CHAPTER 9. USING THE NAI PRINCIPLE FOR COASTAL HAZARD MANAGEMENT

This handbook has presented the concept of No Adverse Impact floodplain management and how it can be applied to the coastal area so that a community can build its disaster resilience and help establish long-term sustainability. In this last, final chapter, two fictional scenarios provide a more detailed and in-depth exploration of the applicability of NAI concepts for coastal communities.

The two examples presented in this chapter draw on the No Adverse Impact (NAI) building block information from Chapters 3 through 9. Both examples presume that basic and better floodplain management practices are already in use, so the discussion focuses on possible NAI-level applications. Both examples further assume that there will be an integration of NAI actions into existing hazard-related programs (described in Chapter 4).

For each example situation, there are a series of steps that correspond to the NAI building blocks mentioned in earlier chapters. The sequence of the steps explained here may not correspond to the order warranted in a given situation. NAI is a managing principle, an approach, a more effective way to tackle coastal hazards, not a set of procedures, standards, requirements, or practices (ASFPM, 2003). Both examples show that even projects located miles inland in a coastal watershed can do harm to shoreline neighbors, communities, and ecosystems.

EXAMPLE A: A MUNICIPAL WASTEWATER TREATMENT PLANT

City council members in an east coast city are concerned about the city’s aging wastewater treatment plant. The plant sits by a harbor where a river runs to the sea and has little spare capacity for additional growth. During times of river floods or combinations of high tide and extreme storm surge, the plant has experienced some flooding and operational problems due to high water. The city council directs the public works staff to develop recommendations for replacing the wastewater treatment plant and adding enough treatment capacity to accommodate anticipated growth in the sewer service area. The directed planning horizon extends to 2060.

There are three feasible sites for a new wastewater treatment plant:

Site A. An old industrial site in the city next to the harbor. Little site remediation would be required and the site is outside of the existing floodplain.

Site B. An upland site at a higher elevation within the city near the harbor.

Site C. An upland site close to the city and on the coast.

The State and local floodplain managers are concerned that development in the city (including a new wastewater treatment plant) not encroach into the floodplain and be done in a way that lessens the city’s vulnerability to future riverine and coastal natural hazard events. The MSD staff and the city floodplain managers are determined that a new or expanded plant neither worsen flood conditions for property owners in the city nor support (through extension of services) development into areas subject to future riverine and coastal hazards. City administrators are concerned about the legal liability implications of the extension of services.
The situation seems made to order for the NAI “do no harm” policy that “requires those who alter flooding conditions to mitigate the impact their actions have on individuals and adjacent communities” (Larson and Plasencia, 2001). City staff developed the following vision statement for the project to expand the plant.

NAI Vision Statement for Expansion of Wastewater Treatment Plant

“The wastewater collection and treatment facilities are adequate to handle the increased load as the service area grows through the year 2060. Adequate treatment continues without interruption and facilities are not flooded or otherwise damaged by anticipated flood events. Existing and new wastewater treatment facilities do not impede riverine or storm surge flood flow, storage, or drainage in the floodplain. Additions to the wastewater treatment plant collector system do not encourage development in areas subject to future hazards from natural riverine and coastal processes including sea level rise, subsidence and coastal erosion.”

Hazard Identification and Mapping

The city has a well-documented history of river floods and coastal storms. Floodplain managers prepare a new flood study using future-conditions hydrology based on projections of watershed development. They are aware that the climate is changing and that future floods and storms may be more frequent and more intense than in the past. The staff considers a set of plausible future flood elevations above the base 100-year flood elevations of the National Flood Insurance Program (NFIP), including flooding from storm surges from a Category 5 hurricane approaching the city along various possible storm tracks.

Consultants are hired to help with the hazard evaluation. These consultants use computer models to simulate river flooding, storm surge, wave heights and wave run-up. The simulation models have sufficient resolution to model flow characteristics on individual parcels of land. Storm wave simulation is used to help evaluate the coastal site (Site C). Results are entered in the city’s geographic information system (GIS). The influence of expanded existing and proposed wastewater treatment plant buildings on storm surge and flood flow around neighboring buildings and properties in the coastal floodplain is also examined. A range of scenarios is modeled that use various combinations of river flood, storm surge, sea level rise and wave heights. Some scenarios have simultaneous river flood and tropical storm events.

Results of the hazards identification and mapping work lead the staff to conclude that

- An updated watershed development plan is needed to account for changes in land use and climate expected throughout the 21st century;
- The present wastewater treatment plant adversely affects flood flow on adjoining properties during extreme flood and storm surge conditions compared to a baseline situation with no plant on the site. An expanded plant on the site makes the situation worse;
- The former industrial site (Site A) lies within a new floodplain area subject to both river floods and extreme storm surge during some possible Category 5 hurricanes;
- A new treatment plant on Site A would adversely affect flood flow on adjoining properties;
• The present treatment plant is vulnerable to serious flooding from some high intensity hurricanes and other extreme events;

• The upland site (Site B) is not in a future floodplain, based on the assumptions used in this study. A treatment plant at this site is less likely to adversely affect flood flow on adjoining properties;

• Coastal Site C is not likely to be vulnerable to flooding from storm surge and storm wave run-up before 2060. The site is vulnerable to erosion, however, and will need armored shore protection, meticulously maintained at an unknown cost. A wastewater treatment plant at this site is likely to adversely affect neighbors due to interference with sediment transport. Uncertainty about the future frequency and severity of storms as a result of a changing climate raises concerns regarding use of this site.

Planning

Concerns about the wastewater treatment plant are intertwined with many other interests and issues related to growth and sustainability of the city and the surrounding sewer service area. The interests and concerns are public and private, individual and corporate. The city staff creates an advisory committee to help them create a consensus-building, participatory process that considers economic development and ecological, cultural, historic, and aesthetic values in the planning process. The staff uses a multi-objective management (M-O-M) approach with the information from the hazards identification and mapping work to identify all of the hazards, all of the concerned parties, and all of the potentially adverse effects on others. All of the alternative measures to mitigate (avoid or reduce) adverse impacts are identified. As more information is gathered, more outreach is conducted to keep people informed.

The city staff and the advisory committee use sustainability principles in planning for the future of their wastewater treatment plant. Sustainability to them means passing along to the next generation of city managers and residents a plant and collector system they can use for years—not an inherited burden of a dysfunctional system that should have been replaced long before.

The city’s principles of sustainability are used with the wastewater treatment plant vision statement to adopt these goals:

• Develop an expandable wastewater treatment system adequate to meet the city’s needs until 2100;

• Develop a hazard-resistant wastewater treatment system that maintains performance during extreme weather events as the climate changes;

• Maintain the sustainability of adjoining properties; and

• Identify areas where sewer service should not be provided because of coastal hazards.

All the advantages and disadvantages of the optional sites for a new or expanded plant are considered. All concerns of the community are aired in public forums and in advisory committee meetings.

The city uses risk analysis to determine the threats (and opportunities) that could adversely (or favorably) affect achievement of the sustainability goals for the wastewater treatment plant and potentially affected properties.

The team analyzes
- Floodproofing and expanding the wastewater treatment plant on the present site;
- Building a new wastewater treatment plant on the upland site (Site B) outside of a future floodplain and beyond the reach of a Category 5 storm surge; and
- Building a new wastewater treatment site on coastal Site C.

The risk analysis will continue with the identification of construction and mitigation options and costs, and end with a preliminary judgment about each option.

**Regulations and Development Standards**

A 0.2% annual chance (500-year) river flood and a 0.2% annual chance storm surge are adopted for all critical facilities in the city exposed to the identified hazards. The city staff did hazard identification, mapping, and planning using a set of future-conditions scenarios for the watershed, harbor, and coast that seem reasonable and defensible as a basis for siting new development. Issues under consideration include:

- How best to create additional flood storage capacity in the watershed upstream of the city and in the coastal floodplain between the city and the sea without damaging important, critical habitat that needs to be preserved; and
- The extent to which the NAI tools of planned development and Transfer of Development Rights are needed to increase flood storage capacity and reduce stormwater runoff in the upstream watershed and increase storm surge capacity in the coastal floodplain.

Acceptance of new development standards by upstream communities will reduce some of the uncertainty about future conditions and help the city staff make risk management plans for the wastewater treatment plant and other critical facilities likely to be positively affected by such flood mitigation efforts.

**Mitigation**

The hazard identification and risk analyses of the upstream watershed and the four possible wastewater treatment plant sites revealed that the plant’s system will have some vulnerability to hazards and that the plant’s operation and siting will have adverse impacts on the neighbors at some of the possible sites. The city staff studies how each situation might be mitigated. With the aid of consultants, they investigate

- Mitigation of future flooding of the existing expanded wastewater treatment plant at the existing site;
- Mitigation of future flooding of a new wastewater treatment plant at Site A;
- Mitigation of adversely affected flood flow on properties adjoining the sites during record floods or extreme storm surge;
- Mitigation of erosion that would threaten a wastewater treatment plant at coastal Site C and mitigation of adversely affected sediment transport to distant beaches; and
- The feasibility of establishing a stormwater utility and fee structure to provide funds that can be used to reduce flooding and provide the local match on federal mitigation projects.

The city identifies residual risks that will remain after mitigation measures have been taken. The overall impact of residual risks on the project is estimated. An action plan is drawn up for every option.
Education and Outreach

The consultants prepare displays and help the city staff make presentations to city administration and council members, and in several public forums. One purpose of this work is to make people aware of the situation: the need to do something about the wastewater treatment plant in light of the capacity limitations and the flood and storm hazards facing the city. An equally important purpose is to set the stage for creating a consensus-building, participatory process in deciding what to do about the plant. Education and outreach will play a role in communicating work done during each of the remaining NAI steps as the city staff informs people of options and seeks their support for recommendations to be made.

Infrastructure

Acquisition of land for public purposes in the upstream watershed gains community support as a tool to insure increased flood storage capacity even though it is not likely to be needed for several decades or more. Maintaining or acquiring public or private green space in the coastal floodplain is a favored mitigation option for flood flow impacts that the wastewater treatment plant will have at the existing site and Site A.

The city staff is aware that there may be changes in the tracks, frequency, and severity of storms as a result of climate change. This uncertainty leads them and their advisory committee to recommend adoption of a 0.2% annual chance (500-year) flood and storm surge elevations for the wastewater treatment plant options and for other critical facilities to be modified or replaced in the future. The new standard will be reviewed periodically as more knowledge is gained about climate change and as experience is gained with future extreme events.

Emergency Services

The city reviews the mitigation strategy for each wastewater treatment plant option and determines the emergency response plan needed for each option.

The city staff and the advisory committee evaluate suggestions for improving wastewater treatment plant preparedness for extreme flood and storm events and for recovery from such events. The city begins to participate in the NOAA National Weather Service’s StormReady and TsunamiReady programs to improve the timeliness and effectiveness of hazardous weather warnings to emergency responders and the public. The hazard preparedness planning includes pre-planning, post-disaster response, and recovery operations for the plant for each site.

Once a wastewater treatment plant option has been selected, city management establishes accountability for risk management by assigning responsibilities to appropriate staff.

Resources are obtained and training is provided. Risk management becomes a conscious, ongoing part of mainstream management of the wastewater treatment plant. Uncertainty about future development and watershed changes, future storminess, and other aspects of climate change motivates the vigilant monitoring needed for risk management of critical facilities for which the city is responsible.
EXAMPLE B: A COASTAL COMMUNITY ON THE GULF OF MEXICO

A city located on the Gulf of Mexico suffered damage from several hurricanes over the past century but was spared the devastation brought to other Gulf Coast communities by Hurricanes Katrina and Rita in 2005. However, the havoc caused by those hurricanes raised doubts about the city’s capacity to prepare for a major hurricane, and recover after it departs.

Critics claim that the city’s long-range plan with its implied commitment of city services encourages development into low areas that are vulnerable to hurricane storm surge and storm waves. Concerns have been raised about the city’s vulnerability and the long-term sustainability of a significant portion of the city and its surrounding landscape and ecosystem.

A large river flows through the city and a large estuarine wetland to the sea. Barrier beaches, barrier islands, and the wetlands provide some protection from hurricanes. However, the shorelands behind the beaches are developed; the barrier islands have been heavily damaged by hurricanes, and development is encroaching into the wetlands. The land surface is stable and not subsiding. The river watershed extends upstream into other States, far beyond the influence of the city and region.

The city council requests that city staff study three principal questions:

- **The watershed development plan upstream of the city**: does it account for the possibility of a rapid sequence of storm surge followed by a storm system that stalls out somewhere over the upstream watershed? What changes are needed?

- **The city’s development plan in the coastal plain**: does it make the city more vulnerable and less sustainable in the face of major hurricanes than the city is today? What improvements are needed?

- **The city’s emergency response plan**: How good is the city’s emergency preparedness, resistance to damage, and resilience? Can the city quickly return to full service after a major hurricane? What improvements are needed?

The council appropriates funds and directs the city staff to use the city’s long-range development plan as the starting point for the study.

The city staff recruits an advisory committee of community members and a few council members to represent public, business, and private concerns and motivate the community to influence the evaluation and support efforts to implement recommended measures that might be developed. The committee is adamant about avoiding adverse impacts from the combination of human development and natural hazards that were evident after Hurricanes Katrina and Rita. The committee expresses concern about avoiding legal trouble for the city during the aftermath of such a disaster.

The committee is briefed on ASFPM’s NAI approach, and recommends that the NAI approach be used. The city staff and the advisory committee develop an NAI vision.

**A Community Vision Statement**

“The National Hurricane Center forecasts a Category 5 hurricane that is likely to reach our coast and city in three days. The hurricane sweeps ashore. A high storm surge bearing large storm waves batters the coast and reaches into the city. There is no serious injury and loss of life
in our community. Property damage from high wind, flooding, and wave action is substantial but manageable. There is no major harm to neighbors from prior actions or inaction of property owners or the city. City services are interrupted but restored within three days after the hurricane winds have subsided."

**Hazard Identification and Mapping**

The city staff identifies all natural hazards that the community has experienced and might reasonably expect to experience. The city has experienced river flooding, hurricane storm surge, wind and waves, tornados (with hurricanes), and coastal erosion. The city staff seeks outside help to answer the council’s three questions.

One of the consultants hired provides computer simulation modeling of river flood, storm surge, storm waves, and coastal recession for hazard mapping. The city’s geographic information system (GIS) is utilized as the spatial and graphical foundation for this work. The models are used to:

- Simulate a nearly simultaneous river flood and hurricane storm surge from a Category 5 hurricane following various possible storm tracks on its approach to the city;
- Help estimate the cumulative impacts on the city’s coastal defenses from deterioration of barrier islands, incremental development of the coastal plain, and encroachment on wetlands;
- Help investigate helpful and harmful alterations in storm surge and storm waves from new roadbeds and other new infrastructure in coastal areas planned for future development; and
- Locate and estimate the long-term losses of shoreland from coastal erosion and sea level rise.

The hazard identification and mapping work leads to the following conclusions:

- Category 5 hurricanes approaching on several possible storm tracks would create large storm surges, rapidly followed by river floods that would be catastrophic for portions of the city. The city’s development plan does not address these scenarios;
- Past hurricane damage to barrier islands, human modifications of beaches and dunes, and human encroachment on wetlands have weakened and compromised the city’s natural defenses from the power of a storm surge and storm waves like those that came ashore with Hurricanes Katrina and Rita. The paths of those hurricanes were favorable to the city and luck was the city’s primary defense;
- The present development plan for the coastal plain will place new neighborhoods at risk from damage and destruction by hurricane storm surge and storm waves. There is some indication that storm surge will become more focused and amplified as development continues, with a long-established neighborhood and adjacent industrial area bearing the brunt of the increased damage; and
- The majority of buildings within the city do not meet modern wind resistance requirements.

Estimates are obtained from U.S. Environmental Protection Agency and U.S. Geological Survey reports posted on agency websites about the present rate of sea level rise in the region.
Planning

From the work done to identify and map hazards, it is apparent that the existing river Base Flood Elevations (BFEs) are inadequate and need to be raised. The city’s long-range development plans for the upstream watershed and the coastal plain need to be scrapped and rewritten. A long-range natural coastal hazards plan needs to be written. A plan for retrofitting buildings to improve their resistance to hurricane winds needs to be developed. The advisory committee insists that new plans include provisions for avoiding adverse impacts on neighbors. During the hazards work, a number of potentially adverse neighbor-to-neighbor and city-to-neighborhood impacts were identified.

The city staff adopts a multi-objective-management (M-O-M) approach with the advisory committee and holds some town meetings to bring more participants into the planning process—people who represent the diverse, long-term interests of the community; those who live, work and recreate here. More objectives are added and the vision statement is revised to include smart growth and sustainability.

Sustainability becomes a critical issue in the planning effort. To guide the planning, floodplain management and coastal zone management practices are adopted that follow these six principles of sustainability:

- Maintain and, if possible, enhance, residents’ quality of life;
- Enhance local economic vitality;
- Ensure social and intergenerational equity;
- Maintain and, if possible, enhance environmental quality;
- Incorporate disaster resilience and mitigation into daily local and regional land use decision making; and
- Use a consensus-building, participatory process when making decisions.

In this participatory process, the city staff makes sure that discussion is not confined to the competing present concerns, but includes consideration of the perceived needs of future generations who are not participating in this planning.

Regulations and Development Standards

Possible changes to regulations and development standards are drafted and revised through negotiation, debate, and consensus-seeking discussions between disparate representatives of the various interests in the city, upstream watershed, and coastal plain. This effort is aided by a shared desire to realize the accepted NAI vision statement.

The city staff reviews relevant reference materials including the Federal Emergency Management Agency’s Coastal Construction Manual and the American Society of Civil Engineers’ Flood Resistant Design and Construction. The city staff investigates several possible measures that address the issue of record floods approaching the city from the extensive and distant watershed upstream. One possibility is a new flood elevation based upon a revised 0.2% annual chance (500-year) flood. Another possibility is major acquisition of upstream watershed property for flood storage or bypass around the city. A third possibility is a new initiative to obtain inter-State and regional cooperation of developers in protecting natural areas that provide
a vital flood storage function, and using all reasonable measures for intercepting surface water runoff from developing properties. The biggest challenge is to draft regulations and development standards to protect against damage from storm surge and storm waves generated by a Category 5 hurricane approaching on several possible storm paths. Draft regulations and development standards are written for presentation to decision makers.

**Mitigation**

Facilities in the coastal floodplain with functions that affect many people (such as infrastructure) receive the most attention and get the highest priority in the mitigation discussions. Revising the coastal development plan is a top priority and alternative approaches are reviewed for lessening the city’s exposure to risk from coastal hazards.

The hazard identification work identified some adverse impacts of existing and planned development in the coastal plain. Storm surge simulation showed that a river levee and railroad and roadway embankments crossing a wetland and other portions of the coastal floodplain focused and funneled storm surge flow toward a city neighborhood, or provided some useful buffering of storm waves, depending on the orientation of the structure to the surge and direction of the waves. The existing development plan shows more of these raised roadways.

The hazard identification work also identified hurricane damage to barrier islands and human modifications of beaches and dunes as contributing to the weakening of the city’s coastal defenses.

Mitigation options are identified for the coastal plain that include:

- Piling-supported roadways over wetlands and selected other portions of the floodplain to eliminate the roadway embankments focusing and funneling effect on the storm surge. Removal of portions of the embankment of the abandoned rail line;
- Removal of embankments crossing wetlands and restoration of wetlands to include their natural floodwater storage function;
- Public acquisition and restoration of barrier islands;
- Public acquisition of private property and structure demolition in the coastal floodplain to expand its storm surge dissipation and flood storage capacity;
- An increased setback for new structures along actively eroding portions of the shore; and
- A new policy on shore protection structures that limits them to a “last resort” option with “do no harm” requirements for design and monitoring.

**Infrastructure**

Infrastructure in the riverine and coastal floodplains and in the city receives special attention because the roads, bridges, water, power, wastewater treatment, parks, public buildings, and other facilities are vital to the life of the city. Hurricane Katrina provided examples of the cascading impacts of a catastrophic hurricane on the intricate, interdependent activities in neighboring Gulf Coast communities.

An inventory is made of all infrastructure, including public buildings and critical facilities; facilities that are vital to maintaining or restoring normal services, facilities that are
critical to public health and safety, and facilities that produce, use, or store dangerous materials. The 0.2% annual chance river flood and the worst-case storm surge/storm wave combination from a Category 5 hurricane are adopted as the standard hazards for new and existing critical infrastructure.

A capital improvements plan is developed that includes a schedule for the staged replacement, or relocation of infrastructure believed to be vulnerable to flooding, erosion, and other identified hazards.

A recommendation is considered and debated within the advisory committee to refrain from extending city services into undeveloped floodplain land or into erosion hazard areas in order to discourage intensive development in these areas. Such areas are viewed as prime candidates for acquisition and public use as parks, greenways, and for restoration to natural habitat.

The road network is studied to identify vulnerable areas where flooding or erosion and road closure might create transportation bottlenecks and blockages. Major roads, routing procedures, and signage are evaluated for their adequacy when mandatory evacuations are ordered in advance of a hurricane.

**Emergency Services**

The city staff obtains the services of an emergency management consultant to satisfy the city council’s request for an evaluation of the city’s emergency preparedness, state of resilience in quickly returning to provision of full services, and identification of needed improvements.

The GIS system and simulation modeling are used to show areas of the upstream watershed, city, and coastal floodplain that will be inundated by river flood or storm surge, stages, and tsunami wave inundation. A series of training sessions is begun for emergency responders in order to rehearse the sequence and timing of the steps needed to adequately respond to each of the identified coastal hazards. In these training sessions, readiness for pre-disaster preparations and post-disaster responses will be periodically assessed and corrective actions taken as needed. Each of these hazards has its own advance warning time and duration.

The consultant recommends

- Participation in the National Weather Service’s StormReady and TsunamiReady programs to improve the timeliness and effectiveness of hazardous weather warnings to emergency responders and the public;
- Relocation of the city’s emergency operations center; and
- Adoption of a risk analysis and management process.

A risk process manager is hired by the city and made an active member of the city management team. A risk management team is assembled from the city’s department managers. The risk process manager initiates a series of periodic risk reviews. A risk mitigation strategy and risk response plans are developed. Individuals are assigned responsibility for specific tasks and charged with making adequate pre-disaster preparations and adequate post-disaster responses. Changes in risk exposures are monitored and the strategy and plans updated as warranted by such changes or by the occurrence of risk events, such as hurricanes, river floods, and unanticipated erosion.
Risk management becomes a conscious, ongoing part of city management. Risk management is extended to the management of the entire city’s infrastructure. The working relationship on the risk management team and the work itself become preparation for future participation in a post-disaster redevelopment plan, should a disaster strike. A seasoned, well-informed team will be needed that can work under the pressure of public expectations for a quick recovery after a hurricane or flood.

Education and Outreach

The city staff takes FEMA’s *Coastal Construction Manual* training in a two-day short course held in a major city nearby. The training helps the staff understand the rationale and the measures available and needed to retrofit the city’s vulnerable buildings to make them more resistant to hurricane winds. Sea Grant specialists will help city staff conduct education and outreach to help residents understand the rationale for revised or new plans, regulations, and standards that are developed. They can also help establishing outreach partnerships with appropriate community organizations. Staff make a concerted effort to encourage public participation in the decision-making process.

CONCLUSION

The scenarios presented in this handbook demonstrate how States and communities can take advantage of innovations and ideas that have been successful elsewhere. These fictional coastal communities have been pro-active in their efforts to be responsive to the needs of all of their constituents, to protect the Public Trust, and to be good neighbors—all while reducing the vulnerability of their residents to coastal hazards.