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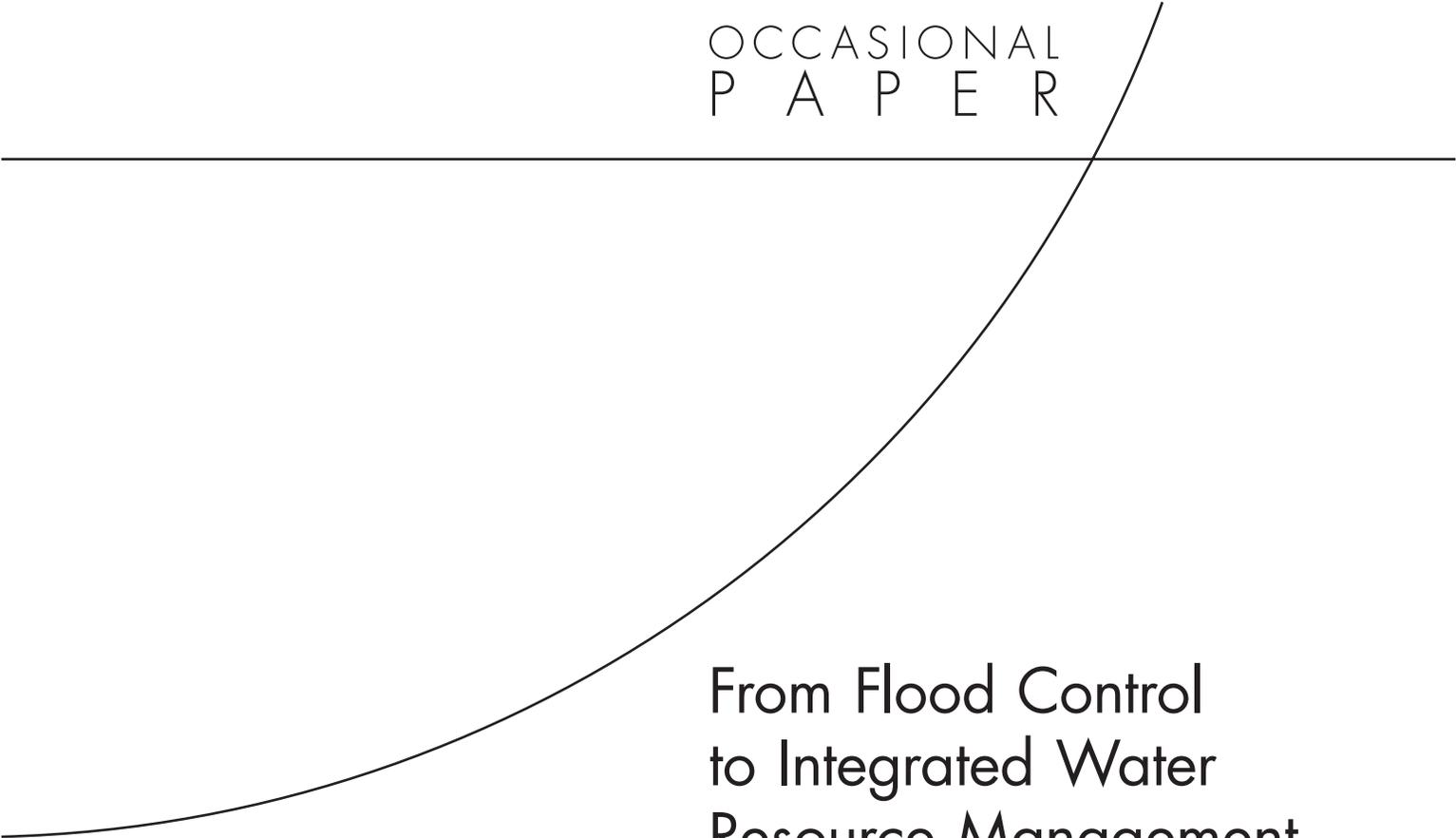
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OCCASIONAL
P A P E R



From Flood Control to Integrated Water Resource Management

Lessons for the Gulf Coast from
Flooding in Other Places in the
Last Sixty Years

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Summary

Introduction

This occasional paper presents a historical analysis intended to seek insights that might guide current reconstruction efforts in the Gulf of Mexico coastal region of the United States in the aftermath of Hurricane Katrina, which struck in the late summer of 2005. Katrina—and the failure of multiple levees in New Orleans stressed by the storm’s surges—brought unprecedented death and destruction over a 90,000-square-mile area. As of this writing (June 2006), many area residents who evacuated before the storm have not yet returned. The social infrastructure will require significant repair and renovation. There is much work to be done.

In this paper, we examine four mid- to late-20th-century cases of severe flooding to observe whether and how lessons were incorporated into water management, both before and after the disaster (see Table S.1). In each of the four cases, the areas involved were subject to record rainfall or storms that overwhelmed the systems that had been designed to cope with these events.

Table S.1
Characteristics of the Four Cases

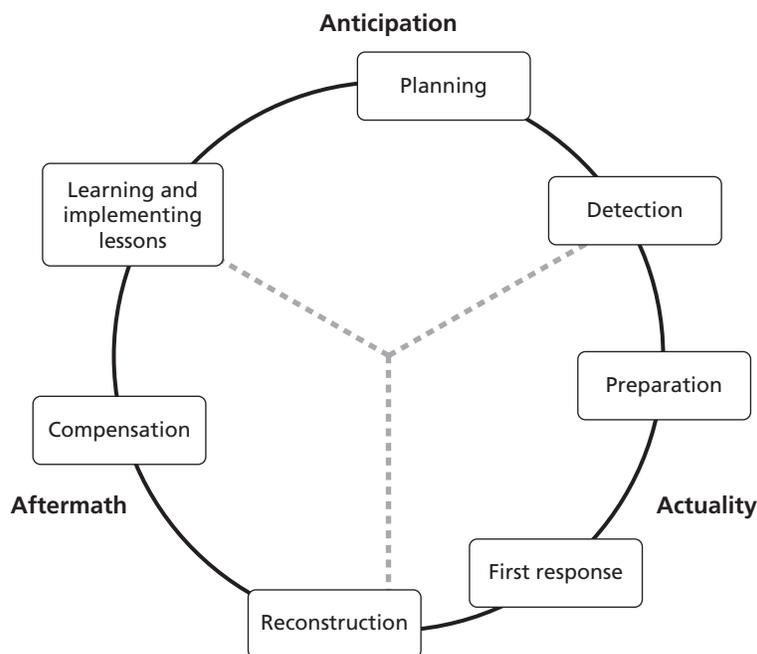
Case	Date	Geographic Location	Type of Catastrophe	Population of Affected Area (thousands)	Lives Lost	Economic Damage (US \$ millions)
Vanport	30 May 1948	Columbia River near Portland, Oregon, United States	Failure of enclosing dike during river flood	20	15–32 ^a	100
Zeeland	31 January 1953	Southwest part of the Netherlands	Storm surge overwhelms sea defenses	300	1,835	800–1,100 ^a
Mississippi	June to August 1993	Upper Mississippi River, United States	River flood overwhelms levee system	64,000	47–52 ^a	16,000
Yangtze	June to August 1998	Yangtze River basin, China	Severe river flood exceeds defenses	71,140	1,562	20,500

^a Number varies depending on source.

We cast our examination within a seven-step analytic framework that is based on a *cycle of restoration*, as illustrated in Figure S.1. The cycle may be roughly divided into three stages: (1) *anticipation* of the next possible flooding event, (2) the *actuality* of the event, and (3) the *aftermath*.

- **Planning.** Before an event threatens, there should be planning about what to do when the next event comes.
- **Detection.** An ongoing information-gathering system is required, to provide warning of when and where an event will take place and also to monitor prevention and mitigation systems.
- **Preparation.** When an event is imminent, preparation should intensify. Lines of communication must be put in place, needed resources marshaled, and evacuation and other contingency plans set in motion.
- **First response.** Once the event has occurred, the negative consequences can be minimized by prompt and appropriate action to save lives; provide food, shelter, and clothing to survivors; and prevent further damage to property.
- **Reconstruction.** After the event has passed, rebuilding can begin. With the passage of time, decisions can be made about the extent to which the status quo ante can or should be restored.

Figure S.1
The Cycle of Restoration



- **Compensation.** Compensation, broadly defined to include public and private insurance payouts and other public assistance, is closely tied to reconstruction decisions. Where reconstruction is not completely possible or desirable, social insurance of some form can compensate individuals and businesses for their losses.
- **Learning and implementing lessons.** Finally, the experience of the event should be examined to understand the successes and failures and to apply the knowledge gained in anticipation of the start of the next cycle.

Lessons Learned from Four Cycles of Restoration

The four cases that we have examined are all illustrative of the evolution in thinking about flood management that has taken place in the past 60 years. All illustrate the evolution from flood control to integrated water resource management and the role of political, economic, environmental, and cultural factors alongside concerns about safety in reacting to the event.

Anticipation. In flood-prone regions, the question is not whether flooding will happen but when it will happen again.¹ Although modern technology, such as satellite weather observations and improved modeling of storms and rivers, has greatly increased our ability to detect emerging threats, our planning for an imminent threat is less consistently adequate. Especially when there is a long time between the previous flood and the imminent one, memories fade, training and readiness can become lax, and complacency among residents and public officials can set in. Financial and human resources that could be applied to readiness for low-probability, high-consequence events are instead pressed into service for what are perceived as more immediate problems—and then not replaced.

Actuality. Success at managing the actuality is in part a function of how well the anticipatory planning was carried out. Unfortunately, damage in major floods typically exceeds local and regional capabilities for prevention and mitigation, as was true in all of our cases.

First response, on the other hand, can be accomplished—within limits—independently of the magnitude of the flood. Even when local systems are overwhelmed, well-coordinated regional efforts guided by effective communication and situational awareness can mitigate the suffering. Although the amount of advanced planning differed considerably from case to case, first response was generally adequate in the four cases studied. Rescue operations minimized the number of lives lost, refugee centers were rapidly set up to provide food and shelter for the homeless, and social infrastructure to manage the health and safety needs of the victims was not a major shortcoming.

For three of the four cases (the Yangtze being the exception, because of the ability of the Chinese government to enforce—in this case benevolent—policies), steps other than first response in the actuality stage that should have been taken were not. Inadequate execution

¹ The ability of a measure to protect against a flood is generally expressed in the “design level” of the measure. The design level is based on engineers’ estimates of the probability of flooding to an extent that will exceed protective capacity; it is expressed as a recurrence interval, say once in 100 years. The choice of design level (say, against a 100-year flood versus a 500-year flood) is a matter of policy, of balancing cost and risk.

ranged from the policy errors of ignoring warnings of inadequate protection and failing to have a response and rescue plan in place should flooding occur to the practical error of not ensuring that levees and dikes were adequately maintained. Moreover, even when post-disaster analyses led to clear recommendations, they were not always followed. In short, better preparation is almost always possible as experience is gained, but sometimes the leadership of a region is not organized or inclined to act on the knowledge gained.

Aftermath. The lessons learned from the cases we studied were varied and broad. The 1953 Zeeland case triggered a period of analysis and reconsideration of water management in the Netherlands that proceeds to the present day. From thinking in terms of building walls of protection, the Dutch moved to including environmental considerations, which necessitated technologically advanced flood control solutions that were produced at considerable expense. Yet further thinking contemplates giving more land back to the sea—a move that is contrary to a long Dutch tradition in the opposite direction. This move is not only under consideration but is presently being planned. The Mississippi case was extensively studied, and a number of strong recommendations were made. They have been unevenly implemented, however, and this implementation failure could be a factor in the extent of the 2005 damage in the Gulf Coast region. The Yangtze case provided a validation of earlier lessons learned and reinforced the convictions of Chinese water management planners. Finally, the Vanport case led to almost no lessons learned because the abandonment of the town eliminated any incentive to learn from past errors.

The lessons for the reconstruction step drawn from the case studies can be captured in the following points:

- *Building bigger and better flood protection works does not necessarily maximize safety.* Surrendering land to the water in the form of forgoing development of floodplains or actively removing formerly reclaimed land can lead to reduction in property loss and lives at risk.
- *Differing perceptions among residents and political leaders of the permanence and transience of the physical environment can create conflicts in deciding what to rebuild, what to modify, and what to leave as is.* In democratic societies, resolution of these differing viewpoints is best accomplished in an open political process—in particular, a broad public discussion about alternatives to the status quo ante. In that discussion, flood control should not be the only objective considered.
- *Some potential improvements to the status quo ante are not intuitively apparent or politically palatable.* In the absence of analysis, there is an inherent bias toward recreating what used to be. Regional leaders would do well to expend effort designing and analyzing a number of alternative policies following a flood disaster that could serve as a foundation for informed public debate and increased public awareness of the options and the tradeoffs.
- *Structural solutions are necessary but not sufficient.* Decisionmakers and the public tend to be overconfident about engineering solutions because the solutions appear to offer substantial protection along with economic development benefits. Residual risks always remain; indeed, they increase over time as the existence of flood works such as levees

induces further development. Instead, decisionmakers need to choose structural elements that are compatible with nonstructural approaches intended to achieve other longer-term economic, environmental, and social objectives. Although this lesson has evolved in the past century from being implicit to being explicit, it is still salient as long as the Army Corps of Engineers continues to play a dominant role in flood management in the United States.

Compensation was not a major feature in the Zeeland and Yangtze cases and was a sore point that could not be resolved in the Vanport case. The Mississippi case provides the leading lesson, and produced strong recommendations in terms of who takes responsibility for risks and the relationship of insurance and government compensation after losses. These recommendations were not, however, fully implemented. The role of insurance remains an underappreciated tool in mitigation of losses from flood damage, particularly in the context of an increasing expectation of federal disaster assistance.

Lessons from History for the Aftermath of Katrina

As our examples show, Katrina and its aftermath, like many crises, present an opportunity to improve conditions that existed prior to the catastrophe.

In terms of *planning* and *preparation*, all the examples demonstrate to varying degrees the limits of planning when the natural disaster exceeds expectations. Government officials had anticipated catastrophic flooding in New Orleans from flooding and levee failures. Further, officials also were well aware of the connection between loss of Louisiana's coastal wetlands and reduction in the city's protection from storm surges. On the coasts of the Gulf of Mexico, storm surges had been anticipated, but not at the heights wrought by Katrina. In the future, regional leaders should consider policies and plans that are more robust against a wider range of disaster scenarios.

Throughout the region, however, the biggest blind spot was the failure to anticipate the possibility of widespread regional breakdown in infrastructure and services and the disabling of first-response and public safety systems. Some activities, such as evacuation planning, simply cannot be implemented on the fly. Evacuation services for all segments of the population must be worked through in sufficient detail well in advance of the event. The fragility of many structures on the Gulf Coast, along with the fact that so many of them were built to out-of-date building codes, underscores another opportunity for improvement. Here, the lessons of history are that, while determining safety levels might be defensible on cost-benefit or IWRM bases, the planning for regional infrastructure and services must cover total catastrophic breakdown and must include secondary, contingency responses that can be invoked when primary responses are overwhelmed. In Zeeland, lack of such planning led to catastrophe, but in the Yangtze case, this planning was a major reason why loss was only a fraction of what had been suffered in previous floods.

At the federal level, much has already been published about the shortcomings of the Federal Emergency Management Agency (FEMA) and other agency planning efforts, par-

ticularly in developing logistics for deploying supplies and personnel in advance. Although scenario planning had been employed by FEMA, it will need to anticipate a wider range of scenarios in the future to fully prepare its staff for a wider range of catastrophic conditions in major metropolitan areas.

Detection of the storm itself was certainly adequate in the case of Katrina—as it was in the historical examples—but detection fell short in anticipating structural failures and collapse under the forces unleashed by the storm. In the case of New Orleans, as with Vanport, the Corps and the local levee districts had no monitoring equipment in place to detect structural weaknesses, soil anomalies, and impending failure. This shortcoming can be remedied through deployment of sensors on all structural features of the flood protection system.

The examples suggest that decisions about how to proceed with *reconstruction* in the affected areas are strongly influenced by the answer to the question of what the level of flood protection will be in the future. In the four cases we examined, this decision was intimately tied to the commitment of the affected population to restore their way of life to pre-disaster conditions, albeit with some accommodation to the natural hazard. The Vanport example offers one extreme: The community was temporary and residents' emotional ties to the place were weak. The Zeeland example is at the opposite end of the continuum: Wholesale abandonment of the flooded lands was simply not an option for a small country, although over time the Dutch became willing to give back some land to the sea in return for more security.

The areas affected by Katrina and its aftermath fall in between these two extremes. By and large, Gulf Coast residents feel a strong connection to these special places, and yet they do have choices of where to live within the United States in ways that the Dutch did not perceive that they had. This psychological difference casts the public decision about the appropriate level of flood protection in more complex terms.

This consideration raises the larger issue of how to deal with the long-term evacuee population we face in Katrina. Most instances of flooding are short-term in nature—in terms of how long it takes for the floodwaters to recede and how long it is before people can be back in their communities. But Katrina resulted in a situation where there is permanent or semi-permanent displacement. This is an entirely different class of problem, one that requires possibly pioneering thinking in the restoration of the Gulf region.

Investments in additional flood control and protective measures will depend on the density and magnitude of populations and property requiring protection, which in part depend on the investments themselves—the classic “chicken and egg” problem. Many Gulf Coast residents have already seized options to move elsewhere within the United States. Under these circumstances, estimates of population return and the quality of a range of locally provided public services become important determinants of the extent to which the federal government should rebuild preexisting levees and improve flood protection through other nonstructural means.

Finally, it is still too soon to tell the full story of compensation in the aftermath of Katrina. Preliminary analysis from FEMA shows that in areas of the disaster zone where it applied, compliance with the National Flood Insurance Program (NFIP) was relatively good. However, the program's coverage is incomplete in the flood-prone areas hit by Katrina. Beyond the limits of the NFIP, private insurers faced major losses in Katrina. They will likely support more robust

flood protection measures, reforms in building codes, and enlightened land-use planning that will reduce their exposure in the future, assuming they choose to continue to serve the region. This issue is clearly an important area for future analysis and policy change.

Final Observations

We close with some final general observations that span the cycle of restoration.

- George Santayana (1905) said, “Those who cannot remember the past are condemned to repeat it.” This has clearly been shown in our case studies. Attending to history leads to mitigating the potential damage of floods even when major floods are few and far between; ignoring history leads to even larger disasters. Whether the Gulf Coast region will adequately attend to its recent flooding history remains to be seen.
- The critical concept of integrated water resource management policy—particularly its implication that flood damage control includes conceding land to the water from time to time—is a psychologically difficult one. This problem goes well beyond flood control. In almost all areas of preventive policy, there are times when an excess of cure can be worse than the disease.
- Delineation of roles and responsibilities in advance shapes outcomes. As with any large-scale event, there were many different actors in each flood, including national governments, local governments, engineers, the private business sector, and communities. When the actors had well-defined and well-understood roles, things generally went well. However, when such definition and understanding were lacking, the consequences of the disaster were magnified. The flooding of New Orleans has shown that this lesson has yet to be fully absorbed for disasters in which local capacity is overwhelmed and the impacts are regional in scope.
- Out of tragedy can come opportunity. In each of the cases, improvements to the social and physical infrastructure in the reconstruction phase went beyond flood protection. This shows that disruption of the status quo can create political conditions for broader-based social and economic change that might otherwise have been delayed or might not have happened at all. It is still too soon to tell whether the latest cycle of restoration in the Gulf Coast region will lead upward or downward.

In sum, the cases provide a sufficiently diverse set of circumstances from which to draw useful similarities and contrasts to the current situation in the Gulf. While social, economic, environmental, and political conditions before the disaster provide the stage and the props for the post-disaster response and reconstruction efforts, the cases clearly show that the past need not be prologue.