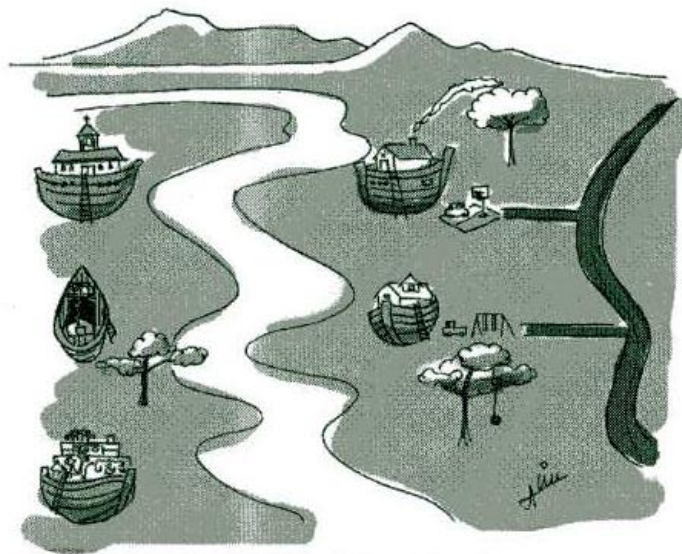
Chapter 14

Flood Risk Management in 2050

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ABSTRACT

Today the United States faces increasing annual flood damages. Climate change and sea level rise will only exacerbate this problem. In spite of over 74 years of flood control and 42 years of floodplain management, the challenge continues. We cannot control floods or even focus on simply reducing damages, but rather must identify and manage our growing flood risks. Over the next 40 years, if action is not taken to deal with the problem, it will grow substantially worse. Climate change, population growth, unbridled development in hazardous areas, and a lack of personal responsibility on the part of individuals subject to flooding will lead to an untenable situation by the middle of the 21st century. With attention to these opportunities, the American floodplain of the future can be far different than it is today. Civil engineers are at the nexus of this challenge and must take on the task of ensuring that the floodplain of 2050 is sustainably developed and managed. This chapter provides a positive vision of how the floodplains of 2050 might appear if appropriate measures are taken by governments and the public at large in the years ahead. It is based on the results of the 2007 Association of State Floodplain Managers Foundation Gilbert F. White National Flood Policy Forum that examined this topic.



“Sustainable Floodplain Development”

YEARS OF FLOODS

Floods have been a constant part of American history. Early eastern colonists battled overflows from the Delaware River into nearby agricultural lands. At the start of the 18th century, the founders of New Orleans initiated levee building to protect their growing city. Over time, as the nation moved to the west, it established its towns and cities alongside rivers, the principal highways for movement of goods and people. As these new communities grew, they had to address the problems of periodic flooding. By the middle of the 19th century, the federal government began to take limited actions to reduce flood losses, and, as the 20th century began, it actively assisted states and municipalities in dealing with the flood challenge. Major floods in 1927 and 1936 caused Congress to reevaluate the federal role and legislate a national approach to flooding that would drive federal and state efforts for the rest of the 20th century. The Flood Control Act of 1936 defined the method by which engineers would address flooding - *control* the waters by keeping them off the land, storing them behind dams, and speeding them to the oceans through channel works and floodways. Acts of 1928 and 1936 targeted at the lower Mississippi Valley were focused on preventing disasters - no more destructive flooding. These acts led to the construction of large systems such as the Mississippi River and Tributaries project that still protects the lower Mississippi Valley from Cairo, Illinois to the Gulf of Mexico against inundation, as well as countless smaller projects designed to protect individual communities, agricultural areas, and critical infrastructure.

The environmental movement of the 1960s, coupled with the growing knowledge of the work of the University of Chicago geographer Gilbert F. White, who focused on adjusting human use of the floodplain to avoid flood losses as opposed to protecting humans in the floodplain from flooding, began to slow down the construction of large flood control structures and to seek alternative approaches - nonstructural methods - to deal with flooding. These methods included land-use controls to prevent unwise development in the floodplain, floodproofing and elevation of structures, acquisition of most frequently flooded lands, use of natural storage of flood waters in upstream wetlands and the development of early warning systems to permit timely evacuation of flood hazard areas. In 1968, Congress established the National Flood Insurance Program (NFIP) to sell previously unavailable insurance to those at risk in the floodplain. Today over 20,000 communities and more than 5.7 million policyholders participate in the program.

In 1993, the Midwest was devastated by massive flooding that took 38 lives and caused over \$16 billion in damages in eight Midwestern states. Because the flooding was extensive (water remained in homes and on the land in some places for over six months) the nation was exposed through media coverage to the devastation and human trauma that resulted from this flood. Calls for action in Congress and by the Administration led to a White House study of the flood's causes and the development of recommendations to deal with future such events. The Interagency Floodplain Management Review Committee (IFMRC) report, which was issued in 1994, indicated that although the flood was a significant event, floods of that magnitude

were natural events and would continue to occur. It pointed out that national flood damages were growing and that people and property across the country were at risk. It noted that occupation of the floodplain and attempts to protect those in the floodplain had caused significant environmental damage and threatened ecosystems that provided substantial goods and services to both the natural and human environment. The report acknowledged that flood control structures had prevented \$18 billion in damages during the 1993 flood, and it recommended that, in moving forward with efforts to reduce flood damages, the nation should not only strive to reduce flood losses, but also concurrently protect and enhance the floodplain's natural environment. The report offered a vision for the future of the floodplain that would carefully balance the use of both structural and nonstructural methods to bring about both sustainable occupation of lands that were already the home for many long settled communities and important for the conduct of commerce, as well as ensuring that the degradation of riverine and coastal ecosystems was reversed (IFMRC 1994). Although there was some support for action on the recommendations, other national priorities moved onto the scene and the report was soon forgotten.

The 1993 Mississippi River Flood was another wake up call for improved floodplain management, but once again the nation went back to sleep.

INTO THE 21ST CENTURY

While non-governmental organizations, such as the Association of State Floodplain Managers (ASFPM), pointed out the escalation of flood losses in the latter half of the 20th century, entreaties for a retrospective look at the national approach generally fell on deaf ears. Although these organizations were unable to promote any detailed examination by Congress of the flood problem, they were at least able to convince Congress to support a \$1 billion modernization of flood mapping by the National Flood Insurance Program (NFIP) in order to more accurately depict the threat faced by those who live in and near floodplains and coastal hazard areas.

On August 29, 2005, Hurricane Katrina smashed into the Louisiana-Mississippi Gulf Coast and inflicted massive damages on the people and the built and natural environment of the region. Over 1800 people lost their lives. The costs of property losses, response and recovery operations, and insurance claims payouts have not been completely identified but likely will exceed \$100 billion. Over 300 km² (120 mi.²) of the wetland buffer that existed between New Orleans and the Gulf were also destroyed by the hurricane. Four years after the hurricane, only 70% of the pre-Katrina population had returned to the region and many parts of the city of New Orleans and the Gulf Coast had yet to be restored or have plans made for their eventual resettlement or reuse (Galloway et al. 2009). Once again, just as it occurred after the 1993 Flood, the outcries about the need to deal with flooding were loud and the promises great. Some initial debate about alternative approaches to the restoration of below-sea level areas of New Orleans (move people out) were quickly seen to be impolitic and President George W. Bush appeared in that city on September 15, 2005

with a promise to make “ the flood protection system stronger than it has ever been.” Since 2005, the focus of federal effort in New Orleans has been on restoration of the hurricane protection system (levees, pumps and other structures) to a level that would protect the city against the 100-year (1% annual chance of occurrence) flood event, a level that is far less than the return interval of the approximately 400-year Katrina storm surge event.

The property losses, response and recovery operations, and insurance claims payouts resulting from the 2005 Katrina storm surge event likely will exceed \$100 billion.

Questions about why levees failed in New Orleans during the hurricane and why the destruction along the Mississippi coastline was so complete did bring calls for investigations, reviews, studies and Congressional hearings. Two reports by the US Army Corps of Engineers (USACE) dealt with the technical issues surrounding the levee failures as well as the flaws in the decision-making from Washington to New Orleans over the 40-year history of the New Orleans hurricane protection project (IPET 2009a, 2009b; Woolley and Shabman 2007). The Interagency Performance Evaluation Task Force (IPET) report was supplemented by reports from the American Society of Civil Engineers (ASCE 2008) and a blue ribbon panel of the National Research Council (NAE/NRC 2009). The Federal Emergency Management Agency (FEMA) commissioned an Interagency Levee Policy Review Committee (ILPRC) to examine how levees were treated in the NFIP (ILPRC 2006). The net result of the conduct of these studies, together with the attention of the Association of State Floodplain Managers (ASFPM) and the National Association of Flood and Storm Water Management Agencies (NAFSMA), was the identification of the fragile nature of tens of thousands of kilometers of levees across the entire nation and the need for evaluation of the condition of these levees (a conclusion also reached in IFMRC (1994)). This attention eventually led to the passage, in the Water Resources Development Act of 2007, of provisions to establish a national levee safety program (NCLS 2009).

FLOOD RISK MANAGEMENT

In recognition of the gradual shift away from a structural-only approach, during the last decades of the 20th century organizations such as FEMA and the USACE began to drop use of “flood control” in favor of “flood damage reduction” in describing activities related to floodplain management. However, in Europe, the approach was to move even farther away from flood control.

Under flood control, those responsible for reducing damages chose a level of protection for areas in danger based on either an economic analysis that determined that benefits of providing the protection (i.e., flood damages avoided) exceeded the cost of constructing the protection, or a national policy such as “no more floods.” Following the disastrous floods in 1953, the government of the Netherlands took action to prevent recurrence of such catastrophic events and eventually established a

10,000-year level of protection for coastal areas (in 2008 a Netherlands Delta Committee recommended that, to accommodate potential climate change, the level be increased to 100,000-year protection (Royal Netherlands Embassy 2008)). In the late 1990s, the European Community began to consider a different approach, flood risk management. Under this approach, the risk to a given area would be defined by examining the probability that the flood might occur, the probability that whatever protection system existed would function as designed, and the consequences that would result should the area actually flood. Establishing a risk-based approach not only identified the level of risk faced by each community, but also offered a method of prioritizing protection efforts. Using flood risk management, it became clear that risk could be reduced not only by increasing the probability that the protection system would do the job, but also by taking steps within the protected community to reduce its vulnerability to flooding through use of nonstructural methods including the avoidance of development. While Europe moved ahead with this concept, it was not until Katrina that the US began to examine a comprehensive approach to risk management (Galloway 2008). Now, as USACE and FEMA move to deal with post-Katrina flood vulnerability, they have both adopted a flood risk management paradigm.

WHAT ABOUT THE FUTURE?

With flood damages increasing each decade, the nation's population growing at a high rate and moving to coastal and riverine areas, and climate change promising an increased potential for flooding even in areas where total rainfall may decrease, it became obvious to professionals in the floodplain management business that something needed to be done. In 2007, the ASFPM Foundation decided to conduct a Gilbert F. White Flood Policy Forum, the Foundation's vehicle for addressing critical issues in floodplain management. The Forum was directed to determine what actions needed to be taken to ensure that the flood risk situation that existed at the start of the 21st century would be mitigated by the mid-point of the century.

In November 2007, the Foundation brought 75 national and international flood experts together in Washington to discuss what the floodplain might look like in 2050 if no actions were taken to slow the growth in damages and what it might look like if specific actions were taken to move in the opposite direction. The group quickly agreed that an unchecked 2050 would present the nation with significant problems because it would threaten the lives and property of those living in and near the floodplain and the coasts, and it could endanger the economic viability of the nation as a whole. They also agreed that if the nation was willing to address the challenges it faced in managing the floodplain, future damages could be reduced and the badly damaged ecology of floodplains could be rejuvenated.

If the nation is willing to address the challenges in managing floodplains, future damages could be reduced and the badly damaged ecology could be rejuvenated.

GILBERT WHITE'S THESIS

In defining a broader than "structures-only" approach to dealing with floods, Gilbert White identified eight adjustments that could be made to floodplain use that would reduce the potential for losses and ensure long-term sustainable use of the riverine environment (White 1945):

- *Elevation*: Raising structures above the expected flood level.
- *Flood abatement*: Using measures "taken outside of stream channels with the effect of reducing the crest of flood flows or changing the debris load for a flood event."
- *Flood protection*: Using engineering works to minimize impacts of flooding.
- *Emergency measures*: In areas already occupied, taking actions to mitigate floods that do occur through temporary evacuation, the adjustment of services, and flood fighting.
- *Structural adjustments*: Designing buildings and other structures to reduce losses when floods occur.
- *Land use*: Permanently removing property and services beyond the reach of floods.
- *Public relief*: Using public grants and direct rehabilitation to relieve the impact of flood losses.
- *Insurance*: Mitigating the financial effects of flooding on structure owners and businesses through use of insurance.

During the Forum, participants examined the eight methods of adjustment to determine if White's original list was still relevant, and, where it was not or where it was in need of modification, what changes might be made to increase its 21st century utility. They were also asked to identify new adjustments that might be added to White's list to better address the needs of the future.

A SUSTAINABLE 2050 FLOODPLAIN

Not surprisingly, Forum participants determined that the adjustments posited by White in 1945 largely remain relevant today. They also identified several areas where new adjustments measures could be added to those developed by White. The Forum participants concluded that, should action be taken in accordance with a suite of adjustment measures, the floodplain of 2050 would be far less dangerous, environmentally more suitable, and overall more sustainable than it would be if no action be taken to deal with the impending challenges.

Looking forward to 2050 in light of the White recommended adjustments to floodplain use, participants forecast that the more sustainable floodplain would see:

- Land use in which all states would have comprehensive land-use planning that effectively identified their land and water resources and associated natural hazards, and that permitted development only when there would be no adverse impact on flooding or on the natural and beneficial functions of the floodplain.

- Building and development standards targeted at avoiding new construction in flood prone and residual risk areas behind levees and below dams to reduce the exposure to flood damages. Where structures were built, the nature of their construction would reduce the potential for losses should floods occur. Those who took actions that increased their flood risk would not be rewarded with federal benefits.
- Elevating structures in the floodplain were no longer considered as the best or even desirable solution since structures surrounded by water pose a risk to both those in the structures and the emergency personnel who would be concerned about the welfare of the occupants.
- Mandatory purchase of all-hazard insurance throughout the United States.
- Structural flood protection only used to deal with existing development or where no other alternatives existed. The first choice would be nonstructural.
- Emergency measures based on robust pre-disaster mitigation activities that took full advantage of the lessons learned in previous flooding events.
- Public understanding that disaster relief and assistance would be available only as a backup to other adjustments.
- Watershed planning used to clearly identify the impacts of upstream activities on those downstream and vice versa. Every effort would be made to ensure maximum natural storage of flood waters.

While 21st century consideration of Gilbert White's eight adjustments would certainly go a long way to ensure that the floodplain of 2050 was more sustainable, participants also recommended that four additional adjustments should be considered:

- Providing room for rivers and oceans by choosing not to occupy flood-prone areas and thus avoiding the hazard as well as precluding unintended adverse impacts on ecosystems. This adjustment would ensure that development would routinely place distance between human occupation of the landscape and rivers and oceans.
- Requiring exercise of personal responsibility by the public in recognizing the hazards that are faced, the risks that are taken in dealing with these hazards and the need to become concerned with the sustainability of the environment.
- Recognizing the geographic interdependence of floodplain activities and taking steps to minimize the impacts of these interdependencies. Damages to one community, business, or industry may have significant economic and social impacts at locations far from the flooded area.
- Ensuring national awareness of flood risk and education of the population on flood processes, mitigation and avoidance. Those who are well-educated are far more likely to take appropriate action to reduce their vulnerability to flooding or to totally avoid placing themselves at risk. 21st century information technology offers the rare opportunity for near real-time distribution of hazard information to the entire population.

Attention to the above adjustments would result in a 2050 floodplain where (ASFPM Foundation 2008):

“... in spite of rapidly growing populations and a changing climate, both flood risk and land and water resources are being managed towards more sustainable outcomes. The nation views land and water as precious resources, and therefore protects the natural and beneficial functions of floodplains, wetlands, and coastal areas. Because these areas have been reserved—and in some cases, restored—a maximum amount of natural mitigation of flooding takes place continually. Integrated water management is an accepted practice. All new development is designed and built so that it has no adverse impact on flood levels, sedimentation, erosion, riparian or coastal habitat, or other community-designated values. The market strongly favors sustainable development, which means that floodprone construction rarely occurs. Private and public losses due to floods are indemnified through a government-backed but private system of universal insurance coverage that encourages mitigation. Floodplain management programs are funded from fees charged for development impacts, a highway trust fund, or other secure sources. Risk communication through all levels of government has become advanced enough that local decision making is well informed; policy decisions are based on sound science.”

GETTING TO 2050

Change doesn't just happen. Even though flood professionals may strongly endorse modified White-developed adjustments and the addition of other adjustments to deal with the uniqueness of our current situation, these approaches must be understood and accepted by the population at large and they must find their way into clear and holistic public policies that treat land and water as important natural resources. As the Forum report notes, the twin goals of these policies must be “to protect people and property from flooding while also protecting flood prone lands from people.” Even with new policies there remains a need for dealing with the nation's fragmented system of water resource management, disaster relief, and mitigation. Efforts must be made to eliminate disincentives to correct action, duplication of programs and minimization of costly and time-consuming litigation. Moving to a safe and sustainable 2050 floodplain will require access to accurate and comprehensive data about our natural resources, the risks we face, and integration of these data with increasingly available data and information about other aspects of society (ASFPM Foundation 2008). A movement to this better floodplain of 2050 will also require adequate funding to support not only proper siting and construction of future development and removal of unwise past development, but also to maintain existing infrastructure that provides protection for many areas.

The Forum report points out that circumstances that surround early 21st century development are unique and represent opportunity for significant change in the way we do business. The report concludes by providing six guidelines that “capsulize the new ways of thinking and operating that will be needed to achieve safe and sustainable relationships with our water resources,” and lead to the safe and

sustainable floodplain of 2050. These guidelines ask decision-makers and the public at large to (ASFPM Foundation 2008):

- Make room for rivers, oceans, and adjacent lands.
- Reverse perverse incentives in government programs that make it more profitable to act unwisely than to recognize the need for long-term safety and sustainability.
- Restore and enhance the natural, beneficial functions of riverine and coastal areas.
- Generate a renaissance in water resources governance and development of the policies and organization that will support this renaissance.
- Identify risks and communicate them at the public and individual levels.
- Assume personal and public responsibility for their actions in the floodplain.

IMPLICATIONS FOR CIVIL ENGINEERS

According to ASCE's *Vision 2025* (ASCE 2007):

“Entrusted by society to create a sustainable world and enhance the global quality of life, civil engineers serve competently, collaboratively, and ethically as master

- *planners, designers, constructors, and operators of society's economic and social engine—the built environment;*
- *stewards of the natural environment and its resources;*
- *innovators and integrators of ideas and technology across the public, private, and academic sectors;*
- *managers of risk and uncertainty caused by natural events, accidents, and other threats; and*
- *leaders in discussions and decisions shaping public environmental and infrastructure policy.”*

Moving from where we are today in floodplain and flood risk management to the future described above will require civil engineers to live up to the aspirational expectations of *Vision 2025*. Recognition of Gilbert White's original adjustments to floodplain use, the suggested modifications and additions to his list, and the guidelines proposed in the report of the Gilbert F. White Forum will demand from civil engineers full exercise of the knowledge, skills and attitudes needed to serve the nation in the manner described above. It is important that, as floodplain professionals define a visionary state for 2050, civil engineers are prepared to support this effort and see it through to its fulfillment.

IN SUM

The United States faces major challenges in dealing with flooding. We have learned that we cannot control floods or even focus on simply reducing damages. We must identify and manage our growing flood risks. Damages from disastrous floods are on the rise, and people and property remain at risk. Over the next 40 years, if action is

not taken to deal with the problem, it will grow substantially worse. Climate change, population growth, unbridled development in hazardous areas, and a lack of personal responsibility on the part of individuals subject to flooding will lead to an untenable situation by the middle of the 21st century. Gilbert White's seminal work identified what actions could be taken to deal with the flood threat and proposed eight adjustments that have stood the test of time. Those attending the Association of State Flood Plain Managers Foundation 2007 Forum identified four additional areas where human adjustment might result in even better future conditions. With attention to these opportunities, the American floodplain of the future can be far different than it is today. Civil engineers are at the nexus of this challenge and must, along with their many other responsibilities, take on the challenge of ensuring that the floodplain of 2050 is sustainably developed and managed.

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